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

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

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Contents

i Executive summary

The ICES herring assessment working group (HAWG) met for seven days in March 2019 to assess the state of five herring stocks and three sprat stocks. HAWG also provided advice for seven sandeel stocks but reported on those prior to this meeting in February. The working group conducted update assessments for the five herring stocks. An analytical assessment was performed for the combined North Sea and Division 3.a sprat, and data limited assessments (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)** SSB in 2018 was estimated at 1.9 mill tonnes while $F_{2–6}$ in 2018 was estimated at 0.21, which is below F_{MSY}. Fishing mortality on juveniles, mean $F_{0–1}$ is 0.028, below the agreed ceiling. Recruitment in 2018 has increased compared to 2017 but remains within the low recruitment regime observed since 2015. Year classes since 2002 are estimated to be consistently weak with year classes 2015 to 2017 some of the weakest on record. ICES considers that the stock is still in a low productivity phase.

The **Western Baltic spring spawning herring (her.27.20-24)** assessment was updated. The SSB in 2018 is estimated to be around 74 132 tonnes. Fishing mortality has been estimated at 0.416 which is above the estimate of F_{MSY} (0.31). Recruitment has been low since 2006 and continues to decrease with 2018 the lowest observed in the time-series. Under a historical perspective the estimate of SSB in 2018 is considered low, below both B_{pa} and B_{lim}, 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, declining from a high biomass that peaked in 2011. SSB is currently estimated at 23 000 tonnes in 2018, coming down from 136 000 tonnes in 2011. The stock is now below B_{lim} (34 000 t). Mean $F_{(2–5 \text{ rings})}$ was estimated at 0.33 in 2018, having increased from 0.06 in 2009. Recruitment has been consistently below average since 2013.The assessment of the combined stock 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 now based on trends from an analytical assessment. SSB and recruitment have been declining since around 2000 and are currently at the lowest level in the time series. 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 a stable SSB in 2018 compared to previous years at around 22 020 tonnes. The stock has experienced large incoming year classes in most recent years. Fishing mortality ($F_{4–6}$) is estimated at 0.16, one of the lowest in the time series and below F_{MSY} (0.266). Catches have been relatively stable since the 1980s, and close to TAC levels in recent years. **North Sea and 3.a Sprat (spr.27.3a4)** were combined into a single assessment unit during the recent WKSPRAT benchmark. The long-term dynamics and perception of the status of the combined stock is consistent with previous perception for sprat in Subarea 4. Despite the fact that 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 2019 show an SSB of 249 000 t which is nearly double of B_{pa} (125 000 t).

Catch advice for **sprat in the English Channel (7.d, e) (spr.27.7de)** was based on criteria for an ICES category 3-based method. Data available are landings and a short time series of acoustic biomass (2013–2018). The acoustic biomass indicates an overall decline in the stock size. Quantitative advice was provided for **Sprat in the Celtic Sea (spr.27.67a–cf–k)** using an ICES category 5-based method where only data on landings are available.

The HAWG reviewed the assessments performed on seven sandeel stocks and the related advice of these stocks. Section 9 of this report contains the assessments of sandeel in Division 3.a and Subarea 4.

Standard issues such as 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 stock discrimination relevant for small pelagic fish were discussed.

All data and scripts used to perform the assessments and perform the forecast calculations are available on GitHub 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	2019
Reporting year in cycle	1/1
Chairs	Valerio Bartolino, Sweden
	Susan Mærsk Lusseau, United Kingdom
Meeting venue and dates	HAWG Sandeel: 29-31 January 2019, Copenhagen, Denmark (6 participants)
	HAWG: 13-21 March 2019, Copenhagen, Denmark (29 participants)

1 Introduction

1.1 Terms of Reference

2018/2/ACOM07 The Herring Assessment Working Group for the Area South of 62ºN (HAWG), chaired by Susan Lusseau*, UK, and Valerio Bartolino*, Sweden, will meet at ICES Head-quarters for two meetings: 29–31 January 2019 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 13–21 March 2019 to:

b) compile the catch data of North Sea and Western Baltic herring on 13–14 March;

c) address generic ToRs for Regional and Species Working Groups 15-21 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 2019 ICES data call. HAWG will report by 11 February and 5 April 2019 for the attention of ACOM.

Fish Stock	Stock Name	Stock Coord.	Assesss. Coord. 1	Assess. Coord. 2	Advice	Review (SA)
san-sa	Sandeel in Division 3.a and Subarea 4	Denmark	Denmark	Norway	Update	Sweden/Germany/Norway/Denmark
her-27.20-24	Herring in Subdivisions 20–24 (Western Baltic Spring spawners)	Denmark	Denmark	Denmark	Update	UK/Denmark
her-27.3a47d	Herring in Subarea 4 and Division 3.a and 7.d (North Sea Autumn spawners)	Germany	NL	UK (Scotland)	Update	Norway/UK (Scotland)/Denmark
her-27.irls	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		Update	Netherlands
her-27.6a7bc	Herring in Divisions 6.a and 7.b and 7.c	UK (Scotland) / Ireland	Ireland	UK (Scotland)	Update	UK (Northern Ireland)
her-27.nirs	Herring in Division 7.a North of 52° 30’ N (Irish Sea)	UK (Northern Ireland)	UK (Northern Ireland)	-	Update	Netherlands

Fish Stock	Stock Name	Stock Coord.	Assesss. Coord. 1	Assess. Coord. 2	Advice	Review (SA)
spr-27.3a4	Sprat in Division 3.a (Skagerrak - Kattegat) and Subarea 4 (North Sea)	Norway	Denmark	-	Update	France/(Denmark/Norway
spr-27.7de	Sprat in the Western Channel	UK	UK	-	Update	Norway / Ireland
spr-27.67a-cf-k	Sprat in the Celtic Seas	UK	UK	-	Update	

1.2 Generic ToRs for Regional and Species Working Groups

2018/2/ACOM05 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:

- Consider and comment on Ecosystem and Fisheries overviews where available;
- b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:
- i) descriptions of ecosystem impacts of fisheries
- ii) descriptions of developments and recent changes to the fisheries
- iii) mixed fisheries considerations, and
- iv) emerging issues of relevance for the management of the fisheries;
- c) Conduct an assessment on the stock(s) to be addressed in 2019 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarising where the item is relevant:
- i) Input data and examination of data quality;
- 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 2018.
- iv) Estimate MSY proxy reference points for the category 3 and 4 stocks
- v) The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;
- vi) The state of the stocks against relevant reference points;
- vii) Catch scenarios for next year(s) 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 succint description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. 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.Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines.

- d) Review progress on benchmark processes of relevance to the Expert Group;
- e) Prepare the data calls for the next year update assessment and for planned data evaluation workshops;
- f) Identify research needs of relevance for the work of the Expert Group.

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

The ToRs are addressed in the sections shown in the text table below.

Stock	Addressed in Section
Herring in Subarea 4 and Division 3.a and 7.d (North Sea Autumn spawners)	Section 02
Herring in Division 3.a and subdivisions 20–24 (Western Baltic Spring spawners)	Section 03
Herring in divisions 6.a and 7.b-c	Section 04
Herring in divisions 6.a (South), 7.b–c, and 6.a (North), separately	Section 05
Herring in Division 7.a South of 52° 30’ N and 7.g-h and 7.j-k (Celtic Sea and South of Ireland)	Section 06
Herring in Division 7.a North of 52° 30’ N (Irish Sea)	Section 07
Stocks with limited data	Section 08
Sandeel in Division 3.a and Subarea 4	Section 09
Sprat in Division 3.a (Skagerrak - Kattegat)	Section 10
Sprat in Subarea 4 (North Sea) and Division 3.a (Kattegat-Skagerrak)	Section 11
Sprat in Division 7.d and 7.e	Section 12
Sprat in the Celtic Seas	Section 13

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)

As usual WGCHAIRS met at the beginning of the year in preparation of the new year of advice and science working groups’ activities.

Under the new ICES strategy, a new steering group, Fisheries Resources Steering Group (FRSG), will be created. Activities of advisory working groups such as HAWG will be conducted under the umbrella of FRSG. This re-organisation is mainly motivated by the intention to enhance the transfer of new science into advice and facilitate interaction between the individual working groups and both ACOM and SCICOM, FRSG will become operative throughout 2019. Advisory expert groups will maintain their prerogative of “closed groups” in the sense that members will be still nominated at a national level.

Overall, the format of the advice had no major changes. WGCHAIRS remarked the importance of quality assurance of the ICES advice and the role of the audit system in this. Audits should be performed rigorously according to a given template (same as last year). At HAWG this is implemented assigning at least two members as auditors for each stock.

This year ICES has increased its attention towards evaluation of potential Conflict of Interest (CoI) in relation to any of its advisory activity. Expert groups are now considering CoI even more carefully than before with specific reference to a code of conduct which has been discussed and explicitly agreed by all members of HAWG at the beginning of the meeting.

WGCHAIRS remarked that while considerable progresses have been made in the documentation and quality assurance of scientific data (incl. both surveys and commercial data collected for scientific purposes), quality of the landing data is generally poorly documented by member countries. It remains the responsibility of the individual countries to implement quality assurance frameworks for the landings data.

From 2019, ICES will publish the reports from expert working groups (incl. assessment groups) as part of the new ICES scientific report series. This means that all the reports will have an ISSN and a DOI number, and most importantly authorship of the report will now lay on the members of the working group with the chairs named as editors and all the members presented as authors.

1.3.2 Working Group for International Pelagic Surveys (WGIPS)

The Working Group of International Pelagic Surveys (WGIPS) met in Santa Cruz, Spain on 14–18 January 2019. 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 2019 surveys.

Results of the surveys covered by WGIPS and coordination plans for the 2019 pelagic acoustic surveys are available from the WGIPS report (WGIPS, ICES 2019). The following text refers only to the surveys of relevance to HAWG.

Review of larvae surveys in 2018:

These surveys are no longer dealt with in WGIPS. From 2019 the planning, analysis and reporting on larvae surveys will fall under WGSINS. In the interim period results from for the 2017/18 larvae surveys can be found in the HAWG report, Section 3.3.2 and for 2018/19 they will be coordinated and reported on in WGEGGS2.

North Sea, West of Scotland and Malin Shelf summer herring acoustic surveys in 2018: Six surveys were carried out during late June and July covering most of the continental shelf in the North Sea, West of Scotland, Malin Shelf, West of Ireland and Celtic Sea.

The estimate of **North Sea autumn spawning herring** spawning stock biomass is higher than previous year at 2.3 million tonnes (2017: 1.9) due to an increase in the number of fish (2017: 11.621 mill. fish, 2018: 12.315) and an increase in weight-at-age for mature herring. The spawning stock is dominated by young fish of age 4 and 5 wr, which is in accordance with the strongest year classes in the 2017 survey.

The 2018 estimate of **Western Baltic spring-spawning herring** 3+ group is 107 000 tonnes and 745 million. This is a decrease of 52 and 45%, respectively, compared to the 2017 estimates of 221 000 tonnes and 1353 million fish.

The **West of Scotland** estimate (6.a.N) of SSB is 152 000 tonnes and 875 million individuals, a small increase compared to the 139 000 tonnes and 765 million herring estimate in 2017.

The 2018 SSB estimate for the **Malin Shelf area (6.a and 7.b,c)** is 159 000 tonnes and 925 million individuals. This is a about the same level as the 2017 estimates (145 000 tonnes and 798 million herring). There was some herring distribution south of 56°N in 2017–2018; this resulted in a slightly higher estimate for the Malin Shelf compared to the West of Scotland.

There was a sprat benchmark in November 2018 (ICES, 2018), resulting in the two sprat stocks in the North Sea and Skagerrak-Kattegat being merged into one. For consistency, the survey results are presented separately in this report for these two areas.

The total abundance of **North Sea sprat (Subarea 4)** in 2018 was estimated at 120 141 million individuals and the biomass at 834 000 tonnes (Table 5.10). This is nearly 3 times as many sprat as last year, the second highest in the time series and high above the long-term average of the time series, in terms of both abundance (137% above) and biomass (88%). The stock is dominated by 1-year-old sprat (89% in numbers). The estimate also included 0-gr sprat (3% in numbers, and 0.1% in biomass), which only occasionally is observed in the HERAS survey.

In for **sprat in Division 3.a**, the abundance in 2018 is estimated at 3438 million individuals and the biomass at 33 400 tonnes; the second highest estimate of the time series as for the North Sea. This is well above the long-term average both in terms of abundance (86%) and biomass (38%). The stock is dominated by 1- and 2-year-old sprat.

Irish Sea Acoustic Survey:

The herring abundance for the Irish Sea and North Channel (7.a.N) in Aug/Sept 2017 and Aug/Sept 2018 was reported by Northern Ireland The estimate of herring SSB of 91 332 tonnes for 2016 was near the series high 2010 estimate. In 2018 the estimate was 39 997 tonnes, similar to that observed in 2017. The biomass estimate of 54 661 tonnes for 1+ ringers is a 25% increase on last year's biomass estimate. Unlike in previous years when a large proportion of the 1+biomass estimate is seen in north of the Isle of Man and in North Channel, in the current year the majority of biomass was observed in the south east of the Isle of Man area. The western and northern Irish Sea are areas of mixed size fish. In 2018 the sampling intensity was relatively high during the 2018 survey with 32 successful trawls completed. The herring were fairly widely distributed within mixed schools at low abundance, with a few distinct high abundance areas. The bulk of 1+ herring targets in 2018 were observed off the east coast of the Isle of Man, and on the eastern coast of Northern Ireland, with a fairly scattered lower abundance observed throughout the Irish Sea. 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. The length frequencies generated from these trawls highlight the spatial heterogeneous nature of herring age groups in the Irish Sea. The survey estimates are influenced by the timing of the spawning migration.

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 exactly the same as for AC(7.aN) 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 is reported in the WGIPS 2018 report (ICES, 2018). The survey is included in the assessment as a SSB index. The SSB in 2017 was estimated as 2017 1 41, 683 declining to 38 974 in 2018. The herring were distributed within a few distinct high abundance areas to the southwest and southeast of the Isle of Man. The estimate of herring SSB from the 2018 commercial acoustic survey remain within range for the time series.

Celtic Sea herring acoustic survey (CSHAS): Herring and sprat abundance for the Celtic Sea in October 2018 was reported by the Marine Institute, Ireland. The Celtic Sea herring stock was considered to have been contained within the survey area in 2018. The spawning stock biomass (SSB) estimate in 2018 was 7760 tonnes and is comparable to the 2017 survey estimate. Both years represent the lowest SSB points in the survey time series. The CV on the survey estimate was high (~0.50) in 2018. The downward trend in the standing stock biomass has continued from a medium term high around 2012 and has been exacerbated by a prolonged period of poor recruitment since then. Observations made during the WESPAS summer survey in June 2018 confirm the currently low standing stock abundance of herring in the Celtic Sea. The potential of a positive signal in recruitment was evident from survey catches with 0-group herring observed across the CSHAS survey area and further east into UK waters. The biomass and abundance of sprat in 2018 was higher than in 2017 and more in line with the 2016 estimate.

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 2018. Geographical coverage extended southwards in 2017 to include French waters in the western Channel and in 2018 was further extended in to Division 7.d Both the number of completed acoustic transects and trawls exceeded those achieved in 2017. Preliminary results indicated some differences in ichthyofauna observations when compared to 2017. In the Bristol Channel, other than the usual hotspot inside the estuary, the majority of fish biomass was found more inshore, as demonstrated also by the location of the trawl effort. In the French waters of the western Channel more fish activity was found along the western-most transects. Further east in the western Channel, very few schools were encountered, which matched last year's results. The transects east of Lyme Bay, sampled for the first time during PELTIC, yielded little fish biomass. 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. 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. 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 the hypothesis of two different stocks.

Sprat biomass had increased in Lyme Bay in 2017 (English Channel: 34 109 tonnes) compared to the low biomass estimate from 2016. A decline in biomass was observed in 2018 again to 17 091 tonnes.

1.3.3 PGDATA, WGBIOP and WGCATCH

The Planning Group on Data Needs for Assessments and Advice (PGDATA coordinates the activities of both WGBIOP and WGCATCH. One of its main focuses is on 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.

The ICES Working Group on 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 stock-assessment working groups and WGBIOP is through the benchmark process. WGBIOP works in close association with the BSG (ICES benchmark steering group), reviewing all issue lists pointing to either missing issues in relation to specific stocks and guiding the process to get issues related to biological parameters resolved. WGBIOP will align its scheduling of age and maturity calibration exchanges and workshops with the newly proposed ICES benchmark prioritisation 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 2018) reviewed the following activities falling within its remit and of interest for HAWG:

- Herring (*Clupea harengus*) Otolith Microstructure (OM) exchange. In 2018, 4 readers from Sweden and Denmark took part in an exchange of ground and polished otoliths (n=96) from ICES areas 3.aN, 3.aS and 4.b, the overall agreement across readers was 45%. 23 of the samples had a genetically validated stock ID, there were just 5 of these where all 4 readers were in agreement with the genetic results. Readers agreed that overtime OM patterns have changed and it has become more and more difficult to clearly distinguish between the spawning types, mostly between the Western Baltic spring spawners (WBSS) and the Downs winter spawners. In early 2019 another exchange took place with the same 4 readers participating and all samples (n=93) had a genetically validated stock ID assigned. The overall agreement was 85% with the Downs winter spawners being the most difficult to identify correctly. The presence of samples from sub-stocks where the OM varies from those described in the past can cause confusion for the readers and work continues on updating reading guidelines using genetically identified stock IDs.
- The Workshop on sexual maturity staging of herring and sprat (WKMSHS2) concluded; agreement with the validated material (herring 52%) was much lower compared to the agreement with the modal stage (herring 74%); there was no improvement achieved over the calibration rounds for herring and a small improvement for sprat; males are generally more difficult to stage compared to females and a mismatch exists between the herring stage description and the WKMATCH scale.
- The Workshop for advancing sexual maturity staging in fish (WKASMSF) proposed the 'WKMATCH 2012 maturity scale revised', prepared conversion tables to be used when uploading national maturity data to the ICES survey and commercial fisheries databases and prepared an implementation plan for reporting maturity data in the 'WKMATCH 2012 maturity scale revised' to these databases from 1 January 2020.

The ICES Working Group on Commercial Catches (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 data sets can be weighted in an assessment model according to their relative quality.

WGCATCH 2018 finalized best practice guidelines for sampling and estimation of foreign landings in national ports. These guidelines were based on case studies highlighting the present problems and successes with sampling of foreign landing (a lot of the case studies focused on small pelagic fish). WGCATCH 2018 started to work on best practice guidelines in data request and provision for frequency data (e.g. DLS stocks), by summarising current national practise and developing tools to support national data submitters and stock coordinators to summarise the quality of the data provided. Further the group continued the work on guidelines for best-practice in sampling of small-scale fisheries, data recording, estimation of commercial catches under the landing obligation and sampling of commercial catches, including by-catch of protected, endangered and threatened species (PETS).

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 (updated at WKPELA 2018), North Sea sprat (evaluated and updated at HAWG 2018), sandeel SA1 (evaluated and updated at HAWG 2018), sandeel SA3 (evaluated and NOT updated at HAWG 2018). No update of natural mortalities are available from WGSAM for the 2019 HAWG assessments.

1.3.5 WKNSMSE

The Workshop on North Sea stocks Management Strategy Evaluation (WKNSMSE) evaluated long-term management strategies for a number of jointly-managed stocks in the North Sea between the European Union and Norway, following a request from EU-Norway. The North Sea Autumn spawning herring was among those stocks. The full-feedback simulations performed by WKNSMSE aimed to find "optimal" combinations of harvest control rule parameters (F_{target} and $B_{trigger}$) for management strategies with (scenarios C,D,E) or without (scenarios A,B) stability mechanisms (TAC constraints and banking and borrowing scenarios; see Table 1.2.5.1). "Optimal" combinations were defined as those combinations of F_{target} and $B_{trigger}$ that simultaneously maximised long-term yield while being precautionary (long-term risk 3 ≤ 5%).

The Management Strategy Evaluation (MSE) considers four components: the biological stock unit of herring in the North Sea [1], four fisheries targeting the stock unit [2], the fisheries-independent surveys [3], the stock assessment procedure which is used to obtain a perceived status of the stock unit and to set management targets [4]. The framework includes feedback loops, where over time, the result of setting management targets affects the stock unit the year after, and thereby also affects the fisheries and management. In order to reflect the uncertainties related to stock dynamics, fisheries dynamics and management implementation, the simulations are run with 1000 replicates, each representing a different but likely version of the true dynamics of the stock unit and fisheries.

Contrary to the expectations, the risk criteria does not stabilize in the medium to long term. Therefore the results referred to as "long-term" are achieved at equilibrium and are actually conditional to some of the assumptions (i.e., 20-year projection period, 1000 replicates and risk 3 ≤ 5% over the last 10 years). This means that the outcomes of the MSE should be considered precautionary only within the 20 years evaluated and the strategies should be re-evaluated within that time frame.

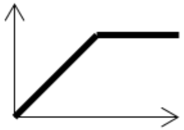
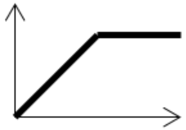
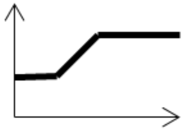
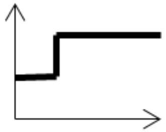
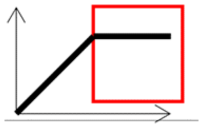
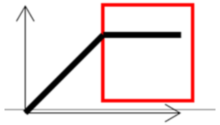
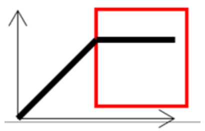
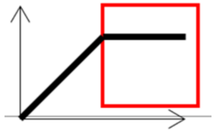
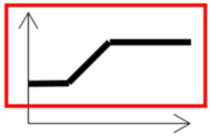
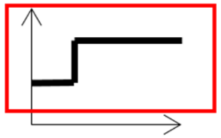
All the scenarios tested are precautionary with the exception of the strategy E for which no optimal target was found. In general, for all the other scenarios (A–D) there is less than 0.2% difference in the long-term yield (Table 1.2.5.2).

The optimal F_{target} values for all the scenarios (0.22–0.23) are somewhat smaller than the F_{MSY} value (0.26) estimated using EqSim at the last benchmark in 2018. Thus, the current F_{MSY} in combination with an MSY $B_{trigger}$ of 1.4 mt has an associated risk > 5%. There are fundamental differences in the way EqSim and the MSE evaluate risk and make use of implementation error which may explain the difference (i.e., the up to 50% flexibility for the human consumption fishery in 3a is accounted in the identification of the F_{target} but it is not part of the EqSim calculation).

Among the sensitivity tests performed, the MSE evaluated the consequences of reducing the bycatch of the B and D fleets which showed a reduction in risk and some consequent increase in fishing opportunities for the human consumption fishery (A-fleet). These results are in line with previous results as obtained in ICES 2015 (WKHerTAC).

Despite the use of high-performance clusters, computational time represented a challenge (running time for a 1000 replicate scenario was around 500 h with approx. 50 evaluations per core) which limited part of the evaluation.

Table 1.2.5.1 Management strategies for the North Sea herring stock tested at WKNSMSE.

HCR	A-fleet	B-fleet	Condition	Stability	Bank & Borrowing
A					
B					
C			if SSB > B_{trig}	TAC_y A-fleet in AdY 0.8 TAC_{y-1} < TAC_y < 1.25 TAC_{y-1}	+/-10%
D			if SSB > B_{trig}	TAC_y A+B-fleet in AdY 0.8 TAC_{y-1} < TAC_y < 1.25 TAC_{y-1}	+/-10%
E				TAC_y A+B-fleet in AdY 0.8 TAC_{y-1} < TAC_y < 1.25 TAC_{y-1}	+/-10% except when: SSB < B_{pa} & F > F_{pa} in AdY B < B_{pa} in AdY and CtY

SSB and F are calculated at spawning time; ImY, AdY, CtY are the intermediate, advice and continuation years. The red square shows when stability and flexibility measures apply.

Table 1.2.5.2 Short-, medium- and long-term yield (total catch) and SSB for the "optimised" strategies and for FMSY given the "optimal" $B_{trigger}$. Cases where risk3 > 5% are in red text. E is not included since no "optimum" was found for it. The time period are: short = 2019:2021, med = 2022:2026, long = 2027:2036. Management strategies with an asterisk indicate F_{target} = F_{MSY} and $B_{trigger}$ = MSY $B_{trigger}$.

Management Strategy	F case	F_{target}	$B_{trigger}$	Yield			SSB			risk3			IAV			Realised mean $F_{(2–6)}$		
				short	med	long	short	med	long	short	med	Long	short	med	long	short	med	long
F=0	**F=0**	**0**	**0**	**0**	**0**	**0**	**2310249**	**2643789**	**2687033**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
A	**F_{target}**	**0.22**	**1400000**	**269747**	**339827**	**345646**	**1293350**	**1461235**	**1471026**	**0.037**	**0.025**	**0.046**	**0.186**	**0.147**	**0.151**	**0.179**	**0.219**	**0.219**
A*	F_{MSY}	0.26	1400000	296446	361936	358346	1253241	1370185	1363961	0.065	0.053	0.072	0.190	0.164	0.168	0.205	0.253	0.248
B	**F_{target}**	**0.22**	**1400000**	**271574**	**338313**	**344582**	**1291883**	**1456469**	**1467080**	**0.037**	**0.029**	**0.05**	**0.183**	**0.147**	**0.149**	**0.179**	**0.219**	**0.219**
B*	F_{MSY}	0.26	1400000	298388	359776	356365	1250953	1360849	1354684	0.061	0.054	0.081	0.188	0.165	0.168	0.205	0.251	0.247
C	**F_{target}**	**0.22**	**1400000**	**269690**	**335932**	**345095**	**1293654**	**1469648**	**1473686**	**0.037**	**0.025**	**0.048**	**0.186**	**0.158**	**0.157**	**0.179**	**0.219**	**0.219**
C*	F_{MSY}	0.26	1400000	296510	359024	358001	1253728	1377431	1365667	0.062	0.051	0.076	0.190	0.172	0.171	0.205	0.253	0.249
D	**F_{target}**	**0.23**	**1400000**	**276805**	**342173**	**349286**	**1283906**	**1446680**	**1446241**	**0.048**	**0.03**	**0.049**	**0.186**	**0.162**	**0.159**	**0.186**	**0.228**	**0.228**
D*	F_{MSY}	0.26	1400000	296510	359438	358937	1253750	1378526	1368652	0.061	0.047	0.076	0.189	0.171	0.171	0.205	0.254	0.249

1.3.6 WKSPRAT & WKSPRATMSE

The 2018 benchmark workshop on sprat (WKSPRAT) focused on the following three stocks: North Sea (area 4) sprat, Kattegat-Skagerrak (area 3.a) sprat and the Channel sprat. During the benchmark process, several evidences including genetics, otolith shape, recruitment and cohort dynamics were presented on the connection between sprat in the North Sea and in the Kattegat-Skagerrak. It was therefore agreed to merge the two stocks and assess them as one stock assessment unit. For the purposes of the new joined assessment for the two areas, both the catch data and the indices of abundance from 3.a were included in the data from area 4. Three surveys are carried out throughout the assessment area including the IBTS in Q1 and Q3 and the acoustic HERAS survey. All the surveys were used as tuning indices in the model. The indices were standardized using a delta-GAM approach: the inclusion of 3.a data increased the internal consistency between all age classes for all indices. The SMS model, previously used to assess the North Sea component, was used to assess the new combined stock. The final model formulation includes a power function for the age 0 catchability of IBTS Q1, a constant maturity ogive and the inclusion of the very few catches reported for Q4 in the Q1 of the following year. The new stock assessment shows a considerable improvement in the retrospective pattern, as well a better fitting to some ages of the IBTS surveys. The stock reference points were revised following ICES standard guidelines using a segmented stock recruitment relationship limited to years from 1982 and onwards. B_{lim} was estimated at 94 000 t as the breakpoint of the segmented regression and B_{pa} was derived from B_{lim} at a value of 124 946 t. However, an escapement strategy, where the stock is fished down to B_{pa}, has been proved not to be precautionary for such stock, unless an F limit control rule (F_{cap}) is applied. For this reason, a full closed loop management strategy evaluation was carried out after the benchmark by WKSPRATMSE to test for different F_{cap} values, where the F_{cap} chosen corresponds to the F providing a probability of SSB falling below B_{lim} lower than 5%. The results suggested that an F_{cap} of 0.69 is precautionary under the assumption that only errors in the stock numbers and exploitation patterns are included.

WKSPRAT benchmarked also sprat from the area 7.d,e. Not enough evidences were available to change the boundaries of this stock. An acoustic survey (revised for the benchmark) is carried out in the English part of area 7.e since 2013, and extended to the French part of 7.e in 2017 and to the Eastern Channel in 2018. In addition, an IBTS index in Q1 is available for the Eastern Channel from 2007 onwards. Overall, the short time series in the acoustic index and the lack of sufficient contrast in the data do not allow any analytical model to converge. Thus, the stock is in a category 3 (data poor stock). The benchmark proposed a seasonal advice based on an empirical method where trends are informed by both the indices, but only the acoustic survey is used for provision of the advice. In line with preliminary results from WKLIFE, the benchmark agreed that the "2-over-3" rule is not appropriate for short, highly productive stocks as sprat in area 7.d,e. Therefore, WKSPRATMSE compared through simulations the performances of the alternative "1-over-2" rule and of different fixed harvest rates. The results suggested that a 1-over-2 rule might cause the stock to fall below safe levels and eventually to collapse because the rule is not reactive enough to limit the catches when there is a recruitment failure. The risk decreases but remains still above safe limits also when removing the uncertainty cap. Simulations suggest that a 20% fixed harvest rate may be considered appropriate to maintain the stock at safe biomass levels and to produce relatively high yield. Further work is required in the light of the relevant upcoming Workshop for Data-limited Short-lived Stocks (WKDLSSLS).

1.3.7 IBPher6a7bc

The Inter-Benchmark Protocol for Herring in 6.a, 7.b-c 2019 (IBPher6a7bc, ICES 2019) was held to seek a solution to the consistent and increasing retrospective bias in the assessment of this herring stock.

At the meeting several improvements to the survey series used in the assessment were presented and reviewed. This included re-calculated and extended Scottish West Coast International Bottom Trawl Survey Quarter 1 and Quarter 4 (SWS BTS Q1 and Q4) and the two acoustic survey indices used in the assessment were re-examined and combined in to one to give a better acoustic index. Survey data analysis improvements were carried out first and agreed, and model optimisation was performed with the improved indices in the attempt to minimise the retrospective bias.

Extensive work was carried out to find a model configuration that would improve the retrospective, but it became clear that minimising the retrospective bias caused problems elsewhere in the models. Eventually, the interbenchmark agreed on a final model configuration. Although it was agreed the final model is a better assessment, there is still a retrospective bias. The new assessment also provides a radically different perception of the stock than previously and the assessment output raises a number of questions as to the dynamics of these combined stocks, over the time series that could not be investigated in depth during the inter-benchmark.

With an agreed final assessment the MSY and PA reference points were investigated according to ICES guidelines. The new stock assessment data, when implemented in the routines for estimating the reference points, using the same procedures as previously, lead to a number of questions as to how one could 'objectively' apply the ICES guidelines for estimating reference points. Extensive explorations, including limiting the length of the time series, indicated that the reference points were very sensitive to the choice of input data.

Surplus Production in Continuous Time (SPiCT) analysis was also undertaken but did not provide an alternative way of estimating sensible/believable reference points. The final conclusion was that since there was no objective way to choose a definitive data set for use in calculating a set of plausible reference points, no new reference points, based on the new assessment, were presented.

In regard to advice, it was decided that the assessment should be considered as a representation of trends rather than absolute estimates of stock size. Therefore, it is appropriate to consider the stock assessment as category 3 so that relative changes in fishing and stock size are used as basis for ICES advice (i.e the 2/3 rule, where advice based on previous advice, modified according to index information; typically the trend in the last 5-years of the index).

1.3.8 IHLS and MIK surveys

The International herring larvae survey (IHLS) index provides information on the contribution and distribution of the different spawning components to the North Sea herring stock. This is the only index currently used in the assessment to provide information on the relative sizes of the four North Sea herring stock components, as in the other surveys or catch data the fish cannot be split into the different spawning components. The IHLS thus provides important information for the management of this stock.

In recent years the coverage of the IHLS survey has been compromised due to technical issues with the vessels available to conduct the surveys. This has led to the decision in 2018 to reject the information of 3 of the 4 surveys in the IHLS. Due to this break in the time-series it is necessary to review the current setup of the IHLS. Because information on the relative sizes of stock components of North Sea herring is required, HAWG is recommending that the Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS) review the current design of the IHLS, in the light of the available survey effort, to deliver information on the relative stock components abundances, and if necessary to implement a new survey protocol that can deliver these data.

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 2018.

The DRS was carried out in April, following the IBTS-MIK protocol, but the sampling was carried out both day and night, instead of only at night. Results were presented at HAWG. Due to time constraints it was not possible to cover the whole larvae distribution area. Compared to the MIK, numbers of herring larvae found in the DRS samples were much higher per sample. Length distributions of the herring larvae in the DRS were very similar to that for the MIK in 2018.

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 one year 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. In 2019 IMR, Norway will participate in the DRS and for 2020 Danish Industry and IFREMER, France are investigating possibly participation. 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.

1.3.9 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. Presently only the mixing between North Sea herring and Western Baltic Spring spawning herring in catches in the transfer area and in the HERAS survey in the Danish and Norwegian strata is 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 also arranged to facilitate exchange of ideas and foster collaboration of researchers working of different aspects and methods and to update HAWG on progress on projects currently underway of relevance to HAWG stocks.

1.3.9.1 Stock separation mini symposium

The mini symposium was held on 19th March with 6 talks on projects of relevance to HAWG stocks. Detailed summaries of these talks are in Annex 6.

Edward Farrell from UCD updated the HAWG on progress made to assess the genetic population structure of herring stocks in ICES 6.a/7.bc and to develop genetic baselines of the 6.aN and 6.aS/7.bc stocks to be used to discriminate mixed aggregations of non-spawning herring in area 6a.

Dorte Bekkevold from DTU Aqua presented how Single Nucleotide Polymorphism (SNP) marker classification tools can already be used with high statistical accuracy to distinguish among major herring stocks and sub-stocks mixing in the North Sea, 3.a and Division 22–25.

Florian Berg from IMR is working on splitting Norwegian Spring-spawning herring, North Sea and Western Baltic Spring spawning herring in the HERAS survey and in catches using otolith shape analysis.

Julie Coad Davies from DTU Aqua presented the latest in using otolith microstructure to separate mixed catches of Western Baltic Spring spawners and North Sea herring and presented results from calibration exercises between readers using otoliths from fish genetically assigned to stock.

Jan Arge Jacobsen from Faroe Marine Research Institute presented the otolith classification method used to separate Norwegian spring-spawning herring (NSSH) and other herring stocks (e.g. Icelandic summer-spawning ISSH, Faroese autumn-spawning (FASH) and North Sea type autumn-spawning herring (NASH)) in the International ecosystem surveys in the Nordic Seas (IESNS and IESSNS).

Finally, Michaël Gras from the Marine Institute in Ireland gave an update on the project to use body and otolith morphometry to discriminate herring in 6.a, 7.bc.

Seeing these projects presented together made it clear how much progress is being made towards understanding the population structures of the herring stocks assessed in HAWG and towards developing operational tools to allow routine discrimination of different stocks in the surveys and catches used in the assessments. Many of the researchers already collaborate and exchange material and compare results and will continue to do so, and already were discussing how to further increase these collaborations. One of the outcomes from the symposium is a drive to collect tissue samples for genetic analysis from the entire HERAS survey area in 2019 as well as otoliths from the same fish for shape analysis from the northern most area. This will create a unique dataset to compare results from several methods and help to identify the best method (or combination of methods) to reliably separate different stocks in this survey (6.aN, 6.aS, North Sea Autumn spawners, Western Baltic Spring spawners and potentially also Norwegian spring spawners).

It would be valuable to continue to invite presentations to HAWG on this topic to continue to work towards solutions until enough progress is made to warrant a second round of workshops along the lines of WKSIDAC and WKMIXHER.

1.3.9.2 WKMIXHER 2018

The workshop on mixing of western and central Baltic herring stocks (WKMixHer) took place on 11–13 September 2018 in Gdynia. The aims of workshop were to review recent research and available methods to discriminate western Baltic spring spawning herring and central Baltic herring in mixed catches, evaluate potential implication of mixing for the assessment, develop a coordinated plan to collect and analyse relevant data to quantify the mixing. The central Baltic herring is dominated by a northern component and a southern component and analyses presented at the workshop suggested how the latter actually shares numerous characters with the adjacent western Baltic herring stock (i.e., growth pattern, otolith shape, parasite infestation, etc.). Preliminary analyses performed in conclusion of the workshop suggested a progressive genetic differentiation along the entire southern Baltic coasts from SD24 to SD26 rather than a clear cut division between different assessment units. The workshop results suggest that the issue of separating of the Central Baltic herring stock from the western Baltic spring spawning herring stock is related to understand if the southern component should be considered together with the western Baltic herring, maintained with the central Baltic herring, or if it should be considered separately. Depending on the task, the methodologies reviewed for stock identification could be promising or insufficient. A coordinated plan for sampling herring at spawning time was delineated at the workshop with the objective to validate herring assessment units in the area and look for operational methods to separate them in mixed catches.

Table 1.2.9.2.1 Methodologies for separating the different herring components found in the western and central Baltic (SD22–26) and discussed at the workshop. WBC: WBSSH from SD22–24; CBSC: Southern component of Spring spawning CBH; CBNC: Northern component of the Spring spawning CBH; AC: Autumn spawning component. The score-card below is limited to the results presented at the workshop, the suitability of the different techniques for stock discrimination span from high (green), limited or *to be confirmed* TBC (yellow) and none (red). Copied from WKMixHer report (ICES, 2018).

Stock discrimination methods	WBC-CBSC	WBC-CBNC	CBSC-CBNC	WBC-AC	CBSC-AC	CBNC-AC
Growth	NO	YES	YES	limited	limited	limited
Natural tags *Anisakis simplex*	NO	YES	YES	NA	NA	NA
Otolith shape	limited	YES	YES	YES	YES	YES
Body morphometry	TBC	YES	YES	NA	NA	NA
Vertebrae	NA	NA	NA	NA	NA	NA
Other meristics	NA	NA	NA	NA	NA	NA
Otolith chemistry	TBC	TBC	NA	NA	NA	NA
Genetics 9 microsatellite	limited	limited	limited	NA	NA	NA
Genetics 96 SNPs	TBC	YES	YES	YES	YES	YES

1.3.9.3 WKSIDAC 2017

In 2017 the "Workshop on stock identification and allocation of catches of herring to stocks" (WKSIDAC) was held in Galway, Ireland.

This workshop had several objectives; improve the accuracy and precision of the methods currently applied across laboratories by area; compare alternative available methods; outline a common generic approach in terms of methods; and draft guidelines for conducting stock-splits for assessment purposes. Key issues relating to stock mixes in each of the management areas (2, 3, 5, 6 and 7) were outlined along with why the stock identification was important for the assessments of each of these stocks (see Table 1.2.5.1).

Table 1.2.5.1: Co-occurrence of herring stocks in management areas.

Stocks/stock complexes	stockcode	Spawning components	2a	3a	3 sd22-24	3 sd25	4a	4bc	5a	5b	6aN	6aS	clyde	7aN	7bc	7d	7e	7g-k
Norwegian Spring Spawning	her.27.1-24a514a	NSSH	x	?			?		?	?	?							
North Sea Autumn Spawning	her.3a47d	Downs	x2							x	x	x	x					
		Banks	x2							x	x	x	x					
		Buchan	x2							x	x	x	x					
		Orkney-Shetland	x2							x	x	x	x					
Western Baltic Spring Spawning	her.27.20-24	Rugen	?	x	x	x	x											
		local Spring		x	x													
		local Aut-Winter		x	?													
Central Baltic	her.27.25-2932	CBH		?	x	x												
North West of the British Isles	her.27.6a7bc	6aN	?				?			?	x	x			x			
		6aS-7bc					?				x	x		?	x			
		Clyde									x	x	x		x			
Irish Sea	her.27.7c	Douglas Bank									x	x	x	x	x			
		Mourne									x	x	x	x	x			
Celtic Sea, South West Ireland	her.27.irls	Celtic Sea					-							x			?	x

The workshop concluded from the review on information on stock identification and validation work done so far that there was no consistency between areas and in most either there was no validation or the validation needed to be updated. Only a few areas currently utilize herring stock identification methodology for the assessments, namely areas 3.a and 4 for separation of WBSS from NSAS although the methodology was not ideal, Icelandic waters for separation of ISS from NSS and in Faroese waters for separating autumn from spring spawners. The workshop was focused on potential methods and highlighted the necessity of validation and Standard protocols or operating procedures. The workshop also concluded that the optimal allocation method for stock assessment purposes (as perceived by the Workshop members) varied by area (see Table 1.2.5.2). Otolith shape analyses appeared the most widely recommended, however, other techniques such as genetics and otolith microstructure and micro-chemistry would be necessary for validating the shape analyses results. In the Baltic, separation based on the growth, through length-at-age was favoured and in Area 6.a, a combined approach using genetics and morphology is preferred. Baselines would also need to be updated on a regular basis.

The Workshop was not able to provide an outline of a manual by method for stock identification of herring for implementation in individual laboratories nor provide guidance on retrospective corrections of herring survey time-series but recommended that these topics need to be taken up in some future Workshop/Meeting when further progress has been made.

Table 1.2.5.2. Methodologies for separating herring stocks in each of the management areas.

Table 2: methods in areas	2a	3a	3 sd22-24	3 sd25	4a	4bc	5a	5b	6aN	6aS	Clyde	7bc	7aN	7d	7e	7g-k
Genetic analyses		a,c	a,c	a,c	a,c,e	a,c,e	a	a	c	c		c	c	b	b	c
Otoliths shape analyses		a,b,d	c	c	b	b	b	b	c	c		c	c	a		a
Otolith microstructure		a,b,d			e	e							c			c
Otolith microchemistry		a			e	e			a	a		a	a	a		a
Otolith isotopes		a														
Morphometrics			a						c	c		c	a			a
Parasites		a?,b	a,b	a,b	a	a			a	a		a	a			a
Fatty acids									-	-		-	-			-
Vertebrae counts		d?			a,b,d	a			a	a		a	a			a
Pyloric caecae					a	a			a	a		a	a			a
Tagging			a		a	a			a	a		a	a			a
Growth			a,b,d													

a paper/historic
b data collection
c planned application
d in use in the assessment
e screening/validation

1.3.10 Other activities relevant for HAWG

Industry-Science survey of herring in 6.a, 7b–c. in 2018.

(see Section 06 for additional details).

In 2018, industry and scientific institutions from Scotland, Northern Ireland, Netherlands and Ireland again 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 5800 t (EU2018/120), 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 and 2017 surveys.

Biological samples taken during the survey and subsequent commercial catches were used to construct a catch-at-age used in the 2019 stock assessment. Acoustic surveys on the biomass of the spawning components (ICES, 2019) provide a third set of data points in a spawning stock time series. Morphometric and 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. This information would be considered in a future benchmark assessment.

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 1.2.6.1). 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 and 2019 IBTSQ1 surveys, the occurrences of *Ichthyophonus* in the Norwegian part were again fairly low: 4.4% and less than 1%, respectively. In the Kattegat-Skagerrak, the data suggests levels of incidence generally < 3% but with areas of > 20% infestation (Figure 1.2.6.2) and with a peak around 50% in 45G0 in 2018, although the sample was rather small. Infestation in Q3 2018 appears more localised in the north-eastern part of the Skagerrak compared to 2017. In 2017 the infestation affected mainly age 0-4 and rapidly declined for older fish, while in 2018 also fish of age 5–7 present some level of infestation. 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.

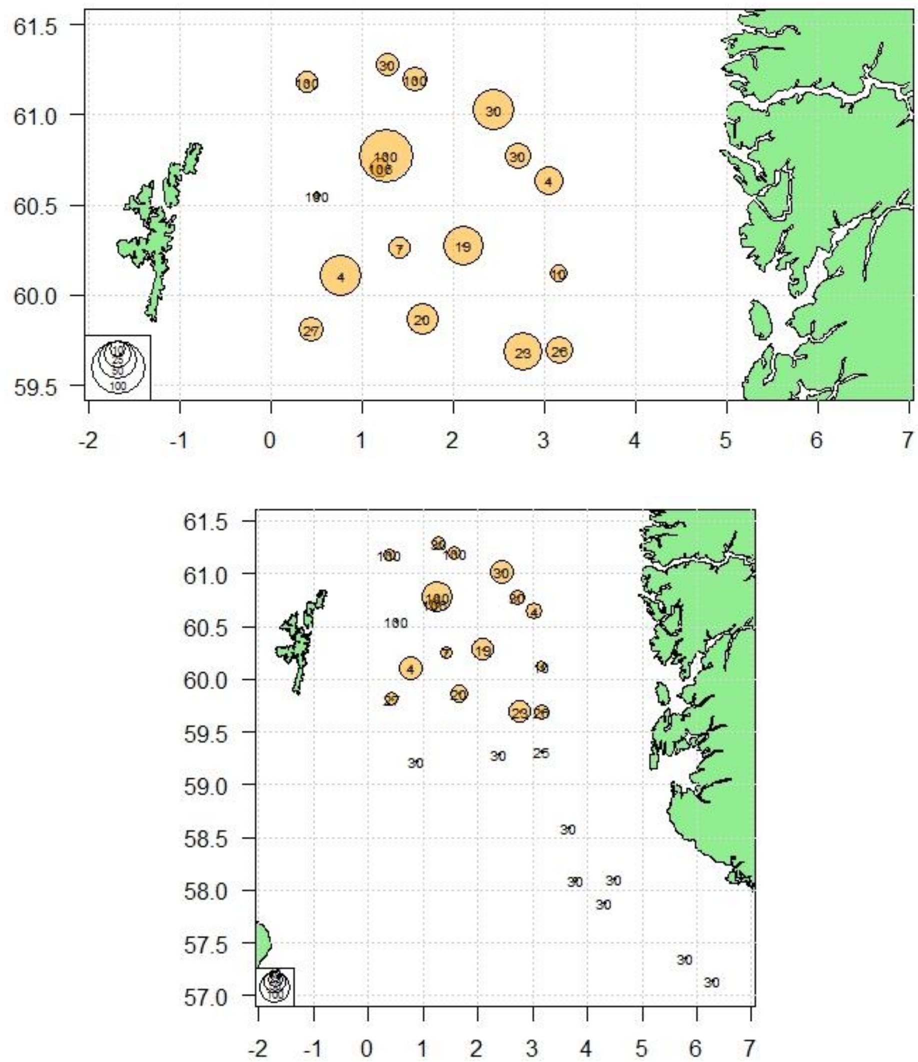


Figure 1.2.6.1 Occurrence of *Ichthyophonus hoferi* in the Norwegian part of the IBTSQ1 2017. Bubble size show the percentage of diseased herring, whereas the numbers show the number of herring.

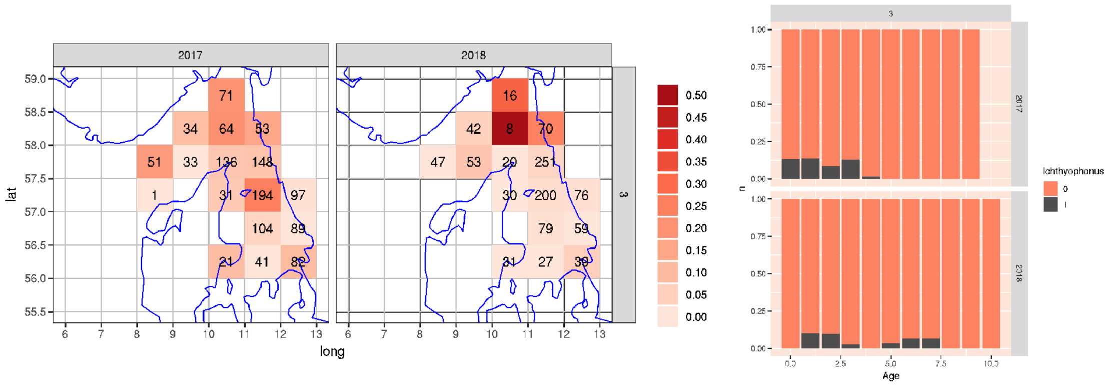


Figure 1.2.6.2 Occurrence of *Ichthyophonus hoferi* in the Kattegat-Skagerrak from Swedish samples collected during the IBTSQ3 2017–2018. Left map with distribution of the proportion of infested herring and number of samples in each rectangle; right distribution of infestation among ages.

HAWG's feedbacks to RDBES

During this year meeting, HAWG had a discussed on the process leading to a joint regional estimation of assessment input data. In particular, HAWG finds that it would be preferable if the estimator role is led by a single individual with input from national experts. This is preferred over an intermediate step within the RDBES wherein the estimation is carried out by multiple individuals with intermediate creation of data subsets. A single estimation would be carried out using a scripted method prepared with input from all national experts currently carrying out estimation procedures. This represents a collaborative approach to define a combined method as a foundation of a single estimation process, it is foreseen that the responsibility to apply the combined method would be taken by a single individual e.g. the stock coordinator.

<table>
<tr><th>Countries\Role</th><th>National Expert</th><th>Estimator Role</th><th>Stock coordinator Role</th></tr>
<tr><td>Tasks-></td><td>View data and view estimation</td><td>Perform the estimation</td><td>View/check all data and combine all national estimates into the stock estimate and export it</td></tr>
<tr><td>Country 1</td><td>Person 1</td><td>Person 1 working with Person 3</td><td rowspan="4">Person 3</td></tr>
<tr><td>Country 2</td><td>Person 2</td><td>Person 3</td></tr>
<tr><td>Country 3</td><td>Person 3</td><td>Person 3</td></tr>
<tr><td>Country 4</td><td>Person 4</td><td>Person 4 working with Person 3</td></tr>
</table>

HAWG also discussed the importance of implementing a framework for co-production and feedback which could allow participation of the different actors to the actual estimation. Need for data check and quality control procedures has been stressed by the group. The general process discussed and proposed by HAWG can be summarised in the main following steps:

- Data are submitted by individual countries which have responsibility on the quality of what they submit (procedures for checking data quality at the level of submission are necessary and should be expected).

- Once data are in the RDB the stock coordinator runs a first diagnostic script which check the data quality once again and eventually report back to the data submitter possible "anomalies". Ideally, this should trigger an iterative process where errors are corrected with amendments on the initial submission.
- The stock coordinator runs an exploratory data analysis script which produces both visual and tabulated representation of the data. These are circulated among the stock coordinator, assessor and all the experts working on the stock for comments and feedback.
- Once agreed on the quality and interpretation of the data, the stock coordinator runs the estimation script which implements an estimation procedure agreed among the stock coordinator, assessor and other experts contributing to the assessment of the stock. Visual and tabulated output (i.e., WECA, CANUM, …) are circulated among these same experts for comments and feedback.
- Once agreed on the representativeness and quality of the estimation outputs, these can be passed to the assessment model.

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 data set.

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 1 March 2019 All EU member states and Norway 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 required 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)	74581	71183	1247	17
4.a(W)	374490	335958	5612	15
4.b	107796	80034	1455	13
4.c	2188	671	109	50
7.d	43277	14284	445	10
7.a(N)	6804	3567	1119	164
6.a(N)	4 063	3 867	717	176
3.a	23258	20745	3567	153
SD22-24	18992	18860	4675	246
Celtic, 7.j	3982	3671	599	150
6.a(S), 7.b and 7.c	1495	1495	1852	1239

Given the diversity of the fleets harvesting most stocks assessed by HAWG, an appropriate spread of sampling effort over the different metiers is more important to the quality of catch-at-age data than a sufficient overall sampling level. The WG therefore recommends that all metiers with substantial catch should be sampled (including by-catches 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 multi-species 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 multi-fleet forecast routine available at www.stockassessment.org.

1.5.5 Reference Points

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

For sprat in the North Sea (Division 4) and sandeel in management area 1–4, the ICES guide for setting management reference points for category 1 stocks is used to find B_{lim}. MSY $B_{escapement}$ is equal to B_{pa} and is calculated as $B_{lim} \times e^{\sigma \times 1.645}$. An upper level on the fishing mortality is implemented (F_{cap}) if the 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 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 on-going discussion on reference points.

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 for 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, 2016a, b).

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 in the biology and ecology of species and populations (including biological and environmental drivers), and disease.

It should be pointed out that whilst 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. 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 currently 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 recent ACOM request (March 2019), HAWG has collected information 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 parenthesis) 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 was explicitly included in the assessment model through data inputs or estimated parameters.

Stock code	Stock assessment					Short term forecast				
	variable w@a	length distribution	variable mat@a	estimated variable nat mort	estimated variable sex ratio	environ. driven recruitment	truncating recruitment time series	recent or trend weight@a	recent or trend mat@a	recent or trend nat mort
her.27.20-24	3	2	3	3	0	1	3	3	3	3
her.27.3a47d	3	2	0	3	0	1	3	3	0	3
her.27.6a7bc	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
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 popula-tion 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	0	0	0	0	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
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 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, especially in the purse-seine fishery. The by-catch 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 by-catch juvenile herring. The pelagic fisheries on herring and mackerel 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 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 larvae 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. The influence of the environment of herring productivity means that the biomass will always fluctuate. 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 show similar recruitment trends and differ from the Downs component, 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 may occur in the trawl fishery for herring. In addition, North Sea herring are also caught within Division 3.a. The by-catch of sea mammals and birds is low enough to be below detection levels based on observer programmes. At present there is a very limited 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 by-catch 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 by-catch of other fish. Herring represent an important prey item for many predators including cod and other large gadoids, dog-fish and sharks, marine mammals and sea birds. 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 temperature**s** from Malin head on the North coast of Ireland since 1958 indicate that since 1990 sea surface temperatures have displayed a sustained increasing trend, with winter temperatures > 6°C and higher summer temperatures. Environmental conditions can cause significant fluctuations in abundance in a variety of marine species including fish. Oceanographic variation associated with temperature and salinity fluctuations appears to affect herring in the first year of life, probably during the 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 by-catch 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. Whilst 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 from the Celtic Sea are present in the Irish Sea. The majority of mixing between these populations occurs at winterrings 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 second order 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 by-catch is acknowledged for this fishery with by-catch regulations in force. The by-catch 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 by-catch 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 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 by-catch. If a fishery was to be prosecuted in the Clyde and Irish Seas then by-catch of young herring may become an issue due to the overlap in distribution between young herring and sprat. 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. 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 sub-populations. 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 15 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.

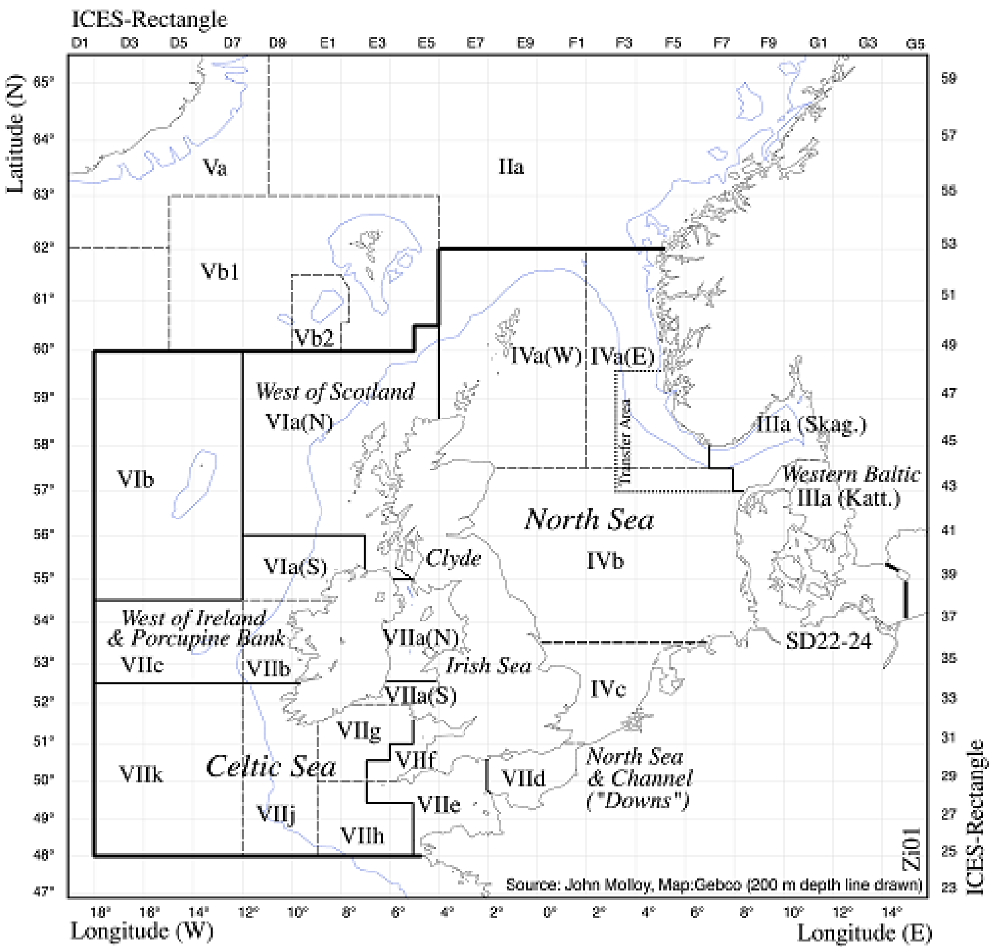


Figure 1.7.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North 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 is classified as being at full reproductive capacity and is being harvested sustainably at F_{MSY} and under management plan target for several years. In 2019, no management plan was in place and the advice is based on the F_{MSY} advice rule. The spawning stock at spawning time in 2018 is estimated at 1.9 million tonnes. Recruitment in 2018 has increased compared to 2017 but remains within the low recruitment regime observed since 2015. The strongest recruitment remains the one observed back in 2014. Mean F_{2-6} in 2018 is estimated at approximately 0.21, which is below F_{MSY}. The SSB for the stock from the 2019 assessment has been revised upward for a number of years.

In 2019 SSB is expected to decrease to ~1.5 million tonnes. Under all scenarios, SSB is predicted to decrease in 2020 (to approx. 1.3 million tonnes) and further in 2021 to around 1.1 million tonnes. SSB is expected to be above B_{pa} in 2020 and 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. SSB was at a minimum of about 70 000 t in 2011 and recruitment is record low in 2018. Under a historical perspective the estimate of SSB of 74 132 tonnes in 2018 is considered low, below both B_{pa} and B_{lim}. Fishing mortality (F_{3-6}) was reduced from 0.50 in 2009 to 0.37 in 2011. It had then remained stable slightly above F_{MSY} (0.31) until 2015 (~0.36) but showed an increase in recent years with an estimated F_{3-6} in 2018 well above F_{MSY} (0.416). The 2020 advised catch of WBSS is 0 t, which if applied by managers, will result in an increase in SSB from 76 273 t in 2020 to 101 269 t in 2021. The zero catch will not allow the stock to rebuild above B_{lim} (120 000 t) by 2021.

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 around 23 000 t in 2018, which is below B_{pa} (at 54 000 t) and B_{lim} (34 000 t). Recruitment has been below average since 2013. Fishing mortality (F_{2-5}) declined between 2003 and 2009 but started to rise again in 2010 due to increased catches. F decreased in 2018 in line with reduced catches. This year assessment estimates a fishing mortality, F_{2-5} of 0.33 in 2018 which a decrease from 2017 (0.64) but above the F_{MSY} (0.26) and below F_{lim} (0.45). Short term projections predict SSB to remain around 23 000 t in 2019.

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 estimated combined. 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 in 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 2018, SSB and recruitment have been estimated at 22 020 t and 333 701 thousand respectively, estimates of SSB in recent years appear to be relatively stable. $F_{4–6}$ is estimated at 0.16 in 2018. Under the MSY approach the stock is expected to show minor decline to 22 005 t in 2020.

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. Sprat in Division 3.a and Subarea 4 were combined into a single assessment unit during the recent WKSPRAT benchmark (ICES, 2018). Various changes were made to the assessment model, which improved the quality in terms of both fitting and retrospective bias. The advice is based on the MSY escapement strategy with an additional precautionary F_{cap} which has been re-evaluated by a dedicated workshop (WKSPRATMSE; ICES 2019). The F_{cap} of 0.69 is used to ensure that after the fishery has been conducted, escapement biomass is preserved above B_{lim} with high probability. The long-term dynamics and perception of the status of the combined stock is consistent with previous perception for sprat in Subarea 4. Despite the fact that 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 2019 show an SSB of 249 000 t which is nearly double of B_{pa} (125 000 t). The ICES advise for the period 1 July 2019–30 June 2020 indicates that catches of sprat should not exceed 138 726 t.

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 advice provided is based on the biomass estimates from the acoustic survey which in 2018 remained at low level in relation to the estimates for 2013–2015. The advised catch for 2020 is 20% lower compared to last year (applying the uncertainty cap).

Sprat in the Celtic Sea (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 inter-annual 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 2800 tonnes for 2020 and 2021 in this eco-region based on the precautionary approach.

Sandeel in 4 (san-nsea): Sandeels in the North Sea can be divided into a number of more or less reproductively isolated sub-populations. 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) since 2016, but a marked decrease is estimated in the last year which brings the SSB at the beginning of 2019 down to 97 000 t which is below B_{lim} (110 000 t). Recruitment in 2018 was slightly above the geometric mean of the time-series, following the 2017 lowest record. Fishing mortality (F) has fluctuated, showing a declining trend since the mid-2000s followed by an increase in 2017 and 2018 to approximately the long-term average. The pronounced decrease in SSB contributes to a reduction in the advised catch.

A2: SSB has been below B_{lim} since 2004 (except in 2011), it increased in 2018 to above B_{pa} as the result of the exceptionally high 2016 year class but decreased again in 2019 to just below B_{lim}. With the exception of 2016, recruitment has been low since 2000 and continued to be very low in the last two years. A zero-catch advice is confirmed for this year.

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) where it has been since 2015. SSB had a peak of more than 270 000 t in 2018 followed by a decrease to around 182 600 t at the beginning of 2019 consistently with the low 2017 recruitment. The recruitments in 2016 and 2018 were among the five highest on record which explain the 23% increase in the advised catch.

A4: Fishing mortality (F) has been low since 2006 but increased in 2018. SSB has increased from the time-series low in 2009 to levels well above precautionary reference points (B_{pa} = MSY $B_{escapement}$) and has remained at this level since 2016. The 2016 and 2017 year classes are estimated to be above the long-term average, but the 2018 year class is estimated to be the second lowest on record. This results in SSB falling to just below MSY $B_{escapement}$ in 2020, even in the absence of fishing, which triggered a zero-catch advice.

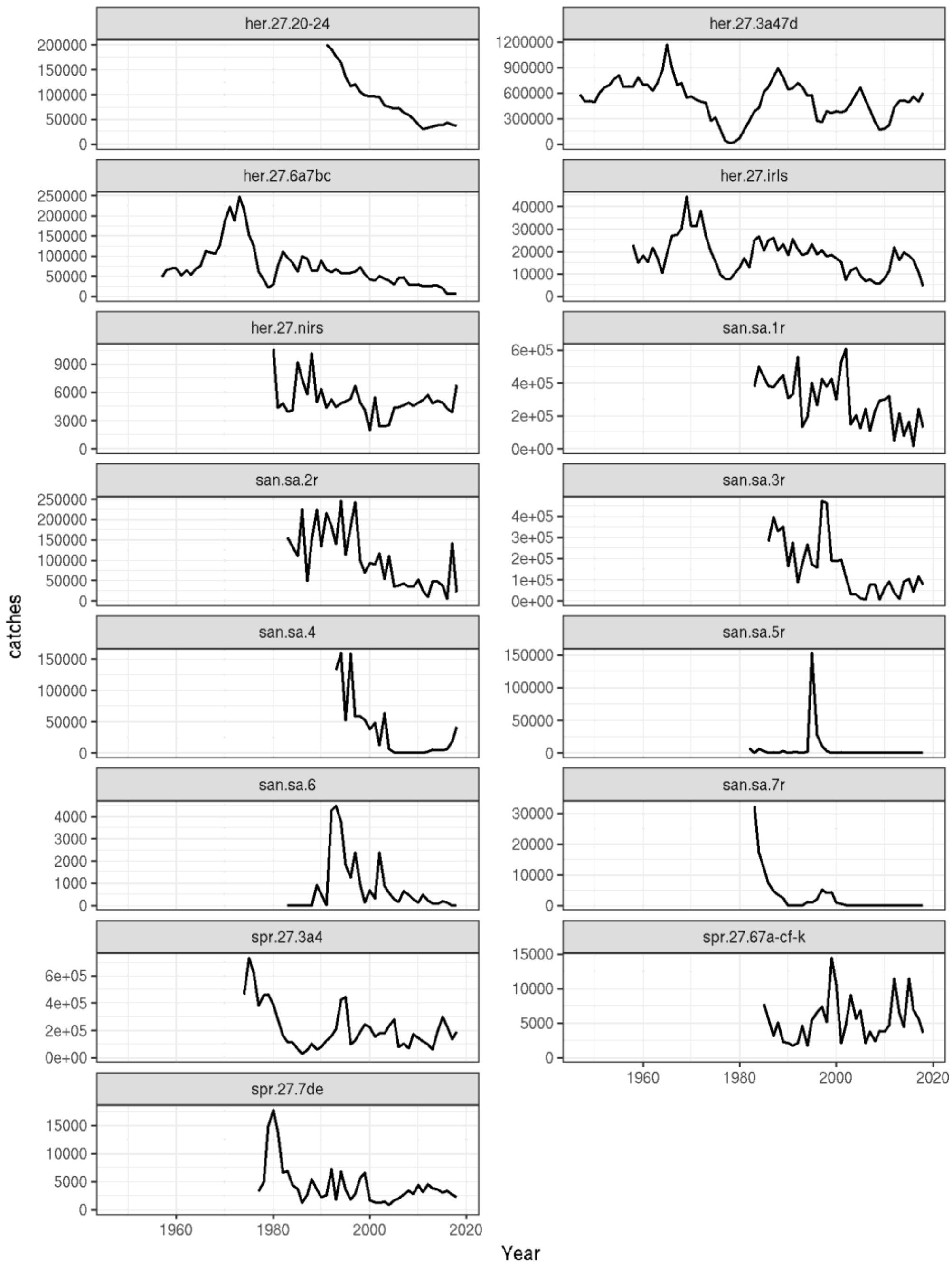


Figure 1.7.2 WG estimates of catch/landings (yield) of the herring, sprat and sandeel stocks presented in HAWG 2019.

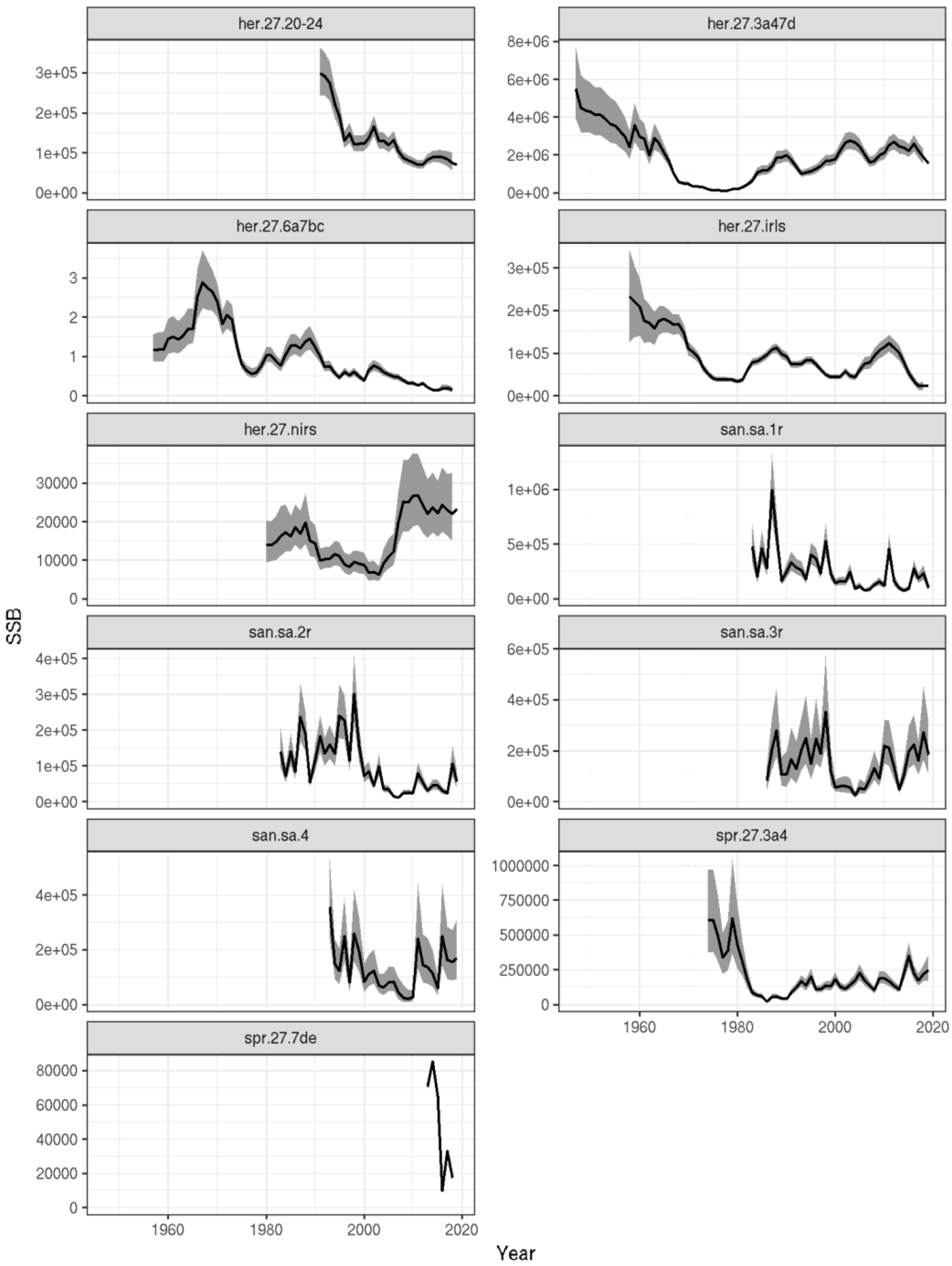


Figure 1.7.3 Spawning stock biomass estimates for the sprat, herring and sandeel stocks presented in HAWG 2019.

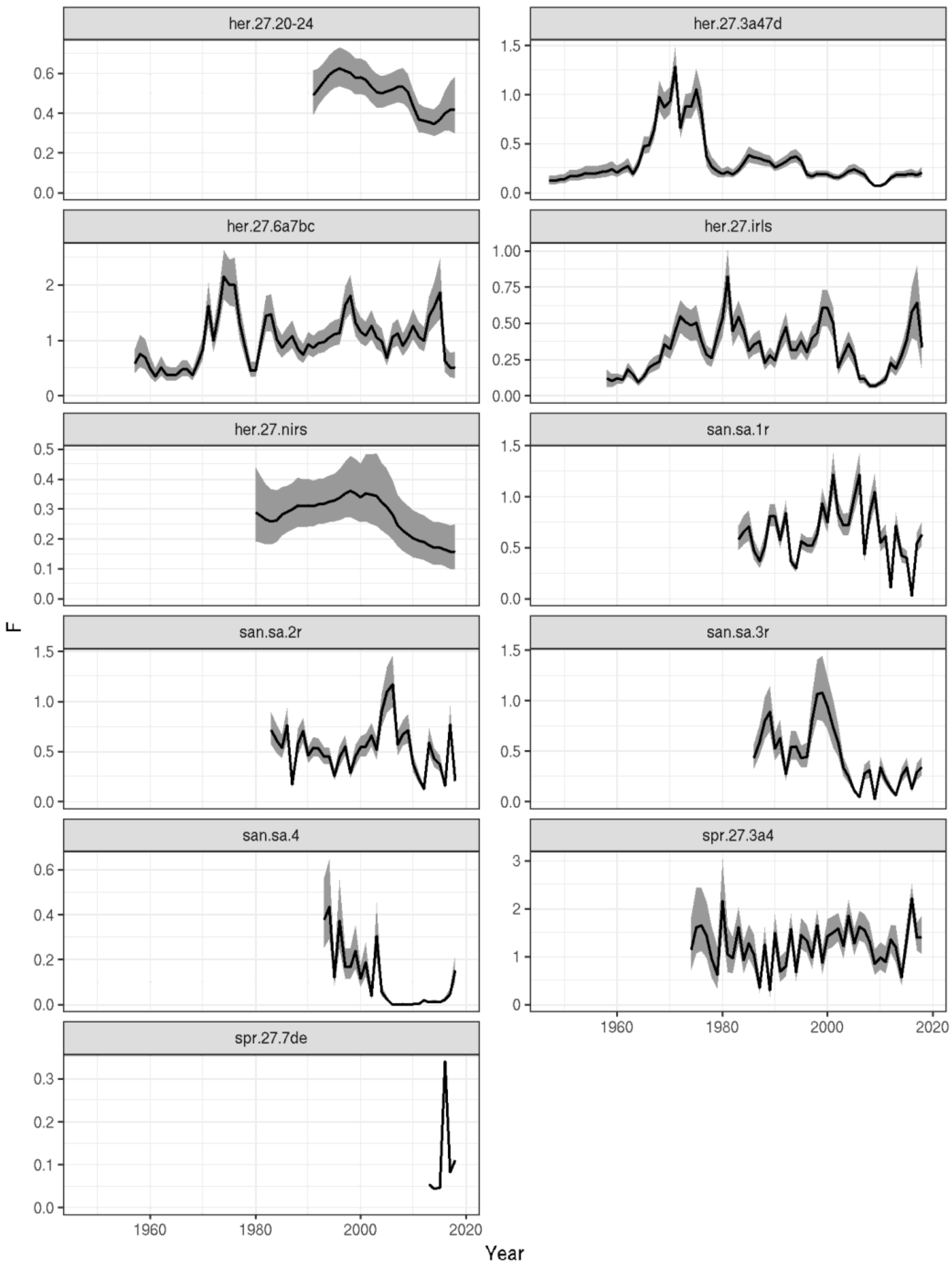


Figure 1.7.4 Estimates of mean F for the sprat, herring and sandeel stocks presented in HAWG 2019.

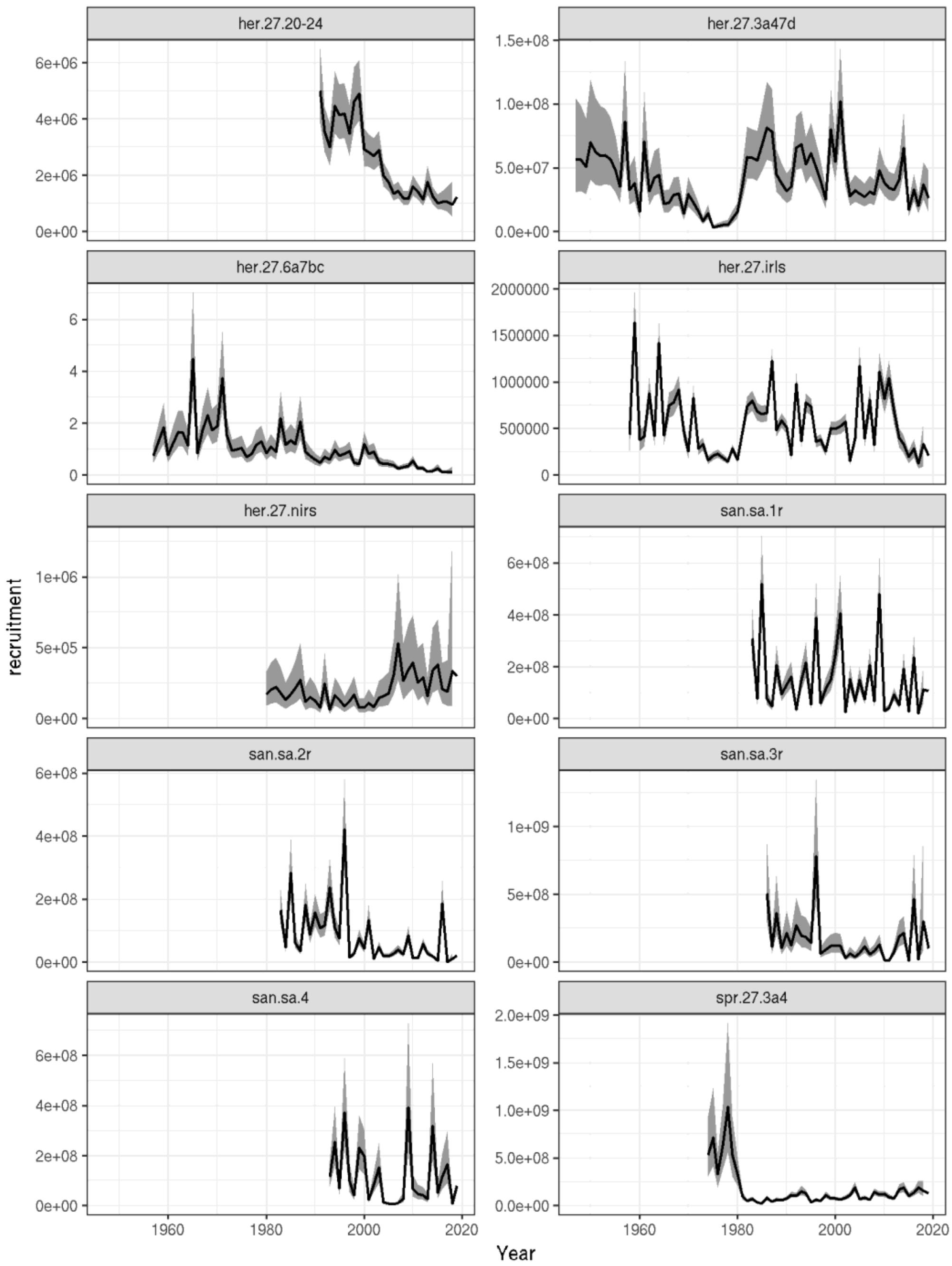


Figure 1.7.5 Estimates of recruitment for the sprat, herring and sandeel stocks presented in HAWG 2019.

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) for the stocks in the North Sea (NSH, her.27.3a47d), the Malin Shelf (MSH, her.27.6a7bc) and the Irish Sea (ISH, her.27.nirs).

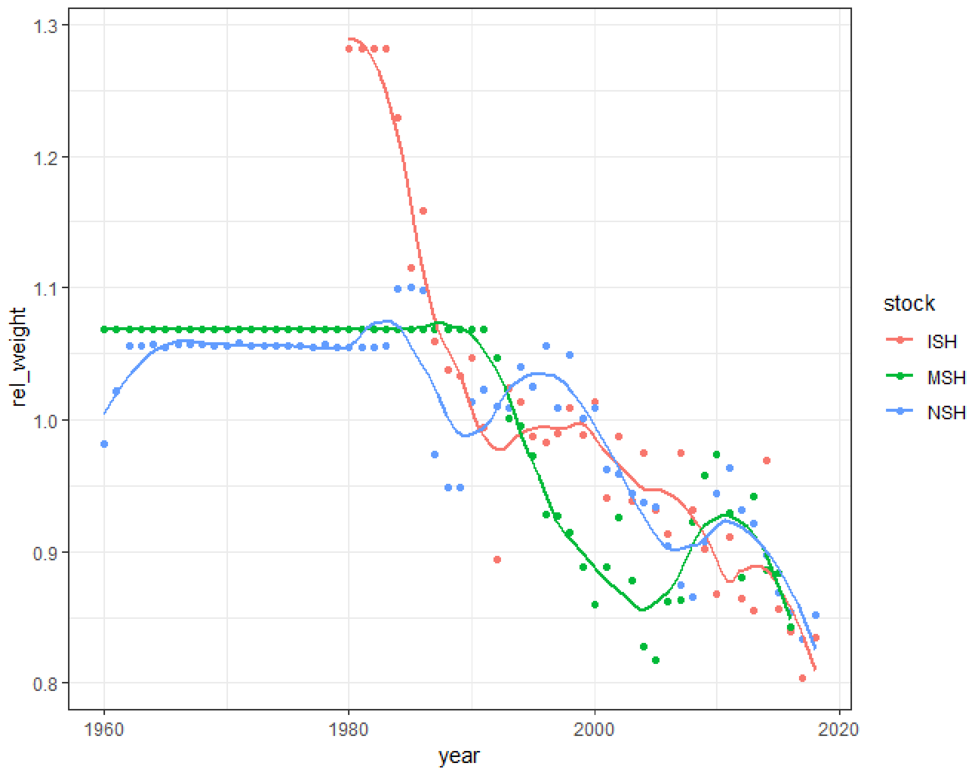


Figure 1.7.6 Relative mean individual weight is calculated by average of stock weight-at-age by year and then it is divided by the mean weight of the time series for each stock.

1.9 Mohn's rho and Bias in the assessments

ICES is planning a workshop in Autumn 2019 (WKFORBIAS) to document the extent of the retrospective bias in SSB, F_{bar} and recruitment for category 1 and 2 assessments based on the 2018–2019 assessments. Additional objectives are to identify and compile possible causes for retrospective bias and to develop approaches for retrospective bias correction and guidelines for acceptability of a stock assessment with retrospective bias. To support the workshop and in response to the ToR c-viii, HAWG reports on retrospective bias in category 1 and 2 age-based fish stock assessments made in 2019. Mohn's rho values have been uploaded at https://community.ices.dk/ExpertGroups/Lists/Retrobias2019/Allitems.aspx and they are included in this report in Table 1.8.1.

Mohn's rho (ρ) is a measure of 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*:

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

* From ICES guidelines https://community.ices.dk/ExpertGroups/HAWG/_layouts/15/WopiFrame.aspx?sourcedoc=%2FExpert-Groups%2FHAWG%2F2018%20Meeting%20docs1%2F03%2E%20Background%20documents%2FGuide%5FMohnsRho%5Fcalculation%5FRetroBias%2Edocx&action=view

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: $X_{y=T-i,d=T} = X_{y=2016,d=2017}$ 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 $X_{y=T-i,d=T-i} = X_{y=2016,d=2016}$ which is the estimate of the assessment quantity for the same year T-i = 2016) estimated from an assessment where the data is truncated to have terminal year 2016 (T-i).

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 intermediate 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.nirs	2018	5	0.0520	No	0.0.700	No	-13.8000
her.27.3a47d	2018	5	-12.0000	No	11.1000	No	8.0000
her.27.6a7bc	2018	5	25.0000	No	-23.2700	No	-7.8700
san.sa.1r	2018	3	-0.1200	Yes	0.2800	Yes	-0.1200
san.sa.2r	2018	3	-0.0900	Yes	0.7300	Yes	0.7600
san.sa.3r	2018	5	0.0200	Yes	0.1000	Yes	1.1000
san.sa.4	2018	5	-0.0300	Yes	0.1300	Yes	0.2200
her.27.irls	2018	5	-0.0580	No	0.1720	No	1.1000
her.27.20-24	2018	5	-0.0700	No	0.1300	No	-0.0700
spr.27.3a4	2019	5	0.0890	No	0.2700	No	0.2200

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 2019 scripts are now on TAF:

1. North Sea herring (her.27.3a47d) update single-fleet SAM assessment, multifleet model run required for the forecast, and the forecast analysis.
2. Herring west of Scotland and Ireland (her.27.6a7bc) SAM assessment.
3. Herring south of 52°30'N Irish Sea, Celtic Sea, and southwest of Ireland (her.27.irls) ASAP assessment.
4. Sandeel in area 1r (san.sa.1r) SMS assessment.
5. Sandeel in area 5r (san.sa.5r) category 5.4 analysis.
6. Sandeel in area 6 (san.sa.6) category 5.2 analysis.
7. Sandeel in area 7r (san.sa.7r) category 5.3 analysis.

1.11 Benchmark process

HAWG has made some strategic decisions regarding the future benchmarking of its stocks listed in the table below. In the next 12 months (end of 2019) there are no plans to benchmark stocks assessed by HAWG.

Stock	Ass status	Latest benchmark	Benchmark next 12 months	Planning Year +2	Further planning	Comments
NSAS	Update	2018	No	No		Issue list in prep
WBSS	Update	2018	No	No	Split mixed catches with central Baltic herring. Compile catch matrix by fleet from data in the Regional Database	Issue list in prep, likely need for an interbenchmark to revisit reference points
6.a, 7.bc	Update	2015, interbenchmark in 2019	No	2021*	Splitting of surveys and assessment, recruitment signal	Issue list in prep
Celtic Sea	Update	2015, Interbenchmark in 2018	No	No	Mixing with Irish Sea herring, recruitment signal	Issue list in prep
7.aN	Update	2017	No	No	Explore stock mixing and review acoustic survey design and methods, recruitment signal	Issue list in prep
Sprat NS.3a	Update	2018	No	No	Consider stock component, local components in 3a, boundary with the Baltic	Issue list in prep
Sprat 7.d and 7.e	Exploratory	2018	No	No	Consider stock components	Issue list in prep
Sprat Celtic	Exploratory	2013	No	No	Consider stock components	Issue list in prep
Sandeel areas 1–4	Update	2016	No	2021*	Update reference points for sandeel area 3 based on the new M estimates.	Issue list in prep

*** Provisional, timeline to be decided**

1.11.1 Ecosystem and long-term benchmark planning

HAWG is developing a longer-term perspective towards its benchmark process, by identifying issues that should be addressed in the next round of benchmarks, even though they are several years in the future. The following list of issues is intended to focus development work during this inter-benchmark period.

General

- Develop assessment tools that can take account of uncertainty estimates in surveys.

North Sea Autumn Spawning (NSAS) herring

- Splitting of catches, where possible, into autumn and winter-spawning components.
- Refinement of the IBTS0 index calculation to provide component-resolved information.
- Modification of the assessment model to account for reduced precision in catch statistics prior to the 1960s.
- In-depth understanding of the reasons at the origin of the retrospective pattern related to inclusion of the 2018 data
- Investigate the use of a wider range of ages for the F_{bar} (currently age2–6) and application of a weighted mean of F

Western Baltic Spring Spawning (WBSS) herring

- Account for mixing of central Baltic herring (CBH) in the commercial catches in SD22–24. Check for mixing of WBSS-CBH in SD25 catch
- Account for mixing of WBSS-NSAS outside of the transfer area (4.a.E, 4.b.E).
- Improve estimation of catch matrix in synergy with the RDBES
- Identify main drivers of stock productivity
- Reference points may need to be revisited.

6.a herring

- Extraction of West of Scotland herring larval abundance estimates from the North Sea IBTS0 survey.
- Develop genetic methods to split surveys and commercial catches by components

Irish Sea herring

- Develop techniques to maximize the information content in the Irish Sea larval survey. Explore levels of stock mixing, spawning behaviour and timing.

Celtic Sea herring

- Use genetic techniques to assess the mixture of Celtic Sea herring in the Irish Sea.
- Assess the interannual variation in this mixing as well as the distribution patterns.

1.12 Recommendations

All recommendations have been uploaded to the ICES Recommendation database.

1 Introduction

1.1 Terms of Reference

2018/2/ACOM07 The Herring Assessment Working Group for the Area South of 62ºN (HAWG), chaired by Susan Lusseau*, UK, and Valerio Bartolino*, Sweden, will meet at ICES Head-quarters for two meetings: 29–31 January 2019 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 13–21 March 2019 to:

b) compile the catch data of North Sea and Western Baltic herring on 13–14 March;

c) address generic ToRs for Regional and Species Working Groups 15-21 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 2019 ICES data call. HAWG will report by 11 February and 5 April 2019 for the attention of ACOM.

Fish Stock	Stock Name	Stock Coord.	Assesss. Coord. 1	Assess. Coord. 2	Advice	Review (SA)
san-sa	Sandeel in Division 3.a and Subarea 4	Denmark	Denmark	Norway	Update	Sweden/Germany/Norway/Denmark
her-27.20-24	Herring in Subdivisions 20–24 (Western Baltic Spring spawners)	Denmark	Denmark	Denmark	Update	UK/Denmark
her-27.3a47d	Herring in Subarea 4 and Division 3.a and 7.d (North Sea Autumn spawners)	Germany	NL	UK (Scotland)	Update	Norway/UK (Scotland)/Denmark
her-27.irls	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		Update	Netherlands
her-27.6a7bc	Herring in Divisions 6.a and 7.b and 7.c	UK (Scotland) / Ireland	Ireland	UK (Scotland)	Update	UK (Northern Ireland)
her-27.nirs	Herring in Division 7.a North of 52° 30' N (Irish Sea)	UK (Northern Ireland)	UK (Northern Ireland)	-	Update	Netherlands

Fish Stock	Stock Name	Stock Coord.	Assesss. Coord. 1	Assess. Coord. 2	Advice	Review (SA)
spr-27.3a4	Sprat in Division 3.a (Skagerrak - Kattegat) and Subarea 4 (North Sea)	Norway	Denmark	-	Update	France/(Denmark/Norway
spr-27.7de	Sprat in the Western Channel	UK	UK	-	Update	Norway / Ireland
spr-27.67a-cf-k	Sprat in the Celtic Seas	UK	UK	-	Update	

1.2 Generic ToRs for Regional and Species Working Groups

2018/2/ACOM05 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:

- Consider and comment on Ecosystem and Fisheries overviews where available;
- b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:
- i) descriptions of ecosystem impacts of fisheries
- ii) descriptions of developments and recent changes to the fisheries
- iii) mixed fisheries considerations, and
- iv) emerging issues of relevance for the management of the fisheries;
- c) Conduct an assessment on the stock(s) to be addressed in 2019 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarising where the item is relevant:
- i) Input data and examination of data quality;
- 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 2018.
- iv) Estimate MSY proxy reference points for the category 3 and 4 stocks
- v) The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;
- vi) The state of the stocks against relevant reference points;
- vii) Catch scenarios for next year(s) 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 succint description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. 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.Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines.

- d) Review progress on benchmark processes of relevance to the Expert Group;
- e) Prepare the data calls for the next year update assessment and for planned data evaluation workshops;
- f) Identify research needs of relevance for the work of the Expert Group.

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

The ToRs are addressed in the sections shown in the text table below.

Stock	Addressed in Section
Herring in Subarea 4 and Division 3.a and 7.d (North Sea Autumn spawners)	Section 02
Herring in Division 3.a and subdivisions 20–24 (Western Baltic Spring spawners)	Section 03
Herring in divisions 6.a and 7.b-c	Section 04
Herring in divisions 6.a (South), 7.b–c, and 6.a (North), separately	Section 05
Herring in Division 7.a South of 52° 30’ N and 7.g-h and 7.j-k (Celtic Sea and South of Ireland)	Section 06
Herring in Division 7.a North of 52° 30’ N (Irish Sea)	Section 07
Stocks with limited data	Section 08
Sandeel in Division 3.a and Subarea 4	Section 09
Sprat in Division 3.a (Skagerrak - Kattegat)	Section 10
Sprat in Subarea 4 (North Sea) and Division 3.a (Kattegat-Skagerrak)	Section 11
Sprat in Division 7.d and 7.e	Section 12
Sprat in the Celtic Seas	Section 13

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)

As usual WGCHAIRS met at the beginning of the year in preparation of the new year of advice and science working groups’ activities.

Under the new ICES strategy, a new steering group, Fisheries Resources Steering Group (FRSG), will be created. Activities of advisory working groups such as HAWG will be conducted under the umbrella of FRSG. This re-organisation is mainly motivated by the intention to enhance the transfer of new science into advice and facilitate interaction between the individual working groups and both ACOM and SCICOM, FRSG will become operative throughout 2019. Advisory expert groups will maintain their prerogative of “closed groups” in the sense that members will be still nominated at a national level.

Overall, the format of the advice had no major changes. WGCHAIRS remarked the importance of quality assurance of the ICES advice and the role of the audit system in this. Audits should be performed rigorously according to a given template (same as last year). At HAWG this is implemented assigning at least two members as auditors for each stock.

This year ICES has increased its attention towards evaluation of potential Conflict of Interest (CoI) in relation to any of its advisory activity. Expert groups are now considering CoI even more carefully than before with specific reference to a code of conduct which has been discussed and explicitly agreed by all members of HAWG at the beginning of the meeting.

WGCHAIRS remarked that while considerable progresses have been made in the documentation and quality assurance of scientific data (incl. both surveys and commercial data collected for scientific purposes), quality of the landing data is generally poorly documented by member countries. It remains the responsibility of the individual countries to implement quality assurance frameworks for the landings data.

From 2019, ICES will publish the reports from expert working groups (incl. assessment groups) as part of the new ICES scientific report series. This means that all the reports will have an ISSN and a DOI number, and most importantly authorship of the report will now lay on the members of the working group with the chairs named as editors and all the members presented as authors.

1.3.2 Working Group for International Pelagic Surveys (WGIPS)

The Working Group of International Pelagic Surveys (WGIPS) met in Santa Cruz, Spain on 14–18 January 2019. 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 2019 surveys.

Results of the surveys covered by WGIPS and coordination plans for the 2019 pelagic acoustic surveys are available from the WGIPS report (WGIPS, ICES 2019). The following text refers only to the surveys of relevance to HAWG.

Review of larvae surveys in 2018:

These surveys are no longer dealt with in WGIPS. From 2019 the planning, analysis and reporting on larvae surveys will fall under WGSINS. In the interim period results from for the 2017/18 larvae surveys can be found in the HAWG report, Section 3.3.2 and for 2018/19 they will be coordinated and reported on in WGEGGS2.

North Sea, West of Scotland and Malin Shelf summer herring acoustic surveys in 2018: Six surveys were carried out during late June and July covering most of the continental shelf in the North Sea, West of Scotland, Malin Shelf, West of Ireland and Celtic Sea.

The estimate of **North Sea autumn spawning herring** spawning stock biomass is higher than previous year at 2.3 million tonnes (2017: 1.9) due to an increase in the number of fish (2017: 11.621 mill. fish, 2018: 12.315) and an increase in weight-at-age for mature herring. The spawning stock is dominated by young fish of age 4 and 5 wr, which is in accordance with the strongest year classes in the 2017 survey.

The 2018 estimate of **Western Baltic spring-spawning herring** 3+ group is 107 000 tonnes and 745 million. This is a decrease of 52 and 45%, respectively, compared to the 2017 estimates of 221 000 tonnes and 1353 million fish.

The **West of Scotland** estimate (6.a.N) of SSB is 152 000 tonnes and 875 million individuals, a small increase compared to the 139 000 tonnes and 765 million herring estimate in 2017.

The 2018 SSB estimate for the **Malin Shelf area (6.a and 7.b,c)** is 159 000 tonnes and 925 million individuals. This is a about the same level as the 2017 estimates (145 000 tonnes and 798 million herring). There was some herring distribution south of 56°N in 2017–2018; this resulted in a slightly higher estimate for the Malin Shelf compared to the West of Scotland.

There was a sprat benchmark in November 2018 (ICES, 2018), resulting in the two sprat stocks in the North Sea and Skagerrak-Kattegat being merged into one. For consistency, the survey results are presented separately in this report for these two areas.

The total abundance of **North Sea sprat (Subarea 4)** in 2018 was estimated at 120 141 million individuals and the biomass at 834 000 tonnes (Table 5.10). This is nearly 3 times as many sprat as last year, the second highest in the time series and high above the long-term average of the time series, in terms of both abundance (137% above) and biomass (88%). The stock is dominated by 1-year-old sprat (89% in numbers). The estimate also included 0-gr sprat (3% in numbers, and 0.1% in biomass), which only occasionally is observed in the HERAS survey.

In for **sprat in Division 3.a**, the abundance in 2018 is estimated at 3438 million individuals and the biomass at 33 400 tonnes; the second highest estimate of the time series as for the North Sea. This is well above the long-term average both in terms of abundance (86%) and biomass (38%). The stock is dominated by 1- and 2-year-old sprat.

Irish Sea Acoustic Survey:

The herring abundance for the Irish Sea and North Channel (7.a.N) in Aug/Sept 2017 and Aug/Sept 2018 was reported by Northern Ireland The estimate of herring SSB of 91 332 tonnes for 2016 was near the series high 2010 estimate. In 2018 the estimate was 39 997 tonnes, similar to that observed in 2017. The biomass estimate of 54 661 tonnes for 1+ ringers is a 25% increase on last year's biomass estimate. Unlike in previous years when a large proportion of the 1+biomass estimate is seen in north of the Isle of Man and in North Channel, in the current year the majority of biomass was observed in the south east of the Isle of Man area. The western and northern Irish Sea are areas of mixed size fish. In 2018 the sampling intensity was relatively high during the 2018 survey with 32 successful trawls completed. The herring were fairly widely distributed within mixed schools at low abundance, with a few distinct high abundance areas. The bulk of 1+ herring targets in 2018 were observed off the east coast of the Isle of Man, and on the eastern coast of Northern Ireland, with a fairly scattered lower abundance observed throughout the Irish Sea. 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. The length frequencies generated from these trawls highlight the spatial heterogeneous nature of herring age groups in the Irish Sea. The survey estimates are influenced by the timing of the spawning migration.

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 exactly the same as for AC(7.aN) 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 is reported in the WGIPS 2018 report (ICES, 2018). The survey is included in the assessment as a SSB index. The SSB in 2017 was estimated as 2017 1 41, 683 declining to 38 974 in 2018. The herring were distributed within a few distinct high abundance areas to the southwest and southeast of the Isle of Man. The estimate of herring SSB from the 2018 commercial acoustic survey remain within range for the time series.

Celtic Sea herring acoustic survey (CSHAS): Herring and sprat abundance for the Celtic Sea in October 2018 was reported by the Marine Institute, Ireland. The Celtic Sea herring stock was considered to have been contained within the survey area in 2018. The spawning stock biomass (SSB) estimate in 2018 was 7760 tonnes and is comparable to the 2017 survey estimate. Both years represent the lowest SSB points in the survey time series. The CV on the survey estimate was high (~0.50) in 2018. The downward trend in the standing stock biomass has continued from a medium term high around 2012 and has been exacerbated by a prolonged period of poor recruitment since then. Observations made during the WESPAS summer survey in June 2018 confirm the currently low standing stock abundance of herring in the Celtic Sea. The potential of a positive signal in recruitment was evident from survey catches with 0-group herring observed across the CSHAS survey area and further east into UK waters. The biomass and abundance of sprat in 2018 was higher than in 2017 and more in line with the 2016 estimate.

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 2018. Geographical coverage extended southwards in 2017 to include French waters in the western Channel and in 2018 was further extended in to Division 7.d Both the number of completed acoustic transects and trawls exceeded those achieved in 2017. Preliminary results indicated some differences in ichthyofauna observations when compared to 2017. In the Bristol Channel, other than the usual hotspot inside the estuary, the majority of fish biomass was found more inshore, as demonstrated also by the location of the trawl effort. In the French waters of the western Channel more fish activity was found along the western-most transects. Further east in the western Channel, very few schools were encountered, which matched last year’s results. The transects east of Lyme Bay, sampled for the first time during PELTIC, yielded little fish biomass. 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. 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. 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 the hypothesis of two different stocks.

Sprat biomass had increased in Lyme Bay in 2017 (English Channel: 34 109 tonnes) compared to the low biomass estimate from 2016. A decline in biomass was observed in 2018 again to 17 091 tonnes.

1.3.3 PGDATA, WGBIOP and WGCATCH

The Planning Group on Data Needs for Assessments and Advice (PGDATA coordinates the activities of both WGBIOP and WGCATCH. One of its main focuses is on 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.

The ICES Working Group on 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 stock-assessment working groups and WGBIOP is through the benchmark process. WGBIOP works in close association with the BSG (ICES benchmark steering group), reviewing all issue lists pointing to either missing issues in relation to specific stocks and guiding the process to get issues related to biological parameters resolved. WGBIOP will align its scheduling of age and maturity calibration exchanges and workshops with the newly proposed ICES benchmark prioritisation 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 2018) reviewed the following activities falling within its remit and of interest for HAWG:

- Herring (*Clupea harengus*) Otolith Microstructure (OM) exchange. In 2018, 4 readers from Sweden and Denmark took part in an exchange of ground and polished otoliths (n=96) from ICES areas 3.aN, 3.aS and 4.b, the overall agreement across readers was 45%. 23 of the samples had a genetically validated stock ID, there were just 5 of these where all 4 readers were in agreement with the genetic results. Readers agreed that overtime OM patterns have changed and it has become more and more difficult to clearly distinguish between the spawning types, mostly between the Western Baltic spring spawners (WBSS) and the Downs winter spawners. In early 2019 another exchange took place with the same 4 readers participating and all samples (n=93) had a genetically validated stock ID assigned. The overall agreement was 85% with the Downs winter spawners being the most difficult to identify correctly. The presence of samples from sub-stocks where the OM varies from those described in the past can cause confusion for the readers and work continues on updating reading guidelines using genetically identified stock IDs.
- The Workshop on sexual maturity staging of herring and sprat (WKMSHS2) concluded; agreement with the validated material (herring 52%) was much lower compared to the agreement with the modal stage (herring 74%); there was no improvement achieved over the calibration rounds for herring and a small improvement for sprat; males are generally more difficult to stage compared to females and a mismatch exists between the herring stage description and the WKMATCH scale.
- The Workshop for advancing sexual maturity staging in fish (WKASMSF) proposed the 'WKMATCH 2012 maturity scale revised', prepared conversion tables to be used when uploading national maturity data to the ICES survey and commercial fisheries databases and prepared an implementation plan for reporting maturity data in the 'WKMATCH 2012 maturity scale revised' to these databases from 1 January 2020.

The ICES Working Group on Commercial Catches (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 data sets can be weighted in an assessment model according to their relative quality.

WGCATCH 2018 finalized best practice guidelines for sampling and estimation of foreign landings in national ports. These guidelines were based on case studies highlighting the present problems and successes with sampling of foreign landing (a lot of the case studies focused on small pelagic fish). WGCATCH 2018 started to work on best practice guidelines in data request and provision for frequency data (e.g. DLS stocks), by summarising current national practise and developing tools to support national data submitters and stock coordinators to summarise the quality of the data provided. Further the group continued the work on guidelines for best-practice in sampling of small-scale fisheries, data recording, estimation of commercial catches under the landing obligation and sampling of commercial catches, including by-catch of protected, endangered and threatened species (PETS).

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 (updated at WKPELA 2018), North Sea sprat (evaluated and updated at HAWG 2018), sandeel SA1 (evaluated and updated at HAWG 2018), sandeel SA3 (evaluated and NOT updated at HAWG 2018). No update of natural mortalities are available from WGSAM for the 2019 HAWG assessments.

1.3.5 WKNSMSE

The Workshop on North Sea stocks Management Strategy Evaluation (WKNSMSE) evaluated long-term management strategies for a number of jointly-managed stocks in the North Sea between the European Union and Norway, following a request from EU-Norway. The North Sea Autumn spawning herring was among those stocks. The full-feedback simulations performed by WKNSMSE aimed to find "optimal" combinations of harvest control rule parameters (F_{target} and $B_{trigger}$) for management strategies with (scenarios C,D,E) or without (scenarios A,B) stability mechanisms (TAC constraints and banking and borrowing scenarios; see Table 1.2.5.1). "Optimal" combinations were defined as those combinations of F_{target} and $B_{trigger}$ that simultaneously maximised long-term yield while being precautionary (long-term risk 3 ≤ 5%).

The Management Strategy Evaluation (MSE) considers four components: the biological stock unit of herring in the North Sea [1], four fisheries targeting the stock unit [2], the fisheries-independent surveys [3], the stock assessment procedure which is used to obtain a perceived status of the stock unit and to set management targets [4]. The framework includes feedback loops, where over time, the result of setting management targets affects the stock unit the year after, and thereby also affects the fisheries and management. In order to reflect the uncertainties related to stock dynamics, fisheries dynamics and management implementation, the simulations are run with 1000 replicates, each representing a different but likely version of the true dynamics of the stock unit and fisheries.

Contrary to the expectations, the risk criteria does not stabilize in the medium to long term. Therefore the results referred to as "long-term" are achieved at equilibrium and are actually conditional to some of the assumptions (i.e., 20-year projection period, 1000 replicates and risk 3 ≤ 5% over the last 10 years). This means that the outcomes of the MSE should be considered precautionary only within the 20 years evaluated and the strategies should be re-evaluated within that time frame.

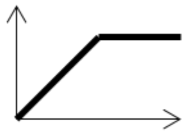
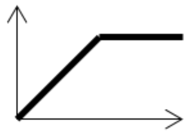
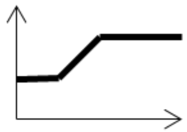
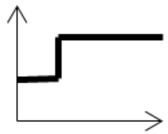
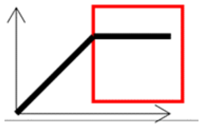
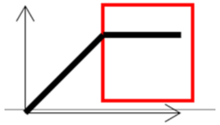
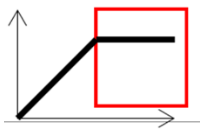
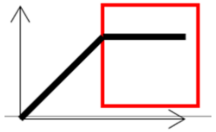
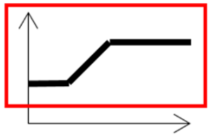
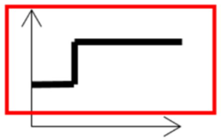
All the scenarios tested are precautionary with the exception of the strategy E for which no optimal target was found. In general, for all the other scenarios (A–D) there is less than 0.2% difference in the long-term yield (Table 1.2.5.2).

The optimal F_{target} values for all the scenarios (0.22–0.23) are somewhat smaller than the F_{MSY} value (0.26) estimated using EqSim at the last benchmark in 2018. Thus, the current F_{MSY} in combination with an MSY $B_{trigger}$ of 1.4 mt has an associated risk > 5%. There are fundamental differences in the way EqSim and the MSE evaluate risk and make use of implementation error which may explain the difference (i.e., the up to 50% flexibility for the human consumption fishery in 3a is accounted in the identification of the F_{target} but it is not part of the EqSim calculation).

Among the sensitivity tests performed, the MSE evaluated the consequences of reducing the bycatch of the B and D fleets which showed a reduction in risk and some consequent increase in fishing opportunities for the human consumption fishery (A-fleet). These results are in line with previous results as obtained in ICES 2015 (WKHerTAC).

Despite the use of high-performance clusters, computational time represented a challenge (running time for a 1000 replicate scenario was around 500 h with approx. 50 evaluations per core) which limited part of the evaluation.

Table 1.2.5.1 Management strategies for the North Sea herring stock tested at WKNSMSE.

HCR	A-fleet	B-fleet	Condition	Stability	Bank & Borrowing
A					
B					
C			if SSB > B_{trig}	TAC_y A-fleet in AdY 0.8 TAC_{y-1} < TAC_y < 1.25 TAC_{y-1}	+/-10%
D			if SSB > B_{trig}	TAC_y A+B-fleet in AdY 0.8 TAC_{y-1} < TAC_y < 1.25 TAC_{y-1}	+/-10%
E				TAC_y A+B-fleet in AdY 0.8 TAC_{y-1} < TAC_y < 1.25 TAC_{y-1}	+/-10% except when: SSB < B_{pa} & F > F_{pa} in AdY B < B_{pa} in AdY and CtY

SSB and F are calculated at spawning time; ImY, AdY, CtY are the intermediate, advice and continuation years. The red square shows when stability and flexibility measures apply.

Table 1.2.5.2 Short-, medium- and long-term yield (total catch) and SSB for the "optimised" strategies and for FMSY given the "optimal" $B_{trigger}$. Cases where risk3 > 5% are in red text. E is not included since no "optimum" was found for it. The time period are: short = 2019:2021, med = 2022:2026, long = 2027:2036. Management strategies with an asterisk indicate F_{target} = F_{MSY} and $B_{trigger}$ = MSY $B_{trigger}$.

Management Strategy	F case	F_{target}	$B_{trigger}$	Yield			SSB			risk3			IAV			Realised mean $F_{(2–6)}$		
				short	med	long	short	med	long	short	med	Long	short	med	long	short	med	long
F=0	**F=0**	**0**	**0**	**0**	**0**	**0**	**2310249**	**2643789**	**2687033**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
A	**F_{target}**	**0.22**	**1400000**	**269747**	**339827**	**345646**	**1293350**	**1461235**	**1471026**	**0.037**	**0.025**	**0.046**	**0.186**	**0.147**	**0.151**	**0.179**	**0.219**	**0.219**
A*	F_{MSY}	0.26	1400000	296446	361936	358346	1253241	1370185	1363961	0.065	0.053	0.072	0.190	0.164	0.168	0.205	0.253	0.248
B	**F_{target}**	**0.22**	**1400000**	**271574**	**338313**	**344582**	**1291883**	**1456469**	**1467080**	**0.037**	**0.029**	**0.05**	**0.183**	**0.147**	**0.149**	**0.179**	**0.219**	**0.219**
B*	F_{MSY}	0.26	1400000	298388	359776	356365	1250953	1360849	1354684	0.061	0.054	0.081	0.188	0.165	0.168	0.205	0.251	0.247
C	**F_{target}**	**0.22**	**1400000**	**269690**	**335932**	**345095**	**1293654**	**1469648**	**1473686**	**0.037**	**0.025**	**0.048**	**0.186**	**0.158**	**0.157**	**0.179**	**0.219**	**0.219**
C*	F_{MSY}	0.26	1400000	296510	359024	358001	1253728	1377431	1365667	0.062	0.051	0.076	0.190	0.172	0.171	0.205	0.253	0.249
D	**F_{target}**	**0.23**	**1400000**	**276805**	**342173**	**349286**	**1283906**	**1446680**	**1446241**	**0.048**	**0.03**	**0.049**	**0.186**	**0.162**	**0.159**	**0.186**	**0.228**	**0.228**
D*	F_{MSY}	0.26	1400000	296510	359438	358937	1253750	1378526	1368652	0.061	0.047	0.076	0.189	0.171	0.171	0.205	0.254	0.249

1.3.6 WKSPRAT & WKSPRATMSE

The 2018 benchmark workshop on sprat (WKSPRAT) focused on the following three stocks: North Sea (area 4) sprat, Kattegat-Skagerrak (area 3.a) sprat and the Channel sprat. During the benchmark process, several evidences including genetics, otolith shape, recruitment and cohort dynamics were presented on the connection between sprat in the North Sea and in the Kattegat-Skagerrak. It was therefore agreed to merge the two stocks and assess them as one stock assessment unit. For the purposes of the new joined assessment for the two areas, both the catch data and the indices of abundance from 3.a were included in the data from area 4. Three surveys are carried out throughout the assessment area including the IBTS in Q1 and Q3 and the acoustic HERAS survey. All the surveys were used as tuning indices in the model. The indices were standardized using a delta-GAM approach: the inclusion of 3.a data increased the internal consistency between all age classes for all indices. The SMS model, previously used to assess the North Sea component, was used to assess the new combined stock. The final model formulation includes a power function for the age 0 catchability of IBTS Q1, a constant maturity ogive and the inclusion of the very few catches reported for Q4 in the Q1 of the following year. The new stock assessment shows a considerable improvement in the retrospective pattern, as well a better fitting to some ages of the IBTS surveys. The stock reference points were revised following ICES standard guidelines using a segmented stock recruitment relationship limited to years from 1982 and onwards. B_{lim} was estimated at 94 000 t as the breakpoint of the segmented regression and B_{pa} was derived from B_{lim} at a value of 124 946 t. However, an escapement strategy, where the stock is fished down to B_{pa}, has been proved not to be precautionary for such stock, unless an F limit control rule (F_{cap}) is applied. For this reason, a full closed loop management strategy evaluation was carried out after the benchmark by WKSPRATMSE to test for different F_{cap} values, where the F_{cap} chosen corresponds to the F providing a probability of SSB falling below B_{lim} lower than 5%. The results suggested that an F_{cap} of 0.69 is precautionary under the assumption that only errors in the stock numbers and exploitation patterns are included.

WKSPRAT benchmarked also sprat from the area 7.d,e. Not enough evidences were available to change the boundaries of this stock. An acoustic survey (revised for the benchmark) is carried out in the English part of area 7.e since 2013, and extended to the French part of 7.e in 2017 and to the Eastern Channel in 2018. In addition, an IBTS index in Q1 is available for the Eastern Channel from 2007 onwards. Overall, the short time series in the acoustic index and the lack of sufficient contrast in the data do not allow any analytical model to converge. Thus, the stock is in a category 3 (data poor stock). The benchmark proposed a seasonal advice based on an empirical method where trends are informed by both the indices, but only the acoustic survey is used for provision of the advice. In line with preliminary results from WKLIFE, the benchmark agreed that the "2-over-3" rule is not appropriate for short, highly productive stocks as sprat in area 7.d,e. Therefore, WKSPRATMSE compared through simulations the performances of the alternative "1-over-2" rule and of different fixed harvest rates. The results suggested that a 1-over-2 rule might cause the stock to fall below safe levels and eventually to collapse because the rule is not reactive enough to limit the catches when there is a recruitment failure. The risk decreases but remains still above safe limits also when removing the uncertainty cap. Simulations suggest that a 20% fixed harvest rate may be considered appropriate to maintain the stock at safe biomass levels and to produce relatively high yield. Further work is required in the light of the relevant upcoming Workshop for Data-limited Short-lived Stocks (WKDLSSLS).

1.3.7 IBPher6a7bc

The Inter-Benchmark Protocol for Herring in 6.a, 7.b-c 2019 (IBPher6a7bc, ICES 2019) was held to seek a solution to the consistent and increasing retrospective bias in the assessment of this herring stock.

At the meeting several improvements to the survey series used in the assessment were presented and reviewed. This included re-calculated and extended Scottish West Coast International Bottom Trawl Survey Quarter 1 and Quarter 4 (SWS BTS Q1 and Q4) and the two acoustic survey indices used in the assessment were re-examined and combined in to one to give a better acoustic index. Survey data analysis improvements were carried out first and agreed, and model optimisation was performed with the improved indices in the attempt to minimise the retrospective bias.

Extensive work was carried out to find a model configuration that would improve the retrospective, but it became clear that minimising the retrospective bias caused problems elsewhere in the models. Eventually, the interbenchmark agreed on a final model configuration. Although it was agreed the final model is a better assessment, there is still a retrospective bias. The new assessment also provides a radically different perception of the stock than previously and the assessment output raises a number of questions as to the dynamics of these combined stocks, over the time series that could not be investigated in depth during the inter-benchmark.

With an agreed final assessment the MSY and PA reference points were investigated according to ICES guidelines. The new stock assessment data, when implemented in the routines for estimating the reference points, using the same procedures as previously, lead to a number of questions as to how one could ‘objectively’ apply the ICES guidelines for estimating reference points. Extensive explorations, including limiting the length of the time series, indicated that the reference points were very sensitive to the choice of input data.

Surplus Production in Continuous Time (SPiCT) analysis was also undertaken but did not provide an alternative way of estimating sensible/believable reference points. The final conclusion was that since there was no objective way to choose a definitive data set for use in calculating a set of plausible reference points, no new reference points, based on the new assessment, were presented.

In regard to advice, it was decided that the assessment should be considered as a representation of trends rather than absolute estimates of stock size. Therefore, it is appropriate to consider the stock assessment as category 3 so that relative changes in fishing and stock size are used as basis for ICES advice (i.e the 2/3 rule, where advice based on previous advice, modified according to index information; typically the trend in the last 5-years of the index).

1.3.8 IHLS and MIK surveys

The International herring larvae survey (IHLS) index provides information on the contribution and distribution of the different spawning components to the North Sea herring stock. This is the only index currently used in the assessment to provide information on the relative sizes of the four North Sea herring stock components, as in the other surveys or catch data the fish cannot be split into the different spawning components. The IHLS thus provides important information for the management of this stock.

In recent years the coverage of the IHLS survey has been compromised due to technical issues with the vessels available to conduct the surveys. This has led to the decision in 2018 to reject the information of 3 of the 4 surveys in the IHLS. Due to this break in the time-series it is necessary to review the current setup of the IHLS. Because information on the relative sizes of stock components of North Sea herring is required, HAWG is recommending that the Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS) review the current design of the IHLS, in the light of the available survey effort, to deliver information on the relative stock components abundances, and if necessary to implement a new survey protocol that can deliver these data.

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 2018.

The DRS was carried out in April, following the IBTS-MIK protocol, but the sampling was carried out both day and night, instead of only at night. Results were presented at HAWG. Due to time constraints it was not possible to cover the whole larvae distribution area. Compared to the MIK, numbers of herring larvae found in the DRS samples were much higher per sample. Length distributions of the herring larvae in the DRS were very similar to that for the MIK in 2018.

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 one year 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. In 2019 IMR, Norway will participate in the DRS and for 2020 Danish Industry and IFREMER, France are investigating possibly participation. 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.

1.3.9 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. Presently only the mixing between North Sea herring and Western Baltic Spring spawning herring in catches in the transfer area and in the HERAS survey in the Danish and Norwegian strata is 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 also arranged to facilitate exchange of ideas and foster collaboration of researchers working of different aspects and methods and to update HAWG on progress on projects currently underway of relevance to HAWG stocks.

1.3.9.1 Stock separation mini symposium

The mini symposium was held on 19th March with 6 talks on projects of relevance to HAWG stocks. Detailed summaries of these talks are in Annex 6.

Edward Farrell from UCD updated the HAWG on progress made to assess the genetic population structure of herring stocks in ICES 6.a/7.bc and to develop genetic baselines of the 6.aN and 6.aS/7.bc stocks to be used to discriminate mixed aggregations of non-spawning herring in area 6a.

Dorte Bekkevold from DTU Aqua presented how Single Nucleotide Polymorphism (SNP) marker classification tools can already be used with high statistical accuracy to distinguish among major herring stocks and sub-stocks mixing in the North Sea, 3.a and Division 22–25.

Florian Berg from IMR is working on splitting Norwegian Spring-spawning herring, North Sea and Western Baltic Spring spawning herring in the HERAS survey and in catches using otolith shape analysis.

Julie Coad Davies from DTU Aqua presented the latest in using otolith microstructure to separate mixed catches of Western Baltic Spring spawners and North Sea herring and presented results from calibration exercises between readers using otoliths from fish genetically assigned to stock.

Jan Arge Jacobsen from Faroe Marine Research Institute presented the otolith classification method used to separate Norwegian spring-spawning herring (NSSH) and other herring stocks (e.g. Icelandic summer-spawning ISSH, Faroese autumn-spawning (FASH) and North Sea type autumn-spawning herring (NASH)) in the International ecosystem surveys in the Nordic Seas (IESNS and IESSNS).

Finally, Michaël Gras from the Marine Institute in Ireland gave an update on the project to use body and otolith morphometry to discriminate herring in 6.a, 7.bc.

Seeing these projects presented together made it clear how much progress is being made towards understanding the population structures of the herring stocks assessed in HAWG and towards developing operational tools to allow routine discrimination of different stocks in the surveys and catches used in the assessments. Many of the researchers already collaborate and exchange material and compare results and will continue to do so, and already were discussing how to further increase these collaborations. One of the outcomes from the symposium is a drive to collect tissue samples for genetic analysis from the entire HERAS survey area in 2019 as well as otoliths from the same fish for shape analysis from the northern most area. This will create a unique dataset to compare results from several methods and help to identify the best method (or combination of methods) to reliably separate different stocks in this survey (6.aN, 6.aS, North Sea Autumn spawners, Western Baltic Spring spawners and potentially also Norwegian spring spawners).

It would be valuable to continue to invite presentations to HAWG on this topic to continue to work towards solutions until enough progress is made to warrant a second round of workshops along the lines of WKSIDAC and WKMIXHER.

1.3.9.2 WKMIXHER 2018

The workshop on mixing of western and central Baltic herring stocks (WKMixHer) took place on 11–13 September 2018 in Gdynia. The aims of workshop were to review recent research and available methods to discriminate western Baltic spring spawning herring and central Baltic herring in mixed catches, evaluate potential implication of mixing for the assessment, develop a coordinated plan to collect and analyse relevant data to quantify the mixing. The central Baltic herring is dominated by a northern component and a southern component and analyses presented at the workshop suggested how the latter actually shares numerous characters with the adjacent western Baltic herring stock (i.e., growth pattern, otolith shape, parasite infestation, etc.). Preliminary analyses performed in conclusion of the workshop suggested a progressive genetic differentiation along the entire southern Baltic coasts from SD24 to SD26 rather than a clear cut division between different assessment units. The workshop results suggest that the issue of separating of the Central Baltic herring stock from the western Baltic spring spawning herring stock is related to understand if the southern component should be considered together with the western Baltic herring, maintained with the central Baltic herring, or if it should be considered separately. Depending on the task, the methodologies reviewed for stock identification could be promising or insufficient. A coordinated plan for sampling herring at spawning time was delineated at the workshop with the objective to validate herring assessment units in the area and look for operational methods to separate them in mixed catches.

Table 1.2.9.2.1 Methodologies for separating the different herring components found in the western and central Baltic (SD22–26) and discussed at the workshop. WBC: WBSSH from SD22–24; CBSC: Southern component of Spring spawning CBH; CBNC: Northern component of the Spring spawning CBH; AC: Autumn spawning component. The score-card below is limited to the results presented at the workshop, the suitability of the different techniques for stock discrimination span from high (green), limited or *to be confirmed* TBC (yellow) and none (red). Copied from WKMixHer report (ICES, 2018).

Stock discrimination methods	WBC-CBSC	WBC-CBNC	CBSC-CBNC	WBC-AC	CBSC-AC	CBNC-AC
Growth	NO	YES	YES	limited	limited	limited
Natural tags *Anisakis simplex*	NO	YES	YES	NA	NA	NA
Otolith shape	limited	YES	YES	YES	YES	YES
Body morphometry	TBC	YES	YES	NA	NA	NA
Vertebrae	NA	NA	NA	NA	NA	NA
Other meristics	NA	NA	NA	NA	NA	NA
Otolith chemistry	TBC	TBC	NA	NA	NA	NA
Genetics 9 microsatellite	limited	limited	limited	NA	NA	NA
Genetics 96 SNPs	TBC	YES	YES	YES	YES	YES

1.3.9.3 WKSIDAC 2017

In 2017 the "Workshop on stock identification and allocation of catches of herring to stocks" (WKSIDAC) was held in Galway, Ireland.

This workshop had several objectives; improve the accuracy and precision of the methods currently applied across laboratories by area; compare alternative available methods; outline a common generic approach in terms of methods; and draft guidelines for conducting stock-splits for assessment purposes. Key issues relating to stock mixes in each of the management areas (2, 3, 5, 6 and 7) were outlined along with why the stock identification was important for the assessments of each of these stocks (see Table 1.2.5.1).

Table 1.2.5.1: Co-occurrence of herring stocks in management areas.

Stocks/stock complexes	stockcode	Spawning components	2a	3a	3 sd22-24	3 sd25	4a	4bc	5a	5b	6aN	6aS	clyde	7aN	7bc	7d	7e	7g-k
Norwegian Spring Spawning	her.27.1-24a514a	NSSH	x	?			?		?	?	?							
North Sea Autumn Spawning	her.3a47d	Downs	x2							x	x	x	x					
		Banks	x2							x	x	x	x					
		Buchan	x2							x	x	x	x					
		Orkney-Shetland	x2							x	x	x	x					
Western Baltic Spring Spawning	her.27.20-24	Rugen	?	x	x	x	x											
		local Spring		x	x													
		local Aut-Winter		x	?													
Central Baltic	her.27.25-2932	CBH		?	x	x												
North West of the British Isles	her.27.6a7bc	6aN	?				?			?	x	x			x			
		6aS-7bc					?				x	x		?	x			
		Clyde									x	x	x		x			
Irish Sea	her.27.7c	Douglas Bank									x	x	x	x	x			
		Mourne									x	x	x	x	x			
Celtic Sea, South West Ireland	her.27.irls	Celtic Sea					-							x			?	x

The workshop concluded from the review on information on stock identification and validation work done so far that there was no consistency between areas and in most either there was no validation or the validation needed to be updated. Only a few areas currently utilize herring stock identification methodology for the assessments, namely areas 3.a and 4 for separation of WBSS from NSAS although the methodology was not ideal, Icelandic waters for separation of ISS from NSS and in Faroese waters for separating autumn from spring spawners. The workshop was focused on potential methods and highlighted the necessity of validation and Standard protocols or operating procedures. The workshop also concluded that the optimal allocation method for stock assessment purposes (as perceived by the Workshop members) varied by area (see Table 1.2.5.2). Otolith shape analyses appeared the most widely recommended, however, other techniques such as genetics and otolith microstructure and micro-chemistry would be necessary for validating the shape analyses results. In the Baltic, separation based on the growth, through length-at-age was favoured and in Area 6.a, a combined approach using genetics and morphology is preferred. Baselines would also need to be updated on a regular basis.

The Workshop was not able to provide an outline of a manual by method for stock identification of herring for implementation in individual laboratories nor provide guidance on retrospective corrections of herring survey time-series but recommended that these topics need to be taken up in some future Workshop/Meeting when further progress has been made.

Table 1.2.5.2. Methodologies for separating herring stocks in each of the management areas.

Table 2: methods in areas	2a	3a	3 sd22-24	3 sd25	4a	4bc	5a	5b	6aN	6aS	Clyde	7bc	7aN	7d	7e	7g-k
Genetic analyses		a,c	a,c	a,c	a,c,e	a,c,e	a	a	c	c		c	c	b	b	c
Otoliths shape analyses		a,b,d	c	c	b	b	b	b	c	c		c	c	a		a
Otolith microstructure		a,b,d			e	e							c			c
Otolith microchemistry		a			e	e			a	a		a	a	a		a
Otolith isotopes		a														
Morphometrics			a						c	c		c	a			a
Parasites		a?,b	a,b	a,b	a	a			a	a		a	a			a
Fatty acids									-	-		-	-			-
Vertebrae counts		d?			a,b,d	a			a	a		a	a			a
Pyloric caecae					a	a			a	a		a	a			a
Tagging			a		a	a			a	a		a	a			a
Growth			a,b,d													

a paper/historic
b data collection
c planned application
d in use in the assessment
e screening/validation

1.3.10 Other activities relevant for HAWG

Industry-Science survey of herring in 6.a, 7b–c. in 2018.

(see Section 06 for additional details).

In 2018, industry and scientific institutions from Scotland, Northern Ireland, Netherlands and Ireland again 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 5800 t (EU2018/120), 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 and 2017 surveys.

Biological samples taken during the survey and subsequent commercial catches were used to construct a catch-at-age used in the 2019 stock assessment. Acoustic surveys on the biomass of the spawning components (ICES, 2019) provide a third set of data points in a spawning stock time series. Morphometric and 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. This information would be considered in a future benchmark assessment.

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 1.2.6.1). 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 and 2019 IBTSQ1 surveys, the occurrences of *Ichthyophonus* in the Norwegian part were again fairly low: 4.4% and less than 1%, respectively. In the Kattegat-Skagerrak, the data suggests levels of incidence generally < 3% but with areas of > 20% infestation (Figure 1.2.6.2) and with a peak around 50% in 45G0 in 2018, although the sample was rather small. Infestation in Q3 2018 appears more localised in the north-eastern part of the Skagerrak compared to 2017. In 2017 the infestation affected mainly age 0-4 and rapidly declined for older fish, while in 2018 also fish of age 5–7 present some level of infestation. 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.

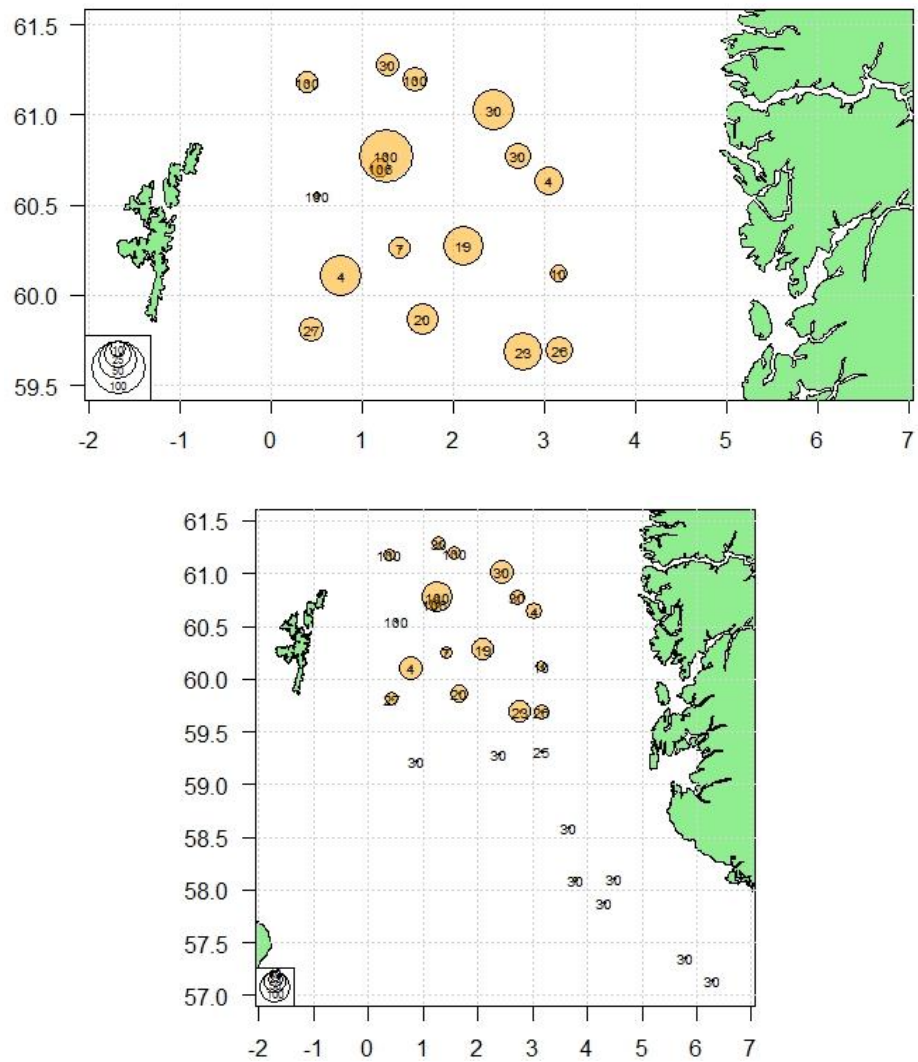


Figure 1.2.6.1 Occurrence of *Ichthyophonus hoferi* in the Norwegian part of the IBTSQ1 2017. Bubble size show the percentage of diseased herring, whereas the numbers show the number of herring.

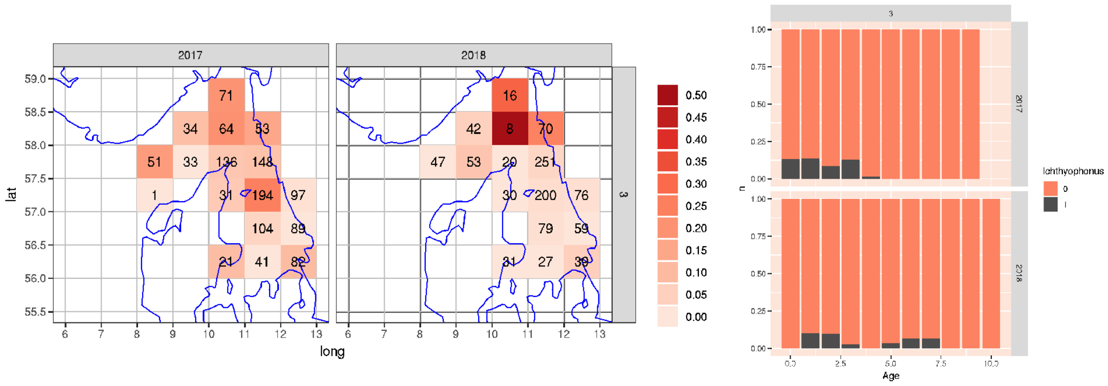


Figure 1.2.6.2 Occurrence of *Ichthyophonus hoferi* in the Kattegat-Skagerrak from Swedish samples collected during the IBTSQ3 2017–2018. Left map with distribution of the proportion of infested herring and number of samples in each rectangle; right distribution of infestation among ages.

HAWG's feedbacks to RDBES

During this year meeting, HAWG had a discussed on the process leading to a joint regional estimation of assessment input data. In particular, HAWG finds that it would be preferable if the estimator role is led by a single individual with input from national experts. This is preferred over an intermediate step within the RDBES wherein the estimation is carried out by multiple individuals with intermediate creation of data subsets. A single estimation would be carried out using a scripted method prepared with input from all national experts currently carrying out estimation procedures. This represents a collaborative approach to define a combined method as a foundation of a single estimation process, it is foreseen that the responsibility to apply the combined method would be taken by a single individual e.g. the stock coordinator.

Countries\Role	National Expert	Estimator Role	Stock coordinator Role
Tasks->	View data and view estimation	Perform the estimation	View/check all data and combine all national estimates into the stock estimate and export it
Country 1	Person 1	Person 1 working with Person 3	Person 3
Country 2	Person 2	Person 3	
Country 3	Person 3	Person 3	
Country 4	Person 4	Person 4 working with Person 3	

HAWG also discussed the importance of implementing a framework for co-production and feedback which could allow participation of the different actors to the actual estimation. Need for data check and quality control procedures has been stressed by the group. The general process discussed and proposed by HAWG can be summarised in the main following steps:

- Data are submitted by individual countries which have responsibility on the quality of what they submit (procedures for checking data quality at the level of submission are necessary and should be expected).

- Once data are in the RDB the stock coordinator runs a first diagnostic script which check the data quality once again and eventually report back to the data submitter possible "anomalies". Ideally, this should trigger an iterative process where errors are corrected with amendments on the initial submission.
- The stock coordinator runs an exploratory data analysis script which produces both visual and tabulated representation of the data. These are circulated among the stock coordinator, assessor and all the experts working on the stock for comments and feedback.
- Once agreed on the quality and interpretation of the data, the stock coordinator runs the estimation script which implements an estimation procedure agreed among the stock coordinator, assessor and other experts contributing to the assessment of the stock. Visual and tabulated output (i.e., WECA, CANUM, …) are circulated among these same experts for comments and feedback.
- Once agreed on the representativeness and quality of the estimation outputs, these can be passed to the assessment model.

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 data set.

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 1 March 2019 All EU member states and Norway 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 required 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)	74581	71183	1247	17
4.a(W)	374490	335958	5612	15
4.b	107796	80034	1455	13
4.c	2188	671	109	50
7.d	43277	14284	445	10
7.a(N)	6804	3567	1119	164
6.a(N)	4 063	3 867	717	176
3.a	23258	20745	3567	153
SD22-24	18992	18860	4675	246
Celtic, 7.j	3982	3671	599	150
6.a(S), 7.b and 7.c	1495	1495	1852	1239

Given the diversity of the fleets harvesting most stocks assessed by HAWG, an appropriate spread of sampling effort over the different metiers is more important to the quality of catch-at-age data than a sufficient overall sampling level. The WG therefore recommends that all metiers with substantial catch should be sampled (including by-catches 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 multi-species 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 multi-fleet forecast routine available at www.stockassessment.org.

1.5.5 Reference Points

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

For sprat in the North Sea (Division 4) and sandeel in management area 1–4, the ICES guide for setting management reference points for category 1 stocks is used to find B_{lim}. MSY $B_{escapement}$ is equal to B_{pa} and is calculated as $B_{lim} \times e^{\sigma \times 1.645}$. An upper level on the fishing mortality is implemented (F_{cap}) if the 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 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 on-going discussion on reference points.

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 for 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, 2016a, b).

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 in the biology and ecology of species and populations (including biological and environmental drivers), and disease.

It should be pointed out that whilst 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. 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 currently 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 recent ACOM request (March 2019), HAWG has collected information 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 parenthesis) 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 was 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
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 popula-tion 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	0	0	0	0	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
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 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, especially in the purse-seine fishery. The by-catch 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 by-catch juvenile herring. The pelagic fisheries on herring and mackerel 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 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 larvae 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. The influence of the environment of herring productivity means that the biomass will always fluctuate. 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 show similar recruitment trends and differ from the Downs component, 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 may occur in the trawl fishery for herring. In addition, North Sea herring are also caught within Division 3.a. The by-catch of sea mammals and birds is low enough to be below detection levels based on observer programmes. At present there is a very limited 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 by-catch 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 by-catch of other fish. Herring represent an important prey item for many predators including cod and other large gadoids, dog-fish and sharks, marine mammals and sea birds. 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 temperature**s** from Malin head on the North coast of Ireland since 1958 indicate that since 1990 sea surface temperatures have displayed a sustained increasing trend, with winter temperatures > 6°C and higher summer temperatures. Environmental conditions can cause significant fluctuations in abundance in a variety of marine species including fish. Oceanographic variation associated with temperature and salinity fluctuations appears to affect herring in the first year of life, probably during the 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 by-catch 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. Whilst 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 from the Celtic Sea are present in the Irish Sea. The majority of mixing between these populations occurs at winterrings 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 second order 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 by-catch is acknowledged for this fishery with by-catch regulations in force. The by-catch 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 by-catch 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 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 by-catch. If a fishery was to be prosecuted in the Clyde and Irish Seas then by-catch of young herring may become an issue due to the overlap in distribution between young herring and sprat. 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. 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 sub-populations. 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 15 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.

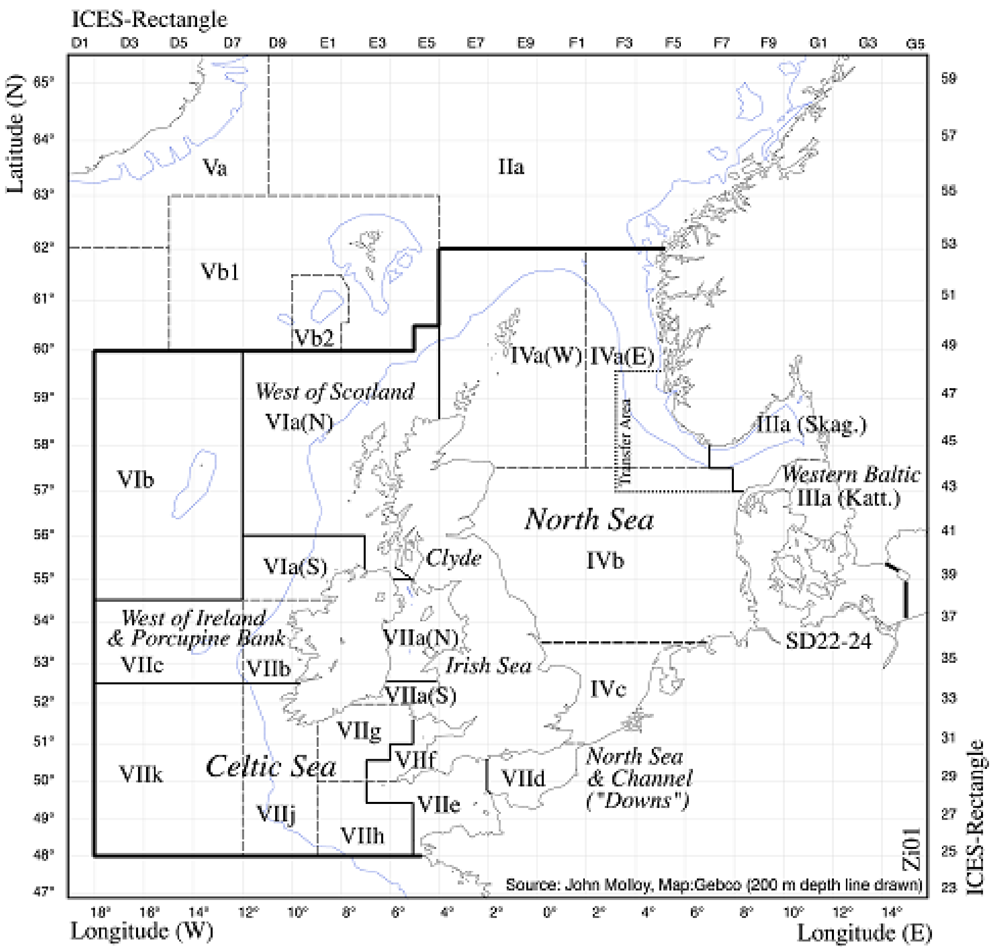


Figure 1.7.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North 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 is classified as being at full reproductive capacity and is being harvested sustainably at F_{MSY} and under management plan target for several years. In 2019, no management plan was in place and the advice is based on the F_{MSY} advice rule. The spawning stock at spawning time in 2018 is estimated at 1.9 million tonnes. Recruitment in 2018 has increased compared to 2017 but remains within the low recruitment regime observed since 2015. The strongest recruitment remains the one observed back in 2014. Mean F_{2-6} in 2018 is estimated at approximately 0.21, which is below F_{MSY}. The SSB for the stock from the 2019 assessment has been revised upward for a number of years.

In 2019 SSB is expected to decrease to ~1.5 million tonnes. Under all scenarios, SSB is predicted to decrease in 2020 (to approx. 1.3 million tonnes) and further in 2021 to around 1.1 million tonnes. SSB is expected to be above B_{pa} in 2020 and 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. SSB was at a minimum of about 70 000 t in 2011 and recruitment is record low in 2018. Under a historical perspective the estimate of SSB of 74 132 tonnes in 2018 is considered low, below both B_{pa} and B_{lim}. Fishing mortality (F_{3-6}) was reduced from 0.50 in 2009 to 0.37 in 2011. It had then remained stable slightly above F_{MSY} (0.31) until 2015 (~0.36) but showed an increase in recent years with an estimated F_{3-6} in 2018 well above F_{MSY} (0.416). The 2020 advised catch of WBSS is 0 t, which if applied by managers, will result in an increase in SSB from 76 273 t in 2020 to 101 269 t in 2021. The zero catch will not allow the stock to rebuild above B_{lim} (120 000 t) by 2021.

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 around 23 000 t in 2018, which is below B_{pa} (at 54 000 t) and B_{lim} (34 000 t). Recruitment has been below average since 2013. Fishing mortality (F_{2-5}) declined between 2003 and 2009 but started to rise again in 2010 due to increased catches. F decreased in 2018 in line with reduced catches. This year assessment estimates a fishing mortality, F_{2-5} of 0.33 in 2018 which a decrease from 2017 (0.64) but above the F_{MSY} (0.26) and below F_{lim} (0.45). Short term projections predict SSB to remain around 23 000 t in 2019.

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 estimated combined. 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 in 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 2018, SSB and recruitment have been estimated at 22 020 t and 333 701 thousand respectively, estimates of SSB in recent years appear to be relatively stable. $F_{4\text{–}6}$ is estimated at 0.16 in 2018. Under the MSY approach the stock is expected to show minor decline to 22 005 t in 2020.

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. Sprat in Division 3.a and Subarea 4 were combined into a single assessment unit during the recent WKSPRAT benchmark (ICES, 2018). Various changes were made to the assessment model, which improved the quality in terms of both fitting and retrospective bias. The advice is based on the MSY escapement strategy with an additional precautionary F_{cap} which has been re-evaluated by a dedicated workshop (WKSPRATMSE; ICES 2019). The F_{cap} of 0.69 is used to ensure that after the fishery has been conducted, escapement biomass is preserved above B_{lim} with high probability. The long-term dynamics and perception of the status of the combined stock is consistent with previous perception for sprat in Subarea 4. Despite the fact that 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 2019 show an SSB of 249 000 t which is nearly double of B_{pa} (125 000 t). The ICES advise for the period 1 July 2019–30 June 2020 indicates that catches of sprat should not exceed 138 726 t.

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 advice provided is based on the biomass estimates from the acoustic survey which in 2018 remained at low level in relation to the estimates for 2013–2015. The advised catch for 2020 is 20% lower compared to last year (applying the uncertainty cap).

Sprat in the Celtic Sea (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 inter-annual 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 2800 tonnes for 2020 and 2021 in this eco-region based on the precautionary approach.

Sandeel in 4 (san-nsea): Sandeels in the North Sea can be divided into a number of more or less reproductively isolated sub-populations. 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) since 2016, but a marked decrease is estimated in the last year which brings the SSB at the beginning of 2019 down to 97 000 t which is below B_{lim} (110 000 t). Recruitment in 2018 was slightly above the geometric mean of the time-series, following the 2017 lowest record. Fishing mortality (F) has fluctuated, showing a declining trend since the mid-2000s followed by an increase in 2017 and 2018 to approximately the long-term average. The pronounced decrease in SSB contributes to a reduction in the advised catch.

A2: SSB has been below B_{lim} since 2004 (except in 2011), it increased in 2018 to above B_{pa} as the result of the exceptionally high 2016 year class but decreased again in 2019 to just below B_{lim}. With the exception of 2016, recruitment has been low since 2000 and continued to be very low in the last two years. A zero-catch advice is confirmed for this year.

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) where it has been since 2015. SSB had a peak of more than 270 000 t in 2018 followed by a decrease to around 182 600 t at the beginning of 2019 consistently with the low 2017 recruitment. The recruitments in 2016 and 2018 were among the five highest on record which explain the 23% increase in the advised catch.

A4: Fishing mortality (F) has been low since 2006 but increased in 2018. SSB has increased from the time-series low in 2009 to levels well above precautionary reference points (B_{pa} = MSY $B_{escapement}$) and has remained at this level since 2016. The 2016 and 2017 year classes are estimated to be above the long-term average, but the 2018 year class is estimated to be the second lowest on record. This results in SSB falling to just below MSY $B_{escapement}$ in 2020, even in the absence of fishing, which triggered a zero-catch advice.

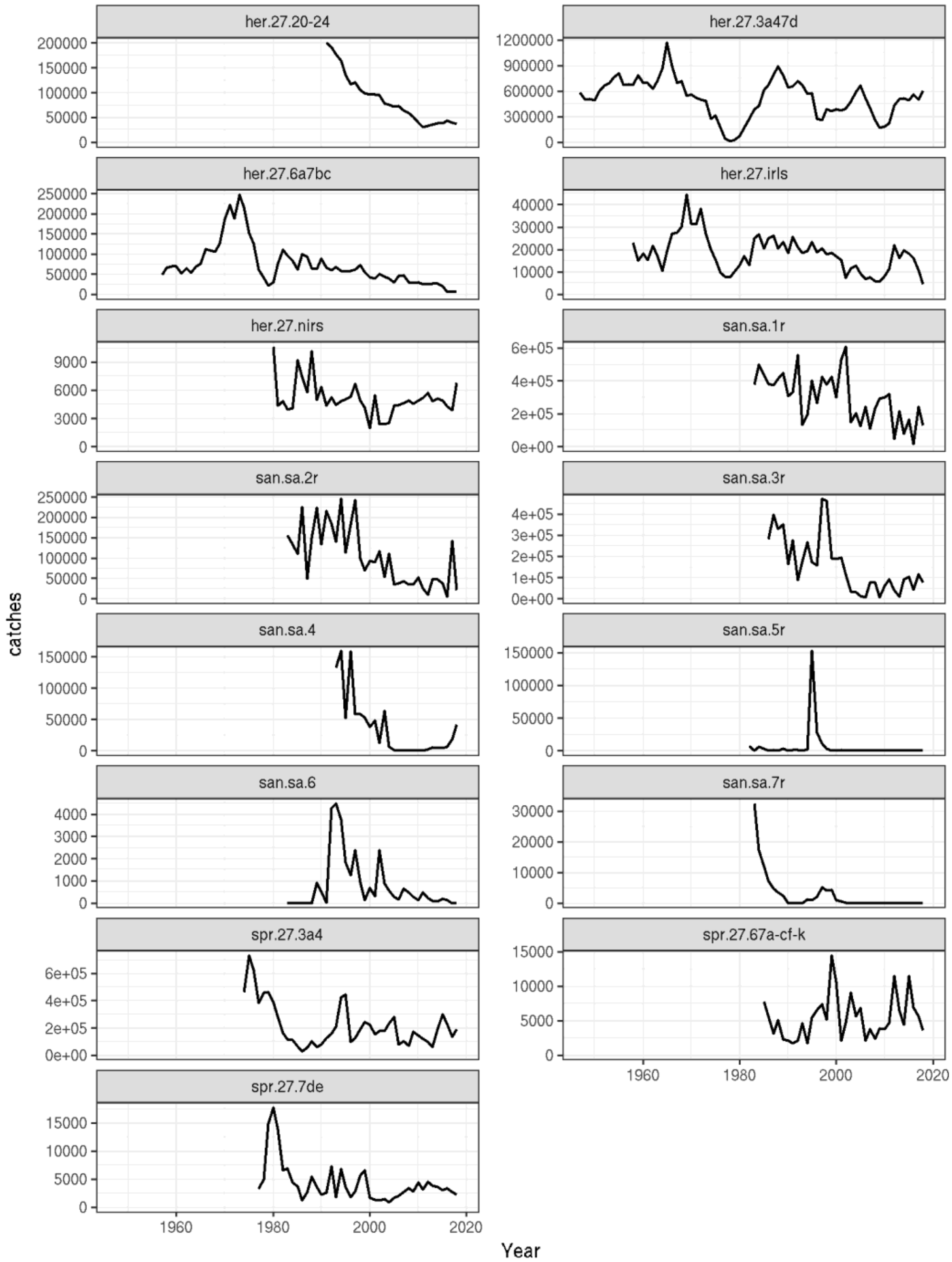


Figure 1.7.2 WG estimates of catch/landings (yield) of the herring, sprat and sandeel stocks presented in HAWG 2019.

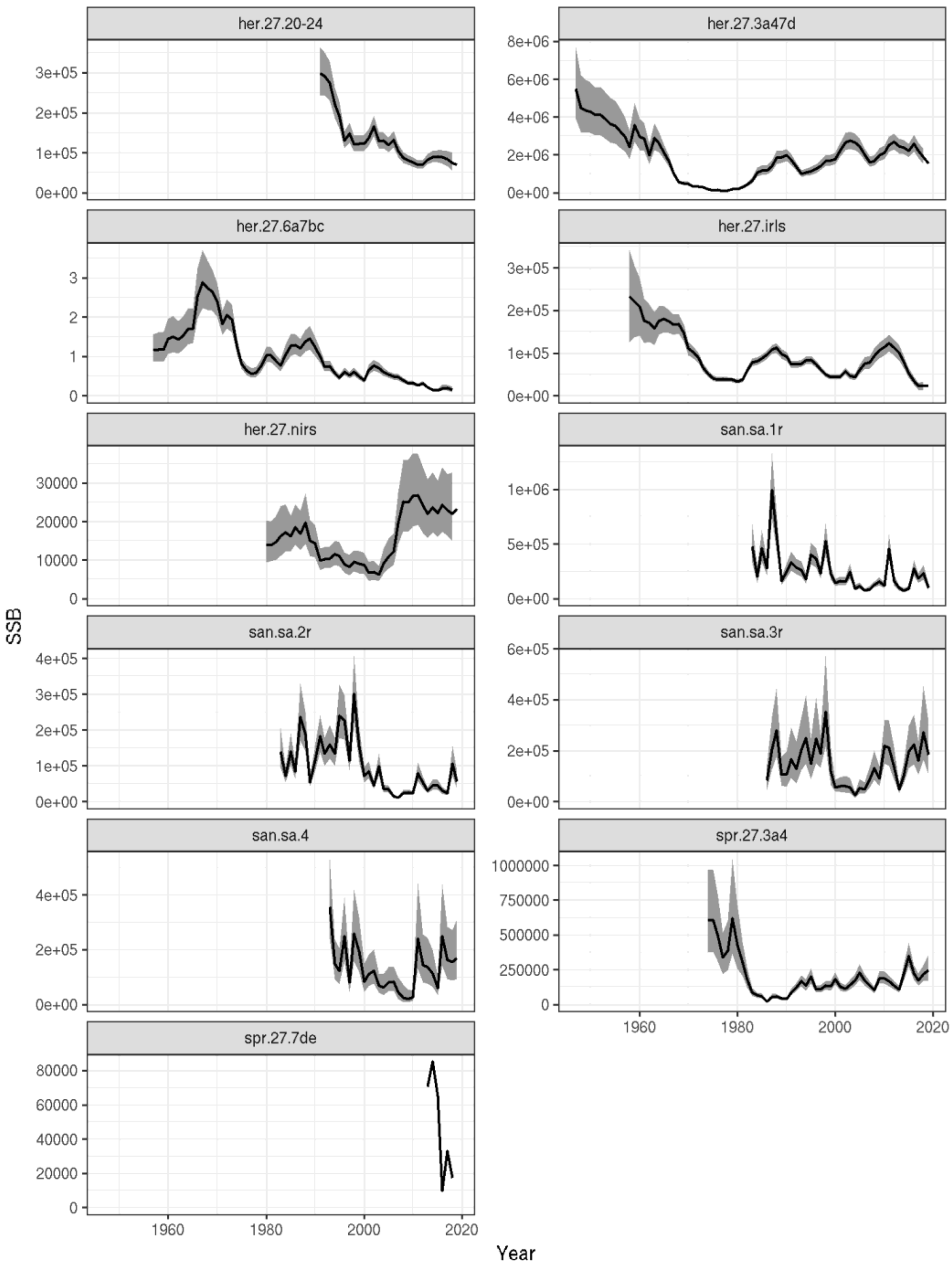


Figure 1.7.3 Spawning stock biomass estimates for the sprat, herring and sandeel stocks presented in HAWG 2019.

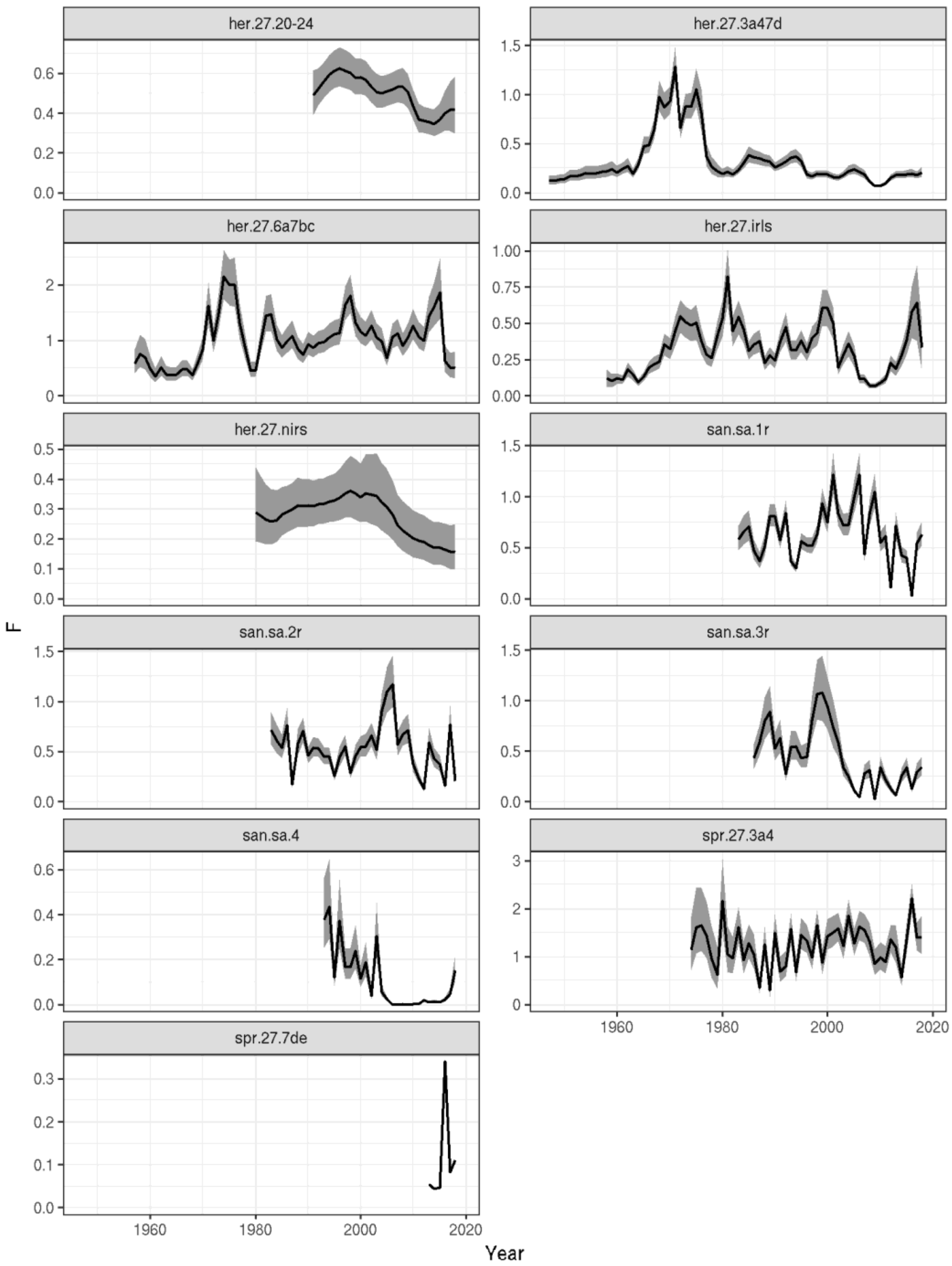


Figure 1.7.4 Estimates of mean F for the sprat, herring and sandeel stocks presented in HAWG 2019.

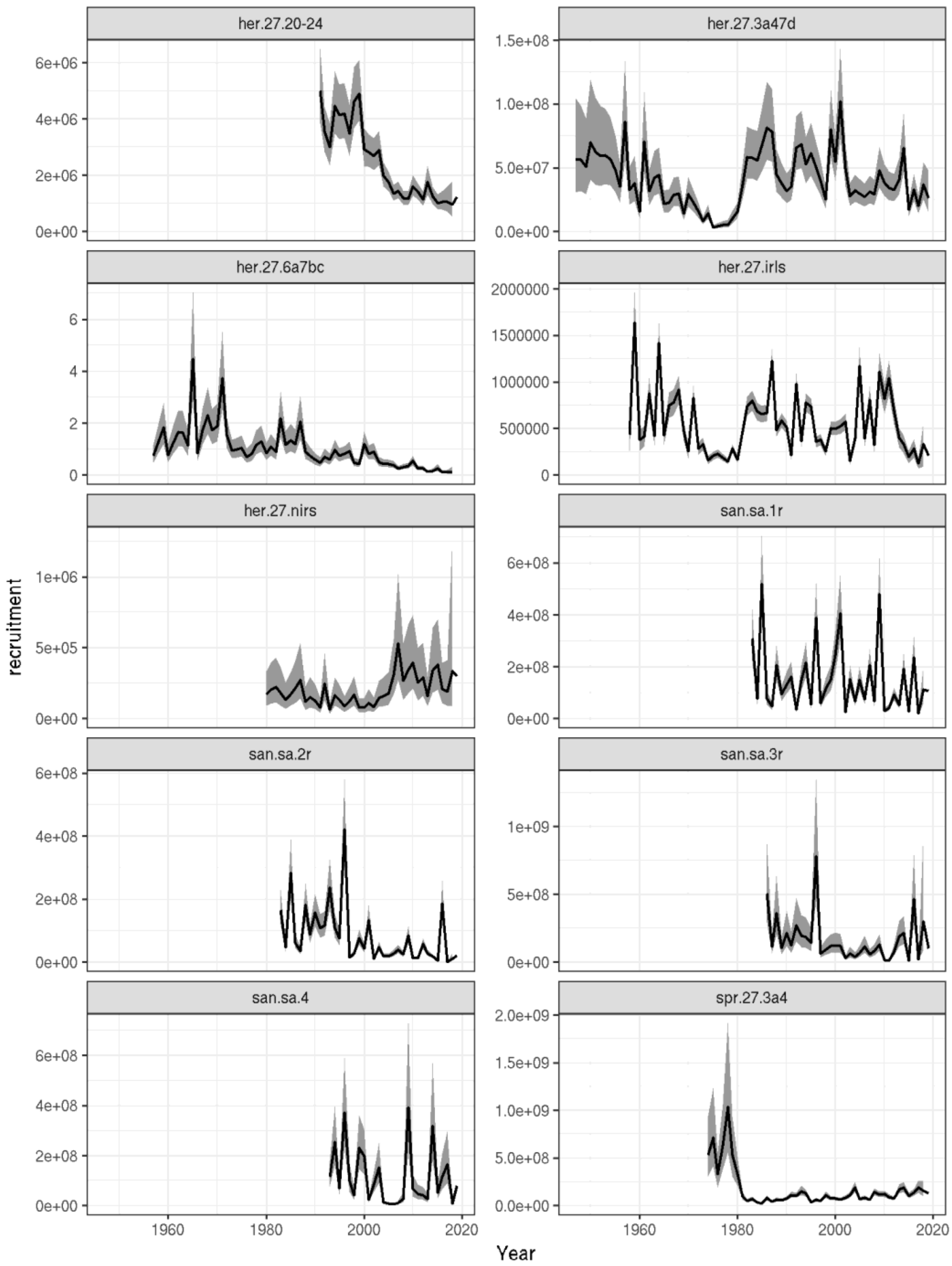


Figure 1.7.5 Estimates of recruitment for the sprat, herring and sandeel stocks presented in HAWG 2019.

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) for the stocks in the North Sea (NSH, her.27.3a47d), the Malin Shelf (MSH, her.27.6a7bc) and the Irish Sea (ISH, her.27.nirs).

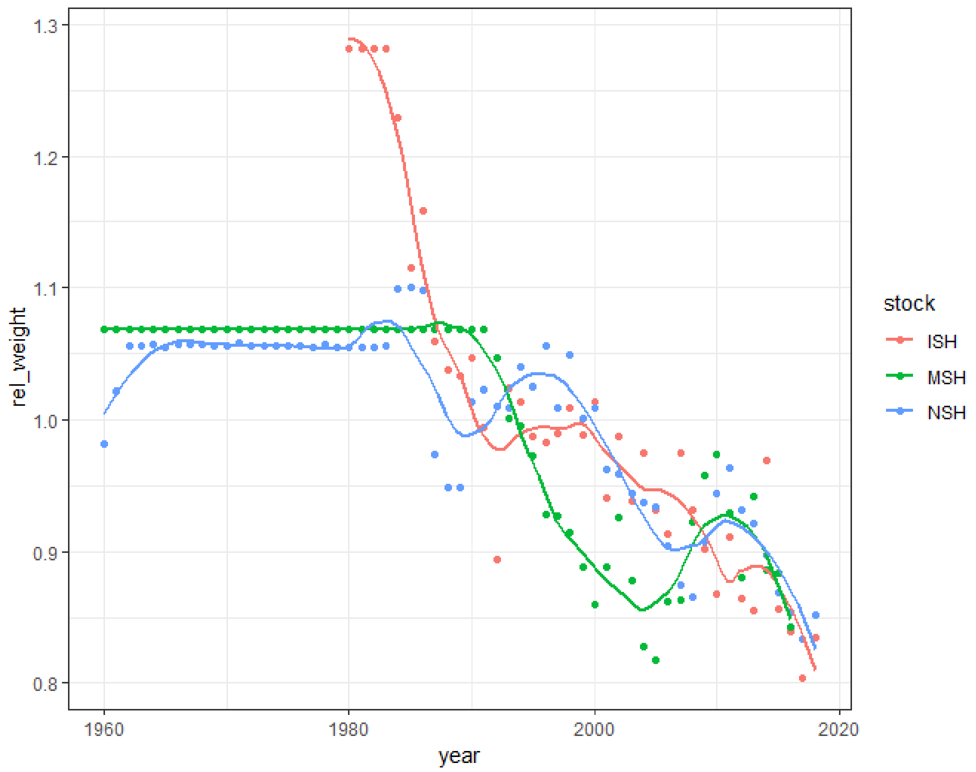


Figure 1.7.6 Relative mean individual weight is calculated by average of stock weight-at-age by year and then it is divided by the mean weight of the time series for each stock.

1.9 Mohn's rho and Bias in the assessments

ICES is planning a workshop in Autumn 2019 (WKFORBIAS) to document the extent of the retrospective bias in SSB, F_{bar} and recruitment for category 1 and 2 assessments based on the 2018–2019 assessments. Additional objectives are to identify and compile possible causes for retrospective bias and to develop approaches for retrospective bias correction and guidelines for acceptability of a stock assessment with retrospective bias. To support the workshop and in response to the ToR c-viii, HAWG reports on retrospective bias in category 1 and 2 age-based fish stock assessments made in 2019. Mohn's rho values have been uploaded at https://community.ices.dk/ExpertGroups/Lists/Retrobias2019/Allitems.aspx and they are included in this report in Table 1.8.1.

Mohn's rho (ρ) is a measure of 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*:

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

* From ICES guidelines https://community.ices.dk/ExpertGroups/HAWG/_layouts/15/WopiFrame.aspx?sourcedoc=%2FExpertGroups%2FHAWG%2F2018%20Meeting%20docs1%2F03%2E%20Background%20documents%2FGuide%5FMohnsRho%5Fcalculation%5FRetroBias%2Edocx&action=view

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: $X_{y=T-i,d=T} = X_{y=2016,d=2017}$ 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 $X_{y=T-i,d=T-i} = X_{y=2016,d=2016}$ which is the estimate of the assessment quantity for the same year T-i = 2016) estimated from an assessment where the data is truncated to have terminal year 2016 (T-i).

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 intermediate 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.nirs	2018	5	0.0520	No	0.0.700	No	-13.8000
her.27.3a47d	2018	5	-12.0000	No	11.1000	No	8.0000
her.27.6a7bc	2018	5	25.0000	No	-23.2700	No	-7.8700
san.sa.1r	2018	3	-0.1200	Yes	0.2800	Yes	-0.1200
san.sa.2r	2018	3	-0.0900	Yes	0.7300	Yes	0.7600
san.sa.3r	2018	5	0.0200	Yes	0.1000	Yes	1.1000
san.sa.4	2018	5	-0.0300	Yes	0.1300	Yes	0.2200
her.27.irls	2018	5	-0.0580	No	0.1720	No	1.1000
her.27.20-24	2018	5	-0.0700	No	0.1300	No	-0.0700
spr.27.3a4	2019	5	0.0890	No	0.2700	No	0.2200

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 2019 scripts are now on TAF:

1. North Sea herring (her.27.3a47d) update single-fleet SAM assessment, multifleet model run required for the forecast, and the forecast analysis.
2. Herring west of Scotland and Ireland (her.27.6a7bc) SAM assessment.
3. Herring south of 52°30'N Irish Sea, Celtic Sea, and southwest of Ireland (her.27.irls) ASAP assessment.
4. Sandeel in area 1r (san.sa.1r) SMS assessment.
5. Sandeel in area 5r (san.sa.5r) category 5.4 analysis.
6. Sandeel in area 6 (san.sa.6) category 5.2 analysis.
7. Sandeel in area 7r (san.sa.7r) category 5.3 analysis.

1.11 Benchmark process

HAWG has made some strategic decisions regarding the future benchmarking of its stocks listed in the table below. In the next 12 months (end of 2019) there are no plans to benchmark stocks assessed by HAWG.

Stock	Ass status	Latest benchmark	Benchmark next 12 months	Planning Year +2	Further planning	Comments
NSAS	Update	2018	No	No		Issue list in prep
WBSS	Update	2018	No	No	Split mixed catches with central Baltic herring. Compile catch matrix by fleet from data in the Regional Database	Issue list in prep, likely need for an interbenchmark to revisit reference points
6.a, 7.bc	Update	2015, interbenchmark in 2019	No	2021*	Splitting of surveys and assessment, recruitment signal	Issue list in prep
Celtic Sea	Update	2015, Interbenchmark in 2018	No	No	Mixing with Irish Sea herring, recruitment signal	Issue list in prep
7.aN	Update	2017	No	No	Explore stock mixing and review acoustic survey design and methods, recruitment signal	Issue list in prep
Sprat NS.3a	Update	2018	No	No	Consider stock component, local components in 3a, boundary with the Baltic	Issue list in prep
Sprat 7.d and 7.e	Exploratory	2018	No	No	Consider stock components	Issue list in prep
Sprat Celtic	Exploratory	2013	No	No	Consider stock components	Issue list in prep
Sandeel areas 1–4	Update	2016	No	2021*	Update reference points for sandeel area 3 based on the new M estimates.	Issue list in prep

*** Provisional, timeline to be decided**

1.11.1 Ecosystem and long-term benchmark planning

HAWG is developing a longer-term perspective towards its benchmark process, by identifying issues that should be addressed in the next round of benchmarks, even though they are several years in the future. The following list of issues is intended to focus development work during this inter-benchmark period.

General

- Develop assessment tools that can take account of uncertainty estimates in surveys.

North Sea Autumn Spawning (NSAS) herring

- Splitting of catches, where possible, into autumn and winter-spawning components.
- Refinement of the IBTS0 index calculation to provide component-resolved information.
- Modification of the assessment model to account for reduced precision in catch statistics prior to the 1960s.
- In-depth understanding of the reasons at the origin of the retrospective pattern related to inclusion of the 2018 data
- Investigate the use of a wider range of ages for the F_{bar} (currently age2–6) and application of a weighted mean of F

Western Baltic Spring Spawning (WBSS) herring

- Account for mixing of central Baltic herring (CBH) in the commercial catches in SD22–24. Check for mixing of WBSS-CBH in SD25 catch
- Account for mixing of WBSS-NSAS outside of the transfer area (4.a.E, 4.b.E).
- Improve estimation of catch matrix in synergy with the RDBES
- Identify main drivers of stock productivity
- Reference points may need to be revisited.

6.a herring

- Extraction of West of Scotland herring larval abundance estimates from the North Sea IBTS0 survey.
- Develop genetic methods to split surveys and commercial catches by components

Irish Sea herring

- Develop techniques to maximize the information content in the Irish Sea larval survey. Explore levels of stock mixing, spawning behaviour and timing.

Celtic Sea herring

- Use genetic techniques to assess the mixture of Celtic Sea herring in the Irish Sea.
- Assess the interannual variation in this mixing as well as the distribution patterns.

1.12 Recommendations

All recommendations have been uploaded to the ICES Recommendation database.

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

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 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 2018 and 2019

Norway and the European Union had submitted a joint request to ICES to evaluate possible elements for long-term management strategies for several fish stocks, including North Sea autumn spawning herring.

These management strategy evaluations are in progress, but not finalized at the time of HAWG 2019. Results will become available in April 2019. There is currently no agreed EU-Norway management plan as the basis of advice. 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 2018 was 610 257 tonnes for Area 4 and Division 7.d, where no more than 66 040 tonnes should be caught in Division 4.c and 7.d. For 2019, the total TAC has decreased by 35% to 398 198 tonnes (385 008 tonnes for the A-Fleet), including a TAC of 42 351 tonnes for Division 4.c and 7.d.

The by-catch TAC for the B-Fleet in the North Sea (and Division 2.a) was 9669 tonnes in 2018 and has increased by 36% to 13 190 tonnes for 2019. 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 2018

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 602 328 tonnes in 2018. Official catches by the human consumption fishery were 593 851 tonnes, corresponding to a slight undershoot of 1% of the TAC for the human consumption fishery (600 588 tonnes).

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 45 462 tonnes. The separate TAC for this area was 66 040 tonnes, so 31% 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). The obtained catch continues to relieve the fishing pressure on the Downs stock component, as observed since 2012.

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

Landings of herring taken as by-catch in the Danish small-meshed fishery were 8477 tonnes in 2018. The by-catch ceiling for the B-Fleet was 9669 tonnes. Since the introduction of yearly by-catch ceilings in 1996, these ceilings have only fully been taken in 2014 and 2016.

The total North Sea TAC and catch estimates for the years 2013 to 2018 are shown in the table below (adapted from Table 2.1.6).

Year	2013	2014	2015	2016	2017	2018
TAC HC ('000 t)	478	470	445	518	482	601
"Official" landings HC ('000 t) *	490	490	472	545	485	594
Working Group catch HC ('000 t)	490	493	474	545	485	594
Excess of landings over TAC HC ('000 t)	12	23	28	27	3	-7
By-catch ceiling ('000 t) **	14	13	16	13	11	10
Reported by-catches ('000 t) ***	8	14	8	15	7	8
Working Group catch North Sea ('000 t)	498	507	482	560	492	602

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 by-catches included in this figure.**

**** by-catch ceiling for EU industrial fleets only, Norwegian by-catches included in the HC figure.**

***** provided by Denmark only.**

2.1.3 Regulations and their effects

Following the apparent recovery of the NSAS herring, some regulatory measures were amended. A licence scheme introduced in 1997 by UK/Scotland to reduce misreporting between the North Sea and 6.aN was relaxed. The minimal amount of target species in the EU industrial fisheries in 3.a has been reduced to 50% (for sprat, blue whiting and Norway pout).

In 2019, half of the EU quota for Division 3.a can be taken in the North Sea (4); based on correspondence with the Pelagic RAC, HAWG notes that this transfer will be in the order of magnitude of 48%. Norway can take up to 50% of its quota for Division 3.a in the North Sea (4).

In the North Sea, Norway can take up to 50 000 tonnes of its quota in EU-waters in divisions 4.a and 4.b. 50 000 tonnes of the EU-quota can be taken within Norwegian waters south of 62°N.

Half of the EU quota for divisions 4.c and 7.d can be taken in Division 4.b. HAWG has no information to which extend these transfers were utilised.

In 2014, an agreed record between EU and Norway was applied, enabling an inter-annual quota flexibility of 10% of the TAC. Each party could transfer non-utilised 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 inter-annual flexibility has changed in 2015 so that 25% of the TAC can be transferred into the next year, while up to 10% can be borrowed.

HAWG has not applied this record to national catches, e.g. to what extent or which party may have used this annual quota flexibility.

Since 2015, a landing obligation is in place for pelagic fleets operating in the North Sea and the Baltic. All catches of (quota) regulated species have to be landed into port.

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.

The fishery concentrated in the north-western part of the North Sea, around the Fladen Ground area (figures 2.1.1 a–e). The majority of catches is taken in Subdivision 4.aW, in the order of 60% of the total. In line with the TAC, catches in 2018 increased in all areas except Subdivision 4.aEast. Their proportion of the total North Sea catch was 12% in 2018. Catches in Division 4.b contributed 18% in 2018.

The utilisation 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 2188 tonnes in 2018.

As in former years, most of the catches in the B-Fleet are taken in Division 4.b (76%). The by-catch ceiling for this fleet has not fully been taken in 2018.

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 2.2 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 2003–2018 (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 2008–2018.

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 4.5 billion fish and the estimated overall number of NSAS caught in the North Sea and 3a amounts to 4.6 billion fish in 2018. The proportion of 0- and 1-ringers of herring taken in the North Sea is 31% of the total catch in numbers in 2018 (Table 2.2.5), compared to 18% in 2017. Most of these young herring are still taken in the B-Fleet in Division 4.b. Here, 0- and 1-ringers amount to 73% of the total catch in numbers.

The proportion of 3+ winterring herring is 65% of the total catch in numbers taken in the North Sea (compared to 80% in 2017). The 4 and 5 winterring herring contributed most to the catches in 2018, both in terms of numbers and in biomass.

Western Baltic (WBSS) and local Division 3.a spring-spawners are taken in the eastern North Sea during the summer feeding migration (see Stock Annex and Section 2.2.2). 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 2003–2018. After splitting the herring caught in the North Sea and 3.a between stocks, the total catch of North Sea Autumn spawners amounts to 603 536 tonnes.

Area	Allocated		Unallocated	BMS	Total
4.a West		374 491			374 491
4.a East		74 580			74 580
4.b		107 795			107 795
4.c/7.d		45 462			45 462
	Total catch in the North Sea				602 328
	Autumn spawners caught in Division 3.a (SOP)				3 372
	Baltic spring spawners caught in the North Sea (SOP)				-2 164
	Total catch NSAS used for the assessment				603 536

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 310 tonnes in 2018.

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 and also in 2018 only 10 tonnes were caught.

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 non-allocation of catches were often substantial, but have reduced in the recent decade and are meanwhile regarded as a minor issue in the North Sea herring fishery. In 2018, no unallocated catches were reported. The **Working Group catch**, which include estimates of all fleets (and misreported or unallocated catches; see Section 1.5), is thus estimated to be the same as the official catch.

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 fishes lost or damaged during processing procedures) were zero in 2018. 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 2018 North Sea herring fishery. However, discards occurred in demersal fisheries not targeting on herring. These discards sum to 96 tonnes in 2018.

The sampling of commercial landings covers 83% of the total catch (2017: 84%).

More important than a sufficient overall sampling level is an appropriate spread of sampling effort over the different metiers (here defined as each combination of fleet/nation/area and quarter). Of 103 different reported metiers, 33 were sampled in 2018. The recommended sampling level of more than 1 sample per 1000 tonnes catch has been met for only 14 metiers. With regards to age readings, 14 metiers appear to be sampled sufficiently (recommended level >25 fish aged per 1000 tonnes catch).

However, some of the metiers yielded very little catch. In 52 metiers the catch is below 1000 t. The total catch in these metiers sums to 9742 t, so the remaining 51 metiers represent 592 589 tonnes of the working group catch (98%). Of these 51 metiers 27 were sampled. Only 8 fulfil the recommended level of more than 1 sample per 1000 tonnes catch and of 25 age readings per 1000 tonnes 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 metiers with substantial catch should be sampled (including by-catches in the industrial fisheries), and that catches landed abroad should be sampled based on criteria provided above, and information on these samples should 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 2018

Six 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 CM 2018/EOSG:14). 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.

The estimate of North Sea autumn spawning herring spawning stock biomass is higher than previous year at 2.3 million tonnes (2017: 1.9) due to an increase in the number of fish (2017: 11,621 mill. fish, 2018: 12,315) and an increase in weight-at-age for mature herring. The spawning stock is dominated by fish of age 4 and 5 wr, which is in accordance with the strongest year classes in the 2017 survey.

The time series of abundance of North Sea autumn spawning herring is given in Table 2.3.1.3.

The coverage per country is shown in Figure 2.3.1 and the spatial distribution of herring from the survey is shown in Figure 2.3.1.2. The distribution of adult herring in the North Sea is still concentrated in the areas east and north of Scotland. This year the distribution is slightly further north compared to the previous two years. Substantial aggregations of juvenile herring were encountered around the Dogger Bank area in addition to the usual distribution in the south eastern parts of the North Sea and in Kattegat.

The abundance of immature fish in the stock has increased from 18 434 million in 2017 to 20 290 million this year. This is mainly due to the high number of 1 wr fish this year and partly due to the exceptionally low maturity level of the 2 wr fish this year.

Maturity of 2 winter ringers was at an all-time low at 37%. Maturities for ages 3 and above were comparable to the long-term average, with 91% of 3 winter ringers and 98% or higher maturity for all ages 4 and above. 100% maturity was achieved by age 5.

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

Four survey areas were covered within the framework of the International Herring Larval Surveys in the North Sea during the sampling period 2018/2019. 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 the second half of September and in the southern North Sea (SNS) in the second half of December 2018 (Figure 2.3.2.1).

The German survey contribution around the Orkneys started as scheduled, but after one day of sampling the research vessel had to face severe technical problems. There was no opportunity to conduct a safe journey any further, thus the survey had to be stopped after 28 plankton hauls. The vessel steamed back to Bremerhaven, where it is still in repair at the time of HAWG 2019. No charter vessel was available for the survey planned in early January 2019. As a consequence, the estimate for the Orkney/Shetland area is very low and biased due to the low area coverage, and no estimate for the Downs components is available in January 2019.

The survey contribution of The Netherlands in September 2018 was as planned and covered the Buchan and the central North Sea. The December survey in the Southern North Sea was conducted on-board a smaller vessel, which turned out to be more sensitive to weather conditions. Thus the area coverage is limited, and no information about larvae abundance in the western part of the sampling area (the main spawning ground) is available.

No survey was planned for the second half of January 2019. An additional MIK sampling will be undertaken instead in March/April in the German Bight and southern North Sea. This sampling should shade light on the foraging and recruitment of herring larvae originating from the Downs stock component.

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. However, only the estimates from the Buchan and central North Sea were included in the assessment. The biased estimates of the Orkney/Shetlands and the southern North Sea were excluded and not used as data input to the assessment at HAWG 2019. Instead these larval abundances were estimated by the model.

Most of the survey areas have not been fully covered since the beginning of the 1990s, e.g. the first half of September in Orkney/Shetland and Buchan and CNS. It is very unlikely that survey effort will increase in the upcoming years. Thus the survey design will be revisited at the Working Group on Surveys of Ichthyoplankton in the North Sea (WGSINS) meetings, examining different and more efficient ways to make use of the current survey effort.

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 a fine meshed 2 m ring trawl provide abundance estimates for large herring larvae in late development stage (0-ringers) of the autumn spawning stock components.

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, 637 depth-integrated hauls were completed with the MIK-net. The coverage of the survey area was good with at least 2 hauls in most of ICES rectangles in the North Sea as well as in the Kattegat and Skagerrak.

Index values are calculated as described in detail in the Stock Annex.

Larvae were measured to standard length (SL). As in most years, the smallest larvae <10 mm were the most numerous but. Larger larvae >18 mm SL were rarer and were caught in lower densities than last year (Figure 2.3.3.1). The smallest larvae were chiefly caught in 7.d and in the Southern Bight. The large larvae appeared in moderate to high quantities only in the western part of the North Sea, in 3 rectangles of the Southern Bight and in the Skagerrak. In the eastern part of the North Sea, the potential nurseries, abundance of large herring larvae was very low, and virtually no larvae occurred in the German Bight. Instead sardine larvae were found in considerable numbers in the German Bight, which has not been shown before.

To exclude the newly hatched Downs larvae from the index, the rule has been applied to exclude larvae below 18 mm for the calculation of the MIK index. The results of the calculation can be found in Table 2.3.3.1.2. The 2019 index is 51.6.

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 1995 to 2016 is shown in Table 2.3.3.2. The index from the 2019 survey is 1539 which is almost double that of 2018 but lower than the long-term average of the time series. Figure 2.3.3.3 illustrates the spatial distribution of 1-ringers as estimated by trawling in January/February 2017, 2018 and 2019. For the 2017 year class, the majority of the 1-ringers were distributed chiefly in the southern German Bight and in the Kattegat. The mean abundance in the southeastern North Sea was apparently lower and more dispersed than in 2018. Highest abundances, however, were observed in 3 rectangles in the Kattegat contributing the most to the higher index for this year. It appears noteworthy, that the trajectories for five recent 1-ringer abundances (year classes 2013–2017) correspond very well to the trajectories of their 5 respective 0-ringer indices (Figure 2.3.3.4).

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 2018 for comparison. The data for 2018 were sourced from Table 2.3.1.2. and Table 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 2018 were lighter for groups 1 to 4-wr and 7-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 discontinued in 2018. Only 1, 2 and 3-wr in the acoustic survey had lower mean weight at age compared to 2017, while all other ages had higher mean weight. In the 3rd quarter catch, all aged were heavier expect of 1 and 3-wr.

The mean weight-at-age of the 9+ wr are almost the same weight than the 8-wr in the survey. The 2007 year class (part of the plus group) seems to 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 2018 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 was described fully in ICES (HAWG; ICES CM 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 at 37%. Maturities for ages 3 and above were comparable to the long-term average, with 91% of 3 winter ringers and 98% or higher maturity for all ages 4 and above. 100% maturity was achieved by age 5.

2.4.3 Natural mortality

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

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

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. The optimal offset obtained is of 0.11.

2.5 Recruitment

Information on the development in North Sea herring recruitment comes from the International Bottom Trawl Surveys, from which IBTS0 and the 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. 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, the relationship between the two indices started to erode. This was particularly true in recent years (the 2009 and the 2006–2007 year classes), but also already for the 1995 year class, when the predicted levels of recruitment have 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 30% 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 (Figure 2.5.1.1).

2.6 Assessment of North Sea herring

2.6.1 Data exploration and preliminary results

Thorough investigation of the assessment was undertaken during the last benchmark (2018). These are described in the WKPELA report (ICES WKPELA, 2018). The subsequent assessment methodology is described in the Stock Annex. In short, the changes to the assessment are as follows:

- Use of the new natural mortality from the last SMS key run (ICES WGSAM, 2018) together with a new strategy for using different SMS key runs and during interim years.
- Use of revised IBTS0 index.
- Standardization of IBTSQ1 and IBTSQ1 indices
- Introduction of IBTSQ3 age 2–5 index as a new data source
- Calculation of larvae index within the model as opposed to the SCAI model index.

The tool for the assessment of North Sea herring is FLSAM, an implementation of the State-space assessment model (www.stockassessment.org), 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 37%, 91% and 98% respectively. The historical proportion mature at age are given in Table 2.6.3.5 and plotted in Figure 2.6.1.1. There is an overall decreasing trend for 2-wr individuals since 2012. The tracking of each cohort can be observed in Figure 2.6.1.2 and time series of natural mortality at age is shown in Figure 2.6.1.3.

The numbers at age over all ages in the acoustic survey can still be considered relatively high in the recent time period (see Figure 2.6.1.4). The internal consistency of the acoustic survey remains high, as it has been for a long period (see Figure 2.6.1.5).

The SAM model fits the catch and the surveys well and residuals are random and small for all ages (figures 2.6.1.6–2.6.1.41). 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 2.6.1.12 and 2.6.1.13). 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 (figures 2.6.1.31–2.6.1.41). All other surveys fit well inside the model. Further visualisation of residuals for the catch data and the survey indices can be observed in figures 2.6.1.43–2.6.1.46.

A feature of the assessment model is the estimation of an observation variance parameter for each data set (see Figure 2.6.1.46). 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 increase in observation variance from the SCAI index that was used in previous years is due to the change in methodology. Previously the observation variance was perceived as lower because of the pre-processing (e.g. smoothing) when modelling the SCAI index. The uncertainty associated with the parameter estimated is low for most data sources where only the CV of the catch at age 0 is somewhat high (Figure 2.6.1.47). However, the CV quantities do not indicate a lack of convergence of the assessment model.

The analytical retrospective pattern has increased compared to the 2018 assessment. This is particularly pronounced in the SSB showing a higher perception in the current assessment, but a very similar perception in F and recruits (Figure 2.6.1.48). The mean mohn's rho with a 5 year period for the peel is of -12% (Fbar), 8% (rec), 11.3% (SSB). The difference in perception of SSB is a result of the inclusion of the 2018 HERAS (Figure 2.6.2.9). For 2018, the HERAS index for ages 2–8+ exemplifies an increase in the SSB while the assessment model predicts a decrease in the SSB (Figure 2.6.2.10).

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 (see Figure 2.6.1.50).

2.6.2 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. The configuration of the multi-fleet model is presented in Table 2.6.2.1. 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 multi-fleet assessment and results (including fleet wise fishing mortalities) are given in Table 2.6.2.2 to 2.6.2.5.

Of particular relevance when running the SAM model using a multi-fleet configuration is the fishing mortality at age that is outputted for each fleet. The subsequent catch residuals for each fleet is shown in Figure 2.6.2.1 to Figure 2.6.2.3. The observation variance is shown in Figure 2.6.2.4, with high levels for fleet B and D. Expectedly, the model is driven by catch data from fleet A which represents most of the overall catches. The model uncertainty and the correlation coefficients between the estimated parameters are shown in Figure 2.6.2.5 and 2.6.2.6 respectively.

As for the single fleet assessment, the retrospective over 7 year for SSB, F_{bar} and the recruitment is low (Figure 2.6.2.7). With respect to SSB, F_{bar} and recruitment, the multi-fleet assessment yields very similar results to the single fleet assessment (Figure 2.6.2.8).

2.6.3 Final Assessment for NS herring

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 and model settings are shown in tables 2.6.3.1–2.6.3.11, the SAM output is presented in tables 2.6.3.13–2.6.3.33, the stock summary in Table 2.6.3.12. Figure 2.6.3.1 shows the stock time series for SSB, F_{bar} and recruitment and Figure 2.6.3.2 shows the management strategy currently under assessment, including the biomass trigger points and contains the $F_{2\text{–}6}$ vs SSB estimates of the past 10 years.

The spawning stock at spawning time in 2018 is estimated at approximately 1.5 million tonnes, which is a decrease of 21% in comparison to 2017.

The abundance of 0-wr fish in 2019 (2018 year class) is estimated to be at approximately 26 billion, which is 22% below the 10 year weighted mean (33 billion, see Table 2.6.3.14).

Mean $F_{2\text{–}6}$ in 2018 is estimated at approximately 0.21, which is below the management agreement target F. The mean $F_{0\text{–}1}$ is 0.052.

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} (0.26) and the management plan target (0.26).

The SSB in autumn 2018 was estimated at 1.5 million tonnes, which is above B_{pa} (0.9 million t) and MSY $B_{trigger}$(1.4 million t).

The recruitment for the stock in recent years (since 2013) is low and the further aging of the 2013 and 2012 year classes is driving the decrease in SSB. In line with the recruitment level since 2014, the recruitment in 2019 remains low (26 billion, 22% lower than the 10 years weighted mean).

Similarly to recent years' assessments, fishing mortality on older ages remains high in recent years. According to the assessment, the fishing mortality at age 7 is around 0.54 in 2018, which is substantially higher than $F_{bar2\text{–}6}$ (0.21). 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 2019, 2020 and 2021 were done with code developed in the R programming language. During HAWG 2019, a modification to the code has been 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. The revamping of the R code also resulted in a more functional and intelligible code. As a result, it is now easier to implement different assumptions on the different fleets (e.g. TAC status quo or zero TAC for WBSS).

The various assumptions for the short term predictions for both the stock and the four different fleets are given in Table 2.7.1 and 2.7.2 respectively.

In the short-term predictions, recruitment is assumed constant at 33 billion for the years 2020 and 2021 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 2018 year class, obtained from the assessment served as the estimate for 2019.

For the intermediate year (2019), no overshoot for the A fleet was assumed, as there was minimal deviation from the TAC in 2018. 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 2019, 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 2019. 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 (amounting to 22 276 t) in the intermediate year. In the projected year 2020, the C and D fleet outtake was set to 0 in agreement with the 0-catch advice for WBSS for 2020.

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.

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. The MSY AR stipulates a fishing mortality of $F_{MSY} = 0.26$ when the stock is above MSY $B_{trigger}$ (1 400 000 tonnes) and a linear decline in F when the stock is below MSY $B_{trigger}$. 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. Therefore additional assumptions needed to be made for e.g. the B-fleet. An 86% uptake (3 year average) of the advised TAC in 2019 was used. For the projection year 2020, an F status quo for the B fleet was assumed ($F_{0\text{-}1} = 0.046$). In addition, two scenarios are presented in which the TACs of the C and D fleet are the same as in 2019.

EU and Norway have requested ICES to evaluate a number of different potential management strategies to be used in the future (EU-Norway 2018[1]). While the Management Strategy Evaluations (MSE) have not been completely finalized, preliminary results for applicable target fishing mortalities and trigger biomasses were already available and have been tentatively used as scenarios in the projection.

It is noted that making fleet-wise predictions for four fleets that are more or less independent, could potentially result in many different options for 2020. The scenarios presented in Table 2.7.5 are based on certain assumptions to limit the number of options. The scenarios are for illustrative purposes only.

All predictions are for North Sea autumn spawning herring only.

2.7.1 Comments on the short-term projections

Although the SSB is expected to decrease between 2019 to 2021, due to a series of weak year-classes recruiting to the fishery, the projection still estimates a substantially higher catch compared to the projection that was carried out in HAWG 2018. This counter-intuitive result was further investigated during the working group. It was concluded that the main reasons for the higher predicted catch were: 1) a higher estimate of stock size due to a retrospective bias in this year's assessment (see Section 2.10), 2) a relatively large contribution of older fish in the population (year classes 2012 and 2013, age 6 and 7 in 2020), and 3) a high selection on the oldest ages in the population. The high proportion of age 6 and 7 in the forecast year (2020) is exemplified in Figure 2.7.2.1 and 2.7.2.2. This leads to a projection where the estimated catch (in tonnes) in 2020 consists for around 50% of fish that are age 6 (WR) and older, and that the average fishing mortality on ages 7 and 8 (WR) is around 0.54.

[1] EU–Norway. 2018. Agreed record of consultations of long-term management strategies on joint stocks between Norway and the European Union, London, 7 June 2018. 5 pp.

The predicted catch according to the MSY Advice Rule for 2020 (418 649 tonnes) implies a 44% increase compared to the recommended catch for the A fleet in 2019 (291 040 tonnes) and a 9% increase compared to the A fleet TAC in 2019 (385 008 tonnes).

2.7.2 Exploratory short-term projections

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 2019 carried out two exploratory short-term projections:

1. Using an age range of 2–8 WR for fishing mortality instead of the standard 2–6 WR.
2. Extending the MSY AR projection to 2025, using a fixed recruitment and fixed F patterns.

Age range 2–8

When using the age range 2–8 instead of 2–6, the highly selected older ages are included in the average fishing mortality which is being optimizing in the projection to comply to the MSY approach (F = 0.26). This resulted in a projected catch of 309 000 tonnes with an $F_{2\text{–}8}$ of 0.25, compared to the recommended catch of 418 000 tonnes with the $F_{2\text{–}6}$. Of course, it was noted that, although this may be seen as an expression of the dependency of the forecast on the oldest ages, it is not a fair comparison. Normally, if the mean age of fishing mortality would be changed, this would also require the re-estimation of reference points and this has not been attempted as part of the HAWG 2019.

Extending projection to 2025

To explore the future consequences of harvesting the recommended catch in 2020, the MSY AR projection was extended, deterministically, using the same (low) recruitment and the same fishing patterns by fleet for the years 2021–2025 (Figure 2.7.2.3). This resulted in a catch for the A fleet of 311 000 tonnes in 2021 and catches around 280 000 tonnes in the subsequent year, while the SSB would be around 1 200 000 tonnes in all years. 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.

Conclusions on the sensitivity of the short-term projections

The projection according to the MSY AR resulted in an A-fleet catch of 418 000 tonnes in 2020. This result is heavily dependent on the skewed age composition of the stock (many old fish due to strong 2013 year class) and a high selection for the oldest ages. Using a different age range for calculating the average fishing mortality resulted in a substantially lower projected catch (311 000 tonnes) under the assumption that F_{MSY} would not change (untested). If the current projection is extended into the future, the projected catches would be in the range of 280–310 000 tonnes.

2.8 Medium term predictions and HCR simulations

No medium term prediction or HCR simulations were carried out during the Working Group. The management strategy evaluation was still being evaluated (ICES WKNSMSE, 2019) at the time of the working group, following a EU-Norway request (EU–Norway, 2018[2]).

2.9 Precautionary and Limit Reference Points and FMSY targets

The precautionary reference points for this stock were originally adopted in 1998.

New reference points were calculated during the 2018 benchmark meeting (ICES WKPELA, 2018) and did not change the perception of the stock assessment. Reference points prior to 2018 and out of the 2018 benchmark are presented in Table 2.9.1 and 2.9.2 respectively. Overall, the fishing pressure remains below F_{MSY} while the SSB is above MSY $B_{Trigger}$. The derivation of reference points and the history of the reference points for North Sea herring are further described in the Stock Annex.

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 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 2019 assessment was classified as an update assessment and was carried out following these procedures and settings.

The natural mortality is very impactful for the assessment and. The time series are those from the latest SMS key run available. To date, it is the SMS key run from 2017 (ICES WGSAM, 2018). However, the assessment model is sensitive to the absolute level of these time series and previous changes have caused the perception of the stock to change (ICES HAWG, 2016). During the benchmark in 2018 (ICES WKPELA, 2018), a methodology was developed to use an optimal offset (time and age independent) based on the assessment performance. This resulted in improved consistency between different assessments.

The 2019 assessment has increased the estimates of the 2016–2018 recruitments by 4.6% compared to the 2018 assessment. The SSB has been increased by 33% for 2018 and the fishing mortality is estimated to be lower by around 44.7% (see text table below and discussion in Section 2.6.4 and 2.7).

	2018 Assessment				2019 Assessment				% change 2019/2018			
Year	Rec	SSB	Catch	F_{2-6}	Rec	SSB	Catch	F_{2-6}	Rec	SSB	Catch	F_{2-6}
2016	321	2357	544	0.22	329	2596	563	0.2	2.5	10.1	3.5	-9.1
2017	185	1887	497	0.21	200	2214	498	0.18	8.1	17.3	0.2	-14.3
2018	357	1404	639	0.38	368	1870	603	0.21	3.1	33.2	-5.6	-44.7

[2] EU–Norway. 2018. Agreed record of consultations of long-term management strategies on joint stocks between Norway and the European Union, London, 7 June 2018. 5 pp.

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 (SSB based on index proportions) and Figure 2.11.2 (proportions).

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 inter-annual variability. However, the Downs component may be under-represented in some years due late spawning and Orkney-Shetland due to a lack of sampling due to vessel constraints.

2.11.2 IBTS0 Larval Index

The ring net hauls for 0-ringers during the IBTS in the North Sea and eastern English Channel also include Downs herring larvae. These larvae are, however, too small to have passed their critical period of high and highly variable mortality. Their abundance cannot be used for recruitment prediction. These small larvae (separated as <18 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 all 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 in spite of 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 data sets 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 in the larvae survival relationship between SSB/LAI and IBTS0 indices). The most recent observation continues the trend of relatively poor survival.

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

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

Table 2.1.1: Herring caught in the North Sea. Total catch (tonnes) by country, 2014–2018. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2014	2015	2016	2017	2018
Belgium	27	18	26	13	32
Denmark *	124423	113481	133962	110318	132231
Faroe Islands	118	981	833	442	497
France	29679	30269	35177	28801	31505
Germany	36767	44377	44231	43707	51636
Netherlands	74647	70076	98859	84914	111302
Norway	142002	134349	150183	134132	162594
Lithuania	9830	-	-	-	-
Sweden	15583	13184	16625	18518	19408
Ireland	68	183	127	868	515
UK (England)	19287	18897	20485	16997	19591
UK (Scotland)	45119	48332	59240	49514	66005
UK (N.Ireland)	6612	5948	-	3469	6916
Unallocated landings	3292	1516	8	0	0
Total landings	507454	481611	559756	491693	602232
Discards/BMS	31	-	170	-	96
Total catch	507485	481611	559926	491693	602328
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
WBSS	2953	2204	1839	632	2164
Thames estuary **	10	10	1	0	0
Norw. Spring Spawners ***	2307	2191	216	83	310

*** Including any by-catches 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	2014	2015	2016	2017	2018
Denmark *	74719	68017	81080	76277	90763
Faroe Islands	118	981	811	405	496
France	12620	13401	15073	11064	14745
Germany	23245	32253	27926	32736	35884
Netherlands	37380	44309	66740	55832	56990
Norway	89974	47010	57056	57744	78647
Lithuania	8129	-	-	-	-
Sweden	7760	10388	9933	12447	14132
Ireland	68	183	127	868	515
UK (England)	10085	12249	13010	12072	12313
UK (Scotland)	41844	46931	58557	49012	64424
UK (N. Ireland)	6021	4878	-	3469	5582
Unallocated landings **	3292	1939	0	0	0
Total Landings	315255	282539	330313	311926	374491
Discards/BMS	31	-	100	-	-
Total catch	315286	282539	330413	311926	374491

*** Including any by-catches in the industrial fishery.**

**** May include misreported catch from 6.aN and discards. Negative unallocated catches due to misreporting into other areas.**

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	2014	2015	2016	2017	2018
Denmark *	-	16739	16305	3928	751
Faroe Islands	-	-	-	-	-
France	30	-	-	-	-
Germany	-	-	-	-	-
Netherlands	-	-	-	-	-
Norway	44060	67254	78125	74216	73452
UK (Scotland)	124	1369	-	-	-
Sweden	940	570	3985	705	377
Unallocated landings	0	-423	0	0	0
Total landings	45154	85509	98415	78849	74580
Discards/BMS	-	-	-	-	-
Total catch	45154	85509	98415	78849	74580
Norw. Spring Spawners ***	2307	2191	216	85	310

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

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

***** 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	2014	2015	2016	2017	2018
Denmark*	49118	28551	36149	30045	4067
Faroe Islands	-	-	22	37	1
France	7839	6342	6225	7423	6090
Germany	4424	107	3419	2048	4964
Lithuania	1701	-	-	-	-
Netherlands	22628	10606	17233	15739	34491
UK (N. Ireland)	591	1070	-	-	1334
Norway	7968	20077	15002	2172	10495
Sweden	6883	2226	2705	5366	4899
UK (England)	4498	3484	3820	2435	3262
UK (Scotland)	3151	32	683	502	1581
Unallocated landings**	0	0	0	0	0
Total landings	108801	72495	85258	65767	107794
Discards	-	-	-	-	1
Total catch	108801	72495	85258	65767	107795

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

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

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	2014	2015	2016	2017	2018
Belgium	27	18	26	13	32
Denmark*	586	174	428	68	40
France	9190	10526	13879	10314	10670
Germany	9098	12017	12886	8923	10788
Netherlands	14639	15161	14886	13343	19821
Norway	-	8	-	-	-
Sweden	-	-	2	-	-
UK (England)	4704	3164	3655	2490	4016
UK (Scotland)	-	-	-	-	-
Unallocated landings***	0	0	8	0	0
Total landings	38244	41068	45770	35151	45367
Discards/BMS	-	-	70	-	95
Total catch	38244	41068	45840	35151	45462
Coastal spring spawners included above**	10	10	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	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sub-Area 4 and Division 7.d: TAC (4 and 7.d)														
Agreed Divisions 4.a,b	404.7	303.5	174.6	147.4	149.0	173.5	360.4	427.7	418.3	396.3	461.2	428.7	534.5	342.7
Agreed Div. 4.c, 7.d	50.0	37.5	26.7	23.6	15.3	26.5	44.6	50.3	51.7	49.0	57.0	53.0	66.0	42.4
Bycatch ceiling in the small mesh fishery *	42.5	31.9	18.8	16.0	13.6	16.5	17.9	14.4	13.1	15.7	13.4	11.4	9.7	13.2
CATCH (4 and 7.d)														
National catch Divisions 4.a,b **	439.2	326.8	201.2	145.0	148.1	191.7	387.2	453.8	465.9	439	514.0	456.5	556.9	
Unallocated catch Divisions 4.a,b	13.3	21.9	14.0	-1.1	0.0	0.0	-3.0	0.0	3.3	1.5	0.0	0.0	0.0	
Discard/slipping Divisions 4.a,b ***	1.5	0.1	0.2	0.1	0.0	-	-	-	0.0	-	0.1	-	0.0	
Total catch Divisions 4.a,b #	454.0	348.8	215.4	143.9	148.1	191.7	384.2	453.9	469.2	440.5	514.1	456.5	556.9	
National catch Divisions 4.c, 7.d **	51.2	34.3	26.5	21.5	26.5	26.7	37.1	44.7	38.2	41.1	45.8	35.2	45.4	
Unallocated catch Divisions 4.c,7.d	5.4	4.7	3.1	0.4	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	
Discard/slipping Divisions 4.c, 7.d ***	-	-	-	-	-	-	-	-	-	-	0.1	-	0.1	
Total catch Divisions 4.c, 7.d	56.6	39.0	29.6	21.9	26.5	26.7	40.4	44.7	38.2	41.1	45.8	35.2	45.5	
Total catch 4 and 7.d as used by ICES #	510.6	387.8	245.0	165.8	174.6	218.4	424.6	498.5	507.5	481.6	559.9	491.7	602.3	
CATCH BY FLEET/STOCK (4 and 7.d) ##														
North Sea autumn spawners directed fisheries (Fleet A)	487.1	379.6	236.3	152.1	164.8	209.2	411.8	489.9	490.5	471.5	543.6	484.1	591.7	
North Sea autumn spawners industrial (Fleet B)	11.9	7.1	8.6	9.8	9.1	8.9	10.6	8.1	14.0	7.9	14.5	7.0	8.5	

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
North Sea autumn spawners in 4 and 7.d total	499.0	386.7	244.9	161.9	173.9	218.1	422.5	498.1	504.5	479.4	558.1	491.1	600.2	
Baltic-3.a-type spring spawners in 4	11.0	1.1	0.1	3.9	0.8	0.3	2.1	0.5	3.0	2.2	1.8	0.6	2.2	
Coastal-type spring spawners	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
Norw. Spring Spawners caught under a separate quota in 4 ###	0.6	0.7	2.7	44.6	56.9	12.2	9.6	3.2	2.3	2.2	0.2	0.1	0.3	
Division 3.a: TAC (3.a)														
Agreed herring TAC	81.6	69.4	51.7	37.7	33.9	30.0	45.0	55.0	46.8	43.6	51.1	50.7	48.4	29.3
Bycatch ceiling in the small mesh fishery	20.5	15.4	11.5	8.4	7.5	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
CATCH (3.a)														
National catch	88.9	47.3	38.2	38.8	37.3	20.0	27.7	31.2	28.9	27.8	29.9	26.8	23.3	
Catch as used by ICES	51.2	47.4	38.2	38.8	37.3	20.0	27.7	31.2	28.9	27.8	29.9	26.8	23.3	
CATCH BY FLEET/STOCK (3.a) ##														
Autumn spawners human consumption (Fleet C)	11.6	16.4	9.2	5.1	12.0	6.6	7.8	11.8	9.5	10.2	4.1	7.4	3.2	
Autumn spawners mixed clupeoid (Fleet D)	3.4	3.4	3.7	1.5	1.8	1.8	4.4	1.6	3.3	4.4	1.4	0.2	0.2	
Autumn spawners in 3.a total	15.0	19.8	12.9	6.5	13.8	8.4	12.2	13.4	12.8	14.7	5.5	7.6	3.4	
Spring spawners human consumption (Fleet C)	30.2	25.3	23.0	29.4	23.0	10.8	14.5	16.6	15.4	11.3	23.3	19.0	19.7	
Spring spawners mixed clupeoid (Fleet D)	5.9	2.3	2.2	2.9	0.5	0.8	1.0	1.3	0.6	1.8	1.1	0.2	0.2	
Spring spawners in 3.a total	36.1	27.6	25.2	32.3	23.5	11.6	15.5	17.9	16.1	13.1	24.4	19.2	19.9	
North Sea autumn spawners Total as used by ICES	514.6	406.5	257.9	168.4	187.6	226.5	434.6	511.4	517.3	494.1	563.6	498.7	603.5	

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 2018. Catch in numbers (millions) at age (CANUM), by quarter and division.

WR	3.a NSAS	4.aE all	4.aE WBBS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	14.5	0.0	0.0	0.0	54.1	1266.6	2.2	0.0	1320.7	2.2	1337.4	1322.9
1	19.2	1.4	0.0	1.4	11.0	40.5	1.2	0.0	52.9	1.2	73.3	54.1
2	28.5	35.5	0.3	35.2	94.5	25.8	0.3	22.0	155.4	22.3	206.2	178.1
3	1.1	23.3	0.9	22.4	111.7	26.8	4.0	34.4	161.0	38.4	200.5	200.3
4	1.8	110.1	2.3	107.8	798.9	179.5	7.5	83.1	1086.3	90.6	1178.6	1179.1
5	1.0	136.7	4.3	132.5	476.6	154.4	4.6	79.9	763.5	84.4	849.0	852.2
6	0.2	40.1	1.7	38.4	128.8	37.5	0.3	18.4	204.7	18.8	223.6	225.2
7	0.1	19.8	0.9	18.9	91.9	23.4	0.5	10.1	134.2	10.6	145.0	145.7
8	0.1	18.4	0.3	18.2	95.8	19.8	0.4	10.0	133.8	10.3	144.2	144.4
9+	0.0	24.3	0.4	24.0	115.1	26.9	0.0	22.3	166.0	22.3	188.3	188.7
Sum	66.5	409.8	11.0	398.7	1978.5	1801.2	21.0	280.3	4178.4	301.2	4546.1	4490.6
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	5.2	0.0	0.0	0.0	1.3	11.1	1.0	0.0	12.4	1.0	18.6	13.4
2	23.6	0.2	0.0	0.2	6.4	1.6	0.3	0.9	8.2	1.2	33.1	9.5
3	0.5	0.1	0.0	0.1	5.4	0.0	2.3	4.4	5.6	6.6	12.7	12.2
4	0.1	0.5	0.0	0.5	25.4	0.3	6.1	11.9	26.1	18.0	44.3	44.1
5	0.0	0.6	0.0	0.6	16.6	0.2	3.6	10.7	17.4	14.3	31.8	31.7
6	0.0	0.2	0.0	0.2	3.7	0.0	0.2	1.2	3.9	1.4	5.3	5.3
7	0.0	0.1	0.0	0.1	1.7	0.0	0.3	3.5	1.8	3.8	5.5	5.5
8	0.0	0.1	0.0	0.1	0.2	0.0	0.2	2.7	0.3	2.9	3.2	3.2
9+	0.0	0.1	0.0	0.1	2.1	0.0	0.0	6.1	2.2	6.1	8.4	8.4
Sum	29.5	1.7	0.0	1.7	62.9	13.3	14.0	41.4	77.9	55.4	162.8	133.3
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	232.5	0.0	0.0	232.5	0.0	232.5	232.5
1	0.5	1.1	0.0	1.1	1.9	5.1	0.0	0.0	8.1	0.0	8.6	8.1
2	0.6	31.1	0.2	30.9	36.2	0.1	0.0	0.0	67.2	0.0	67.8	67.4
3	0.0	18.4	0.1	18.2	20.3	0.0	0.0	0.0	38.6	0.1	38.7	38.8
4	0.0	84.9	0.4	84.5	117.6	0.7	0.1	0.1	202.9	0.2	203.1	203.5
5	0.0	111.4	0.8	110.5	80.2	0.5	0.1	0.1	191.2	0.2	191.4	192.2
6	0.0	31.1	0.0	31.1	11.8	0.2	0.0	0.0	43.0	0.0	43.1	43.1
7	0.0	15.3	0.0	15.3	6.4	0.1	0.0	0.0	21.7	0.0	21.8	21.8
8	0.0	15.0	0.0	15.0	8.7	0.1	0.0	0.0	23.7	0.0	23.7	23.7
9+	0.0	19.3	0.0	19.3	8.7	0.1	0.0	0.1	28.1	0.1	28.1	28.1
Sum	1.2	327.5	1.6	325.9	291.7	239.4	0.2	0.4	857.0	0.6	858.8	859.2
Quarter: 3												
0	4.0	0.0	0.0	0.0	1.9	899.9	0.0	0.0	901.8	0.0	905.9	901.8
1	4.8	0.2	0.0	0.2	2.1	15.1	0.0	0.0	17.3	0.0	22.1	17.4
2	3.7	3.6	0.1	3.5	35.8	10.0	0.0	0.0	49.4	0.0	53.1	49.5
3	0.5	4.2	0.8	0.0	74.7	14.6	0.1	0.0	89.3	0.1	89.9	93.6
4	1.6	21.5	1.8	0.0	533.8	127.3	0.1	0.0	661.0	0.1	662.7	682.6
5	1.0	21.5	3.5	0.0	283.5	98.1	0.1	0.0	381.6	0.1	382.6	403.2
6	0.2	7.7	1.7	0.0	93.9	26.3	0.0	0.0	120.2	0.0	120.3	127.9
7	0.1	3.9	0.8	0.0	68.1	15.9	0.0	0.0	84.0	0.0	84.1	87.8
8	0.1	3.0	0.2	0.0	71.8	11.3	0.0	0.0	83.0	0.0	83.1	86.1
9+	0.0	4.3	0.3	0.0	83.7	11.4	0.0	0.0	95.2	0.0	95.2	99.5
Sum	15.9	70.0	9.2	3.8	1249.3	1229.7	0.4	0.0	2482.8	0.4	2499.0	2549.3
Quarter: 4												
0	10.5	0.0	0.0	0.0	52.2	134.2	2.2	0.0	186.4	2.2	199.1	188.6
1	8.7	0.0	0.0	0.0	5.7	9.3	0.1	0.0	15.1	0.1	23.9	15.2
2	0.6	0.6	0.0	0.6	16.0	14.1	0.0	21.1	30.7	21.1	52.3	51.7
3	0.1	0.6	0.0	0.6	11.3	12.2	1.5	30.0	24.1	31.6	55.7	55.7
4	0.1	3.2	0.0	3.1	122.2	51.2	1.2	71.1	176.5	72.2	248.8	248.8
5	0.1	3.3	0.0	3.3	96.3	55.6	0.8	69.0	155.2	69.8	225.1	225.1
6	0.0	1.2	0.1	1.1	19.5	11.0	0.2	17.2	31.6	17.3	48.9	49.0
7	0.0	0.6	0.0	0.6	15.8	7.4	0.2	6.6	23.8	6.8	30.6	30.6
8	0.0	0.4	0.0	0.4	15.1	8.4	0.2	7.2	23.9	7.4	31.3	31.4
9+	0.0	0.6	0.1	0.6	20.6	15.4	0.0	16.1	36.5	16.1	52.7	52.7
Sum	20.0	10.5	0.2	10.3	374.5	318.9	6.4	238.4	703.8	244.8	968.5	948.8

Table 2.2.2: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2018. 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	**0.010**	**0.000**	**0.000**	**0.010**	**0.005**	**0.010**	**0.000**	**0.005**	**0.010**	**0.005**	**0.005**
1	**0.049**	**0.091**	**0.096**	**0.065**	**0.027**	**0.011**	**0.000**	**0.037**	**0.011**	**0.039**	**0.036**
2	**0.058**	**0.125**	**0.127**	**0.114**	**0.117**	**0.061**	**0.114**	**0.117**	**0.113**	**0.109**	**0.117**
3	**0.103**	**0.152**	**0.163**	**0.156**	**0.138**	**0.104**	**0.118**	**0.152**	**0.116**	**0.145**	**0.145**
4	**0.156**	**0.173**	**0.183**	**0.188**	**0.192**	**0.121**	**0.146**	**0.187**	**0.144**	**0.184**	**0.184**
5	**0.179**	**0.188**	**0.197**	**0.193**	**0.211**	**0.132**	**0.157**	**0.195**	**0.156**	**0.191**	**0.192**
6	**0.190**	**0.201**	**0.213**	**0.220**	**0.237**	**0.170**	**0.164**	**0.220**	**0.164**	**0.215**	**0.215**
7	**0.187**	**0.212**	**0.224**	**0.241**	**0.248**	**0.164**	**0.190**	**0.238**	**0.189**	**0.234**	**0.234**
8	**0.203**	**0.219**	**0.232**	**0.250**	**0.246**	**0.218**	**0.195**	**0.245**	**0.196**	**0.242**	**0.242**
9+	**0.000**	**0.230**	**0.243**	**0.258**	**0.258**	**0.259**	**0.209**	**0.254**	**0.209**	**0.249**	**0.249**
Quarter: 1											
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**	**0.000**
1	0.029	0.088	0.088	0.015	0.013	0.007	0.000	0.013	0.007	**0.017**	**0.013**
2	0.050	0.110	0.110	0.085	0.028	0.055	0.075	0.074	0.000	**0.057**	**0.074**
3	0.074	0.125	0.125	0.102	0.085	0.084	0.092	0.102	0.000	**0.094**	**0.095**
4	0.096	0.154	0.154	0.137	0.135	0.111	0.113	0.137	0.112	**0.127**	**0.127**
5	0.118	0.174	0.174	0.150	0.148	0.119	0.136	0.150	0.132	**0.142**	**0.142**
6	0.143	0.190	0.190	0.170	0.170	0.113	0.149	0.171	0.145	**0.164**	**0.164**
7	0.175	0.200	0.200	0.177	0.176	0.135	0.153	0.178	0.000	**0.160**	**0.160**
8	0.000	0.216	0.216	0.196	0.000	0.193	0.175	0.200	0.176	**0.178**	**0.178**
9+	0.000	0.224	0.224	0.214	0.215	0.000	0.187	0.214	0.187	**0.194**	**0.194**
Quarter: 2											
0	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	**0.003**	**0.003**
1	0.023	0.088	0.088	0.078	0.010	0.000	0.000	0.037	0.000	**0.036**	**0.037**
2	0.048	0.123	0.123	0.104	0.136	0.071	0.075	0.113	0.000	**0.112**	**0.113**
3	0.063	0.149	0.149	0.128	0.142	0.084	0.092	0.138	0.088	**0.138**	**0.138**
4	0.091	0.169	0.169	0.149	0.201	0.111	0.113	0.157	0.112	**0.157**	**0.157**
5	0.119	0.185	0.185	0.163	0.215	0.119	0.136	0.176	0.130	**0.176**	**0.176**
6	0.000	0.198	0.198	0.180	0.229	0.113	0.149	0.193	0.143	**0.193**	**0.193**
7	0.000	0.208	0.208	0.190	0.246	0.135	0.153	0.203	0.000	**0.203**	**0.203**
8	0.000	0.216	0.216	0.204	0.259	0.193	0.175	0.212	0.177	**0.212**	**0.212**
9+	0.000	0.227	0.227	0.220	0.270	0.000	0.187	0.225	0.187	**0.225**	**0.225**
Quarter: 3											
0	0.008	0.000	0.000	0.005	0.005	0.000	0.000	0.005	0.000	**0.005**	**0.005**
1	0.059	0.104	0.104	0.094	0.033	0.000	0.000	0.041	0.000	**0.045**	**0.041**
2	0.106	0.138	0.138	0.127	0.127	0.000	0.000	0.128	0.000	**0.126**	**0.128**
3	0.133	0.164	0.164	0.168	0.137	0.131	0.000	0.163	0.131	**0.163**	**0.163**
4	0.161	0.186	0.186	0.203	0.199	0.170	0.000	0.202	0.170	**0.202**	**0.202**
5	0.181	0.200	0.200	0.207	0.223	0.184	0.000	0.211	0.184	**0.211**	**0.211**
6	0.192	0.213	0.213	0.233	0.246	0.225	0.000	0.235	0.225	**0.235**	**0.235**
7	0.187	0.224	0.224	0.254	0.261	0.212	0.000	0.254	0.212	**0.254**	**0.254**
8	0.202	0.232	0.232	0.262	0.267	0.245	0.000	0.262	0.245	**0.262**	**0.262**
9+	0.000	0.244	0.244	0.270	0.284	0.000	0.000	0.270	0.000	**0.271**	**0.271**
Quarter: 4											
0	0.011	0.000	0.000	0.010	0.010	0.010	0.000	0.010	0.010	**0.010**	**0.010**
1	0.056	0.104	0.104	0.061	0.045	0.041	0.000	0.051	0.041	**0.053**	**0.051**
2	0.082	0.138	0.138	0.122	0.121	0.127	0.116	0.122	0.116	**0.119**	**0.120**
3	0.119	0.164	0.164	0.152	0.139	0.131	0.122	0.146	0.122	**0.132**	**0.132**
4	0.148	0.184	0.184	0.173	0.174	0.169	0.152	0.173	0.152	**0.167**	**0.167**
5	0.178	0.200	0.200	0.182	0.189	0.184	0.161	0.185	0.161	**0.177**	**0.177**
6	0.181	0.213	0.213	0.192	0.216	0.224	0.165	0.201	0.165	**0.188**	**0.188**
7	0.196	0.223	0.223	0.211	0.220	0.212	0.210	0.214	0.210	**0.213**	**0.213**
8	0.226	0.231	0.231	0.219	0.217	0.244	0.203	0.219	0.204	**0.215**	**0.215**
9+	0.000	0.242	0.242	0.231	0.238	0.259	0.218	0.234	0.218	**0.229**	**0.229**

Table 2.2.3: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2018. 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.**	**11.0**	**8.8**	**11.1**	**0.0**	**8.9**	**11.1**	**8.9**
1	**n.d.**	**20.6**	**n.d.**	**19.0**	**14.7**	**11.5**	**0.0**	**15.8**	**11.5**	**15.7**
2	**n.d.**	**23.1**	**n.d.**	**23.2**	**23.3**	**20.1**	**23.9**	**23.2**	**23.8**	**23.3**
3	**n.d.**	**24.8**	**n.d.**	**25.7**	**24.7**	**23.7**	**24.2**	**25.4**	**24.2**	**25.2**
4	**n.d.**	**26.0**	**n.d.**	**27.1**	**27.1**	**24.9**	**25.9**	**27.0**	**25.8**	**26.9**
5	**n.d.**	**26.9**	**n.d.**	**27.5**	**28.0**	**25.9**	**26.5**	**27.5**	**26.5**	**27.4**
6	**n.d.**	**27.6**	**n.d.**	**28.6**	**29.0**	**27.4**	**26.9**	**28.5**	**26.9**	**28.4**
7	**n.d.**	**28.1**	**n.d.**	**29.5**	**29.5**	**27.4**	**28.6**	**29.3**	**28.5**	**29.2**
8	**n.d.**	**28.5**	**n.d.**	**29.7**	**29.6**	**30.3**	**28.7**	**29.6**	**28.7**	**29.5**
9+	**n.d.**	**29.0**	**n.d.**	**29.9**	**30.1**	**30.5**	**29.3**	**29.8**	**29.3**	**29.8**
Quarter: 1										
0	n.d.	0.0	n.d.	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1	n.d.	20.4	n.d.	12.3	12.1	10.6	0.0	12.1	10.6	**12.0**
2	n.d.	22.6	n.d.	21.9	16.2	19.6	21.7	20.8	0.0	**20.8**
3	n.d.	23.9	n.d.	23.3	22.6	23.0	23.3	23.3	0.0	**23.2**
4	n.d.	26.0	n.d.	25.8	26.1	24.6	24.5	25.9	24.5	**25.3**
5	n.d.	26.8	n.d.	26.7	26.9	25.6	26.1	26.7	26.0	**26.4**
6	n.d.	27.6	n.d.	27.6	27.7	25.8	27.6	27.6	27.4	**27.6**
7	n.d.	28.0	n.d.	28.0	28.1	27.0	27.9	28.0	0.0	**27.9**
8	n.d.	28.4	n.d.	28.2	0.0	29.8	28.7	28.2	28.8	**28.7**
9+	n.d.	29.0	n.d.	29.3	29.4	0.0	29.6	29.3	29.6	**29.5**
Quarter: 2										
0	n.d.	0.0	n.d.	0.0	7.6	0.0	0.0	0.0	0.0	**7.6**
1	n.d.	20.4	n.d.	19.8	11.0	0.0	0.0	14.4	0.0	**14.4**
2	n.d.	23.0	n.d.	22.3	24.2	20.8	21.7	22.6	0.0	**22.6**
3	n.d.	24.7	n.d.	23.9	24.6	23.0	23.3	24.3	23.2	**24.3**
4	n.d.	25.9	n.d.	25.1	27.4	24.6	24.5	25.5	24.5	**25.5**
5	n.d.	26.8	n.d.	26.0	28.0	25.6	26.1	26.5	25.9	**26.5**
6	n.d.	27.5	n.d.	26.8	28.7	25.8	27.6	27.3	27.3	**27.3**
7	n.d.	28.0	n.d.	27.4	29.5	27.0	27.9	27.8	0.0	**27.8**
8	n.d.	28.4	n.d.	28.0	30.1	29.8	28.7	28.3	28.8	**28.3**
9+	n.d.	28.9	n.d.	28.6	30.6	0.0	29.6	28.8	29.6	**28.8**
Quarter: 3										
0	n.d.	0.0	n.d.	8.8	8.8	0.0	0.0	8.8	0.0	**8.8**
1	n.d.	21.4	n.d.	21.2	15.9	0.0	0.0	16.6	0.0	**16.6**
2	n.d.	23.8	n.d.	24.0	24.0	0.0	0.0	24.0	0.0	**24.0**
3	n.d.	25.3	n.d.	26.3	24.7	24.6	0.0	26.0	24.6	**26.0**
4	n.d.	26.6	n.d.	27.6	27.4	26.4	0.0	27.6	26.4	**27.6**
5	n.d.	27.3	n.d.	27.8	28.4	27.2	0.0	27.9	27.2	**27.9**
6	n.d.	27.9	n.d.	28.9	29.2	28.8	0.0	28.9	28.8	**28.9**
7	n.d.	28.4	n.d.	29.7	29.9	27.8	0.0	29.7	27.8	**29.7**
8	n.d.	28.8	n.d.	30.0	30.5	30.8	0.0	30.0	30.8	**30.0**
9+	n.d.	29.3	n.d.	30.1	31.0	0.0	0.0	30.2	0.0	**30.2**
Quarter: 4										
0	n.d.	0.0	n.d.	11.1	11.1	11.1	0.0	11.1	11.1	**11.1**
1	n.d.	21.4	n.d.	19.4	18.1	17.8	0.0	18.6	17.8	**18.6**
2	n.d.	23.8	n.d.	24.2	23.5	25.0	24.0	23.9	24.0	**23.9**
3	n.d.	25.3	n.d.	26.0	24.8	24.6	24.4	25.4	24.4	**24.8**
4	n.d.	26.5	n.d.	27.2	26.4	26.4	26.1	27.0	26.1	**26.7**
5	n.d.	27.3	n.d.	27.9	27.2	27.2	26.6	27.6	26.6	**27.3**
6	n.d.	27.9	n.d.	28.4	28.4	28.8	26.9	28.4	26.9	**27.8**
7	n.d.	28.4	n.d.	29.4	28.6	28.0	28.9	29.1	28.9	**29.1**
8	n.d.	28.8	n.d.	29.5	28.5	30.8	28.7	29.2	28.7	**29.1**
9+	n.d.	29.3	n.d.	29.9	29.4	30.5	29.2	29.7	29.2	**29.5**

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 2018. Catches (tonnes) at-age (SOP figures), by quarter and division.

WR	3.a NSAS	4.aE all	4.aE WBSS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	**0.1**	**0.0**	**0.0**	**0.0**	**0.5**	**6.6**	**0.0**	**0.0**	**7.1**	**0.0**	**7.3**	**7.1**
1	**0.9**	**0.1**	**0.0**	**0.1**	**0.7**	**1.1**	**0.0**	**0.0**	**1.9**	**0.0**	**2.9**	**2.0**
2	**1.6**	**4.4**	**0.0**	**4.4**	**10.8**	**3.0**	**0.0**	**2.5**	**18.2**	**2.5**	**22.4**	**20.8**
3	**0.1**	**3.5**	**0.1**	**3.4**	**17.4**	**3.7**	**0.4**	**4.1**	**24.5**	**4.5**	**29.1**	**29.1**
4	**0.3**	**19.0**	**0.4**	**18.6**	**150.4**	**34.4**	**0.9**	**12.1**	**203.3**	**13.0**	**216.7**	**216.8**
5	**0.2**	**25.7**	**0.8**	**24.8**	**91.8**	**32.5**	**0.6**	**12.6**	**149.2**	**13.2**	**162.5**	**163.2**
6	**0.0**	**8.1**	**0.4**	**7.7**	**28.4**	**8.9**	**0.1**	**3.0**	**45.0**	**3.1**	**48.1**	**48.4**
7	**0.0**	**4.2**	**0.2**	**4.0**	**22.1**	**5.8**	**0.1**	**1.9**	**31.9**	**2.0**	**34.0**	**34.1**
8	**0.0**	**4.0**	**0.1**	**4.0**	**23.9**	**4.9**	**0.1**	**2.0**	**32.8**	**2.0**	**34.8**	**34.9**
9+	**0.0**	**5.6**	**0.1**	**5.5**	**29.7**	**6.9**	**0.0**	**4.7**	**42.2**	**4.7**	**46.8**	**46.9**
Sum	**3.4**	**74.7**	**2.2**	**72.5**	**375.8**	**107.8**	**2.2**	**42.8**	**556.1**	**45.0**	**604.5**	**603.3**
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
1	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	**0.3**	**0.2**
2	1.2	0.0	0.0	0.0	0.5	0.0	0.0	0.1	0.6	0.1	**1.9**	**0.7**
3	0.0	0.0	0.0	0.0	0.6	0.0	0.2	0.4	0.6	0.6	**1.2**	**1.2**
4	0.0	0.1	0.0	0.1	3.5	0.0	0.7	1.3	3.6	2.0	**5.6**	**5.6**
5	0.0	0.1	0.0	0.1	2.5	0.0	0.4	1.5	2.6	1.9	**4.5**	**4.5**
6	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.2	0.7	0.2	**0.9**	**0.9**
7	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.5	0.3	0.6	**0.9**	**0.9**
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.1	0.5	**0.6**	**0.6**
9+	0.0	0.0	0.0	0.0	0.5	0.0	0.0	1.1	0.5	1.1	**1.6**	**1.6**
Sum	**1.4**	**0.3**	**0.0**	**0.3**	**8.5**	**0.3**	**1.4**	**5.6**	**9.1**	**7.0**	**17.5**	**16.1**
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.7	0.0	**0.7**	**0.7**
1	0.0	0.1	0.0	0.1	0.2	0.1	0.0	0.0	0.3	0.0	**0.3**	**0.3**
2	0.0	3.8	0.0	3.8	3.7	0.0	0.0	0.0	7.6	0.0	**7.6**	**7.6**
3	0.0	2.7	0.0	2.7	2.6	0.0	0.0	0.0	5.3	0.0	**5.3**	**5.3**
4	0.0	14.4	0.1	14.3	17.5	0.1	0.0	0.0	31.9	0.0	**31.9**	**32.0**
5	0.0	20.6	0.1	20.5	13.1	0.1	0.0	0.0	33.7	0.0	**33.7**	**33.8**
6	0.0	6.2	0.0	6.2	2.1	0.0	0.0	0.0	8.3	0.0	**8.3**	**8.3**
7	0.0	3.2	0.0	3.2	1.2	0.0	0.0	0.0	4.4	0.0	**4.4**	**4.4**
8	0.0	3.2	0.0	3.2	1.8	0.0	0.0	0.0	5.0	0.0	**5.0**	**5.0**
9+	0.0	4.4	0.0	4.4	1.9	0.0	0.0	0.0	6.3	0.0	**6.3**	**6.3**
Sum	**0.0**	**58.6**	**0.3**	**58.3**	**44.1**	**1.1**	**0.0**	**0.1**	**103.5**	**0.1**	**103.6**	**103.9**
Quarter: 3												
0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	4.5	0.0	**4.5**	**4.5**
1	0.3	0.0	0.0	0.0	0.2	0.5	0.0	0.0	0.7	0.0	**1.0**	**0.7**
2	0.4	0.5	0.0	0.5	4.5	1.3	0.0	0.0	6.3	0.0	**6.7**	**6.3**
3	0.1	0.7	0.1	0.6	12.6	2.0	0.0	0.0	15.1	0.0	**15.2**	**15.3**
4	0.3	4.0	0.3	0.0	108.3	25.3	0.0	0.0	133.6	0.0	**137.5**	**137.6**
5	0.2	4.3	0.7	3.6	58.7	21.8	0.0	0.0	84.2	0.0	**84.4**	**84.9**
6	0.0	1.6	0.4	0.0	21.9	6.5	0.0	0.0	28.4	0.0	**29.7**	**30.0**
7	0.0	0.9	0.2	0.7	17.3	4.1	0.0	0.0	22.1	0.0	**22.1**	**22.3**
8	0.0	0.7	0.1	0.6	18.8	3.0	0.0	0.0	22.5	0.0	**22.5**	**22.5**
9+	0.0	1.0	0.1	1.0	22.6	3.3	0.0	0.0	26.8	0.0	**26.8**	**26.9**
Sum	**1.3**	**13.8**	**1.8**	**7.0**	**264.9**	**72.3**	**0.1**	**0.0**	**344.2**	**0.1**	**350.5**	**351.1**
Quarter: 4												
0	0.1	0.0	0.0	0.0	0.5	1.3	0.0	0.0	1.9	0.0	**2.0**	**1.9**
1	0.5	0.0	0.0	0.0	0.3	0.4	0.0	0.0	0.8	0.0	**1.3**	**0.8**
2	0.0	0.1	0.0	0.1	2.0	1.7	0.0	2.4	3.7	2.4	**6.2**	**6.2**
3	0.0	0.1	0.0	0.1	1.7	1.7	0.2	3.7	3.5	3.9	**7.4**	**7.4**
4	0.0	0.6	0.0	0.6	21.1	8.9	0.2	10.8	30.6	11.0	**41.6**	**41.5**
5	0.0	0.7	0.0	0.7	17.5	10.5	0.1	11.1	28.7	11.2	**39.9**	**39.9**
6	0.0	0.2	0.0	0.2	3.7	2.4	0.0	2.8	6.4	2.9	**9.2**	**9.2**
7	0.0	0.1	0.0	0.1	3.3	1.6	0.0	1.4	5.1	1.4	**6.5**	**6.5**
8	0.0	0.1	0.0	0.1	3.3	1.8	0.0	1.5	5.2	1.5	**6.7**	**6.8**
9+	0.0	0.2	0.0	0.1	4.7	3.7	0.0	3.5	8.5	3.5	**12.1**	**12.1**
Sum	**0.7**	**2.1**	**0.0**	**2.0**	**58.2**	**34.1**	**0.7**	**37.2**	**94.3**	**37.9**	**132.9**	**132.2**

Table 2.2.5: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2018. Percentage age composition (based on numbers, 3+ group summarised), 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	21.8%	0.0%	0.0%	0.0%	2.7%	70.3%	10.6%	0.0%	31.6%	0.7%	29.4%	29.5%
1	28.8%	0.3%	0.3%	0.3%	0.6%	2.2%	5.7%	0.0%	1.3%	0.4%	1.6%	1.2%
2	42.8%	8.7%	3.0%	8.8%	4.8%	1.4%	1.6%	7.9%	3.7%	7.4%	4.5%	4.0%
3	1.7%	5.7%	8.2%	5.6%	5.6%	1.5%	19.0%	12.3%	3.9%	12.8%	4.4%	4.5%
4	2.7%	26.9%	20.6%	27.0%	40.4%	10.0%	35.7%	29.6%	26.0%	30.1%	25.9%	26.3%
5	1.6%	33.4%	38.7%	33.2%	24.1%	8.6%	21.7%	28.5%	18.3%	28.0%	18.7%	19.0%
6	0.3%	9.8%	15.8%	9.6%	6.5%	2.1%	1.6%	6.6%	4.9%	6.2%	4.9%	5.0%
7	0.2%	4.8%	7.8%	4.7%	4.6%	1.3%	2.4%	3.6%	3.2%	3.5%	3.2%	3.2%
8	0.1%	4.5%	2.3%	4.6%	4.8%	1.1%	1.7%	3.6%	3.2%	3.4%	3.2%	3.2%
9+	0.0%	5.9%	3.3%	6.0%	5.8%	1.5%	0.0%	8.0%	4.0%	7.4%	4.1%	4.2%
Sum 3+	6.5%	91.0%	96.8%	90.8%	91.9%	26.0%	82.1%	92.1%	63.4%	91.4%	64.4%	65.4%
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	17.6%	0.2%	0.0%	0.2%	2.1%	83.4%	7.5%	0.0%	15.9%	1.9%	11.4%	10.1%
2	80.0%	8.8%	2.9%	8.8%	10.2%	12.3%	2.2%	2.3%	10.5%	2.2%	20.3%	7.1%
3	1.8%	6.1%	3.8%	6.1%	8.6%	0.3%	16.3%	10.5%	7.1%	12.0%	7.8%	9.2%
4	0.4%	30.8%	22.3%	30.8%	40.3%	1.9%	43.6%	28.7%	33.6%	32.4%	27.2%	33.1%
5	0.1%	32.6%	61.6%	32.5%	26.5%	1.4%	25.8%	25.9%	22.3%	25.9%	19.5%	23.8%
6	0.0%	8.9%	9.3%	8.9%	5.9%	0.4%	1.1%	3.0%	5.0%	2.5%	3.2%	4.0%
7	0.0%	4.2%	0.0%	4.2%	2.6%	0.2%	2.2%	8.3%	2.3%	6.8%	3.4%	4.1%
8	0.0%	3.1%	0.0%	3.1%	0.4%	0.0%	1.3%	6.6%	0.4%	5.2%	2.0%	2.4%
9+	0.0%	5.4%	0.0%	5.4%	3.4%	0.2%	0.0%	14.8%	2.9%	11.1%	5.1%	6.3%
Sum 3+	2.3%	91.0%	97.1%	91.0%	87.7%	4.4%	90.3%	97.7%	73.6%	95.9%	68.3%	82.8%
Quarter: 2												
0	0.0%	0.0%	0.0%	0.0%	0.0%	97.1%	0.0%	0.0%	27.1%	0.0%	27.1%	27.1%
1	41.6%	0.3%	0.8%	0.3%	0.7%	2.1%	0.0%	0.0%	0.9%	0.0%	1.0%	0.9%
2	55.4%	9.5%	14.3%	9.5%	12.4%	0.0%	1.4%	2.3%	7.8%	2.0%	7.9%	7.8%
3	2.3%	5.6%	6.4%	5.6%	7.0%	0.0%	17.8%	10.5%	4.5%	13.0%	4.5%	4.5%
4	0.5%	25.9%	26.9%	25.9%	40.3%	0.3%	47.6%	28.7%	23.7%	35.1%	23.6%	23.7%
5	0.1%	34.0%	50.2%	33.9%	27.5%	0.2%	28.2%	25.9%	22.3%	26.7%	22.3%	22.4%
6	0.0%	9.5%	0.0%	9.5%	4.0%	0.1%	1.2%	3.0%	5.0%	2.4%	5.0%	5.0%
7	0.0%	4.7%	1.3%	4.7%	2.2%	0.1%	2.4%	8.3%	2.5%	6.3%	2.5%	2.5%
8	0.0%	4.6%	0.0%	4.6%	3.0%	0.0%	1.4%	6.6%	2.8%	4.8%	2.8%	2.8%
9+	0.0%	5.9%	0.0%	5.9%	3.0%	0.0%	0.0%	14.8%	3.3%	9.8%	3.3%	3.3%
Sum 3+	2.9%	90.2%	84.8%	90.2%	86.9%	0.7%	98.6%	97.7%	64.1%	98.0%	64.0%	64.2%
Quarter: 3												
0	25.3%	0.0%	0.0%	0.0%	0.2%	73.2%	0.0%	0.0%	36.3%	0.0%	36.2%	35.4%
1	29.9%	0.4%	0.2%	6.2%	0.2%	1.2%	0.0%	0.0%	0.7%	0.0%	0.9%	0.7%
2	23.2%	5.2%	1.1%	93.8%	2.9%	0.8%	0.0%	0.0%	2.0%	0.0%	2.1%	1.9%
3	3.3%	6.0%	8.6%	0.0%	6.0%	1.2%	40.0%	0.0%	3.6%	40.0%	3.6%	3.7%
4	9.9%	30.7%	19.5%	0.0%	42.7%	10.4%	28.0%	0.0%	26.6%	28.0%	26.5%	26.8%
5	6.1%	30.8%	37.5%	0.0%	22.7%	8.0%	20.0%	0.0%	15.4%	20.0%	15.3%	15.8%
6	1.0%	11.0%	18.2%	0.0%	7.5%	2.1%	4.0%	0.0%	4.8%	4.0%	4.8%	5.0%
7	0.7%	5.5%	9.1%	0.0%	5.5%	1.3%	4.0%	0.0%	3.4%	4.0%	3.4%	3.4%
8	0.5%	4.3%	2.4%	0.0%	5.7%	0.9%	4.0%	0.0%	3.3%	4.0%	3.3%	3.4%
9+	0.0%	6.2%	3.4%	0.0%	6.7%	0.9%	0.0%	0.0%	3.8%	0.0%	3.8%	3.9%
Sum 3+	21.5%	94.4%	98.7%	0.0%	96.8%	24.8%	100.0%	0.0%	61.0%	100.0%	60.7%	62.0%
Quarter: 4												
0	52.5%	0.0%	0.0%	0.0%	13.9%	42.1%	35.0%	0.0%	26.5%	0.9%	20.6%	19.9%
1	43.7%	0.4%	0.0%	0.4%	1.5%	2.9%	2.3%	0.0%	2.1%	0.1%	2.5%	1.6%
2	2.8%	5.4%	0.0%	5.5%	4.3%	4.4%	0.4%	8.8%	4.4%	8.6%	5.4%	5.5%
3	0.3%	6.1%	0.0%	6.3%	3.0%	3.8%	23.8%	12.6%	3.4%	12.9%	5.8%	5.9%
4	0.4%	30.1%	21.0%	30.2%	32.6%	16.1%	18.2%	29.8%	25.1%	29.5%	25.7%	26.2%
5	0.3%	31.1%	0.0%	31.8%	25.7%	17.4%	12.7%	29.0%	22.1%	28.5%	23.2%	23.7%
6	0.1%	11.1%	32.9%	10.7%	5.2%	3.4%	2.4%	7.2%	4.5%	7.1%	5.1%	5.2%
7	0.0%	5.5%	0.0%	5.6%	4.2%	2.3%	2.7%	2.8%	3.4%	2.8%	3.2%	3.2%
8	0.0%	4.2%	18.8%	3.9%	4.0%	2.6%	2.5%	3.0%	3.4%	3.0%	3.2%	3.3%
9+	0.0%	6.1%	27.3%	5.7%	5.5%	4.8%	0.1%	6.8%	5.2%	6.6%	5.4%	5.6%
Sum 3+	1.0%	94.2%	100.0%	94.1%	80.3%	50.6%	62.4%	91.2%	67.0%	90.4%	71.6%	73.1%

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.

2016	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	0.0	0.000	1450.3	0.007	0.0	0.000	133.3	0.007	**1'583.6**	**0.007**
1	2.3	0.102	83.6	0.021	10.8	0.054	12.5	0.023	**109.2**	**0.026**
2	556.2	0.135	23.0	0.055	42.1	0.061	5.4	0.040	**626.7**	**0.127**
3	807.1	0.156	9.6	0.084	5.9	0.124	0.1	0.081	**822.7**	**0.155**
4	292.7	0.181	1.2	0.093	0.5	0.149	0.0	0.000	**294.4**	**0.180**
5	281.3	0.206	0.0	0.000	0.2	0.188	0.1	0.078	**281.6**	**0.206**
6	368.0	0.215	0.8	0.146	0.2	0.208	0.0	0.000	**369.0**	**0.215**
7	308.0	0.231	0.0	0.000	0.0	0.209	0.0	0.000	**308.0**	**0.231**
8	186.3	0.221	0.0	0.000	0.1	0.235	0.0	0.000	**186.4**	**0.221**
9+	173.9	0.239	0.0	0.000	0.0	0.000	0.0	0.000	**173.9**	**0.239**
TOTAL	2'975.7		1'568.4		59.9		151.4		4'755.4	
SOP catch		**545.5**		**14.4**		**4.1**		**1.4**		**565.4**

Figures for A fleet include unsampled bycatch in the industrial fishery

2017	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	0.0	0.000	462.0	0.009	0.1	0.034	0.0	0.000	**462.1**	**0.009**
1	11.4	0.083	121.9	0.026	75.6	0.052	0.4	0.016	**209.4**	**0.039**
2	74.3	0.114	0.0	0.000	26.7	0.080	7.7	0.025	**108.7**	**0.099**
3	1072.9	0.156	0.0	0.000	6.9	0.103	0.0	0.075	**1'079.9**	**0.156**
4	834.8	0.173	0.0	0.000	3.0	0.138	0.0	0.000	**837.8**	**0.173**
5	221.6	0.188	0.0	0.000	1.2	0.172	0.0	0.000	**222.8**	**0.188**
6	145.4	0.215	0.0	0.000	0.1	0.153	0.0	0.000	**145.5**	**0.214**
7	175.5	0.220	0.0	0.000	0.0	0.147	0.0	0.000	**175.5**	**0.220**
8	106.5	0.230	0.0	0.000	0.0	0.160	0.0	0.000	**106.6**	**0.230**
9+	114.7	0.231	0.0	0.000	0.0	0.000	0.0	0.000	**114.7**	**0.231**
TOTAL	2'757.2		583.9		113.8		8.0		3'463.0	
SOP catch		**484.2**		**7.3**		**7.4**		**0.2**		**499.1**

Figures for A fleet include unsampled bycatch in the industrial fishery

2018	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	0.0	0.000	1322.9	0.005	0.1	0.022	14.4	0.010	**1'337.4**	**0.005**
1	8.6	0.089	45.5	0.026	17.6	0.050	1.6	0.036	**73.3**	**0.039**
2	175.9	0.118	1.9	0.027	28.2	0.057	0.3	0.044	**206.2**	**0.108**
3	199.4	0.145	0.0	0.000	1.1	0.105	0.0	0.048	**200.5**	**0.145**
4	1176.8	0.184	0.0	0.000	1.8	0.158	0.0	0.000	**1'178.6**	**0.184**
5	847.9	0.191	0.0	0.000	1.0	0.181	0.0	0.000	**849.0**	**0.191**
6	223.5	0.215	0.0	0.000	0.2	0.189	0.0	0.000	**223.6**	**0.215**
7	144.9	0.234	0.0	0.000	0.1	0.187	0.0	0.000	**145.0**	**0.234**
8	144.1	0.242	0.0	0.000	0.1	0.202	0.0	0.000	**144.2**	**0.241**
9+	188.3	0.249	0.0	0.000	0.0	0.000	0.0	0.000	**188.3**	**0.249**
TOTAL	3'109.3		1'370.3		50.2		16.3		4'546.1	
SOP catch		**592.7**		**8.4**		**3.1**		**0.2**		**604.5**

Figures for A fleet include unsampled bycatch in the industrial fishery

Table 2.2.7: Catch at age (numbers in millions) of North Sea herring, 2003–2018.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2003	347	172	1022	507	809	244	106	121	37	8	3375
2004	627	136	274	1333	517	721	170	100	70	22	3970
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

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, 2003–2018.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2003	0.0	0.0	0.0	3.1	6.0	3.5	1.2	1.3	0.5	0.1	15.7
2004	0.0	0.0	15.1	27.9	3.5	4.1	1.0	0.5	0.1	0.0	52.3
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
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

Table 2.2.9: Catch at age (numbers in millions) of NSAS taken in 3.a, and transferred to the assessment of NSAS, 2003–2018.

Year/rings	0	1	2	3	4	5	6	7	8+	Total
2003	21.6	445.0	182.3	13.0	16.2	1.8	1.1	1.2	0.2	682.4
2004	88.4	70.9	179.9	20.7	6.0	9.7	1.8	2.0	0.9	380.4
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

Table 2.2.10: Catch at age (numbers in millions) of the total NSAS stock 2003–2018.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2003	369	617	1204	517	820	243	106	120	37	8	4042
2004	716	207	439	1326	520	726	171	101	71	22	4298
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

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 2008–2018

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
3.a	2008	0.087	0.109	0.139	0.168	0.176	0.204	0.198	-
	2009	0.101	0.082	0.206	0.000	0.000	0.000	0.269	-
	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	0.200	0.221	0.216	-
	2013	0.075	0.134	0.160	0.201	0.000	0.000	0.000	-
	2014	0.074	0.109	0.162	0.191	0.209	0.221	0.228	-
	2015	0.068	0.133	0.157	0.180	0.196	0.197	0.215	-
	2016	0.059	0.123	0.149	0.157	0.208	0.211	0.235	-
	2017	0.068	0.103	0.139	0.173	0.171	0.185	0.162	-
	2018	0.058	0.103	0.156	0.179	0.190	0.187	0.203	-
4.a(E)	2008	0.138	0.173	0.172	0.174	0.216	0.210	0.253	0.266
	2009	0.139	0.167	0.208	0.219	0.232	0.245	0.253	0.288
	2010	0.131	0.154	0.201	0.201	0.210	0.223	0.248	0.235
	2011	0.142	0.162	0.180	0.204	0.215	0.209	0.216	0.222
	2012	0.146	0.185	0.195	0.203	0.216	0.225	0.225	0.232
	2013	0.129	0.147	0.184	0.191	0.205	0.215	0.215	0.228
	2014	0.146	0.161	0.167	0.195	0.200	0.216	0.227	0.224
	2015	0.127	0.148	0.163	0.178	0.191	0.203	0.212	0.227
	2016	0.129	0.153	0.167	0.183	0.195	0.205	0.216	0.229
	2017	0.132	0.154	0.170	0.182	0.193	0.198	0.203	0.209
	2018	0.125	0.152	0.173	0.188	0.201	0.212	0.219	0.230
4.a(W)	2008	0.142	0.187	0.187	0.188	0.230	0.219	0.262	0.281
	2009	0.152	0.180	0.211	0.223	0.266	0.251	0.252	0.278
	2010	0.137	0.166	0.195	0.223	0.220	0.216	0.236	0.252
	2011	0.141	0.161	0.185	0.195	0.216	0.223	0.220	0.243
	2012	0.132	0.184	0.186	0.206	0.226	0.240	0.242	0.254
	2013	0.139	0.158	0.201	0.197	0.218	0.234	0.234	0.251

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
	2014	0.143	0.172	0.184	0.215	0.212	0.227	0.246	0.242
	2015	0.124	0.158	0.198	0.211	0.233	0.228	0.239	0.252
	2016	0.138	0.161	0.189	0.215	0.227	0.242	0.233	0.250
	2017	0.120	0.160	0.177	0.192	0.218	0.226	0.236	0.236
	2018	0.114	0.156	0.188	0.193	0.220	0.241	0.250	0.258
4.b	2008	0.142	0.172	0.185	0.191	0.222	0.228	0.265	0.223
	2009	0.140	0.188	0.228	0.219	0.223	0.243	0.255	0.255
	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	0.240	0.268
	2012	0.131	0.141	0.178	0.209	0.214	0.245	0.250	0.258
	2013	0.125	0.162	0.205	0.206	0.228	0.251	0.261	0.246
	2014	0.133	0.187	0.208	0.233	0.240	0.249	0.256	0.277
	2015	0.140	0.162	0.189	0.203	0.208	0.216	0.227	0.250
	2016	0.126	0.161	0.192	0.211	0.218	0.236	0.236	0.253
	2017	0.095	0.157	0.184	0.194	0.230	0.240	0.249	0.263
	2018	0.117	0.138	0.192	0.211	0.237	0.248	0.246	0.258

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 2008–2018.

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
4.a & 4.b	2008	0.142	0.182	0.185	0.188	0.226	0.220	0.262	0.275
	2009	0.142	0.183	0.217	0.221	0.248	0.248	0.253	0.277
	2010	0.136	0.167	0.192	0.224	0.222	0.220	0.236	0.250
	2011	0.142	0.161	0.184	0.198	0.220	0.224	0.224	0.243
	2012	0.132	0.171	0.185	0.207	0.222	0.239	0.243	0.248
	2013	0.132	0.158	0.198	0.198	0.217	0.234	0.235	0.244
	2014	0.138	0.174	0.187	0.216	0.213	0.227	0.246	0.243
	2015	0.129	0.157	0.190	0.203	0.223	0.219	0.228	0.245
	2016	0.134	0.159	0.185	0.210	0.218	0.235	0.226	0.242
	2017	0.116	0.159	0.176	0.190	0.217	0.223	0.231	0.230
	2018	0.117	0.152	0.187	0.195	0.220	0.238	0.245	0.254
4.c & 7.d	2008	0.120	0.157	0.156	0.173	0.188	0.192	0.215	0.247
	2009	0.156	0.162	0.197	0.197	0.211	0.192	0.219	0.244
	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	0.180	0.196	0.206	0.216	0.218	0.226
	2014	0.119	0.148	0.166	0.183	0.208	0.222	0.227	0.233
	2015	0.114	0.127	0.154	0.157	0.183	0.197	0.204	0.210
	2016	0.114	0.127	0.137	0.166	0.177	0.199	0.193	0.216
	2017	0.100	0.122	0.146	0.165	0.186	0.193	0.220	0.241
	2018	0.113	0.116	0.144	0.156	0.164	0.189	0.196	0.209
Total	2008	0.141	0.180	0.181	0.183	0.216	0.216	0.256	0.273
North Sea	2009	0.145	0.181	0.216	0.216	0.239	0.243	0.248	0.273
Catch	2010	0.138	0.167	0.192	0.222	0.219	0.217	0.234	0.245
	2011	0.141	0.160	0.183	0.197	0.217	0.221	0.223	0.240
	2012	0.130	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

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
	2014	0.137	0.173	0.186	0.215	0.212	0.226	0.244	0.241
	2015	0.123	0.154	0.188	0.200	0.221	0.217	0.226	0.243
	2016	0.132	0.155	0.180	0.206	0.215	0.231	0.221	0.239
	2017	0.114	0.156	0.173	0.189	0.215	0.220	0.230	0.231
	2018	0.117	0.145	0.184	0.192	0.215	0.234	0.242	0.249

Table 2.2.12: Sampling of commercial landings of North Sea herring (Division 4 and 7.d) in 2018 by quarter. Sampled catch means the proportion of the reported catch to which sampling was applied. It is not possible to judge the quality of the sampling by this figure alone. Note that only one nation sampled their by-catches in the industrial fishery (Denmark, fleet B). Metiers are each reported combination of nation/fleet/area/quarter.

Country (fleet)	Quarter	No of metiers	Metiers sampled	Sampled Catch %	Official landings	No. of samples	No. fish aged	No. fish measured	>1 sample per 1 kt catch
Belgium	1	2	0	0%	17	0	0	0	n
	2	2	0	0%	2	0	0	0	n
	3	1	0	0%	1	0	0	0	n
	4	2	0	0%	11	0	0	0	n
total		**7**	**0**	**0%**	**31**	**0**	**0**	**0**	**n**
Denmark (A)	1	3	1	97%	6335	7	184	888	y
	2	2	1	81%	1893	1	29	138	n
	3	3	2	99%	77149	43	1184	4859	n
	4	2	2	100%	38379	22	612	2500	n
total		**10**	**6**	**99%**	**123756**	**73**	**2009**	**8385**	**n**
Denmark (B)	1	3	2	90%	214	7	17	17	y
	2	2	1	100%	768	3	23	47	y
	3	3	1	100%	5126	42	382	798	y
	4	3	1	71%	2368	16	92	99	y
total		**11**	**5**	**92%**	**8476**	**68**	**514**	**961**	**y**
England and Wales	1	3	2	100%	736	7	175	1430	y
	2	4	1	100%	3479	10	250	1870	y
	3	4	2	100%	11563	15	375	1744	y
	4	3	1	84%	3814	6	150	1372	y
total		**14**	**6**	**97%**	**19592**	**38**	**950**	**6416**	**y**
France	1	2	0	0%	4541	0	0	0	n
	2	4	0	0%	3454	0	0	0	n
	3	4	0	0%	15537	0	0	0	n
	4	4	0	0%	8072	0	0	0	n
total		**14**	**0**	**0%**	**31604**	**0**	**0**	**0**	**n**
Germany	2	1	0	0%	2221	0	0	0	n
	3	3	1	89%	33936	21	200	15505	n
	4	3	1	70%	15479	53	195	15559	y
total		**7**	**2**	**79%**	**51636**	**74**	**395**	**31064**	**y**
Ireland	4	1	0	0%	515	0	0	0	n
total		**1**	**0**	**0%**	**515**	**0**	**0**	**0**	**n**
Netherlands	1	1	0	0%	1721	0	0	0	n
	2	2	0	0%	1270	0	0	0	n
	3	2	2	100%	81019	59	1475	7321	n
	4	4	2	6%	27292	2	50	261	n
total		**9**	**4**	**74%**	**111302**	**61**	**1525**	**7582**	**n**
Norway	1	2	0	0%	763	0	0	0	n
	2	3	2	100%	83313	33	1438	3300	n
	3	3	2	95%	47128	8	269	800	n
	4	3	2	93%	31390	5	220	430	n
total		**11**	**6**	**97%**	**162594**	**46**	**1927**	**4530**	**n**
Scotland	1	1	0	0%	1269	0	0	0	n
	2	1	1	100%	2882	5	187	781	y
	3	2	2	100%	60965	26	1163	4074	n
	4	1	0	0%	888	0	0	0	n
total		**5**	**3**	**97%**	**66005**	**31**	**1350**	**4855**	**n**
Sweden	2	2	0	0%	4378	0	0	0	n
	3	3	1	65%	11983	3	198	198	n
	4	2	0	0%	3046	0	0	0	n
total		**7**	**1**	**40%**	**19407**	**3**	**198**	**198**	**n**
Faroese	3	2	0	0%	401	0	0	0	n
	4	1	0	0%	96	0	0	0	n
total		**3**	**0**	**0%**	**497**	**0**	**0**	**0**	**n**
Northern Ireland	1	1	0	0%	453	0	0	0	n
	3	2	0	0%	5411	0	0	0	n
	4	1	0	0%	1052	0	0	0	n
total		**4**	**0**	**0%**	**6916**	**0**	**0**	**0**	**n**
grand total		103	33	83%	602328	394	8868	63991	n
Period total	1	18	5	44%	16050	21	376	2335	y
Period total	2	23	6	89%	103660	52	1927	6136	n
Period total	3	32	13	91%	350219	217	5246	35299	n
Period total	4	30	9	64%	132403	104	1319	20221	n
Total for stock 2018		103	33	83%	602328	394	8868	63991	n
Human Cons. only		92	28	84%	593851	326	8354	63030	n
Total for stock 2016		109	42	89%	559919	445	10296	69930	n
Total for stock 2017		100	27	84%	491694	326	7783	58280	n
Human Cons. only		89	24	84%	484718	288	7439	57846	n

Table 2.3.1.1. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June–July 2018. Vessels, areas and cruise dates.

Vessel	Period	Contributing to Stocks	Strata
Celtic Explorer (IRL) EIGB	3 – 21 July	MSHAS, WoS	2, 3, 4, 5, 6
Scotia (SCO) MXHR6	29 June – 19 July	MSHAS,WoS, NSAS, Sprat NS	1, 91 (north of 58°30’N), 111, 121
Johan Hjort (NOR) LDGJ	2 – 17 July	NSAS, WBSS	11, 141
Tridens (NED) PBVO	2 – 20 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 – 10 July	NSAS, WBSS, Sprat NS, Sprat 3.a	21, 31, 41, 42, 151, 152
Celtic Explorer (IRL) EIGB	3 – 21 July	MSHAS, WoS	2, 3, 4, 5, 6

Table 2.3.1.2. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June–July 2018. 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	7,480	39	0.00	5.2	8.9
1	9,938	401	0.01	40.3	17.2
2	4,254	392	0.37	92.3	22.0
3	1,692	246	0.91	145.4	25.2
4	5,150	991	0.98	192.4	27.2
5	2,440	546	1.00	223.8	28.5
6	719	164	1.00	228.0	28.8
7	529	127	1.00	240.1	29.3
8	293	80	1.00	272.1	30.3
9+	111	30	1.00	272.9	30.4
Immature	20,290	679		33.5	14.7
Mature	12,315	2,337		189.7	27.0
Total	32,606	3,016	0.38	92.5	19.4

Table 2.3.1.3. Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1986–2018. 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 2018 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 ('000 t)
1986	1,639	3,206	1,637	833	135	36	24	6	8	7,542	942
1987	13,736	4,303	955	657	368	77	38	11	20	20,165	817
1988	6,431	4,202	1,732	528	349	174	43	23	14	13,496	897
1989	6,333	3,726	3,751	1,612	488	281	120	44	22	16,377	1,637
1990	6,249	2,971	3,530	3,370	1,349	395	211	134	43	18,262	2,174
1991	3,182	2,834	1,501	2,102	1,984	748	262	112	56	12,781	1,874
1992	6,351	4,179	1,633	1,397	1,510	1,311	474	155	163	17,173	1,545
1993	10,399	3,710	1,855	909	795	788	546	178	116	19,326	1,216
1994	3,646	3,280	957	429	363	321	238	220	132	13,003	1,035
1995	4,202	3,799	2,056	656	272	175	135	110	84	11,220	1,082
1996	6,198	4,557	2,824	1,087	311	99	83	133	206	18,786	1,446
1997	9,416	6,363	3,287	1,696	692	259	79	78	158	22,028	1,780
1998	4,449	5,747	2,520	1,625	982	445	170	45	121	16,104	1,792
1999	5,087	3,078	4,725	1,116	506	314	139	54	87	15,107	1,534
2000	24,735	2,922	2,156	3,139	1,006	483	266	120	97	34,928	1,833
2001	6,837	12,290	3,083	1,462	1,676	450	170	98	59	26,124	2,622
2002	23,055	4,875	8,220	1,390	795	1,031	244	121	150	39,881	2,948
2003	9,829	18,949	3,081	4,189	675	495	568	146	178	38,110	2,999
2004	5,183	3,415	9,191	2,167	2,590	317	328	342	186	23,722	2,584
2005	3,113	1,890	3,436	5,609	1,211	1,172	140	127	107	16,805	1,868
2006	6,823	3,772	1,997	2,098	4,175	618	562	84	70	20,199	2,130
2007	6,261	2,750	1,848	898	806	1,323	243	152	65	14,346	1,203
2008	3,714	2,853	1,709	1,485	809	712	1,749	185	270	20,355	1,784
2009	4,655	5,632	2,553	1,023	1,077	674	638	1,142	578	31,526	2,591
2010	14,577	4,237	4,216	2,453	1,246	1,332	688	1,110	1,619	43,705	3,027
2011	10,119	4,166	2,534	2,173	1,016	651	688	440	1,207	25,524	2,431

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000 t)
2012	7,437	4,718	4,067	1,738	1,209	593	247	218	478	23,641	2,269
2013	6,388	2,683	3,031	2,895	1,546	849	464	250	592	36,484	2,261
2014	11,634	4,918	2,827	2,939	1,791	1,236	669	211	250	61,339	2,610
2015	6,714	9,495	2,831	1,591	1,549	926	520	275	221	24,508	2,280
2016	9,034	12,011	5,832	1,273	822	909	395	220	146	51,686	2,648
2017	3,054	1,761	6,095	3,142	787	365	298	153	140	30,055	1,943
2018	9,938	4,254	1,692	5,150	2,440	719	529	293	111	32,606	2,337

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.

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

	Orkney/ Shetland		Buchan		Central North Sea			Southern North Sea		
Period/ Year	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Oct.	16–31 Dec.	1–15 Jan.	16–31 Jan.
1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512
1990		10144	4590	2045	19955	1239	975	2552	1204	
1991	1021	2397		2032	4823	2110	1249	4400	873	
1992	189	4917		822	10	165	163	176	1616	
1993		66		174		685	85	1358	1103	
1994	26	1179				1464	44	537	595	
1995		8688					43	74	230	164
1996		809		184		564		337	675	691
1997		3611		23				9374	918	355
1998		8528		1490	205	66		1522	953	170
1999		4064		185		134	181	804	1260	344
2000		3352	28	83		376		7346	338	106
2001		11918		164		1604		971	5531	909
2002		6669		1038			3291	2008	260	925
2003		3199		2263		12018	3277	12048	3109	1116
2004		7055		3884		5545		7055	2052	4175
2005		3380		1364		5614		498	3999	4822
2006	6311	2312		280		2259		10858	2700	2106
2007		1753		1304		291		4443	2439	3854
2008	4978	6875		533		11201		8426	2317	4008
2009		7543		4629		4219		15295	14712	1689
2010		2362		1493		2317		7493	13230	8073
2011		3831		2839		17766		5461	6160	1215
2012		19552		5856		517		22768	11103	3285
2013		21282		8618		7354		5	9314	2957
2014		6604		5033		1149				1851

	Orkney/ Shetland		Buchan		Central North Sea			Southern North Sea		
Period/ Year	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Oct.	16–31 Dec.	1–15 Jan.	16–31 Jan.
2015		9631		3496		3424		2011	1200	645
2016				3872		3288		20710	1442	1545
2017				5833		3965		10553	5880	
2018		102		1740		1509		1140		

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 2018 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 1994, calculated with the old algorithm, are recorded in the stock annex.

Area	North west	North east	Central west	Central east	South west	South east	Division 3.a	South'Bight	IBTS-0 index
Area $m^2 \times 10^9$	83	34	86	102	37	93	31	31	
Year class									no. in 10^9
1991	0.227	0.074	0.364	0.444	0.466	0.329	0.330	0.259	164.0
1992	0.191	0.037	0.576	0.387	0.638	0.300	0.359	0.871	195.8
1993	0.574	0.231	0.545	0.178	0.117	0.140	0.223	0.322	155.1
1994	0.131	0.023	0.438	0.359	0.360	0.174	0.503	1.277	170.5
1995	0.222	0.053	0.644	0.069	0.246	0.015	0.015	0.424	107.0
1996	0.026	0.003	0.878	0.099	0.443	0.298	0.040	0.034	134.5
1997	0.039	0.021	0.295	0.059	0.181	0.035	0.021	0.186	51.7
1998	0.095	0.054	1.074	0.543	0.994	0.296	0.242	0.839	255.5
1999	0.042	0.011	0.725	0.149	0.316	0.141	0.105	0.043	111.1
2000	0.237	0.005	0.764	0.161	0.813	0.790	0.065	4.354	342.0
2001	0.076	0.018	0.528	0.456	0.487	0.301	0.261	NA	152.9
2002	0.117	0.031	0.241	0.030	0.127	0.058	0.003	0.841	70.9
2003	0.044	0.004	0.248	0.068	0.119	0.019	0.036	0.145	43.9
2004	0.016	0.008	0.205	0.097	0.511	0.228	0.053	0.399	83.3
2005	0.013	0.018	0.315	0.079	0.291	0.154	0.011	0.068	64.5

Area	North west	North east	Central west	Central east	South west	South east	Division 3.a	South'Bight	IBTS-0 index
Area $m^2 \times 10^9$	83	34	86	102	37	93	31	31	
Year class									no. in 10^9
2006	0.004	0.001	0.213	0.038	0.133	0.020	0.065	0.698	52.9
2007	0.013	0.009	0.185	0.031	0.084	0.058	0.019	0.320	39.5
2008	0.145	0.138	0.281	0.253	0.158	0.139	0.160	0.279	99.2
2009	0.073	0.074	0.194	0.052	0.390	0.291	0.000	0.042	73.5
2010	0.025	0.004	0.595	0.063	0.188	0.082	NA	0.096	77.6
2011	0.008	0.001	0.312	0.132	0.214	0.129	0.076	0.059	65.1
2012	0.022	0.003	0.193	0.072	0.144	0.257	0.005	0.195	61.2
2013	0.132	0.151	0.240	0.253	0.389	0.313	0.037	0.213	113.8
2014	0.009	0.006	0.150	0.047	0.038	0.002	0.009	0.038	21.7
2015	0.015	0.015	0.136	0.059	0.083	0.324	0.002	0.927	81.2
2016	0.005	0.001	0.143	0.020	0.082	0.035	0.020	0.196	27.8
2017	0.111	0.001	0.395	0.181	0.397	0.260	0.031	0.019	102.1
2018	0.017	0.023	0.290	0.103	0.112	0.029	0.083	0.144	51.6

Table 2.3.3.2. North Sea herring. Indices of 1-ringers from the IBTS 1st Quarter for the 1995 to 2017 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	1539	432	0.28	397	0.26	0.15

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

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

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 2018. 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	0.98	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	1972–2018	1973–2018
IBTS 1st Quarter (Trawl survey)	1 wr	1971–2019	1984–2019
IBTS 3rd Quarter (Trawl survey)	0-5 wr	1991–2018	1998–2018
Acoustic (+trawl)	1 wr	1995–2018	1997–2018
	2-9+ wr	1984–2018	1989–2018
IBTS0	0wr	1977–2019	1992–2019

Table 2.6.2.1 North Sea herring multi-fleet assessment model. SAM model configuration (control object).

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

Slot "desc":
[1] "Imported from a VPA file. ( ./data/index.txt ).  Sun Mar 18 16:36:34 2018"

Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2018         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  2  3  4  4  4  4  4  4
  IBTS-Q1  -1  0 -1 -1 -1 -1 -1 -1 -1
```

```
  IBTS0      1 -1 -1 -1 -1 -1 -1 -1 -1
  IBTS-Q3    5  6  7  8  9 10 -1 -1 -1
  LAI-ORSH 11 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN  11 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS  11 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS  11 -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
```

Table 2.6.2.1 (continued) North Sea herring multi-fleet assessment model. SAM model configuration (control object).

```
  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  0  0  0  0  1  1  1
  catch BD  2  3  3  3  3  3 -1 -1 -1
  catch C  -1  4  5  6  6  6  6 -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  2  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 10 10 10 10 11 11
  IBTS-Q1  -1 12 -1 -1 -1 -1 -1 -1 -1
  IBTS0    13 -1 -1 -1 -1 -1 -1 -1 -1
```

```
  IBTS-Q3  14 15 16 16 16 16 -1 -1 -1
  LAI-ORSH 17 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-BUN  17 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-CNS  17 -1 -1 -1 -1 -1 -1 -1 -1
  LAI-SNS  17 -1 -1 -1 -1 -1 -1 -1 -1
  sumFleet -1 -1 -1 -1 -1 -1 -1 -1 -1

Slot "srr":
[1] 0

Slot "scaleNoYears":
[1] 0

Slot "scaleYears":
[1] NA

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

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

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

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

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

Table 2.6.2.1 (continued) North Sea herring multi-fleet assessment model. SAM model configuration (control object).

```
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] FALSE

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

Table 2.6.2.2 North Sea herring. Weights at age in the catch

```
Units  :  kg
, , area = A

   year
age      1997      1998      1999      2000     2001      2002      2003
  0 0.0000000 0.0000000 0.0090000 0.0170000 0.000000 0.0000000 0.0380000
  1 0.0800000 0.0730000 0.0660000 0.0770000 0.104000 0.0820000 0.0780000
  2 0.1180000 0.1200000 0.1240000 0.1270000 0.126000 0.1290000 0.1150000
  3 0.1480000 0.1460000 0.1530000 0.1600000 0.149000 0.1530000 0.1580000
  4 0.1920000 0.1840000 0.1700000 0.1800000 0.175000 0.1690000 0.1740000
  5 0.2300000 0.2210000 0.2080000 0.2000000 0.194000 0.1990000 0.1850000
  6 0.2300000 0.2370000 0.2330000 0.2190000 0.216000 0.2150000 0.2040000
  7 0.2280000 0.2500000 0.2440000 0.2440000 0.229000 0.2280000 0.2210000
  8 0.2602961 0.2805291 0.2718305 0.2707487 0.221922 0.2505347 0.2358647
   year
age      2004      2005      2006      2007      2008      2009      2010
  0 0.0000000 0.1190000 0.0650000 0.0080000 0.0100000 0.0170000 0.0000000
  1 0.0730000 0.0880000 0.1110000 0.0990000 0.0610000 0.0760000 0.0860000
  2 0.1210000 0.1220000 0.1270000 0.1490000 0.1410000 0.1480000 0.1390000
  3 0.1380000 0.1550000 0.1450000 0.1520000 0.1800000 0.1810000 0.1670000
  4 0.1830000 0.1660000 0.1720000 0.1640000 0.1810000 0.2160000 0.1920000
  5 0.2060000 0.2080000 0.1810000 0.1940000 0.1830000 0.2160000 0.2220000
  6 0.2210000 0.2230000 0.2200000 0.1900000 0.2160000 0.2390000 0.2220000
  7 0.2290000 0.2400000 0.2370000 0.2240000 0.2160000 0.2430000 0.2170000
  8 0.2467643 0.2657338 0.2460451 0.2375272 0.2622255 0.2538328 0.2393368
   year
age      2011     2012      2013      2014      2015      2016      2017
  0 0.0000000 0.035000 0.0000000 0.0180000 0.0000000 0.0000000 0.0000000
```

```
  1 0.1120000 0.086000 0.0460000 0.0840000 0.0750000 0.1020000 0.0832800
  2 0.1410000 0.131000 0.1400000 0.1370000 0.1230000 0.1350000 0.1136900
  3 0.1600000 0.171000 0.1560000 0.1730000 0.1540000 0.1560000 0.1561400
  4 0.1830000 0.185000 0.1980000 0.1860000 0.1880000 0.1810000 0.1732200
  5 0.1970000 0.206000 0.1980000 0.2150000 0.2000000 0.2060000 0.1884900
  6 0.2170000 0.222000 0.2150000 0.2120000 0.2210000 0.2150000 0.2145200
  7 0.2210000 0.239000 0.2330000 0.2260000 0.2170000 0.2310000 0.2203100
  8 0.2318784 0.243845 0.2375962 0.2428564 0.2345792 0.2296907 0.2307355
   year
age      2018
  0 0.0000000
  1 0.0890300
  2 0.1175900
  3 0.1453400
  4 0.1838400
  5 0.1914100
  6 0.2151200
  7 0.2342400
  8 0.2455873

, , area = BD

   year
age       1997       1998        1999       2000       2001       2002
  0 0.01494580 0.01928857 0.009363923 0.01434264 0.01194930 0.01240503
  1 0.02865087 0.03231327 0.029272000 0.01893101 0.02900000 0.02303098
  2 0.04290294 0.06041595 0.066093750 0.06787500 0.05234839 0.05288193
  3 0.09153333 0.11767785 0.123714286 0.12972222 0.09616484 0.11445833
  4 0.12472727 0.13614439 0.142531915 0.14900000 0.12600000 0.16755556
  5 0.15035714 0.19657143 0.163000000 0.11900000 0.12100000 0.18000000
  6 0.15700000 0.21000000 0.174000000 0.18900000 0.12200000 0.19300000
  7 0.00000000 0.23200000 0.165000000 0.17000000 0.15400000 0.22800000
  8 0.00000000 0.28500000 0.000000000 0.19900000 0.25100000 0.24400000
   year
age       2003       2004       2005       2006       2007        2008
  0 0.01343119 0.01396358 0.01133906 0.01010078 0.01191188 0.007894138
  1 0.02360108 0.03315918 0.03273352 0.02647022 0.03649933 0.036908795
  2 0.04800000 0.07020707 0.06800000 0.05114936 0.05900000 0.085000000
  3 0.11653846 0.11005543 0.10500000 0.11453979 0.08500000 0.110000000
  4 0.13278261 0.14056193 0.15800000 0.15009706 0.13000000 0.133000000
  5 0.16200000 0.17357541 0.15700000 0.16580142 0.14500000 0.187000000
  6 0.16880000 0.17186877 0.16000000 0.19700000 0.19100000 0.161000000
  7 0.17800000 0.20480886 0.17800000 0.22500000 0.16500000 0.184000000
  8 0.17800000 0.23136654 0.00000000 0.21352474 0.21600000 0.159000000
   year
age       2009       2010        2011       2012       2013        2014
  0 0.00900000 0.00700000 0.007740515 0.01037637 0.00800000 0.007425728
  1 0.02991054 0.02686938 0.033147062 0.02889486 0.02685119 0.029558819
  2 0.08613572 0.06883792 0.045000000 0.07448209 0.04592681 0.026215384
  3 0.14813705 0.18399001 0.071000000 0.13067637 0.14816174 0.116530800
  4 0.18600000 0.14300000 0.000000000 0.00000000 0.19718703 0.188000000
  5 0.00000000 0.20500000 0.000000000 0.19500000 0.28800000 0.214000000
  6 0.31200000 0.19100000 0.000000000 0.16000000 0.21500000 0.206000000
```

```
  7 0.00000000 0.00000000 0.000000000 0.00000000 0.23300000 0.227000000
  8 0.26300000 0.00000000 0.000000000 0.18400000 0.23400000 0.226309343
   year
age        2015       2016       2017        2018
  0 0.008428322 0.00700000 0.00890000 0.005449234
  1 0.020214437 0.02126004 0.02636988 0.026532076
  2 0.055000000 0.05212731 0.02479000 0.029537017
  3 0.095000000 0.08397668 0.07500000 0.048000000
  4 0.000000000 0.09300000 0.00000000 0.000000000
  5 0.147000000 0.07800000 0.00000000 0.000000000
  6 0.000000000 0.14600000 0.00000000 0.000000000
  7 0.000000000 0.00000000 0.00000000 0.000000000
  8 0.000000000 0.00000000 0.00000000 0.000000000

, , area = C

   year
age  1997  1998  1999  2000  2001  2002  2003  2004  2005  2006  2007
  0 0.021 0.029 0.018 0.022 0.025 0.015 0.013 0.024 0.027 0.020 0.048
  1 0.032 0.060 0.054 0.041 0.066 0.054 0.054 0.060 0.065 0.068 0.071
  2 0.084 0.082 0.091 0.078 0.076 0.101 0.073 0.069 0.072 0.081 0.075
  3 0.130 0.119 0.118 0.108 0.108 0.120 0.124 0.120 0.106 0.119 0.111
  4 0.170 0.163 0.139 0.164 0.130 0.143 0.151 0.138 0.154 0.141 0.123
  5 0.183 0.178 0.159 0.191 0.147 0.161 0.163 0.149 0.175 0.184 0.152
  6 0.192 0.196 0.191 0.183 0.221 0.179 0.193 0.169 0.189 0.188 0.179
  7 0.194 0.179 0.202 0.212 0.179 0.177 0.214 0.187 0.216 0.213 0.175
  8 0.201 0.226 0.210 0.198 0.000 0.000 0.187 0.178 0.209 0.206 0.144
   year
age  2008  2009  2010  2011  2012  2013  2014  2015  2016    2017    2018
  0 0.036 0.018 0.028 0.021 0.027 0.034 0.014 0.015 0.000 0.03380 0.02163
  1 0.071 0.086 0.072 0.053 0.065 0.091 0.065 0.042 0.054 0.05160 0.04951
  2 0.087 0.102 0.080 0.085 0.073 0.080 0.090 0.071 0.061 0.08015 0.05690
  3 0.109 0.081 0.122 0.115 0.124 0.135 0.117 0.133 0.124 0.10318 0.10484
  4 0.139 0.207 0.149 0.134 0.169 0.161 0.162 0.157 0.149 0.13839 0.15789
  5 0.168 0.000 0.191 0.191 0.175 0.200 0.191 0.180 0.188 0.17196 0.18110
  6 0.175 0.000 0.221 0.193 0.199 0.000 0.209 0.196 0.208 0.15292 0.18925
  7 0.203 0.000 0.216 0.234 0.220 0.000 0.221 0.197 0.209 0.14710 0.18664
  8 0.199 0.269 0.205 0.248 0.216 0.000 0.228 0.215 0.235 0.15980 0.20210
```

Table 2.6.2.3 North Sea herring. Fishing mortality at age in the stock

```
Units  :  f
, , area = A

   year
age        1947        1948        1949       1950        1951        1952
  0 0.000000000 0.000000000 0.000000000 0.00000000 0.000000000 0.000000000
  1 0.001169498 0.001137948 0.001394607 0.00180942 0.002770707 0.003361101
  2 0.036142885 0.034857073 0.043694035 0.05780169 0.091086620 0.111485848
  3 0.083349094 0.082967687 0.097375128 0.11422967 0.157135869 0.165444314
  4 0.096381376 0.097284351 0.114020430 0.12942817 0.172595304 0.178207629
  5 0.126601498 0.124855905 0.144059181 0.14720594 0.178781054 0.191601796
  6 0.201566782 0.182792643 0.230566945 0.19885984 0.211122461 0.253210357
  7 0.225319608 0.205576929 0.271372399 0.21492187 0.206739870 0.281855825
  8 0.225319608 0.205576929 0.271372399 0.21492187 0.206739870 0.281855825
   year
age        1953      1954        1955        1956        1957        1958
  0 0.000000000 0.0000000 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.003965779 0.0050085 0.005357893 0.006175305 0.006577958 0.006933927
  2 0.132475384 0.1696193 0.181136524 0.210052569 0.223574944 0.235579638
  3 0.179067999 0.2139477 0.204589980 0.215402896 0.225238078 0.227002241
  4 0.180611010 0.2049446 0.182735362 0.184080302 0.195995168 0.187292100
  5 0.192360078 0.2216014 0.189053115 0.187156189 0.208650546 0.188640856
  6 0.243002037 0.3079924 0.213264194 0.202271047 0.232228579 0.164578375
  7 0.265687713 0.3338752 0.193517590 0.201666847 0.226967523 0.140567031
  8 0.265687713 0.3338752 0.193517590 0.201666847 0.226967523 0.140567031
   year
age        1959        1960      1961        1962        1963        1964
  0 0.000000000 0.000000000 0.0000000 0.000000000 0.000000000 0.000000000
  1 0.007984775 0.006804058 0.0074636 0.007351346 0.005592108 0.008251031
  2 0.273429590 0.228739997 0.2521264 0.246658184 0.181815926 0.275623784
  3 0.259591831 0.210018074 0.2411735 0.277656201 0.187721071 0.292061896
  4 0.221744357 0.178730431 0.2086920 0.256052291 0.155196157 0.249323647
  5 0.222763429 0.180008138 0.2015160 0.260383896 0.149616544 0.239023630
  6 0.244576084 0.200624995 0.2074843 0.314262496 0.113534890 0.194911852
  7 0.242922185 0.226590520 0.1978591 0.298293791 0.124197617 0.189720089
  8 0.242922185 0.226590520 0.1978591 0.298293791 0.124197617 0.189720089
   year
age       1965       1966       1967       1968       1969       1970
  0 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
  1 0.01402998 0.01277427 0.01525286 0.02630874 0.01955873 0.02149259
  2 0.48839311 0.43872583 0.52916627 0.95312464 0.68557111 0.75621445
  3 0.54593223 0.51442258 0.68542072 1.20180888 0.86221304 0.95230315
  4 0.47731597 0.45306529 0.62398482 0.95064757 0.77365429 0.86091820
  5 0.46442529 0.45767109 0.64947769 0.90434202 0.80266984 0.81439004
  6 0.46582072 0.39136531 0.73981738 1.12527176 1.13502376 1.13918944
  7 0.47480496 0.47814241 0.90539475 1.16470657 1.01116067 0.87102139
  8 0.47480496 0.47814241 0.90539475 1.16470657 1.01116067 0.87102139
   year
age      1971       1972       1973       1974       1975       1976
  0 0.0000000 0.00000000 0.00000000 0.00000000 0.00000000 0.00000000
  1 0.0233425 0.01656327 0.02331373 0.02175198 0.02630721 0.01843697
  2 0.8217631 0.56246210 0.81204050 0.75016280 0.91901782 0.62263842
```

```
  3 1.0493504 0.64108415 0.95426570 0.88038294 1.14897726 0.85532943
  4 1.0256065 0.54018084 0.81078464 0.77873437 1.01228610 0.73828466
  5 1.0991274 0.49695633 0.81126259 0.84255776 1.11858418 0.78303777
  6 2.7645006 0.48838316 1.00952180 0.89005915 1.21718531 0.69402811
  7 1.6631636 0.28676433 0.66717546 0.78787253 1.52461754 0.98119349
  8 1.6631636 0.28676433 0.66717546 0.78787253 1.52461754 0.98119349
   year
age        1977        1978       1979        1980        1981        1982
  0 0.000000000 0.000000000 0.00000000 0.000000000 0.000000000 0.000000000
  1 0.006505918 0.005317893 0.00505360 0.005204518 0.005976583 0.005135481
  2 0.199427935 0.159379737 0.15010870 0.154371350 0.178393214 0.150444554
  3 0.301904035 0.222252047 0.19487674 0.187851109 0.230943561 0.193657473
  4 0.266490116 0.191236050 0.15841367 0.144649268 0.214026911 0.168324348
  5 0.316097997 0.211637757 0.16129184 0.131864576 0.228563176 0.152831311
  6 0.206828553 0.106940172 0.06497829 0.043439160 0.182324153 0.091158048
  7 0.341610828 0.184961461 0.11320405 0.073402500 0.323501186 0.130631218
  8 0.341610828 0.184961461 0.11320405 0.073402500 0.323501186 0.130631218
   year
age       1983        1984        1985        1986        1987        1988
  0 0.00000000 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.00607374 0.007259319 0.009172353 0.008689891 0.008276882 0.007822664
  2 0.17964803 0.217013529 0.278334702 0.261240495 0.246785279 0.231149105
  3 0.23863970 0.300451761 0.384844976 0.339836476 0.302989580 0.275135866
  4 0.24133319 0.333448447 0.431261836 0.387717124 0.355899497 0.337441415
  5 0.24149479 0.336577266 0.420065203 0.392829425 0.365139176 0.357992212
  6 0.22056152 0.348661399 0.471495991 0.463762242 0.393165517 0.393537145
  7 0.30014060 0.451038648 0.534541986 0.524262692 0.399796623 0.411269558
  8 0.30014060 0.451038648 0.534541986 0.524262692 0.399796623 0.411269558
   year
age        1989        1990        1991       1992       1993       1994
  0 0.000000000 0.000000000 0.000000000 0.00000000 0.00000000 0.00000000
  1 0.008092362 0.007168658 0.008587611 0.00948557 0.01075777 0.01051794
  2 0.239090319 0.208860084 0.253720539 0.28207685 0.32279018 0.31461714
  3 0.271846932 0.224437679 0.257470735 0.29777361 0.36834541 0.39692750
  4 0.330242439 0.260394771 0.273661366 0.31906446 0.38869970 0.41683999
  5 0.340836805 0.264843554 0.259349382 0.29916153 0.33763841 0.33298279
  6 0.359184410 0.247422331 0.237649899 0.31634595 0.36200932 0.31799641
  7 0.369429803 0.265620756 0.220929567 0.30545155 0.34718163 0.27566160
  8 0.369429803 0.265620756 0.220929567 0.30545155 0.34718163 0.27566160
   year
age        1995        1996        1997        1998        1999
  0 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.008167802 0.003853034 0.003185023 0.004046158 0.003811862
  2 0.238076074 0.104627329 0.084874360 0.108634654 0.099230443
  3 0.342928904 0.162774955 0.143330651 0.186015701 0.184839631
  4 0.364438588 0.171796287 0.154121602 0.195569410 0.192636382
  5 0.324841100 0.164434605 0.150457059 0.195875238 0.189753719
  6 0.328249001 0.125447248 0.118910514 0.180143355 0.159068300
  7 0.273847756 0.094385568 0.094453528 0.119659096 0.099199973
  8 0.273847756 0.094385568 0.094453528 0.119659096 0.099199973
   year
age        2000        2001        2002        2003       2004        2005
  0 0.000000000 0.000000000 0.000000000 0.000000000 0.0000000 0.000000000
```

```
  1 0.003589421 0.002716575 0.002409158 0.002354906 0.00226575 0.002699024
  2 0.090853935 0.065700332 0.056451973 0.053942103 0.05111798 0.059776552
  3 0.176601411 0.137999093 0.120530936 0.122501137 0.12424791 0.141244129
  4 0.197187957 0.169291337 0.157247458 0.175835573 0.19405195 0.228018803
  5 0.197825118 0.186408684 0.179798950 0.220548567 0.26374291 0.313811806
  6 0.162611260 0.164368847 0.162577339 0.211371234 0.32117289 0.455301525
  7 0.106540545 0.144811340 0.149179726 0.183661609 0.27867914 0.474793354
  8 0.106540545 0.144811340 0.149179726 0.183661609 0.27867914 0.474793354
   year
age        2006        2007        2008        2009        2010
  0 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.002911738 0.002809547 0.002688573 0.001938206 0.002050783
  2 0.063168652 0.058869710 0.054464161 0.037628045 0.039612275
  3 0.140164399 0.128220366 0.093108299 0.055318719 0.060053852
  4 0.217166292 0.194025445 0.126495940 0.071509774 0.071543216
  5 0.284763822 0.249630544 0.154333114 0.087347412 0.084475618
  6 0.385458758 0.327381827 0.151669088 0.065109955 0.059720998
  7 0.437922286 0.384243535 0.191012156 0.091894370 0.072728563
  8 0.437922286 0.384243535 0.191012156 0.091894370 0.072728563
   year
age        2011        2012        2013        2014        2015
  0 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.002338586 0.003337446 0.002959385 0.002765175 0.002177255
  2 0.045618917 0.066329964 0.057714957 0.054708370 0.043722274
  3 0.077040133 0.127472235 0.124004224 0.122078685 0.103709645
  4 0.094583522 0.164276293 0.180549048 0.182706187 0.169082281
  5 0.111825994 0.197064741 0.234882768 0.233656512 0.242764995
  6 0.087299693 0.211294742 0.303034914 0.279546869 0.351920810
  7 0.095140620 0.225081061 0.351250994 0.341557584 0.491015440
  8 0.095140620 0.225081061 0.351250994 0.341557584 0.491015440
   year
age        2016        2017        2018        2019
  0 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.002135441 0.001781414 0.001964486 0.001964561
  2 0.044023560 0.036437381 0.040719119 0.040720541
  3 0.118857830 0.112133968 0.126632708 0.126636771
  4 0.191939429 0.183535435 0.223534424 0.223541007
  5 0.266123147 0.231406492 0.285192514 0.285200224
  6 0.397733888 0.286839099 0.368016036 0.368031274
  7 0.605846106 0.440086912 0.579202991 0.579225007
  8 0.605846106 0.440086912 0.579202991 0.579225007

, , area = BD

   year
age         1947         1948         1949         1950         1951
  0 0.0004308753 0.0004101282 0.0007586030 0.0013130647 0.0021697177
  1 0.0006286880 0.0005686453 0.0019860730 0.0060628199 0.0168332478
  2 0.0001758601 0.0001653714 0.0003471257 0.0006761594 0.0012501567
  3 0.0002529521 0.0002442054 0.0003770118 0.0005571681 0.0007983842
   year
age         1952        1953        1954        1955        1956
  0 0.0030001105 0.003729627 0.004697127 0.004948493 0.004461943
```

```
  1 0.0325318031 0.050653124 0.072151780 0.102999129 0.105884951
  2 0.0018512485 0.002398864 0.002943234 0.003641530 0.003712477
  3 0.0009905517 0.001144244 0.001277606 0.001433136 0.001428982
   year
age        1957        1958        1959        1960       1961        1962
  0 0.005084987 0.005402454 0.009176446 0.014875082 0.01523108 0.009042185
  1 0.129662457 0.118814505 0.145484721 0.160634396 0.11384242 0.077984367
  2 0.004143640 0.003937690 0.004398226 0.004604385 0.00373483 0.002901230
  3 0.001512647 0.001460329 0.001531056 0.001536058 0.00136032 0.001175422
   year
age        1963        1964        1965        1966        1967
  0 0.013132038 0.016660653 0.015295214 0.022237794 0.029456463
  1 0.120071551 0.211658023 0.203044662 0.226606310 0.282736252
  2 0.003722241 0.005200043 0.005073039 0.005362213 0.006019418
  3 0.001349254 0.001667440 0.001667439 0.001740669 0.001875400
   year
age        1968        1969        1970        1971        1972
  0 0.031513131 0.021476181 0.035517040 0.049720420 0.065319524
  1 0.299176361 0.259298251 0.313203133 0.495596935 0.563369790
  2 0.006259859 0.005723343 0.006400774 0.008347661 0.009091763
  3 0.001927786 0.001830203 0.001964014 0.002292534 0.002425260
   year
age        1973        1974        1975        1976        1977
  0 0.070502646 0.092877772 0.115611467 0.083816075 0.075558350
  1 0.565283896 0.469487928 0.440053093 0.187769368 0.110590380
  2 0.009063563 0.008072741 0.007687611 0.004550954 0.003228502
  3 0.002429585 0.002276470 0.002220589 0.001630533 0.001325561
   year
age        1978        1979        1980        1981        1982
  0 0.093894997 0.115974144 0.143448131 0.324923014 0.320385250
  1 0.100277331 0.093721593 0.086085796 0.180227216 0.172645054
  2 0.003092176 0.003030648 0.002952982 0.004506611 0.004465142
  3 0.001288112 0.001270840 0.001250345 0.001571264 0.001560173
   year
age        1983        1984        1985        1986        1987
  0 0.317458795 0.192582893 0.126008430 0.099842672 0.135466758
  1 0.201647446 0.181323993 0.228377766 0.237009822 0.320344506
  2 0.005015408 0.004883518 0.005886646 0.006368538 0.008116381
  3 0.001670043 0.001659781 0.001862617 0.001940922 0.002236236
   year
age        1988        1989        1990        1991        1992
  0 0.128996432 0.116733450 0.093809951 0.119791175 0.204018258
  1 0.400976448 0.325952567 0.276054020 0.229697963 0.271072846
  2 0.009877430 0.009636276 0.009769915 0.010223003 0.012634381
  3 0.002500554 0.002455701 0.002455145 0.002512647 0.002857337
   year
age        1993        1994        1995        1996        1997
  0 0.222036668 0.146745052 0.139011122 0.067667348 0.023768167
  1 0.248690283 0.125787734 0.111286449 0.066870381 0.022721983
  2 0.013593518 0.010339827 0.010796173 0.009121549 0.005947058
  3 0.003028262 0.002623274 0.002727878 0.002468370 0.001943285
   year
age        1998        1999        2000        2001        2002
```

```
  0 0.021229026 0.025186593 0.030066107 0.020566130 0.026126945
  1 0.022818314 0.017644046 0.018896219 0.007026746 0.016336999
  2 0.006570483 0.006338086 0.006736067 0.004049759 0.006677948
  3 0.002014357 0.001989735 0.001841882 0.001284373 0.001334168
   year
age        2003         2004         2005        2006         2007
  0 0.028251025 0.0363813207 0.0522822356 0.043048438 0.0302461105
  1 0.024831019 0.0294468367 0.0392793632 0.020246005 0.0112945841
  2 0.007603846 0.0083311712 0.0084456718 0.005443603 0.0027274768
  3 0.001003498 0.0008512123 0.0005845575 0.000395756 0.0001407086
   year
age          2008         2009         2010         2011         2012
  0 0.03136458899 0.0251592233 0.0263721531 0.0312818557 0.0344530762
  1 0.01147505260 0.0108995567 0.0102602778 0.0121202132 0.0176274987
  2 0.00205231879 0.0020225402 0.0023440871 0.0022278983 0.0032948113
  3 0.00007903096 0.0001015617 0.0001968298 0.0001855711 0.0002646568
   year
age        2013         2014         2015          2016          2017
  0 0.025511983 0.0331986882 0.0458908101 0.06059885335 0.04486903308
  1 0.014826916 0.0157264724 0.0168750431 0.01982957074 0.01256092602
  2 0.003233521 0.0031696099 0.0024208938 0.00248500709 0.00132270577
  3 0.000243034 0.0002117316 0.0001066504 0.00009276139 0.00003299441
   year
age          2018          2019
  0 0.04609561841 0.04616935994
  1 0.00880101292 0.00881408292
  2 0.00092349257 0.00092430301
  3 0.00002310725 0.00002311924
```

Table 2.6.2.4 North Sea Herring. Negative log-likelihood

```
1518.22018831688
```

Table 2.6.2.5 North Sea herring. FLR, R software versions

FLSAM.version	2.1.0
FLCore.version	2.6.9
R.version	R version 3.5.2 (2018-12-20)
platform	x86_64-w64-mingw32
run.date	2019-03-17 14:06:48

Table 2.6.3.1 North Sea Herring. CATCH IN NUMBER

Units : thousands

age \ year	1947	1948	1949	1950	1951	1952	1953	1954	1955
0	0	0	0	0	0	0	150000	219000	164000
1	0	3000	0	0	462000	722000	1023000	1451000	2072000
2	494000	247000	478000	535000	660000	1346000	1322000	1493000	1931000
3	415000	672000	644000	1039000	959000	576000	1003000	1111000	1032000
4	638000	328000	396000	617000	1255000	610000	474000	591000	479000
5	526000	601000	287000	290000	630000	652000	386000	361000	337000
6	756000	487000	652000	254000	262000	464000	473000	330000	232000
7	431000	400000	462000	331000	142000	236000	278000	379000	120000
8	1311000	917000	1037000	597000	445000	554000	392000	511000	215000

age \ year	1956	1957	1958	1959	1960	1961	1962	1963
0	96000	279000	97000	0	194600	1269200	141800	442800
1	1697000	1483000	4279000	1609000	2392700	336000	2146900	1262200
2	1860000	1644000	1029000	4934000	1142300	1889400	269600	2961200
3	1221000	736000	999000	488000	1966700	479900	797400	177200
4	516000	644000	322000	497000	165900	1455900	335100	158300
5	249000	344000	461000	233000	167700	124000	1081800	80600
6	194000	207000	147000	249000	112900	157900	126900	229700
7	104000	147000	73000	120000	125800	61400	145100	22400
8	292000	253000	118000	301000	270600	143500	173100	93000

age \ year	1964	1965	1966	1967	1968	1969	1970	1971
0	496900	157100	374500	645400	839300	112000	898100	684000
1	2971700	3209300	1383100	1674300	2425000	2503300	1196200	4378500
2	1547500	2217600	2569700	1171500	1795200	1883000	2002800	1146800
3	2243100	1324600	741200	1364700	1494300	296300	883600	662500
4	148400	2039400	450100	371500	621400	133100	125200	208300
5	149000	145100	889800	297800	157100	190800	50300	26900
6	95000	151900	45300	393100	145000	49900	61000	30500
7	256300	117600	64800	67900	163400	42700	7900	26800
8	84000	491400	331800	254400	105500	52500	24200	12500

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	750400	289400	996100	263800	238200	256800	NA	NA	1262700	9519700
1	3340600	2368000	846100	2460500	126600	144300	NA	NA	245100	872000
2	1440500	1344200	772600	541700	901500	44700	NA	NA	134000	284300
3	343800	659200	362000	259600	117300	186400	NA	NA	91800	56900
4	130600	150200	126000	140500	52000	10800	NA	NA	32200	39500
5	32900	59300	56100	57200	34500	7000	NA	NA	21700	28500
6	5000	30600	22300	16100	6100	4100	NA	NA	2300	22700
7	200	3700	5000	9100	4400	1500	NA	NA	1400	18700
8	1500	2000	3100	4800	1400	700	NA	NA	500	6600

age \ year	1982	1983	1984	1985	1986	1987	1988	1989
0	11956700	13296900	6973300	4211000	3724700	8229200	3164800	3057800
1	1116400	2448600	1818400	3253000	4801400	6836300	7867000	3145900
2	299400	573800	1146200	1326300	1266700	2137200	2232500	1593700
3	230100	216400	441400	1182400	840800	667900	1090700	1363800

4	33700	105100	201500	368500	465900	467100	383700	809300
5	14400	26200	81100	124500	129800	245800	255800	211800
6	6800	22800	22600	43600	62100	74700	128100	123700
7	7800	12800	25200	20200	20500	23800	38000	61000
8	4700	23100	29700	29200	28400	16200	23800	28200

age \ year	1990	1991	1992	1993	1994	1995	1996	1997
0	1302800	2386600	10331300	10265400	4498900	7438469	2311226	431175
1	3020000	2138900	2303100	3826800	1785200	1664874	1606393	479702
2	899300	1132800	1284900	1176300	1783200	1444061	642084	687920
3	779100	556700	442700	609000	489100	816703	525601	446909
4	861000	548900	361500	305500	347600	231794	172099	284920
5	387500	501200	360500	215600	109000	118536	57586	109178
6	80200	205300	375600	226000	91800	55128	22534	31389
7	54400	39300	152400	188000	76400	41409	9264	11832
8	40700	38600	62500	129000	116600	98200	21143	24467

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	259526	1566349	1105085	1832691	730279	369074	715597	1015554	878637
1	977680	303520	1171677	614469	837557	617021	206648	715547	222111
2	1220105	616354	622853	842635	579592	1221992	447918	355453	401087
3	537932	1058716	463170	485628	970577	529386	1366155	485746	310602
4	276333	294066	646814	278884	292205	835552	543376	1318647	464620
5	175817	135648	213466	321743	140701	244780	753231	479961	997782
6	88927	69299	82481	90918	174570	107751	169324	576154	252150
7	15232	27998	35706	38252	48908	123291	104945	115212	247042
8	20550	12228	17087	20602	43322	46715	97142	146808	106412

age \ year	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	621005	798284	650043	574895	778927	773241	461571	1388685	538228
1	235553	235022	175923	280728	159504	284906	413000	370590	394878
2	219115	331772	259434	293887	367820	455259	324920	382990	551802
3	417452	184771	106738	236804	275016	673465	485185	386131	247555
4	285746	199069	93321	126241	218711	404265	571269	616563	282813
5	309454	137529	86137	83893	130127	306234	422765	487582	461041
6	629187	118349	37951	61542	62938	152577	327213	284562	432034
7	147830	215542	53130	33305	52081	104461	145330	191729	271280
8	156750	117258	143131	113675	125734	205427	313638	214513	337811

age \ year	2016	2017	2018
0	1583568	462148	1337404
1	109135	209356	73260
2	625483	108706	206232
3	818585	1079854	200527
4	293372	837770	1178604
5	280451	222790	848961
6	367844	145511	223637
7	307347	175533	144999
8	359076	221296	332482

Table 2.6.3.2 North Sea Herring. WEIGHTS AT AGE IN THE CATCH

Units : kg

age	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957
0	0.015	0.015	0.0150	0.015	0.0150	0.015	0.015	0.0150	0.0150	0.015	0.0150
1	0.050	0.050	0.0500	0.050	0.0500	0.050	0.050	0.0500	0.0500	0.050	0.0500
2	0.122	0.122	0.1280	0.128	0.1340	0.137	0.137	0.1390	0.1400	0.140	0.1410
3	0.140	0.140	0.1450	0.151	0.1570	0.165	0.167	0.1690	0.1700	0.172	0.1730
4	0.156	0.156	0.1610	0.166	0.1760	0.183	0.190	0.1930	0.1950	0.197	0.1980
5	0.171	0.171	0.1760	0.180	0.1890	0.199	0.205	0.2110	0.2140	0.216	0.2180
6	0.185	0.185	0.1890	0.193	0.2010	0.210	0.218	0.2230	0.2280	0.231	0.2330
7	0.197	0.197	0.2010	0.204	0.2110	0.219	0.226	0.2330	0.2380	0.242	0.2440
8	0.242	0.242	0.2435	0.245	0.2475	0.251	0.254	0.2565	0.2595	0.261	0.2625

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
0	0.0150	0.0150	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1	0.0500	0.0500	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.1410	0.1430	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
3	0.1740	0.1760	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
4	0.1990	0.2010	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
5	0.2190	0.2210	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
6	0.2340	0.2360	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251
7	0.2450	0.2470	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
8	0.2635	0.2645	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271

age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
3	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
4	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
5	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251
7	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
8	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271

age	1980	1981	1982	1983	1984	1985	1986	1987
0	0.015	0.007	0.010000	0.0100000	0.0100000	0.0090000	0.0060000	0.0110000
1	0.050	0.049	0.059000	0.0590000	0.0590000	0.0360000	0.0670000	0.0350000
2	0.126	0.118	0.118000	0.1180000	0.1180000	0.1280000	0.1210000	0.0990000
3	0.176	0.142	0.149000	0.1490000	0.1490000	0.1640000	0.1530000	0.1500000
4	0.211	0.189	0.179000	0.1790000	0.1790000	0.1940000	0.1820000	0.1800000
5	0.243	0.211	0.217000	0.2170000	0.2170000	0.2110000	0.2080000	0.2110000
6	0.251	0.222	0.238000	0.2380000	0.2380000	0.2200000	0.2210000	0.2340000
7	0.267	0.267	0.265000	0.2650000	0.2650000	0.2580000	0.2380000	0.2580000
8	0.271	0.271	0.274234	0.2745238	0.2746263	0.2821301	0.2572113	0.2881358

age	1988	1989	1990	1991	1992	1993	1994
0	0.0110000	0.0170000	0.0190000	0.0170000	0.0100000	0.0100000	0.0060000
1	0.0550000	0.0430000	0.0550000	0.0580000	0.0530000	0.0330000	0.0560000
2	0.1110000	0.1150000	0.1140000	0.1300000	0.1020000	0.1150000	0.1300000
3	0.1450000	0.1530000	0.1490000	0.1660000	0.1750000	0.1450000	0.1590000

```
  4 0.1740000 0.1730000 0.1770000 0.1840000 0.1890000 0.1890000 0.1810000
  5 0.1970000 0.2080000 0.1930000 0.2030000 0.2070000 0.2040000 0.2140000
  6 0.2160000 0.2310000 0.2290000 0.2170000 0.2230000 0.2280000 0.2400000
  7 0.2370000 0.2470000 0.2360000 0.2350000 0.2370000 0.2440000 0.2550000
  8 0.2565714 0.2631489 0.2608182 0.2630415 0.2631664 0.2734558 0.2761973
   year
age      1995      1996      1997      1998     1999      2000     2001
  0 0.0090000 0.0150000 0.0150000 0.0210000 0.009000 0.0150000 0.012000
  1 0.0420000 0.0180000 0.0440000 0.0510000 0.045000 0.0330000 0.048000
  2 0.1300000 0.1120000 0.1080000 0.1140000 0.115000 0.1130000 0.118000
  3 0.1690000 0.1560000 0.1480000 0.1450000 0.151000 0.1570000 0.149000
  4 0.1980000 0.1880000 0.1950000 0.1830000 0.171000 0.1790000 0.177000
  5 0.2070000 0.2040000 0.2270000 0.2190000 0.207000 0.2010000 0.198000
  6 0.2430000 0.2120000 0.2260000 0.2380000 0.233000 0.2160000 0.213000
  7 0.2470000 0.2610000 0.2350000 0.2470000 0.245000 0.2460000 0.238000
  8 0.2809153 0.2814938 0.2549437 0.2878952 0.267719 0.2731261 0.269744
   year
age      2002      2003      2004      2005      2006      2007     2008
  0 0.0120000 0.0140000 0.0140000 0.0110000 0.0100000 0.0124000 0.007900
  1 0.0370000 0.0370000 0.0360000 0.0440000 0.0490000 0.0638000 0.053500
  2 0.1180000 0.1040000 0.1000000 0.0990000 0.1170000 0.1214000 0.128800
  3 0.1530000 0.1580000 0.1380000 0.1530000 0.1440000 0.1513000 0.179600
  4 0.1700000 0.1740000 0.1830000 0.1660000 0.1720000 0.1634000 0.181200
  5 0.1990000 0.1840000 0.2010000 0.2080000 0.1810000 0.1933000 0.183200
  6 0.2140000 0.2050000 0.2160000 0.2230000 0.2200000 0.1900000 0.215700
  7 0.2280000 0.2220000 0.2280000 0.2400000 0.2370000 0.2232000 0.216100
  8 0.2504017 0.2366464 0.2545115 0.2653676 0.2460061 0.2374933 0.262076
   year
age      2009      2010     2011      2012      2013      2014      2015
  0 0.0094000 0.0075000 0.008000 0.0106000 0.0077000 0.0075000 0.0087000
  1 0.0514000 0.0571000 0.041300 0.0463000 0.0468000 0.0522000 0.0261000
  2 0.1440000 0.1292000 0.131700 0.1243000 0.1162000 0.1240000 0.1135000
  3 0.1811000 0.1669000 0.159300 0.1706000 0.1563000 0.1719000 0.1538000
  4 0.2158000 0.1912000 0.183100 0.1854000 0.1977000 0.1861000 0.1883000
  5 0.2162000 0.2203000 0.197000 0.2058000 0.1980000 0.2148000 0.2001000
  6 0.2390000 0.2193000 0.216700 0.2215000 0.2154000 0.2118000 0.2212000
  7 0.2428000 0.2160000 0.221100 0.2387000 0.2334000 0.2264000 0.2170000
  8 0.2532723 0.2383892 0.231918 0.2427213 0.2378432 0.2426541 0.2347182
   year
age      2016      2017      2018
  0 0.0071000 0.0090000 0.0054000
  1 0.0265000 0.0380000 0.0394000
  2 0.1267000 0.0990000 0.1085000
  3 0.1549000 0.1560000 0.1451000
  4 0.1803000 0.1730000 0.1838000
  5 0.2059000 0.1880000 0.1914000
  6 0.2151000 0.2150000 0.2151000
  7 0.2313000 0.2200000 0.2342000
  8 0.2299244 0.2305184 0.2455776
```

Table 2.6.3.3 North Sea Herring. WEIGHTS AT AGE IN THE STOCK

Units : kg

age \ year	1947	1948	1949	1950	1951	1952	1953
0	0.0150	0.0150	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000
1	0.0500	0.0500	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000
2	0.1220	0.1220	0.1240000	0.1260000	0.1300000	0.1330000	0.1360000
3	0.1400	0.1400	0.1416667	0.1453333	0.1510000	0.1576667	0.1630000
4	0.1560	0.1560	0.1576667	0.1610000	0.1676667	0.1750000	0.1830000
5	0.1710	0.1710	0.1726667	0.1756667	0.1816667	0.1893333	0.1976667
6	0.1850	0.1850	0.1863333	0.1890000	0.1943333	0.2013333	0.2096667
7	0.1970	0.1970	0.1983333	0.2006667	0.2053333	0.2113333	0.2186667
8	0.2625	0.2625	0.2630000	0.2640000	0.2658333	0.2683333	0.2713333

age \ year	1954	1955	1956	1957	1958	1959	1960
0	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000
1	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000
2	0.1376667	0.1386667	0.1396667	0.1403333	0.1406667	0.1416667	0.1463333
3	0.1670000	0.1686667	0.1703333	0.1716667	0.1730000	0.1743333	0.1790000
4	0.1886667	0.1926667	0.1950000	0.1966667	0.1980000	0.1993333	0.2076667
5	0.2050000	0.2100000	0.2136667	0.2160000	0.2176667	0.2193333	0.2263333
6	0.2170000	0.2230000	0.2273333	0.2306667	0.2326667	0.2343333	0.2486667
7	0.2260000	0.2323333	0.2376667	0.2413333	0.2436667	0.2453333	0.2636667
8	0.2743333	0.2771667	0.2795000	0.2815000	0.2828333	0.2840000	0.2936240

age \ year	1961	1962	1963	1964	1965	1966	1967
0	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000
1	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000
2	0.1510000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000
3	0.1833333	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000
4	0.2156667	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000
5	0.2330000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000
6	0.2626667	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000
7	0.2816667	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000
8	0.3034146	0.3090087	0.3092903	0.3101214	0.3069573	0.3102731	0.3100755

age \ year	1968	1969	1970	1971	1972	1973	1974	1975
0	0.0150000	0.0150000	0.0150000	0.015000	0.0150	0.0150	0.015000	0.01500
1	0.0500000	0.0500000	0.0500000	0.050000	0.0500	0.0500	0.050000	0.05000
2	0.1550000	0.1550000	0.1550000	0.155000	0.1550	0.1550	0.155000	0.15500
3	0.1870000	0.1870000	0.1870000	0.187000	0.1870	0.1870	0.187000	0.18700
4	0.2230000	0.2230000	0.2230000	0.223000	0.2230	0.2230	0.223000	0.22300
5	0.2390000	0.2390000	0.2390000	0.239000	0.2390	0.2390	0.239000	0.23900
6	0.2760000	0.2760000	0.2760000	0.276000	0.2760	0.2760	0.276000	0.27600
7	0.2990000	0.2990000	0.2990000	0.299000	0.2990	0.2990	0.299000	0.29900
8	0.3112209	0.3088686	0.3090248	0.311952	0.3076	0.3078	0.308129	0.30775

age \ year	1976	1977	1978	1979	1980	1981	1982	1983
0	0.0150000	0.015	0.0150	0.0150000	0.0150	0.015	0.0150000	0.0150000
1	0.0500000	0.050	0.0500	0.0500000	0.0500	0.050	0.0500000	0.0500000
2	0.1550000	0.155	0.1550	0.1550000	0.1550	0.155	0.1550000	0.1550000
3	0.1870000	0.187	0.1870	0.1870000	0.1870	0.187	0.1870000	0.1870000

```
  4 0.2230000 0.223 0.2230 0.2230000 0.2230 0.223 0.2230000 0.2230000
  5 0.2390000 0.239 0.2390 0.2390000 0.2390 0.239 0.2390000 0.2390000
  6 0.2760000 0.276 0.2760 0.2760000 0.2760 0.276 0.2760000 0.2760000
  7 0.2990000 0.299 0.2990 0.2990000 0.2990 0.299 0.2990000 0.2990000
  8 0.3077143 0.306 0.3096 0.3068571 0.3072 0.307 0.3074043 0.3091429
   year
age       1984       1985      1986       1987       1988        1989
  0 0.01733333 0.01566667 0.0140000 0.00900000 0.00800000 0.008666667
  1 0.05666667 0.05633333 0.0610000 0.05033333 0.04833333 0.043666667
  2 0.15033333 0.13800000 0.1300000 0.12166667 0.12300000 0.122333333
  3 0.19033333 0.18700000 0.1833333 0.17000000 0.16633333 0.165333333
  4 0.22966667 0.23233333 0.2316667 0.21233333 0.20833333 0.204666667
  5 0.24333333 0.24666667 0.2520000 0.23000000 0.22900000 0.228333333
  6 0.28200000 0.27466667 0.2730000 0.24200000 0.24833333 0.252333333
  7 0.31066667 0.32100000 0.3146667 0.27466667 0.25866667 0.261333333
  8 0.34351178 0.35438242 0.3627746 0.30562963 0.28535714 0.288595745
   year
age       1990       1991       1992        1993        1994       1995
  0 0.01233333 0.01133333 0.01033333 0.005666667 0.007333333 0.00600000
  1 0.05200000 0.05900000 0.06366667 0.061000000 0.060000000 0.05733333
  2 0.12566667 0.13900000 0.13666667 0.134000000 0.126333333 0.12933333
  3 0.17433333 0.18366667 0.19400000 0.184333333 0.191666667 0.18566667
  4 0.21166667 0.21200000 0.21400000 0.213000000 0.214333333 0.21066667
  5 0.24366667 0.23866667 0.23433333 0.234333333 0.239666667 0.22433333
  6 0.27066667 0.26533333 0.25300000 0.261666667 0.274666667 0.26800000
  7 0.28366667 0.27966667 0.27166667 0.272666667 0.291333333 0.29333333
  8 0.30788452 0.30953886 0.29870453 0.307936434 0.320523728 0.32614016
   year
age      1996       1997        1998       1999        2000       2001
  0 0.0060000 0.00500000 0.005666667 0.00600000 0.005666667 0.00600000
  1 0.0540000 0.04866667 0.047333333 0.05066667 0.051333333 0.05066667
  2 0.1296667 0.12333333 0.116000000 0.11600000 0.115666667 0.12166667
  3 0.1993333 0.18333333 0.187333333 0.17933333 0.183666667 0.17166667
  4 0.2273333 0.23033333 0.241333333 0.22633333 0.221333333 0.21000000
  5 0.2343333 0.23733333 0.264333333 0.25600000 0.248333333 0.23266667
  6 0.2736667 0.25666667 0.283666667 0.27333333 0.278666667 0.25533333
  7 0.3006667 0.28033333 0.286666667 0.27600000 0.286000000 0.27466667
  8 0.3270679 0.31004007 0.308339011 0.27811880 0.284171183 0.27449422
   year
age        2002        2003        2004        2005        2006       2007
  0 0.006333333 0.006666667 0.006666667 0.005666667 0.006666667 0.00600000
  1 0.047333333 0.047000000 0.042000000 0.041333333 0.041000000 0.05133333
  2 0.128000000 0.123000000 0.119333333 0.118000000 0.125666667 0.12800000
  3 0.171666667 0.173000000 0.165333333 0.164333333 0.155333333 0.16066667
  4 0.205333333 0.202333333 0.202666667 0.198000000 0.191000000 0.17966667
  5 0.228333333 0.222000000 0.223000000 0.224666667 0.216000000 0.20700000
  6 0.248333333 0.242333333 0.247666667 0.248000000 0.242000000 0.22366667
  7 0.270333333 0.265666667 0.267666667 0.265000000 0.252333333 0.23800000
  8 0.286521182 0.284946134 0.280490193 0.284851772 0.270150625 0.25639104
   year
age       2008        2009        2010        2011       2012       2013
  0 0.00800000 0.007333333 0.007333333 0.006666667 0.00600000 0.00600000
  1 0.05766667 0.061333333 0.052000000 0.043000000 0.04033333 0.04033333
```

age						
2	0.13033333	0.137333333	0.142333333	0.145666667	0.13800000	0.13566667
3	0.16433333	0.181000000	0.190333333	0.187333333	0.18200000	0.17466667
4	0.18066667	0.196666667	0.216000000	0.225000000	0.21133333	0.20866667
5	0.19533333	0.210000000	0.223666667	0.239666667	0.23300000	0.22133333
6	0.21766667	0.222666667	0.234333333	0.243666667	0.24100000	0.24200000
7	0.22600000	0.233666667	0.240000000	0.250666667	0.24266667	0.24933333
8	0.25556215	0.255734029	0.260650879	0.257270953	0.25251076	0.25179433

age \ year	2014	2015	2016	2017	2018
0	0.005666667	0.005333333	0.00500000	0.004166667	0.004566667
1	0.043333333	0.043666667	0.04333333	0.042866667	0.039966667
2	0.128666667	0.127333333	0.12100000	0.110866667	0.101300000
3	0.176666667	0.161333333	0.16033333	0.153166667	0.152966667
4	0.203666667	0.200000000	0.18866667	0.182966667	0.185766667
5	0.215666667	0.211666667	0.21600000	0.207100000	0.215033333
6	0.228666667	0.224666667	0.22433333	0.226533333	0.229200000
7	0.241333333	0.229000000	0.22433333	0.227066667	0.238766667
8	0.246572539	0.239358137	0.23372066	0.229232697	0.246755779

Table 2.6.3.4 North Sea Herring. NATURAL MORTALITY

Units : NA

age \ year	1947	1948	1949	1950	1951	1952	1953
0	0.8156160	0.8156160	0.8156160	0.8156160	0.8156160	0.8156160	0.8156160
1	0.6679101	0.6679101	0.6679101	0.6679101	0.6679101	0.6679101	0.6679101
2	0.4406172	0.4406172	0.4406172	0.4406172	0.4406172	0.4406172	0.4406172
3	0.3879247	0.3879247	0.3879247	0.3879247	0.3879247	0.3879247	0.3879247
4	0.3611933	0.3611933	0.3611933	0.3611933	0.3611933	0.3611933	0.3611933
5	0.3444702	0.3444702	0.3444702	0.3444702	0.3444702	0.3444702	0.3444702
6	0.3356422	0.3356422	0.3356422	0.3356422	0.3356422	0.3356422	0.3356422
7	0.3302643	0.3302643	0.3302643	0.3302643	0.3302643	0.3302643	0.3302643
8	0.3295564	0.3295564	0.3295564	0.3295564	0.3295564	0.3295564	0.3295564

age \ year	1954	1955	1956	1957	1958	1959	1960
0	0.8156160	0.8156160	0.8156160	0.8156159	0.8156160	0.8156159	0.8156161
1	0.6679101	0.6679101	0.6679101	0.6679101	0.6679100	0.6679103	0.6679096
2	0.4406172	0.4406172	0.4406172	0.4406172	0.4406171	0.4406172	0.4406171
3	0.3879247	0.3879247	0.3879247	0.3879247	0.3879247	0.3879248	0.3879246
4	0.3611933	0.3611933	0.3611933	0.3611933	0.3611933	0.3611933	0.3611933
5	0.3444702	0.3444702	0.3444702	0.3444702	0.3444702	0.3444702	0.3444702
6	0.3356422	0.3356422	0.3356422	0.3356422	0.3356422	0.3356421	0.3356422
7	0.3302643	0.3302643	0.3302643	0.3302643	0.3302643	0.3302642	0.3302644
8	0.3295564	0.3295564	0.3295564	0.3295564	0.3295564	0.3295564	0.3295565

age \ year	1961	1962	1963	1964	1965	1966	1967
0	0.8156157	0.8156166	0.8156147	0.8156185	0.8156109	0.8156261	0.8155957
1	0.6679110	0.6679082	0.6679138	0.6679026	0.6679251	0.6678800	0.6679703
2	0.4406174	0.4406167	0.4406182	0.4406151	0.4406213	0.4406090	0.4406336
3	0.3879249	0.3879243	0.3879256	0.3879230	0.3879282	0.3879177	0.3879387

```
  4 0.3611934 0.3611931 0.3611936 0.3611926 0.3611947 0.3611905 0.3611990
  5 0.3444702 0.3444702 0.3444702 0.3444702 0.3444702 0.3444702 0.3444702
  6 0.3356421 0.3356424 0.3356418 0.3356430 0.3356406 0.3356454 0.3356358
  7 0.3302641 0.3302646 0.3302637 0.3302654 0.3302620 0.3302688 0.3302552
  8 0.3295563 0.3295567 0.3295559 0.3295575 0.3295542 0.3295609 0.3295474
   year
age      1968      1969      1970      1971      1972      1973      1974
  0 0.8156566 0.8155348 0.8157783 0.8152912 0.8162654 0.8143171 0.8182138
  1 0.6677896 0.6681510 0.6674282 0.6688739 0.6659825 0.6717652 0.6601998
  2 0.4405844 0.4406828 0.4404859 0.4408797 0.4400921 0.4416673 0.4385170
  3 0.3878968 0.3879806 0.3878129 0.3881483 0.3874775 0.3888192 0.3861357
  4 0.3611820 0.3612159 0.3611480 0.3612838 0.3610122 0.3615555 0.3604690
  5 0.3444703 0.3444701 0.3444704 0.3444698 0.3444710 0.3444687 0.3444733
  6 0.3356550 0.3356165 0.3356934 0.3355396 0.3358473 0.3352320 0.3364625
  7 0.3302824 0.3302281 0.3303366 0.3301196 0.3305537 0.3296854 0.3314221
  8 0.3295745 0.3295202 0.3296288 0.3294117 0.3298458 0.3289777 0.3307138
   year
age      1975      1976      1977      1978      1979      1980      1981
  0 0.8104203 0.8057025 0.8047344 0.8064925 0.8102209 0.8172173 0.8274914
  1 0.6833306 0.7028286 0.7182187 0.7301416 0.7391092 0.7443256 0.7458190
  2 0.4448176 0.4496803 0.4530271 0.4549542 0.4555319 0.4544437 0.4517433
  3 0.3915027 0.3953336 0.3974290 0.3980001 0.3972606 0.3948411 0.3907612
  4 0.3626420 0.3638296 0.3639133 0.3629697 0.3611322 0.3583281 0.3545417
  5 0.3444641 0.3438615 0.3425790 0.3406726 0.3382412 0.3352751 0.3317545
  6 0.3340014 0.3313040 0.3283186 0.3250641 0.3216048 0.3180074 0.3142432
  7 0.3279486 0.3243595 0.3206191 0.3167357 0.3127549 0.3087363 0.3046563
  8 0.3272416 0.3236265 0.3198121 0.3158315 0.3117531 0.3076064 0.3033674
   year
age      1982      1983      1984      1985      1986      1987      1988
  0 0.8383555 0.8590581 0.8809267 0.8934130 0.9037276 0.9089402 0.9055544
  1 0.7453371 0.7391267 0.7304259 0.7230871 0.7138885 0.7044524 0.6956670
  2 0.4480561 0.4428878 0.4366100 0.4275364 0.4159904 0.4069106 0.3996457
  3 0.3858179 0.3782072 0.3694208 0.3592993 0.3472028 0.3381516 0.3327748
  4 0.3499919 0.3438174 0.3366285 0.3266155 0.3141998 0.3051551 0.3001102
  5 0.3277630 0.3228028 0.3171952 0.3096474 0.3004945 0.2934900 0.2889626
  6 0.3102333 0.3057392 0.3008707 0.2945230 0.2870705 0.2811765 0.2771440
  7 0.3004356 0.2958686 0.2910635 0.2850467 0.2781549 0.2727453 0.2690913
  8 0.2990244 0.2941664 0.2890815 0.2833436 0.2770111 0.2718492 0.2681644
   year
age      1989      1990      1991      1992      1993      1994      1995
  0 0.8969649 0.8905781 0.8847789 0.8765258 0.8710855 0.8653465 0.8611988
  1 0.6872170 0.6789194 0.6670819 0.6525472 0.6419350 0.6322777 0.6253381
  2 0.3924870 0.3887871 0.3910214 0.3965857 0.4012131 0.4062928 0.4119019
  3 0.3287391 0.3266214 0.3289607 0.3346403 0.3387533 0.3412051 0.3434764
  4 0.2964264 0.2949764 0.2990174 0.3070347 0.3127427 0.3169675 0.3205615
  5 0.2852925 0.2833107 0.2848702 0.2889228 0.2919481 0.2950066 0.2978004
  6 0.2738176 0.2716721 0.2719104 0.2738530 0.2751515 0.2759697 0.2768056
  7 0.2661460 0.2642858 0.2646607 0.2666571 0.2680060 0.2687452 0.2695653
  8 0.2651373 0.2628437 0.2619613 0.2622382 0.2623560 0.2617543 0.2614389
   year
age      1996      1997      1998      1999      2000      2001      2002
  0 0.8644131 0.8714153 0.8809581 0.8953693 0.9138225 0.9303382 0.9462271
  1 0.6266946 0.6323094 0.6414736 0.6612056 0.6887892 0.7089131 0.7237124
```

```
  2 0.4148836 0.4175451 0.4218480 0.4291405 0.4376797 0.4447908 0.4528783
  3 0.3428210 0.3407633 0.3411658 0.3447208 0.3494167 0.3550605 0.3641446
  4 0.3193077 0.3158974 0.3144479 0.3140061 0.3129517 0.3144011 0.3206260
  5 0.2970118 0.2949494 0.2944949 0.2949689 0.2952192 0.2974189 0.3032716
  6 0.2759604 0.2744636 0.2745619 0.2760781 0.2779683 0.2811793 0.2871590
  7 0.2692426 0.2684613 0.2687931 0.2699709 0.2713117 0.2737630 0.2783370
  8 0.2612232 0.2610349 0.2620768 0.2649014 0.2687185 0.2727170 0.2774175
   year
age      2003      2004      2005      2006      2007      2008      2009
  0 0.9636406 0.9778611 0.9924404 1.0051537 1.0126169 1.0176157 1.0160229
  1 0.7391891 0.7458320 0.7351250 0.7212731 0.7089871 0.6927028 0.6815790
  2 0.4623603 0.4675825 0.4670940 0.4651993 0.4606177 0.4534194 0.4486089
  3 0.3756800 0.3842515 0.3917235 0.3982069 0.3992761 0.3979235 0.3972307
  4 0.3294129 0.3371511 0.3469816 0.3567311 0.3614871 0.3648674 0.3680856
  5 0.3111539 0.3182483 0.3270457 0.3358458 0.3408919 0.3449711 0.3487946
  6 0.2949874 0.3020598 0.3098954 0.3176953 0.3228500 0.3272613 0.3316144
  7 0.2843214 0.2900766 0.2964710 0.3030145 0.3082212 0.3132112 0.3182143
  8 0.2830219 0.2882408 0.2937930 0.2992683 0.3031155 0.3064383 0.3102376
   year
age      2010      2011      2012      2013      2014      2015      2016
  0 1.0077651 0.9945248 0.9758610 0.9522143 0.9234139 0.8891311 0.8495409
  1 0.6742762 0.6682724 0.6657074 0.6645925 0.6661190 0.6716350 0.6800092
  2 0.4455843 0.4427270 0.4410072 0.4395108 0.4388913 0.4398892 0.4419012
  3 0.3969625 0.3960316 0.3949324 0.3931928 0.3911678 0.3893188 0.3873211
  4 0.3710640 0.3734170 0.3753545 0.3766790 0.3775302 0.3781232 0.3783272
  5 0.3522990 0.3552698 0.3578357 0.3598761 0.3615013 0.3628765 0.3639009
  6 0.3358301 0.3397322 0.3434756 0.3469157 0.3501437 0.3532930 0.3562775
  7 0.3231951 0.3281086 0.3330175 0.3378633 0.3426801 0.3475198 0.3523502
  8 0.3144489 0.3187356 0.3232706 0.3278875 0.3326709 0.3377392 0.3430125
   year
age      2017      2018
  0 0.8693360 0.8495409
  1 0.6758221 0.6800092
  2 0.4408952 0.4419012
  3 0.3883200 0.3873211
  4 0.3782252 0.3783272
  5 0.3633887 0.3639009
  6 0.3547852 0.3562775
  7 0.3499350 0.3523502
  8 0.3403759 0.3430125
```

Table 2.6.3.5 North Sea Herring. PROPORTION MATURE

Units : NA

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

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
1	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
2	1	1	1	1	1	1	1	1	1	1	1	0.82	0.82	0.82
3	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00
4	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00
5	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00
6	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00
7	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00
8	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00

age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00
2	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.7	0.75	0.8	0.85
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	0.93
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00

age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0	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
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
2	0.82	0.91	0.86	0.50	0.47	0.73	0.67	0.61	0.64	0.64	0.69	0.67	0.77	0.87
3	0.94	0.97	0.99	0.99	0.61	0.93	0.95	0.98	0.94	0.89	0.91	0.96	0.92	0.97
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
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
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
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
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

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	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
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
2	0.43	0.70	0.76	0.66	0.71	0.86	0.89	0.45	0.87	0.91	0.83	0.85	0.70	0.71
3	0.93	0.65	0.96	0.88	0.92	0.98	1.00	0.90	0.84	0.99	0.96	1.00	0.90	0.89

```
  4 1.00 1.00 0.96 0.98 0.93 0.99 1.00 1.00 1.00 1.00 0.98 1.00 0.96 0.95
  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
  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
  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
  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
   year
age 2017 2018
  0 0.00 0.00
  1 0.00 0.00
  2 0.55 0.37
  3 0.96 0.91
  4 0.97 0.98
  5 1.00 1.00
  6 1.00 1.00
  7 1.00 1.00
  8 1.00 1.00
```

Table 2.6.3.6 North Sea Herring. FRACTION OF HARVEST BEFORE SPAWNING

```
Units  :  NA
   year
age 1947 ...  2018
  0 0.67      0.67
  1 0.67      0.67
  2 0.67      0.67
  3 0.67      0.67
  4 0.67      0.67
  5 0.67      0.67
  6 0.67      0.67
  7 0.67      0.67
  8 0.67      0.67
```

Table 2.6.3.7 North Sea Herring. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

```
Units  :  NA
   year
age 1947 ...  2018
  0 0.67      0.67
  1 0.67      0.67
  2 0.67      0.67
  3 0.67      0.67
  4 0.67      0.67
  5 0.67      0.67
  6 0.67      0.67
  7 0.67      0.67
  8 0.67      0.67
```

Table 2.6.3.8 North Sea Herring. SURVEY INDICES

HERAS - Configuration

Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) (13/Mar/2018 17:31) .
Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	8.00	8.00	1989.00	2018.00	0.54	0.56

Index type : number

HERAS - Index Values

Units : NA

age	1989	1990	1991	1992	1993	1994	1995	1996
1	-1	-1	-1	-1	-1	-1	-1	-1
2	4090000	3306000	2634000	3734000	2984000	3185000	3849000	4497000
3	3903000	3521000	1700000	1378000	1637000	839000	2041000	2824000
4	1633000	3414000	1959000	1147000	902000	399000	672000	1087000
5	492000	1366000	1849000	1134000	741000	381000	299000	311000
6	283000	392000	644000	1246000	777000	321000	203000	99000
7	120000	210000	228000	395000	551000	326000	138000	83000
8	66000	176000	145000	218000	296000	350000	212000	339000

age	1997	1998	1999	2000	2001	2002	2003	2004
1	9361000	4449000	5087000	24736000	6837000	23055000	9829400	5183700
2	5960000	5747000	3078000	2923000	12290000	4875000	18949400	3415900
3	2935000	2520000	4725000	2156000	3083000	8220000	3081000	9191800
4	1441000	1625000	1116000	3140000	1462000	1390000	4188900	2167300
5	601000	982000	506000	1007000	1676000	794600	675100	2590700
6	215000	445000	314000	483000	450000	1031000	494800	317100
7	46000	170000	139000	266000	170000	244400	568300	327600
8	237000	166000	141000	217000	157000	270500	323200	527650

age	2005	2006	2007	2008	2009	2010	2011	2012
1	3114100	6822800	6261000	3714000	4655000	14577000	10119000	7437000
2	2055100	3772300	2750000	2853000	5632000	4237000	4166000	4719000
3	3648500	1997200	1848000	1709000	2553000	4216000	2534000	4067000
4	5789600	2097500	898000	1485000	1023000	2453000	2173000	1738000
5	1212900	4175100	806000	809000	1077000	1246000	1016000	1209000
6	1174900	618200	1323000	712000	674000	1332000	651000	593000
7	139900	562100	243000	1749000	638000	688000	688000	247000
8	233200	154700	217000	455000	1720000	2729000	1737000	696000

age	2013	2014	2015	2016	2017	2018
1	6388000	11634000	6714000	9034000	3054000	9938000
2	2683000	4918000	9495000	12011000	1761000	4254000
3	3031000	2827000	2831000	5832000	6095000	1692000
4	2895000	2939000	1591000	1273000	3142000	5150000
5	1546000	1791000	1549000	822000	787000	2440000
6	849000	1236000	926000	909000	365000	719000
7	464000	669000	520000	395000	298000	529000
8	842000	461000	496000	366000	293000	404000

IBTS-Q1 - Configuration

```
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) (13/Mar/2018 17:31) .
Imported from VPA file.
         min          max    plusgroup      minyear      maxyear
   1.0000000    1.0000000           NA 1984.0000000 2019.0000000
      startf         endf
   0.1008259    0.1008259
Index type : number
```

IBTS-Q1 - Index Values

```
Units  :  NA
   year
age    1984    1985    1986    1987    1988    1989     1990    1991
  1 1183824 1761019 1944621 3737913 1800985 1969284 905937.3 1284049
   year
age    1992    1993    1994    1995    1996    1997    1998     1999
  1 1345606 2213999 3260479 2671352 1493010 2166324 1945292 799496.3
   year
age    2000    2001    2002    2003     2004    2005     2006    2007
  1 2476525 1891274 2096503 1577394 856713.3 1073097 832198.3 1016684
   year
age     2008     2009    2010    2011     2012     2013    2014    2015
  1 896865.2 845210.2 1066098 1867168 956023.3 584592.2 1902857 2271779
   year
age     2016    2017     2018    2019
  1 659354.3 1583103 810957.2 1097713
```

IBTS0 - Configuration

```
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) (13/Mar/2018 17:31) .
Imported from VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      0.00        NA   1992.00   2019.00      0.08      0.17
Index type : number
```

IBTS0 - Index Values

```
Units  :  NA
   year
age     1992     1993     1994     1995    1996     1997     1998     1999
  0 164.0899 195.7571 155.1368 170.4691 106.264 134.6798 51.71666 255.4222
   year
age     2000     2001     2002     2003     2004     2005     2006
  0 109.8237 341.3018 150.7038 70.83748 43.88171 82.06045 64.41743
   year
age     2007     2008     2009     2010     2011     2012     2013
  0 50.91532 39.53371 99.18411 74.10116 77.63466 65.07967 61.17656
   year
age     2014     2015     2016     2017     2018     2019
  0 113.7963 21.76008 81.69031 27.83202 102.1129 51.62587
```

IBTS-Q3 - Configuration

```
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) (13/Mar/2018 17:31) .
Imported from VPA file.
        min          max    plusgroup      minyear      maxyear
   0.0000000    5.0000000           NA 1998.0000000 2018.0000000
      startf         endf
   0.6084662    0.6084662
Index type : number
```

IBTS-Q3 - Index Values

```
Units  :  NA
   year
age      1998       1999       2000       2001       2002      2003
  0 736601.74 4972332.03 1906224.50 1999130.84 2429793.66 969337.07
  1 503116.29  335340.88  884908.89  366278.27 2249516.49 537357.22
  2 295664.01  218744.95  271211.49  229974.57  462271.51 588611.98
  3  97947.77  128557.89  121583.57   97732.25  358071.99 151484.50
  4  26069.94   51915.71   69939.37   43207.59   82500.29 114603.90
  5  10968.11   18172.64   17499.39   25681.82   31901.09  18828.77
   year
age       2004       2005       2006       2007       2008       2009
  0 2316312.94 1185971.32 1145166.63 2472359.75 611072.31 3114966.00
  1  448285.49  445773.12  332771.36  152252.41 175498.86  232951.78
  2  297259.33  118760.62  203191.92   96658.31 118214.70   97866.71
  3  430839.99   85509.40   80358.44  101800.71  60413.30   62699.97
  4   97392.71  100442.35   46358.27   50755.44  35406.44   26467.19
  5   49998.34   31117.92   51925.25   29973.92  18444.29   11648.39
   year
age       2010      2011      2012       2013       2014      2015
  0 1458525.29 904306.31 862989.93 2041832.85 7921339.34 572307.70
  1  581879.00 360794.49 236794.88  294376.27  504621.14 818928.15
  2  180894.77 182921.12  93819.91  144672.53  201905.50 365465.79
  3   82406.95 100642.58  66221.97  122645.81   88459.80 127502.65
  4   36443.07  49896.20  37440.73   84485.75   78276.21  66737.91
  5   14884.50  20846.98  21009.84   38344.82   43240.10  43526.09
   year
age       2016      2017       2018
  0 1863251.77 949196.45 1936647.39
  1  193708.69 317596.11  213373.48
  2  373987.31  78964.29   95044.71
  3  214504.31 200060.41   49447.41
  4   67007.08 127534.76   84363.78
  5   41023.59  39218.35   40977.28
```

LAI-ORSH - Configuration

```
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      1.00      1.00   1972.00   2018.00      0.67      0.67
Index type : partial
```

LAI-ORSH - Index Values

```
Units  :  NA
   year
age 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985
  0 1133 2029  758  371  545 1133 3047 2882 3534 3667 2353 2579 1795 5632
  1 4583  822  421   50   81  221   50 2362  720  277 1116  812 1912 3432
   year
age 1986 1987 1988  1989  1990 1991 1992 1993 1994 1995 1996 1997 1998
  0 3529 7409 7538 11477    -1 1021  189   -1   26   -1   -1   -1   -1
  1 1842 1848 8832  5725 10144 2397 4917   66 1179 8688  809 3611 8528
   year
age 1999 2000  2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
  0   -1   -1    -1   -1   -1   -1   -1 6311   -1 4978   -1   -1   -1
  1 4064 3972 11918 6669 3199 7055 3380 2312 1753 6875 7543 2362 3831
   year
age  2012  2013 2014 2015 2016 2017 2018
  0    -1    -1   -1   -1   -1   -1   -1
  1 19552 21282 6604 9631   -1   -1   -1
```

LAI-BUN - Configuration

```
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      1.00      1.00   1972.00   2018.00      0.67      0.67
Index type : partial
```

LAI-BUN - Index Values

```
Units  :  NA
   year
age 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985
  0   30    3  101  312    0  124   -1  197   21    3  340 3647 2327 2521
  1    0    4  284   -1    1   32  162   10    1   12  257  768 1853 1812
   year
age 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
  0 3278 2551 6812 5879 4590   -1   -1   -1   -1   -1   -1   -1   -1   -1
  1  341  670 5248  692 2045 2032  822  174   -1   -1  184   23 1490  185
   year
age 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
  0   28   -1   -1   -1   -1   -1   -1   -1   -1   -1   -1   -1   -1   -1
  1  155  164 1038 2263 3884 1364  280 1304  533 4629 1493 2839 5856 8618
   year
age 2014 2015 2016 2017 2018
  0   -1   -1   -1   -1   -1
  1 5033 3496 3872 5833 1740
```

LAI-CNS - Configuration

```
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      3.00      3.00   1972.00   2018.00      0.67      0.67
```

Index type : partial

LAI-CNS - Index Values

Units : NA

year

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	165	492	81	-1	64	520	1406	662	317	903	86	1459	688	130
1	88	830	-1	90	108	262	81	131	188	235	64	281	2404	13039
2	134	1213	1184	77	0	89	269	507	9	119	1077	63	824	1794
3	22	152	-1	6	10	3	2	7	13	0	23	-1	433	215

year

age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	1611	799	5533	1442	19965	4823	10	-1	-1	-1	-1	-1	205	-1
1	6112	4927	3808	5010	1239	2110	165	685	1464	-1	564	-1	66	134
2	188	1992	1960	2364	975	1249	163	85	44	43	-1	-1	-1	181
3	36	113	206	2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

year

age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1	376	1604	-1	12018	5545	5614	2259	291	11201	4219	2317	17766	517
2	-1	-1	3291	3277	-1	-1	-1	-1	-1	-1	-1	-1	-1
3	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

year

age	2013	2014	2015	2016	2017	2018
0	-1	-1	-1	-1	-1	-1
1	7354	1149	3424	3288	3965	1509
2	-1	-1	-1	-1	-1	-1
3	-1	-1	-1	-1	-1	-1

LAI-SNS - Configuration

min	max	plusgroup	minyear	maxyear	startf	endf
0.00	2.00	2.00	1972.00	2018.00	0.67	0.67

Index type : partial

LAI-SNS - Index Values

Units : NA

year

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	2	-1	-1	1	-1	1	33	-1	247	1456	710	71	523	1851
1	46	-1	10	2	3	0	3	111	129	-1	275	243	185	407
2	0	1	-1	0	-1	-1	-1	89	40	70	54	58	39	38

year

age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	780	934	1679	1514	2552	4400	176	1358	537	74	337	9374	1522	804
1	123	297	162	2120	1204	873	1616	1103	595	230	675	918	953	1260
2	18	146	112	512	-1	-1	-1	-1	-1	164	691	355	170	344

year

age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	7346	971	2008	12048	6528	498	10858	4443	8426	15295	7493	5461	22768

```
  1  338 5531  260  3109 2052 3999  2700 2439 2317 14712 13230 6160 11103
  2  106  909  925  1116 4175 4822  2106 3854 4008  1689  8073 1215  3285
   year
age 2013 2014 2015  2016  2017 2018
  0    5   -1 2011 20710 10553   -1
  1 9314   -1 1200  1442  5880   -1
  2 2957 1851  645  1545    -1   -1
```

Table 2.6.3.9 North Sea Herring. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2018         2         6
```

Table 2.6.3.10 North Sea Herring. sam CONFIGURATION SETTINGS

```
name           : North Sea Herring
desc            : Imported from a VPA file. ( ./data/index.txt ).  Sat Mar 16 11:07:58
2019
range          :       min       max plusgroup   minyear   maxyear   minfbar   maxfbar
range          :         0         8         8      1947      2019         2         6
fleets         : catch unique        HERAS      IBTS-Q1        IBTS0      IBTS-Q3
fleets         :            0            2            2            2            2
fleets         :     LAI-ORSH      LAI-BUN      LAI-CNS      LAI-SNS
fleets         :            6            6            6            6
plus.group     : TRUE
states         :               age
states         : fleet           0  1  2  3  4  5  6  7  8
states         :   catch unique  0  1  2  3  4  5  6  7  7
states         :   HERAS        -1 -1 -1 -1 -1 -1 -1 -1 -1
states         :   IBTS-Q1      -1 -1 -1 -1 -1 -1 -1 -1 -1
states         :   IBTS0        -1 -1 -1 -1 -1 -1 -1 -1 -1
states         :   IBTS-Q3      -1 -1 -1 -1 -1 -1 -1 -1 -1
states         :   LAI-ORSH     -1 -1 -1 -1 -1 -1 -1 -1 -1
states         :   LAI-BUN      -1 -1 -1 -1 -1 -1 -1 -1 -1
states         :   LAI-CNS      -1 -1 -1 -1 -1 -1 -1 -1 -1
states         :   LAI-SNS      -1 -1 -1 -1 -1 -1 -1 -1 -1
logN.vars      : 0 1 1 1 1 1 1 1 1
logP.vars      : 0 1 2
catchabilities :               age
catchabilities : fleet           0  1  2  3  4  5  6  7  8
catchabilities :   catch unique -1 -1 -1 -1 -1 -1 -1 -1 -1
catchabilities :   HERAS        -1  1  2  3  3  3  3  3  3
catchabilities :   IBTS-Q1      -1  4 -1 -1 -1 -1 -1 -1 -1
catchabilities :   IBTS0         0 -1 -1 -1 -1 -1 -1 -1 -1
catchabilities :   IBTS-Q3       5  6  7  8  9 10 -1 -1 -1
catchabilities :   LAI-ORSH     11 -1 -1 -1 -1 -1 -1 -1 -1
catchabilities :   LAI-BUN      11 -1 -1 -1 -1 -1 -1 -1 -1
```

```
catchabilities :   LAI-CNS      11 -1 -1 -1 -1 -1 -1 -1 -1
catchabilities :   LAI-SNS      11 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :               age
power.law.exps : fleet           0  1  2  3  4  5  6  7  8
power.law.exps :   catch unique -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :   HERAS        -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 :   IBTS0        -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :   IBTS-Q3      -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :   LAI-ORSH     -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :   LAI-BUN      -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :   LAI-CNS      -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :   LAI-SNS      -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars         :               age
f.vars         : fleet           0  1  2  3  4  5  6  7  8
f.vars         :   catch unique  0  0  1  1  1  1  2  2  2
f.vars         :   HERAS        -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars         :   IBTS-Q1      -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars         :   IBTS0        -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars         :   IBTS-Q3      -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars         :   LAI-ORSH     -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars         :   LAI-BUN      -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars         :   LAI-CNS      -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars         :   LAI-SNS      -1 -1 -1 -1 -1 -1 -1 -1 -1
obs.vars       :               age
obs.vars       : fleet           0  1  2  3  4  5  6  7  8
obs.vars       :   catch unique  0  0  1  1  1  1  2  2  2
obs.vars       :   HERAS        -1  3  4  4  4  4  4  5  5
obs.vars       :   IBTS-Q1      -1  6 -1 -1 -1 -1 -1 -1 -1
obs.vars       :   IBTS0         7 -1 -1 -1 -1 -1 -1 -1 -1
obs.vars       :   IBTS-Q3       8  9 10 10 10 10 -1 -1 -1
obs.vars       :   LAI-ORSH     11 -1 -1 -1 -1 -1 -1 -1 -1
obs.vars       :   LAI-BUN      11 -1 -1 -1 -1 -1 -1 -1 -1
obs.vars       :   LAI-CNS      11 -1 -1 -1 -1 -1 -1 -1 -1
obs.vars       :   LAI-SNS      11 -1 -1 -1 -1 -1 -1 -1 -1
srr            : 0
scaleNoYears   : 0
scaleYears     : NA
scalePars      :
cor.F          : 0
cor.obs        : NA -1 -1 -1 0 -1 -1 -1 -1 NA NA -1 -1 0 -1 -1 -1 -1 NA NA -1 -1 0 -1 -1
-1 -1 NA NA -1 -1 0 -1 -1 -1 -1 NA NA -1 -1 0 -1 -1 -1 -1 NA NA -1 -1 -1 -1 -1 -1 -1 NA
NA -1 -1 -1 -1 -1 -1 -1 NA NA -1 -1 -1 -1 -1 -1 -1
cor.obs.Flag   : ID ID ID ID AR ID ID ID ID
biomassTreat   : -1 -1 -1 -1 -1 -1 -1 -1 -1
timeout        : 3600
likFlag        : LN LN LN LN LN LN LN LN LN
fixVarToWeight : FALSE
simulate       : FALSE
residuals      : TRUE
sumFleets      :
```

Table 2.6.3.11 North Sea Herring. FLR, R SOFTWARE VERSIONS

FLSAM.version	2.1.0
FLCore.version	2.6.9
R.version	R version 3.5.2 (2018-12-20)
platform	x86_64-w64-mingw32
run.date	2019-03-16 11:10:54

Table 2.6.3.12 North Sea Herring. STOCK SUMMARY

Year	Recruitment	Low	High	TSB	Low	High	SSB	Low	High	Fbar	Low	High	Landings	Landings
	Age 0									(Ages 2-6)				SOP
										f	f	f	tonnes	
1947	56498843	30620640	104247309	9606501	7210950	12797880	5499127	3921926	7710598	0.1202	0.0809	0.1785	581760	1.4609
1948	56131111	31906700	98747337	8389309	6325501	11126471	4474572	3211959	6233517	0.1199	0.0832	0.1726	502100	1.3326
1949	50827034	29110164	88745203	8202009	6229780	10798608	4340323	3154805	5971337	0.1316	0.0918	0.1886	508500	1.4502
1950	69744880	40862620	119041518	8194126	6275345	10699603	4292964	3158431	5835029	0.1383	0.0984	0.1943	491700	1.3073
1951	62253823	36950804	104883739	8437900	6505363	10944534	4110431	3037857	5561699	0.1674	0.1214	0.2307	600400	1.3238
1952	59223654	35647795	98391534	8217672	6340386	10650794	4115723	3030463	5589635	0.1696	0.1223	0.2352	664400	1.2720
1953	59817829	37160716	96289123	7871497	6098818	10159421	3893052	2851634	5314796	0.1768	0.1271	0.2459	698500	1.1979
1954	57013588	36110404	90016974	7645433	5950167	9823699	3650056	2657419	5013477	0.1977	0.1414	0.2765	762900	1.2509
1955	48110288	30783785	75188929	7163514	5593932	9173501	3546303	2594784	4846749	0.1948	0.1401	0.2710	806400	1.0598
1956	35317077	22695283	54958376	6468230	5079069	8237336	3280044	2403396	4476454	0.1967	0.1436	0.2694	675200	1.2712
1957	85860021	54954481	134146355	6412407	5087747	8081960	2960955	2179799	4022046	0.2096	0.1534	0.2864	682900	1.1575
1958	32872393	21327397	50666953	6306514	5021727	7920009	2407651	1773153	3269196	0.2190	0.1622	0.2957	670500	1.1674
1959	37590204	23776823	59428606	6855324	5504165	8538165	3582878	2691780	4768969	0.2386	0.1779	0.3199	784500	1.5186
1960	15840010	10045722	24976395	5593026	4519846	6921020	2963112	2238848	3921676	0.2083	0.1577	0.2753	696200	1.1830
1961	70192832	45117348	109204860	5666933	4647609	6909818	2853716	2201424	3699284	0.2437	0.1896	0.3133	696700	1.1348
1962	31786138	20723437	48754390	5193356	4269575	6317011	1996944	1523397	2617693	0.2738	0.2118	0.3539	627800	1.1705
1963	42242324	28200543	63275873	5726691	4749076	6905553	2890983	2266494	3687540	0.1935	0.1514	0.2474	716000	0.8602
1964	44126903	29599452	65784447	5704432	4902714	6637253	2637471	2146847	3240220	0.2842	0.2336	0.3456	871200	1.0656
1965	21543007	14426084	32170971	5119294	4491825	5834415	2127516	1775531	2549279	0.4737	0.3935	0.5702	1168800	1.1496
1966	22437282	15239848	33033900	3788113	3351346	4281801	1627149	1367011	1936789	0.4827	0.4088	0.5698	895500	1.0707
1967	28707627	19583756	42082215	2932396	2612121	3291940	1030211	876347	1211088	0.6403	0.5462	0.7506	695500	1.1757
1968	29523424	20089552	43387356	2525017	2219929	2872033	572620	485464	675423	0.9759	0.8329	1.1436	717800	1.2551
1969	13917587	9291194	20847614	1908024	1655079	2199627	495461	401913	610783	0.8695	0.7420	1.0188	546700	0.9674
1970	29134241	19823998	42816992	1866419	1622797	2146614	476038	384571	589260	0.9354	0.8082	1.0826	563100	0.9657
1971	22495314	15547340	32548280	1725102	1487553	2000585	327242	267550	400253	1.2768	1.0977	1.4850	520100	1.0747
1972	15700734	10873732	22670509	1525825	1326524	1755069	332972	271597	408217	0.6593	0.5564	0.7813	497500	0.9197
1973	7943077	5454630	11566774	1215162	1073350	1375711	296816	245365	359056	0.8735	0.7562	1.0091	484000	0.9575
1974	14125092	9519630	20958611	873783	764106	999201	199400	166314	239069	0.8749	0.7526	1.0170	275100	0.9680
1975	3234709	2120580	4934189	703078	591377	835878	114031	93368	139268	1.0492	0.8666	1.2703	312800	0.9343
1976	4172725	2648909	6573135	507825	424717	607195	152997	114926	203679	0.8144	0.6262	1.0592	174800	0.9530
1977	5007480	3092230	8108989	350528	280200	438508	103059	74928	141752	0.3691	0.2722	0.5006	46000	1.1979
1978	5351563	3213764	8911428	422916	330133	541777	136726	100538	185942	0.2652	0.1909	0.3685	11000	1.2152
1979	10154904	6327825	16296608	559792	444963	704254	180923	137973	237243	0.2170	0.1581	0.2980	25100	1.0056
1980	15476298	10488097	22836918	758817	614997	936270	198388	156486	251510	0.1918	0.1512	0.2433	70764	1.0936
1981	36915280	25882473	52650991	1367608	1112296	1681523	298043	234631	378593	0.2134	0.1695	0.2687	174879	1.0081
1982	58525556	41480591	82574539	2088227	1701799	2562402	416941	331573	524289	0.1890	0.1510	0.2364	275079	0.9786
1983	57946932	41779245	80371172	2880920	2385997	3478504	636454	508532	796554	0.2348	0.1899	0.2903	387202	1.0771
1984	55810044	39556240	78742596	3737447	3153966	4428871	1063317	850072	1330055	0.3046	0.2484	0.3734	428631	1.0543

1985	67271137	46873404	96545278	4267288	3637854	5005628	1161899	944100	1429942	0.3842	0.3117	0.4736	613780	1.0419
1986	81400120	56476345	117323095	4792740	4070076	5643718	1178763	966922	1437016	0.3608	0.2945	0.4420	671488	1.1373
1987	78363264	54933974	111785125	4855865	4152448	5678440	1401032	1148329	1709345	0.3474	0.2860	0.4221	792058	1.0173
1988	44888160	31394064	64182416	4730061	4077637	5486875	1834721	1506527	2234411	0.3287	0.2719	0.3974	887686	1.1641
1989	37759805	26470260	53864330	4127771	3616380	4711477	1875132	1582179	2222327	0.3163	0.2644	0.3785	787899	1.0335
1990	31642520	21947133	45620950	4063191	3565240	4630690	1977732	1675189	2334914	0.2599	0.2159	0.3128	645229	1.0515
1991	35056748	24507867	50146167	3862999	3388321	4404176	1749100	1485708	2059187	0.2848	0.2378	0.3411	658008	1.0197
1992	65995432	48296353	90180662	3942160	3442500	4514344	1367746	1157046	1616815	0.3154	0.2622	0.3794	716799	0.9950
1993	68551684	49507263	94922101	3701372	3188302	4297005	997149	835950	1189432	0.3564	0.2959	0.4293	671397	1.0231
1994	52883203	37595401	74387639	3591860	3042023	4241078	1062653	889581	1269397	0.3709	0.3080	0.4467	568234	1.0498
1995	61076456	43597797	85562431	3520559	2983411	4154417	1137472	943837	1370833	0.3212	0.2629	0.3925	579371	1.0084
1996	50221463	35941421	70175170	3459214	2934664	4077524	1257945	1046952	1511459	0.1841	0.1463	0.2316	275098	0.9987
1997	39918411	28334610	56237919	3529498	3011553	4136523	1422790	1189096	1702413	0.1675	0.1357	0.2069	264313	1.0006
1998	25190062	18165504	34931000	3821681	3288631	4441132	1667748	1407251	1976465	0.1920	0.1572	0.2344	391628	1.0018
1999	80033627	57682107	111046247	3795927	3283609	4388179	1714787	1447404	2031565	0.1850	0.1523	0.2248	363163	1.0000
2000	54550943	39602297	75142241	4668472	4008258	5437433	1775676	1500791	2100909	0.1861	0.1532	0.2261	388157	1.0004
2001	101911822	72472174	143310443	5272611	4526414	6141822	2260925	1911336	2674455	0.1617	0.1320	0.1981	374065	0.9901
2002	49214248	35455231	68312690	6235461	5321187	7306824	2670349	2257415	3158818	0.1511	0.1230	0.1855	394709	0.9974
2003	27618571	19952416	38230231	6587881	5651521	7679380	2743141	2332247	3226426	0.1779	0.1458	0.2171	482281	1.0153
2004	32210582	23242587	44638819	5525183	4787041	6377142	2666900	2268245	3135620	0.2222	0.1795	0.2751	587698	0.9985
2005	29939013	21795786	41124670	4637352	4043810	5318013	2459492	2083990	2902652	0.2400	0.1947	0.2960	663813	1.0033
2006	27222228	19707704	37602032	3924472	3423446	4498826	2003189	1699934	2360543	0.2135	0.1733	0.2631	514597	0.9950
2007	31275814	22313507	43837866	3270134	2838327	3767634	1624274	1375888	1917500	0.1855	0.1501	0.2291	406482	1.0056
2008	29088826	20825130	40631670	3306520	2850154	3835960	1691045	1433299	1995141	0.1164	0.0955	0.1419	257870	1.0040
2009	47585226	34220233	66170028	3773138	3238403	4396169	1986853	1679150	2350941	0.0678	0.0542	0.0848	168443	1.0023
2010	38129806	27593327	52689628	4582165	3934257	5336772	2103979	1767809	2504076	0.0720	0.0586	0.0884	187611	1.0034
2011	34223670	24825811	47179108	4617809	3997698	5334110	2527300	2159041	2958372	0.0935	0.0767	0.1140	226478	0.9938
2012	32791167	23699940	45369761	4629001	4023237	5325973	2682517	2291650	3140051	0.1519	0.1243	0.1856	434710	1.0109
2013	40829468	29131873	57224108	4470275	3903649	5119149	2450179	2097507	2862148	0.1791	0.1464	0.2190	511416	1.0014
2014	65480092	46469608	92267671	4772852	4158357	5478153	2382257	2036402	2786850	0.1823	0.1494	0.2223	517356	1.0029
2015	17336518	12345488	24345321	5039562	4349746	5838773	2207598	1884709	2585804	0.1890	0.1518	0.2354	494099	1.0017
2016	32864572	23764831	45448677	4976585	4275864	5792139	2596513	2198151	3067069	0.1958	0.1573	0.2438	563610	1.0000
2017	20022379	14043056	28547607	4125961	3549110	4796571	2214966	1853509	2646911	0.1792	0.1449	0.2218	498437	1.0013
2018	36780645	24968423	54181069	3808857	3232792	4487574	1870362	1518929	2303106	0.2083	0.1632	0.2658	603536	1.0015
2019	26191234	14436771	47516219	3243613	2585965	4068511	1454934	1090442	1941261	0.2083	0.1310	0.3311		

Table 2.6.3.13 North Sea Herring. ESTIMATED FISHING MORTALITY

Units : f

age \ year	1947	1948	1949	1950	1951
0	0.0038661741	0.0038662635	0.0038676221	0.003863291	0.003864838
1	0.0002098233	0.0002098233	0.0009181941	0.004018362	0.017558989
2	0.0424970463	0.0319309926	0.0403457560	0.053293389	0.079736246
3	0.0912614961	0.1052793472	0.1085242628	0.121412008	0.144898098
4	0.0985225772	0.1087694263	0.1164251562	0.144906319	0.199024504
5	0.1339668466	0.1424411147	0.1492052864	0.148456334	0.199266141
6	0.2345331861	0.2108477341	0.2435877214	0.223369315	0.213920148
7	0.2418795492	0.2339693985	0.3026499558	0.238360684	0.213387269
8	0.2418795492	0.2339693985	0.3026499558	0.238360684	0.213387269

```
    year
age        1952        1953        1954        1955        1956
  0 0.003865515 0.003865372 0.005289537 0.004921243 0.004171613
  1 0.035354971 0.054507651 0.075824545 0.115973417 0.118790273
  2 0.111221338 0.133454174 0.160285163 0.191426319 0.240727208
  3 0.129706337 0.159378397 0.201779790 0.204962636 0.211341119
  4 0.172272203 0.166798611 0.170308933 0.172121970 0.182093352
  5 0.189643470 0.185633608 0.200369491 0.174985448 0.164451316
  6 0.244995088 0.238827195 0.255827470 0.230554862 0.184684729
  7 0.298467993 0.280197650 0.323562492 0.176964932 0.200123751
  8 0.298467993 0.280197650 0.323562492 0.176964932 0.200123751
    year
age        1957        1958        1959       1960       1961        1962
  0 0.004683415 0.004779727 0.009000079 0.01708684 0.02184032 0.008357611
  1 0.148446919 0.139758260 0.168802750 0.17490714 0.10235820 0.096209595
  2 0.230769348 0.253565188 0.284151084 0.28493838 0.31544371 0.197236911
  3 0.216028018 0.247308253 0.247310882 0.21052883 0.24009517 0.321303257
  4 0.189465994 0.182028330 0.219959134 0.18000616 0.23008441 0.279953377
  5 0.209871019 0.233408354 0.215188430 0.15884462 0.20917331 0.259917987
  6 0.201995179 0.178614180 0.226257754 0.20741318 0.22383356 0.310412202
  7 0.207992203 0.131055807 0.231430460 0.24866003 0.19644619 0.268994385
  8 0.207992203 0.131055807 0.231430460 0.24866003 0.19644619 0.268994385
    year
age       1963       1964       1965       1966       1967       1968
  0 0.01434202 0.01569993 0.01237093 0.02344326 0.03224588 0.03619225
  1 0.12876105 0.23296138 0.23865661 0.22547150 0.28230872 0.30735982
  2 0.23377283 0.30893292 0.48427202 0.47341294 0.46101161 0.91672083
  3 0.23384228 0.31176011 0.50153155 0.51565315 0.68470867 1.35089733
  4 0.18280909 0.28559700 0.48741846 0.46726029 0.65696694 0.79921522
  5 0.16577602 0.26600996 0.46481070 0.58680520 0.68864602 0.87449193
  6 0.15132524 0.24856125 0.43053844 0.37015167 0.71021691 0.93833361
  7 0.15834006 0.20263480 0.46157870 0.55571962 0.94617856 1.14944834
  8 0.15834006 0.20263480 0.46157870 0.55571962 0.94617856 1.14944834
    year
age       1969       1970       1971       1972       1973       1974
  0 0.01579872 0.04027013 0.04683482 0.06684017 0.06067618 0.09978477
  1 0.32174722 0.31670313 0.56605303 0.59045575 0.64750393 0.48927003
  2 0.70671094 0.77171172 0.74592531 0.70429489 0.82012018 0.85328377
  3 0.80181003 0.99287505 0.92840418 0.72588849 0.98090840 0.82546871
  4 0.75197970 0.96714238 0.94907720 0.67890078 0.78090078 0.79130625
  5 0.83619094 0.83731167 0.75445327 0.55096336 0.76632178 0.97457008
  6 1.25061482 1.10777171 3.00607256 0.63660476 1.01937475 0.92970974
  7 1.01124709 0.95802464 1.38763493 0.34470995 0.59813915 0.80510541
  8 1.01124709 0.95802464 1.38763493 0.34470995 0.59813915 0.80510541
    year
age      1975       1976       1977      1978      1979       1980
  0 0.1198694 0.08905352 0.08104804 0.1008820 0.1190851 0.14397283
  1 0.5223482 0.20786616 0.12870926 0.1167623 0.1109513 0.09945719
  2 0.9940270 0.69899014 0.18868726 0.1926415 0.2043881 0.21999129
  3 1.0787004 0.95388078 0.51893882 0.3310773 0.2831328 0.25339636
  4 0.9714990 0.88212239 0.32059951 0.2553486 0.1989259 0.18411116
  5 1.2642925 0.90953803 0.47763160 0.3457965 0.2885803 0.23402367
  6 0.9375579 0.62756619 0.33977298 0.2011652 0.1101807 0.06763346
```

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  7 1.5244753 0.99234772 0.41815722 0.3491106 0.2501784 0.14571034
  8 1.5244753 0.99234772 0.41815722 0.3491106 0.2501784 0.14571034
   year
age      1981      1982      1983      1984      1985       1986      1987
  0 0.3790312 0.3481326 0.3653219 0.2037279 0.1053484 0.08186219 0.1487193
  1 0.1931539 0.1729455 0.1941994 0.1830232 0.2715018 0.28736046 0.3293834
  2 0.1977607 0.1787028 0.1939369 0.2103835 0.2607749 0.27884497 0.2804539
  3 0.2083509 0.2704849 0.2367794 0.2845386 0.3865792 0.34073400 0.3024146
  4 0.2064171 0.2015985 0.2559786 0.3523707 0.4369316 0.37117973 0.3621733
  5 0.2436061 0.1522824 0.2334168 0.3567532 0.4107788 0.36500382 0.3812674
  6 0.2108298 0.1416916 0.2539085 0.3188318 0.4261175 0.44821426 0.4108958
  7 0.4516399 0.2099404 0.3700967 0.5149909 0.5321671 0.52786866 0.3889579
  8 0.4516399 0.2099404 0.3700967 0.5149909 0.5321671 0.52786866 0.3889579
   year
age      1988      1989       1990      1991      1992      1993      1994
  0 0.1177234 0.1196483 0.07410944 0.1134739 0.2327973 0.2353767 0.1509562
  1 0.4573337 0.3472972 0.35247595 0.2654312 0.2835709 0.2728099 0.1432269
  2 0.2497685 0.2619148 0.24279484 0.3320650 0.3438465 0.3680766 0.3556057
  3 0.2728146 0.2657190 0.23226298 0.2674202 0.2935521 0.3699112 0.3886336
  4 0.3414287 0.3527375 0.27539778 0.2714939 0.3074742 0.3847875 0.5070142
  5 0.3830658 0.3499021 0.29828502 0.2702035 0.2994690 0.3190256 0.3016247
  6 0.3964282 0.3513449 0.25062582 0.2829347 0.3327166 0.3402880 0.3017511
  7 0.4061951 0.3614222 0.28427796 0.2206371 0.3164573 0.3689236 0.2840365
  8 0.4061951 0.3614222 0.28427796 0.2206371 0.3164573 0.3689236 0.2840365
   year
age      1995       1996       1997       1998       1999       2000
  0 0.1687947 0.06725581 0.01955715 0.01726855 0.02806390 0.03049085
  1 0.1345996 0.10859619 0.04291320 0.07114879 0.04405623 0.05132189
  2 0.2525195 0.13467828 0.11838422 0.14472363 0.12268453 0.11924626
  3 0.3562753 0.20690441 0.17367296 0.18422512 0.22061705 0.17439384
  4 0.3496113 0.18403822 0.19413855 0.20114426 0.19388531 0.22269825
  5 0.3668984 0.19506964 0.18226333 0.21449718 0.20132377 0.22482521
  6 0.2807715 0.19973977 0.16917464 0.21524704 0.18665826 0.18953329
  7 0.2555028 0.09686403 0.12978200 0.12003350 0.10728503 0.11317385
  8 0.2555028 0.09686403 0.12978200 0.12003350 0.10728503 0.11317385
   year
age       2001       2002       2003       2004       2005       2006
  0 0.02764159 0.02366436 0.02272897 0.03484553 0.05131387 0.04971467
  1 0.04210166 0.03123226 0.04348625 0.03376312 0.06229266 0.03520171
  2 0.07963210 0.07882749 0.07180531 0.07863036 0.09573269 0.08221436
  3 0.15555868 0.13730315 0.12817111 0.13553384 0.13696618 0.13740312
  4 0.18276319 0.17909833 0.19310517 0.20362299 0.22521775 0.21782266
  5 0.20155476 0.17488475 0.27534712 0.30189423 0.31292837 0.27925252
  6 0.18911555 0.18516021 0.22099824 0.39130647 0.42938667 0.35082425
  7 0.12309150 0.16194949 0.18684813 0.28245081 0.52186381 0.46723093
  8 0.12309150 0.16194949 0.18684813 0.28245081 0.52186381 0.46723093
   year
age       2007       2008       2009       2010       2011       2012
  0 0.03466932 0.03991967 0.02400061 0.02520725 0.03462607 0.03451844
  1 0.03587872 0.03083513 0.02377248 0.02205477 0.01688644 0.03094793
  2 0.06812824 0.07793902 0.05654685 0.05781323 0.05923026 0.07427581
  3 0.14427665 0.08882657 0.04808283 0.06777258 0.08515577 0.13639793
  4 0.19459089 0.12528973 0.07634260 0.07240315 0.09918710 0.15838979
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  5 0.24604275 0.14765894 0.08954221 0.09020184 0.11911432 0.19263406
  6 0.27422981 0.14243047 0.06833312 0.07164222 0.10484653 0.19775562
  7 0.37705869 0.18213992 0.09579685 0.07167322 0.09513919 0.22179500
  8 0.37705869 0.18213992 0.09579685 0.07167322 0.09513919 0.22179500
   year
age       2013       2014       2015       2016       2017       2018
  0 0.02060872 0.03231707 0.04733709 0.06452758 0.03970319 0.05275195
  1 0.04366785 0.02901607 0.02157146 0.02148032 0.02148952 0.01258808
  2 0.07331662 0.07076370 0.05918835 0.05167726 0.04311670 0.04606404
  3 0.12450024 0.12659413 0.09216315 0.12622307 0.14185241 0.11455586
  4 0.18084262 0.19949177 0.16237291 0.17368945 0.20756407 0.25293465
  5 0.23384042 0.24772573 0.26240532 0.25684190 0.21826380 0.31694265
  6 0.28280236 0.26671677 0.36905700 0.37066147 0.28544336 0.31095937
  7 0.33868727 0.34838909 0.50227857 0.62608893 0.47431093 0.53511001
  8 0.33868727 0.34838909 0.50227857 0.62608893 0.47431093 0.53511001
   year
age       2019
  0 0.05286042
  1 0.01259689
  2 0.04606404
  3 0.11455586
  4 0.25293465
  5 0.31694265
  6 0.31095937
  7 0.53511001
  8 0.53511001
```

Table 2.6.3.14 North Sea Herring. ESTIMATED POPULATION ABUNDANCE

```
Units  :  NA
   year
age     1947     1948     1949     1950       1951       1952     1953
  0 56498843 56131111 50827034 69744880 62253823.0 59223654.4 59817829
  1 20124116 24912696 24960383 21503904 32055912.2 27262116.9 25944896
  2 14176580 10317061 14966214 12904080 10544409.2 15507285.7 13042336
  3  5817385  8010399  7550991 10921771  8250421.6  5909396.2  8235633
  4  8168927  3760007  4371523  5438422  7748375.0  4637209.1  3670170
  5  4974061  5312821  2419714  2564945  3902886.9  4449448.3  2708273
  6  4137732  3138543  3334941  1492115  1629215.5  2371668.2  2641210
  7  2336022  2312380  1895938  1852699   864301.2   990039.6  1351357
  8  7079019  5296559  4416593  3331819  2943427.8  2352906.9  1859602
   year
age     1954       1955     1956       1957       1958       1959
  0 57013588 48110288.2 35317077 85860021.2 32872392.6 37590204.4
  1 27411634 24363702.3 21255320 14264551.3 44809877.0 13886715.9
  2 12395440 13643517.7 10410898  9905460.6  5689157.1 23746836.1
  3  7132134  6692307.1  7644136  4637102.3  5355424.5  2637384.0
  4  4484722  3627320.4  3668141  4370854.7  2361066.2  2856691.7
  5  2276278  2497201.1  2004699  2105709.4  2547157.2  1380067.0
  6  1633101  1295567.1  1449731  1251193.6  1152601.1  1368005.4
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```
  7  1517427   903987.9   715244   874487.5   735956.5   689324.7
  8  1866585  1734663.1  1704524  1460359.1  1332053.2  1448605.3
   year
age       1960       1961       1962       1963       1964       1965
  0 15840010.0 70192832.2 31786137.6 42242324.5 44126903.3 21543006.5
  1 18172321.9  5266581.8 33278829.7 14735631.6 17975395.9 19969958.4
  2  5721975.6  8034311.0  2006842.9 17452435.5  7186773.6  6787185.0
  3 12716953.0  2739859.1  3302974.4  1083079.3 10068894.5  3767154.1
  4  1260751.9  8232700.1  1515391.5  1254592.8   699851.4  5762338.0
  5  1440182.5   764922.7  5120766.9   692419.4   752846.7   431590.2
  6   744573.8   941970.5   447419.0  2548986.1   480701.7   429356.0
  7   726760.2   420400.7   589487.6   212643.4  1661522.5   301977.1
  8  1255377.7  1040292.8   849057.2   763841.2   585125.0  1447218.4
   year
age       1966       1967       1968        1969        1970        1971
  0 22437282.1 28707626.5 29523423.9 13917586.70 29134240.71 22495314.31
  1  9602256.2  9190230.6 12288613.9 12280796.07  6329345.21 12523943.11
  2  8251792.5  4101186.2  3368541.2  4615771.90  4455549.32  2577297.06
  3  2290565.5  3352679.9  2042059.3   700719.08  1579430.19  1276895.69
  4  1478381.0   895864.6  1261869.6   309965.76   226118.11   386805.73
  5  2336319.6   689734.9   307443.0   391124.55   101595.81    58103.79
  6   196508.6   877884.9   258390.4    83847.68   120686.93    30450.99
  7   192132.7   107016.0   291577.0    73827.64    16286.98    30995.93
  8   851938.8   453813.8   161855.0   100120.16    45591.62    17302.46
   year
age          1972        1973         1974       1975        1976
  0 15700733.9271 7943076.866 14125092.423 3234709.25 4172725.320
  1  9795713.2861 6381948.503  3135694.825 6553338.63 1046285.694
  2  3513171.8538 2848571.313  1642853.093  988291.43 1982118.999
  3   815701.7697 1177680.057   788292.062  446901.26  219066.693
  4   325206.2241  310085.493   276876.803  251592.19   97120.467
  5    96943.7296  125089.205   102874.670   87463.13   65158.134
  6    18229.8261   44308.336    42013.145   27983.99   15859.999
  7      975.0296    8019.109    11416.107   12023.08    7665.757
  8     7921.2639    4846.571     5611.231    5873.64    2682.971
   year
age         1977        1978         1979         1980        1981
  0 5007480.019 5351562.757 10154904.335 15476298.269 36915279.62
  1 1752335.823 2154658.742  2041709.032  4096447.291  6152909.92
  2  373527.111  799291.331   963878.938   824894.198  1942664.57
  3  565718.869  259513.488   445970.612   488685.794   383690.06
  4   50944.315  220117.345   165380.243   231014.656   246942.90
  5   22790.044   29230.248   115508.654   122340.889   144906.58
  6   17431.531    9565.108    16741.060    59251.238    91226.64
  7    5665.782    8609.189     5386.860    12335.635    47153.21
  8    2615.846    3890.813     6085.963     5892.008    14306.51
   year
age         1982        1983        1984        1985        1986
  0 58525556.13 57946931.70 55810044.06 67271136.67 81400120.13
  1 10359627.88 18682601.00 16144251.92 18395576.42 25807940.91
  2  2305944.79  4005117.02  7495017.22  6895231.07  6300391.79
  3  1105022.61  1262192.38  2138491.63  4137379.93  3416311.62
  4   222843.30   552197.77   772301.59  1157311.87  1776992.74
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  5   131913.28   144897.85   303711.51   411617.05   499159.48
  6    75164.94   100125.65    91618.14   143917.35   194442.30
  7    56922.56    49945.68    64641.27    53291.18    65078.80
  8    30302.93    66066.12    70627.73    70001.22    61913.26
   year
age        1987        1988        1989        1990        1991        1992
  0 78363263.87 44888159.60 37759804.8 31642519.6 35056747.8 65995431.9
  1 33823678.13 26202203.62 15997431.2 13006384.7 12900272.9 12700999.7
  2 10324219.62 12347074.15  8159086.9  5251088.5  4661049.5  5324481.8
  3  3008955.73  5360616.88  6674402.4  4500903.9  2745198.8  2074120.2
  4  1756881.89  1541820.38  2999095.3  4176418.9  2684785.1  1584340.2
  5   884391.21   907941.30   808964.6  1716497.7  2463569.5  1580296.5
  6   255200.14   442163.50   452439.1   452617.6   950619.0  1478449.8
  7    90446.66   127942.44   220194.6   246932.3   259779.8   560641.0
  8    57081.34    77612.86   104287.4   185914.2   227617.4   287234.4
   year
age       1993       1994       1995       1996        1997       1998
  0 68551684.4 52883202.7 61076455.8 50221462.9 39918410.72 25190061.9
  1 20565871.0 20721078.5 18044265.3 18990414.4 19407717.18 16606604.0
  2  4606851.3  7023828.4  7699248.5  6635355.9  7860880.78 10556274.4
  3  2291559.0  1767269.8  3068008.3  3475724.7  3411962.42  3848461.6
  4  1116290.4   953140.3   885847.0  1299885.9  1880069.57  1765809.2
  5   893943.4   499166.0   409727.4   400967.0   773888.11  1030993.6
  6   893055.0   431857.4   255354.9   158614.4   251635.04   490983.2
  7   731188.0   415562.9   215263.5   124687.3    89986.19   158561.9
  8   449317.4   533836.9   441690.3   332734.5   270408.82   207608.4
   year
age       1999       2000        2001       2002       2003       2004
  0 80033627.2 54550943.0 101911821.9 49214247.8 27618571.2 32210582.5
  1 10535662.4 30573076.8  20465526.1 41876954.2 18667350.1 10134082.6
  2  6687727.4  6468850.4  14244543.1  9393766.6 22413767.6  7496517.2
  3  5980672.1  3476095.4   3983131.6  9031064.0  5330603.5 12867375.5
  4  1984394.6  3605743.8   1985262.9  2112443.6  5536534.9  3459407.2
  5   878068.0  1192910.0   2023825.6  1089122.6  1139616.2  3325101.0
  6   502441.5   548156.2    623529.0  1243096.2   677246.7   566807.2
  7   254700.8   307535.5    312616.9   356660.0   742895.0   420325.6
  8   187174.4   240138.9    271438.0   353562.9   395167.7   596573.5
   year
age       2005       2006       2007       2008       2009       2010
  0 29939013.4 27222228.3 31275813.6 29088826.3 47585226.3 38129806.3
  1 13609493.2  9922317.3  9058784.5 10495247.4 10575994.8 17095801.6
  2  4651229.7  6307520.2  4306535.7  5181597.5  6066119.9  6449802.5
  3  4553671.3  2922099.4  3527159.5  2586207.8  3078075.8  4298517.7
  4  7552218.4  2773776.7  1829740.9  1997448.8  1592200.7  2251212.5
  5  2044709.7  4745558.4  1581176.0  1173749.5  1255794.8  1184694.4
  6  1797291.7  1002087.9  2636368.1   991318.2   795678.7  1104435.3
  7   277500.8   827752.9   511835.3  1776143.4   694013.6   598787.8
  8   470502.2   308807.8   514826.5   629664.9  1834395.5  2008962.4
   year
age       2011       2012       2013       2014       2015       2016
  0 34223670.4 32791166.5 40829468.0 65480092.4 17336518.0 32864572.2
  1 15030054.8 12253462.7 11563672.1 17913819.8 26517416.0  7078298.5
  2  8080422.2  7615785.5  5649089.4  6781838.9 11847802.6 15229436.7
```

3	4169972.8	5905447.5	5016394.8	3744237.3	3655273.0	8061944.0
4	2809933.8	3126418.4	4066106.1	3874968.1	2320502.1	2220746.0
5	1404793.6	1979680.1	2319224.2	2607203.8	2328081.5	1439131.5
6	786174.5	917523.3	1326328.4	1488758.4	1490263.7	1308824.7
7	729885.8	498623.4	575660.9	789299.8	824532.0	744497.5
8	1716852.4	1378781.5	1151820.4	847829.8	878714.3	768926.3

year

age	2017	2018	2019
0	20022378.5	36780645.0	26191234.3
1	12461780.5	8790338.4	14066353.7
2	3274372.2	5620370.6	4397586.7
3	9410218.1	2275811.4	3450200.5
4	5291507.4	6114577.5	1377760.9
5	1416926.3	3498836.4	3252467.2
6	726788.5	922321.2	1771075.3
7	606557.2	462910.6	473265.6
8	610748.7	656236.1	463287.4

Table 2.6.3.18 North Sea Herring. PREDICTED INDEX AT AGE catch unique

Units : NA

year

age	1947	1948	1949	1950	1951	1952
0	149093.09	148126.108	134176.07	183910.6	164223.1	156256.9
1	3079.91	3812.781	16711.53	62921.4	407407.9	692167.4
2	477791.72	262536.199	479344.73	542693.3	655501.1	1325532.4
3	421802.00	665721.108	645920.46	1039053.7	926751.0	598328.8
4	645197.03	326312.546	404656.23	618425.2	1180679.0	619111.6
5	529604.20	599115.866	284937.23	300626.4	599909.1	653751.6
6	739642.13	509822.692	616623.04	255316.0	268130.2	440769.2
7	430273.02	413468.284	425161.35	336821.1	142271.0	219357.6
8	1304305.70	947362.442	990728.71	605919.8	484668.2	521485.9

year

age	1953	1954	1955	1956	1957	1958	1959
0	157818.8	205714.7	161529.2	100546.7	274370.1	107201.1	230406.0
1	1007027.9	1466251.6	1958603.3	1748078.2	1447281.3	4296443.1	1588124.6
2	1324270.8	1493432.0	1935915.5	1817312.4	1664904.8	1040119.2	4799961.9
3	1010852.9	1087224.1	1034782.5	1215241.7	751953.0	980327.0	482785.9
4	475619.4	592459.5	483892.6	515341.3	636790.7	331600.2	476545.3
5	390221.9	351645.3	340823.0	258376.0	339253.0	451558.1	227428.0
6	479841.5	315381.6	228071.9	208746.4	195495.7	160953.6	236796.2
7	283398.3	360410.6	125473.5	111086.0	140653.3	77264.2	122058.5
8	390108.3	443480.5	240849.3	264818.5	234961.0	139890.9	256586.5

year

age	1960	1961	1962	1963	1964	1965
0	183685.0	1038289.02	180972.7	411651.08	470453.91	181238.42
1	2147738.6	375900.98	2238592.3	1307923.92	2760131.71	3133725.54
2	1159389.1	1778234.56	292638.2	2967610.46	1562266.77	2144428.86
3	2014669.3	488486.51	760112.4	188599.88	2257829.01	1251384.67
4	175260.6	1430023.63	313184.7	176894.33	147182.01	1893131.65
5	179750.9	122866.72	998895.7	89906.98	149886.84	137531.44

```
  6  119163.9  161481.72  102303.6  305364.12   90491.79  129129.94
  7  137193.4   64201.02  119280.5   26635.16  260993.19   96285.58
  8  237058.5  158918.48  171858.2   95707.87   91941.54  461588.42
   year
age       1966       1967       1968       1969        1970       1971
  0  356002.26  624159.88  719214.04  149313.48  788277.136  706025.03
  1 1431604.21 1674633.90 2412526.31 2508285.23 1275546.438 4070908.83
  2 2560500.88 1245788.34 1689599.10 1940438.23 1992520.808 1125494.84
  3  777619.64 1407990.58 1307708.30  328530.93  850248.956  659069.30
  4  469676.42  369227.10  596759.81  140601.36  121021.227  204593.25
  5  892039.89  296131.71  155377.66  191946.90   49903.031   26597.80
  6   52176.69  386669.86  137079.75   52575.27   70751.566   26424.15
  7   70823.92   57192.66  174922.87   41102.46    8771.718   20545.37
  8  314136.45  242600.25   97126.25   55755.89   24561.270   11471.73
   year
age         1972        1973       1974        1975       1976        1977
  0  696971.9577  321197.024 922271.019  252396.235 245566.303 269229.6373
  1 3292994.9052 2294934.764 911863.223 1988869.326 142752.820 152132.5329
  2 1473663.9481 1327236.187 786989.850  520809.681 823738.057  52016.9073
  3  357141.8414  629010.376 377170.480  252519.065 114695.767 192229.7351
  4  137260.7811  144332.085 130098.357  134951.821  48980.298  11826.7246
  5   35286.9984   57879.943  55684.551   54979.173  33781.776   7427.4195
  6    7421.0714   24738.961  22152.333   14847.930   6401.160   4320.1339
  7     244.3769    3125.513   5491.670    8342.521   4228.936   1674.9742
  8    1985.9730    1889.557   2700.038    4076.594   1480.530    773.5961
   year
age        1978       1979         1980        1981         1982
  0 354860.9227 787505.756 1431592.0074 8126759.249 11929698.967
  1 169699.4856 152593.451  275186.0356  770774.794  1172206.357
  2 113342.7855 144221.654  131993.3519  282557.515   306172.822
  3  61002.6569  91600.074   91126.4882   60139.007   219162.567
  4  41919.6770  25189.591   32827.8115   39013.138    34530.454
  5   7312.7770  24765.968   21830.2554   26841.840    15953.638
  6   1496.1424   1497.945    3325.1100   14962.809     8568.694
  7   2194.4811   1030.541    1444.4442   14940.922     9359.598
  8    992.1669   1164.813     690.2866    4535.705     4985.835
   year
age        1983       1984       1985       1986       1987       1988
  0 12207637.11 6939324.04 4482099.01 4237678.33 7192322.56 3308093.51
  1  2358664.79 1937163.13 3164236.19 4685474.39 6943835.39 7112062.87
  2   574519.67 1161021.15 1299838.32 1266340.19 2093995.13 2268235.69
  3   223228.34  446637.03 1127247.61  841627.12  671925.61 1096974.44
  4   106302.83  196665.91  353639.46  477429.13  464279.20  388550.66
  5    25941.59   78826.33  120507.58  133048.68  245222.46  253246.73
  6    19469.27   21772.26   43703.33   61709.34   75676.99  127544.64
  7    13495.74   22854.46   19376.09   23584.84   25733.72   37786.22
  8    17865.14   24992.50   25470.43   22448.76   16247.16   22931.44
   year
age       1989       1990       1991       1992      1993       1994
  0 2836122.32 1504446.63 2516428.70 9282177.19 9759965.6 5012028.60
  1 3461832.54 2860245.39 2226800.45 2338661.47 3676295.3 2064747.88
  2 1568273.57  945228.74 1101821.07 1293406.15 1182905.4 1748044.26
  3 1336983.31  800860.88  552945.89  452091.63  607287.0  487480.49
```

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  4  778174.25  876557.50  555467.40  363940.26  309243.3  329206.76
  5  209518.31  388227.69  510839.21  357741.77  213401.9  113390.75
  6  118192.76   88362.27  206426.88  368810.85  226942.8   98983.24
  7   59108.55   54029.86   45410.51  134435.47  199514.5   90675.78
  8   28007.33   40705.50   39837.82   69013.28  122912.7  116853.83
   year
age       1995       1996       1997       1998       1999       2000
  0 6435805.34 2197378.36 516746.493  287038.70 1466297.14 1076303.70
  1 1701238.00 1460233.79 605566.360  844997.20  333032.94 1108653.93
  2 1420447.78  687507.53 720401.319 1166309.86  630576.05  591473.30
  3  786172.33  553220.82 463240.383  551483.34 1007849.44  471881.05
  4  225691.43  187969.81 285910.411  277518.44  301677.95  621693.64
  5  109816.90   61775.62 112167.027  173312.28  139348.59  209126.66
  6   54958.17   25211.42  34381.689   83555.66   75079.03   82989.08
  7   42788.44   10113.66   9633.388   15768.89   22762.60   28895.03
  8   88122.35   27090.73  29048.980   20711.53   16767.57   22590.07
   year
age       2001      2002       2003      2004       2005     2006     2007
  0 1812368.28 745533.46  399078.80  705734.8  953590.08 836178.1 672059.4
  1  605898.93 918140.76  562999.23  237619.9  584208.60 245028.6 229168.7
  2  882724.12 574331.82 1246894.99  454178.5  340509.28 399343.0 227869.8
  3  485229.55 975151.43  536711.39 1360021.6  484415.16 310859.6 392575.7
  4  285898.88 297764.18  832717.96  544101.4 1295192.41 459588.4 273113.1
  5  321152.58 151400.67  237404.48  748056.5  472600.55 989788.6 294276.5
  6   94070.98 183450.53  116922.47  159976.0  545480.65 256380.8 544375.5
  7   31762.22  46722.83  110691.14   90390.2   98894.81 269686.2 139700.3
  8   27591.88  46336.86   58915.15  128398.6  167870.40 100775.9 140835.3
   year
age     2008      2009      2010      2011     2012     2013      2014
  0 716679.1 709995.75 599270.21 740034.69 712402.6 537986.3 1362736.1
  1 230333.1 180383.38 271596.74 183730.03 273124.6 361826.6  374618.5
  2 313280.1 269298.63 292980.16 376295.41 442042.4 324019.0  375991.5
  3 181881.6 119440.94 233001.14 281864.64 624856.5 487511.9  369987.1
  4 197830.7  98135.63 131652.54 222106.28 383721.5 563670.6  587357.8
  5 136849.9  91040.41  86351.80 133238.56 293268.0 408976.6  483670.7
  6 112670.1  44813.84  64987.25  66543.36 140122.2 278320.2  296339.1
  7 255123.3  54439.62  35457.09  56616.64  84879.8 141679.1  198541.2
  8  90726.1 144428.92 119447.73 133756.80 235749.4 284740.6  214212.2
   year
age     2015      2016      2017       2018     2019
  0 532803.4 1389956.8  522152.6 1278088.79 911947.0
  1 412614.0  109272.7  192819.5   79839.08 127847.9
  2 552075.7  621160.2  111918.7  204864.60 160293.7
  3 267369.3  795839.8 1036061.3  204984.39 310762.7
  4 291073.0  296417.4  831229.4 1146793.35 258400.0
  5 454197.4  275374.8  234492.9  804298.07 747663.7
  6 391653.1  344767.9  153213.2  209278.09 401863.5
  7 279004.3  297318.2  195964.4  164206.41 167879.6
  8 298592.8  308280.9  198135.9  233714.82 164997.2
```

Table 2.6.3.19 North Sea Herring. INDEX AT AGE RESIDUALS catch unique

Units : NA

age \ year	1947	1948	1949	1950	1951	1952
0	0.0000000	0.00000000	0.00000000	0.00000000	0.0000000	0.0000000
1	0.0000000	1.94346471	0.00000000	0.00000000	3.8170622	0.8222697
2	1.8421113	1.20391087	1.36193081	0.30552405	-1.0685014	-0.7855888
3	1.5470236	2.42735109	1.33964311	-0.02375496	-0.7444538	-1.9332768
4	1.9543560	1.19933020	-0.37954817	1.47835609	0.7114516	-1.6193702
5	1.2860612	-0.02786206	0.06485348	-0.46358838	1.3739474	-0.8769467
6	1.2760881	0.04097824	0.38747974	-0.23811965	-0.1609107	0.1022259
7	2.6652682	-0.11252856	0.87989143	-0.45480347	-0.1655704	0.5963787
8	0.2787166	0.30777779	0.59626633	-0.07948342	-0.1644379	0.6530203

age \ year	1953	1954	1955	1956	1957	1958
0	2.1651379	0.47383769	-0.30651699	-0.6479877	1.20511809	-1.15536367
1	0.3042004	0.21876212	0.25146097	-0.0455826	0.09566492	0.80305250
2	-0.6878225	-0.33746714	-0.08440229	-0.5010708	-0.03806113	-0.48515294
3	-1.0722129	-0.25177817	-0.55799161	-0.3447222	-1.20221550	0.55530763
4	-0.8793797	-1.33501009	-1.04430364	-0.2568855	-0.18526513	-0.95811303
5	-0.7775660	-0.30473657	-1.38525397	-1.0315976	0.13504574	0.03153996
6	-0.4420838	-0.17993819	-0.64613189	-0.8962650	-0.01900979	-0.88405197
7	-0.4280307	-0.09078207	-1.36045958	-0.4294156	-0.09305762	-1.06653176
8	0.1248446	0.53670420	-0.86038212	0.6924429	0.03756783	-0.88671725

age \ year	1959	1960	1961	1962	1963	1964
0	0.0000000	0.6163014	2.22172762	-2.4131977	1.16878620	0.2122808
1	-0.5570481	0.2440031	-2.61338671	0.9781509	0.60578414	0.6022140
2	1.4680605	-1.1130528	-0.06630833	-2.1256002	1.64886176	0.5711457
3	-0.5132241	0.1373801	-0.44710271	-0.1913299	0.01063235	1.0456373
4	0.3332807	-0.9676762	1.35843252	-0.0344911	-2.55916769	2.3013291
5	-0.4506934	-1.5140449	0.81116772	0.9378105	-2.30820954	1.0419713
6	0.1080948	-0.4059496	0.35862291	0.6111654	-1.93861603	1.2126919
7	0.4392387	-0.6798594	-0.49210475	1.2249883	-1.60133018	0.8509192
8	1.1884657	0.6225652	-0.94415741	-0.8044316	-0.45975257	-0.7972422

age \ year	1965	1966	1967	1968	1969	1970
0	-1.3351960	0.9263975	0.70094765	0.35568294	-2.33417586	2.2801530
1	0.1256037	-0.4253516	-0.30233029	0.06463085	-0.04816627	0.1010212
2	-0.2675679	0.1117252	-0.29117314	0.14191289	-0.41447653	-0.1285849
3	0.6755196	-1.7964929	0.52526053	1.71544013	-3.54706730	1.0364728
4	1.3214629	-1.4585439	-0.48286382	0.14999330	-2.65129123	0.6189823
5	1.7967214	-0.7406609	-0.22259117	-1.10062003	-1.10900550	-1.3702788
6	0.6797649	-0.9658635	-0.09957544	0.02150147	-1.14693741	-0.7064129
7	1.8039591	-0.8127937	0.68028763	-1.47777704	-0.82266246	-1.4986882
8	0.1744003	0.3065786	-0.66069283	-0.43723248	-2.44060087	-1.3210978

age \ year	1971	1972	1973	1974	1975	1976
0	-0.1656694	0.09593125	-1.1520999	1.3859931	-1.47992005	-0.2273537
1	0.5406456	-0.20247029	-0.5099261	-0.9651437	0.64525123	-3.0575551
2	0.4350879	-1.09915773	-0.1484415	-0.8021310	0.10282243	-0.4707146
3	-0.5047930	-0.17505112	0.1021686	-0.9673700	-0.20140585	-0.4264093

```
  4 -0.4612794 -0.66063386  1.1460789 -1.1815665  0.56935591 -0.6939589
  5 -1.0540414 -0.91490704  1.4935872  0.3325670 -0.09937525 -0.5687259
  6  0.2314600 -1.80539682  1.8776681 -0.4547026 -0.44554566 -1.3203331
  7 -1.0169002 -3.49743349  2.7147912 -0.1623169  0.51547252 -0.6427491
  8 -2.6974843 -1.47408061  2.0513726  1.5275829  0.90153084 -1.4126692
   year
age       1977 1978 1979       1980       1981       1982       1983
  0  0.0773059    0    0  1.3163004  2.5837657  0.4763490  0.1855080
  1 -0.1876420    0    0 -0.2400897  1.0606562 -0.5926166  0.7219756
  2 -2.7076758    0    0 -0.8903279  0.7128919 -0.9999738 -0.1071316
  3  0.2503787    0    0 -1.5764137 -0.7749925  1.1202437 -0.5298739
  4 -1.1464003    0    0 -1.1938387 -0.6014581  0.1974118 -0.1458076
  5 -1.2060857    0    0  1.8799093 -1.1834880 -1.8034376  1.0052919
  6 -0.2846519    0    0 -0.7175033  3.7672383 -1.4740319  1.8241983
  7 -0.9802701    0    0  1.6717579  2.7088576 -1.2506028  0.5455615
  8 -0.9155971    0    0 -0.2221135  4.1768745  0.2626584  2.8350745
   year
age       1984       1985        1986         1987         1988
  0 -0.7870204 -0.6779534 -0.19685825  0.943001720 -1.076706649
  1 -0.2806486  1.0209462  0.96689628  0.682278076 -0.122312446
  2  0.3743608  1.0057687  0.04337091  0.888179674 -0.555824703
  3  0.1363107  1.1245469 -0.13176607 -0.435086617 -0.019302262
  4  1.3415404  0.5609999 -0.85141585  0.260366159 -0.228042711
  5  0.5641788  0.6667780 -0.91119752  0.139001608  0.160410950
  6  0.1771584 -0.3157969 -0.12827536 -0.232068954 -0.212182571
  7  1.1436133 -0.0600321 -1.46886763 -0.846299215 -0.001799564
  8  1.9434334  1.7209342  1.85515742 -0.009515068  0.216200278
   year
age        1989        1990        1991       1992         1993
  0 -0.12117287 -1.02622599  0.65105275  1.8034422  0.124855081
  1 -0.73798595 -0.11170943 -0.05270445 -0.3134555 -0.156116536
  2  0.01754074 -0.99820958  1.15119632  0.3896613 -0.308780450
  3  0.09821208 -0.45927000  0.18109875 -0.2684612  0.001664254
  4  0.44071147 -0.28283501 -0.02022524  0.3710180  0.375662423
  5 -0.06718194  0.06301689 -0.10861969  0.3805161  0.272381197
  6 -0.15015527 -0.53413520  0.24075495  0.4048049  0.198310544
  7 -0.24471121 -0.37122756 -0.66948395  0.9745291 -0.119292921
  8 -0.18306436 -0.03001701 -0.33980360 -0.4010850  0.338504941
   year
age        1994       1995       1996       1997        1998       1999
  0 -1.00445519  0.5029326 -1.3618230 -2.1100892 -0.83047902  2.1108385
  1 -1.33379257 -0.1063281 -0.3165317 -1.4544390  0.98213362 -0.6212383
  2 -0.71430882 -1.9907337 -2.8825110 -0.8408304  1.17029453 -1.1148200
  3 -0.60123126 -0.6088555 -1.9375378 -0.9685606 -0.40545530  0.7223627
  4  0.06041035 -0.6906329 -2.4031358 -0.1470455 -0.46454570 -0.4798811
  5 -0.73375288  0.8937614 -1.8831296 -0.3965354 -0.01253578 -0.7406529
  6 -0.54254036 -0.1908471 -1.3668233 -0.2748007  0.55545480 -0.7630360
  7 -1.05878965 -0.3789460 -2.1984638  0.7286039 -0.11820557 -0.1561018
  8 -0.11936906 -0.2314674 -1.2178434 -0.8245446 -0.52354346 -1.5677166
   year
age         2000        2001        2002       2003        2004       2005
  0 -0.329409114  0.62683166 -1.08842848 -0.8373581  0.75989858  0.5192909
  1 -0.001335337 -0.30824534 -0.48794548  0.5259788 -0.67848865  1.7738782
```

```
  2  0.871543104 -1.29693452 -0.09971803  0.1639090 -0.27581625  0.6421128
  3 -0.997194189  0.03446253 -0.01008369 -0.2681858 -0.04104904  0.1924584
  4  0.706837897 -0.60504080 -0.41630136  0.3711593  0.36392803  0.2628070
  5  0.334295259 -0.29917288 -0.97222745  0.8757329  0.41505493  0.1606577
  6  0.104412961 -0.25243343 -0.03069281  0.1504675  0.78358406  0.2889529
  7  0.556981877  0.42065409  0.38039614  0.3957233  1.19766878  1.4420664
  8 -1.644601333 -1.67795371 -0.14821008 -0.9631578 -1.24377235 -0.7297025
   year
age        2006         2007       2008       2009         2010       2011
  0 -0.11068115 -0.406750733  0.2128440 -0.1809278 -0.251895772  0.3649548
  1 -1.35781535  0.044101584 -0.5259603 -0.1992293 -0.190808591 -0.3580449
  2 -0.37715548 -0.877583901  1.1341852 -0.2260714  0.728319925 -0.1670180
  3  0.33703657  0.087276506 -1.2176703 -1.8359593  1.472446002  0.7782027
  4  0.01271054 -0.001212949 -1.3416433 -1.4562849  0.035056135  0.9877643
  5  0.20894062 -0.150234657 -1.0326809 -1.4535711  0.219193514  0.5633343
  6 -0.48642302 -0.131628575 -1.0184010 -1.4694591  0.636517000  0.6582280
  7 -0.38114812 -0.213711574 -1.0864035 -1.0215439 -0.413423571  0.3512444
  8 -0.06649090 -0.130153658  0.4111375 -0.0230213  0.007620405  0.1029386
   year
age        2012       2013       2014       2015       2016       2017
  0  0.03991368 -0.6018539  1.2047903 -1.0769918 1.33910063 -1.3830113
  1  1.05989130  0.8272874 -0.2836109 -0.8438681 0.12041411 -0.0508591
  2  0.51308401 -0.4251481  0.6276753  0.5669175 0.14514375 -0.8666124
  3  1.94003301 -0.1349728  0.3861336 -1.3528921 1.41628979  0.3589712
  4  2.00062295  0.7769652  1.2696679 -0.5331685 0.05336169  0.7267264
  5  1.82841923  1.3786845  0.5559808  0.4399412 0.14341234 -0.1452581
  6  1.43950751  1.2877036  0.0988419  0.8695554 0.19614930 -0.6316221
  7  1.91231855  0.9761748  0.4346081  0.5582410 0.46672640 -0.9108986
  8 -0.53375136  0.4683506 -0.4316434  0.7430224 0.57794257  0.5358086
   year
age       2018 2019
  0  1.1750628    0
  1 -0.6263576    0
  2 -0.1683390    0
  3 -0.3666175    0
  4  0.8633635    0
  5  1.6585807    0
  6  0.3645246    0
  7  0.3874848    0
  8  1.4733597    0
```

Table 2.6.3.20 North Sea Herring. PREDICTED INDEX AT AGE LAI-ORSH

Units : NA

age \ year	1972	1973	1974	1975	1976	1977	1978
0	2010.607	1792.284	1053.7661	617.9344	945.1026	573.0173	720.7835
1	1274.497	1136.105	667.9682	391.7003	599.0879	363.2280	456.8950

age \ year	1979	1980	1981	1982	1983	1984	1985
0	1034.3124	1245.3690	1806.704	2230.787	2481.913	3856.294	4473.396
1	655.6368	789.4227	1145.246	1414.066	1573.252	2444.454	2835.626

age \ year	1986	1987	1988	1989	1990	1991	1992
0	4896.612	5757.758	6809.703	7455.893	NA	3904.464	918.3486
1	3103.897	3649.766	4316.580	4726.191	4412.202	2474.987	582.1289

age \ year	1993	1994	1995	1996	1997	1998	1999	2000
0	NA	885.3702	NA	NA	NA	NA	NA	NA
1	536.3866	561.2243	1789.011	4717.807	6098.57	7194.262	7739.55	8040.251

age \ year	2001	2002	2003	2004	2005	2006	2007	2008
0	NA	NA	NA	NA	NA	5999.077	NA	4407.035
1	9162.548	9181.56	6943.136	5633.295	5025.835	3802.735	2591.637	2793.561

age \ year	2009	2010	2011	2012	2013	2014	2015
0	NA	NA	NA	NA	NA	NA	NA
1	2834.292	2966.867	4027.229	4591.077	4352.545	4181.661	3986.522

Table 2.6.3.21 North Sea Herring. INDEX AT AGE RESIDUALS LAI-ORSH

Units : NA

age \ year	1972	1973	1974	1975	1976	1977
0	0.9490267	-0.4157534	-0.5276573	-0.7739073	0.3010899	1.9468407
1	1.4993577	-0.7449251	-0.5728094	-1.8471075	-0.9093256	0.7534575

age \ year	1978	1979	1980	1981	1982	1983
0	2.8129509	2.104064	1.4317779	0.848349	0.31561605	-0.1226669
1	-0.5261923	1.833793	0.3452657	-0.943263	0.04063867	-0.6490039

age \ year	1984	1985	1986	1987	1988	1989
0	-0.6968928	0.18531729	-0.1259333	0.3959302	0.2612484	0.7176941
1	-0.2588474	0.06856921	-0.3035306	-0.4168490	0.6748034	0.3943493

age \ year	1990	1991	1992	1993	1994	1995
0	NA	-1.2625979	-2.001111	NA	-1.730110	NA
1	0.6566063	-0.1901818	1.260943	-1.098491	1.966871	2.294189

age \ year	1996	1997	1998	1999	2000	2001
0	NA	NA	NA	NA	NA	NA

```
  1 -0.01235815 0.00768455 0.2559046 -0.2674838 -0.503655 0.1055157
   year
age       2002       2003       2004      2005       2006       2007
  0         NA         NA         NA        NA  0.1835403         NA
  1 -0.4377433 -0.9313368 0.09634665 -0.133518 -0.2962107 -0.1714446
   year
age      2008      2009       2010      2011     2012     2013      2014
  0 0.4385315        NA         NA        NA       NA       NA        NA
  1 0.9142136 0.8323503 -0.0262811 0.3392524 1.564697 1.629567 0.4608897
   year
age      2015
  0        NA
  1 0.8190273
```

Table 2.6.3.22 North Sea Herring. PREDICTED INDEX AT AGE LAI-BUN

```
Units  :  NA
   year
age     1972      1973      1974     1975     1976     1977     1978
  0 20.17108 17.980788 115.21680 79.23387       NA 62.17679       NA
  1       NA  6.894264  44.17688       NA 9.976697 23.84007 46.30571
   year
age     1979      1980     1981     1982     1983     1984     1985
  0 62.50242 15.543846 28.18107 353.2187 1912.314 3095.003 2775.272
  1 23.96492  5.959882 10.80530 135.4325  733.227 1186.698 1064.106
   year
age      1986     1987     1988     1989     1990     1991     1992
  0 2442.7277 2729.098 4852.736 4347.070 5222.146       NA       NA
  1  936.6002 1046.401 1860.655 1666.771 2002.296 3183.409 4406.128
   year
age     1993     1996     1997     1998     1999      2000     2001
  0       NA       NA       NA       NA       NA 198.95632       NA
  1 3000.924 585.9286 167.9755 341.6611 160.0735  76.28461 224.2111
   year
age     2002    2003     2004     2005     2006     2007     2008     2009
  0       NA      NA       NA       NA       NA       NA       NA       NA
  1 736.3416 1438.28 1751.812 1299.705 712.9991 826.2714 720.1596 1283.587
   year
age     2010     2011     2012     2013     2014     2015     2016
  0       NA       NA       NA       NA       NA       NA       NA
  1 1364.208 2063.419 2731.211 3558.615 3340.625 2829.269 3052.609
   year
age     2017     2018
  0       NA       NA
  1 2555.367 2041.325
```

Table 2.6.3.23 North Sea Herring. INDEX AT AGE RESIDUALS LAI-BUN

Units : NA

age	1972	1973	1974	1975	1976	1977	1978
0	-0.192697	-1.44740636	1.392899	0.3871624	NA	2.0335323	NA
1	NA	0.03000258	2.020192	NA	-2.344996	0.8131908	1.980602

age	1979	1980	1981	1982	1983	1984
0	0.5277311	-0.7308945	-0.9774579	1.586980	1.3387578	-0.3309883
1	-1.1060083	-1.7826202	1.0775252	1.267803	0.3130329	0.2181331

age	1985	1986	1987	1988	1989	1990
0	-0.2487577	-0.04353208	-0.06607528	0.7538161	0.4927131	0.2022081
1	0.2442604	-0.99252176	-0.34130037	0.9628135	-0.5722317	0.1940743

age	1991	1992	1993	1996	1997	1998
0	NA	NA	NA	NA	NA	NA
1	0.02600095	-0.4470565	-2.669971	-2.165549	-2.270617	1.224697

age	1999	2000	2001	2002	2003	2004
0	NA	-1.6878898	NA	NA	NA	NA
1	-0.7027666	0.9883683	0.3863908	0.9177875	0.533921	0.7381779

age	2005	2006	2007	2008	2009	2010
0	NA	NA	NA	NA	NA	NA
1	-0.1688856	-0.8455476	0.6599171	-0.06212379	1.440589	0.08051891

age	2011	2012	2013	2014	2015	2016	2017
0	NA	NA	NA	NA	NA	NA	NA
1	0.5370518	1.178228	1.443701	0.6086508	0.4513514	0.1892798	0.7267083

age	2018
0	NA
1	-0.1543912

Table 2.6.3.24 North Sea Herring. PREDICTED INDEX AT AGE LAI-CNS

Units : NA

age	1972	1973	1974	1975	1976	1977
0	436.97309	389.52405	293.0104	NA	181.199918	133.717081
1	615.41030	548.58553	NA	216.800085	255.192596	188.320223
2	299.17351	266.68754	200.6095	105.394469	NA	91.549364
3	20.53753	18.30745	NA	7.235074	8.516313	6.284642

age	1978	1979	1980	1981	1982	1983
0	173.667767	204.228614	169.960254	259.0735	382.18278	564.0432
1	244.584704	287.625021	239.363234	364.8658	538.24646	794.3693
2	118.901590	139.825066	116.363242	177.3746	261.66134	386.1720

```
  3   8.162305   9.598651   7.988054        NA  17.96242        NA
   year
age       1984       1985       1986       1987       1988       1989
  0 1184.90921 1419.58991 1449.14463 1759.87536 2049.04685 1741.33764
  1 1668.76487 1999.27704 2040.90037 2478.51748 2885.77164 2452.40991
  2  811.24778  971.92186  992.15648 1204.89820 1402.87938 1192.20635
  3   55.69019   66.72008   68.10913   82.71334   96.30426   81.84207
   year
age     1990     1991     1992     1993     1994     1995     1996
  0 1759.153 1041.749 200.8764       NA       NA       NA       NA
  1 2477.500 1467.145 282.9039 246.5006 206.1376       NA 539.1198
  2 1204.403  713.233 137.5300 119.8330 100.2110 163.2379       NA
  3       NA       NA       NA       NA       NA       NA       NA
   year
age     1998     1999     2000     2001     2002     2003     2004
  0 339.3828       NA       NA       NA       NA       NA       NA
  1 477.9692 521.2126 700.2131 1456.917       NA 3334.394 3232.993
  2       NA 253.3806       NA       NA 1287.909 1620.971       NA
  3       NA       NA       NA       NA       NA       NA       NA
   year
age     2005     2006     2007     2008     2009     2010     2011
  0       NA       NA       NA       NA       NA       NA       NA
  1 3065.506 2261.331 1594.225 1877.436 2022.673 2089.757 2712.303
  2       NA       NA       NA       NA       NA       NA       NA
  3       NA       NA       NA       NA       NA       NA       NA
   year
age     2012     2013     2014     2015     2016     2017     2018
  0       NA       NA       NA       NA       NA       NA       NA
  1 2476.588 2342.377 2207.447 2216.571 2591.573 2146.804 1814.087
  2       NA       NA       NA       NA       NA       NA       NA
  3       NA       NA       NA       NA       NA       NA       NA
```

Table 2.6.3.25 North Sea Herring. INDEX AT AGE RESIDUALS LAI-CNS

```
Units  :  NA
   year
age       1972      1973      1974       1975       1976        1977
  0  0.3973697 0.6810220 -1.243468         NA -0.7104605  2.07419265
  1 -0.5600099 0.6728195        NA -1.2555050 -0.4229849  0.94892775
  2  0.4471919 1.4043932  1.333157 -0.5658798         NA  0.54685897
  3  0.9580033 1.6642744        NA -0.3548709  0.4380947 -0.08224662
   year
age       1978       1979       1980       1981       1982       1983
  0  2.6079172  1.1603823  0.4101570  1.1408653 -1.1487182  0.8363521
  1 -0.3153520 -0.5677118 -0.3352371 -0.3694387 -1.4416647 -0.8536445
  2  1.2431209  1.1396007 -2.1217312 -0.2900957  1.5467230 -1.3216019
  3 -0.6759367 -0.2797871  0.5526948         NA  0.4141005         NA
   year
age       1984      1985        1986       1987      1988       1989
  0 0.09048517 -1.729994 -0.02282842 -0.4969550 0.8762427 -0.3030657
```

```
  1 0.74543702  1.856765  0.74931566  0.7232437 0.1769417  0.4405487
  2 0.33456137  0.563368 -1.53381168  0.4724372 0.1957637  0.3653056
  3 1.88126478  0.928993 -0.54059484  0.2615294 0.5129956 -3.2019186
   year
age       1990        1991       1992       1993      1994      1995
  0  1.9471020  0.88308982 -3.6505950         NA        NA        NA
  1 -0.7867734 -0.21253955 -0.5623065  0.9732768  1.329654        NA
  2 -0.3228175 -0.04450022  0.1060051 -0.3516324 -1.109544 -1.466135
  3         NA          NA         NA         NA        NA        NA
   year
age       1996      1998       1999      2000     2001     2002      2003
  0         NA -1.000978         NA        NA       NA       NA        NA
  1 -0.4196611 -1.741295 -0.7120917 0.2410947 1.011164       NA 1.5269742
  2         NA        NA  0.2319685        NA       NA 1.566209 0.7346993
  3         NA        NA         NA        NA       NA       NA        NA
   year
age      2004      2005       2006      2007     2008      2009      2010
  0        NA        NA         NA        NA       NA        NA        NA
  1 0.6104844 0.6437605 -0.1176368 -1.177745 1.789406 0.7473975 0.1319794
  2        NA        NA         NA        NA       NA        NA        NA
  3        NA        NA         NA        NA       NA        NA        NA
   year
age    2011     2012     2013       2014      2015      2016     2017
  0      NA       NA       NA         NA        NA        NA       NA
  1 1.63655 -1.19891 1.254208 -0.3677732 0.6006234 0.3949573 0.777624
  2      NA       NA       NA         NA        NA        NA       NA
  3      NA       NA       NA         NA        NA        NA       NA
   year
age          2018
  0           NA
  1 -0.008393717
  2           NA
  3           NA
```

Table 2.6.3.26 North Sea Herring. PREDICTED INDEX AT AGE LAI-SNS

```
Units  :  NA
   year
age     1972     1973     1974     1975     1976     1977     1978
  0 7.902370       NA       NA 3.586381       NA 6.202026 19.15012
  1 6.238526       NA 5.407603 2.831268 4.203718       NA 15.11806
  2       NA 2.340763       NA       NA       NA       NA       NA
   year
age     1979     1980      1981      1982      1983     1984     1985
  0       NA 99.65826 190.50796 261.12185 242.96086 335.5443 377.5922
  1 51.01048 78.67522        NA 206.14265 191.80546 264.8954 298.0902
  2 21.47115 33.11569  63.30436  86.76882  80.73406 111.4988 125.4710
   year
age     1986     1987     1988      1989     1990     1991     1992
  0 337.0138 506.5710 770.2386 1326.6631 1794.013 1678.971 605.5996
```

```
  1 266.0555 399.9125 608.0649 1047.3342 1416.283 1325.464 478.0906
  2 111.9871 168.3297 255.9445  440.8401       NA       NA       NA
   year
age     1993     1994     1995      1996      1997     1998      1999
  0 622.5602 457.5958 579.2585 1077.7781 1270.6562 1276.309 1190.2914
  1 491.4801 361.2490 457.2957  850.8519 1003.1196 1007.583  939.6755
  2       NA       NA 192.4832  358.1375  422.2295  424.108  395.5248
   year
age      2000     2001      2002     2003     2004     2005     2006
  0 1184.6146 2003.991 2581.9084 3872.084 4529.302 4831.710 5123.479
  1  935.1940 1582.051 2038.2876 3056.817 3575.657 3814.393 4044.731
  2  393.6385  665.911  857.9487 1286.664 1505.053 1605.541 1702.493
   year
age     2007     2008     2009     2010     2011     2012      2013
  0 4581.339 4663.266 5471.740 5882.609 5568.579 5028.711 2506.2060
  1 3616.738 3681.415 4319.665 4644.026 4396.115 3969.916 1978.5244
  2 1522.345 1549.568 1818.218 1954.747 1850.397 1671.003  832.7934
   year
age     2014      2015     2016     2017
  0       NA 2708.8780 4186.297 4110.988
  1       NA 2138.5238 3304.872 3245.420
  2 921.8612  900.1397 1391.075       NA
```

Table 2.6.3.27 North Sea Herring. INDEX AT AGE RESIDUALS LAI-SNS

```
Units  :  NA
   year
age       1972       1973      1974         1975      1976       1977
  0 -0.3436058         NA        NA -1.037185489        NA -0.1125556
  1  1.9649304         NA 0.3953511 -0.006516598 0.5462398         NA
  2         NA -0.9882598        NA           NA        NA         NA
   year
age       1978     1979      1980        1981       1982         1983
  0  2.1403865       NA 1.4831072  1.89604703  0.4670675 -1.477541202
  1 -0.1410572 1.979629 0.7537183          NA -0.1909969  0.001776721
  2         NA 1.831647 0.3565640 -0.02975208 -0.7453715 -0.428241718
   year
age       1984       1985       1986        1987       1988      1989
  0 -0.0104493  1.0622316  0.3752982  0.77808659  0.8842070 0.8527329
  1 -0.6035512 -0.1691486 -0.9162394 -0.10552493 -0.9107911 1.0564683
  2 -0.9995780 -1.2831276 -1.5200202  0.03275564 -0.3520904 0.4185960
   year
age      1990       1991       1992      1993        1994       1995
  0 0.6713228  0.9809731 -0.5974161 0.6762656 -0.26927439 -1.9184910
  1 0.1190824 -0.3192837  1.3424928 0.4095101  0.05942296 -0.2840734
  2        NA         NA         NA        NA          NA  0.1785786
   year
age       1996       1997       1998       1999      2000       2001
  0 -0.7850661  1.5335364 -0.2349257 -0.3829672  1.319074 -0.3062637
  1  0.1531099 -0.4491055 -0.3551512  0.2215876 -1.146096  1.2409494
```

```
  2  0.7529942 -0.4195821 -0.9340476 -0.1565826 -1.130872  0.2706269
   year
age       2002       2003       2004       2005       2006        2007
  0 -0.2308005 1.34525983  0.6619628 -1.3701593  0.9887725  0.34107362
  1 -1.5456231 0.20063622 -0.1885606  0.6646223 -0.1079630 -0.01274843
  2  0.3842286 0.03683787  1.0669840  1.3503173  0.3845864  1.02583295
   year
age        2008       2009      2010        2011      2012      2013
  0  0.85590931 1.23993099 0.3244882 -0.05923322 1.2815459 -5.001002
  1 -0.09829849 1.25059987 0.9154226  0.21734052 0.7214930  1.967243
  2  1.04304087 0.08691057 1.1281742 -0.41874880 0.3619254  1.350660
   year
age      2014         2015       2016      2017
  0        NA -0.007473306  1.7011867 1.1735474
  1        NA -0.231789761 -0.5270191 0.6712067
  2 0.8197007 -0.007107003  0.2749441        NA
```

Table 2.6.3.28 North Sea Herring. PREDICTED INDEX AT AGE IBTS-Q1

```
Units  :  NA
   year
age    1984    1985    1986    1987    1988    1989    1990    1991
  1 1431037 1617310 2267470 2961980 2267154 1400818 1139265 1141292
   year
age    1992    1993    1994    1995    1996    1997    1998     1999
  1 1123254 1822733 1862454 1624404 1713833 1762133 1502130 953697.8
   year
age    2000    2001    2002    2003     2004    2005     2006     2007
  1 2757796 1844032 3771799 1676648 910496.9 1220550 893551.4 816741.6
   year
age     2008     2009    2010    2011    2012    2013    2014    2015
  1 948290.4 957340.1 1548922 1363295 1110158 1046438 1623232 2403300
   year
age     2016    2017     2018    2019
  1 640977.8 1128956 796726.2 1274925
```

Table 2.6.3.29 North Sea Herring. INDEX AT AGE RESIDUALS IBTS-Q1

```
Units  :  NA
   year
age       1984        1985      1986     1987      1988      1989
  1 -0.5983535 -0.02108412 0.1714256 0.999168 -1.333818 0.9813158
   year
age       1990      1991        1992         1993     1994      1995
  1 -0.7428275 0.9269406 -0.08925471 -0.005913962 1.379777 0.8798408
   year
age       1996     1997      1998      1999       2000      2001      2002
```

```
  1 -0.8198707 1.352621 0.8475135 0.1238665 -0.8663838 0.4228553 -1.281313
   year
age       2003       2004      2005       2006      2007        2008
  1 -0.5338658 -0.1567298 0.4342834 -0.3732443 0.3052899 -0.02695991
   year
age    2009      2010     2011       2012      2013     2014      2015
  1 0.40285 -1.273407 1.229416 -0.7958101 -1.684211 1.164109 0.2899732
   year
age       2016    2017      2018       2019
  1 -0.2531854 1.18272 0.2108529 -0.8614033
```

Table 2.6.3.30 North Sea Herring. PREDICTED INDEX AT AGE HERAS

```
Units  :  NA
   year
age       1989      1990      1991      1992      1993       1994
  1 6942865.74 5654446.3 5921770.9 5818747.4 9533314.8 10369753.0
  2 4703570.23 3065393.3 2587400.4 2927615.4 2493147.2  3816656.7
  3 4638824.04 3190013.1 1905943.6 1415049.5 1495708.7  1140147.6
  4 2022640.30 2941387.9 1890710.5 1089067.0  733082.3   583885.8
  5  549787.19 1201464.9 1749716.9 1102003.8  615687.8   346514.5
  6  309187.20  327313.0  675249.2 1020725.9  613567.2   302924.1
  7  150277.29  176009.4  191723.4  392093.8  496454.8   295520.2
  8   71213.01  132621.8  168236.4  201371.1  306022.6   381091.2
   year
age      1995       1996        1997      1998      1999       2000
  1 9107802.3 9716190.92 10263229.73 8603141.3 5480197.7 15600889.7
  2 4414089.2 4052215.85  4836774.60 6386692.7 4079118.6  3934562.6
  3 2012340.3 2475858.51  2478072.06 2778306.7 4223779.4  2511668.0
  4  590566.6  949869.62  1368783.21 1281673.4 1446442.1  2588436.0
  5  273976.1  294820.74   573692.48  751045.2  644127.2   863729.6
  6  181112.8  117680.62   190016.70  361458.8  375443.3   408531.0
  7  155432.0   98256.69    69669.01  123399.1  199483.6   239908.3
  8  320353.2  263362.19   210212.49  162166.9  147005.8   187599.6
   year
age       2001       2002       2003      2004      2005      2006
  1 10380748.2 21195424.6  9305204.3 5060150.4 6729205.8 5017815.1
  2  8820264.7  5793396.5 13804503.3 4586568.0 2819860.9 3856560.3
  3  2898986.0  6606190.3  3894166.0 9317984.2 3281457.4 2097717.8
  4  1455637.8  1546710.1  4003292.2 2476397.0 5313575.2 1949042.9
  5  1482436.9   806960.6   795526.7 2278585.5 1385974.2 3261014.1
  6   463991.6   924005.6   491458.1  373083.0 1153509.5  668668.5
  7   242218.9   269820.9   552550.4  295678.5  170523.5  522284.7
  8   210434.1   267613.2   294128.0  420084.2  289548.5  195249.4
   year
age      2007      2008      2009      2010      2011      2012      2013
  1 4610461.8 5404575.5 5500905.5 8936286.4 7904907.5 6403965.6 6005012.6
  2 2660287.2 3196245.6 3796175.3 4040188.8 5065628.5 4739483.1 3520312.8
  3 2521041.3 1907156.4 2322200.9 3208485.9 3084500.2 4249395.5 3636834.0
  4 1298831.1 1470228.1 1201793.3 1700113.8 2088324.1 2246698.7 2884011.3
```

age							
5	1103501.2	862767.5	951055.1	895155.9	1043011.6	1409605.8	1612558.1
6	1829680.8	737922.2	615452.3	850745.4	593355.5	656638.8	904116.3
7	338401.2	1303606.3	532678.8	464454.2	557373.2	354191.4	382431.3
8	341336.0	463869.4	1414150.9	1565780.5	1317840.8	984666.1	769403.8

age	2014	2015	2016	2017	2018
1	9370040.6	13884976.3	3689472.8	6510486.9	4604315.2
2	4233582.7	7439177.7	9591454.8	2073069.1	3550637.9
3	2714430.3	2703342.3	5858177.8	6775644.6	1664354.7
4	2719120.7	1661372.2	1579908.9	3695264.9	4164577.6
5	1797391.9	1590856.8	985865.3	991748.5	2318915.6
6	1022041.9	965406.3	845731.3	492573.2	615876.5
7	520188.5	497980.1	418928.9	371517.9	273845.5
8	561847.3	533566.2	434902.8	376057.1	390210.6

Table 2.6.3.31 North Sea Herring. INDEX AT AGE RESIDUALS HERAS

Units : NA

age	1989	1990	1991	1992	1993	1994
1	0.0000000	0.00000000	0.0000000	0.0000000	0.0000000	0.0000000
2	-0.4997891	0.08757695	-0.4071305	0.7125765	-0.3001368	-1.5932529
3	-0.2556513	0.92770463	-0.6537292	-0.6756033	-0.7038773	-2.1003089
4	-0.4760817	1.57243138	0.3712930	0.1707639	0.2750398	-2.4455885
5	-0.1256785	1.24715698	0.4932707	0.1203052	0.5835859	-0.1014317
6	-0.3032145	1.18595806	-0.2924060	0.7010468	0.6742106	-0.4707923
7	-0.5756844	0.79127019	0.3433285	-0.2531009	-0.2470806	-0.4225409
8	0.1022161	1.01423918	-0.9326227	0.1042860	-0.5994916	-1.1088739

age	1995	1996	1997	1998	1999	2000
1	0.000000000	0.0000000	0.59382846	-1.50905212	0.27004185	0.5811244
2	-1.023898782	0.1874657	0.29114901	-0.48405705	-1.52419947	-0.1909411
3	-0.007069201	0.6541166	0.21408537	-1.21928096	0.04896456	-0.4842538
4	1.090183571	0.6974731	-0.24028014	0.01362543	-1.53747617	0.7241888
5	-0.241085008	0.3221618	0.17189788	0.15302782	-1.61748372	0.3257476
6	-0.107687482	-1.8689733	0.52417606	0.45547149	-1.57925943	0.5236265
7	-1.023275066	-1.1011936	-2.07931732	0.63824175	-2.30220841	-0.4686081
8	-2.077204403	0.4160988	0.01380628	-0.64313061	-0.71669693	-0.1368256

age	2001	2002	2003	2004	2005	2006
1	-0.56963743	0.4522552	-0.11714039	-0.0410010	-1.20845824	0.60810395
2	1.75976096	-0.6432086	1.68693013	-1.7201674	-1.23057036	0.28505147
3	0.61397256	1.1525890	-0.97163992	-0.1832011	0.60204945	0.28863591
4	0.09630612	-0.8717869	-0.04250517	-0.2963818	0.08909411	0.52912669
5	0.25257261	-0.2619733	-1.71162429	0.2293520	-0.49929914	1.38733159
6	-0.84799271	0.3331718	-0.17045622	-1.5202492	-0.05102923	-0.47035055
7	-2.09014712	-0.9236711	-0.57202497	-0.2672249	-1.42679007	0.06125273
8	-1.57942502	-0.3828816	-0.11579984	0.1413266	-1.23842369	-1.04927764

age	2007	2008	2009	2010	2011	2012

1	0.470777792	-0.7661988	0.4653971	1.031416	0.88754517	-0.02028598
2	0.007592787	0.3428270	2.8843242	1.061746	-0.89248394	-0.35772785
3	-1.277377383	0.4689400	1.3311281	1.323719	-0.68802995	-0.06349536
4	-0.757689938	0.8028564	0.2511395	1.996154	-0.09257157	-0.75625636
5	-0.663157023	1.1796720	1.4432803	1.917712	-0.55986642	-0.65041405
6	-0.497106932	1.2102040	1.3594423	2.914958	0.21338543	-0.50887296
7	-0.581515584	2.6221923	1.4629882	1.808710	0.44074215	-1.73942688
8	-0.894969084	0.6959986	1.5662652	2.214007	0.48996415	-1.39359975

year

age	2013	2014	2015	2016	2017	2018
1	-0.01701774	1.3085861	-1.2213366	1.965612851	-1.6266804	2.0492775
2	-1.13413528	1.5207392	2.3216758	1.495511522	-0.5625399	0.2686137
3	0.01840042	0.6783569	0.2864125	0.008896981	-0.4173627	0.7782660
4	0.67093220	1.2694409	0.3106172	-0.848643502	-0.2989013	0.9292208
5	0.65611111	0.5554172	0.1429052	-0.263051787	-0.0631868	0.4203207
6	0.38998213	1.4698560	-0.0541759	0.583447562	-0.8696689	1.3297020
7	0.83958064	1.0689964	0.2927098	0.109332765	-0.1919954	3.1888322
8	0.24183081	-0.7852922	-0.2110726	-0.334532817	-0.2616707	0.1486244

Table 2.6.3.32 North Sea Herring. PREDICTED INDEX AT AGE IBTS0

Units : NA

year

age	1992	1993	1994	1995	1996	1997	1998
0	141.5892	147.1261	114.7846	132.3417	110.1666	88.01224	55.48879

year

age	1999	2000	2001	2002	2003	2004	2005
0	175.7439	119.4748	222.8213	107.4426	60.17169	69.94551	64.76096

year

age	2006	2007	2008	2009	2010	2011	2012
0	58.80255	67.62273	62.81363	102.9794	82.58967	74.16434	71.22697

year

age	2013	2014	2015	2016	2017	2018	2019
0	89.10461	143.2068	38.00685	72.25102	44.04582	80.97941	57.66408

Table 2.6.3.33 North Sea Herring. INDEX AT AGE RESIDUALS IBTS0

Units : NA

year

age	1992	1993	1994	1995	1996	1997
0	-0.2111753	0.2642233	0.4882644	-0.007001825	0.5985823	2.000488

year

age	1998	1999	2000	2001	2002	2003	2004
0	-0.4833896	1.546787	-0.7140618	1.567597	0.3369015	-0.2801556	-1.084573

year

age	2005	2006	2007	2008	2009	2010
0	0.1449227	0.05225986	-0.08132162	-1.057652	1.271977	-0.3363734

age \ year	2011	2012	2013	2014	2015	2016
0	-0.4354624	-0.300994	0.4554999	-0.2777381	-2.649368	0.369407

age \ year	2017	2018	2019
0	-0.8051455	0.7306622	-0.6343659

Table 2.6.3.34 North Sea Herring. PREDICTED INDEX AT AGE IBTS-Q3

Units : NA

age \ year	1998	1999	2000	2001	2002	2003
0	1140152.35	3567345.94	2400807.59	4448035.42	2132489.17	1184793.84
1	455137.95	290047.49	824019.29	547948.58	1118545.07	490267.56
2	263600.35	168504.20	162484.28	364940.29	239600.94	570838.94
3	93633.59	142016.37	84655.24	97785.10	222951.56	131405.29
4	36063.96	40718.58	72748.52	41003.15	43562.00	112599.75
5	16596.62	14244.52	19074.40	32778.13	17864.42	17500.09

age \ year	2004	2005	2006	2007	2008	2009
0	1359817.08	1240266.33	1120119.06	1292863.75	1194983.67	1975765.89
1	266654.48	354239.28	264781.21	243451.09	285739.59	291141.96
2	189528.60	116410.66	159351.64	110042.12	132191.71	157244.58
3	314134.61	110569.28	70654.38	84873.14	64419.74	78629.33
4	69578.79	149020.32	54653.79	36460.34	41431.11	33957.27
5	50026.10	30393.65	71616.33	24274.33	19083.71	21103.44

age \ year	2010	2011	2012	2013	2014	2015
0	1589978.41	1430418.28	1386288.94	1766017.59	2861852.41	766637.49
1	473213.08	418870.84	339109.85	317768.38	496216.84	735400.86
2	167369.27	209866.91	196201.92	145752.45	175316.67	308253.97
3	108515.50	104221.83	143162.02	122622.57	91521.66	91341.35
4	48040.26	58909.52	63150.96	80952.14	76236.81	46679.97
5	19858.23	23095.19	31074.07	35458.28	39486.74	34916.60

age \ year	2016	2017	2018
0	1473246.33	900309.97	1660651.40
1	195313.82	344737.26	243870.64
2	397564.74	85976.56	147221.86
3	197567.19	228286.74	56168.71
4	44361.19	103552.16	116393.83
5	21643.81	21822.79	50731.18

Table 2.6.3.35 North Sea Herring. INDEX AT AGE RESIDUALS IBTS-Q3

Units : NA

age	1998	1999	2000	2001	2002	2003
0	-0.7560070	0.4200079	-0.4668525	-1.525232	-0.23934514	-0.69209641
1	0.6074119	0.6503711	0.3219327	-0.241683	3.18019506	0.56108311
2	0.5447389	0.6180975	2.7377160	-1.208554	1.09556288	-0.07957729
3	-0.3819099	-1.2269802	0.1646301	1.116597	0.08614789	0.85982490
4	-1.9013636	1.2625924	-1.3528556	0.300127	1.21076555	-0.45107882
5	-1.3468705	0.4560511	-0.5832169	-1.173541	0.73598111	-0.05445450

age	2004	2005	2006	2007	2008	2009
0	1.30840879	-0.4224704	-0.09665864	1.516398	-0.6617842	1.22109093
1	0.97464397	1.6598890	0.71555364	-2.820022	-0.8048809	-0.90986104
2	0.76091742	-0.1225612	0.73680025	0.256353	0.8010929	-1.64108674
3	0.08391895	-1.2703853	0.18252924	1.417595	0.3608337	0.35448710
4	0.82927172	-1.1661535	-1.02661536	1.577488	-0.3978765	0.07894876
5	-1.06134281	1.1157579	-1.01472310	0.450406	0.7192678	-1.64378549

age	2010	2011	2012	2013	2014	2015
0	-0.06903613	-0.97012647	-0.7225147	1.0108577	1.9719730	-0.39763630
1	0.99289163	0.06020663	-0.7026192	-0.2480358	-0.8204336	1.23428222
2	0.17052129	0.08292843	-2.0401699	0.1118545	0.3052040	0.49548939
3	-1.63836736	0.37284146	-1.1120149	0.4017984	-0.3427725	0.62032115
4	-0.67924773	-0.82516698	0.1294128	0.1144980	0.3611965	0.91215772
5	-0.56724093	-0.20497729	-0.3170592	0.4589684	0.3118637	0.09091115

age	2016	2017	2018
0	0.30393817	0.5972817	0.10096161
1	-0.51121593	-0.7619947	-0.45961360
2	-0.09002203	0.1131114	-1.85644017
3	0.45555807	-0.2698410	0.90005666
4	1.58875726	1.2795814	-1.20897485
5	1.79299417	2.2780654	-0.06095479

Table 2.6.3.37 North Sea Herring. FIT PARAMETERS

	name	value	std.dev
1	logFpar	-12.9135007	0.09439437
2	logFpar	-0.2657307	0.12262130
3	logFpar	-0.1908894	0.07304127
4	logFpar	-0.0368668	0.07044761
5	logFpar	-2.3310657	0.07536233
6	logFpar	-2.5487471	0.14163121
7	logFpar	-3.1633485	0.10161671
8	logFpar	-3.3453018	0.09427366
9	logFpar	-3.3963570	0.09491828
10	logFpar	-3.5773500	0.09694926
11	logFpar	-3.8193747	0.09894651
12	logFpar	-4.2600988	0.11287755

```
13         logSdLogFsta  -0.5960752 0.11981768
14         logSdLogFsta  -1.1344043 0.09819444
15         logSdLogFsta  -0.6697067 0.09990409
16            logSdLogN  -0.5519211 0.11601123
17            logSdLogN  -1.7136356 0.09217653
18            logSdLogP   0.1509277 0.09921606
19            logSdLogP  -0.3418938 0.17591259
20            logSdLogP  -0.1961220 0.12796682
21          logSdLogObs  -1.5048191 0.45071808
22          logSdLogObs  -2.1971163 0.49099302
23          logSdLogObs  -1.4005467 0.18500732
24          logSdLogObs  -0.7421974 0.16017598
25          logSdLogObs  -1.5753020 0.08853870
26          logSdLogObs  -1.2410904 0.14189622
27          logSdLogObs  -1.2473213 0.15130768
28          logSdLogObs  -1.1127152 0.18083902
29          logSdLogObs  -0.6097656 0.18316388
30          logSdLogObs  -1.0802296 0.18090664
31          logSdLogObs  -1.1723392 0.10694524
32          logSdLogObs   0.1697697 0.04443655
33       transfIRARdist  -0.3945483 0.27665461
34                 rhop   0.4174042 0.24047329
35 logAlphaSCB.LAI-ORSH  -0.4558852 0.31715525
36  logAlphaSCB.LAI-BUN  -0.9586141 0.34968719
37  logAlphaSCB.LAI-CNS   0.3424176 0.33883253
38  logAlphaSCB.LAI-CNS  -0.3788479 0.35328456
39  logAlphaSCB.LAI-CNS  -3.0576174 0.40751305
40  logAlphaSCB.LAI-SNS  -0.2364188 0.25391303
41  logAlphaSCB.LAI-SNS  -1.1017398 0.27359799
```

Table 2.6.3.38 North Sea Herring. NEGATIVE LOG-LIKELIHOOD

```
1305.49216198626
```

Table 2.7.1. North Sea herring. Intermediate year (2019) assumptions for the stock.

Variable	Value	Notes
$F_{ages\ (wr)\ 2–6}$ (2019)	0.19	Catch constraint
SSB (2019)	1 528 855	Calculated based on catch constraint (in tonnes).
$R_{age\ (wr)\ 0}$ (2019)	26 191 234	Estimated by assessment model (in thousands).
$R_{age\ (wr)\ 0}$ (2020)	33 943 979	Weighted mean over 2009–2018 (in thousands)
Total catch (2019)	412 462	Agreed catch options, including a 48% transfer (14 076t) of C-fleet TAC to the A-fleet in the North Sea (in tonnes).

Table 2.7.1. North Sea herring. Intermediate year (2019), fleet wise assumptions for the catches and the fishing mortality. Weights are in tonnes

	Field	Value	Note
TACs	A-fleet TAC	385008	
	B-fleet TAC	13190	
	C-fleet TAC	29326	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	0.0036	Value from terminal year
	B-fleet uptake	0.86	Average over the last 3 years (2016-2018)
	C-fleet transfer	0.48	Value for the Intermediate year
	C-fleet NSAS/WBSS split	0.19	Average over the last 3 years (2016-2018)
	D-fleet NSAS/WBSS split	0.56	Average over the last 3 years (2016-2018)
	D-fleet uptake	0.16	Average over the last 3 years (2016-2018)
F by fleet and total	$F_{(wr)\ 2\text{–}6}$ A-fleet	0.19	
	$F_{(wr)\ 0\text{–}1}$ B-fleet	0.046	
	$F_{(wr)\ 0\text{–}1}$ C-fleet	0.002	
	$F_{(wr)\ 0\text{–}1}$ D-fleet	0.002	
	$F_{(wr)\ 2\text{–}6}$	0.19	
	$F_{(wr)\ 0\text{–}1}$	0.052	
NSAS catches by fleet	Catches A-fleet	397648	Includes C-fleet transfer and split of WBSS/NSAS in the north sea
	Catches B-fleet	11324	Includes fleet uptake
	Catches C-fleet	2886	Includes TAC transfer to the A fleet and WBSS/NSAS split.
	Catches D-fleet	604	Includes WBSS/NSAS split and fleet uptake

Table 2.7.1. North Sea herring. Reference points prior used at HAWG 2018.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	1 500 000 t	Biomass trigger value that results in < 5% probability of being below B_{lim} when the ICES MSY AR is applied.	ICES (2016a)
	F_{MSY}	0.33	Stochastic simulations with Beverton and Ricker stock–recruitment curve from short time-series (2002–2015).	ICES (2016a)
Precautionary approach	B_{lim}	800 000 t	Breakpoint in the segmented regression of the stock-recruitment time-series (1985–2015).	ICES (2016a)
	B_{pa}	1 000 000 t	$B_{pa} = B_{lim} \times \exp(1.645 \times \sigma)$ with $\sigma \approx 0.10$, based on the average CV from the terminal assessment year.	ICES (2012)
	F_{lim}	0.39	FP50% from stochastic simulations with Beverton and Ricker stock–recruitment curve (2002–2015).	ICES (2016a)
	F_{pa}	0.34	$F_{pa} = F_{lim} \times \exp(-1.645 \times \sigma)$ with $\sigma \approx 0.08$, based on the average CV from the terminal assessment year.	ICES (2016a)
Management plan	SSB_{mgt}	800 000 t and 1 500 000 t	Informed by simulations and chosen by managers.	EU–Norway (2014)
	F_{mgt}	$F_{ages\ (wr)0-1} = 0.05$ $F_{ages\ (wr)2-6} = 0.26$	SSB is greater than the SSB_{MGT} upper trigger of 1.5 million t (based on simulations).	EU–Norway (2014)
		$F_{ages\ (wr)0-1} = 0.05$ $F_{ages\ (wr)2-6} = 0.26 - (0.16 \times (1\,500\,000 - SSB) / 700\,000)$	SSB is between the SSB_{MP} triggers of 0.8 and 1.5 million t (based on simulations).	EU–Norway (2014)
		$F_{ages\ (wr)0-1} = 0.04$ $F_{ages\ (wr)2-6} = 0.10$	SSB is less than the SSB_{MP} lower trigger of 0.8 million t (based on simulations).	

Table 2.7.2. North Sea herring. Framework from new management plan requested (ICES, 2018).

Framework^	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	1 400 000	5th percentile of B_{FMSY}	ICES (2018d)
	F_{MSY}	0.26	Stochastic simulations with a segmented regression and Ricker stock–recruitment curve from the short time-series (2002–2016).	ICES (2018d)
Precautionary approach	B_{lim}	800 000	Breakpoint in the segmented regression of the stock–recruitment time-series (1947–2016).	ICES (2018d)
	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 (2018d)
	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 (2018d)
	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 (2018d)
Management plan option A	$B_{trigger}$	1 500 000 t	Informed by simulations.	EU–Norway (2017; 2018)
	F_{target}	$F_{ages\ (wr)0–1} = 0.05$ $F_{ages\ (wr)2–6} = 0.23$	SSB is greater than $B_{trigger}$	EU–Norway (2017; 2018)
		$F_{ages\ (wr)0–1} =$ $0.05*SSB/B_{trigger}$ $F_{ages\ (wr)2–6} =$ $0.23*SSB/B_{trigger}$	SSB is less than $B_{trigger}$	EU–Norway (2017; 2018)
Management plan option A+C*	$B_{trigger}$	1 500 000 t	Informed by simulations.	EU–Norway (2017; 2018)
	F_{target}	$F_{ages\ (wr)0–1} = 0.05$ $F_{ages\ (wr)2–6} = 0.23$	SSB is greater than $B_{trigger}$	EU–Norway (2017; 2018)
		$F_{ages\ (wr)0–1} =$ $0.05*SSB/B_{trigger}$ $F_{ages\ (wr)2–6} =$ $0.23*SSB/B_{trigger}$	SSB is less than $B_{trigger}$	EU–Norway (2017; 2018)
Management plan option A+D**	$B_{trigger}$	1 500 000 t	Informed by simulations.	EU–Norway (2017; 2018)
	F_{target}	$F_{ages\ (wr)0–1} = 0.05$ $F_{ages\ (wr)2–6} = 0.23$	SSB is greater than $B_{trigger}$	EU–Norway (2017; 2018)
		$F_{ages\ (wr)0–1} =$ $0.05*SSB/B_{trigger}$ $F_{ages\ (wr)2–6} =$ $0.23*SSB/B_{trigger}$	SSB is less than $B_{trigger}$	EU–Norway (2017; 2018)
Management plan option B	$B_{trigger}$	1 500 000 t	Informed by simulations.	EU–Norway (2017; 2018)
	F_{target}	$F_{ages\ (wr)0–1} = 0.05$ $F_{ages\ (wr)2–6} = 0.23$	SSB is greater than $B_{trigger}$	EU–Norway (2017; 2018)
		$F_{ages\ (wr)0–1} = 0.05$ $F_{ages\ (wr)2–6} =$ $0.23*SSB/B_{trigger}$	SSB is less than $B_{trigger}$ and greater than B_{lim}	EU–Norway (2017; 2018)
		$F_{ages\ (wr)0–1} = 0.04$ $F_{ages\ (wr)2–6} = 0.1$	SSB is less than B_{lim}	EU–Norway (2017; 2018)

* When SSB is greater $B_{trigger}$ TAC inter annual variability limited to 25% up and 20% down from the intermediate TAC for the A fleet.

** When SSB is greater $B_{trigger}$ TAC inter annual variability limited to 25% up and 20% down from the intermediate TAC for the A and B fleets.

^ No reference points satisfying long term risk criteria could be achieved for management plan option B+E.

Table 2.7.3. North Sea Herring. Scenarios for prediction year (2019). Weights in tonnes.

Basis	F values by fleet and total						Catches by fleet				Total stock catch	Biomass*				% Advice change ^
	A-fleet $F_{ages\ (wr)\ 2–6}$	B-fleet $F_{ages\ (wr)\ 0–1}$ ^^^	C-fleet $F_{ages\ (wr)\ 0–1}$	D-fleet $F_{ages\ (wr)\ 0–1}$	$F_{ages\ (wr)\ 2–6}$	$F_{ages\ (wr)\ 0–1}$	A-fleet	B-fleet	C-fleet#	D-fleet#		SSB 2020	SSB 2021 **	%SSB change ***	A-fleet **** %TAC change	
MSY approach^^	0.24	0.046	0	0	0.24	0.048	418649	12413	0	0	431062	1286788	1167712	-15.8	8.7	38.4
Other scenarios																
EU–Norway Management strategy option A‡	0.20	0.043	0	0	0.20	0.044	364795	11563	0	0	376359	1323117	1227801	-13.5	-5.2	20.8
EU–Norway Management strategy option A+C‡‡	0.20	0.043	0	0	0.20	0.044	364795	11563	0	0	376359	1323117	1227801	-13.5	-5.2	20.8
EU–Norway Management strategy option A+D‡‡‡	0.20	0.043	0	0	0.20	0.044	364795	11563	0	0	376359	1323117	1227801	-13.5	-5.2	20.8
EU–Norway Management strategy option B‡‡‡‡	0.21	0.049	0	0	0.21	0.050	376286	13090	0	0	389376	1315365	1214353	-14.0	-2.3	25.0
$F = F_{MSY}$	0.26	0.046	0	0	0.26	0.048	448772	12412	0	0	461185	1266292	1135230	-17.2	16.6	48.0
F = 0	0	0	0	0	0	0	0	0	0	0	0	1558516	1699799	1.9	-100.0	-100.0
No change in A-fleet TAC	0.22	0.046	0	0	0.22	0.047	385008	12414	0	0	397422	1309518	1204811	-14.3	0.0	27.6
A-fleet TAC reduction of 15%	0.18	0.046	0	0	0.18	0.047	327257	12415	0	0	339672	1348146	1270564	-11.8	-15.0	9.0

Basis	F values by fleet and total						Catches by fleet				Total stock catch	Biomass*				% Advice change ^
	A-fleet $F_{ages\ (wr)\ 2\text{–}6}$	B-fleet $F_{ages\ (wr)\ 0\text{–}1}$ ^^^	C-fleet $F_{ages\ (wr)\ 0\text{–}1}$	D-fleet $F_{ages\ (wr)\ 0\text{–}1}$	$F_{ages\ (wr)\ 2\text{–}6}$	$F_{ages\ (wr)\ 0\text{–}1}$	A-fleet	B-fleet	C-fleet#	D-fleet#		SSB 2020	SSB 2021 **	%SSB change ***	A-fleet **** %TAC change	
A-fleet TAC increase of 15%	0.26	0.046	0	0	0.26	0.048	442759	12412	0	0	455172	1270395	1141659	-16.9	15.0	46.1
F = F_{2018}	0.19	0.046	0	0	0.19	0.047	351394	12415	0	0	363809	1332061	1242761	-12.9	-8.7	16.8
F_{pa}	0.30	0.046	0	0	0.30	0.048	503560	12411	0	0	515971	1228661	1077894	-19.6	30.8	65.6
F_{lim}	0.34	0.046	0	0	0.34	0.048	555312	12409	0	0	567721	1192695	1025745	-22.0	44.2	82.2
$SSB_{2020} = B_{pa}$	0.75	0.046	0	0	0.75	0.050	957157	12395	0	0	969552	899590	679381	-41.2	148.6	211.2
$SSB_{2020} = B_{lim}$	0.95	0.046	0	0	0.95	0.051	1087848	12388	0	0	1100237	799618	585305	-47.7	182.6	253.1
SSB_{2020} = MSY $B_{trigger}$	0.13	0.046	0	0	0.13	0.047	249400	12417	0	0	261817	1399457	1363458	-8.5	-35.2	-16.0
MSY approach with C and D fleets catches and C fleet TAC transfer##	0.25	0.046	0.002	0.002	0.25	0.052	429474	12392	2886	604	445357	1286867	1165739	-15.8	11.5	42.9
MSY approach with C and D fleets catches and no C fleet TAC transfer###	0.24	0.046	0.003	0.002	0.24	0.053	415398	12388	5550	604	433940	1286942	1164080	-15.8	7.9	39.3

* For autumn-spawning stocks, the SSB is determined at spawning time and is influenced by fisheries between 1 January and spawning.

** Assuming same catch scenario in 2020 as in 2019.

*** SSB (2020) relative to SSB (2019).

**** A-fleet catches (2020) relative to TAC 2019 for the A-fleet (385 008 tonnes).

^ Advice value 2020 relative to advice value 2019, using catches for all fleets.

^^ Following the MSY advise rule $F_{MSY} \times SSB_{2020}$/MSY $B_{trigger}$ (ICES, 2016).

^^^ Status quo on the fishing mortality for the B fleet for all catch options except management strategy options

The catch for C and D fleets are set to zero because of the zero catch advice given for 2019 for the Western Baltic spring-spawning herring stock.

Following the MSY advise rule $F_{MSY} \times SSB_{2020}/MSY\ B_{trigger}$ (ICES, 2016), assuming same catches as in 2019 for the C and D fleet and a 48% C fleet TAC transfer to the A fleet.

Following the MSY advise rule $F_{MSY} \times SSB_{2020}/MSY\ B_{trigger}$ (ICES, 2016), assuming same catches as in 2019 for the C and D fleet and no C fleet TAC transfer to the A fleet.

‡ scenario based on current MSE results[1)] for case A: $B_{trigger}$ = 1500000, F_{target} = 0.23 , F_{01}=0.05.

‡‡ scenario based on current MSE results[1)] for case A+C: $B_{trigger}$ = 1500000, F_{target} = 0.23, F_{01}=0.05.

‡‡‡ scenario based on current MSE results[1)] for case A+D: $B_{trigger}$ = 1500000, F_{target} = 0.23, F_{01}=0.05.

‡‡‡‡ scenario based on current MSE results[1)] for case B: $B_{trigger}$ = 1500000, F_{target} = 0.23, F_{01}=0.05.

1) The MSE assumed a fixed transfer from the C-fleet into the North Sea (between 19 370 tonnes and 24214 tonnes) while the scenarios above are based on a 0 catch option for the C and D fleet because of the advice on WBSS herring.

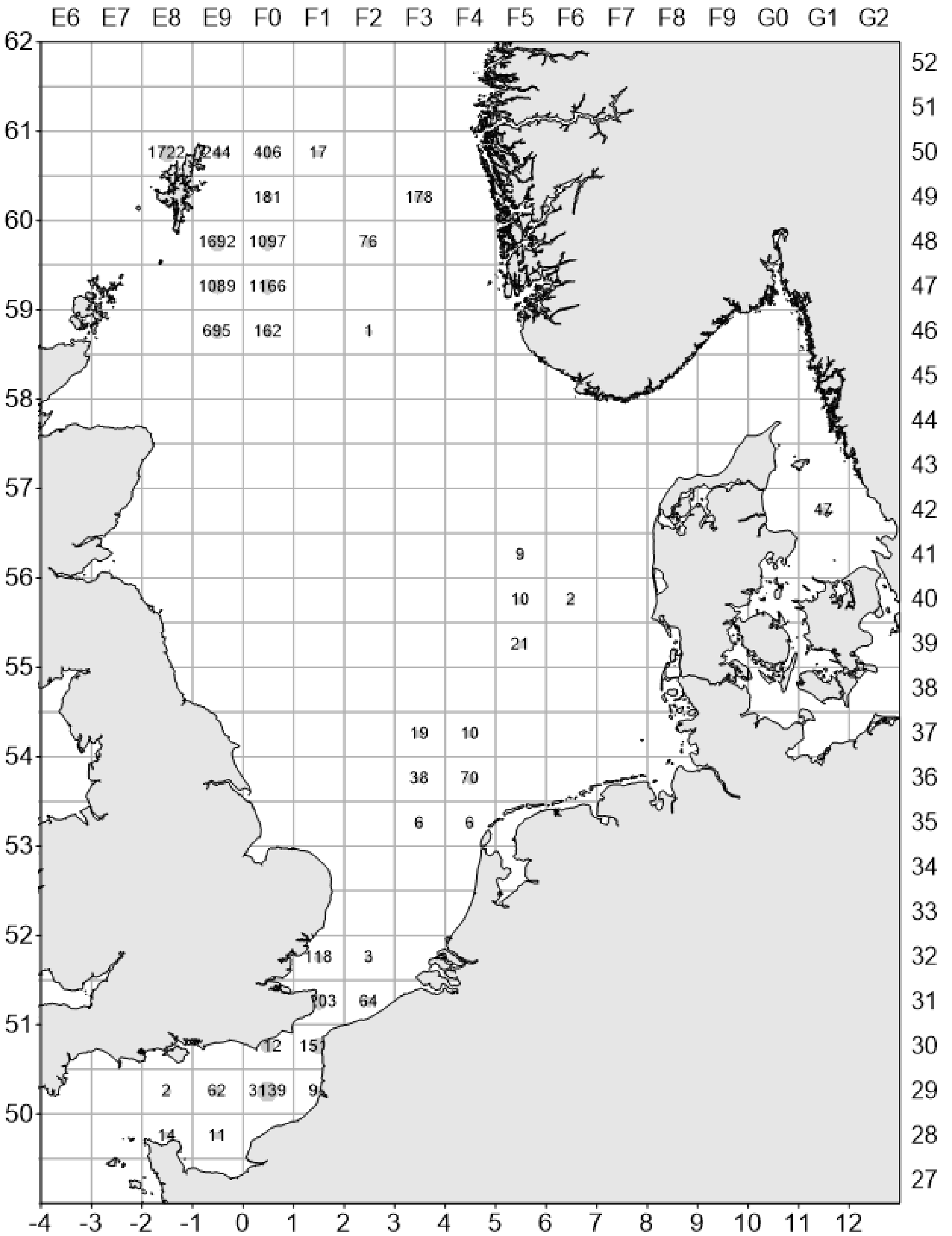


Figure 2.1.1a: Herring catches in the North Sea in the 1st quarter of 2018 (in tonnes) by statistical rectangle.

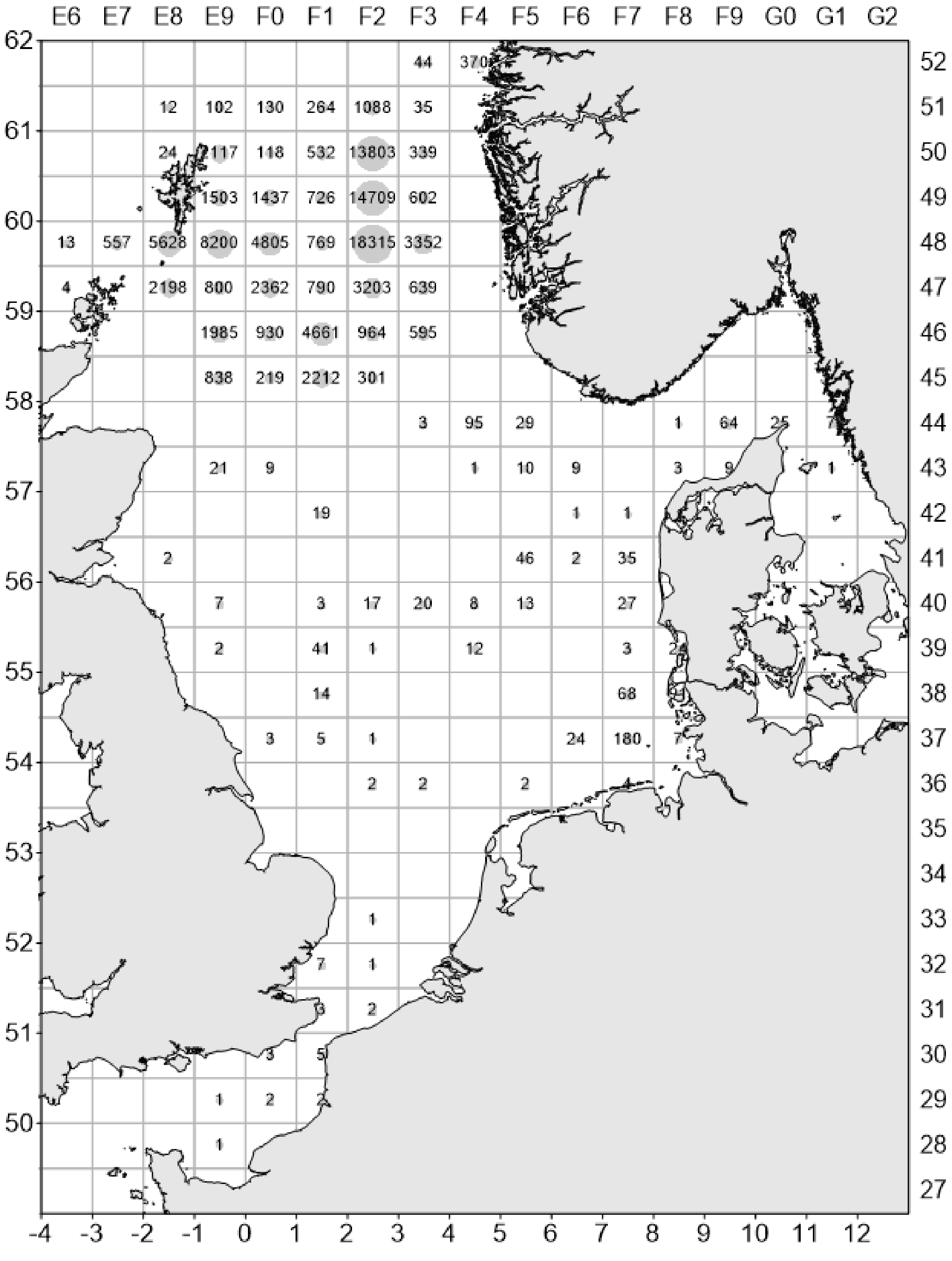


Figure 2.1.1b: Herring catches in the North Sea in the 2nd quarter of 2018 (in tonnes) by statistical rectangle.

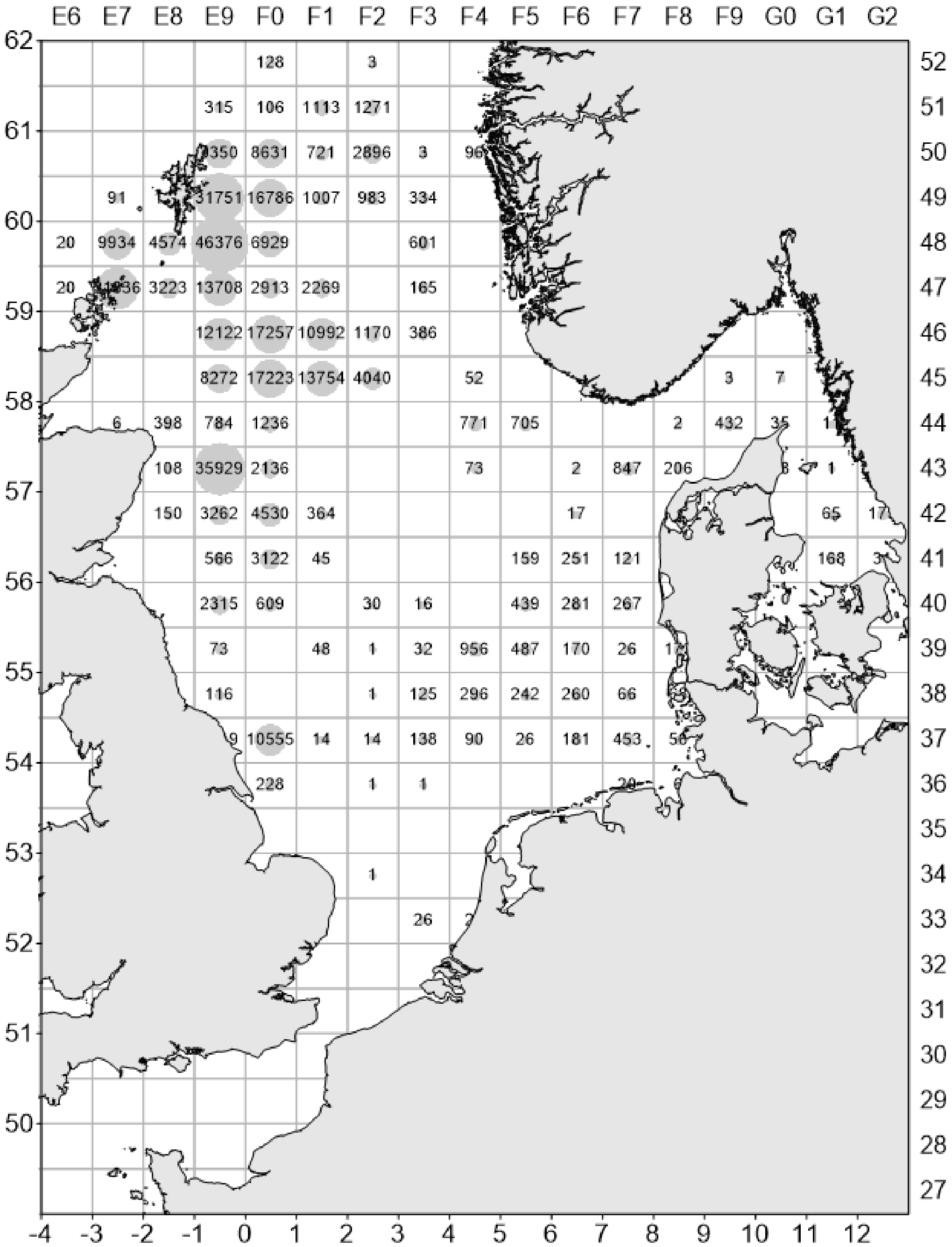


Figure 2.1.1c: Herring catches in the North Sea in the 3rd quarter of 2018 (in tonnes) by statistical rectangle.

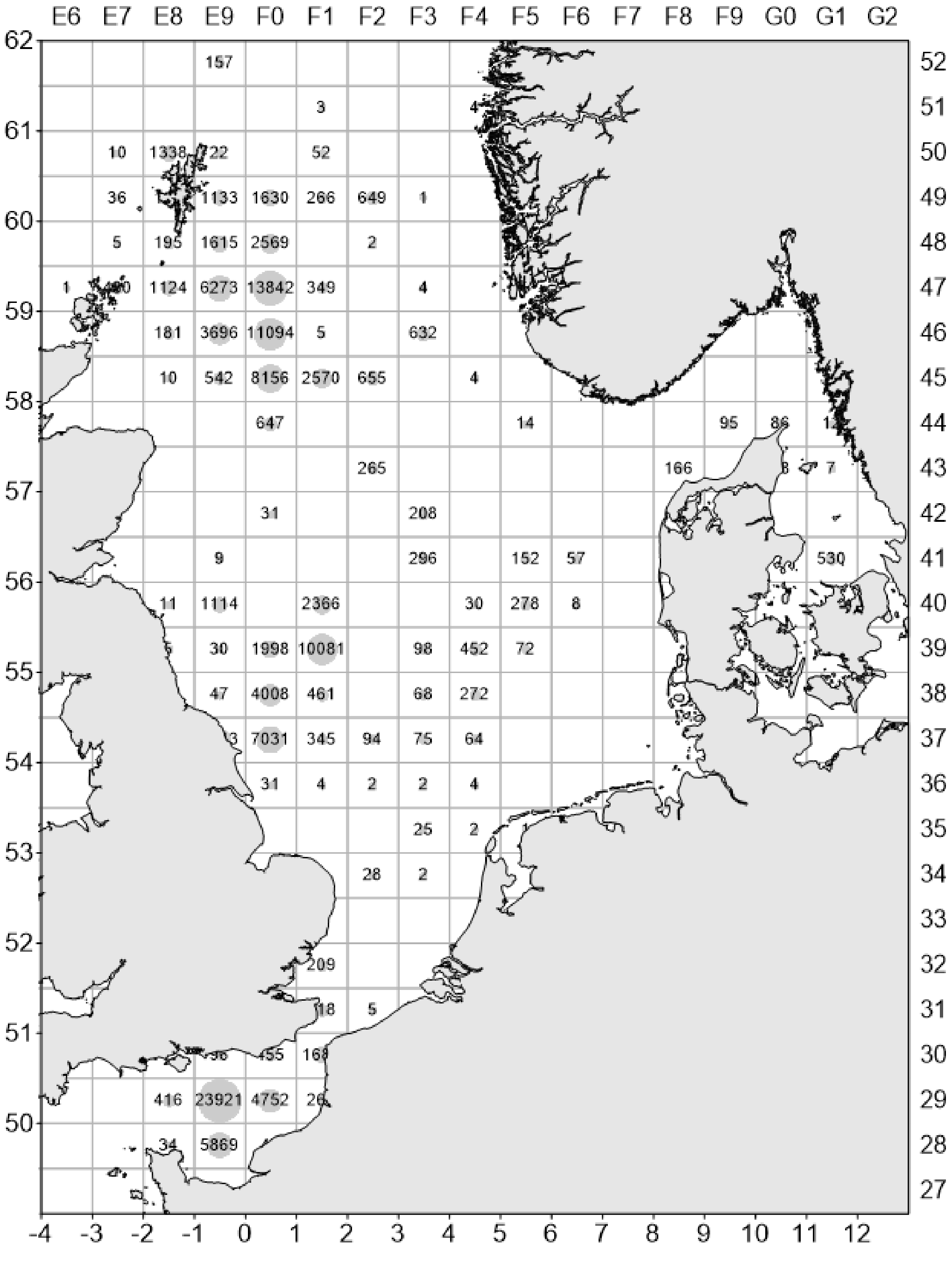


Figure 2.1.1d: Herring catches in the North Sea in the 4th quarter of 2018 (in tonnes) by statistical rectangle.

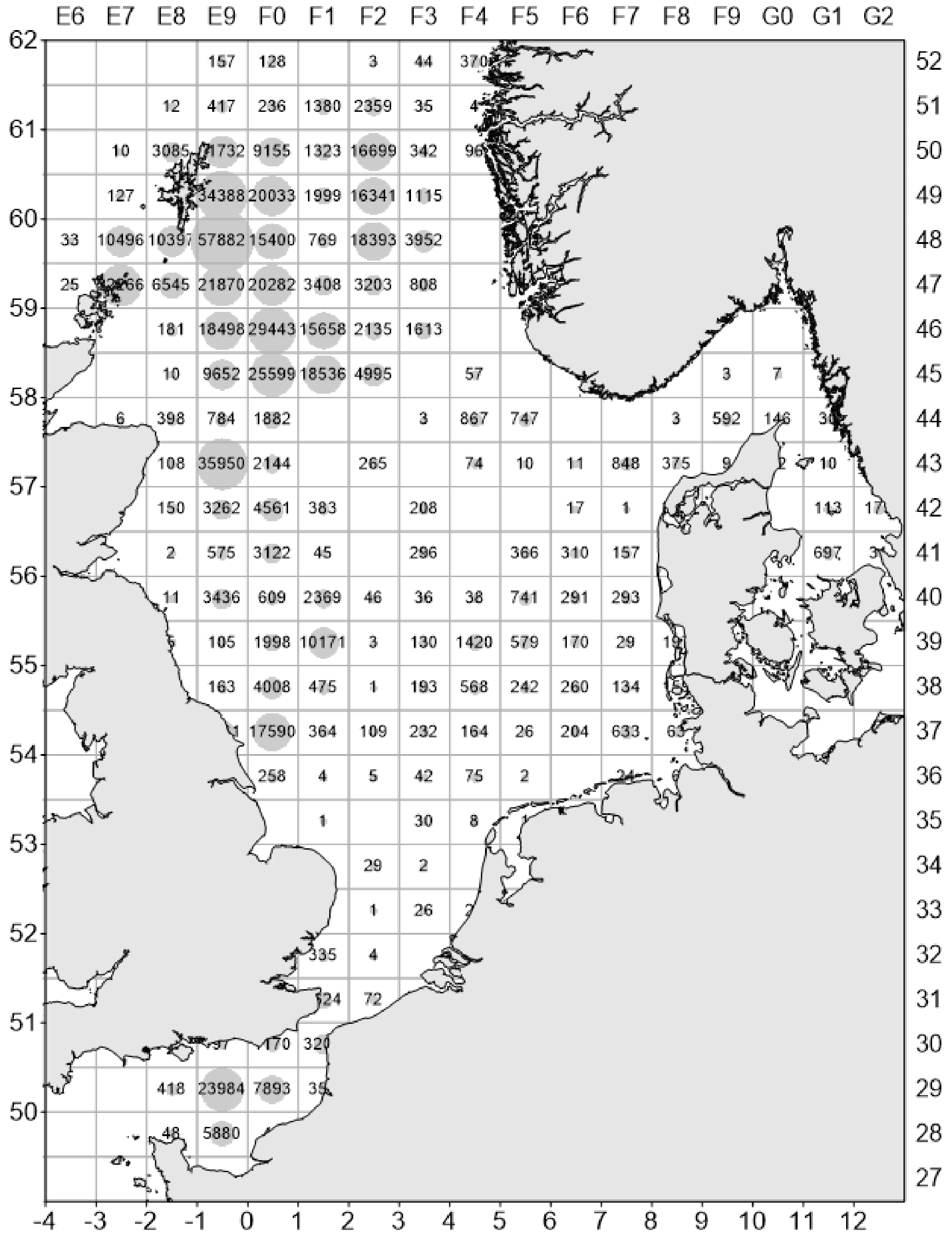
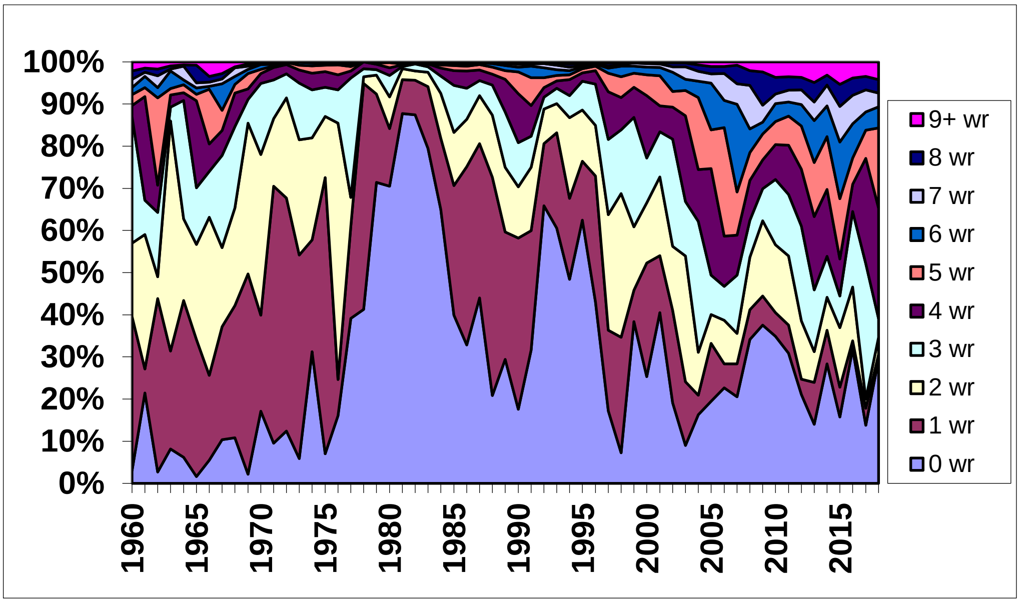


Figure 2.1.1e: Herring catches in the North Sea in all quarters of 2018 (in tonnes) by statistical rectangle.



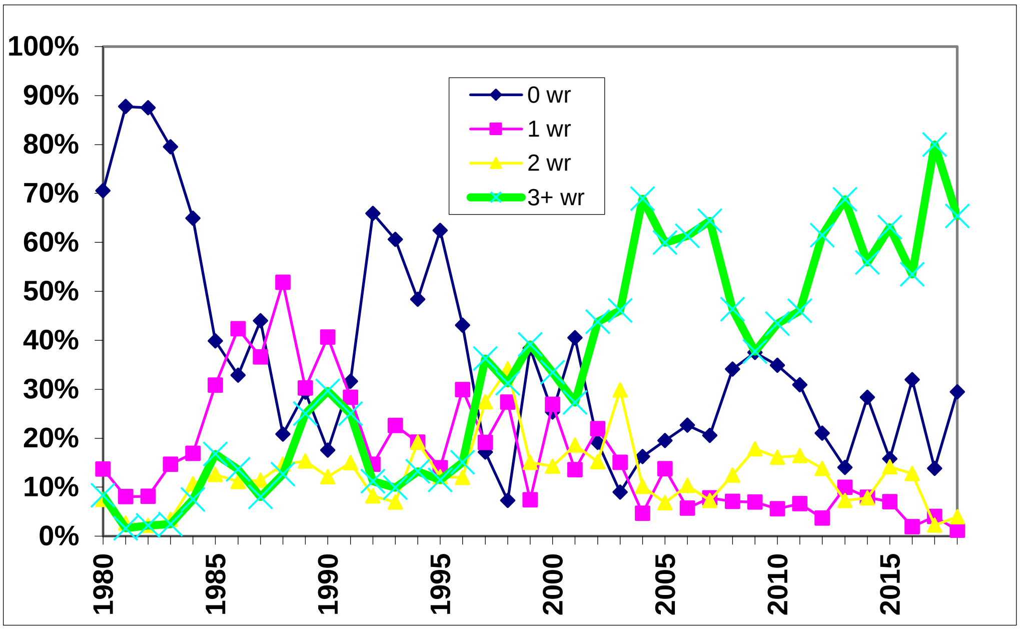


Figure 2.2.1: Proportions of age groups (numbers) in the total catch of herring caught in the North Sea (upper, 1960–2018, and lower panel, 1980–2018).

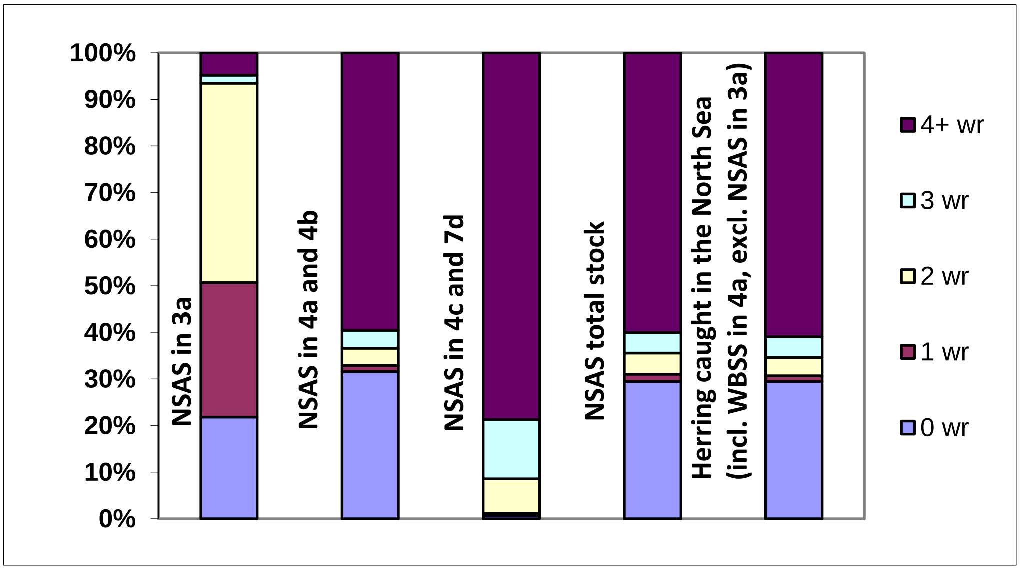


Figure 2.2.2: Proportion of age groups (numbers) in the total catch of NSAS and herring caught in the North Sea in 2018.

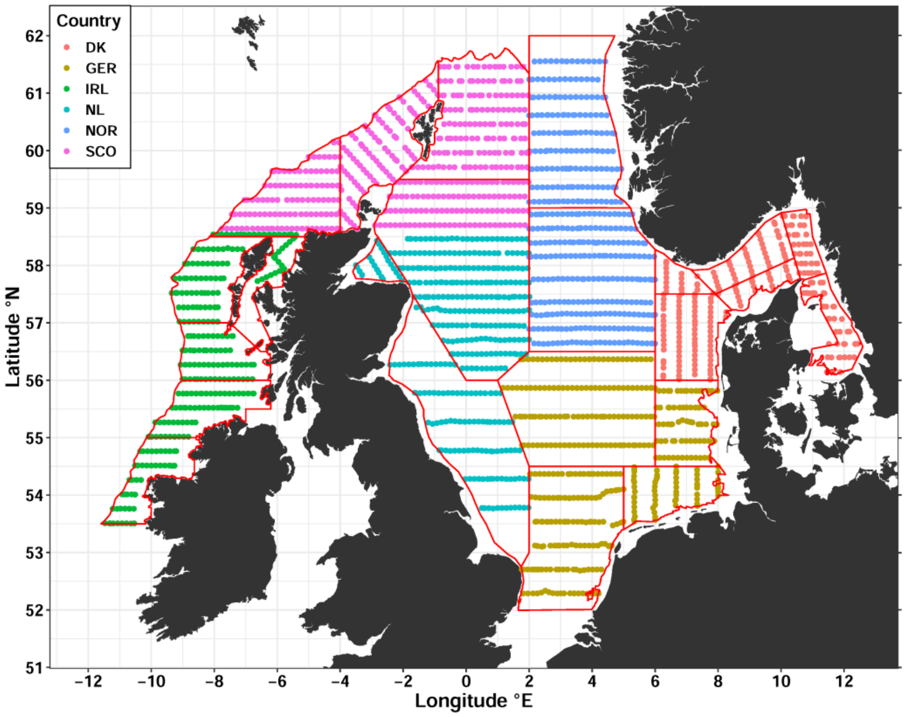


Figure 2.3.1.1. Cruise tracks and survey area coverage in the HERAS acoustic surveys in 2018 by nation.

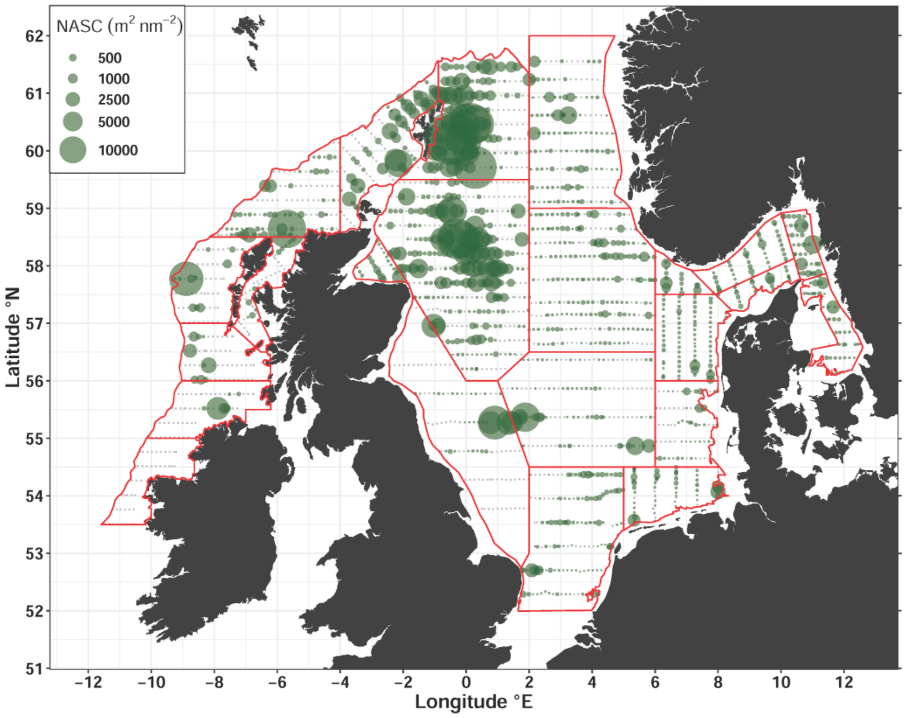


Figure 2.3.1.2. Distribution of NASC attributed to herring in HERAS in 2018. Acoustic intervals represented by light grey dot with green circles representing size and location of herring aggregations. NASC values are resampled at 5 nmi intervals along the cruise track. The red lines show the strata system.

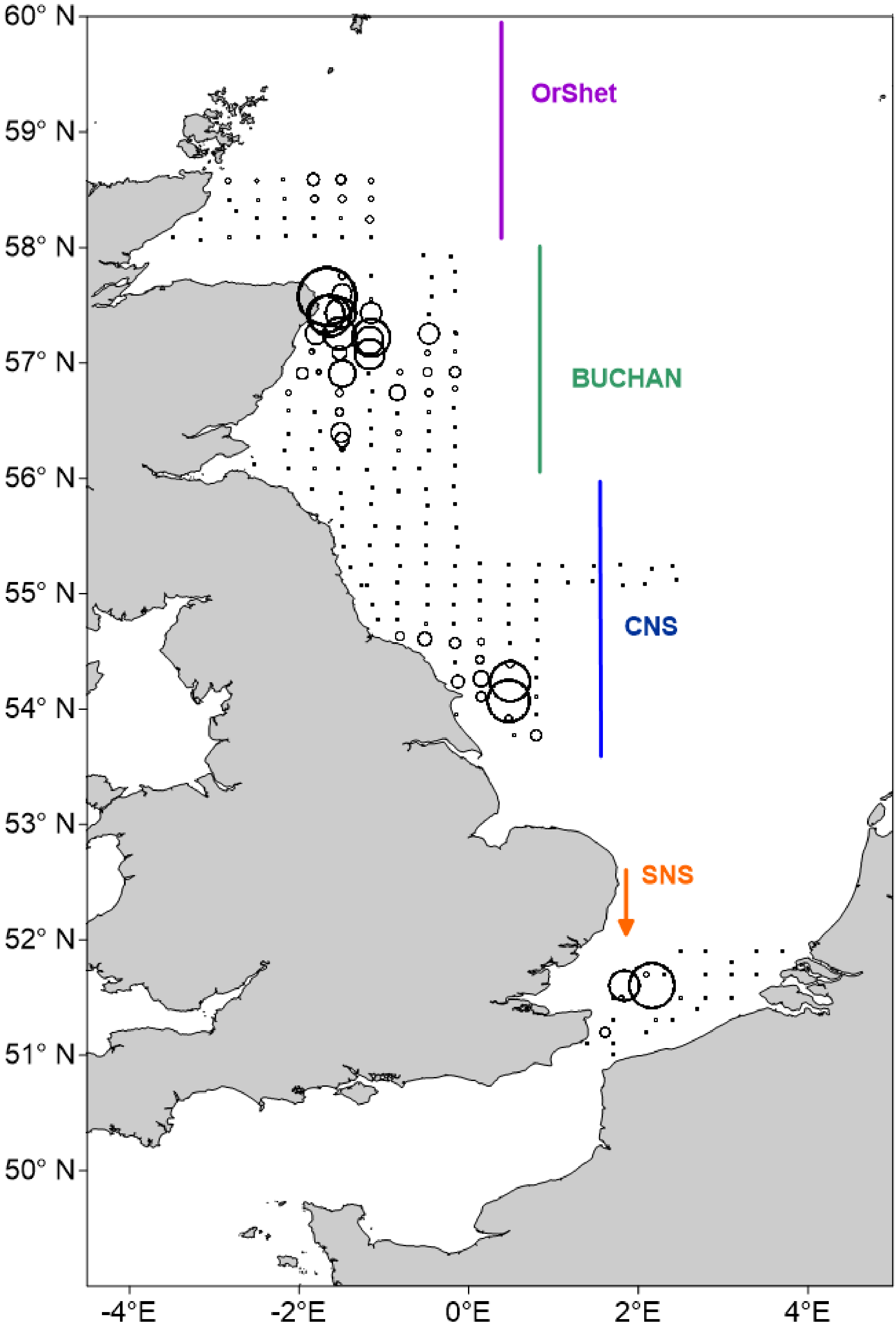


Figure 2.3.2.1: North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Buchan, Central and Southern North Sea as obtained from the International Herring Larvae Surveys in autumn and winter 2018/2019 (maximum circle size = 3500 n/m²). The survey around the Orkneys had to be stopped after 28 hauls due to technical problems of the research vessel.

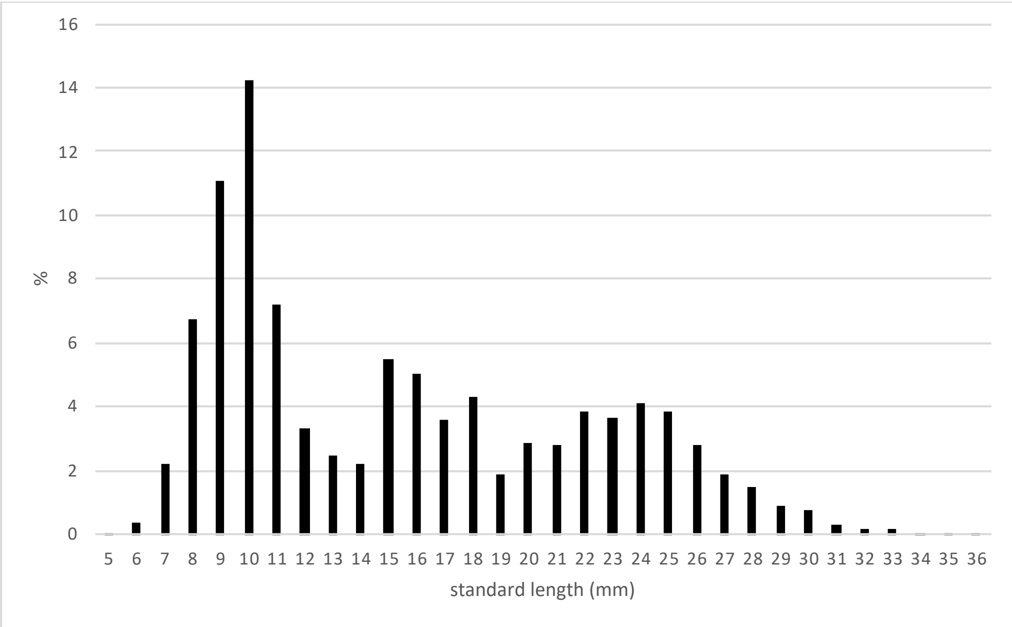


Figure 2.3.3.1. North Sea herring. Length distribution of all herring larvae caught during the 2019 Q1 IBTS.

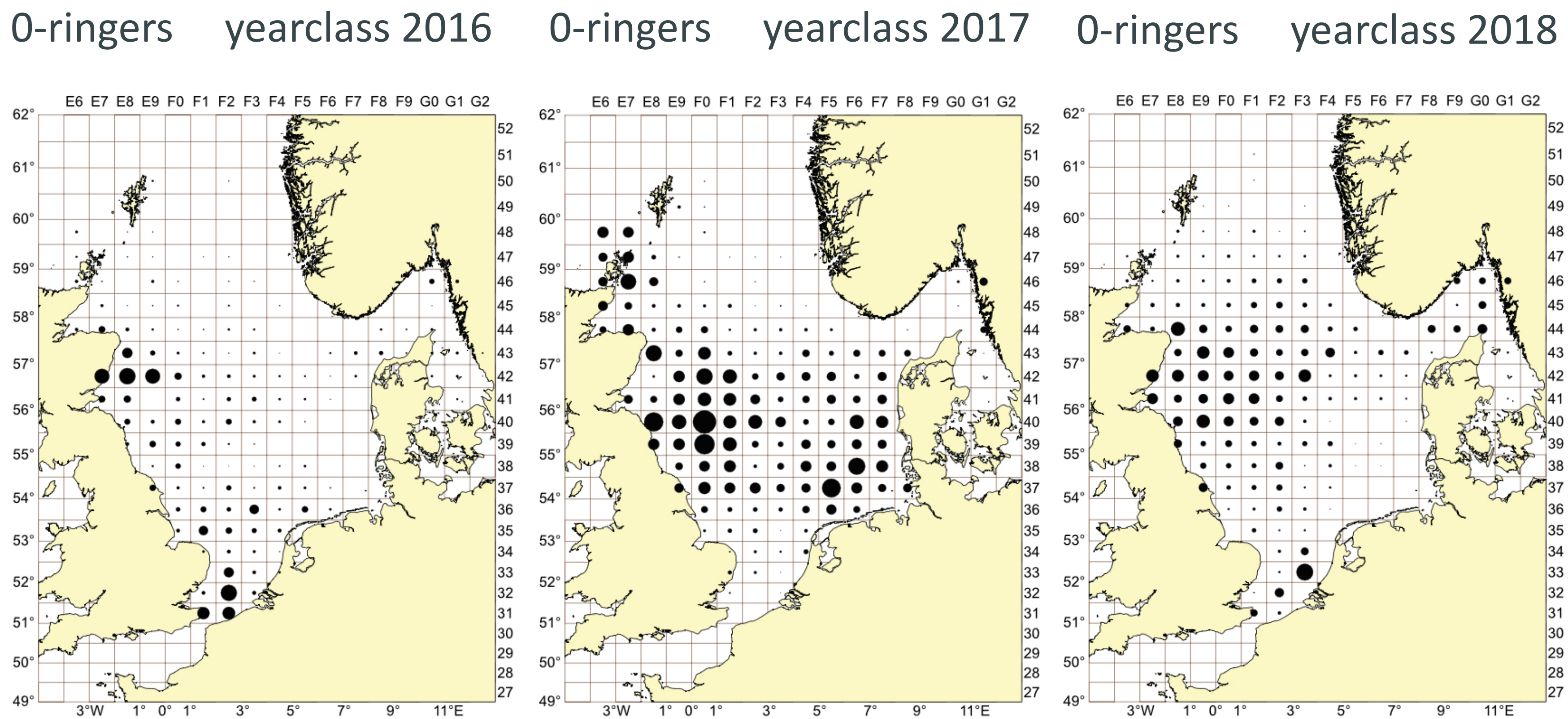


Figure 2.3.3.2. North Sea herring. Distribution of 0-ringer herring, year classes 2015–2017. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in January/February 2016–2018. Areas of filled circles illustrate densities in no m^{-2}, the area of the largest circle represents a density of 1.83 m^{-2}. All circles are scaled to the same order of magnitude of the square root transformed densities.

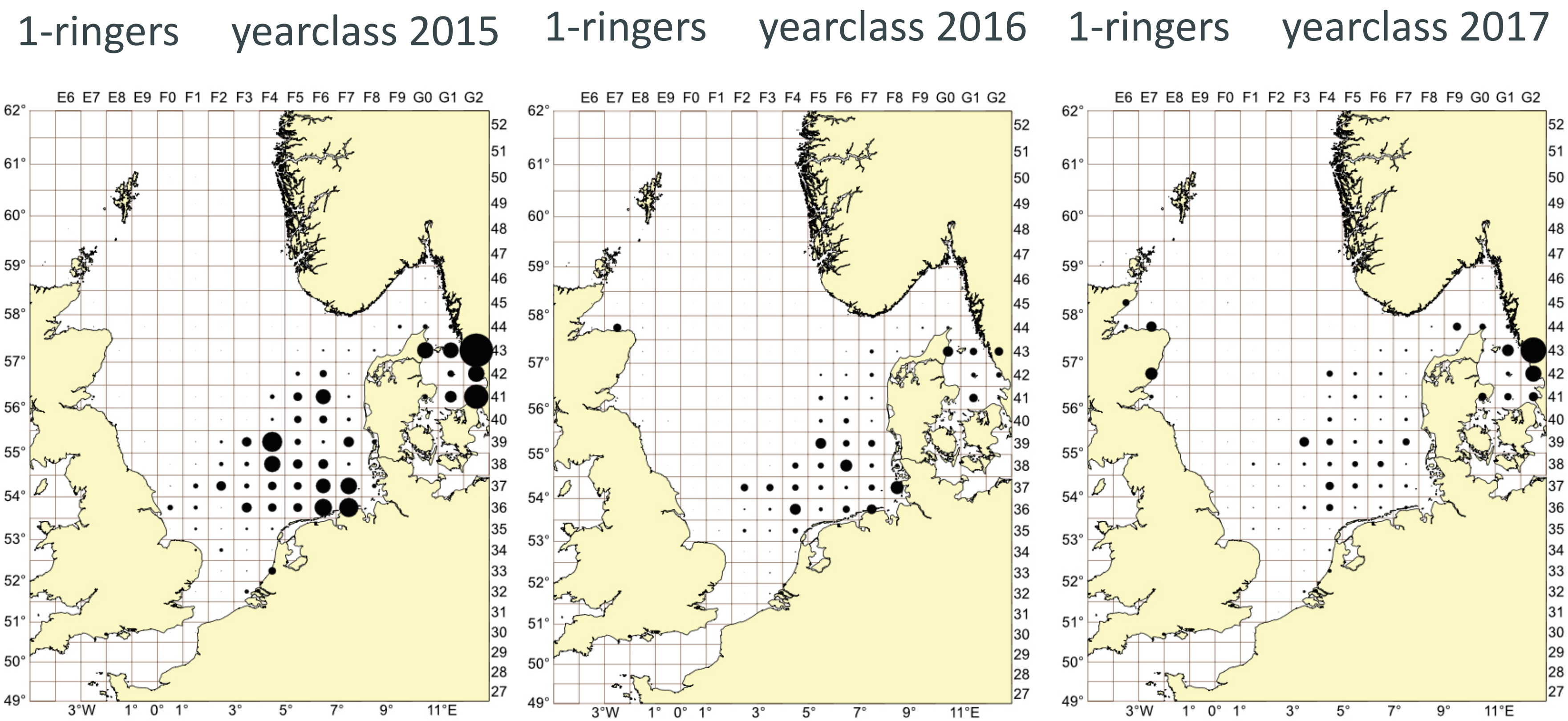


Figure 2.3.3.3. North Sea herring. Distribution of 1-ringer herring, year classes 2014–2016. Density estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in January/February 2016–2018. Areas of filled circles illustrate numbers per hour, scaled proportionally to the square root transformed CPUE data, the area of the largest circle extending across the boundary of a rectangle represents 99 136 h^{-1}.

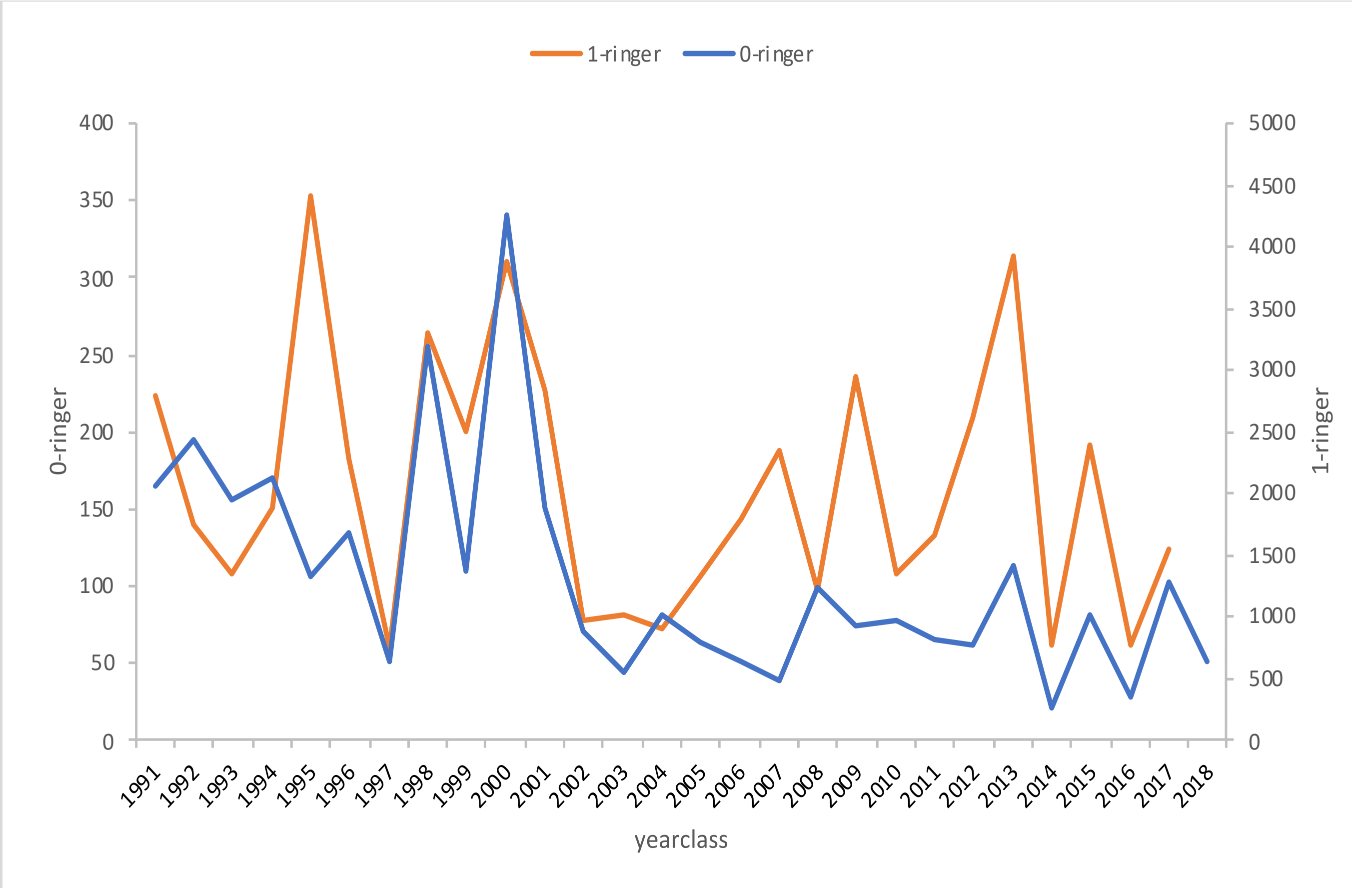
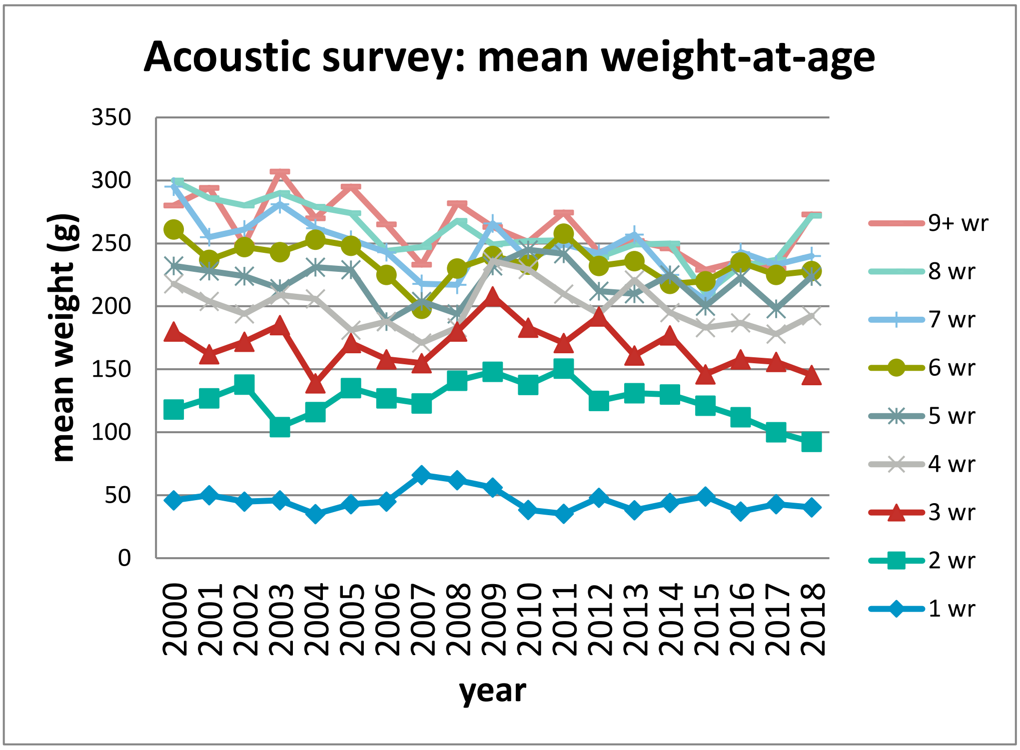


Figure 2.3.3.4 North Sea herring. Time series of 0-ringer, and 1-ringer indices (red). Year classes 1991 to 2018 for 0-ringers, year classes 1991–2017 for 1-ringers. The new 0-ringer index only covers the 1991–2017 year classes



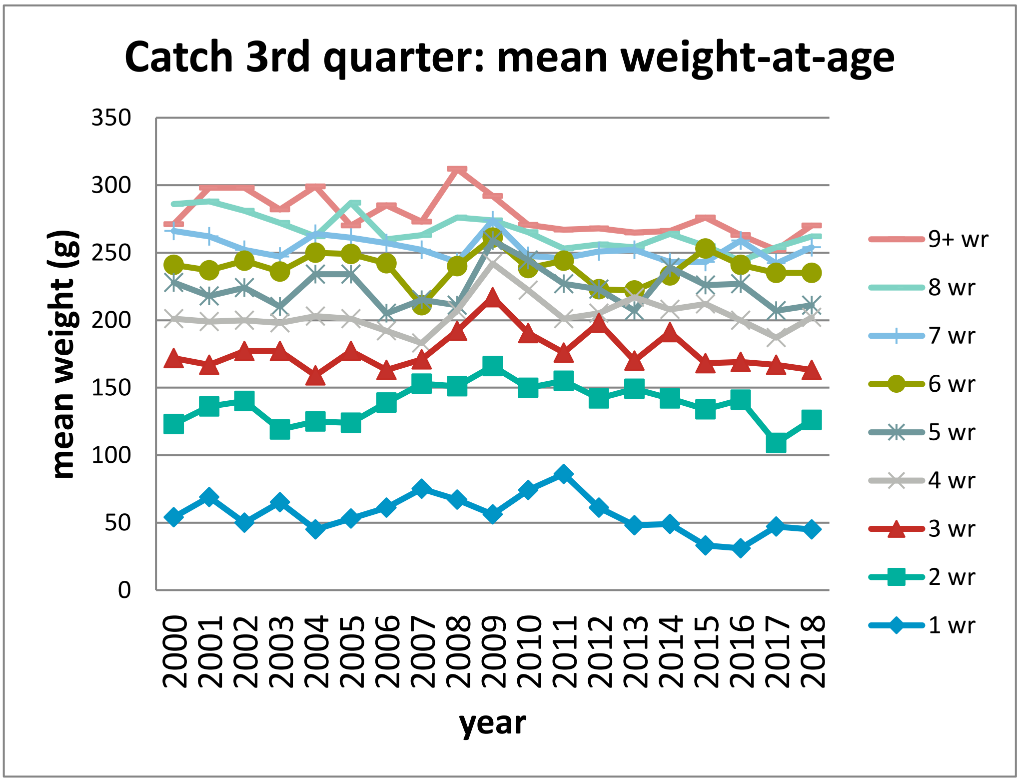


Figure 2.4.1.1. North Sea Herring. Mean weights-at-age for the 3rd quarter in Divisions 4 and 3.a from the acoustic survey (upper panel) and mean weights-in-the-catch (lower panel) for comparison.

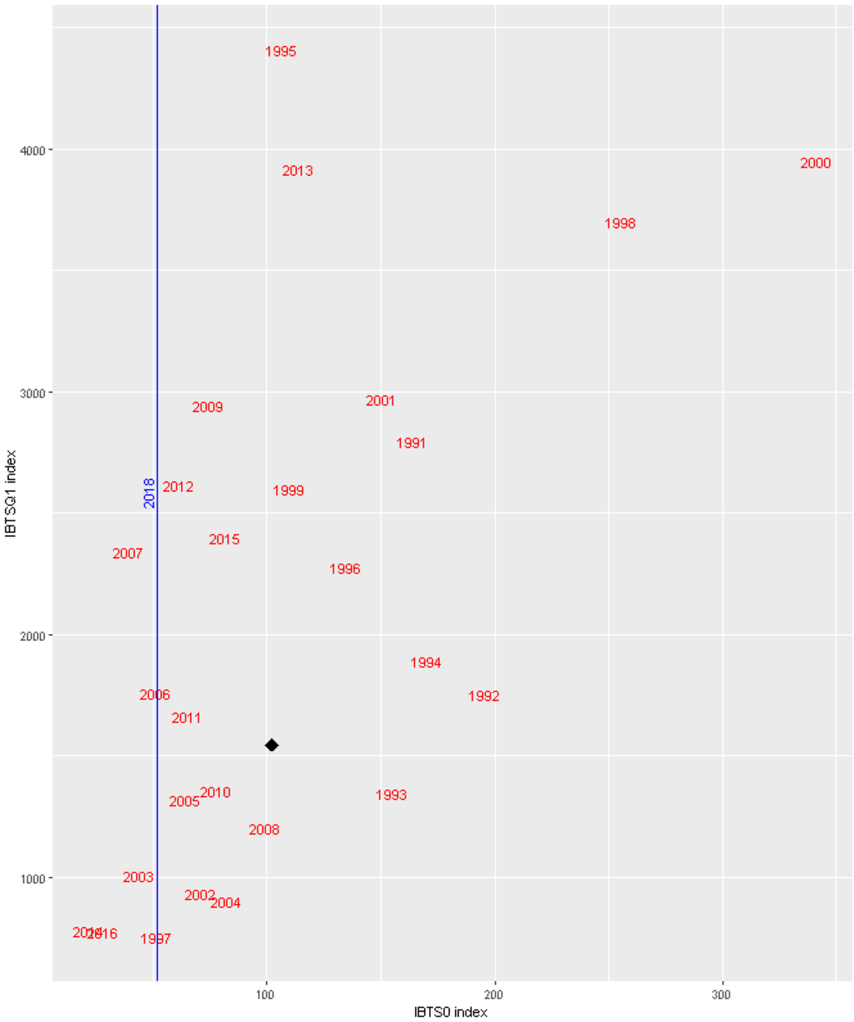


Figure 2.5.1.1 North Sea herring. Relationship between indices of 0-ringers, calculated with the new algorithm, and 1-ringers for year classes 1991 to 2018.

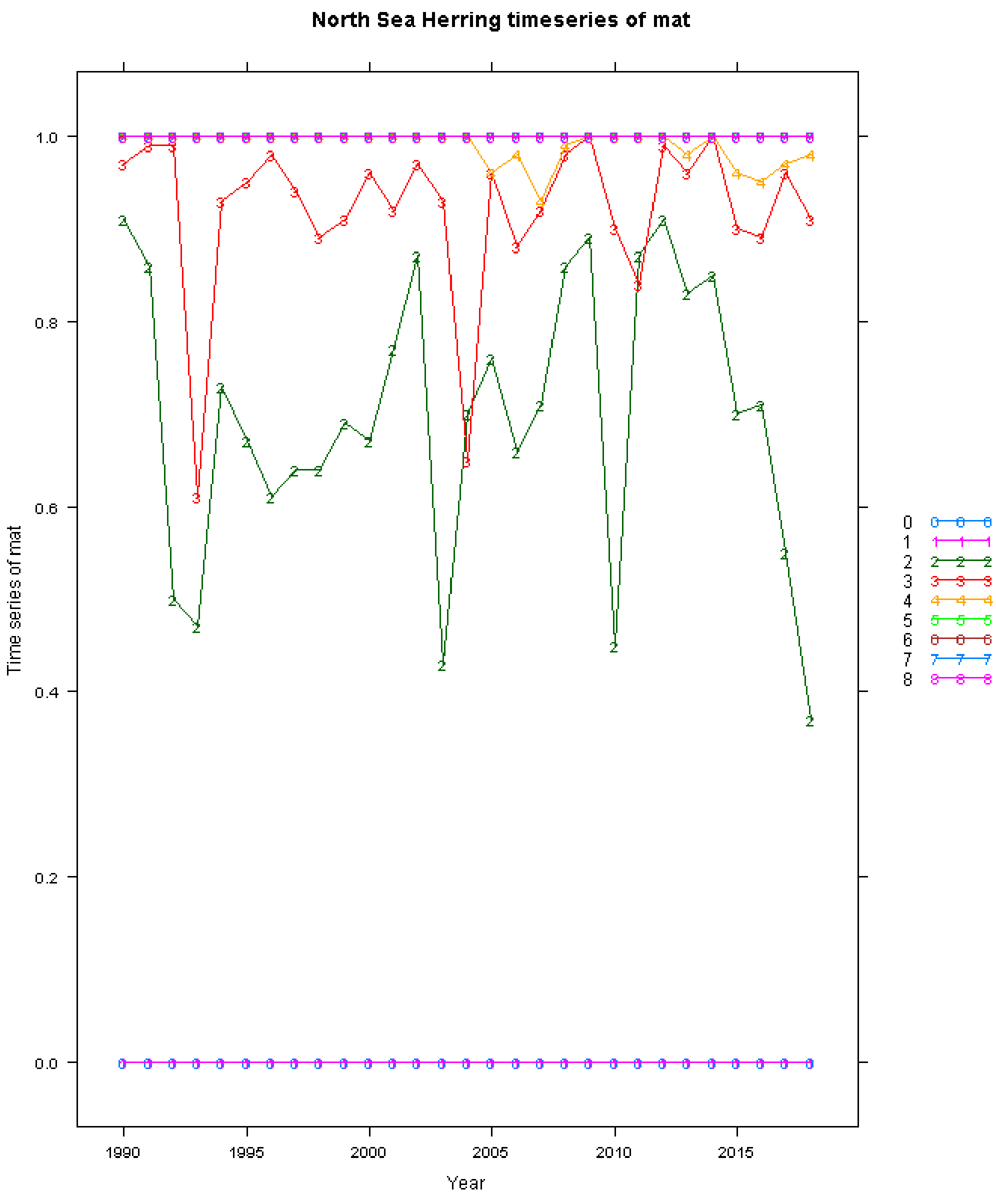


Figure 2.6.1.1 North Sea Herring. Time series of proportion mature at ages 0 to 8+ as used in the North Sea herring assessment.

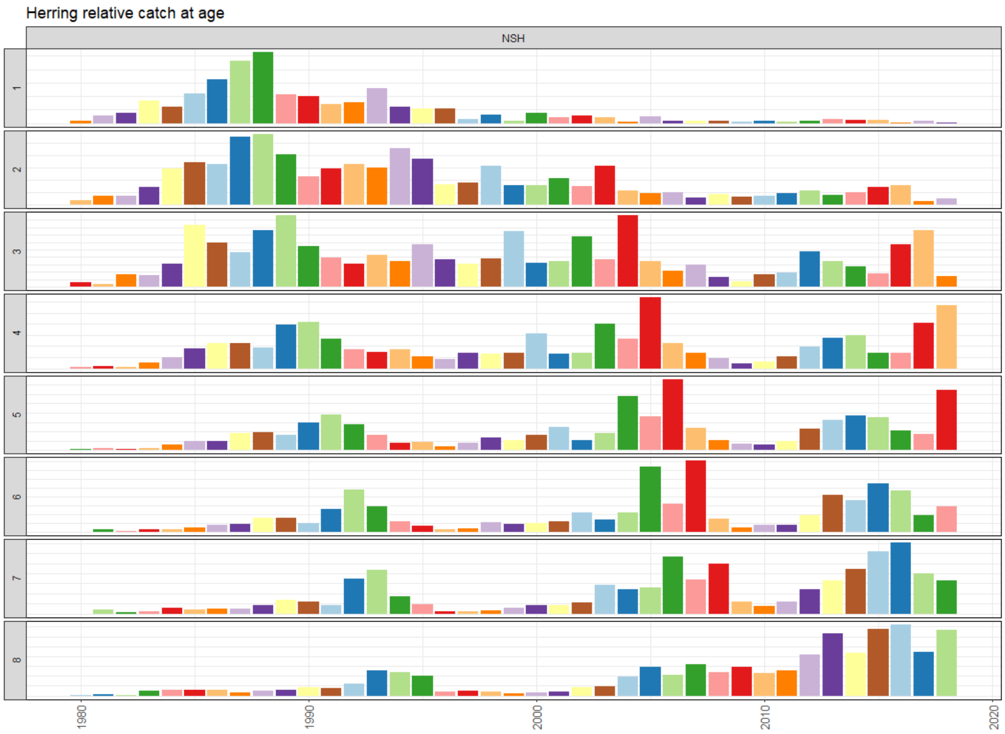


Figure 2.6.1.2. North Sea Herring. Time series of catch-at-age proportion at ages 0–8+ as used in the North Sea herring assessment. Colours indicate year-classes. All ages are scaled independently and therefore the size of the bars can only be compared within an age.

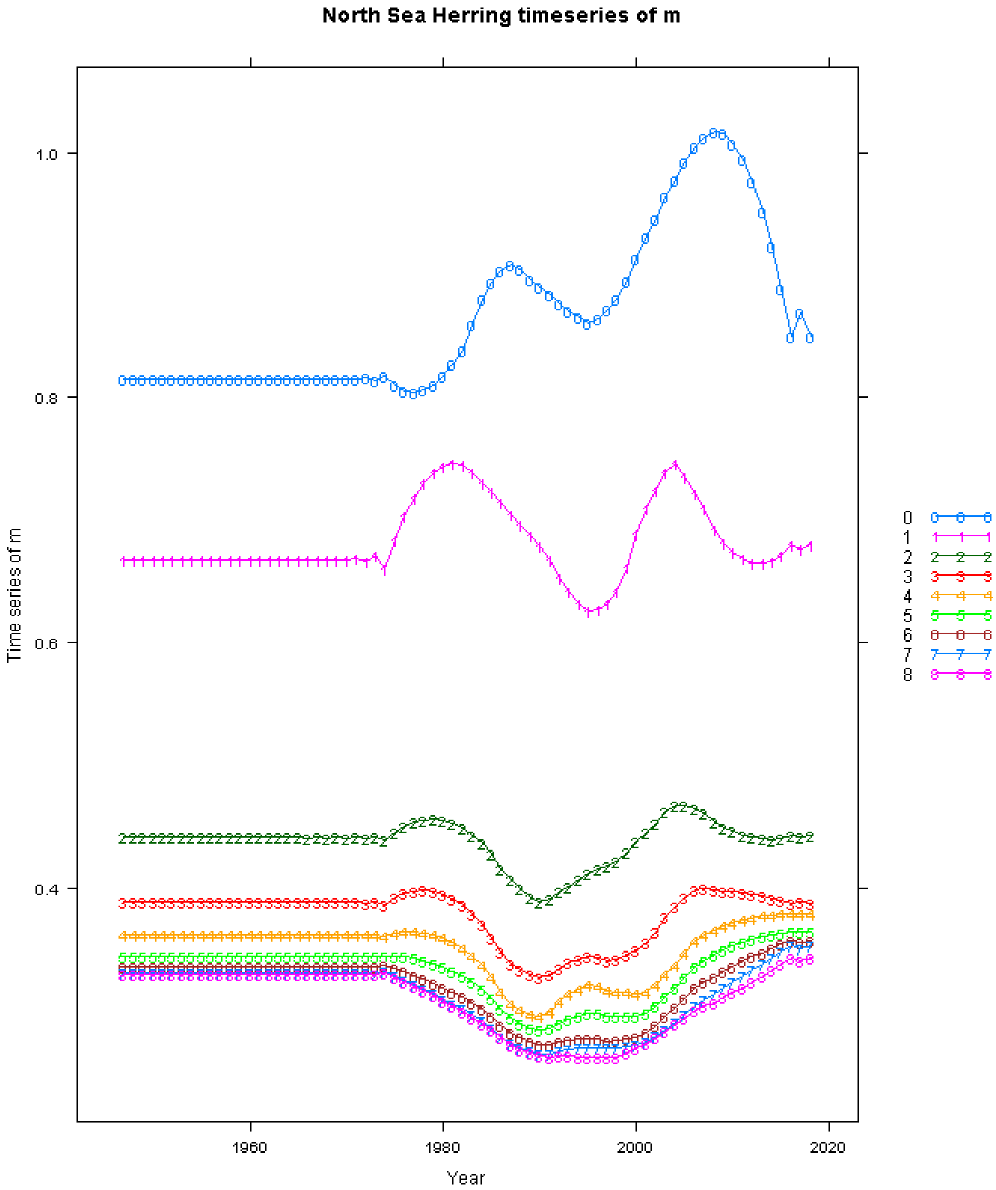


Figure 2.6.1.3. North Sea Herring. Time series of absolute natural mortality values at age 0–8+ as used in the North Sea herring assessment. Natural mortality values are based on the 2017 North Sea key-run (ICES WGSAM, 2018).

Figure 2.6.1.4. North Sea Herring. Time series of the HERAS acoustic index by age 1–8+. Colours indicate year-classes. All ages are scaled independently and cannot be compared between ages.

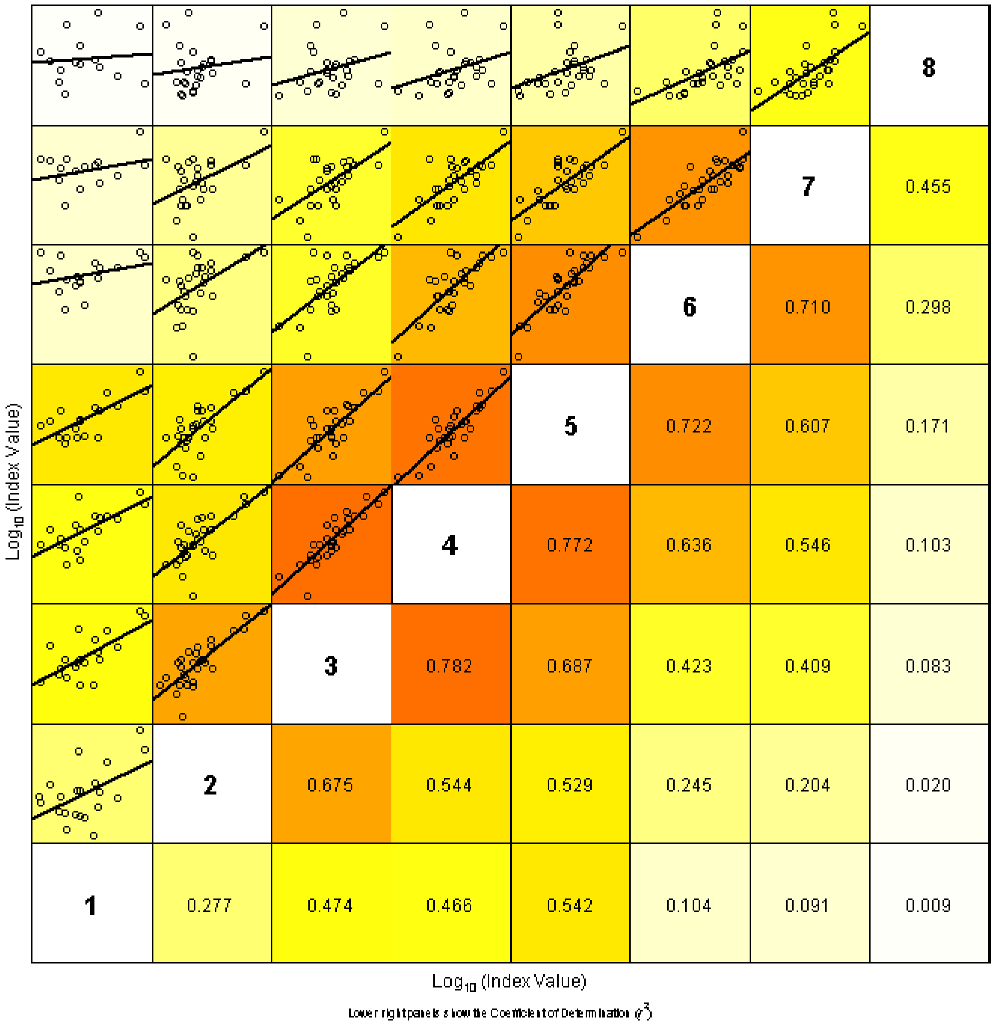


Figure 2.6.1.5. North Sea herring. Internal consistency plot of the acoustic survey (HERAS). Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r² value that is associated with the linear regression is given.

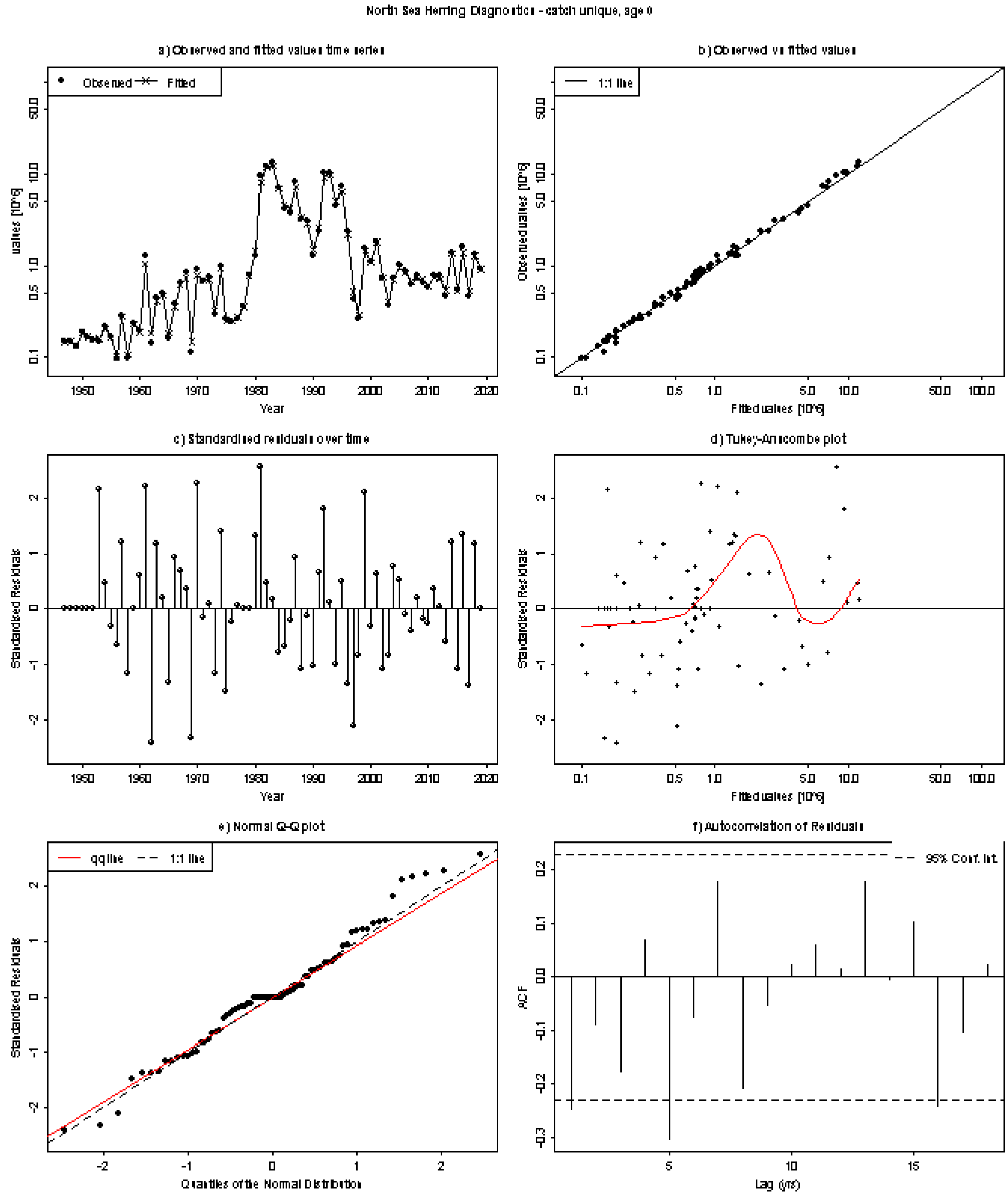


Figure 2.6.1.6 North Sea herring. Diagnostics of the assessment model fit to the catch at age 0 time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from catch abundance at 0 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the catch at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

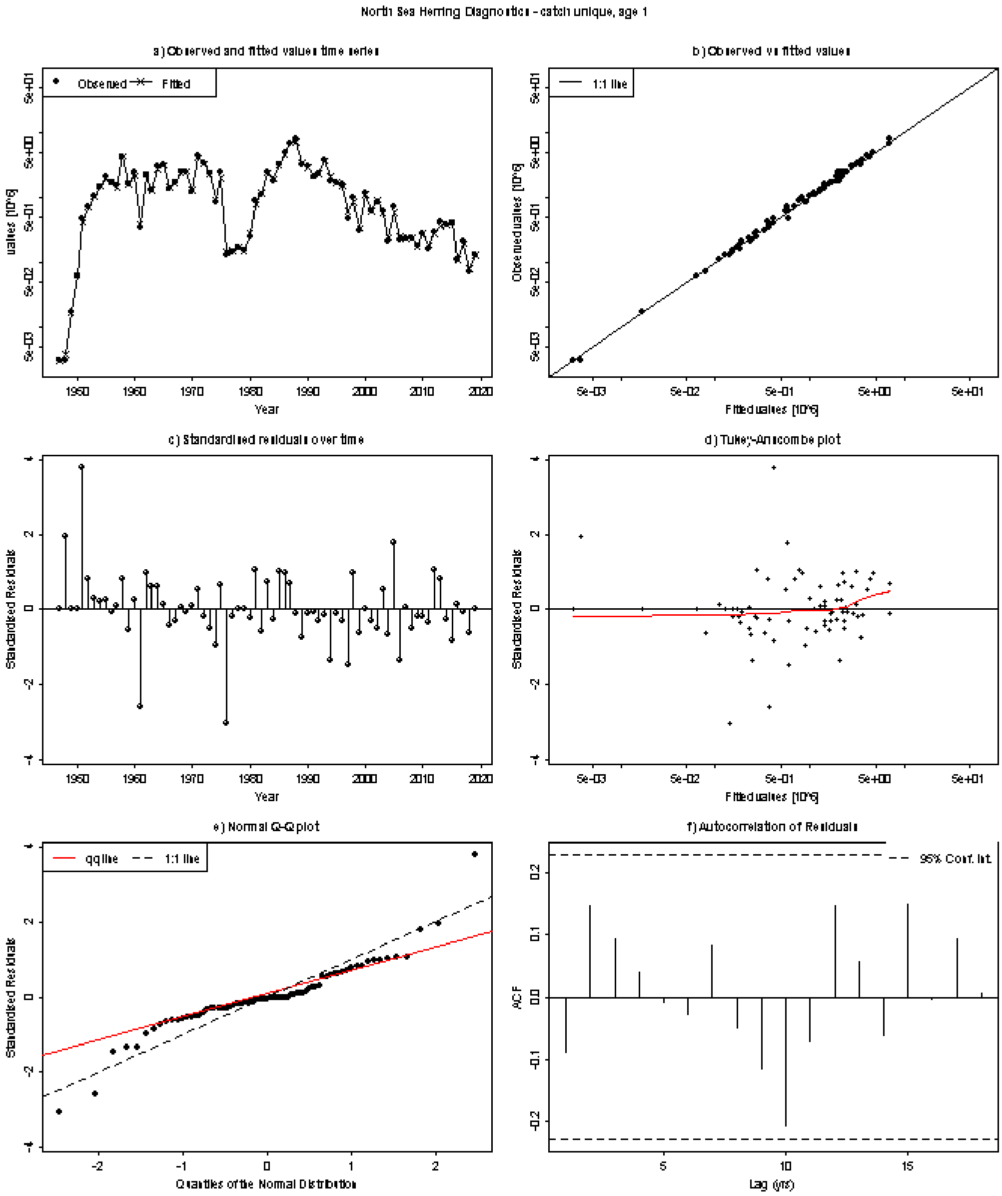


Figure 2.6.1.7 North Sea herring. Diagnostics of the assessment model fit to the catch at age 1 time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from catch abundance at 1 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 1 wr. Middle left: Time series of standardized residuals of the catch at 1 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

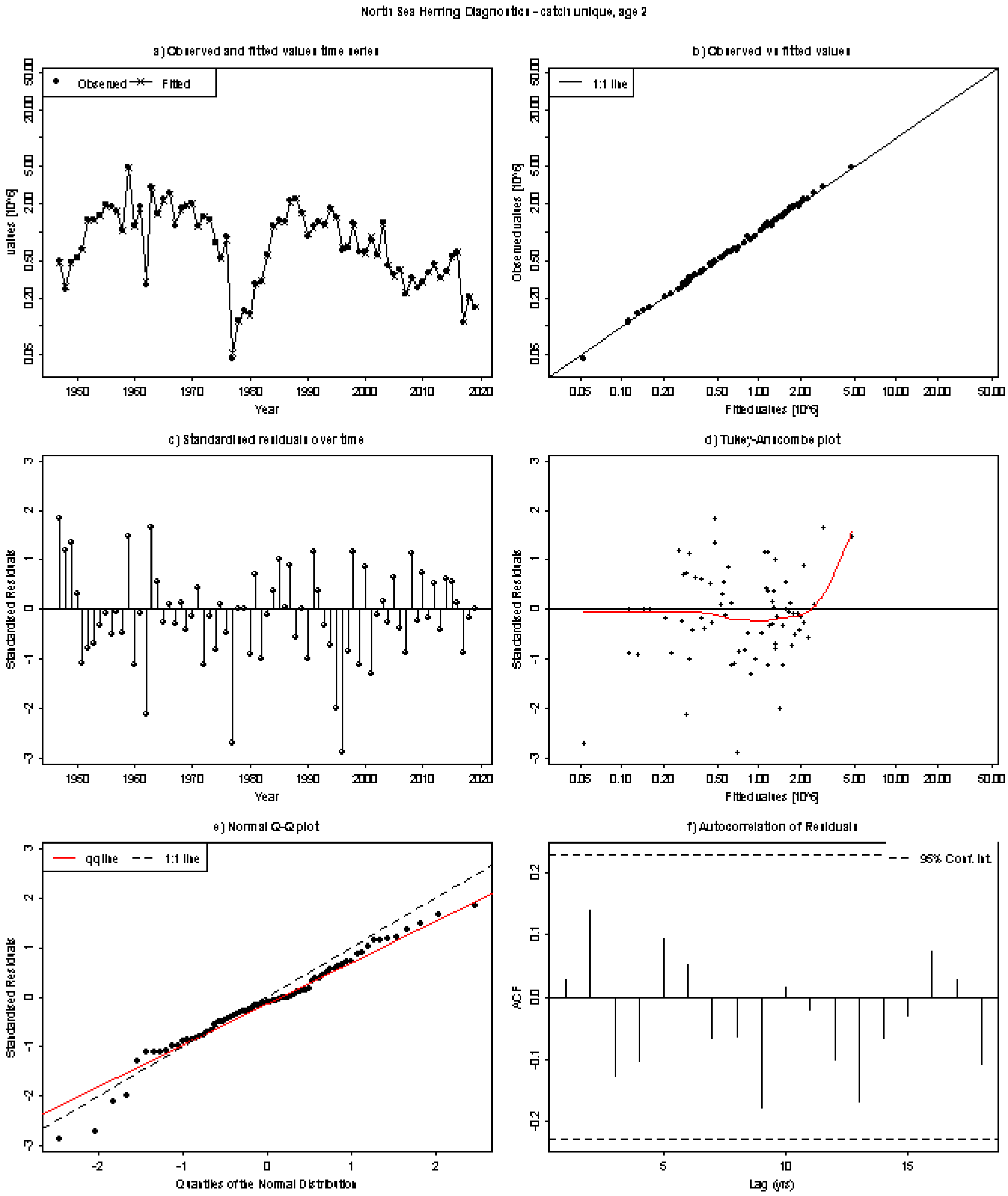


Figure 2.6.1.8 North Sea herring. Diagnostics of the assessment model fit to the catch at age 2 time series. Top left: Estimates of numbers at 2 wr (line) and numbers predicted from catch abundance at 2 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 2 wr. Middle left: Time series of standardized residuals of the catch at 2 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

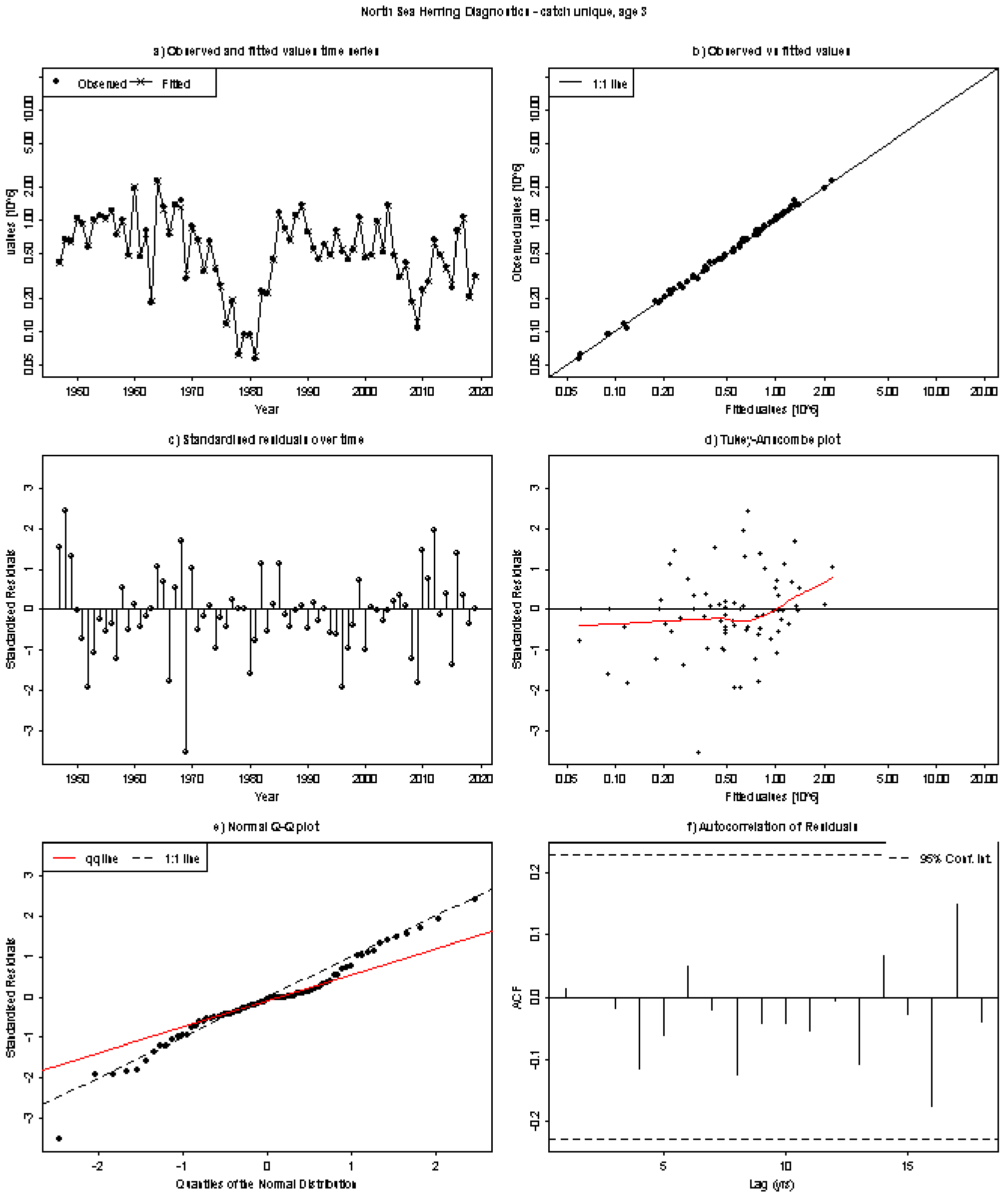


Figure 2.6.1.9 North Sea herring. Diagnostics of the assessment model fit to the catch at age 3 time series. Top left: Estimates of numbers at 3 wr (line) and numbers predicted from catch abundance at 3 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 3 wr. Middle left: Time series of standardized residuals of the catch at 3 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

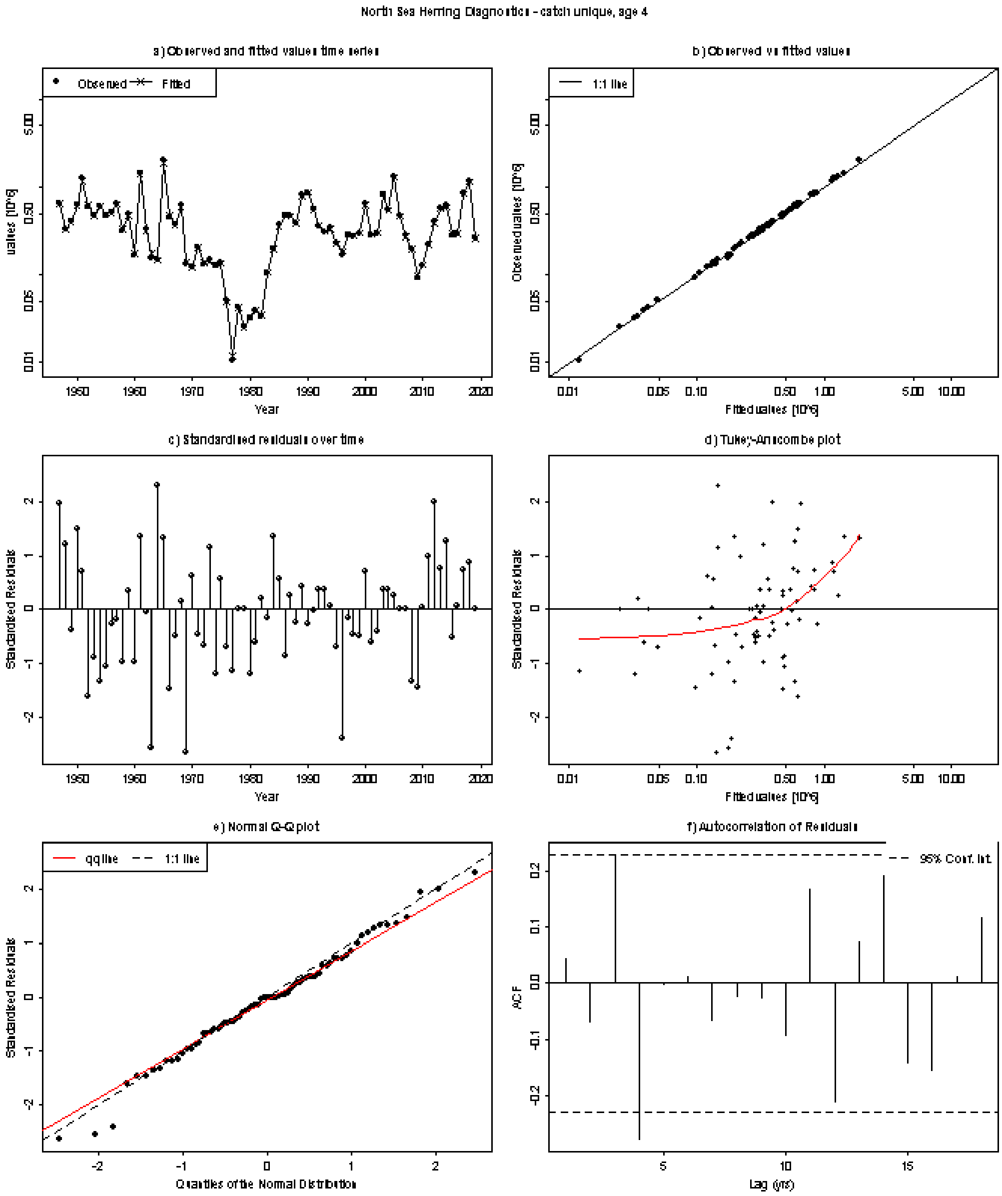


Figure 2.6.1.10 North Sea herring. Diagnostics of the assessment model fit to the catch at age 4 time series. Top left: Estimates of numbers at 4 wr (line) and numbers predicted from catch abundance at 4 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 4 wr. Middle left: Time series of standardized residuals of the catch at 4 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

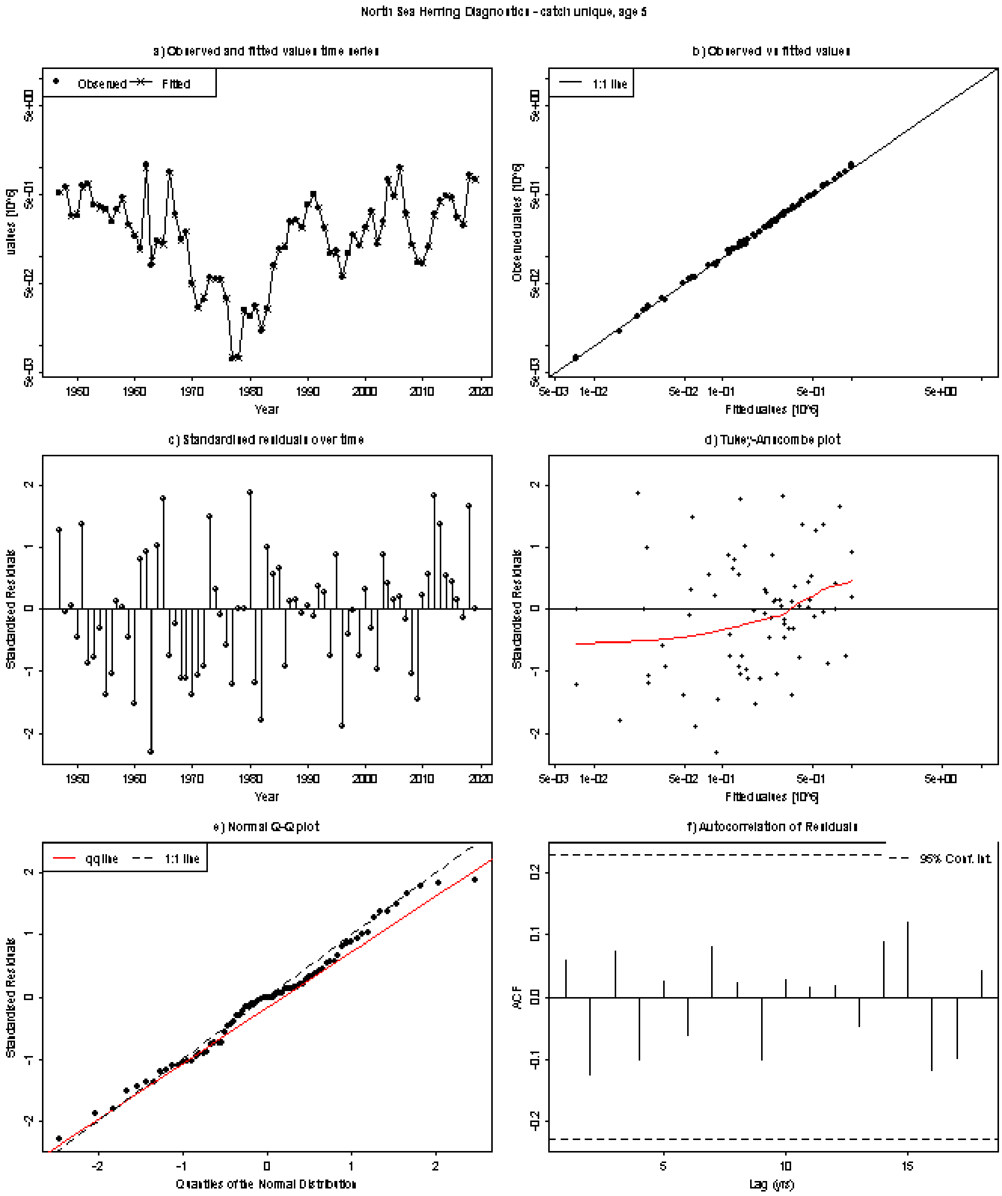


Figure 2.6.1.11 North Sea herring. Diagnostics of the assessment model fit to the catch at age 5 time series. Top left: Estimates of numbers at 5 wr (line) and numbers predicted from catch abundance at 5 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 5 wr. Middle left: Time series of standardized residuals of the catch at 5 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

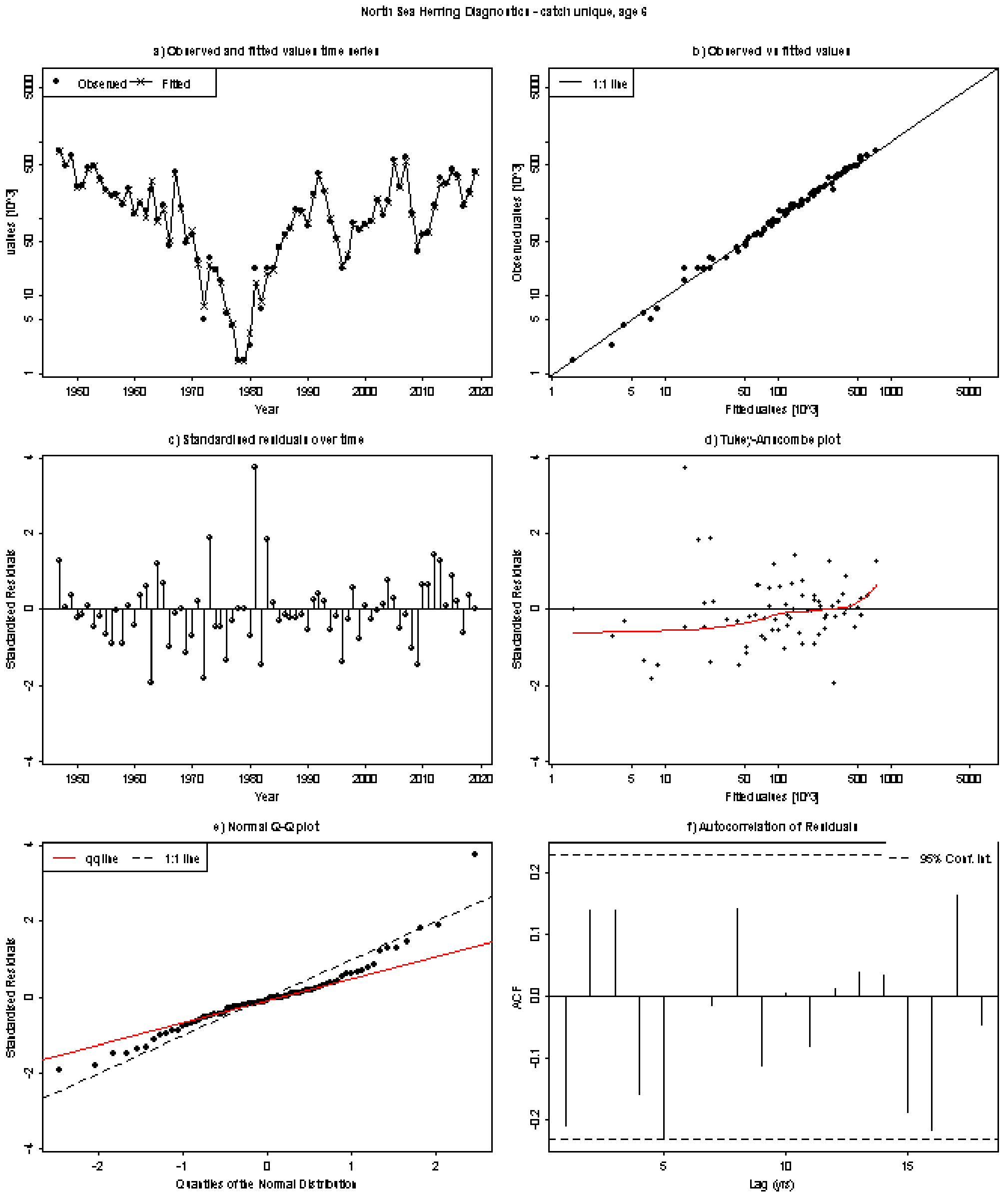


Figure 2.6.1.12 North Sea herring. Diagnostics of the assessment model fit to the catch at age 6 time series. Top left: Estimates of numbers at 6 wr (line) and numbers predicted from catch abundance at 6 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 6 wr. Middle left: Time series of standardized residuals of the catch at 6 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

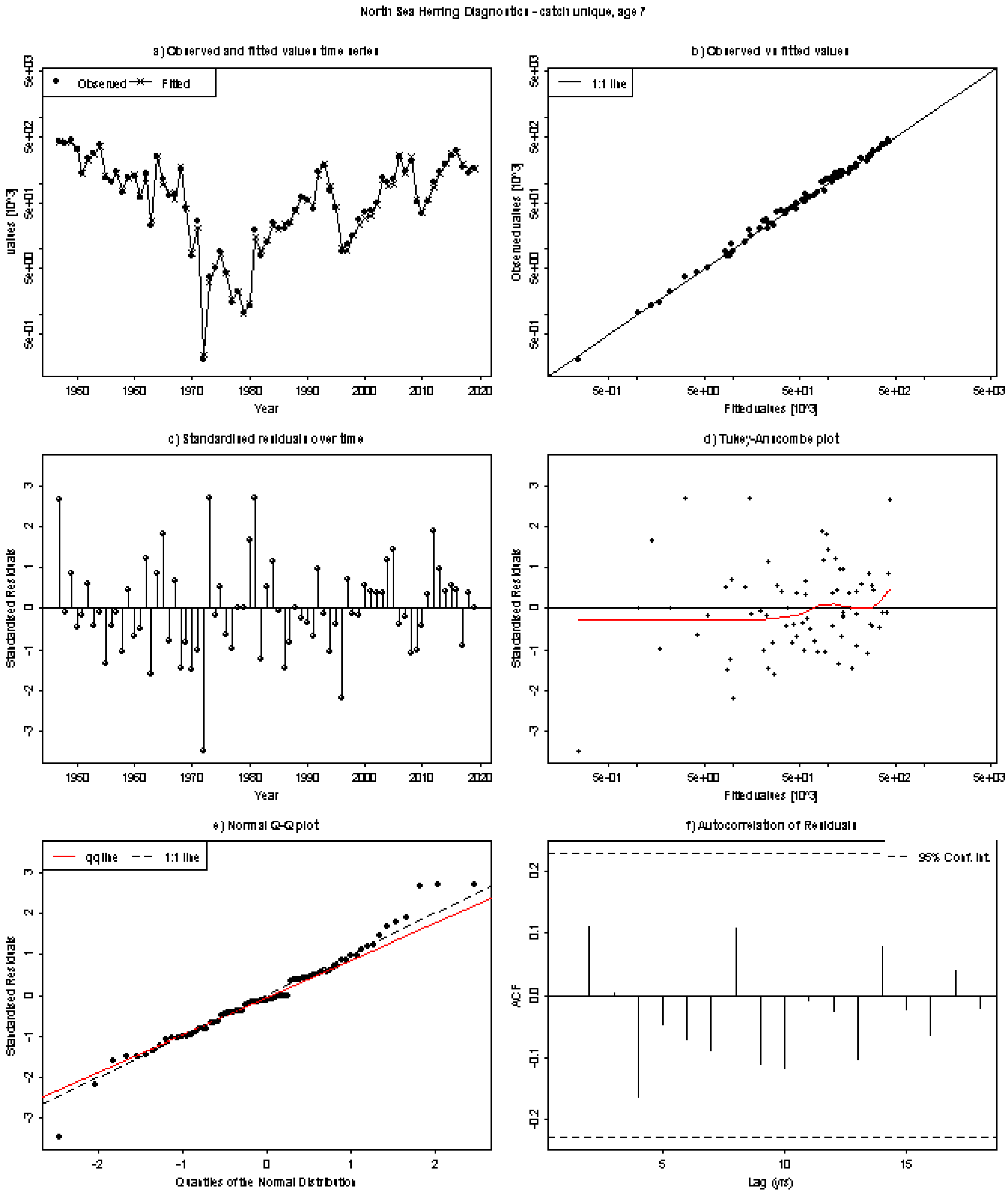


Figure 2.6.1.13 North Sea herring. Diagnostics of the assessment model fit to the catch at age 7 time series. Top left: Estimates of numbers at 7 wr (line) and numbers predicted from catch abundance at 7 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 7 wr. Middle left: Time series of standardized residuals of the catch at 7 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

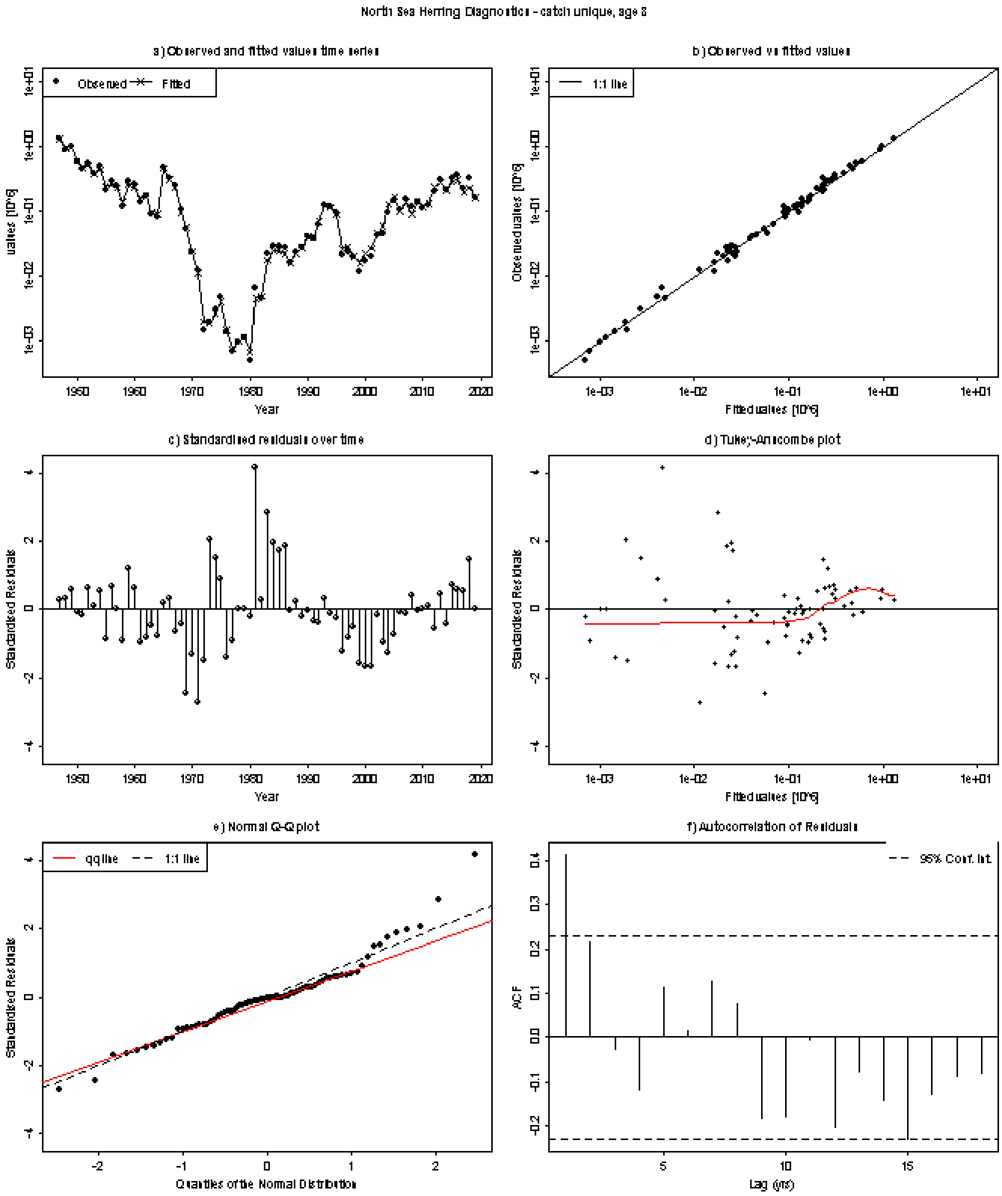


Figure 2.6.1.14. North Sea herring. Diagnostics of the assessment model fit to the catch at age 8+ time series. Top left: Estimates of numbers at 8+ wr (line) and numbers predicted from catch abundance at 8+ wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 8+ wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 8+ wr. Middle left: Time series of standardized residuals of the catch at 8+ wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

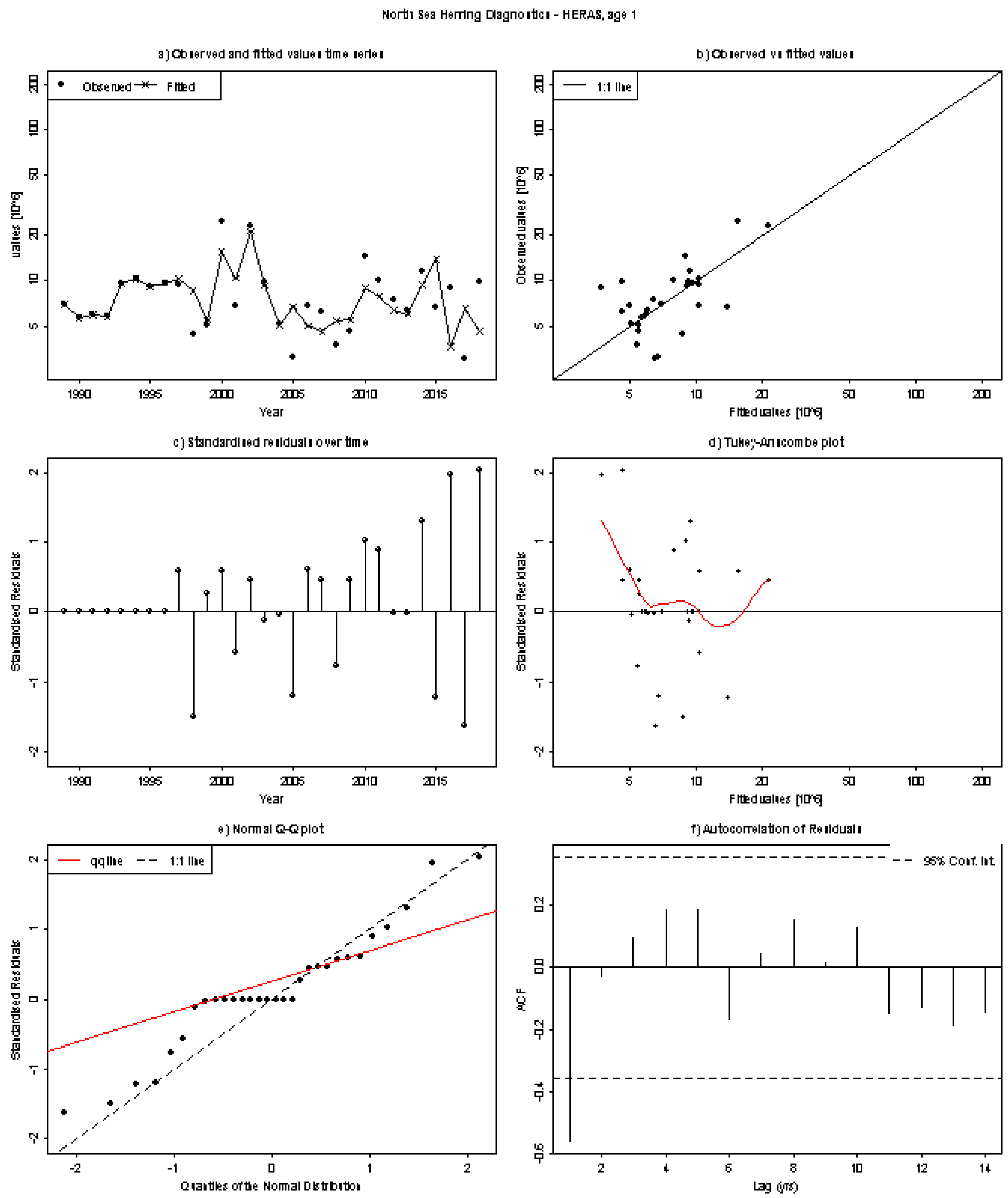


Figure 2.6.1.15. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 1 wr time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 1 wr. Middle left: Time series of standardized residuals of the index at 1 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

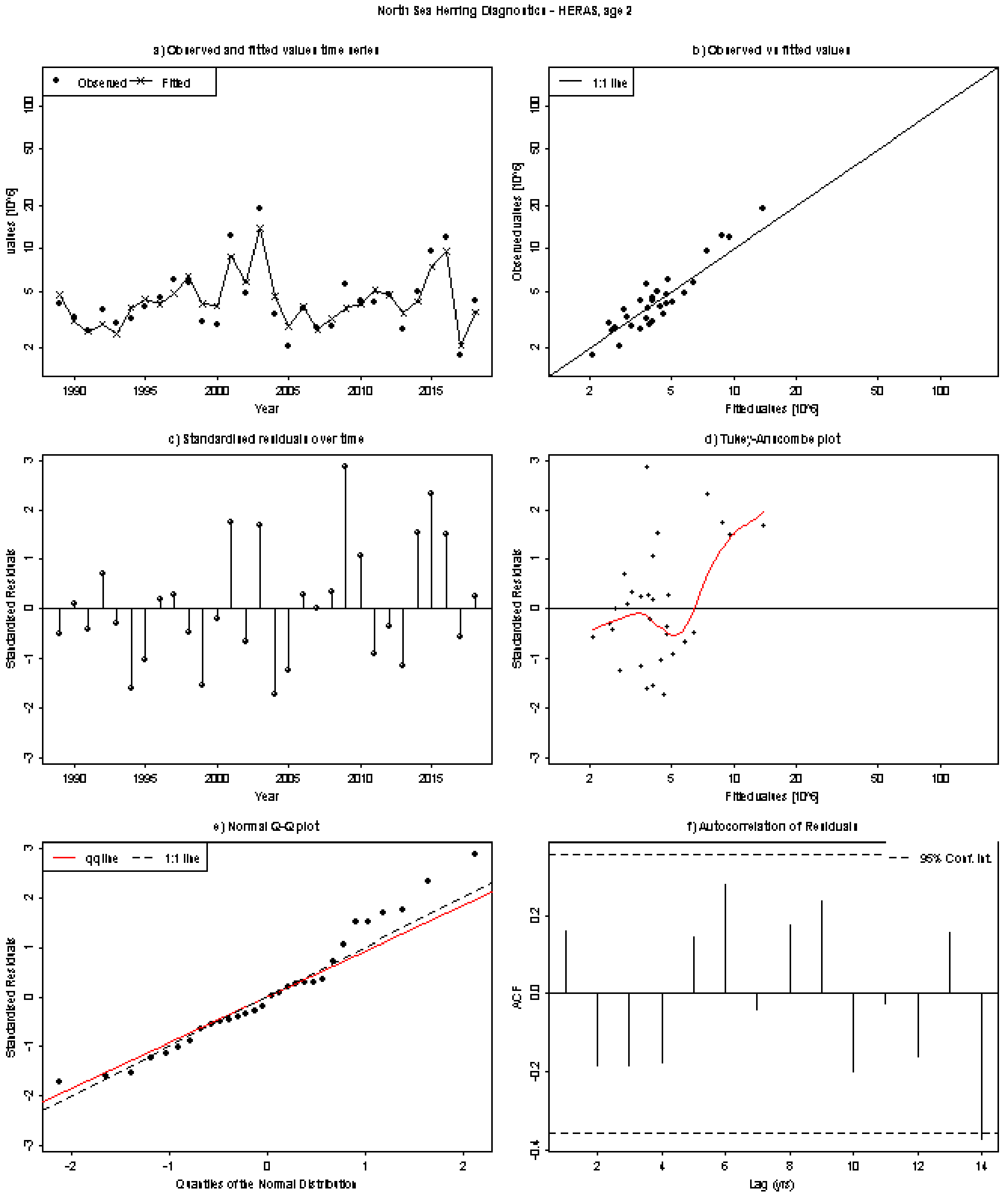


Figure 2.6.1.16. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 2 wr time series. Top left: Estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 2 wr. Middle left: Time series of standardized residuals of the index at 2 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

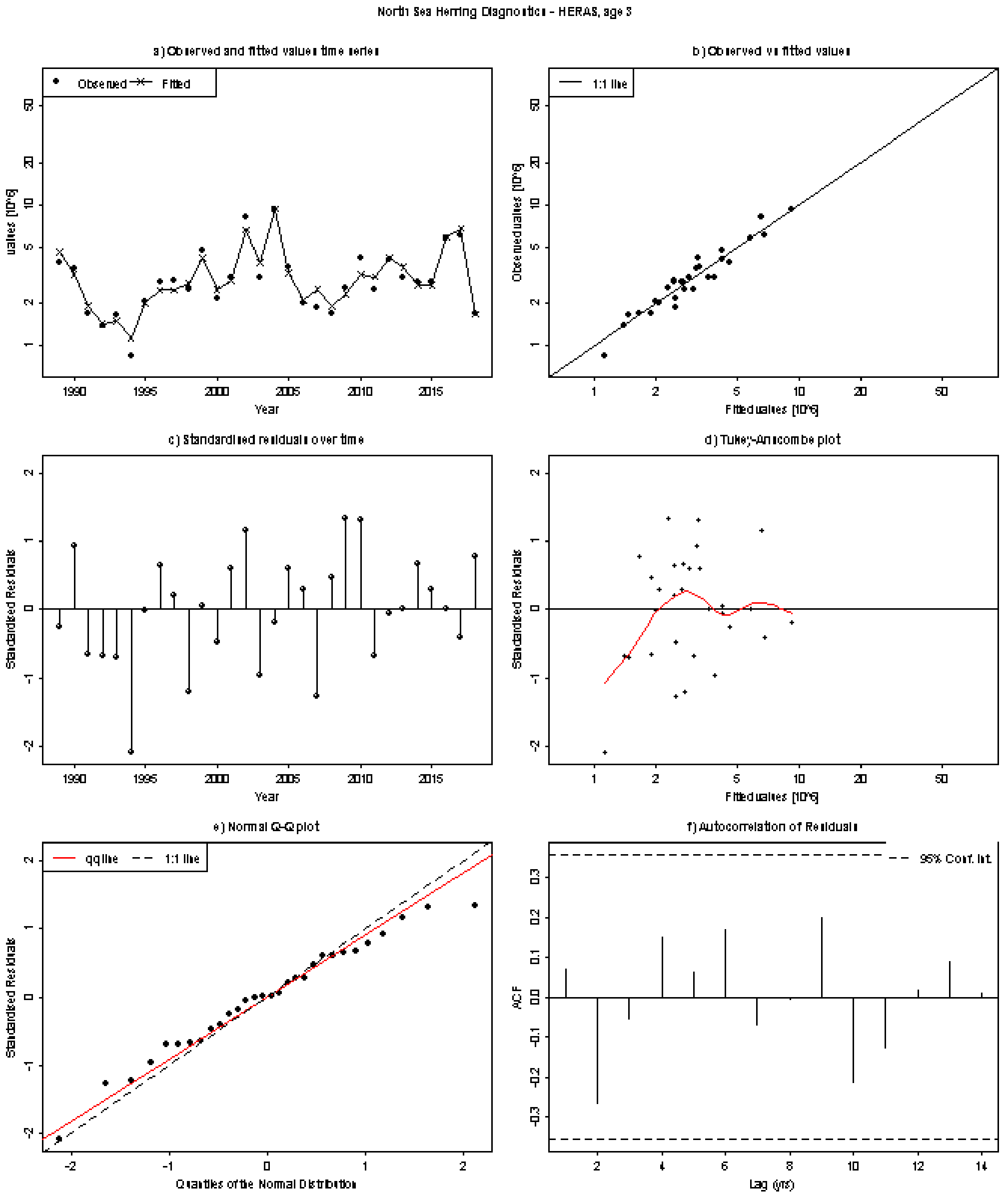


Figure 2.6.1.17. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 3 wr time series. Top left: Estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 3 wr. Middle left: Time series of standardized residuals of the index at 3 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

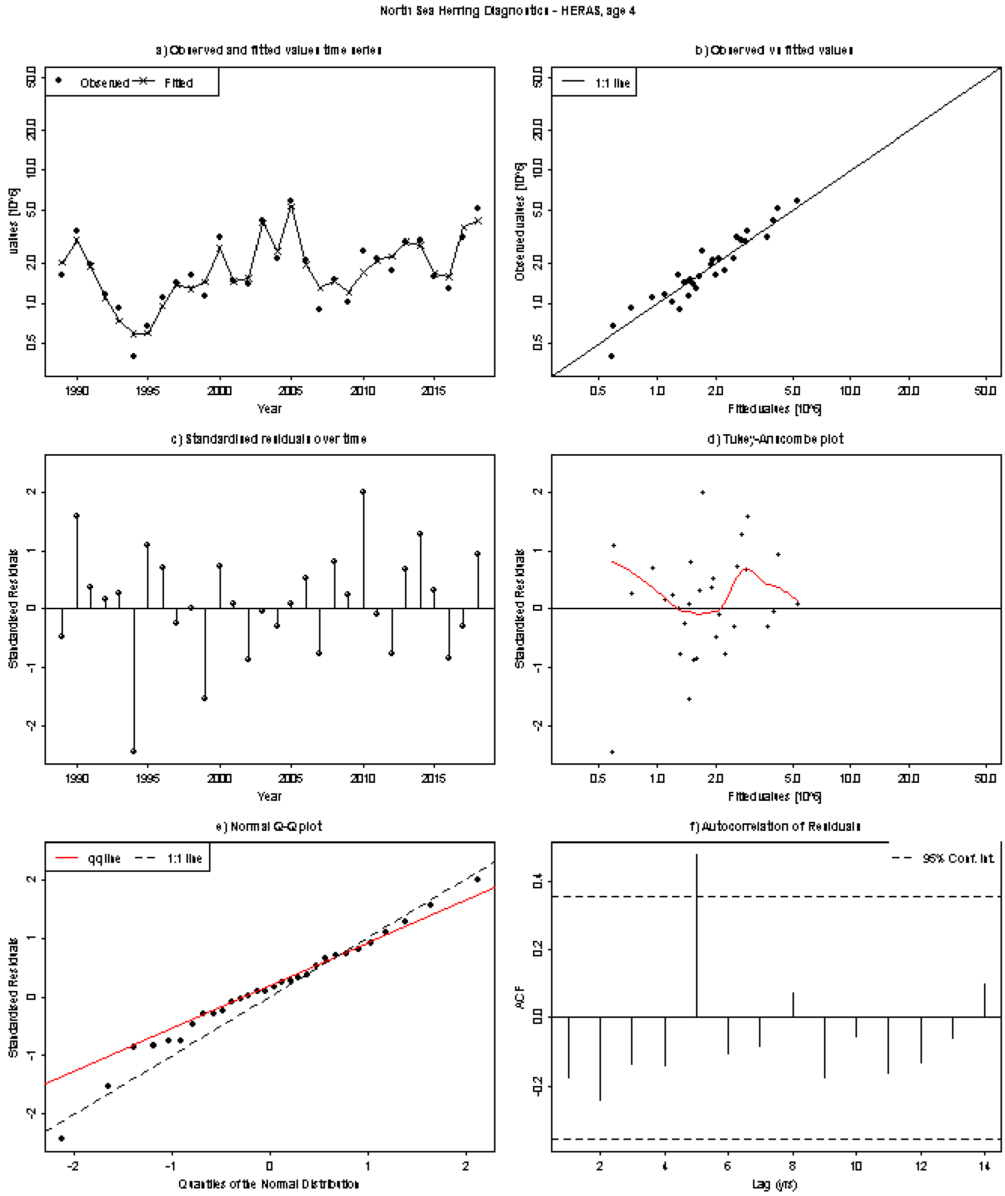


Figure 2.6.1.18. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 4 wr time series. Top left: Estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 4 wr. Middle left: Time series of standardized residuals of the index at 4 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

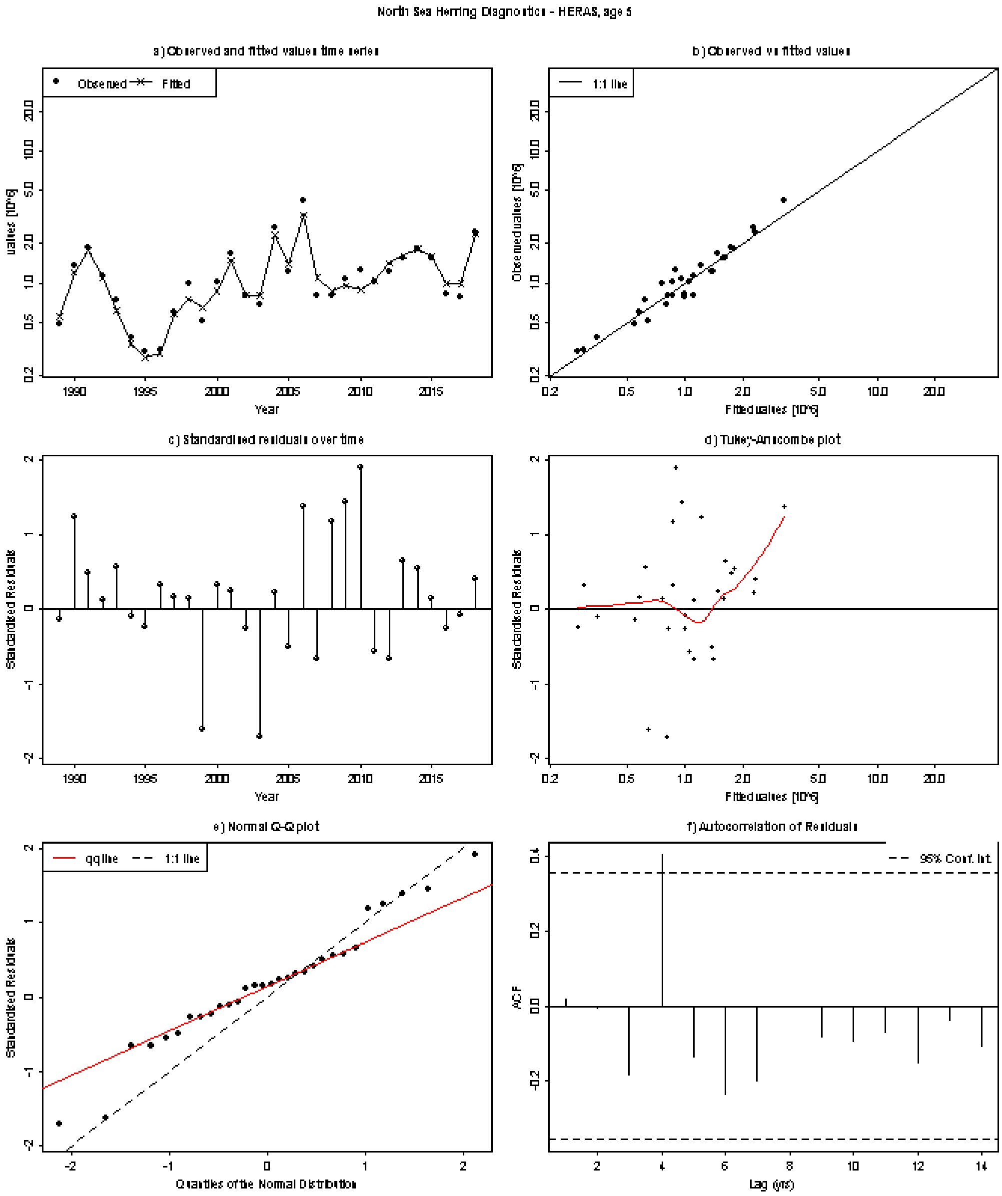


Figure 2.6.1.19. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 5 wr time series. Top left: Estimates of numbers at 5 wr (line) and numbers predicted from index abundance at 5 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 5 wr. Middle left: Time series of standardized residuals of the index at 5 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

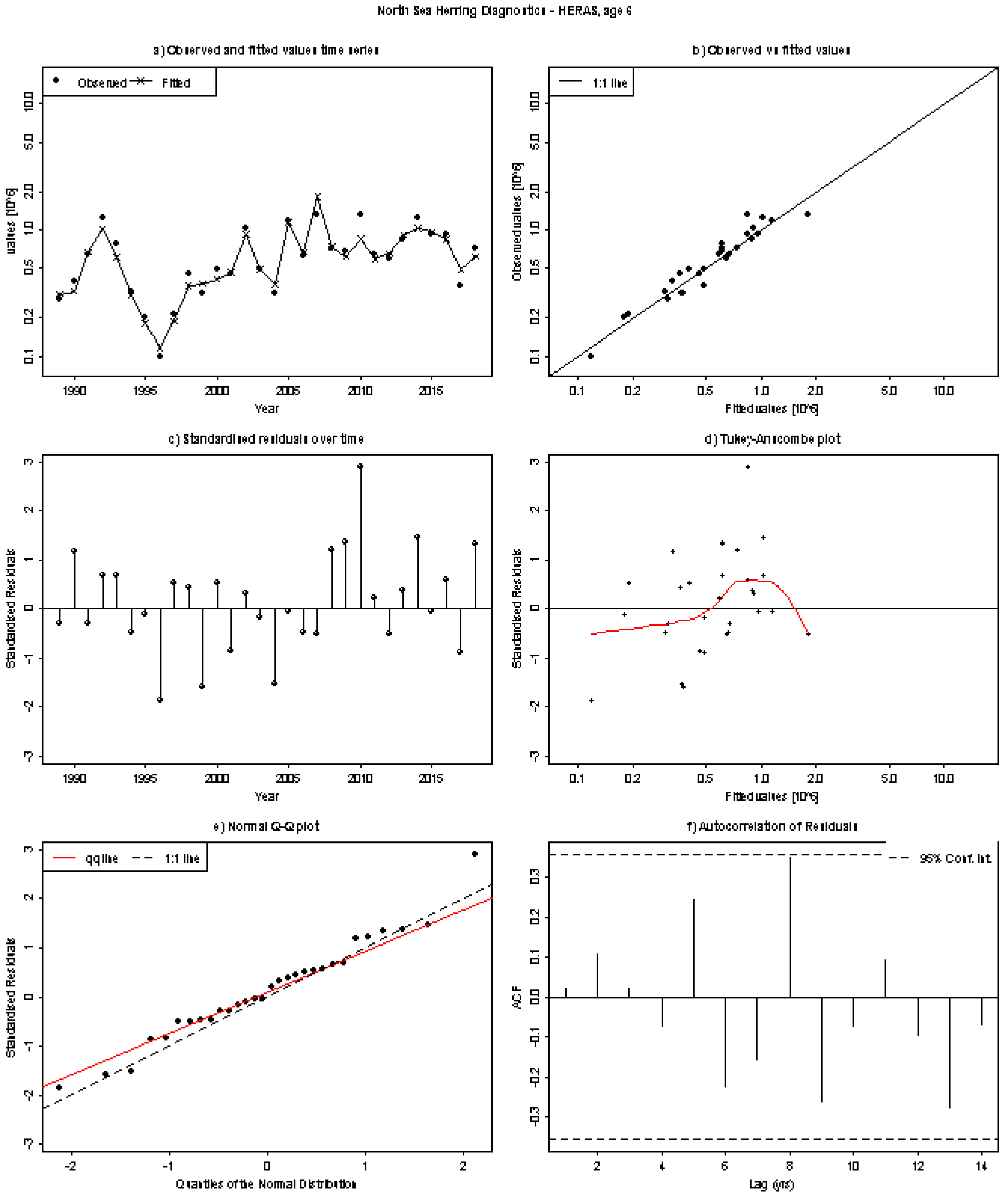


Figure 2.6.1.20. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 6 wr time series. Top left: Estimates of numbers at 6 wr (line) and numbers predicted from index abundance at 6 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 6 wr. Middle left: Time series of standardized residuals of the index at 6 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

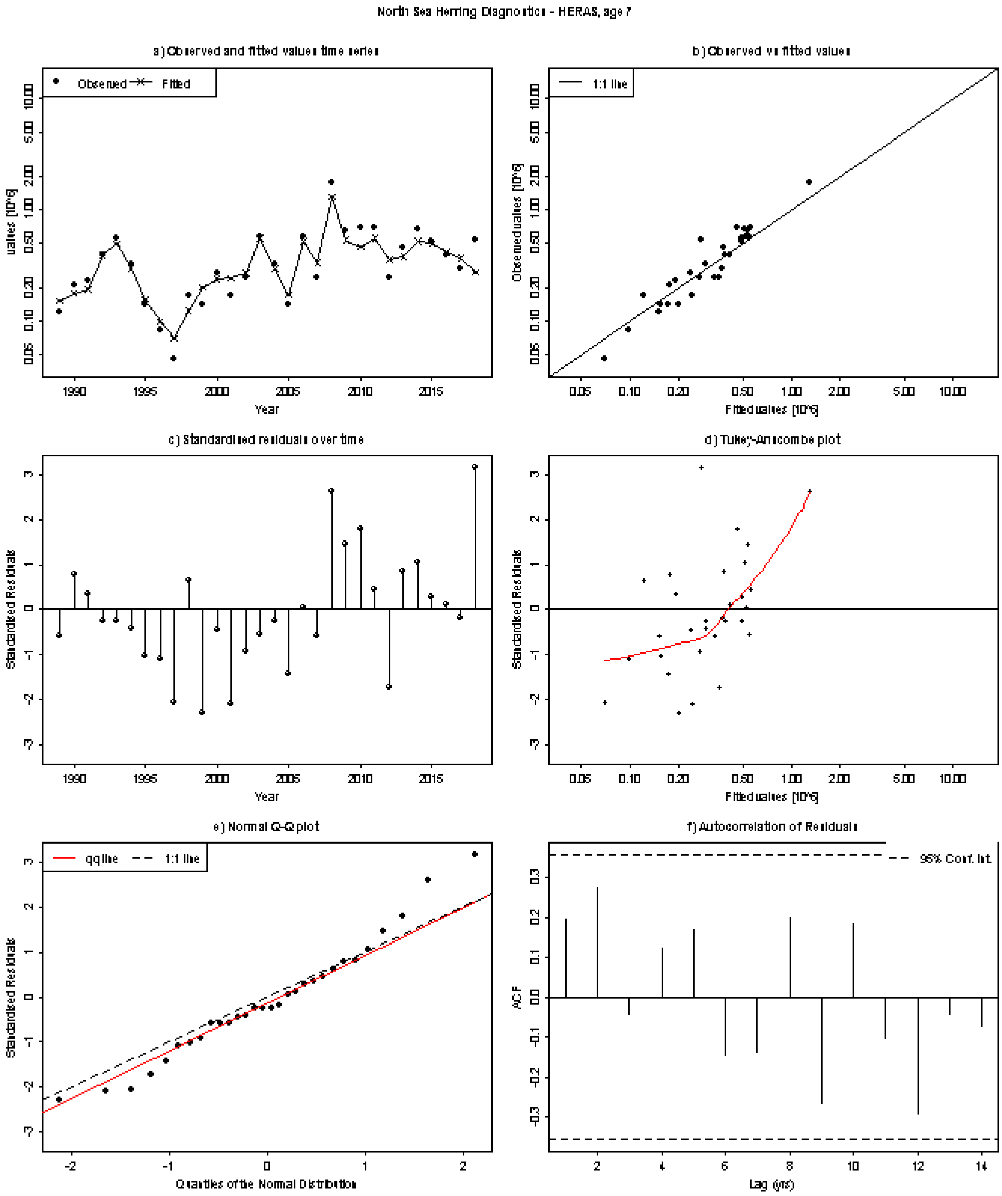


Figure 2.6.1.21. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 7 wr time series. Top left: Estimates of numbers at 7 wr (line) and numbers predicted from index abundance at 7 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 7 wr. Middle left: Time series of standardized residuals of the index at 7 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

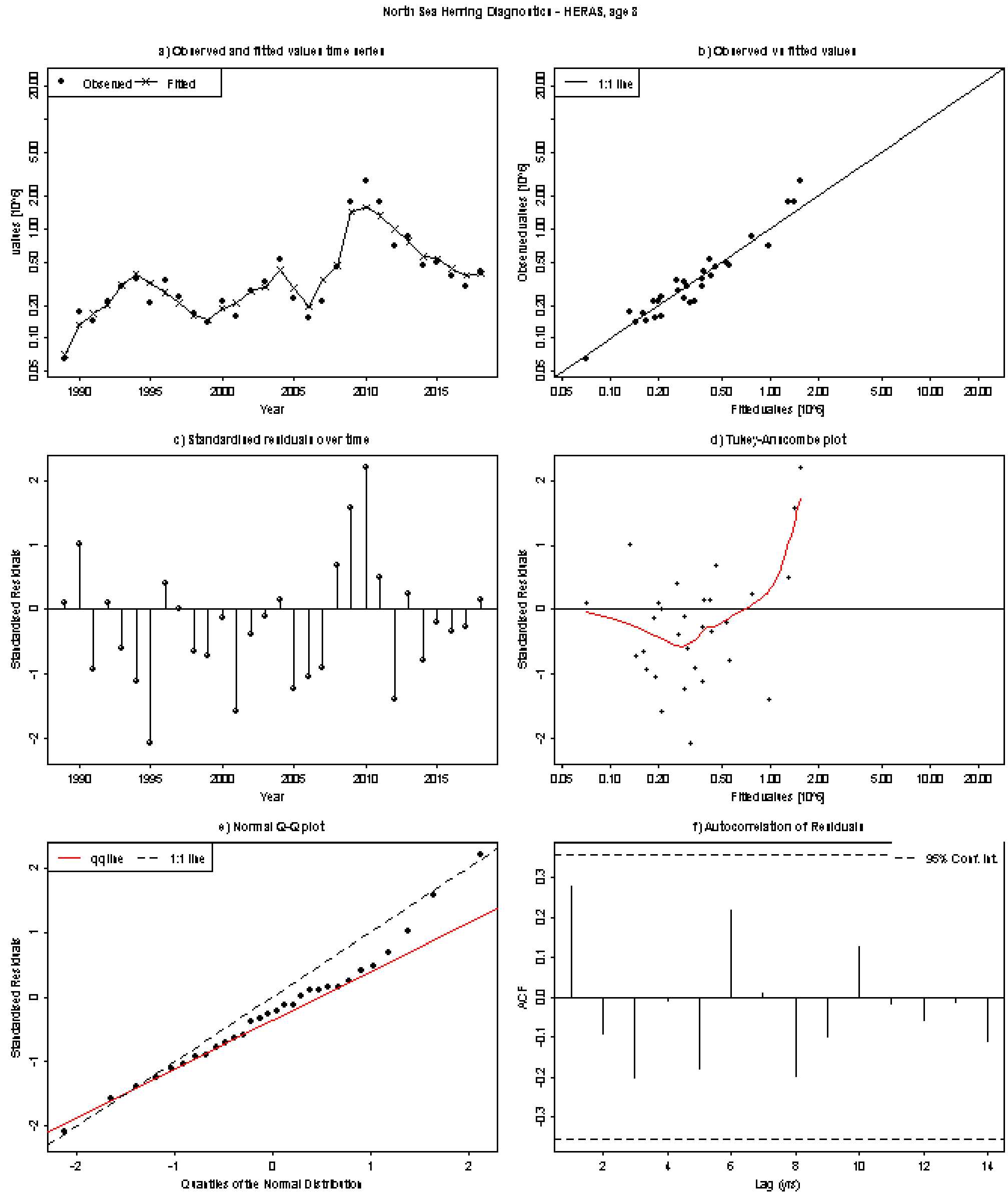


Figure 2.6.1.22. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 8+ wr time series. Top left: Estimates of numbers at 8+ wr (line) and numbers predicted from index abundance at 8+ wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 8+ wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 8+ wr. Middle left: Time series of standardized residuals of the index at 8+ wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

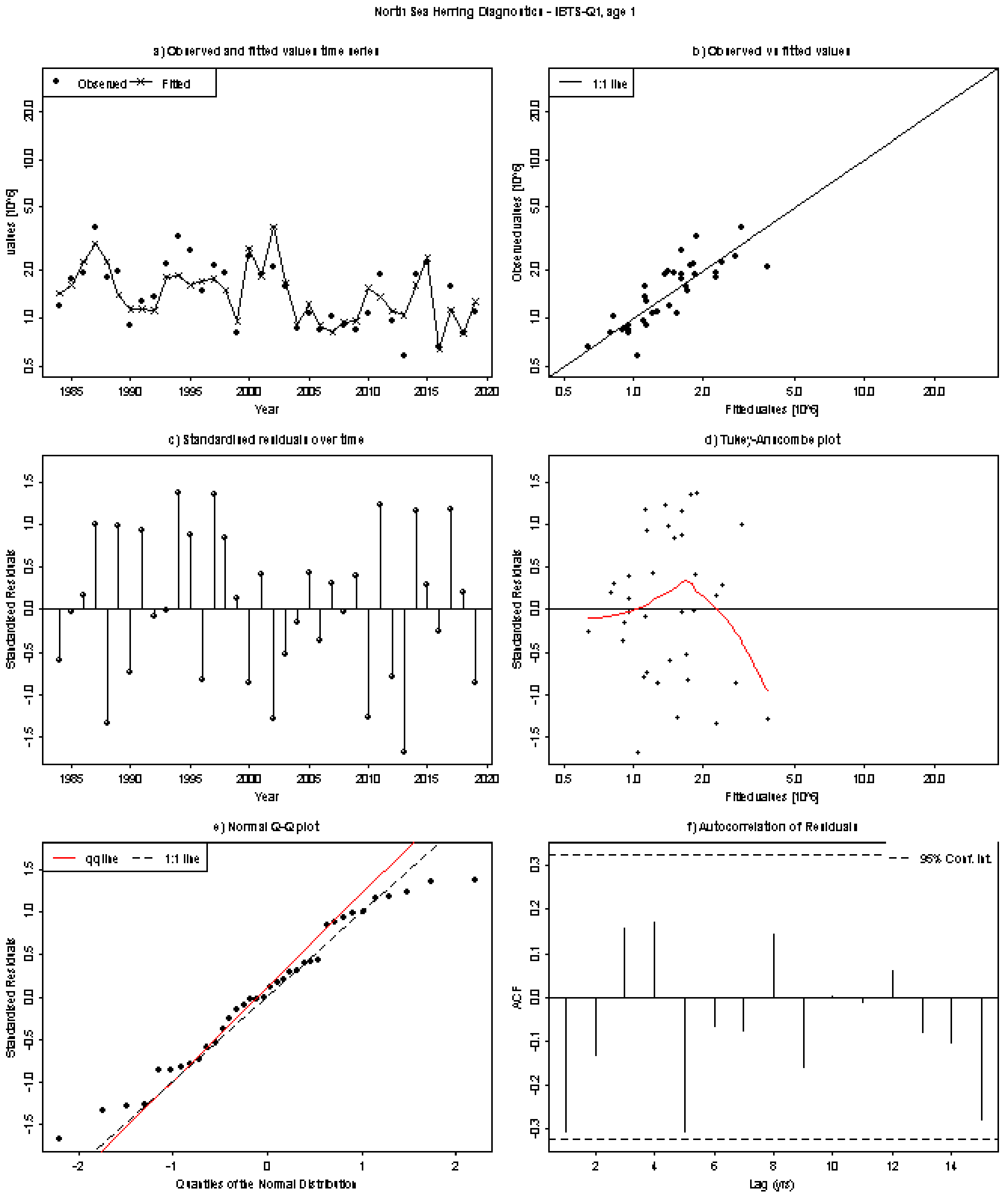


Figure 2.6.1.23 North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q1 index at age 1 wr time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 1 wr. Middle left: Time series of standardized residuals of the index at 1 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

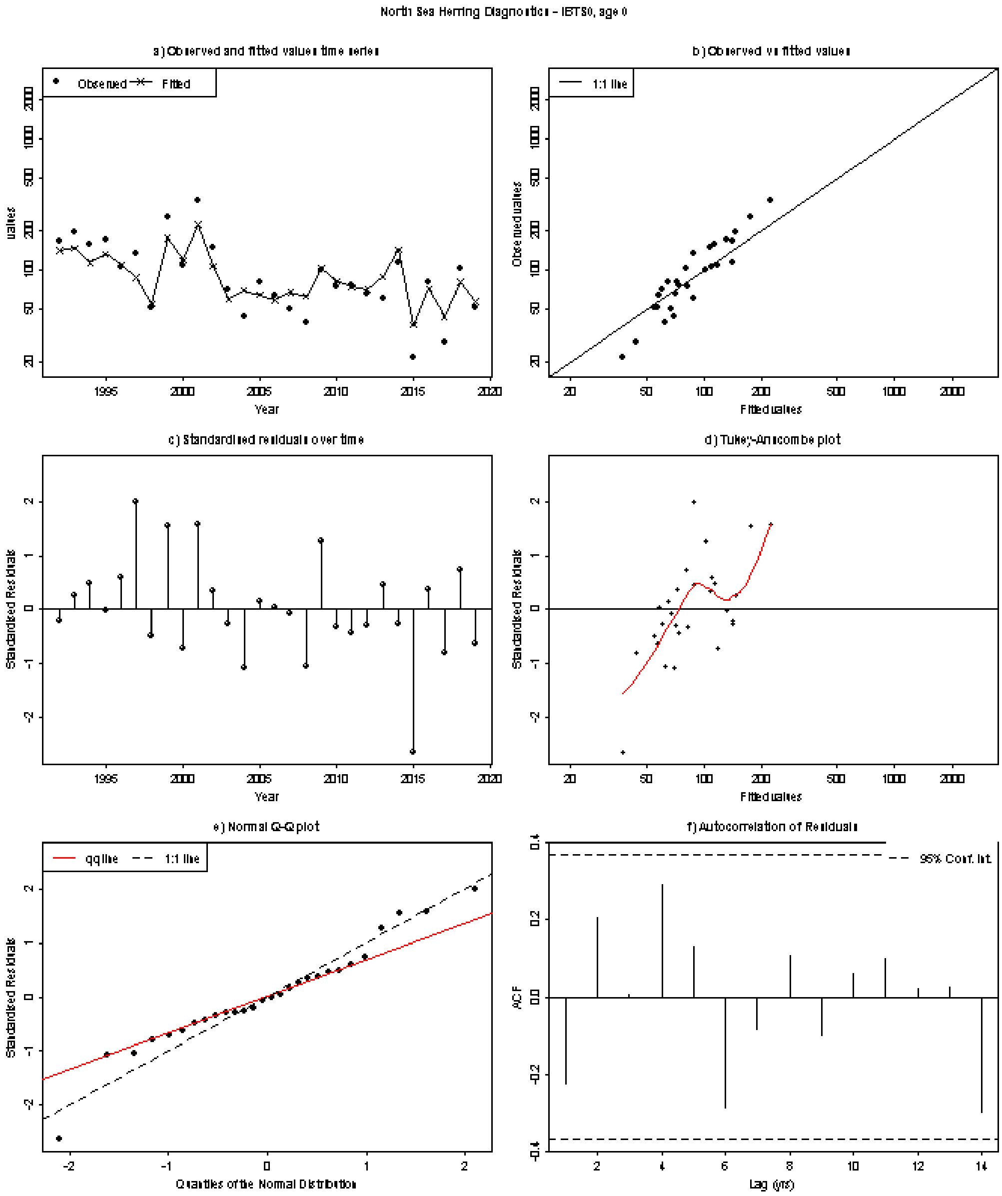


Figure 2.6.1.24. North Sea herring. Diagnostics of the assessment model fit to the IBTS0 index at age 0 wr time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

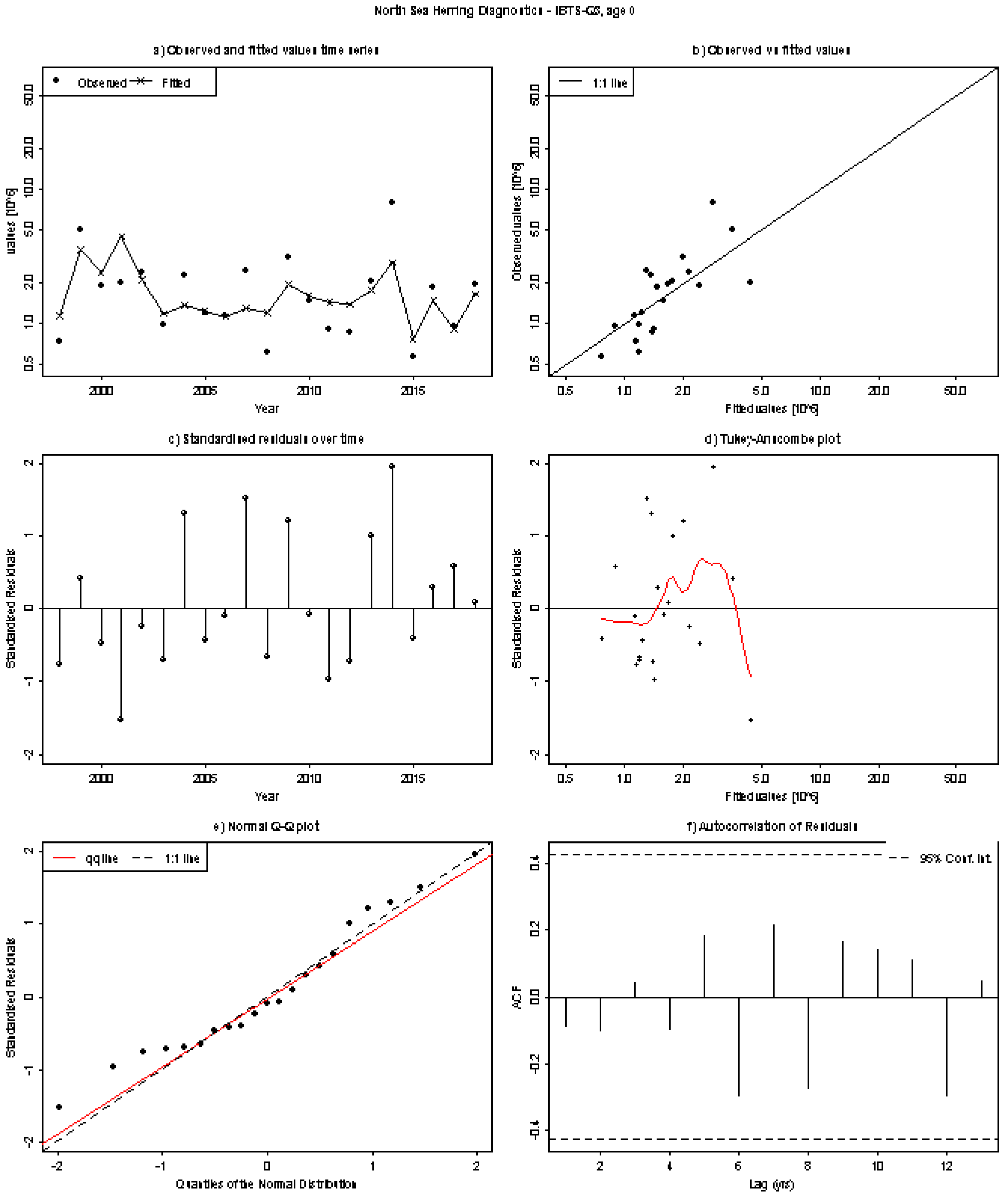


Figure 2.6.1.25. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q3 index at age 0 wr time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

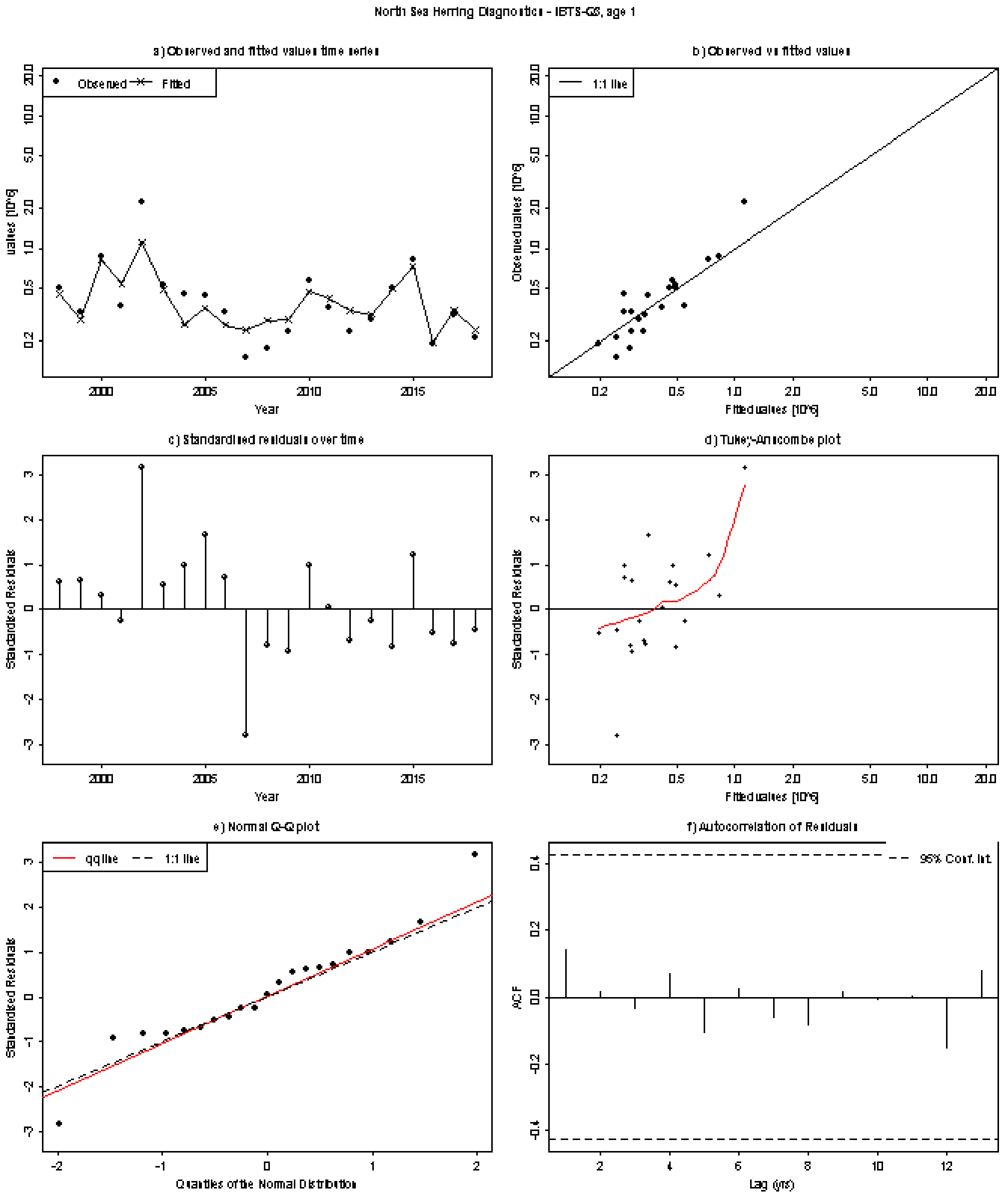


Figure 2.6.1.26. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q3 index at age 1 wr time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

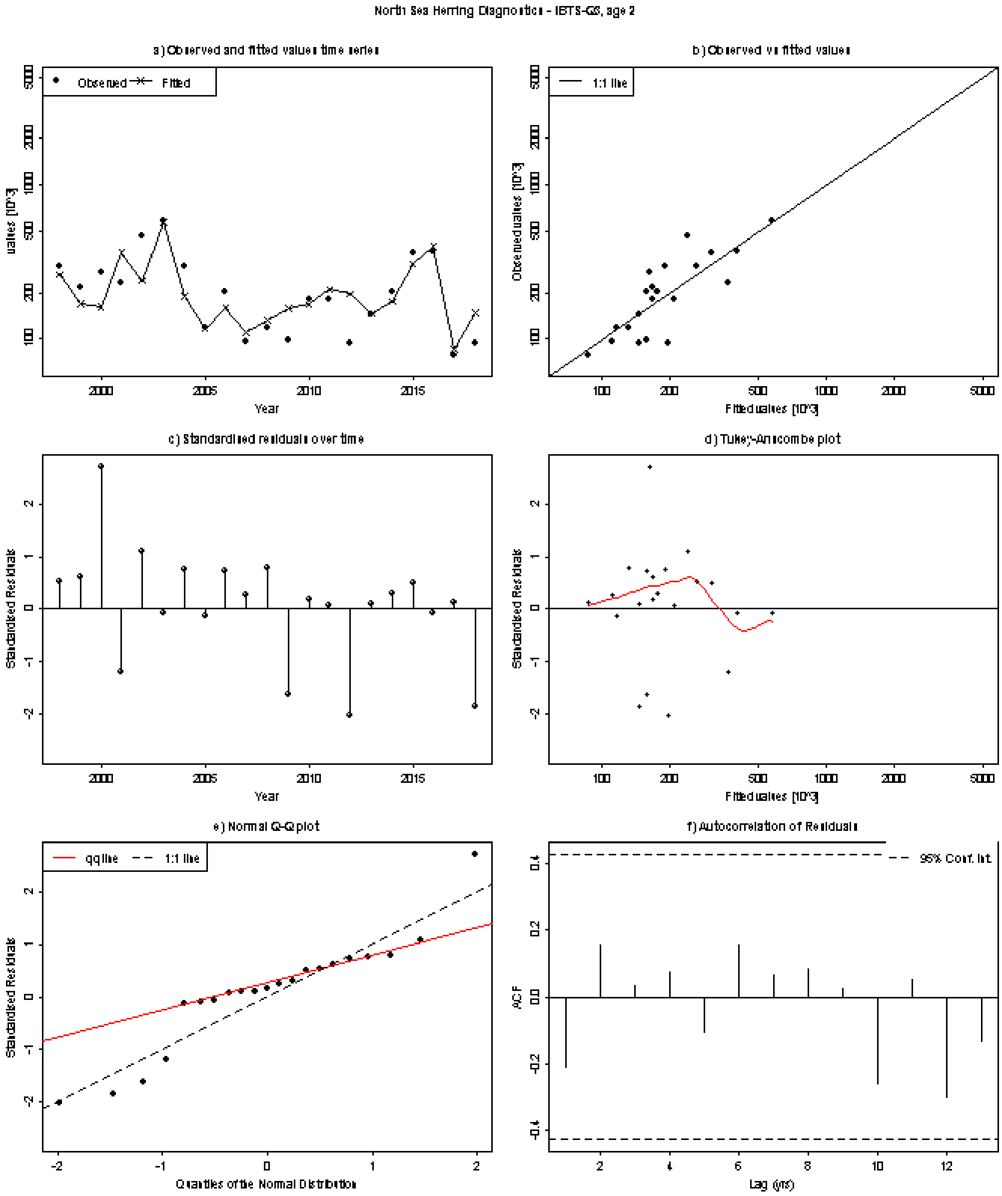


Figure 2.6.1.27. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q3 index at age 2 wr time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

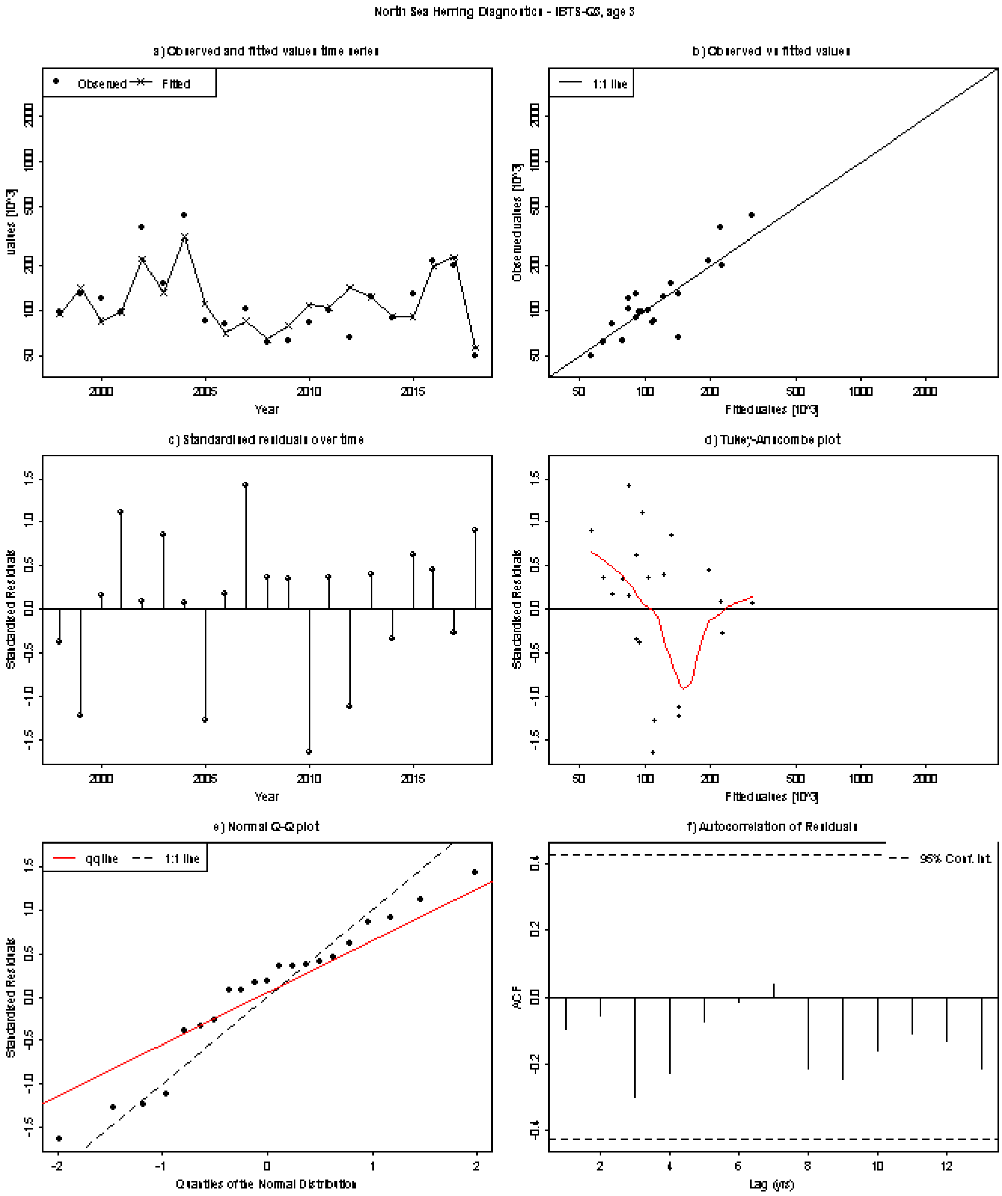


Figure 2.6.1.28. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q3 index at age 3 wr time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

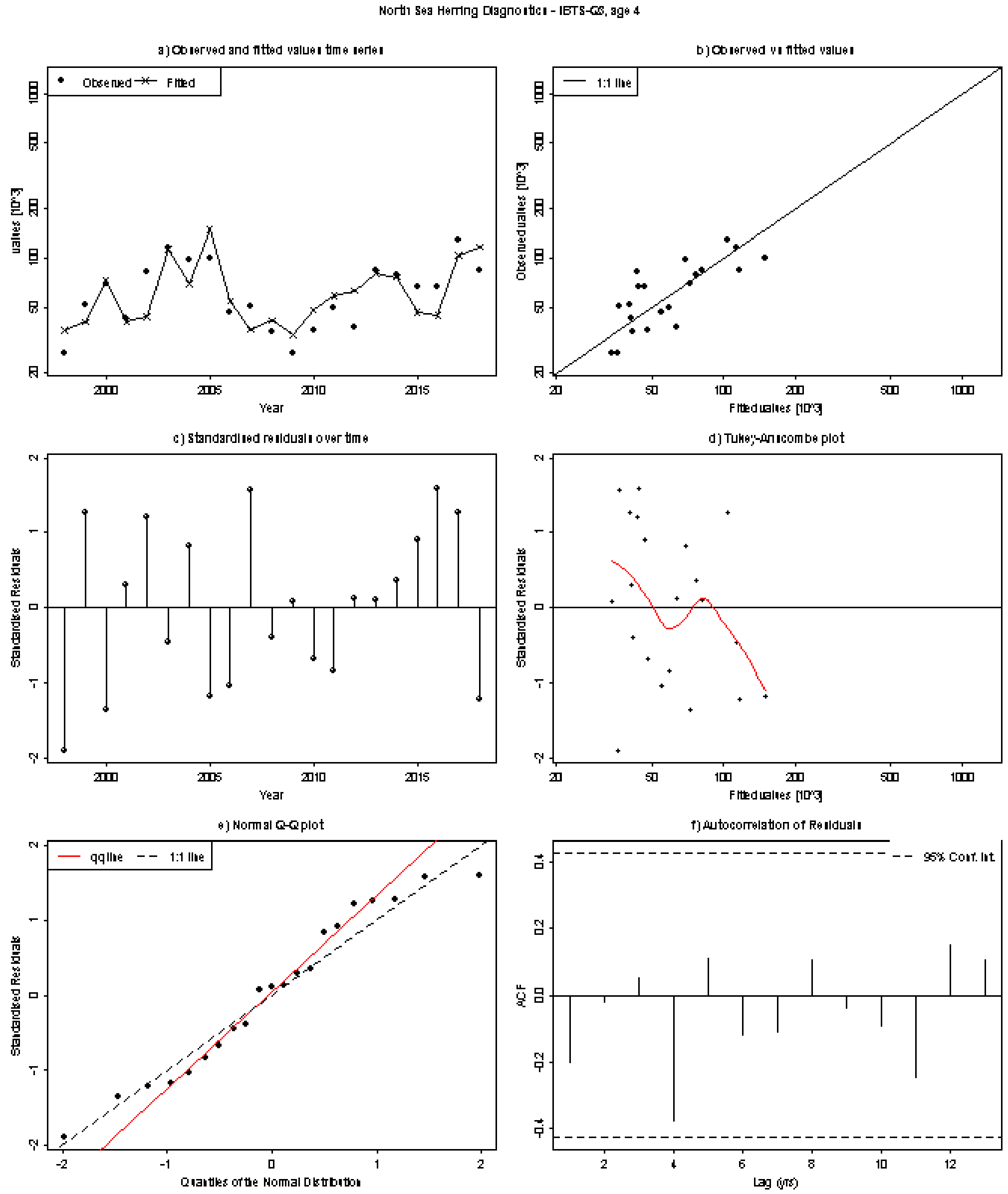


Figure 2.6.1.29. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q3 index at age 4 wr time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

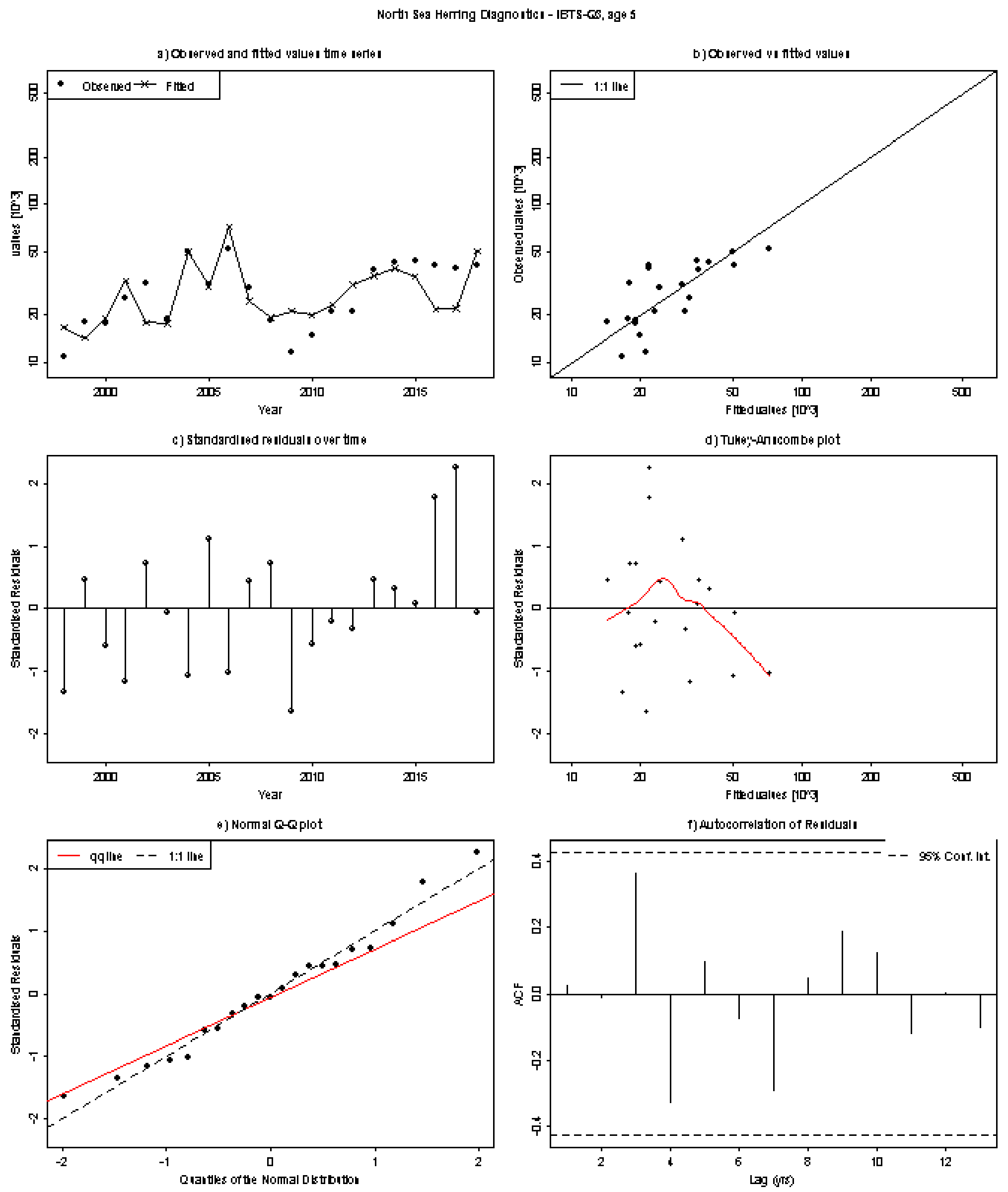


Figure 2.6.1.30. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q3 index at age 5 wr time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

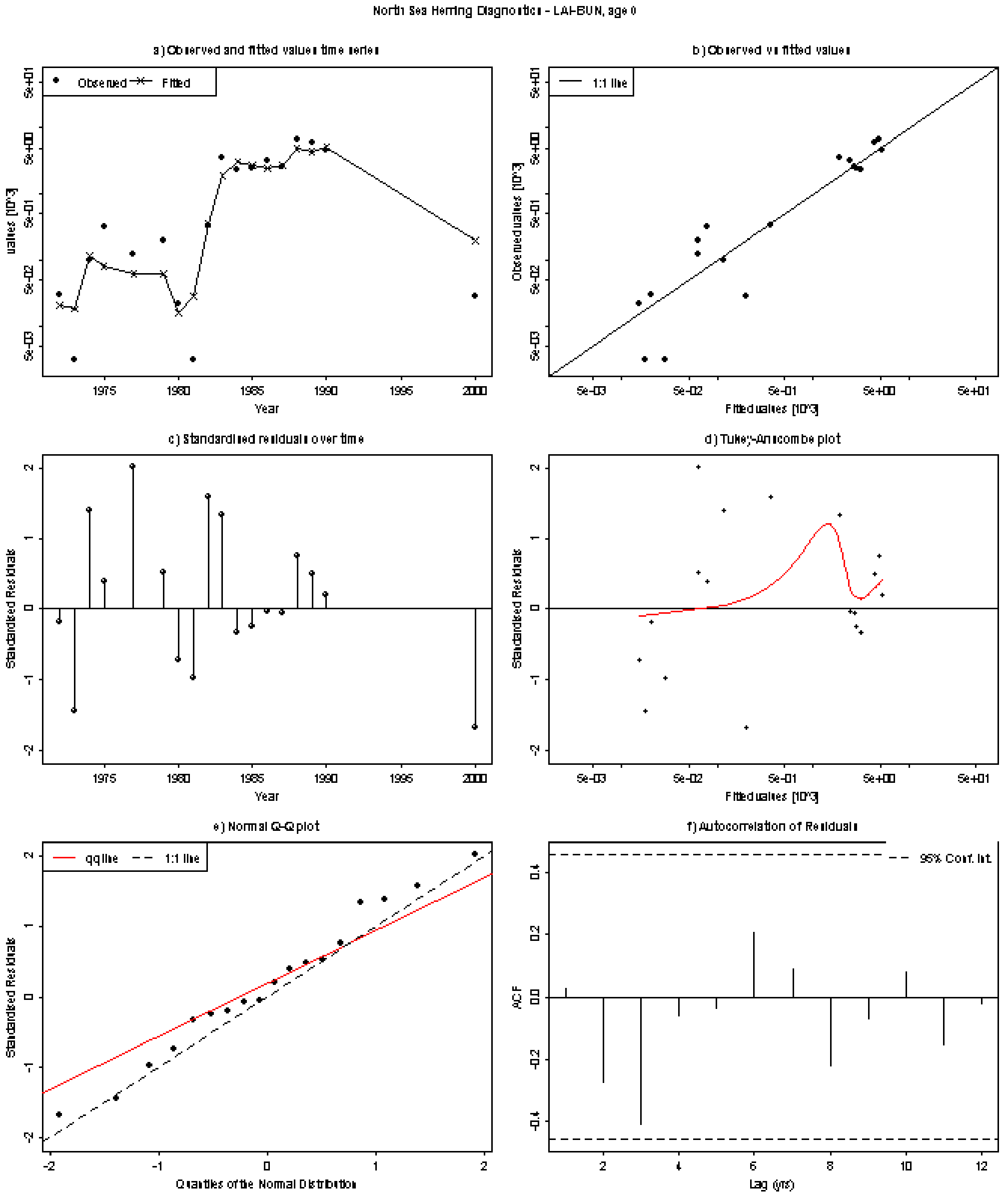


Figure 2.6.1.31. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Buchan area for the first week time series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

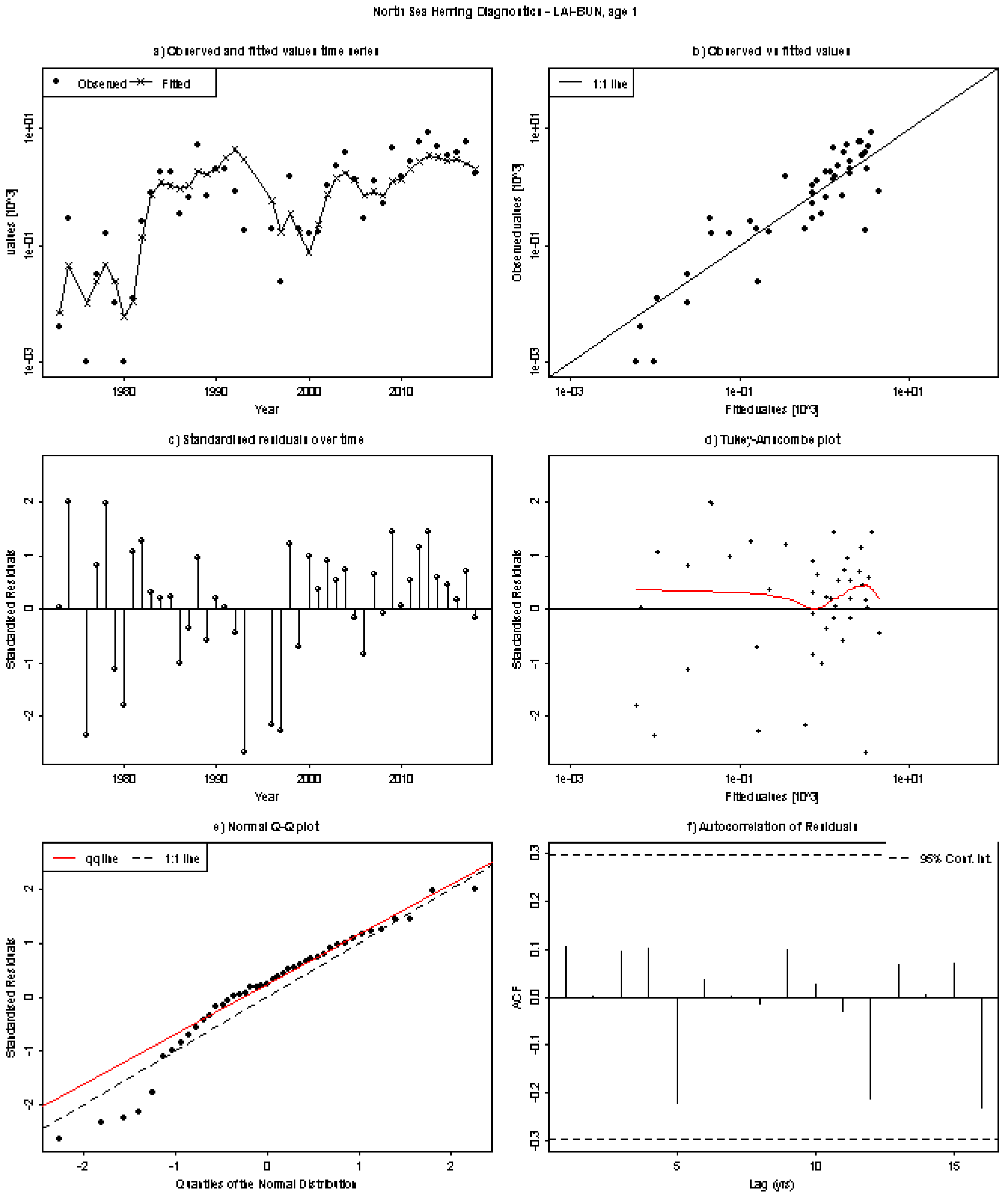


Figure 2.6.1.32. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Buchan area for the second week time series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

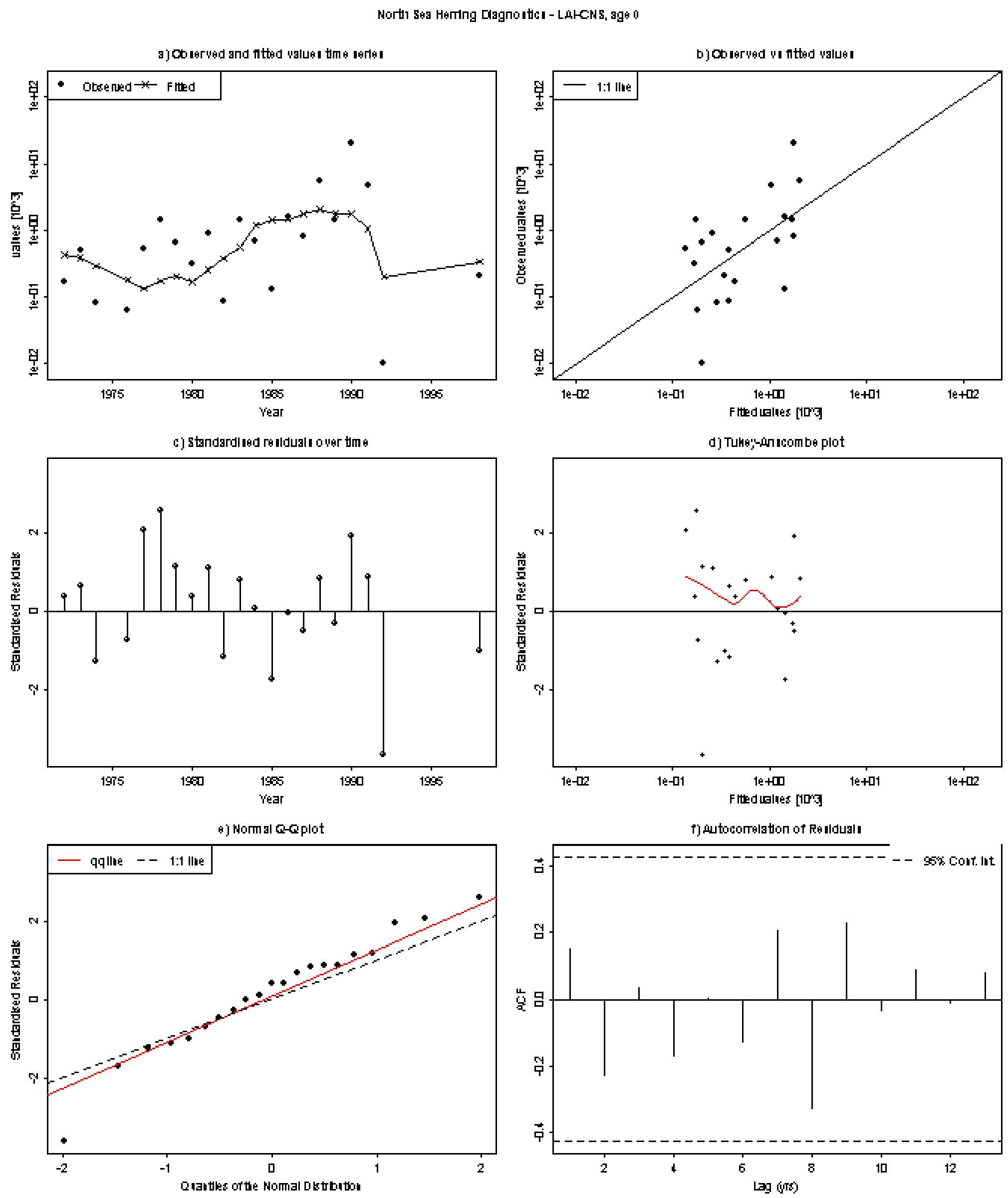


Figure 2.6.1.33. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Banks area for the first week time series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

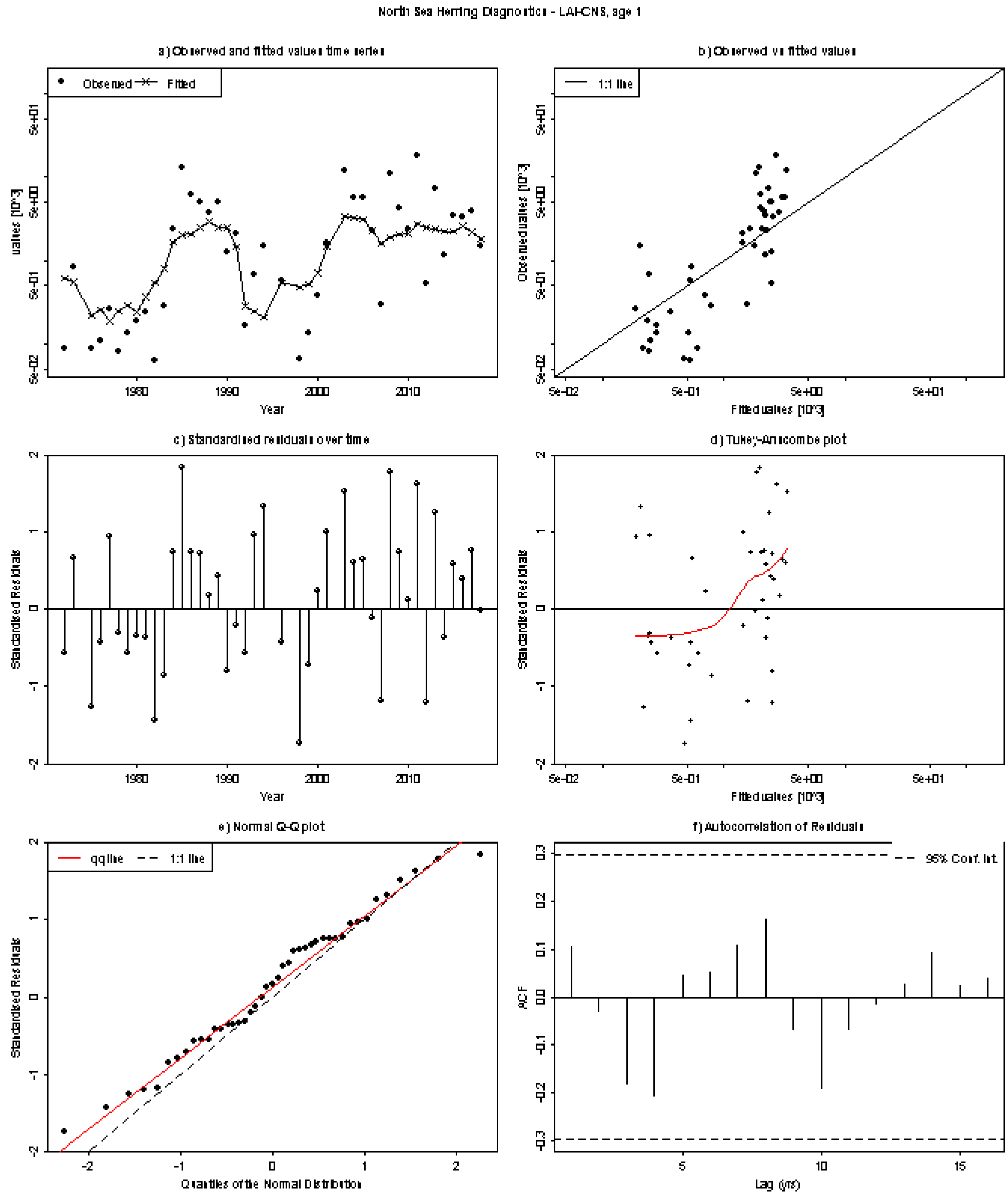


Figure 2.6.1.34. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Banks area for the second week time series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

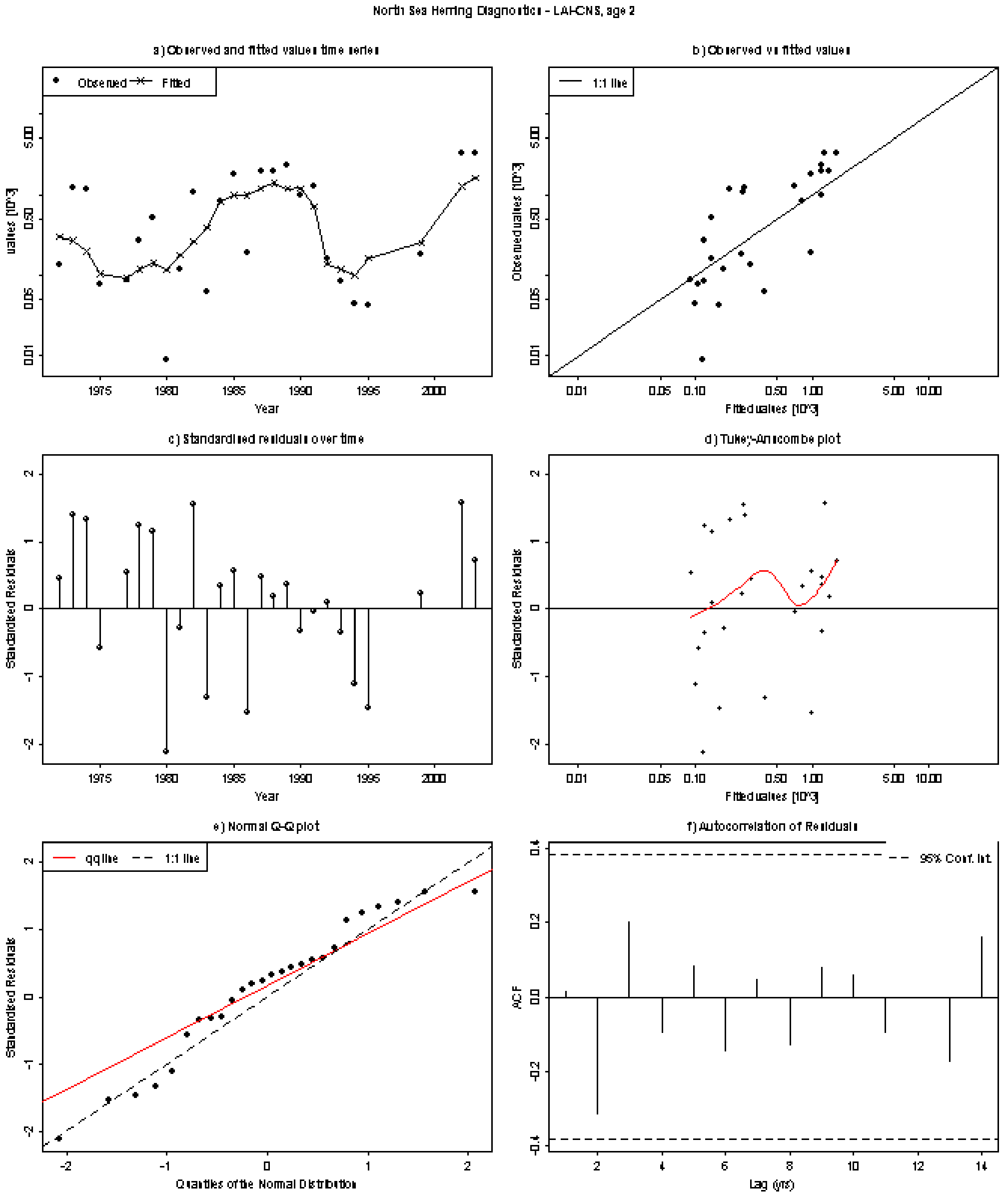


Figure 2.6.1.35. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Banks area for the third week time series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

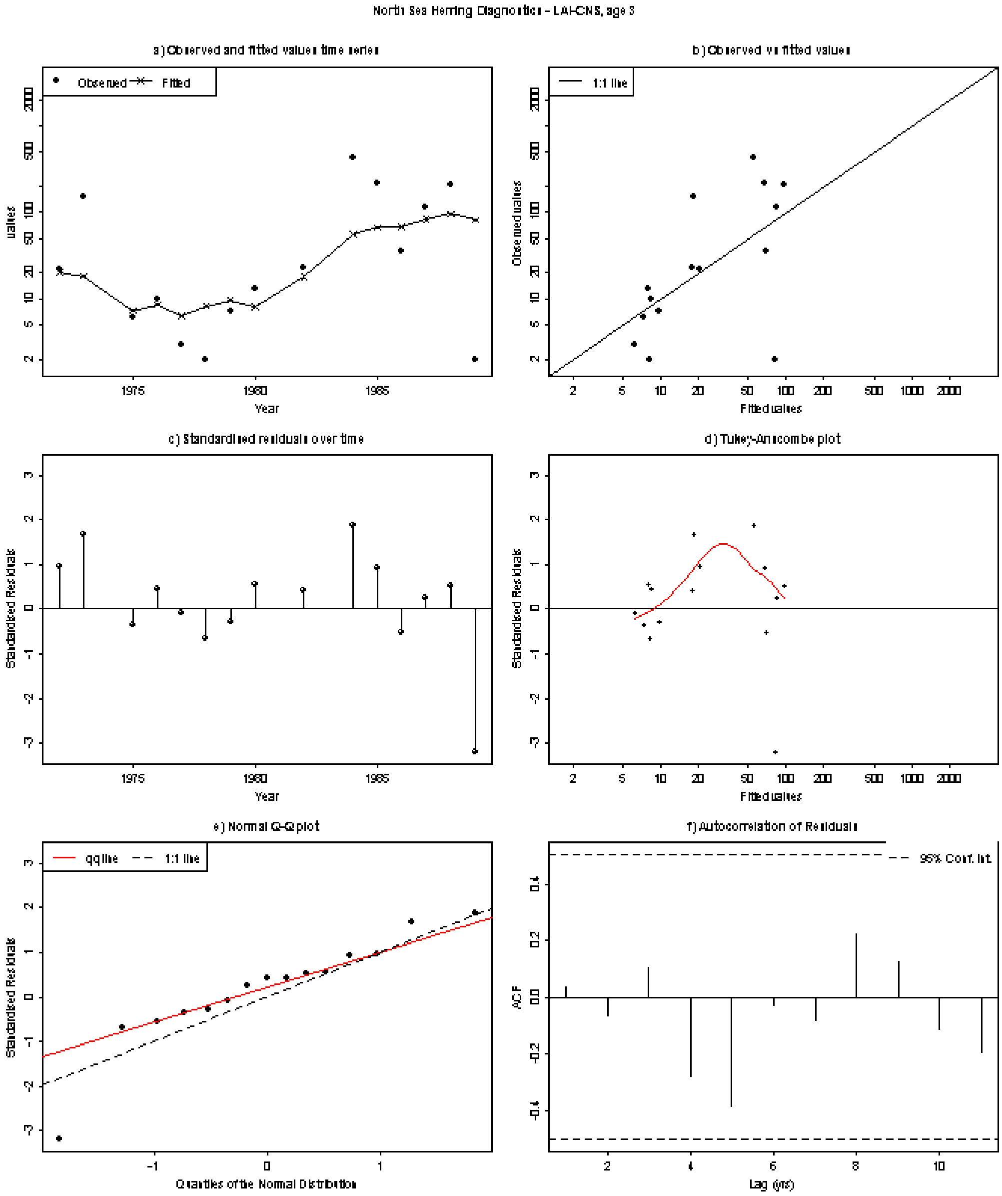


Figure 2.6.1.36. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Banks area for the fourth week time series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

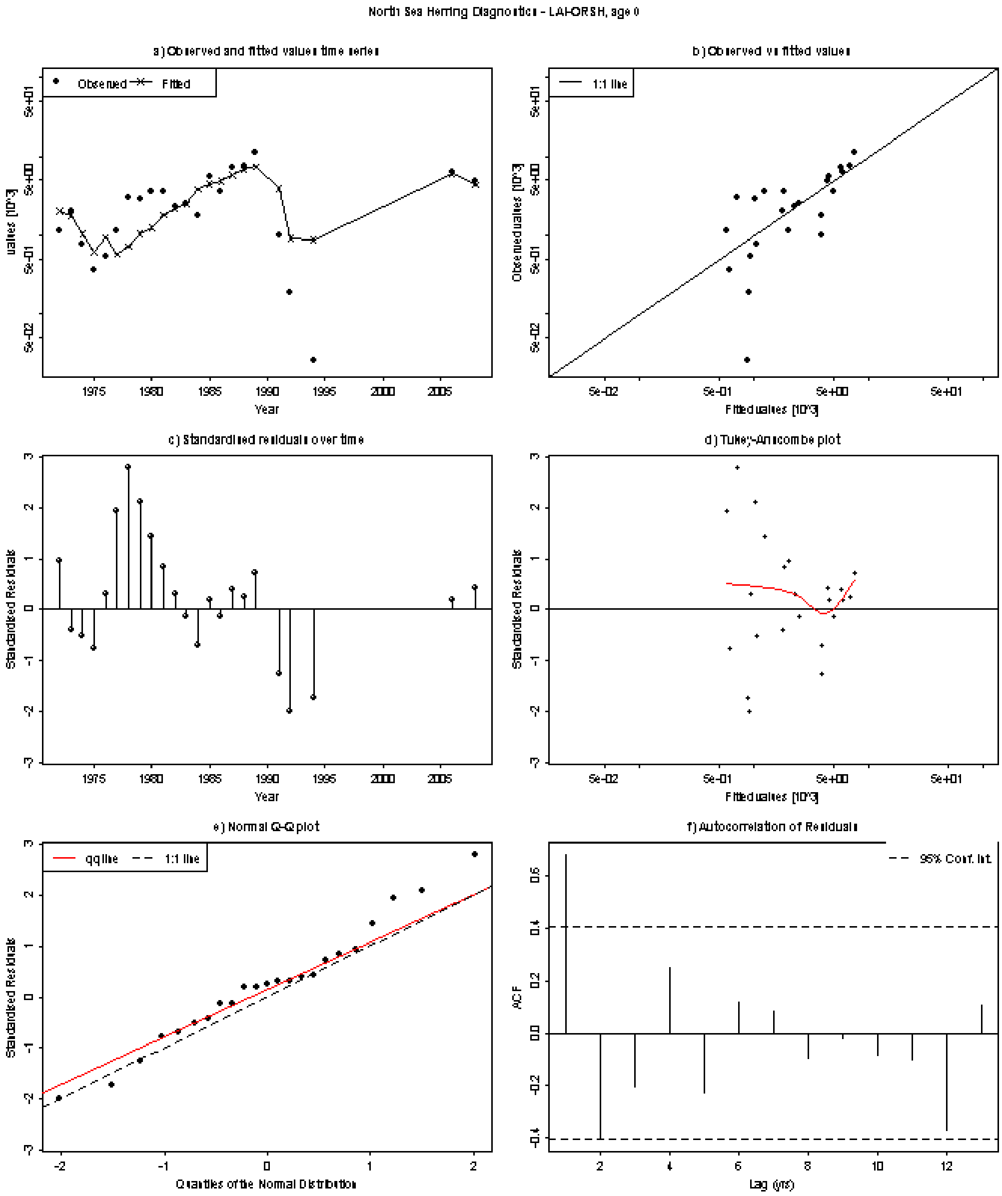


Figure 2.6.1.37. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Orkney/Shetland area for the first week time series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

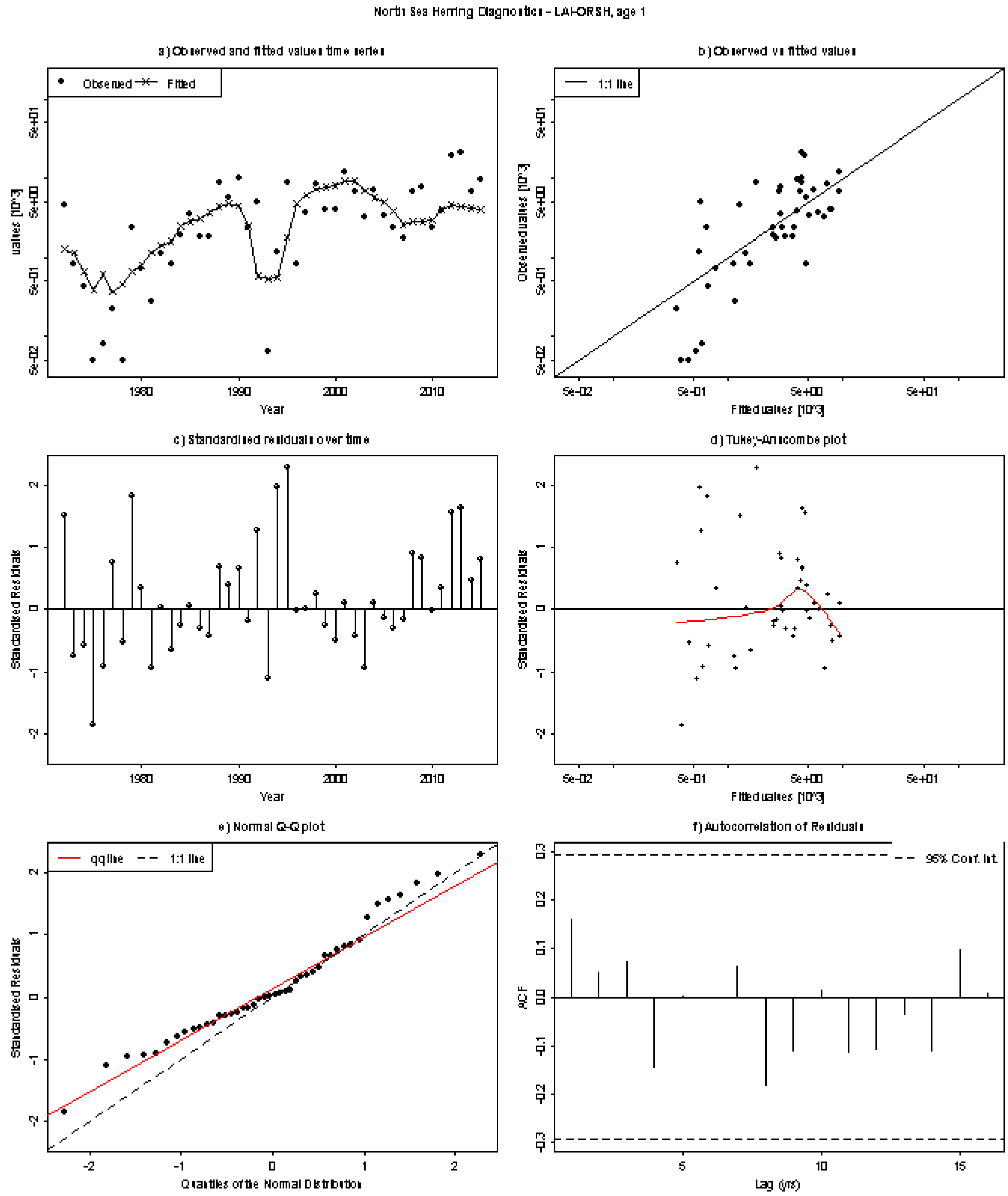


Figure 2.6.1.38. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Orkney/Shetland area for the second week time series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

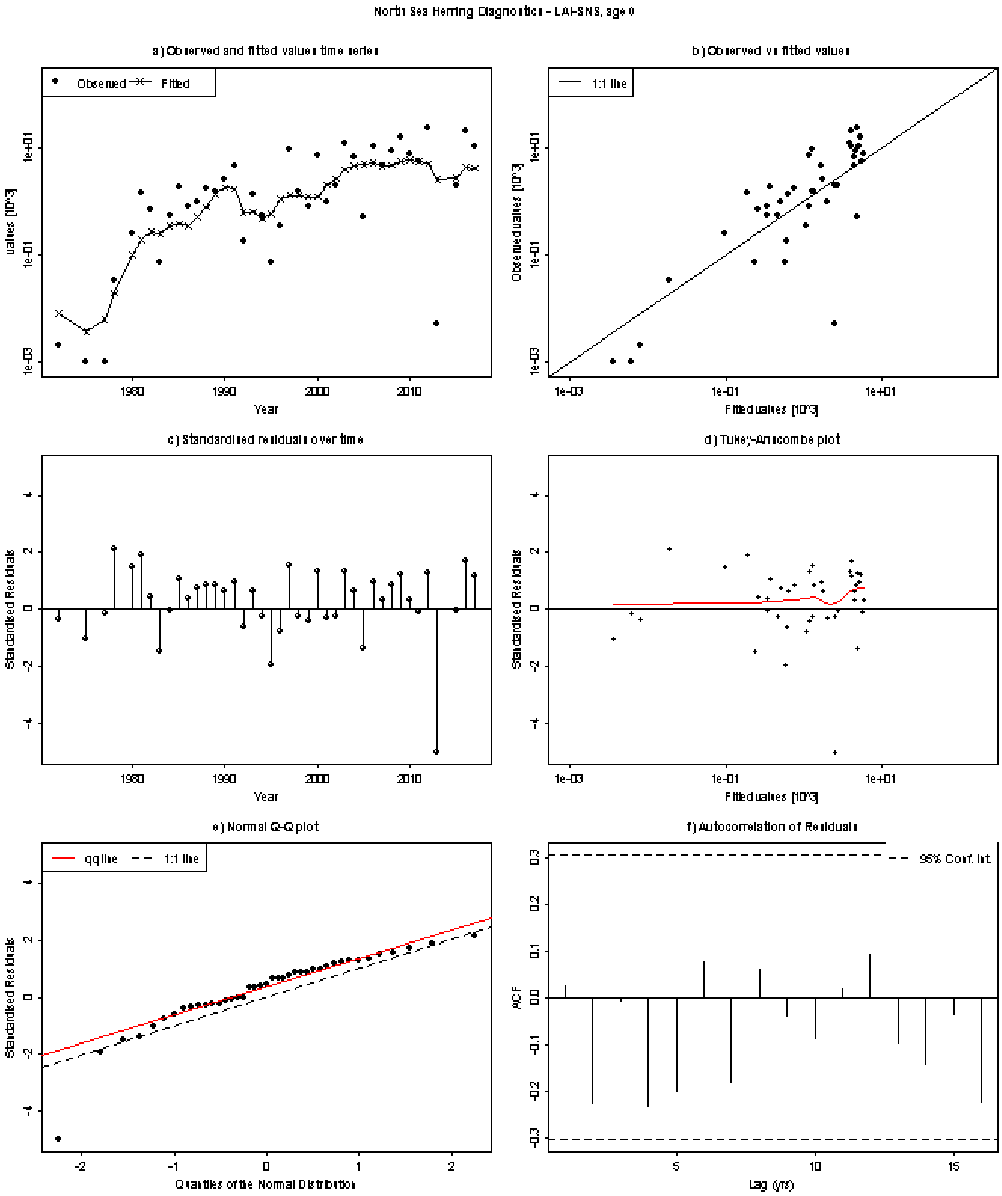


Figure 2.6.1.39. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Downs area for the first week time series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

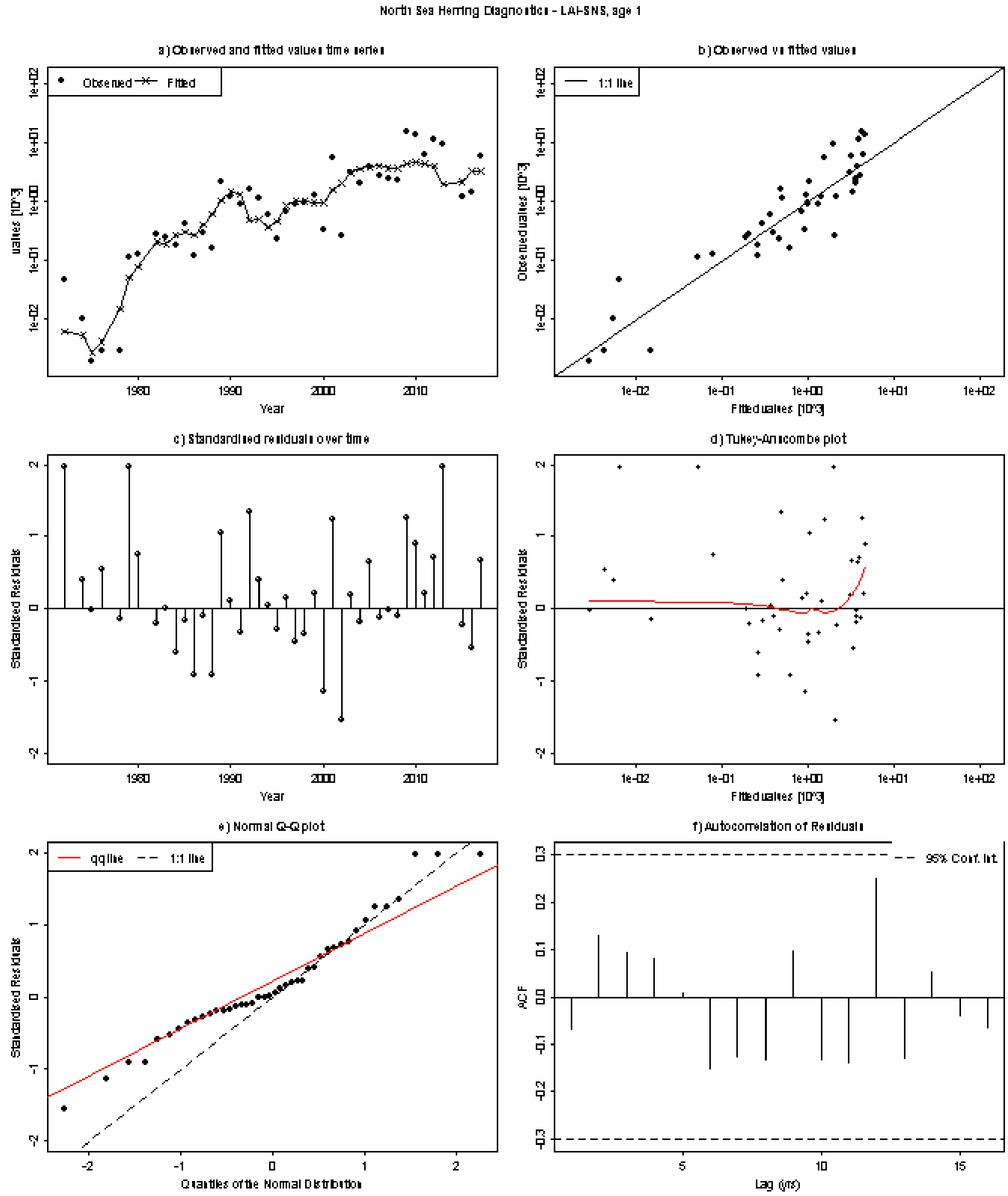


Figure 2.6.1.40. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Downs area for the second week time series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

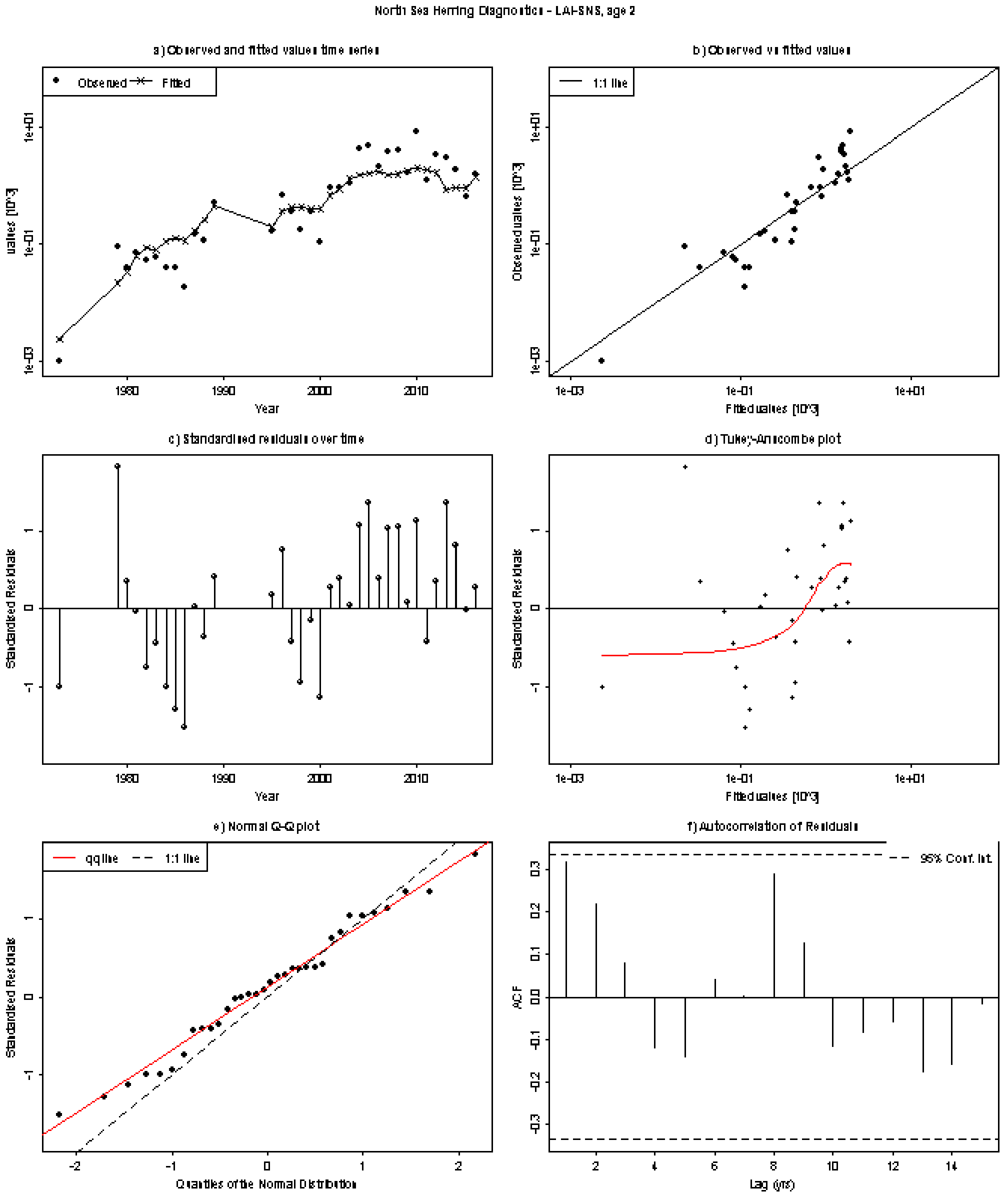


Figure 2.6.1.41. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Downs area for the third week time series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

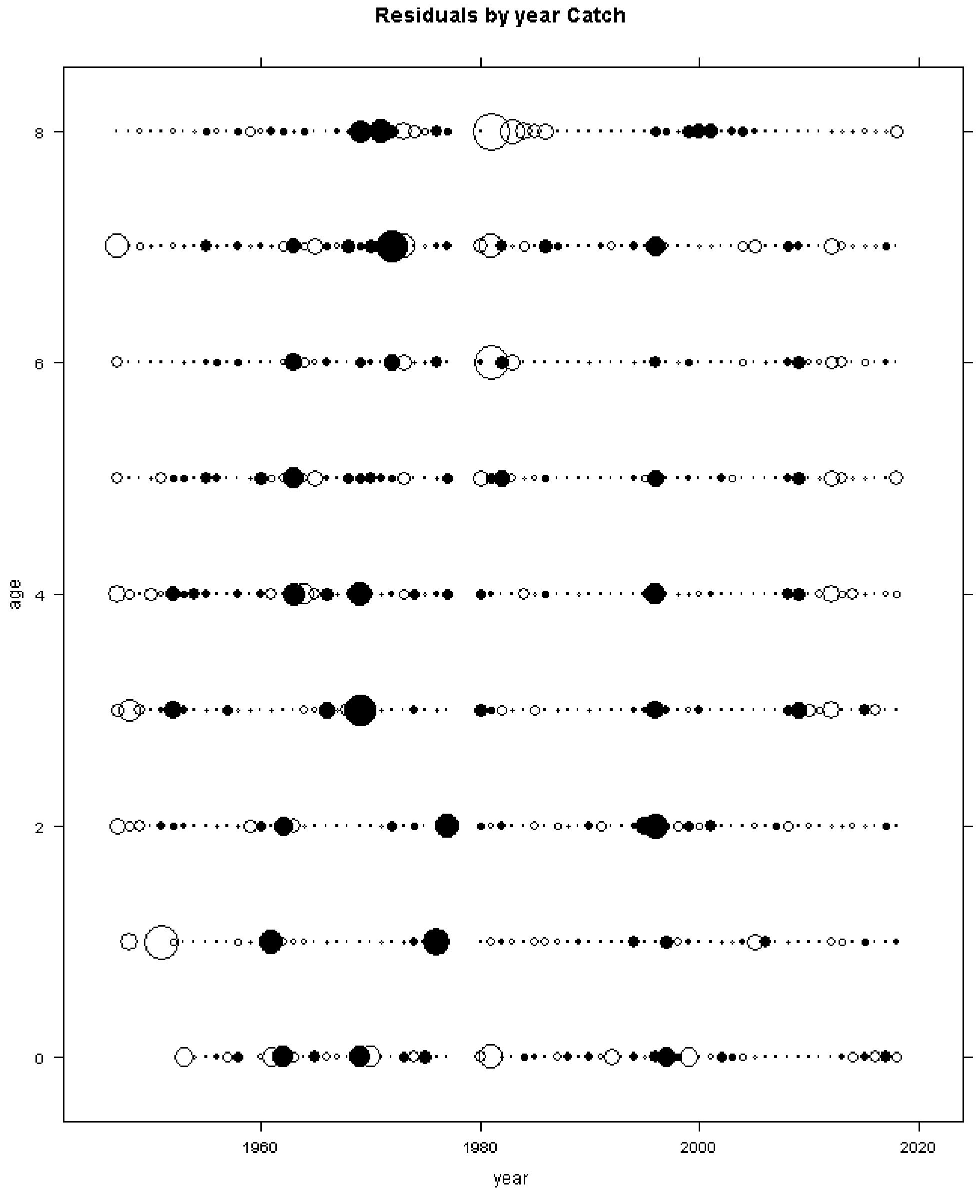


Figure 2.6.1.42. North Sea herring. Bubble plot of standardised catch residual.

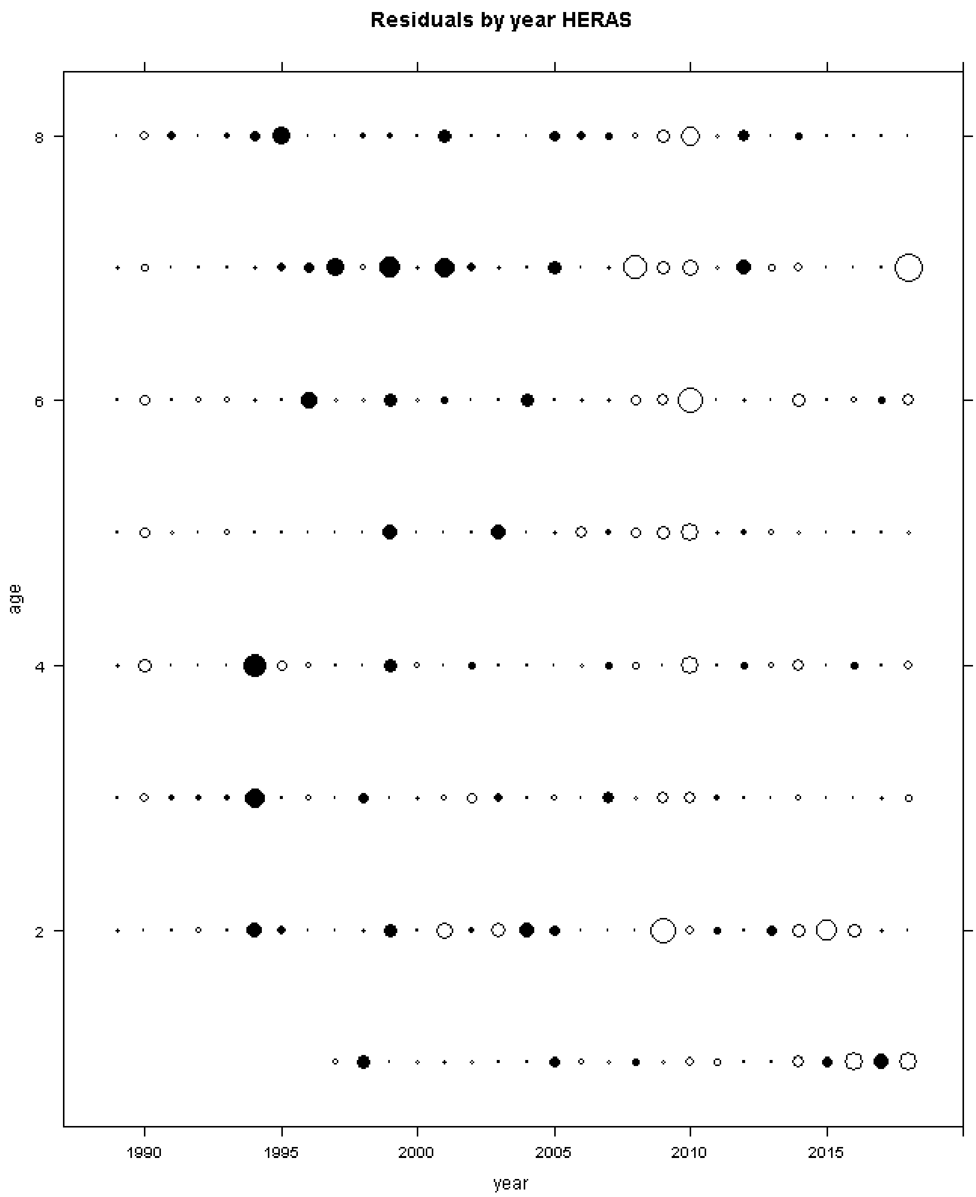


Figure 2.6.1.43. North Sea herring. Bubble plot of standardised acoustic survey residuals.

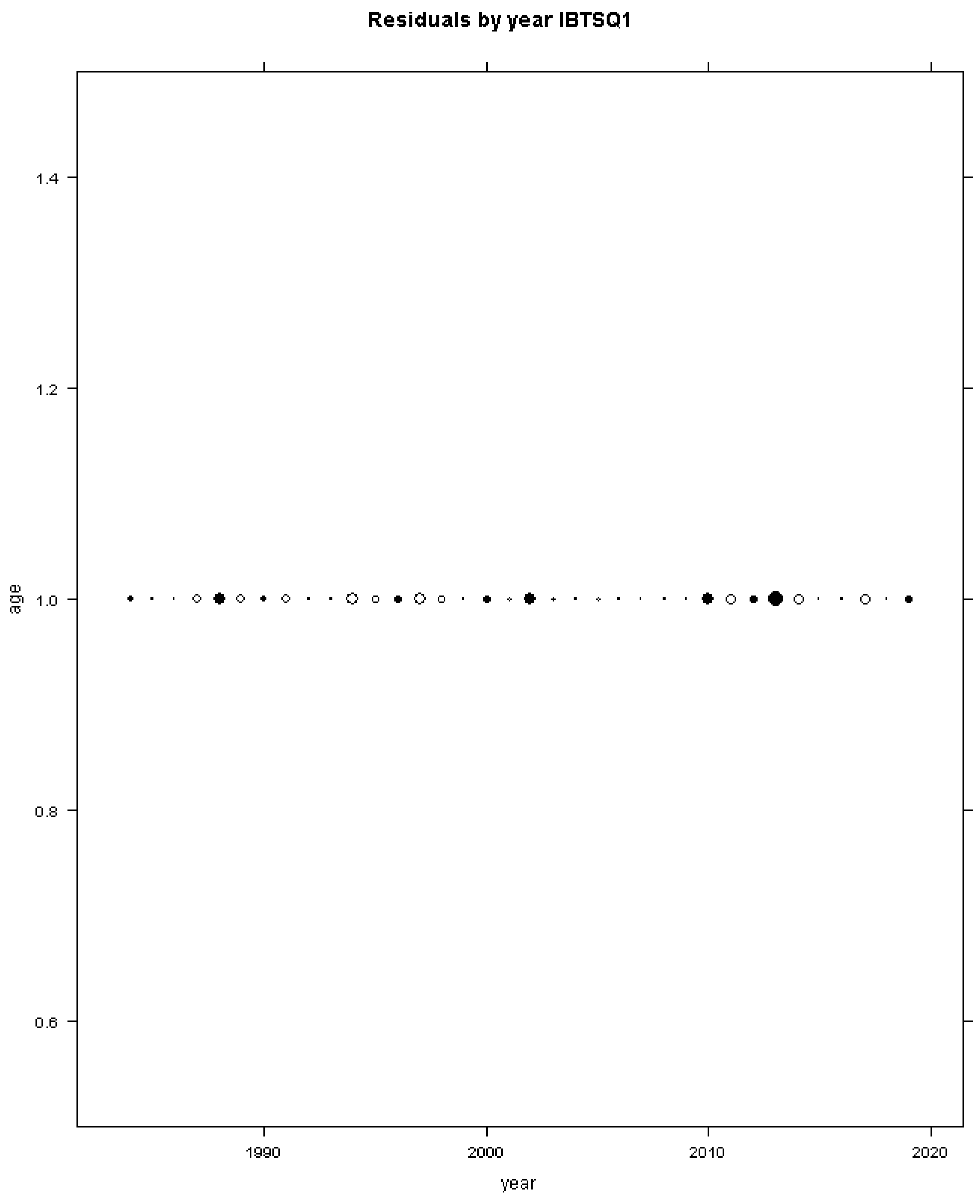


Figure 2.6.1.44. North Sea herring. Bubble plot of standardised IBTSQ1 residuals.

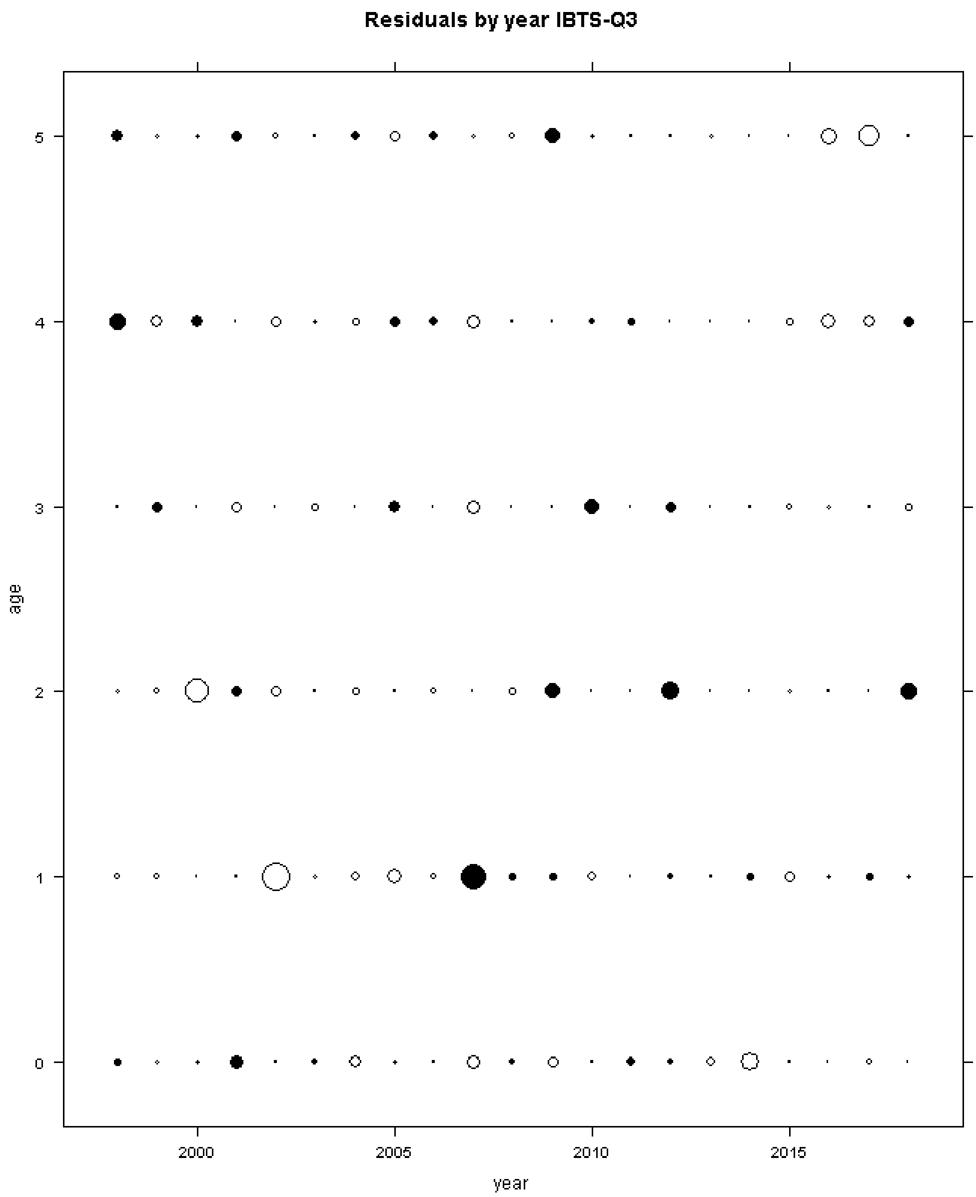


Figure 2.6.1.45. North Sea herring. Bubble plot of standardised IBTSQ3 residuals.

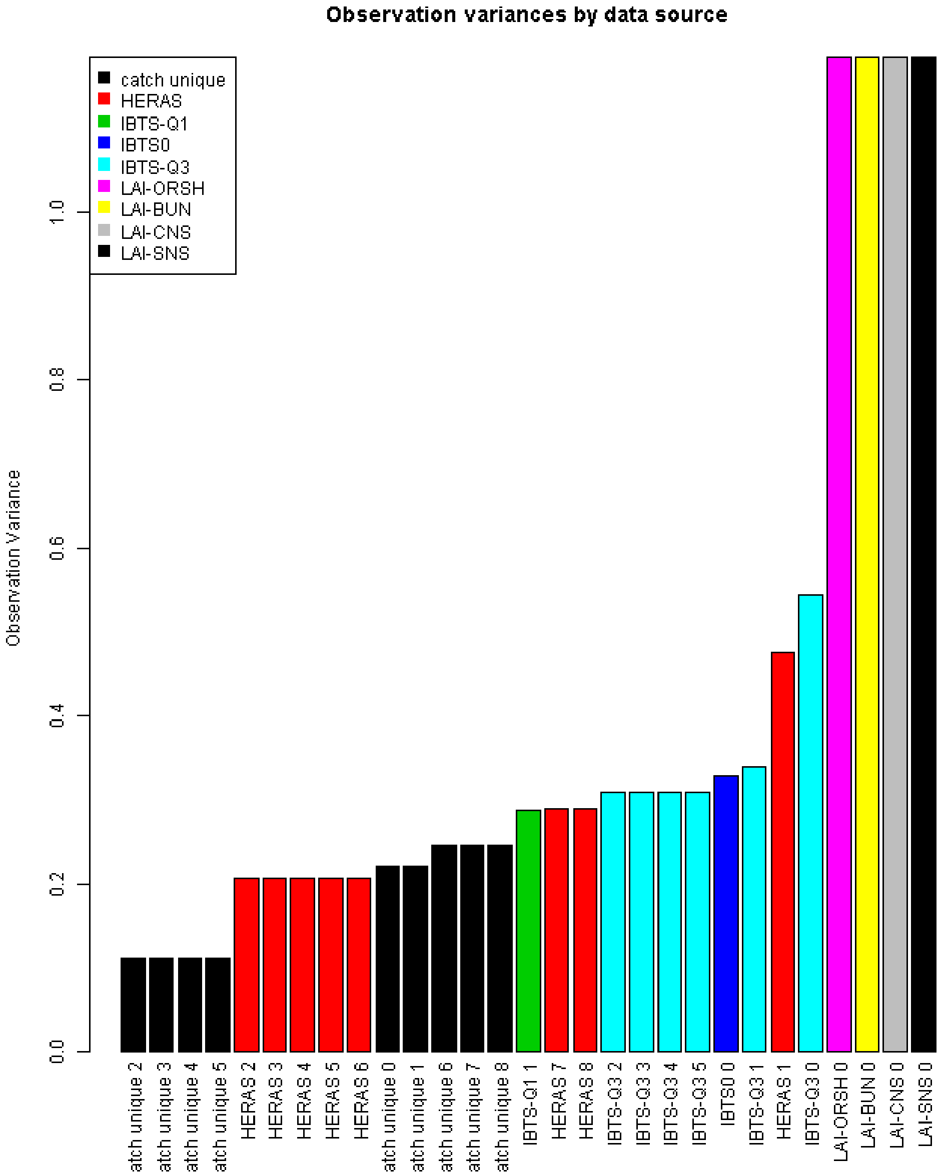


Figure 2.6.1.46. North Sea herring. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for each data source thereby reducing the parameters needed to be estimated in the assessment model. In these cases of parameter bindings, observation variances have equal values.

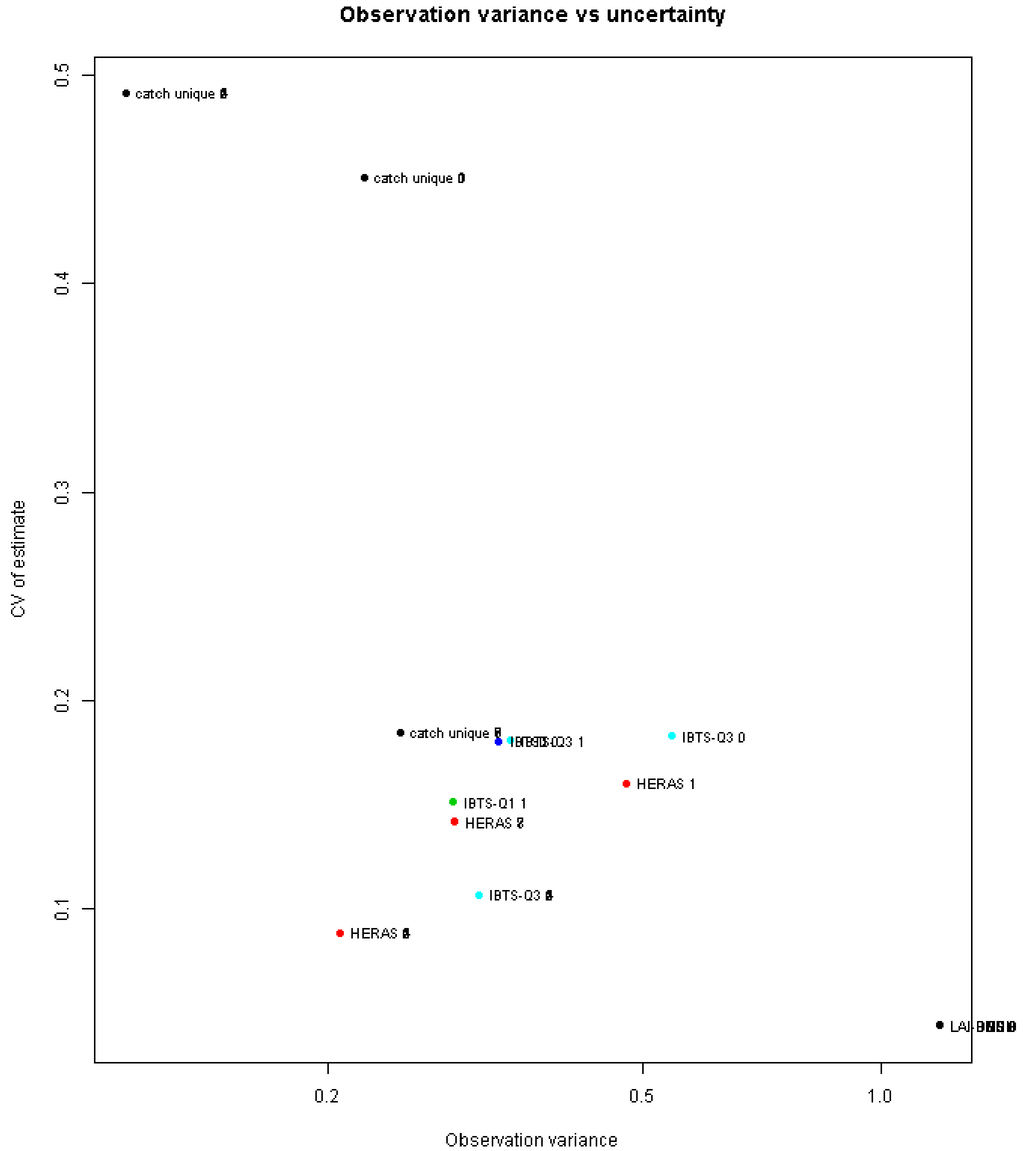


Figure 2.6.1.47. North Sea herring. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

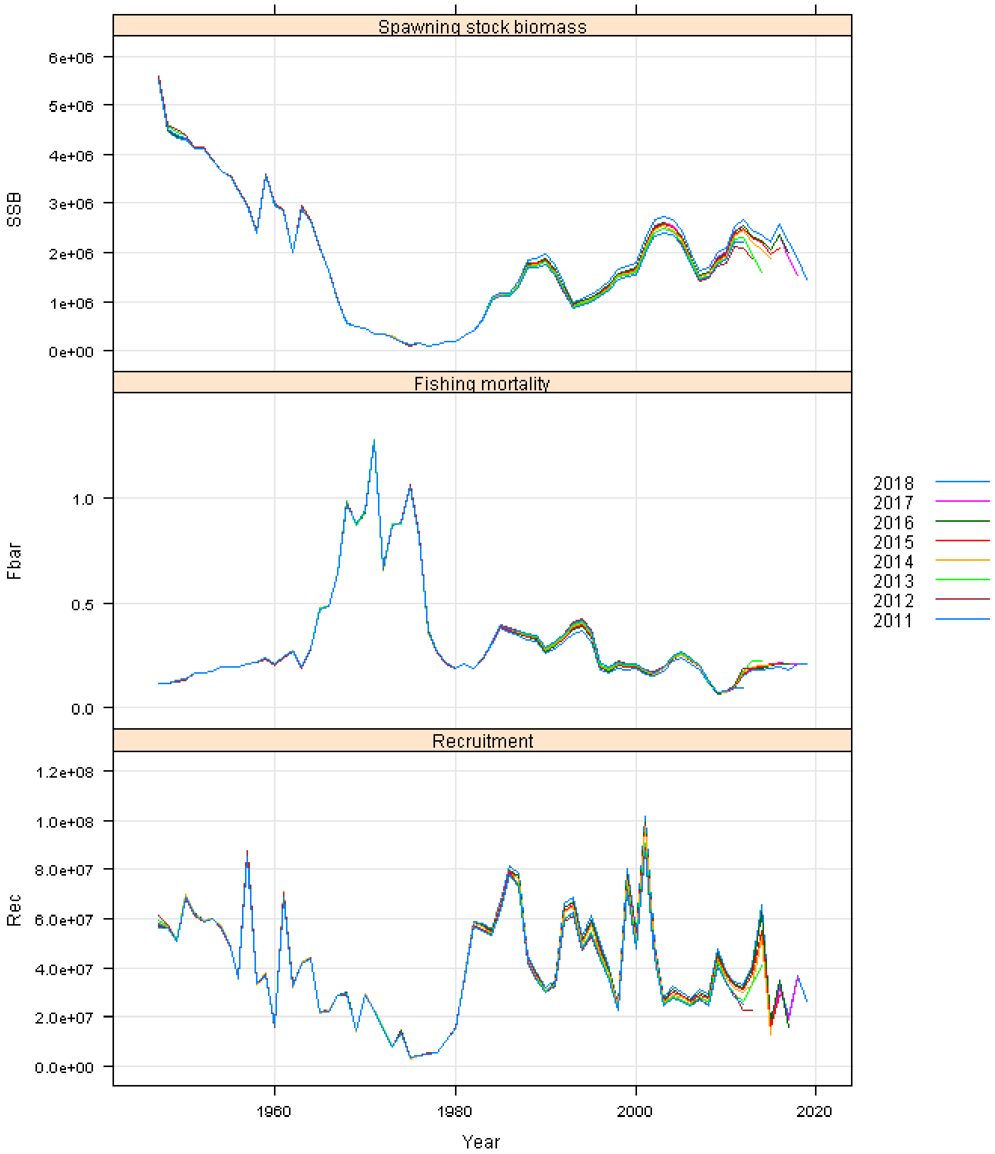


Figure 2.6.1.48. North Sea herring. Assessments retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel) from 2011 to 2018.

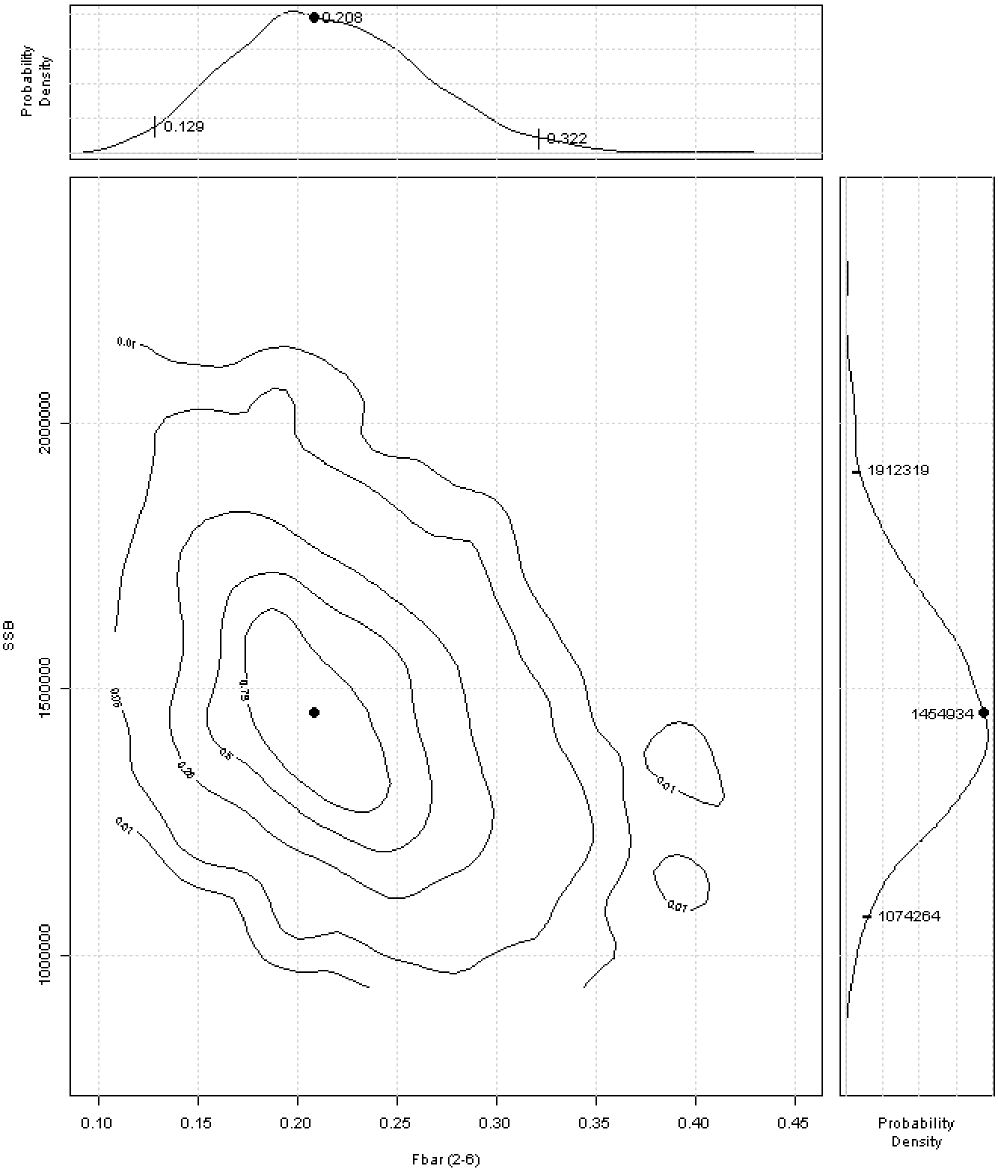


Figure 2.6.1.49. North Sea herring. Model uncertainty; distribution and quantiles of estimated SSB and F_{2-6} in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLSAM estimated variance / covariance estimates from the model.

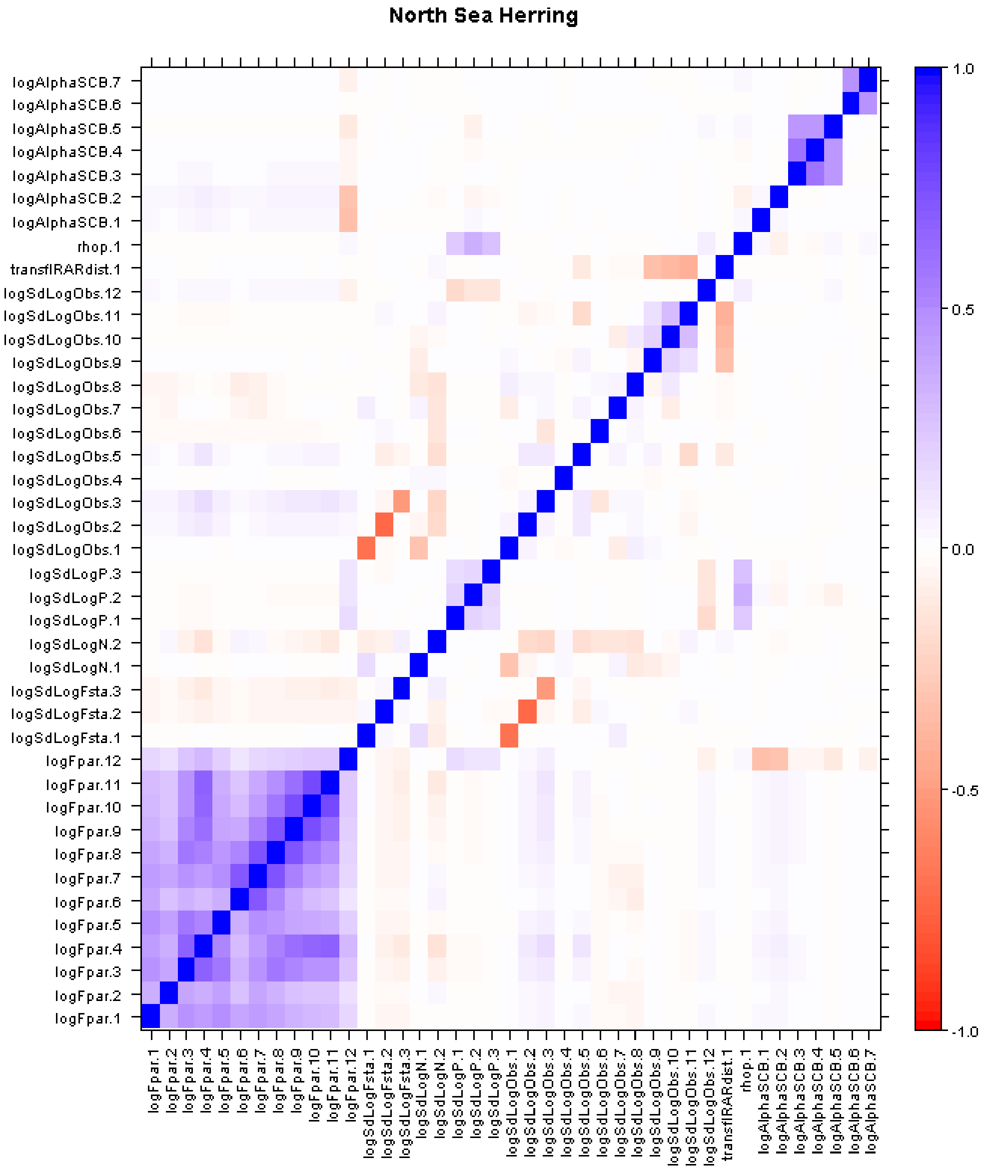


Figure 2.6.1.50. North Sea herring. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

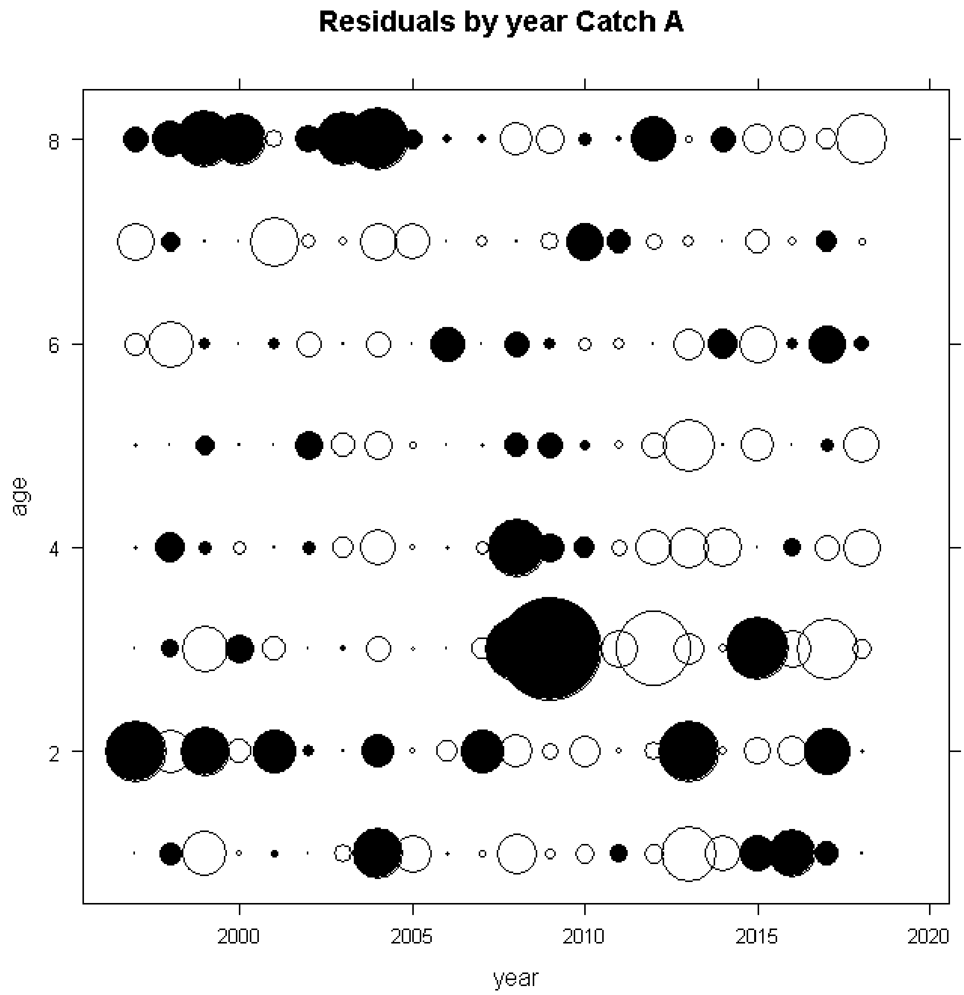


Figure 2.6.2.1. North Sea herring multi-fleet assessment model. Bubble plot of standardised residuals for catches of fleet A.

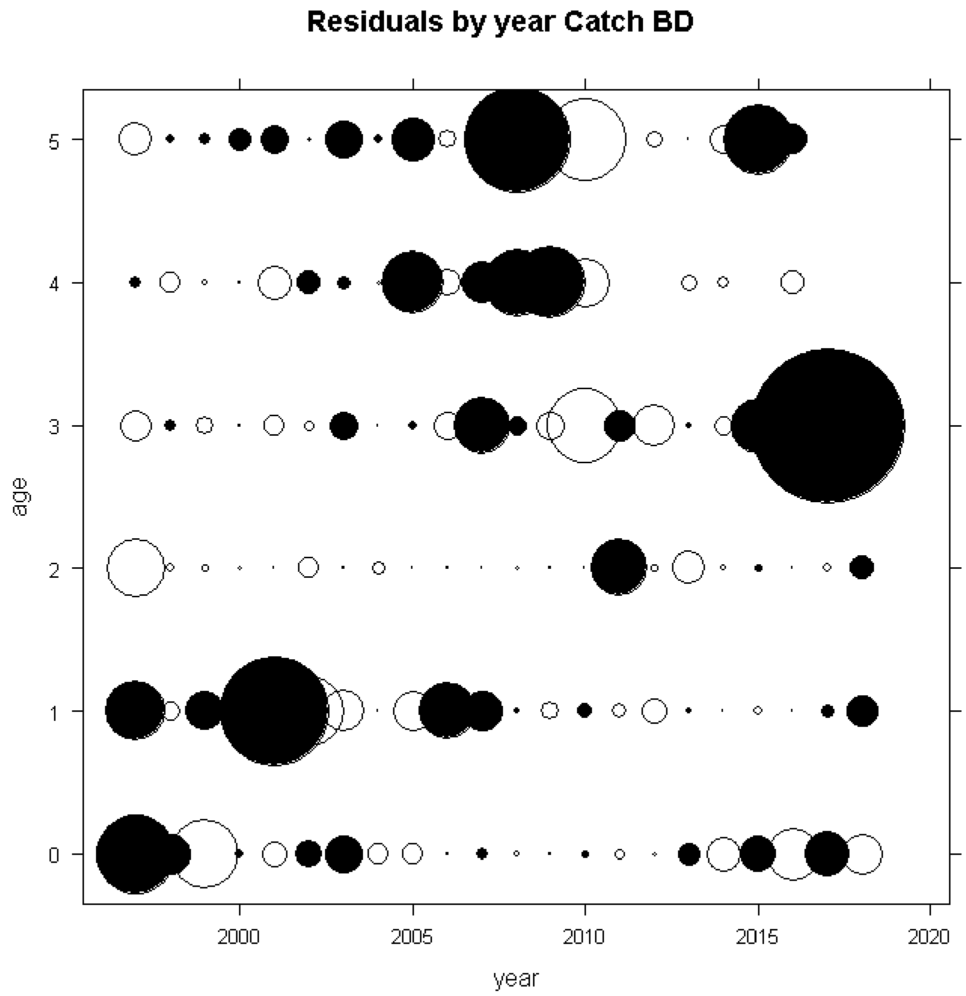


Figure 2.6.2.2. North Sea herring multi-fleet assessment model. Bubble plot of standardised residuals for catches of fleet B&D.

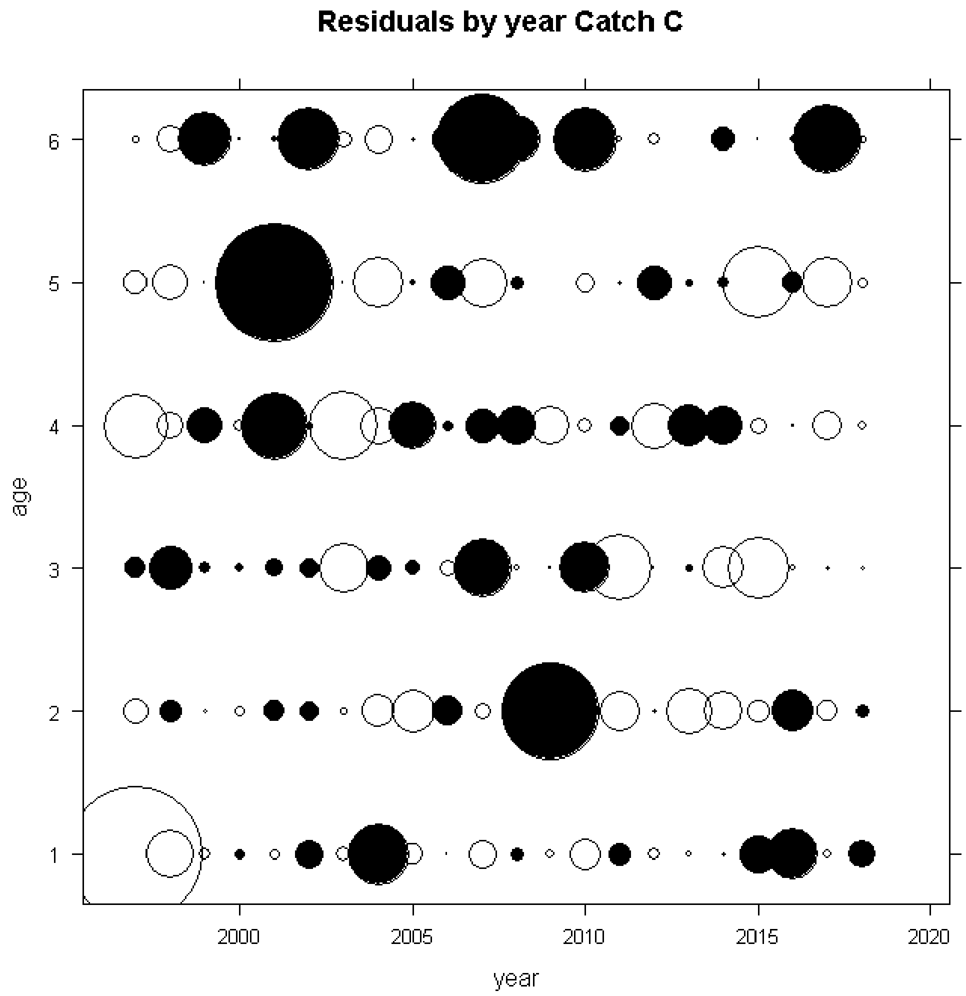


Figure 2.6.2.3. North Sea herring multi-fleet assessment model. Bubble plot of standardised residuals for catches of fleet C.

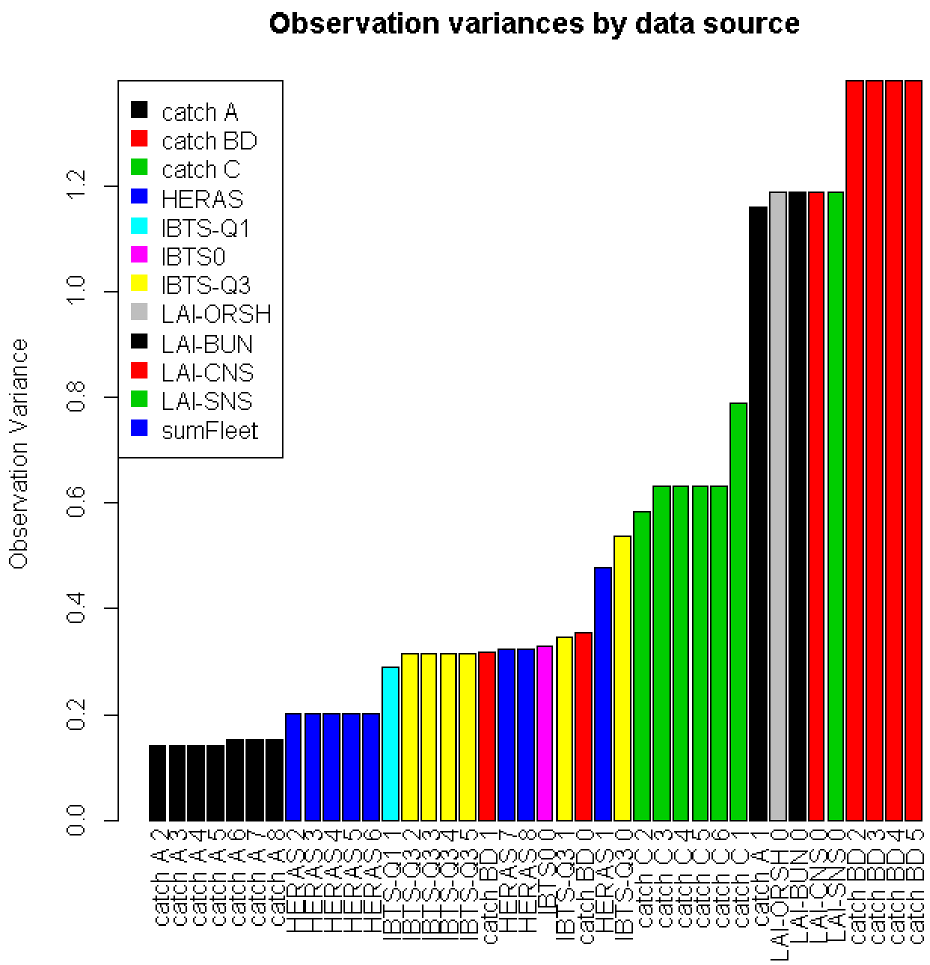


Figure 2.6.2.4. North Sea herring multi-fleet assessment model. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated 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.

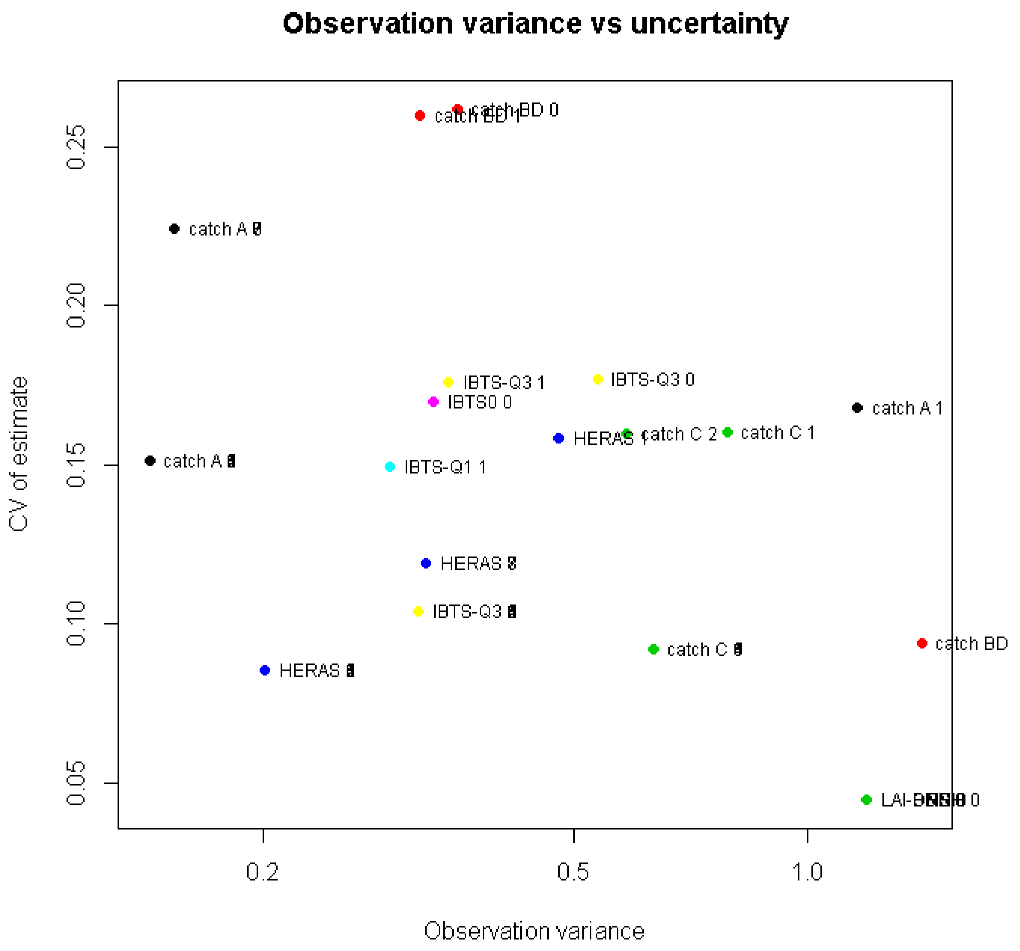


Figure 2.6.2.5. North Sea herring multi-fleet assessment model. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

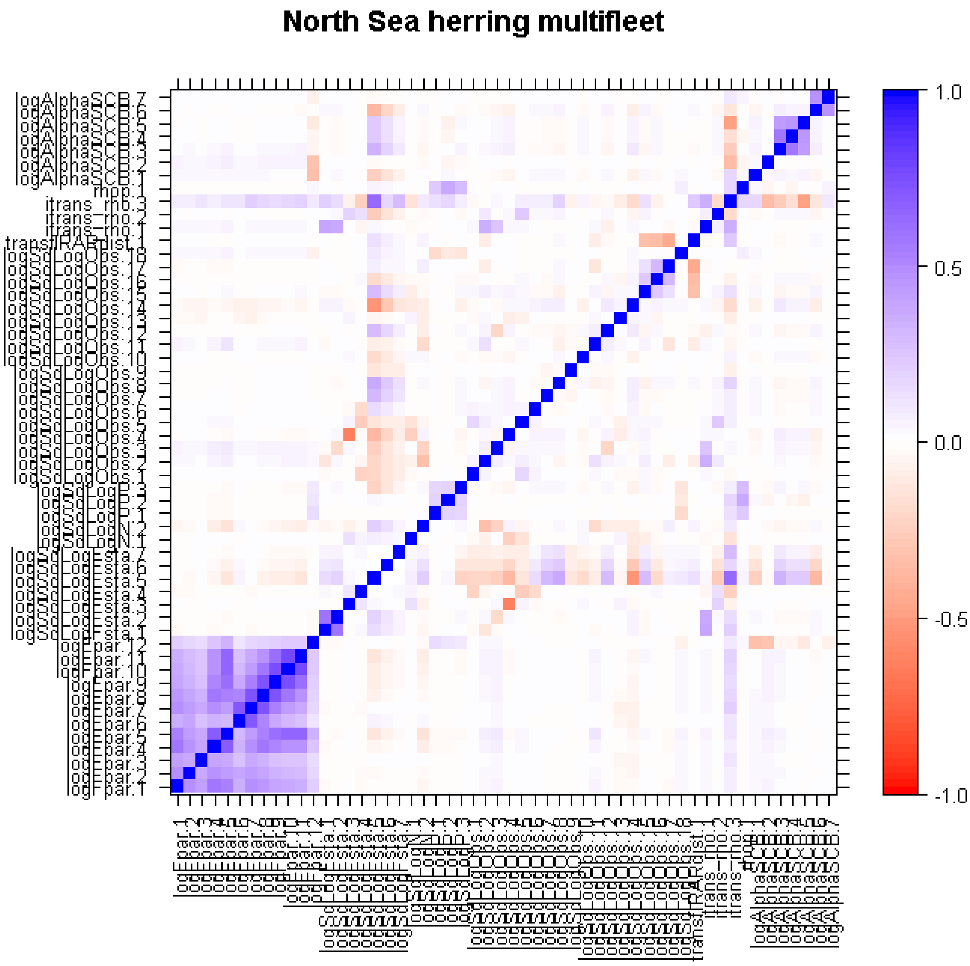


Figure 2.6.2.6. North Sea multi-fleet assessment model. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

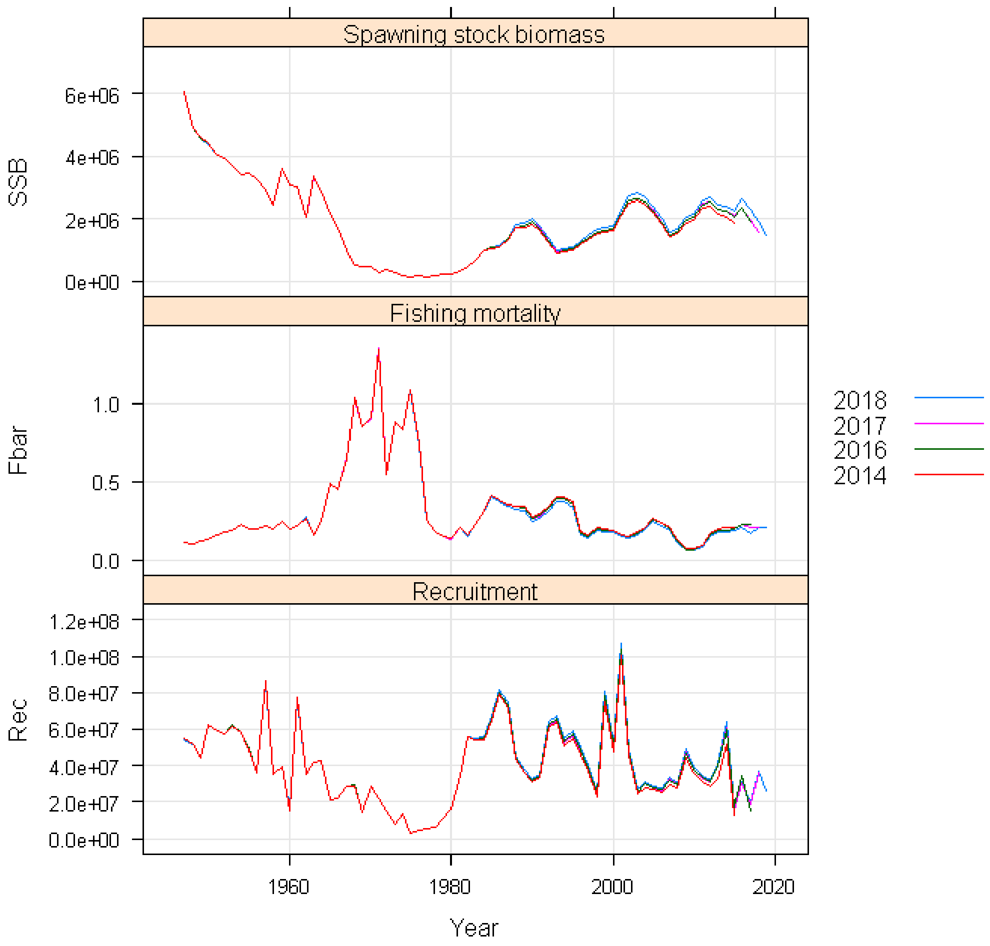


Figure 2.6.2.7. North Sea herring multi-fleet assessment model. Assessments retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel) from 2006 to 2018.

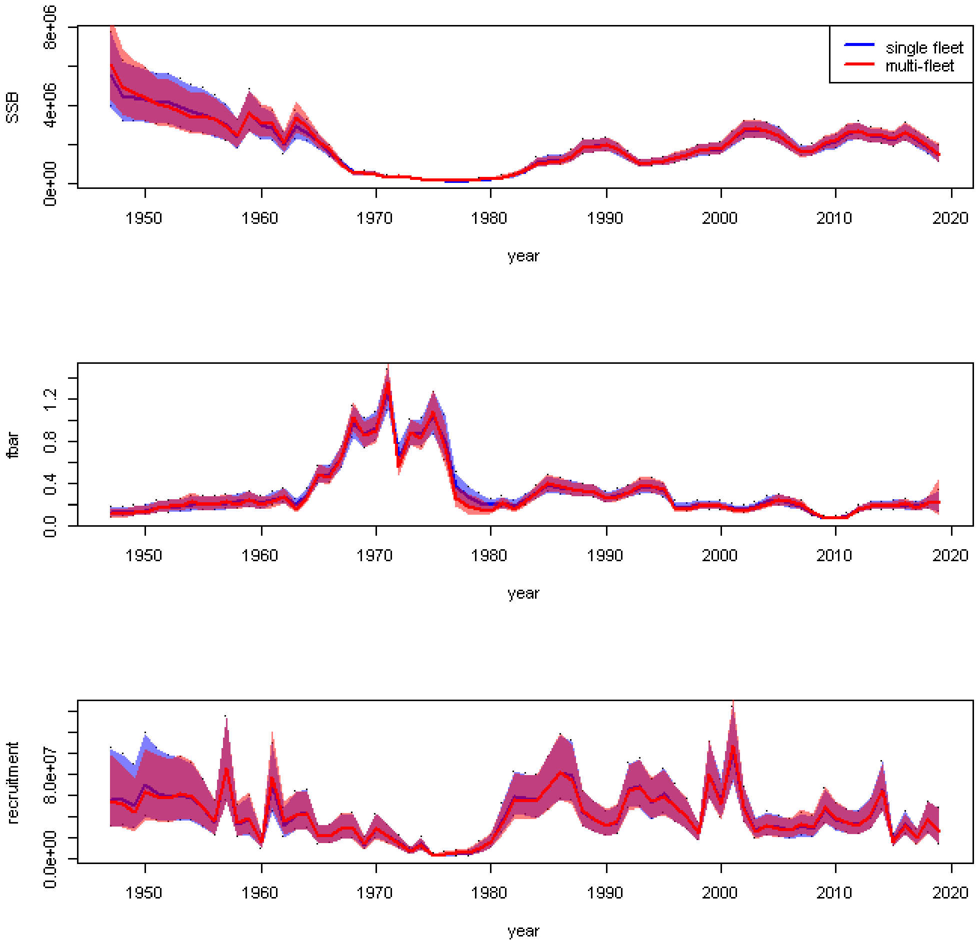


Figure 2.6.2.8. North Sea herring multi-fleet assessment model. Comparison SSB, F_{bar} and recruitment trajectories for multi-fleet and single fleet assessment model outputs.

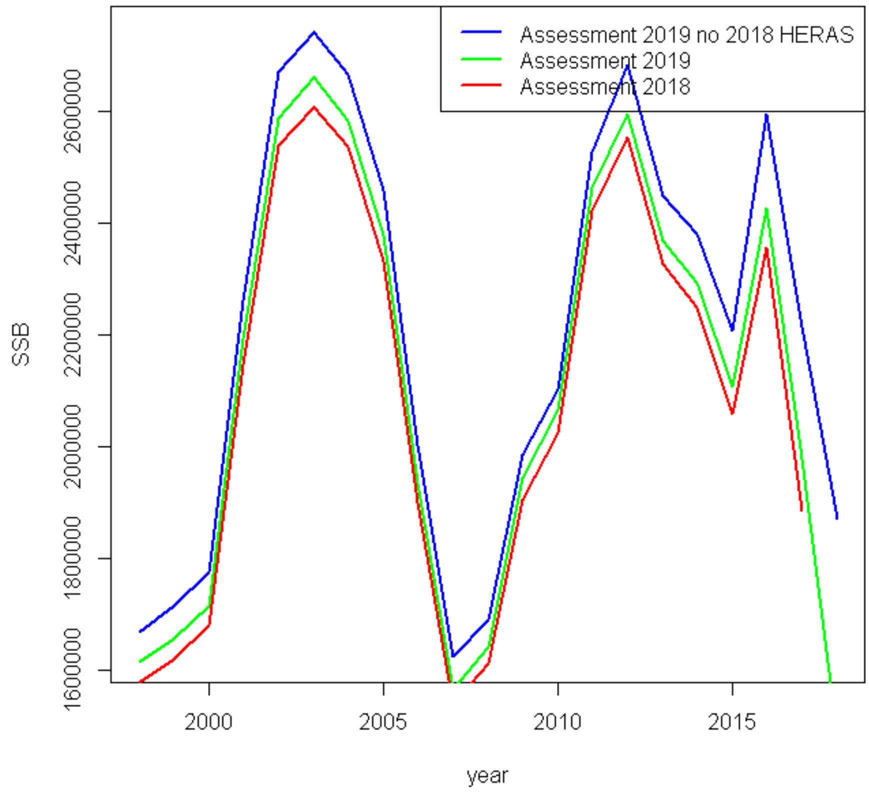


Figure 2.6.2.9. North Sea herring. SSB trajectory for the 2018 and 2019 assessments and the 2019 assessment without including the 2018 from HERAS.

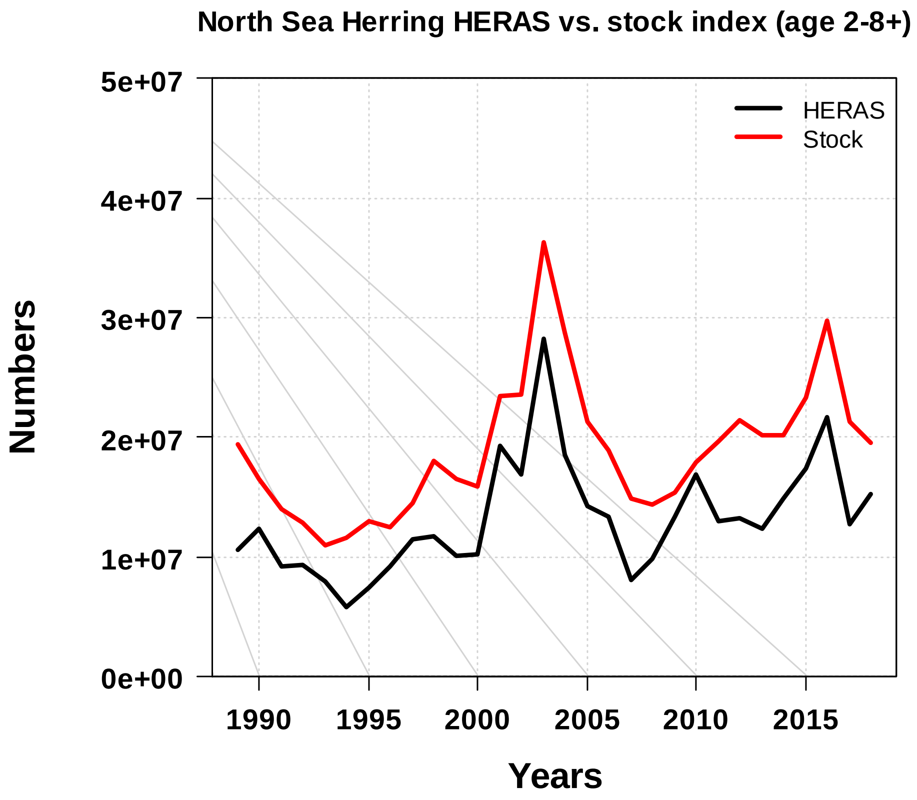


Figure 2.6.2.10. North Sea herring. SSB trajectory (age 2–8+ winter rings) for the 2019 assessments and the HERAS SSB index.

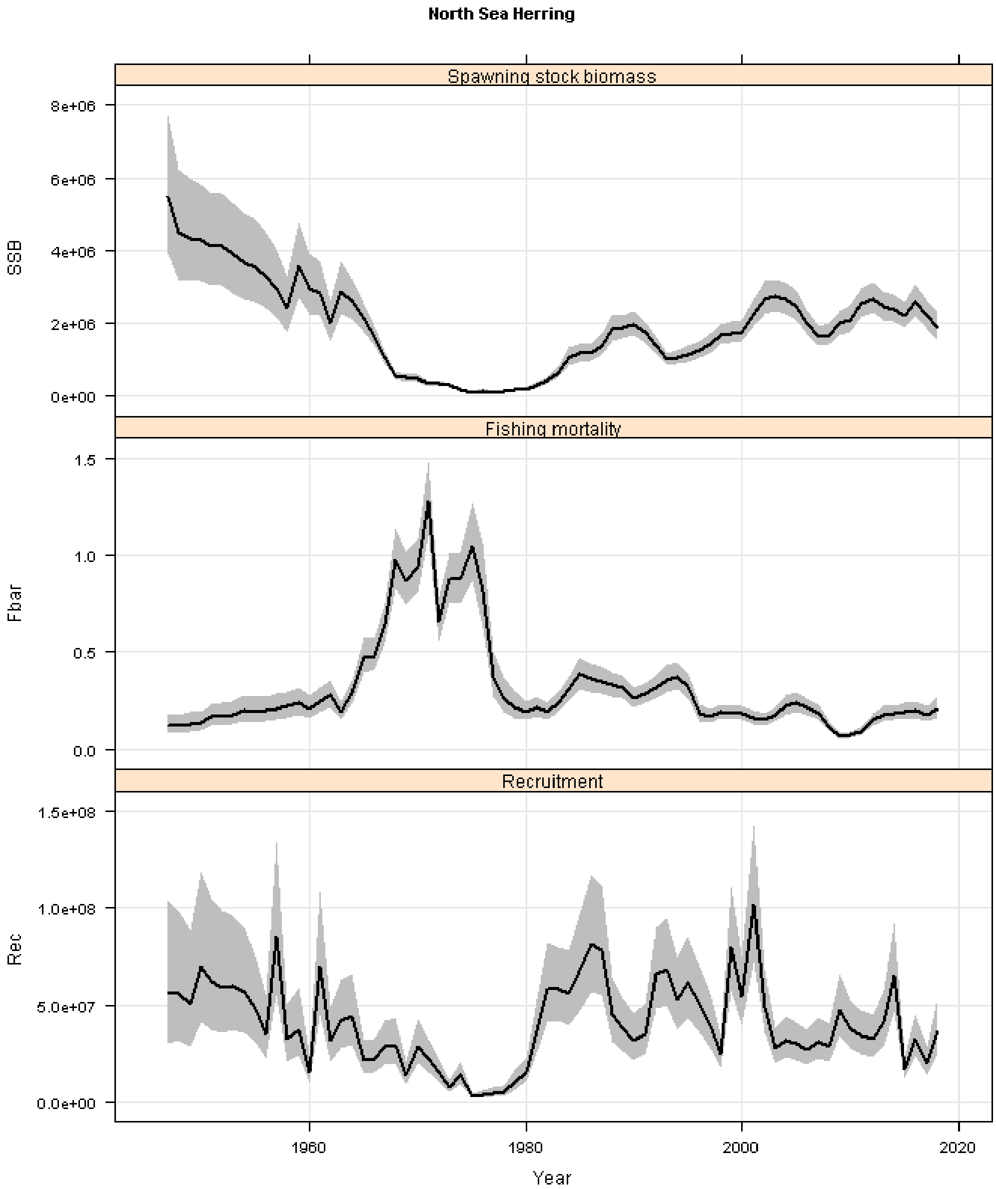


Figure 2.6.3.1 North Sea herring. Stock summary plot of North Sea herring with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

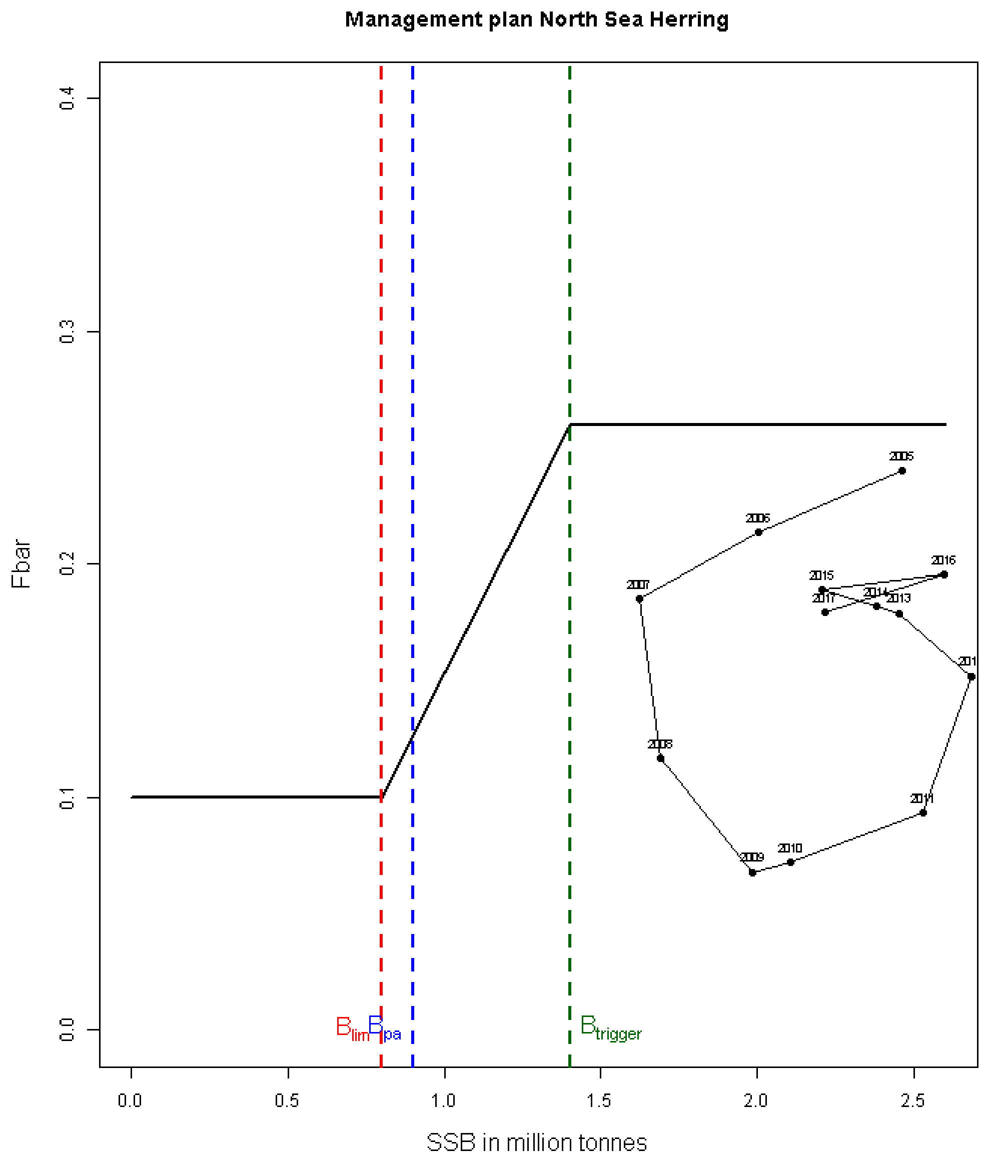


Figure 2.6.3.2. North Sea herring. Agreed management plan for North Sea herring including the most recent 10 years of SSB and F as estimated within the assessment in relation with the management plan.

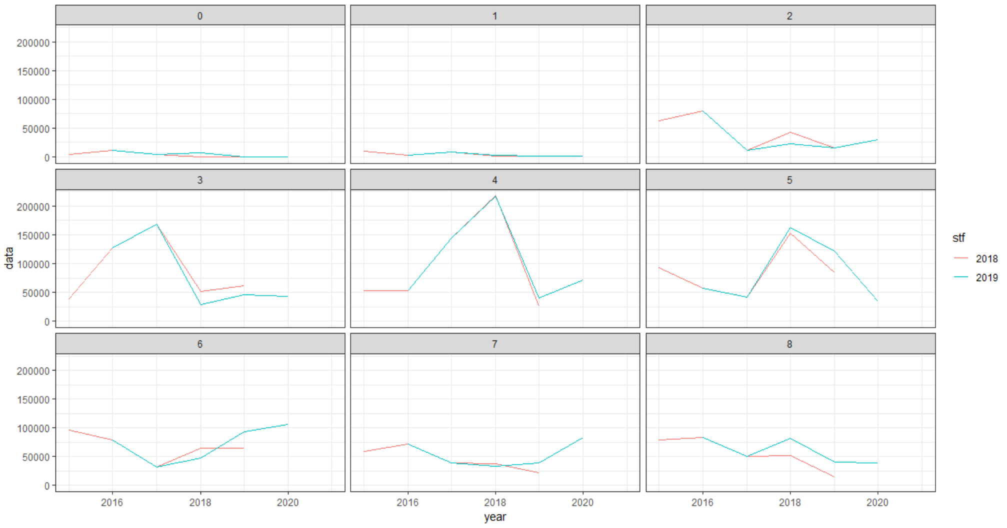


Figure 2.7.2.1. North Sea Herring. Predicted and projected catch (in weight) between 2018 assessment (2019 as forecast year) and 2019 assessment (2020 as forecast year).

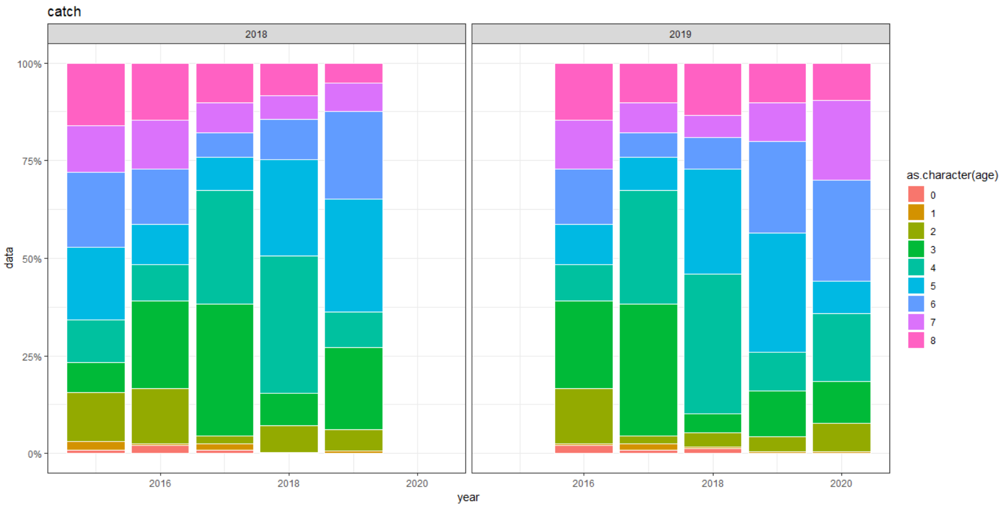


Figure 2.7.2.2. North Sea Herring. Catch proportions for the different ages between the 2018 short term forecast (2019 as forecast year) and the 2019 short term forecast (2020 as forecast year).

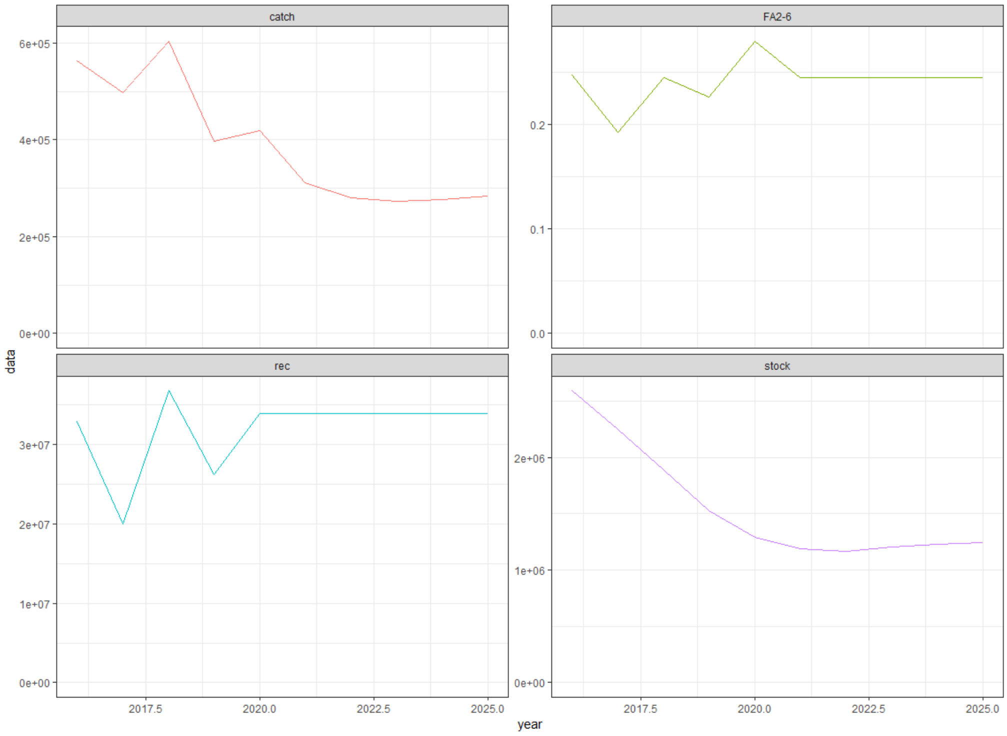


Figure 2.7.2.3. North Sea Herring. Short term projections using an F status quo from TAC year (i.e. advice year). Intermediate year is in 2019 and the TAC year is 2020.

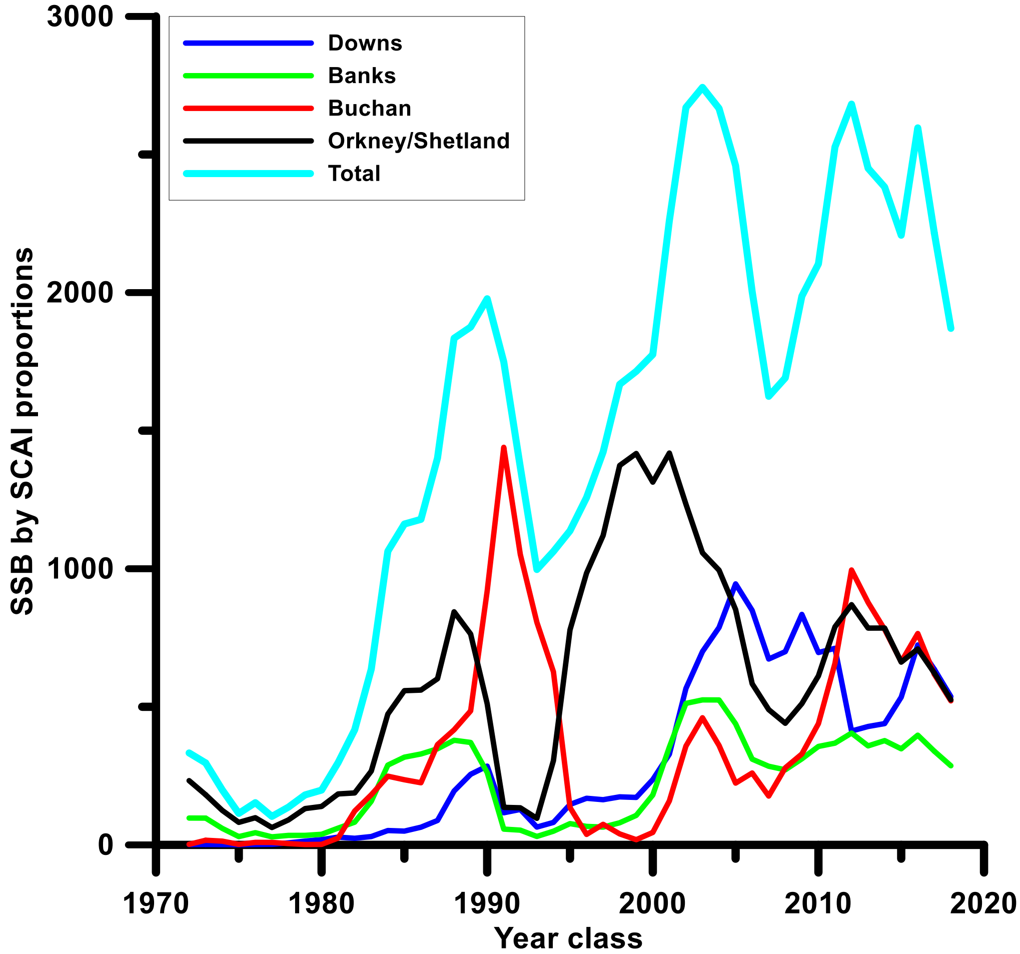


Figure 2.11.1. North Sea herring. Time-series of spawning stock biomass of each component, as estimated from the LAI index. Areas are arranged from top to bottom according to the south-to-north arrangement of the components.

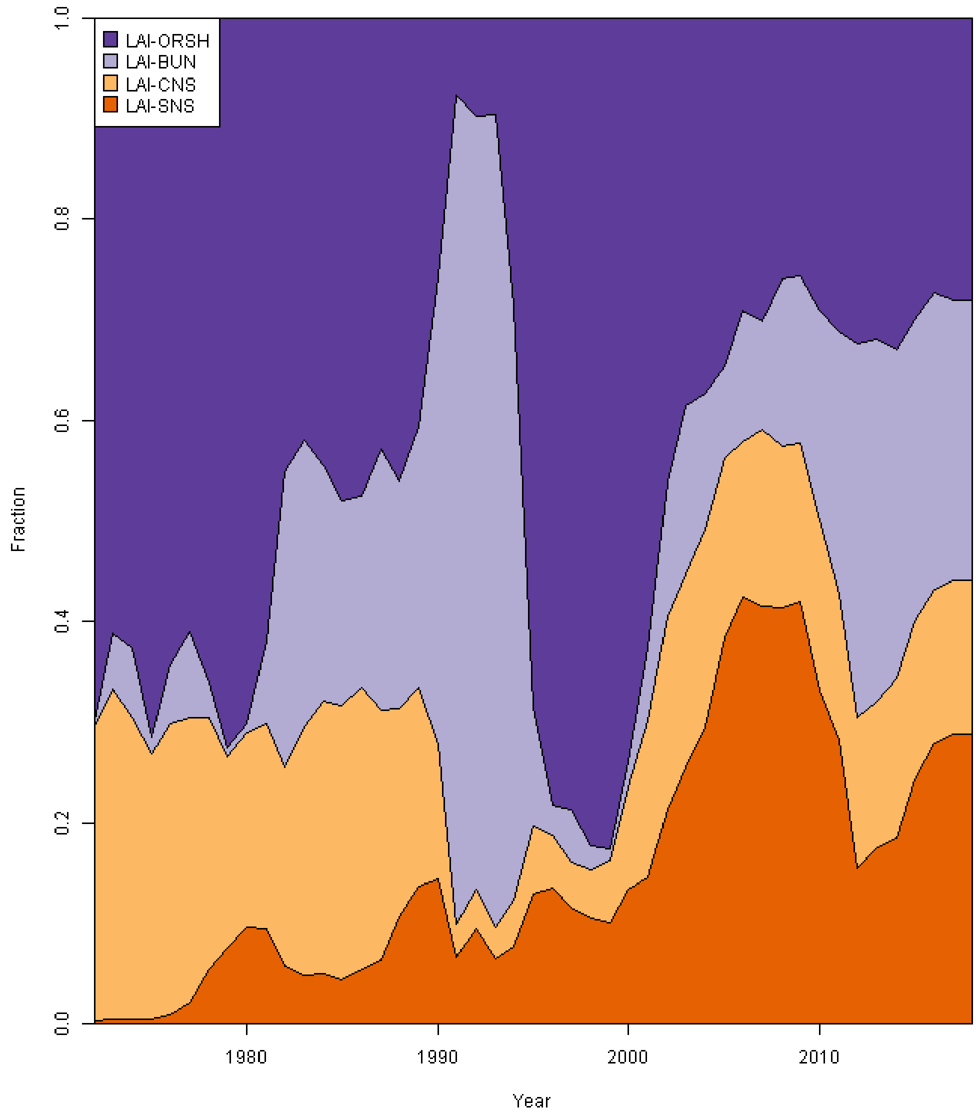


Figure 2.11.2. North Sea herring. Time-series of the contribution of each spawning component to the total stock, as estimated from the LAI index (Payne, 2010). Areas are arranged from top to bottom according to the north-to-south arrangement of the components.

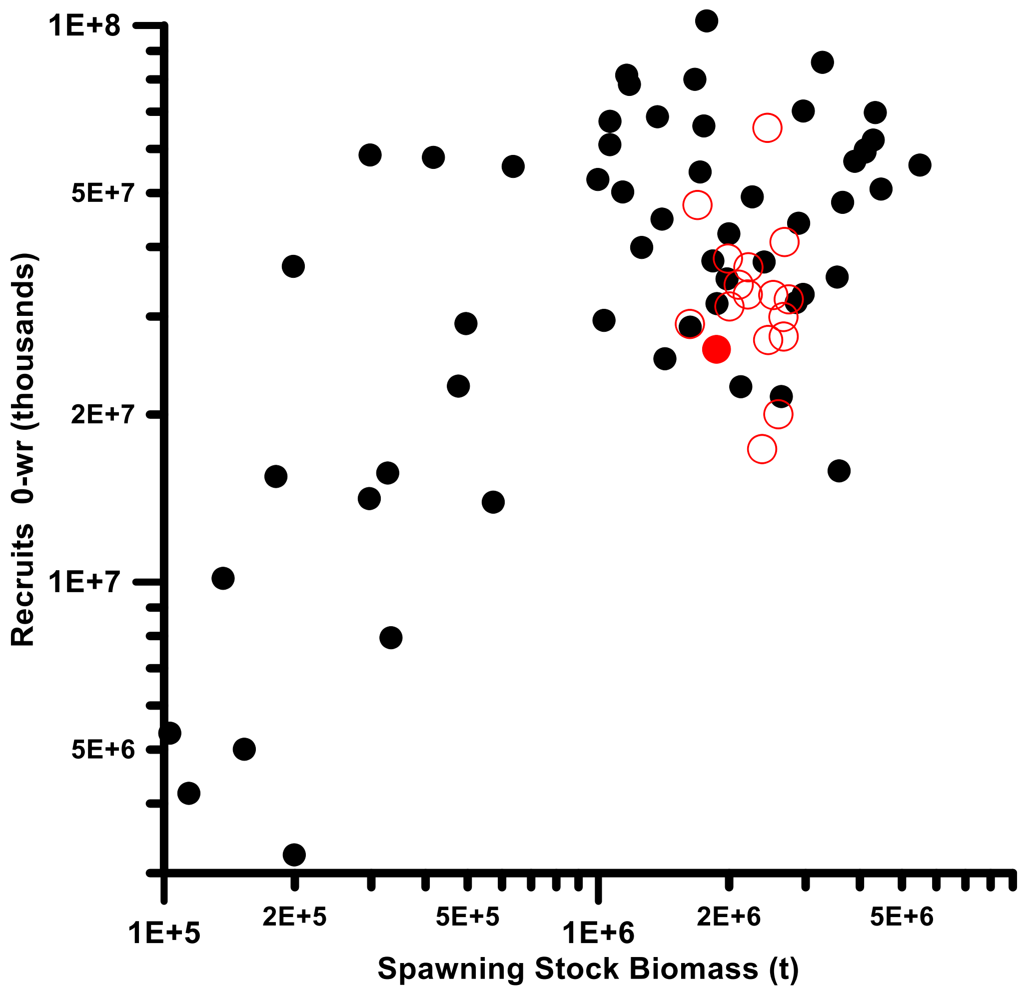


Figure 2.13.1. North Sea Autumn Spawning Herring stock recruitment curve, plotting estimated spawning stock biomass against the resulting recruitment. Year classes spawned after 2001 are plotted with open red circles, to highlight the years of recent poor recruitment. The most recent year class is plotted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

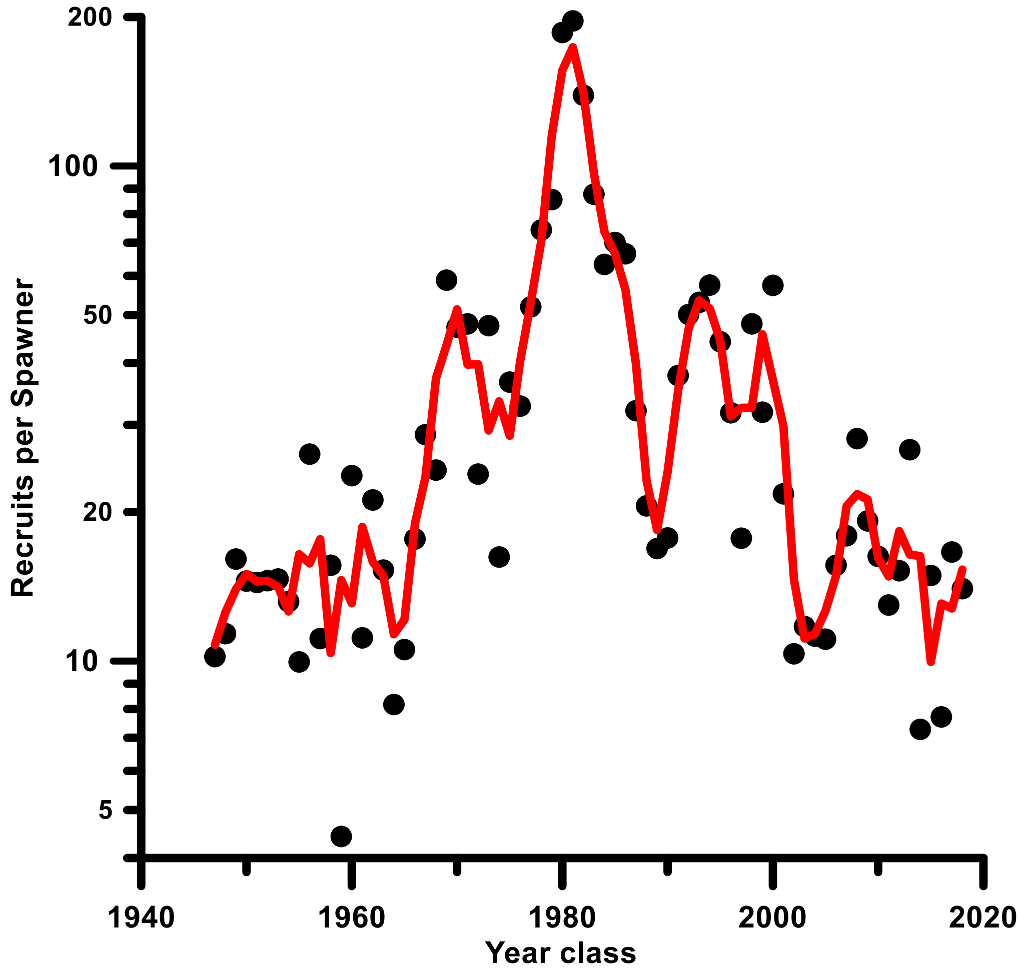


Figure 2.13.2. North Sea Autumn Spawning Herring time series of recruits per spawner (RPS). RPS is calculated as the estimated number of recruits from the assessment divided by the estimated number of mature fish at the time of spawning and is plotted against the year in which spawning occurred. Black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

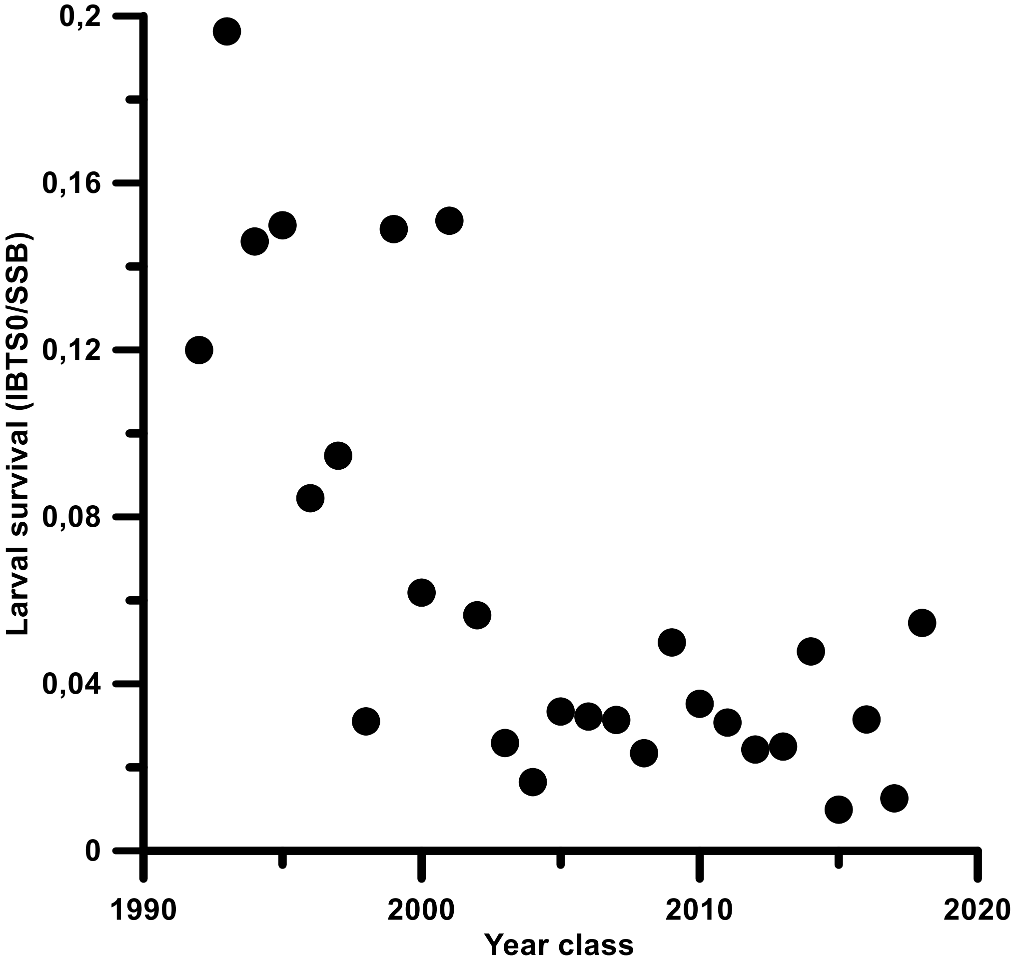


Figure 2.13.3. North Sea Autumn Spawning Herring time series of larval survival ratio (Dickey-Collas & Nash, 2005; Payne *et al.,* 2009), defined as the ratio of the SSB larval index (representing larvae less than 10–11 mm) and the IBTS0 index (representing the late larvae, > 18 mm). Survival ratio is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

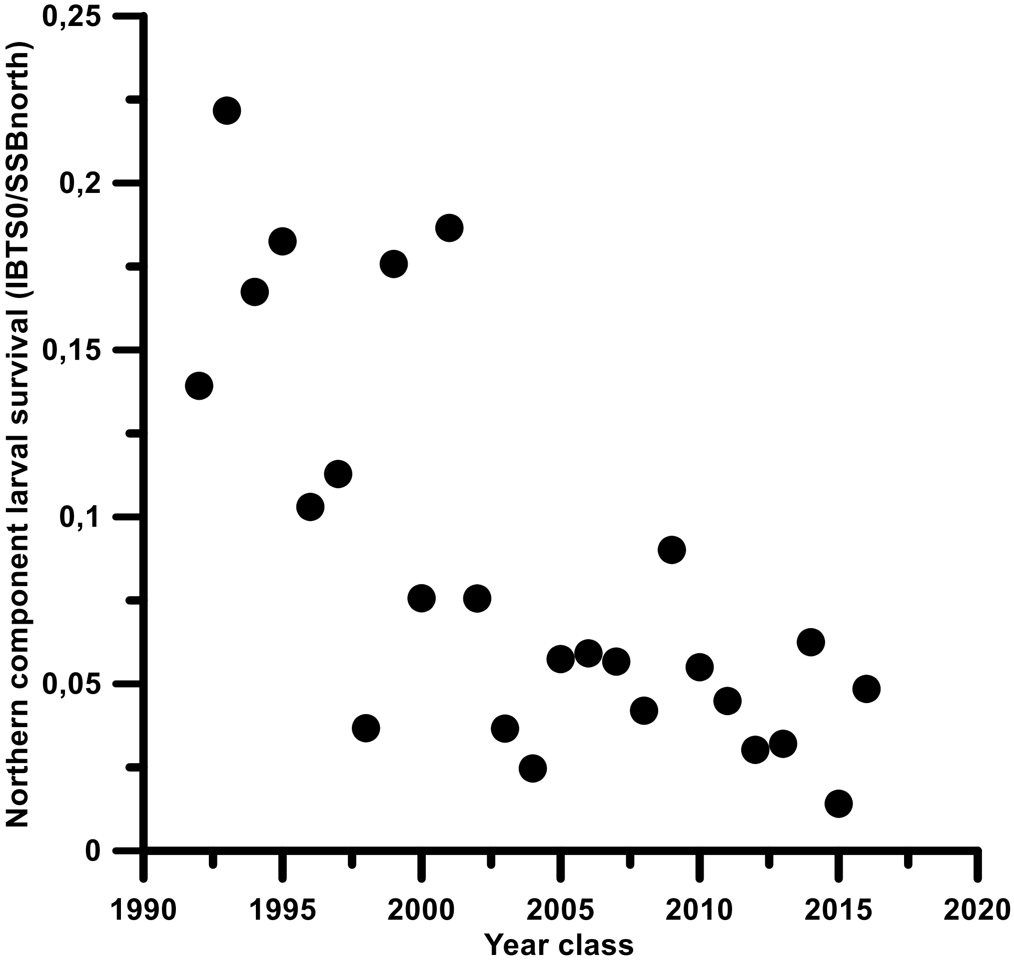


Figure 2.13.4. North Sea Autumn Spawning Herring time series of larval survival ratio (Dickey-Collas & Nash, 2005; Payne *et al.,* 2009) for the northern-most spawning components (Banks, Buchan, Orkney-Shetland), defined as the ratio of the sum of the larvae indices for these components (representing 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 2018 and 2019

ICES advised in 2018 on the basis of the MSY approach. This corresponds to zero catch in 2019 (ICES CM 2018/ACOM:07).

The EU and Norway agreement on a herring TAC for 2018 was 48 427 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 2019, the EU and Norway agreement on herring TACs in Division 3.a was 29 326 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 2018, a TAC of 17 309 t was set on the Western Baltic stock component. The TAC for 2019 was set at 9001 t.

3.1.2 Landings in 2018

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 the spring spawners.

Landings from 1989 to 2018 are given in Table 3.1.1 and Figure 3.1.1. In 2018, the total landings in Division 3.a and subdivisions 22–24 have overall increased to 42 250 t. Landings in 2018 decreased by 14% in the Skagerrak, by 12% in the Kattegat and by 28% in subdivisions 22–24. As in previous years the 2018 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 2003 to 2018 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
		2018						
Div. 3.a fleet-C	48 427	20 255	324	200		21 189	41 768	6459
Div. 3.a fleet-D	6659	5692	51			916	6659	
SD 22–24 fleet-F	17 309	2426	9551	1	2252	3079	17 309	17 309
% 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**
		2019						
Div. 3.a fleet-C	29 326	12 325	197	0		12 893	25 415	3 911
Div. 3.a fleet-D	6659	5692	51			916	6659	
SD 22–24 fleet-F	9 001	1 262	4 966	1	1 171	1 601	9 001	
% 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%

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 Area 4. These catches have been allocated to the North Sea stock and accounted for under the A-fleet. 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. Thus no catches were moved out of Division 3.a to the North Sea for catches taken in 2018.

Regulations allowing quota transfers from Division 3.a to the North Sea were introduced as an incentive to decrease misreporting of the fishery, and the percentage has gradually been reduced until 2010. 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 realised distribution of the catches. For the fishery in 2019 the industry (Pelagic RAC) informed HAWG that about 52% of the predicted catches in the C-fleet will be taken in Division 3.a.

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 taken into account 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 caught in the D-fleet was reduced from a typical catch of 1107 t in 2016 to 151 t in 2018. This was caused by an early in the year closure of the sprat fishery as agreed between fishers and the Danish regulation authorities due to problems with bycatch issues.

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

Table 3.2.1 and Table 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.

In 2018, a small correction was made to the number at age in subdivision 24 1st quarter 2017. In 2017 a small amount of 0 wr was reported caught in this stratum. The estimates were based on a single fish and after re-evaluation the fish was judged to be 1 wr. This correction also influenced the mean weight at age in the stock.

The 42 250 t of landed herring were submitted stratified by area, fleet and quarter, resulting in 66 strata with landings. 30 of these strata were sampled – accounting for 96% of the landings – and in general strata with the majority of the landings were well sampled. A minor number of strata had less than 3 samples, but in general the landings were minor and in total these only account for 7556 t (Table 3.2.4). Un-sampled strata accounted in total for 1792 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 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 2018 was estimated to be 20 066 t, which represents an increase of 11% compared to 2016 (Table 3.2.13).

Total catches of WBSS from the North Sea, Division 3.a, and subdivisions 22–24 respectively, by quarter, were estimated for 2018 (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 1993–2018, are presented in tables 3.2.15 and 3.2.16.

The total catch of NSAS in Division 3.a amounted to 3372 t in 2018, which represents the third lowest value in the 26 year time series (Table 3.2.17).

The catches of WBSS from Subarea 4.aE and the catches of NSAS from Division 3.a in 2018 were reallocated to the appropriate stocks as shown in the text table below:

Stock	Catch reallocation	Tonnes
WBSS	4.aE (A-fleet)	2164
NSAS	3.a (C+D-fleet)	3372

3.2.1 Quality of Catch Data and Biological Sampling Data

No quantitative estimates of discards were available to the Working Group. However, the amount of discards for 2018 is assumed to be insignificant, as in previous years.

Table 3.2.4 shows the number of fish aged by country, area, fishery and quarter. The overall sampling in 2018 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). Fortunately occasional lack of national sampling of catches by quarter and area has been covered by similar fisheries in other countries.

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 of hatch type and extended with discriminant analysis of otolith shape calibrated with hatch type and applied on production samples with classification parameters: herring otolith metrics as well as age, length and ICES Subdivision (see Stock Annex). The total sample size for hatch type was 1424 with 26% of the samples in Subdivision 20 (Skagerrak) and 74% in Subdivision 21 (Kattegat). There were no split samples available for the second quarter.

No samples for split of commercial catches in the transfer area in Division 4.a East were available in 2018. The split was therefor based on 724 Norwegian vertebral count (VC) observations from scientific cruises and commercial catches in the period 2008–2016, and from 424 vs counts from the HERAS in the 3rd quarter of 2018. The applied method was based on the average VC by age group and quarters 1–4 as described in the Stock Annex.

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 are not corrected for this mixing neither potential catches of Western Baltic Spring Spawning herring from 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 1–19 October 2018 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, 2019). 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 based on baseline samples of WBSSH and CBH in 2011–2017 and in 2018 (despite the occurrence of some CBH in the GERAS baseline samples of WBSSH in SD 21 and 23) support the applicability of the SF (Oeberst *et al.*, 2013 – WD for HAWG 2013; Oeberst *et al.*, 2014 – WD for WGIPS 2014; Oeberst *et al.*, 2015 – WD for WGIPS 2015; Oeberst et al., 2016 – WD for WGBIFS 2016, Oeberst et al., 2017 – WD for WGIPS 2017; Gröhsler, T. and Schaber, M., 2018 – WD for WGBIFS 2018 Gröhsler, T. and Schaber, M., 2019 – WD for WGBIFS 2019). Thus, the SF was applied to correct the GERAS index for WBSS from 2005–2018.

Individual mean weight, total numbers and biomass by age as estimated from the GERAS are presented in Table 3.3.1. The Western Baltic spring spawning herring stock index in 2017 was estimated to be 3.2 x 10^9 fish or about 65.1 x 10^3 tonnes in subdivisions 21–24. Compared to previous results, the present estimates of herring show a further significant decrease in biomass. The biomass index in 2018 represents the second record low in the 24 year time series (with a difference of only 9000 tonnes compared to the former record low in 2009).

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

The Herring acoustic survey (HERAS) was conducted from 25 June to 10 July 2018 and covered the Skagerrak and the Kattegat. The 2018 estimate of Western Baltic spring-spawning herring was 130 tonnes and 1,074 million herring. Compared to the value in 2018, the 2018 estimates represent a decrease of 57% in numbers and of 56% in biomass. The stock biomass is dominated by 1–4 winter ring (62%). The present numbers of older herring (3+ group) in the stock decreased to 51% of the average of the whole times series (2018: 744 million; mean 1991–2018: 1468 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 2018 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 1563 million larvae, the 2018 N20 recruitment index is in similar dimensions as the previous year and more than double as high as the record low of 2016. However, the value is only in the range of about 1/5 of the time series mean thus not countering the decreasing trend of larval production observed in the system during the past two decades.
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 Figure 3.3.1). 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. The following equation describes the model considered for both the presence/absence and positive parts of the Delta-Lognormal model:

$$g(\mu_i) = \text{Year}(i) + \text{Gear}(i) + f_1(\text{lon}_i; \text{lat}_i) + f_2(\text{Depth}_i) + f_3(\text{time}_i) + \log(\text{HaulDur}_i)$$

where Gear(i) and Year(i) maps the i^{th} haul to categorical gear/year effects for each age group.
Age (wr) classes (1–3) and (2-3) are included in the assessment from the surveys in Q1 and Q3-4.

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 3.6.3).

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 2018 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 ($R^2 = 0.7$, 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 (1992–2018: 5828 million). The 2016 N20 recruitment index represents the sixth record low in the 27 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 2018 were available for Subdivision 27.4.a (East, 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–f). 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–f; 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 1991–2018. 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.

For this year's 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_2019) and the single fleet (WBSS_HAWG_2019_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.

3.6.4 Final run

The results of the assessment are given in tables 3.6.11–3.6.14. The estimated SSB for 2018 is 74 132 [55 092, 99 751 (95% CI)] t. The mean fishing mortality (ages 3–6) is estimated as 0.416 [0.297, 0.584 (95% CI)] yr^{-1}.

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 stabilised 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 the lowest SSB (69 kt) observed in the time series. SSB has only slightly increased in the following period up to 90 kt in 2015 and then has declined to 74 kt in 2018, which is the lowest SSB since 2013.

Fishing mortality on this stock was high in the mid-1990s, reaching a maximum of over 0.6 yr^{-1}. In 1999–2009, $F_{3–6}$ stabilised between 0.5 and 0.6. In 2010 and 2011, $F_{3–6}$ decreased significantly to a value of approx. 0.36 yr^{-1}, where it stabilized for few years until increasing again above 0.4 since 2016. (Table 3.6.11, Figure 3.6.4.2).

Recruitment has been decreasing overall since 2000 and the 2018 estimate of 954 391 thousands 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 1991–1998 and no signs of density-dependence. This is followed by a distinct decline in recruitment to values below 2 billion at a relatively constant spawning stock biomass between 120 and 160 kt over the period from 1998–2006. In the most recent period, from 2007 to 2018 recruitment has varied from about 2 billion to less than 1 billion at SSB between 74 kt and 105 kt, with a worrying trend of declining recruitment in the latest years from 2013 to 2018.

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.

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). For all fleets except the C-fleet there is a decreasing trend in F for the last three decades. The corresponding selectivity pattern for the F-fleet is relatively stable throughout the time period of the assessment, whereas 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 over time but showed an increase in the past 4 years.

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. 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, 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 has a lower observation variance than the GERAS and the fleet C, and the IBTS Q3.4 surveys variance is lower than the HERAS, the IBTS Q1 and the N20. Both the D-fleet and the A-fleet have very high observation variances (Figure 3.6.4.12).

Inspection of model diagnostics shows the occurrence of high residuals in some years (i.e. 2009 and 2018 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.

Residuals for catch in different fleets generally show poorer fit to the youngest year-classes 0–1 wr (Figure 3.6.4.13). 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 in 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).

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 3.6.4.19–24). In general, a similar fit is found for all included ages (wr) 3–6 of the HERAS index (Figure 3.6.4.19). The GERAS appears to fit slightly better for the ages (wr) 3–4 than for the younger ages (Figure 3.6.4.20). In recent years, GERAS shows a clear drop in indices for ages (wr) 2–4 that was poorly fitted in the last year assessment (ICES, 2018). In this year assessment, while the estimated indices for ages (wr) 2–4 are not as low as the observed ones, a clear decrease is seen (Figure 3.6.4.20) and residuals in 2018 are larger (Figure 3.6.4.13). The N20 pics 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 analysis suggests that the assessment method gives a consistent perception of the stock until the 2017 assessment but the 2018 SSB estimates differ from the estimates from the previous assessment years (Figure 3.6.4.24). The SSB has a Mohn's rho of 13% and the retrospective estimates are within the confidence interval of this year SSB estimates. Average fishing mortality retrospective is within the confidence bounds for F (Mohn's rho = -7%, Figure 3.6.4.25) and the retrospective for recruitment is acceptable having a Mohn's rho =- 7%, with little bias and two outliers (Figure 3.6.4.26). Changes from year to year retrospective are very tight for total catch (Figure 3.6.4.27). The difference between the 2018 assessment estimates and the 2019 ones seems to be mainly due to the GERAS survey that pushes the stock down due to very low indices for ages 2–4 in 2018. Indeed, for the single fleet model, leaving out the GERAS survey from the dataset induces an increase in the perception of the stock with increasing SSB in recent year (Figures 3.6.4.28–31). However, this pattern is less obvious in the multi-fleet model (figures 3.6.4.32–35). The reason for this difference may be that disaggregating the catch into fleets in the multi-fleet model gives relatively more weight to the catch than in the single fleet model (four observation errors with specific estimated variance vs. one in the single fleet) and therefore the effect of GERAS is less strong in the multi-fleet model.

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 2011. With the new B_{lim} 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 2009 and 2011 from above 0.50 to 0.37. $F_{3–6}$ has then remained stable slightly above F_{MSY} until 2015 (~0.36) but shows an increase in recent years with an estimated $F_{3–6}$ in 2018 well above F_{MSY} (0.416).

Recruitment has be declining in the last five years with a historical low value in 2018 of 954 391 thousands (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 90 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 perception of the stock

The table below summarises the differences between the current and the previous year's assessment. The addition of the 2018 data resulted in a change in the perception of the stock compared to last year's assessment. While the recent estimates of recruitment are more optimistic in the current assessment (+11%), F appears to be larger than previously estimated (+17 to +20%) and SSB smaller (-16 to -24%).

In this year's assessment, recruitment for the 2013 year-class was estimated to be 1 743 986 thousands compared to 1 946 458 thousands in the 2018 assessment. This decrease in recruitment induced a decrease in the SSB estimates in the following years compared to the 2018 assessment. This change in the perception of the stock resulted in an increase in the fishing mortality estimates since 2013 to satisfy the observed catches. The change in the perception of the stock is supported by all surveys but mainly GERAS (see 3.6.4).

Parameter	Assessment in 2018	Assessment in 2019	Difference 2019/2018 (+/-)%
SSB (t) 2016	102 294	88 443	-15.66%
$F_{(3–6)}$ 2016	0.334	0.402	16.92%
Recr. ('000) 2016	934 898	1 054 035	11.30%
SSB (t) 2017	104 170	83 895	-24.17%
$F_{(3–6)}$ 2017	0.332	0.416	20.19%

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 geometric mean of the last five years prior the last year model estimate (i.e. for the 2019 assessment, recruitment for the forecasts was calculated on the period 2013–2017). 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 (2014–2018). Based on earlier considerations in the herring working group, the different periods were chosen to reflect recent levels in recruitment and weights.

3.9.2 Intermediate year 2019

A catch constraint was assumed for the intermediate year (2019). Predicted 2019 catch by fleet is summarised in the Table below and depends on two main assumptions:

- Both NSAS and WBSS herring stocks are caught in the divisions 3.a (C and D-fleets) and 4.aE (A-fleet) whereas the subdivision 22–24 catch (F-fleet) is assumed to be only WBSS herring.
- The C- and D-fleets do not use their entire TAC.

Fleets	TAC 2019 NSAS+WBSS (t)	TAC WBSS (t)	TAC WBSS given utilization (t)
A	385 008	1545	100% = 1545
C	29 326	81% = 23 754	52% = 12 352
D	6659	44% = 2930	16% = 469
F	9001	9001	100% = 9001
Total	429 994	37 230	23 367

The amount of WBSS taken in Division 4.aE by the A-fleet in 2019 is assumed equal to the average over the last 3 years (2016–2018) corresponding to 1545 t.

The expected catch of WBSS in Division 3.a was calculated assuming the same WBSS proportions in the catch of each fleet in 2019 as the average of 2016–2018 in Division 3.a. This resulted in 81%

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 Area 4 in the North Sea (A-fleet). Based on information from the Pelagic Advisory Council (AC) and last year's value, ICES assumes a 48% TAC transfer in 2019 so that the TAC utilisation for the C-fleet in Division 3.a is assumed 52%.

Forty four percent of the D-fleet 2019 catch is assumed to be WBSS herring (average NSAS/WBSS split 2016–2018). 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% to the minimum of 6% recorded in 2017 and 2018 due to choke species effects of restricting whiting quotas. The problems with bycatches under the landings obligation may persist and 16% utilisation of the TAC in 2019 for the D-fleet is assumed as the average utilisation over the last 3 years.

The catch by the F-fleet fishing for human consumption in subdivisions 22–24 is usually very close to the TAC (9001 t) and an utilisation of 100% is assumed for the intermediate year.

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 a total of 23 367 t WBSS in 2019.

3.9.3 Catch scenarios for 2020

The output of the short-term prediction, based on a catch constraint in the intermediate year 2019 of 23 367 t is given in tables 3.9.1–3.9.14.

Different catch options for 2020 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, all scenarios (except the constant 2019 TAC and F = 0 scenarios) assume the F fleet gets 50% of the total catch for WBSS herring.

3.9.4 Exploring a range of total WBSS catches for 2020 (advice year)

ICES gives advice according to the F_{MSY} approach for the WBSS stock. Because SSB in 2019 is below B_{lim}, ICES advises a zero catch for 2020. None of the catch scenarios for 2020, including zero catch, is expected to bring SSB above B_{lim} in 2021. Besides requested standard scenarios HAWG also calculated the potential development of the stock projections until 2022 with different low F scenarios, where $F_{2021} = F_{2020}$. The highest fishing mortality that brings SSB above B_{lim} in 2022 will be F = 0.05 with a yield of 5301 t in 2020. The TAC for 2019 was set according to the agreed management rule between EU and 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 be developed for the WBSS stock, taking advantage of the fleet-wise analysis and projection for this stock.

Table	Basis	Total catch (2020)	$F_{3–6}$ (2020)	SSB* (2020)	SSB* (2021)	% SSB change **	% advice change ***
	ICES advice basis						
3.9.2	MSY approach: F = 0 ʻ {$SSB_{2019} < B_{lim}$}	0	0	76 273	101 269	33%	
	Other scenarios						
3.9.3	MAP 2018^: F = F_{MSY} (0.310) × SSB_{y-1}/MSY $B_{trigger}$	15 704	0.144	75 137	86 888	16%	
3.9.4	MAP 2018^: F = $F_{MSYlower}$ (0.216) × (SSB_{y-1}/MSY $B_{trigger}$)	11 123	0.1	75 482	91 026	21%	
3.9.5	MAP 2018^: F = $F_{MSY\ upper}$ (0.379) × (SSB_{y-1}/MSY $B_{trigger}$)	18 922	0.176	74 886	83 997	12%	
3.9.6	F = F_{MSY} (0.310)	31 428	0.31	73 848	73 111	-1%	
3.9.7	F = F_{pa} (0.350)	34 878	0.35	73 541	70 130	-5%	
3.9.8	F = F_{lim} (0.450)	42 984	0.45	72 779	63 222	-13%	
	SSB (2021) = B_{lim} ^^	0	0	76 273	101 269	33%	
	SSB (2021) = B_{pa} ^^	0	0	76 273	101 269	33%	
	SSB (2021) = MSY $B_{trigger}$ ^^	0	0	76 273	101 269	33%	
3.9.9	F = F_{2019} (0.238)	24 897	0.238	74 404	78 820	6%	
3.9.10	F = 0 {SSB_{2022} = 132 063 t} ^^^^	0	0	76 273	101 269	33%	
3.9.11	F = 0.05 {SSB_{2022} = 134 648 t} ^^^	5 301	0.05	75 877	96 189	27%	
3.9.12	F = 0.1 {SSB_{2022} = 122 673 t} ^^^	10 359	0.1	75 483	91 383	21%	
3.9.13	F = 0.15 {SSB_{2022} = 111 881 t} ^^^	15 186	0.15	75 092	86 838	16%	
3.9.14	Constant 2019 TAC^^^^	23 367	0.222	74 532	80 342	8%	

ʻ There is no catch option for 2020 that is consistent with a stock recovering to above B_{lim}.

*** 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 (2021) relative to SSB (2020).**

***** The advice catch in 2019 was 0 tonne.**

^ Revised Baltic MAP (2018) which refers to most recent reference points. As SSB is currently (2018) below MSY $B_{trigger}$, the F_{lower} and F_{upper} values in the MAP are adjusted by the SSBy–1/MSY $B_{trigger}$ ratio.

^^ The B_{lim} and B_{pa} cannot be achieved in 2020 even with zero catch advice.

^^^ To explore potential development of the stock, projections until 2022 with different low F scenarios are provided, where F2021 = F2020.

^^^^ Assumptions for 2019 catches kept constant for 2020–2021. These include a 48% transfer of the C-fleet TAC to the North Sea.

3.10 Reference points

The WBSS stock was benchmarked in 2018 (ICES WKPELA, 2018) with subsequent changes of reference points. B_{lim} was revised from 90 000 to 120 000 t to take account of the new perception that recruitment is impaired when the spawning-stock biomass (SSB) is below 120 000 t. B_{pa} and MSY $B_{trigger}$ were subsequently set to 150 000 t. Using the eqSim software F_{MSY} was estimated to 0.31, F_{lim} 0.45 (5% risk to B_{lim}) and F_{pa} 0.35. 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. The 2019 assessment shows a downward revision in the SSB estimates in recent years compared to the 2018 assessment, which is supported by all the surveys, especially GerAS (see 3.6.4).

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 presently unknown but are likely to affect the precision of the assessment. Moreover, mixing between WBSS and central Baltic herring in subdivisions 22–24 may contribute to uncertainty in the assessment.

Inter-annual variability in the herring migration patterns and in 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.

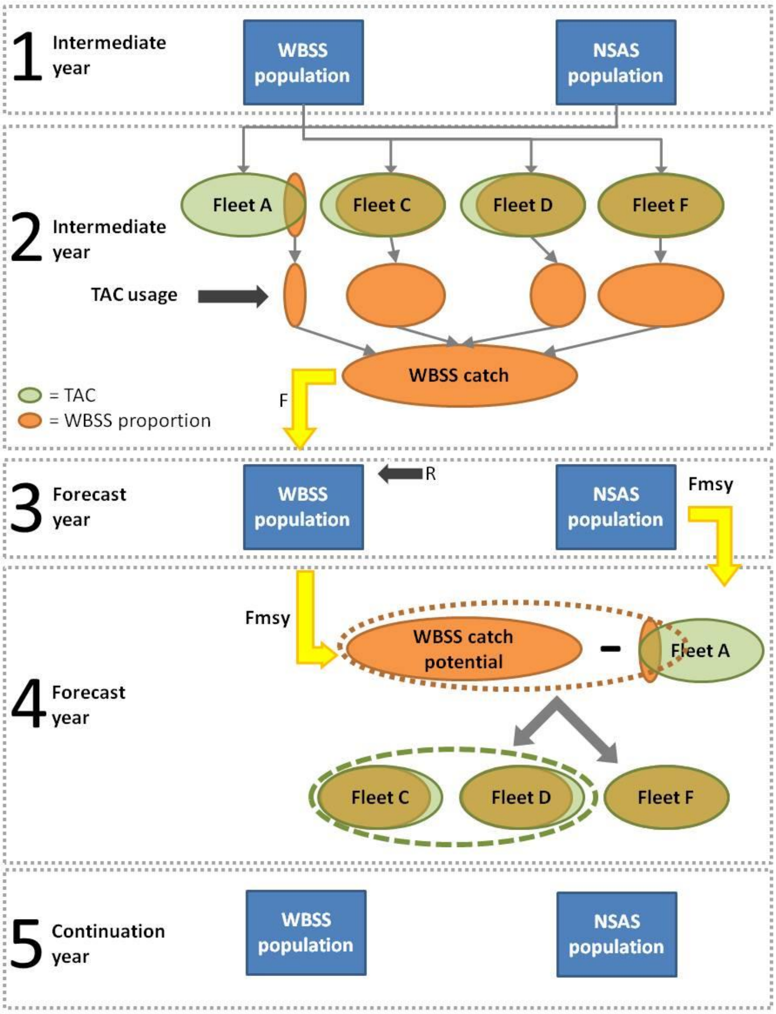
3.12 Management Considerations

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 Area 4 as NSAS in 2018. ICES assumes that a transfer of 48% will be applied in 2019 (cf. part 3.9).

ICES catch predictions versus 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 SD22–24 takes into account the occurrence of different fleets 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 4.a East 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 area 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 F_{MSY} advice plus a fraction of the NSAS LTMP 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 realised WBSS catches may deviate from the predictions based on F_{MSY}.

Box 5: The TAC advice from box 4 is taken into the political arena. The result of this will be taken into account to calculate the WBSS population again the year after. Hence box 5 is similar to box 1.

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 management plan determined TAC for the A-fleet, with a further associated TAC constraint of +/- 15% for the C-fleet.

However, given the new B_{lim}, the stock has been below SSB for ten years 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.

3.13 Ecosystem considerations

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 Rügen area (SD 24) and other spawning areas at the beginning of the winter. Moreover, there are recent indications that Central Baltic herring perform migrations into Subdivision 24 (Gröhsler *et al.*, 2013).

Similar to the NSAS, the WBSS has produced a series of poor year classes in the last one and a half decade and the trend continues to decline. 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 linked 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 Changes in the Environment

There are no evident changes in the environment in the last decade that are thought to strongly affect productivity, migration patterns or growth of WBSS. There are indications that higher SST observed in the last decades might affect recruitment negatively, although the analyses were not conclusive (Cardinale *et al.*, 2009).

Table 3.1.1 Western Baltic herring. Total catch (both WBSS and NSAS) in 1989–2018 (1000 tonnes). (Data provided by Working Group members 2019).

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
Faroe Islands															
Germany															0.7
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
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
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
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
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
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
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
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
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
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
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
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
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
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**

Year	2004	2005	2006**	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018*
Skagerrak															
Denmark	11.8	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
Faroe Islands		0.4			0.0	0.6	0.4					0.5	0.3	0.4	0.1
Germany	0.5	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
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
Sweden	21.8	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
Total	34.1	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
Kattegat															
Denmark	7.6	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
Sweden	9.6	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
Germany						0.6	0.0								
Total	17.2	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
Subdivisions 22+24															
Denmark	7.3	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
Finland															0.001
Germany	18.5	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
Poland	5.5	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
Sweden	9.9	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
Total	41.2	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
Subdivision 23															
Denmark	0.1	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
Sweden	0.3	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
Total	0.4	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
Grand Total	**92.8**	**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**

***Preliminary data**

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

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

Table 3.1.2 Western Baltic herring. Catch (SOP) in 2004–2018 by fleet and quarter (1000 t). (both WBSS and NSAS)

Year	Quarter	Div. IIIa		SD 22-24	Div. IIIa + SD 22-24
		Fleet C	Fleet D	Fleet F	Total
2004	1	13.5	2.8	20.4	36.7
	2	2.8	3.3	10.4	16.5
	3	8.2	10.8	2.4	21.4
	4	5.9	5.0	8.6	19.4
	Total	30.3	22.0	41.7	93.9
2005	1	16.6	6.1	20.4	43.1
	2	3.4	1.9	15.6	20.9
	3	23.4	3.4	1.9	28.7
	4	12.0	2.6	5.8	20.5
	Total	55.4	14.1	43.7	113.3
2006	1	15.3	5.9	15.1	36.2
	2	2.6	0.1	17.2	19.9
	3	15.7	0.8	3.0	19.5
	4	8.3	2.4	6.5	17.3
	Total	41.9	9.3	41.9	93.0
2007	1	7.7	3.0	18.8	29.5
	2	3.8	0.1	10.5	14.4
	3	22.4	0.8	1.7	24.9
	4	7.7	1.8	9.5	18.9
	Total	41.6	5.7	40.5	87.7
2008	1	8.2	3.9	18.4	30.5
	2	2.7	0.3	11.3	14.3
	3	14.9	0.6	6.0	21.5
	4	6.5	1.0	8.4	16.0
	Total	32.3	5.9	44.1	82.3
2009	1	11.1	2.7	19.5	33.2
	2	3.1	0.1	6.8	10.1
	3	14.3	0.9	1.4	16.6
	4	6.0	0.7	3.3	10.0
	Total	34.5	4.3	31.0	69.9
2010	1	8.4	1.1	10.2	19.8
	2	3.9	0.7	5.4	10.1
	3	13.4	0.4	0.4	14.3
	4	9.2	0.1	1.8	11.1
	Total	35.0	2.3	17.9	55.2
2011	1	7.0	0.5	7.8	15.3
	2	0.5	0.2	4.1	4.8
	3	6.5	1.0	0.8	8.3
	4	3.4	0.9	3.2	7.4
	Total	17.4	2.6	15.8	35.9
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
2013	1	8.5	0.8	11.7	20.9
	2	1.7	0.6	8.5	10.8
	3	8.4	1.0	1.1	10.4
	4	9.8	0.5	4.3	14.7
	Total	28.4	2.9	25.5	56.7
2014	1	6.2	0.2	10.8	17.3
	2	2.3	0.5	2.3	5.1
	3	10.7	2.4	0.8	14.0
	4	5.7	0.8	4.4	10.9
	Total	24.9	4.0	18.3	47.2
2015	1	9.0	1.9	14.2	25.1
	2	1.0	0.1	2.8	3.9
	3	7.5	1.5	0.9	9.9
	4	4.1	2.8	4.3	11.1
	Total	21.6	6.3	22.1	50.0
2016	1	7.9	0.7	15.5	24.0
	2	0.4	0.3	3.5	4.1
	3	15.7	1.3	1.4	18.5
	4	3.4	0.3	4.7	8.3
	Total	27.4	2.5	25.1	55.0
2017	1	7.5	0.0	16.8	24.3
	2	0.2	0.1	3.4	3.6
	3	12.1	0.1	1.0	13.2
	4	6.6	0.3	5.3	12.2
	Total	26.4	0.4	26.5	53.3
2018	1	10.0	0.0	12.0	21.9
	2	0.2	0.1	3.4	3.8
	3	10.2	0.1	0.2	10.6
	4	2.5	0.1	3.4	6.0
	Total	22.9	0.4	19.0	42.2

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: 2018 Country: ALL

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.78	34			0.78	34
	2	88.63	52			88.63	52
	3	2.73	74			2.73	74
	4	1.04	91			1.04	91
	5	0.52	119			0.52	119
	6	0.13	174			0.13	174
	7	0.13	175			0.13	175
	8+						
	Total	93.96		0.00		93.96	
	SOP		4,995		0		4,995
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.03	34	0.52	23	0.55	23
	2	3.81	52	1.56	42	5.36	49
	3	0.12	74	0.06	48	0.18	65
	4	0.04	91			0.04	91
	5	0.02	119			0.02	119
	6	0.01	174			0.01	174
	7	0.01	175			0.01	175
	8+						
	Total	4.04		2.14		6.17	
	SOP		215		80		295
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			1.27	8	1.27	8
	1	5.66	65	0.55	42	6.21	63
	2	13.80	115	0.02	77	13.81	115
	3	8.52	135			8.52	135
	4	11.07	163			11.07	163
	5	15.58	181			15.58	181
	6	4.34	190			4.34	190
	7	2.74	187			2.74	187
	8+	2.18	202			2.18	202
	Total	63.89		1.84		65.72	
	SOP		9,510		35		9,545
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			0.54	11	0.54	11
	1	8.55	57	0.03	44	8.58	57
	2	2.57	84			2.57	84
	3	0.50	135			0.50	135
	4	0.54	171			0.54	171
	5	0.91	187			0.91	187
	6	0.23	198			0.23	198
	7	0.14	190			0.14	190
	8+	0.04	226			0.04	226
	Total	13.47		0.57		14.04	
	SOP		1,114		7		1,121
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.00	0	1.81	9	1.81	9
	1	15.02	59	1.10	33	16.12	57
	2	108.80	60	1.57	42	110.37	60
	3	11.87	120	0.06	48	11.94	120
	4	12.69	157			12.69	157
	5	17.03	179			17.03	179
	6	4.70	190			4.70	190
	7	3.01	187			3.01	187
	8+	2.22	203			2.22	203
	Total	175.35		4.54		179.89	
	SOP		15,834		122		15,956

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: 2018 Country: ALL

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	5.08	29	0.03	23	5.11	29
	2	87.75	48	0.08	42	87.83	48
	3	4.68	73	0.00	48	4.69	73
	4	1.07	100			1.07	100
	5	1.07	118			1.07	118
	6	0.13	113			0.13	113
	7						
	8+	0.27	168			0.27	168
	Total	100.06		0.11		100.17	
	SOP		4,959		4		4,964
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.0010	29	0.22	23	0.2172	23
	2	0.0175	48	0.65	42	0.6660	42
	3	0.0009	73	0.03	48	0.0280	49
	4	0.0002	100			0.0002	100
	5	0.0002	118			0.0002	118
	6	0.0000	113			0.0000	113
	7						
	8+	0.0001	168			0.0001	168
	Total	0.0200		0.89		0.9116	
	SOP		0.991		33.448		34.439
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			2.81	8	2.81	8
	1	2.93	59	1.23	42	4.16	54
	2	3.23	68	0.04	77	3.26	68
	3	0.36	82			0.36	82
	4	0.44	109			0.44	109
	5	0.69	187			0.69	187
	6	0.38	210			0.38	210
	7	0.11	178			0.11	178
	8+	0.11	188			0.11	188
	Total	8.25		4.08		12.33	
	SOP		718		77		795
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.10	22	10.07	11	10.18	11
	1	13.51	55	0.49	44	14.00	55
	2	5.16	81			5.16	81
	3	0.84	110			0.84	110
	4	0.51	124			0.51	124
	5	0.28	149			0.28	149
	6	0.06	119			0.06	119
	7	0.04	215			0.04	215
	8+						
	Total	20.50		10.56		31.07	
	SOP		1,380		129		1,509
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.10	22	12.89	10	12.99	10
	1	21.53	50	1.96	40	23.49	49
	2	96.16	50	0.76	44	96.92	50
	3	5.88	79	0.03	48	5.91	79
	4	2.02	108			2.02	108
	5	2.04	145			2.04	145
	6	0.58	178			0.58	178
	7	0.15	187			0.15	187
	8+	0.38	174			0.38	174
	Total	128.83		15.64		144.48	
	SOP		7,059		243		7,302

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: 2018 Country: ALL

		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0								
	1	38.98	12			5.40	16	44.37	12
	2	0.40	37	0.01	144	11.21	42	11.62	42
	3	0.16	94	0.01	162	22.54	86	22.71	86
	4	0.11	114	0.03	174	12.26	111	12.40	111
1	5	0.33	147	0.06	186	33.05	144	33.45	144
	6	0.10	159	0.02	207	9.40	155	9.52	155
	7	0.08	173	0.01	210	4.75	169	4.83	169
	8+	0.04	190	0.00	232	2.56	187	2.61	187
	Total	40.21		0.14		101.17		141.51	
	SOP		584		25		11,347		11,957
		Sub-division 22		**Sub-division 23**		**Sub-division 24**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	1	0.00	44			0.72	21	0.72	21
	2	0.00	55	0.0001	144	1.34	50	1.34	50
	3	0.00	97	0.0001	162	4.94	67	4.94	67
	4	0.00	146	0.0001	174	5.01	85	5.01	85
2	5	0.04	150	0.0003	186	10.25	126	10.30	126
	6	0.06	160	0.0001	207	4.74	123	4.79	123
	7	0.04	165	0.0001	210	3.20	138	3.24	139
	8+	0.02	176	0.0000	232	1.60	152	1.62	153
	Total	0.16		0.0007		31.80		31.96	
	SOP		26		0.1		3,402		3,428
		Sub-division 22		**Sub-division 23**		**Sub-division 24**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0					0.10	11	0.10	11
	1	0.0000	46			0.92	29	0.92	29
	2	0.0002	55	0.05	144	0.20	41	0.24	61
	3	0.0001	76	0.05	162	0.26	42	0.31	61
	4	0.0002	133	0.13	174	0.60	42	0.72	65
3	5	0.0012	150	0.24	186	0.06	63	0.31	161
	6	0.0017	160	0.07	207	0.38	51	0.45	74
	7	0.0011	165	0.05	210	0.10	68	0.15	112
	8+	0.0005	176	0.01	232	0.04	83	0.05	107
	Total	0.0051		0.58		2.65		3.24	
	SOP		0.8		106		105		212
		Sub-division 22		**Sub-division 23**		**Sub-division 24**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0					0.27	18	0.27	18
	1	0.00	46			2.36	49	2.36	49
	2	0.00	55	0.03	140	5.22	74	5.25	75
	3	0.00	75	0.13	139	6.55	108	6.68	109
	4	0.00	132	0.72	179	4.21	123	4.93	131
4	5	0.01	150	0.89	209	6.32	150	7.22	158
	6	0.02	160	0.06	209	1.41	153	1.50	156
	7	0.01	165			0.61	176	0.62	176
	8+	0.01	176	0.01	241	0.22	104	0.23	111
	Total	0.06		1.84		27.17		29.08	
	SOP		9		353		3,033		3,395
		Sub-division 22		**Sub-division 23**		**Sub-division 24**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0					0.37	16	0.37	16
	1	38.98	12			9.40	26	48.38	14
	2	0.41	38	0.09	143	17.96	52	18.46	52
	3	0.16	94	0.19	146	34.28	87	34.64	87
	4	0.12	116	0.87	178	22.07	106	23.06	108
Total	5	0.39	148	1.20	203	49.69	141	51.27	143
	6	0.18	160	0.14	208	15.93	143	16.26	143
	7	0.13	170	0.06	210	8.66	157	8.84	158
	8+	0.07	185	0.02	237	4.42	170	4.51	170
	Total	40.43		2.56		162.79		205.79	
	SOP		620		485		17,887		18,992

Table 3.2.4 Western Baltic spring spawning herring. Samples of commercial catch by quarter and area for 2018 available to the Working Group.

	Country	Fleet	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Skagerrak	**Denmark**	**C**	**1**	0.00001		No data available	
		C	**2**	0.00003		No data available	
		C	**3**	0.47449		No data available	
		C	**4**	0.26170		No data available	
	Total	**Total**		0.73623	0	0	0
	Denmark	**D**	**1**	0.000		-	
		D	**2**	0.080		No data available	
		D	**3**	0.035		No data available	
		D	**4**	0.007		No data available	
	Total	**Total**		0.122	0	0	0
	Germany	**C**	**1**	0.000		-	
		C	**2**	0.000		-	
		C	**3**	0.104		No data available	
		C	**4**	0.102		No data available	
	Total	**Total**		0.206			
	Norway	**C**	**1**	0.017		No data available	
		C	**2**	0.191		No data available	
		C	**3**	3.069	1	100	50
		C	**4**	0.133		No data available	
	Total	**Total**		3.411	1	100	50
	Faroe Islands	**C**	**1**	0.000		-	
		C	**2**	0.000		-	
		C	**3**	0.149		No data available	
		C	**4**	0.000		-	
	Total	**Total**		0.149	0	0	0
	Sweden	**C**	**1**	4.978	12	725	723
		C	**2**	0.023		No data available	
		C	**3**	5.713	10	679	677
		C	**4**	0.618	1	165	165
	Total	**Total**		11.332	23	1,569	1,565
Kattegat	**Denmark**	**C**	**1**	0.047		No data available	
		C	**2**	0.001		No data available	
		C	**3**	0.440	1	189	48
		C	**4**	0.527	6	1,328	312
	Total	**Total**		1.015	7	1,517	360
	Denmark	**D**	**1**	0.004	1	33	33
		D	**2**	0.033		No data available	
		D	**3**	0.077	6	116	116
		D	**4**	0.129	8	329	241
	Total	**Total**		0.243	15	478	390
	Sweden	**C**	**1**	4.912	15	750	748
		C	**2**	0.000		-	
		C	**3**	0.278	1	54	54
		C	**4**	0.853	4	400	400
	Total	**Total**		6.044	20	1,204	1,202

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Table 3.2.4 (continued) Western Baltic spring spawning herring. Samples of commercial catch by quarter and area for 2018 available to the Working Group.

	Country	Fleet	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Subdivision 22	**Denmark**	**F**	**1**	0.469	7	396	209
		F	**2**	0.012	No data available		
		F	**3**	0.000	No data available		
		F	**4**	0.002	No data available		
	Total	**Total**		0.484	7	396	209
	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**	0.1149	1	339	70
		F	**2**	0.0135	4	1,538	218
		F	**3**	0.0005	No data available		
		F	**4**	0.0074	No data available		
	Total	**Total**		0.1363	5	1,877	288
Subdivision 23	**Denmark**	**F**	**1**	0.000	No data available		
		F	**2**	0.000	No data available		
		F	**3**	0.024	1	177	60
		F	**4**	0.046	1	101	51
	Total	**Total**		0.069	2	278	111
	Sweden	**F**	**1**	0.025	No data available		
		F	**2**	0.000	-		
		F	**3**	0.083	No data available		
		F	**4**	0.308	2	52	52
	Total	**Total**		0.416	2	52	52
Subdivision 24	**Denmark**	**F**	**1**	3.328	4	702	214
		F	**2**	0.015	1	172	58
		F	**3**	0.001	No data available		
		F	**4**	0.659	7	1,006	156
	Total	**Total**		4.003	12	1,880	428
	Finland	**F**	**1**	0.001	No data available		
		F	**2**	0.000	-		
		F	**3**	0.000	-		
		F	**4**	0.000	-		
	Total	**Total**		0.001	0	0	0
	Germany	**F**	**1**	7.5213	13	5,048	1,069
		F	**2**	2.4715	8	3,122	548
		F	**3**	0.0001	No data available		
		F	**4**	1.1749	1	349	119
	Total	**Total**		11.1679	22	8,519	1,736
	Poland	**F**	**1**	0.104	1	194	54
		F	**2**	0.916	1	820	132
		F	**3**	0.103	1	1,021	100
		F	**4**	0.650	1	451	126
	Total	**Total**		1.773	4	2,486	412
	Sweden	**F**	**1**	0.393	7	776	774
		F	**2**	0.000	No data available		
		F	**3**	0.000	No data available		
		F	**4**	0.549	5	666	665
	Total	**Total**		0.943	12	1,442	1,439
Total	**Skagerrak**	**C**	**1-4**	**15.834**	**24**	**1,669**	**1,615**
		D	**1-4**	**0.122**	**0**	**0**	**0**
	Kattegat	**C**	**1-4**	**7.059**	**27**	**2,721**	**1,562**
		D	**1-4**	**0.243**	**15**	**478**	**390**
	Subdivision 22	**F**	**1-4**	**0.620**	**12**	**2,273**	**497**
	Subdivision 23	**F**	**1-4**	**0.485**	**4**	**330**	**163**
	Subdivision 24	**F**	**1-4**	**17.887**	**50**	**14,327**	**4,015**
	Total	**Total**	**1-4**	**42.250**	**132**	**21,798**	**8,242**

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 2018.

	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**	Sweden Q3 27.3.a.20 fleet-C
		4	**C**	Sweden Q3 27.3.a.20 fleet-C
	Germany	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	Sweden Q3 27.3.a.20 fleet-C
		4	**C**	Sweden Q3 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 Q1 27.3.a.21 fleet-D
		3	**D**	Denmark Q3 27.3.a.21 fleet-D
		4	**D**	Denmark Q4 27.3.a.21 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**	Sweden Q3 27.3.a.20 fleet-C
		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 Q3 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**	Denmark Q3 27.3.a.21 fleet-C
		4	**C**	Denmark Q4 27.3.a.21 fleet-C
	Sweden	**1**	**C**	Sweden Q1 27.3.a.21 fleet-C
		2	**C**	Sweden Q1 27.3.a.21 fleet-C
		3	**C**	Sweden Q3 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**	Denmark Q1 27.3.a.21 fleet-D
		2	**D**	Denmark Q1 27.3.a.21 fleet-D
		3	**D**	Denmark Q3 27.3.a.21 fleet-D
		4	**D**	Denmark Q4 27.3.a.21 fleet-D
Subdivision 22	**Denmark**	**1**	**F**	Denmark Q1 27.3.c.22 fleet-F
		2	**F**	Germany Q2 27.3.c.22 fleet-F
		3	**F**	Germany Q3 27.3.c.22 fleet-F
		4	**F**	Germany Q4 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 (WD Gröhsler)
		2	**F**	Germany Q2 27.3.c.22 fleet-F (WD Gröhsler)
		3	**F**	German sampling as in WD Gröhsler
		4	**F**	German sampling as in WD Gröhsler

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

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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 2018.

	Country	Quarter	Fleet	Sampling
Subdivision 23	**Denmark**	**1**	**F**	Denmark Q3 27.3.b.23 fleet-F
		2	**F**	Denmark Q3 27.3.b.23 fleet-F
		3	**F**	Denmark Q3 27.3.b.23 fleet-F
		4	**F**	Denmark Q4 27.3.b.23 fleet-F
	Sweden	**1**	**F**	Denmark Q3 27.3.b.23 fleet-F
		2	**F**	No landings
		3	**F**	Denmark Q3 27.3.b.23 fleet-F
		4	**F**	Sweden Q4 27.3.b.23 fleet-F
Subdivision 24	**Denmark**	**1**	**F**	Denmark Q1 27.3.d.24 fleet-F
		2	**F**	Denmark Q1 27.3.d.24 fleet-F
		3	**F**	Denmark Q4 27.3.d.24 fleet-F
		4	**F**	Denmark Q4 27.3.d.24 fleet-F
	Finland	**1**	**F**	Germany Q1 27.3.d.24 fleet-F
		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**	German sampling as in WD Gröhsler
		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**	Poland Q4 27.3.d.24 fleet-F
	Sweden	**1**	**F**	Sweden Q1 27.3.d.24 fleet-F
		2	**F**	Germany Q2 27.3.d.24 fleet-F
		3	**F**	Sweden Q4 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: 2018

		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
1	1	50.00%	50.00%	6	93.94%	6.06%	45
	2	9.80%	90.20%	51	16.97%	83.03%	78
	3	14.29%	85.71%	21	2.91%	97.09%	35
	4	12.50%	87.50%	8	0.00%	100.00%	8
	5	4.62%	95.38%	3	0.00%	100.00%	8
	6	4.62%	95.38%	1	0.00%	100.00%	1
	7	4.62%	95.38%	1	0.00%	100.00%	0
	8+	4.62%	95.38%	0	0.00%	100.00%	2
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
2	1	50.00%	50.00%	0	93.94%	6.06%	0
	2	9.80%	90.20%	0	16.97%	83.03%	0
	3	14.29%	85.71%	0	2.91%	97.09%	0
	4	12.50%	87.50%	0	0.00%	100.00%	0
	5	4.62%	95.38%	0	0.00%	100.00%	0
	6	4.62%	95.38%	0	0.00%	100.00%	0
	7	4.62%	95.38%	0	0.00%	100.00%	0
	8+	4.62%	95.38%	0	0.00%	100.00%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
3	0	98.73%	1.27%	0	98.73%	1.27%	79
	1	40.00%	60.00%	50	54.72%	45.28%	53
	2	20.41%	79.59%	49	26.71%	73.29%	24
	3	6.12%	93.88%	49	0.00%	100.00%	4
	4	14.29%	85.71%	14	0.00%	100.00%	6
	5	4.55%	95.45%	22	37.50%	62.50%	24
	6	3.85%	96.15%	6	0.00%	100.00%	14
	7	3.85%	96.15%	6	3.85%	96.15%	4
	8	3.85%	96.15%	2	3.85%	96.15%	4
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
4	0	98.73%	1.27%	0	97.75%	2.25%	222
	1	36.00%	64.00%	50	40.36%	59.64%	260
	2	9.37%	90.63%	32	6.32%	93.68%	100
	3	6.12%	93.88%	0	2.37%	97.63%	34
	4	14.29%	85.71%	0	0.00%	100.00%	25
	5	4.55%	95.45%	0	2.94%	97.06%	17
	6	3.85%	96.15%	0	2.94%	97.06%	3
	7	3.85%	96.15%	0	2.94%	97.06%	2
	8	3.85%	96.15%	0	2.94%	97.06%	1

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(4-8+)	5-8+	mean(5-8+)
2	1-8+	Q1 Sk(age)	1-8+	Q1 Ka(age)
3	6-8+	mean(6-8+)	7-8+	mean(6-8+)
4	3-8+	Q3 Sk(age)	5-8+	mean(5-8+)

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: 2018 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	4.78	29	0.03	23	4.80	29
	2	14.89	48	0.01	42	14.91	48
	3	0.14	73	0.00	48	0.14	73
	4					0.00	
	5					0.00	
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	19.80		0.04		19.84	
	SOP		856.3		1.1		857.5
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.0010	29	0.20	23	0.20	23
	2	0.00298	48	0.11	42	0.11	42
	3	0.00003	73	0.00	48	0.00	49
	4					0.00	
	5					0.00	
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	0.004		0.31		0.32	
	SOP		0.2		9.3		9.4
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			2.78	8	2.78	8
	1	1.61	59	0.67	42	2.28	54
	2	0.86	68	0.01	77	0.87	68
	3					0.00	
	4					0.00	
	5	0.26	187			0.26	187
	6					0.00	
	7	0.00	178			0.00	178
	8+	0.00	188			0.00	188
	Total	2.73		3.46		6.19	
	SOP		202.6		51.4		253.9
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.10	22	9.85	11	9.95	11
	1	5.45	55	0.20	44	5.65	55
	2	0.33	81			0.33	81
	3	0.02	110			0.02	110
	4					0.00	
	5	0.01	149			0.01	149
	6	0.00	119			0.00	119
	7	0.00	215			0.00	215
	8+					0.00	
	Total	5.91		10.04		15.96	
	SOP		334.4		113.7		448.1
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.10	22	12.62	10	12.73	10
	1	11.83	45	1.10	38	12.93	45
	2	16.08	49	0.13	44	16.22	49
	3	0.16	78	0.001	48	0.16	78
	4	0.00		0.00		0.00	
	5	0.27	186	0.00		0.27	186
	6	0.002	119	0.00		0.00	119
	7	0.01	186	0.00		0.01	186
	8+	0.00	188	0.00		0.00	188
	Total	28.45		13.86		42.31033	
	SOP		1,393.5		175.4		1,569.0

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: 2018 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.39	34			0.39	34
	2	8.69	52			8.69	52
	3	0.39	74			0.39	74
	4	0.13	91			0.13	91
	5	0.02	119			0.02	119
	6	0.01	174			0.01	174
	7	0.01	175			0.01	175
	8+					0.00	
	Total	9.63		0.00		9.63	
	SOP		506.2		0.0		506.2
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.02	34	0.26	23	0.28	23
	2	0.37	52	0.15	42	0.53	49
	3	0.02	74	0.01	48	0.03	65
	4	0.01	91			0.01	91
	5	0.00	119			0.00	119
	6	0.00	174			0.00	174
	7	0.00	175			0.00	175
	8+					0.00	
	Total	0.41		0.42		0.83	
	SOP		21.7		12.7		34.5
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			1.25	8	1.25	8
	1	2.26	65	0.22	42	2.48	63
	2	2.82	115	0.00	77	2.82	115
	3	0.52	135			0.52	135
	4	1.58	163			1.58	163
	5	0.71	181			0.71	181
	6	0.17	190			0.17	190
	7	0.11	187			0.11	187
	8+	0.08	202			0.08	202
	Total	8.25		1.48		9.72	
	SOP		995.9		19.6		1,015.5
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			0.53	11	0.53	11
	1	3.08	57	0.01	44	3.09	57
	2	0.24	84			0.24	84
	3	0.03	135			0.03	135
	4	0.08	171			0.08	171
	5	0.04	187			0.04	187
	6	0.01	198			0.01	198
	7	0.01	190			0.01	190
	8+	0.00	226			0.00	226
	Total	3.48		0.54		4.03	
	SOP		224.5		6.1		230.6
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.00		1.78	9	1.78	9
	1	5.75	59	0.49	32	6.24	56
	2	12.12	67	0.16	43	12.27	67
	3	0.96	109	0.01	48	0.97	109
	4	1.79	158	0.00		1.79	158
	5	0.78	179	0.00		0.78	179
	6	0.18	190	0.00		0.18	190
	7	0.12	187	0.00		0.12	187
	8+	0.09	203	0.00		0.09	203
	Total	21.78		2.44		24.21	
	SOP		1,748.3		38.5		1,786.8

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. Baltic Spring spawners
Division: Kattegat Year: 2018 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.31	29	0.00	23	0.31	29
	2	72.86	48	0.07	42	72.93	48
	3	4.55	73	0.00	48	4.55	73
	4	1.07	100			1.07	100
	5	1.07	118			1.07	118
	6	0.13	113			0.13	113
	7					0.00	
	8+	0.27	168			0.27	168
	Total	80.26		0.07		80.33	
	SOP		4,103.1		3.0		4,106.1
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.0001	29	0.01	23	0.01	23
	2	0.01	48	0.54	42	0.55	42
	3	0.0009	73	0.03	48	0.03	49
	4	0.0002	100			0.00	100
	5	0.0002	118			0.00	118
	6	0.0000	113			0.00	113
	7					0.00	
	8+	0.0001	168			0.00	168
	Total	0.016		0.58		0.59	
	SOP		0.8		24.2		25.0
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			0.04	8	0.04	8
	1	1.33	59	0.56	42	1.89	54
	2	2.37	68	0.03	77	2.39	68
	3	0.36	82			0.36	82
	4	0.44	109			0.44	109
	5	0.43	187			0.43	187
	6	0.38	210			0.38	210
	7	0.11	178			0.11	178
	8+	0.11	188			0.11	188
	Total	5.52		0.62		6.13	
	SOP		515.2		25.4		540.6
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.00	22	0.23	11	0.23	11
	1	8.06	55	0.29	44	8.35	55
	2	4.83	81			4.83	81
	3	0.82	110			0.82	110
	4	0.51	124			0.51	124
	5	0.27	149			0.27	149
	6	0.06	119			0.06	119
	7	0.04	215			0.04	215
	8+					0.00	
	Total	14.59		0.52		15.11	
	SOP		1,046.0		15.1		1,061.1
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.00	22	0.26	10	0.26	10
	1	9.69	55	0.86	42	10.56	54
	2	80.08	50	0.63	43	80.71	50
	3	5.72	79	0.03	48	5.75	79
	4	2.02	108	0.00		2.02	108
	5	1.77	139	0.00		1.77	139
	6	0.58	178	0.00		0.58	178
	7	0.14	187	0.00		0.14	187
	8+	0.37	173	0.00		0.37	173
	Total	100.38		1.79		102.17	
	SOP		5,665.1		67.7		5,732.9

Table 3.2.10 Western Baltic spring spawning herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet. Baltic Spring spawners
Division: Skagerrak Year: 2018 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.39	34			0.39	34
	2	79.94	52			79.94	52
	3	2.34	74			2.34	74
	4	0.91	91			0.91	91
	5	0.50	119			0.50	119
	6	0.12	174			0.12	174
	7	0.12	175			0.12	175
	8+					0.00	
	Total	84.33		0.00		84.33	
	SOP		4,488.9		0		4,488.9
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.02	34	0.26	23	0.28	23
	2	3.43	52	1.40	42	4.84	49
	3	0.10	74	0.06	48	0.16	65
	4	0.04	91			0.04	91
	5	0.02	119			0.02	119
	6	0.01	174			0.01	174
	7	0.01	175			0.01	175
	8+					0.00	
	Total	3.62		1.72		5.34	
	SOP		192.8		67.5		260.3
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			0.02	8	0.02	8
	1	3.39	65	0.33	42	3.73	63
	2	10.98	115	0.01	77	10.99	115
	3	8.00	135			8.00	135
	4	9.48	163			9.48	163
	5	14.87	181			14.87	181
	6	4.17	190			4.17	190
	7	2.64	187			2.64	187
	8+	2.10	202			2.10	202
	Total	55.64		0.36		56.00	
	SOP		8,514.3		14.9		8,529.2
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			0.01	11	0.01	11
	1	5.47	57	0.02	44	5.49	57
	2	2.33	84			2.33	84
	3	0.47	135			0.47	135
	4	0.46	171			0.46	171
	5	0.87	187			0.87	187
	6	0.22	198			0.22	198
	7	0.13	190			0.13	190
	8+	0.04	226			0.04	226
	Total	9.99		0.02		10.01	
	SOP		889.9		0.8		890.7
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.00		0.02	9	0.02	9
	1	9.27	59	0.61	34	9.88	57
	2	96.69	60	1.42	42	98.10	59
	3	10.91	121	0.06	48	10.97	121
	4	10.90	157	0.00		10.90	157
	5	16.26	179	0.00		16.26	179
	6	4.52	190	0.00		4.52	190
	7	2.90	187	0.00		2.90	187
	8+	2.14	203	0.00		2.14	203
	Total	153.58		2.10		155.68	
	SOP		14,085.8		83.3		14,169.1

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: 2018 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	5.17	29	0.03	23	5.19	29
	2	23.58	49	0.01	42	23.59	49
	3	0.53	74	0.00	48	0.53	74
	4	0.13	91			0.13	91
	5	0.02	119			0.02	119
	6	0.01	174			0.01	174
	7	0.01	175			0.01	175
	8+					0.00	
	Total	29.43		0.04		29.47	
	SOP		1,362.5		1.1		1,363.7
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.02	33	0.46	23	0.48	23
	2	0.38	51	0.26	42	0.64	48
	3	0.02	74	0.01	48	0.03	65
	4	0.01	91			0.01	91
	5	0.0010	119			0.0010	119
	6	0.0003	174			0.0003	174
	7	0.0003	175			0.0003	175
	8+					0.00	
	Total	0.42		0.74		1.15	
	SOP		21.9		22.0		43.9
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			4.03	8	4.03	8
	1	3.87	62	0.90	42	4.76	58
	2	3.68	104	0.01	77	3.69	104
	3	0.52	135			0.52	135
	4	1.58	163			1.58	163
	5	0.97	183			0.97	183
	6	0.17	190			0.17	190
	7	0.11	187			0.11	187
	8+	0.09	202			0.09	202
	Total	10.98		4.94		15.92	
	SOP		1,198.5		71.0		1,269.5
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.10	22	10.38	11	10.48	11
	1	8.53	56	0.21	44	8.74	56
	2	0.57	82			0.57	82
	3	0.05	125			0.05	125
	4	0.08	171			0.08	171
	5	0.05	181			0.05	181
	6	0.01	185			0.01	185
	7	0.01	195			0.01	195
	8+	0.002	226			0.002	226
	Total	9.40		10.59		19.98	
	SOP		558.9		119.8		678.7
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.10	22	14.41	10	14.51	10
	1	17.58	50	1.59	36	19.17	48
	2	28.20	57	0.29	44	28.49	57
	3	1.12	105	0.01	48	1.13	104
	4	1.79	158	0.00		1.79	158
	5	1.04	181	0.00		1.04	181
	6	0.18	189	0.00		0.18	189
	7	0.12	187	0.00		0.12	187
	8+	0.09	202	0.00		0.09	202
	Total	50.23		16.29		66.52	
	SOP		3,141.8		213.9		3,355.7

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. Baltic Spring spawners
Division: 3.a Year: 2017 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.70	31	0.00	23	0.70	31
	2	152.80	50	0.07	42	152.87	50
	3	6.88	74	0.00	48	6.89	74
	4	1.98	96			1.98	96
	5	1.57	118			1.57	118
	6	0.26	142			0.26	142
	7	0.12	175			0.12	175
	8+	0.27	168			0.27	168
	Total	164.58		0.07		164.65	
	SOP		8,592.0		3.0		8,595.0
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.02	34	0.27	23	0.29	23
	2	3.45	51	1.94	42	5.39	48
	3	0.10	74	0.08	48	0.18	63
	4	0.04	91			0.04	91
	5	0.02	119			0.02	119
	6	0.01	174			0.01	174
	7	0.01	175			0.01	175
	8+	0.00	168			0.00	168
	Total	3.64		2.30		5.93	
	SOP		193.6		91.7		285.3
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			0.05	8	0.05	8
	1	4.72	63	0.89	42	5.61	60
	2	13.35	107	0.04	77	13.39	107
	3	8.36	133			8.36	133
	4	9.92	161			9.92	161
	5	15.30	181			15.30	181
	6	4.55	192			4.55	192
	7	2.74	187			2.74	187
	8+	2.20	202			2.20	202
	Total	61.15		0.98		62.13	
	SOP		9,029		40.4		9,069.8
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.00	22	0.23	11	0.24	11
	1	13.53	56	0.31	44	13.84	56
	2	7.16	82			7.16	82
	3	1.29	119			1.29	119
	4	0.97	146			0.97	146
	5	1.14	178			1.14	178
	6	0.28	181			0.28	181
	7	0.17	196			0.17	196
	8+	0.04	226			0.04	226
	Total	24.58		0.54		25.12	
	SOP		1,935.9		15.9		1,951.8
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	**Numbers**	**Mean W.**	**Numbers**	**Mean W.**	Numbers	Mean W.
Total	0	**0.00**	**22**	**0.29**	**10**	0.29	10
	1	**18.97**	**57**	**1.47**	**38**	20.44	56
	2	**176.76**	**55**	**2.05**	**43**	178.81	55
	3	**16.63**	**107**	**0.09**	**48**	16.72	106
	4	**12.91**	**149**	**0.00**		12.91	149
	5	**18.03**	**175**	**0.00**		18.03	175
	6	**5.10**	**189**	**0.00**		5.10	189
	7	**3.04**	**187**	**0.00**		3.04	187
	8+	**2.51**	**198**	**0.00**		2.51	198
	Total	253.96		3.89		257.85	
	SOP		**19,750.9**		**151.0**		19,901.9

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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 1993–2018.

Year/	W-rings	0	1	2	3	4	5	6	7	8+	Total
1993	Numbers	161.25	371.50	315.82	219.05	94.08	59.43	40.97	21.71	8.22	1,292.03
	Mean W.	15.1	25.9	81.4	127.5	150.1	171.1	195.9	209.1	239.0	
	SOP	2,435	9,612	25,696	27,936	14,120	10,167	8,027	4,541	1,966	104,498
1994	Numbers	60.62	153.11	261.14	221.64	130.97	77.30	44.40	14.39	8.62	972.19
	Mean W.	20.2	42.6	94.8	122.7	150.3	168.7	194.7	209.9	220.2	
	SOP	1,225	6,524	24,767	27,206	19,686	13,043	8,642	3,022	1,898	106,013
1995	Numbers	50.31	302.51	204.19	97.93	90.86	30.55	21.28	12.01	7.24	816.86
	Mean W.	17.9	41.5	97.8	138.0	163.1	198.5	207.0	228.8	234.3	
	SOP	902	12,551	19,970	13,517	14,823	6,065	4,404	2,747	1,696	76,674
1996	Numbers	166.23	228.05	317.74	75.60	40.41	30.63	12.58	6.73	5.63	883.60
	Mean W.	10.5	27.6	90.1	134.9	164.9	186.6	204.1	208.5	220.2	
	SOP	1,748	6,296	28,618	10,197	6,665	5,714	2,568	1,402	1,241	64,449
1997	Numbers	25.97	73.43	158.71	180.06	30.15	14.15	4.77	1.75	2.31	491.31
	Mean W.	19.2	49.7	76.7	127.2	154.4	175.8	184.4	192.0	208.0	
	SOP	498	3,648	12,176	22,913	4,656	2,489	879	337	480	48,075
1998	Numbers	36.26	175.14	315.15	94.53	54.72	11.19	8.72	2.19	2.09	699.98
	Mean W.	27.8	51.3	71.5	108.8	142.6	171.7	194.4	184.2	230.0	
	SOP	1,009	8,980	22,542	10,287	7,804	1,922	1,695	403	481	55,121
1999	Numbers	41.34	190.29	155.67	122.26	43.16	22.21	4.42	3.02	2.40	584.77
	Mean W.	11.5	51.0	83.6	114.9	121.2	145.2	169.6	123.8	152.3	
	SOP	477	9,698	13,012	14,048	5,232	3,225	749	373	366	47,179
2000	Numbers	114.83	318.22	302.10	99.88	50.85	18.76	8.21	1.35	1.40	915.60
	Mean W.	22.6	31.9	67.4	107.7	140.2	170.0	157.0	185.0	210.1	
	SOP	2,601	10,145	20,357	10,756	7,131	3,189	1,288	249	294	56,010
2001	Numbers	121.68	36.63	208.10	111.08	32.06	19.67	9.84	4.17	2.42	545.65
	Mean W.	9.0	51.2	76.2	108.9	145.3	171.4	188.2	187.2	203.3	
	SOP	1,096	1,875	15,863	12,093	4,657	3,371	1,852	780	492	42,079
2002	Numbers	69.63	577.69	168.26	134.60	53.09	12.05	7.48	2.43	2.02	1,027.26
	Mean W.	10.2	20.4	78.2	117.7	143.8	169.8	191.9	198.2	215.5	
	SOP	709	11,795	13,162	15,848	7,632	2,046	1,435	481	435	53,544
2003	Numbers	52.11	63.02	182.53	65.45	64.37	21.47	6.26	4.35	1.81	461.38
	Mean W.	13.0	37.4	76.5	113.3	132.7	142.2	153.5	169.9	162.2	
	SOP	678	2,355	13,957	7,416	8,540	3,053	961	740	294	37,994
2004	Numbers	25.67	209.34	96.02	93.98	18.24	16.84	4.51	1.51	0.59	466.71
	Mean W.	27.1	43.2	81.9	117.1	145.4	157.4	170.7	184.4	187.1	
	SOP	695	9,047	7,869	11,005	2,652	2,651	769	279	111	35,078
2005	Numbers	95.3	96.9	203.3	75.4	46.9	9.3	11.5	3.5	1.4	543.51
	Mean W.	14.1	54.9	85.6	121.6	148.3	162.7	176.3	178.3	200.6	
	SOP	1,341	5,319	17,415	9,163	6,961	1,519	2,028	618	282	44,645
2006 c	Numbers	7.3	104.1	115.6	114.2	48.9	55.7	11.1	10.3	5.2	472.49
	Mean W.	16.6	36.9	82.9	113.0	142.5	175.2	198.2	209.5	220.0	
	SOP	121	3,847	9,584	12,907	6,972	9,765	2,199	2,159	1,134	48,688
2007	Numbers	1.6	103.9	90.9	36.9	30.8	12.8	9.4	6.2	2.7	295.22
	Mean W.	25.2	65.6	85.0	115.7	138.4	159.2	190.8	178.6	211.9	
	SOP	41	6,816	7,723	4,269	4,265	2,035	1,802	1,114	567	28,632
2008	Numbers	4.9	101.8	71.1	38.9	13.5	15.1	7.7	4.5	1.3	258.80
	Mean W.	19.2	71.5	91.1	114.5	142.2	171.2	181.4	200.0	196.4	98.02
	SOP	94	7,281	6,472	4,456	1,917	2,590	1,402	900	256	25,368
2009	Numbers	14.8	149.6	132.3	45.9	24.4	10.9	7.8	7.7	5.3	398.63
	Mean W.	13.4	52.0	90.3	118.6	167.5	181.4	213.9	228.9	259.5	90.89
	SOP	199	7,783	11,946	5,436	4,094	1,974	1,669	1,757	1,371	36,230
2010	Numbers	9.1	48.6	106.1	45.2	20.8	8.6	5.9	7.2	5.9	257.38
	Mean W.	8.2	59.3	84.7	129.8	165.9	196.2	221.8	234.3	257.2	106.71
	SOP	75	2,878	8,991	5,870	3,445	1,686	1,311	1,696	1,513	27,465
2011	Numbers	6.2	83.1	29.9	21.0	13.4	6.0	3.0	1.0	1.1	164.56
	Mean W.	8.4	33.7	89.0	120.4	140.2	170.2	185.9	216.3	211.8	72.57
	SOP	52	2,797	2,660	2,522	1,878	1,020	554	222	237	11,941
2012	Numbers	1.5	30.5	94.3	20.7	9.5	7.1	4.2	2.2	8.6	178.68
	Mean W.	9.3	47.0	76.1	134.2	165.1	182.0	204.1	222.0	225.6	98.24
	SOP	14	1,434	7,180	2,780	1,570	1,290	858	495	1,931	17,553
2013	Numbers		12.0	51.7	71.4	11.3	4.4	1.4	0.5	1.0	153.62
	Mean W.		59.5	94.2	131.8	162.6	195.0	207.8	247.9	238.1	119.29
	SOP		716	4,872	9,409	1,830	848	290	118	242	18,325
2014	Numbers	25.3	31.5	22.4	24.2	44.6	7.6	4.6	2.3	2.9	165.42
	Mean W.	9.3	52.2	98.5	137.4	178.2	199.2	211.7	225.1	227.0	114.98
	SOP	236	1,647	2,203	3,332	7,942	1,513	964	524	659	19,020
2015	Numbers	3.3	57.8	59.9	21.0	14.1	14.6	4.9	2.7	3.9	182.10
	Mean W.	16.0	31.8	67.9	115.2	152.4	172.8	193.4	198.7	212.9	84.28
	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

Data for 1995 to 2001 was revised in 2003.

[C] values have been corrected in 2007.

Table 3.2.14 Western Baltic spring spawning herring. Catch in numbers (mill.), mean weight (g.) and SOP (t) by age as W-ringers, quarter and fleet. Western Baltic Spring spawners. (values from the North Sea, see tables 2.2.1–2.2.5)
Division: 4 + 3.a + 22–24 Year: 2018 Country: All

		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	0							0.00	
	1	0.0000	88.00	0.70	31.46	44.37	12.23	45.07	12.53
	2	0.000	109.50	152.87	49.64	11.62	41.53	164.49	49.06
	3	0.000	125.00	6.89	73.60	22.71	85.65	29.60	82.84
	4	0.001	154.40	1.98	95.94	12.40	111.17	14.38	109.07
	5	0.002	174.10	1.57	117.98	33.45	144.36	35.02	143.18
	6	0.000	190.20	0.26	142.45	9.52	154.74	9.78	154.41
	7			0.12	175.10	4.83	169.42	4.96	169.56
	8+			0.27	167.60	2.61	187.17	2.87	185.35
	Total	0.004		164.65		141.51		306.17	
	SOP		0.6		8,595.0		11,956.7		20,552.3
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.014	88.00	0.29	23.29	0.72	20.65	1.03	22.28
	2	0.229	123.00	5.39	48.08	1.34	49.82	6.96	50.88
	3	0.103	149.00	0.18	62.60	4.94	67.02	5.22	68.48
	4	0.431	169.00	0.04	90.75	5.01	85.41	5.48	92.02
	5	0.804	185.00	0.02	118.79	10.30	126.11	11.12	130.36
	6			0.01	173.60	4.79	123.49	4.80	123.54
	7	0.021	208.00	0.01	175.10	3.24	138.71	3.26	139.21
	8+			0.00	167.60	1.62	152.74	1.62	152.74
	Total	1.601		5.93		31.96		39.50	
	SOP		270.6		285.3		3,428.1		3,984.0
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			0.05	8.14	0.10	11.22	0.15	10.15
	1	0.02	104.00	5.61	59.73	0.92	28.68	6.55	55.46
	2	0.10	137.80	13.39	106.64	0.24	60.65	13.73	106.05
	3	0.80	164.40	8.36	132.59	0.31	61.22	9.46	132.95
	4	1.80	186.00	9.92	160.65	0.72	64.61	12.45	158.76
	5	3.46	200.30	15.30	181.28	0.31	160.82	19.07	184.41
	6	1.68	213.40	4.55	191.75	0.45	74.26	6.68	189.33
	7	0.84	224.00	2.74	186.83	0.15	111.97	3.73	192.21
	8+	0.53	238.91	2.20	201.65	0.05	107.20	2.78	207.20
	Total	9.23		62.13		3.24		74.60	
	SOP		1,848.8		9,069.8		212.0		11,130.6
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			0.24	10.78	0.27	17.59	0.51	14.42
	1			13.84	55.85	2.36	49.41	16.20	54.91
	2			7.16	81.72	5.25	74.51	12.41	78.67
	3			1.29	119.04	6.68	108.78	7.97	110.44
	4	0.042	184.00	0.97	146.50	4.93	131.37	5.94	134.21
	5			1.14	177.92	7.22	157.68	8.36	160.44
	6	0.066	213.00	0.28	181.20	1.50	155.80	1.84	161.68
	7			0.17	195.90	0.62	175.93	0.79	180.17
	8+	0.092	237.52	0.04	225.70	0.23	111.35	0.37	156.20
	Total	0.201		25.12		29.08		54.40	
	SOP		43.8		1,951.8		3,395.4		5,391.0
		Division IV		Division IIIa		**Subdivision 22-24**		Total	
Quarter	W-rings	**Numbers**	**Mean W.**	Numbers	Mean W.	**Numbers**	**Mean W.**	Numbers	Mean W.
Total	0	**0.00**		0.29	10.31	**0.37**	**15.90**	0.655	13.44
	1	**0.03**	**96.43**	20.44	55.62	**48.38**	**14.48**	68.850	26.73
	2	**0.33**	**127.50**	178.81	55.14	**18.46**	**51.77**	197.598	54.95
	3	**0.90**	**162.63**	16.72	106.47	**34.64**	**87.24**	52.255	94.69
	4	**2.28**	**182.73**	12.91	149.46	**23.06**	**108.43**	38.254	126.70
	5	**4.27**	**197.41**	18.03	175.50	**51.27**	**142.67**	73.574	153.89
	6	**1.74**	**213.38**	5.10	188.67	**16.26**	**143.41**	23.098	158.68
	7	**0.86**	**223.62**	3.04	186.83	**8.84**	**157.66**	12.745	169.08
	8+	**0.62**	**238.70**	2.51	198.42	**4.51**	**170.05**	7.642	184.97
	Total	11.03		257.85		205.79		474.672	
	SOP		**2,163.7**		19,901.9		**18,992.2**		41,057.8

single fleet assessment input
multifleet assessment input

Table 3.2.15 Western Baltic spring spawning herring. Total catch in numbers (mill) of Western Baltic Spring Spawners in Division 3.a + North Sea + Subdivisions 22–24 in the years 1993–2018.

Year	W-rings / Area	0	1	2	3	4	5	6	7	8+	Total
1993	Div. IV+Div. IIIa	161.3	371.5	315.8	219.0	94.1	59.4	41.0	21.7	8.2	1130.8
	Subdiv. 22-24	44.9	159.2	180.1	196.1	166.9	151.1	61.8	42.2	16.3	973.7
1994	Div. IV+Div. IIIa	60.6	153.1	261.1	221.6	131.0	77.3	44.4	14.4	8.6	911.6
	Subdiv. 22-24	202.6	96.3	103.8	161.0	136.1	90.8	74.0	35.1	24.5	721.6
1995	Div. IV+Div. IIIa	50.3	302.5	204.2	97.9	90.9	30.6	21.3	12.0	7.2	816.9
	Subdiv. 22-24	491.0	1,358.2	233.9	128.9	104.0	53.6	38.8	20.9	13.2	1951.5
1996	Div. IV+Div. IIIa	166.2	228.1	317.7	75.6	40.4	30.6	12.6	6.7	5.6	883.6
	Subdiv. 22-24	4.9	410.8	82.8	124.1	103.7	99.5	52.7	24.0	19.5	917.1
1997	Div. IV+Div. IIIa	26.0	73.4	158.7	180.1	30.2	14.2	4.8	1.8	2.3	491.3
	Subdiv. 22-24	350.8	595.2	130.6	96.9	45.1	29.0	35.1	19.5	21.8	973.2
1998	Div. IV+Div. IIIa	36.3	175.1	315.1	94.5	54.7	11.2	8.7	2.2	2.1	700.0
	Subdiv. 22-24	513.5	447.9	115.8	88.3	92.0	34.1	15.0	13.2	12.0	818.4
1999	Div. IV+Div. IIIa	41.3	190.3	155.7	122.3	43.2	22.2	4.4	3.0	2.4	584.8
	Subdiv. 22-24	528.3	425.8	178.7	123.9	47.1	33.7	11.1	6.5	3.7	830.5
2000	Div. IV+Div. IIIa	114.83	318.22	302.10	99.88	50.85	18.76	8.21	1.35	1.40	915.6
	Subdiv. 22-24	37.7	616.3	194.3	86.7	77.8	53.0	30.1	12.4	9.3	1079.9
2001	Div. IV+Div. IIIa	121.7	36.6	208.1	111.1	32.1	19.7	9.8	4.2	2.4	545.6
	Subdiv. 22-24	634.6	486.5	280.7	146.8	76.0	48.7	29.3	14.1	4.3	1721.0
2002	Div. IV+Div. IIIa	69.6	577.7	168.3	134.6	53.1	12.0	7.5	2.4	2.0	1027.3
	Subdiv. 22-24	80.6	81.4	113.6	186.7	119.2	45.1	31.1	11.4	6.3	675.4
2003	Div. IV+Div. IIIa	52.1	63.0	182.5	64.0	62.2	20.3	5.9	3.8	1.6	455.5
	Subdiv. 22-24	1.4	63.9	82.3	95.8	125.1	82.2	22.9	13.1	7.0	493.6
2004	Div. IV+Div. IIIa	25.7	209.3	96.0	94.0	18.2	16.8	4.5	1.5	0.6	466.7
	Subdiv. 22-24	217.9	248.4	101.8	70.8	75.0	74.4	44.5	13.4	10.4	856.5
2005	Div. IV+Div. IIIa	95.3	96.9	203.3	75.4	46.9	9.3	11.5	3.5	1.4	543.5
	Subdiv. 22-24	11.6	207.6	115.9	102.5	83.5	51.3	54.2	27.8	11.2	665.5
2006 c	Div. IV+Div. IIIa	7.3	104.1	115.6	114.2	48.9	55.7	11.1	10.3	5.2	472.5
	Subdiv. 22-24	0.6	44.8	72.1	119.0	101.7	43.0	31.4	22.1	12.2	446.8
2007	Div. IV+Div. IIIa	1.6	103.9	90.9	36.9	30.8	12.8	9.4	6.2	2.7	295.2
	Subdiv. 22-24	19.0	668.5	158.3	169.7	112.8	65.1	24.6	5.9	1.8	1206.8
2008	Div. IV+Div. IIIa	4.9	101.8	71.1	38.9	13.5	15.1	7.7	4.5	1.3	258.8
	Subdiv. 22-24	19.0	668.5	158.3	169.7	112.8	65.1	24.6	5.9	1.8	1206.8
2009	Div. IV+Div. IIIa	14.8	149.6	132.3	45.9	24.4	10.9	7.8	7.7	5.3	398.6
	Subdiv. 22-24	5.9	31.5	110.7	55.5	45.5	37.2	31.9	13.2	7.2	338.7
2010	Div. IV+Div. IIIa	9.1	48.6	106.1	45.2	20.8	8.6	5.9	7.2	5.9	257.4
	Subdiv. 22-24	3.3	26.5	31.3	39.3	28.5	22.4	13.9	8.0	7.5	180.6
2011	Div. IV+Div. IIIa	6.2	83.1	29.9	21.0	13.4	6.0	3.0	1.0	1.1	164.6
	Subdiv. 22-24	5.6	15.5	16.4	17.8	35.9	21.6	19.6	11.2	8.2	152.0
2012	Div. IV+Div. IIIa	1.5	30.5	94.3	20.7	9.5	7.1	4.2	2.2	8.6	178.7
	Subdiv. 22-24	0.5	46.3	36.5	43.8	37.8	28.4	14.0	9.0	8.4	224.6
2013	Div. IV+Div. IIIa		12.0	51.7	71.4	11.3	4.4	1.4	0.5	1.0	153.6
	Subdiv. 22-24	1.0	60.6	37.1	43.3	55.9	28.7	25.3	11.5	11.0	274.5
2014	Div. IV+Div. IIIa	25.3	31.5	22.4	24.2	44.6	7.6	4.6	2.3	2.9	165.4
	Subdiv. 22-24	5.8	35.3	37.7	42.1	37.5	19.0	11.2	6.5	6.2	201.4
2015	Div. IV+Div. IIIa	3.3	57.8	59.9	21.0	14.1	14.6	4.9	2.7	3.9	182.1
	Subdiv. 22-24	26.7	46.2	72.8	38.5	48.4	29.8	14.9	7.9	9.1	294.3
2016	Div. IV+Div. IIIa	23.9	27.2	161.7	43.0	13.3	12.1	13.2	3.6	6.6	304.6
	Subdiv. 22-24	20.0	22.3	37.2	93.9	45.7	30.5	17.4	10.5	8.3	285.8
2017	Div. IV+Div. IIIa	1.4	48.4	42.2	42.8	34.2	10.2	10.9	7.4	2.9	200.4
	Subdiv. 22-24	0.1	9.4	32.8	38.5	78.3	38.5	26.9	13.5	10.2	248.3
2018	Div. IV+Div. IIIa	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

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 Division 3.a + North Sea + Subdivisions 22–24 in the years 1993–2018.

	W-rings	0	1	2	3	4	5	6	7	8+	SOP
Year	Area										
1993	Div. IV+Div. IIIa	15.1	25.9	81.4	127.5	150.1	171.1	195.9	209.1	239.0	104,498
	Subdiv. 22-24	16.2	24.5	44.5	73.6	94.1	122.4	149.4	168.5	178.7	80,512
1994	Div. IV+Div. IIIa	20.2	42.6	94.8	122.7	150.3	168.7	194.7	209.9	220.2	106,013
	Subdiv. 22-24	12.9	28.2	54.2	76.4	95.0	117.7	133.6	154.3	173.9	66,425
1995	Div. IV+Div. IIIa	17.9	41.5	97.8	138.0	163.1	198.5	207.0	228.8	234.3	76,674
	Subdiv. 22-24	9.3	16.3	42.8	68.3	88.9	125.4	150.4	193.3	207.4	74,157
1996	Div. IV+Div. IIIa	10.5	27.6	90.1	134.9	164.9	186.6	204.1	208.5	220.2	64,449
	Subdiv. 22-24	12.1	22.9	45.8	74.0	92.1	116.3	120.8	139.0	182.5	56,817
1997	Div. IV+Div. IIIa	19.2	49.7	76.7	127.2	154.4	175.8	184.4	192.0	208.0	48,075
	Subdiv. 22-24	30.4	24.7	58.4	101.0	120.7	155.2	181.3	197.1	208.8	67,513
1998	Div. IV+Div. IIIa	27.8	51.3	71.5	108.8	142.6	171.7	194.4	184.2	230.0	55,121
	Subdiv. 22-24	13.3	26.3	52.2	78.6	103.0	125.2	150.0	162.1	179.5	51,911
1999	Div. IV+Div. IIIa	11.5	51.0	83.6	114.9	121.2	145.2	169.6	123.8	152.3	47,179
	Subdiv. 22-24	11.1	26.9	50.4	81.6	112.0	148.4	151.4	167.8	161.0	50,060
2000	Div. IV+Div. IIIa	22.6	31.9	67.4	107.7	140.2	170.0	157.0	185.0	210.1	56,010
	Subdiv. 22-24	16.5	22.2	42.8	80.4	123.5	133.2	143.4	155.4	151.4	53,904
2001	Div. IV+Div. IIIa	9.0	51.2	76.2	108.9	145.3	171.4	188.2	187.2	203.3	42,079
	Subdiv. 22-24	12.9	22.3	46.8	69.0	93.5	150.8	145.1	146.3	153.1	63,724
2002	Div. IV+Div. IIIa	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	Div. IV+Div. IIIa	13.0	37.4	76.5	112.7	132.1	140.8	151.9	167.4	158.2	37,075
	Subdiv. 22-24	22.4	25.8	46.4	75.3	95.2	117.2	125.9	157.1	162.6	40,315
2004	Div. IV+Div. IIIa	27.1	43.2	81.9	117.1	145.4	157.4	170.7	184.4	187.1	35,078
	Subdiv. 22-24	3.7	14.3	47.4	77.7	96.4	125.5	150.4	165.8	151.0	41,736
2005	Div. IV+Div. IIIa	14.1	54.9	85.6	121.6	148.3	162.7	176.3	178.3	200.6	50,765
	Subdiv. 22-24	13.6	14.2	48.3	73.3	89.3	115.5	143.6	159.9	170.2	37,013
2006 c	Div. IV+Div. IIIa	16.6	36.9	82.9	113.0	142.5	175.2	198.2	209.5	220.0	25,965
	Subdiv. 22-24	21.2	34.0	56.7	84.0	102.2	125.3	143.9	175.8	170.0	70,911
2007	Div. IV+Div. IIIa	25.2	65.6	85.0	115.7	138.4	159.2	190.8	178.6	211.9	28,632
	Subdiv. 22-24	11.9	27.8	57.3	74.9	106.3	121.3	140.8	162.7	185.5	39,548
2008	Div. IV+Div. IIIa	19.2	71.5	91.1	114.5	142.2	171.2	181.4	200.0	196.4	25,368
	Subdiv. 22-24	16.3	49.5	65.2	88.1	110.5	133.2	140.3	156.7	172.2	43,116
2009	Div. IV+Div. IIIa	13.4	52.0	90.3	118.6	167.5	181.4	213.9	228.9	259.5	36,230
	Subdiv. 22-24	10.5	28.3	48.1	90.5	123.7	145.2	160.4	171.2	181.8	31,032
2010	Div. IV+Div. IIIa	8.2	59.3	84.7	129.8	165.9	196.2	221.8	234.3	257.2	27,465
	Subdiv. 22-24	12.2	22.2	52.2	87.1	119.8	154.8	170.6	191.9	194.1	17,917
2011	Div. IV+Div. IIIa	8.4	33.7	89.0	120.4	140.2	170.2	185.9	216.3	211.8	11,941
	Subdiv. 22-24	12.4	23.0	55.1	78.1	113.2	136.6	147.6	161.2	168.0	15,830
2012	Div. IV+Div. IIIa	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	Div. IV+Div. IIIa		59.5	94.2	131.8	162.6	195.0	207.8	247.9	238.1	18,325
	Subdiv. 22-24	13.7	17.8	54.1	86.8	129.4	136.9	145.3	159.1	179.8	25,504
2014	Div. IV+Div. IIIa	9.3	52.2	98.5	137.4	178.2	199.2	211.7	225.1	227.0	19,020
	Subdiv. 22-24	16.5	30.0	59.0	82.3	122.1	158.4	156.0	163.0	175.5	18,338
2015	Div. IV+Div. IIIa	16.0	31.8	67.9	115.2	152.4	172.8	193.4	198.7	212.9	15,348
	Subdiv. 22-24	7.1	15.9	50.4	79.3	107.6	144.7	170.6	135.6	149.4	22,144
2016	Div. IV+Div. IIIa	7.1	40.1	63.8	126.1	160.7	175.1	200.8	212.8	235.0	26,224
	Subdiv. 22-24	10.3	34.1	51.7	84.6	95.0	129.5	160.4	168.1	169.2	25,073
2017	Div. IV+Div. IIIa	30.5	44.1	61.3	113.2	141.8	162.8	171.2	182.9	169.9	19,827
	Subdiv. 22-24	18.1	34.3	57.7	82.8	117.9	123.5	137.6	147.5	139.8	26,513
2018	Div. IV+Div. IIIa	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

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 1993–2018.

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

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 1993–2018 (September/October).

Year	1993	1994	1995	1996	1997	1998	1999	2000	* 2001	** 2002	2003	2004	*** 2005
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
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
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
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
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
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
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
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
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
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
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
W-rings/Biomass ('000 tonnes)													
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

Year	*** 2006	*** 2007	*** 2008	*** 2009	*** 2010	*** 2011	*** 2012	*** 2013	*** 2014	**** 2015	***** 2016	*** 2017	*** 2018
W-rings/Numbers in millions													
0	4,159.311	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	940.892	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
2	226.959	260.402	165.347	95.866	305.540	360.354	294.242	456.204	242.590	509.769	155.417	145.360	89.280
3	279.618	117.412	166.301	43.553	214.539	210.455	193.974	307.567	279.650	221.344	196.061	123.230	41.160
4	212.201	76.782	102.018	17.761	107.364	115.984	124.548	262.908	332.660	129.795	60.953	137.500	20.240
5	139.813	43.919	82.174	9.016	85.635	57.840	70.135	87.114	317.240	95.579	30.490	46.550	17.570
6	97.261	12.144	29.727	3.227	47.140	50.844	45.017	32.684	211.600	86.150	14.980	21.230	4.940
7	66.937	9.262	11.443	1.947	25.021	29.234	22.520	22.565	85.630	47.093	3.300	2.130	1.060
8+	27.789	8.839	9.262	1.704	15.309	14.774	21.404	11.300	56.590	37.886	0.000	1.790	1.100
Total	6,150.781	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
3+ group	823.619	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
W-rings/Biomass ('000 tonnes)													
0	42.958	25.202	23.699	29.449	36.791	35.064	46.955	85.185	61.640	8.179	24.072	13.623	32.010
1	38.230	22.782	17.602	10.473	21.336	46.384	29.825	38.404	30.369	16.822	18.553	18.296	18.825
2	18.013	20.202	10.446	7.069	24.593	29.560	20.380	30.587	21.490	38.573	10.579	10.159	5.797
3	31.946	11.366	15.297	4.433	23.540	24.382	22.068	27.349	32.448	22.841	18.068	11.511	3.323
4	31.253	9.679	11.077	1.961	15.193	16.361	18.653	27.350	58.819	15.196	5.859	17.427	1.785
5	24.876	6.724	11.584	1.385	15.433	9.867	11.450	10.934	63.755	14.581	3.417	6.711	2.239
6	17.959	2.001	4.823	0.616	9.018	8.391	7.985	4.849	45.705	14.304	1.723	3.175	0.719
7	13.431	1.703	1.756	0.384	4.728	5.295	4.448	3.751	18.709	8.433	0.450	0.257	0.182
8+	6.344	1.798	1.303	0.284	3.013	3.015	3.876	1.821	13.498	7.108	0.000	0.190	0.203
Total	225.010	101.456	97.588	56.055	153.646	178.320	165.640	230.231	346.433	146.035	82.722	81.349	65.083
3+ group	125.809	33.270	45.840	9.064	70.926	67.312	68.480	76.055	232.933	82.462	29.518	39.271	8.451
W-rings/Mean weight (g)													
0	10.3	9.7	11.0	10.4	8.1	12.0	11.4	9.5	11.3	9.2	9.1	10.6	12.1
1	40.6	40.8	44.8	38.7	39.9	38.4	39.5	43.0	39.5	38.2	37.6	39.4	43.9
2	79.4	77.6	63.2	73.7	80.5	82.0	69.3	67.0	88.6	75.7	68.1	69.9	64.9
3	114.2	96.8	92.0	101.8	109.7	115.9	113.8	88.9	116.0	103.2	92.2	93.4	80.7
4	147.3	126.1	108.6	110.4	141.5	141.1	149.8	104.0	176.8	117.1	96.1	126.7	88.2
5	177.9	153.1	141.0	153.6	180.2	170.6	163.3	125.5	201.0	152.5	112.1	144.2	127.4
6	184.6	164.8	162.2	190.9	191.3	165.0	177.4	148.4	216.0	166.0	115.0	149.5	145.6
7	200.6	183.8	153.5	197.4	189.0	181.1	197.5	166.2	218.5	179.1	136.4	120.5	172.0
8+	228.3	203.4	140.7	166.9	196.8	204.1	181.1	161.1	238.5	187.6	-	106.4	184.2
Total	36.6	27.6	31.4	17.2	26.1	35.8	29.4	20.8	44.6	59.5	23.0	36.4	20.1

small revision in 2015

small revision in 2017 (<0.5 %)

small revision in 2018

*incl. mean for Sub-division 23, which was not covered by RV SOLEA

**incl. mean for Sub-division 21, which was not covered by RV SOLEA

***** excl. Central Baltic Herring in SD 24 (SD 23) based on SF (Gröhsler et al. 2013)**

****** excl. Central Baltic Herring in SD 22, SD 24 (SD 23) based on SF & excl. mature herring in SD 23 (stages>=6)**

******* excl. Central Baltic Herring in SD 22, SD 24 (SD 23) based on SF**

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 1991–2018 (July).

		*	*	*	*	*			**					
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
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	1,864	2,092	2,768	413	1,887	1,005	715	1,682	1,143	1,891	641	1,577	1,110	930
3	1,927	1,799	1,274	935	1,022	247	787	901	523	674	452	1,393	395	726
4	866	1,593	598	501	1,270	141	166	282	135	364	153	524	323	307
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18
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
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
W-rings/Biomass ('000 tonnes)														
0		34.3	1	8.7										
1		26.8	7	0.4	77.4	52.9	4.7	7.1	74.8	61.4	3.5	137.2	79.0	63.9
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
W-rings/Numbers in millions														
0				112				1		314	2	203	1	
1	2,687	2,081	3,918	5,852	565	999	2,980	1,018	49	513	1,949	425	696	106
2	1,342	2,217	3,621	1,160	398	511	473	1,081	627	415	1,244	255	424	224
3	464	1,780	933	843	205	254	259	236	525	176	446	381	661	271
4	201	490	499	333	161	115	163	87	53	248	224	99	401	175
5	103	180	154	274	82	65	70	76	30	28	171	40	94	169
6	84	27	34	176	86	24	53	33	12	37	82	40	53	50
7	37	10	26	45	39	28	22	14	8	26	89	12	52	35
8+	21	0.1	14	44	65	34	46	60	15	42	115	28	92	44
Total	**4,939**	**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**
3+ group	**910**	**2,487**	**1,660**	**1,715**	**638**	**520**	**613**	**506**	**643**	**557**	**1,127**	**600**	**1,353**	**744**
W-rings/Biomass ('000 tonnes)														
0								0.0		1.0	0.03	1.00	0.00	
1	105.9	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
2	100.1	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
3	46.6	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
4	28.9	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
5	16.5	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
6	14.9	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
7	7.5	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
8+	4.9	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
Total	325.3	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
3+ group	119.3	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
W-rings/Mean weight (g)														
0				6.3				3.0		4.3	14.2	4.0	23.0	
1	39.4	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
2	74.6	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
3	100.5	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
4	143.7	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
5	160.9	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
6	177.7	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
7	202.3	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
8+	229.2	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
Total	65.9	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

* 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	1563

*** 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

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

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

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

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	0.1036	0.1478	0.1595	0.1666	0.1957	0.1997	0.2116	0.2215
2015	0.0000	0.1147	0.1367	0.1436	0.1624	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

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	0.0662	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

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	0.1102	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	0.1102	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

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	0.0258	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	0.1748
2009	0.0105	0.0283	0.0480	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

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	0.0130	0.0459	0.0708	0.1327	0.1674	0.1892	0.2097	0.2338
1996	0.0001	0.0182	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	0.0870	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

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

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

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

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

Table 3.6.8.a WESTERN BALTIC SPRING SPAWNING HERRING. ***Multi fleet.*** **Survey indices: HERAS (number).**

	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

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

	1	2	3	4
1994	415730	883810	559720	443730
1995	1675340	328610	357960	353850
1996	1439460	590010	434090	295170
1997	1955400	738180	394530	162430
1998	801350	678530	394070	236830
1999	1338710	287240	232510	155950
2000	1429880	453980	328960	201590
2001	NA	NA	NA	NA
2002	837549	421393	575356	341119
2003	1238480	222530	217270	260350
2004	968860	592360	346230	163150
2005	750199	590756	295659	142778
2006	940892	226959	279618	212201
2007	558851	260402	117412	76782
2008	392737	165347	166301	102018
2009	270959	95866	43553	17761
2010	534633	305540	214539	107364
2011	1206762	360354	210455	115984
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

Table 3.6.8.c WESTERN BALTIC SPRING SPAWNING HERRING, continued. ***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

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

	1	2	3
2002	1685921	66568	15361
2003	677316	137968	4606
2004	397528	79234	16531
2005	281731	135149	8461
2006	171192	34974	8390
2007	259420	40925	4085
2008	226275	38457	4944
2009	760622	45336	1568
2010	330962	87048	12069
2011	217289	78029	15795
2012	419748	91357	4881
2013	206366	87070	17144
2014	179149	20326	4118
2015	364206	74560	2527
2016	246559	116596	7753
2017	570307	80518	13972
2018	128716	72751	3773

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

	2	3
2002	3994	1727
2003	7980	1839
2004	4164	1592
2005	4376	790
2006	3412	1557
2007	4432	805.2
2008	2900	1520
2009	3984	726.1
2010	4688	1430
2011	3458	845.1
2012	7288	1065
2013	6334	1842
2014	1540	1585
2015	12370	1788
2016	9957	2785
2017	6436	1973
2018	7455	1198

Table 3.6.9 WESTERN BALTIC SPRING SPAWNING HERRING. SAM software version.

Multi fleet:

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. Multi fleet. SAM configuration settings.

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

continued

Table 3.6.10- WESTERN BALTIC SPRING SPAWNING HERRING. *Multi fleet.* SAM configuration settings.

```
$keyQpow
# Density dependent catchability power parameters (if any).
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyVarF
# Coupling of process variance parameters for log(F)-process (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"
```

continued

Table 3.6.10 WESTERN BALTIC SPRING SPAWNING HERRING. *Multi fleet.* SAM configuration settings.

```
$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#0-1 1-2 2-3 3-4 4-5 5-6 6-7 7-8
 NA  NA  NA  NA  NA  NA  NA  NA
 3  3  3  3  4  4  4  4
 NA  NA  NA  NA  NA  NA  NA  NA
 3  3   3  3 4  4  4  4
 -1  -1  -1  0  0  1  -1  -1
 -1  2  1  0  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1
 -1  2  1  -1  -1  -1  -1  -1
 -1  -1  NA  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1
$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt).
 0
$noScaledYears
# Number of years where catch scaling is applied.
 0
$keyScaledYears
# A vector of the years where catch scaling is applied.

$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).
$fbarRange
# lowest and higest age included in Fbar
 3 6
$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "LN" "LN" "LN" "LN" "LN" "LN" "LN" "LN" "LN" "LN"

$fixVarToWeight
# If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight).
 0
```

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

Year	$R_{(age\ 0)}$	Low	High	SSB	Low	High	$F_{bar(3–6)}$	Low	High	TSB	Low	High
1991	4994620	3840771	6495110	297743	243137	364614	0.490	0.390	0.617	593376	501032	702739
1992	3542228	2823683	4443621	292363	243576	350921	0.523	0.438	0.624	506385	433303	591795
1993	3004215	2344313	3849874	274789	230037	328247	0.560	0.477	0.656	438432	374855	512793
1994	4456350	3472205	5719437	221515	186391	263259	0.592	0.507	0.692	365959	314514	425820
1995	4132201	3270593	5220793	190874	160150	227491	0.614	0.526	0.717	310882	267681	361056
1996	4186672	3325467	5270907	131122	110988	154908	0.626	0.534	0.733	274398	237783	316652
1997	3474711	2685029	4496643	148064	125219	175078	0.614	0.526	0.718	280206	242093	324320
1998	4623046	3659476	5840333	120878	102496	142556	0.602	0.517	0.702	266555	231021	307554
1999	4896152	3935234	6091709	121711	103214	143523	0.576	0.493	0.674	272034	236687	312661
2000	2921274	2324862	3670689	122677	104350	144224	0.580	0.498	0.676	256410	223269	294470
2001	2822649	2298761	3465930	136818	116982	160017	0.568	0.486	0.664	277696	241921	318763
2002	2694436	2183779	3324505	164949	141056	192890	0.533	0.453	0.625	294439	256279	338282
2003	2894969	2349207	3567520	129138	110356	151118	0.506	0.428	0.600	222932	194373	255686
2004	1976097	1585086	2463565	129940	111175	151873	0.499	0.425	0.588	221749	193512	254106
2005	1747738	1426297	2141622	119352	102382	139135	0.509	0.437	0.593	208597	181824	239311
2006	1352125	1098553	1664228	132111	113193	154191	0.520	0.447	0.605	223781	194888	256959
2007	1446726	1180408	1773130	104839	89580	122697	0.531	0.456	0.619	171371	148965	197146
2008	1189959	967196	1464028	86646	74402	100905	0.531	0.449	0.628	152469	133355	174324
2009	1155814	933572	1430963	80833	69388	94166	0.505	0.427	0.597	141308	123827	161258
2010	1593242	1272694	1994526	75973	65286	88408	0.437	0.368	0.519	126606	110627	144893
2011	1403676	1146518	1718514	69299	59508	80700	0.368	0.301	0.450	115018	100362	131816
2012	1152037	916988	1447335	70821	60753	82558	0.361	0.302	0.432	124242	108255	142590
2013	1743986	1298427	2342439	83044	70988	97148	0.354	0.295	0.426	140170	121422	161812
2014	1247045	977042	1591663	89459	75831	105538	0.345	0.284	0.419	148422	128372	171603
2015	1014505	778367	1322280	90109	75905	106972	0.367	0.298	0.451	150846	129126	176219
2016	1054035	769034	1444655	88443	73246	106793	0.402	0.315	0.513	135468	113683	161426
2017	1057849	702464	1593028	83895	66603	105676	0.416	0.311	0.557	130734	105897	161398
2018	954391	512215	1778279	74132	55092	99751	0.416	0.297	0.584	114957	88016	150145

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	0.212	0.344	0.394	0.459	0.515	0.594	0.667	0.667
1992	0.026	0.211	0.360	0.416	0.487	0.550	0.638	0.721	0.721
1993	0.033	0.242	0.387	0.444	0.521	0.588	0.686	0.775	0.775
1994	0.039	0.269	0.415	0.471	0.551	0.621	0.726	0.820	0.820
1995	0.063	0.352	0.451	0.494	0.571	0.641	0.750	0.847	0.847
1996	0.048	0.299	0.434	0.492	0.579	0.658	0.774	0.880	0.880
1997	0.050	0.295	0.419	0.478	0.566	0.646	0.767	0.883	0.883
1998	0.054	0.304	0.420	0.471	0.556	0.633	0.750	0.873	0.873
1999	0.036	0.244	0.395	0.451	0.532	0.606	0.717	0.839	0.839
2000	0.028	0.221	0.388	0.449	0.535	0.610	0.725	0.851	0.851
2001	0.029	0.219	0.369	0.431	0.522	0.599	0.720	0.844	0.844
2002	0.028	0.211	0.353	0.405	0.490	0.562	0.673	0.793	0.793
2003	0.025	0.200	0.331	0.381	0.465	0.535	0.645	0.762	0.762
2004	0.025	0.199	0.315	0.370	0.459	0.528	0.641	0.757	0.757
2005	0.017	0.176	0.320	0.379	0.471	0.538	0.649	0.766	0.766
2006	0.017	0.186	0.356	0.403	0.483	0.545	0.648	0.756	0.756
2007	0.013	0.171	0.357	0.410	0.496	0.558	0.660	0.763	0.763
2008	0.013	0.171	0.364	0.411	0.496	0.558	0.657	0.752	0.752
2009	0.014	0.187	0.380	0.401	0.472	0.528	0.619	0.704	0.704
2010	0.008	0.135	0.309	0.342	0.409	0.457	0.540	0.613	0.613
2011	0.006	0.104	0.237	0.276	0.344	0.389	0.465	0.530	0.530
2012	0.006	0.098	0.218	0.262	0.336	0.385	0.461	0.522	0.522
2013	0.006	0.097	0.211	0.253	0.330	0.380	0.455	0.514	0.514
2014	0.006	0.094	0.210	0.249	0.321	0.370	0.439	0.495	0.495
2015	0.007	0.113	0.245	0.270	0.342	0.393	0.462	0.521	0.521
2016	0.006	0.117	0.284	0.310	0.377	0.428	0.494	0.554	0.554
2017	0.005	0.110	0.292	0.328	0.390	0.441	0.505	0.562	0.562
2018	0.005	0.111	0.295	0.330	0.391	0.442	0.503	0.557	0.557

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	0.002	0.012	0.015	0.017	0.021	0.026	0.026
1992	0.000	0.000	0.002	0.012	0.015	0.017	0.021	0.027	0.027
1993	0.000	0.000	0.002	0.012	0.015	0.017	0.022	0.028	0.028
1994	0.000	0.000	0.002	0.012	0.015	0.017	0.022	0.029	0.029
1995	0.000	0.000	0.002	0.012	0.015	0.017	0.022	0.030	0.030
1996	0.000	0.000	0.002	0.012	0.015	0.017	0.023	0.031	0.031
1997	0.000	0.000	0.002	0.012	0.015	0.017	0.023	0.033	0.033
1998	0.000	0.000	0.002	0.012	0.015	0.017	0.023	0.035	0.035
1999	0.000	0.000	0.002	0.012	0.015	0.018	0.023	0.037	0.037
2000	0.000	0.000	0.002	0.012	0.016	0.018	0.024	0.039	0.039
2001	0.000	0.000	0.002	0.011	0.016	0.018	0.024	0.039	0.039
2002	0.000	0.000	0.002	0.011	0.015	0.017	0.023	0.039	0.039
2003	0.000	0.000	0.001	0.011	0.015	0.016	0.022	0.038	0.038
2004	0.000	0.000	0.001	0.010	0.014	0.014	0.021	0.036	0.036
2005	0.000	0.000	0.001	0.009	0.013	0.013	0.021	0.036	0.036
2006	0.000	0.000	0.001	0.008	0.012	0.012	0.020	0.035	0.035
2007	0.000	0.000	0.001	0.007	0.011	0.010	0.018	0.031	0.031
2008	0.000	0.000	0.001	0.006	0.010	0.008	0.017	0.028	0.028
2009	0.000	0.000	0.001	0.006	0.009	0.008	0.017	0.028	0.028
2010	0.000	0.000	0.001	0.005	0.009	0.007	0.016	0.026	0.026
2011	0.000	0.000	0.001	0.005	0.008	0.006	0.016	0.024	0.024
2012	0.000	0.000	0.001	0.005	0.008	0.006	0.016	0.022	0.022
2013	0.000	0.000	0.001	0.005	0.008	0.006	0.016	0.023	0.023
2014	0.000	0.000	0.001	0.005	0.008	0.007	0.017	0.025	0.025
2015	0.000	0.000	0.001	0.005	0.008	0.007	0.017	0.026	0.026
2016	0.000	0.000	0.001	0.005	0.008	0.007	0.016	0.025	0.025
2017	0.000	0.000	0.001	0.005	0.008	0.007	0.016	0.024	0.024
2018	0.000	0.000	0.001	0.005	0.008	0.008	0.016	0.024	0.024

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	0.000	0.047	0.166	0.136	0.111	0.099	0.095	0.094	0.094
1992	0.000	0.050	0.175	0.144	0.118	0.105	0.100	0.099	0.099
1993	0.000	0.053	0.185	0.152	0.125	0.111	0.106	0.105	0.105
1994	0.000	0.057	0.199	0.164	0.134	0.119	0.114	0.113	0.113
1995	0.000	0.060	0.210	0.173	0.141	0.126	0.120	0.119	0.119
1996	0.000	0.058	0.204	0.167	0.137	0.122	0.116	0.115	0.115
1997	0.000	0.055	0.193	0.159	0.130	0.116	0.110	0.109	0.109
1998	0.000	0.056	0.196	0.161	0.132	0.117	0.112	0.111	0.111
1999	0.000	0.055	0.194	0.160	0.130	0.116	0.111	0.110	0.110
2000	0.000	0.055	0.193	0.159	0.130	0.116	0.110	0.109	0.109
2001	0.000	0.049	0.173	0.142	0.116	0.104	0.099	0.098	0.098
2002	0.000	0.049	0.173	0.142	0.116	0.104	0.099	0.098	0.098
2003	0.000	0.043	0.151	0.124	0.101	0.090	0.086	0.085	0.085
2004	0.000	0.035	0.122	0.101	0.082	0.073	0.070	0.069	0.069
2005	0.000	0.041	0.143	0.118	0.096	0.086	0.082	0.081	0.081
2006	0.000	0.049	0.170	0.140	0.114	0.102	0.097	0.096	0.096
2007	0.000	0.052	0.183	0.150	0.123	0.109	0.104	0.103	0.103
2008	0.000	0.055	0.191	0.157	0.129	0.115	0.109	0.108	0.108
2009	0.000	0.059	0.208	0.171	0.140	0.125	0.119	0.118	0.118
2010	0.000	0.054	0.190	0.156	0.128	0.114	0.109	0.108	0.108
2011	0.000	0.040	0.139	0.114	0.093	0.083	0.079	0.079	0.079
2012	0.000	0.033	0.117	0.097	0.079	0.070	0.067	0.066	0.066
2013	0.000	0.029	0.102	0.084	0.069	0.061	0.058	0.058	0.058
2014	0.000	0.031	0.108	0.089	0.073	0.065	0.062	0.061	0.061
2015	0.000	0.035	0.123	0.101	0.083	0.074	0.070	0.070	0.070
2016	0.000	0.049	0.171	0.141	0.115	0.103	0.098	0.097	0.097
2017	0.000	0.057	0.199	0.164	0.134	0.119	0.114	0.113	0.113
2018	0.000	0.058	0.202	0.166	0.136	0.121	0.116	0.115	0.115

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	0.016	0.051	0.017	0.008	0.004	0.003	0.005	0.004	0.004
1992	0.014	0.041	0.014	0.007	0.004	0.003	0.004	0.003	0.003
1993	0.021	0.062	0.020	0.010	0.005	0.004	0.005	0.004	0.004
1994	0.026	0.080	0.025	0.012	0.006	0.004	0.006	0.005	0.005
1995	0.050	0.158	0.047	0.020	0.009	0.006	0.009	0.006	0.006
1996	0.035	0.103	0.030	0.013	0.006	0.004	0.006	0.005	0.005
1997	0.037	0.103	0.029	0.012	0.006	0.004	0.006	0.005	0.005
1998	0.041	0.116	0.033	0.013	0.006	0.004	0.006	0.005	0.005
1999	0.024	0.064	0.020	0.008	0.004	0.003	0.004	0.003	0.003
2000	0.016	0.042	0.014	0.005	0.003	0.002	0.003	0.003	0.003
2001	0.018	0.050	0.019	0.008	0.005	0.005	0.009	0.010	0.010
2002	0.018	0.057	0.021	0.007	0.004	0.003	0.004	0.003	0.003
2003	0.016	0.060	0.031	0.014	0.009	0.008	0.010	0.008	0.008
2004	0.016	0.068	0.043	0.023	0.014	0.012	0.012	0.009	0.009
2005	0.009	0.040	0.026	0.012	0.007	0.005	0.004	0.003	0.003
2006	0.008	0.049	0.043	0.023	0.013	0.013	0.011	0.009	0.009
2007	0.005	0.031	0.030	0.015	0.008	0.009	0.008	0.007	0.007
2008	0.005	0.032	0.033	0.014	0.005	0.006	0.005	0.006	0.006
2009	0.007	0.054	0.048	0.014	0.004	0.004	0.003	0.003	0.003
2010	0.003	0.021	0.016	0.003	0.000	0.000	0.000	0.000	0.000
2011	0.001	0.013	0.008	0.001	0.000	0.000	0.000	0.000	0.000
2012	0.001	0.012	0.009	0.001	0.000	0.000	0.000	0.000	0.000
2013	0.001	0.014	0.017	0.002	0.000	0.000	0.000	0.000	0.000
2014	0.001	0.013	0.014	0.001	0.000	0.000	0.000	0.000	0.000
2015	0.002	0.027	0.031	0.003	0.000	0.000	0.000	0.000	0.000
2016	0.001	0.017	0.022	0.001	0.000	0.000	0.000	0.000	0.000
2017	0.000	0.004	0.005	0.000	0.000	0.000	0.000	0.000	0.000
2018	0.000	0.003	0.005	0.000	0.000	0.000	0.000	0.000	0.000

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

Year Age	0	1	2	3	4	5	6	7	8
1991	0.011	0.113	0.159	0.237	0.328	0.395	0.473	0.544	0.544
1992	0.011	0.120	0.169	0.252	0.351	0.425	0.513	0.591	0.591
1993	0.012	0.127	0.180	0.270	0.377	0.456	0.553	0.638	0.638
1994	0.012	0.132	0.188	0.283	0.396	0.480	0.584	0.674	0.674
1995	0.013	0.135	0.193	0.290	0.406	0.493	0.600	0.693	0.693
1996	0.013	0.139	0.198	0.299	0.421	0.514	0.629	0.728	0.728
1997	0.013	0.136	0.195	0.295	0.416	0.509	0.628	0.736	0.736
1998	0.012	0.132	0.189	0.286	0.403	0.494	0.610	0.722	0.722
1999	0.012	0.124	0.179	0.271	0.383	0.469	0.579	0.688	0.688
2000	0.011	0.124	0.179	0.272	0.387	0.475	0.588	0.700	0.700
2001	0.011	0.119	0.175	0.269	0.385	0.473	0.588	0.698	0.698
2002	0.010	0.105	0.157	0.245	0.355	0.439	0.548	0.653	0.653
2003	0.009	0.097	0.147	0.233	0.340	0.421	0.527	0.630	0.630
2004	0.009	0.097	0.149	0.237	0.348	0.429	0.537	0.643	0.643
2005	0.009	0.095	0.149	0.240	0.354	0.434	0.542	0.646	0.646
2006	0.008	0.089	0.142	0.232	0.344	0.418	0.519	0.616	0.616
2007	0.008	0.088	0.144	0.238	0.355	0.430	0.529	0.621	0.621
2008	0.008	0.084	0.139	0.234	0.352	0.429	0.526	0.610	0.610
2009	0.007	0.073	0.123	0.210	0.319	0.391	0.481	0.554	0.554
2010	0.006	0.061	0.103	0.177	0.272	0.336	0.415	0.479	0.479
2011	0.005	0.052	0.089	0.155	0.242	0.300	0.370	0.428	0.428
2012	0.005	0.053	0.091	0.160	0.250	0.309	0.378	0.433	0.433
2013	0.005	0.053	0.092	0.162	0.253	0.313	0.381	0.433	0.433
2014	0.005	0.050	0.087	0.154	0.241	0.298	0.360	0.409	0.409
2015	0.005	0.052	0.090	0.160	0.251	0.312	0.375	0.425	0.425
2016	0.005	0.051	0.090	0.162	0.253	0.317	0.380	0.431	0.431
2017	0.005	0.050	0.088	0.159	0.248	0.314	0.375	0.425	0.425
2018	0.005	0.050	0.087	0.158	0.246	0.313	0.371	0.418	0.418

Table 3.6.13 - WESTERN BALTIC SPRING SPAWNING HERRING. ***Multi fleet.*** **Estimated stock numbers at age**

Year Age	0	1	2	3	4	5	6	7	8
1991	4994620	4038068	2224444	1882555	930749	565330	169222	50680	17225
1992	3542228	3633694	1974043	1295106	1040321	479862	275737	76996	28818
1993	3004215	2559018	1806525	1119318	705523	522434	225700	119294	42294
1994	4456350	2124513	1216170	1018802	580691	347199	236468	92873	60949
1995	4132201	3206989	987145	649441	533794	267367	154653	93111	55316
1996	4186672	2866299	1373342	516011	322248	246379	114815	59835	52103
1997	3474711	2962036	1283619	737858	257955	146702	103191	43234	38322
1998	4623046	2419112	1335824	691050	377637	119788	63347	38593	27590
1999	4896152	3256134	1072965	714066	354101	179109	51733	24723	22288
2000	2921274	3537911	1552326	587459	370617	171616	80307	20723	16611
2001	2822649	2080789	1725163	871579	303087	177744	75916	32094	13061
2002	2694436	2027765	995229	978877	472807	145169	80442	29769	16017
2003	2894969	1927662	997820	566183	534587	238800	67358	33694	16926
2004	1976097	2115708	960310	590429	316185	273675	114903	29008	19242
2005	1747738	1414362	1059363	581960	333121	163850	131957	49776	18487
2006	1352125	1274935	706236	630405	333682	169634	79484	56019	26028
2007	1446726	976824	646563	402046	340762	171607	78771	35079	31137
2008	1189959	1066907	492654	371050	216954	168798	81822	33339	25354
2009	1155814	867890	550821	279555	198901	108907	78077	35040	22685
2010	1593242	833844	436318	306303	154406	102442	52818	33657	23547
2011	1403676	1180495	437100	260108	176959	83932	53720	25308	25135
2012	1152037	1032210	657141	281883	160209	102505	46643	27762	24305
2013	1743986	838529	562871	441787	177078	93940	56596	24228	25328
2014	1247045	1315245	451557	369587	285285	102699	52736	29428	24565
2015	1014505	918454	750014	299880	234844	165992	58554	27721	27320
2016	1054035	740328	496479	491326	187232	136851	90031	30174	27009
2017	1057849	779493	397635	298736	301847	105514	73898	44314	26778
2018	954391	785232	429157	241251	170043	171417	55844	36731	32596

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	115143.85	647736.81	643672.84	613948.60	342269.57	227230.90	76051.46	24909.60	8466.32
1992	77887.58	579320.76	595502.77	443072.04	402904.36	203535.37	131219.63	40146.44	15025.92
1993	86026.80	467140.53	584000.71	407006.15	289484.38	234322.18	113697.82	65745.86	23309.32
1994	148758.06	429357.34	419456.23	390656.39	250429.43	163087.03	124745.88	53511.82	35117.91
1995	219718.04	837414.12	369426.20	260796.31	237696.37	129266.16	83980.51	55126.28	32749.68
1996	170505.31	641939.32	493668.64	205516.99	144723.28	120990.89	63490.69	36231.53	31549.74
1997	148756.29	653278.23	447270.91	285933.25	113420.00	70864.83	56490.80	26186.07	23211.27
1998	210270.44	549938.39	467044.28	265002.62	163737.99	57035.86	34178.72	23255.89	16625.83
1999	150584.74	598901.15	353474.58	262849.33	148073.46	82378.57	26986.33	14503.76	13075.61
2000	70133.35	589457.01	501656.63	215171.71	155600.65	79354.74	42199.30	12279.97	9843.10
2001	70450.50	344429.48	533363.73	307410.91	124236.84	80640.96	39614.28	18895.44	7689.51
2002	64092.60	325129.12	295391.40	327478.96	183922.77	62568.19	39836.00	16713.90	8992.85
2003	62416.07	292664.21	280276.46	179539.17	198597.01	98617.98	32208.81	18316.85	9201.50
2004	41955.97	320660.33	258509.86	181889.96	115412.24	111175.86	54187.07	15539.64	10307.94
2005	26312.32	189531.83	287672.66	183052.76	124396.23	67557.92	62867.77	26945.91	10007.96
2006	19336.02	181080.65	213036.77	211083.52	128825.74	71689.06	38340.40	30463.23	14154.36
2007	16348.70	127804.46	194508.99	136449.64	134295.75	73830.94	38543.03	19190.82	17034.14
2008	12851.29	139399.93	150915.35	126208.41	85483.99	72590.30	39896.81	18059.62	13734.30
2009	13596.70	123960.86	175786.23	93104.80	75429.21	44907.03	36540.76	18172.99	11765.12
2010	11528.80	86807.34	113700.57	87719.71	51623.14	37335.93	22071.15	15612.35	10922.86
2011	7785.18	95031.85	88751.38	60923.70	50246.77	26372.37	19626.22	10309.83	10239.57
2012	6105.53	78376.22	123817.08	62857.98	44384.85	31662.36	16807.65	11084.09	9704.09
2013	9167.43	62926.66	103280.18	95054.89	47957.97	28580.44	20079.70	9513.68	9945.69
2014	6222.23	95309.16	82016.15	78658.01	75749.62	30615.72	18212.93	11260.56	9399.88
2015	5891.92	80401.71	158713.61	68802.80	66116.98	52360.85	21178.64	11098.80	10938.55
2016	5538.19	67001.93	120024.96	128437.54	58024.53	46970.11	34887.05	12877.10	11526.51
2017	4618.04	65846.66	97626.83	82398.20	96960.66	37425.32	29344.02	19255.07	11635.53
2018	4164.73	66787.36	106175.61	66873.56	54686.57	60928.32	22142.54	15870.56	14084.11

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	11.74	3813.84	20239.28	12387.52	8686.22	3188.94	1185.30	402.86
1992	0.00	10.57	3385.87	13903.77	13861.23	7330.07	5263.25	1854.74	694.19
1993	0.00	7.44	3095.72	12057.60	9458.96	7959.15	4373.53	2957.87	1048.67
1994	0.00	6.18	2084.58	10925.16	7889.62	5282.00	4660.33	2373.93	1557.93
1995	0.00	9.32	1691.65	6971.93	7270.59	4094.04	3099.12	2458.75	1460.71
1996	0.00	8.33	2350.89	5527.54	4408.17	3805.97	2333.25	1657.04	1442.92
1997	0.00	8.61	2196.43	7874.86	3537.72	2271.89	2113.49	1278.78	1133.51
1998	0.00	7.03	2288.06	7335.06	5211.63	1878.72	1296.09	1215.47	868.95
1999	0.00	9.47	1838.24	7591.61	4915.41	2846.53	1072.06	816.27	735.90
2000	0.00	10.29	2657.50	6216.12	5253.13	2753.13	1706.48	711.21	570.07
2001	0.00	6.27	2847.18	8983.70	4271.24	2803.97	1630.81	1118.56	455.20
2002	0.00	5.90	1516.71	9800.61	6464.85	2184.41	1690.65	1038.74	558.89
2003	0.00	5.57	1335.33	5416.06	7012.09	3342.35	1358.50	1146.45	575.92
2004	0.00	6.23	1248.73	5444.56	3970.86	3543.85	2212.42	937.18	621.66
2005	0.00	4.36	1244.32	4923.25	3995.15	1939.05	2467.12	1586.80	589.35
2006	0.00	4.20	712.60	4730.53	3669.73	1816.04	1409.59	1744.35	810.49
2007	0.00	3.26	533.30	2611.72	3324.87	1531.25	1288.19	968.34	859.52
2008	0.00	3.66	349.40	2070.98	1908.27	1288.20	1230.93	838.09	637.37
2009	0.00	3.13	349.50	1455.35	1676.69	760.86	1165.86	891.75	577.31
2010	0.00	3.21	239.25	1466.78	1213.25	640.51	760.54	785.88	549.83
2011	0.00	4.69	218.15	1172.24	1298.25	474.73	750.28	534.78	531.14
2012	0.00	4.33	308.03	1221.60	1126.97	532.27	674.36	555.04	485.93
2013	0.00	3.80	268.39	1925.21	1226.40	529.85	826.99	500.74	523.48
2014	0.00	6.58	228.46	1689.34	2041.56	627.90	793.28	658.18	549.42
2015	0.00	4.93	375.78	1404.23	1684.93	1085.82	878.01	644.08	634.78
2016	0.00	4.17	255.27	2382.01	1346.29	915.24	1314.42	686.08	614.12
2017	0.00	4.49	200.11	1478.37	2180.28	714.32	1037.00	955.47	577.38
2018	0.00	4.66	219.26	1190.43	1262.81	1204.68	804.46	805.05	714.43

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	887.74	147021.76	308782.12	218026.79	89093.36	48522.84	13864.25	4118.16	1399.69
1992	664.25	139417.06	287875.94	157691.16	104760.38	43342.46	23776.36	6585.00	2464.62
1993	596.76	103867.40	277719.53	143792.48	75012.77	49839.71	20558.50	10777.74	3821.11
1994	952.92	92657.14	199937.75	140120.71	66164.42	35512.56	23097.86	8998.09	5905.13
1995	928.94	146850.99	169802.94	93533.47	63733.61	28666.34	15837.13	9457.75	5618.71
1996	913.71	127519.08	229991.48	72317.03	37424.39	25689.07	11433.07	5909.99	5146.31
1997	719.11	125133.07	204851.69	98457.63	28502.38	14547.79	9771.64	4060.81	3599.49
1998	970.58	103634.65	215980.14	93440.00	42289.50	12040.09	6080.21	3674.24	2626.74
1999	1019.29	138351.69	172158.48	95802.13	39340.40	17858.87	4925.69	2334.85	2104.94
2000	606.08	149824.93	248303.35	78567.83	41043.68	17056.40	7621.47	1950.81	1563.68
2001	523.54	78984.37	249072.41	105037.67	30202.49	15884.82	6476.96	2716.07	1105.30
2002	499.36	76912.82	143583.56	117879.08	47078.16	12963.48	6857.70	2517.49	1354.53
2003	468.91	64080.93	127106.32	60092.63	46843.34	18752.63	5048.28	2505.11	1258.45
2004	259.07	57138.39	100361.16	51290.10	22630.22	17537.54	7024.63	1759.23	1166.95
2005	268.79	44687.38	128590.30	58818.90	27781.77	12243.93	9410.01	3521.62	1307.96
2006	246.80	47646.11	100478.09	74843.31	32750.75	14933.18	6679.71	4671.23	2170.43
2007	283.22	39090.76	98092.40	50950.42	35732.47	16147.30	7077.24	3127.54	2776.06
2008	244.05	44681.17	77990.16	49100.55	23770.42	16601.20	7684.81	3107.33	2363.12
2009	257.77	39439.89	94091.46	39972.23	23575.62	11594.20	7939.71	3536.24	2289.35
2010	324.78	34715.32	68699.06	40312.60	16825.71	10020.87	4934.22	3120.24	2183.01
2011	208.99	36134.81	51492.20	25507.19	14317.76	6085.88	3717.58	1737.85	1726.00
2012	144.86	26758.99	66053.74	23545.15	11025.05	6317.50	2742.86	1619.91	1418.23
2013	191.05	18975.69	49648.15	32342.30	10669.45	5066.79	2912.13	1236.96	1293.13
2014	144.59	31478.07	42039.12	28572.37	18161.27	5854.13	2868.34	1588.21	1325.78
2015	134.00	24993.28	78985.25	26257.40	16951.20	10735.16	3614.39	1698.00	1673.48
2016	193.67	27851.97	71108.25	58737.90	18514.78	12145.71	7632.19	2538.57	2272.32
2017	225.72	33933.98	65288.86	41033.73	34360.74	10790.41	7221.34	4297.95	2597.18
2018	206.88	34712.54	71479.49	33622.74	19644.67	17792.91	5539.07	3616.01	3208.98

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	68487.87	159277.74	33274.14	14272.67	3525.85	1603.68	698.42	167.76	57.02
1992	43001.67	116039.36	24930.26	8449.06	3474.02	1229.79	1059.71	242.34	90.70
1993	54695.65	121770.51	32266.18	9952.70	3102.93	1711.42	1089.33	462.64	164.02
1994	100451.64	128360.75	27495.86	10922.90	3021.70	1315.46	1306.73	407.83	267.64
1995	174101.72	370232.48	40712.44	11612.54	4283.82	1473.97	1186.63	545.82	324.26
1996	123184.49	220694.49	36569.73	6062.03	1770.27	974.90	660.60	275.43	239.84
1997	110253.70	229838.95	33291.63	8015.65	1289.27	528.28	545.67	187.91	166.56
1998	160673.68	210094.69	39321.78	7866.07	1910.40	428.35	327.11	166.26	118.86
1999	100877.76	159149.03	19211.11	5039.48	1140.86	423.70	183.20	76.76	69.20
2000	40745.85	114407.73	19048.57	2850.19	846.65	296.31	214.40	50.49	40.47
2001	43062.29	80218.79	29104.92	6303.02	1358.82	779.86	637.49	281.99	114.76
2002	40968.79	88417.97	18609.40	6217.54	1594.54	370.86	269.61	77.67	41.79
2003	39538.81	88028.00	27694.94	7161.31	4280.66	1676.39	593.01	237.97	119.55
2004	26489.63	109701.50	36463.00	11927.41	4037.44	2994.10	1292.62	247.03	163.86
2005	12819.55	43366.34	24697.32	6359.74	1989.85	748.07	520.15	137.52	51.08
2006	9577.00	48123.92	27129.43	12944.45	3974.82	2042.77	814.60	453.51	210.72
2007	5964.32	23674.23	17294.33	5383.97	2442.37	1394.61	580.38	237.09	210.44
2008	4689.66	26872.52	14320.40	4522.12	1054.38	926.89	369.82	169.86	129.17
2009	6613.52	36205.70	23326.55	3592.11	683.79	383.76	182.16	104.52	67.66
2010	3486.40	13453.36	6095.68	783.14	54.95	28.20	6.69	5.66	3.96
2011	1688.56	11548.50	3230.45	241.44	10.89	4.00	1.41	1.19	1.18
2012	1049.17	9402.95	5531.23	252.31	6.90	3.51	0.88	1.04	0.91
2013	1521.51	9498.85	8509.59	836.36	15.07	6.08	1.56	1.24	1.30
2014	1061.87	13008.04	5586.48	464.98	12.62	5.32	1.04	1.10	0.92
2015	1579.98	19015.36	20793.83	754.47	24.42	30.42	2.78	2.03	2.00
2016	1045.04	10052.16	9920.71	635.91	8.85	17.56	3.25	1.84	1.65
2017	209.89	2167.18	1876.82	76.98	2.73	2.90	0.93	1.26	0.76
2018	185.13	2080.71	1995.33	61.67	1.40	4.07	0.71	1.13	1.00

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	45768.24	341425.57	297802.74	361409.86	237262.84	168418.16	58299.85	19438.38	6606.75
1992	34221.66	323853.77	279310.70	263028.05	280808.73	151633.05	101120.31	31464.36	11776.41
1993	30734.39	241495.18	270919.28	241203.37	201909.72	174811.90	87676.46	51547.61	18275.52
1994	47353.50	208333.27	189938.04	228687.62	173353.69	120977.01	95680.96	41731.97	27387.21
1995	44687.38	320321.33	157219.17	148678.37	162408.35	95031.81	63857.63	42663.96	25346.00
1996	46407.11	293717.42	224756.54	121610.39	101120.45	90520.95	49063.77	28389.07	24720.67
1997	37783.48	298297.60	206931.16	171585.11	80090.63	53516.87	44060.00	20658.57	18311.71
1998	48626.18	236202.02	209454.30	156361.49	114326.46	42688.70	26475.31	18199.92	13011.28
1999	48687.69	301390.96	160266.75	154416.11	102676.79	61249.47	20805.38	11275.88	10165.57
2000	28781.42	325214.06	231647.21	127537.57	108457.19	59248.90	32656.95	9567.46	7668.88
2001	26864.67	185220.05	252339.22	187086.52	88404.29	61172.31	30869.02	14778.82	6014.25
2002	22624.45	159792.43	131681.73	193581.73	128785.22	47049.44	31018.04	13080.00	7037.64
2003	22408.35	140549.71	124139.87	106869.17	140460.92	74846.61	25209.02	14427.32	7247.58
2004	15207.27	153814.21	120436.97	113227.89	84773.72	87100.37	43657.40	12596.20	8355.47
2005	13223.98	101473.75	133140.72	112950.87	90629.46	52626.87	50470.49	21699.97	8059.57
2006	9512.22	85306.42	84716.65	118565.23	88430.44	52897.07	29436.50	23594.14	10962.72
2007	10101.16	65036.21	78588.96	77503.53	92796.04	54757.78	29597.22	14857.85	13188.12
2008	7917.58	67842.58	58255.39	70514.76	58750.92	53774.01	30611.25	13944.34	10604.64
2009	6725.41	48312.14	58018.72	48085.11	49493.11	32168.21	27253.03	13640.48	8830.80
2010	7717.62	38635.45	38666.58	45157.19	33529.23	26646.35	16369.70	11700.57	8186.06
2011	5887.63	47343.85	33810.58	34002.83	34619.87	19807.76	15156.95	8036.01	7981.25
2012	4911.50	42209.95	51924.08	37838.92	32225.93	24809.08	13389.55	8908.10	7799.02
2013	7454.87	34448.32	44854.05	59951.02	36047.05	22977.72	16339.02	7774.74	8127.78
2014	5015.77	50816.47	34162.09	47931.32	55534.17	24128.37	14550.27	9013.07	7523.76
2015	4177.94	36388.14	58558.75	40386.70	47456.43	40509.45	16683.46	8754.69	8628.29
2016	4299.48	29093.63	38740.73	66681.72	38154.61	33891.60	25937.19	9650.61	8638.42
2017	4182.43	29741.01	30261.04	39809.12	60416.91	25917.69	21084.75	14000.39	8460.21
2018	3772.72	29989.45	32481.53	31998.72	33777.69	41926.66	15798.30	11448.37	10159.70

Table 3.9.1 - WESTERN BALTIC SPRING SPAWNING HERRING. *Multi fleet.* Input table for short term predictions

2018

wr	N	M	Mat	PM	PF	SWt
0	954391	0.3	0.00	0.25	0.1	0.0001
1	785232	0.5	0.00	0.25	0.1	0.0125
2	429157	0.2	0.20	0.25	0.1	0.0491
3	241251	0.2	0.75	0.25	0.1	0.0828
4	170043	0.2	0.90	0.25	0.1	0.1091
5	171417	0.2	1.00	0.25	0.1	0.1432
6	55844	0.2	1.00	0.25	0.1	0.1544
7	36731	0.2	1.00	0.25	0.1	0.1696
8+	32596	0.2	1.00	0.25	0.1	0.1853

2019

wr	N	M	Mat	PM	PF	SWt
0	1223484	0.3	0.00	0.25	0.1	0.0001
1		0.5	0.00	0.25	0.1	0.0150
2		0.2	0.20	0.25	0.1	0.0479
3		0.2	0.75	0.25	0.1	0.0829
4		0.2	0.90	0.25	0.1	0.1158
5		0.2	1.00	0.25	0.1	0.1468
6		0.2	1.00	0.25	0.1	0.1675
7		0.2	1.00	0.25	0.1	0.1768
8+		0.2	1.00	0.25	0.1	0.1899

2020

wr	N	M	Mat	PM	PF	SWt
0	1223484	0.3	0.00	0.25	0.1	0.0001
1		0.5	0.00	0.25	0.1	0.0150
2		0.2	0.20	0.25	0.1	0.0479
3		0.2	0.75	0.25	0.1	0.0829
4		0.2	0.90	0.25	0.1	0.1158
5		0.2	1.00	0.25	0.1	0.1468
6		0.2	1.00	0.25	0.1	0.1675
7		0.2	1.00	0.25	0.1	0.1768
8+		0.2	1.00	0.25	0.1	0.1899

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_{2018} wr 0-8+: Populations numbers from the assessment
$N_{2019/2020}$ wr 0: Geometric Mean of wr 0 for the years 2013-2017
Natural Mortality (M): Constant
Weight in the Stock 2019-2020 (SWt): Average for 2014-2018

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

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.000	0.000	0.000
fbar:low	0.416	0.238	0.000	0.000	0.000
fbar:high	0.416	0.238	0.000	0.000	0.000
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	76273	101269	132063
ssb:low	74132	69743	76273	101269	132063
ssb:high	74132	69743	76273	101269	132063
catch:Estimate	36561	23367	0	0	0
catch:low	36561	23367	0	0	0
catch:high	36561	23367	0	0	0

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	0	0	0
Fleet C : Estimate	16302	12352	0	0	0
Fleet D : Estimate	155	469	0	0	0
Fleet F : Estimate	19114	9001	0	0	0

Table 3.9.3 - WESTERN BALTIC SPRING SPAWNING HERRING. *Multi fleet.* Forecast table. MAP 2018: F = F_{MSY}(0.31) * SSBy-1/MSY $B_{trigger}$

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.144	0.155	0.180
fbar:low	0.416	0.238	0.144	0.155	0.180
fbar:high	0.416	0.238	0.144	0.155	0.180
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	75138	87270	100826
ssb:low	74132	69743	75138	87270	100826
ssb:high	74132	69743	75138	87270	100826
catch:Estimate	36561	23367	14619	18227	23649
catch:low	36561	23367	14619	18227	23649
catch:high	36561	23367	14619	18227	23649

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	820	1003	1346
Fleet C : Estimate	16302	12352	6250	7814	10129
Fleet D : Estimate	155	469	239	297	350
Fleet F : Estimate	19114	9001	7309	9114	11825

Table 3.9.4 - WESTERN BALTIC SPRING SPAWNING HERRING. *Multi fleet.* Forecast table. MAP 2018: F = $F_{MSY\ lower}$ (0.216) * SSBy-1/MSY $B_{trigger}$

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.100	0.109	0.131
fbar:low	0.416	0.238	0.100	0.109	0.131
fbar:high	0.416	0.238	0.100	0.109	0.131
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	75483	91298	109170
ssb:low	74132	69743	75483	91298	109170
ssb:high	74132	69743	75483	91298	109170
catch:Estimate	36561	23367	10359	13568	18846
catch:low	36561	23367	10359	13568	18846
catch:high	36561	23367	10359	13568	18846

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	584	762	1112
Fleet C : Estimate	16302	12352	4427	5807	8045
Fleet D : Estimate	155	469	168	215	266
Fleet F : Estimate	19114	9001	5180	6784	9423

Table 3.9.5 - WESTERN BALTIC SPRING SPAWNING HERRING. *Multi fleet.* Forecast table. MAP 2018: F = $F_{MSY\ upper}$ (0.379) *SSBy-1/MSY $B_{trigger}$

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.176	0.189	0.213
fbar:low	0.416	0.238	0.176	0.189	0.213
fbar:high	0.416	0.238	0.176	0.189	0.213
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	74889	84458	95186
ssb:low	74132	69743	74889	84458	95186
ssb:high	74132	69743	74889	84458	95186
catch:Estimate	36561	23367	17609	21329	26339
catch:low	36561	23367	17609	21329	26339
catch:high	36561	23367	17609	21329	26339

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	984	1156	1459
Fleet C : Estimate	16302	12352	7531	9154	11306
Fleet D : Estimate	155	469	289	355	404
Fleet F : Estimate	19114	9001	8805	10664	13170

Table 3.9.6 - WESTERN BALTIC SPRING SPAWNING HERRING. ***Multi fleet.*** **Forecast table. F = F_{MSY} = 0.31**

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.310	0.310	0.310
fbar:low	0.416	0.238	0.310	0.310	0.310
fbar:high	0.416	0.238	0.310	0.310	0.310
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	73852	73874	76971
ssb:low	74132	69743	73852	73874	76971
ssb:high	74132	69743	73852	73874	76971
catch:Estimate	36561	23367	29215	29824	30807
catch:low	36561	23367	29215	29824	30807
catch:high	36561	23367	29215	29824	30807

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	1608	1518	1538
Fleet C : Estimate	16302	12352	12510	12857	13330
Fleet D : Estimate	155	469	491	537	535
Fleet F : Estimate	19114	9001	14608	14912	15404

Table 3.9.7 - WESTERN BALTIC SPRING SPAWNING HERRING. ***Multi fleet.*** **Forecast table. F = F_{pa} = 0.35**

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.350	0.350	0.350
fbar:low	0.416	0.238	0.350	0.350	0.350
fbar:high	0.416	0.238	0.350	0.350	0.350
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	73546	70975	72021
ssb:low	74132	69743	73546	70975	72021
ssb:high	74132	69743	73546	70975	72021
catch:Estimate	36561	23367	32413	32085	32415
catch:low	36561	23367	32413	32085	32415
catch:high	36561	23367	32413	32085	32415

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	1775	1602	1564
Fleet C : Estimate	16302	12352	13883	13850	14058
Fleet D : Estimate	155	469	548	591	585
Fleet F : Estimate	19114	9001	16206	16042	16207

Table 3.9.8 - WESTERN BALTIC SPRING SPAWNING HERRING. ***Multi fleet.*** **Forecast table. F = F_{lim} = 0.45**

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.450	0.450	0.450
fbar:low	0.416	0.238	0.450	0.450	0.450
fbar:high	0.416	0.238	0.450	0.450	0.450
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	72786	64257	61199
ssb:low	74132	69743	72786	64257	61199
ssb:high	74132	69743	72786	64257	61199
catch:Estimate	36561	23367	39917	36641	35148
catch:low	36561	23367	39917	36641	35148
catch:high	36561	23367	39917	36641	35148

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	2162	1741	1554
Fleet C : Estimate	16302	12352	17112	15866	15326
Fleet D : Estimate	155	469	685	714	694
Fleet F : Estimate	19114	9001	19959	18321	17574

Table 3.9.9 - WESTERN BALTIC SPRING SPAWNING HERRING. ***Multi fleet.*** **Forecast table. F = F_{2019} =0.238**

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.238	0.238	0.238
fbar:low	0.416	0.238	0.238	0.238	0.238
fbar:high	0.416	0.238	0.238	0.238	0.238
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	74407	79426	86916
ssb:low	74132	69743	74407	79426	86916
ssb:high	74132	69743	74407	79426	86916
catch:Estimate	36561	23367	23157	25008	26943
catch:low	36561	23367	23157	25008	26943
catch:high	36561	23367	23157	25008	26943

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	1285	1318	1430
Fleet C : Estimate	16302	12352	9909	10755	11606
Fleet D : Estimate	155	469	384	431	436
Fleet F : Estimate	19114	9001	11579	12504	13472

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

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.000	0.000	0.000
fbar:low	0.416	0.238	0.000	0.000	0.000
fbar:high	0.416	0.238	0.000	0.000	0.000
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	76273	101269	132063
ssb:low	74132	69743	76273	101269	132063
ssb:high	74132	69743	76273	101269	132063
catch:Estimate	36561	23367	0	0	0
catch:low	36561	23367	0	0	0
catch:high	36561	23367	0	0	0

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	0	0	0
Fleet C : Estimate	16302	12352	0	0	0
Fleet D : Estimate	155	469	0	0	0
Fleet F : Estimate	19114	9001	0	0	0

Table 3.9.11 - WESTERN BALTIC SPRING SPAWNING HERRING. ***Multi fleet.*** **Forecast table. F = 0.05**

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.050	0.050	0.050
fbar:low	0.416	0.238	0.050	0.050	0.050
fbar:high	0.416	0.238	0.050	0.050	0.050
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	75877	96189	120704
ssb:low	74132	69743	75877	96189	120704
ssb:high	74132	69743	75877	96189	120704
catch:Estimate	36561	23367	5301	6665	8115
catch:low	36561	23367	5301	6665	8115
catch:high	36561	23367	5301	6665	8115

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	301	384	501
Fleet C : Estimate	16302	12352	2264	2847	3449
Fleet D : Estimate	155	469	85	102	107
Fleet F : Estimate	19114	9001	2651	3333	4058

Table 3.9.12 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. F = 0.1

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.100	0.100	0.100
fbar:low	0.416	0.238	0.100	0.100	0.100
fbar:high	0.416	0.238	0.100	0.100	0.100
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	75483	91383	110440
ssb:low	74132	69743	75483	91383	110440
ssb:high	74132	69743	75483	91383	110440
catch:Estimate	36561	23367	10359	12500	14706
catch:low	36561	23367	10359	12500	14706
catch:high	36561	23367	10359	12500	14706

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	584	703	873
Fleet C : Estimate	16302	12352	4427	5349	6275
Fleet D : Estimate	155	469	168	198	205
Fleet F : Estimate	19114	9001	5180	6250	7353

Table 3.9.13 - WESTERN BALTIC SPRING SPAWNING HERRING. Multi fleet. Forecast table. F = 0.15

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.150	0.150	0.150
fbar:low	0.416	0.238	0.150	0.150	0.150
fbar:high	0.416	0.238	0.150	0.150	0.150
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	75092	86838	101160
ssb:low	74132	69743	75092	86838	101160
ssb:high	74132	69743	75092	86838	101160
catch:Estimate	36561	23367	15186	17594	20028
catch:low	36561	23367	15186	17594	20028
catch:high	36561	23367	15186	17594	20028

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	851	967	1143
Fleet C : Estimate	16302	12352	6493	7543	8576
Fleet D : Estimate	155	469	248	287	295
Fleet F : Estimate	19114	9001	7593	8797	10014

Table 3.9.14 - WESTERN BALTIC SPRING SPAWNING HERRING. ***Multi fleet.*** **Forecast table. Constant 2019 TAC**

Year	2018	2019	2020	2021	2022
fbar:Estimate	0.416	0.238	0.222	0.202	0.182
fbar:low	0.416	0.238	0.222	0.202	0.182
fbar:high	0.416	0.238	0.222	0.202	0.182
rec:Estimate	954391	1223484	1223484	1223484	1223484
rec:low	954391	1223484	1223484	1223484	1223484
rec:high	954391	1223484	1223484	1223484	1223484
ssb:Estimate	74132	69743	74532	80342	89893
ssb:low	74132	69743	74532	80342	89893
ssb:high	74132	69743	74532	80342	89893
catch:Estimate	36561	23367	23367	23367	23367
catch:low	36561	23367	23367	23367	23367
catch:high	36561	23367	23367	23367	23367

Per fleet

Year	2018	2019	2020	2021	2022
Fleet A : Estimate	990	1545	1545	1545	1545
Fleet C : Estimate	16302	12352	12352	12352	12352
Fleet D : Estimate	155	469	469	469	469
Fleet F : Estimate	19114	9001	9001	9001	9001

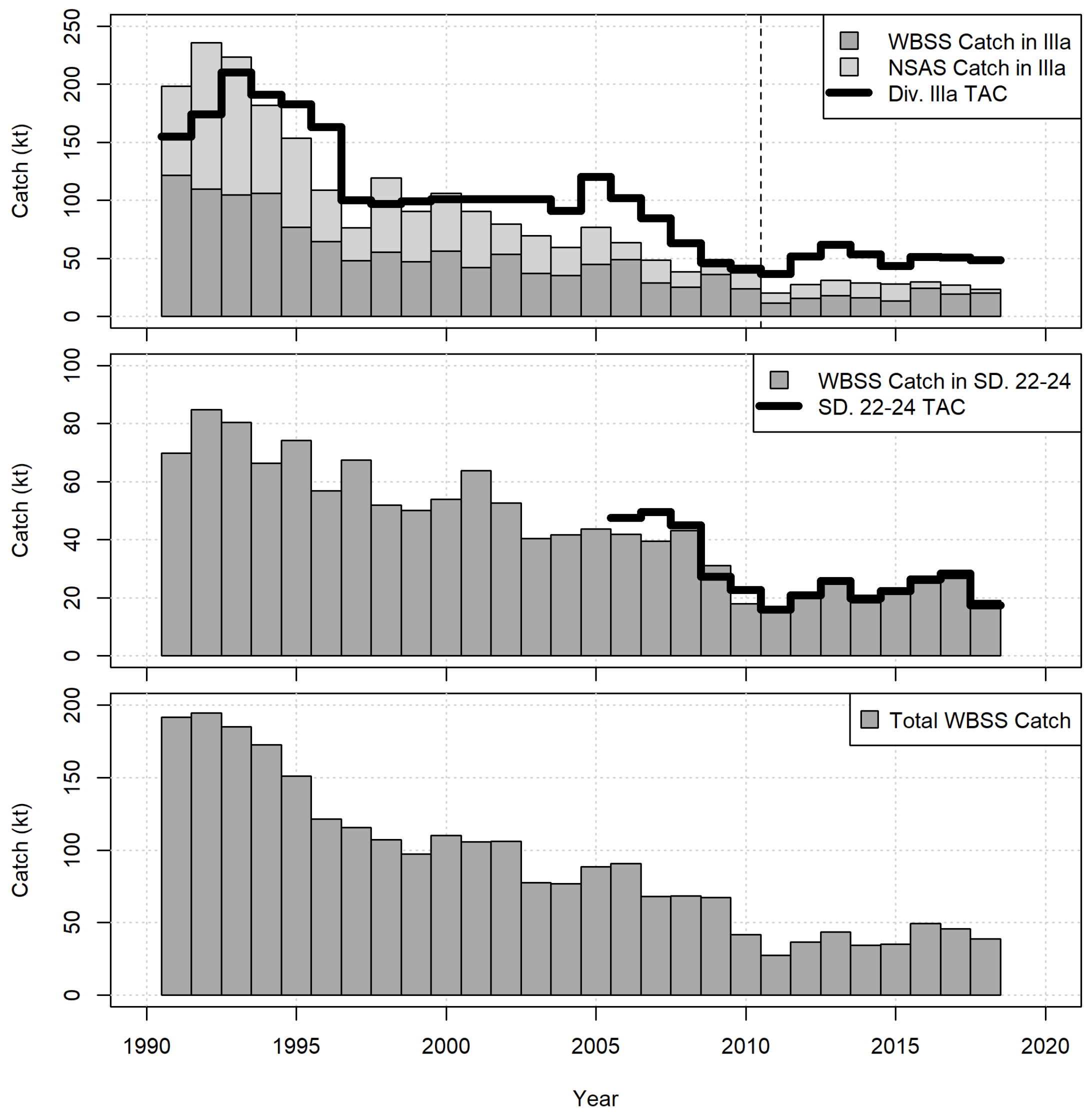

Figure 3.1.1 Western Baltic Spring Spawning Herring. CATCH and TACs (1000 t) by area. Note, the TAC for IIIa excludes the bycatch TAC, while the CATCH includes the bycatch

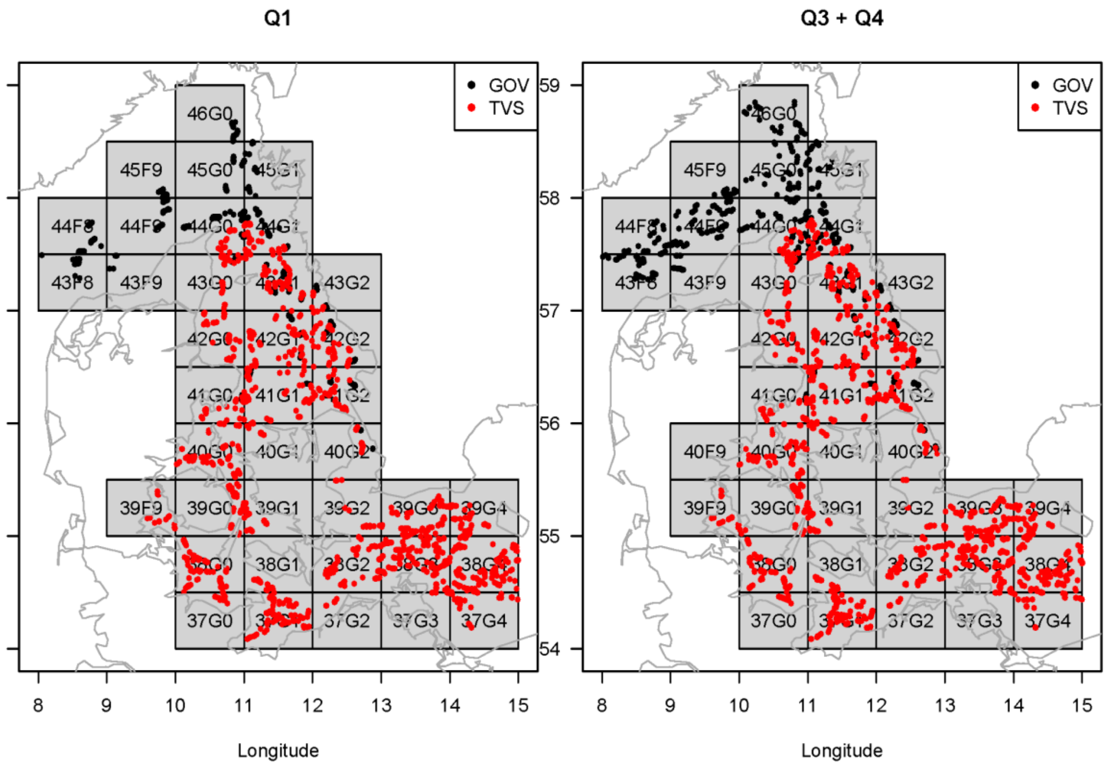

Figure 3.3.1 WESTERN BALTIC SPRING SPAWNING HERRING. Map showing the hauls used in the calculation of the IBTS+BITS-Q1 and IBTS+BITS-Q3.3 indices. Hauls colored by gear type.

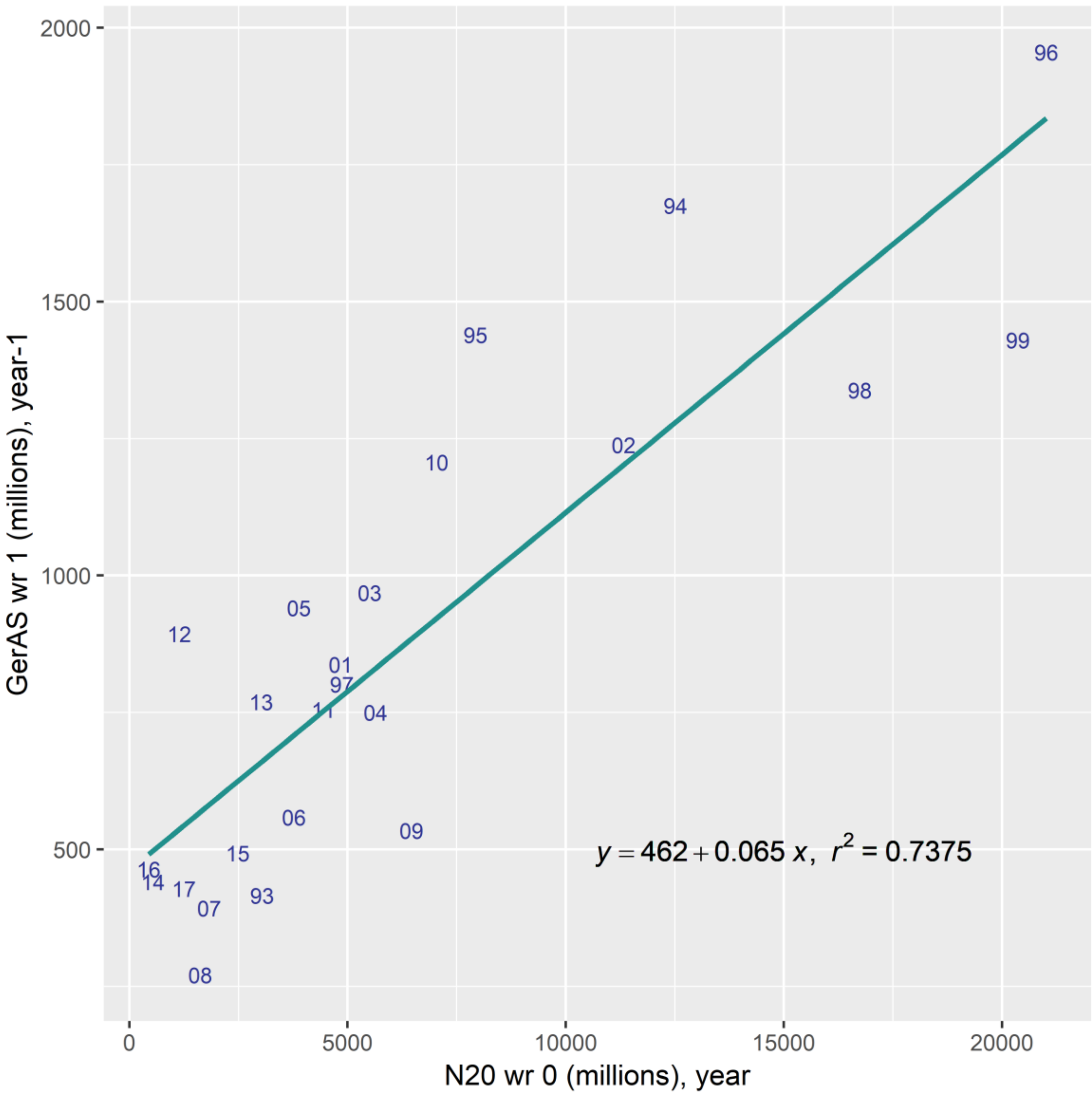

Figure 3.5.1 WESTERN BALTIC SPRING SPAWNING HERRING. Correlation of 1 wr herring from GERAS with the N20 larvae index. Note the year lag between surveys. Labels show the year of the N20.

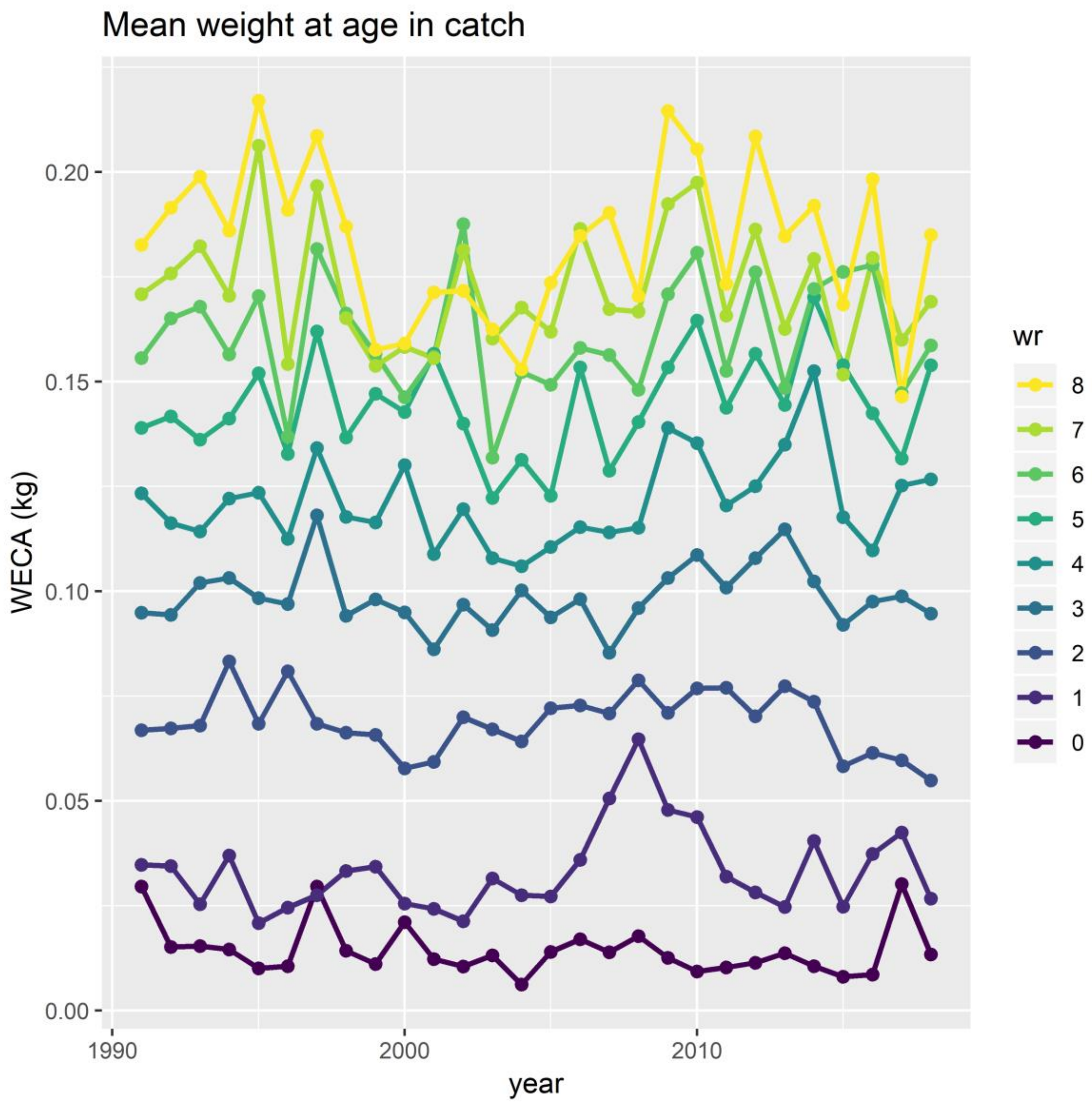

Figure 3.6.1.1 WESTERN BALTIC SPRING SPAWNING HERRING. Weight (kg) at age as W-ringers (wr) in the catch (WECA).

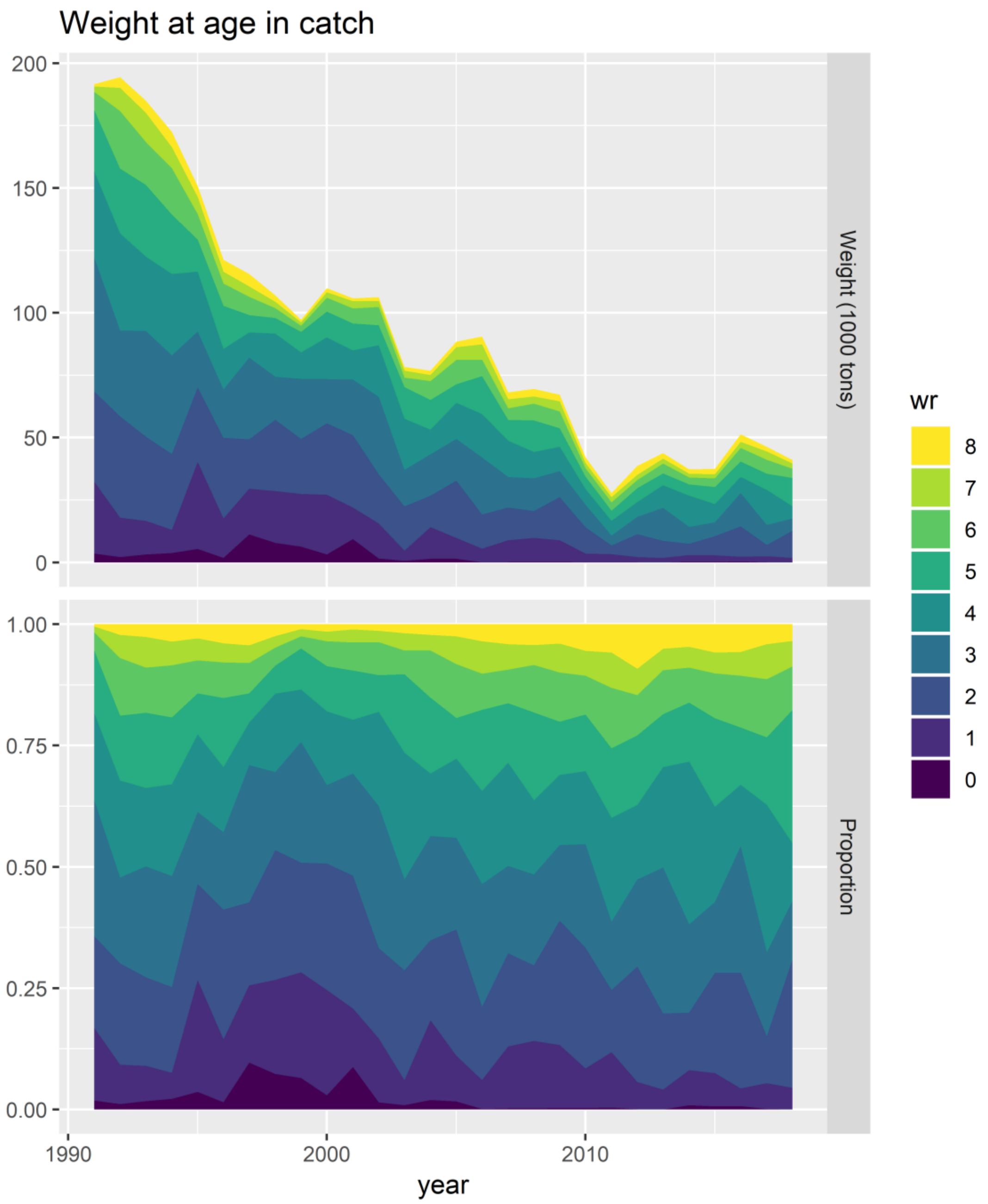

Figure 3.6.1.2 WESTERN BALTIC SPRING SPAWNING HERRING. Catch in weight. Upper panel: Catch in weight (1000 tons) at age as W-ringers (wr). Lower panel: Proportion (by weight) of a given age as W-ringers (wr) in the catch.

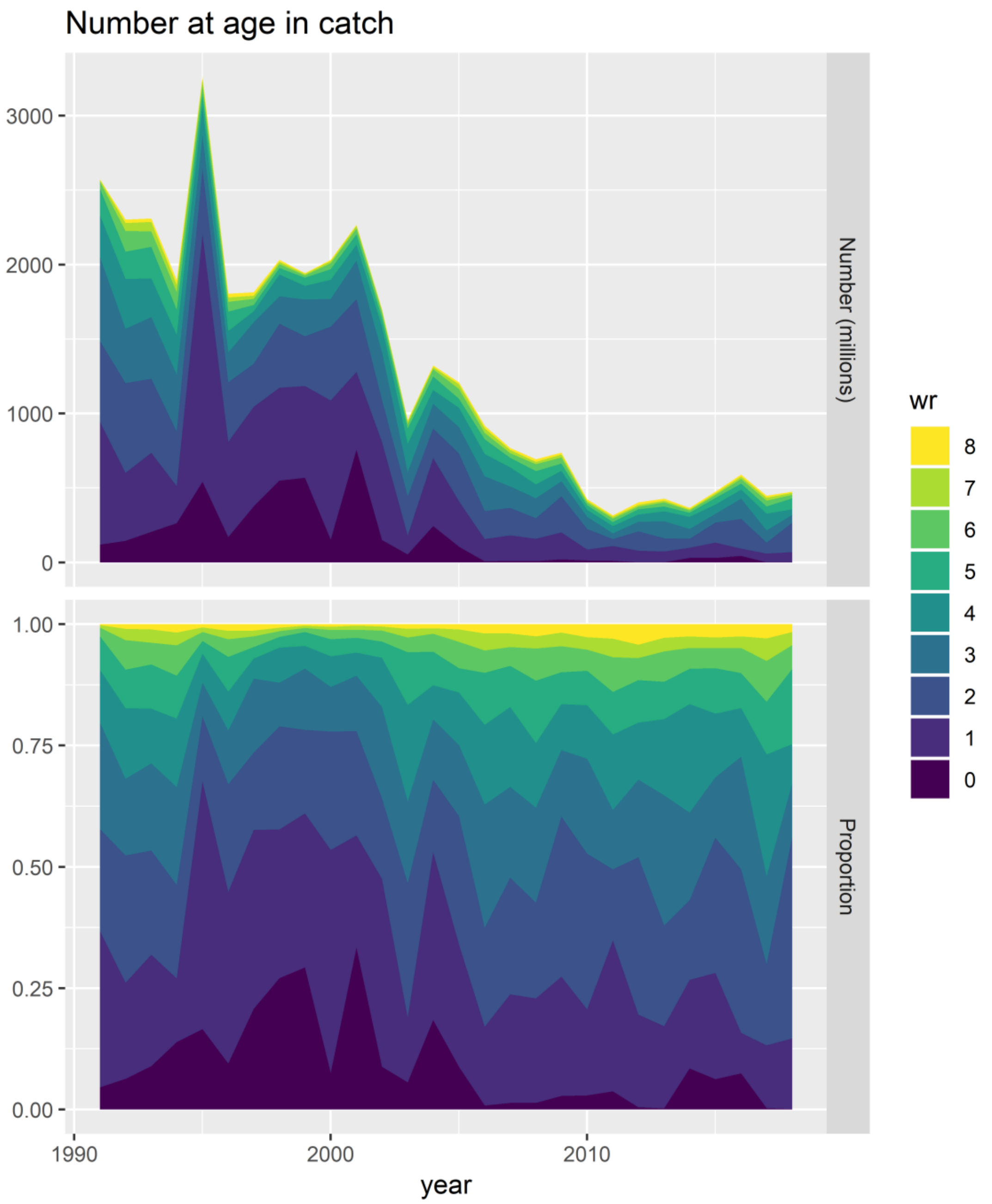

Figure 3.6.1.3 WESTERN BALTIC SPRING SPAWNING HERRING. Catch in Numbers. Upper panel: Catch in numbers (millions) at age as W-ringers (wr). Lower panel: Proportion (by number) of a given age as W-ringers (wr) in the catch.

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

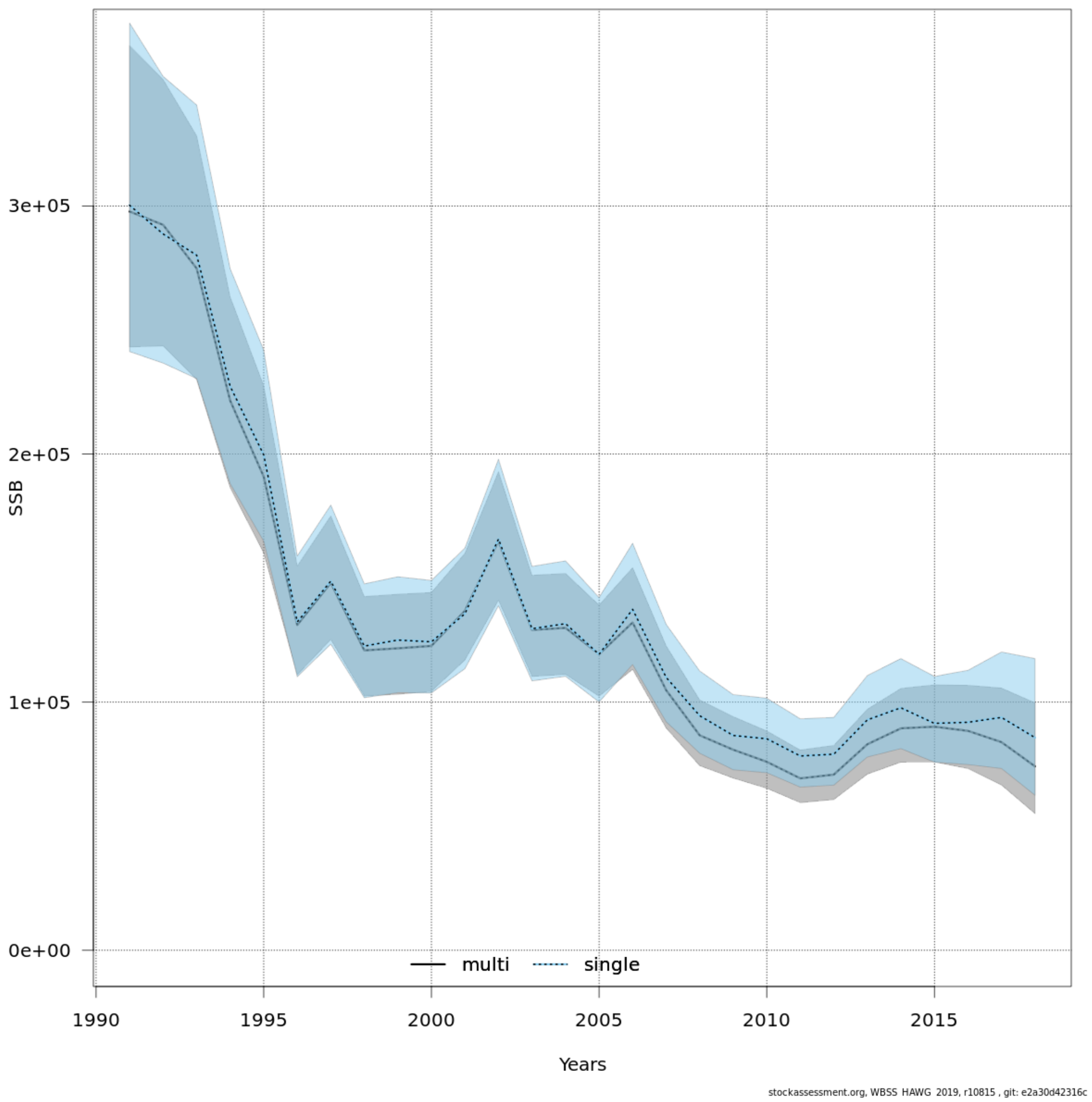

Figure 3.6.4.1 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Spawning stock biomass (SSB). Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

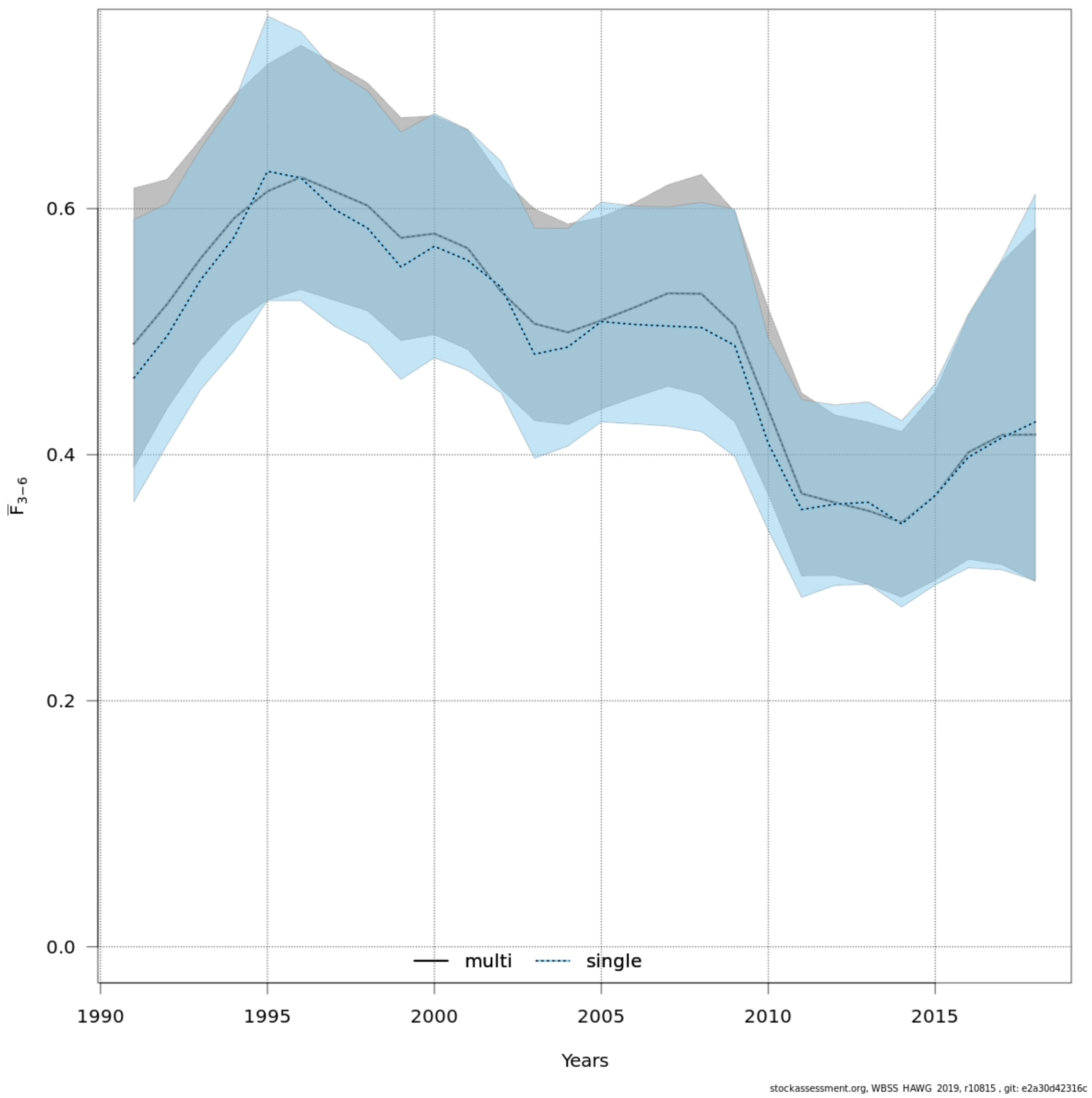

Figure 3.6.4.2 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Average fishing mortality (F) for the shown age range. Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

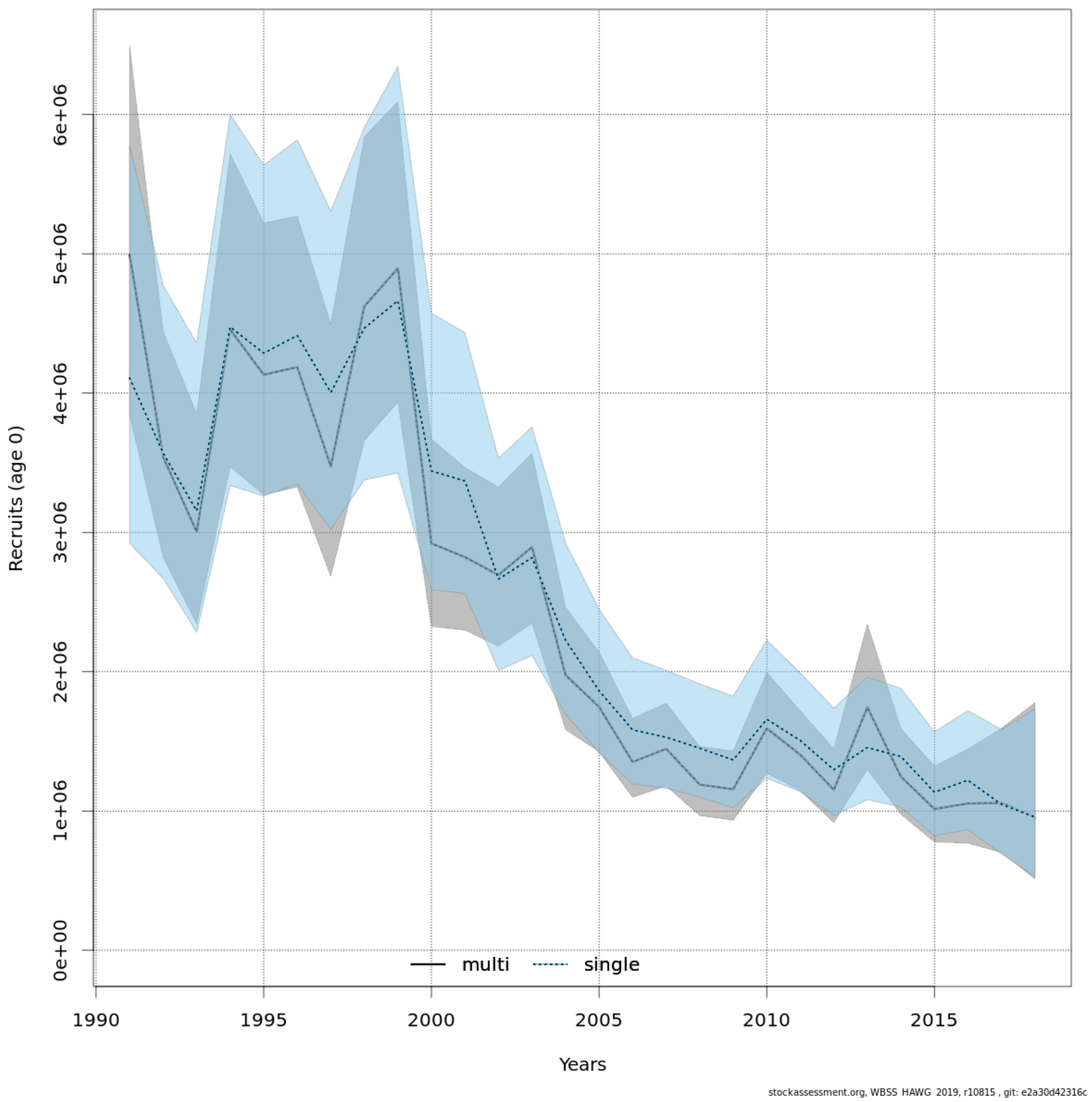

Figure 3.6.4.3 WESTERN BALTIC SPRING SPAWNING HERRING. Stock summary plot. Yearly recruitment (age 0 equal 0 W-ringers). Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

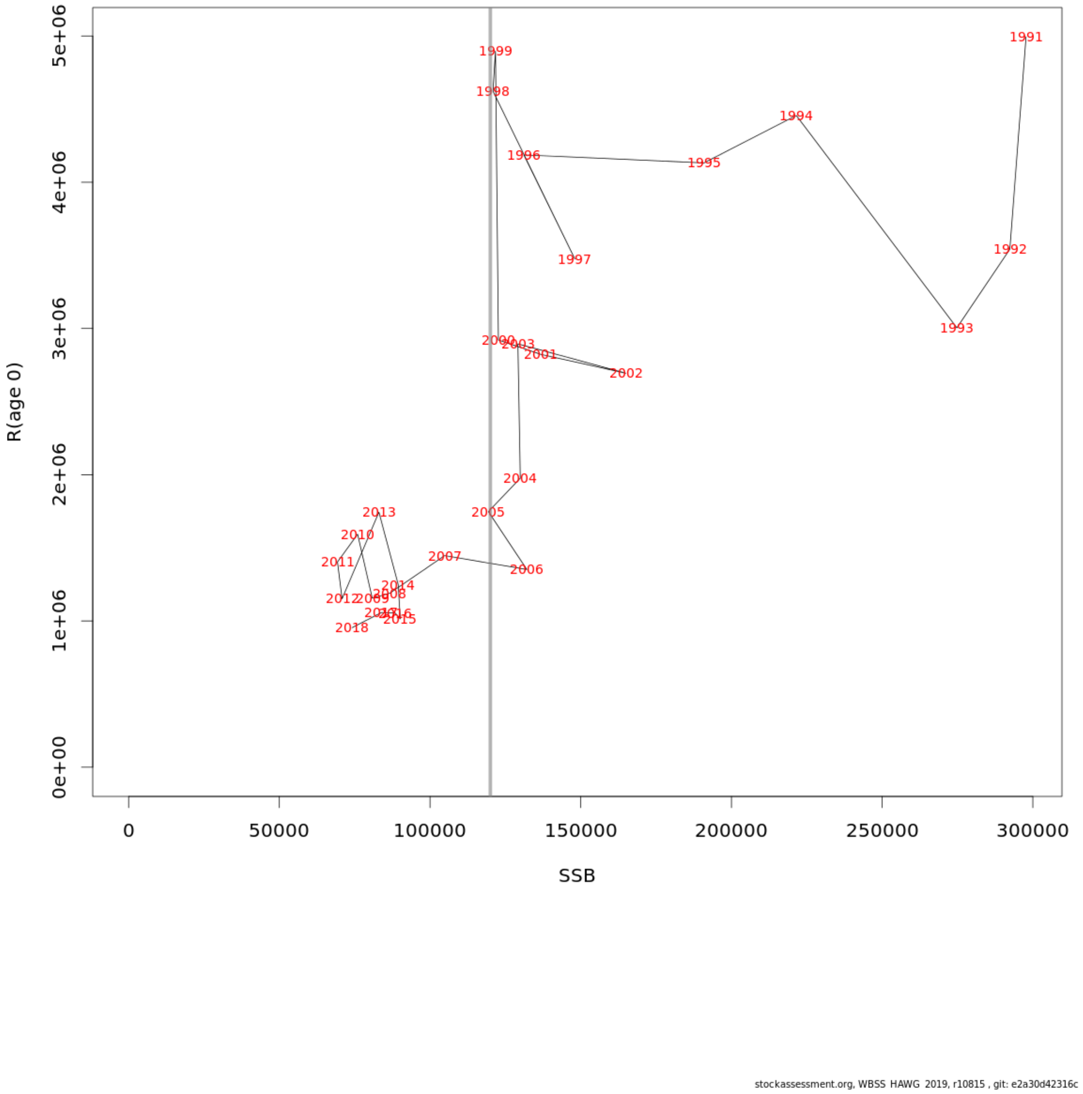

Figure 3.6.4.4 WESTERN BALTIC SPRING SPAWNING HERRING. Recruitment at age 0-wr (in thousands) is plotted against spawning stock biomass (tonnes) as estimated by the assessment.

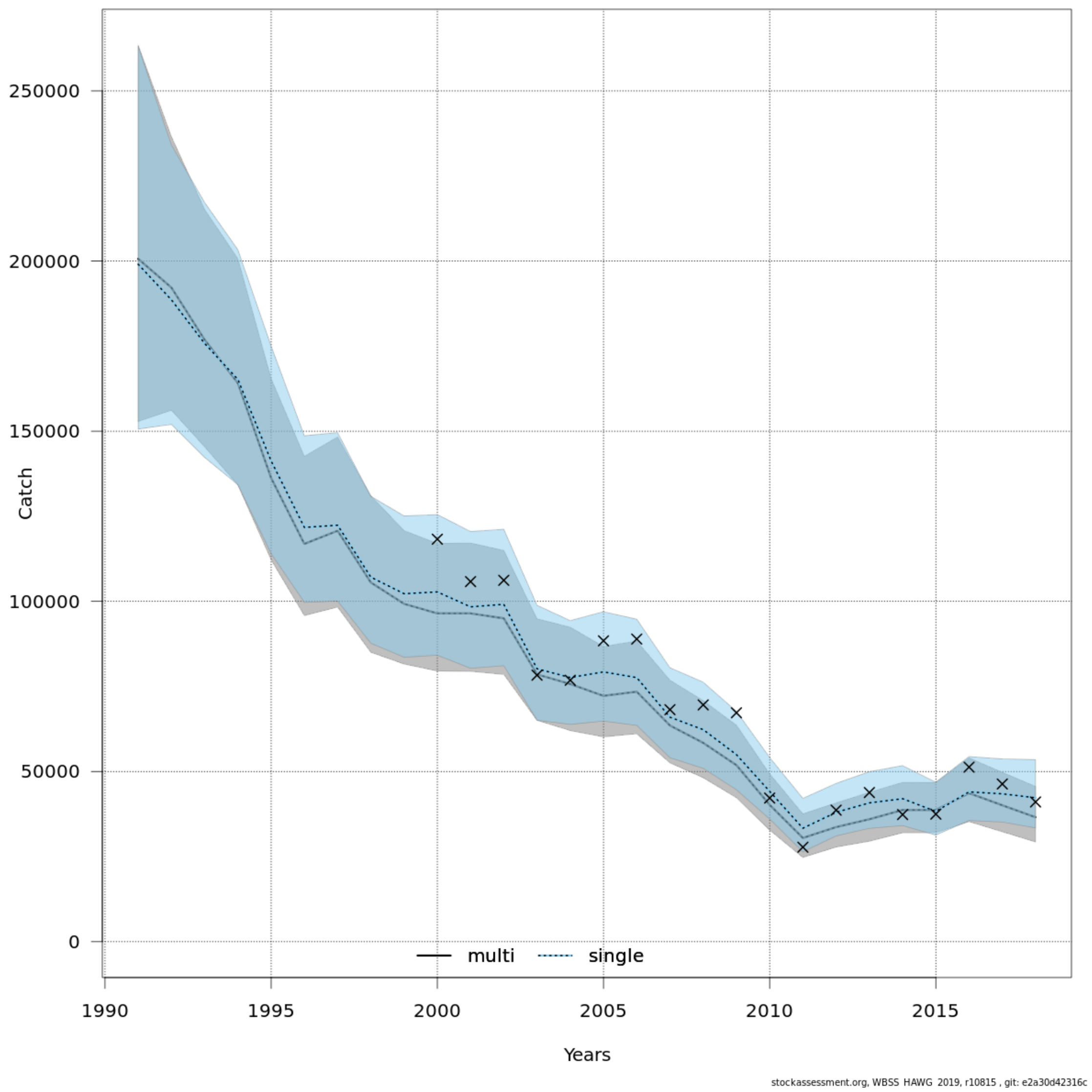

Figure 3.6.4.5 WESTERN BALTIC SPRING SPAWNING HERRING. Total catch in weight (tons). Prediction from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area. The yearly observed total catch weight (crosses)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

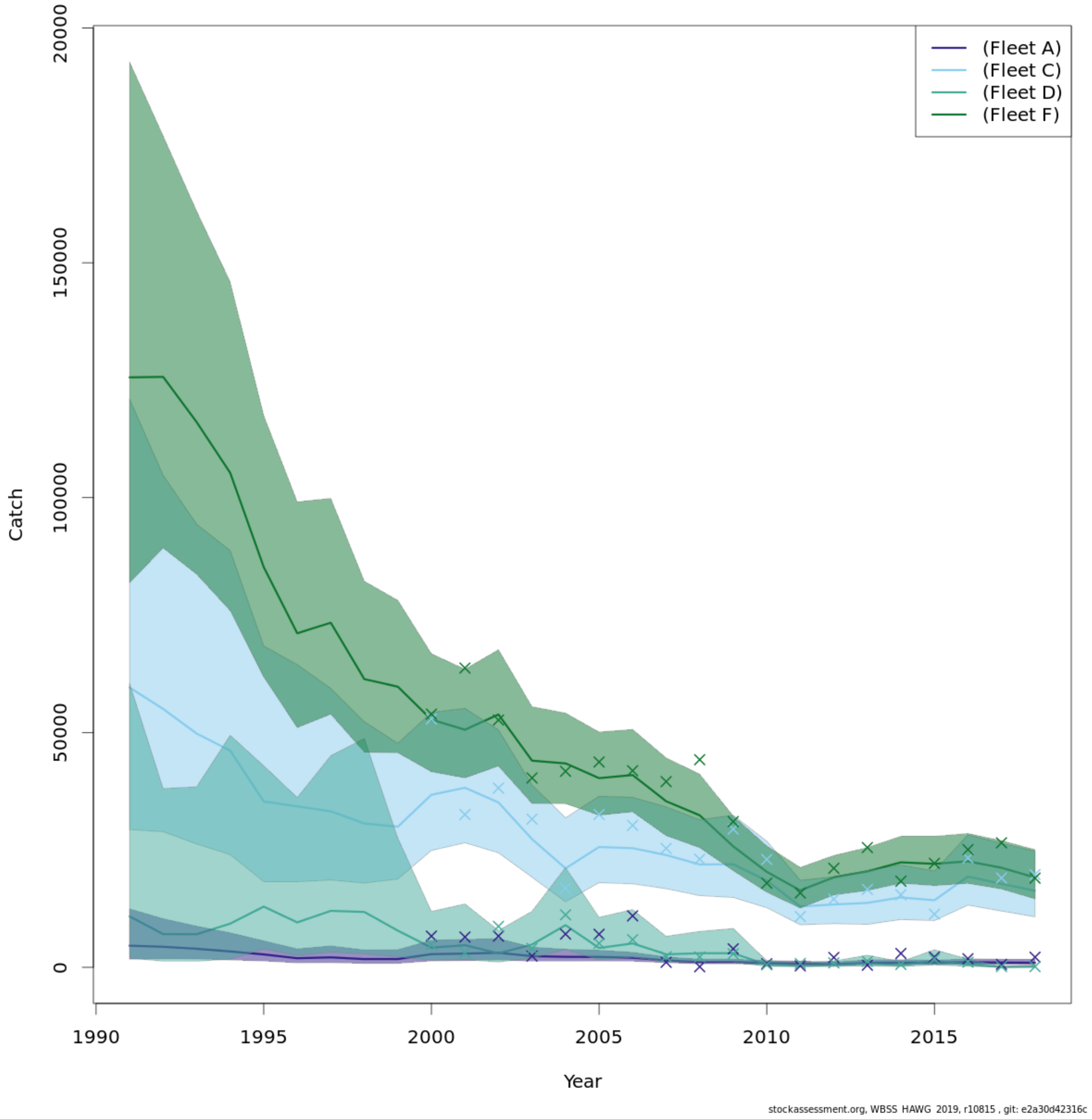

Figure 3.6.4.6 WESTERN BALTIC SPRING SPAWNING HERRING. Total catch in weight (tons) by fleet. Prediction from the WBSS multi fleet assessment run and point wise 95% confidence intervals are shown by line and shaded area. The plot also show the observed total catch weight per fleet (crosses)

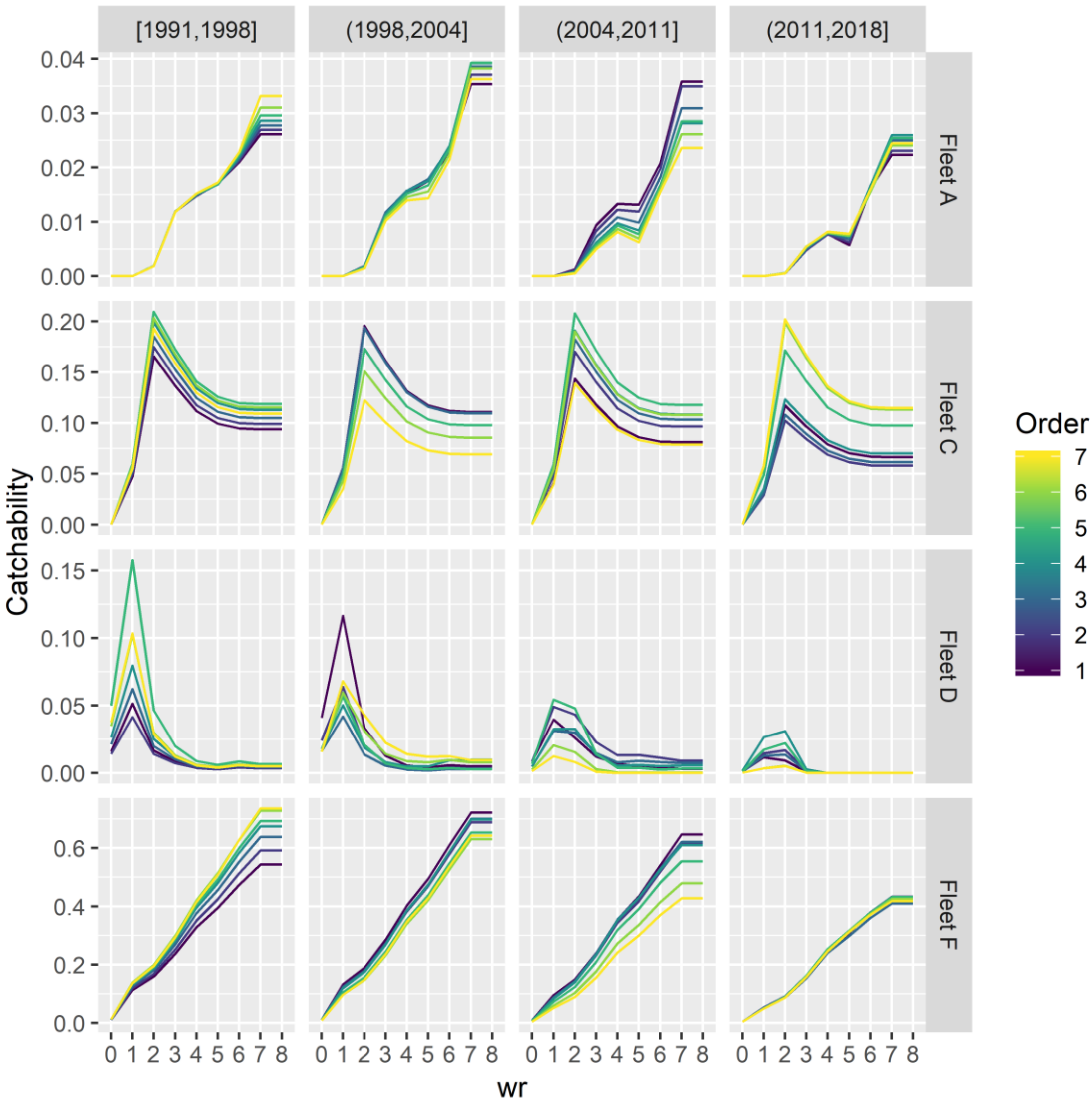

Figure 3.6.4.7 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated selection pattern at age as W-ringers (wr) per fleet and year. Order: 1 equal 1st year in the respective time span.

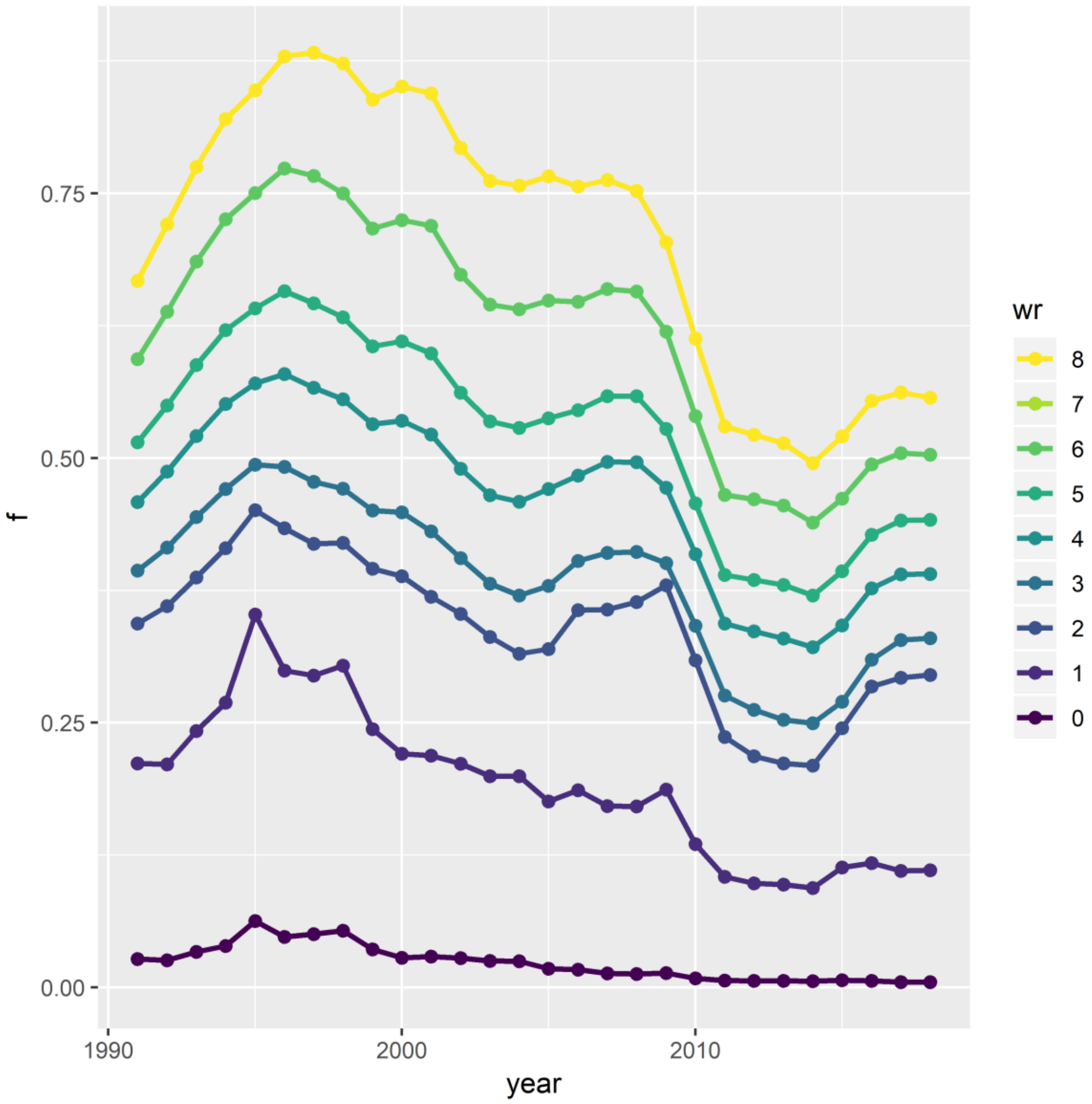

Figure 3.6.4.8 Western Baltic Spring Spawning Herring. Time-series of estimated fishing mortality-at-age as W-ringers (wr)

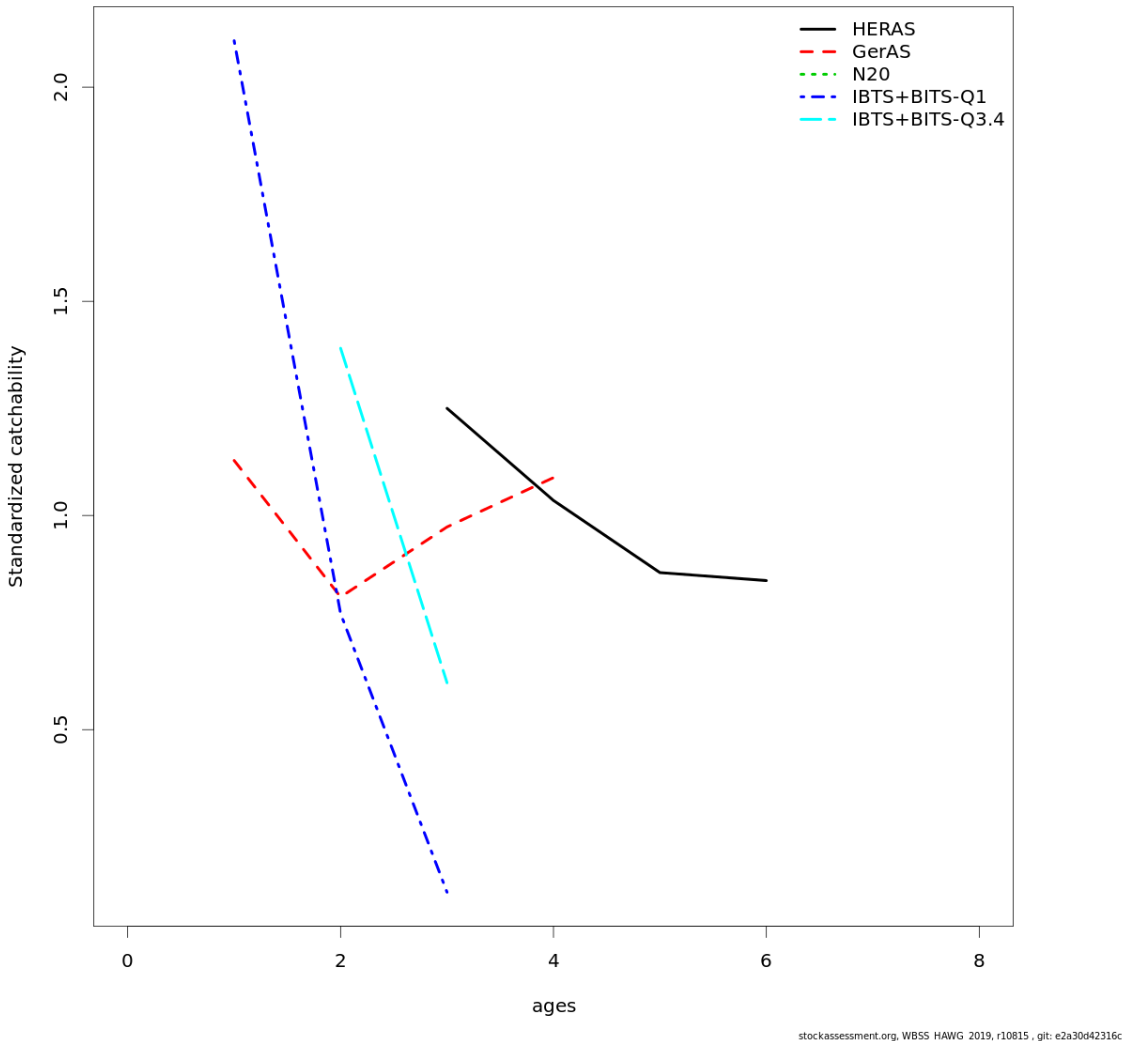

Figure 3.6.4.9 Western Baltic Spring Spawning Herring. Estimated survey catchabilities. N20 only covers an age 0 and therefore no line

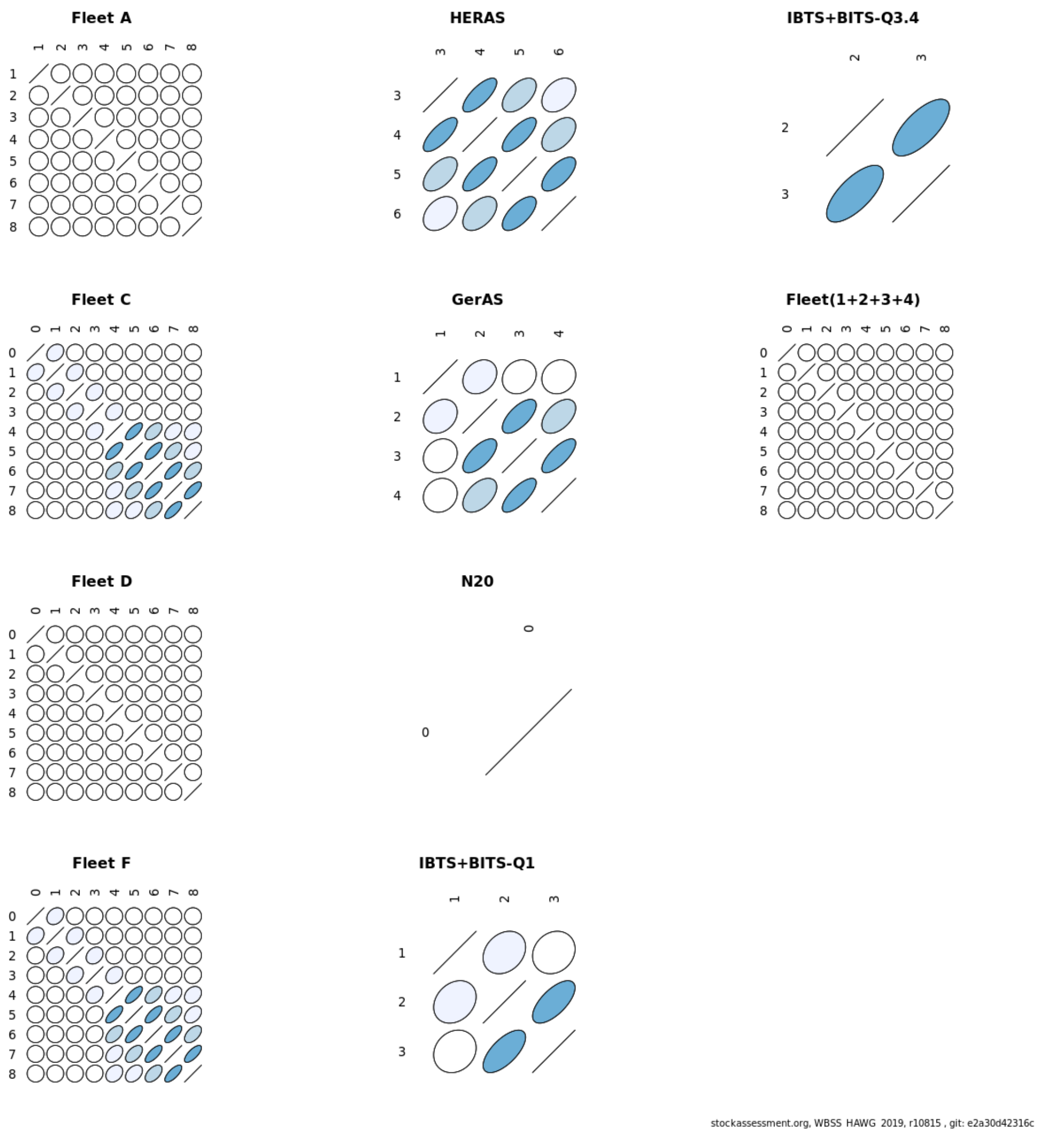

Figure 3.6.4.10 WESTERN BALTIC SPRING SPAWNING HERRING. Estimates correlations between age groups for each fleet.

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

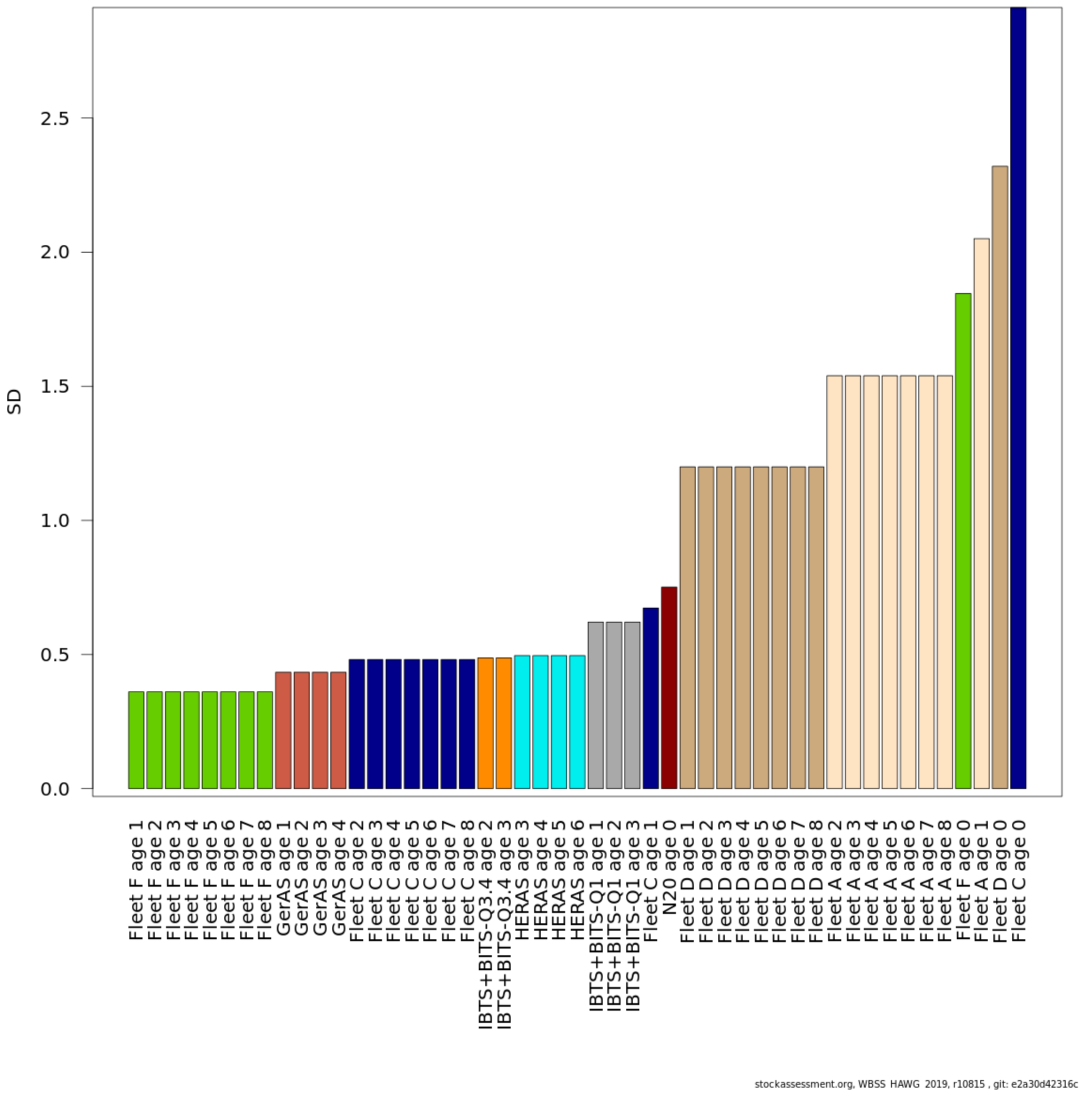

Figure 3.6.4.12 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated observation variance in the WBSS multi fleet assessment run.

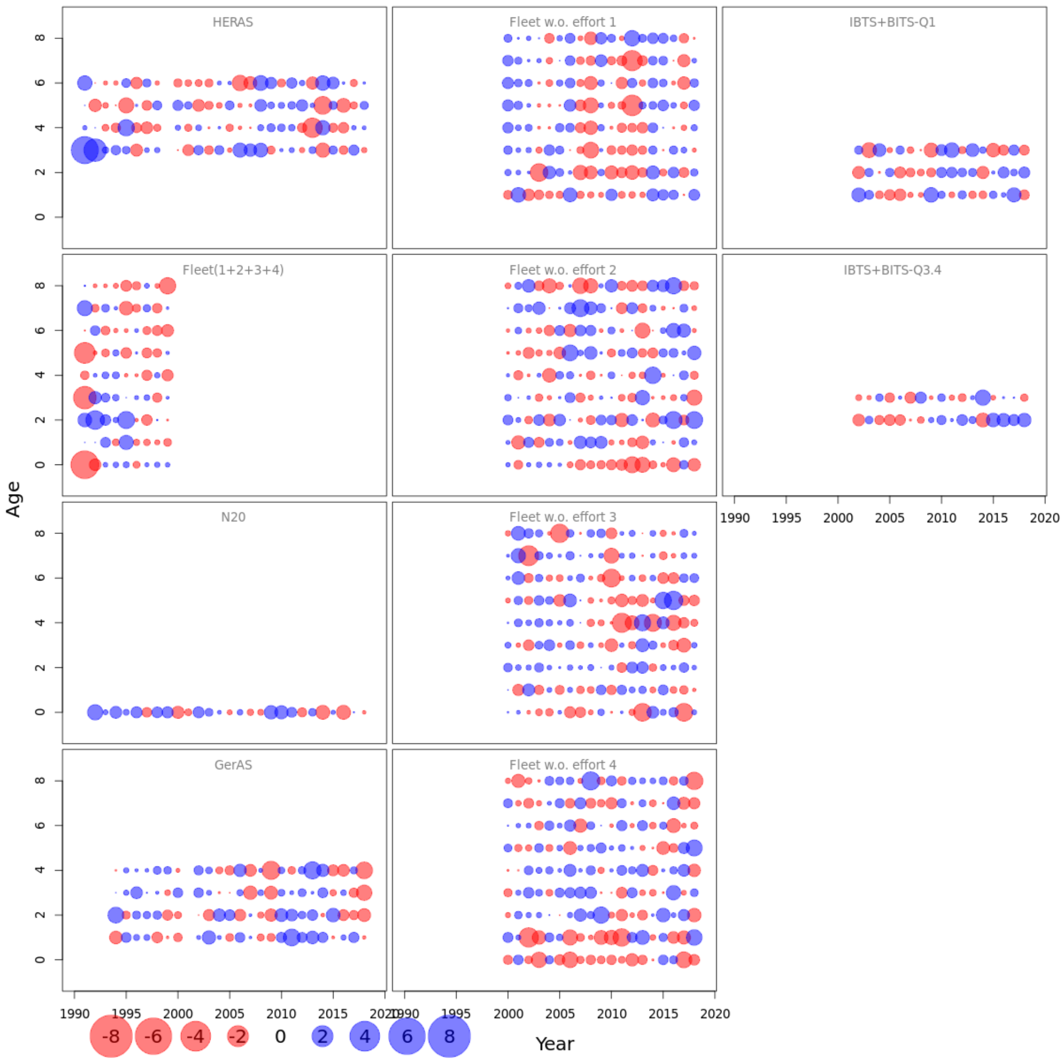

Figure 3.6.4.13 WESTERN BALTIC SPRING SPAWNING HERRING. BUBBLE PLOT. Standardized one-observation-ahead residuals from multi fleet run.

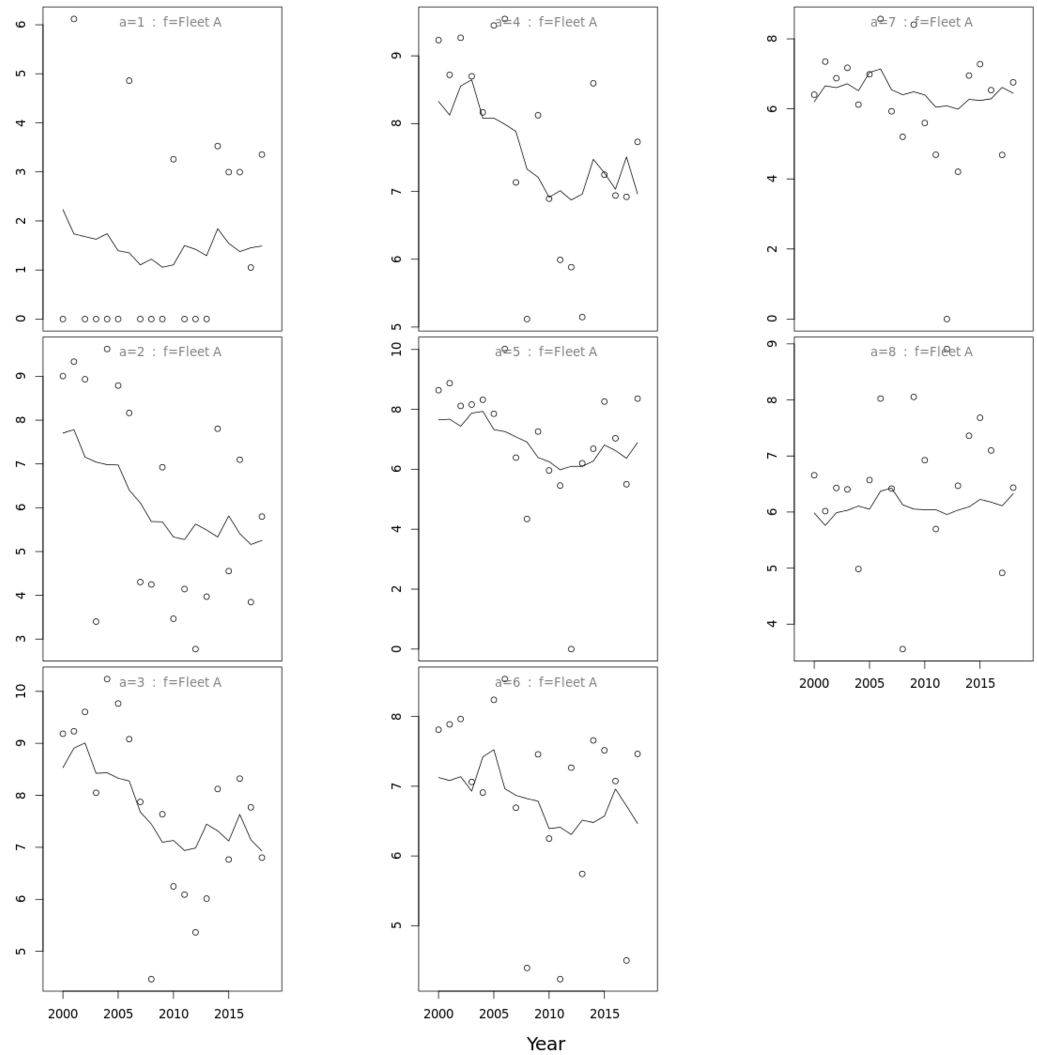

Figure 3.6.4.14 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet A. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

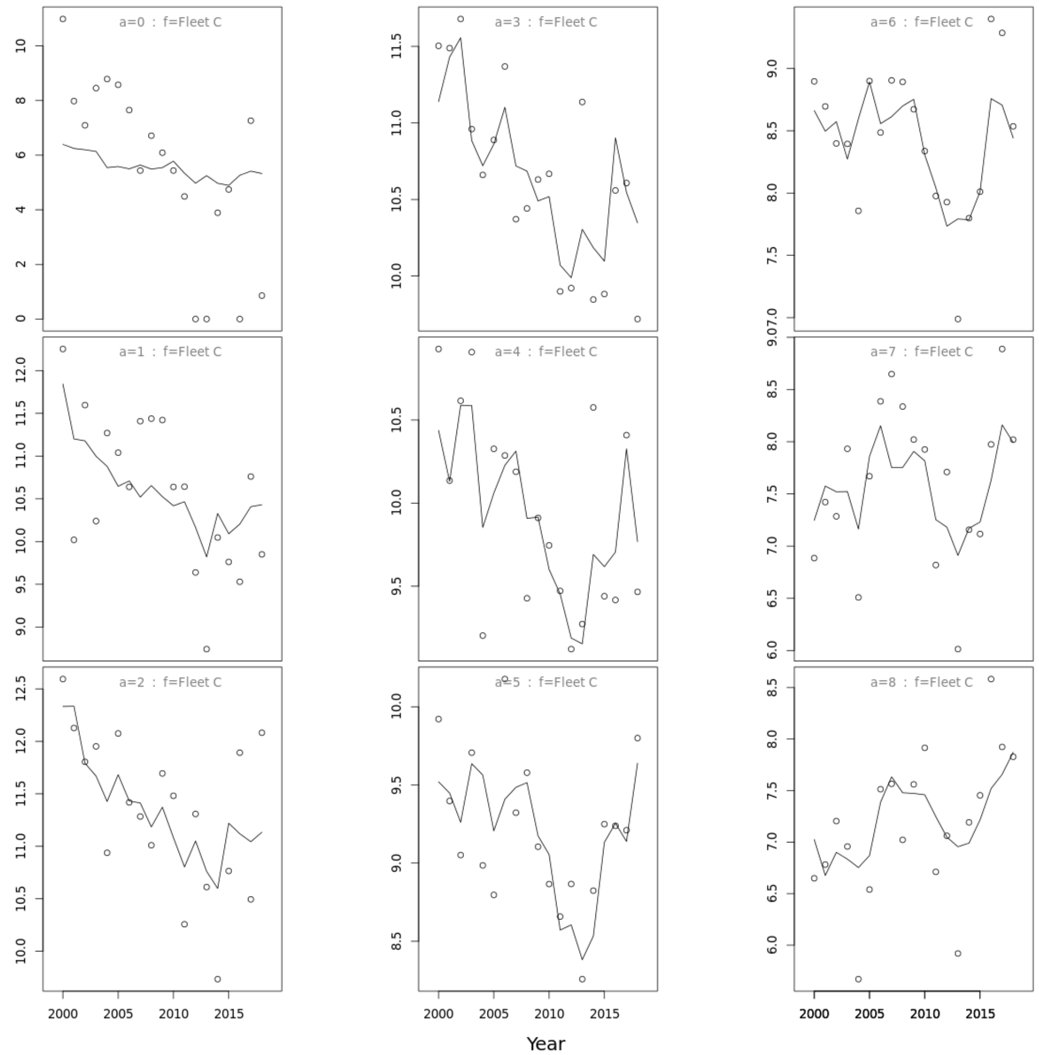

Figure 3.6.4.15 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet C. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

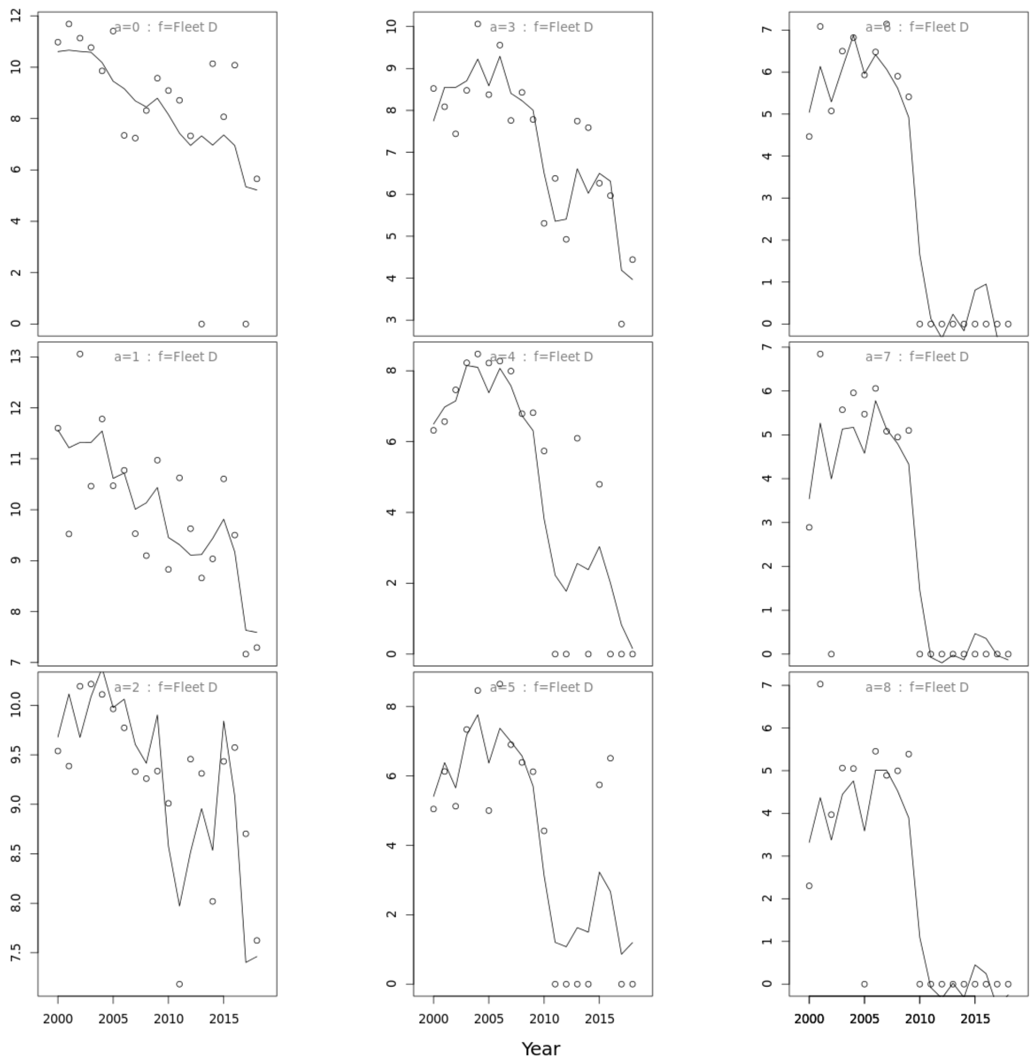

Figure 3.6.4.16 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet D. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

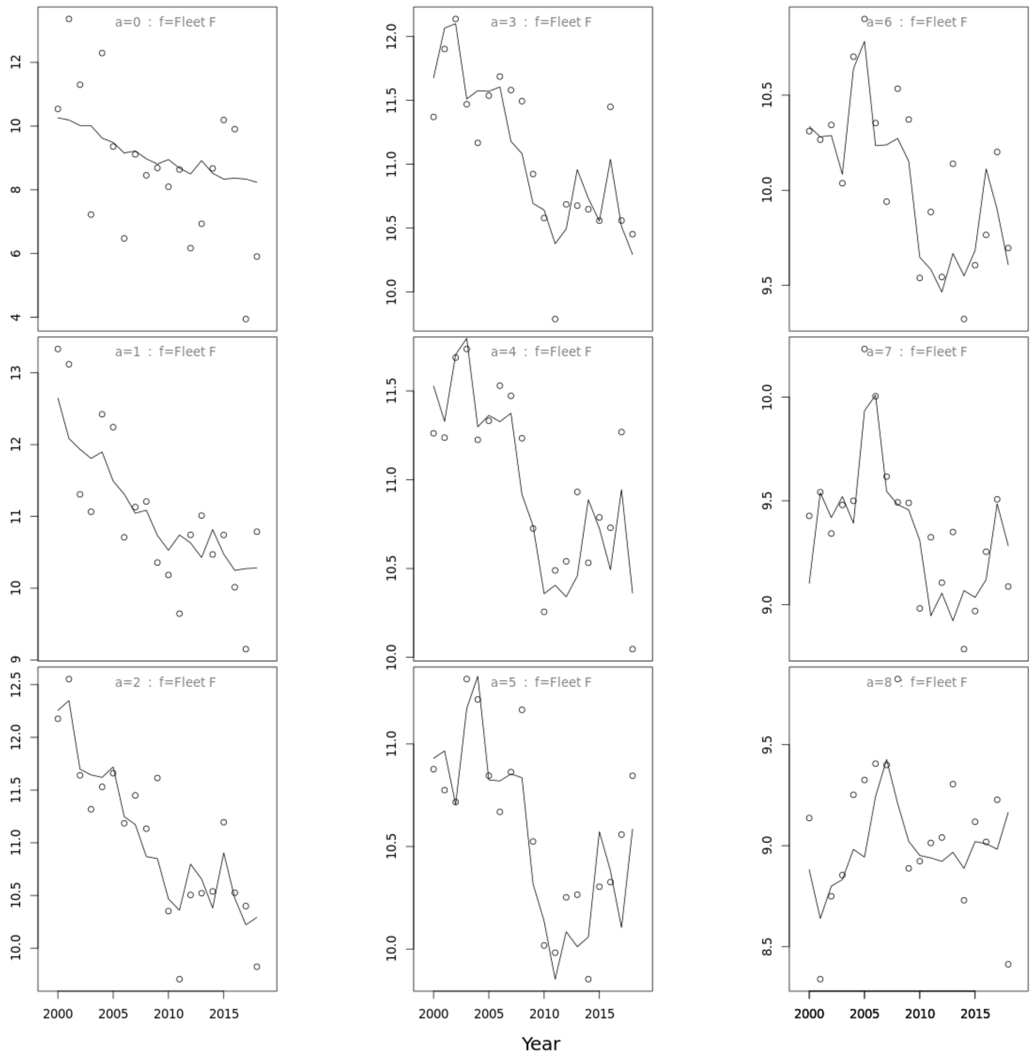

Figure 3.6.4.17 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Fleet F. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

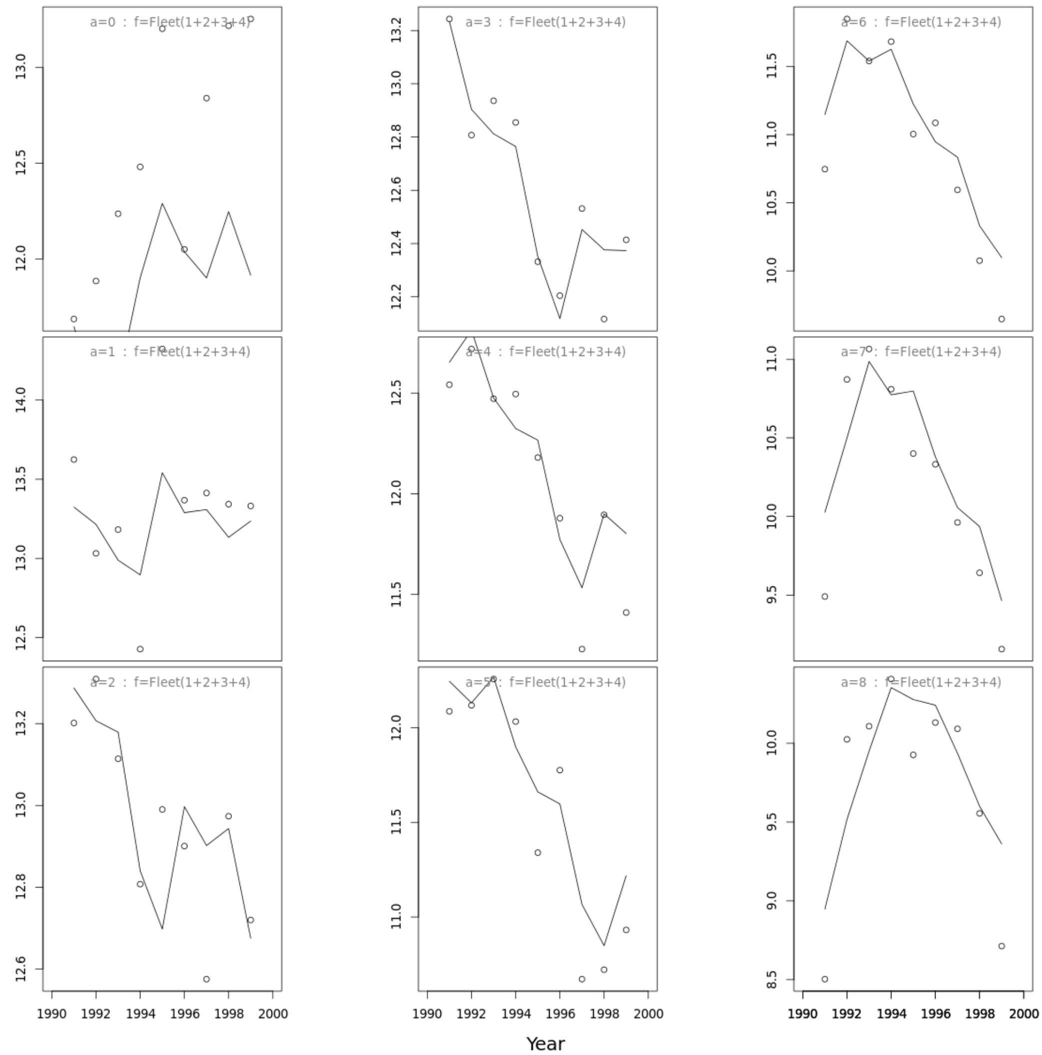

Figure 3.6.4.18 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of commercial catches fit per fleet. Sum of fleets Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

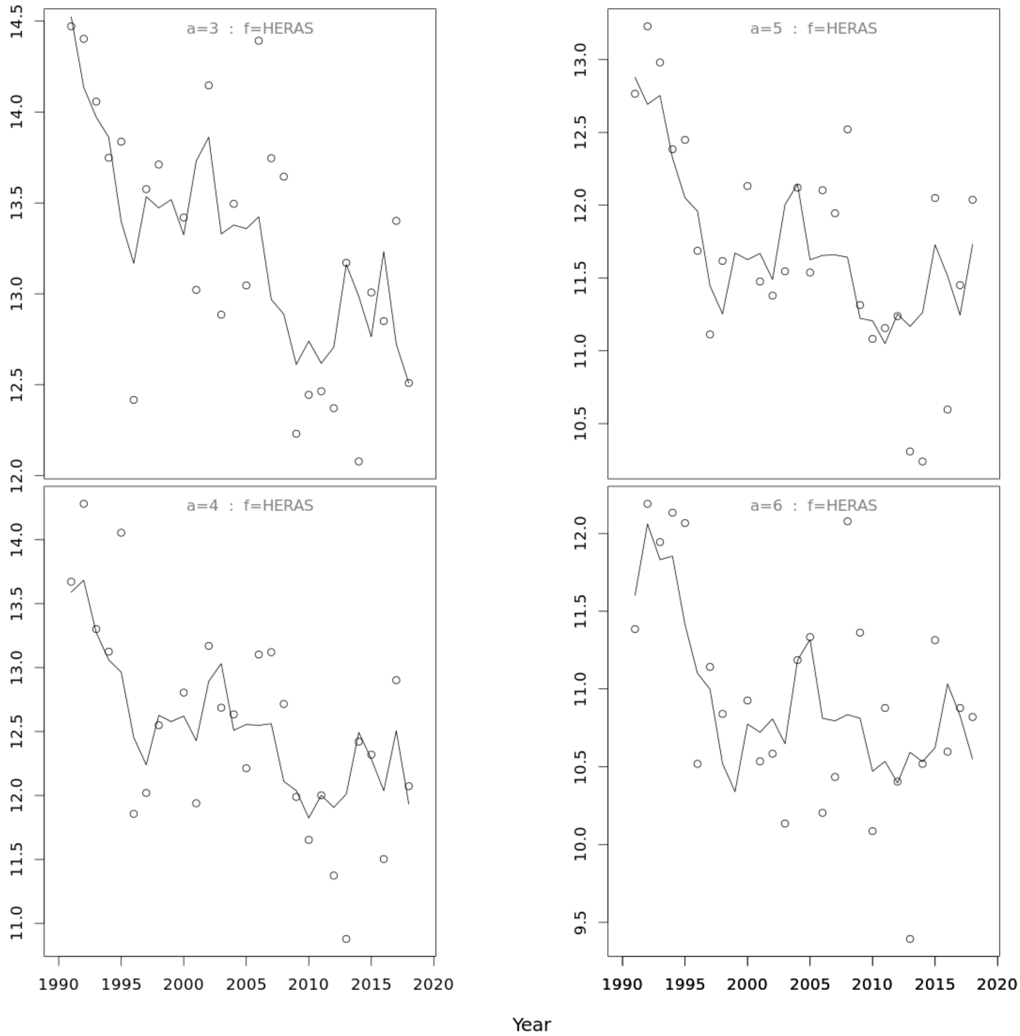

Figure 3.6.4.19 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the HERAS index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

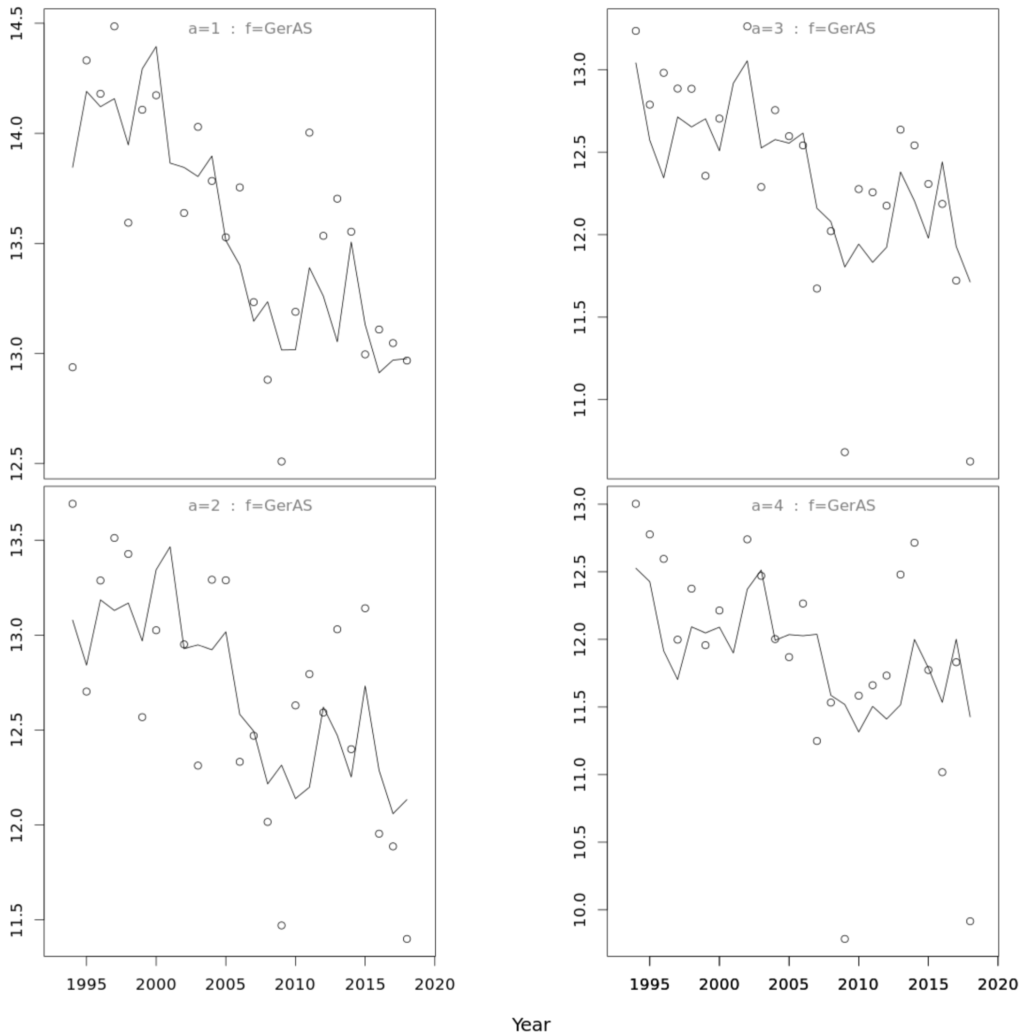

Figure 3.6.4.20 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the GerAs index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

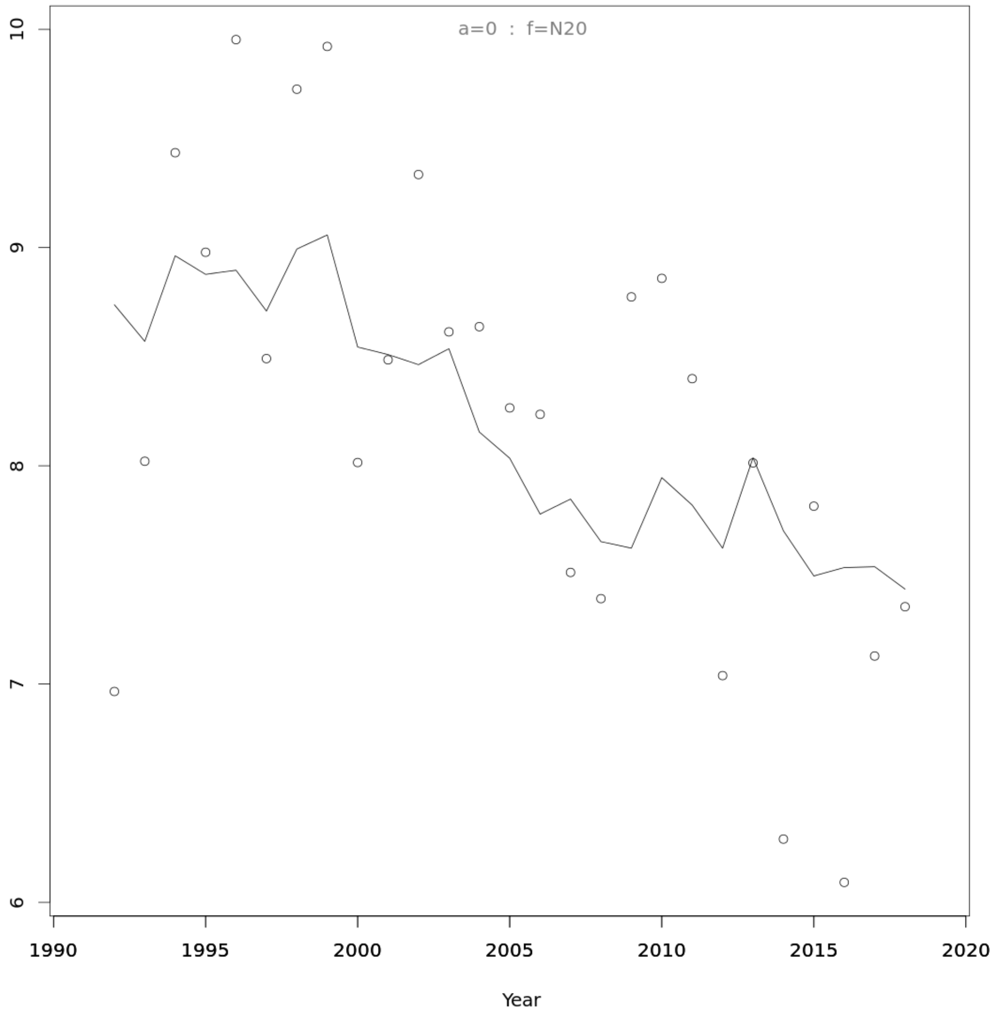

Figure 3.6.4.21 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the N20 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

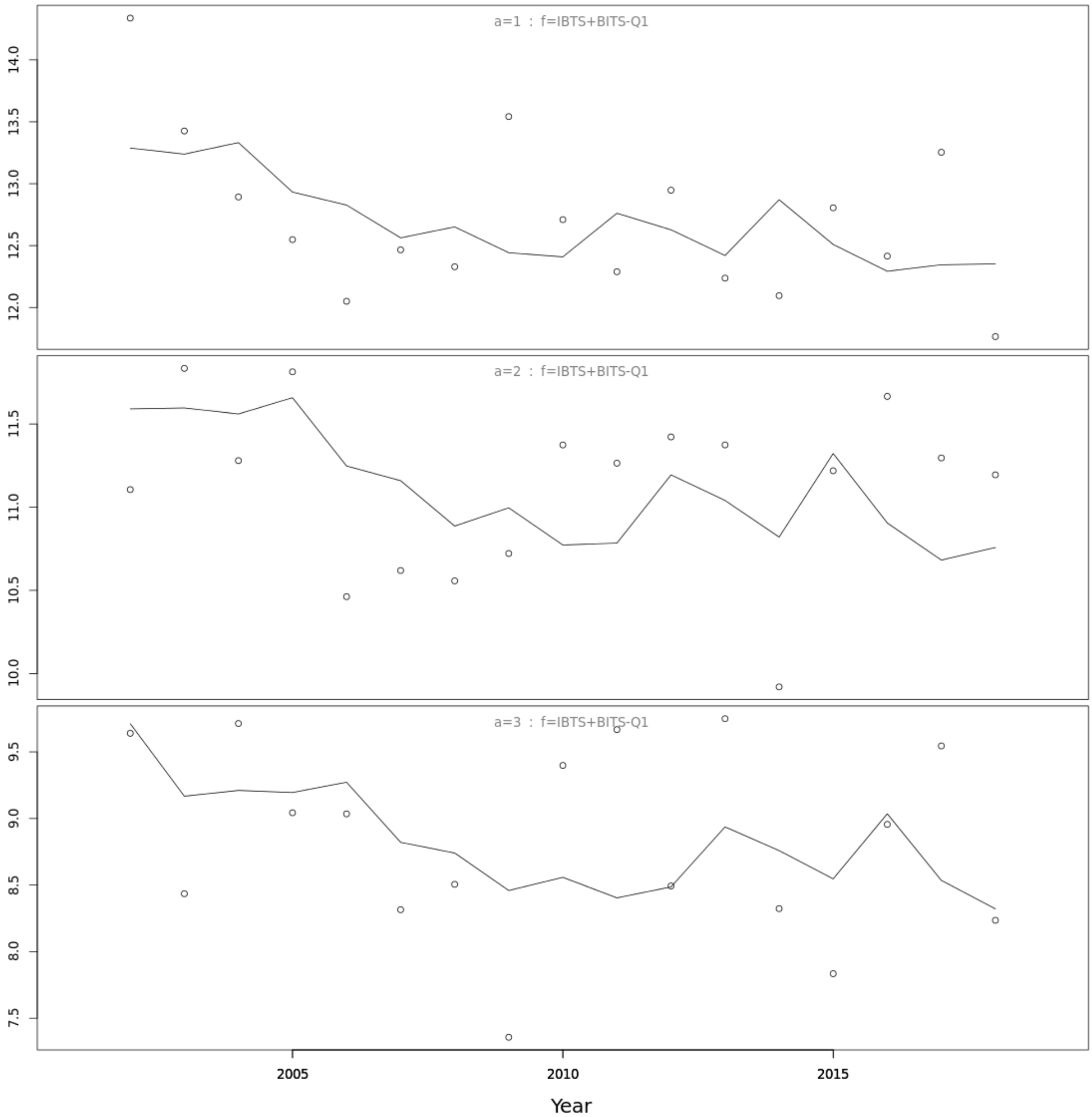

Figure 3.6.4.22 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the IBTS+BITS-Q1 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

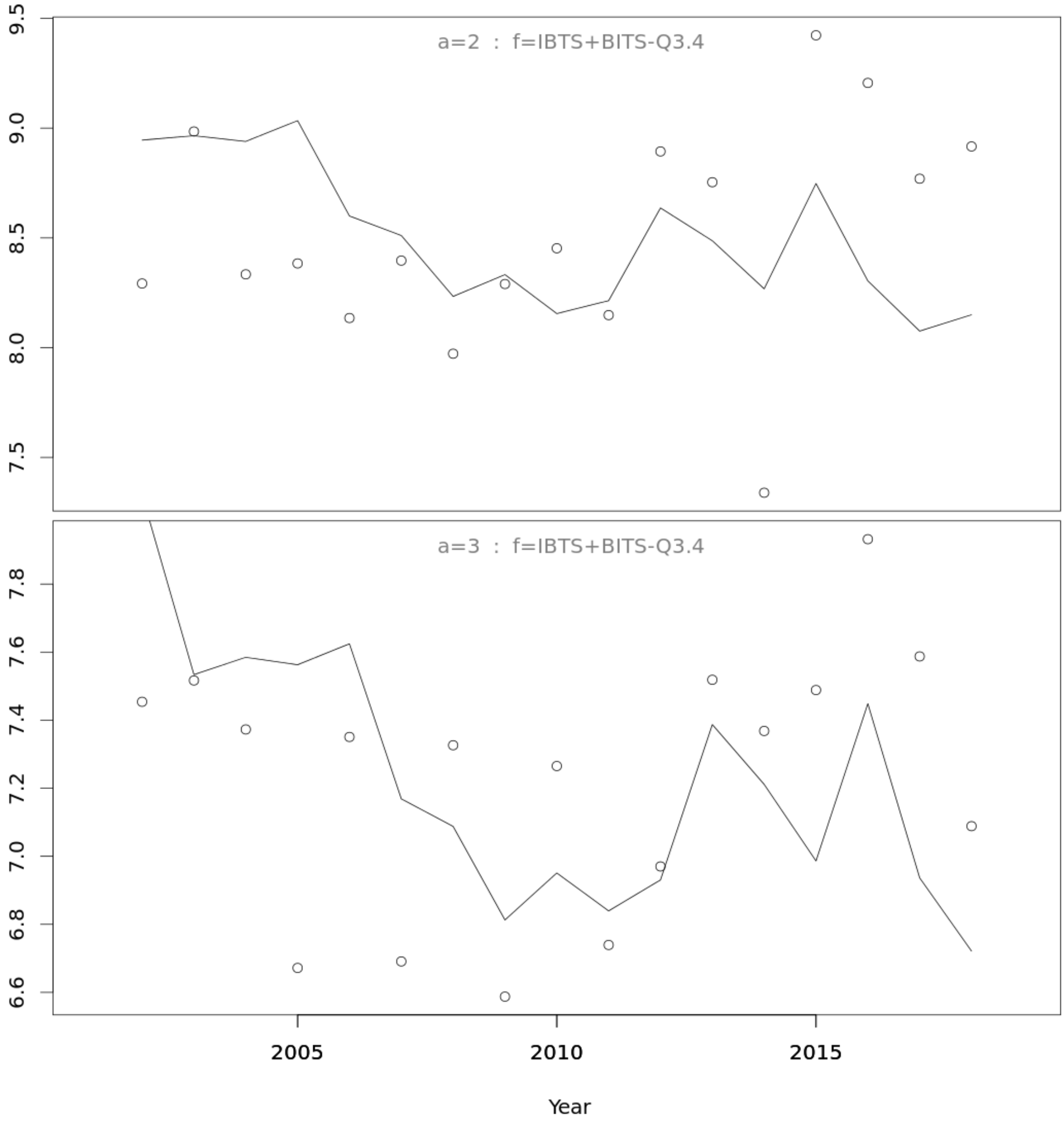

Figure 3.6.4.23 WESTERN BALTIC SPRING SPAWNING HERRING. Diagnostics of the IBTS+BITS-Q3.4 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

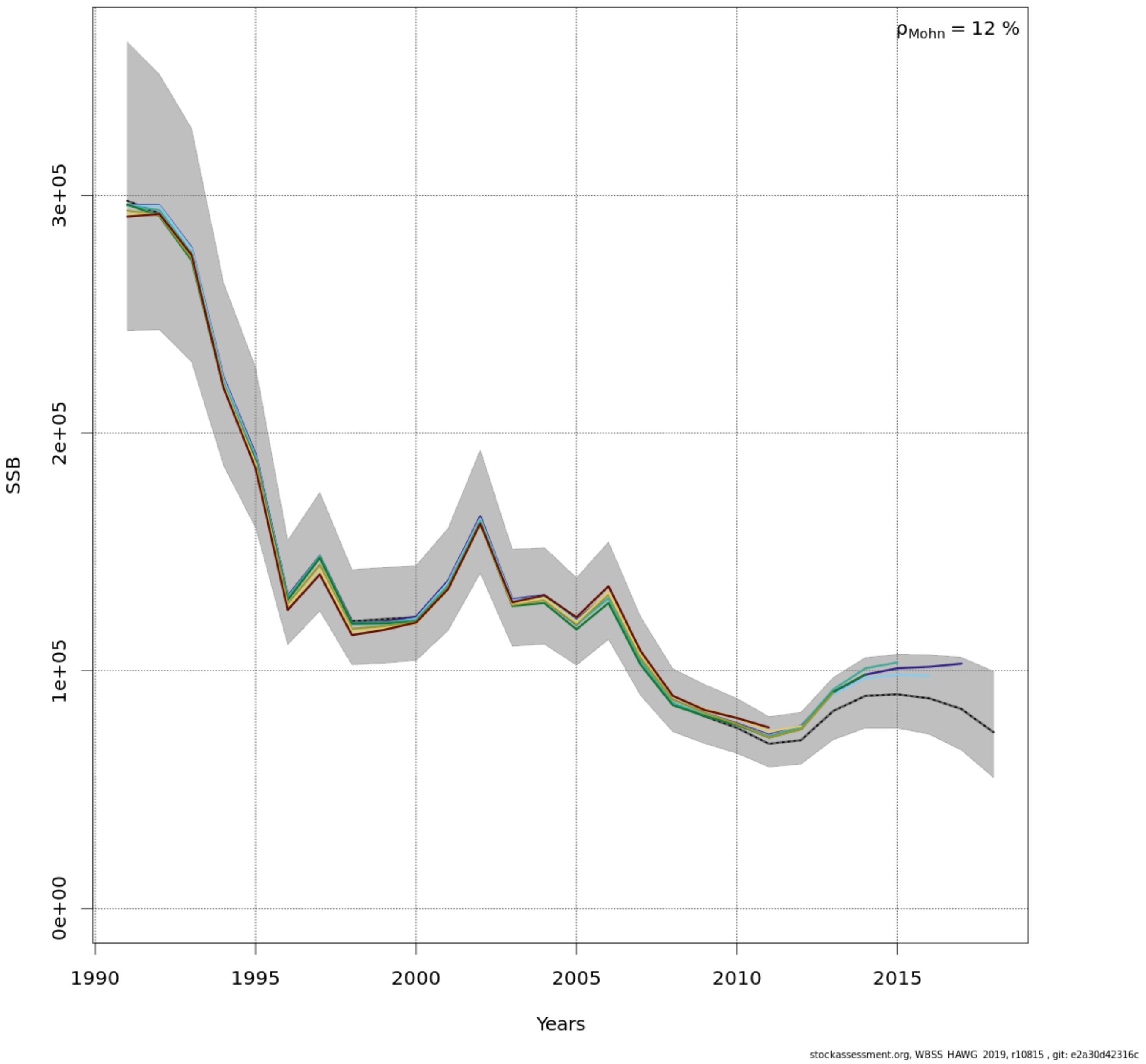

Figure 3.6.4.24 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Spawning stock biomass.

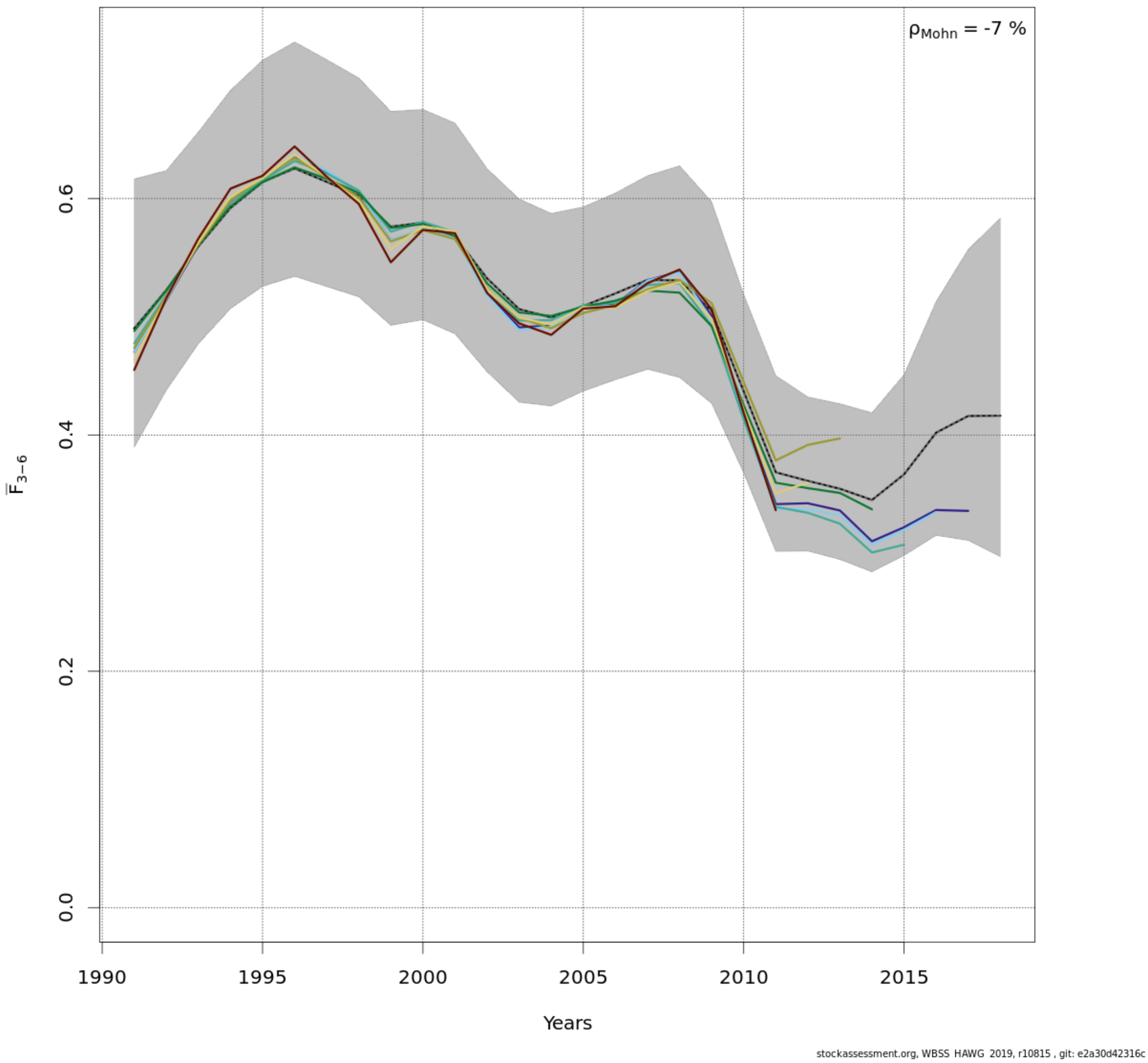

Figure 3.6.4.25 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Average fishing mortality for the shown age range.

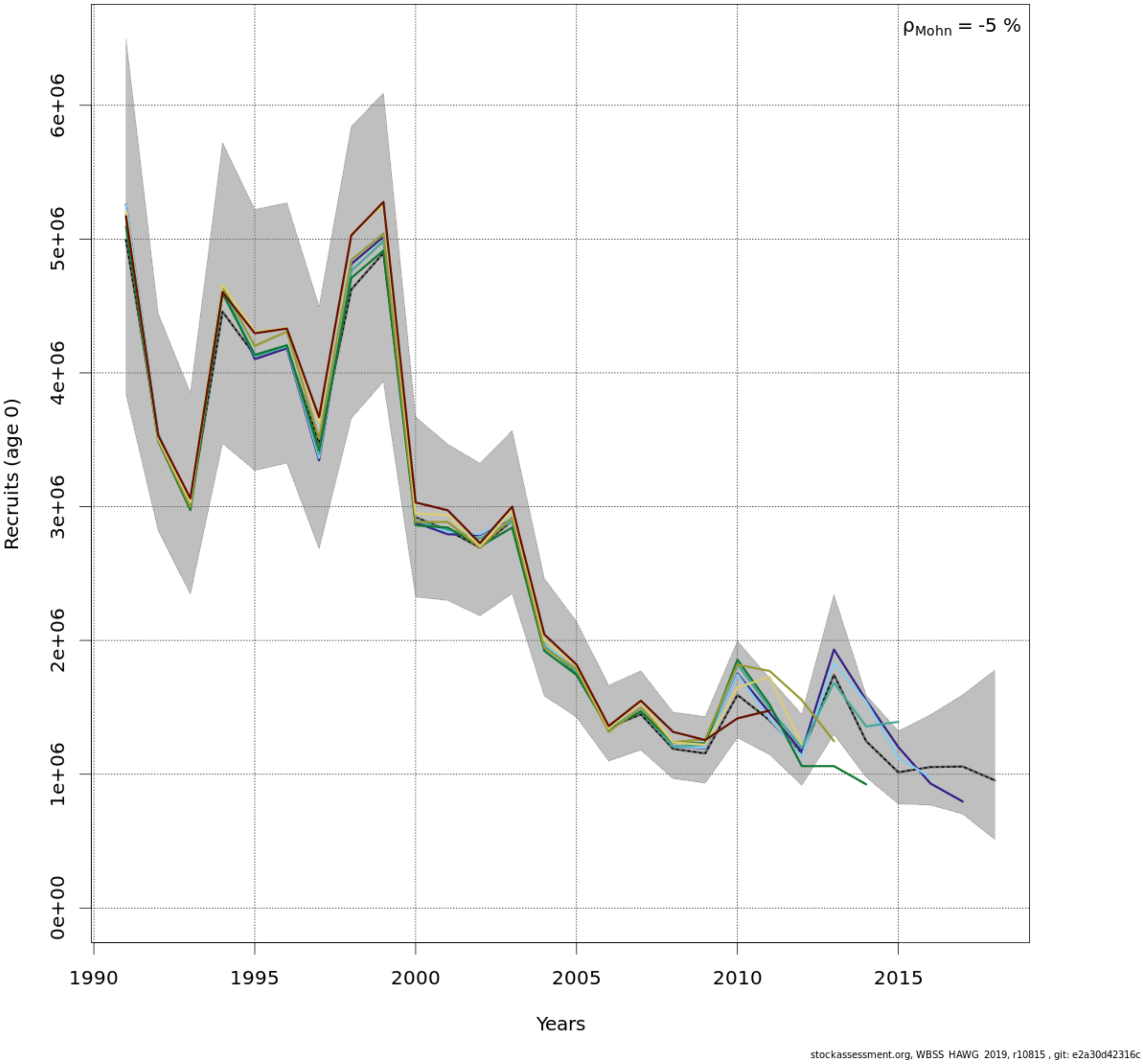

Figure 3.6.4.26 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Recruitment.

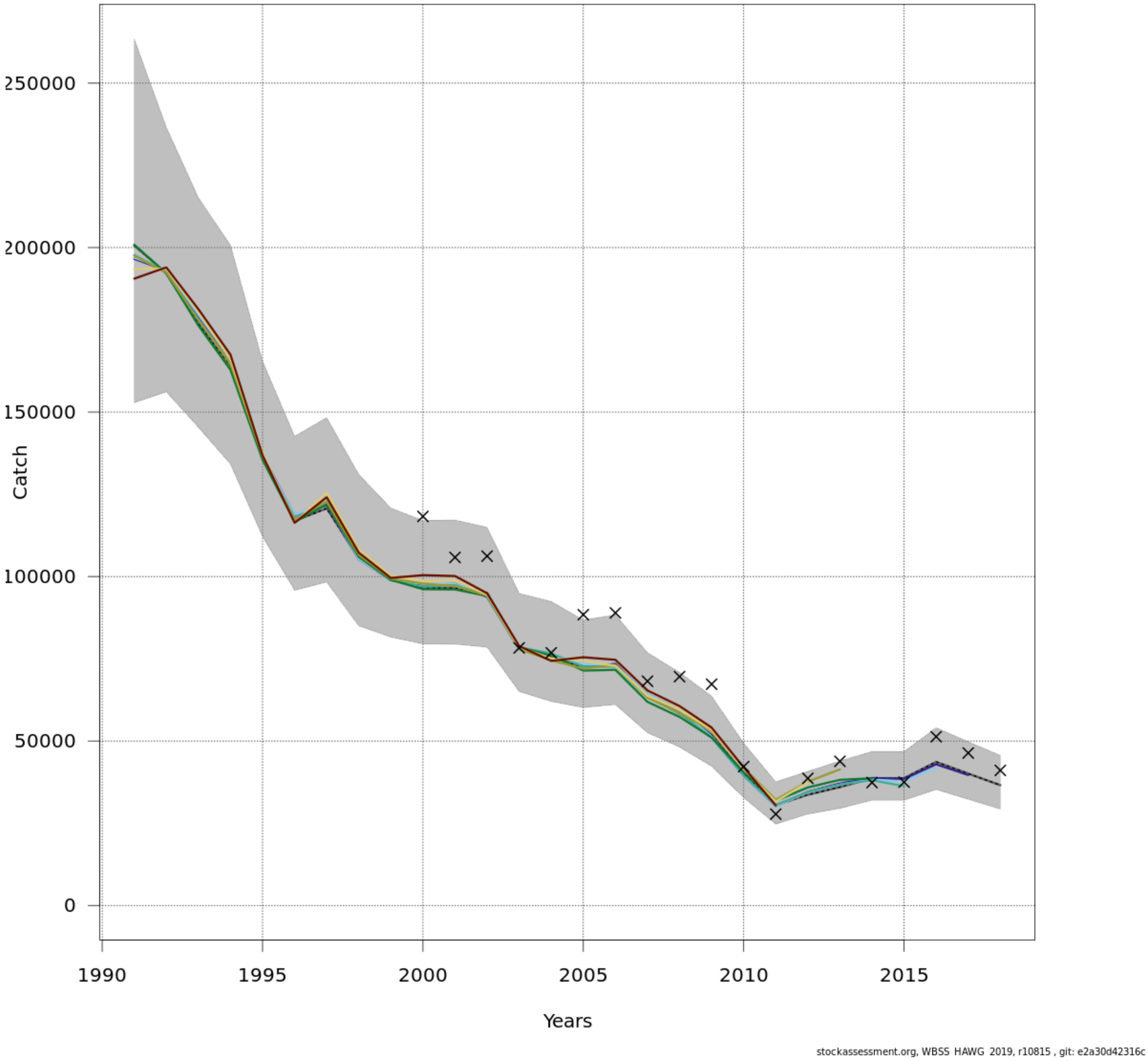

Figure 3.6.4.27 WESTERN BALTIC SPRING SPAWNING HERRING. Analytical retrospective pattern over 5 years from multi fleet run. Catch.

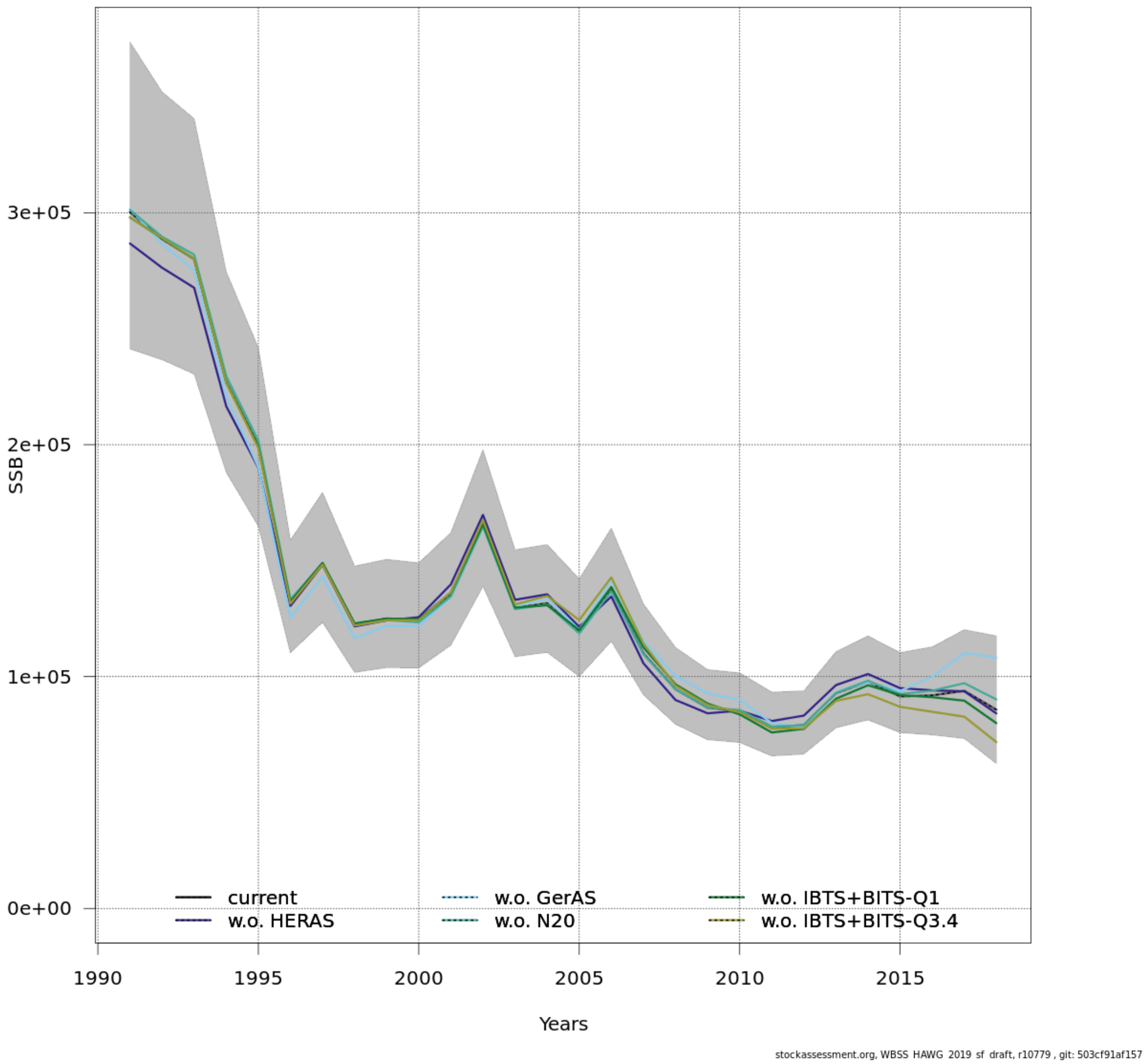

Figure 3.6.4.28 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from single fleet run. Spawning stock biomass.

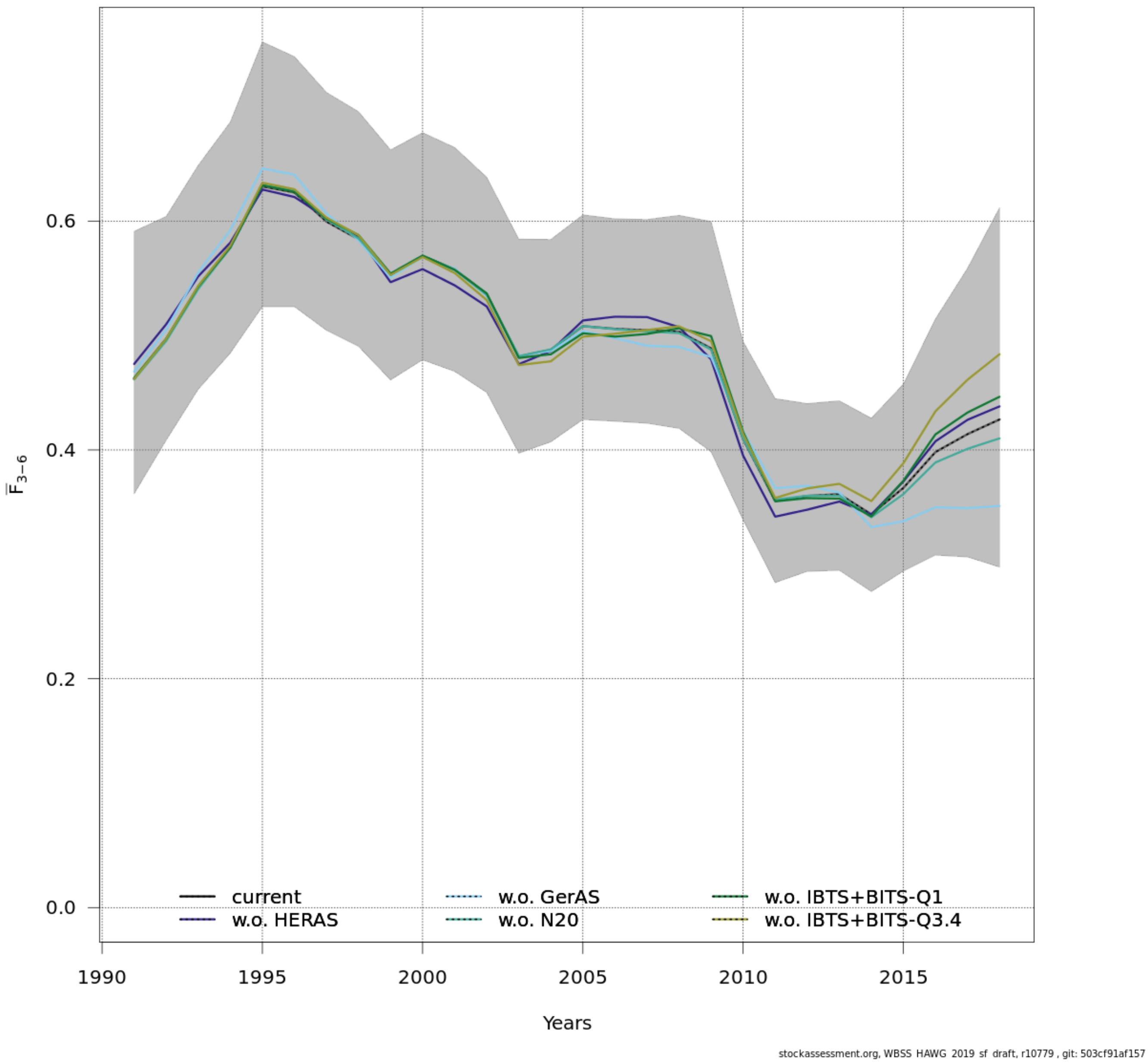

Figure 3.6.4.29 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from single fleet run. Average fishing mortality for the shown age range.

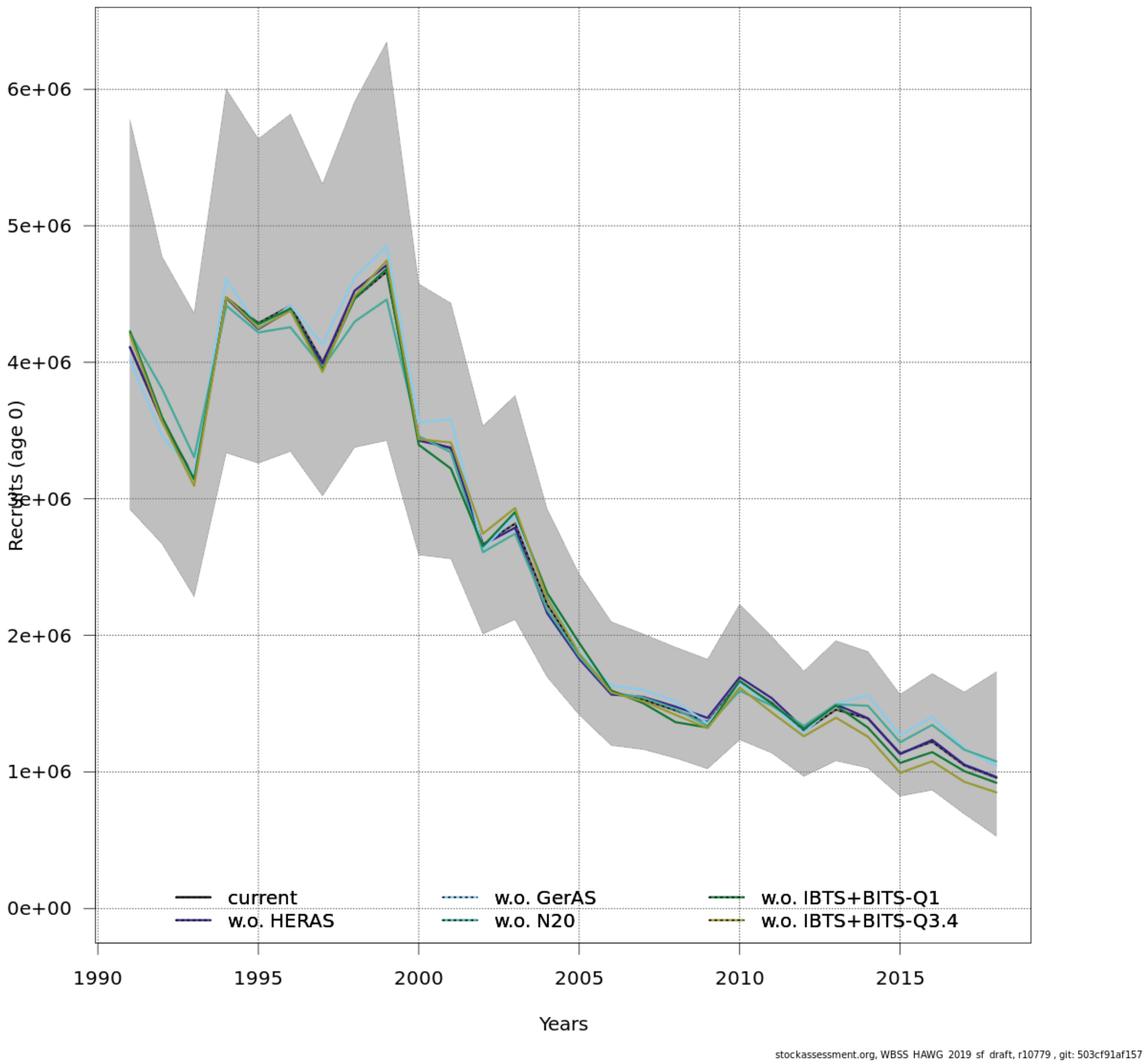

Figure 3.6.4.30 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from single fleet run. Recruitment.

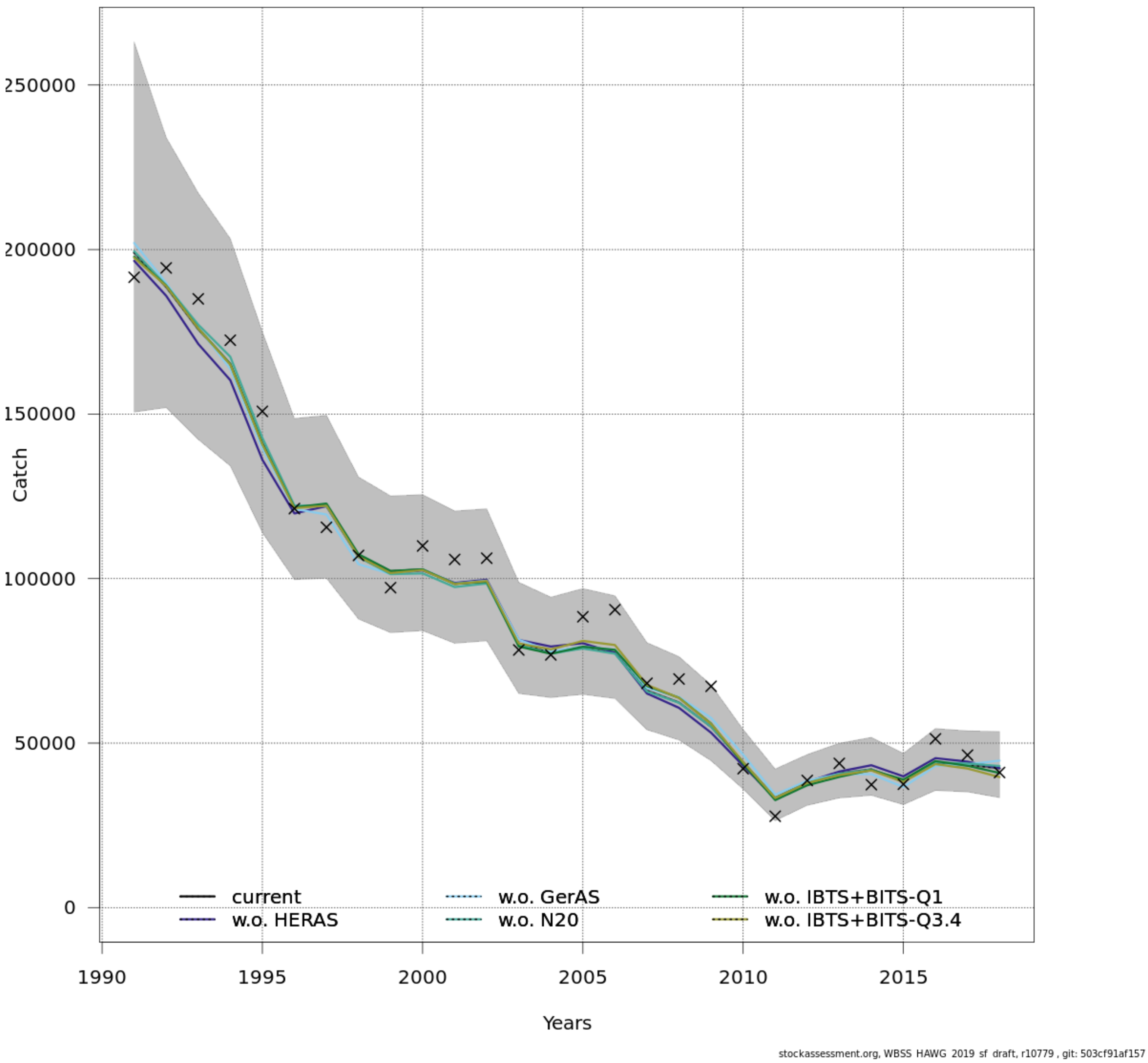

Figure 3.6.4.31 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from single fleet run. Catch.

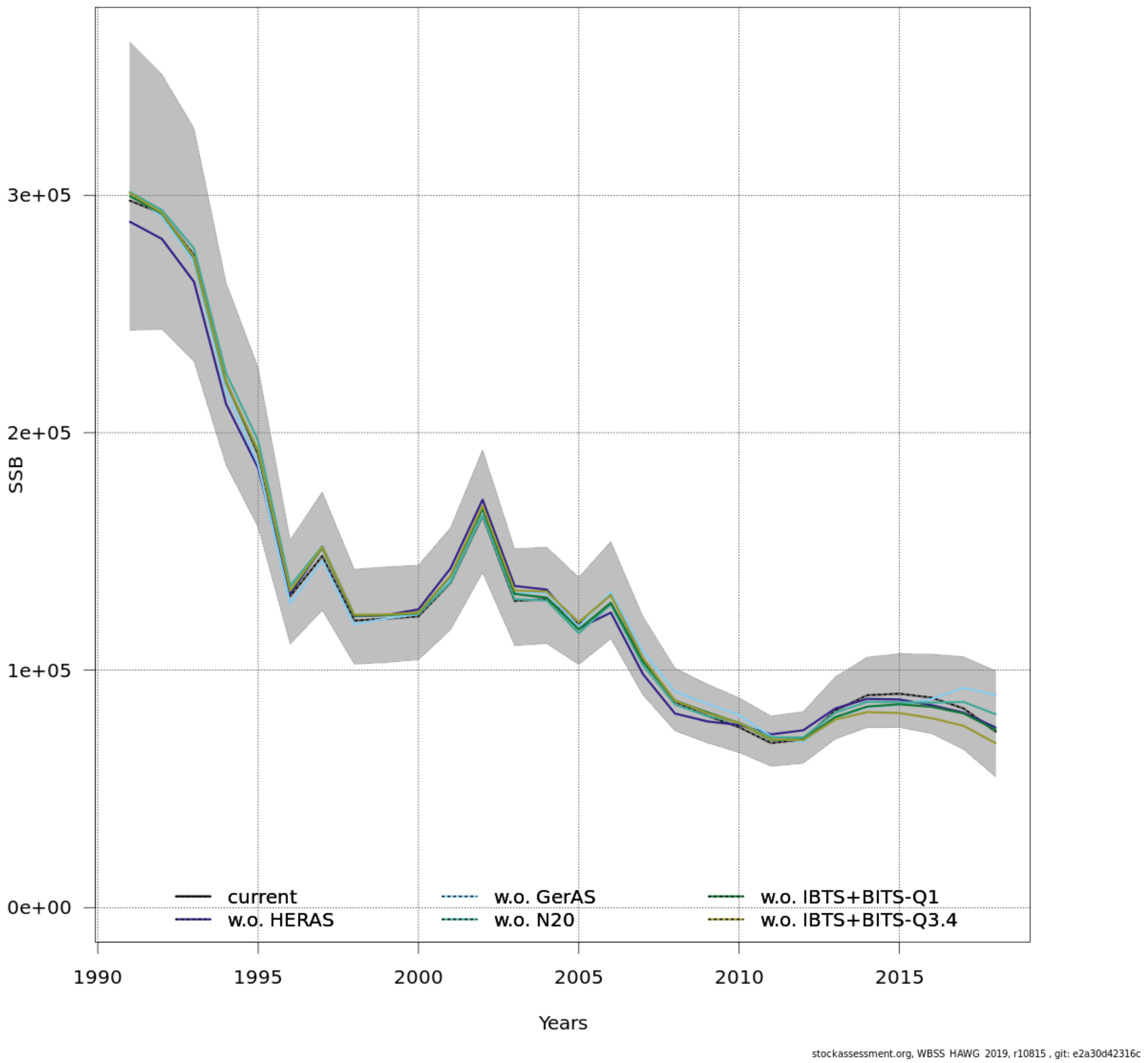

Figure 3.6.4.32 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Spawning stock biomass.

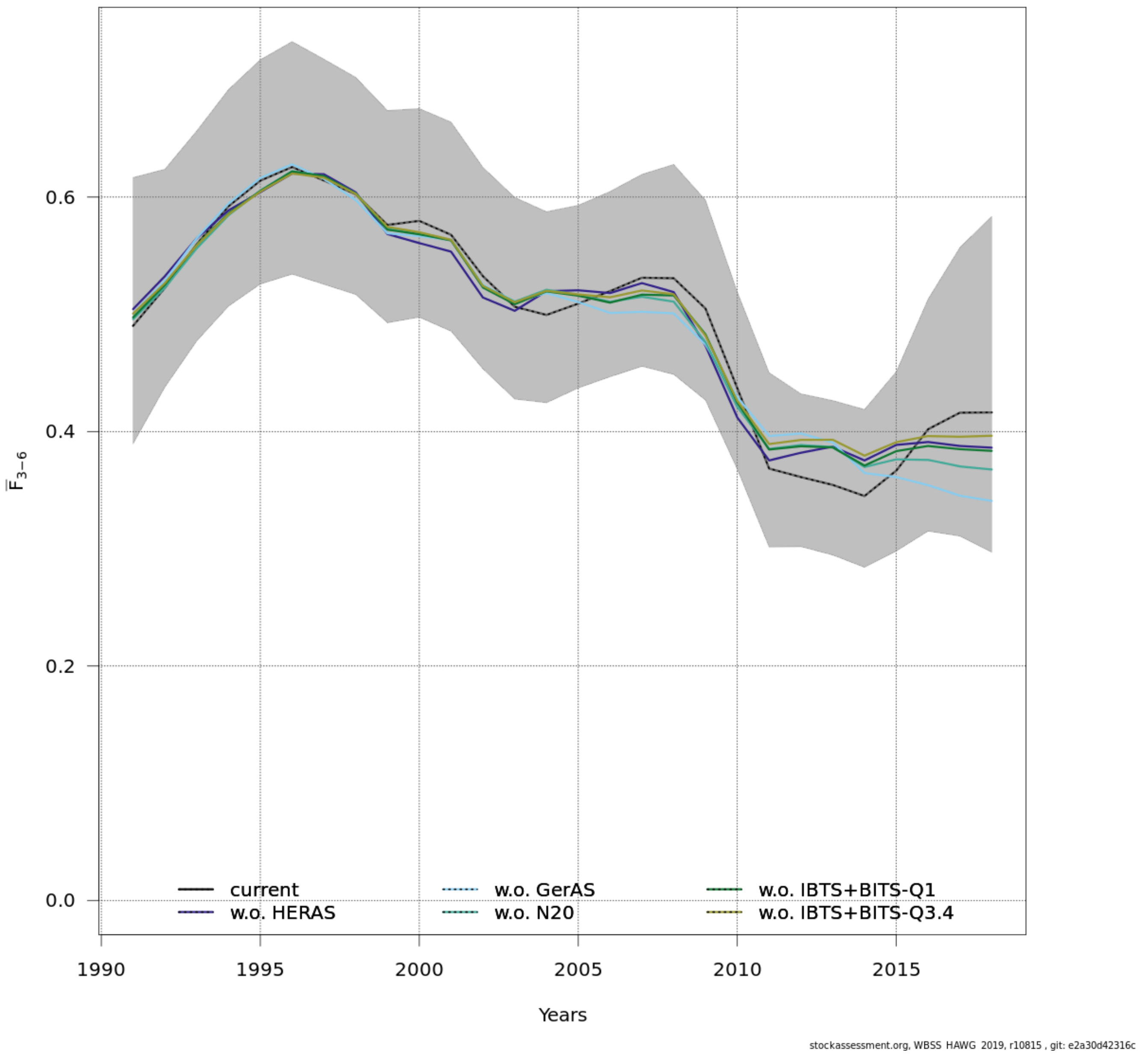

Figure 3.6.4.33 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Average fishing mortality for the shown age range.

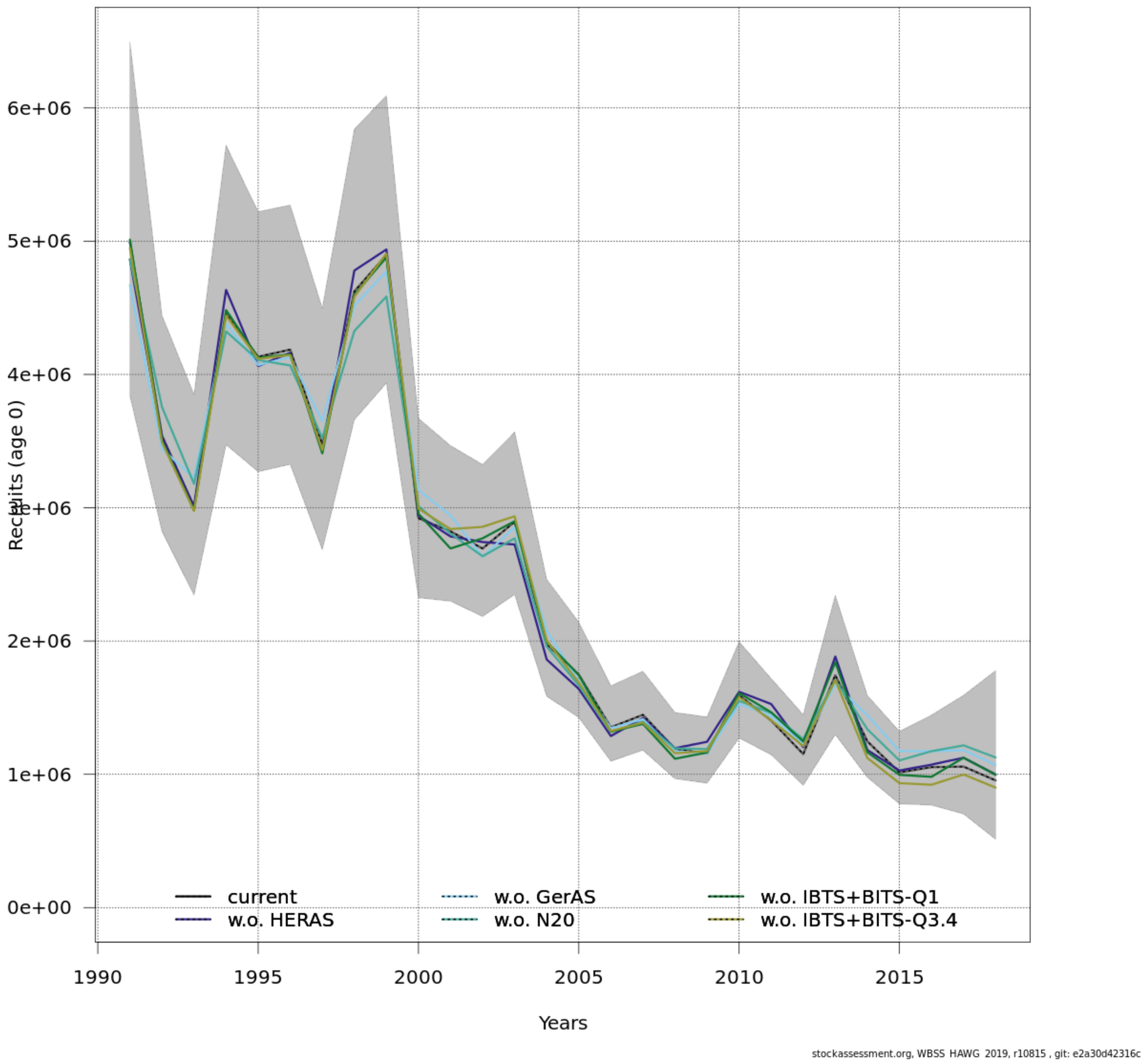

Figure 3.6.4.34 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Recruitment.

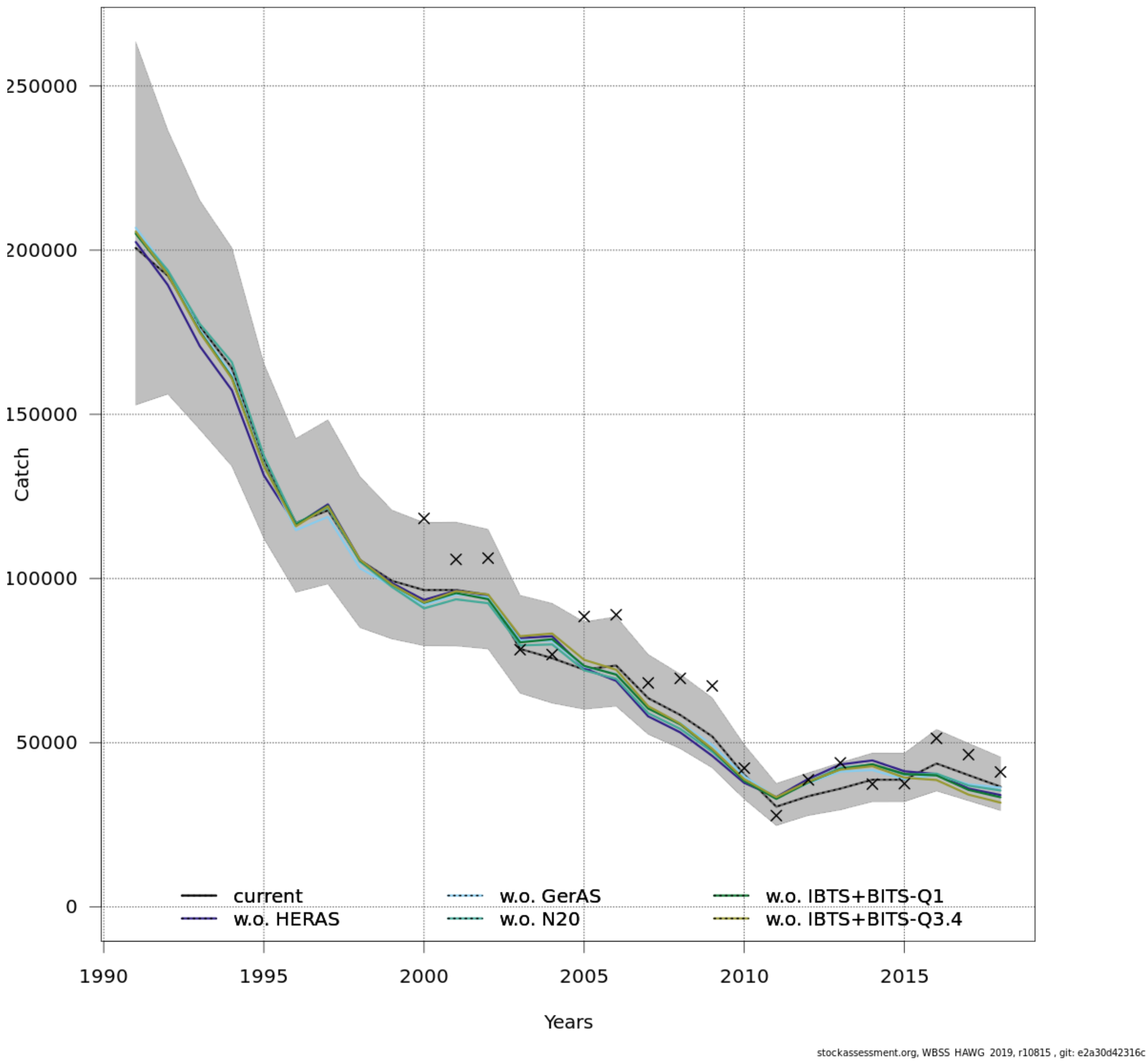

Figure 3.6.4.35 WESTERN BALTIC SPRING SPAWNING HERRING. Leave-one out from multi fleet run. Catch.

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

This is the fifth 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 2016–2018

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) and 2018 (EU2018/120).

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.aS, only 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.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 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, 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 (56th parallel) is not appropriate as a boundary, because it traverses the spawning and feeding grounds of 6.aS herring. Transboundary catches have occurred along this line in the past, although this has been less of an issue recently.

4.1.4 Catches in 2018

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 2013 year class (age 4-wr) dominates both in the catches and the acoustic survey in 2018. This year class was already strongly represented at-age 3 wr in the 2017 catches. Previous stronger cohorts are less influential in the stock with small amounts of older fish present.

4.3 Fishery-independent Information

4.3.1 Acoustic surveys

An acoustic survey has been carried out in Division 6.aN by Marine Scotland Science in June–July since 1991. It originally covered an area bounded by the 200 m depth contour in the north and west, to the 4°W in the east and extended south to 56°N; it had provided an age-disaggregated index of abundance as the sole tuning index for the analytical assessment of 6.aN herring since 2002. In 2008, it was decided that this survey should be expanded into a larger coordinated summer survey on recommendation from WESTHER, HAWG and SGHERWAY (Hatfield *et al.*, 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 2018 as well as maintaining coverage of the original survey area in 6.aN.

The Malin Shelf herring estimate of SSB for 2018 is 159 000 tonnes and 925 million individuals (Table 4.3.1.2), a slight increase compared to the 145 000 tonnes and 798 million herring estimate in 2017. The estimate is still however very low in the time-series (Table 4.3.1.3). In 2018, 83% of the biomass was observed north of 56°N (the geographic area included in the West of Scotland (6.aN index) in line with observations through the time-series. The West of Scotland (6.aN) estimate of SSB is 152 000 tonnes and 875 million individuals (Table 5.2.4), an increase compared to the 139 000 tonnes and 765 million herring estimate in 2017. Long-term indices of abundance per age class for West of Scotland herring are provided in Table 5.2.5. In 2018, the biomass of herring located in 6.aS and 7.b–c during the MSHAS was 7000 tonnes.

Although there was a slight increase in the 2018 estimates for the Malin Shelf and West of Scotland compared to 2017, the estimates are still among the lowest in the time-series. The distribution of herring schools was similar to 2017 with some herring distributed south of 56°N line of latitude (WGIPS ICES, 2019). There were some strong herring marks found to the west and north-west of the Outer Hebrides and around St. Kilda in 2018 again. This year larger aggregations of herring were observed around the Northern end of the Hebrides, around the Butt of Lewis and the North Minch and on Stanton banks. These were predominantly juvenile herring. Herring has in the past been found in high densities to the east of the 4°W line in association with a specific bathymetric feature and the occurrence of these herring west of the line in some years has the ability to strongly influence the annual estimate of abundance of the Malin Shelf/West of Scotland estimates. There no evidence in 2018 that herring distributions in this area influenced the Malin Shelf/West of Scotland estimates. 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.

In 2017, 3 to 6 winter ringed fish dominated the index representing 89% of both biomass and total abundance. This year (2018), the 2012- and 2013-year classes (age 4 and 5 winter rings in 2018) are still strong in the stock and comprised 20% of total abundance and 35% of the biomass. In contrast to recent years, a large proportion of the stock was made up of 1 and 2 winter ring fish this year (69% of the total abundance and 44% of total biomass). As 1 winter ring fish are only sporadically picked up in the survey due to their distribution typically being in the more inshore areas it cannot be confirmed yet whether 2016 is a strong year class, but it looks like the 2015-year class (2 winter ringers in 2018) is above average. 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 the summer acoustic surveys.

4.3.1.1 Industry–Science Acoustic survey

In 2016–2018 industry acoustic surveys of herring during the spawning and pre-spawning period were undertaken as part of the monitoring fishery on this stock. The surveys covers 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, 2019) and a summary for each of the components is in Section 05 of this report. Consistent with observations from other surveys, the industry acoustic/trawl survey recorded an abundance of juvenile herring, which has not previously been seen during these surveys (Figure 4.3.1.1.1)

4.3.2 Scottish Bottom-trawl surveys

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 Ground fish 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 part 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 particularly in the Q1 and Q4 indices (figures 4.3.2.1 and 4.3.2.2). Historic retrospectives for the index calculations for Q1 and Q4 are given in Figures 4.3.2.5 and 4.3.2.6, no new data were added to the index calculations between the interbenchmark and the calculations for the assessment and the lines therefore overlap completely. For Q4 data from 2018 were added to the calculations after the interbenchmark and the two calculated Q4 indices show good agreement.

The abundance of 2 winter ring fish were 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). Recent years show an increase in 3 wr for quarter 4 and an increase in 4 wr for the most recent year in quarter 1. 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 2018 the catch weights have decreased slightly for most age classes.

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 2018 (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, 3- and 4-wr in 2018 were lower than in 2016 and 2017 (Figure 4.4.2.1). A greater proportion of immature fish were encountered in the survey in 2018 than in previous years.

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 (IBPher6a7bc, ICES 2019). The tool for the assessment of herring in 6.a and 7.b–c is a multi-fleet 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 higher proportion of 1 winter ring fish but this is variable between years.

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 were slightly higher in 2018 than 2017. 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 data set 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 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 (Figure 4.6.7). 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 problem in this update 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 1957–2018. 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, 2017 and 2018 and the resulting monitoring fishery has decreased F.

The analytical retrospective for this stock is shown in Figure 4.6.12. The 2018 assessment had a strong retrospective bias in SSB, pulling down the series as far back as the mid-1980s (ICES, 2018). The changes applied to the assessment following the interbenchmark have improved the retrospective but bias is still present. The Mohn's Rho on 5 year peels is -23.

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.

The final assessment in 2018 and 2019 are compared in Figure 4.6.58. The new assessment shows a very different perception of stock status. The SSB has been significantly revised downwards and F has been revised upwards. Recruitment has also been revised downwards. SSB and recruitment are at very low levels with decreases in F evident in 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 2018 is estimated to be at a very low level. Recruitment has been low with no big cohorts evident in recent years. Recent catches have been amongst the lowest in the time-series.

4.7 Short-term Projections

4.7.1 Short-term projections

No short term projections were carried out in 2019.

4.7.2 Yield per Recruit

No yield per recruit analysis was conducted at HAWG 2019.

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. It is anticipated that a full benchmark will be carried out within a few years 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 inter-benchmark 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 is at a very low level. Recruitment is estimated to be the lowest in the series. This reflects very low numbers of 1-wr fish in the catches in recent years. Since 2012, there have been very few 1-wr herring observed in the 6.a (combined) and 7.b–c fishery.

The updated assessment shows a very different perception of the stock with SSB and recruitment revised downwards and at very low levels. The fishing mortality has been revised upward with a decrease evident since the introduction of the monitoring TAC in 2016.

The interbenchmark points to continued concerns with 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 new 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 are not 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 over-exploited. There is a clear need to determine the relative stock sizes and to ensure that the smaller / weaker stock is adequately assessed and protected from over-exploitation.

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 is currently underway to assess the identity of herring stocks in this area through genetic analysis. The project also aims to develop genetic profiles of these stocks, which can be used in the future to discriminate the stocks even during times of mixing. The final results of this project are expected at the end of 2020. It is anticipated that when these results are available it will be possible to carry out a full benchmark on these stocks.

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 2016–2018 and agreed for 2019 (5800 t) is associated with decreased F.

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.

Observers monitor some of the fleets. Herring fisheries tend to be clean with little bycatch of other fish. Scottish pelagic 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 pelagic discard observer programme has recorded occasional catches of seals and zero catches of cetaceans in the past. Unfortunately, the Scottish pelagic discard observer programme is no longer active.

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 2018. Mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	294	0.7	0.00	2.5	6.6
1	1289	64.2	0.00	49.8	17.7
2	447	47.9	0.40	107.0	22.7
3	106	16.2	0.85	152.1	25.4
4	343	60.2	0.98	175.8	26.8
5	153	29.1	0.98	190.0	27.5
6	52	10.8	1.00	208.8	28.6
7	72	15.1	1.00	209.4	28.8
8	27	5.8	1.00	218.0	29.1
9+	13	3.0	1.00	224.4	29.4
Immature	**1872**	**95**		**50.5**	**16.7**
Mature	**925**	**159**		**171.4**	**26.5**
Total	**2797**	**253**	**0.33**	**90.5**	**19.9**

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 2018.

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
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

Table 4.6.1a. Herring in 6.a (combined) and 7.b–c. CATCH-IN-NUMBER for 6.aN

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	6496	15616	53092	3561	13081	55048	11796	26546	299483	211675	207947
2	74622	30980	67972	102124	45195	92805	78247	82611	19767	500853	27416
3	58086	145394	35263	60290	61619	22278	53455	70076	62642	33456	218689
4	25762	39070	116390	22781	33125	67454	11859	26680	59375	60502	37069
5	33979	24908	24946	48881	22501	44357	40517	7283	22265	40908	39246
6	19890	27630	17332	11631	12412	19759	26170	24227	5120	19344	29793
7	8885	17405	16999	10347	5345	24139	8687	18637	22891	5563	11770
8	1427	9857	7372	6346	4814	6147	13662	8797	18925	17811	5533
9	4423	7159	8595	4617	2582	7082	6088	15103	19531	27083	25799

age	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	220255	37706	238226	207711	534963	51170	309016	172879	69053	34836	22525
2	94438	92561	99014	335083	621496	235627	124944	202087	319604	47739	46284
3	20998	71907	253719	412816	175137	808267	151025	89066	101548	95834	20587
4	159122	23314	111897	302208	54205	131484	519178	63701	35502	22117	40692
5	13988	211243	27741	101957	66714	63071	82466	188202	25195	10083	6879
6	23582	21011	142399	25557	25716	54642	49683	30601	76289	12211	3833
7	15677	42762	21609	154424	10342	18242	34629	12297	10918	20992	2100
8	6377	26031	27073	16818	55763	6506	22470	13121	3914	2758	6278
9	10814	26207	24082	31999	16631	32223	21042	13698	12014	1486	1544

age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	247	2692	36740	13304	81923	2207	40794	33768	19463	1708	6216
2	142	279	77961	250010	77810	188778	68845	154963	65954	119376	36763
3	77	95	105600	72179	92743	49828	148399	86072	45463	41735	109501
4	19	51	61341	93544	29262	35001	17214	118860	32025	28421	18923
5	13	13	21473	58452	42535	14948	15211	18836	50119	19761	18109
6	8	9	12623	23580	27318	11366	6631	18000	8429	28555	7589
7	4	8	11583	11516	14709	9300	6907	2578	7307	3252	15012
8	1	1	1309	13814	8437	4427	3323	1427	3508	2222	1622
9	0	0	1326	4027	8484	1959	2189	1971	5983	2360	3505

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	14294	26396	5253	17719	1728	266	1952	1193	9092	7635	4511.46
2	40867	23013	24469	95288	36554	82176	37854	55810	74167	35252	22960.61
3	40779	25229	24922	18710	40193	30398	30899	34966	34571	93910	21825.16
4	74279	28212	23733	10978	6007	21272	9219	31657	31905	25078	51420.22
5	26520	37517	21817	13269	7433	5376	7508	23118	22872	13364	15504.75
6	13305	13533	33869	14801	8101	4205	2501	17500	14372	7529	9002.21
7	9878	7581	6351	19186	10515	8805	4700	10331	8641	3251	3897.69
8	21456	6892	4317	4711	12158	7971	8458	5213	2825	1257	1835.56
9	5522	4456	5511	3740	10206	9787	31108	9883	3327	1089	576.39

	year							
age	2001	2002	2003	2004	2005	2006	2007	2008
1	147.07	992.20	56.11	0.00	182.50	132.46	130.75	0.00
2	83318.40	38481.61	33331.96	7235.79	9632.71	6691.49	34326.00	7898.43
3	15368.56	93975.05	46865.58	23483.32	23236.71	9186.07	17754.83	13039.08
4	9569.99	9014.40	53766.66	29421.79	20602.39	13644.88	6555.14	5427.59
5	25175.08	18113.71	7462.98	48394.28	10237.93	41067.79	14264.99	3219.52
6	9544.89	28016.08	4344.55	4151.94	9783.17	27781.86	30566.16	5688.56
7	6813.78	9040.10	12818.38	8100.36	1014.99	20972.98	21517.07	14832.27

8	4741.98	1547.87	9187.62	9023.67	1194.95	3041.71	13585.45	8142.31
9	1028.78	1422.68	1407.96	4265.93	1430.76	5088.99	4242.60	8968.60

age	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
1	1923.62	10074.12	1667.19	979.53	0.00	0.00	231.18	12
2	11508.54	20339.85	40587.92	14952.63	13681.14	8705.73	10854.96	8148
3	10475.63	16331.31	15782.93	46647.39	18181.74	15144.82	13937.56	3341
4	16586.96	9957.96	10333.90	9704.45	53116.88	21063.66	15716.60	3197
5	8332.17	14608.15	7190.29	8097.30	11681.99	42229.47	19386.70	2791
6	5688.68	6322.33	5071.43	6311.66	7093.01	7130.95	21621.33	2821
7	7514.70	4322.24	3164.16	3873.67	5098.64	2944.09	6397.35	3148
8	11793.98	5388.91	2611.38	1129.80	4324.63	2854.21	1932.73	739
9	9443.85	13199.28	7225.68	4013.80	5031.77	3511.43	1250.55	431

age	**2017**	**2018**
1	0.00	0.00
2	1122.16	1508.98
3	11929.71	3215.53
4	4082.50	6873.26
5	2075.35	5253.61
6	1443.79	3068.25
7	1416.35	844.50
8	767.37	852.31
9	273.34	680.89

Table 4.6.1b Herring in 6.a (combined) and 7.b–c. CATCH-IN-NUMBER for 6.aS/7.bc.

	year												
age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0	100	1060	516	1768	259	132	88	234	0	0	574	1495
2	7709	3349	7251	18221	7129	7170	6446	7030	3847	16809	1232	10192	15038
3	9965	9410	3585	7373	14342	5535	5929	5903	10135	11894	55013	4702	13013
4	1394	6130	8642	3551	6598	10427	2032	4048	9008	10319	12681	78638	4410
5	6235	4065	3222	2284	2481	5235	3192	2195	2426	7392	9071	5316	54809
6	2062	5584	1757	770	2392	3322	3541	3972	2019	3356	6348	4534	4918
7	943	3279	2002	1020	566	4111	2079	3779	6349	7112	3455	1889	3234
8	287	1192	858	578	706	1653	1293	1830	2737	2987	4862	839	1954
9	490	2195	839	326	387	1525	2517	3559	4276	6109	8165	3340	3136

	year											
age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	135	883	1001	6423	3374	7360	16613	4485	10170	5919	2856	1620
2	35114	6177	28786	40390	29406	41308	29011	44512	40320	50071	40058	22265
3	26007	7038	20534	47389	41116	25117	37512	13396	27079	19161	64946	41794
4	13243	10856	6191	16863	44579	29192	26544	17176	13308	19969	25140	31460
5	3895	8826	11145	7432	17857	23718	25317	12209	10685	9349	22126	12812
6	40181	3938	10057	12383	8882	10703	15000	9924	5356	8422	7748	12746
7	2982	40553	4243	9191	10901	5909	5208	5534	4270	5443	6946	3461
8	1667	2286	47182	1969	10272	9378	3596	1360	3638	4423	4344	2735
9	1911	2160	4305	50980	30549	32029	15703	4150	3324	4090	5334	5220

	year											
age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	748	1517	2794	9606	918	12149	0	2241	878	675	2592	191
2	18136	43688	81481	15143	27110	44160	29135	6919	24977	34437	15519	20562
3	17004	49534	28660	67355	27818	80213	46300	78842	19500	27810	42532	22666
4	28220	25316	17854	12756	66383	41504	41008	26149	151978	12420	26839	41967

age												
5	18280	31782	7190	11241	14644	99222	23381	21481	24362	100444	12565	23379
6	8121	18320	12836	7638	7988	15226	45692	15008	20164	17921	73307	13547
7	4089	6695	5974	9185	5696	12639	6946	24917	16314	14865	8535	67265
8	3249	3329	2008	7587	5422	6082	2482	4213	8184	11311	8203	7671
9	2875	4251	4020	2168	2127	10187	1964	3036	1130	7660	6286	6013

year

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	11709	284	4776	7458	7437	2392	4101	2316	4058	1731	1401	209
2	56156	34471	24424	56329	72777	51254	34564	21717	32640	32819	15122	28123
3	31225	35414	69307	25946	80612	61329	38925	21780	37749	28714	32992	30896
4	16877	18617	31128	38742	38326	34901	30706	17533	18882	24189	19720	26887
5	21772	19133	9842	14583	30165	10092	13345	18450	11623	9432	9006	10774
6	13644	16081	15314	5977	9138	5887	2735	9953	10215	5176	4924	5452
7	8597	5749	8158	8351	5282	1880	1464	1741	2747	2525	1547	1348
8	31729	8585	12463	3418	3434	1086	690	1027	1605	923	975	858
9	10093	14215	6472	4264	2942	949	1602	508	644	303	323	243

year

age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	598	76	483	202	1271	121	5142	61	34	22	69	30	6
2	22036	24577	12265	12574	13507	14207	12844	3118	465	1320	1983	1051	1567
3	36700	43958	19661	12077	20127	9315	16387	4532	8825	994	4252	5241	1838
4	30581	23399	28483	12096	6541	9114	4042	12238	6735	2291	1369	4078	3280
5	21956	13738	11110	12574	7588	3386	1776	1665	12146	1886	3025	1025	2288
6	9080	5474	5989	5239	6780	3780	553	1792	2406	663	2085	2250	613
7	2418	1825	2738	2040	2563	2871	541	425	1045	107	824	1061	700
8	832	231	745	853	661	980	103	382	437	23	43	480	260
9	369	131	267	17	189	95	21	202	204	10	9	76	29

Table 4.6.2a. Herring in 6.a (combined) and 7.b–c. WEIGHTS-AT-AGE IN THE CATCH for 6.aN

Units : kg

, , area = 6.aN

year

age	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

year

age	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	0.224	0.224

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	0.1580	0.1667	0.1705	0.1726	0.1549	0.1550	0.1469	0.1441
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 \ year	2014	2015	2016	2017	2018
1	0.0000	0.0769	0.100	0.000	0.000
2	0.1451	0.1425	0.144	0.137	0.126
3	0.1877	0.1795	0.178	0.167	0.151
4	0.2030	0.2059	0.204	0.187	0.174
5	0.2279	0.2136	0.219	0.204	0.190
6	0.2449	0.2307	0.229	0.213	0.208
7	0.2608	0.2386	0.237	0.221	0.218
8	0.2614	0.2454	0.251	0.233	0.238
9	0.2835	0.2685	0.257	0.249	0.246

Table 4.6.2b. Herring in 6.a (combined) and 7.b–c. WEIGHTS-AT-AGE IN THE CATCH for 6.aS/7.bc.

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
2	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129
3	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165
4	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191
5	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209
6	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
7	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231
8	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.237
9	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241

year

age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
2	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129
3	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165
4	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191	0.191
5	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209
6	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222
7	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231
8	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.237
9	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241

year

age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.110	0.110	0.090	0.106	0.077	0.095	0.085	0.082	0.080	0.094	0.089	0.095
2	0.129	0.129	0.129	0.141	0.122	0.138	0.102	0.098	0.130	0.138	0.134	0.141
3	0.165	0.165	0.165	0.181	0.161	0.164	0.150	0.133	0.141	0.148	0.145	0.147
4	0.191	0.191	0.191	0.210	0.184	0.194	0.169	0.153	0.164	0.160	0.157	0.157
5	0.209	0.209	0.209	0.226	0.196	0.212	0.177	0.166	0.174	0.176	0.167	0.165
6	0.222	0.222	0.222	0.237	0.206	0.225	0.193	0.171	0.183	0.189	0.185	0.171
7	0.231	0.231	0.231	0.243	0.212	0.239	0.205	0.183	0.192	0.194	0.199	0.180
8	0.237	0.237	0.237	0.247	0.225	0.208	0.215	0.191	0.193	0.208	0.207	0.194
9	0.241	0.241	0.241	0.248	0.230	0.288	0.220	0.201	0.203	0.216	0.230	0.219

year

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.112	0.081	0.080	0.085	0.093	0.095	0.106	0.102	0.086	0.097	0.102	0.085
2	0.138	0.141	0.140	0.135	0.135	0.136	0.144	0.129	0.122	0.127	0.134	0.140
3	0.153	0.164	0.161	0.172	0.155	0.145	0.145	0.154	0.139	0.140	0.150	0.150
4	0.170	0.177	0.173	0.182	0.181	0.173	0.163	0.172	0.167	0.155	0.167	0.167
5	0.181	0.189	0.182	0.199	0.201	0.191	0.186	0.180	0.183	0.175	0.183	0.182
6	0.184	0.187	0.198	0.209	0.217	0.196	0.195	0.184	0.188	0.196	0.196	0.193
7	0.196	0.191	0.194	0.220	0.217	0.202	0.200	0.204	0.222	0.204	0.216	0.222
8	0.229	0.204	0.206	0.233	0.231	0.222	0.216	0.203	0.222	0.218	0.210	0.221
9	0.236	0.220	0.217	0.237	0.239	0.217	0.222	0.204	0.213	0.226	0.228	0.285

year

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.105	0.106	0.118	0.111	0.077	0.104	0.094	0.090	0.083	0.105	0.090	0.090
2	0.135	0.137	0.144	0.148	0.146	0.131	0.122	0.134	0.121	0.139	0.113	0.125
3	0.150	0.141	0.145	0.150	0.171	0.168	0.141	0.179	0.141	0.136	0.145	0.149
4	0.162	0.158	0.168	0.166	0.194	0.189	0.174	0.196	0.170	0.155	0.152	0.163
5	0.174	0.169	0.179	0.175	0.200	0.201	0.193	0.214	0.181	0.168	0.161	0.182
6	0.188	0.178	0.189	0.185	0.207	0.212	0.202	0.237	0.196	0.175	0.168	0.188

age												
7	0.200	0.199	0.197	0.194	0.211	0.218	0.217	0.228	0.202	0.184	0.176	0.190
8	0.237	0.221	0.233	0.199	0.218	0.226	0.218	0.243	0.226	0.183	0.185	0.210
9	0.296	0.243	0.237	0.241	0.275	0.229	0.246	0.236	0.226	0.187	0.188	0.201

age \ year	2017	2018
1	0.072	0.085
2	0.106	0.101
3	0.132	0.127
4	0.145	0.144
5	0.159	0.155
6	0.168	0.166
7	0.172	0.172
8	0.179	0.170
9	0.183	0.174

Table 4.6.3. Herring in 6.a (combined) and 7.b–c. WEIGHTS-AT-AGE IN THE STOCK.

Units : kg

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	0.252
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	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

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	0.1296	0.135	0.168	0.172	0.151	0.162	0.132	0.150	0.15500000	0.108
3	0.1538	0.166	0.183	0.191	0.206	0.194	0.160	0.183	0.16500000	0.158
4	0.1665	0.185	0.191	0.208	0.223	0.227	0.208	0.189	0.20200000	0.180
5	0.1802	0.192	0.195	0.214	0.233	0.239	0.236	0.206	0.21000000	0.206
6	0.1911	0.204	0.195	0.214	0.231	0.248	0.245	0.217	0.23600000	0.214
7	0.2125	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	0.2284	0.231	0.214	0.238	0.238	0.212	0.253	0.215	0.25400000	0.264

year

age	2015	2016	2017	2018
1	0.06373333	0.0638	0.0638	0.0478
2	0.15500000	0.1370	0.1350	0.1100
3	0.18300000	0.1400	0.1700	0.1550
4	0.19500000	0.1750	0.1810	0.1761
5	0.20400000	0.2020	0.1980	0.1901
6	0.21100000	0.2080	0.1990	0.2097
7	0.21700000	0.2090	0.2140	0.2094
8	0.21500000	0.2100	0.2230	0.2180
9	0.22000000	0.2420	0.2360	0.2222

Table 4.6.4. Herring in 6.a (combined) and 7.b–c. 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

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  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
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  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
  1 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
  3 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
  5 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
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
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  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
```

Table 4.6.5. Herring in 6.a (combined) and 7.b–c. 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

age \ year	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

age \ year	2017	2018
1	0.00	0.00
2	0.95	0.40
3	1.00	0.85
4	1.00	0.98
5	1.00	0.98
6	1.00	1.00
7	1.00	1.00
8	1.00	1.00
9	1.00	1.00

Table 4.6.6. Herring in 6.a (combined) and 7.b–c. FRACTION OF HARVEST BEFORE SPAWNING.

Units : NA

age \ year	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

age \ year	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

age \ year	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
1	0.67	0.67
2	0.67	0.67
3	0.67	0.67
4	0.67	0.67
5	0.67	0.67
6	0.67	0.67
7	0.67	0.67
8	0.67	0.67
9	0.67	0.67

Table 4.6.7. Herring in 6.a (combined) and 7.b–c. 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
  1 0.67 0.67
  2 0.67 0.67
  3 0.67 0.67
  4 0.67 0.67
  5 0.67 0.67
  6 0.67 0.67
  7 0.67 0.67
  8 0.67 0.67
  9 0.67 0.67
```

Table 4.6.8. Herring in 6.a (combined) and 7.b–c. SURVEY INDICES.

MS_HERAS - Configuration

```
Malin Shelf assessment  . Imported from VPA file.

      min       max plusgroup   minyear   maxyear    startf      endf

     1.00      9.00      9.00   1991.00   2018.00      0.52      0.57

Index type : number

MS_HERAS - Index Values

Units  :  NA

   year

age    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

	year									
age	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

	year							
age	2011	2012	2013	2014	2015	2016	2017	2018
1	62834	796012	-1	1012160	-1	-1	-1	1287728
2	257258	548481	209403	277504	212467	29593	25426	447304
3	899637	832257	434425	241674	396545	108126	338563	106491
4	484732	517267	671507	502471	747121	87773	155357	342609
5	212913	249024	194706	534431	423139	111676	105728	153194
6	227515	114507	70507	148259	476249	79130	110226	51928
7	205093	111385	61392	32565	90102	62045	47158	72276
8	113298	56526	28597	18677	23931	5530	13069	26636
9	263837	104571	37398	13003	2086	957	4721	12887

IBTS_Q1 - Configuration

Malin Shelf assessment . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
2.00	9.00	9.00	1994.00	2018.00	0.00	0.25

Index type : number

IBTS_Q1 - Index Values

Units : NA

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
2	48858	359063	102681	105593	8228	79866	83246	87821	39782	111770	103820
3	85955	130445	166694	182703	50010	333860	133023	78560	151663	124660	341797
4	27794	99865	51454	86852	34866	208576	174698	57335	39246	128306	200643
5	26540	12344	56103	29176	17070	90024	70164	104040	15131	21032	197167
6	37467	28326	29507	20283	5848	39781	61480	54985	42189	16407	53480
7	24419	12360	12935	11476	6776	26574	33102	40676	13304	30259	48221
8	9183	20940	19509	26942	2517	18665	9304	17583	13566	12989	54582
9	4219	12450	44164	26153	7179	30853	17792	18941	15126	17252	47875

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2	125745	268325	26180	27389	42487	14782	91792	8778	53919	9274	5269
3	140658	327416	80640	33459	85317	41870	103871	125519	55635	36331	9431
4	274189	141568	51265	34702	82570	21274	82452	48715	115480	26226	23111
5	215004	386173	45189	27111	80809	20394	39608	26421	47149	42635	10477
6	204336	372941	79092	23681	58959	21170	47603	13956	38007	8153	12225
7	28338	214968	58735	28915	54262	22578	34354	13225	26073	5237	3574
8	58870	35946	31858	33013	94629	18305	25936	10641	22175	4801	2960
9	52942	104800	28751	20189	114061	38890	69963	28906	32456	4565	863

age	2016	2017	2018
2	12389	6201	6875
3	19720	60854	30327
4	6688	24001	201648
5	14430	11204	45882
6	17865	11704	34825
7	5893	10430	17341
8	1303	5470	13837
9	541	2965	5129

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	2018.00	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 17315 13923 12755  6865  5626 33686 10282 15064 16457 5361 7120 7145 3142
  3 15935  8976 10203 15684  4192  6757  7886 10166 18695 3768 2449 4221 3784
  4  6763  7137  8434 11078 10446  7423  1199 16343 13894 7389 3240 2855 3742
  5  5334  4245 11118  9835  4424 14837  1734  2331  9265 8881 6430 4974 2100
  6  2228  3038  6295  9164  5664 10428  3401  3326  2185 6120 7978 3734 2902
  7  2020   788  1948  4425  3305  6520  2307  3470  2842  910 4498 4438 5691
  8  4236  1821   896  1494  2357  3269  1853  2193  1535 2257 1110 1327 3736
  9  5828  1797  3866  3433  1746  1701   861  2354  1200 2545 1972  500 4075
   year
age 2009 2010  2011 2012 2013  2014  2015  2016  2017  2018
  2 7394   -1 10574 2212   -1  3510  6530 13701  5834  4029
  3 3741   -1  4559 5937   -1  8345  6330 11385 33661  4814
  4 3648   -1  3880 3599   -1  6947 10553 12037 18397 14217
  5 4576   -1  2263 3819   -1 11708 11892 14342 24040  6490
  6 1723   -1  2194 2709   -1  2998  5400 14991 12292  3827
  7 1966   -1   814 2526   -1   935   644  6399  8832  2450
  8 2342   -1   564  865   -1   981   618  1465  3417  1768
  9 3371   -1  2436 5679   -1   255   484   613   666   234
```

Table 4.6.9. Herring in 6.a (combined) and 7.b–c. STOCK OBJECT CONFIGURATION.

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	9	9	1957	2018	3	6

Table 4.6.10. Herring in 6.a (combined) and 7.b–c. SAM CONFIGURATION SETTINGS.

```
name           : Herring in 6.aN and 6aS,7bc multifleet
desc           : Imported from a VPA file. ( ./data/index.txt ).  Wed Mar 13 14:39:39 2019
range          :       min       max plusgroup   minyear   maxyear   minfbar   maxfbar
range          :         1         9         9      1957      2018         3         6
fleets         :  catch N  catch S MS_HERAS  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         :   MS_HERAS -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 :   MS_HERAS  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 :   MS_HERAS -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         :   MS_HERAS -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       :   MS_HERAS  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 6.a (combined) and 7.b–c. FLR, R SOFTWARE VERSIONS.

```
FLSAM.version                        2.1.0

FLCore.version                       2.6.12

R.version      R version 3.5.2 (2018-12-20)

platform                 x86_64-w64-mingw32

run.date                2019-03-13 14:46:47
```

Table 4.6.12. Herring in 6.a (combined) and 7.b–c. STOCK SUMMARY.

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 3-6) f	Landings tonnes	Landings SOP
1957	1610616	758332	352173	0.1515	48508	0.7531
1958	2805288	818733	357815	0.1968	66494	0.7733
1959	3974532	957292	358279	0.1812	70447	0.7446
1960	1697903	889258	437457	0.1277	69160	0.6012
1961	2725457	915450	457029	0.0908	52535	0.6332
1962	3594943	1007184	433310	0.1319	65594	0.7990
1963	3587445	1066244	461062	0.1011	54089	0.7245
1964	2484701	1044910	516068	0.0958	70403	0.6145
1965	9759776	1660952	519841	0.0997	76685	0.8730
1966	1850328	1584135	765094	0.1243	112834	1.0130
1967	3777159	1608164	872184	0.1237	109281	0.8399
1968	5042446	1690873	830094	0.0964	105345	0.8364
1969	3793197	1627792	803348	0.1506	126777	0.7945
1970	4109764	1553572	727088	0.2165	186236	0.7750
1971	8163797	1790285	554595	0.4220	222211	1.0255
1972	3332761	1506324	622156	0.2588	188230	1.0349
1973	2037610	1257246	586239	0.3893	246989	1.0331
1974	2160900	935558	375177	0.5590	214749	1.1069
1975	2285652	705479	245986	0.5217	152765	0.9806
1976	1505048	549530	193415	0.5219	126409	0.9888
1977	1805695	475716	170107	0.3401	61908	0.9200
1978	2540325	546474	177813	0.2315	41871	0.9961
1979	2839959	655878	233321	0.1182	22668	0.9380
1980	1846187	687498	312349	0.1214	30430	1.0375
1981	2384169	736083	310758	0.2517	76342	0.9699
1982	1939624	680362	266446	0.3770	111569	1.0235
1983	4732220	855677	230178	0.3824	96511	1.0182
1984	2535309	859497	316292	0.2652	83462	0.9756
1985	2939428	906494	383682	0.2254	62485	1.0078
1986	2616127	905012	390144	0.2558	99549	1.0389
1987	4460708	1027659	363752	0.2806	92960	1.0148
1988	1977987	932269	418660	0.2187	64691	1.0126
1989	1648685	839529	437738	0.1928	63236	1.0086
1990	1292288	719283	374123	0.2399	88662	0.9933
1991	1039444	577189	301988	0.2258	66229	1.0315
1992	1538777	473741	224000	0.2459	60841	1.0024
1993	1280468	440827	228212	0.2539	68541	0.9932
1994	2094558	411522	172470	0.2752	58338	0.9999
1995	1620770	393747	138517	0.2889	57367	0.9748
1996	1777372	385739	183956	0.2966	58639	1.0233
1997	2009732	414326	156499	0.4271	62458	1.0033
1998	1047501	382878	183125	0.4704	72248	0.9994
1999	932291	307731	148887	0.3447	55845	0.9998
2000	2602809	374851	118796	0.3025	43008	0.9990
2001	1790112	410548	198737	0.2846	40007	1.0028
2002	1935693	471047	230691	0.3271	50740	0.9998
2003	1097488	411641	214875	0.2736	44583	1.0021
2004	952224	337501	184948	0.2551	40186	1.0119
2005	946705	305815	161836	0.1786	30360	1.0021

2006	843148	294471	147296	0.2768	46539	0.9990
2007	549669	254200	143269	0.2927	47407	0.9990
2008	667165	210217	117085	0.2351	29394	1.0008
2009	746488	203230	96390	0.2748	28976	1.0312
2010	1175669	233411	97335	0.3298	30118	0.9960
2011	536483	189613	81330	0.2785	24678	0.9992
2012	559713	186930	93817	0.2592	25087	1.0017
2013	279995	155402	66594	0.3730	26947	0.9978
2014	358520	114563	45040	0.4198	27123	1.0091
2015	564442	117552	39992	0.4837	19885	0.9982
2016	226356	93324	57094	0.1616	6937	1.0011
2017	240130	94444	58095	0.1341	6424	0.9986
2018	230732	82724	42979	0.1305	5558	0.9978

Table 4.6.13. Herring in 6.a (combined) and 7.b–c. ESTIMATED FISHING MORTALITY for 6.aN and 6.aS/7.bc.

Units : f

, , area = 6.aN

year

age	1957	1958	1959	1960	1961	1962
1	0.01278177	0.01610326	0.01594731	0.01316791	0.01094825	0.01626646
2	0.05878204	0.07581411	0.07415057	0.05913794	0.04704914	0.07171389
3	0.10114092	0.12812699	0.11756336	0.08621278	0.06316329	0.09415807
4	0.12324686	0.15969552	0.15032408	0.10468969	0.07244291	0.10809145
5	0.15048065	0.19858106	0.18800697	0.13219529	0.08727377	0.12945948
6	0.16490265	0.22083195	0.20294891	0.13658316	0.08487313	0.13161823
7	0.20112399	0.28288919	0.26062664	0.17196113	0.10313954	0.15956093
8	0.20775537	0.30388987	0.28391669	0.18585710	0.11145080	0.17574467
9	0.20775537	0.30388987	0.28391669	0.18585710	0.11145080	0.17574467

year

age	1963	1964	1965	1966	1967	1968
1	0.01330236	0.01278744	0.01252865	0.01619423	0.01517169	0.01190372
2	0.05592224	0.05189256	0.04931358	0.06451226	0.05989109	0.04609725
3	0.07399567	0.06891798	0.06688024	0.08309303	0.07908722	0.06165659
4	0.08268292	0.07812463	0.08074841	0.10014797	0.09547726	0.07158418
5	0.09604492	0.08730126	0.09036615	0.11096398	0.10594473	0.07781175
6	0.09952039	0.09338508	0.09705964	0.12142231	0.12029169	0.08961747
7	0.12084483	0.11869889	0.12625118	0.15200437	0.15303354	0.11659806
8	0.13896056	0.14387040	0.15881044	0.19096547	0.18987284	0.14252748
9	0.13896056	0.14387040	0.15881044	0.19096547	0.18987284	0.14252748

year

age	1969	1970	1971	1972	1973	1974
1	0.01713674	0.02701114	0.05705368	0.03427909	0.04728765	0.05746725
2	0.07113783	0.12146322	0.29098771	0.16796766	0.25098660	0.32509170
3	0.10213809	0.17912936	0.42447714	0.23431424	0.34461280	0.43796930
4	0.11917066	0.19168413	0.41480664	0.22623811	0.34078920	0.46455641
5	0.13244474	0.19153373	0.37884952	0.21210538	0.32268129	0.46926458
6	0.15382260	0.20071352	0.36358973	0.20808172	0.31886692	0.50834745
7	0.20766037	0.24907304	0.40108500	0.21960390	0.30670125	0.48718406
8	0.25453618	0.29172864	0.43852469	0.22882034	0.29832466	0.45335881
9	0.25453618	0.29172864	0.43852469	0.22882034	0.29832466	0.45335881

year

```
age       1975       1976       1977       1978         1979         1980
  1 0.04962553 0.04690412 0.02664148 0.01478806 0.00004878419 0.00005343669
  2 0.28952022 0.28693908 0.16101544 0.08809487 0.00015006388 0.00017753511
  3 0.37006153 0.35407320 0.20157460 0.10695419 0.00016789105 0.00019090145
  4 0.38203852 0.35037806 0.20097699 0.10967954 0.00015723113 0.00017723446
  5 0.39697678 0.35224012 0.19553514 0.10023319 0.00013922643 0.00015494038
  6 0.46178404 0.44382544 0.25343025 0.12568909 0.00016992195 0.00018068337
  7 0.46027968 0.46828495 0.27863420 0.14267795 0.00019914793 0.00021545996
  8 0.42046880 0.42677958 0.24697224 0.12761064 0.00017130325 0.00018031362
  9 0.42046880 0.42677958 0.24697224 0.12761064 0.00017130325 0.00018031362
   year
age       1981      1982       1983       1984        1985       1986
  1 0.01755653 0.0257593 0.01921557 0.01146841 0.008928836 0.01036853
  2 0.13279036 0.2247249 0.17649501 0.10788163 0.087509220 0.11201649
  3 0.15207306 0.2665520 0.22091020 0.13749947 0.110248755 0.13870318
  4 0.14802983 0.2689499 0.22956689 0.14074597 0.109810758 0.13679712
  5 0.13966180 0.2772086 0.25956520 0.15952817 0.125382670 0.15380591
  6 0.16075887 0.3223159 0.31163899 0.18252316 0.141830290 0.16475123
  7 0.18694822 0.3855203 0.38696947 0.21507346 0.156958108 0.16615139
  8 0.15492649 0.3555088 0.38919552 0.21995284 0.161875035 0.17149119
  9 0.15492649 0.3555088 0.38919552 0.21995284 0.161875035 0.17149119
   year
age        1987        1988        1989        1990        1991        1992
  1 0.007245468 0.005396861 0.004530871 0.005790776 0.004481547 0.004880897
  2 0.081319139 0.063338390 0.055834812 0.079108445 0.064202567 0.077778193
  3 0.102649760 0.080478060 0.071035283 0.100161219 0.080047804 0.094432000
  4 0.107209684 0.082658106 0.070858562 0.102730749 0.080621681 0.089661374
  5 0.131603313 0.101924276 0.087344565 0.128848467 0.099273017 0.105998643
  6 0.152307750 0.115084617 0.097550110 0.148042204 0.115132554 0.122420468
  7 0.173456267 0.133972543 0.120920719 0.190248479 0.146406012 0.155719279
  8 0.201699015 0.163100383 0.156568688 0.259869988 0.192707544 0.199097523
  9 0.201699015 0.163100383 0.156568688 0.259869988 0.192707544 0.199097523
   year
age        1993        1994        1995        1996        1997        1998
  1 0.004903048 0.004005363 0.003850505 0.002574314 0.004231113 0.003964946
  2 0.086018626 0.076176163 0.080281967 0.055041598 0.103512396 0.102156677
  3 0.100635070 0.093292705 0.102645362 0.074271439 0.149610317 0.152688765
  4 0.088028762 0.081383242 0.095711847 0.077657181 0.178584392 0.183960032
  5 0.102082228 0.094188536 0.111429093 0.103057623 0.265840952 0.272377322
  6 0.116444854 0.108180068 0.124628943 0.124050560 0.339289278 0.339735738
  7 0.162480996 0.163604011 0.198631505 0.208305346 0.540351200 0.507937177
  8 0.205062539 0.216265136 0.254722578 0.263018448 0.566707708 0.481151810
  9 0.205062539 0.216265136 0.254722578 0.263018448 0.566707708 0.481151810
   year
age        1999        2000        2001        2002        2003        2004
  1 0.003149817 0.002535134 0.001945686 0.002031844 0.001477374 0.001181301
  2 0.084447384 0.071560431 0.057462177 0.063904760 0.046916904 0.037479888
  3 0.130047255 0.117684562 0.102005490 0.124216328 0.097958979 0.081922898
  4 0.143099767 0.132247471 0.118059574 0.149979478 0.124812312 0.112786551
  5 0.191493075 0.179764622 0.174764967 0.230974303 0.194522024 0.190654142
  6 0.214269162 0.194877542 0.197193930 0.254196306 0.214351432 0.225276836
  7 0.286196757 0.250103850 0.264070765 0.332081821 0.303179720 0.322616984
  8 0.259592111 0.223553408 0.244448168 0.306464285 0.309306733 0.361438034
```

```
  9 0.259592111 0.223553408 0.244448168 0.306464285 0.309306733 0.361438034
   year
age         2005        2006        2007         2008        2009        2010
  1 0.0007333903 0.001080441 0.001437691 0.0009702172 0.001564754 0.002018582
  2 0.0225186830 0.035533432 0.049412290 0.0316488618 0.054061709 0.072285284
  3 0.0473412964 0.073555028 0.092339048 0.0572734325 0.097569908 0.128257385
  4 0.0580753805 0.096804119 0.110683735 0.0660452761 0.117799893 0.156135705
  5 0.0887044790 0.167390525 0.185429500 0.1026524138 0.171746496 0.227730579
  6 0.1040185940 0.224184567 0.260768370 0.1451893537 0.221793394 0.273312025
  7 0.1396443335 0.326201506 0.385431459 0.2207289831 0.313172938 0.354746272
  8 0.1564480167 0.393049589 0.494120339 0.3015101596 0.432626876 0.498871480
  9 0.1564480167 0.393049589 0.494120339 0.3015101596 0.432626876 0.498871480
   year
age        2011        2012        2013        2014        2015         2016
  1 0.001793122 0.001783682 0.002141142 0.002049314 0.002312379 0.0006698209
  2 0.064360977 0.065542822 0.082686375 0.080841367 0.095132695 0.0239647897
  3 0.114395612 0.121514032 0.163911832 0.167952043 0.209982068 0.0544504591
  4 0.139624155 0.151739383 0.228850320 0.245648137 0.305295386 0.0768266804
  5 0.203606155 0.225115704 0.355038431 0.400968415 0.500381454 0.1197889519
  6 0.242708054 0.277198711 0.465345759 0.547094835 0.749126106 0.1754474321
  7 0.303798188 0.335648764 0.582426172 0.704778821 0.997481615 0.2368863480
  8 0.442203100 0.512121956 0.989231889 1.250386797 1.646342940 0.4088762822
  9 0.442203100 0.512121956 0.989231889 1.250386797 1.646342940 0.4088762822
   year
age         2017         2018
  1 0.0005330201 0.0005830342
  2 0.0185296877 0.0204985278
  3 0.0445931532 0.0505987136
  4 0.0591564231 0.0670626578
  5 0.0854696625 0.0998463358
  6 0.1109208818 0.1248782228
  7 0.1302726325 0.1274293945
  8 0.2236598358 0.2147850956
  9 0.2236598358 0.2147850956

, , area = 6aS7bc
   year

age         1957         1958         1959         1960         1961
  1 0.0001589773 0.0002042697 0.0001828107 0.0001484279 0.0001667669
  2 0.0065364441 0.0078171070 0.0070886591 0.0060569519 0.0066217797
  3 0.0125584731 0.0148187859 0.0130706318 0.0109673455 0.0120617523
  4 0.0144572900 0.0175988390 0.0150490615 0.0120804380 0.0133104753
  5 0.0178033591 0.0214425967 0.0172542021 0.0128835828 0.0139366203
  6 0.0214289913 0.0261401890 0.0205906859 0.0150497172 0.0163097676
  7 0.0306303584 0.0376988069 0.0296914693 0.0216963942 0.0234151110
  8 0.0315731831 0.0448287516 0.0300213017 0.0177281391 0.0199461634
  9 0.0315731831 0.0448287516 0.0300213017 0.0177281391 0.0199461634
   year
age         1962         1963         1964         1965        1966
  1 0.0001665472 0.0001017708 9.420517e-05 0.0001044282 0.000144639
  2 0.0068117956 0.0049036203 4.706336e-03 0.0050949340 0.006370028
  3 0.0130200127 0.0099443437 9.926018e-03 0.0110717530 0.013948578
  4 0.0150791394 0.0119818664 1.254819e-02 0.0144100393 0.018557938
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  5 0.0162574449 0.0132474413 1.430961e-02 0.0165386602 0.021372168
  6 0.0199211789 0.0168699651 1.857932e-02 0.0217310636 0.027705518
  7 0.0292845584 0.0255118665 2.826636e-02 0.0327151622 0.040781395
  8 0.0293030011 0.0236239911 2.746558e-02 0.0332697906 0.045007870
  9 0.0293030011 0.0236239911 2.746558e-02 0.0332697906 0.045007870
   year
age         1967         1968         1969         1970         1971
  1 0.0001757384 0.0001705775 0.0002134766 0.0002454161 0.0002493541
  2 0.0072535495 0.0070364169 0.0081788664 0.0090668206 0.0090018534
  3 0.0158174372 0.0147758405 0.0164262938 0.0176301576 0.0173038117
  4 0.0215720128 0.0197914574 0.0216983678 0.0230279648 0.0228191323
  5 0.0249238250 0.0225636450 0.0253286386 0.0274125260 0.0283994994
  6 0.0317827439 0.0277828158 0.0313715356 0.0347430524 0.0377365634
  7 0.0452690212 0.0373469428 0.0406283964 0.0443283074 0.0493512017
  8 0.0513763890 0.0341119472 0.0361487547 0.0391181965 0.0464664152
  9 0.0513763890 0.0341119472 0.0361487547 0.0391181965 0.0464664152
   year
age         1972       1973        1974        1975        1976
  1 0.0004753816 0.00100625 0.002032569 0.003201889 0.004271171
  2 0.0139196510 0.02316667 0.038064614 0.052459926 0.064540910
  3 0.0253040382 0.03917356 0.061987021 0.083678335 0.102374806
  4 0.0328164566 0.04985552 0.078447341 0.107222807 0.133907107
  5 0.0410332544 0.06089953 0.094417854 0.126781046 0.159281889
  6 0.0553201500 0.08038675 0.120961970 0.158237126 0.191633253
  7 0.0729189824 0.10440900 0.152786381 0.194799887 0.228053471
  8 0.0879772526 0.15382251 0.273567726 0.386060549 0.468661448
  9 0.0879772526 0.15382251 0.273567726 0.386060549 0.468661448
   year
age        1977        1978        1979        1980        1981
  1 0.003249554 0.002832315 0.002371403 0.002172779 0.001492657
  2 0.054157623 0.050146604 0.045554575 0.044268395 0.035039648
  3 0.086764206 0.082474057 0.078242530 0.079786892 0.066446901
  4 0.114630548 0.107904694 0.104317654 0.106969533 0.089372679
  5 0.138991509 0.131469950 0.128378003 0.132321121 0.110480667
  6 0.168320600 0.161489881 0.161218843 0.165773966 0.139965772
  7 0.195109902 0.188397618 0.191467908 0.196634784 0.163560958
  8 0.339736387 0.310061888 0.319315197 0.330681889 0.237638413
  9 0.339736387 0.310061888 0.319315197 0.330681889 0.237638413
   year
age        1982       1983        1984        1985        1986
  1 0.001191179 0.00175845 0.001356946 0.001121586 0.001079304
  2 0.030689992 0.04127501 0.034310802 0.030019594 0.029847338
  3 0.060828389 0.08239441 0.070470891 0.063841300 0.065248990
  4 0.082249193 0.11208178 0.095519251 0.088156973 0.091539929
  5 0.101517617 0.13859894 0.119439303 0.112699479 0.117754628
  6 0.128371213 0.17499850 0.154976185 0.149491584 0.154697315
  7 0.148026889 0.19733156 0.176946035 0.172960257 0.177302805
  8 0.190212225 0.28534197 0.232427264 0.217592273 0.215274178
  9 0.190212225 0.28534197 0.232427264 0.217592273 0.215274178
   year
age        1987        1988         1989        1990        1991
  1 0.001785717 0.001165317 0.0009520352 0.001091435 0.001288945
  2 0.043246854 0.032597186 0.0288444308 0.032821806 0.038090023
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  3 0.094526599 0.074100689 0.0662339394 0.073328117 0.083294793
  4 0.134312016 0.106130662 0.0952300091 0.104543227 0.114833921
  5 0.173189336 0.136059875 0.1220428082 0.131351702 0.143801586
  6 0.226539496 0.178373695 0.1608699461 0.170472474 0.186370481
  7 0.253231211 0.198091670 0.1798019766 0.186330810 0.204158943
  8 0.365574587 0.235852863 0.2024422795 0.209601944 0.248363985
  9 0.365574587 0.235852863 0.2024422795 0.209601944 0.248363985
   year
age        1992        1993        1994        1995        1996
  1 0.001510267 0.001636317 0.002245863 0.002122482 0.002697911
  2 0.043766962 0.047857446 0.060277565 0.059173212 0.069738074
  3 0.095400556 0.104866721 0.127803470 0.127378009 0.146479859
  4 0.128846573 0.142872184 0.173239581 0.173648696 0.197794930
  5 0.152354335 0.163595203 0.195545539 0.196322566 0.218302961
  6 0.194462871 0.197063188 0.227014279 0.223943184 0.244733628
  7 0.209338263 0.209703252 0.231947003 0.221189081 0.237988282
  8 0.258352952 0.257024269 0.304176004 0.272896082 0.299015053
  9 0.258352952 0.257024269 0.304176004 0.272896082 0.299015053
   year
age        1997        1998        1999        2000        2001
  1 0.002843992 0.004068604 0.002883136 0.002213862 0.001761528
  2 0.072258408 0.093883635 0.074816153 0.063358660 0.055043020
  3 0.146750085 0.185103797 0.147072019 0.127371244 0.115586992
  4 0.194478802 0.238410479 0.182336885 0.154048886 0.143810977
  5 0.208575812 0.249641807 0.183983130 0.152988925 0.144289950
  6 0.225206739 0.259852527 0.186625018 0.151072892 0.142742851
  7 0.219344966 0.248890655 0.176215379 0.139513293 0.126241495
  8 0.254490300 0.309493389 0.177950920 0.120793342 0.097364445
  9 0.254490300 0.309493389 0.177950920 0.120793342 0.097364445
   year
age        2002        2003        2004        2005        2006
  1 0.001662131 0.001262449 0.001045556 0.001072574 0.001530505
  2 0.054044729 0.045814261 0.041638442 0.044508485 0.059228305
  3 0.114109246 0.098230126 0.090931919 0.098726105 0.133306413
  4 0.144816778 0.121455313 0.108887571 0.114461656 0.155183069
  5 0.146606763 0.123324543 0.106800492 0.106163063 0.138962784
  6 0.143438600 0.119858120 0.103299999 0.096718109 0.117933567
  7 0.122154517 0.098182531 0.082130288 0.074448996 0.084762708
  8 0.087220864 0.056445716 0.039543047 0.031023314 0.034363561
  9 0.087220864 0.056445716 0.039543047 0.031023314 0.034363561
   year
age        2007        2008        2009        2010         2011
  1 0.001353242 0.001401947 0.001051942 0.001126647 0.0007363583
  2 0.055698233 0.057151538 0.046393462 0.047901536 0.0349135597
  3 0.128273459 0.132594829 0.109477876 0.112760772 0.0836460763
  4 0.151354689 0.162310281 0.135685290 0.141716088 0.1064507314
  5 0.134122094 0.150824780 0.132101886 0.145345509 0.1129309505
  6 0.107833327 0.123595701 0.112828614 0.133818757 0.1104700665
  7 0.071881989 0.079629383 0.072518827 0.091156091 0.0816286505
  8 0.022494948 0.024034621 0.019138233 0.029217979 0.0268711485
  9 0.022494948 0.024034621 0.019138233 0.029217979 0.0268711485
   year
age         2012         2013         2014         2015         2016
```

1	0.0004018293	0.0003197844	0.0002969859	0.0001177891	0.0001658619
2	0.0221264628	0.0192405070	0.0186747194	0.0097720916	0.0125053416
3	0.0534987588	0.0500219509	0.0516185641	0.0279236885	0.0353760600
4	0.0663321058	0.0666729176	0.0724792559	0.0384894842	0.0487520727
5	0.0705822141	0.0773105695	0.0901709256	0.0481121137	0.0623865732
6	0.0708167593	0.0848520590	0.1031662529	0.0553136896	0.0735708607
7	0.0557654459	0.0725928308	0.0928753848	0.0513095794	0.0689572323
8	0.0159486652	0.0287221535	0.0466716716	0.0181330149	0.0296255954
9	0.0159486652	0.0287221535	0.0466716716	0.0181330149	0.0296255954

year		
age	2017	2018
1	0.0001744684	0.0001197688
2	0.0131663799	0.0102258848
3	0.0370794782	0.0290036334
4	0.0515349763	0.0393430248
5	0.0665782298	0.0504790904
6	0.0812296454	0.0606409796
7	0.0789686261	0.0593940431
8	0.0392509947	0.0245791324
9	0.0392509947	0.0245791324

Table 4.6.14. Herring in 6.a (combined) and 7.b–c. ESTIMATED POPULATION ABUNDANCE.

Units : NA

year							
age	1957	1958	1959	1960	1961	1962	1963
1	1610615.96	2805288.50	3974532.03	1697902.88	2725456.77	3594942.66	3587444.8
2	1771371.62	722740.65	1326798.30	1906067.39	726257.04	1239482.00	1671885.6
3	616188.84	1155157.62	466763.25	877000.97	1215145.79	401900.57	748487.1
4	261592.85	354935.42	708713.16	319478.81	591316.39	776974.16	225806.7
5	293587.64	175340.91	196004.52	400845.29	230643.24	413692.11	476194.4
6	133240.36	174076.71	108527.57	108424.14	242663.10	161820.24	276533.1
7	59006.40	79050.04	92787.47	66969.00	67386.05	170271.06	102449.5
8	10613.32	35189.44	40273.14	48472.35	41808.96	45093.27	107156.9
9	33821.54	27028.70	32307.77	36811.86	47960.91	58653.93	64381.7

year							
age	1964	1965	1966	1967	1968	1969	1970
1	2484700.95	9759776.38	1850327.58	3777158.64	5042445.61	3793197.4	4109763.6
2	1702988.73	1051739.56	5232226.11	736931.90	1741150.90	2350523.0	1680008.1
3	1087399.14	1112578.63	682251.19	3726170.60	449311.47	1087210.2	1563024.8
4	445913.94	721128.39	725580.31	447112.79	2675235.63	287624.0	691286.9
5	138961.96	275114.68	451980.23	460413.07	273213.90	1835845.3	183812.1
6	310588.53	89871.73	174000.42	278870.01	294870.66	180520.4	1133044.7
7	186236.79	205537.29	60235.69	104484.20	167645.21	196015.7	110093.0
8	67666.48	121706.69	127067.78	38078.46	61157.98	104986.0	109968.5
9	113750.43	118335.31	149982.39	162345.14	114710.30	109040.3	113912.5

year						
age	1971	1972	1973	1974	1975	1976
1	8163796.88	3332761.21	2037609.86	2160900.12	2285652.33	1505048.02
2	1825662.91	3911449.42	1444316.58	861051.38	934359.16	1018962.28
3	966551.35	951038.08	2417613.85	711924.47	403218.07	440027.53
4	898749.51	405493.27	518138.20	1213988.39	299770.51	181543.30

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  5  394448.69  410487.58  229922.19  251305.70  509766.85  131723.22
  6  110321.40  189034.02  232828.17  116582.30  102057.86  220521.22
  7  661911.85   55327.30  106207.19  114942.86   44056.30   39337.36
  8   60504.93  320342.96   29936.85   54362.21   45416.53   16500.99
  9  115750.86   80613.61  214776.86  114540.62   62035.68   36224.95
   year
age       1977       1978       1979       1980       1981       1982
  1 1805695.42 2540324.65 2839958.62 1846186.52 2384168.94 1939623.80
  2  631149.16  805980.14 1162590.25 1337463.68  802459.16 1115883.92
  3  483770.90  336023.85  475751.99  751952.97  859742.35  434726.34
  4  188596.02  257226.21  196991.57  309351.00  491423.03  473682.37
  5   80343.28   98743.67  136208.56  133340.08  193812.40  274372.78
  6   57221.70   41667.83   58212.00   86821.76   90330.25  109001.52
  7   87442.71   25351.81   22792.71   36460.41   59900.00   48820.01
  8   14385.93   40249.46   12966.44   13245.44   20796.92   32947.88
  9   15456.81   12595.65   24712.57   20073.73   17421.50   19099.32
   year
age       1983       1984       1985       1986       1987       1988
  1 4732220.37 2535308.76 2939427.96 2616126.96 4460708.36 1977987.20
  2  845013.29 2358553.22 1136078.90 1334427.73 1169279.43 2175024.33
  3  595955.66  450833.73 1512597.66  702197.44  760259.62  688902.18
  4  216285.49  305048.11  243234.37  948887.24  406517.98  431866.76
  5  231534.43  108864.07  170904.37  144101.27  550805.20  232097.80
  6  134912.07  106717.65   59569.64  101869.51   77737.75  296713.93
  7   51874.23   59935.28   55004.50   31635.74   53921.92   37317.48
  8   21659.51   21274.12   29718.59   27990.63   17343.14   25016.86
  9   22865.09   16464.18   17448.23   23135.35   27106.83   18505.83
   year
age       1989       1990       1991       1992       1993       1994
  1 1648685.45 1292288.47 1039444.11 1538777.45 1280468.25 2094557.85
  2  894761.60  755342.32  591351.09  457199.23  734335.69  599023.79
  3 1462535.57  586682.46  456825.08  361384.62  256931.67  421180.97
  4  403071.87  908843.77  392139.46  281277.77  212489.25  131128.04
  5  246725.27  249666.94  494090.51  281318.20  166690.51  122815.35
  6  133518.92  139554.21  141229.10  255644.47  183816.49   98870.52
  7  156494.24   80987.21   72440.20   76570.94  125686.87  104783.08
  8   19265.48   80969.83   44479.44   37072.82   40411.82   61615.60
  9   21863.62   20714.69   42735.70   40515.67   36254.16   37054.40
   year
age       1995       1996       1997       1998       1999        2000
  1 1620769.77 1777371.67 2009731.93 1047500.80 932291.141 2602808.770
  2  995716.77  773871.62  830721.41  963208.64 454647.401  397915.062
  3  336259.90  555563.07  462346.46  476350.95 650038.389  257116.200
  4  226813.54  182525.43  266773.03  246850.18 237843.603  377285.292
  5   69179.55  103740.51  101599.91  126249.10 115184.498  118810.907
  6   71259.01   40538.49   55532.54   48142.53  49633.954   57901.116
  7   53164.42   37326.53   21011.45   22472.22  19679.432   25115.885
  8   55279.24   28838.55   21490.99    7337.87   7050.697    8718.176
  9   44383.03   45707.57   28533.56   17214.76   8744.604    7609.857
   year
age        2001       2002       2003      2004      2005       2006      2007
  1 1790111.970 1935692.87 1097488.47 952223.78 946705.14 843147.819 549668.68
  2 1291491.952  828547.32  922600.74 504337.80 430109.22 455340.594 406813.97
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3	213419.943	832334.84	497125.11	581053.82	311410.81	243852.397	275439.04
4	136625.322	108615.57	463557.21	305271.22	374338.12	175305.981	126201.75
5	208101.504	77347.05	56430.73	236873.14	200291.76	244199.460	100272.47
6	63875.802	115281.13	41259.86	28087.54	119678.12	138606.604	128930.67
7	31857.617	34750.35	53267.75	27404.15	13106.02	72548.314	76646.41
8	12527.812	15057.47	16861.23	23060.11	15618.15	8179.643	35014.53
9	8395.482	10718.30	12691.02	15389.00	16786.71	19699.141	13249.04

year							
age	2008	2009	2010	2011	2012	2013	2014
1	667164.58	746488.47	1175669.40	536482.565	559713.280	279995.27	358520.358
2	256221.16	314104.80	338568.10	571431.694	239529.315	254031.43	123804.230
3	232692.70	156847.57	191384.55	199294.092	375506.331	160196.25	153123.954
4	148332.25	125646.97	85805.60	102219.938	110960.181	226355.05	103682.821
5	67300.42	83148.67	67740.91	44018.491	52258.476	58559.57	120651.491
6	52706.78	39071.72	39866.51	33555.394	23892.213	25215.61	26377.016
7	68160.73	29980.52	20933.13	17239.873	16789.613	13828.48	10213.488
8	35366.47	37214.42	15223.87	9596.348	7358.307	8012.51	5673.299
9	23058.20	31255.76	33454.63	22186.352	14992.954	9734.98	4347.939

year				
age	2015	2016	2017	2018
1	564442.027	226356.3443	240130.092	230731.697
2	164147.988	285939.2209	100490.150	111951.569
3	77170.660	99657.0864	217108.465	69031.229
4	88747.433	47046.5979	69375.816	147482.236
5	56734.745	42543.8359	32208.033	48040.283
6	46898.085	26097.0808	24500.318	20182.669
7	9192.354	13512.6529	14833.385	14224.709
8	4027.079	2370.7618	5834.938	8540.271
9	1716.545	804.2196	1608.691	3724.353

Table 4.6.15. Herring in 6.a (combined) and 7.b–c. PREDICTED CATCH NUMBERS-AT-AGE.

Units : NA

<0 x 0 matrix>

Table 4.6.16. Herring in 6a (combined) and 7.b-c. CATCH-AT-AGE RESIDUALS.

Units : NA

<0 x 0 matrix>

Table 4.6.18. Herring in 6.a (combined) and 7.b-c. PREDICTED INDEX-AT-AGE catch unique 6.aN and 6.aS/7.bc.

Units : NA

Area: 6.aN

age	1957	1958	1959	1960	1961	1962	1963
1	14294.621	31321.613	43950.093	15522.018	20735.706	40542.831	33129.560
2	83846.886	43751.386	78642.598	90774.079	27664.141	71141.943	75444.345
3	49739.929	116548.265	43455.777	60806.303	62357.341	30293.336	44815.624
4	25646.785	44277.651	83677.959	26864.027	34904.692	67257.258	15150.377
5	34963.706	26911.778	28673.722	42386.976	16431.974	42827.516	37195.703
6	17291.119	29427.447	17041.272	11841.697	16858.505	17031.715	22368.341
7	9175.975	16610.450	18208.642	9060.516	5640.082	21422.725	9955.077
8	1699.011	7843.893	8518.520	7055.813	3772.831	6202.647	11884.055
9	5414.247	6024.826	6833.697	5358.469	4327.982	8067.937	7140.145

age	1964	1965	1966	1967	1968	1969	1970
1	22062.682	84916.440	20775.705	39749.662	41694.365	45049.43	76602.72
2	71450.086	41976.039	271109.062	35510.381	64997.219	133779.26	159464.10
3	60783.629	60377.250	45594.618	237248.228	22494.589	88428.46	215124.47
4	28321.391	47240.875	58312.861	34283.580	155637.016	27226.57	101761.28
5	9901.497	20241.157	40355.029	39275.162	17361.287	193361.22	27224.11
6	23622.741	7081.944	16913.816	26818.825	21468.180	21864.16	175002.48
7	17770.385	20744.537	7206.632	12553.405	15662.700	31236.97	20618.30
8	7738.328	15217.959	18726.024	5566.157	6911.848	20117.71	23720.07
9	13008.482	14796.409	22102.958	23730.965	12964.132	20894.61	24570.79

age	1971	1972	1973	1974	1975	1976	1977
1	317253.52	78578.575	65885.719	84503.28	77408.04	48210.593	33158.159
2	384646.45	501555.066	265501.023	197109.97	192267.00	206940.844	76423.255
3	282728.16	166427.390	588849.595	209534.45	102294.18	106684.287	71898.084
4	259263.74	69052.192	125349.438	374760.74	77879.70	43348.981	27816.327
5	106214.40	66289.553	53286.007	78322.22	136722.25	31513.324	11531.601
6	28657.75	29887.708	53089.986	38372.38	30634.93	63206.271	10268.005
7	186179.08	9139.398	23241.434	36198.16	13024.90	11629.065	16913.496
8	18328.83	54539.429	6258.418	15361.54	11518.42	4097.289	2349.167
9	35064.54	13724.729	44899.955	32366.62	15733.32	8994.859	2524.038

age	1978	1979	1980	1981	1982	1983	1984
1	26031.838	96.643587	68.823034	28987.456	34482.109	62920.022	20190.414
2	55290.615	141.769580	193.063533	81867.969	185205.999	112024.805	197781.847
3	27705.895	64.797850	116.368808	99470.389	83963.904	96421.101	47387.676
4	21637.779	25.019690	44.234192	55293.884	92025.947	36018.630	32651.268
5	7609.135	15.285850	16.622387	20636.765	54744.220	42886.992	13069.256
6	3936.931	7.874077	12.461535	10849.811	24562.675	28937.764	14315.918
7	2674.175	3.574513	6.171651	8207.382	12731.208	13286.250	9275.193
8	3622.173	1.650682	1.765877	2317.787	7881.835	5370.435	3278.734
9	1133.521	3.146016	2.676222	1941.602	4568.964	5669.358	2537.434

age	1985	1986	1987	1988	1989	1990	1991
1	18247.112	18847.246	22480.177	7432.959	5203.805	5209.939	3244.712
2	78154.484	116207.828	74507.988	109377.783	39871.434	47094.825	30055.658
3	129459.863	74590.744	59950.775	43425.456	82023.010	45630.971	28527.791
4	20668.798	99070.856	33065.675	27739.450	22425.622	71944.188	24492.596

```
  5  16426.585  16734.766 53920.468  18135.294 16736.932 24414.436 37515.515
  6   6339.333  12434.861  8543.545  25596.907  9919.004 15313.628 12144.636
  7   6386.029   3864.602  6627.838   3694.539 14181.906 11162.485  7772.921
  8   3480.769   3461.926  2332.201   2926.918  2202.405 14634.006  6035.777
  9   2043.612   2861.416  3645.165   2165.142  2499.421  3743.851  5799.154
   year
age      1992      1993      1994      1995      1996      1997      1998
  1  5230.038  4371.559  5842.385  4346.580  3187.728  5919.604  2890.081
  2 27903.314 49286.690 35562.659 62214.219 33374.074 65827.458 74638.229
  3 26303.483 19787.961 29859.572 26123.405 31361.014 50817.793 52459.621
  4 19334.394 14259.740  8048.704 16264.786 10590.826 34083.135 31791.179
  5 22649.947 12882.283  8663.143  5726.498  7893.986 18641.742 23250.210
  6 23214.390 15901.138  7869.111  6495.020  3644.914 12540.373 10724.208
  7  8682.626 14823.904 12315.744  7505.800  5462.604  6981.280  7027.053
  8  5160.407  5781.996  9064.766  9549.128  5068.377  7302.275  2143.500
  9  5639.639  5187.132  5451.371  7666.879  8033.107  9695.221  5028.684
   year
age      1999      2000      2001      2002      2003       2004       2005
  1  2045.193  4598.157  2428.236  2742.000  1130.868   784.7265   484.4493
  2 29612.596 22207.458 58474.397 41615.813 34417.680 15124.5765  7793.1151
  3 62641.306 22746.830 16569.676 77958.867 37426.537 36974.6763 11592.4753
  4 24868.512 37099.576 12125.780 12066.525 43801.939 26357.7983 17019.3741
  5 15898.720 15689.863 26880.981 12865.244  8117.731 33703.9306 13890.4108
  6  7599.621  8261.855  9247.466 20970.327  6509.635  4669.0160  9732.4155
  7  3929.151  4524.639  6057.803  8079.358 11572.449  6325.8017  1426.5321
  8  1290.834  1432.375  2253.216  3317.917  3796.552  5973.5022  1927.8844
  9  1600.953  1250.281  1509.987  2361.781  2857.568  3986.3749  2072.1298
   year
age       2006       2007       2008       2009      2010       2011       2012
  1   635.4049   551.1607   451.5366   814.7304  1654.916   671.0064   696.4811
  2 12853.0466 15892.6752  6459.4824 13454.2527 19215.805 29155.3286 12512.2312
  3 13718.4710 19331.8326 10271.9603 11703.7038 18486.343 17506.8522 35407.8023
  4 12814.5145 10500.1049  7477.0115 11169.0212  9910.200 10806.0391 12910.4464
  5 30385.0917 13739.7744  5259.1288 10627.1274 11131.376  6631.7879  8786.6550
  6 22790.8276 24370.6542  5800.4718  6377.2538  7764.736  5943.9905  4844.8131
  7 16886.3077 20655.1061 11277.1730  6774.7457  5218.048  3779.5472  4055.9779
  8  2277.5071 11789.0334  7903.0103 11284.0909  5149.437  2951.8000  2555.0585
  9  5484.9497  4460.8151  5152.5973  9477.3171 11315.949  6824.4375  5206.0719
   year
age       2013       2014       2015      2016       2017       2018
  1   418.1869   512.5287   910.4549  105.8361   89.35047   93.90935
  2 16631.1718  7933.2636 12347.3162 5592.3058 1522.99920 1877.83463
  3 20018.7674 19556.6843 12220.9616 4378.8926 7842.24245 2832.02691
  4 38358.2442 18670.3896 19636.0893 2891.3377 3305.64300 7982.29708
  5 14615.5249 33148.4499 18977.4643 4007.5930 2194.92736 3827.59908
  6  7857.7414  9261.3931 21150.6675 3501.7569 2132.97914 1984.20611
  7  5173.3391  4357.6272  5020.2579 2393.4070 1509.53679 1430.61697
  8  4392.4267  3533.4205  2894.8405  683.3515  994.87751 1413.38753
  9  5336.6781  2707.9654  1233.9280  231.8093  274.28749  616.36842
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Units : NA

Area: 6aS7bc

age	1957	1958	1959	1960	1961	1962	1963
1	177.7938	397.3142	503.8182	174.9632	315.8523	415.1054	253.4605
2	9323.6042	4511.1561	7518.0884	9297.1493	3893.5009	6757.4686	6615.4438
3	6176.1113	13479.6248	4831.3901	7735.3234	11907.8462	4188.9093	6022.8112
4	3008.4581	4879.5060	8377.0658	3099.9159	6413.2987	9382.6250	2195.4933
5	4136.5546	2905.9085	2631.5099	4130.9800	2623.9979	5378.2543	5130.3902
6	2246.9696	3483.3683	1728.9646	1304.8035	3239.6390	2577.8484	3791.7167
7	1397.4633	2213.5669	2074.3902	1143.1683	1280.4317	3931.7586	2101.6422
8	258.2036	1157.1031	900.7468	673.0248	675.2173	1034.2059	2020.3487
9	822.8188	888.7609	722.5939	511.1222	774.5717	1345.2173	1213.8603

age	1964	1965	1966	1967	1968	1969	1970
1	162.536	707.7915	185.5585	460.4326	597.4704	561.1917	695.9922
2	6480.083	4336.8407	26769.6799	4300.7450	9921.3629	15380.8839	11903.4588
3	8754.455	9995.2096	7653.8323	47449.6236	5390.7693	14221.4505	21172.8458
4	4548.912	8430.4183	10805.6750	7745.9895	43030.2273	4957.3629	12225.0876
5	1622.961	3704.5022	7772.5621	9239.6035	5034.3801	36978.2641	3896.3451
6	4699.836	1585.6043	3859.3075	7085.9078	6655.4712	4459.1121	30292.5306
7	4231.751	5375.4817	1933.4740	3713.4367	5016.8413	6111.4603	3669.5028
8	1477.286	3188.0667	4413.4599	1506.1083	1654.2537	2857.0795	3180.6490
9	2483.385	3099.7547	5209.3557	6421.1988	3102.7827	2967.4131	3294.7228

age	1971	1972	1973	1974	1975	1976	1977
1	1386.562	1089.726	1402.005	2988.811	4994.444	4390.140	4044.415
2	11899.234	41564.379	24506.383	23079.381	34838.024	46546.989	25704.999
3	11525.414	17972.809	66936.972	29655.997	23130.767	30846.116	30947.254
4	14262.485	10016.209	18337.911	63283.990	21857.692	16567.067	15865.502
5	7962.095	12824.173	10056.650	15758.734	43664.491	14250.227	8196.964
6	2974.355	7945.881	13384.053	9130.760	10497.512	27290.963	6819.694
7	22908.265	3034.717	7911.983	11352.149	5512.408	5663.323	11843.451
8	1942.137	20969.417	3226.973	9269.529	10575.829	4499.375	3231.527
9	3715.466	5276.908	23151.368	19530.803	14445.813	9877.566	3472.081

age	1978	1979	1980	1981	1982	1983	1984
1	4985.804	4697.852	2798.400	2464.515	1594.545	5757.920	2388.938
2	31473.305	43036.691	48140.409	21602.658	25293.018	26198.052	62902.777
3	21364.450	30197.844	48636.117	43462.656	19160.946	35962.849	24287.016
4	21287.634	16599.737	26697.465	33383.559	28143.012	17585.428	22159.247
5	9980.453	14094.787	14195.737	16324.890	20048.092	22900.187	9784.998
6	5058.311	7470.781	11433.250	9446.459	9782.764	16249.781	12155.314
7	3531.087	3436.664	5632.422	7180.636	4888.357	6775.202	7630.921
8	8800.972	3076.929	3238.488	3555.204	4217.115	3937.380	3464.685
9	2754.173	5864.282	4907.994	2978.181	2444.589	4156.538	2681.342

age	1985	1986	1987	1988	1989	1990	1991
1	2292.092	1961.890	5540.460	1604.962	1093.433	981.9601	933.2171
2	26810.499	30964.142	39624.572	56291.419	20597.702	19539.4716	17831.3853
3	74965.798	35089.108	55206.586	39984.266	76478.995	33406.4747	29684.9672
4	16593.080	66294.810	41424.592	35616.666	30138.802	73213.4982	34886.1600
5	14764.940	12812.227	70959.080	24209.010	23385.796	24888.7536	54342.9689
6	6681.767	11676.026	12707.498	39673.546	16357.435	17633.8369	19659.0938
7	7037.096	4123.978	9676.072	5462.741	21087.657	10932.6228	10839.1128

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  8  4678.846  4345.781  4227.059  4232.497  2847.695 11803.2721  7778.9877
  9  2747.021  3591.957  6606.773  3130.924  3231.734  3019.6577  7474.0251
   year
age      1992      1993      1994      1995      1996      1997      1998
  1  1618.300  1458.941  3275.906  2395.929  3340.776  3978.931  2965.638
  2 15701.615 27421.213 28140.437 45856.066 42285.176 45951.862 68593.737
  3 26573.269 20620.034 40905.202 32417.902 61850.920 49846.265 63596.525
  4 27784.209 23143.802 17133.185 29508.979 26975.120 37116.610 41201.071
  5 32555.300 20644.922 17985.617 10089.294 16721.525 14626.100 21309.500
  6 36875.671 26909.983 16513.215 11670.768  7190.882  8323.801  8202.589
  7 11672.323 19132.212 17460.452  8358.196  6241.010  2833.913  3443.276
  8  6696.248  7247.123 12749.556 10230.422  5762.033  3279.218  1378.773
  9  7318.110  6501.522  7667.331  8213.882  9132.515  4353.814  3234.622
   year
age       1999       2000       2001       2002       2003       2004
  1  1872.0349  4015.4427  2198.4054  2243.0673   966.3513   694.5524
  2 26235.2770 19662.1901 56012.6258 35194.8018 33608.7953 16802.7130
  3 70841.8126 24619.1343 18775.8419 71615.6053 37530.1319 41040.7630
  4 31687.3125 43215.5588 14770.6808 11651.1625 42623.8258 25446.6212
  5 15275.2067 13352.8789 22193.5517  8165.9808  5146.5405 18880.2421
  6  6619.1487  6404.7521  6693.9669 11833.1945  3639.9694  2140.9629
  7  2419.2334  2523.9408  2895.9893  2971.9485  3747.6527  1610.3923
  8   884.8695   773.9598   897.4629   944.2913   692.8368   653.5297
  9  1097.4564   675.5683   601.4325   672.1715   521.4805   436.1285
   year
age       2005       2006       2007       2008       2009       2010
  1   708.5009   900.0867   518.7858   652.4627   547.7215   923.6713
  2 15403.1987 21423.8848 17914.4483 11664.5379 11545.8682 12733.8033
  3 24175.0865 24862.4765 26854.9558 23780.8134 13132.0882 16252.7427
  4 33543.7450 20542.4698 14358.3889 18375.2104 12864.7984  8994.9625
  5 16624.2851 25224.8265  9938.0483  7727.1144  8174.0449  7104.4282
  6  9049.3515 11989.2445 10077.7895  4937.7820  3244.1755  3801.7623
  7   760.5313  4387.8681  3852.1249  4068.3118  1568.7710  1340.8369
  8   382.2955   199.1180   536.6986   629.9816   499.1774   301.5930
  9   410.8990   479.5385   203.0797   410.7348   419.2507   662.7542
   year
age       2011        2012        2013        2014        2015        2016
  1   275.5536   156.90386    62.45715    74.27551    46.37720    26.20727
  2 15815.7373  4223.97768  3869.95047 1832.61958 1268.32425 2918.18516
  3 12801.0111 15588.92783  6109.24659 6010.57267 1625.15937 2844.93409
  4  8238.6230  5643.73653 11175.23478 5508.75722 2475.57934 1834.76240
  5  3678.3471  2754.94579  3182.56970 7454.51835 1824.69976 2087.17071
  6  2705.4439  1237.71846  1432.79600 1746.43071 1561.71498 1468.40148
  7  1015.5404   673.86936   644.79818  574.24583  258.23766  696.71690
  8   179.3706    79.57045   127.53325  131.88770   31.88411   49.51301
  9   414.6974   162.12915   154.94940  101.07694   13.59063   16.79601
   year
age       2017       2018
  1   29.24625   19.29117
  2 1082.17615  936.77559
  3 6520.87231 1623.34306
  4 2879.75886 4682.89988
  5 1709.78068 1935.11077
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6	1562.02454	963.53231
7	915.05057	666.80161
8	174.59519	161.74232
9	48.13585	70.53469

Table 4.6.19. Herring in 6.a (combined) and 7.b–c. INDEX-AT-AGE RESIDUALS catch 6.aN and 6.aS/7.bc.

Units : NA

Area 6.aN

age \ year	1957	1958	1959	1960	1961
1	4.3917972158	5.022033576696010	1.70247523	-1.77488509	-0.03983159
2	0.0007331323	1.556387285203030	0.28173625	1.18023271	-0.86506926
3	0.0007765353	1.432487194204824	-0.09186191	-0.01015073	-0.09283212
4	0.4522077984	0.000000026169952	1.42626448	0.06541195	0.10625283
5	1.0739205341	5.889297200829849	-0.76677184	-0.05674340	2.38542371
6	1.8038697426	-0.000000009133377	0.20707534	-1.16350511	-0.82079381
7	2.5811242810	-4.775733081218419	-0.84623080	0.41770971	0.01150809
8	-0.0156308090	-0.610909562467760	-0.45900596	-0.43563998	1.05131617
9	0.2094578318	-0.015843162368102	-0.11765810	-1.48054103	-1.67397781

age \ year	1962	1963	1964	1965	1966	1967
1	1.269258418	-0.44968310	0.796223563	2.3878086	2.04026200	0.67156742
2	0.006445572	0.31751772	0.040389662	-1.2988343	0.97492027	-1.89325120
3	-2.661977958	-0.07217268	-0.007199186	1.1241703	-2.11175109	2.50401816
4	0.133812306	-1.81319449	-1.547110693	1.0888458	-0.77381574	0.77429340
5	1.401858195	0.02582365	-1.196911480	-0.2990116	-0.26040681	-0.02259793
6	2.097960573	1.13472979	0.198874974	-1.0705915	-0.07685659	0.17042617
7	0.625360692	-0.26082616	0.648640421	0.4197033	-1.10908559	-0.47604216
8	0.556184228	0.82575143	0.814302805	0.6795441	-0.25337062	0.09933413
9	0.482647198	0.45854583	0.897037057	0.8988713	0.51124979	0.19912689

age \ year	1968	1969	1970	1971	1972	1973
1	1.3785544	-0.28188070	0.75449313	0.8704819	1.07754106	-1.153220797
2	-0.1060101	0.08349402	-0.54059647	0.2795461	0.50008389	-0.003190731
3	-1.2980853	0.34482081	1.98406248	0.5955658	-0.57635434	2.080997531
4	0.4681987	0.25102076	-0.07464869	-0.1402377	-1.68001974	-0.010204198
5	-1.1803030	1.26393032	-0.42545055	-1.0033699	0.02943696	0.407580545
6	0.2652489	0.17142699	-1.46703936	-0.2422761	-0.29109911	-0.019581108
7	-0.2669021	1.21181720	-0.27784866	-0.9628498	0.21199259	-1.684307647
8	-0.5126255	0.31171576	-0.29538062	-0.2903139	-0.10365019	-0.209019474
9	-0.2738214	0.32718757	-0.47294208	-0.9123296	1.10486894	-0.893016451

age \ year	1974	1975	1976	1977	1978	1979
1	0.1422292	0.05168102	-0.43330660	-0.8311299	-0.42909607	-2.4541592
2	-1.2092655	-0.18202540	0.52613569	-0.7663225	-0.11594789	-3.2375007
3	-0.2183268	-1.07110065	-1.21958117	0.9082179	-1.15028155	-2.2825087
4	2.4417072	-0.66393707	-0.67170603	-0.7034812	1.71193774	-2.3694639
5	0.6140869	0.99552769	-0.69381595	-0.2066251	-1.11112898	-1.6691966
6	1.4282400	0.04495045	0.98942171	0.7003477	-0.64000735	-0.2648352
7	-0.0689113	-0.22175532	-0.04007801	0.8611206	-1.11608855	0.2032683
8	0.6780525	0.08013269	-0.43833676	-0.2090611	0.95378344	-1.7070140
9	-1.0276136	-0.18819528	0.36626645	-1.9070495	-0.01367888	0.0000000

```
   year
age       1980      1981        1982        1983       1984        1985
  1  1.3323675  2.287328 -0.74457174  0.07998807 -1.6169597  0.01548741
  2 -0.3342339  3.284511  1.77438826 -0.51474458  1.8968439 -0.19393072
  3 -1.1390351  2.741852 -1.13712917  0.20046123 -0.8328606  0.83921794
  4  0.2877466  1.788054  0.04451531 -1.06192351 -0.7794058 -1.53450505
  5 -0.3470003  1.199861  0.69322347  0.15117435 -0.2261800 -0.23665098
  6 -1.0065887  1.310477 -0.13908931 -0.20603872 -1.6972269 -0.02068447
  7  1.0267917  1.592876 -0.22524711  0.34586410 -0.7902994 -0.57862836
  8 -1.3665184 -1.224726  2.21345755  1.35050486  0.3872153 -0.23719959
  9  0.0000000 -1.456588 -0.41502612  0.50479145 -1.4021758 -0.63324617
   year
age       1986        1987       1988        1989        1990        1991
  1 -0.1356420 -0.61446545 -1.5022477 -0.53215975  0.05523805  0.28583697
  2  0.5698682 -0.05972924  1.4178990  0.08589540  0.01593894 -0.77088581
  3  0.1736999 -0.64250851 -0.5402370  1.30006566  0.44485120 -0.07990382
  4  0.4199626  0.64797743 -0.3240279 -1.38773148  0.37609913  1.30121983
  5 -0.2258954  0.57137162  0.2151300 -0.23853892  0.31847134 -0.77188178
  6  0.2805172  0.15375861 -0.1693651 -0.88313437 -0.59169815  0.31548680
  7 -2.6179585  0.87890807 -0.8139342  0.32013748  0.46346283 -0.36097224
  8 -2.0700684  1.78631546 -0.3642854 -0.09006003  0.92657029  0.58975651
  9 -1.1563733  0.99312886 -0.3083588  0.42167418 -0.03430650 -1.76396662
   year
age        1992        1993       1994       1995       1996       1997
  1 -0.38347586  0.43108764 -0.7401649 -1.9027985 -0.6006532 -0.7882884
  2  0.07415504  1.50011763  1.1242039  1.9596362  0.5950655  1.1454886
  3  0.25499161 -1.81465404 -0.1606038 -0.3238788 -0.9732834 -0.2510514
  4  0.76876892 -0.36397563 -1.8268762  0.4652382 -0.1492441  0.4904937
  5  0.67026937  0.44486612 -0.1091893 -0.6310172 -0.0535481  1.8705754
  6  0.26303737  0.60848026  0.5458070 -1.0329587  0.3379536  1.7033877
  7 -0.93973863  1.12264217  0.6388384  1.2692288  0.7585103  1.2242269
  8 -0.34078474  0.01302651  1.0420958  0.1440212  1.9392218 -0.7229502
  9  0.01694900 -0.07842021  1.6637021  1.1107856  3.1974302 -0.4967928
   year
age        1998       1999        2000       2001       2002       2003
  1 -0.05541706 -0.1723384 -0.17595453 -1.7947362 -0.7018864 -2.1864311
  2  0.10997431 -0.5262732 -0.37017852  2.1062474  0.5706162  1.2877754
  3 -0.74881122  2.1782942  0.38144779 -1.2526717  0.9027011  0.6578451
  4  0.59628642 -1.2568593  1.34567783 -0.6410266 -1.2858047  0.4597038
  5  0.04385107 -1.2866145 -0.29636476  0.6766599  1.3656502 -0.5597169
  6  1.07549085 -1.1495778 -0.01414491  0.6428161  0.5355600 -0.9180326
  7  0.11631606 -1.0987785 -0.55522214  0.9319922 -0.1081675  0.5116131
  8  0.14615194 -0.4258939  0.29026377  1.6500542 -1.9320623  2.4898505
  9 -0.51520904 -0.1621007 -1.45563062 -0.9627594 -0.9043214 -1.3646884
   year
age        2004       2005        2006       2007       2008         2009
  1  0.00000000 -0.9659948 -0.58622648 -0.5932267  0.0000000  0.931966123
  2 -0.77137155  0.2765088  0.59225515  1.9450531  0.1257339 -0.001491468
  3  0.40350331  0.8773285 -0.82056636 -1.6234822 -0.6249303 -0.371324364
  4  1.71776993 -0.8345316  1.15490996 -2.1052749 -1.3568968  1.155190713
  5  1.23025881 -1.6789009  2.16191048  0.2906616 -1.6171798 -1.096754204
  6 -0.05130849 -0.6285523  2.01006883  0.8782066  0.2708454 -0.638199198
  7  1.94359562 -2.0034600  1.16768317  0.4152053  1.1552937 -0.247997100
```

```
  8  0.74205014 -0.1369614  1.21735119  0.6153892  0.3773517  0.001648594
  9  0.24028030 -0.8055671  0.06385637  0.1464580  1.7387483 -0.034654312
   year
age        2010       2011       2012       2013       2014       2015
  1  1.26348195 -0.0129332 -0.1552613  0.0000000  0.0000000 -0.4430714
  2 -0.56498314  0.3847270 -0.1786066 -0.4392724 -0.3203017  0.4845850
  3 -0.41329309 -0.8211570  1.1994448  1.3508415  0.2029241  0.6181630
  4  0.07272197 -0.1288458 -1.1037785  1.6305154  1.6055511 -0.6210978
  5  0.75034313  0.1807860 -0.2676154 -0.8800551  0.8333459  0.3390211
  6 -1.53750872 -0.4250448  1.2623347 -0.3407591 -0.9826136 -0.1590258
  7 -0.96830317 -1.2649829 -0.5729064  0.7435359 -1.1645701  0.2476817
  8  0.22042849 -0.2175667 -2.1289042  0.2550639  0.1330717 -0.7014103
  9  0.46041282  0.3830976 -0.2052476 -0.2556361 -0.3624311 -1.4333914
   year
age        2016        2017        2018
  1 -1.91656870  0.00000000  0.00000000
  2  1.17848168 -0.75234568  0.03388321
  3 -1.65251515  2.37082235  0.57947239
  4  0.29306482 -0.20982771 -0.39270017
  5 -1.60833567 -0.76141442  1.37794418
  6 -0.06505294 -2.09648883  0.79524817
  7 -0.06002684 -1.35620752 -2.85900054
  8 -0.05484937 -1.84190880 -1.34388727
  9  0.78231276 -0.06251396 -0.26424844

Units  :  NA
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Area 6aS7bc

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   year
age         1957           1958         1959         1960       1961       1962
  1  0.000000000 -0.00001154036  1.299234398  0.12012274  0.3963300 -0.8488289
  2  2.438927976  2.28623830802  1.771175211  1.98403294 -0.3060049 -0.4391285
  3  0.346625541 -2.65423307329 -0.002432615 -0.02072613  0.5640517  0.2152831
  4  0.246431619  0.00581784888  0.266145195  0.82009179  0.7749017  0.5531736
  5  0.004254281  1.71736645378 -1.718123763 -2.97119194  0.3413027  0.5412235
  6  1.841818048  0.13021008621 -0.025617407 -0.21647183  0.1850896  1.4810754
  7  0.131966240  1.71777849047 -0.145918042  0.60278966 -0.4712157  0.8535776
  8  0.005179995  0.00554113526 -0.631754037 -0.11005742  0.4886074  1.2238293
  9 -0.173476870  0.54549813623 -0.557871432 -1.33353006 -0.4428591  0.6274153
   year
age       1963        1964        1965       1966       1967        1968
  1 -1.0967866 -0.96966547  0.07061733  0.0000000  0.0000000  0.24198619
  2 -0.5469598  0.22661170  0.26985868  0.0784538 -2.1205248  0.08898079
  3 -0.8447105 -0.46286632  0.59541030  2.0540424  1.6220396 -0.64254308
  4 -0.4458808  0.15350023  0.45075294  0.3413917  1.5725720  1.51002244
  5 -1.0364109  1.17660080 -0.89778545  0.1128351  0.1763672 -0.17984802
  6  0.5519582  0.06229596  1.12049436 -0.3222501 -0.3934966 -1.23706377
  7  0.6369200  0.34505346  0.45128476  2.0754478 -0.4042260 -1.88779443
  8 -0.2159319  0.50534880 -0.29792968 -0.8604611  1.3999317 -1.61934910
  9  1.5548010  0.68746454  0.51166015  0.1675243 -0.1688788 -0.10066140
   year
age       1969        1970        1971        1972        1973       1974
  1  1.0918879 -1.01011563  0.16945425  0.02237775  1.69452054  0.7491029
  2  0.5054955  1.86815813 -2.30890476  1.20601406  0.62374254  0.4146509
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  3 -0.4480297 -0.26840385 -1.48445341  0.50964846 -0.51939310  0.6584690
  4 -0.4164952 -0.39623912 -0.86155129 -0.64739641  0.04941272 -0.8010545
  5  1.1513201  0.03113083  0.64066564  0.02087480 -0.49963187  0.3347122
  6  0.4421371  0.94021730  1.93834286  0.91610769 -0.12646632 -0.4257344
  7 -1.0317815 -0.22709369  0.49845331  0.70908663  0.39392425 -0.2129399
  8 -0.8578392 -1.03791907  0.60692172  1.65590553 -0.28579773  0.3991478
  9 -0.0139810 -0.58012711 -0.09940247 -0.08974515  1.60578038  0.9584914
   year
age       1975        1976        1977         1978        1979       1980
  1  0.7113929  0.88027983  0.02247884  0.806305165 -0.01913319 -0.8666914
  2 -0.2736174 -1.59426676 -0.10998054 -0.107197274 -0.27697615 -0.7280055
  3 -0.2532532 -0.08581135 -3.13248918 -0.006162482 -1.23625339  1.0947544
  4  0.5266560  0.95014974 -0.25848374 -2.097658799  0.75036519 -0.1563418
  5 -1.7213247  1.07890744  0.59233194 -0.044109970 -1.14804358  1.2649499
  6 -0.3495905 -2.20714581  0.09985050 -0.093428599  0.43958789 -0.8253788
  7 -0.3631677 -0.76389797 -1.79219173 -0.106746391  0.46512189 -0.0139479
  8 -0.1781788 -0.66079376 -1.66269671 -1.379246302  0.69871359  0.5905850
  9  1.2278417  0.29659311  0.06001715  0.215846830 -0.85977000 -0.3425383
   year
age       1981        1982       1983       1984       1985       1986
  1 -0.4473852 -0.67949399  0.1986670  0.2395528  0.9733340 -0.4001281
  2 -0.8618326 -0.46929019  1.6031865  0.6152487 -1.3409010 -0.2619943
  3 -0.4978979 -0.21746337  0.9462775 -0.4836287  0.1212864  0.0489608
  4 -0.3913488 -0.08156550  0.6502812 -1.2621132 -0.5577660  0.6034837
  5 -0.9447739 -0.45765783  0.1262363 -1.2946209 -0.4222053  0.4700672
  6  0.6130807 -0.49829371 -0.2114874 -0.2261643  0.2951142 -1.0402960
  7 -1.1949068 -0.25178566 -0.3728685 -0.5610803  0.3340699  0.4790133
  8 -0.2843664 -0.46420756 -0.4396621 -0.9042712  0.4989841  0.1914753
  9  0.4197364 -0.03723604 -0.3265791  0.3349331 -0.8717841 -1.3498737
   year
age       1987         1988        1989         1990        1991        1992
  1 1.50475958  0.000000000  0.23804112 -0.123545522 -0.37155997  0.55827431
  2 0.64651347 -1.036750581 -1.68014426  0.972311512  1.33745737  0.01331471
  3 1.40216726  0.085745028  0.44473566 -0.409287624 -0.09469925  1.23631816
  4 0.38407916 -0.005903153 -0.14050511  1.808013680 -1.78029053  0.15861160
  5 0.99002955 -0.483001271 -0.35139861 -0.197903560  1.31919703 -1.31999461
  6 0.27483847 -0.126462677  0.02383359 -0.003335206 -0.28975329  1.33751230
  7 0.08151306 -0.199222608 -0.08822319  0.354109765  0.20814234 -0.35502945
  8 0.35473982 -1.268413171  0.50867747 -0.954282477  1.01126372  0.28813170
  9 0.01895785 -1.370982699 -0.74864356 -1.908585894 -0.38510924 -0.27990155
   year
age         1993       1994        1995        1996         1997        1998
  1 -1.926344182  1.9541426 -1.35656978  1.03246091  1.189267823  0.58588892
  2 -0.006357313  1.4406576  0.28600531  0.03141098  0.904684985  0.69451007
  3  0.527445894 -1.1441074  0.24186828  0.52223267 -1.264146708  1.07020582
  4  2.133922598 -0.1175905 -1.01011219  0.46879671 -0.346292507 -0.15926605
  5  0.625849610  0.7121196  1.53196615 -1.71202340 -0.302968951  0.58683871
  6 -0.874052540 -0.1569499  1.08308062  2.02303328 -1.291402895 -0.09140187
  7  1.739959540 -0.8998471 -0.70460753  0.33469641  1.483616737  0.45065942
  8  0.152876100  1.3040314 -0.07404816  1.22349656  0.644990877  1.26482238
  9  0.052380376  0.2532077  0.90118286 -0.60923534  0.002832676  0.21476562
   year
age        1999       2000        2001       2002       2003         2004
```

```
  1 -0.51837177  0.3736147 -0.01294346  0.6369771  0.1957462  0.295545884
  2  0.31406774  0.4054136 -0.93901859  0.2965149  0.3527435  0.424534499
  3 -0.31351493  0.5928672  0.18192596 -1.2203810 -0.7354446 -0.004279228
  4 -0.27673552 -1.1437593  0.57644500  1.0976674 -1.4429527 -0.593566737
  5 -1.34699218 -0.3710227 -0.20429310  0.6430705  1.4097366 -2.121904538
  6 -0.82165418 -2.0877564  1.09523365 -0.3980346  1.0128479  1.815331838
  7 -0.37673295 -0.6869495 -0.90928797 -0.2439391 -1.0522905  0.108250080
  8  0.03114187 -0.3535679 -0.41210949  0.1648984 -0.6187893 -0.463164457
  9  0.09677066  1.3342508 -0.53074976 -0.6268842 -1.3578118 -0.987227093
   year
age        2005        2006       2007       2008       2009         2010
  1 -1.15984856  0.17162452 -1.9858085 -0.1675898 -0.8809157  0.412299984
  2  0.90900068  1.25759576  0.1790318 -0.1901420  0.1764853 -0.344743953
  3  0.46165828  1.27114417  1.0554124 -0.9095596 -0.5407717  0.285586726
  4 -0.04242593  1.05780661  1.0064921  1.1090280 -0.8709138 -1.078603244
  5 -0.32376097  0.01865539  0.6953537  1.2384328  0.9924570  0.004331795
  6 -1.37851862 -0.36610251 -1.7319523  0.7608910  1.3240547  1.425677518
  7  0.75749602 -0.95916560 -1.0982359 -0.4075279  0.4859469  1.432526161
  8  0.83348653  1.24958723 -1.9704124 -0.1526282  0.1184041  1.540895817
  9 -1.63675520 -1.28267769 -0.8922525 -0.7281057 -4.6283770 -1.435634768
   year
age       2011        2012        2013       2014        2015       2016
  1 -1.4968219  2.10305940 -1.03202106 -0.7826962 -0.74239886  0.7505958
  2 -0.5487751 -0.04118249 -0.61763779 -2.0638298 -0.24473311  0.1418034
  3 -1.0764889 -1.19701777 -0.07982554  1.7713074 -1.94997107  1.3718954
  4 -0.1288369 -1.90475346  0.38617936  1.1193788 -0.64247339 -0.3611380
  5 -0.5674248 -1.95215759 -0.97973439  1.3786205 -0.31158143  1.1575249
  6  0.6335438 -2.30536837  0.97849146  0.5978095 -2.82666554  1.2289272
  7  1.3996383 -0.30174470  0.10663319  0.7680451 -1.50245275 -0.1091049
  8  2.3616819  0.50963250  2.57311035  1.6914877 -0.09134806 -0.2181315
  9 -2.2133260 -2.49298732  0.62984123 -0.2409165 -0.95943349 -0.9825197
   year
age        2017        2018
  1  0.02490121 -1.04635313
  2  0.20751043  1.12041830
  3 -0.12532476 -0.09719226
  4  1.01282077 -1.04019078
  5 -0.87946454  0.12660661
  6  1.06379383 -1.64020169
  7  0.39378756  0.08492086
  8  1.20110611  0.30435272
  9  0.61330771 -1.87391211
```

Table 4.6.20. Herring in 6.a (combined) and 7.b–c. PREDICTED INDEX-AT-AGE IBTS_Q1.

Units : NA

age \ year	1994	1995	1996	1997	1998	1999	2000
2	59898.05	99527.14	77494.58	82658.90	95599.197	45332.021	39796.266
3	136531.37	108881.52	180100.86	148472.28	152179.330	209248.037	83098.360
4	53795.28	92879.00	74686.36	107835.26	99168.922	96715.449	154169.710
5	58192.88	32705.20	48960.82	47041.88	58107.937	53995.374	55993.563
6	70717.01	50882.76	28873.62	38597.27	33314.465	35210.267	41358.054
7	88042.09	44535.13	31164.64	16868.90	18048.146	16397.668	21118.828
8	76185.06	68289.12	35472.74	25592.25	8771.637	8808.692	11019.562
9	45816.19	54828.51	56222.39	33978.79	20578.393	10924.952	9618.674

age \ year	2001	2002	2003	2004	2005	2006	2007
2	129527.04	83040.60	92758.99	50792.87	43382.68	45768.67	40838.15
3	69213.20	269231.86	161652.17	189495.52	101899.13	79188.75	89292.60
4	55999.79	44336.34	190373.09	125754.40	155156.10	71942.98	51726.30
5	98242.79	36248.67	26644.45	112127.95	96035.16	115467.48	47334.76
6	45660.01	81813.61	29514.69	20106.20	87050.47	99052.43	91833.20
7	26785.32	28984.95	44724.77	22999.39	11264.73	60840.08	63905.48
8	15839.87	18915.25	21255.24	28941.80	20131.90	10232.07	43314.68
9	10615.05	13464.38	15998.28	19314.11	21638.18	24642.04	16389.70

age \ year	2008	2009	2010	2011	2012	2013	2014	2015
2	25773.33	31549.86	33923.27	57405.21	24097.70	25511.174	12436.820	16478.470
3	75725.43	50933.57	61885.52	64790.25	122428.54	51976.242	49646.616	24963.380
4	61053.45	51554.01	35012.05	41980.57	45729.88	92388.619	42199.566	36005.107
5	32033.42	39328.40	31764.63	20787.26	24742.88	27256.678	55746.323	26026.698
6	38012.70	27947.99	28259.22	23946.56	17061.51	17557.176	18137.556	31632.851
7	57956.36	25221.66	17478.33	14503.84	14114.47	11248.325	8161.019	7118.092
8	44807.55	46410.75	18805.68	11941.91	9089.56	9309.778	6365.826	4315.819
9	29213.58	38979.60	41325.70	27609.18	18520.48	11311.125	4878.682	1839.621

age \ year	2016	2017	2018
2	28951.439	10180.734	11343.277
3	32839.618	71615.878	22776.687
4	19614.726	28978.128	61636.019
5	20431.151	15525.870	23162.786
6	18868.059	17839.973	14708.252
7	11481.794	12757.149	12267.999
8	2961.524	7450.679	10937.286
9	1004.620	2054.150	4769.674

Table 4.6.21. Herring in 6.a (combined) and 7.b–c. INDEX-AT-AGE RESIDUALS IBTS_Q1.

Units : NA

age	1994	1995	1996	1997	1998	1999
2	-0.2339927	1.2860131	0.4885735	0.3413032	-2.3637995	0.2841476
3	-1.1140432	-1.8017036	-1.1998994	0.3390645	0.4195610	1.1733973
4	-0.7636904	-0.3586611	-1.0341681	-1.5046954	-0.4588010	1.3947811
5	-0.3426614	-2.8087745	1.5235293	-0.6981846	-0.8480083	-0.3543068
6	0.5449681	1.1865791	-0.1169654	-0.5672650	-1.5059419	-0.8743364
7	-1.7647226	-1.8256106	-2.2188445	0.5512949	1.4161137	1.1646110
8	-2.3607343	0.1541607	0.4745758	1.5736480	-0.5190211	0.8452474
9	-1.3730777	-1.0610698	0.7138803	-0.6026017	0.6913411	1.5285790

age	2000	2001	2002	2003	2004	2005
2	0.6406441	0.20363406	-0.3829759	0.3968827	1.0779306	0.77641129
3	0.5398035	0.14142785	-0.7390121	-1.0667062	0.4728370	-0.50273549
4	-0.5394337	0.07900812	0.6649731	-0.6521560	-0.0275774	1.44662592
5	0.1984424	-0.10394651	-2.1156629	0.1665567	-0.2459491	1.47038571
6	0.7155699	0.42514604	0.1830605	-0.4575347	1.3498683	-0.02819150
7	0.2922121	0.60519856	-0.3776694	-0.3722311	0.3302790	0.63548498
8	-1.6030607	-0.82644434	0.9351219	-0.2223319	-0.8636014	0.60396127
9	2.0322323	1.30032595	0.8308443	1.4263599	0.9242059	-0.09474366

age	2006	2007	2008	2009	2010	2011
2	1.8088348	-0.6236535	-0.15999528	0.3167245	-1.10109660	0.407434469
3	0.5553793	0.2330136	-2.76185091	0.6787739	0.01145636	-0.114060766
4	-1.1498293	0.2284261	0.45657331	-0.5432999	-0.68697840	0.678115835
5	1.8443135	0.3283264	0.95934510	0.9554874	-0.22065631	0.007057524
6	0.8234830	-0.4160753	-0.75288445	0.2703002	0.04200966	-0.057927739
7	0.2395817	0.4733694	-0.73788956	0.5646233	1.48501801	0.044524352
8	0.3783614	-0.7322199	0.90130740	-0.2038543	-0.64083290	-0.047662392
9	0.9069454	2.2391381	-0.09600786	1.3732293	-0.12649541	0.795511868

age	2012	2013	2014	2015	2016	2017
2	-1.60231915	0.876711765	-0.1400813	-0.7426291	-0.08312669	-0.04602807
3	2.16883008	-0.829538605	-0.2249072	-0.9724493	-0.61653006	0.36431957
4	-0.11745498	-0.006796075	-1.3641691	0.9548023	-1.68048054	-0.14322741
5	-0.17528936	0.625580520	-0.1140443	-1.3576940	1.14991879	-0.43652639
6	-0.62783236	0.439901387	-1.8355889	-0.8952510	0.74453237	-0.87547622
7	-0.18032953	0.290792791	0.5428624	0.2280499	-2.38490344	0.42080719
8	0.01459855	-0.355321700	-0.1988339	1.0248299	-0.01397404	-0.71048919
9	0.86831632	0.256269758	-0.6263003	-0.7941213	0.52436200	1.69797471

age	2018
2	-0.5777772
3	1.8427633
4	2.8109458
5	-1.1663627
6	0.7107380
7	-1.2194089
8	-0.1775555
9	-0.7724783

Table 4.6.22. Herring in 6.a (combined) and 7.b–c. PREDICTED INDEX-AT-AGE WoS_MSHAS.

Units : NA

age	1991	1992	1993	1994	1995	1996	1997	1998
1	208934.3	309198.5	257273.7	420907.9	325748.1	357359.0	403680.57	210294.16
2	469128.0	358917.4	572618.1	466449.3	774079.9	606446.4	633154.63	726067.76
3	715260.4	557717.2	393145.4	639018.3	507699.4	843062.1	673283.17	678188.87
4	864220.7	612157.6	459337.1	279817.8	480131.9	385099.6	533688.73	480738.60
5	1237136.4	698542.2	412260.8	299791.9	167217.0	248902.9	224257.98	271528.75
6	413182.3	741674.9	534269.7	283994.5	203196.7	114330.0	140772.28	119727.11
7	253650.1	266004.6	434938.9	358013.0	179260.4	124055.2	58867.27	63058.38
8	174607.7	144239.1	156833.3	231637.4	207005.2	105985.6	68578.52	23808.57
9	167762.5	157634.2	140698.0	139302.2	166201.9	167981.6	91051.62	55855.27

age	1999	2000	2001	2002	2003	2004	2005
1	187369.09	523470.90	360227.66	389525.99	220966.18	191772.47	190704.79
2	349652.15	310108.72	1018873.94	651714.61	735737.47	405184.31	347833.75
3	956584.67	385037.45	324420.91	1251020.95	764549.33	905063.77	492194.58
4	488326.56	791321.34	290399.30	226758.32	993712.52	663230.26	835358.32
5	268328.56	283296.51	499922.24	179977.59	135652.85	575778.76	514854.24
6	137553.45	165342.39	183002.50	320053.27	118577.95	80969.82	369898.64
7	64832.80	86091.57	109159.34	114994.37	181424.74	93163.83	49434.24
8	27731.36	36076.43	51912.62	60655.73	68963.72	92524.00	70397.71
9	34393.73	31490.12	34789.11	43176.35	51907.23	61745.24	75664.90

age	2006	2007	2008	2009	2010	2011	2012
1	169769.65	110666.13	134352.53	150306.6	236654.68	108026.73	112725.62
2	362714.43	322236.60	204764.40	249433.9	265984.68	454071.92	191542.81
3	372855.71	418007.93	359102.69	239799.1	287234.15	306193.34	584210.43
4	374628.14	268219.29	321094.32	268287.9	178839.56	219148.58	241545.16
5	590715.40	240819.36	167558.57	201410.4	158012.70	105890.83	127148.83
6	396632.48	363657.18	156974.12	112264.2	110109.48	95444.06	68149.85
7	245802.79	253210.01	245286.16	102986.5	69586.36	59229.49	57494.65
8	32349.77	131908.22	147856.31	145239.3	56994.47	37100.69	27548.00
9	77908.37	49912.33	96399.22	121984.0	125246.04	85775.24	56130.56

age	2013	2014	2015	2016	2017	2018
1	56382.27	72199.27	113662.831	45621.462	48400.90	46506.67
2	201567.26	98364.56	130035.898	235125.243	82847.42	92345.49
3	244001.31	232513.82	116016.055	162413.831	355403.36	113130.68
4	472377.58	213725.19	180398.041	107708.891	160123.52	341193.80
5	132254.19	263893.80	120273.626	110118.919	84746.24	126522.99
6	64420.38	63810.99	104311.529	78565.544	76080.26	62899.68
7	41017.42	28029.01	21999.796	48482.070	56097.78	54457.14
8	22968.36	13968.05	8115.699	9319.662	25241.15	37421.22
9	27905.93	10704.92	3459.323	3161.454	6958.98	16319.13

Table 4.6.23. Herring in 6.a (combined) and 7.b–c. INDEX-AT-AGE RESIDUALS WoS_MSHAS.

Units : NA

age	1991	1992	1993	1994	1995	1996
1	-0.38207072	-0.564739830	-2.4210469	0.2732751	0.64986277	-1.0266629
2	-1.36391260	0.657571116	1.1841847	-0.0444795	0.55288602	0.7352207
3	-1.07506185	-1.666190809	0.9439812	-0.5015496	-0.68126148	-0.3988337
4	0.08856845	0.417543822	0.5545097	0.2145568	-0.03944884	-0.4530634
5	-1.78634960	2.011172293	0.4279894	0.4437706	-0.13561660	-2.8799848
6	-0.08291713	-3.090411498	1.8893935	0.2243779	0.89450376	0.9259957
7	-0.33393220	1.079085987	-3.2020075	0.5791505	0.04718490	0.5694067
8	0.49253951	-0.016033976	1.4941230	-1.4377953	1.06367653	0.6874866
9	-1.63245663	0.004155934	0.5709592	0.5621467	0.20431146	-0.2233089

age	1997	1998	1999	2000	2001	2002
1	0.55098142	0.56475369	0.4308374	0.48585808	0.37864182	0.3217654
2	-0.04000537	-0.18451249	-0.6370719	-0.13729122	0.95295845	-0.1936536
3	-1.36496873	-0.13615854	1.3896713	-0.02939282	-1.02527314	0.5685102
4	-2.40209020	-0.19490959	-1.2609518	1.28249000	-0.34369481	-1.4332010
5	-0.59175404	-1.40066738	1.0203610	0.66161178	0.96098149	-0.1852729
6	0.09698535	0.02329595	-0.3312759	0.85808494	-0.70882853	1.3166431
7	-0.21214886	-0.67908231	1.2336112	1.12724977	0.81095924	0.1991398
8	2.20405691	1.20876972	-0.4033402	0.44272027	-0.06992316	-0.4052562
9	-1.73647754	1.23649729	1.1193953	0.23750955	0.30369477	0.5494637

age	2003	2004	2005	2006	2007	2008
1	0.55547744	0.7434190	-0.6917824	0.08839452	0.0000000	-0.51315260
2	0.80401189	-0.1871501	-0.7425716	1.67617282	-1.7916256	0.28890551
3	0.16637549	0.1022588	-1.3977810	-0.74798600	-0.3944309	1.26095086
4	0.74052027	-0.9908571	0.9796532	-0.96372418	0.1243905	0.08979021
5	-0.29781483	0.5065524	0.3790768	1.15121060	-0.4862652	0.41305381
6	-0.02355934	-1.2234318	-1.2773217	0.72243740	1.2513018	0.17996321
7	0.78649673	0.7688306	-1.2742327	-0.50681712	0.5835885	1.04576220
8	-0.09125582	-0.4114687	2.0836023	-0.80288318	0.5504169	0.21003841
9	0.23028413	1.1788691	-1.7182554	0.31667494	-1.3747168	0.84470113

age	2009	2010	2011	2012	2013	2014
1	1.05631700	-0.475833712	-0.65627301	0.52525120	0.0000000	1.9736078608
2	-0.17375634	0.151362835	-0.58906541	0.40146833	0.4711578	1.1903091503
3	0.08165747	0.050899950	2.01115333	0.28316366	1.2850485	-0.5394502300
4	0.50535977	-0.004959979	-0.59910502	1.30433095	-1.2895081	2.1922429006
5	0.93905995	-0.959571267	-0.33103047	-0.25818788	-0.2051069	-0.9395957878
6	0.63977175	0.174746675	0.42795502	-0.32456094	-1.6767752	-0.0002221021
7	0.04368103	0.825204937	0.40255861	-0.05254043	0.9527257	-2.1447839837
8	1.79278739	0.446252562	-0.08613774	-0.43249398	-1.6837454	-0.8626557903
9	1.27882002	1.139953251	0.78712428	0.22359647	-0.3613021	-1.8184675779

age	2015	2016	2017	2018
1	0.00000000	0.000000000	0.000000000	2.1456671
2	1.57059852	-2.059763451	-1.054005661	1.5938764
3	2.23625874	0.242098887	0.887235963	-0.7396830
4	1.37696716	0.640542277	-0.082347933	0.4583092
5	0.16644276	0.210314666	0.990675631	0.2158091

```
  6  0.55059409  0.000790029  0.009104051 -1.2730669
  7 -0.82462491 -0.396057770 -1.500914762  1.2390189
  8  0.02384646 -1.550467808 -2.245276343 -1.6852266
  9 -4.64968914 -1.977259611  0.989580125 -0.4590744
```

Table 4.6.24. Herring in 6.a (combined) and 7.b–c. PREDICTED INDEX-AT-AGE IBTS_Q4.

```
Units  :  NA
   year
age      1996      1997       1998      1999      2000      2001      2002
  2 15487.631 15899.902 18111.6011  8828.494  7893.205 26125.954 16681.262
  3 14881.962 11592.105 11518.0052 16574.695  6742.491  5732.739 21955.661
  4  7631.287 10240.551  9075.6495  9518.562 15625.120  5780.517  4464.939
  5  7181.488  6151.724  7332.3386  7604.938  8143.159 14435.021  5097.363
  6  3829.911  4420.756  3716.5724  4559.297  5580.653  6188.988 10619.786
  7  3849.195  1647.073  1766.0086  2000.966  2721.687  3450.157  3558.715
  8  4056.261  2409.486   844.9836  1105.839  1483.545  2136.551  2454.020
  9  6428.958  3199.072  1982.3445  1371.513  1294.946  1431.805  1746.836
   year
age      2003      2004      2005      2006      2007     2008     2009
  2 18989.282 10504.835  9054.015  9355.338  8282.975 5291.800 6421.465
  3 13605.871 16230.960  8905.144  6611.989  7379.128 6403.912 4252.184
  4 19882.366 13378.157 17125.646  7481.488  5338.719 6462.596 5355.179
  5  3918.475 16744.272 15488.074 17128.274  6952.407 4944.018 5844.887
  6  4017.791  2748.615 13097.703 13404.119 12182.786 5434.855 3803.342
  7  5713.350  2930.600  1656.003  7716.227  7828.101 7986.251 3260.022
  8  2815.983  3734.349  3048.728  1294.326  5124.601 6118.032 5764.565
  9  2119.519  2492.092  3276.835  3117.142  1939.081 3988.829 4841.561
   year
age     2010      2011      2012      2013      2014       2015      2016
  2 6803.109 11694.254  4951.958 5186.6596 2533.0975 3342.75262 6182.2718
  3 5036.538  5445.667 10469.479 4316.8789 4105.9969 2036.38646 2993.5562
  4 3517.855  4385.040  4878.054 9299.0246 4176.0362 3495.12904 2242.6197
  5 4481.927  3060.089  3699.770 3678.6410 7199.1543 3219.60690 3326.5500
  6 3642.145  3213.763  2298.633 2032.6000 1947.9748 3026.38153 2737.9463
  7 2159.410  1875.064  1816.551 1187.9806  774.4735  559.53245 1575.6688
  8 2205.853  1464.144  1066.195  756.2541  419.4431  215.87681  371.5210
  9 4847.388  3385.038  2172.430  918.8280  321.4555   92.01766  126.0289
   year
age      2017      2018
  2 2181.7855 2432.6967
  3 6568.3234 2092.2332
  4 3350.3704 7149.1274
  5 2585.6536 3862.4800
  6 2701.5618 2238.4209
  7 1882.2365 1840.7562
  8 1066.2465 1593.0923
  9  293.9639  694.7364
```

Table 4.6.25. Herring in 6.a (combined) and 7.b–c. INDEX-AT-AGE RESIDUALS IBTS_Q4.

Units : NA

age	1996	1997	1998	1999	2000	2001
2	0.46862791	-0.03232711	-0.3235851135	-0.8224970	-0.6713630	1.4755578
3	-0.56838984	-0.38401522	0.0605013374	1.2038542	0.0393891	-1.6127204
4	-0.70528091	-0.80394739	-0.0008564055	1.1466022	0.6995904	0.7559927
5	-0.50881535	0.10055782	1.6649824386	0.4633583	-0.8819154	-0.8300496
6	-0.48318493	-0.04963468	0.7071205602	1.3036304	1.2376992	1.0972528
7	-0.09015188	-0.57987088	-0.5464856898	0.6095354	0.3640479	0.2933856
8	1.35944111	1.48818828	0.6269522282	-0.5369220	0.7002697	-0.2019155
9	-0.24456337	-0.42356845	1.8307332318	1.7305320	-0.1816295	-0.4007196

age	2002	2003	2004	2005	2006	2007
2	-0.20662553	-0.1237115	1.37603180	-1.46496784	-0.4405871	-0.5256339
3	-1.57478645	-0.1635478	-1.32140321	0.06223746	-2.2308260	-0.8413243
4	-2.23015322	0.1807755	-0.31315645	0.65504778	1.3961733	-0.3804967
5	0.62096755	-1.1526467	-2.53894534	1.09080143	-0.6606085	1.1653362
6	-0.72215370	0.9032819	0.48436660	-0.77575253	0.7559328	-1.9763669
7	1.28291947	-1.1773233	0.83153390	0.15150157	-0.2713922	1.1416289
8	0.05397029	0.3972349	-2.33852887	0.40784387	0.6632950	-1.8201409
9	-1.17644615	0.6939203	-0.09179512	-0.02254330	-0.7687594	-0.5025864

age	2008	2009	2010	2011	2012	2013	2014
2	-1.5088248	0.2990901	0	-0.29524291	-2.09504704	0	0.7613667
3	0.6323104	-1.0381890	0	-0.61940058	1.26326610	0	0.7147430
4	-0.0410025	-1.8385720	0	-0.01808687	0.63201868	0	-1.6227066
5	-1.1786990	0.1585631	0	-0.78776681	0.71058532	0	-0.7401405
6	0.2017415	-1.2975423	0	-0.70566441	0.27232547	0	-0.4110866
7	0.5546091	0.4795667	0	-1.70539940	-0.01807494	0	-0.6815008
8	-0.4109151	-1.1673002	0	-0.80000929	-1.69478566	0	0.2720043
9	1.0325733	0.8194454	0	0.86557823	2.20276017	0	-2.8801446

age	2015	2016	2017	2018
2	1.7861924	2.6182642	2.4514104	1.0034151
3	0.6459794	-0.1600548	0.7069717	0.6067063
4	-0.4508718	2.1615905	0.5173736	-0.7892003
5	1.2418292	-0.7949132	2.0227884	-0.4346098
6	-1.5522245	0.9915353	-0.9603940	0.2467588
7	-0.6724769	-0.4040112	0.5179574	-0.3912039
8	2.3719561	0.8766801	-0.4942643	-0.2781320
9	1.7694622	1.1168667	-0.3364251	-2.7394018

Table 4.6.29. Herring in 6.a (combined) and 7.b–c. FIT PARAMETERS.

	name	value	std.dev
1	logFpar	-1.18325907	0.35572229
2	logFpar	0.03389203	0.14693520
3	logFpar	0.73118787	0.12037409
4	logFpar	1.08137510	0.11956687
5	logFpar	1.22437637	0.12007105
6	logFpar	1.40872258	0.12272301
7	logFpar	1.61146102	0.15320678
8	logFpar	1.77510729	0.16291600
9	logFpar	-2.23750959	0.21286677
10	logFpar	-1.05441706	0.14128409
11	logFpar	-0.81681172	0.14008604
12	logFpar	-0.67077915	0.13976691
13	logFpar	-0.25402893	0.15265421
14	logFpar	-0.08628277	0.15596950
15	logFpar	0.31565603	0.17390541
16	logFpar	-3.46554510	0.12910011
17	logFpar	-3.11549603	0.17697416
18	logFpar	-2.63717032	0.17643915
19	logFpar	-2.10973380	0.17728299
20	logFpar	-1.76234707	0.17987915
21	logFpar	-1.61287915	0.18919391
22	logFpar	-1.20121774	0.20005080
23	logSdLogFsta	-0.80567349	0.22225021
24	logSdLogFsta	-1.20400092	0.17394231
25	logSdLogFsta	-1.30630888	0.14571970
26	logSdLogFsta	-0.79004804	0.18944099
27	logSdLogFsta	0.12892261	0.16613121
28	logSdLogFsta	0.24219326	0.09105500
29	logSdLogN	-0.55502696	0.13086170
30	logSdLogN	-2.05362040	0.12335368
31	logSdLogObs	0.09739185	0.10834383
32	logSdLogObs	-0.59032844	0.11403731
33	logSdLogObs	-0.90556297	0.06139394
34	logSdLogObs	-0.40569153	0.06827268
35	logSdLogObs	0.35904759	0.11621414
36	logSdLogObs	-0.93086747	0.14112957
37	logSdLogObs	-1.29670323	0.07427764
38	logSdLogObs	-0.84707122	0.09608205
39	logSdLogObs	0.51307896	0.15020026
40	logSdLogObs	-0.33423204	0.13854424
41	logSdLogObs	-0.55456444	0.11011930
42	logSdLogObs	-0.32057175	0.11523160
43	logSdLogObs	0.02322622	0.14139983
44	logSdLogObs	-0.42095775	0.12410951
45	logSdLogObs	-0.32899340	0.12186900
46	logSdLogObs	-0.25054065	0.12065350
47	logSdLogObs	-0.69139849	0.18153292
48	logSdLogObs	-0.27537314	0.14362712
49	logSdLogObs	-0.25286437	0.14030869
50	transfIRARdist	0.44709326	0.39935582
51	transfIRARdist	-1.52285373	0.25453568

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52 transfIRARdist -1.48905680 0.25297835
53 transfIRARdist -1.79995564 0.57247491
54 transfIRARdist -3.03487692 0.52824149
55 transfIRARdist -2.07064797 0.46442481
56 transfIRARdist -1.18347971 0.33668081
57     itrans_rho  2.96513107 0.21662760
58     itrans_rho  1.74454624 0.20887268
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Table 4.6.30. Herring in 6.a (combined) and 7.b–c. NEGATIVE LOG-LIKELIHOOD.

1538.0642221481

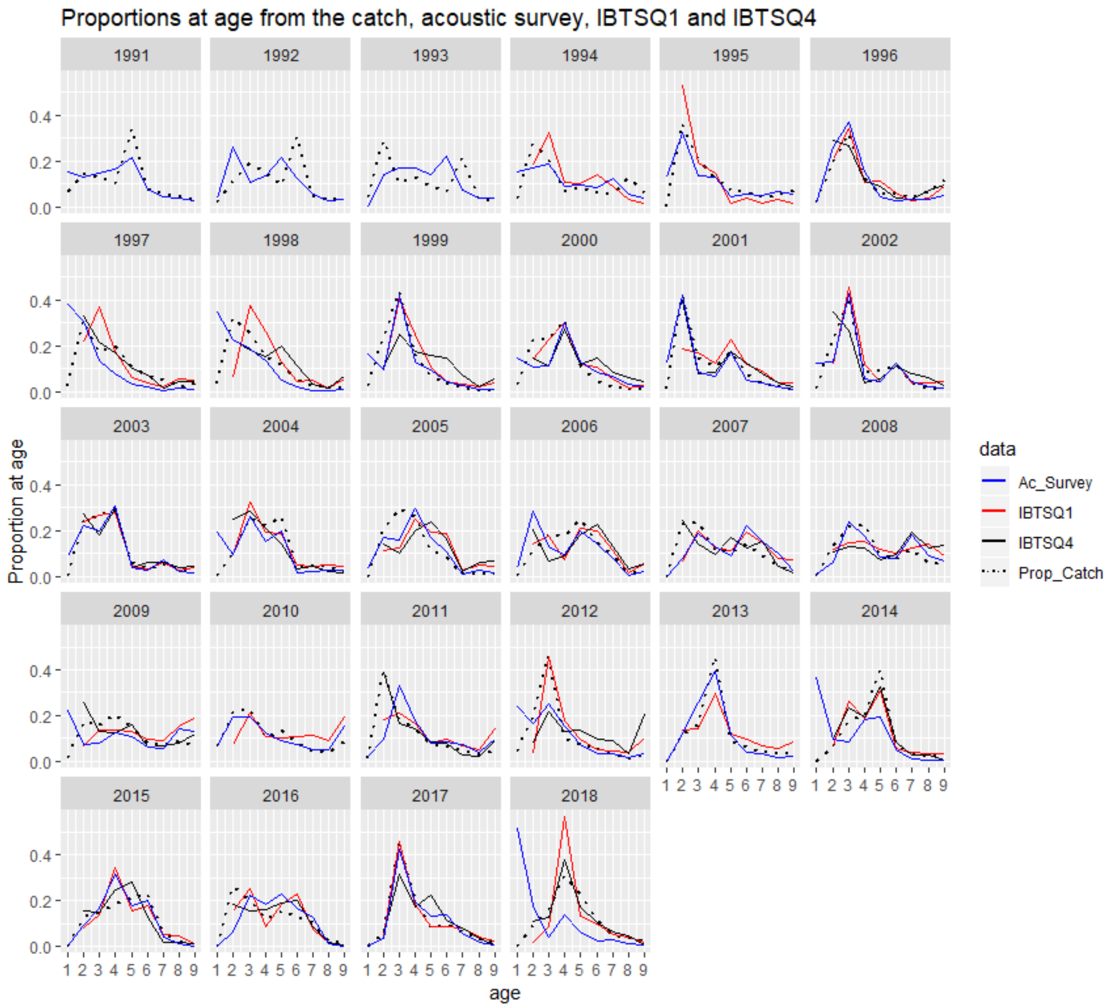


Figure 4.3.1.1. Herring in 6.a (combined) and 7.b–c. Comparison of the proportions-at-age, by age (-wr), of the catch, acoustic survey (WOS MSHAS), IBTS Q1 and IBTSQ4.

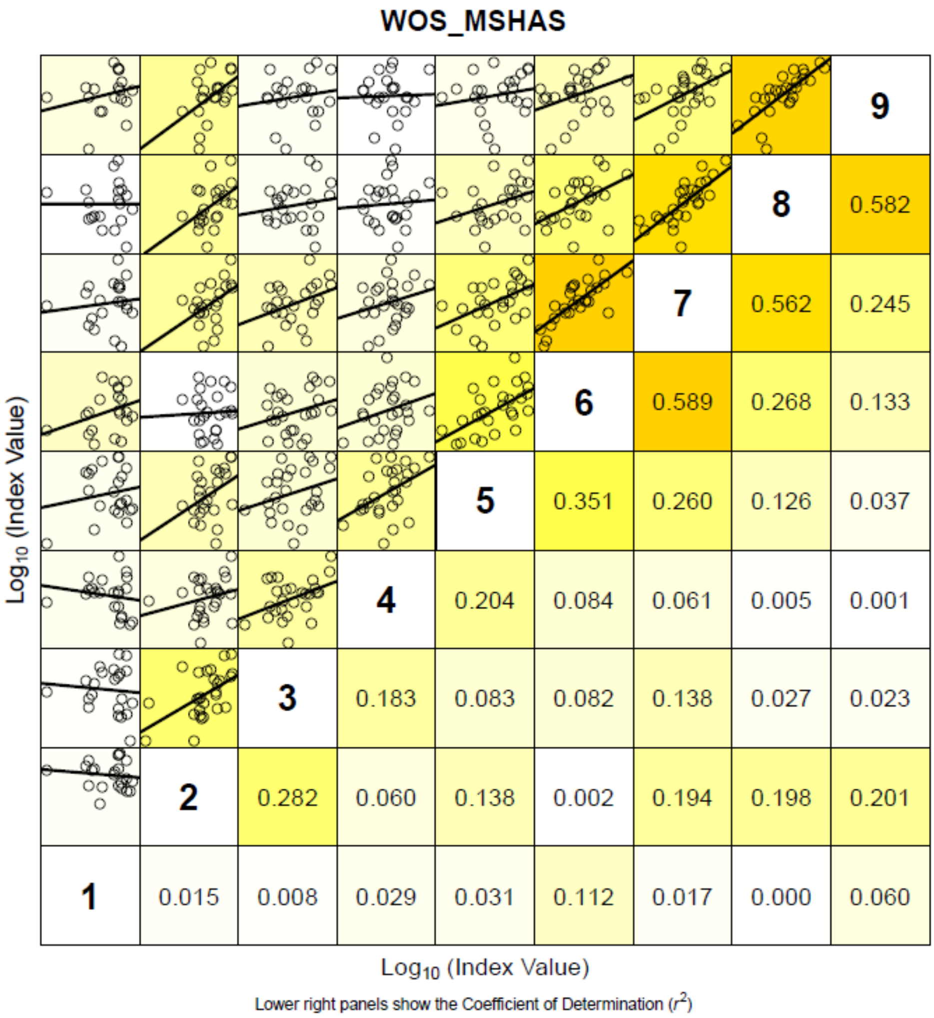


Figure 4.3.1.2. Herring in 6.a (combined) and 7.b–c. Internal consistency between ages (rings) in the WoS_MSHAS herring acoustic survey time-series (1991–2018).

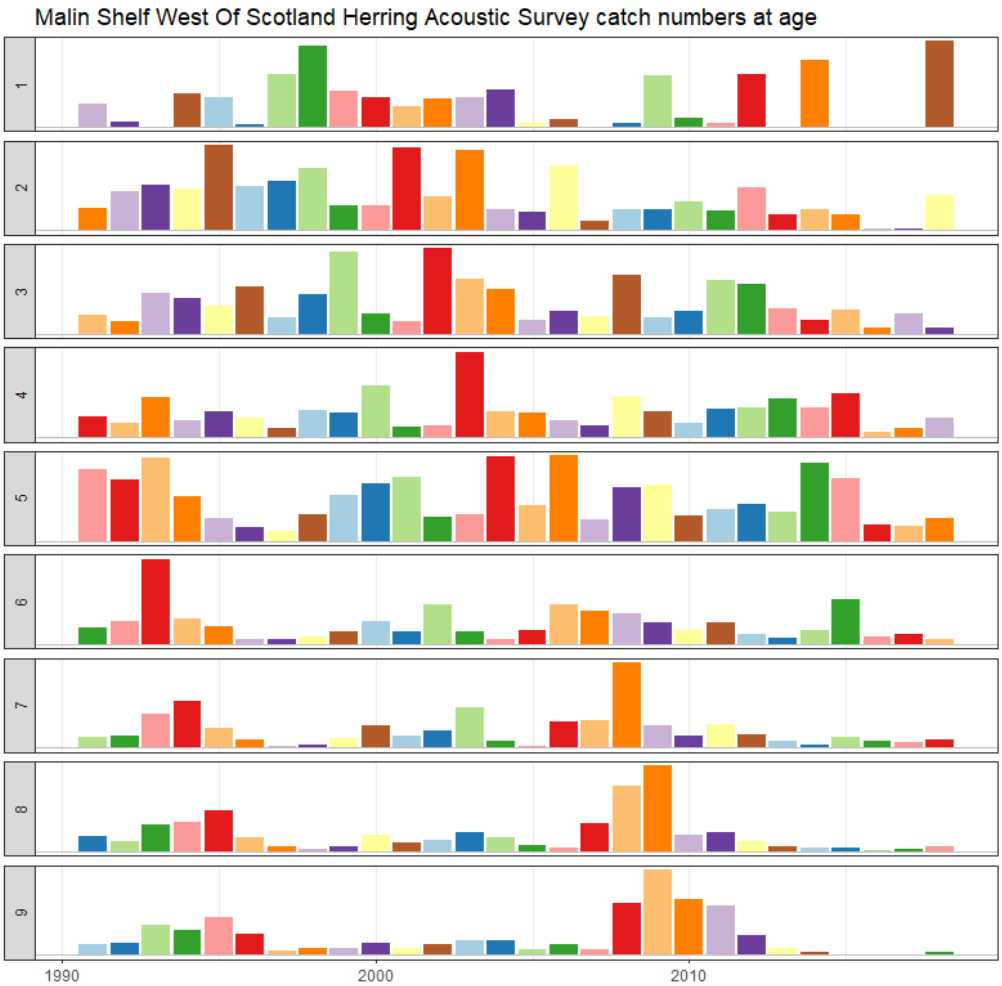


Figure 4.3.1.3 Herring in Divisions 6.a (combined) and 7.b–c. Catch numbers-at-age from Malin Shelf herring acoustic survey combined with West of Scotland acoustic survey (WoS_MSHAS) (6.a.N-S, 7.b and 7.c) time-series. Age (rings) from acoustic surveys 1991 to 2018.

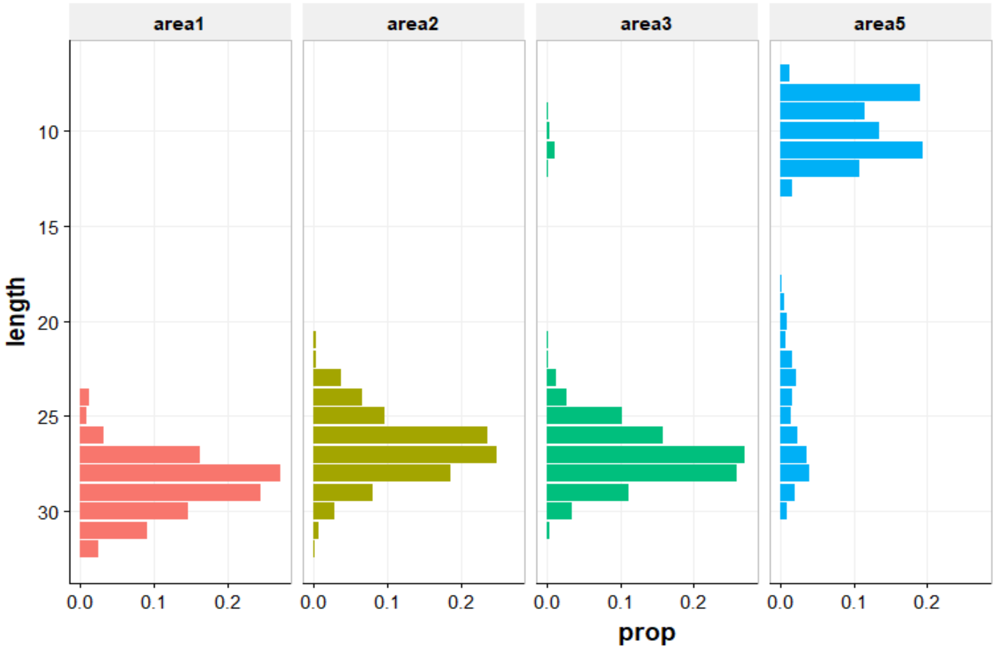


Figure 4.3.1.1.1 Length-frequency distributions recorded from industry survey samples.

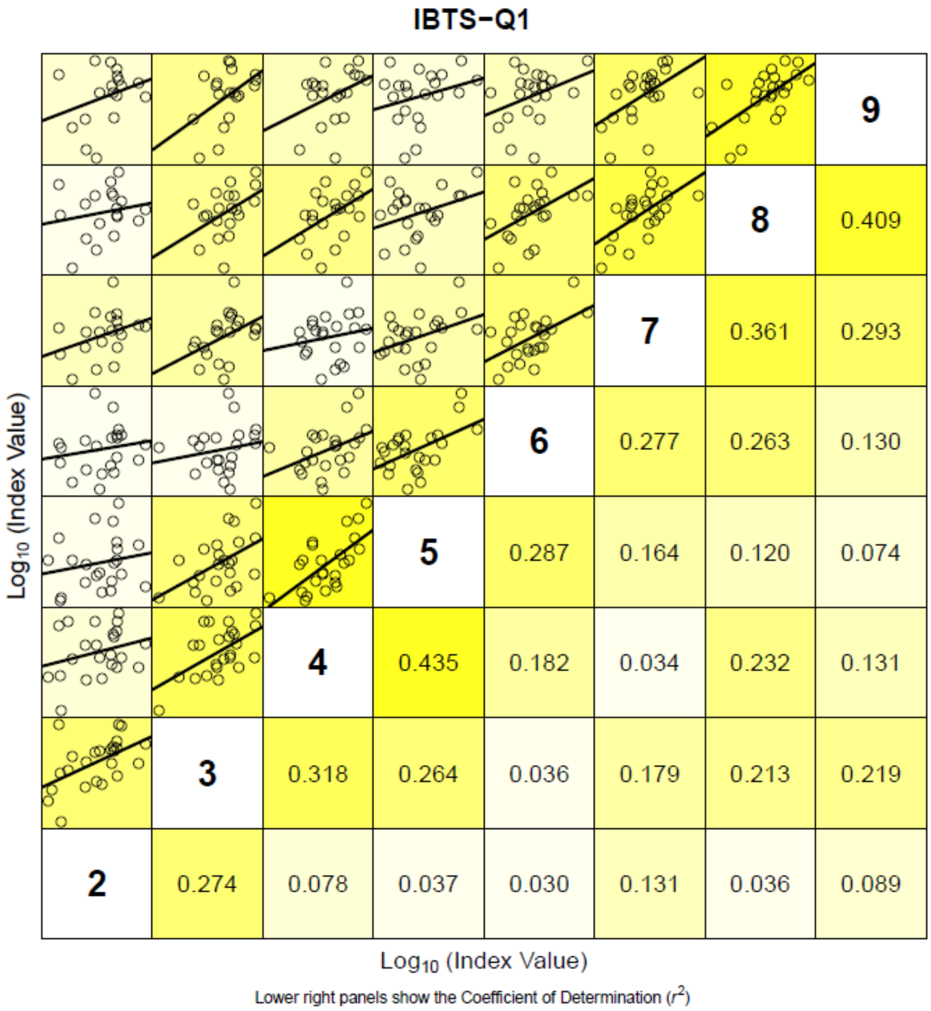


Figure 4.3.2.1. Herring in divisions 6.a (combined) and 7.b–c. Internal consistency plot of the quarter 1 Scottish bottom-trawl survey (1994–2018). Above the numbered diagonal the linear regression is shown including the observations (in points) while under the numbered diagonal the r^2 value that is 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 bottom-trawl survey in (1996–2018). 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.

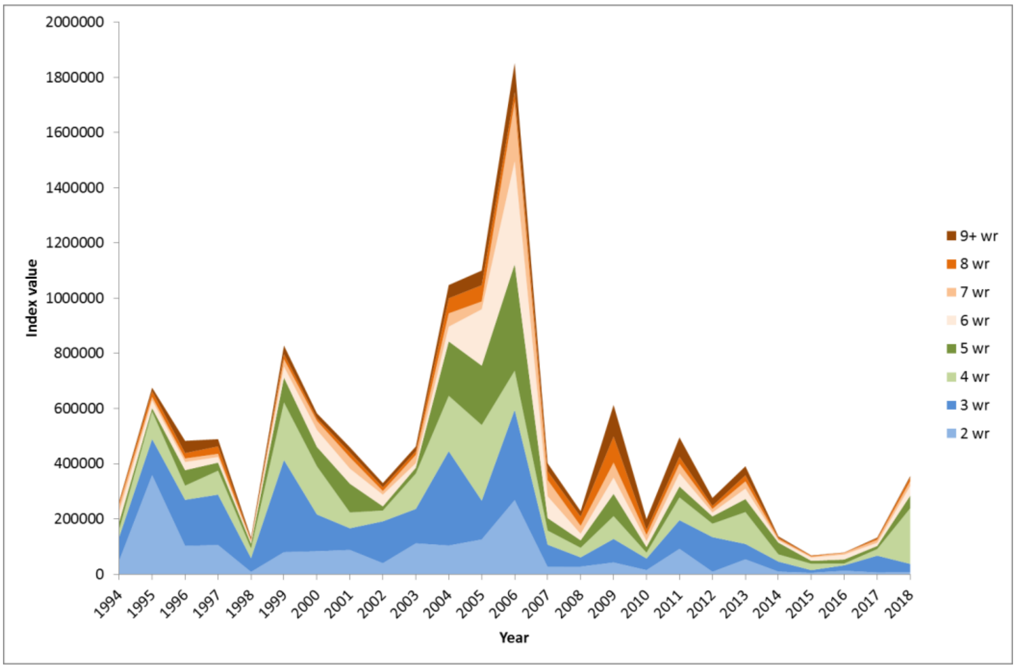


Figure 4.3.2.3. Herring in 6.a (combined) and 7.b-c. Trends in stock composition from abundance-at-age index from Scottish ground fish survey in Quarter 1.

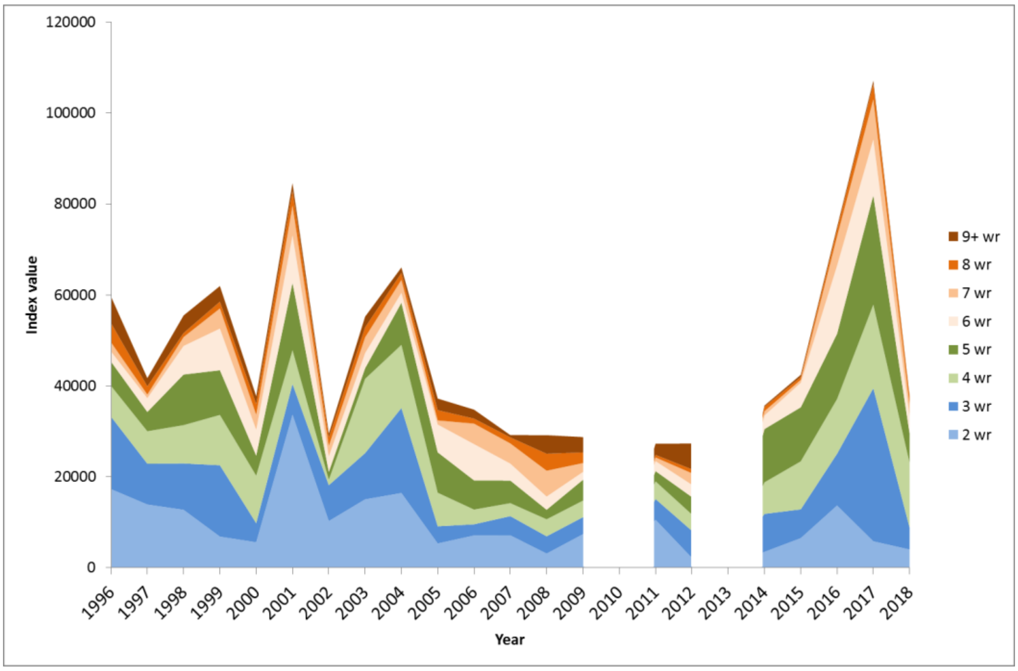


Figure 4.3.2.4. Herring in 6.a (combined) and 7.b-c. Trends in stock composition from abundance-at-age index from Scottish ground fish survey in Quarter 4. There was no survey in 2010 and in 2013 only half of the survey was completed and the data were not used for the index.

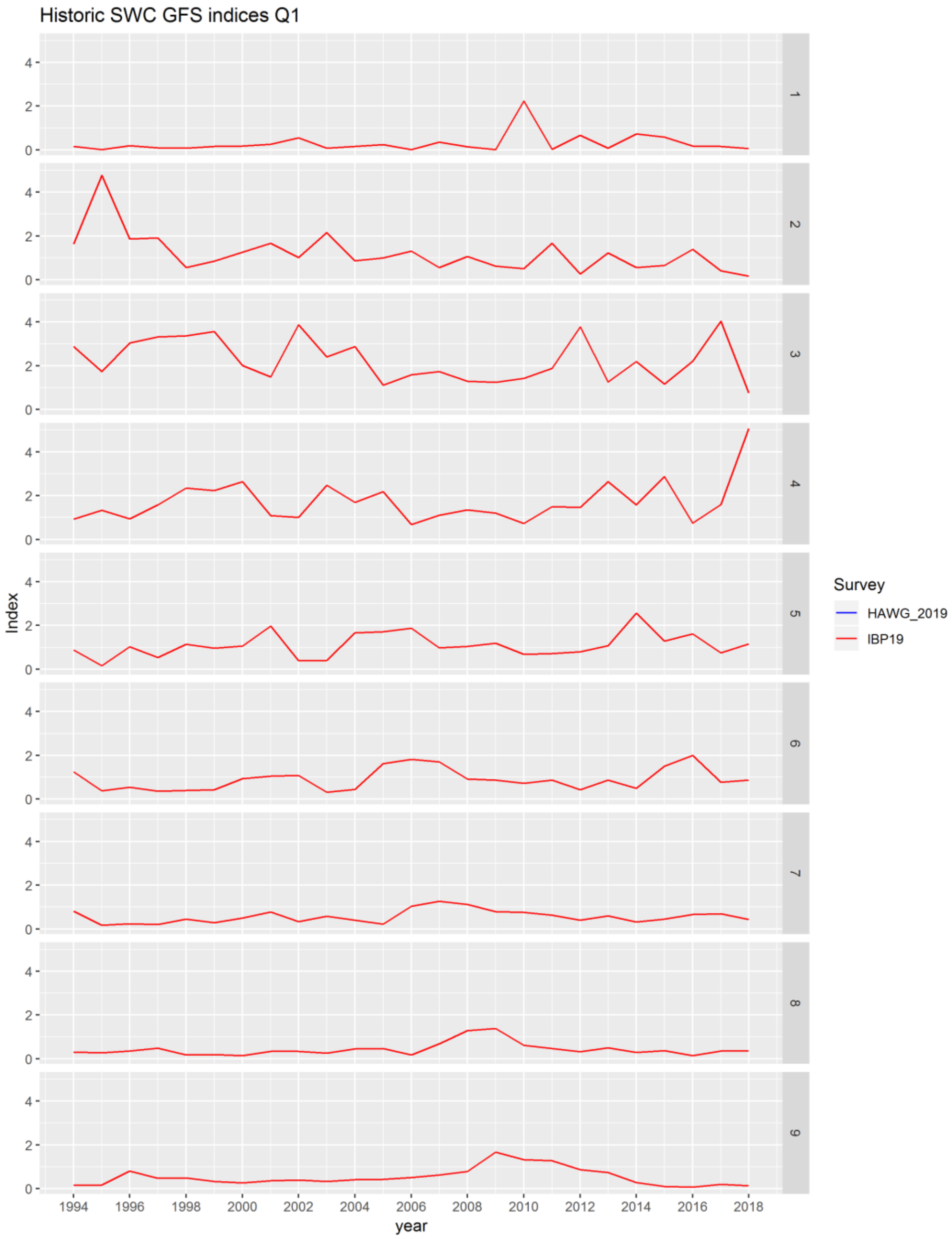


Figure 4.3.2.5 Herring in 6.a (combined) and 7.b–c. Abundance-at-age index from Scottish ground fish survey in Quarter 1 for age from the IBPher6a7bc in 2019 and from HAWG 2019. There were no additional data included between the IBPher6a7bc and HAWG 2019, the line therefor completely overlap. Each index was mean standardized by year.

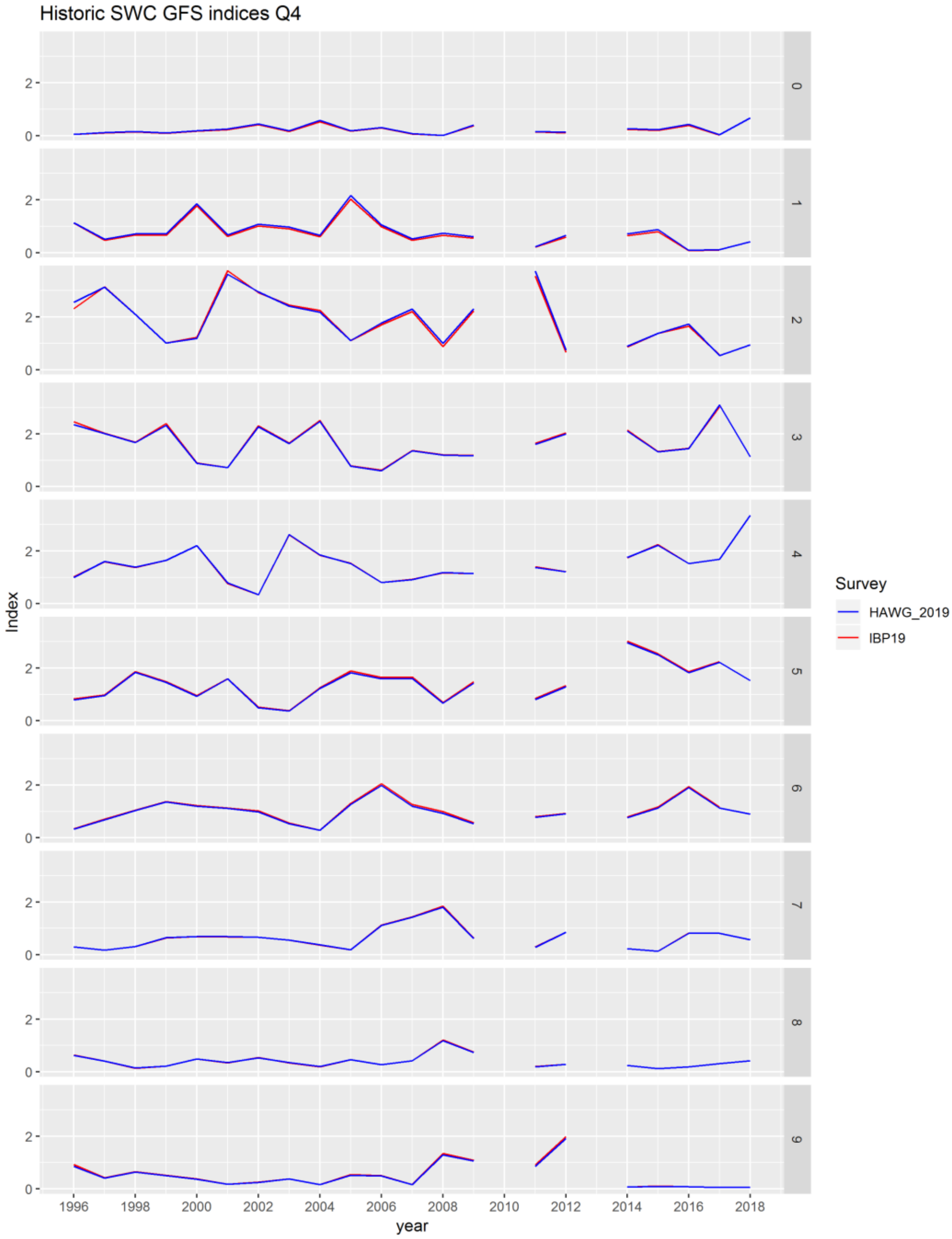


Figure 4.3.2.6 Herring in 6.a (combined) and 7.b–c. Abundance-at-age index from Scottish ground fish survey in Quarter 4 for age from the IBPher6a7bc in 2019 and from HAWG 2019. Each index was mean standardized by years.

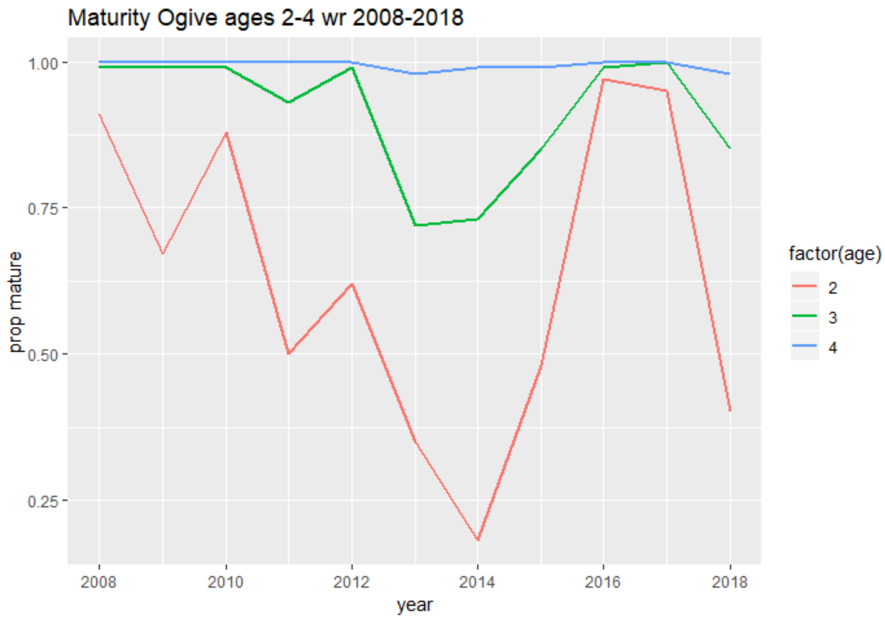


Figure 4.4.2.1. Herring in 6.a (combined) and 7.b–c. Maturity-at-ages 2–4 wr for the years 2008 to 2018.

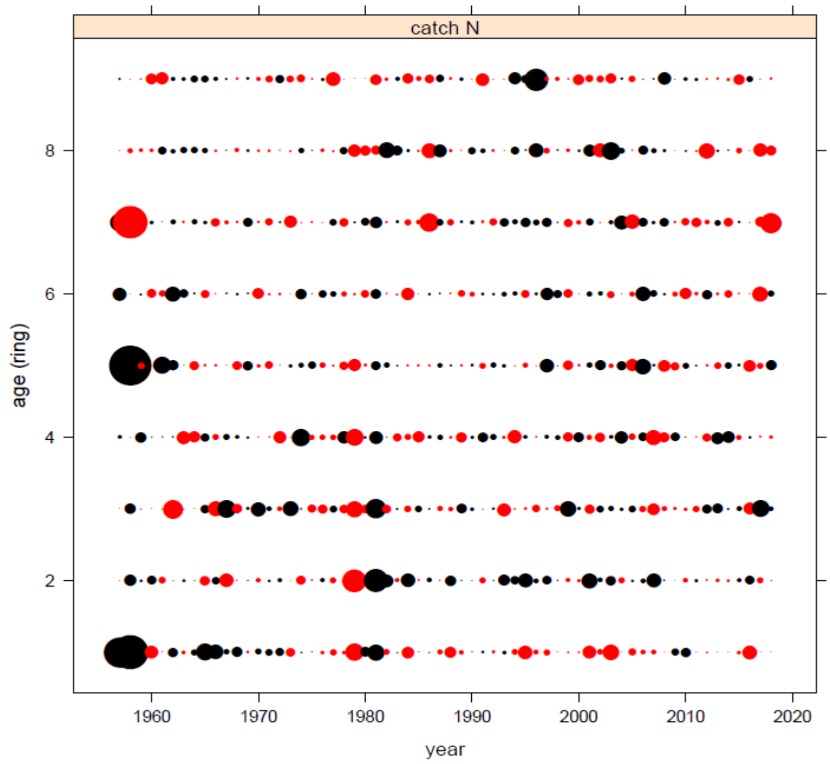


Figure 4.6.1. Herring in 6.a (combined) and 7.b–c. Bubble plot of catch N residuals (1957–2018).

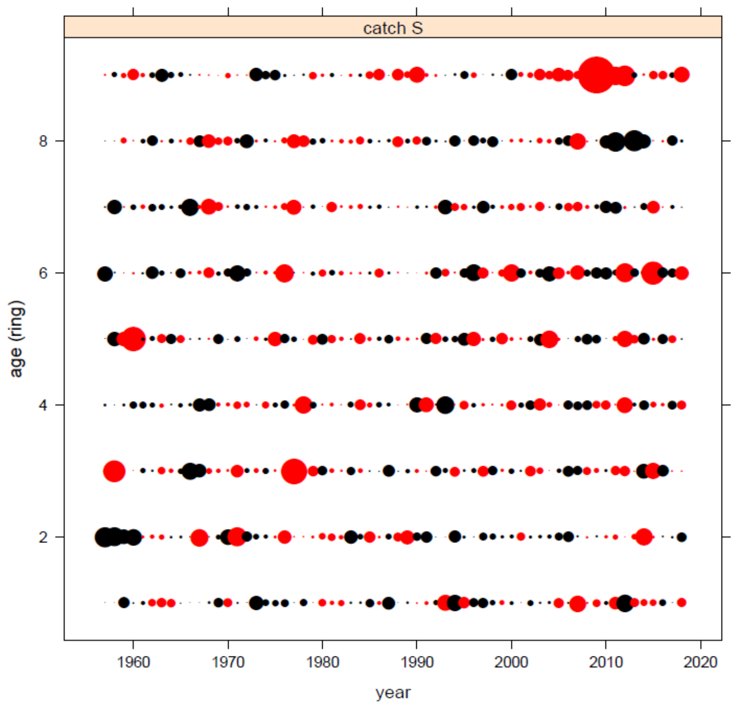


Figure 4.6.2. Herring in 6.a (combined) and 7.b–c. Bubble plot of catch S residuals (1957–2018).

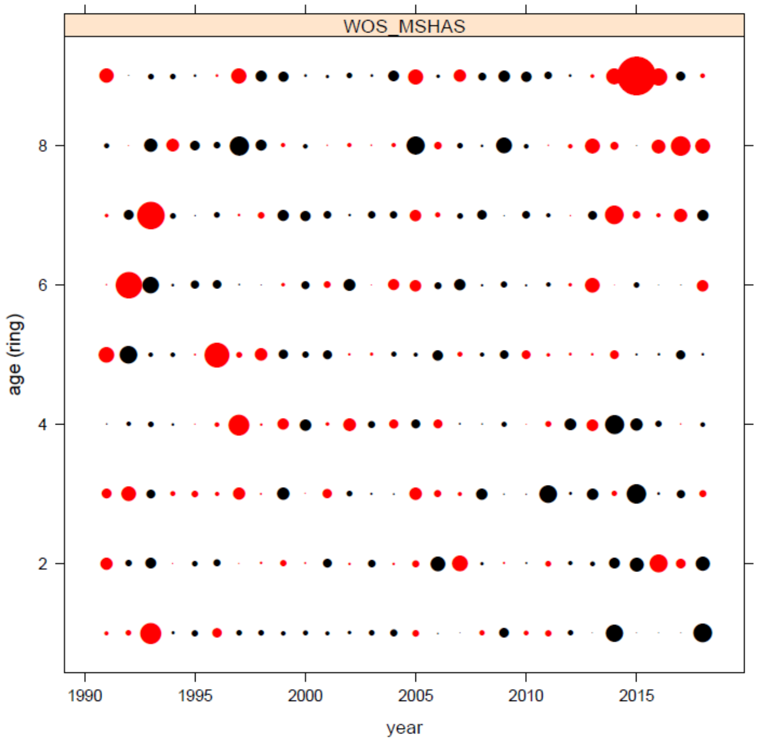


Figure 4.6.3. Herring in 6.a (combined) and 7.b–c. Bubble plot of standardised survey residuals from the WoS_MSHAS acoustic survey (1991–2018).

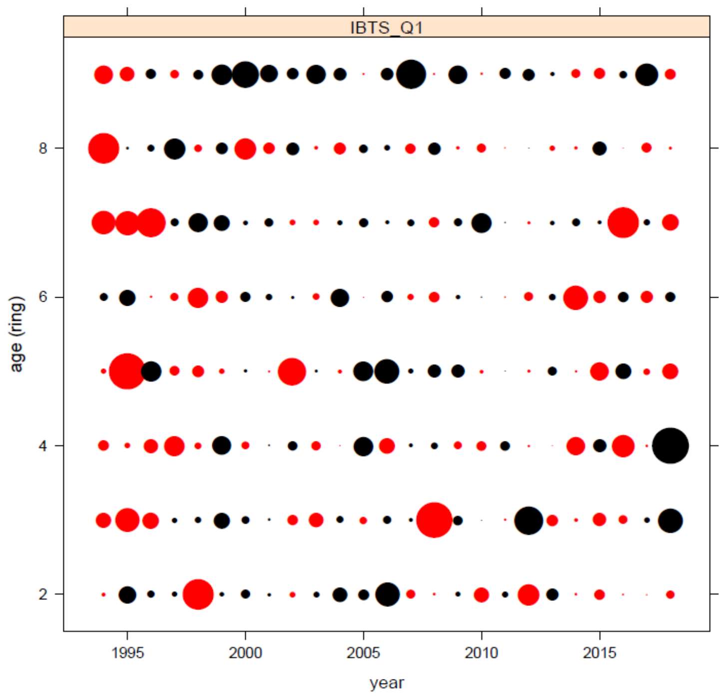


Figure 4.6.4. Herring in 6.a (combined) and 7.b–c. Bubble plot of standardised survey residuals from the Scottish bottom-trawl survey in quarter 1 (1994–2018).

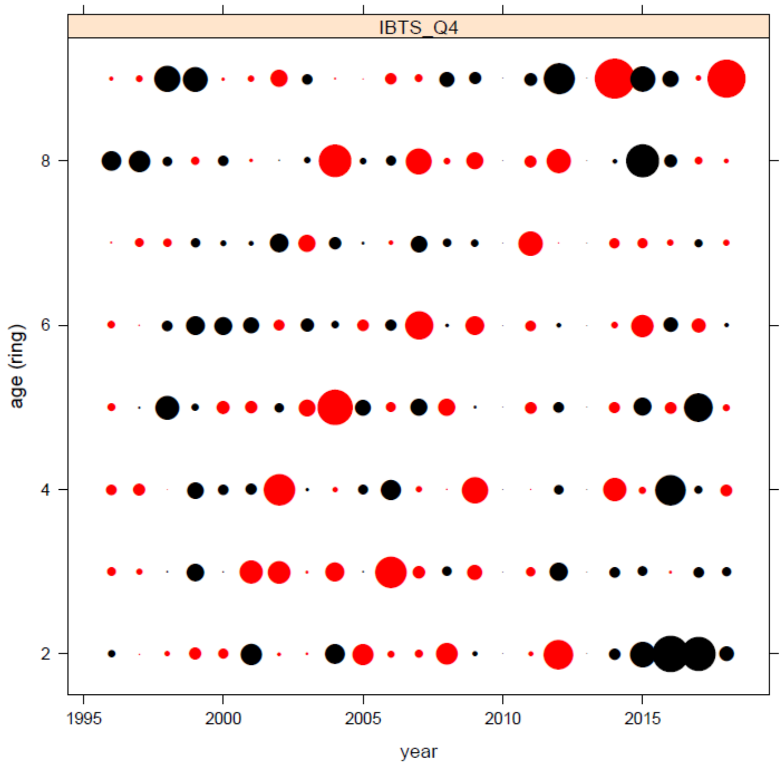


Figure 4.6.5. Herring in 6.a (combined) and 7.b–c. Bubble plot of standardised survey residuals from the Scottish bottom-trawl survey in quarter 4 (1996–2018).

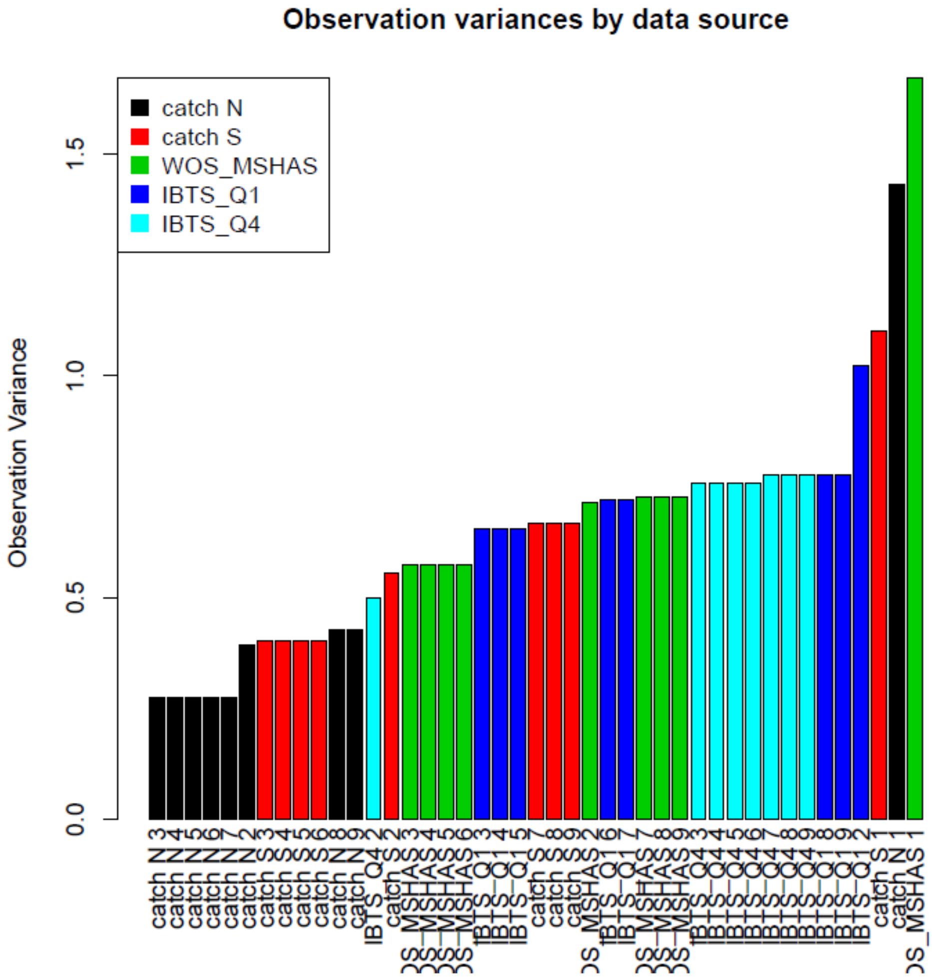


Figure 4.6.6. Herring in 6.a (combined) and 7.b–c. Observation variance by data source, ordered from least (left) to most (right). Colours indicate the different data sources. In cases where parameters are bound, observation variances have equal values.

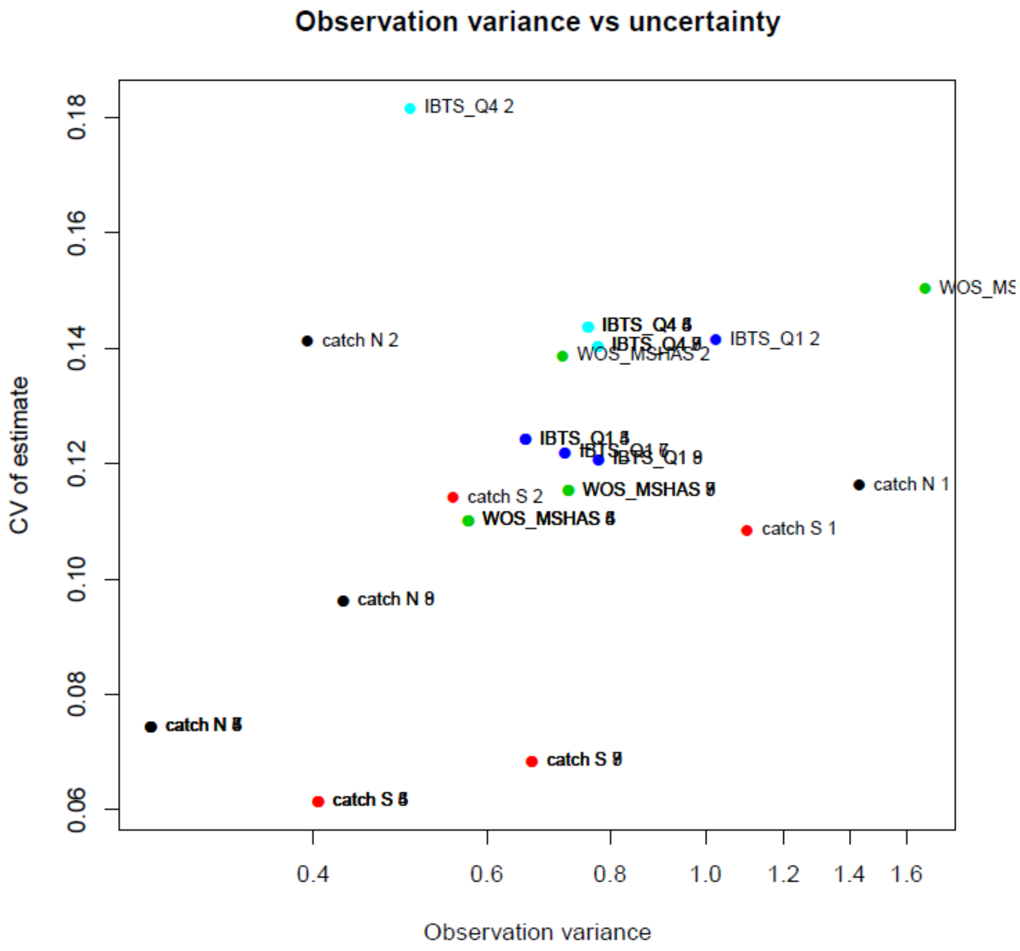


Figure 4.6.7. Herring in 6.a (combined) and 7.b–c. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

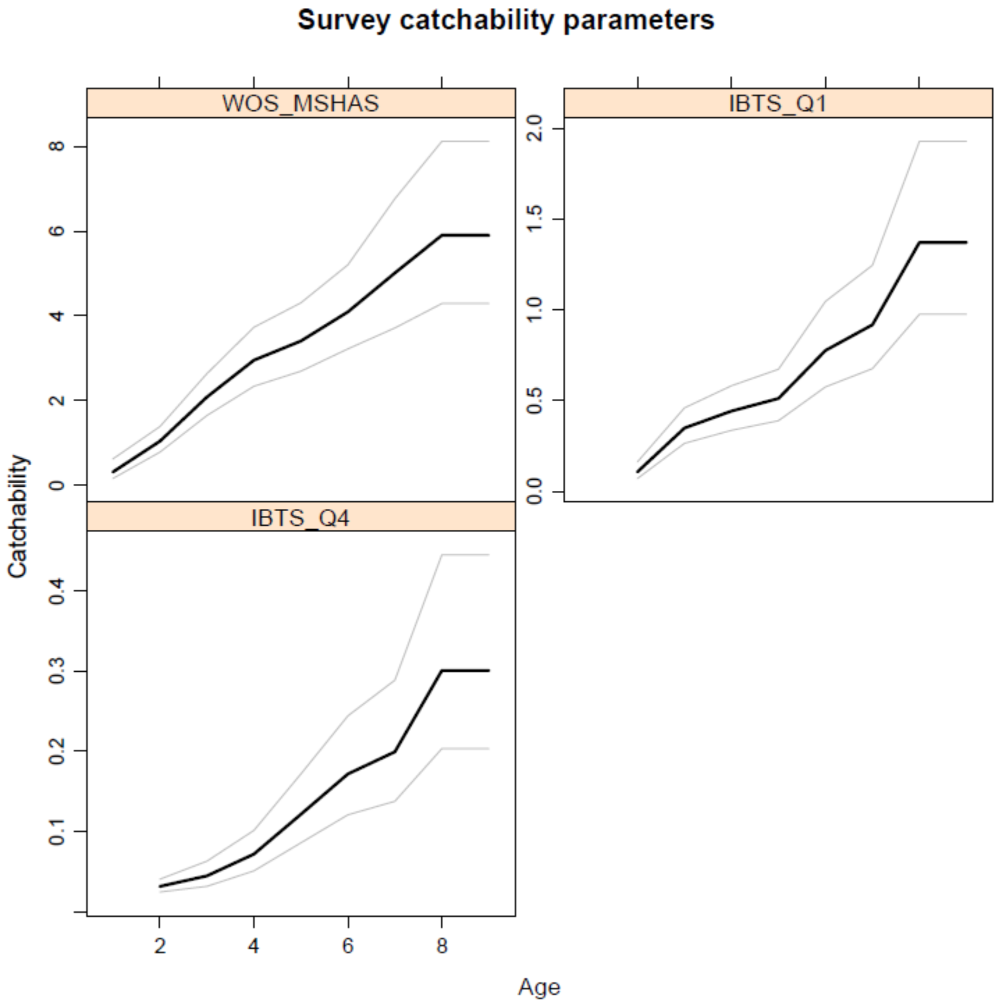


Figure 4.6.8. Herring in 6.a (combined) and 7.b–c. Survey catchability parameters from the WOS_MSHAS acoustic survey (topleft), Scottish groundfish survey index quarter 1 (IBTS_Q1, topright) and Scottish groundfish survey index quarter 4 (IBTS_Q4, bottomleft).

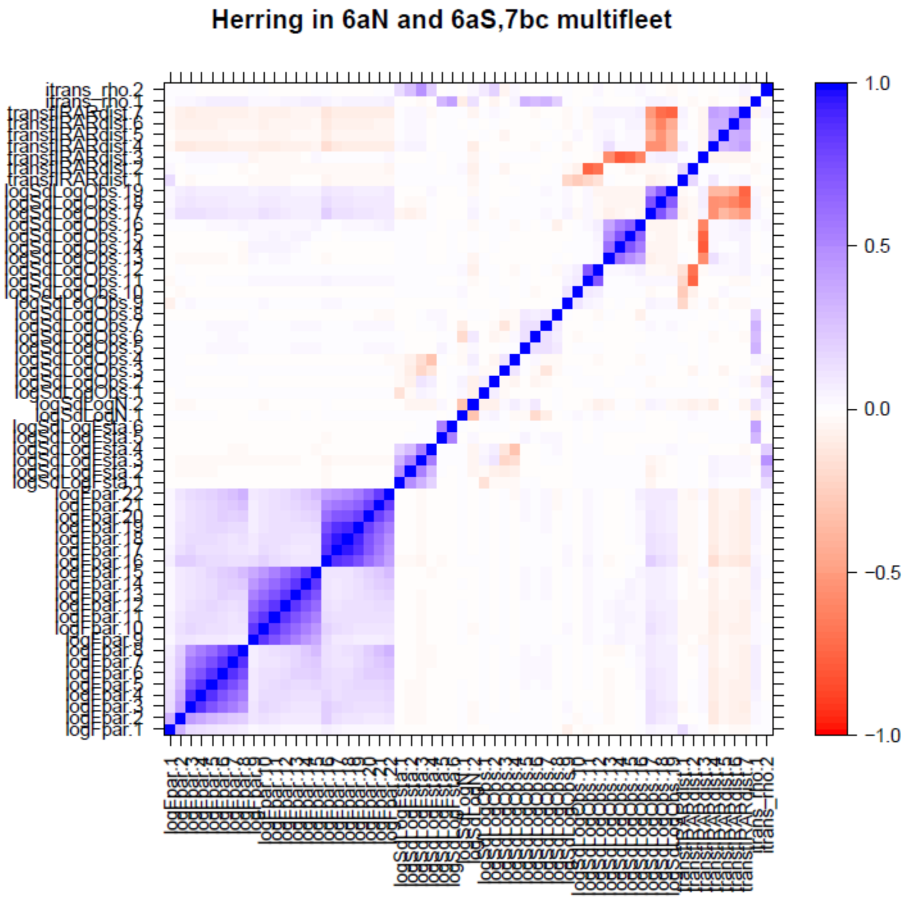


Figure 4.6.9. Herring in 6.a (combined) and 7.b–c. Correlation plot of the parameters estimated in the model. The horizontal and vertical axes show the parameters fitted by the model (labelled with names stored and fitted by FLSAM). The colouring of each pixel indicates the Pearson correlation between the two parameters. The diagonal represents the correlation with the data source itself.

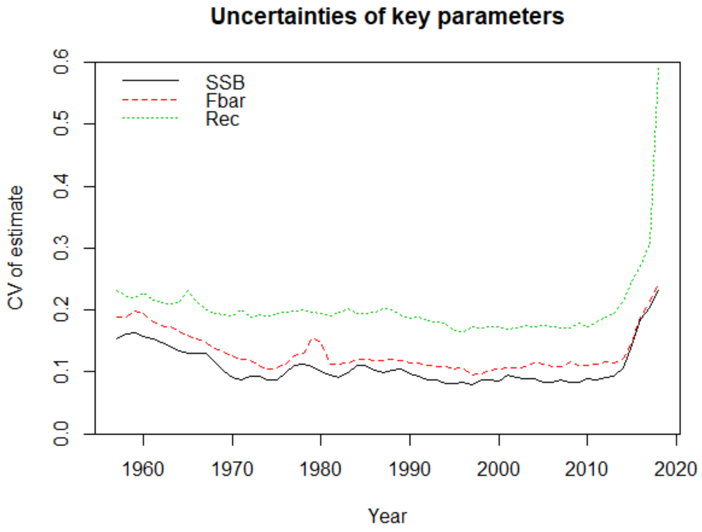


Figure 4.6.10. Herring in 6.a (combined) and 7.b–c. Uncertainty estimates in SSB, F_{bar} and recruitment parameters (1957–2018).

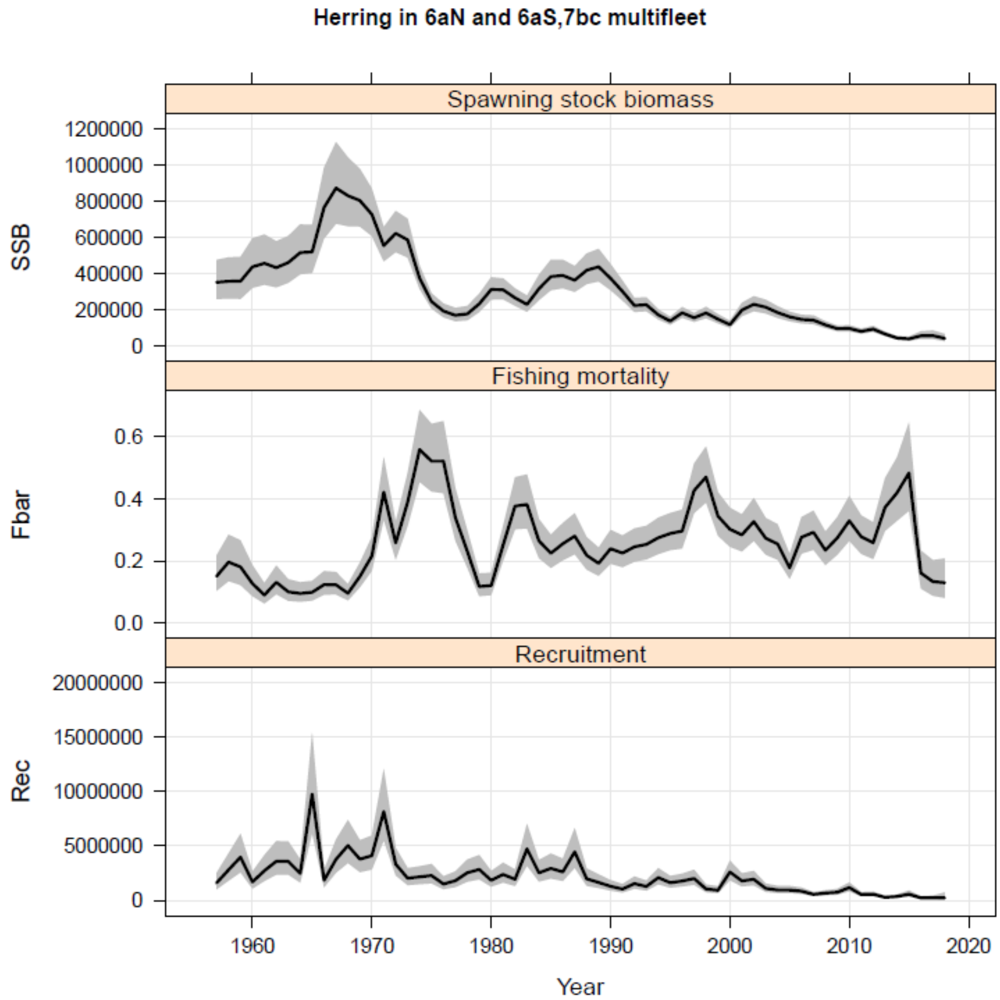


Figure 4.6.11. Herring in 6.a (combined) and 7.b–c. Stock summary plot with associated uncertainty for SSB (top panel), F ages 3–6 (middle panel) and recruitment (bottom panel).

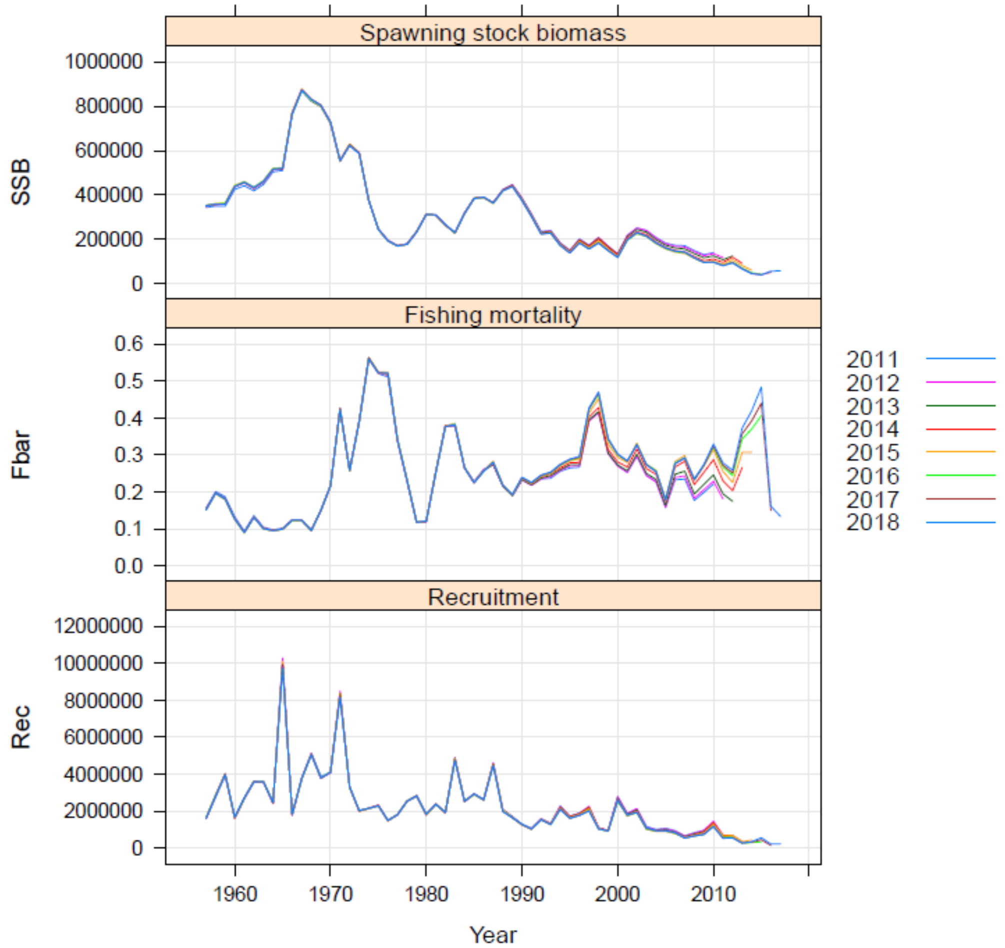


Figure 4.6.12. Herring in 6.a (combined) and 7.b–c. Analytical retrospective of the estimated spawning–stock biomass (top panel), fishing mortality (middle panel) and recruitment (bottom panel) as estimated over the years 2011–2018.

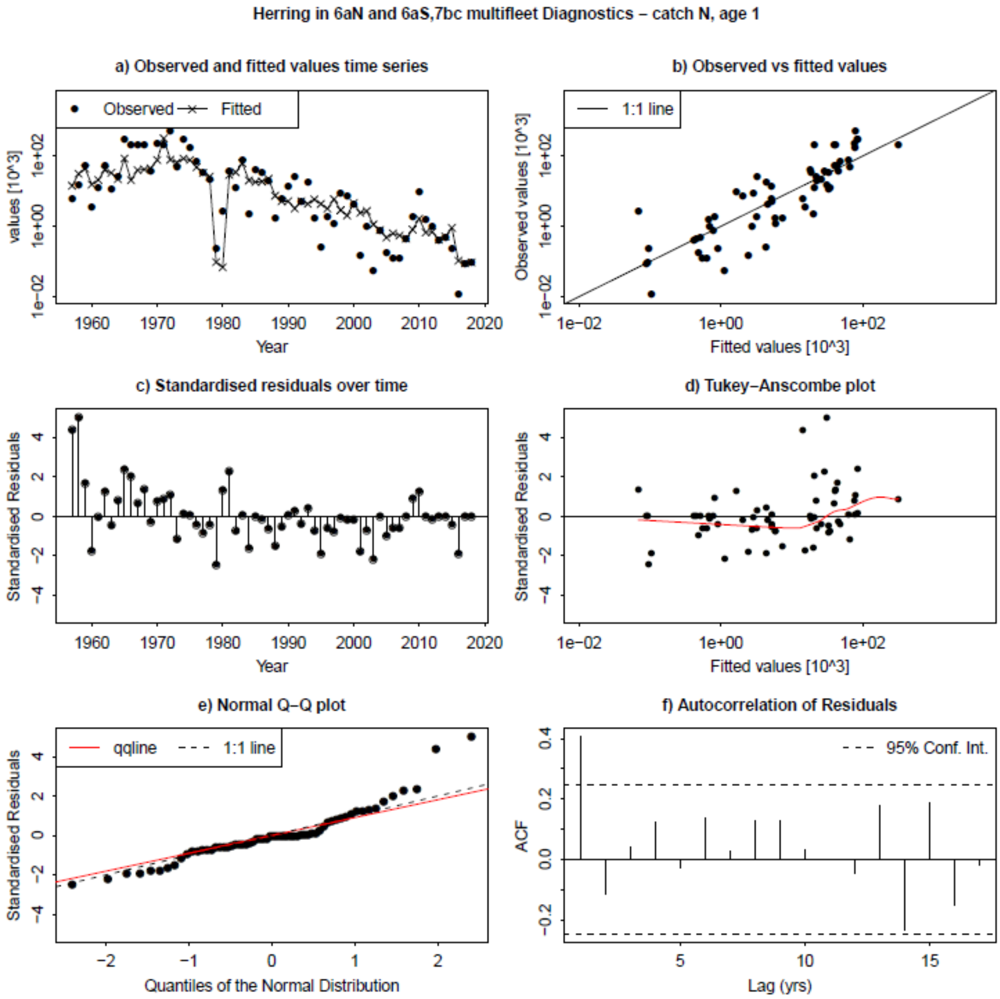


Figure 4.6.13. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 1-winter ring time-series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from catch abundance at 1-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

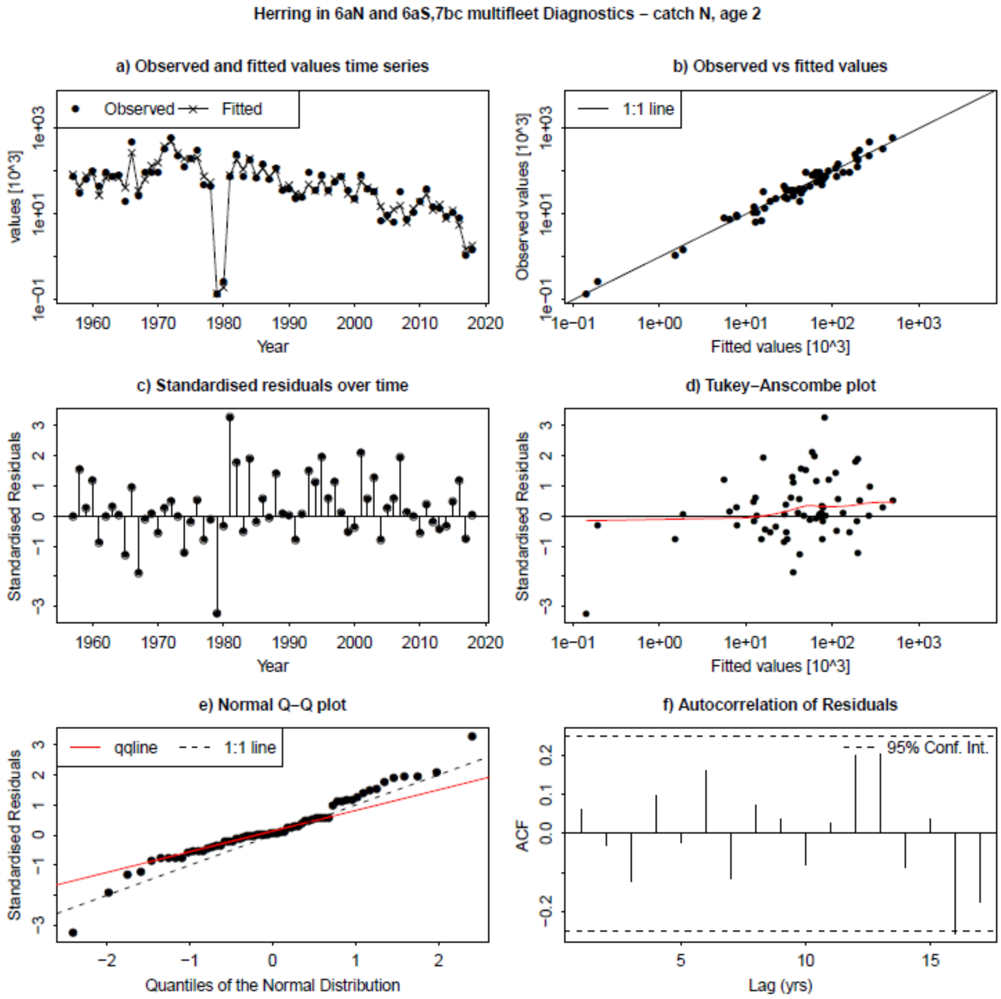


Figure 4.6.16. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from catch abundance at 2-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

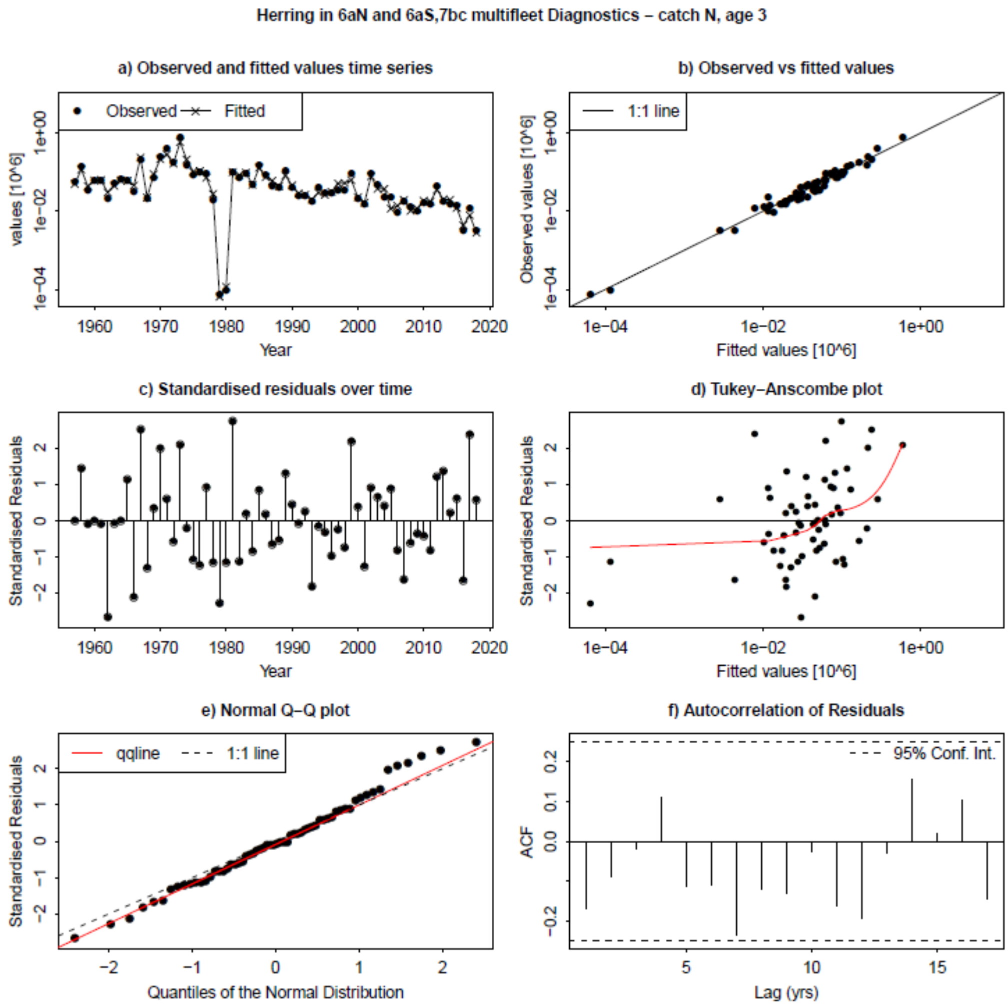


Figure 4.6.17. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from catch abundance at 3-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

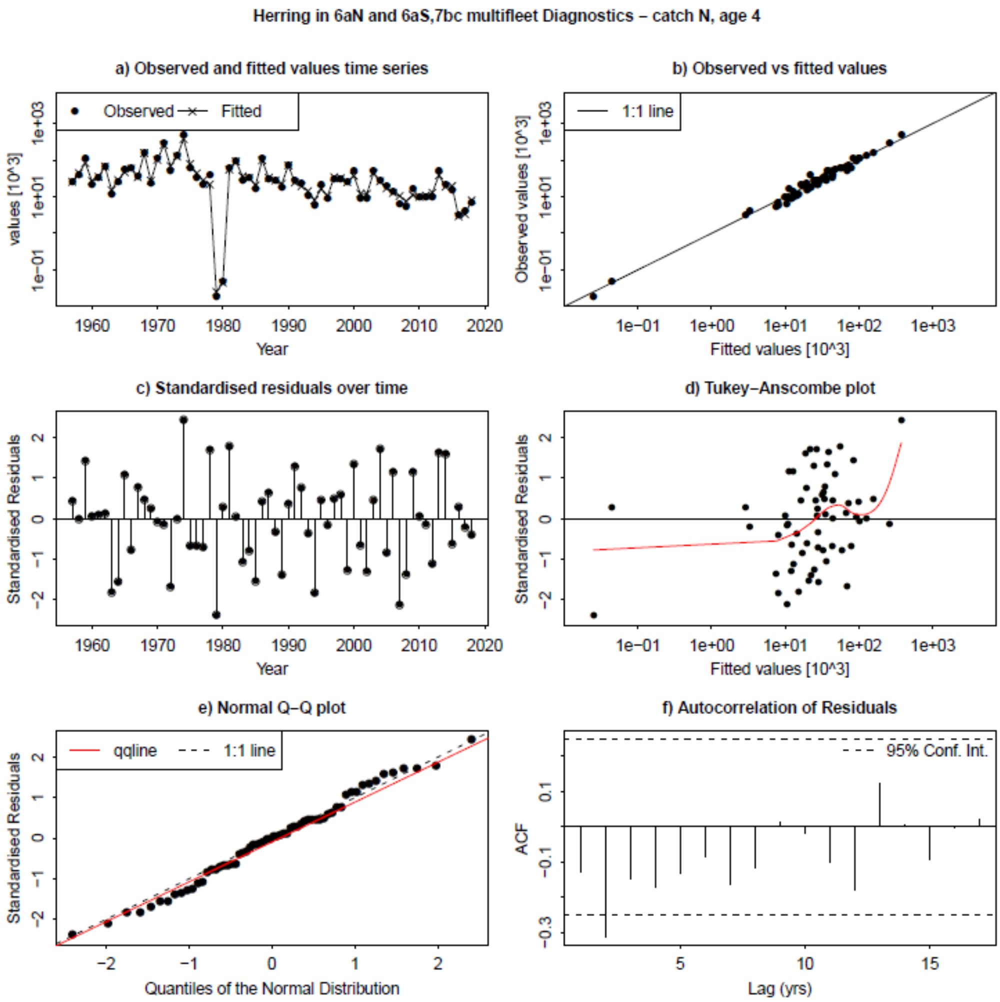


Figure 4.6.18. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from catch abundance at 4-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

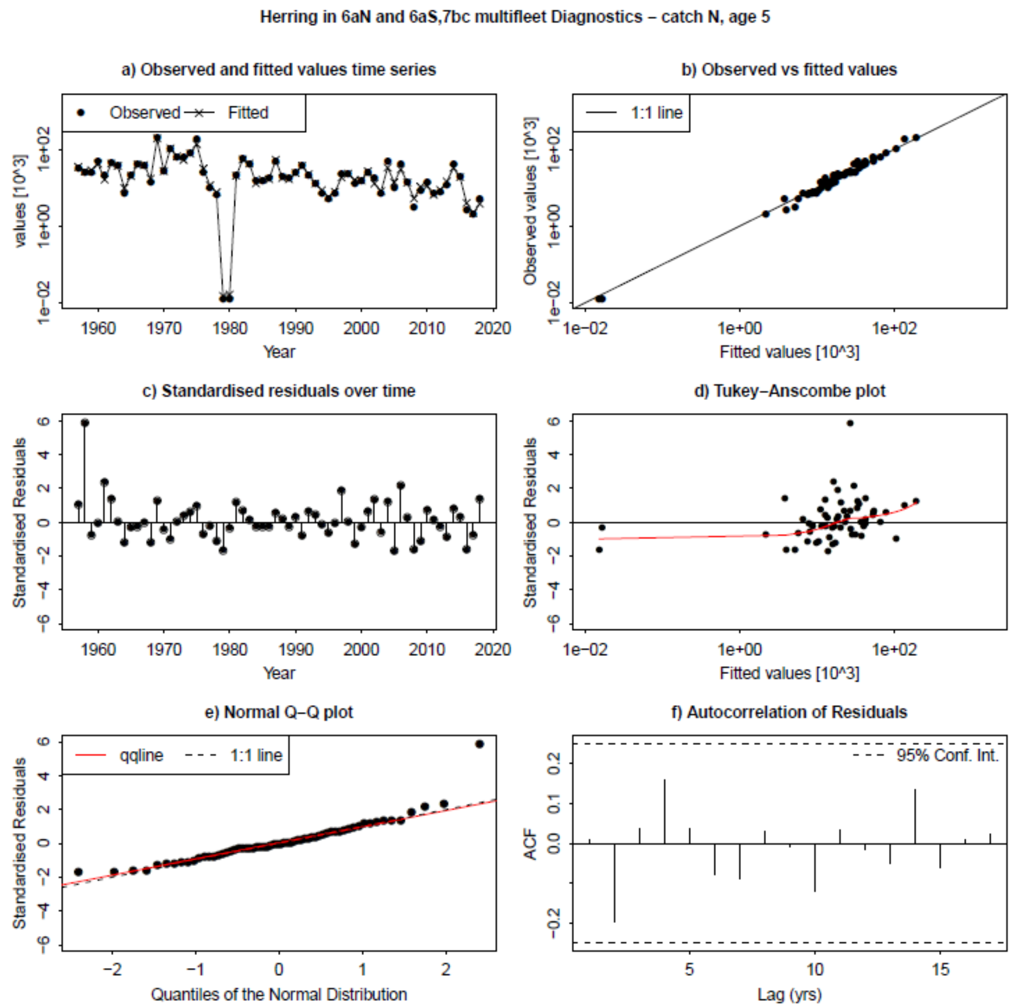


Figure 4.6.19. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from catch abundance at 5-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

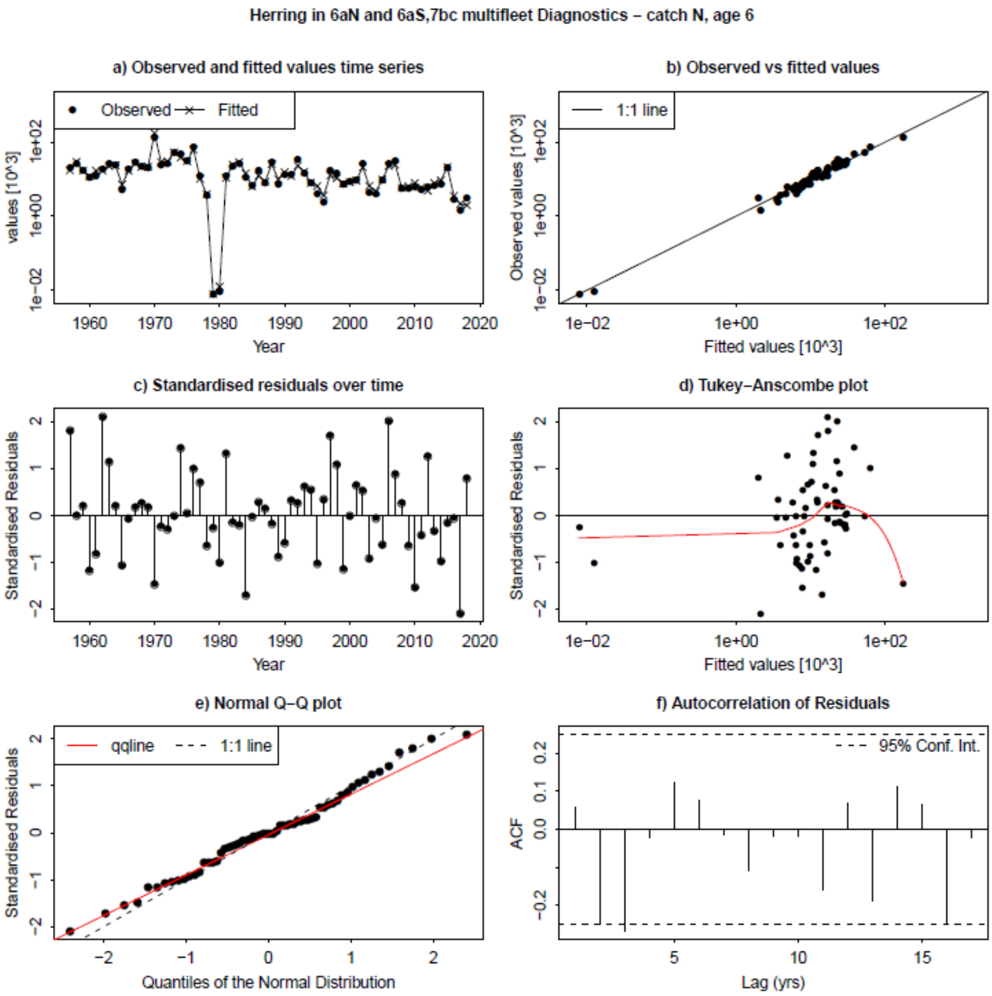


Figure 4.6.20. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from catch abundance at 6-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

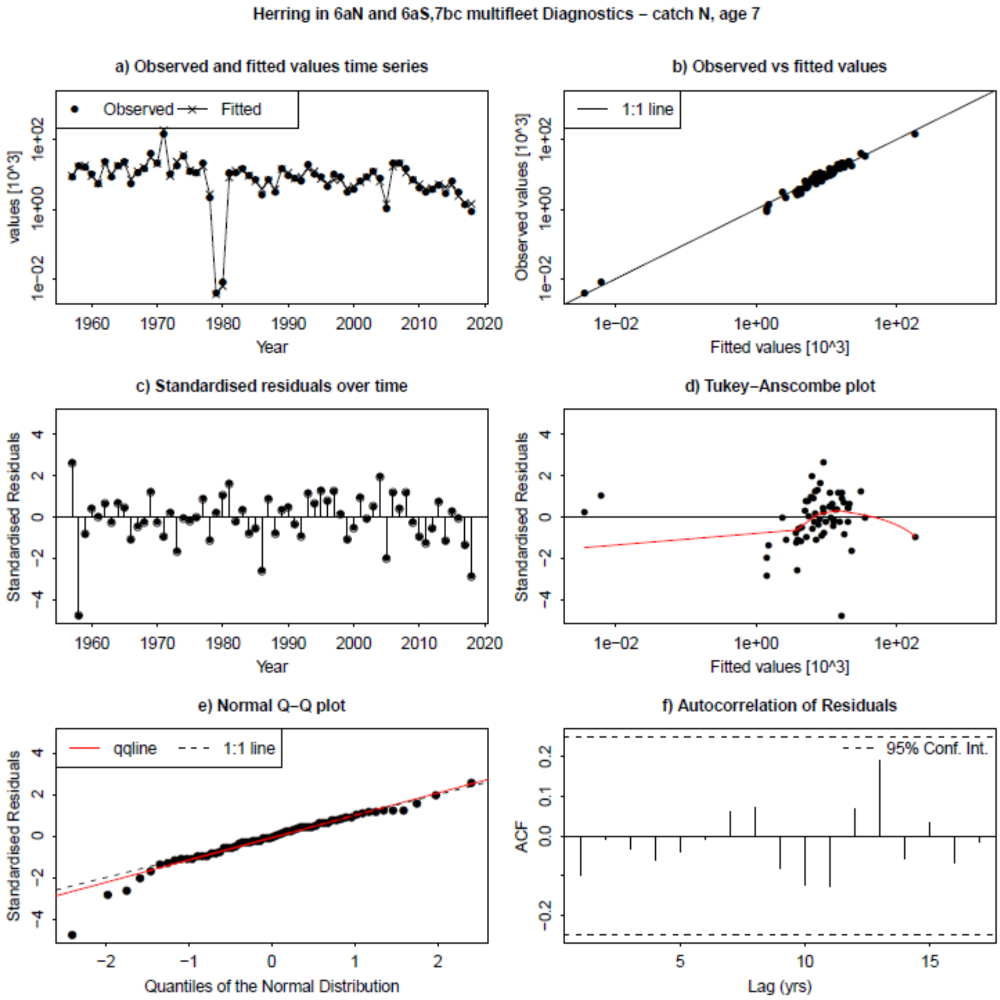


Figure 4.6.21. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from catch abundance at 7-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

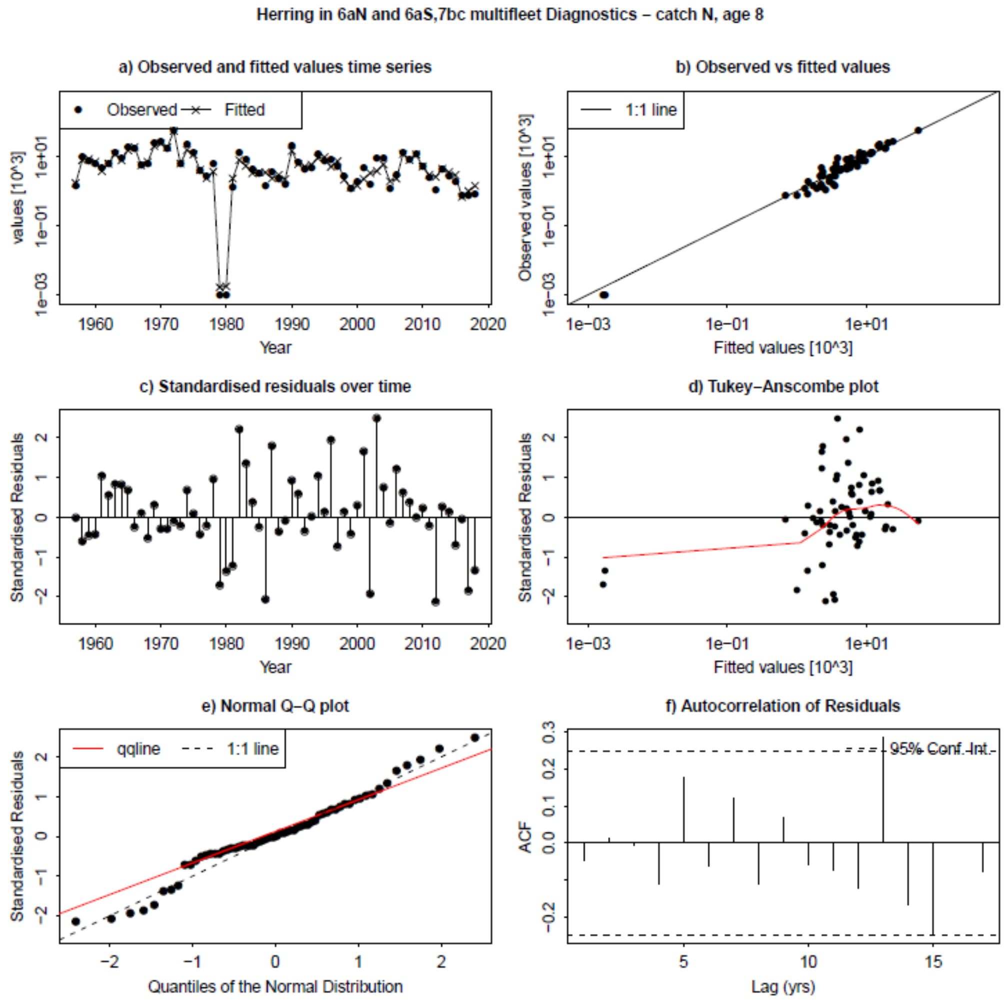


Figure 4.6.22. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from catch abundance at 8-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

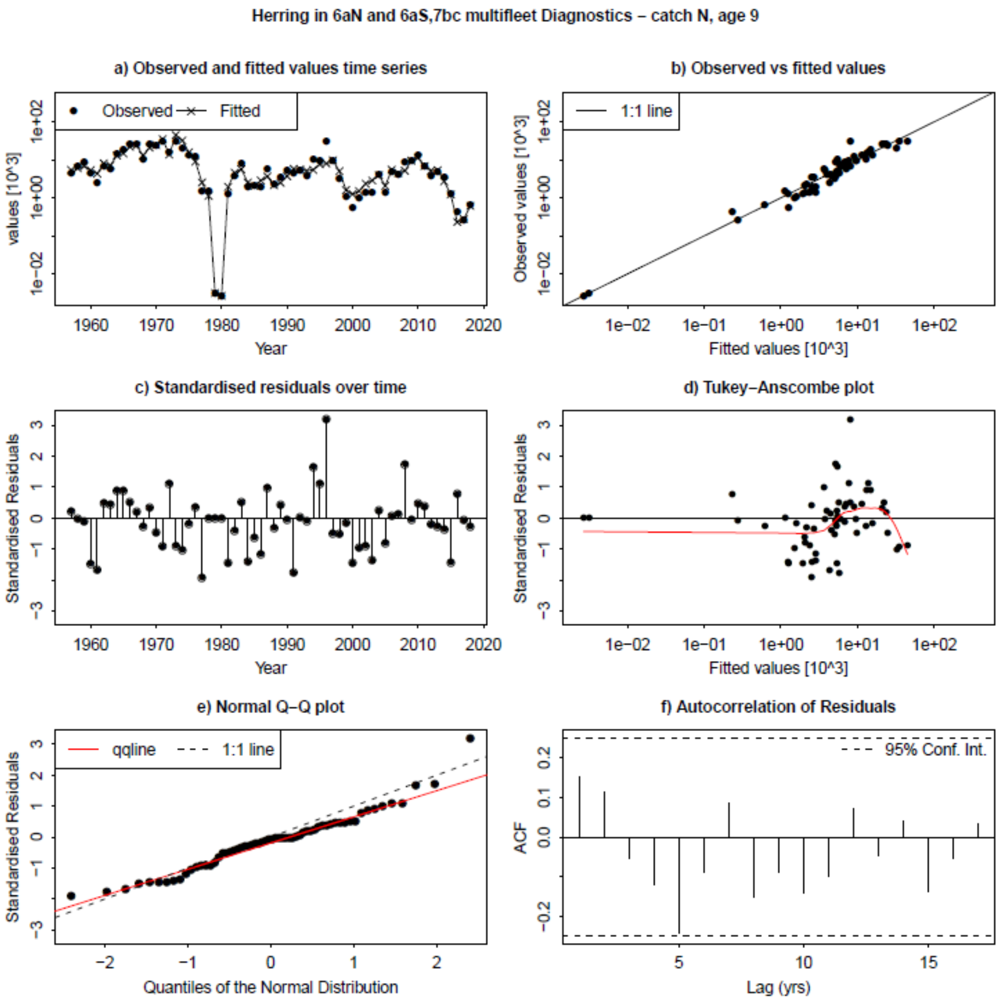


Figure 4.6.23. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from catch abundance at 9-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

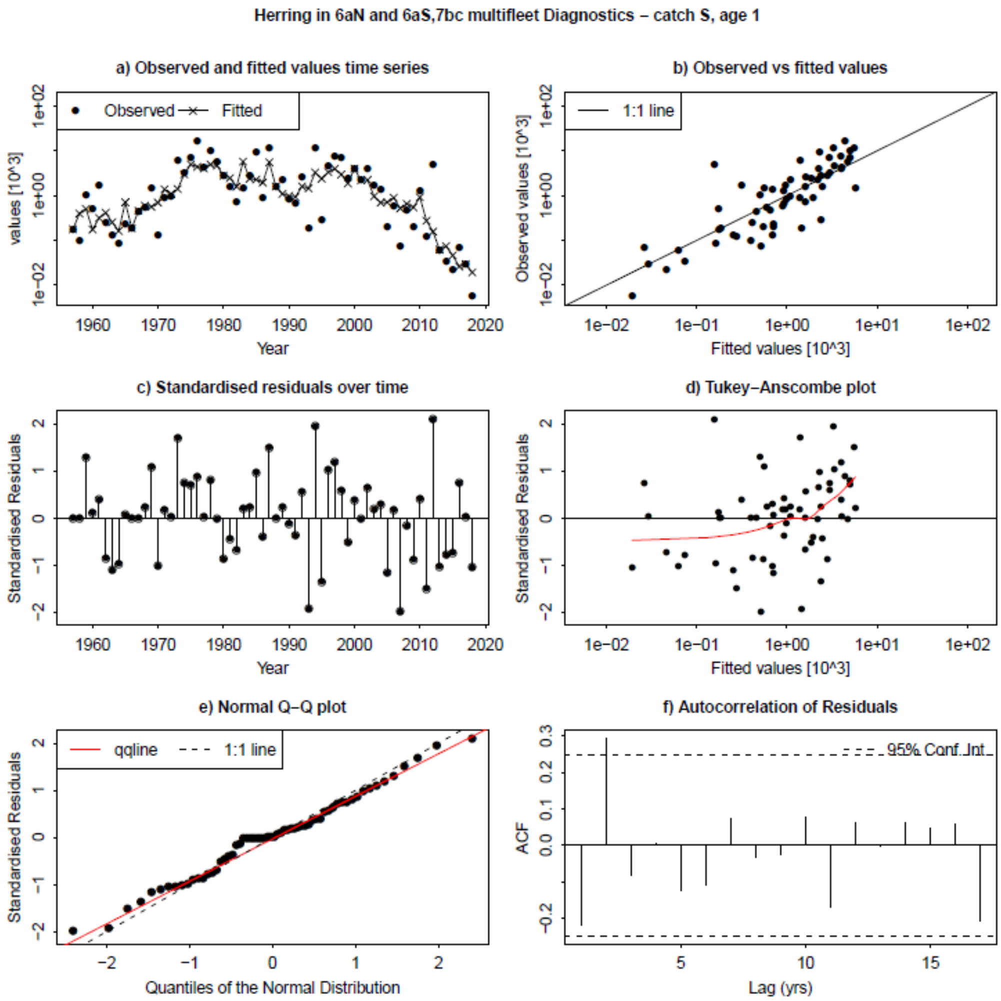


Figure 4.6.24. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 1-winter ring time-series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from catch abundance at 1-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

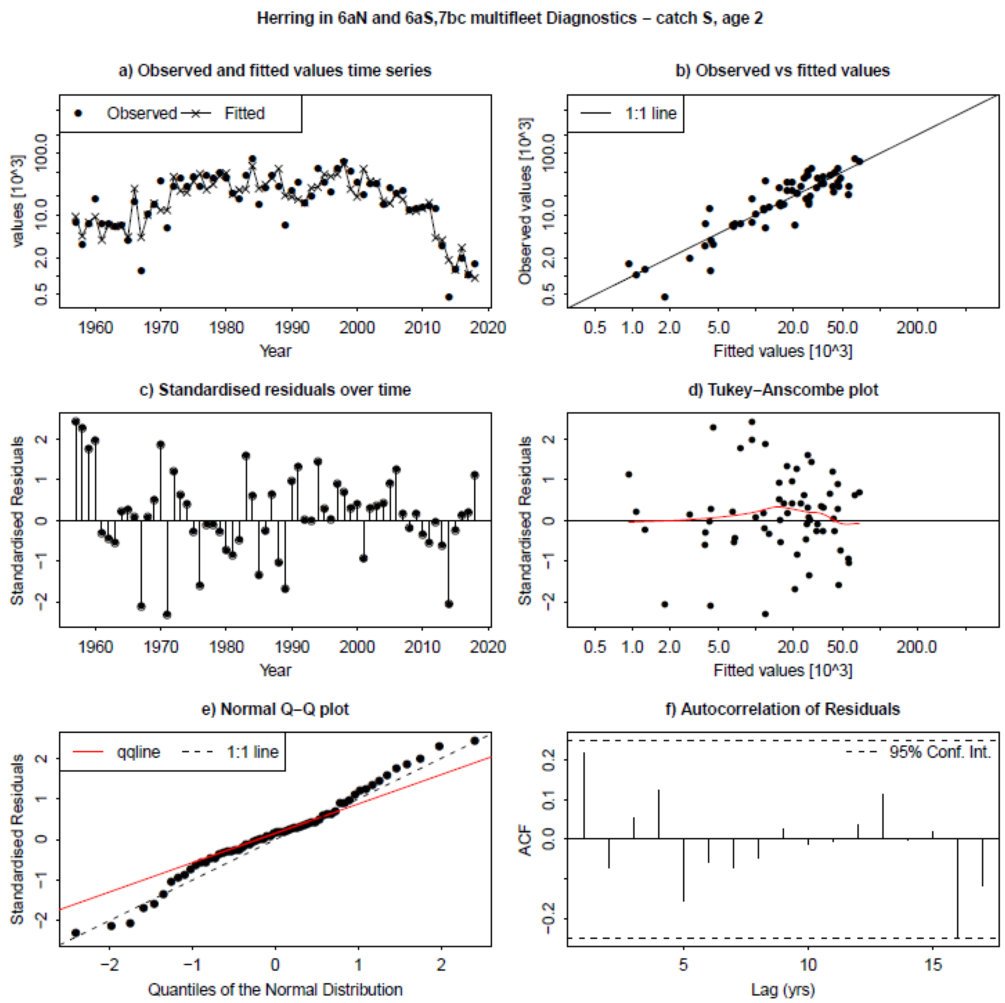


Figure 4.6.25. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from catch abundance at 2-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

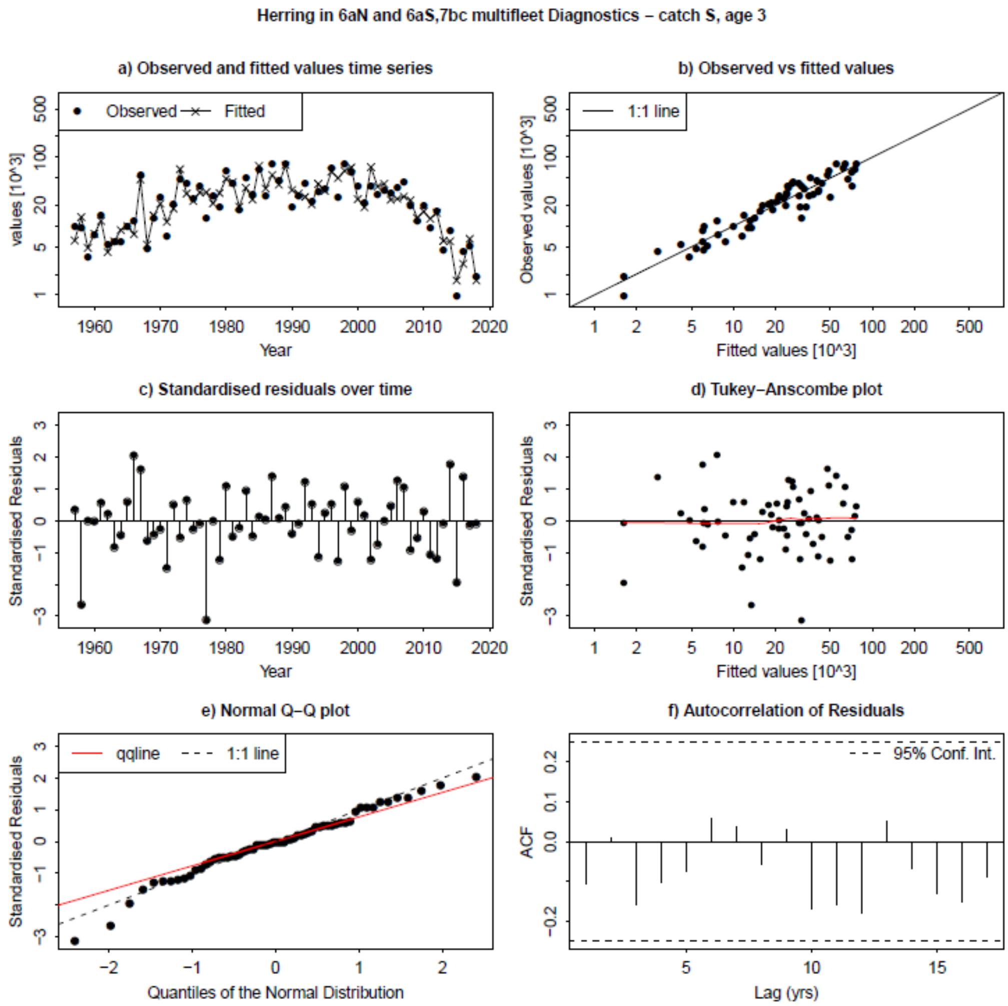


Figure 4.6.26. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from catch abundance at 3-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

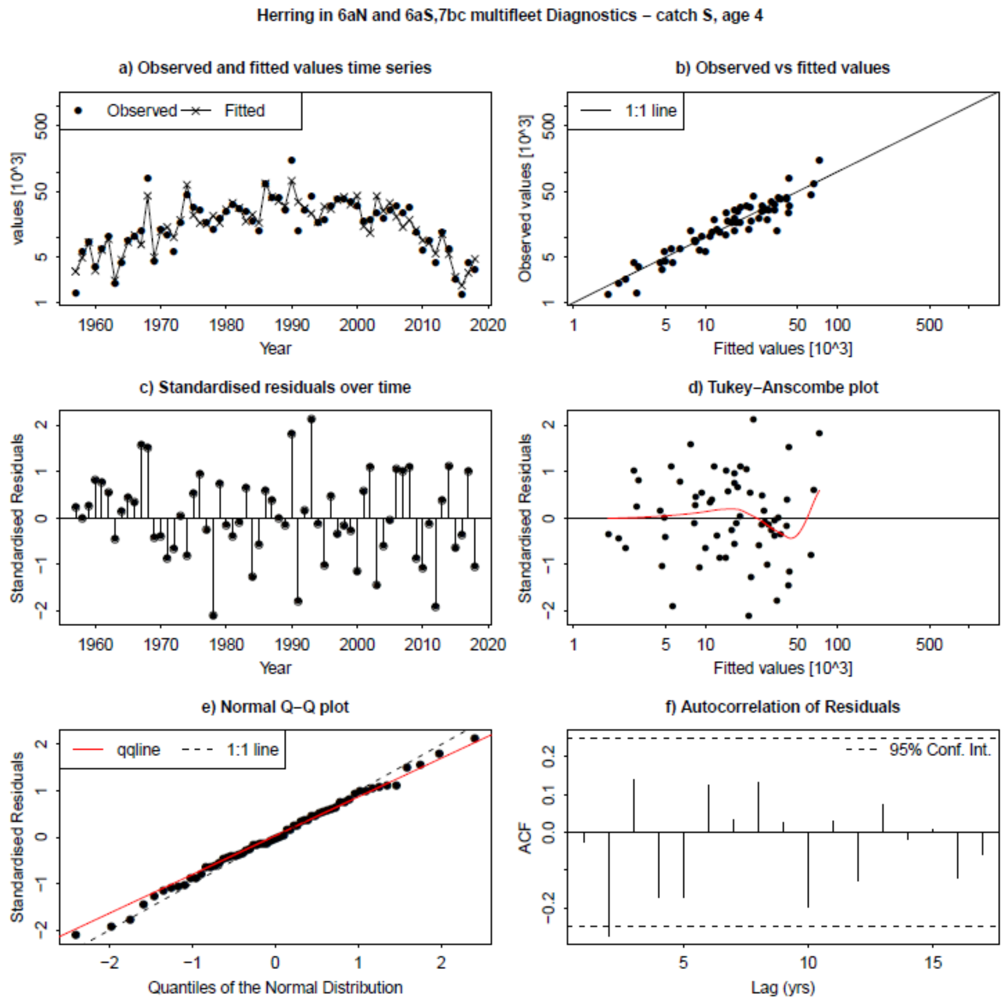


Figure 4.6.27. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from catch abundance at 4-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

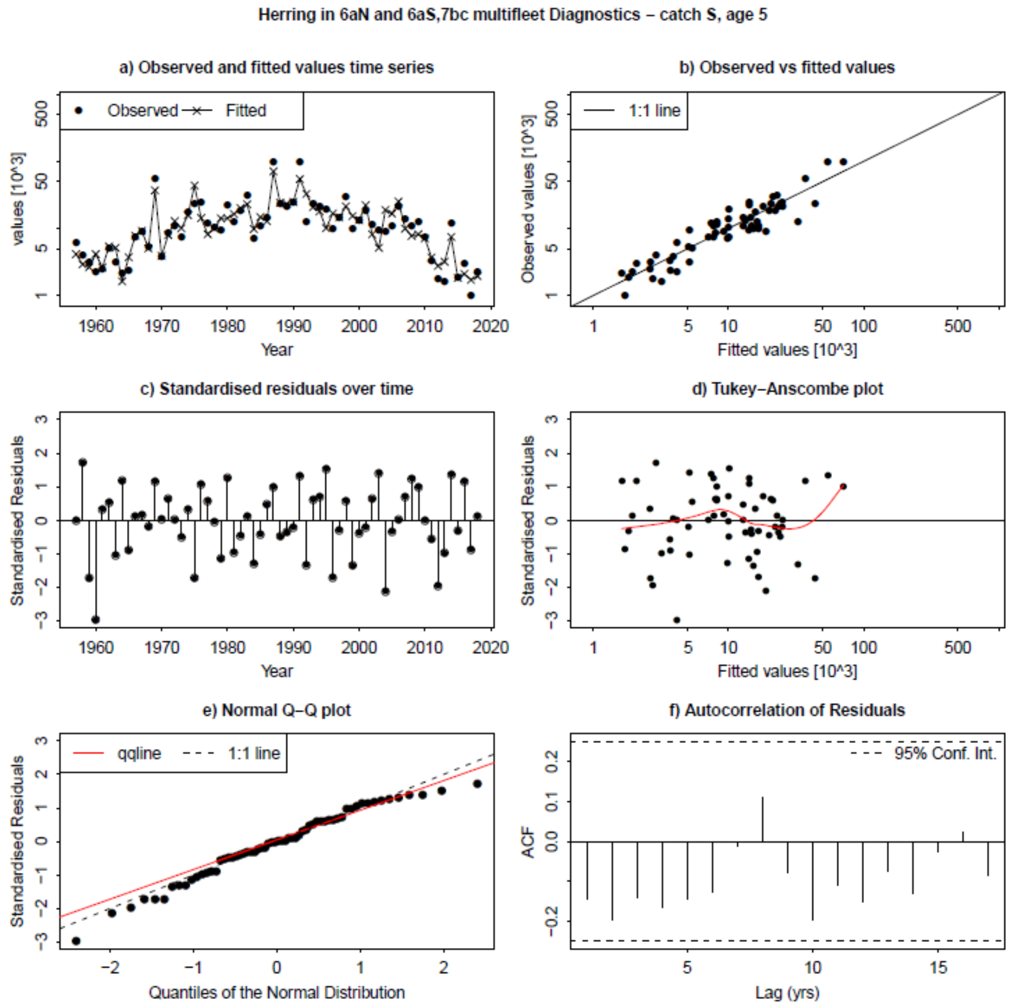


Figure 4.6.28. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from catch abundance at 5-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

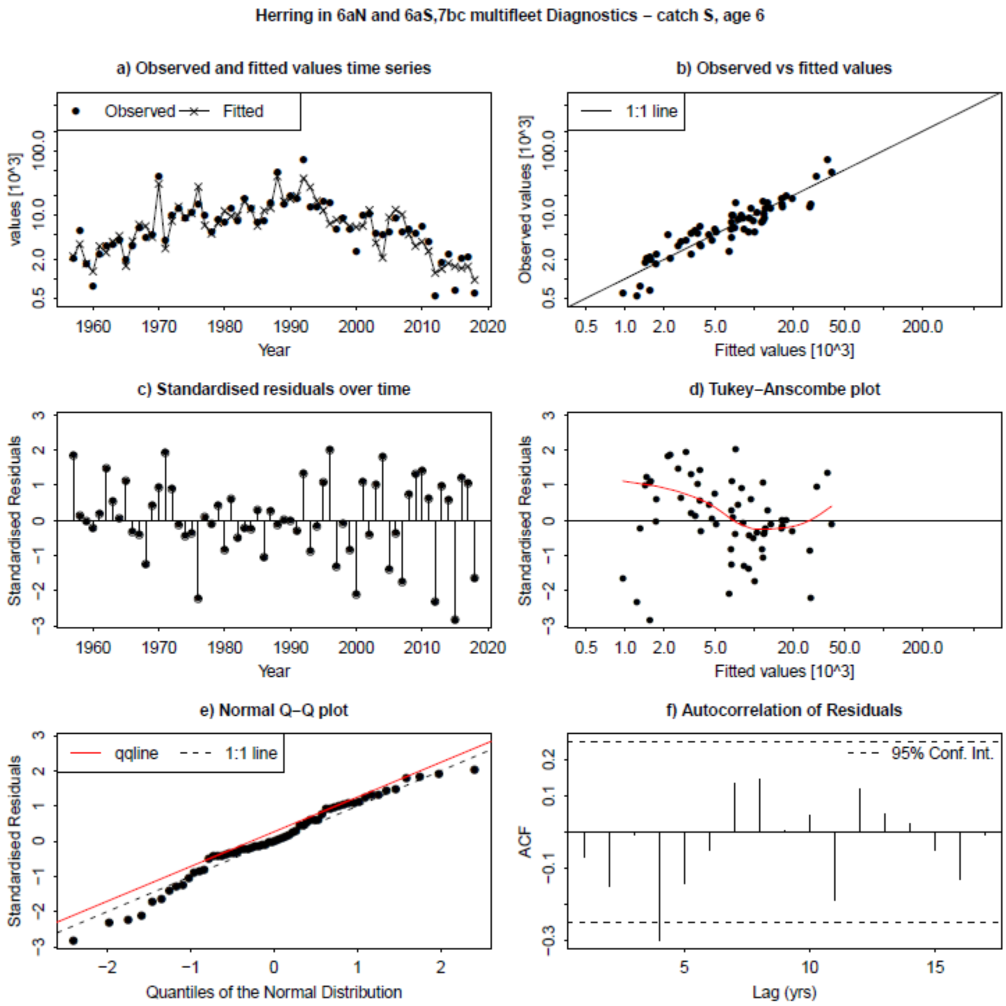


Figure 4.6.29. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from catch abundance at 6-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

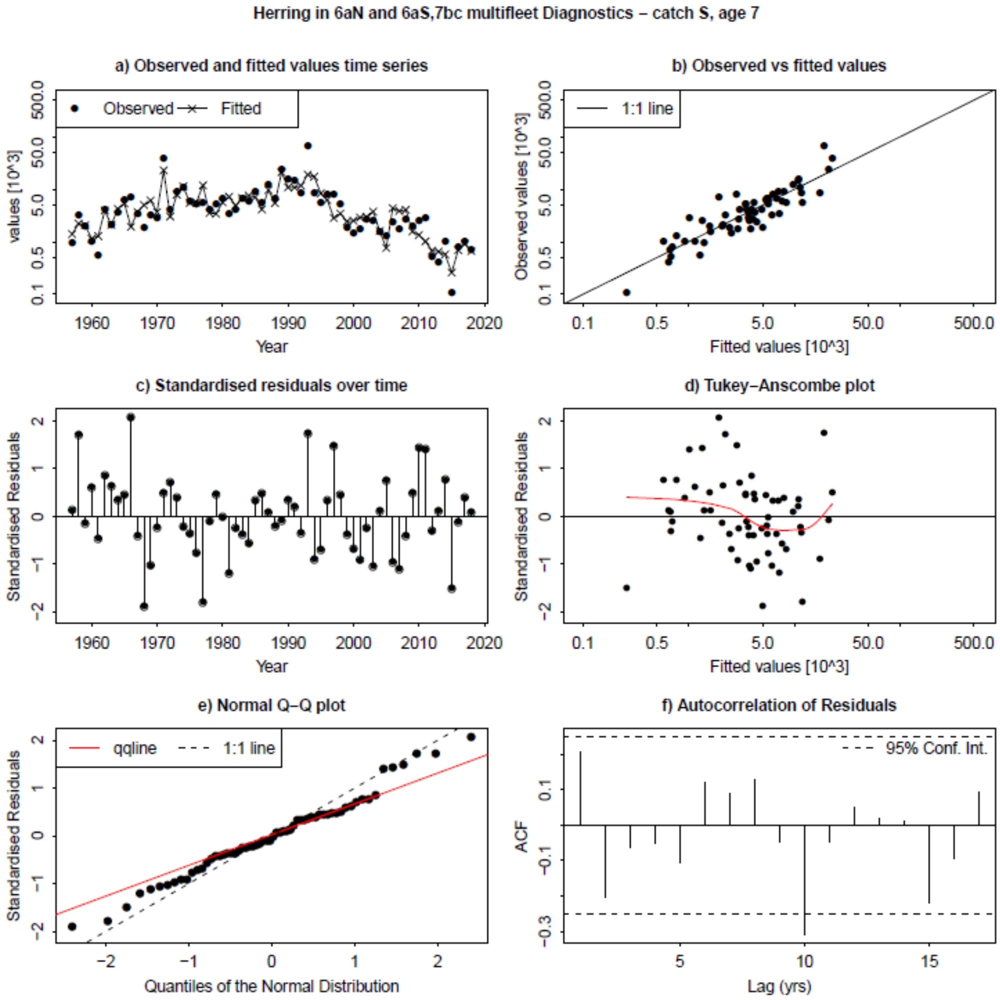


Figure 4.6.30. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from catch abundance at 7-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

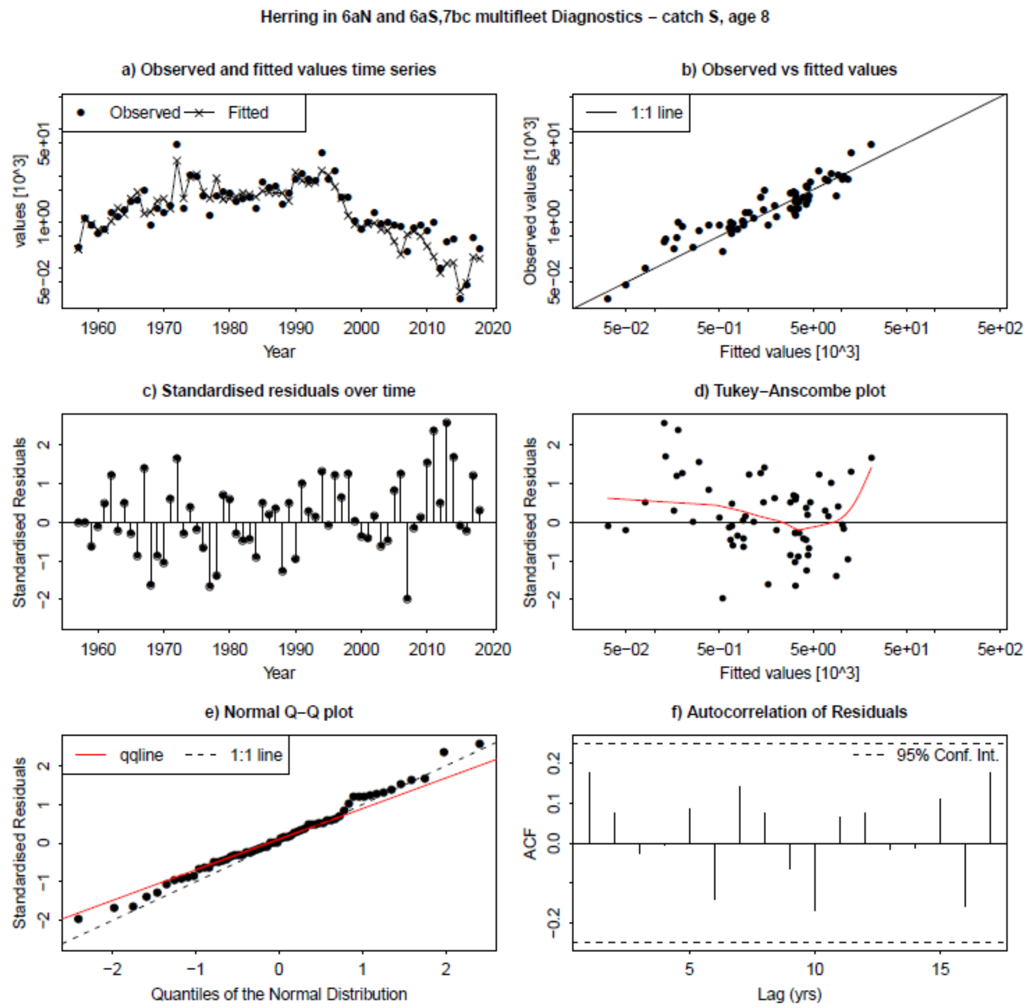


Figure 4.6.31. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from catch abundance at 8-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

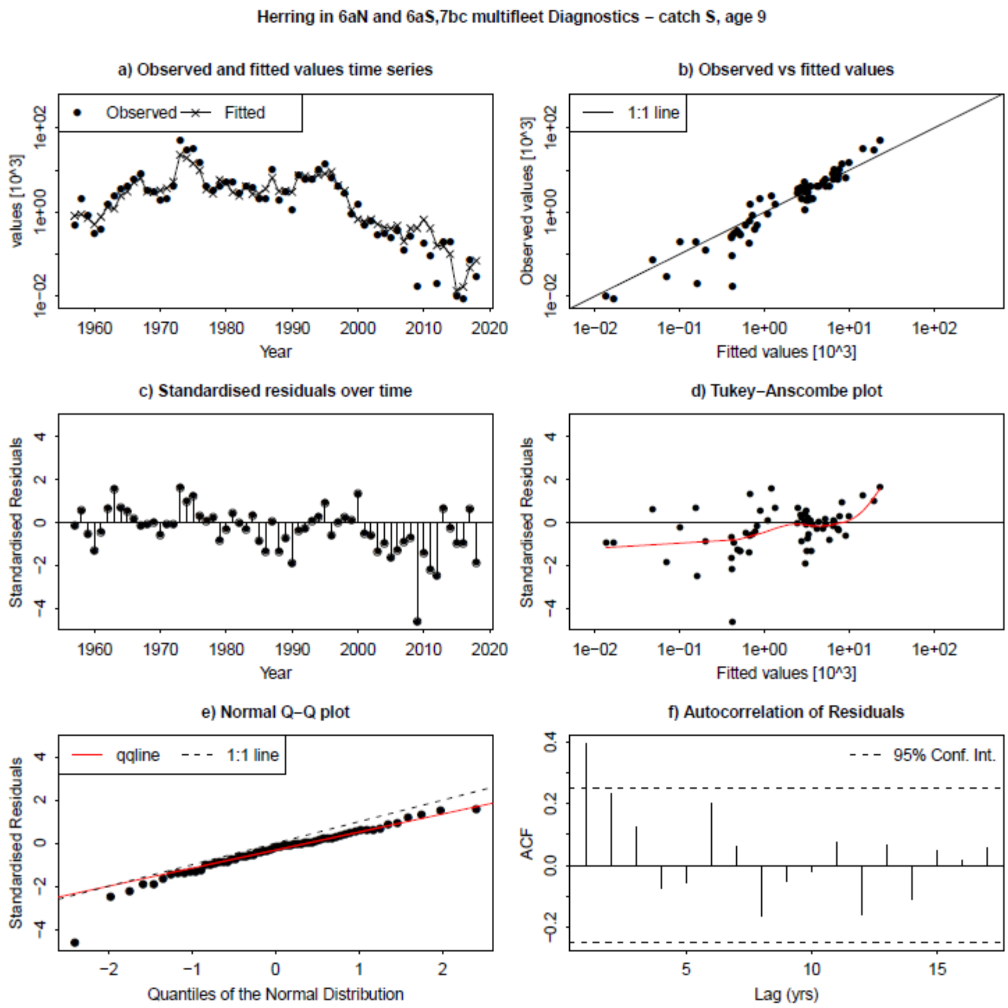


Figure 4.6.32. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from catch abundance at 9-winter ring. Top right: scatterplot of catch observations versus 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 versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

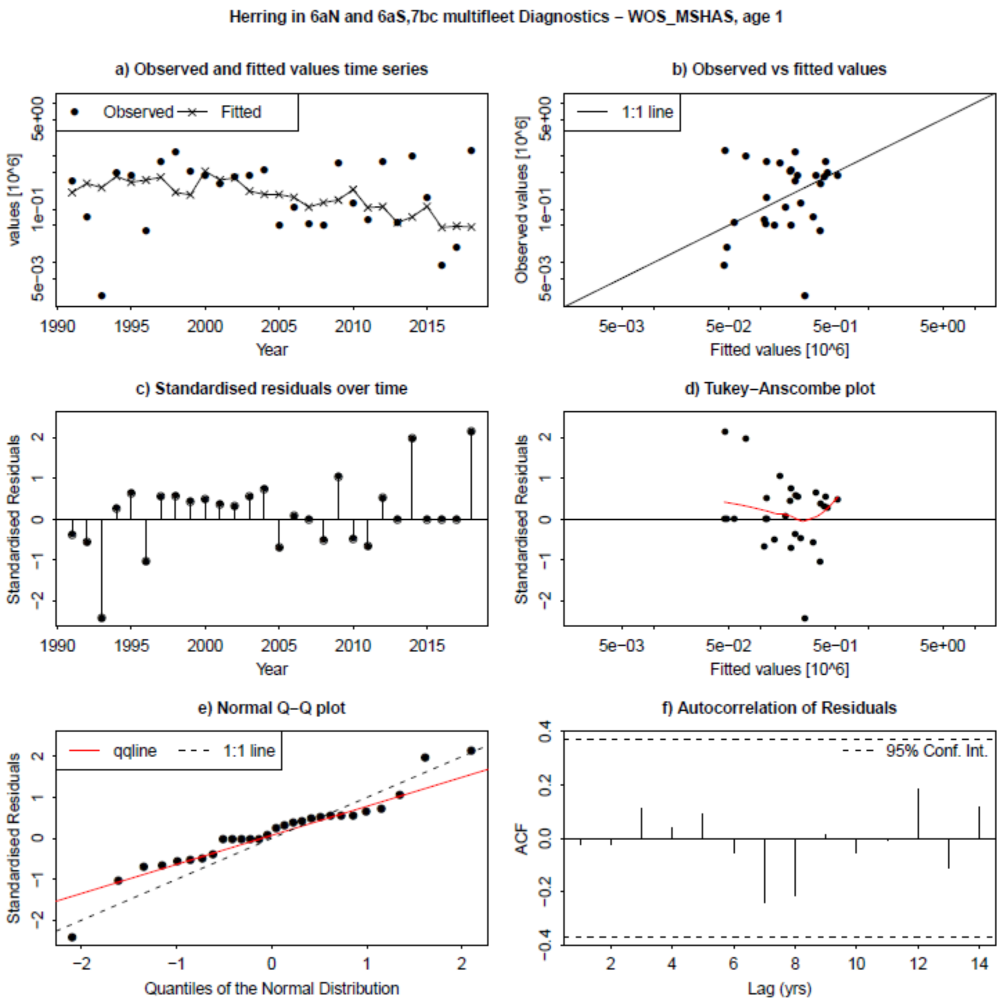


Figure 4.6.33. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 1-winter ring time-series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from index abundance at 1-winter ring. Top right: scatterplot of index observations versus 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 versus 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.

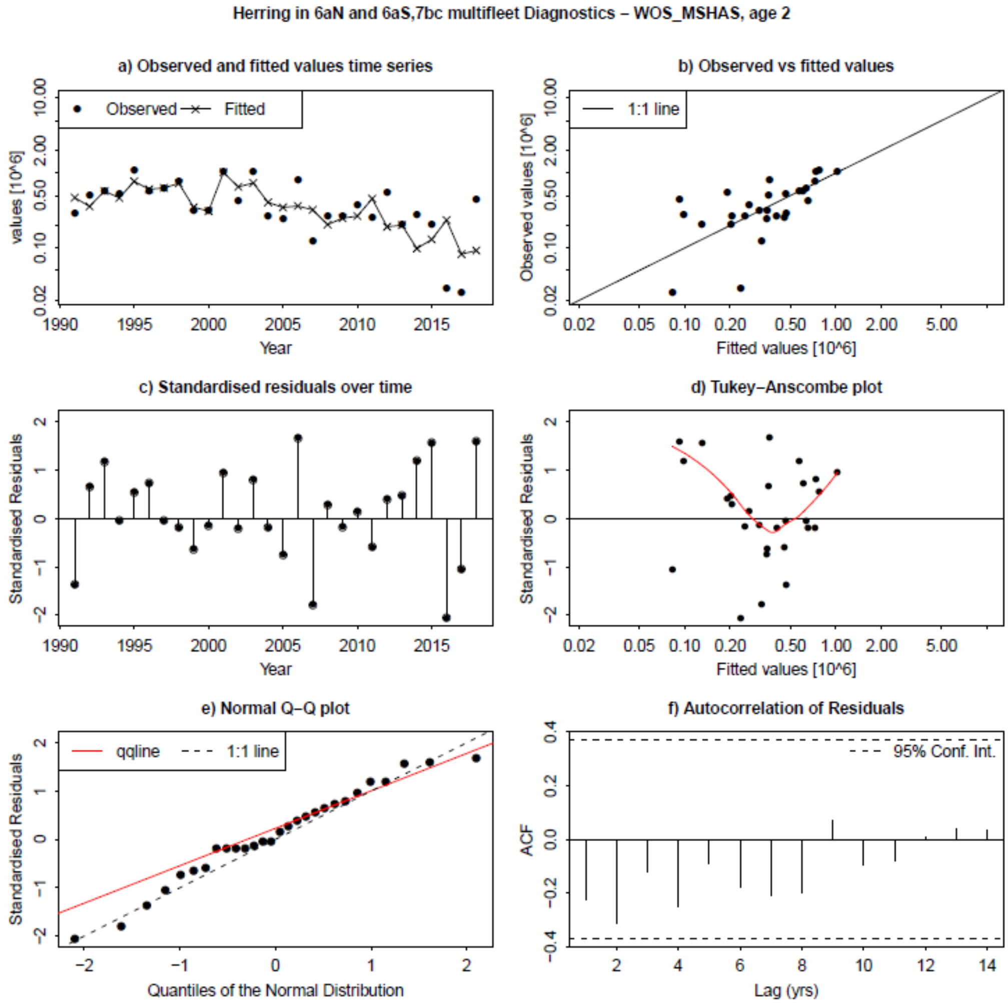


Figure 4.6.34. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

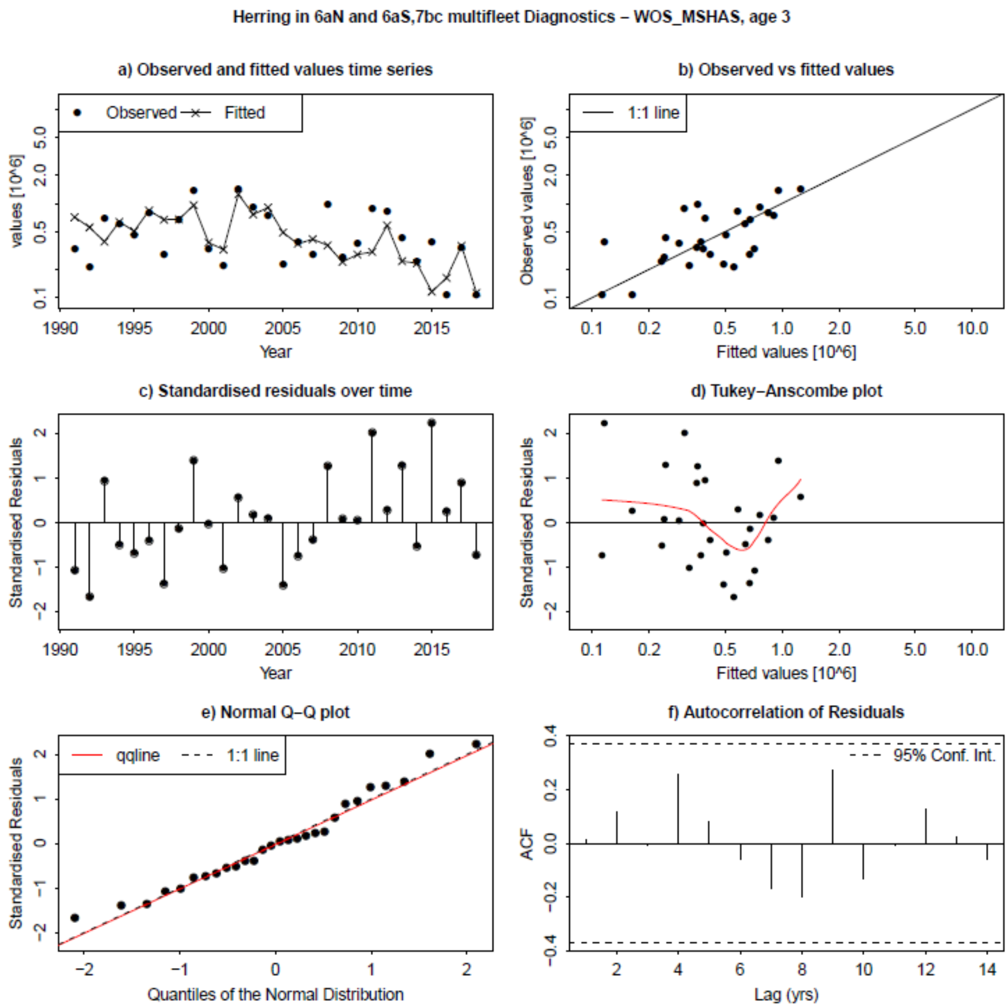


Figure 4.6.35. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

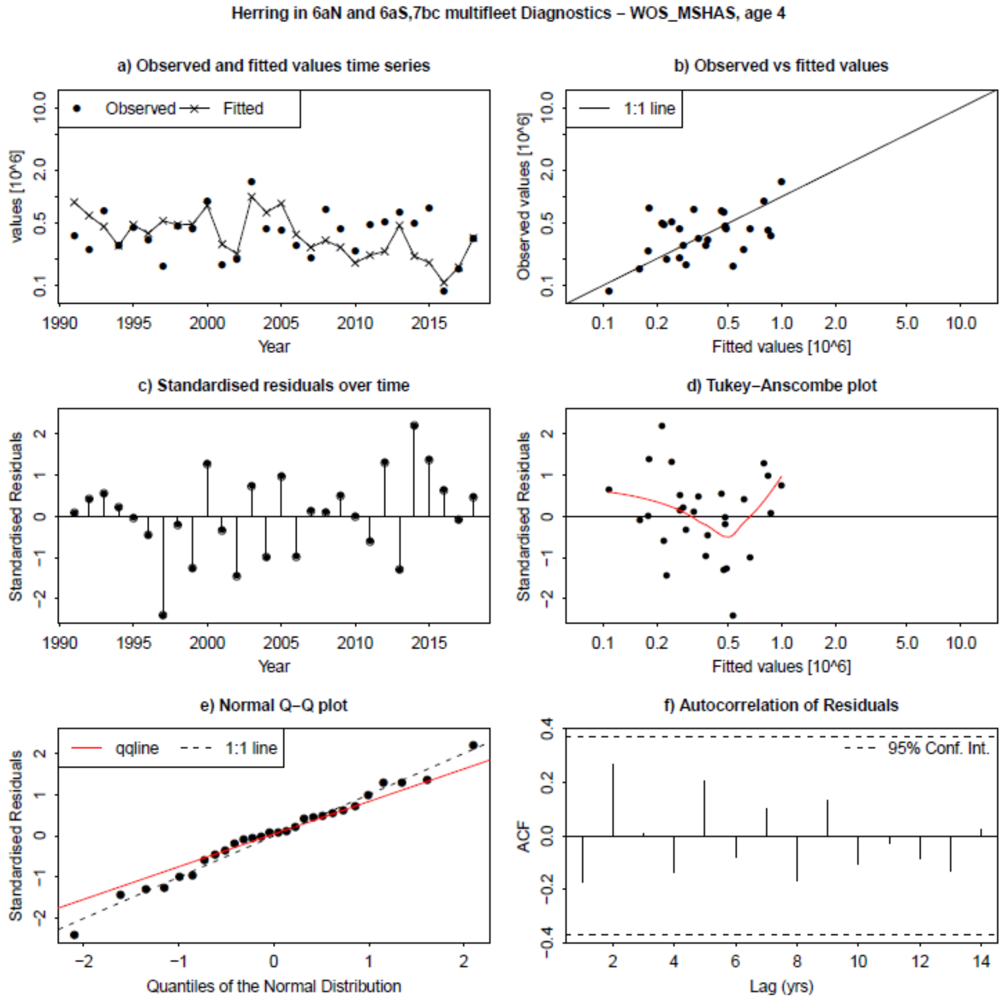


Figure 4.6.36. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

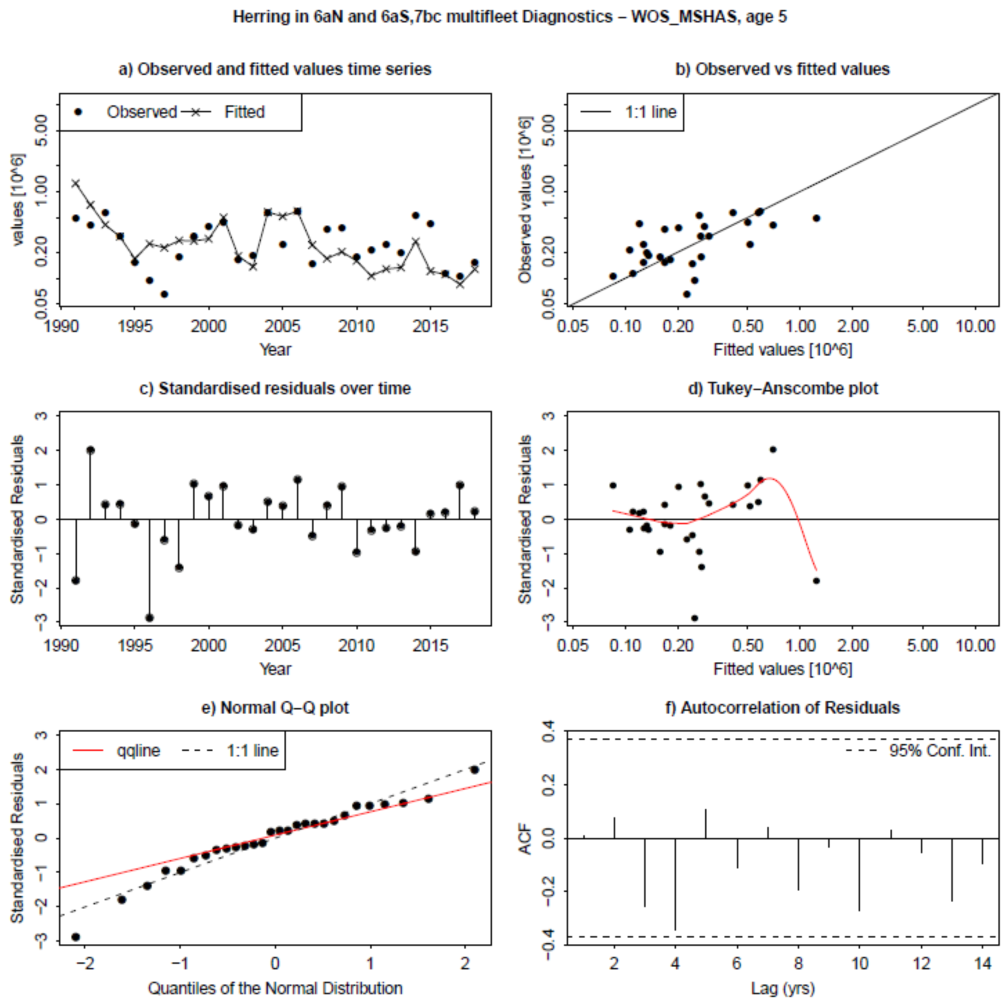


Figure 4.6.37. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

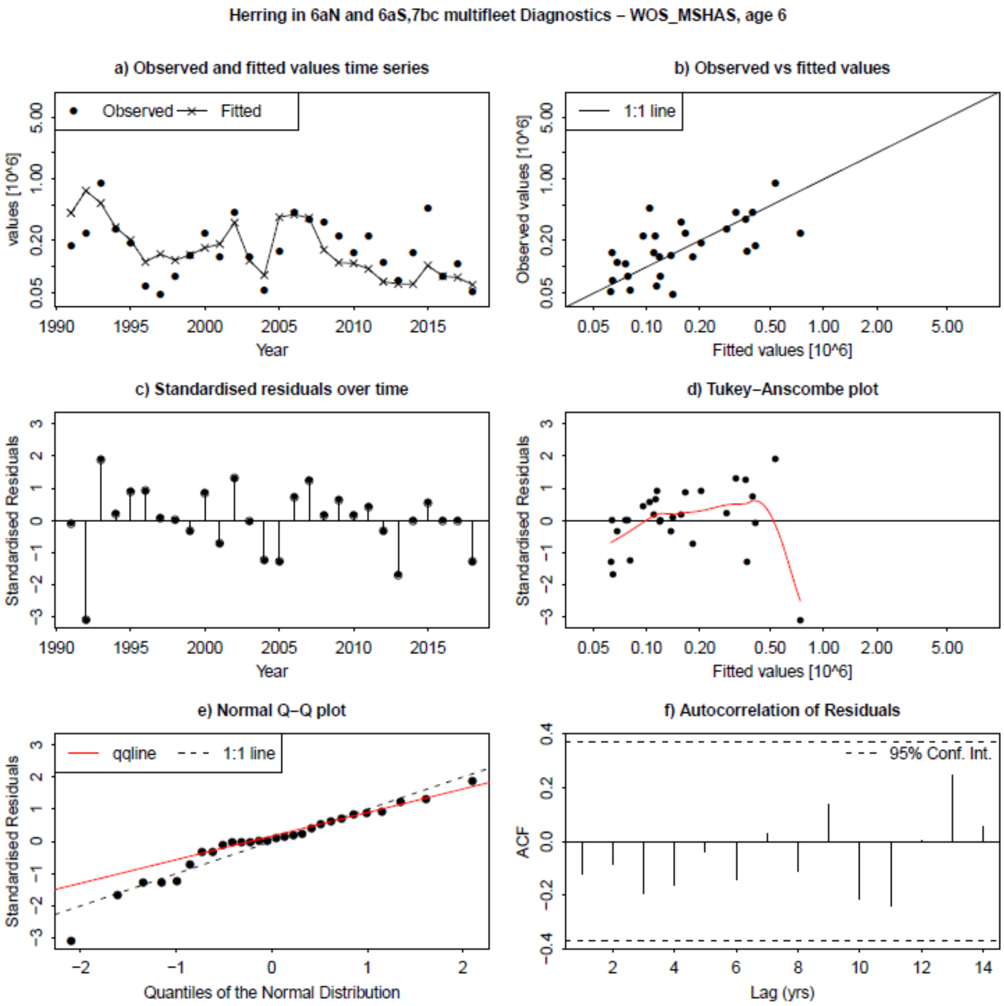


Figure 4.6.38. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

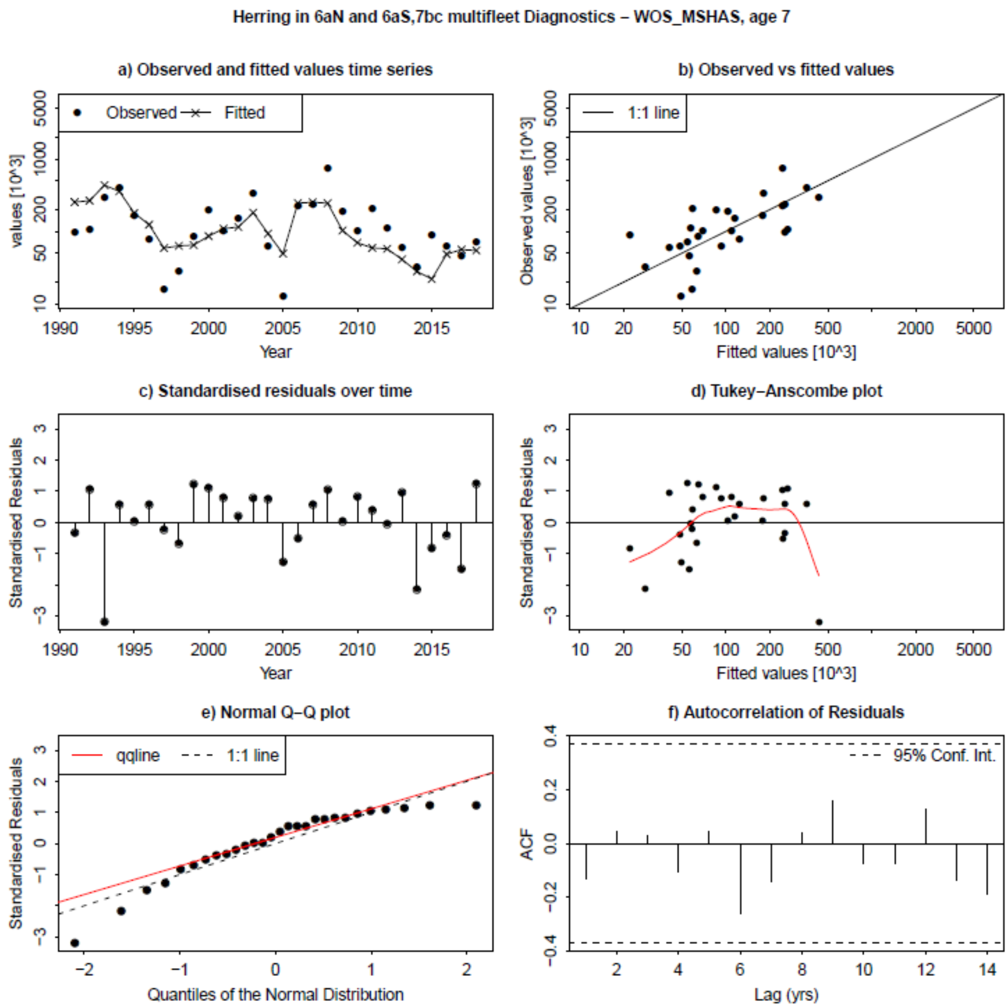


Figure 4.6.39. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

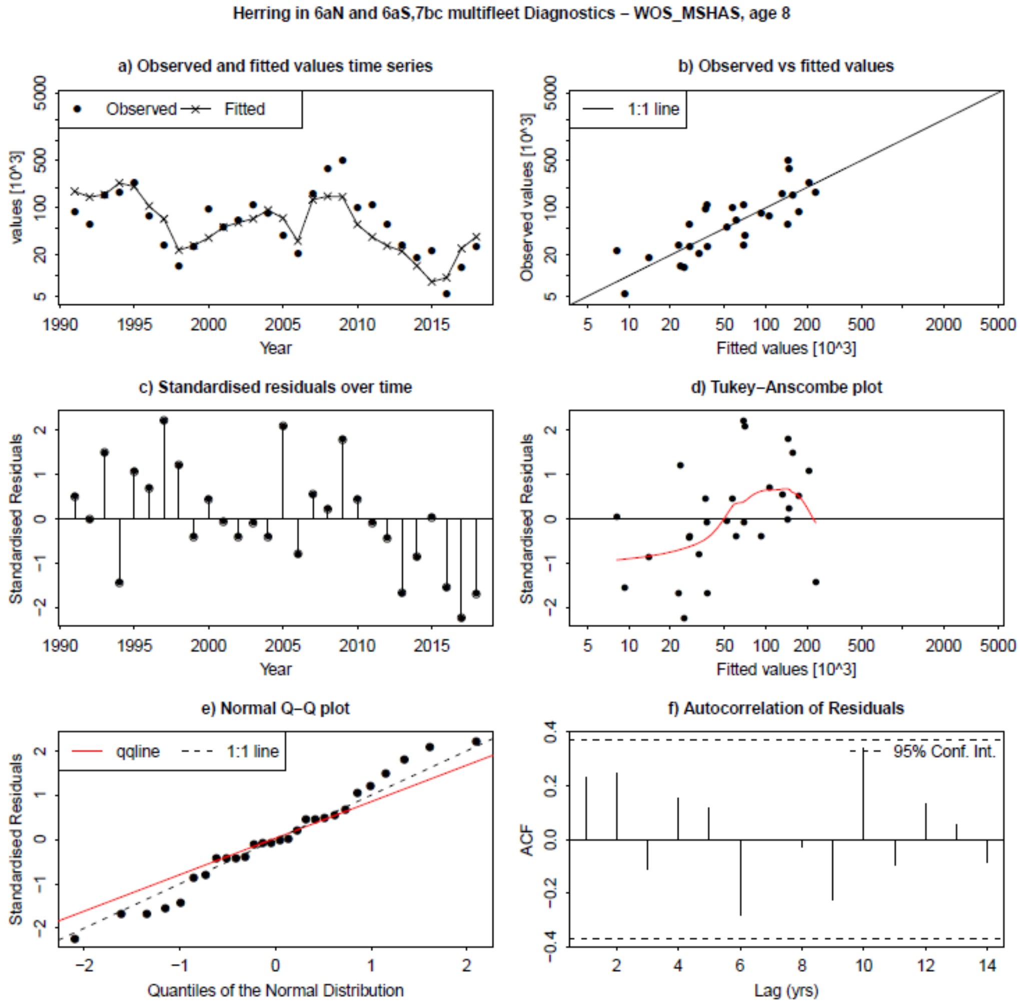


Figure 4.6.40. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

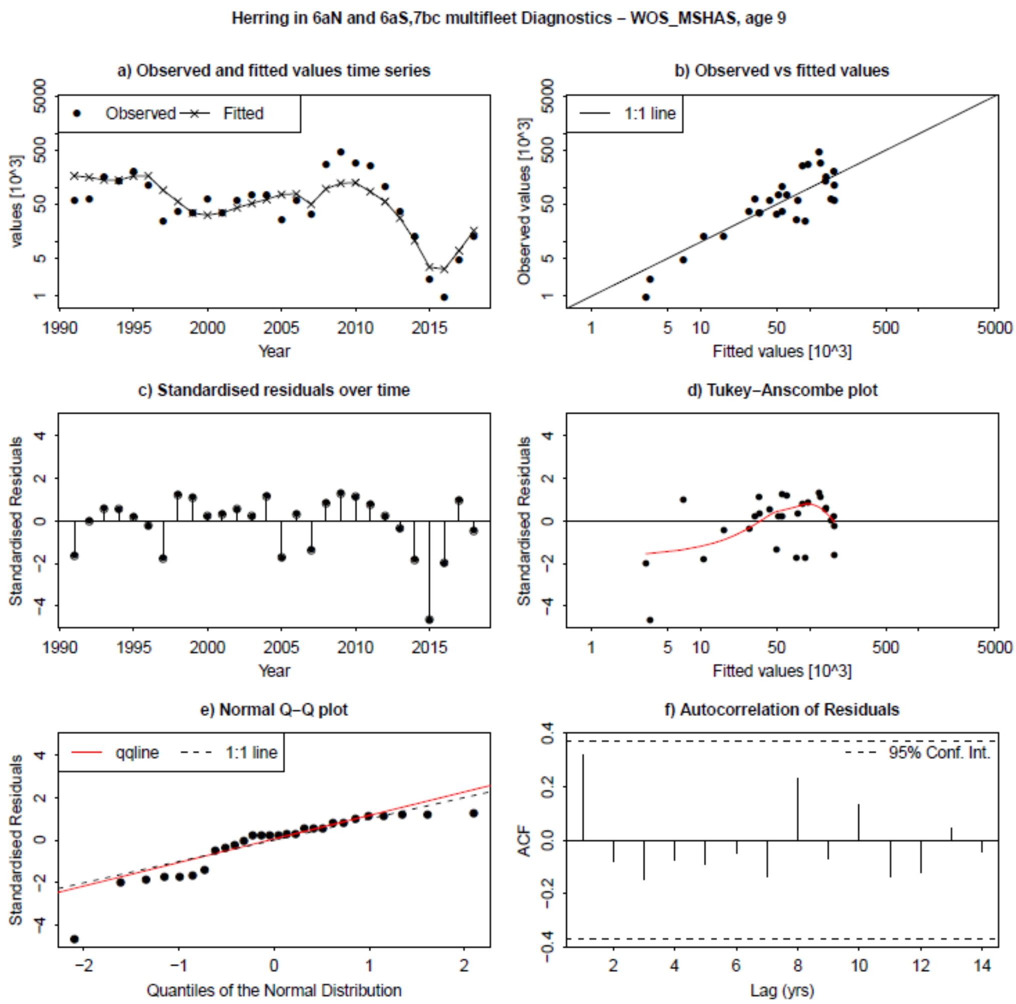


Figure 4.6.41. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

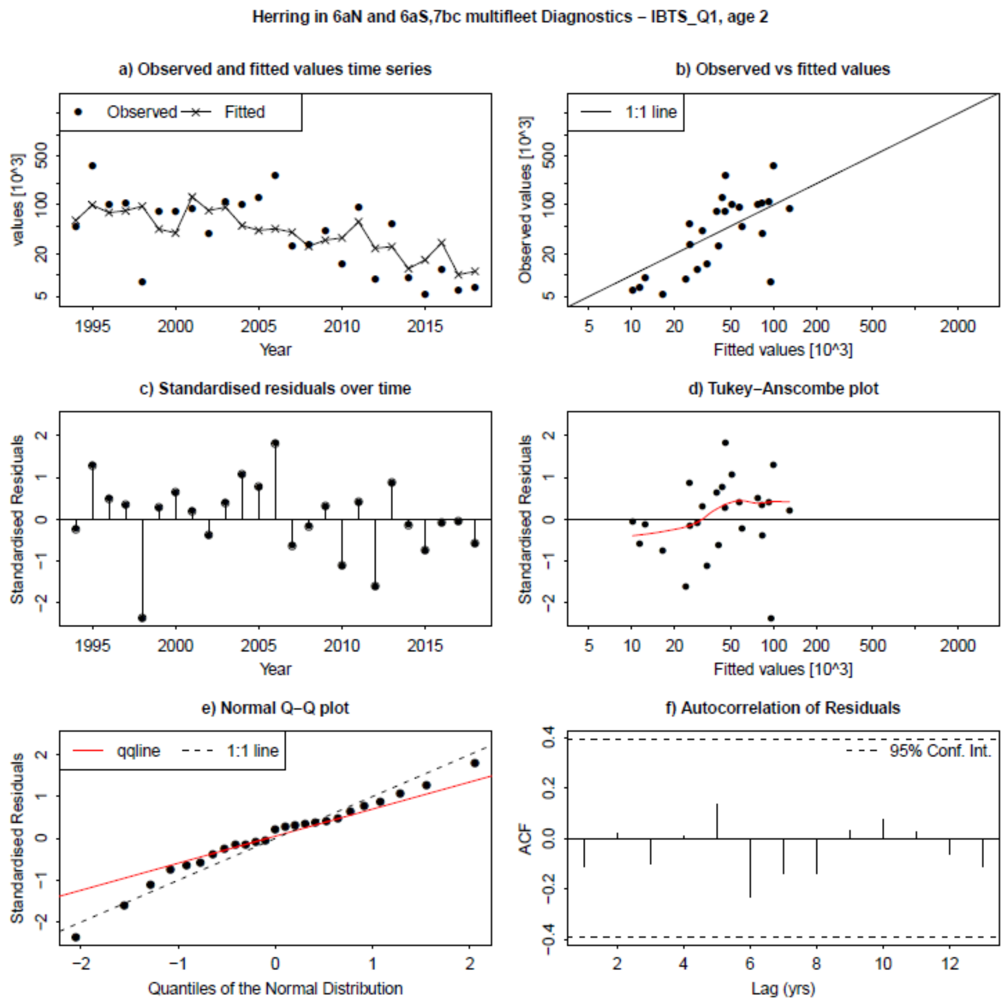


Figure 4.6.42. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

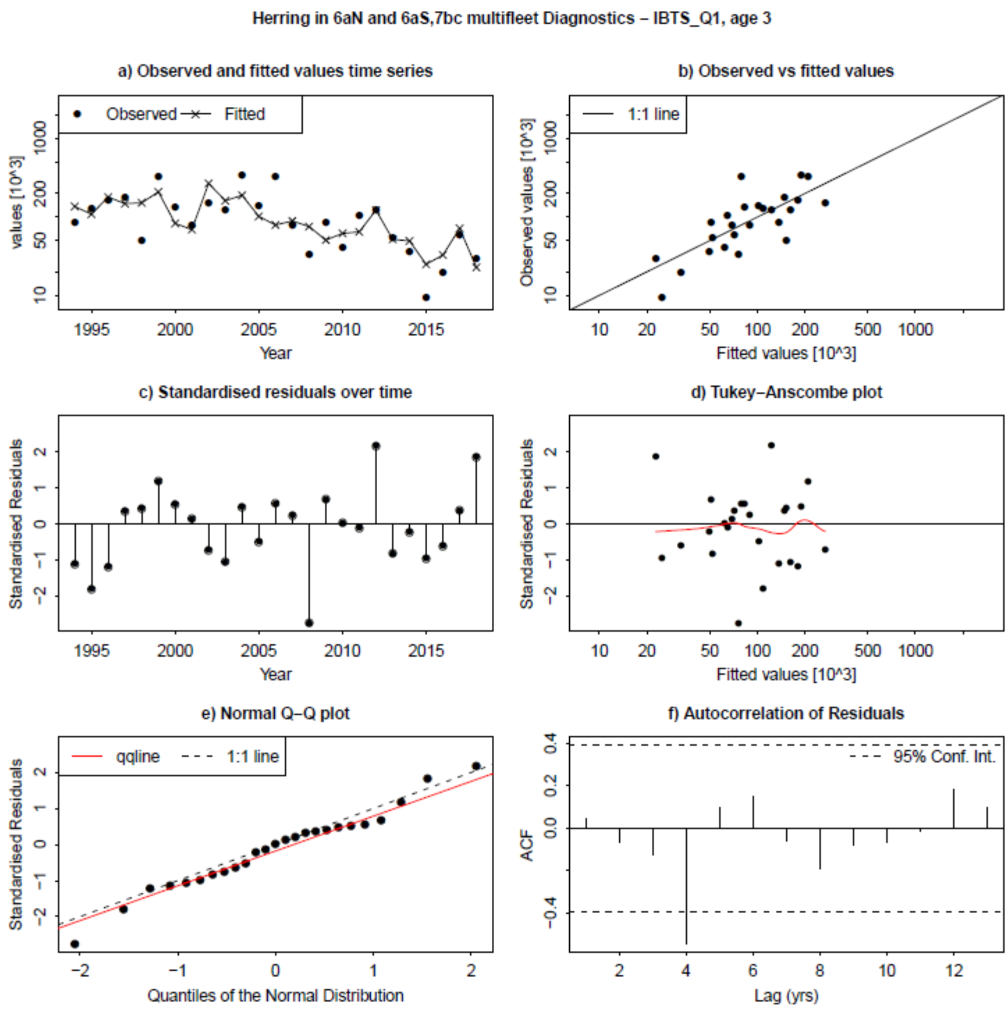


Figure 4.6.43. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

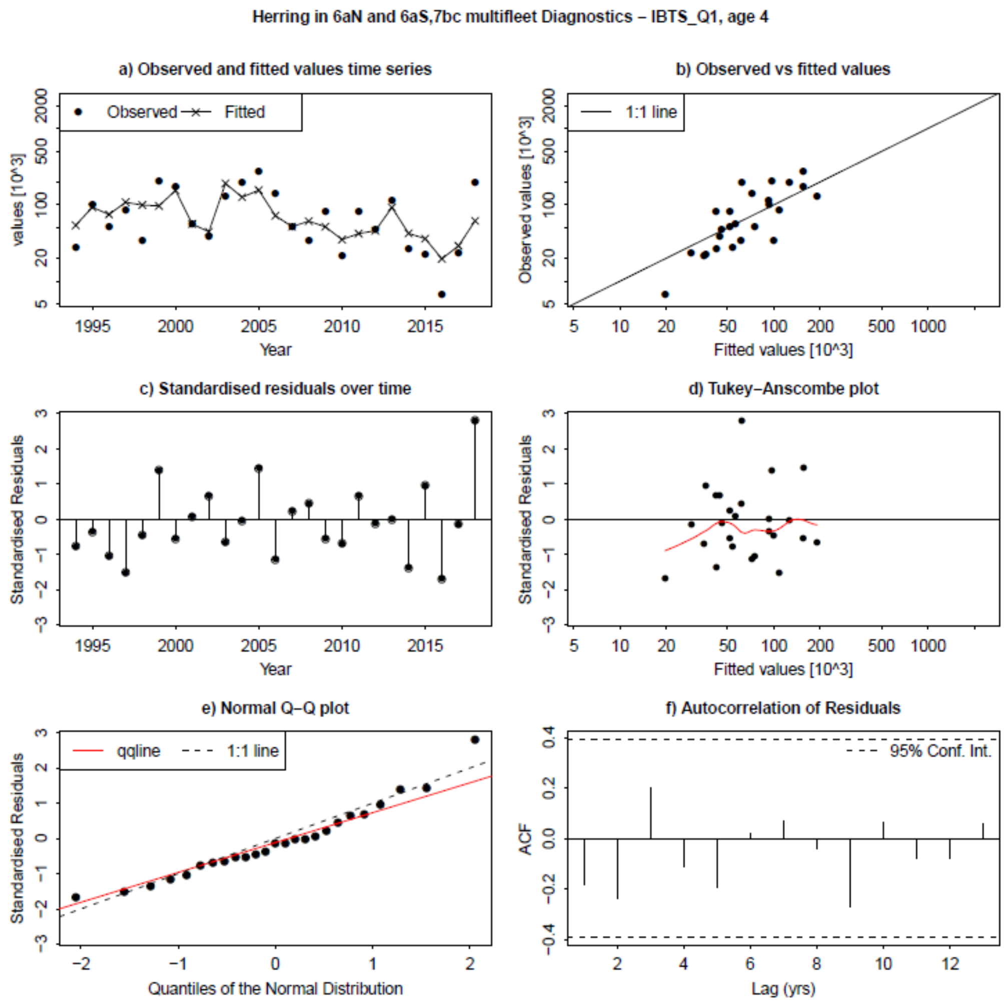


Figure 4.6.44. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

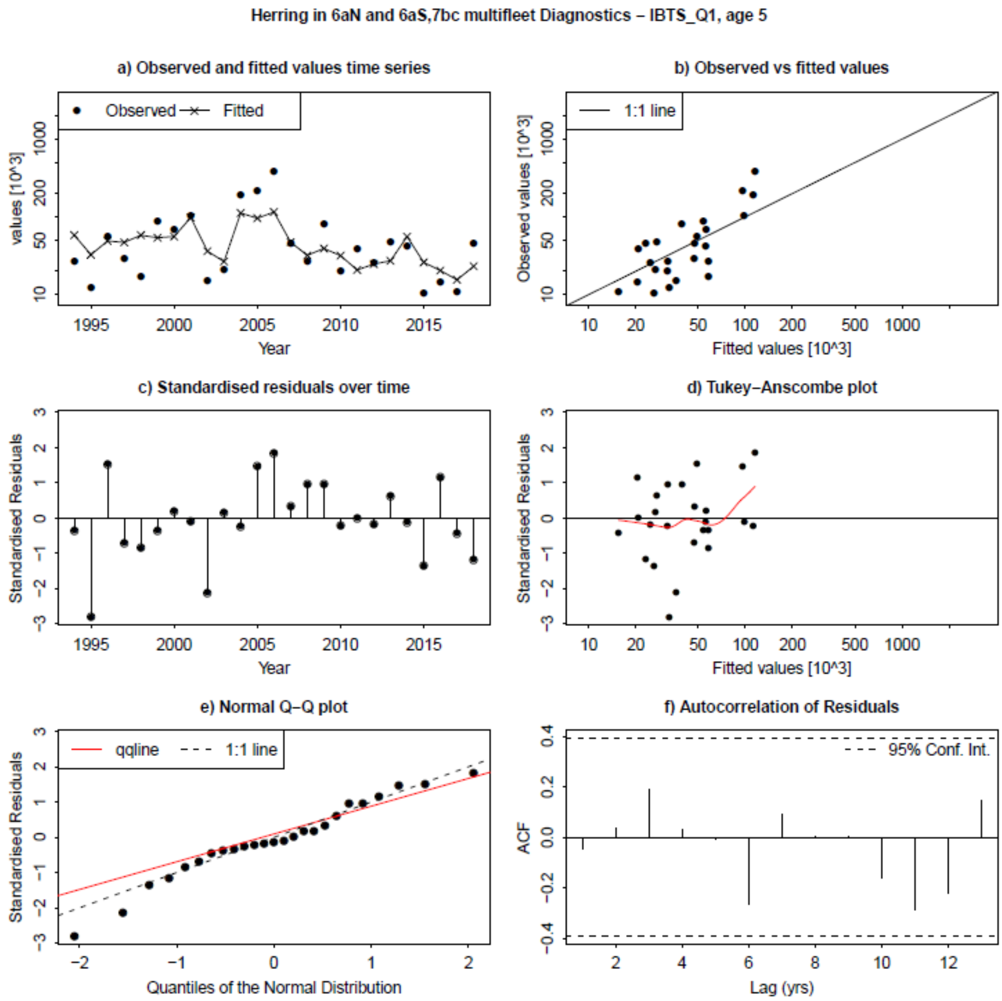


Figure 4.6.45. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

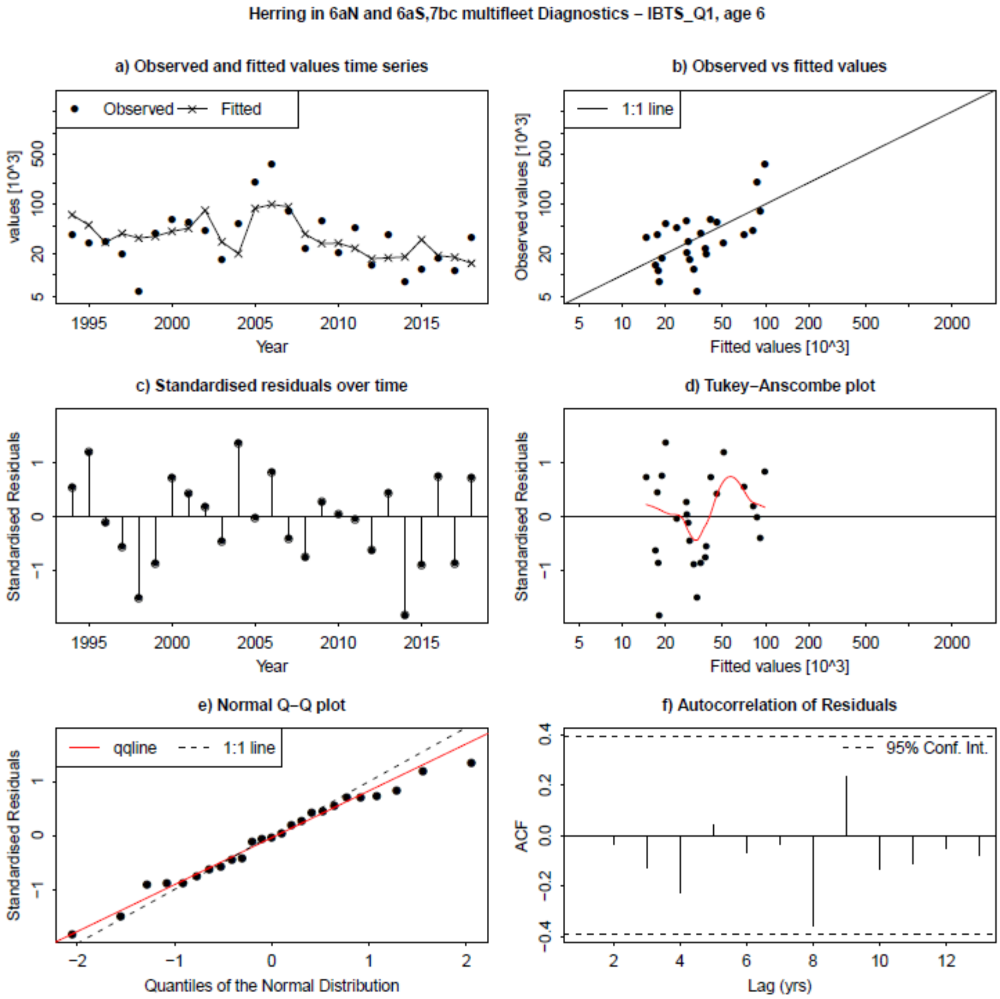


Figure 4.6.46. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

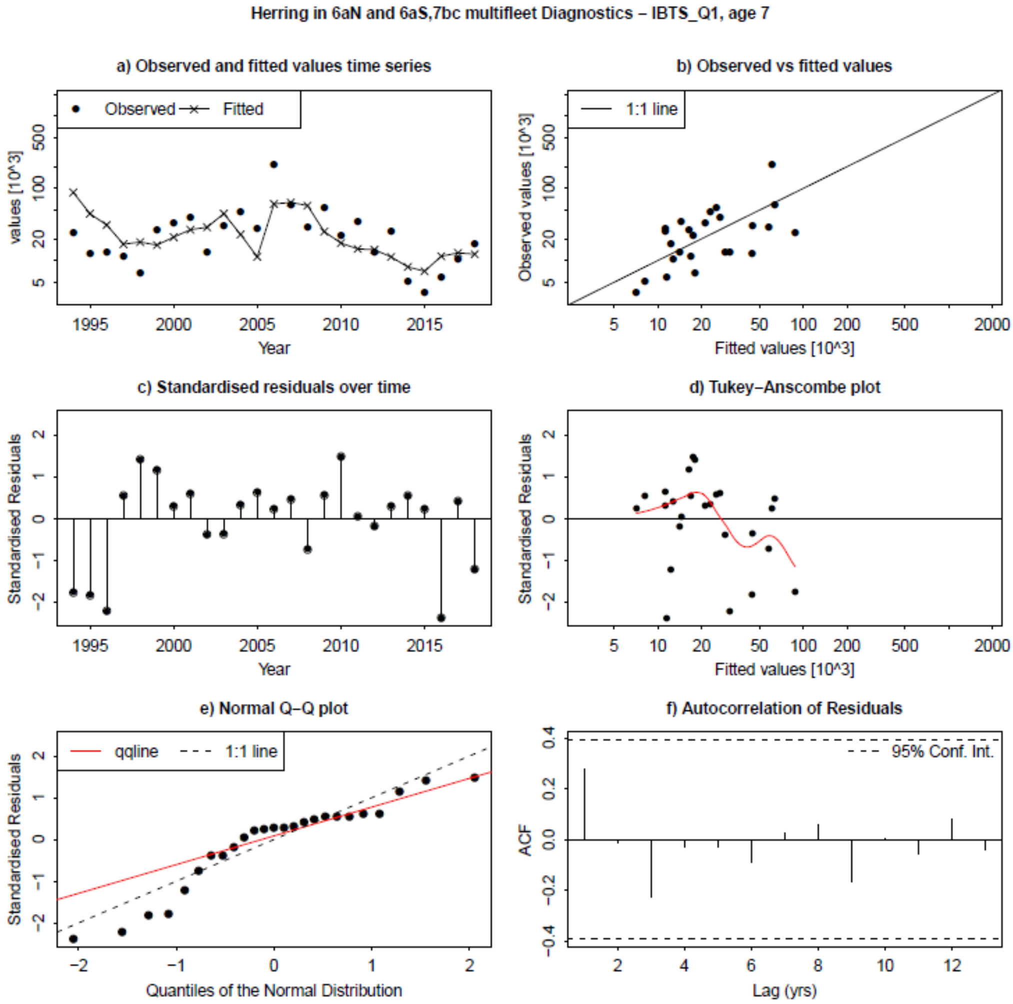


Figure 4.6.47. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

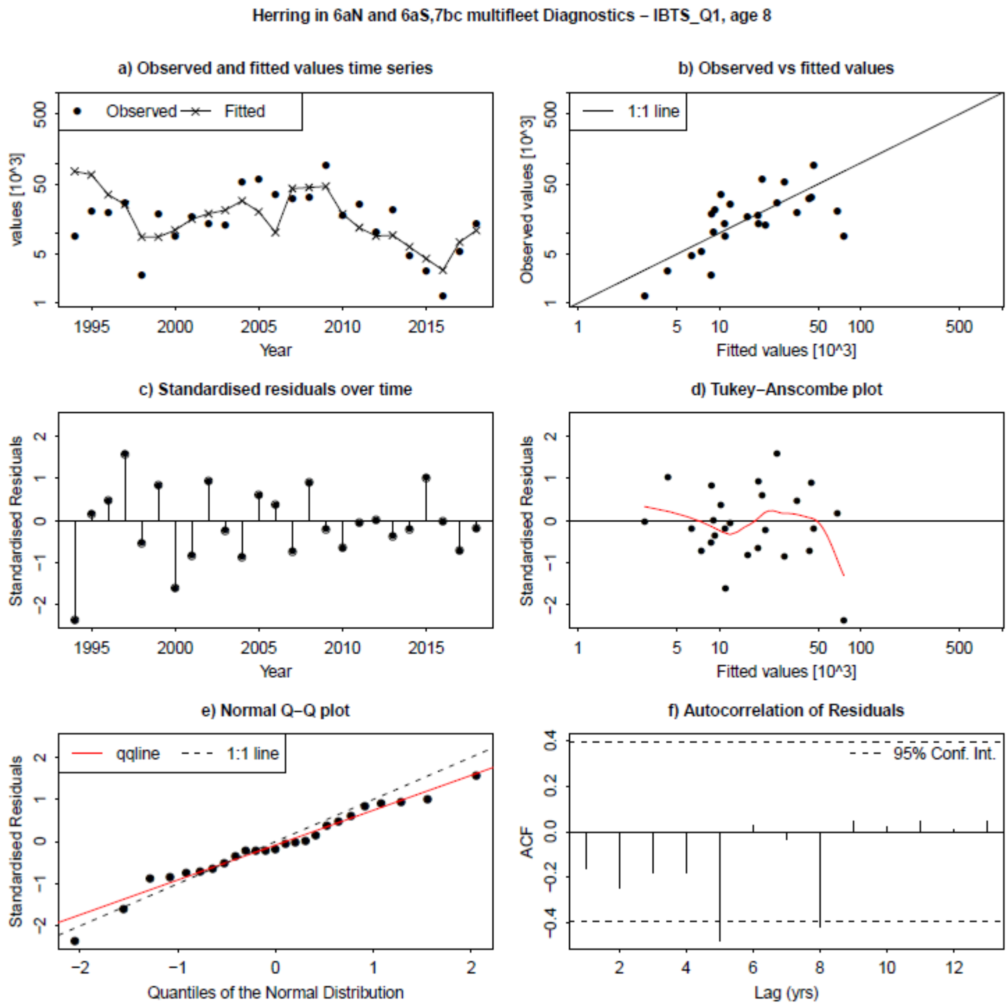


Figure 4.6.48. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

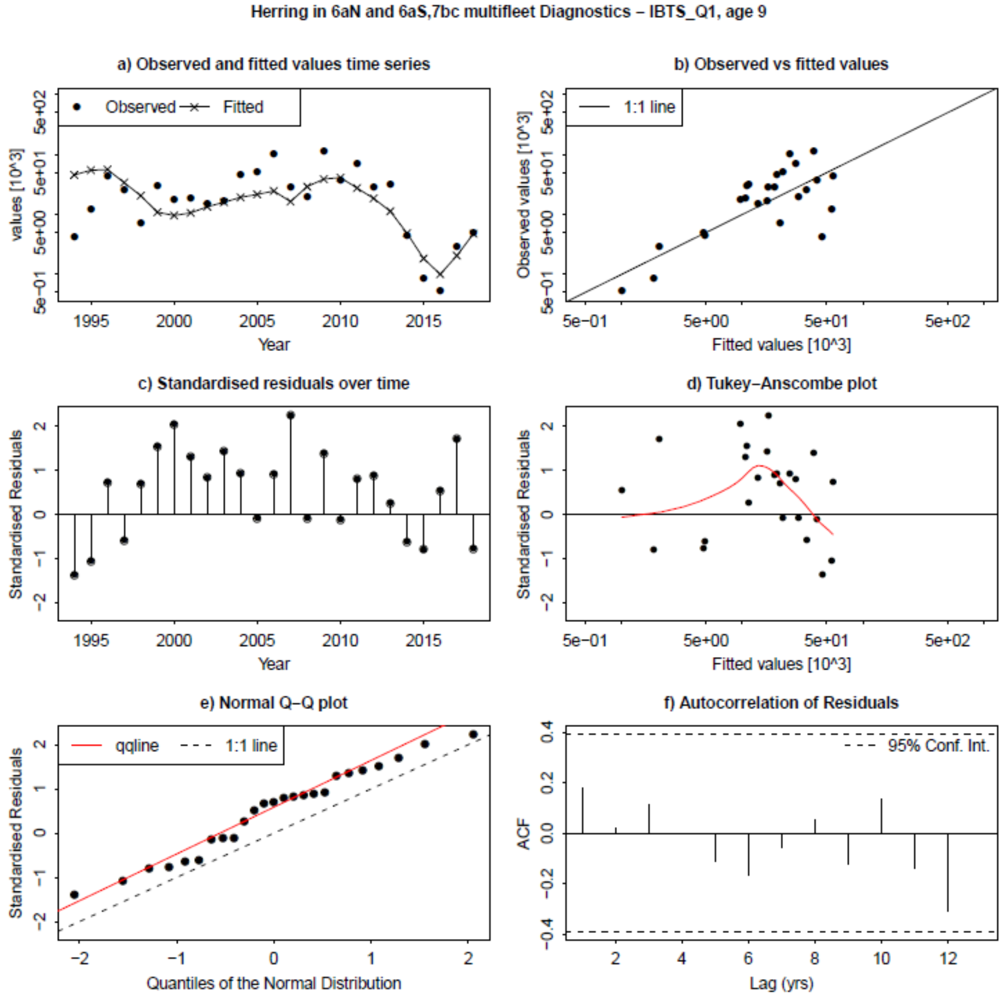


Figure 4.6.49. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

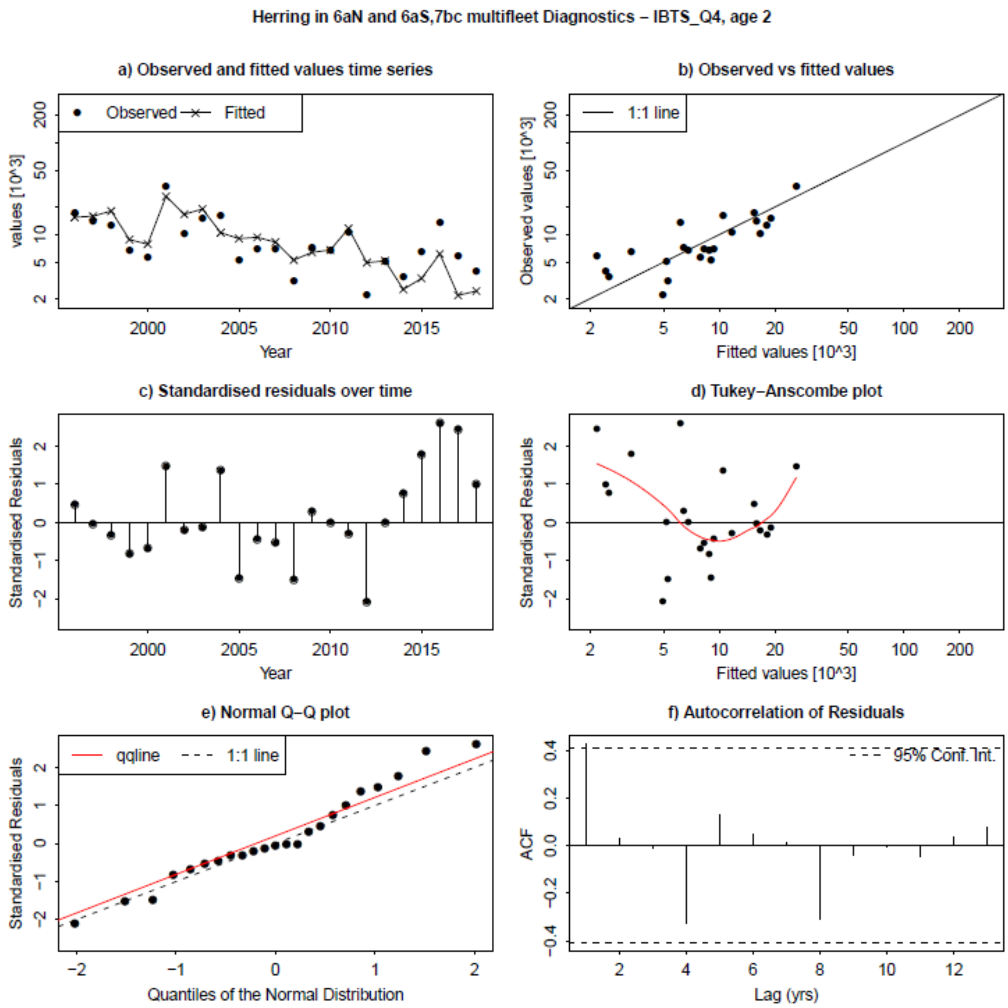


Figure 4.6.50. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

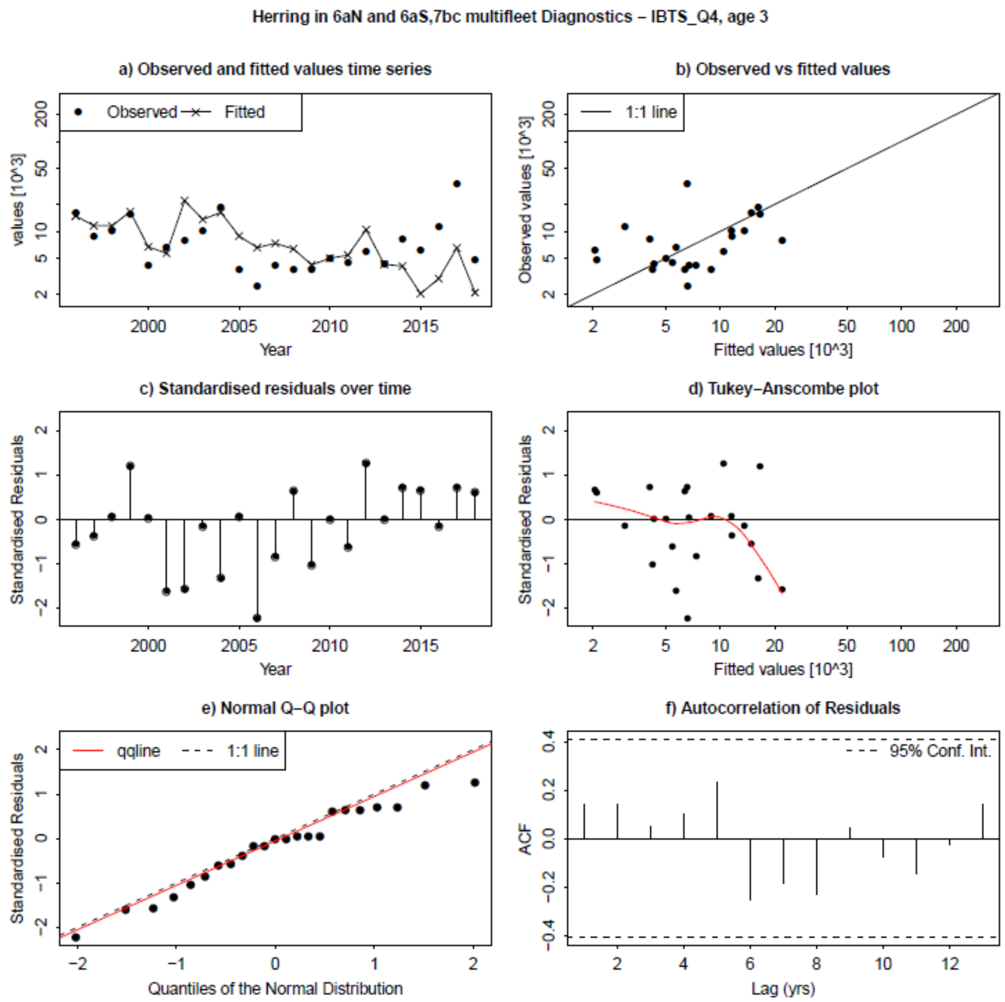


Figure 4.6.51. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

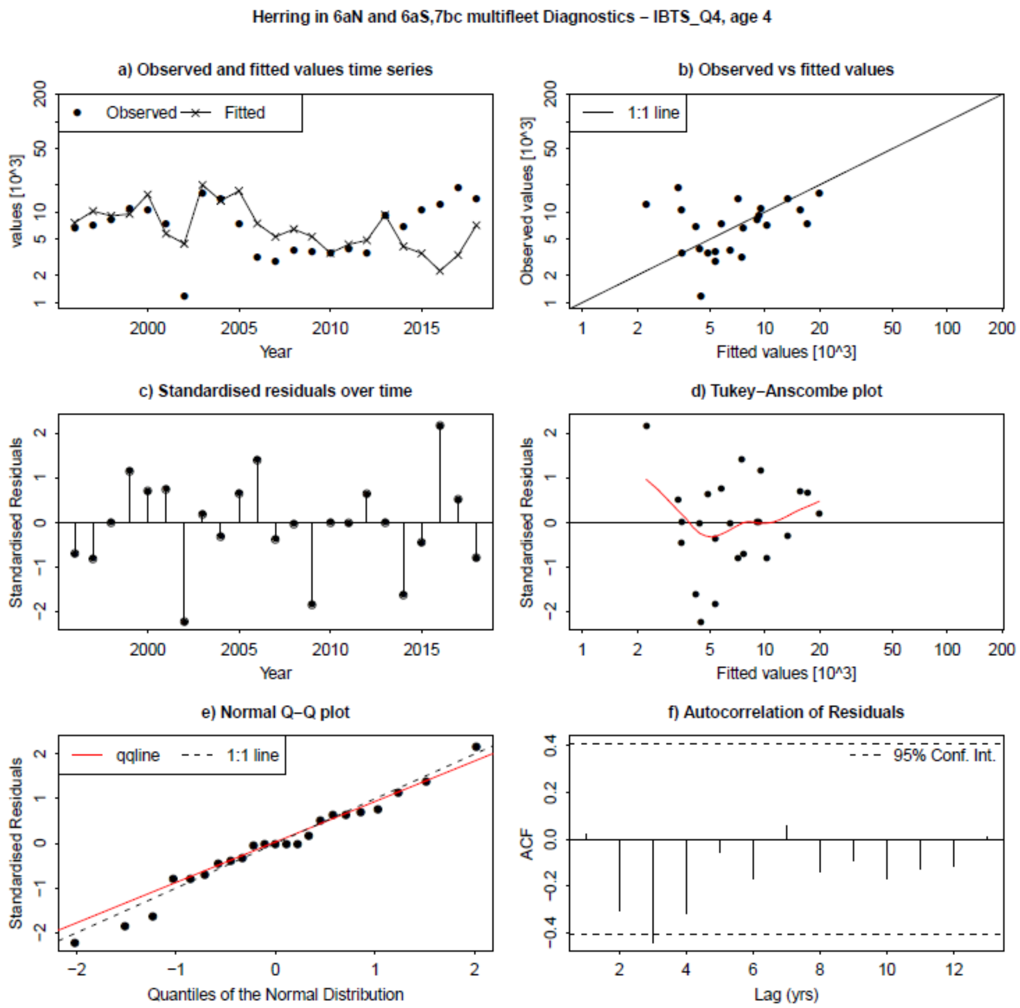


Figure 4.6.52. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

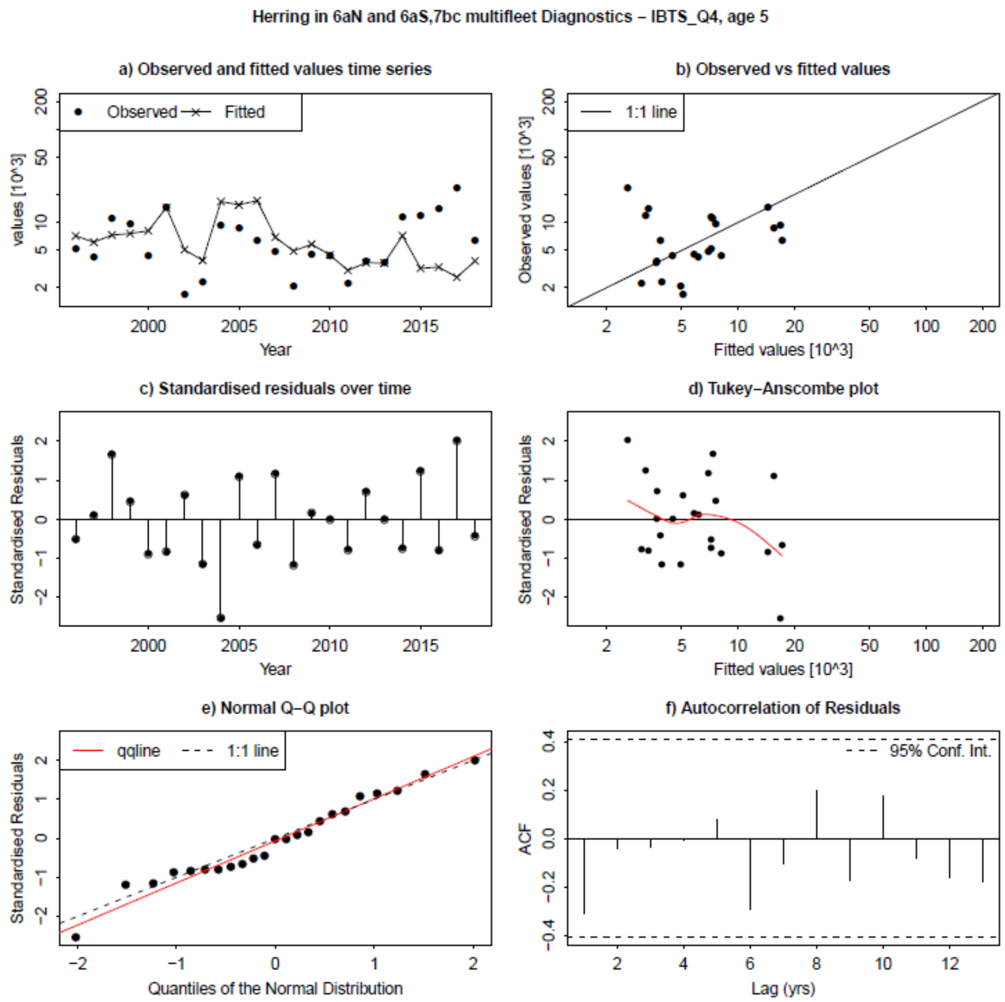


Figure 4.6.53. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

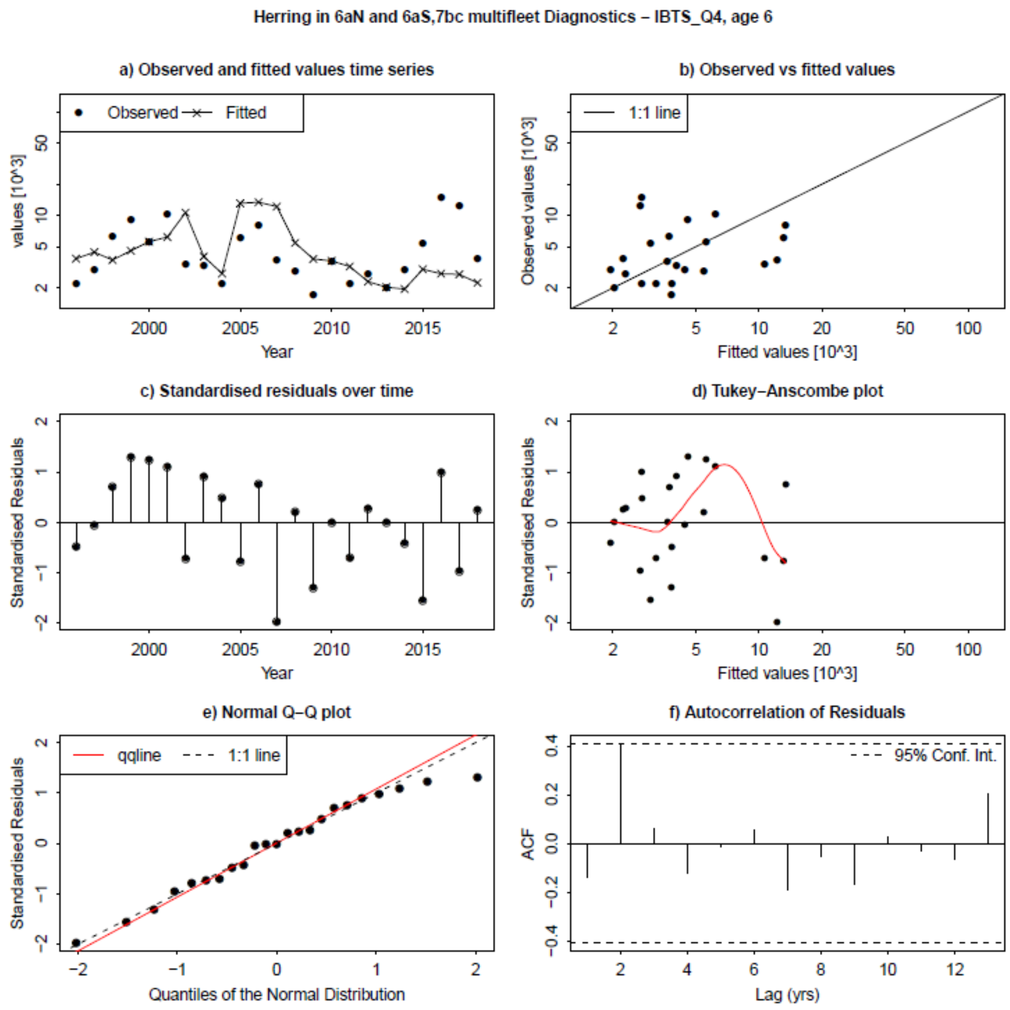


Figure 4.6.54. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

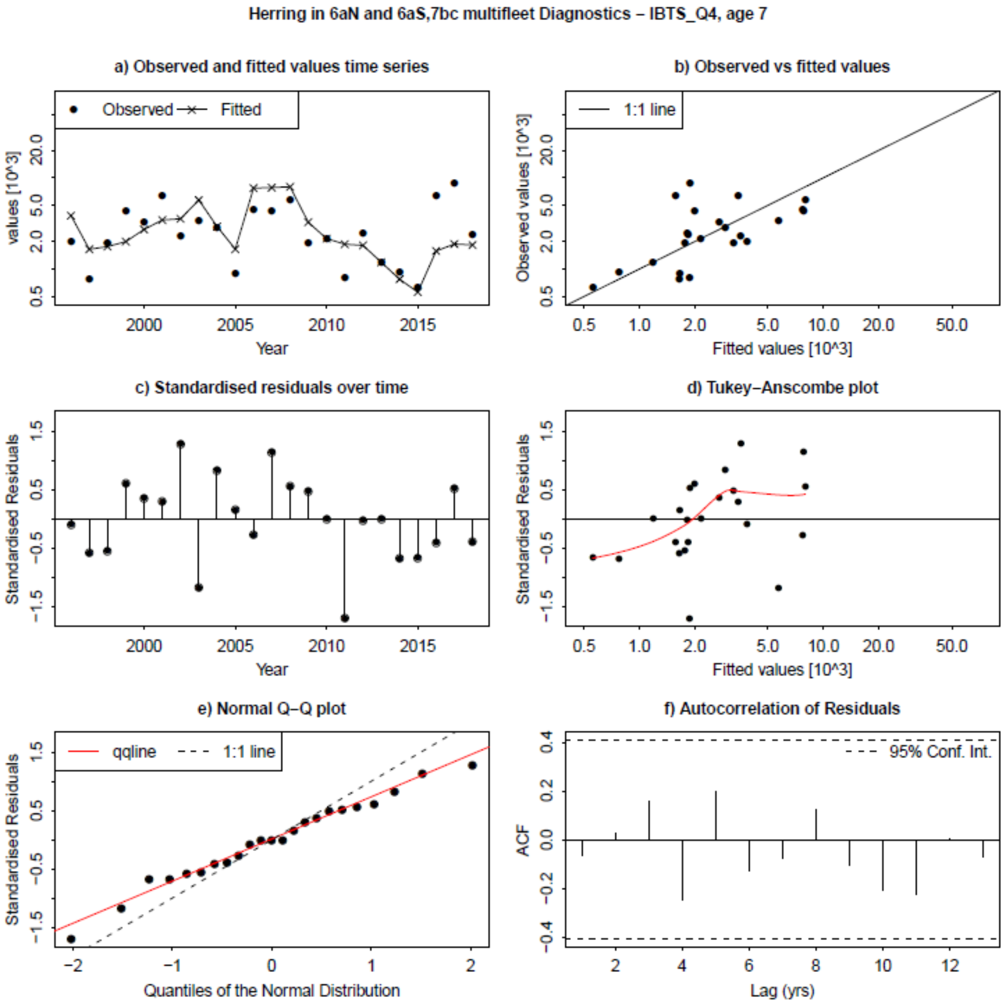


Figure 4.6.55. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

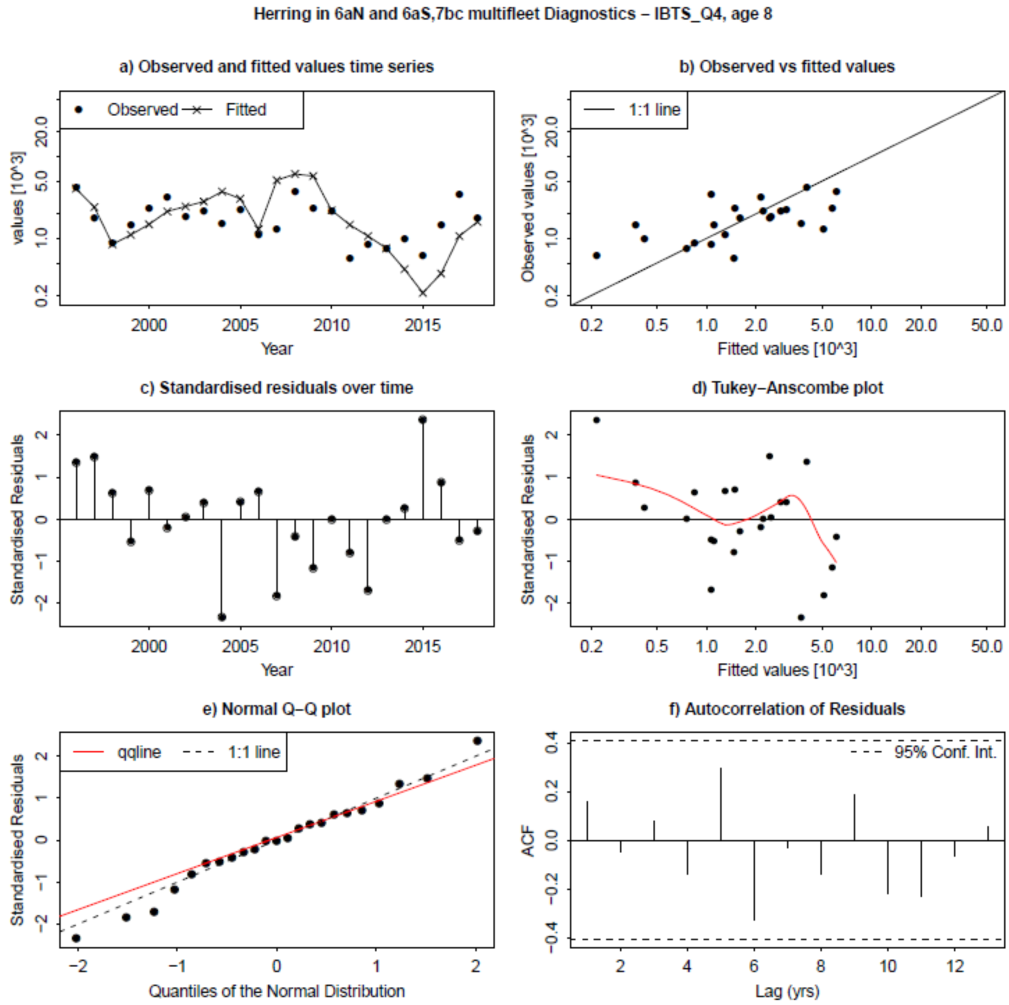


Figure 4.6.56. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

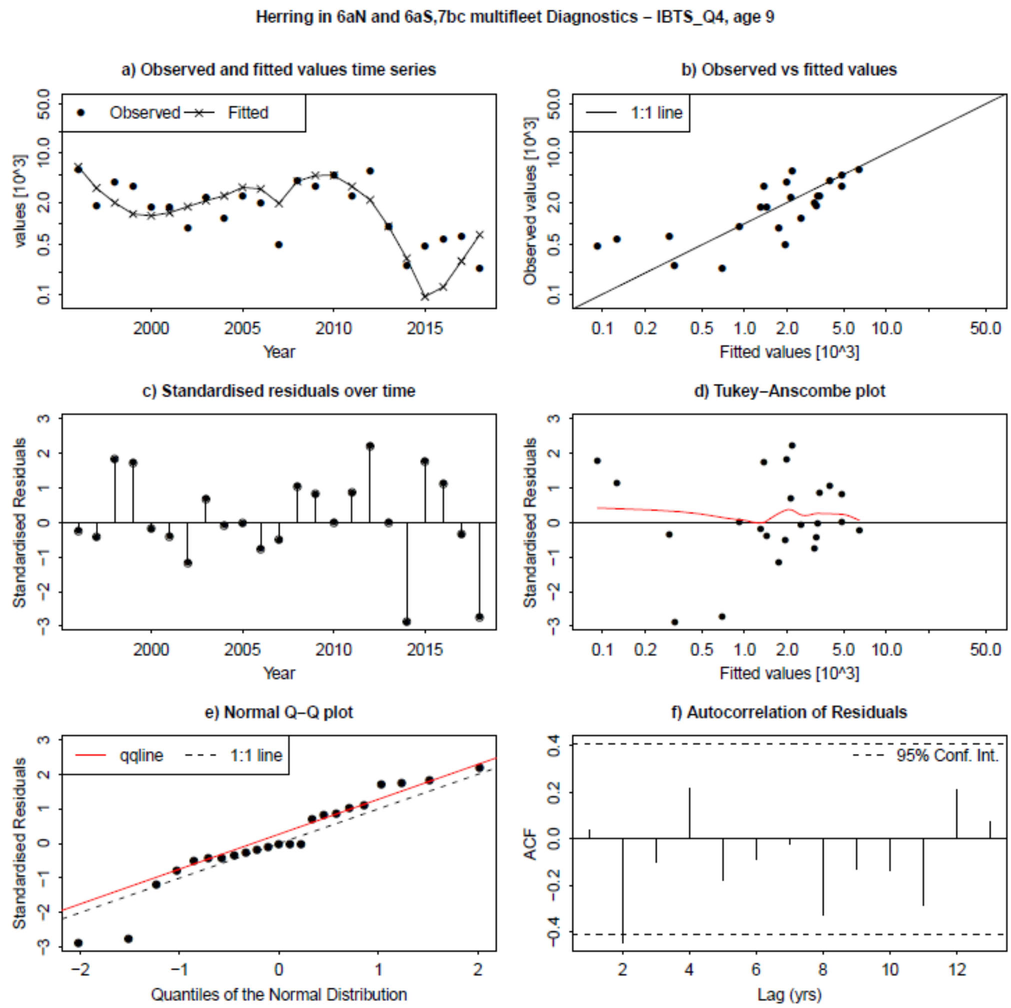


Figure 4.6.57. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations versus 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 versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

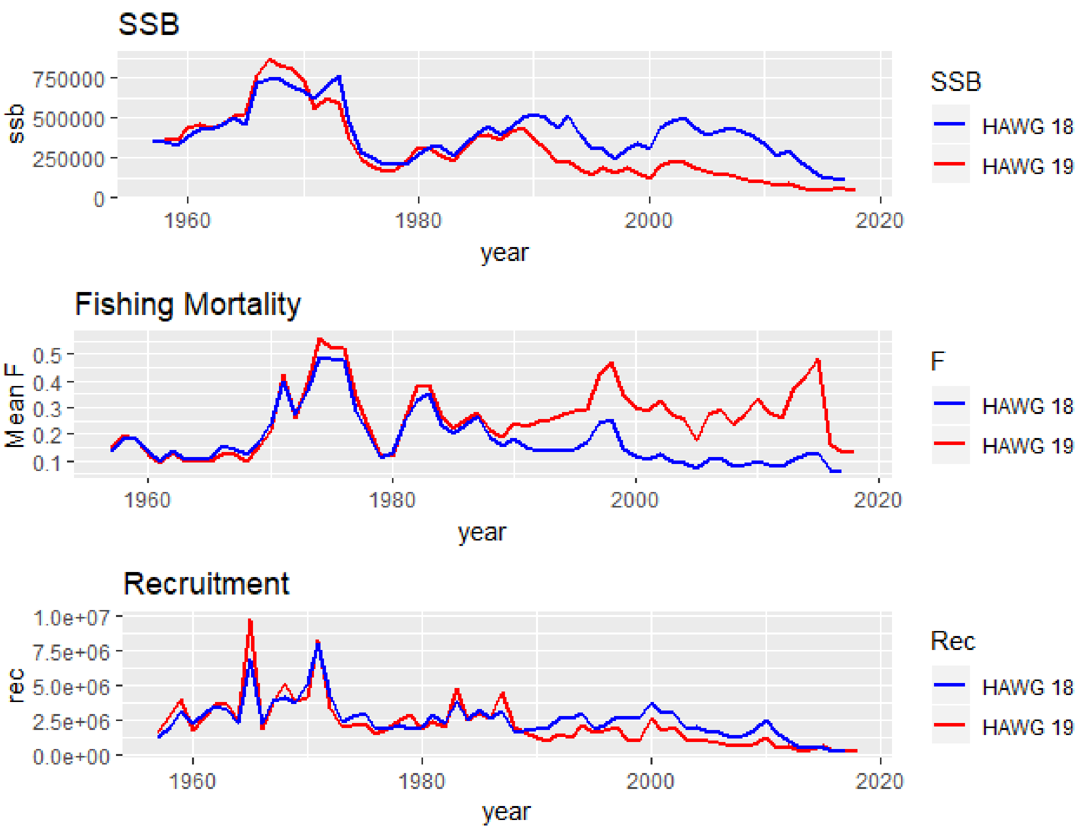


Figure 4.6.58. Herring in 6.a (combined) and 7.b–c. Perception of stock estimates in the 2018 and 2019 HAWG assessments.

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 the 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 2018

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). This TAC was the same in 2017 and 2018.

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 2018

The Working Group estimates of landings from 1991–2018 are given in Table 5.1.2. The catch has declined from 19 000 t in 2006 to 1495 t in 2018 as there is now a monitoring TAC in place for the combined stocks in 6.a and 7.b–c. In 2018 the majority of the quota taken close inshore. Catches over time are shown in Figure 5.1.1.

In 2018 the majority of the catch was taken in the fourth quarter. Subdivision 6.aS accounted 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 2018 was allocated on a similar basis to 2016 and 2017. 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 technology and fishing pattern

The monitoring TAC, introduced in 2016 and continued in 2017 and 2018, 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 larger vessels were unable to utilize their quota in 2018 due to the timing of the fishery which opens in November.

5.1.2 Biological composition of the catch

5.1.2.1 Catch s-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 1992 in Table 5.1.4. In 2018, the fishery was dominated by 4- and 5-ringers (2012 and 2013 cohort), accounting for 53% of the catch, followed by 3-ringer at 17% (Table 5.1.4). These cohorts featured prominently in the previous year. Proportion-at-age in the catches from the fishery are similar to the catches from the MSHAS for most year, in 2018 catches from the MSHAS were dominated my 1-ringers (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 are shown in Table 5.1.7. The catch-at-age matrix tracks cohorts well in the past two years.

Mixing of autumn, winter and spring spawners takes place in this area which may lead to ageing difficulties regarding counting of winter rings.

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.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 2018 as well as maintaining coverage of the original survey area in 6.a.N.

5.1.3.2 Industry acoustic survey in 2018

An acoustic survey of Atlantic herring *Clupea harengus* and horse mackerel *Trachurus trachurus* was conducted in ICES areas 6aS and 7b in November 2018 using the pair trawl vessels MFV Eilean Croine and MFV Sparkling Star. This survey is the third in a time-series that is hoped will be developed into a long-term index of spawning/prespawning herring in 6aS and 7b, for use in stock assessments in future. The survey track and associated biological hauls are presented in Figure 5.1.5 and the herring NASC values in Figure 5.1.6. In total 1400 nmi of cruise track was completed using 37 transects and related to a total area coverage of approximately 5600 nmi^2. Parallel transect spacing was set at 7.5 nmi for the wider area strata, and 3.5 nmi for Donegal Bay and Achill strata. Coverage extended from inshore coastal areas to the 200 m contour in the west and north where possible. A survey was carried out in Lough Swilly using a zig-zag design. Very strong herring marks were evident in Lough Swilly, an area where boats in the monitoring fishery were concentrating effort. There were a few herring marks in discrete areas around Glen Head, Bruckless Bay, Inishmurray and Inishbofin. Biological samples from the monitoring fishery of herring were used to augment the samples from the survey. Herring samples were taken from boats fishing in Lough Swilly and Bruckless Bay as close spatially and temporally as possible to the survey in these areas. Herring were dominated overall by 4-wr fish, 29% of the overall numbers. This age class is dominant in the catch data and the Malin shelf acoustic survey also. The total-stock biomass (TSB) estimate of herring for the combined 6aS/7b area was 50 145 tonnes (Lough Swilly = 32 372 tonnes, Donegal Bay = 9517 tonnes, NW area = 7710 tonnes and the remaining Achill strata = 545 tonnes). This is considered to be a minimum estimate of herring in the 6aS/7b survey area at the time of the survey. The CV estimates on biomass and abundance are high (~0.51 for herring) for the survey in 2018. For herring, this is mostly caused by the over-reliance on a few acoustic marks of herring in Lough Swilly and Bruckless Bay in particular (O'Malley *et al.,* 2019).

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 2018 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 in 2018 relative to 2017.

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 2018 relative to 2017 and have been showing a downward trend recently. Trends over the recent and longer time-series are similar to those in the catches.

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 recent years. 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.aN, 6.aS and 7.b–c concluded that the assessment would be a combined stock assessment. Details of the combined assessment for 6.a and 7.b–c are outlined in Section 4. No separate assessment is presented in 2018.

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 is in a state of collapse.

Fishing mortality should be kept low to allow rebuilding. The monitoring TAC should be maintained allowing sampling to continue.

The combined assessment (6a, 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.

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 favourably 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, 1991–2018. 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

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
France	
Germany Fed. Rep.	
Ireland	970
Netherlands	
UK (N. Ireland)	
UK (England + Wales)	
UK (Scotland)	
Total landings	
Unallocated/ area misreported	525
Discards	
WG catch	1495

Table 5.1.3. Herring in divisions 6.a.S and 7.b–c. Catch in numbers-at-age (winter rings) from 1970–2018.

	1	2	3	4	5	6	7	8	9
1970	135	35114	26007	13243	3895	40181	2982	1667	1911
1971	883	6177	7038	10856	8826	3938	40553	2286	2160
1972	1001	28786	20534	6191	11145	10057	4243	47182	4305
1973	6423	40390	47389	16863	7432	12383	9191	1969	50980
1974	3374	29406	41116	44579	17857	8882	10901	10272	30549
1975	7360	41308	25117	29192	23718	10703	5909	9378	32029
1976	16613	29011	37512	26544	25317	15000	5208	3596	15703
1977	4485	44512	13396	17176	12209	9924	5534	1360	4150
1978	10170	40320	27079	13308	10685	5356	4270	3638	3324
1979	5919	50071	19161	19969	9349	8422	5443	4423	4090
1980	2856	40058	64946	25140	22126	7748	6946	4344	5334
1981	1620	22265	41794	31460	12812	12746	3461	2735	5220
1982	748	18136	17004	28220	18280	8121	4089	3249	2875
1983	1517	43688	49534	25316	31782	18320	6695	3329	4251
1984	2794	81481	28660	17854	7190	12836	5974	2008	4020
1985	9606	15143	67355	12756	11241	7638	9185	7587	2168
1986	918	27110	27818	66383	14644	7988	5696	5422	2127
1987	12149	44160	80213	41504	99222	15226	12639	6082	10187
1988	0	29135	46300	41008	23381	45692	6946	2482	1964
1989	2241	6919	78842	26149	21481	15008	24917	4213	3036
1990	878	24977	19500	151978	24362	20164	16314	8184	1130
1991	675	34437	27810	12420	100444	17921	14865	11311	7660
1992	2592	15519	42532	26839	12565	73307	8535	8203	6286
1993	191	20562	22666	41967	23379	13547	67265	7671	6013
1994	11709	56156	31225	16877	21772	13644	8597	31729	10093
1995	284	34471	35414	18617	19133	16081	5749	8585	14215
1996	4776	24424	69307	31128	9842	15314	8158	12463	6472
1997	7458	56329	25946	38742	14583	5977	8351	3418	4264
1998	7437	72777	80612	38326	30165	9138	5282	3434	2942

	1	2	3	4	5	6	7	8	9
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

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+
1992	1%	8%	22%	14%	6%	37%	4%	4%	3%
1993	0%	10%	11%	21%	12%	7%	33%	4%	3%
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%

Table 5.1.5. Herring in divisions 6.a.S and 7.b–c. Mean weights-at-age in the catches 1970–2018.

	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
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

	1	2	3	4	5	6	7	8	9+
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

Table 5.1.6. Herring in divisions 6.a.S and 7.b–c. Mean weights-at-age in the stock at spawning time 1970–2018.

	1	2	3	4	5	6	7	8	9+
1970	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1971	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1972	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1973	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1974	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1975	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1976	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1977	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1978	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1979	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1980	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1981	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1982	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1983	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1984	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1985	0.100	0.150	0.196	0.227	0.238	0.251	0.252	0.269	0.284
1986	0.098	0.169	0.209	0.238	0.256	0.276	0.280	0.287	0.312
1987	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1988	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1989	0.138	0.157	0.168	0.182	0.200	0.217	0.227	0.238	0.245
1990	0.113	0.152	0.170	0.180	0.200	0.217	0.225	0.233	0.255
1991	0.102	0.149	0.174	0.190	0.195	0.206	0.226	0.236	0.248
1992	0.102	0.144	0.167	0.182	0.194	0.197	0.214	0.218	0.242
1993	0.118	0.166	0.196	0.205	0.214	0.220	0.223	0.242	0.258
1994	0.098	0.156	0.192	0.209	0.216	0.223	0.226	0.230	0.247
1995	0.090	0.144	0.181	0.203	0.217	0.226	0.227	0.239	0.246
1996	0.086	0.137	0.186	0.206	0.219	0.234	0.233	0.249	0.253
1997	0.094	0.135	0.169	0.194	0.210	0.224	0.231	0.230	0.239
1998	0.095	0.136	0.145	0.173	0.191	0.196	0.202	0.222	0.217

	1	2	3	4	5	6	7	8	9+
1999	0.104	0.145	0.154	0.174	0.200	0.222	0.230	0.240	0.246
2000	0.100	0.134	0.157	0.177	0.197	0.207	0.217	0.230	0.245
2001	0.091	0.125	0.150	0.172	0.191	0.200	0.203	0.203	0.216
2002	0.092	0.127	0.146	0.170	0.190	0.201	0.210	0.227	0.229
2003	0.094	0.131	0.155	0.175	0.192	0.203	0.232	0.222	0.243
2004	0.081	0.133	0.151	0.175	0.194	0.207	0.238	0.233	0.276
2005	0.095	0.127	0.15	0.172	0.185	0.196	0.223	0.234	0.274
2006	0.092	0.130	0.133	0.162	0.177	0.186	0.209	0.238	0.247
2007	0.114	0.133	0.133	0.171	0.186	0.196	0.208	0.228	0.229
2008	0.098	0.136	0.140	0.174	0.185	0.196	0.192	0.205	0.234
2009	0.072	0.141	0.162	0.197	0.215	0.223	0.225	0.221	0.286
2010	0.092	0.128	0.157	0.189	0.208	0.227	0.234	0.239	0.247
2011	0.082	0.118	0.136	0.177	0.199	0.207	0.225	0.239	0.240
2012	0.084	0.135	0.182	0.203	0.214	0.226	0.225	0.21	0.226
2013	0.074	0.114	0.140	0.170	0.188	0.198	0.204	0.223	0.222
2014	0.093	0.128	0.135	0.154	0.169	0.170	0.188	0.169	0.206
2015	0.077	0.112	0.146	0.155	0.165	0.173	0.179	0.183	0.217
2016	0.078	0.119	0.147	0.164	0.185	0.191	0.197	0.21	0.175
2017	0.064	0.099	0.130	0.145	0.163	0.173	0.176	0.185	0.180
2018	0.072	0.097	0.126	0.146	0.156	0.168	0.172	0.169	0.170

Table 5.1.7. Herring in divisions 6.a.S and 7.b–c. Sampling intensity of catches in 2018.

Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
6.a.S	4	1495	29	1852	5952	1184
Total	4	1495	29	1852	5952	1184

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

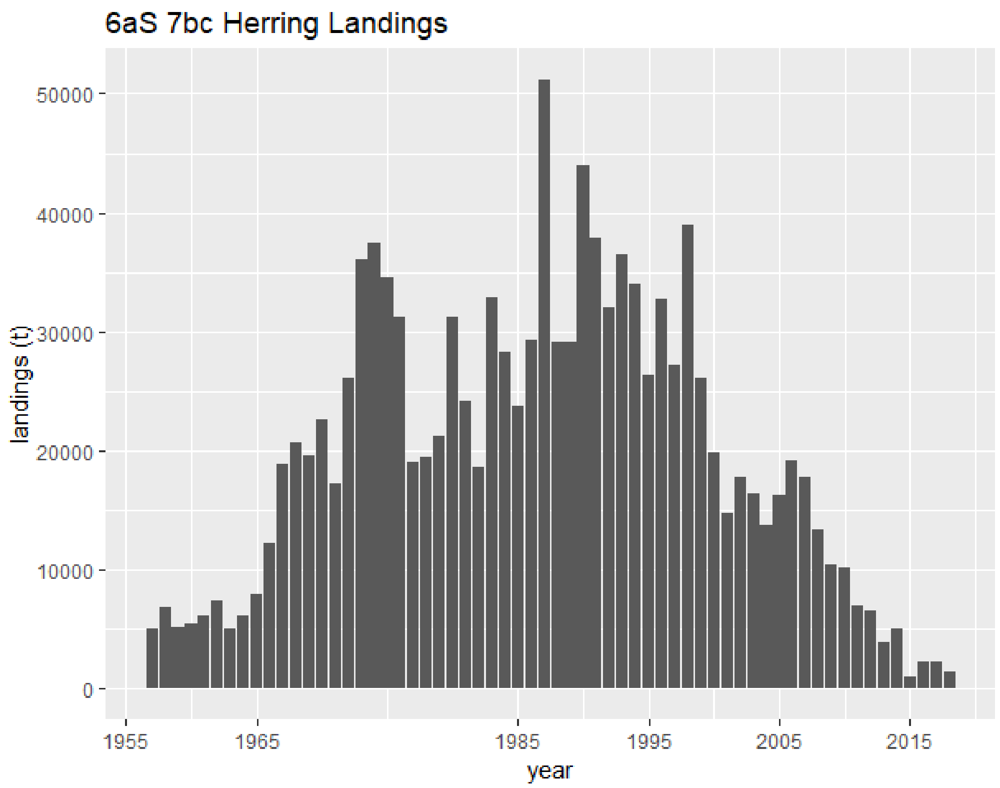


Figure 5.1.1. Herring in divisions 6.a.S and 7.b–c. Working group estimate of catches from 1957–2018.

Figure 5.1.2. Herring in divisions 6.a.S and 7.b–c. catch numbers-at-age standardized by year for the fishery 1957–2018.

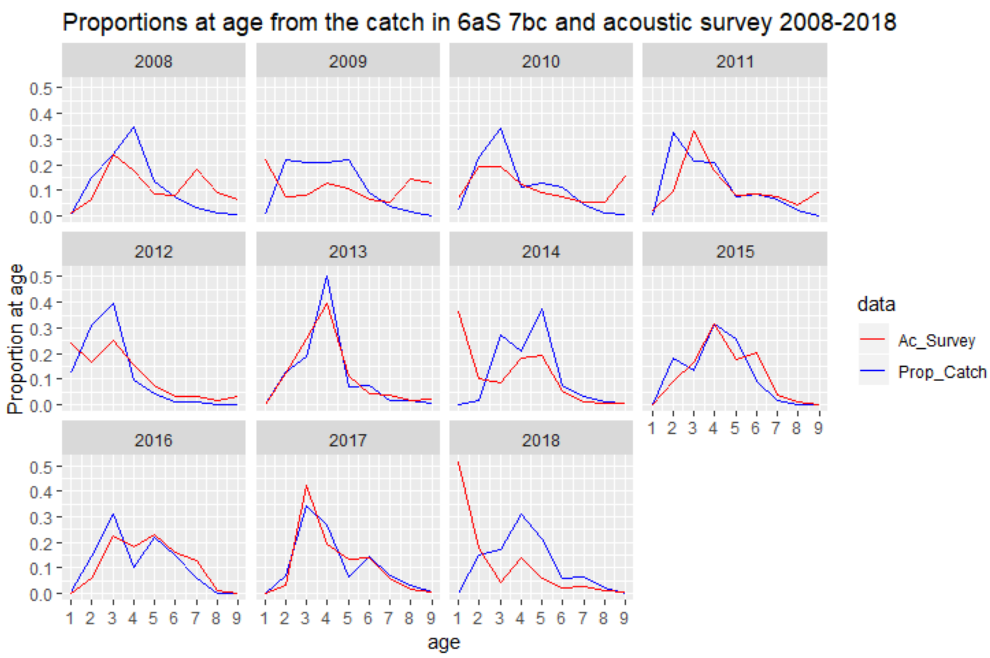


Figure 5.1.4. Herring in divisions 6.a.S and 7.b–c. Percentages-at-age in the 6aS/7.b–c catch and 6aS/7.b–c Malin Shelf acoustic survey (MSHAS) 2008-2018.

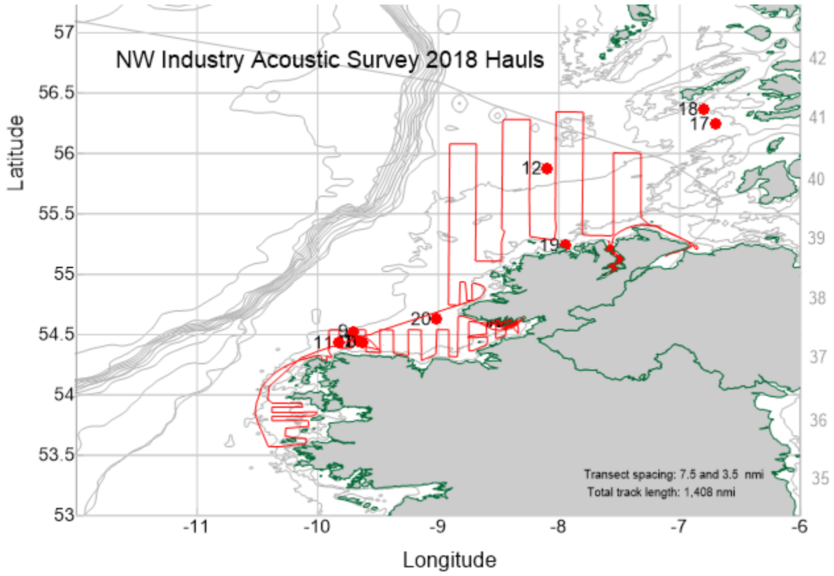


Figure 5.1.5. Herring in divisions 6.a.S and 7.b–c. Acoustic survey in 2018: distribution of biological samples obtained in 6aS.

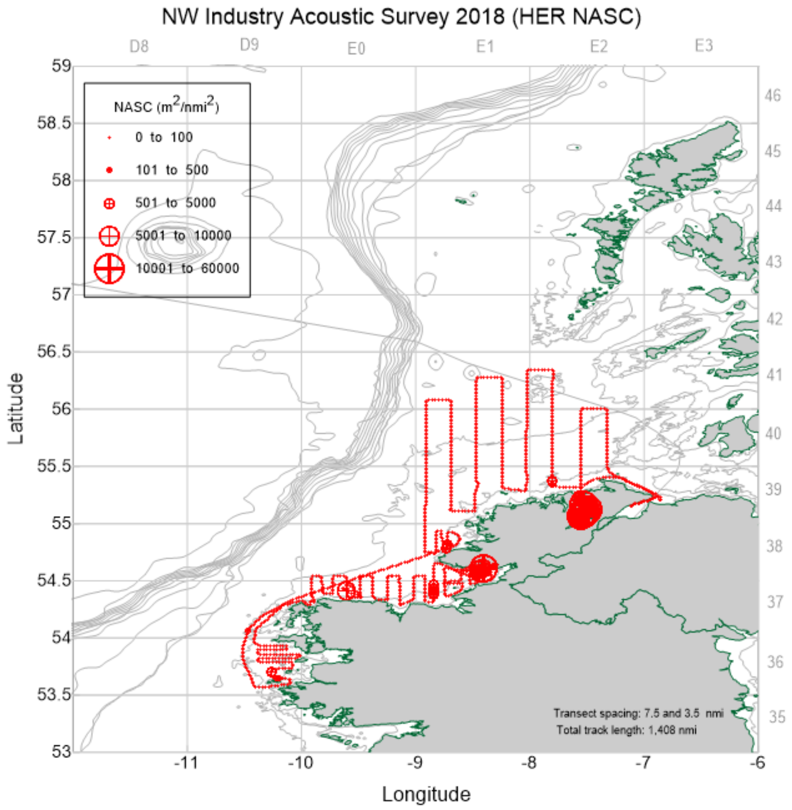


Figure 5.1.6. Herring in division 6.a.S and 7.b–c. Acoustic survey in 2018: NASC of herring.

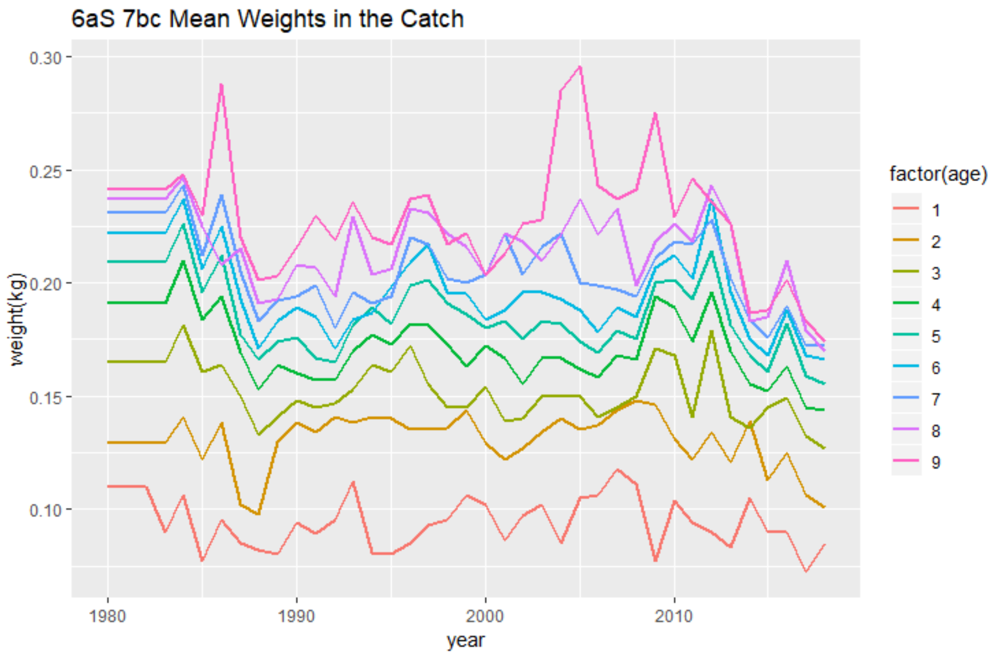


Figure 5.1.7. Herring in divisions 6.a.S and 7.b–c. Mean weights in the catch (kg) by age in winter rings (1980–2018). Prior to 1981 weights were fixed.

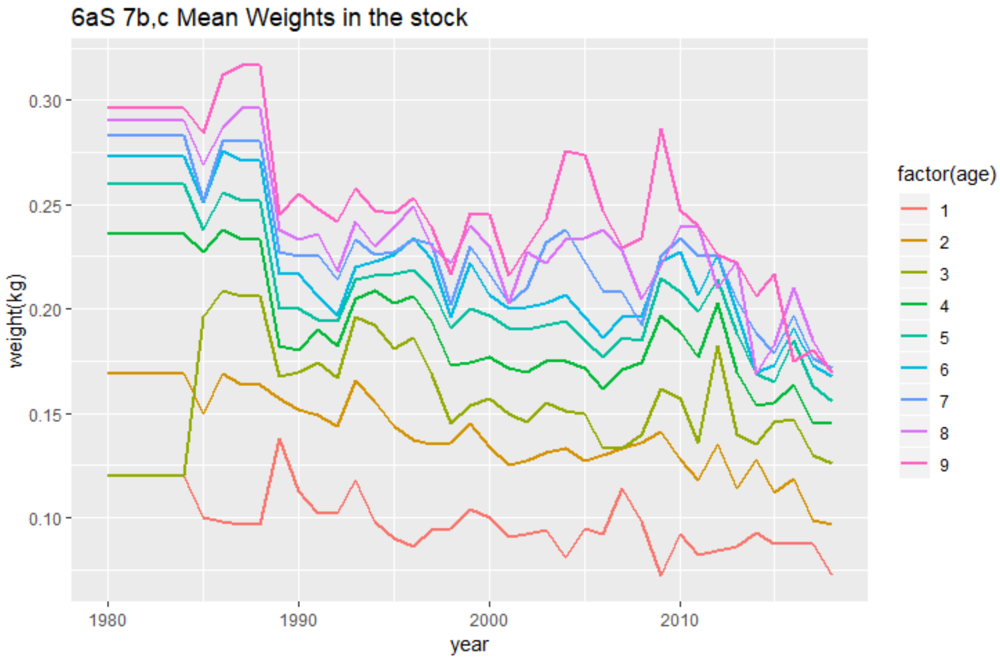


Figure 5.1.8. Herring in divisions 6.a.S and 7.b–c. Mean weights in the stock (kg) at spawning time by age in winter rings (1980–2018). Prior to 1981 weights were fixed.

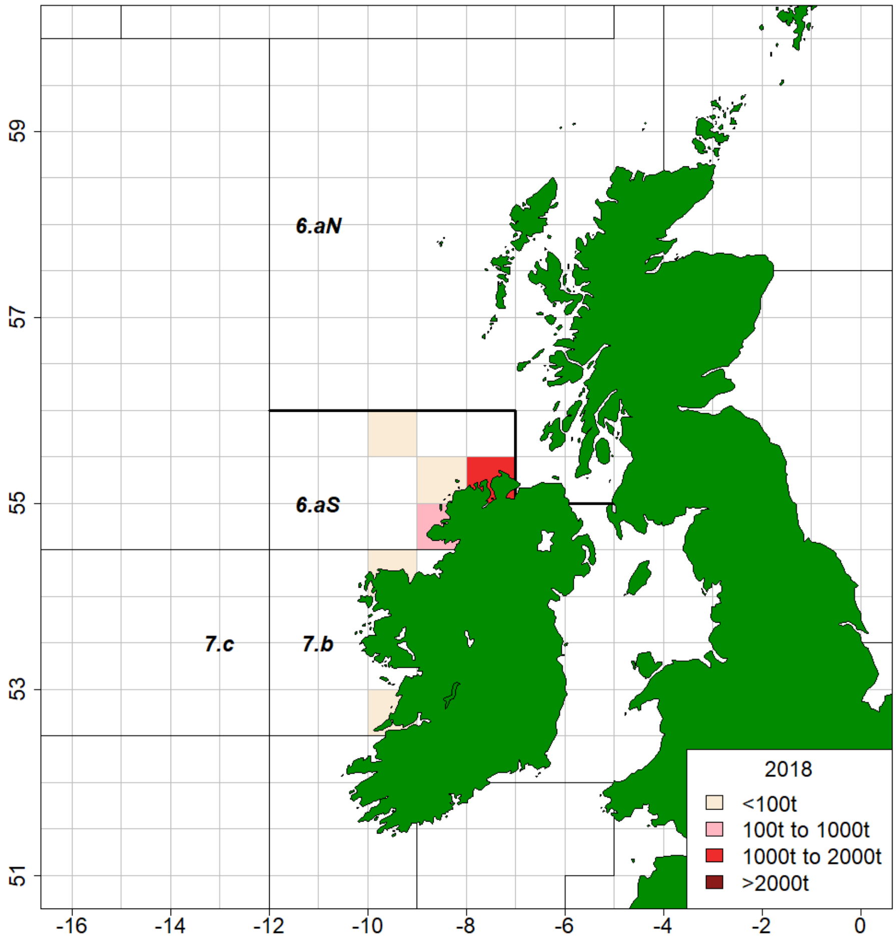


Figure 5.1.9. Herring in divisions 6.a.S and 7.b–c. Irish catches in 2018.

5.2 Herring in Division 6.a (North)

Since 2015 this stock has been combined with herring in 6.aS 7.b–c (Section 5.1) for assessment and advisory purposes. Prior to 2015 6.aN existed as a distinct management unit since 1982 when it was separated from 6.aS 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 the 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 2018

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.aN 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.aN stock component slightly higher than this advice at 4170 t (EU 2016/0203) and the same for 2017 (EU 2017/127) and 2018 ((EU 2018/120).

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.aN and 6.aS 7.b–c and submit relevant data to ICES to assist in assessing the herring stocks and contribute to establishing a rebuilding plan.

Utilizing ICES advice on the monitoring fishery (ICES 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.aN (Figure 5.2.2). Areas 2 and 4 are considered to be active spawning areas and Area 1 a prespawning 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 recent years (ICES 2016). Area 5 was a new addition for 2018 based on evidence from 2017 and local creel fishers of herring on the east side of the North Minch. Systematic acoustic surveys were conducted only in areas 2-5 in 6.aN but *ad hoc* acoustic data recorded by other vessels also.

A limited discard derogation was granted to the vessels during the period of the scientific survey to account for any bycatch of other species and any non-retained catches that could not be landed in marketable condition this particularly being the case for the three Scottish refrigerated-seawater (RSW) vessels.

All vessels completed their scientific survey duties prior to catching their allocated quota. Samples for biological morphometric and genetic data were taken from all areas. Each of the five vessels involved in the survey were assigned specific objectives and provided with a vessel-specific survey manual describing the aims methods and sampling protocols and data recording templates.

Details of the survey are reported in WGIPS ICES (2019) and Mackinson *et al*. (2019).

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)). 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.

5.2.1.4 Catches in 2018

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.

Implementation of the scientific monitoring fishery in 2018 resulted in the 6.aN TAC being split between the seven participating pelagic vessels.

The 2018 official catches of herring in 6.aN total 4063 t compared with the 4170 t monitoring TAC. This included 196 t caught out with the monitoring fishery by primarily as bycatch during the mackerel fishery. There were 4.31 t of non-retained herring catch during the monitoring fishery in 2018 under the discard derogation and 9.76 t of other species (Mackinson *et al.,* 2019).

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

Implementation of the scientific monitoring fishery in 2016–2018 resulted in the 6.aN TAC being split between the seven participating pelagic vessels. In previous years the TAC would have been taken by a larger number of vessels.

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 = 34) were used to allocate the age distribution for the 6.aN catches used in the assessment. One sample provided by Northern Ireland was not used as it contained only 46 fish in total. 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. 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 same principles described in that document were followed in 2018.

The 2012 and 2013 year classes (4 and 5-ringers in 2018) continue to be prominent both in the catch in 6.aN and in the MSHAS_N acoustic survey index (54% of the catch 24% of MSHAS_N index figures 5.2.3 and 5.2.4 Table 5.2.5). These year classes are also coming through clearly in the neighbouring North Sea autumn spawning stock. One ringer herring were absent from the catch again this year which is not unusual. They are observed in survey data in 6.aN intermittently only and are rarely representative of year-class strength.

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 2018 survey values are shown in tables 5.2.4 and 5.2.5.

Full details of the 2018 survey are available in the Report of the Working Group for International Pelagic Surveys (WGIPS ICES 2019 Annex 4c).

Vessel	Period	Strata
Celtic Explorer (IRL) EIGB	03 July–21 July	2 3 4 5 6
Scotia (SCO) MXHR6	29 June–19 July	1 91 (North of 58°30’N) 101 111 121

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 152 kt in 2018 an increase from the estimate of 139 kt in 2017 (Table 5.2.5).

The proportions of each year class in the catch and the survey are shown in Figure 5.2.5. The large proportion of 4-ringers observed in the catches was also evident in the acoustic survey results. The acoustic survey encountered only a very small proportion herring above age 7 (wr) similar to the pattern in the catches.

In contrast to recent years a large proportion of the stock was made up of 1 and 2 winter ring fish this year (64% of the total abundance and 44% of total biomass). As 1 winter ring fish are only sporadically picked up in the survey due to their distribution typically being in the more inshore areas it cannot be confirmed yet whether 2016 is a strong year class but it looks like the 2015-year class (2 winter ringers in 2018) is above average.

5.2.3.2 Acoustic survey- 6.a Herring industry–science survey 2018

An acoustic survey was undertaken to collect acoustic data and information on the size and age of herring required to generate an age-disaggregated acoustic estimate of the biomass of prespawning/ spawning herring in 6.aN. Total herring biomass was estimated to be 118 000 t (Table 5.2.6, figures 5.2.6 5.2.7 and 5.2.8) The survey methods and results were reviewed by ICES WGIPS (2019) who conclude that the survey provides a reliable estimate of the minimum biomass of mature herring at age observed in survey areas 5432 during the survey period. The survey provides a third datapoint in a new SSB survey series.

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 2019) and are given in Table 5.2.4 (for the current year). The weights-at-age in the stock in 2018 were higher for 3 winter rings and similar for other 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 2018 were lower for all age groups compared to 2016 and 2017 except age group 8 which were higher than in 2017 but lower than 2016.

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 2018). The survey provides estimated values for the period 1992–2018 (Table 5.2.9). In 2018 only 48% of age 2 winter ring fish were mature 91% of age 3 winter ring fish. Above age 5 maturity levels were 100%.

5.2.5 Recruitment

There are no specific recruitment indices for this stock. Both catch and acoustic survey recorded no catches of 1-ringer and typically the encounter of this age group occurs only incidentally. The first reliable appearance of a cohort appears at 3-ring in both the catch and the survey for this stock. In 2018 the proportion of 3-ringers was relatively high in the catches but 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.aN 6.aS 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). Details of the 2018 assessment for 6.a (combined) and 7.b–c are outlined in Section 5.6 of this report.

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. The 2008 year class appears to be the only strong year class since 2000 from both the catch data and acoustic survey (Figure 5.2.3). The 2013 year class (4-wr in 2018) was strong in the 2016 catches and again in the 2017 and 2018 in both the catches and survey. This year class was also exceptionally large in the neighbouring North Sea herring stock. There is an almost complete absence in the stock of 8 and 9+ winter ring fish in both the catches and the acoustic survey the last couple of years. The acoustic survey index has been decreasing steadily since 2008. The 2016 value was the lowest on record for this stock. Although the 2017 and 2018 estimates was nearly double of 2016 the stock still remains at a very low level compared to the time-series overall.

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 B_{lim} value. The working group advocates maintaining separate management of each component.

A monitoring TAC of 4170 t was instated since 2016 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 programme has recorded occasional catches of seals and zero catches of cetaceans in the past. The Scottish pelagic discard observer programme 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.aN. 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 1991–2018. 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
Denmark	39
Faroes	
France	7
Germany	17
Ireland	84
Lithuania	
Norway	4
Netherlands	1000
UK	2911
Unallocated	
Discards*	
Total	4063
Area-Misreported	
WG Estimate	4063
Source (WG)	2019

*** Unraised discards.**

Table 5.2.2. Herring in 6.a (North). Catch and sampling effort by nation in the fishery in 2018.

Country	Quarter	Sampled Catch (t)	Official Catch (t)	No. Hauls	No. of samples	No. meas-ured	No. aged	SOP
UK (Sco)	Q1	0	9	-	-	-	-	0%
	Q3	1196	1199	8	8	922	316	99%
UK (NI)	Q1	0	10	-	-	-	-	0%
	Q4	757	758	1	1*	46*	42	100%*
UK(E&W)	Q1	0	7	-	-	-	-	0%
	Q4	925	927	10	9	1553	185	100%
Ireland	Q1	0	67	-	-	-	-	0%
	Q4	0	17	-	-	-	-	0%
Netherlands	Q1	0	1	-	-	-	-	0%
	Q2	0	4	-	-	-	-	0%
	Q3	777	781	12	12	1543	92	99%
	Q4	212	215	4	4	372	82	98%
Others	All	0	68	-	-	-	-	0%
Total		3867	4063	35	34	4436	717	95%

*** This sample was not used in the catch raising as it contained too few fish to be considered representative especially of such a large haul.**

Table 5.2.3. Herring in 6.a (North). Catch in number.
Units: Thousands

Units : thousands

year											
age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	6496	15616	53092	3561	13081	55048	11796	26546	299483	211675	207947
2	74622	30980	67972	102124	45195	92805	78247	82611	19767	500853	27416
3	58086	145394	35263	60290	61619	22278	53455	70076	62642	33456	218689
4	25762	39070	116390	22781	33125	67454	11859	26680	59375	60502	37069
5	33979	24908	24946	48881	22501	44357	40517	7283	22265	40908	39246
6	19890	27630	17332	11631	12412	19759	26170	24227	5120	19344	29793
7	8885	17405	16999	10347	5345	24139	8687	18637	22891	5563	11770
8	1427	9857	7372	6346	4814	6147	13662	8797	18925	17811	5533
9	4423	7159	8595	4617	2582	7082	6088	15103	19531	27083	25799

year											
age	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	220255	37706	238226	207711	534963	51170	309016	172879	69053	34836	22525
2	94438	92561	99014	335083	621496	235627	124944	202087	319604	47739	46284
3	20998	71907	253719	412816	175137	808267	151025	89066	101548	95834	20587
4	159122	23314	111897	302208	54205	131484	519178	63701	35502	22117	40692
5	13988	211243	27741	101957	66714	63071	82466	188202	25195	10083	6879

6	23582	21011	142399	25557	25716	54642	49683	30601	76289	12211	3833
7	15677	42762	21609	154424	10342	18242	34629	12297	10918	20992	2100
8	6377	26031	27073	16818	55763	6506	22470	13121	3914	2758	6278
9	10814	26207	24082	31999	16631	32223	21042	13698	12014	1486	1544

year

age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	247	2692	36740	13304	81923	2207	40794	33768	19463	1708	6216
2	142	279	77961	250010	77810	188778	68845	154963	65954	119376	36763
3	77	95	105600	72179	92743	49828	148399	86072	45463	41735	109501
4	19	51	61341	93544	29262	35001	17214	118860	32025	28421	18923
5	13	13	21473	58452	42535	14948	15211	18836	50119	19761	18109
6	8	9	12623	23580	27318	11366	6631	18000	8429	28555	7589
7	4	8	11583	11516	14709	9300	6907	2578	7307	3252	15012
8	1	1	1309	13814	8437	4427	3323	1427	3508	2222	1622
9	0	0	1326	4027	8484	1959	2189	1971	5983	2360	3505

year

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	14294	26396	5253	17719	1728	266	1952	1193	9092	7635	4511.46
2	40867	23013	24469	95288	36554	82176	37854	55810	74167	35252	22960.61
3	40779	25229	24922	18710	40193	30398	30899	34966	34571	93910	21825.16
4	74279	28212	23733	10978	6007	21272	9219	31657	31905	25078	51420.22
5	26520	37517	21817	13269	7433	5376	7508	23118	22872	13364	15504.75
6	13305	13533	33869	14801	8101	4205	2501	17500	14372	7529	9002.21
7	9878	7581	6351	19186	10515	8805	4700	10331	8641	3251	3897.69
8	21456	6892	4317	4711	12158	7971	8458	5213	2825	1257	1835.56
9	5522	4456	5511	3740	10206	9787	31108	9883	3327	1089	576.39

year

age	2001	2002	2003	2004	2005	2006	2007	2008
1	147.07	992.20	56.11	0.00	182.50	132.46	130.75	0.00
2	83318.40	38481.61	33331.96	7235.79	9632.71	6691.49	34326.00	7898.43
3	15368.56	93975.05	46865.58	23483.32	23236.71	9186.07	17754.83	13039.08
4	9569.99	9014.40	53766.66	29421.79	20602.39	13644.88	6555.14	5427.59
5	25175.08	18113.71	7462.98	48394.28	10237.93	41067.79	14264.99	3219.52
6	9544.89	28016.08	4344.55	4151.94	9783.17	27781.86	30566.16	5688.56
7	6813.78	9040.10	12818.38	8100.36	1014.99	20972.98	21517.07	14832.27
8	4741.98	1547.87	9187.62	9023.67	1194.95	3041.71	13585.45	8142.31
9	1028.78	1422.68	1407.96	4265.93	1430.76	5088.99	4242.60	8968.60

year

age	2009	2010	2011	2012	2013	2014	2015	2016
1	1923.62	10074.12	1667.19	979.53	0.00	0.00	231.18	12
2	11508.54	20339.85	40587.92	14952.63	13681.14	8705.73	10854.96	8148
3	10475.63	16331.31	15782.93	46647.39	18181.74	15144.82	13937.56	3341
4	16586.96	9957.96	10333.90	9704.45	53116.88	21063.66	15716.60	3197
5	8332.17	14608.15	7190.29	8097.30	11681.99	42229.47	19386.70	2791
6	5688.68	6322.33	5071.43	6311.66	7093.01	7130.95	21621.33	2821
7	7514.70	4322.24	3164.16	3873.67	5098.64	2944.09	6397.35	3148
8	11793.98	5388.91	2611.38	1129.80	4324.63	2854.21	1932.73	739
9	9443.85	13199.28	7225.68	4013.80	5031.77	3511.43	1250.55	431

year

age	2017	2018
1	0.00	0.00
2	1122.16	1508.98
3	11929.71	3215.53

```
4  4082.50 6873.26
5  2075.35 5253.61
6  1443.79 3068.25
7  1416.35  844.50
8   767.37  852.31
9   273.34  680.89
```

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 6a (N) part not including Clyde and North Channel of the MSHAS survey in July 2018.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	294	0.7	0.00	2.5	6.6
1	964	46.1	0.00	47.8	17.5
2	323	35.5	0.48	110.0	22.9
3	92	14.3	0.91	155.0	25.6
4	331	58.2	0.98	176.1	26.8
5	153	29.0	0.98	190.1	27.5
6	51	10.6	1.00	209.7	28.7
7	72	15.1	1.00	209.4	28.8
8	27	5.8	1.00	218.0	29.1
9+	13	2.8	1.00	222.2	29.3
Immature	1443	67		46.1	16.0
Mature	875	152		173.2	26.6
Total	2318	218	0.38	94.1	20.0

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

Table 5.2.6. Total Abundance and overall biological composition of herring in 6.a North from the industry acoustic survey in 2018.

Age	Abundance	Mature	Spawning	Biomass	Mean length	Mean weight
	('000s)			(t)	(cm)	(g)
1	3454	0%	0%	198	19.1	57.3
2	14252	98%	3%	1918	25.5	134.6
3	57465	99%	31%	9335	26.7	162.4
4	18576	97%	27%	3366	27.9	181.2
5	8360	100%	40%	1764	28.8	210.9
6	7806	98%	37%	1676	29.4	214.7
7	5307	99%	35%	1215	29.6	229.0
8	1895	100%	54%	447	30.1	235.6
9	593	100%	60%	126	29.0	211.8
10	225	100%	40%	60	31.2	266.7
Immature	4958	-	-	425	21.5	85.7
Mature	112980	-	-	19679	27.3	174.2
Spawning*	33063	-	-	6149	27.8	186.0
TOTAL	117937			20104	27.1	170.5

***Spawning herring is a subset of the mature herring.**

Table 5.2.7. Herring in 6.a (North). 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	0.000	0.000

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	0.0750	0.055	0.059	0.068	0.057	0.066	0.06366667	0.064
2	0.1296	0.135	0.1675	0.172	0.151	0.162	0.132	0.150	0.15500000	0.108
3	0.1538	0.166	0.1830	0.191	0.206	0.194	0.160	0.183	0.16500000	0.158
4	0.1665	0.185	0.1914	0.208	0.223	0.227	0.208	0.189	0.20200000	0.180
5	0.1802	0.192	0.1951	0.214	0.233	0.239	0.236	0.206	0.21000000	0.206
6	0.1911	0.204	0.1951	0.214	0.231	0.248	0.245	0.217	0.23600000	0.214
7	0.2125	0.211	0.2021	0.221	0.232	0.258	0.238	0.214	0.24300000	0.231
8	0.2030	0.224	0.2034	0.224	0.232	0.226	0.222	0.218	0.24500000	0.244
9	0.2284	0.231	0.2138	0.238	0.238	0.212	0.253	0.215	0.25400000	0.264

year

age	2015	2016	2017	2018
1	0.06373333	0.0638	0.0638	0.0478
2	0.15500000	0.1370	0.1350	0.1100
3	0.18300000	0.1400	0.1700	0.1550
4	0.19500000	0.1750	0.1810	0.1761
5	0.20400000	0.2020	0.1980	0.1901
6	0.21100000	0.2080	0.1990	0.2097
7	0.21700000	0.2090	0.2140	0.2094
8	0.21500000	0.2100	0.2230	0.2180
9	0.22000000	0.2420	0.2360	0.2222

Table 5.2.8. Herring in 6.a (North). 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	0.079	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

year

age	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

year

age	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

year

age	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

year

age	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	0.1580	0.1667	0.1705	0.1726	0.1549	0.1550	0.1469	0.1441
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

year

age	2014	2015	2016	2017	2018
1	0.0000	0.0769	0.100	0.000	0.000
2	0.1451	0.1425	0.144	0.137	0.126
3	0.1877	0.1795	0.178	0.167	0.151
4	0.2030	0.2059	0.204	0.187	0.174
5	0.2279	0.2136	0.219	0.204	0.190
6	0.2449	0.2307	0.229	0.213	0.208
7	0.2608	0.2386	0.237	0.221	0.218
8	0.2614	0.2454	0.251	0.233	0.238
9	0.2835	0.2685	0.257	0.249	0.246

Table 5.2.9. Herring in 6.a (North). 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	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

	year
age	2018
1	0.00
2	0.48
3	0.91
4	0.98
5	0.98
6	1.00
7	1.00
8	1.00
9	1.00

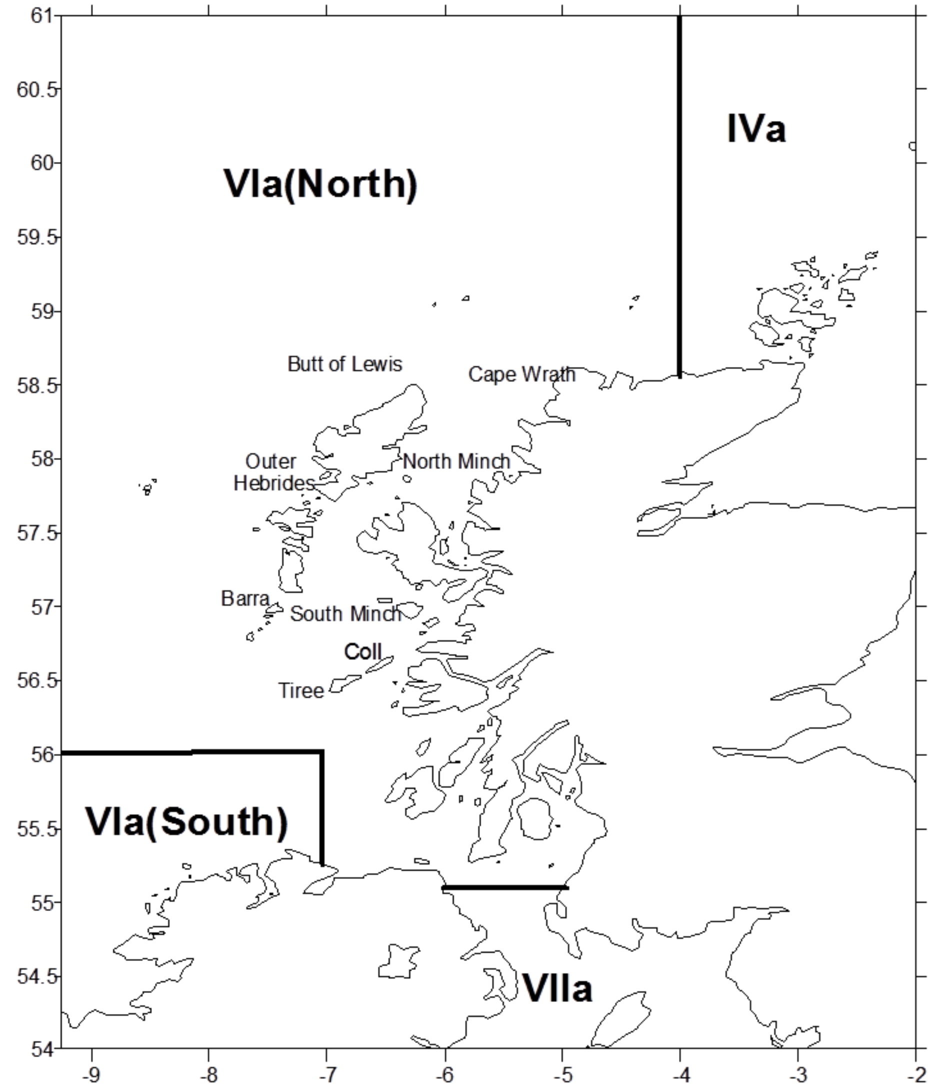


Figure 5.2.1. Location of ICES area 6.a (North) and adjacent areas with place names.

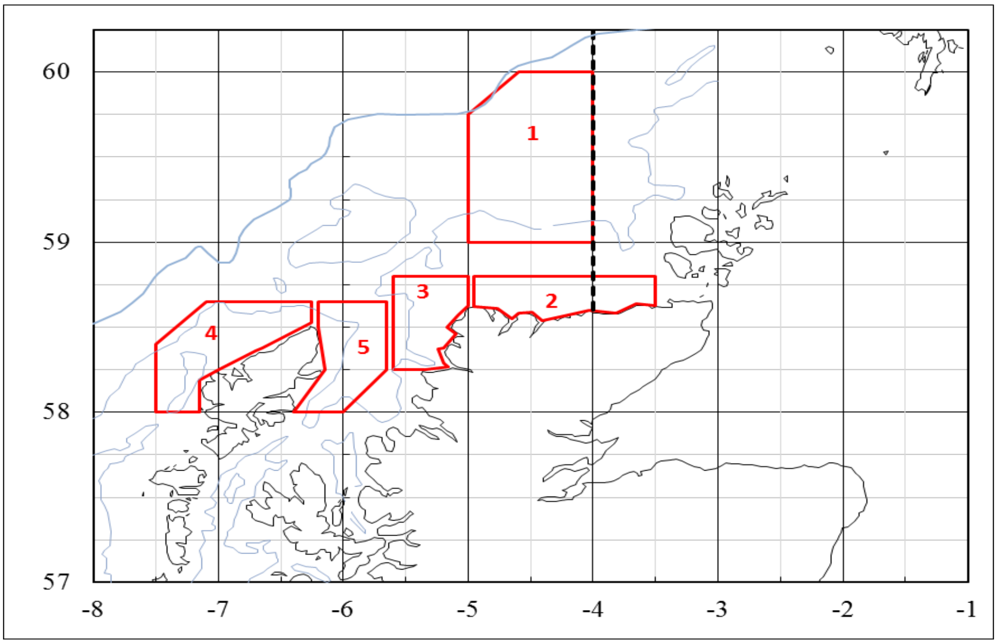


Figure 5.2.2. Planned survey areas used in the 6.a North surveys. Area 1- North pre-spawning mixing area Area 2 -East of cape Wrath Area 3 – The Minch Area 4 – Outer Hebrides Area 5 – east Minch.

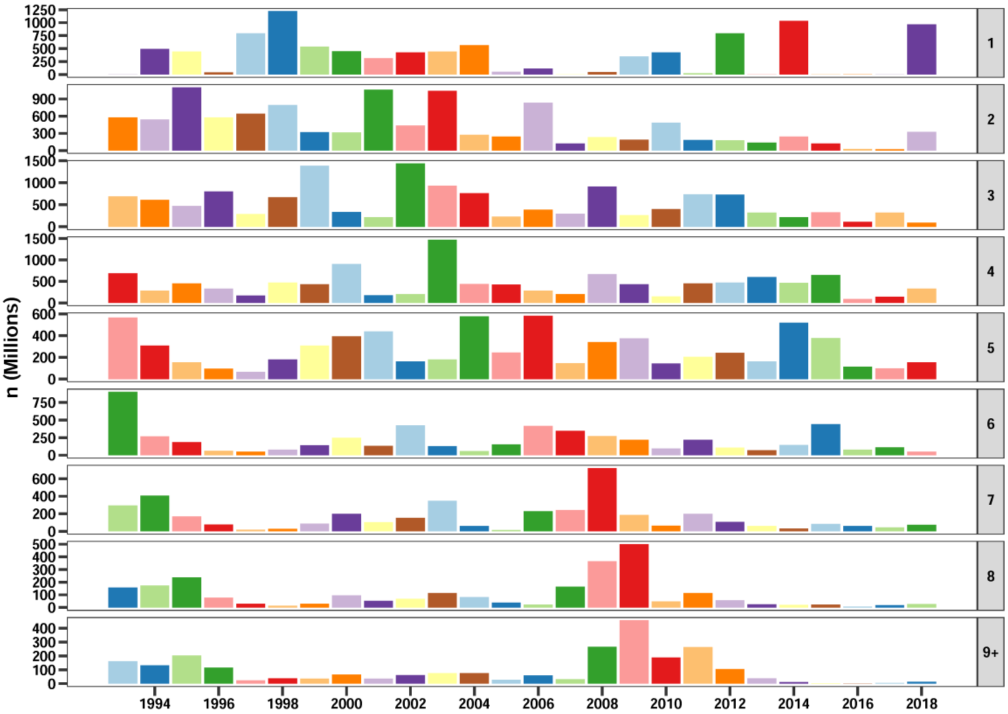


Figure 5.2.3. Herring in 6.a (North). West of Scotland (6.aN) autumn spawning herring subset from MSHAS indices (millions) by age (winter rings) and year from the acoustic surveys 1993–2018. Age 9+ includes ages 9 and older.

Figure 5.2.4. Herring in 6.a (North). Mean standardized catch numbers-at-age standardized by age 1957 to 2018.

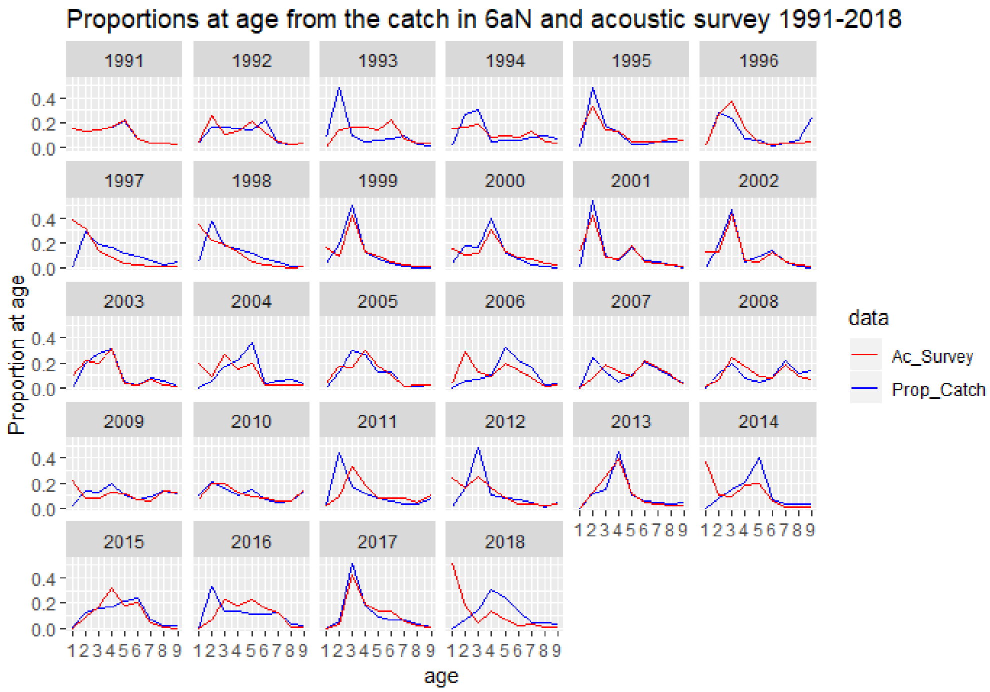
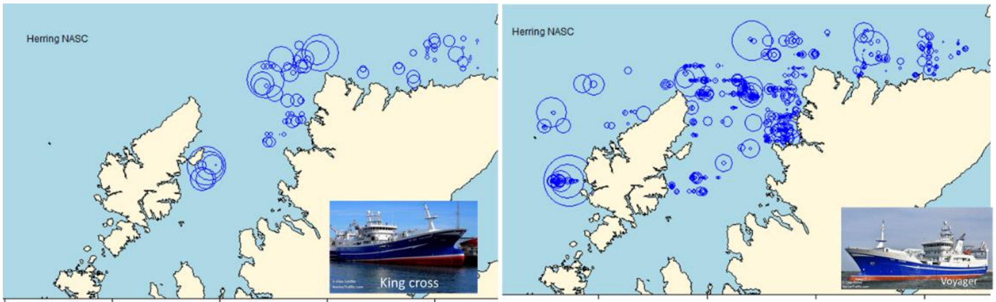
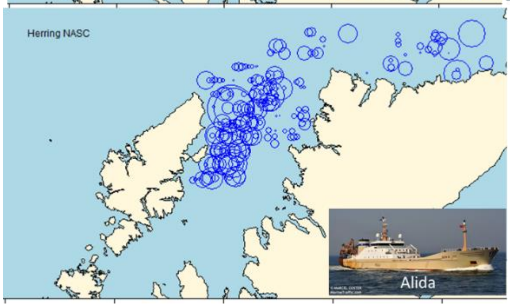


Figure 5.2.5. Herring in 6.a (North). Comparison of the proportions-at-age by year class in the acoustic survey and the catch 1991-2018.





AREA	MAXIMUM ESTIMATE SSB (T)	SURVEY VESSEL
4	37.1	Voyager
5	45.2	Alida
3	23.4	Kings Cross
2	12.1	Voyager
TOTAL	118 t	

Figure 5.2.6. Maps of relative acoustic density (NASC m²/mn²) recorded during the 2018 6.aN herring industry–science survey. Bottom right panel – derived biomass estimates for each area (details in WGIPS 2019).

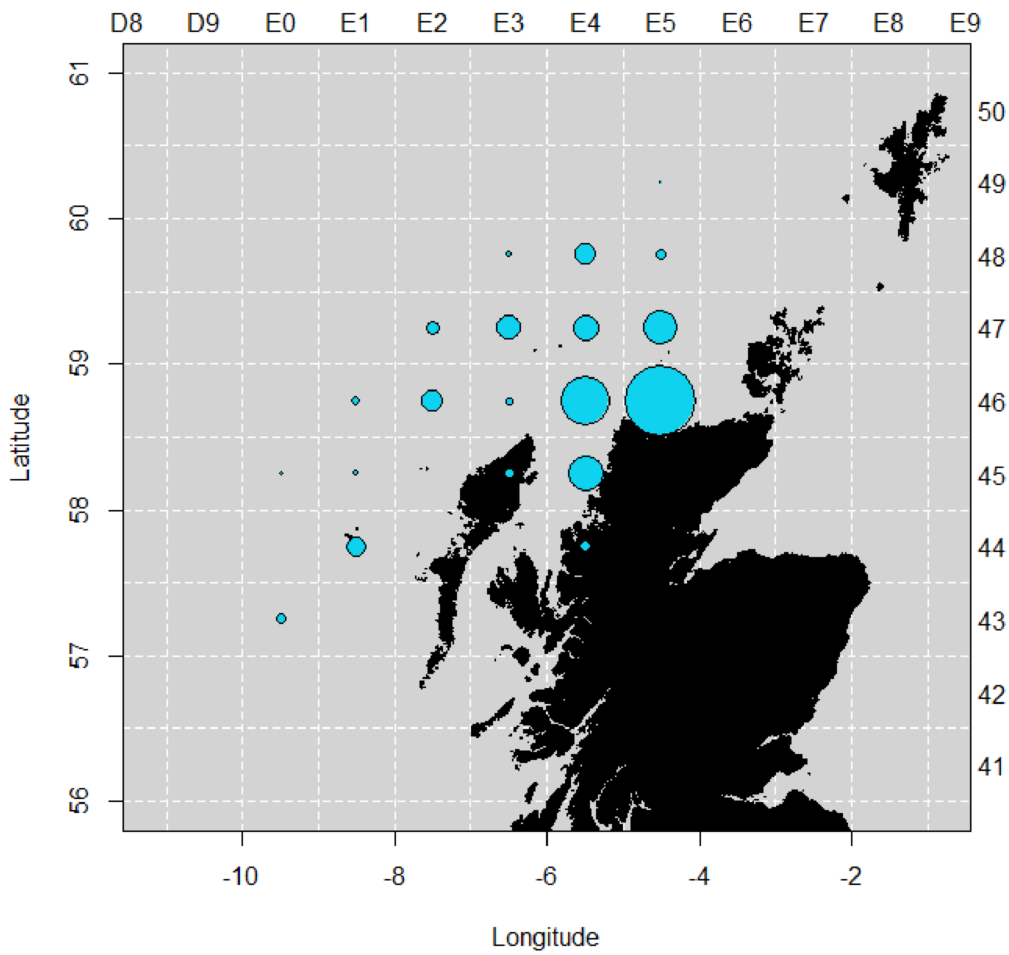


Figure 5.2.7. Herring in 6.a (North). Herring catches in tonnes in all quarters in 2018 by statistical rectangle. (Radius of bubbles of 0.25 degrees latitude = 3000 t). WG estimates.

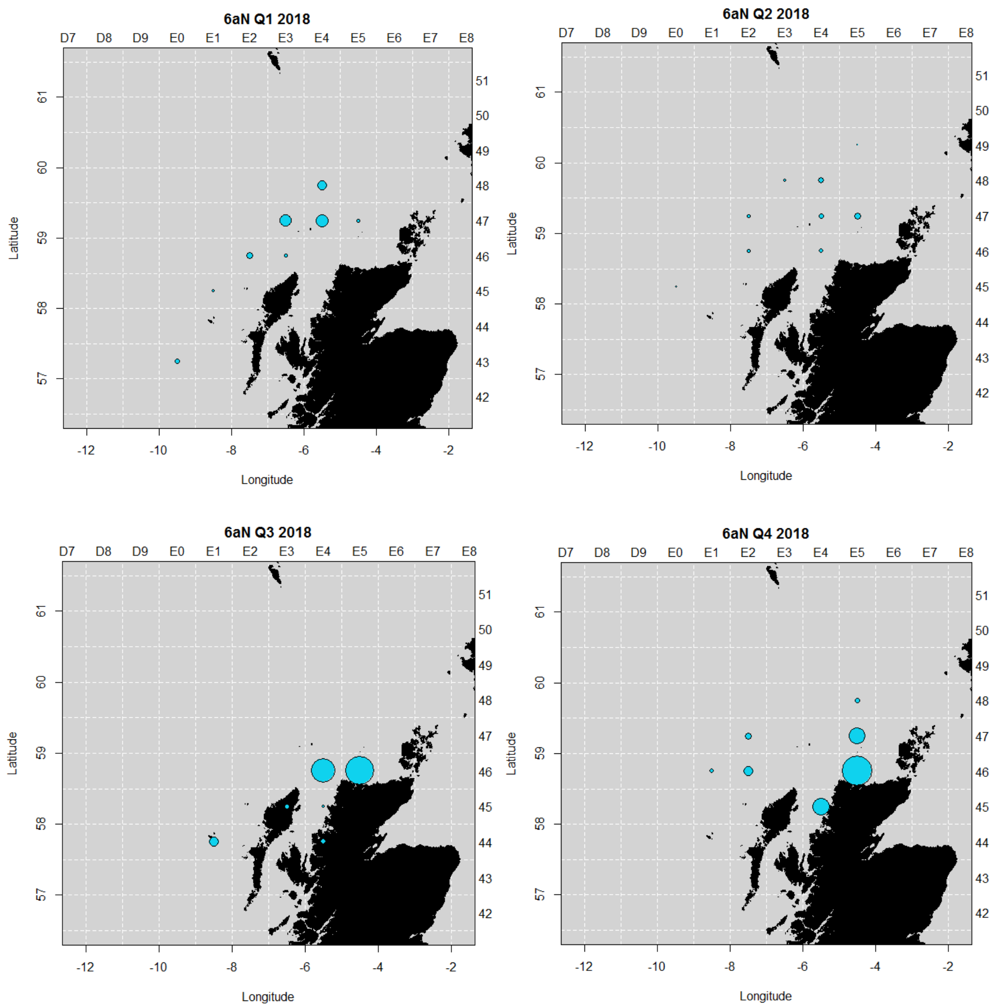


Figure 5.2.8. Herring in 6.a (North). Herring catches in tonnes by quarters in 2018 by statistical rectangle (Radius of bubbles of 0.25 degrees latitude = 3000 t). WG estimates.

References

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/01/2018. Marine Institute

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 1 April until 31 March. Unless otherwise stated, year and year class are referred to by the first year in the season i.e. 2018 refers to the 2018–2019 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 2018–2019

The TAC is set by calendar year and in 2018 was 10 127 t (agreed by the Council of the European Union, based on the long-term management plan). The TAC for 2019 is 4742 t (based on the ICES MSY approach).

Long-Term Management Plan

A long-term management plan has been proposed by the Pelagic RAC. The most recent evaluation of this plan took place in 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 2018–2019

In 2018 the Irish fishery took place in 7.g in Q3 and in 7.g and 7.a.S in Q4.

The Netherlands reported catches of just over 400 t coming from 7.g and 7.h, Germany, France and the UK did not utilize their quota. 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 2018 landings is presented in Figure 6.1.2.1. There was not full quota uptake in 2018.

The estimated catches from 1988–2018 for the combined areas 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 2018–2019 season decreased to about 4400 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.aS from the 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.aS 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.aS 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 technology and fishing patterns

The fishery in the past number of years has changed compared to previous years. In recent years, herring have been found very close to the bottom in the main fishery, in the acoustic dead-zone of the echosounder, particularly offshore in Division 7.g. The fishery reports that herring are often not visible on echosounders at all. Tow duration has increased markedly because it takes longer to catch the desired quantity of herring. In 2017, the fishery was concentrated offshore initially, but effort shifted to more inshore areas in Division 7.g when herring became difficult to locate offshore. It was difficult for the Irish fleet to catch its quota in 2017. The fishery in 2018 was mainly concentrated inshore in 7.g with no significant offshore fishery. Irish vessels had difficulty catching the quota again in 2018.

Vessels greater than 50 feet total length are excluded from 7.aS 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).

The increase in the TAC from 2010 attracted more Irish vessels, and some non-Irish vessels to fish this stock. Irish quota is allocated to vessels on a weekly basis. The large number of vessels involved has led to individual quotas being reduced. This initially led to increased discarding risk due to vessels being unable to catch their small allocations without extra-quota catches that are often slipped. However, in 2012, flexibility was introduced to the system, whereby a vessel could use some of the following week’s quota to mitigate slippage.

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 four herring directed discard trips in 2018 with no discarding observed.

Estimates of discarding from observer trips for the purposes of marine mammal bycatch studies, reported 1% discarding in 2012, 0.8% in 2013 (McKeogh and Berrow, 2013), 3.4% in 2014 (McKeogh and Berrow, 2014), 1.4% in 2015 in the main fishery and 1.5% in the 7.aS 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 and no discard estimates were available.

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 to 2018. Three winter ring fish were the main age class in 2018, followed by 2- and 4-wr respectively (Table 6.2.1.1). The yearly mean standardized catch numbers-at-age are shown in Figure 6.2.1.1. Older ages (8 and 9 wr) are present in very small numbers in 2018. 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 2018. 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.

Length–frequency data by division and quarter are presented in Table 6.2.1.2. The greatest length range was found in 7.g Q4. The fishery here took place inshore and smaller fish were encountered here.

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 2018. Under the Data Collection Framework the sampling of this stock is well above that required by the Minimum Programme (Section 1.5).

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 2018, excluding 2004 and 2017. 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 presented in Figure 6.3.1.4.

The acoustic survey of the 2018–2019 season was carried out from 8 to 28 October 2018, on the Celtic Explorer http://hdl.handle.net/10793/1385 (O'Donnell *et al.*, 2018). Survey effort for the core area consisted of 2311 nautical miles of transects for acoustic integration and the geographical coverage was 19 347 square nautical miles. The three adaptive surveys accounted for 459 nautical miles of transects covering an area of 3304 square nautical miles. The acoustic survey track is shown in Figure 6.3.1.1.

The 2018 survey consisted of replicate surveys (two broad-scale, and three adaptive mini-surveys) covering the same area. The highest biomass estimate from the broad-scale surveys was used to estimate numbers-at-age for the assessment (i.e. Pass 1 in 2018). NASC distribution plots from the broad-scale survey are presented in Figure 6.3.1.2 and from the adaptive mini survey in Figure 6.3.1.3. Herring TSB (total-stock biomass) and abundance (TSN) estimates from the 2018 survey were 9788 t and 213 491 individuals respectively.

A total of 15 trawl hauls were carried out during the survey in 2018, with four hauls containing >50% herring by weight of catch. All hauls contained some herring. A total of 529 herring were aged from survey samples in addition to 1668 length measurements and 807 length–weights recorded. Herring age samples ranged from 0–8 winter-rings.

Immature 0-group herring were observed across the survey area, appearing in every haul in small numbers. The presence of this year class was reported further east toward the UK coast by the RV Cefas Endeavour as part of the PELTIC survey program that takes place at the same time (J. Vanderkooij, pers. comm.). Overall, the contribution of 0-group herring accounts for over 51% of the total stock abundance for the Pass 1 estimate. This signal is encouraging as a potential source of recruitment in a period of low stock abundance and persistent poor recruitment.

The contribution of 1-winter ring fish from around the Cork Harbour area is an annual occurrence in low background numbers. In 2018, this age group represents a significant contribution to the overall biomass (31.7% of TSB and 26.1% of TSN). It is important to note that this proportion is relative to the low contribution of other age classes in the overall low abundance estimate and not a sign of a stronger than normal year class for this cohort.

The spawning-stock-biomass (SSB) estimate in 2018 represents one of the lowest SSB points in the current time-series. The absence of the offshore migratory component of the stock within the wider survey area cannot be attributed to containment as good area coverage was attained.

WGIPS have highlighted in recent years that herring are frequently distributed close to the bottom, within the acoustic dead-zone of the echosounder and therefore it is difficult to accurately estimate the biomass in the survey area. This behaviour was not observed in 2018 and there were no herring observed offshore in the survey.

In 2018 the Western European Shelf Pelagic Acoustic Survey (WESPAS) directed at boarfish, horse mackerel and herring on the Malin Shelf, also had some coverage in the Celtic Sea. An abundance estimate for Celtic Sea herring was calculated for this survey in 2018 http://hdl.handle.net/10793/1380 but cannot be used for stock assessment purposes. This survey will continue in 2019 and methods will be further refined to increase the precision of future estimates. This survey has the potential to be used as an index for the Celtic Sea herring stock when a sufficient time-series of data becomes available.

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 mid-1980s. After a slight increase around 2008, they have declined again. In 2018 slight increases in mean weights at some ages can be seen. Mean weights in the stock at spawning time were calculated from biological samples from the Q4 (Figure 6.4.1.2). The overall trends in stock weights are as in 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 ICES, 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 ring and excluding the 2017 survey. The input data are presented in tables 6.6.1.1 and 6.6.1.2. The ASAP settings are as per the 2018 inter-benchmark and are presented in (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 are no clear patterns in the residuals. Figure 6.6.1.2 shows the observed and predicted catches. In general, the model followed the observed catches quite closely. The observed and predicted catch proportions-at-age are shown in Figure 6.6.1.3. There is some divergence in the most recent year, most notable at 3 wr with a larger proportion observed than predicted. 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. 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 from ASAP is shown in Figure 6.6.1.8. The Mohn's Rho on SSB (Mohn, 1999) is calculated as -0.17 over a five-year peel. This is a slight increase on the 2018 assessment where the Mohns Rho on SSB was -0.12.

Figure 6.6.1.9 shows uncertainties over time in the assessment estimates. The greatest uncertainty is seen with the estimates of recruitment. 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 2018 and the update ASAP assessment in 2019 are presented in Figure 6.6.1.10 and the stock summary in Table 6.6.1.4. The assessment shows SSB is declining and is estimated to be 22 977 t in 2018. The stock is currently below B_{pa} and B_{lim}.

Mean F (2–5 ring) in 2018 is estimated as being 0.33, which is a decrease from 2017 when F was 0.64. F is above F_{pa} and F_{MSY} and just below F_{lim}. Recruitment was good for several years with strong cohorts in 2005, 2007, 2009, 2010, 2011, and 2012 having entered the stock. Recruitment has been lower in recent years and has been below the long-term average since 2013.

6.7 Short-term projections

6.7.1 Deterministic Short-Term Projections

An updated procedure for STF was performed, using the procedure agreed at the 2014 benchmark (ICES 2014/ACOM 43). The 2019 short-term forecast follows the benchmark procedures.

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 (2017). As this SSB value (21 999 t) is below the change-point (47 575 t), the following adjustment is applied.

Recruitment (forecast year) = plateau recruitment *(SSB forecast year -2) / SSB Changepoint)

Recruitment 2019 = 441 902 * (21 999/47 575) = 204 340

Interim year catch was taken to be the TAC, plus carryover on the national quotas. Non-Irish intermediate year catches were further adjusted based on recent quota uptake. The intermediate year catch was estimated as 5320 t.

A deterministic short-term forecast was performed using 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 2020.

6.7.2 Multiannual short-term forecasts

No multiannual simulations were conducted in 2019.

6.7.3 Yield-per-recruit

No yield-per-recruit analyses were conducted in 2019.

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 advises that the harvest control rule 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. The long-term management plan is no longer used to give advice for this stock.

Further simulations are currently being conducted as part of the development of a rebuilding plan for this stock. Harvest control rules with different F values and constant catch options are being explored using the SimpSIM simulation package.

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}	0.27	$F_{pa} = F_{lim} \times \exp(-1.645 \times \sigma F)$, where σF = 0.30 from assessment uncertainty (capped) in the terminal year	ICES (2018a)

6.10 Quality of the Assessment

Figure 6.6.1.9 shows uncertainties over time in the assessment estimates. The uncertainties for the key parameters (SSB, recruitment and F) 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 2018 are compared with the assessment outputs in 2019 and are shown in the text table below. The assessment in 2019 shows a more pessimistic outlook for this stock with SSB revised downwards and F revised upwards. This can also be seen in the historical retrospective plot in Figure 6.10.1

2018 Assessment				2019 Assessment				% change in the estimates	
Year	SSB	Catch	F 2-5	Year	SSB	Catch	F 2-5	SSB	F 2-5
2016	46734	16,318	0.41	2016	35398	16318	0.58	-24%	42%
2017	35738	10767	0.41	2017	21999	10767	0.64	-38%	56%
2018*	36139	10,887	0.44	2018	22977	4418	0.33	-36%	-24%

*** from intermediate year in STF.**

The 2018 acoustic survey estimate is the lowest in the current time-series. The survey time-series used in the assessment includes data from 2002 to 2018 (no survey in 2014 and the 2017 survey excluded). Since 2014, herring have been observed close to the bottom, and less reliably estimated by the acoustic survey.

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 currently forecast to be below B_{lim} in 2019. Fishing is currently above F_{MSY} of 0.26.

The advice provided for this stock for 2020 is based on the ICES MSY approach. The basis for the advice is the same as previous years. The TAC however was set according to the long-term management plan from 2012–2018. Evaluations conducted in 2018 found that the long-term management plan is no longer precautionary (ICES, 2018). A rebuilding plan is currently being developed for this stock

A change in fish behaviour has been observed by the acoustic survey since 2014. The fish have been observed close to the bottom and have been difficult to detect acoustically.

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*. (in prep) 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). It should be noted that declines in mean weights, examined by Harma *et al.* (2013) 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), 1988–2018. (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

*** 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) 1988/1989–2018/2019. (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

*** 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 1970–2018/2019. 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%
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%

Year	1	2	3	4	5	6	7	8	9
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%

Table 6.2.1.2. Herring in the Celtic Sea. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2018/2019 season.

Length cm	7G Q4	7aS Q4
17.5	10	
18	10	
18.5	20	
19	99	
19.5	139	163
20	288	163
20.5	198	325
21	347	
21.5	496	163
22	1190	650
22.5	1329	650
23	2589	650
23.5	3779	325
24	5376	1300
24.5	4176	488
25	2291	488
25.5	1289	488
26	714	975
26.5	298	325
27	317	650
27.5	79	163
28	40	
28.5	20	163
29		
29.5		
30	10	
30.5		

Table 6.2.2.1. Herring in the Celtic Sea. Sampling intensity of commercial catches (2018–2019). Only Ireland provides samples of this stock.

Division	Year	Quarter	Catch (t)	No. Samples	No. Measured	No. aged	Aged/1000 t
7.g	2018	3	311	0			
7.g	2018	4	2787	11	2531	549	197
7.aS	2018	4	884	1	50	50	57
Total	2018		3982	12	2581	599	150

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; it was not recommended for tuning by HAWG in 2018; the single biological sample of herring obtained on the survey in 2017 was considered not adequate.

	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008	2008 2009	2009 2010	2010 2011	2011 2012	2012 2013	2013 2014
0	0	24	-	2	-	1	99	239	5	0	31	4
1	42	13	-	65	21	106	64	381	346	342	270	698
2	185	62	-	137	211	70	295	112	549	479	856	291
3	151	60	-	28	48	220	111	210	156	299	615	197
4	30	17	-	54	14	31	162	57	193	47	330	43
5	7	5	-	22	11	9	27	125	65	71	49	38
6	7	1	-	5	1	13	6	12	91	24	121	10
7	3	0	-	1	-	4	5	4	7	33	25	5
8	0	0	-	0	-	1		6	3	4	23	0
9	0	0	-	0	-	0		1		2	3	1
Nos.	423	183	-	312	305	454	769	1147	1414	1300	2322	1286
SSB	41	20	-	33	36	46	90	91	122	122	246	71
CV	.49	.34	-	.48	.35	.25	.20	.24	.20	.28	.25	.28

	2014 2015	2015 2016	2016 2017	2017 2018	2018 2019
0	0	0	0	0	109
1	41	0	125	0	55
2	117	40	21	6	16
3	112	48	43	3	27
4	69	41	40	7	6
5	20	38	36	5	0
6	24	7	25	4	0
7	7	6	5	1	-
8	17	5	6	1	-
9	1	0	0	0	
Nos.	408	184	301	27	213
SSB	48	25	30	4	8
CV	0.59	0.18	0.33	-	49.6

Table 6.6.1.1. Herring in the Celtic Sea: Natural mortality inputs to the ASAP model. Age is in winter rings.

Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Maturity inputs to the ASAP model. Age is in winter rings.

Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
0.5	1	1	1	1	1	1	1	1

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Weight-at-age in the catch inputs to the ASAP model. Age is in winter rings.

	1	2	3	4	5	6	7	8	9
1958	0.096	0.115	0.162	0.185	0.205	0.217	0.227	0.232	0.23
1959	0.087	0.119	0.166	0.185	0.2	0.21	0.217	0.23	0.231
1960	0.093	0.122	0.156	0.191	0.205	0.207	0.22	0.225	0.239
1961	0.098	0.127	0.156	0.185	0.207	0.212	0.22	0.235	0.235
1962	0.109	0.146	0.17	0.187	0.21	0.227	0.232	0.237	0.24
1963	0.103	0.139	0.194	0.205	0.217	0.23	0.237	0.245	0.251
1964	0.105	0.139	0.182	0.215	0.225	0.23	0.237	0.245	0.253
1965	0.103	0.143	0.18	0.212	0.232	0.243	0.243	0.256	0.26
1966	0.122	0.154	0.191	0.212	0.237	0.248	0.24	0.253	0.257
1967	0.119	0.158	0.185	0.217	0.243	0.251	0.256	0.259	0.264
1968	0.119	0.166	0.196	0.215	0.235	0.248	0.256	0.262	0.266
1969	0.122	0.164	0.2	0.217	0.237	0.245	0.264	0.264	0.262
1970	0.128	0.162	0.2	0.225	0.24	0.253	0.264	0.276	0.272
1971	0.117	0.166	0.2	0.225	0.245	0.253	0.262	0.267	0.283
1972	0.132	0.17	0.194	0.22	0.245	0.259	0.264	0.27	0.285
1973	0.125	0.174	0.205	0.215	0.245	0.262	0.262	0.285	0.285
1974	0.141	0.18	0.21	0.225	0.237	0.259	0.262	0.288	0.27
1975	0.137	0.187	0.215	0.24	0.251	0.26	0.27	0.279	0.284
1976	0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293
1977	0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298
1978	0.127	0.189	0.217	0.24	0.279	0.276	0.291	0.297	0.302
1979	0.127	0.174	0.212	0.23	0.253	0.273	0.291	0.279	0.284
1980	0.117	0.174	0.207	0.237	0.259	0.276	0.27	0.27	0.275
1981	0.115	0.172	0.21	0.245	0.267	0.276	0.297	0.309	0.315
1982	0.115	0.154	0.194	0.237	0.262	0.273	0.279	0.288	0.293
1983	0.109	0.148	0.198	0.22	0.276	0.282	0.276	0.319	0.325
1984	0.093	0.142	0.185	0.213	0.213	0.245	0.246	0.263	0.262
1985	0.104	0.14	0.17	0.201	0.234	0.248	0.256	0.26	0.263

	1	2	3	4	5	6	7	8	9
1986	0.112	0.155	0.172	0.187	0.215	0.248	0.276	0.284	0.332
1987	0.096	0.138	0.186	0.192	0.204	0.231	0.255	0.267	0.284
1988	0.097	0.132	0.168	0.203	0.209	0.215	0.237	0.257	0.283
1989	0.106	0.129	0.151	0.169	0.194	0.199	0.21	0.221	0.24
1990	0.099	0.137	0.153	0.167	0.188	0.208	0.209	0.229	0.251
1991	0.092	0.128	0.168	0.182	0.19	0.206	0.229	0.236	0.251
1992	0.096	0.123	0.15	0.177	0.191	0.194	0.212	0.228	0.248
1993	0.092	0.129	0.155	0.18	0.201	0.204	0.21	0.225	0.24
1994	0.097	0.135	0.168	0.179	0.19	0.21	0.218	0.217	0.227
1995	0.088	0.126	0.151	0.178	0.188	0.198	0.207	0.227	0.227
1996	0.088	0.118	0.147	0.159	0.185	0.196	0.207	0.219	0.231
1997	0.093	0.124	0.141	0.157	0.172	0.192	0.206	0.216	0.22
1998	0.099	0.121	0.153	0.163	0.173	0.185	0.199	0.204	0.225
1999	0.09	0.12	0.149	0.167	0.18	0.183	0.202	0.209	0.208
2000	0.092	0.111	0.148	0.168	0.185	0.187	0.197	0.21	0.224
2001	0.082	0.107	0.139	0.162	0.177	0.19	0.185	0.204	0.229
2002	0.096	0.115	0.139	0.156	0.185	0.196	0.203	0.211	0.226
2003	0.089	0.102	0.128	0.146	0.165	0.184	0.195	0.202	0.214
2004	0.08	0.13	0.134	0.151	0.159	0.174	0.203	0.215	0.225
2005	0.077	0.102	0.142	0.147	0.158	0.168	0.181	0.208	0.252
2006	0.093	0.105	0.127	0.151	0.155	0.165	0.174	0.186	0.198
2007	0.074	0.106	0.123	0.141	0.166	0.162	0.17	0.171	0.229
2008	0.091	0.12	0.144	0.156	0.172	0.191	0.194	0.199	0.224
2009	0.078	0.122	0.146	0.16	0.169	0.185	0.187	0.197	0.211
2010	0.076	0.111	0.131	0.145	0.158	0.159	0.163	0.178	0.19
2011	0.07	0.104	0.127	0.141	0.154	0.161	0.167	0.18	0.179
2012	0.072	0.094	0.124	0.138	0.152	0.157	0.164	0.164	0.171
2013	0.062	0.101	0.122	0.142	0.153	0.164	0.17	0.166	0.18
2014	0.067	0.1	0.127	0.14	0.153	0.161	0.163	0.179	0.176

	1	2	3	4	5	6	7	8	9
2015	0.071	0.102	0.122	0.137	0.143	0.151	0.158	0.167	0.182
2016	0.061	0.095	0.119	0.131	0.140	0.144	0.151	0.157	0.162
2017	0.06	0.080	0.090	0.123	0.143	0.160	0.163	0.171	0.178
2018	0.067	0.092	0.11	0.124	0.136	0.146	0.162	0.143	0.15

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Weight-at-age in the stock inputs to the ASAP model. Age is in winter rings.

	1	2	3	4	5	6	7	8	9
1958	0.096	0.115	0.162	0.185	0.205	0.217	0.227	0.232	0.23
1959	0.087	0.119	0.166	0.185	0.2	0.21	0.217	0.23	0.231
1960	0.093	0.122	0.156	0.191	0.205	0.207	0.22	0.225	0.239
1961	0.098	0.127	0.156	0.185	0.207	0.212	0.22	0.235	0.235
1962	0.109	0.146	0.17	0.187	0.21	0.227	0.232	0.237	0.24
1963	0.103	0.139	0.194	0.205	0.217	0.23	0.237	0.245	0.251
1964	0.105	0.139	0.182	0.215	0.225	0.23	0.237	0.245	0.253
1965	0.103	0.143	0.18	0.212	0.232	0.243	0.243	0.256	0.26
1966	0.122	0.154	0.191	0.212	0.237	0.248	0.24	0.253	0.257
1967	0.119	0.158	0.185	0.217	0.243	0.251	0.256	0.259	0.264
1968	0.119	0.166	0.196	0.215	0.235	0.248	0.256	0.262	0.266
1969	0.122	0.164	0.2	0.217	0.237	0.245	0.264	0.264	0.262
1970	0.128	0.162	0.2	0.225	0.24	0.253	0.264	0.276	0.272
1971	0.117	0.166	0.2	0.225	0.245	0.253	0.262	0.267	0.283
1972	0.132	0.17	0.194	0.22	0.245	0.259	0.264	0.27	0.285
1973	0.125	0.174	0.205	0.215	0.245	0.262	0.262	0.285	0.285
1974	0.141	0.18	0.21	0.225	0.237	0.259	0.262	0.288	0.27
1975	0.137	0.187	0.215	0.24	0.251	0.26	0.27	0.279	0.284
1976	0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293
1977	0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298
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

	1	2	3	4	5	6	7	8	9
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
year	1	2	3	4	5	6	7	8	9
2001	0.082	0.107	0.139	0.162	0.177	0.19	0.185	0.204	0.229
2002	0.096	0.115	0.139	0.156	0.184	0.196	0.203	0.211	0.223
2003	0.078	0.1	0.13	0.141	0.156	0.158	0.168	0.2	0.213
2004	0.077	0.127	0.133	0.151	0.156	0.168	0.216	0.228	0.257
2005	0.074	0.103	0.145	0.143	0.155	0.161	0.175	0.221	0.233
2006	0.085	0.104	0.123	0.153	0.15	0.157	0.164	0.177	0.188
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

	1	2	3	4	5	6	7	8	9
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	0.65	0.95	0.121	0.142	0.154	0.166	0.171	0.166	0.170

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Fishery Selectivity block inputs (1–9) to the ASAP model. Age is in winter rings.

Age	Selectivity	Block	#1	Data
1	0.3	1	0	1
2	0.5	1	0	1
3	1	-1	0	1
4	1	1	0	1
5	1	1	0	1
6	1	1	0	1
7	1	1	0	1
8	1	1	0	1
9	1	1	0	1

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Catch numbers-at-age and total catch inputs to the ASAP model. Age is in winter rings.

Year	1	2	3	4	5	6	7	8	9	Total catch
1958	1642	3742	33094	25746	12551	23949	16093	9384	5584	22978
1959	1203	25717	2274	19262	11015	5830	17821	3745	7352	15086
1960	2840	72246	24658	3779	13698	4431	6096	4379	4151	18283
1961	2129	16058	32044	5631	2034	5067	2825	1524	4947	15372
1962	772	18567	19909	48061	8075	3584	8593	3805	5322	21552
1963	297	51935	13033	4179	20694	2686	1392	2488	2787	17349
1964	7529	15058	17250	6658	1719	8716	1304	577	2193	10599
1965	57	70248	9365	15757	3399	4539	12127	1377	7493	19126
1966	7093	19559	59893	9924	13211	5602	3586	8746	3842	27030
1967	7599	39991	20062	49113	9218	9444	3939	6510	6757	27658
1968	12197	54790	39604	11544	22599	4929	4170	1310	4936	30236
1969	9472	93279	55039	33145	12217	17837	4762	2174	3469	44389
1970	1319	37260	50087	26481	18763	7853	6351	2175	3367	31727
1971	12658	23313	37563	41904	18759	10443	4276	4942	2239	31396
1972	8422	137690	17855	15842	14531	4645	3012	2374	1020	38203
1973	23547	38133	55805	7012	9651	5323	3352	2332	1209	26936
1974	5507	42808	17184	22530	4225	3737	2978	903	827	19940
1975	12768	15429	17783	7333	9006	3520	1644	1136	1194	15588
1976	13317	11113	7286	7011	2872	4785	1980	1243	1769	9771
1977	8159	12516	8610	5280	1585	1898	1043	383	470	7833
1978	2800	13385	11948	5583	1580	1476	540	858	482	7559
1979	11335	13913	12399	8636	2889	1316	1283	551	635	10321
1980	7162	30093	11726	6585	2812	2204	1184	1262	565	13130
1981	39361	21285	21861	5505	4438	3436	795	313	866	17103
1982	15339	42725	8728	4817	1497	1891	1670	335	596	13000
1983	13540	102871	26993	3225	1862	327	372	932	308	24981
1984	19517	92892	41121	16043	2450	1085	376	231	180	26779
1985	17916	57054	36258	16032	2306	228	85	173	132	20426

Year	1	2	3	4	5	6	7	8	9	Total catch
1986	4159	56747	42881	32930	8790	1127	98	29	12	25024
1987	5976	67000	43075	23014	14323	2716	1175	296	464	26200
1988	2307	82027	30962	9398	5963	3047	869	297	86	20447
1989	8260	42413	68399	19601	8205	3837	2589	767	682	23254
1990	2702	41756	24634	35258	8116	3808	1671	695	462	18404
1991	1912	63854	38342	16916	28405	4869	2588	954	593	25562
1992	10410	26752	35019	27591	10139	18061	3021	6285	689	21127
1993	1608	94061	9372	10221	4491	2790	5932	855	508	18618
1994	12130	35768	61737	3289	3025	4773	1713	1705	474	19300
1995	9450	79159	22591	36541	3686	3420	2651	1859	842	23305
1996	3476	61923	38244	7943	16114	2077	1586	1507	1025	18816
1997	3849	37440	53040	31442	8318	6142	1148	827	603	20496
1998	5818	41510	27102	28274	13178	3746	2675	597	387	18041
1999	14274	34072	36086	14642	15515	8877	1865	2012	551	18485
2000	9953	77378	18952	12060	5230	6227	2320	662	578	17191
2001	15724	62153	35816	5953	4249	1774	1145	466	386	15269
2002	3495	26472	18532	5309	1416	1269	437	154	201	7465
2003	2711	37006	24444	14763	5719	3363	2335	388	542	11536
2004	4276	9470	46243	21863	8638	1412	473	191	75	12743
2005	15419	30710	5766	18666	7349	1923	435	77	60	9494
2006	1460	33894	10914	2469	6261	2331	561	57	48	6944
2007	8043	11028	36223	5509	1365	2040	410	56	4	7636
2008	1288	12468	8144	15565	2328	518	321	58	11	5872
2009	10171	4465	12859	4887	8458	971	279	247	80	5745
2010	2468	20929	8183	15917	4846	10080	919	273	321	8370
2011	6384	17151	33453	7301	13087	5347	5165	1089	141	11470
2012	11712	62528	44819	37500	6303	11811	5549	3540	347	21820
2013	6191	30471	42133	22649	16687	3305	5463	1778	535	16247
2014	16664	24120	39102	33320	22450	11165	3047	2774	1022	19574

Year	1	2	3	4	5	6	7	8	9	Total catch
2015	286	12247	23835	32140	27382	19861	9820	4207	3279	18355
2016	2023	9822	25030	22800	25310	22447	10484	4684	1464	16318
2017	707	14144	31912	16004	10718	8963	6722	2401	1473	10767
2018	1654	7646	20545	5974	2296	1011	264	380	188	4418

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

Table 6.6.1.3. Herring in the Celtic Sea. ASAP final Run settings.

Discards Included	No
Use likelihood constant	No
Mean F (Fbar) 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	2002–2018 (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. Downweighted to 5 in 2015, 2016, 2017 and 2018
Lambda for F-Mult in 1st year	0 (freely estimated)
CV for F mult in the first year	0.5
Lambda for F-Mult deviations	0 (freely estimated)

CV for f mult deviations by fleet	0.5
Lambda for N in 1st year deviations	0 (freely estimated)
CV for N in the 1st year deviations	1
Lambda for recruitment deviations	1
Lambda for catchability in 1st year index	0
CV for catchability in 1st year by index	1
Lambda for catchability deviations	0
CV for catchability deviations	1
Lambda for deviation from initial steepness	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	Fbar 2-5	Recruitment
1958	22978	233325	313306	0.120	432921
1959	15086	220788	353876	0.104	1635380
1960	18283	208855	279895	0.118	380345
1961	15372	175958	241391	0.113	411312
1962	21552	170916	271946	0.183	876079
1963	17349	157804	223213	0.146	417379
1964	10599	176475	303892	0.092	1416300
1965	19126	180087	252379	0.134	426955
1966	27030	174004	277211	0.193	749003
1967	27658	166671	270026	0.219	781200
1968	30236	168961	283498	0.237	912571
1969	44389	147456	236457	0.355	468508
1970	31727	111593	171454	0.325	253287
1971	31396	101635	197638	0.446	827508
1972	38203	88827	152559	0.550	283975

Year	Catch	SSB	TSB	Fbar 2-5	Recruitment
1973	26936	66939	121313	0.511	330198
1974	19940	51969	88598	0.486	162981
1975	15588	41249	75930	0.506	205075
1976	9771	38230	70499	0.378	229833
1977	7833	38727	66193	0.283	187854
1978	7559	37387	60642	0.262	147816
1979	10321	37090	72142	0.417	281942
1980	13130	33959	61339	0.534	169396
1981	17103	37537	88462	0.821	471852
1982	13000	58759	128861	0.446	736210
1983	24981	78168	161935	0.542	797560
1984	26779	80971	151676	0.460	678457
1985	20426	87319	157404	0.311	654705
1986	25024	95648	174584	0.356	667243
1987	26200	108449	216165	0.378	1223210
1988	20447	112106	174916	0.225	484625
1989	23254	98534	168464	0.279	586679
1990	18404	91935	150949	0.242	512524
1991	25562	73439	114846	0.374	211557
1992	21127	73225	156456	0.473	978544
1993	18618	75914	122518	0.317	365941
1994	19300	82712	155249	0.315	780801
1995	23305	84144	153260	0.379	733569
1996	18816	74460	119323	0.302	358158
1997	20496	61708	107430	0.400	379927
1998	18041	49665	85509	0.435	254369
Year	Catch	SSB	TSB	Fbar 2-5	Recruitment
1999	18485	43794	90881	0.606	502744
2000	17191	44349	91308	0.605	498757

Year	Catch	SSB	TSB	Fbar 2-5	Recruitment
2001	15269	44550	88144	0.502	520736
2002	7465	57700	106184	0.195	571806
2003	11536	46422	69891	0.284	152742
2004	12743	43225	77350	0.359	393483
2005	9494	60953	129599	0.274	1169160
2006	6944	75416	114578	0.118	393857
2007	7636	78923	131027	0.117	803252
2008	5872	93644	131300	0.070	324154
2009	5745	106082	179467	0.068	1108940
2010	8370	114286	178137	0.090	817497
2011	11470	123378	195407	0.116	1041780
2012	21820	112915	172969	0.225	689412
2013	16247	100858	144540	0.187	399890
2014	19574	79531	119514	0.278	330244
2015	18355	53288	82083	0.385	194060
2016	16318	35398	62727	0.578	286552
2017	10767	21999	37370	0.643	124377
2018	4418	22977	43040	0.333	330242

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

2019								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	204340	0.77	0.5	0.5	0.5	0.06	0.04	0.06
2	149877.9	0.38	1	0.5	0.5	0.09	0.41	0.09
3	28891.37	0.36	1	0.5	0.5	0.11	0.55	0.11
4	25680.19	0.34	1	0.5	0.5	0.13	0.55	0.13
5	6644.41	0.32	1	0.5	0.5	0.14	0.55	0.14
6	5193.834	0.31	1	0.5	0.5	0.16	0.55	0.15
7	3334.937	0.31	1	0.5	0.5	0.16	0.49	0.16
8	3504.547	0.31	1	0.5	0.5	0.17	0.48	0.16
9	16453.6	0.31	1	0.5	0.5	0.17	0.13	0.16

2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	204340	0.77	0.5	0.5	0.5	0.06	0.04	0.06
2	-	0.38	1	0.5	0.5	0.09	0.41	0.09
3	-	0.36	1	0.5	0.5	0.11	0.55	0.11
4	-	0.34	1	0.5	0.5	0.13	0.55	0.13
5	-	0.32	1	0.5	0.5	0.14	0.55	0.14
6	-	0.31	1	0.5	0.5	0.16	0.55	0.15
7	-	0.31	1	0.5	0.5	0.16	0.49	0.16
8	-	0.31	1	0.5	0.5	0.17	0.48	0.16
9	-	0.31	1	0.5	0.5	0.17	0.13	0.16

2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	204340	0.77	0.5	0.5	0.5	0.06	0.04	0.06
2	-	0.38	1	0.5	0.5	0.09	0.41	0.09
3	-	0.36	1	0.5	0.5	0.11	0.55	0.11
4	-	0.34	1	0.5	0.5	0.13	0.55	0.13
5	-	0.32	1	0.5	0.5	0.14	0.55	0.14
6	-	0.31	1	0.5	0.5	0.16	0.55	0.15
7	-	0.31	1	0.5	0.5	0.16	0.49	0.16
8	-	0.31	1	0.5	0.5	0.17	0.48	0.16
9	-	0.31	1	0.5	0.5	0.17	0.13	0.16

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

Rationale	Fbar (2019)	Catch (2019)	SSB (2019)	F_{bar} (2020)	Catch (2020)	SSB (2020)	SSB (2021)
Catch(2020) = Zero	**0.34**	**5320**	**22787**	**0**	**0**	**24248**	**27628**
$F_{bar(2020)} = F_{MSY}$	0.34	5320	22787	0.26	4258	22018	19871
$F_{bar(2020)} = F_{pa}$	0.34	5320	22787	0.27	4404	21938	19779
$F_{bar(2020)} = F_{lim}$	0.34	5320	22787	0.45	6823	20553	18263
$F_{bar(2020)} = F_{2019}$	0.34	5320	22787	0.34	5334	21416	19194
Catch(2020) = 2019 TAC	0.34	5320	22787	0.294	4742	21750	19566

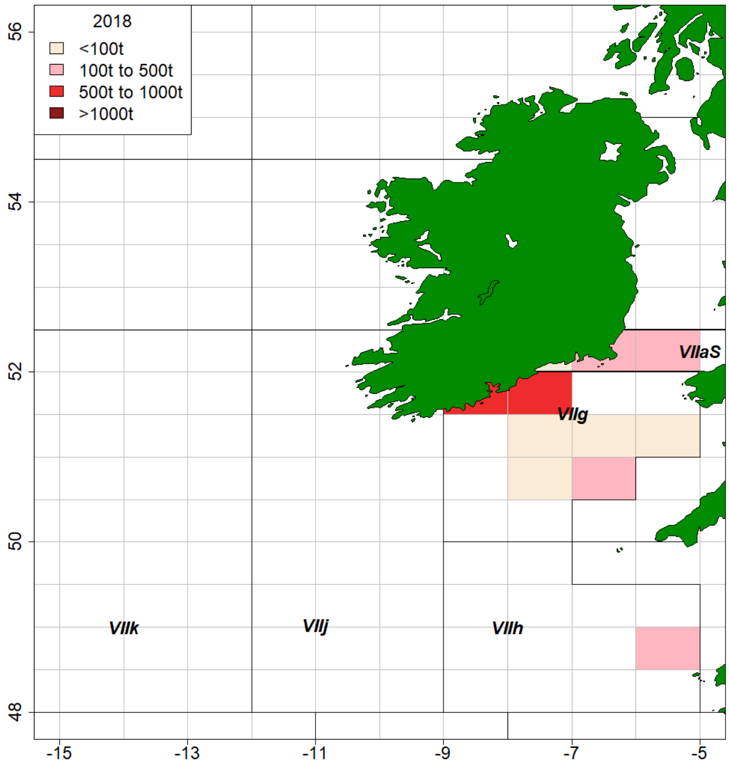


Figure 6.1.2.1. Herring in the Celtic Sea. Total official herring catches by statistical rectangle in 2018/2019.

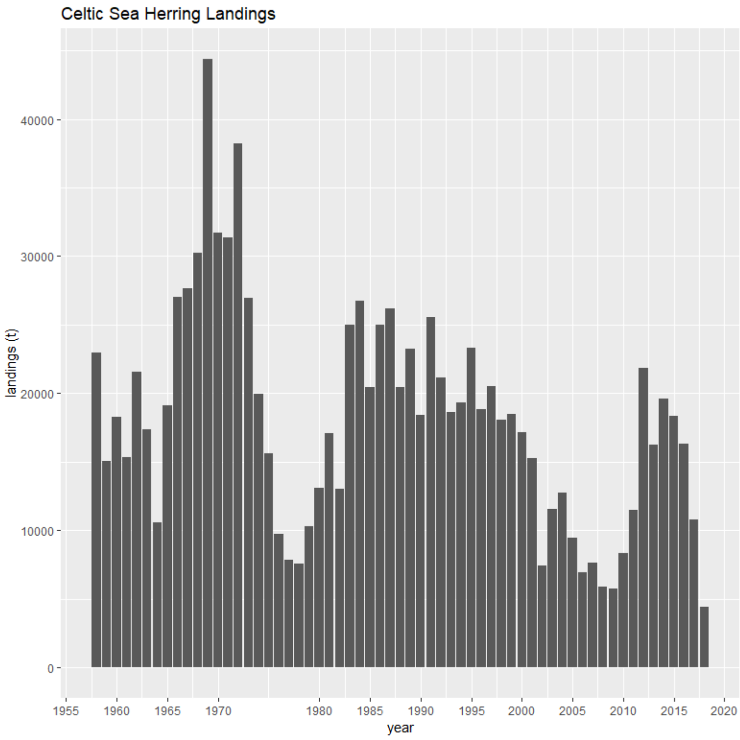


Figure 6.1.2.2. Herring in the Celtic Sea. Working Group estimates of herring catches per season.

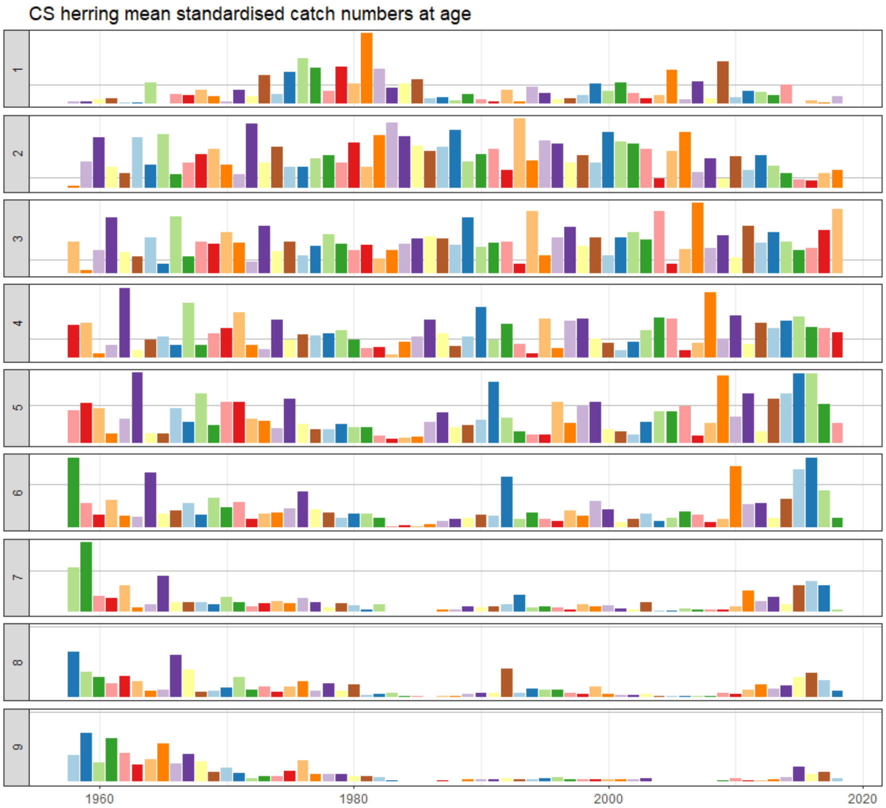


Figure 6.2.1.1. Herring in the Celtic Sea. Catch numbers-at-age standardized by yearly mean. 9-wr is the plus group. Age in winter rings.

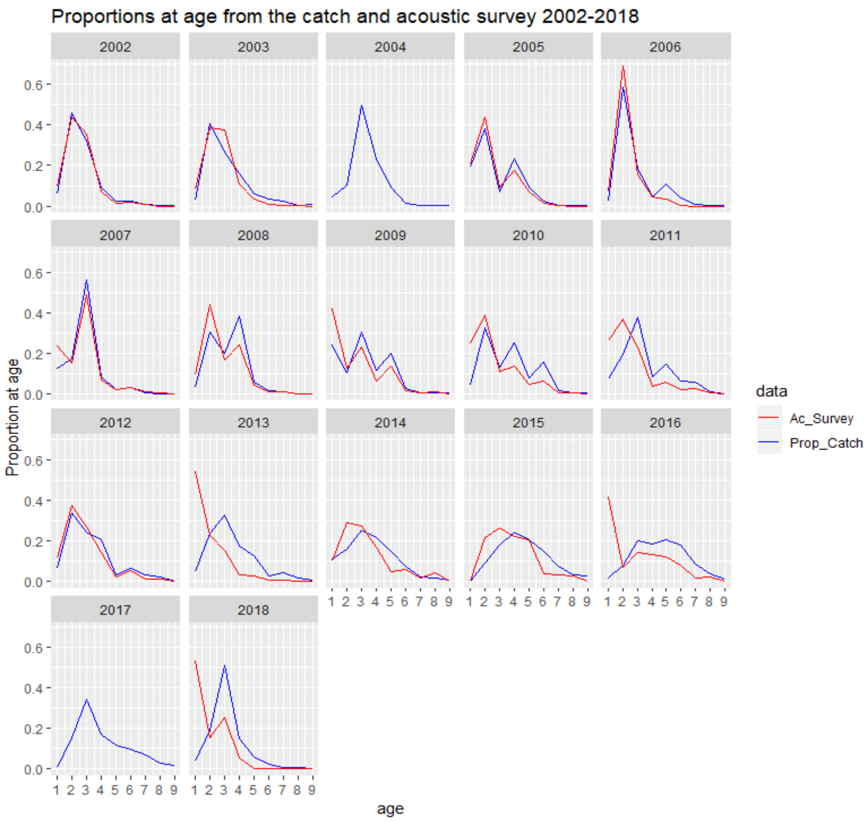


Figure 6.2.1.2. Herring in the Celtic Sea. Proportions at age in the survey (1–9 wr) and the commercial fishery (1–9 wr) by year. Age in winter rings.

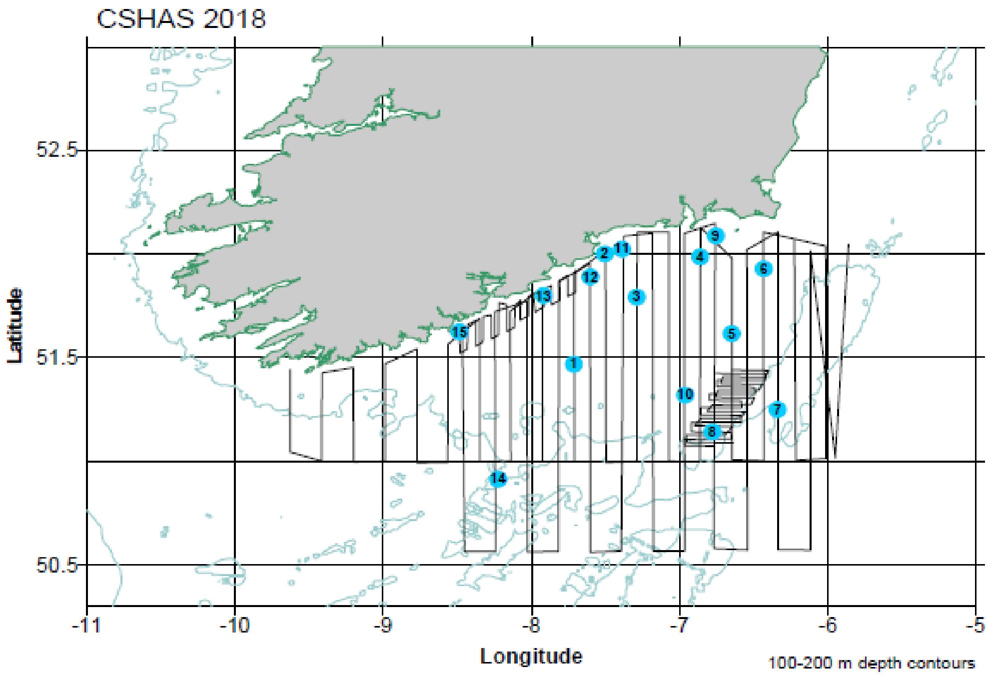


Figure 6.3.1.1. Herring in the Celtic Sea. Acoustic survey tracks for the core and adaptive surveys in 2018, haul positions are numbered.

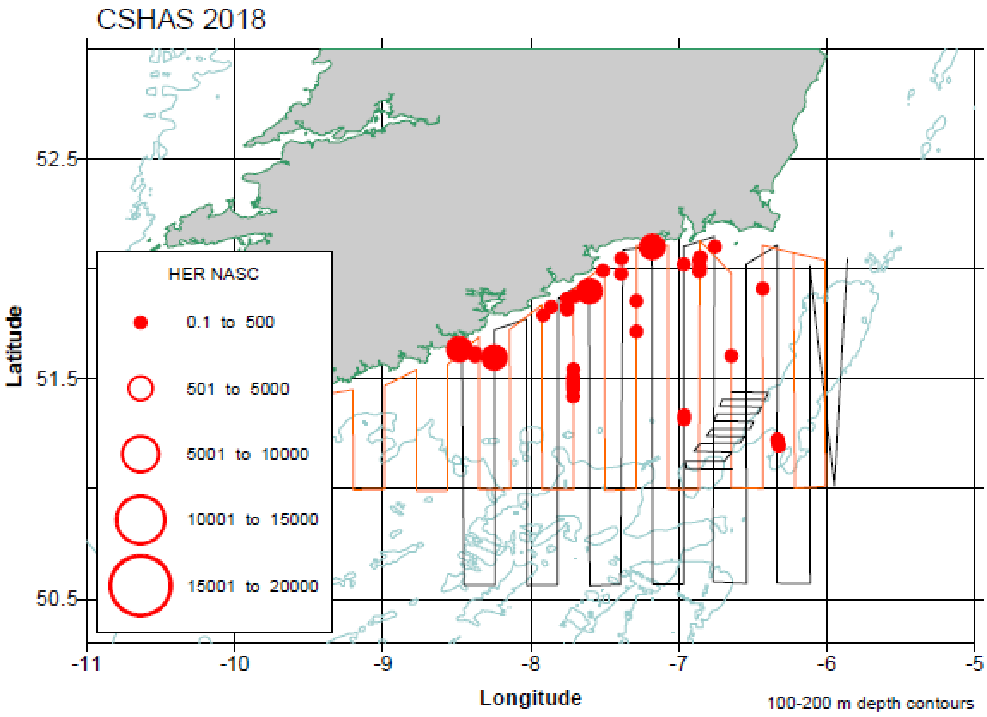


Figure 6.3.1.2. Herring in the Celtic Sea. NASC (Nautical area scattering coefficient) distribution plot of the distribution of herring in 2018 in the broad-scale surveys (1st pass = black lines; 2nd pass = orange lines).

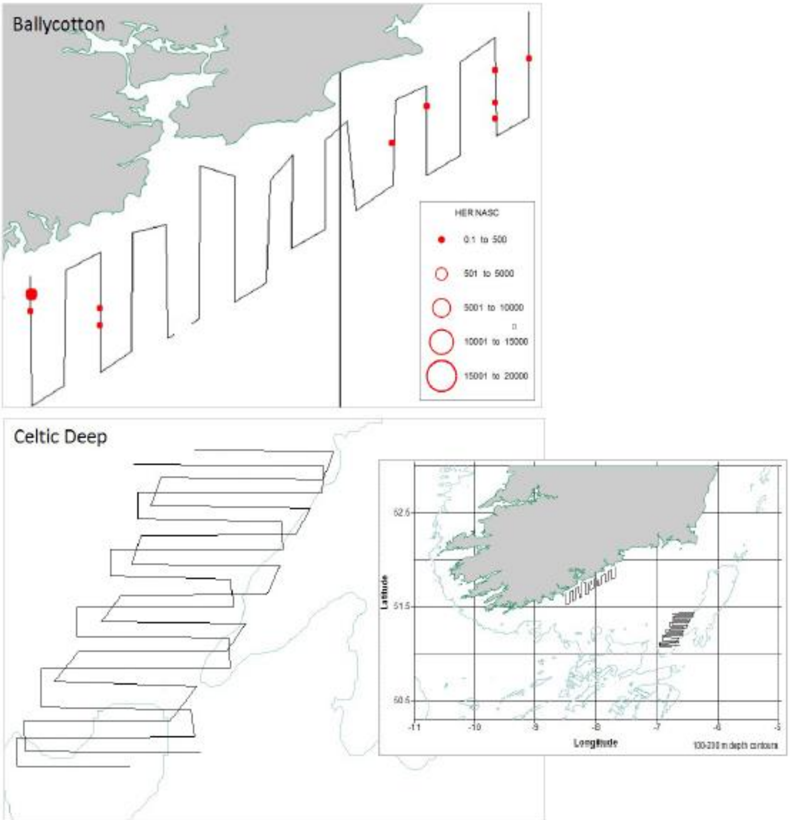


Figure 6.3.1.3. Herring in the Celtic Sea. NASC (nautical area scattering coefficient) plot of the distribution of herring in 2018 in the adaptive mini-survey 2 strata. Top Panel: coastal area; bottom panel: offshore area (no herring).

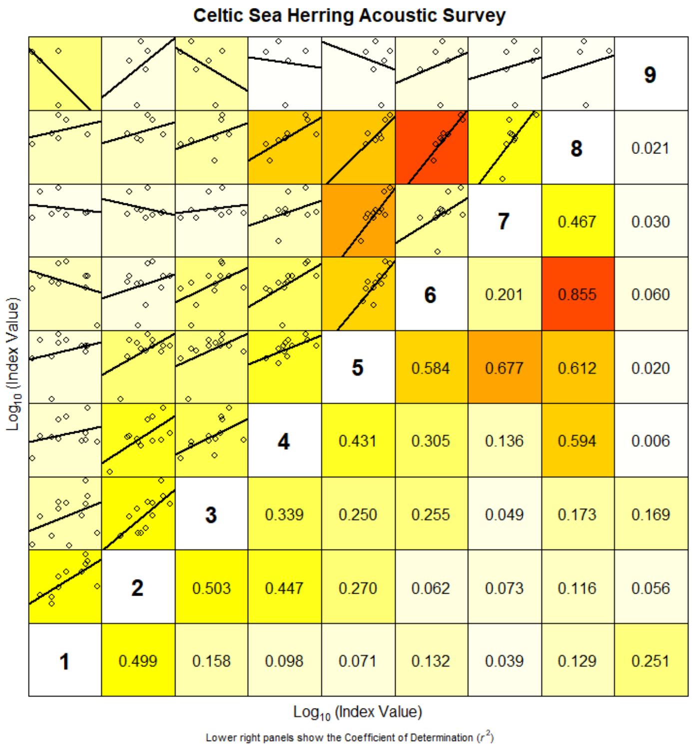


Figure 6.3.1.4. Herring in the Celtic Sea. Internal consistency between ages in the Celtic Sea Herring acoustic survey time-series. Age in winter rings.

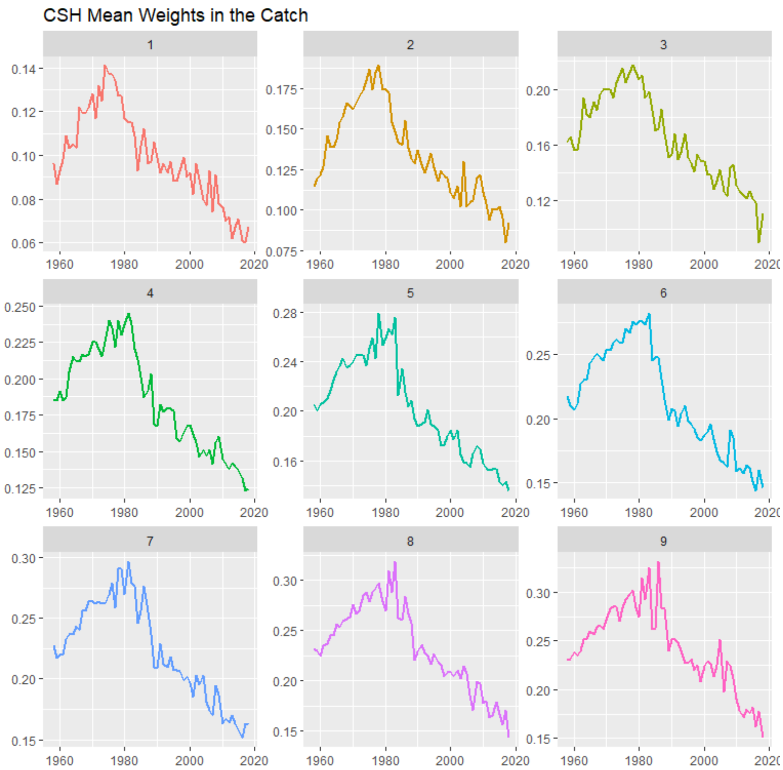


Figure 6.4.1.1. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the catch from 1958–2018 for 1–9+.

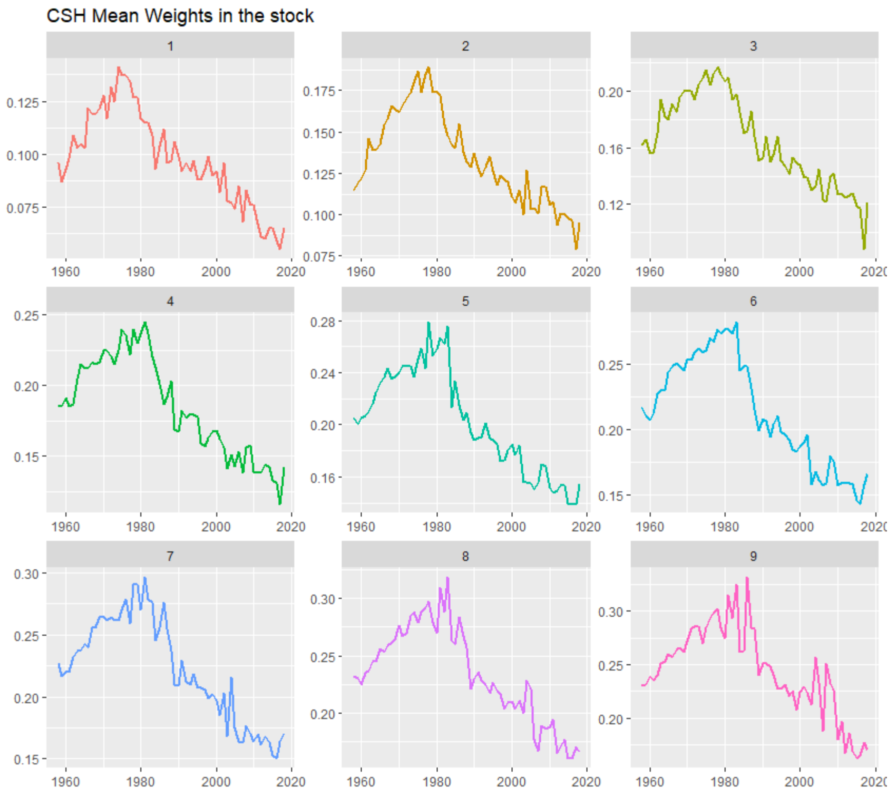


Figure 6.4.1.2. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the stock at spawning time from 1958–2018 for 1–9+. Age in winter rings.

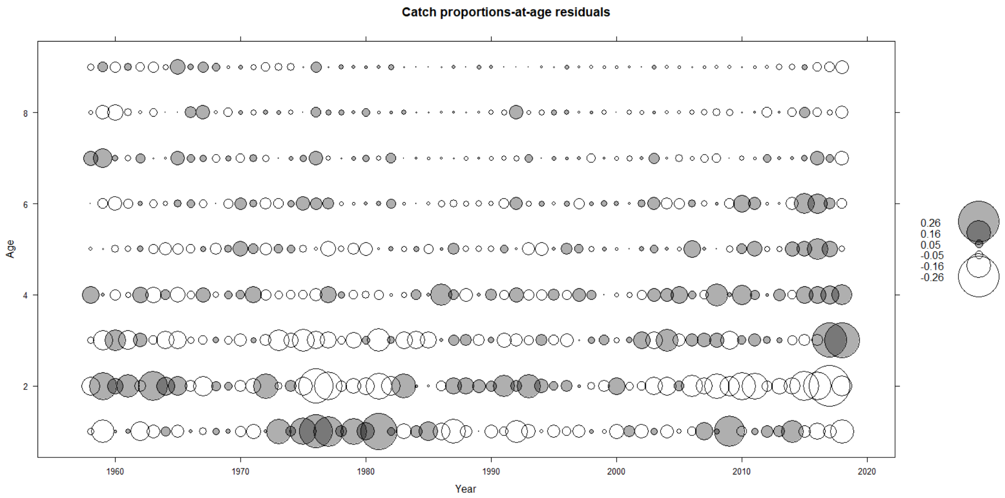


Figure 6.6.1.1. Herring in the Celtic Sea. Catch proportion-at-age residuals. Age in winter rings.

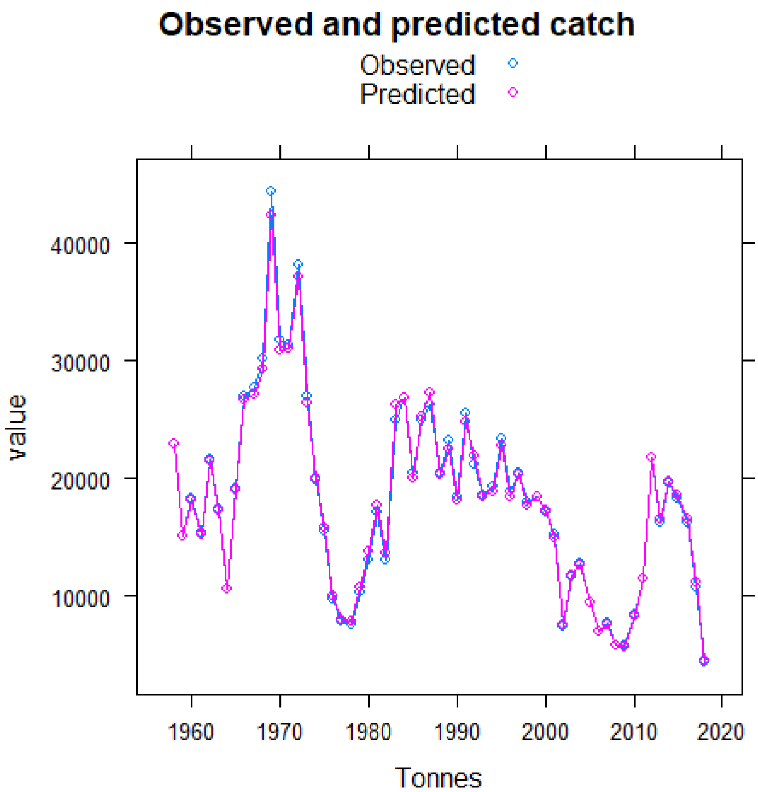


Figure 6.6.1.2. Herring in the Celtic Sea. Observed catch and predicted catch for the final ASAP assessment.

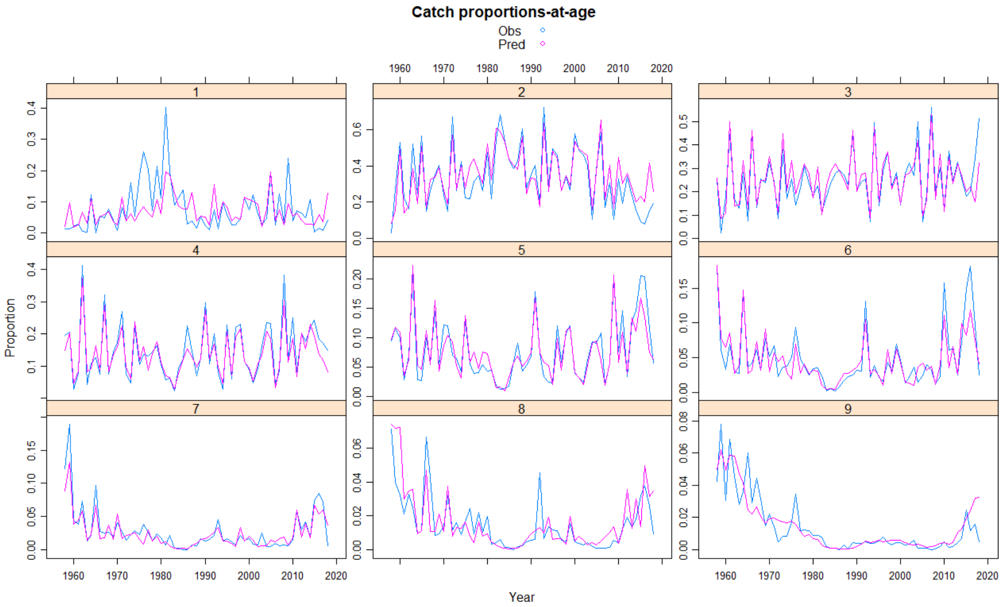


Figure 6.6.1.3. Herring in the Celtic Sea. Observed and predicted catch proportions-at-age for the final ASAP assessment.

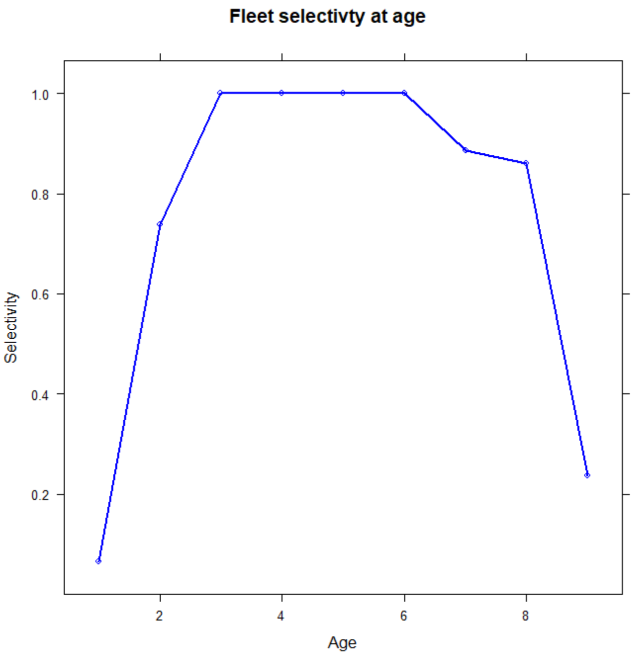


Figure 6.6.1.4. Herring in the Celtic Sea. Selection pattern in the fishery from the final ASAP assessment.

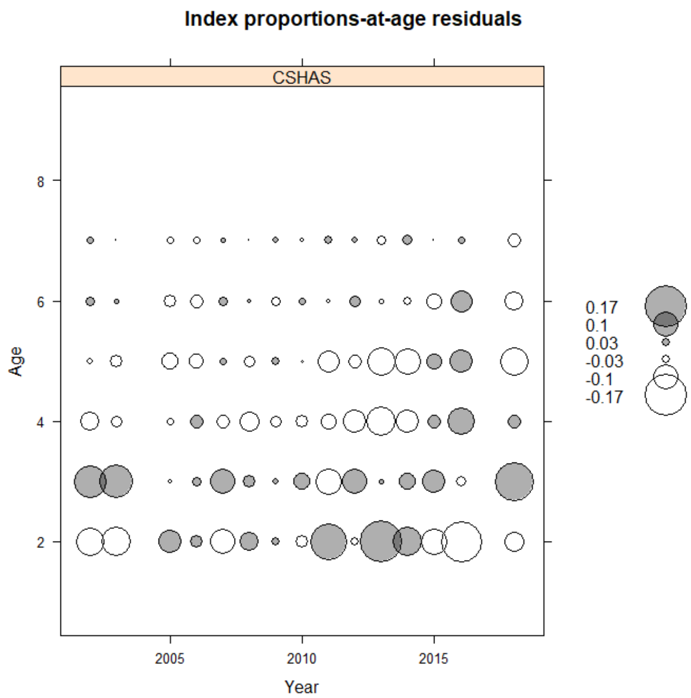


Figure 6.6.1.5. Herring in the Celtic Sea. Index proportions-at-age residuals (observed–predicted). Age in winter rings.

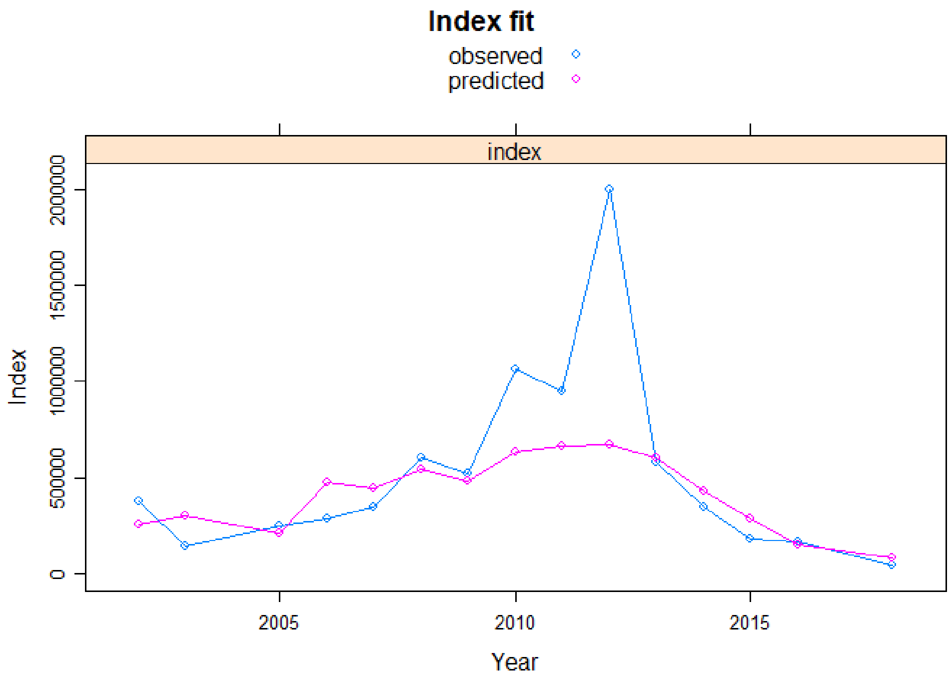


Figure 6.6.1.6. Herring in the Celtic Sea. Index fits.

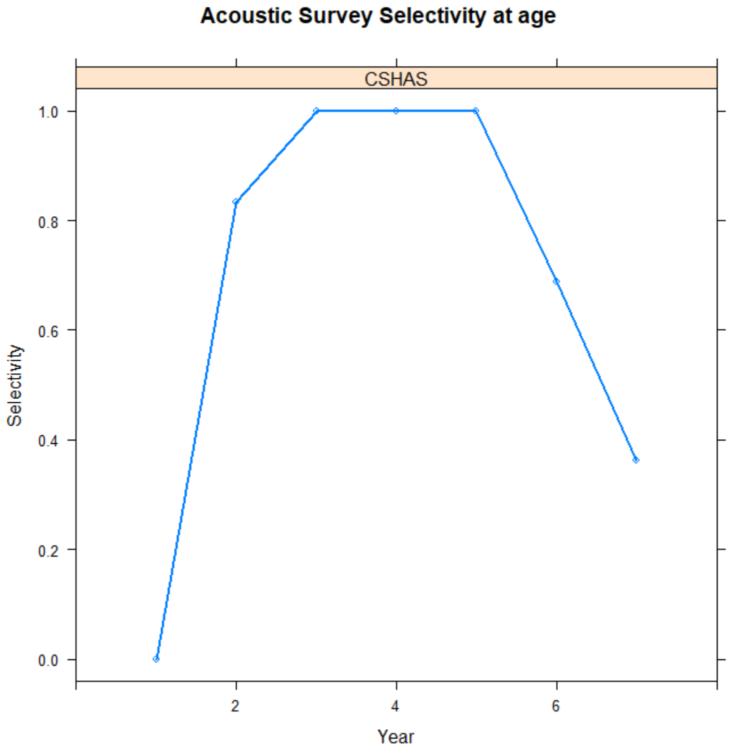


Figure 6.6.1.7. Herring in the Celtic Sea. Survey Selectivity pattern from the final assessment run.

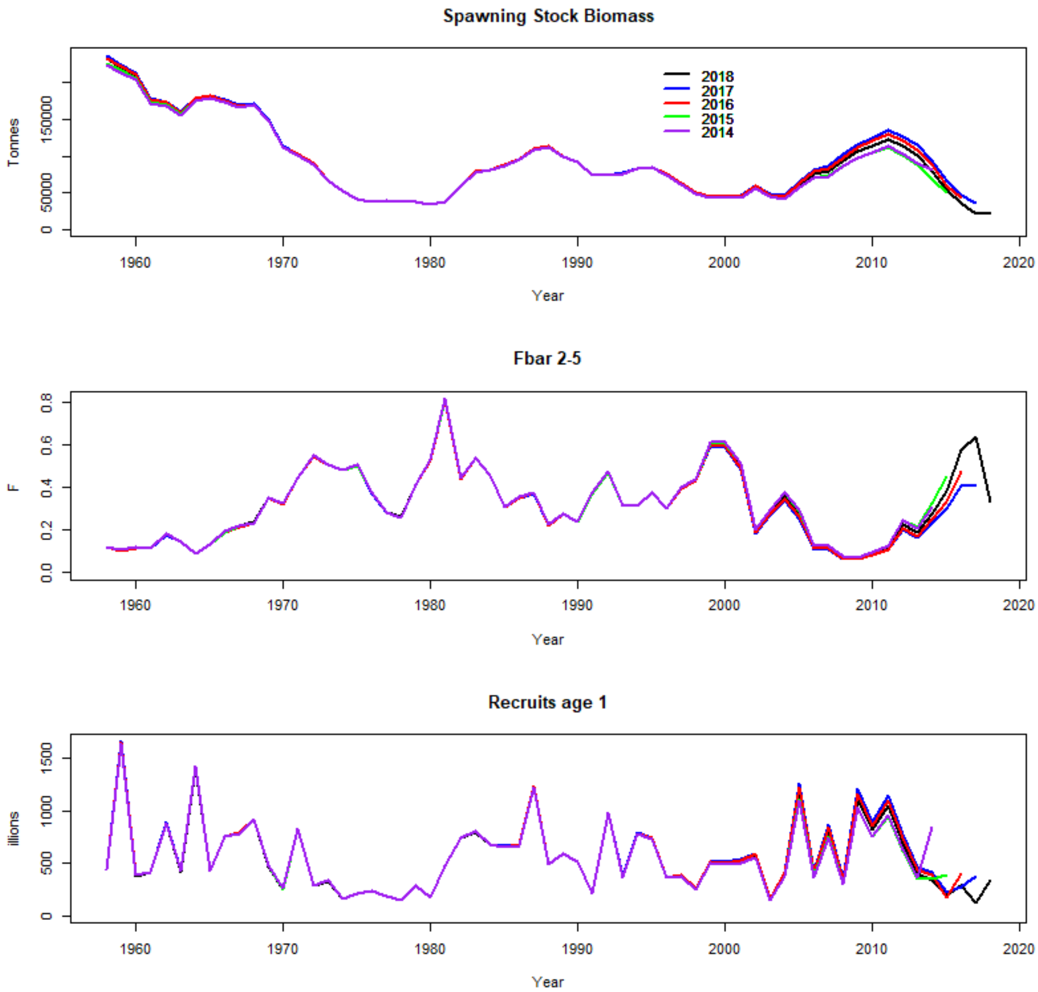


Figure 6.6.1.8. Herring in the Celtic Sea. Retrospective plots for SSB (top right), Mean F (bottom left), Recruitment (bottom right) and the catch data time-series (top left). Age in winter rings.

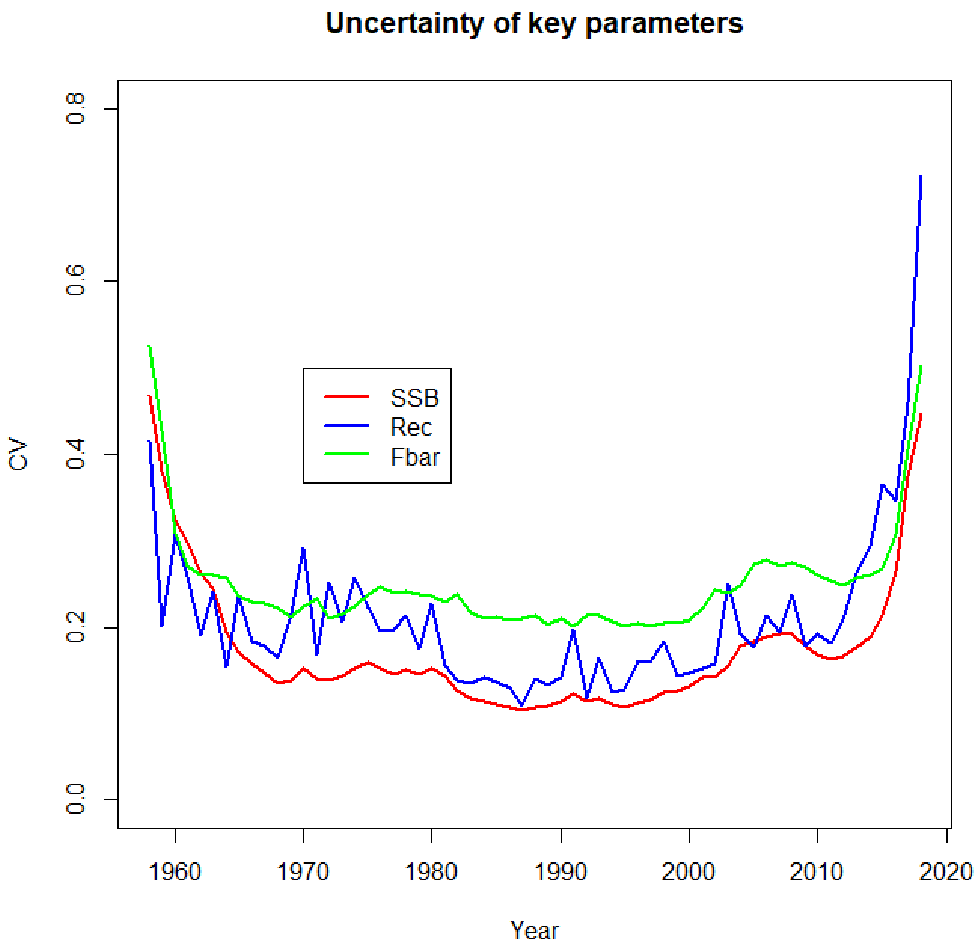


Figure 6.6.1.9. Herring in the Celtic Sea. Uncertainty of key parameters in the final assessment.

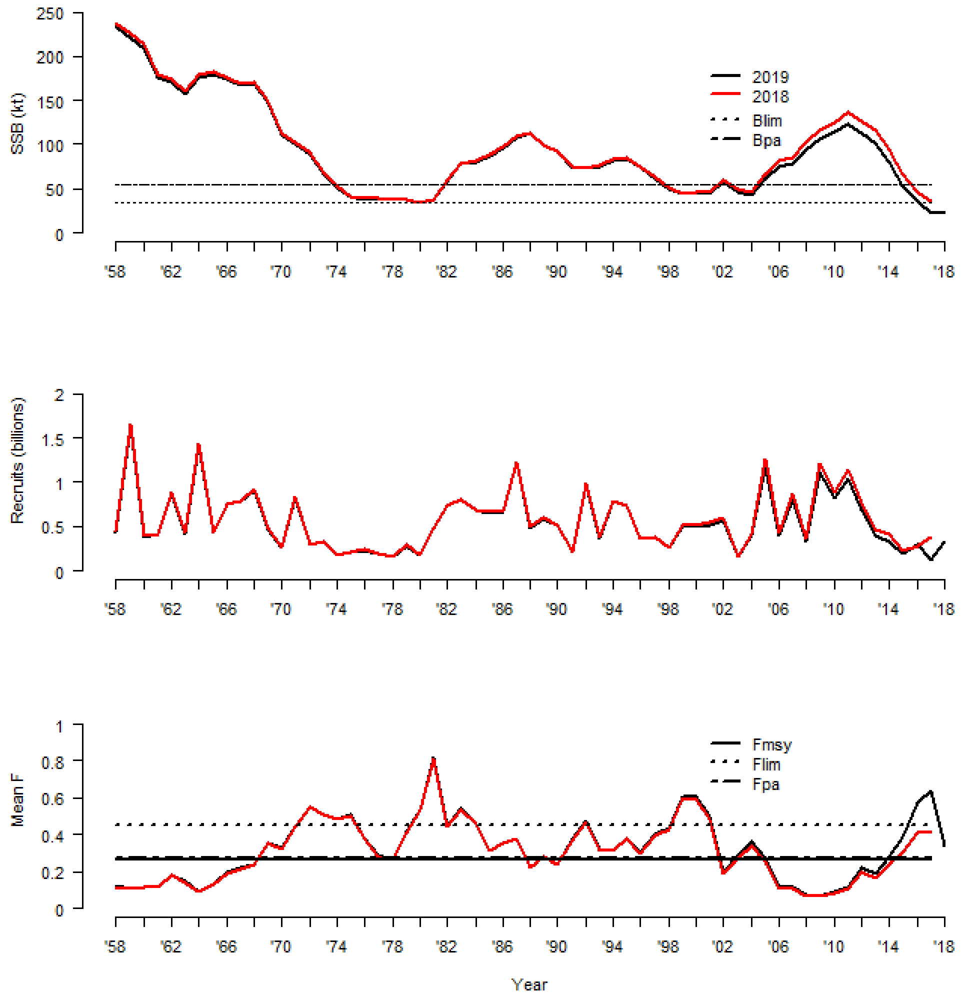


Figure 6.6.1.10. Herring in the Celtic Sea. Stock Summary from the final assessment run showing SSB (top), Recruitment (middle) and Mean F_{2-5} (bottom)

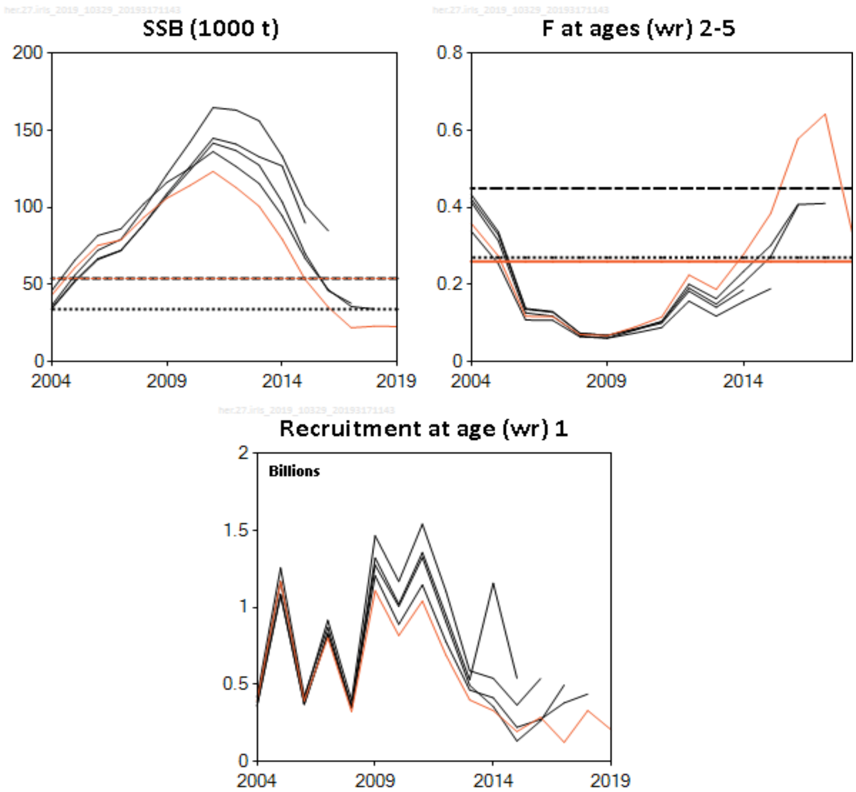


Figure 6.10.1. Herring in the Celtic Sea. Historical retrospective from the final assessments 2015–2019

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 2018 and 2019

In 2018 a TAC of 7016 t was adopted, partitioned as 5190 t to the UK and 1826 t to the Republic of Ireland. In 2018 ACOM advised on the basis of MSY approach that landings in 2019 should be equal or less than 6896 t. A TAC of 6896t was adopted for 2019 as advised by ICES.

7.1.2 The fishery in 2018

The catches reported from each country for the period 1987 to 2018 are given in Table 7.1.1, and total catches from 1961 to 2018 in Figure 7.1.1. Reported international landings in 2018 for the Irish Sea amounted to 6804 t with UK vessels acquiring the majority of the quota through swaps with the Republic of Ireland. The majority of catches in 2018 were taken during the 3rd quarter.

The 2018 7.a(N) herring fishery started off 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 mid-water pelagic fishing vessels from Ireland. In previous years a 'Mourne' fishery, limited to boats under 40ft usually in October and November, this fishery landed 9.5 t in 2018

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. Any alterations to the present closures should be considered carefully.

7.1.4 Changes in fishing technology and fishing patterns

UK pair trawlers takes the majority of catches during the 3rd and 4th quarters, but from 2011 to 2015 a single pelagic trawler took some of the TAC. 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 10t landings attributed to this fishery in 2018. There was a marked increase in the landings made by Irish vessels in 2018 comprising 19% of the landings compared to an average of 2% in the preceding three years.

7.2 Biological Composition of the Catch

7.2.1 Catch in numbers

Routine sampling of the main catch component was conducted in 2018, with sampling coverage concentrated on the pelagic trawlers, with sampling carried out on landings at fish processing factories for both Irish and Northern Irish vessels. There was no biological sampling of the main catch component (pair trawlers) in 2009 due to a failure to acquire samples from the landings. Catches in numbers-at-age are given in Table 7.6.3.1 for the years 1972 to 2018 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 2018, excluding 2009.

7.2.2 Quality of catch and biological data

The number of samples acquired from the main catch component was 21 in 2018, 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 (~7% of fishing trips sampled annually) with no discards observed. 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 2018 was carried out over the period 29 August–13 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). The bulk of 1+ herring targets in 2018 were observed on both the east and western sides of the Isle of Man (Figure 7.3.1) and off the Northern Ireland County Down coast, where herring aggregations have now been observed consistently for a number of years. Abundance of herring was particularly high in this area. The continuing observation of herring aggregation in the western Irish Sea in distinct areas merits an investigation of possibly re-stratifying the survey area and index. The survey followed the methods described in the ICES WGIPS 2018 report. Sampling intensity was high during the 2017 survey with 32 successful trawls completed. The length frequencies generated from these trawls highlight the spatial heterogeneous nature of herring age groups in the Irish Sea (Figure 7.3.2).

The estimate of herring SSB of 91 332 t for 2016 was near the series high 2010 estimate (Table 7.3.1, Figure 7.3.4). In 2018 the estimate was 39 997 t, similar to that observed in 2017. The biomass estimate of 54 661 t for 1+ ringers is a 25% increase on last year's biomass estimate. Unlike in previous years when a large proportion of the 1+biomass estimate is seen in north of the Isle of Man and in North Channel, in the current year the majority of biomass was observed in the south east of the Isle of Man area. The western and northern Irish Sea are areas of mixed size fish.

The age-disaggregated acoustic estimates of the herring abundance, excluding 0-ring fish, are given in Table 7.3.2. Results of a microstructure analysis of 1-ringer+ fish (Figure 7.3.6–7) have not been updated since 2011. Winter hatched fish, of which the majority are thought to be of Celtic Sea origin, are present in the pre-spawning aggregations sampled in the Irish Sea during the acoustic survey. The presence of these winter hatched fish has implications for the estimates of 1-ringer+ biomass and SSB, as well as confounding traditional cohort type assessment methods. However, removal of the 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 highest 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 in 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.

The surveys were roughly timed every fortnight, except for the last survey. The density distributions from the surveys highlight the temporal and spatial complexity of the herring distributions. Problems with timing of the survey are further exacerbated by the significant interannual variation in the migration patterns, evident from the changes in density distributions. The results confirm the high estimate of abundance observed during the routine annual acoustic survey estimates. The survey results support the high abundance of herring in the Irish Sea. Since 2012 this extended survey series has been reduced to one repeat survey in late September to coincide with the main spawning time. The primary aim to generate an SSB index constituted from herring 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.aN. Survey methodology, data processing and subsequent analysis is exactly the same as for AC(7.aN) 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 is reported in the WGIPS 2018 report (ICES, 2018). The survey is included in the assessment as a SSB index. Comparison with the SSB estimates from this survey compared to 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.

7.4 Mean weight, maturity and natural mortality-at-age

Biological sampling in 2018 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 1961 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). 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 2019. 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 focussed 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 recognise 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.aN)) 1–8+ winter rings) and the SSB indices are available for the assessment of Irish Sea herring. 2018 catch-at-age data 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 realised 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 in 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 data set (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 stabilising 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 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 developed in R software. Population abundances, F at age and input data were taken from the final SAM assessment, 1980–2018 (Table 7.7.1). Geometric mean recruitment of 1-ringers (2007–2016) replaced recruitment for 1-ringers in 2018. The forecast was based on a TAC (2019 quota = 6896 t) assuming full uptake of the quota. 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 2018–2020, but is predicted to decrease if fishing at F_{MSY}.SSB with zero catch is forecast to increase (+19.3%). This is largely in response to maturation of the 2018 year class, which will contribute more than 26% of the SSB in 2020.

7.7.2 Yield per recruit

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

7.8 Medium term projections

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

7.9 Reference points

MSY evaluations

New reference points were derived using the stock-recruit pairs generated by the 2017 assessment (WKIRISH3 and HAWG 2017). B_{lim} was set to the lowest SSB that generate above average recruitment, 8500 t. B_{pa}, 11 800 t calculated from B_{lim} with assessment error ($\sigma = 0.201$, based on the average CV from the terminal assessment year) MSY $B_{trigger}$ is set to B_{pa} as the stock has not been fished at or below F_{MSY} for more than five years. F_{MSY} median point estimates is 0.27 (0.266). The upper bound of the F_{MSY} range giving at least 95% of the maximum yield was estimated to 0.35(0.345) and the lower bound at 0.20(0.198). F_{lim} is estimated to be 0.40 (0.397) as F with 50% probability of SSB <B_{lim} with F_{pa} as 0.29 (0.286) calculated as F_{lim} combined with the assessment error; F_{lim} x exp(-1.645 x σ); $\sigma = 0.231$.

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 optimised 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. Very little retrospective bias was also present.

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, 1987–2018. 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
Ireland	119	0	82	200	1299
UK	5089	4868	4245	3696	5504
Unallocated	-	22	-		
Total	5208	4891	4327	3896	6804

Table 7.2.2 Herring in Division 7.a North (Irish Sea). Catch at length data 1995–2018. 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
14															-					-				16
14.5															-					-				0
15															-					15				31
15.5					10								16		-	93				14				54
16	21	21	17		19	12	9					2			-	107	30		8	0		109		47
16.5	55	51	94		53	49	27			13	1	44	33	1	-	487	165		84	14		174		176
17	139	127	281	26	97	67	53			25	39	140	69	3	-	764	356	89	202	213	16	261	86	431
17.5	148	200	525	30	82	97	105			84	117	211	286	11	-	1155	851	143	470	808	32	413	62	749
18	300	173	1022	123	145	115	229			102	291	586	852	34	-	1574	1406	301	533	1644	72	326	148	594
18.5	280	415	1066	206	135	134	240	36		114	521	726	2088	64	-	1405	841	533	555	3246	64	457	148	1097
19	310	554	1720	317	234	164	385	18		203	758	895	2979	85	-	866	1029	479	588	5357	136	522	234	841
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
20	326	749	1366	427	218	109	523	0	73	368	943	984	3516	100	-	787	1062	298	1041	4025	271	826	1121	1608
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
21	468	886	1510	522	449	115	1086	307	272	862	1256	1521	3451	192	-	1470	1874	643	2364	2608	439	1783	3154	3352

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
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
22	1509	1530	2607	1354	1261	289	1748	1750	463	1495	1361	2748	3821	271	-	2363	2372	1586	3052	2906	1896	2588	4374	5232
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
23	4198	2362	3508	2493	4784	607	2670	2490	1158	2089	1035	4358	4196	322	-	4530	4100	3920	3432	2596	2470	2893	3475	7485
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
24	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054	1276	3679	3178	259	-	4559	4759	8849	3882	2161	2124	2849	2649	6912
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
25	3100	4015	5031	2625	2620	2144	5566	776	1163	1749	1086	3438	1503	148	-	3083	3430	7020	3364	2282	2367	2414	2378	4462
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
26	2334	2480	3871	3115	1694	1349	3814	1570	1140	823	438	1714	643	78	-	1777	2343	4835	1934	1612	1962	1936	1331	1455
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
27	1622	1949	1711	2992	1475	616	1489	776	1607	510	165	445	147	23	-	460	1083	1716	412	498	827	826	370	458
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
28	834	906	638	1235	276	212	496	162	726	198	45	104	33	12	-	9	248	231	85	256	141	65	37	104
28.5	123	564	440	170	169	58	179	108	569	51	18	9	26	1	-		53	159	28	156	48	65	12	0
29	248	210	280	111	61	42	10	36	163		12	46			-	9		108		57	16	22	25	16

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
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			
30.5	5	0	5	3					43						-			17		14				
31	1	2							43						-									
31.5															-									
32															-									
32.5															-									
33															-									
33.5															-									

Table 7.2.3 Herring in Division 7.a North (Irish Sea). Sampling intensity of commercial landings in 2018.

Quarter	Country	Landings (t)	No. samples	No. fish measured	No. fish aged
1	Ireland	0	-	-	-
	UK (N. Ireland)	0	-	-	-
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
2	Ireland	0	-	-	-
	UK (N. Ireland)	0	-	-	-
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
3	Ireland	0	-	-	-
	UK (N. Ireland)	3671	11	1671	541
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	275	0	0	0
4	Ireland	1299	5	899	333
	UK (N. Ireland)	1558	5	761	245
	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 1989–2018. 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			66 000[1]	0.20
1992	W. Irish Sea + IOM E. coast	20/07–31/07	17 490	0.19			43 200	0.25
1994	Area 7.a(N)	28/08–8/09	31 400	0.36	25 133	-	68 600	0.10
	Douglas Bank	22/09–26/09			28 200	-	-	-
1995	Area 7.a(N)	11/09–22/09	38 400	0.29	20 167	-	348 600	0.13
	Douglas Bank	10/10–11/10		-	9 840	-	-	-
	Douglas Bank	23/10–24/10			1 750	0.51	-	-
1996	Area 7.a(N)	2/09–12/09	24 500	0.25	21 426	0.25	-[2]	-
1997	Area 7.a(N)-reduced	8/09–12/09	20 100	0.28	10 702	0.35	46 600	0.20
1998	Area 7.a(N)	8/09–14/09	14 500	0.20	9 157	0.18	228 000	0.11
1999	Area 7.a(N)	6/09–17/09	31 600	0.59	21 040	0.75	272 200	0.10
2000	Area 7.a(N)	11/09–21/09	40 200	0.26	33 144	0.32	234 700	0.11
2001	Area 7.a(N)	10/09–18/09	35 400	0.40	13 647	0.42	299 700	0.08
2002	Area 7.a(N)	9/09–20/09	41 400	0.56	25 102	0.83	413 900	0.09
2003	Area 7.a(N)	7/09–20/09	49 500	0.22	24 390	0.24	265 900	0.10
2004	Area 7.a(N)	6/09–10/09 15/09–16/09 28/09–29/09	34 437	0.41	21 593	0.41	281 000	0.07
2005	Area 7.a(N)	29/08–14/09	36 866	0.37	31 445	0.42	141 900	0.10
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

[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
2008	475.7	452.4	114.2	39.1	26.4	17.1	4.3	0.6

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

Table 7.6.3.1 Irish Sea Herring. CATCH IN NUMBER (Thousands)

Year / Age	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	**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
Year / Age	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
1	5669	20290	8939	NA	9588	7454	2491	3889	27377	1654	2216	2112	7991
2	15253	18291	18974	NA	17627	17598	9664	18916	9567	15414	19064	12844	22903
3	8198	4980	7487	NA	6679	8984	12247	6836	7917	4840	5992	12419	15657
4	6318	1655	2696	NA	6201	3982	7944	6631	1997	7376	4677	4407	12364
5	1325	1062	2082	NA	3200	3671	3061	2901	1759	1613	2050	609	3240
6	605	325	1761	NA	925	1751	3158	1472	964	4276	1421	1065	538
7	262	122	328	NA	370	690	1591	625	409	1678	896	487	391
8	246	111	216	NA	185	425	652	352	830	1112	759	623	150

Table 7.6.3.2 Irish Sea Herring. WEIGHTS (Kgs) AT AGE IN THE CATCH

Year / 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	0.07	0.081	0.096	0.073
2	0.155	0.155	0.155	0.155	0.142	0.125	0.143	0.13	0.124	0.128	0.14	0.123
3	0.195	0.195	0.195	0.195	0.187	0.157	0.167	0.16	0.16	0.155	0.166	0.155
4	0.219	0.219	0.219	0.219	0.213	0.186	0.188	0.175	0.17	0.174	0.175	0.171
5	0.232	0.232	0.232	0.232	0.221	0.202	0.215	0.194	0.18	0.184	0.187	0.181
6	0.251	0.251	0.251	0.251	0.243	0.209	0.228	0.21	0.198	0.195	0.195	0.19
7	0.258	0.258	0.258	0.258	0.24	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
Year / Age	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
1	0.062	0.089	0.07	0.075	0.067	0.064	0.08	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	0.12	0.12	0.106	0.113	0.116
3	0.14	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	0.17	0.164	0.162	0.165	0.163	0.167	0.168	0.156	0.167	0.16
5	0.165	0.182	0.18	0.176	0.177	0.176	0.181	0.176	0.188	0.168	0.18	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	0.2	0.204	0.188	0.19	0.2	0.198	0.191	0.186

8	0.197	0.212	0.212	0.207	0.214	0.216	0.222	0.21	0.213	0.205	0.217	0.199
Year / Age	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
1	0.073	0.067	0.064	0.067	0.071	0.062	0.053	0.058	0.07	0.059	0.066	0.07
2	0.107	0.103	0.105	0.112	0.11	0.108	0.106	0.106	0.12	0.1	0.11	0.106
3	0.13	0.136	0.131	0.135	0.135	0.133	0.131	0.134	0.138	0.13	0.146	0.136
4	0.157	0.156	0.149	0.158	0.153	0.149	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	0.18	0.177	0.183	0.182	0.173	0.164	0.175	0.174	0.165	0.176	0.157
7	0.2	0.191	0.184	0.199	0.196	0.1855	0.175	0.187	0.179	0.17	0.196	0.167
8	0.205	0.209	0.211	0.227	0.206	0.189	0.172	0.196	0.191	0.18	0.198	0.171
Year / Age	**2016**	**2017**	**2018**									
1	0.054	0.072	0.060									
2	0.102	0.093	0.096									
3	0.126	0.121	0.120									
4	0.143	0.14	0.132									
5	0.159	0.147	0.147									
6	0.161	0.154	0.159									
7	0.167	0.154	0.164									
8	0.177	0.162	0.204									

Table 7.6.3.3 Irish Sea Herring. WEIGHTS (Kgs) AT AGE IN THE STOCK

Year / 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	0.07	0.081	0.077	0.07
2	0.155	0.155	0.155	0.155	0.142	0.125	0.143	0.13	0.124	0.128	0.135	0.121
3	0.195	0.195	0.195	0.195	0.187	0.157	0.167	0.16	0.16	0.155	0.163	0.153
4	0.219	0.219	0.219	0.219	0.213	0.186	0.188	0.175	0.17	0.174	0.175	0.167
5	0.232	0.232	0.232	0.232	0.221	0.202	0.215	0.194	0.18	0.184	0.188	0.18
6	0.251	0.251	0.251	0.251	0.243	0.209	0.229	0.21	0.198	0.195	0.196	0.189
7	0.258	0.258	0.258	0.258	0.24	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

Year / 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	0.12	0.115	0.119	0.121	0.121	0.12	0.105	0.113	0.116
3	0.136	0.157	0.154	0.147	0.148	0.148	0.15	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	0.16
5	0.159	0.183	0.181	0.18	0.177	0.178	0.179	0.178	0.188	0.167	0.18	0.167
6	0.171	0.191	0.19	0.185	0.195	0.189	0.19	0.189	0.204	0.183	0.184	0.172
7	0.179	0.198	0.203	0.197	0.199	0.206	0.2	0.199	0.205	0.199	0.191	0.186
8	0.191	0.214	0.214	0.212	0.212	0.214	0.23	0.214	0.215	0.205	0.217	0.199
Year / Age	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
1	0.067	0.067	0.064	0.073	0.071	0.066	0.06	0.057	0.059	0.057	0.069	0.07
2	0.114	0.103	0.105	0.114	0.11	0.114	0.118	0.109	0.109	0.1	0.112	0.106
3	0.144	0.136	0.131	0.137	0.135	0.135	0.134	0.136	0.131	0.131	0.15	0.136
4	0.161	0.156	0.149	0.158	0.153	0.15	0.147	0.155	0.149	0.142	0.178	0.148
5	0.17	0.166	0.164	0.174	0.156	0.155	0.153	0.162	0.153	0.157	0.174	0.155
6	0.192	0.18	0.177	0.183	0.182	0.174	0.165	0.177	0.162	0.167	0.176	0.157
7	0.202	0.191	0.184	0.199	0.196	0.186	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	0.19	0.18	0.202	0.171
Year / Age	**2016**	**2017**	**2018**									
1	0.054	0.072	0.060									
2	0.102	0.093	0.096									
3	0.126	0.121	0.120									
4	0.143	0.14	0.132									
5	0.159	0.147	0.147									
6	0.161	0.154	0.159									
7	0.167	0.154	0.164									
8	0.177	0.162	0.204									

Table 7.6.3.4 Irish Sea Herring. NATURAL MORTALITY

Year / 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	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
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
Year / 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	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
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
Year / 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	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
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
Year / Age	**2016**	**2017**	**2018**									
1	0.787	0.787	0.787									
2	0.38	0.38	0.38									

3	0.353	0.353	0.353
4	0.335	0.335	0.335
5	0.315	0.315	0.315
6	0.311	0.311	0.311
7	0.304	0.304	0.304
8	0.304	0.304	0.304

Table 7.6.3.5 Irish Sea Herring. PROPORTION MATURE

Year / Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.2	0.19	0.1	0.02	0	0.14	0.31	0	0	0.07	0.06	0.04	0.28	0	0.19
2	0.88	0.89	0.8	0.73	0.69	0.62	0.73	0.85	0.9	0.63	0.66	0.3	0.48	0.46	0.68
3	0.95	0.9	0.89	0.88	0.83	0.71	0.66	0.91	0.96	0.93	0.9	0.74	0.72	0.99	0.99
4	0.95	0.94	0.91	0.9	0.93	0.88	0.81	0.87	0.99	0.95	0.95	0.82	0.81	1	0.97
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Year / Age	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1	0.1	0.02	0.04	0.3	0.02	0.14	0.15	0.02	0.11	0.114	0.2	0.19	0.16	0.16	0.13
2	0.86	0.6	0.82	0.83	0.84	0.79	0.54	0.92	0.76	1	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	0.97	0.99	1	0.98	1	0.97
4	0.99	0.83	1	0.99	0.97	1	0.97	0.98	0.97	1	1	1	1	1	0.98
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Year / Age	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**						
1	0.11	0.08	0.1	0.06	0.16	0.11	0.07	0.1	0.08						
2	0.92	0.9	0.84	0.82	0.94	0.87	0.81	0.85	0.67						
3	1	1	1	0.99	1	1	0.99	1	0.97						
4	0.98	1	1	1	1	1	1	1	1						
5	0.97	1	1	1	1	1	1	1	1						
6	1	1	1	1	1	1	1	1	1						
7	1	1	1	1	1	1	1	1	1						
8	1	1	1	1	1	1	1	1	1						

Table 7.6.3.6 Irish Sea Herring. FRACTION OF HARVEST BEFORE SPAWNING

Year / 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
Year / 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
Year / Age	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**						
1	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						
3	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						
5	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						
7	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						

Table 7.6.3.7 Irish Sea Herring. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Year / 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
Year / 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
Year / Age	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**						
1	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						
3	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						
5	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						
7	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						

Table 7.6.3.8 Irish Sea Herring. SURVEY INDICES

```
AC(7.aN) - Configuration
Irish Sea herring (Division 7.a) (run name: ICAMDC20) . Imported from VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
      1.0       8.0       8.0    1994.0    2018.0       0.7       0.8
Index type : number
AC(7.aN) - 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
1	491894	131512	42175	237857
2	141854	449316	89653	120683
3	25153	257152	104059	63334
4	17018	110196	56474	110874
5	10340	32232	9007	29555
6	8954	18312	20297	7645

7	1890	8157	4395	7926
8	4342	7042	11779	5053

```
7.aNSpawn - Configuration
FLT05: SSB acoustic (Catch: Unknown) (Effort: Unknown)
      min       max plusgroup   minyear   maxyear    startf      endf
       NA        NA        NA      2007      2018        NA        NA
Index type : biomass
7.aNSpawn - 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
  all 60328.27 74275.73 41683.6 38973.8
```

Table 7.6.3.9 Irish Sea Herring. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        1         8         8      1980      2018         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      2018         4         6
fleets         :      catch  AC(7.aN) 7.aNSpawn
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(7.aN)  NA NA NA NA NA NA NA NA
states         :   7.aNSpawn 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(7.aN)    1  2  3  4  4  4  4  4
catchabilities :   7.aNSpawn 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(7.aN)  NA NA NA NA NA NA NA NA
power.law.exps :   7.aNSpawn 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(7.aN)  NA NA NA NA NA NA NA NA
f.vars         :   7.aNSpawn 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(7.aN)   4  5  5  5  5  6  6  6
obs.vars       :   7.aNSpawn NA NA NA NA NA NA NA NA
srr            : 0
cor.F          : FALSE
nohess         : FALSE
timeout        : 3600
sam.binary     : C:/Work/HAWG2019/SAM/sam.exe
```

Table 7.6.3.11 Irish Sea Herring. FLR, R SOFTWARE VERSIONS

```
FLSAM.version                        1.0
FLCore.version                2.5.20150309
R.version      R version 3.4.4 (2018-03-15)
platform                   i386-w64-mingw32
run.date                2018-03-16 11:27:17
```

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
1980	174556	90497	336695	36243	25863	50788	13874	9473	20321	0.2893	0.1908	0.4385	10613	1.0308
1981	203414	104714	395145	37760	26550	53702	13924	9715	19958	0.2769	0.1869	0.4102	4377	1.0999
1982	222348	114428	432053	42959	29767	61998	14691	10021	21538	0.2637	0.1816	0.383	4855	1.0166
1983	183506	91366	368563	45071	31184	65143	16217	10991	23927	0.2577	0.1808	0.3671	3933	1.0165
1984	131006	67830	253026	43783	32039	59831	17257	12152	24509	0.2628	0.1903	0.3629	4066	1.0392
1985	171099	89174	328293	46028	34426	61539	16205	12237	21460	0.2809	0.2114	0.3733	9187	0.9802
1986	211928	110671	405827	47240	35593	62698	18574	14102	24464	0.2897	0.2215	0.3788	7440	1.0238
1987	273484	140482	532408	46630	34513	63002	16850	12472	22765	0.2981	0.2296	0.3869	5823	0.9632
1988	117360	60942	226008	43391	32880	57261	19732	14272	27281	0.3124	0.2406	0.4056	10172	0.9505
1989	151600	78515	292714	40175	29881	54016	15060	11060	20507	0.3096	0.2393	0.4004	4949	0.9966
1990	128927	67877	244886	37496	28583	49189	14357	10746	19181	0.3112	0.2417	0.4006	6312	0.9872
1991	78905	41609	149633	28796	22533	36801	9860	7453	13044	0.3092	0.2419	0.3953	4398	0.9994
1992	244019	128891	461979	32177	23152	44720	10267	7919	13311	0.3164	0.249	0.4019	5270	0.989
1993	63704	34667	117062	29912	22898	39073	10331	7897	13515	0.3182	0.2507	0.4039	4409	0.9869
1994	161458	89715	290572	30669	23220	40507	11485	8804	14982	0.3241	0.255	0.412	4828	0.9757
1995	132588	72479	242548	29466	22340	38865	11133	8436	14693	0.3287	0.2579	0.4189	5076	1.0007
1996	85991	46370	159468	24441	18768	31828	8962	6675	12034	0.3376	0.2633	0.433	5301	0.9999

Year	Recruitment	Low	High	TSB	Low	High	SSB	Low	High	Fbar	Low	High	Landings	Landings
1997	124991	68798	227084	23506	17571	31446	8309	6087	11342	0.3529	0.2711	0.4592	6651	0.9996
1998	166875	93347	298321	26742	19593	36500	9477	7136	12585	0.3612	0.2726	0.4787	4905	0.9951
1999	77111	42346	140416	22629	17197	29777	9085	6625	12458	0.3517	0.265	0.4666	4127	1.0001
2000	78669	42400	145960	19867	15054	26218	8718	6427	11825	0.3404	0.2562	0.4524	2002	0.9993
2001	109098	57533	206877	19932	14001	28377	6683	4665	9573	0.353	0.2586	0.4819	5461	1.0004
2002	82619	44879	152099	19206	13981	26384	6926	4852	9886	0.3472	0.25	0.4822	2393	0.9984
2003	146825	81138	265693	22629	15826	32356	6243	4520	8622	0.344	0.2425	0.4879	2399	1.001
2004	157000	85158	289449	24612	17465	34684	9118	6463	12864	0.3216	0.2275	0.4547	2531	0.9979
2005	176487	95645	325656	27889	19590	39706	10918	7664	15555	0.3065	0.2157	0.4353	4387	1.0062
2006	306202	167814	558711	36864	25410	53481	12150	8789	16798	0.281	0.1991	0.3966	4402	1.0005
2007	528607	273739	1020772	65251	42347	100543	19585	13970	27456	0.2452	0.1735	0.3467	4629	1.0012
2008	266999	133410	534358	59101	41480	84207	25084	17518	35919	0.2288	0.1602	0.327	4895	1.0008
2009	343176	176804	666107	61636	42963	88424	25034	17371	36077	0.2153	0.1486	0.3119	4594	NA
2010	394352	211814	734199	63831	45195	90152	26556	18647	37819	0.2026	0.1386	0.2961	4894	0.9989
2011	252206	127686	498156	56162	40509	77863	26849	19147	37651	0.1951	0.1331	0.2859	5202	1.0014
2012	291268	158535	535131	54122	39335	74468	24101	16999	34170	0.1898	0.1293	0.2785	5693	0.9999
2013	160011	86427	296247	44312	32632	60172	22018	15639	30998	0.1801	0.1213	0.2674	4828	0.9982
2014	340783	180798	642334	56331	39806	79717	23671	17130	32709	0.1707	0.1133	0.2573	5083	0.9405

Year	Recruitment	Low	High	TSB	Low	High	SSB	Low	High	Fbar	Low	High	Landings	Landings
2015	378890	205288	699299	59516	42493	83358	22093	15960	30583	0.1707	0.1139	0.2559	4891	1.0001
2016	208772	110175	395607	50970	37758	68807	24367	17429	34067	0.1648	0.1082	0.2509	4327	0.9999
2017	192529	89663	413406	48630	34761	68033	22948	16323	32263	0.1566	0.0999	0.2455	3896	0.9999
2018	333701	86352	1289560	54885	30958	97306	22020	14800	32763	0.1563	0.0982	0.2486	6804	1.0061

Table 7.6.3.13 Irish Sea Herring. ESTIMATED FISHING MORTALITY

Units : f

Year / Age	1980	1981	1982	1983	1984	1985	1986
1	0.026292	0.025766	0.024972	0.023971	0.023645	0.023783	0.024026
2	0.330219	0.293376	0.259111	0.230017	0.213931	0.216406	0.219347
3	0.337969	0.298257	0.269146	0.249749	0.24522	0.25459	0.255227
4	0.333137	0.321261	0.300863	0.277843	0.271037	0.283087	0.28176
5	0.269335	0.248976	0.229788	0.23087	0.245539	0.266628	0.278121
6	0.265405	0.260566	0.260488	0.264266	0.271797	0.293054	0.30919
7	0.242731	0.190882	0.166161	0.086917	0.169297	0.318925	0.383794
8	0.242731	0.190882	0.166161	0.086917	0.169297	0.318925	0.383794
Year / Age	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
1	0.024072	0.024682	0.025082	0.026168	0.027305	0.028207	0.028252
2	0.216233	0.21773	0.219874	0.231448	0.243704	0.259059	0.272477
3	0.252991	0.256892	0.251956	0.253118	0.25579	0.264689	0.271145
4	0.277898	0.28462	0.276374	0.272586	0.268931	0.275133	0.273269
5	0.290254	0.306021	0.304313	0.308449	0.30919	0.318574	0.324685
6	0.326084	0.346421	0.348018	0.352502	0.349553	0.355333	0.35665
7	0.470796	0.703097	0.570022	0.553779	0.423929	0.310895	0.336957
8	0.470796	0.703097	0.570022	0.553779	0.423929	0.310895	0.336957
Year / Age	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
1	0.028898	0.030032	0.031039	0.03099	0.029674	0.028504	0.027215
2	0.299063	0.32514	0.350113	0.360523	0.330582	0.300953	0.275436
3	0.282352	0.292	0.298018	0.305563	0.301616	0.289877	0.277926
4	0.275739	0.280495	0.289558	0.312391	0.32566	0.322485	0.323777
5	0.334473	0.341332	0.351375	0.367218	0.373566	0.354836	0.335209
6	0.362149	0.364183	0.371915	0.378984	0.384428	0.37763	0.362366
7	0.408007	0.402951	0.518	0.844636	0.63575	0.410676	0.200008
8	0.408007	0.402951	0.518	0.844636	0.63575	0.410676	0.200008

Year / Age	2001	2002	2003	2004	2005	2006	2007
1	0.02614	0.024833	0.02522	0.026713	0.028184	0.028846	0.029585
2	0.27346	0.251981	0.226774	0.216189	0.214853	0.205255	0.188341
3	0.283569	0.266308	0.260826	0.259266	0.249574	0.234125	0.209779
4	0.347219	0.343764	0.342255	0.320267	0.301285	0.268904	0.229351
5	0.340786	0.328211	0.321937	0.308943	0.295821	0.27101	0.234453
6	0.37109	0.369686	0.367732	0.335679	0.322227	0.303037	0.271851
7	0.481562	0.490917	0.968074	0.5301	0.462962	0.409217	0.217121
8	0.481562	0.490917	0.968074	0.5301	0.462962	0.409217	0.217121
Year / Age	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1	0.029709	0.029349	0.028993	0.02845	0.027529	0.027332	0.026909
2	0.174366	0.169653	0.164212	0.160478	0.160301	0.163687	0.165018
3	0.193206	0.186188	0.178637	0.174122	0.171221	0.168217	0.163213
4	0.211506	0.20303	0.194991	0.19367	0.193728	0.188643	0.184464
5	0.219128	0.204763	0.191455	0.179892	0.170146	0.156343	0.142388
6	0.255892	0.238163	0.221308	0.211697	0.20542	0.19546	0.18537
7	0.225892	0.165002	0.12032	0.16967	0.184981	0.09715	0.116426
8	0.225892	0.165002	0.12032	0.16967	0.184981	0.09715	0.116426
Year / Age	**2015**	**2016**	**2017**	**2018**			
1	0.025253	0.024783	0.024699	0.024967			
2	0.1652	0.167579	0.176453	0.188266			
3	0.160703	0.15812	0.164458	0.174697			
4	0.191283	0.192396	0.186169	0.188266			
5	0.136395	0.12986	0.125531	0.127314			
6	0.18452	0.172131	0.158089	0.153217			
7	0.197247	0.131941	0.087004	0.028607			
8	0.197247	0.131941	0.087004	0.028607			

Table 7.6.3.14 Irish Sea Herring. ESTIMATED POPULATION ABUNDANCE

Units : NA

Year / Age	1980	1981	1982	1983	1984	1985	1986
1	174555.8	203414.3	222348.2	183505.5	131006.2	171099.4	211927.6
2	52891.61	73939.32	87991.9	96567.74	86681.87	60839.83	76879.92
3	32435.22	20702.3	36026.14	46027.76	56726.68	59694.79	34856.68
4	26984.02	12226.98	9595.984	19938.34	28623.98	37835.38	35525.29
5	4932.494	12732.33	4821.788	4507.509	12572.91	20211.36	21074.1
6	3821.889	2284.951	6764.881	2756.729	2721.667	8496.418	12523.97
7	1788.799	2052.472	1169.58	3757.466	1586.364	1761.463	4996.535
8	1172.156	1657.723	2150.38	1699.348	3688.223	3331.24	2894.304
Year / Age	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
1	273484.4	117359.8	151599.9	128926.8	78905.01	244018.7	63703.83
2	92410.88	127899.5	51123.52	71467.64	57182.32	34166.47	100810.7
3	40215.19	52365.33	73791.59	30031.44	40660	31225.8	17349.17
4	19047.67	22359.35	26795.79	44267.23	17525.29	24270.09	16680.57
5	20060.34	11307.26	10784.88	14408.88	25925.96	10988.45	13210.93
6	11958.53	11602.78	5678.827	5593.162	7480.089	15602.71	6284.867
7	7259.745	6561.011	5487.346	2855.208	2669.643	4004.604	8442.215

8	4348.56	6087.544	4690.995	4154.303	2805.957	2408.357	3502.037
Year / Age	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
1	161457.9	132587.8	85991.18	124991.4	166874.9	77110.91	78668.65
2	29554.76	78433	55436.86	39735.49	50412.78	76649.63	32565.22
3	54176.36	14531.88	42873.11	25796.65	16081.1	26186.52	42787.45
4	9379.671	28339.16	7546.959	23365.13	13011.65	7734.143	14071.41
5	9354.38	5106.656	15740.62	4372.106	12911.84	6138.895	4133.997
6	7148.087	4906.911	2752.046	7994.427	2468.831	6299.339	2731.483
7	3491.546	3613.023	2676.593	1369.773	4132.344	1267.498	2747.372
8	6674.837	5080.678	4221.307	2881.885	1267.118	2160.943	1493.384
Year / Age	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
1	109097.8	82619.42	146825.5	156999.8	176486.6	306201.9	528606.7
2	35596.41	44267.23	39300.79	68665.35	67846.29	76191.1	135537
3	17574.43	15269.31	20979.48	21741.97	43044.94	34030.08	39815.04
4	25745.11	8627.413	7264.829	10413.93	10848.69	22538.95	17831.11
5	7912.507	12439.1	3674.602	3101.683	4902.007	4531.009	11984.87
6	2401.383	3876.934	5886.401	1621.651	1541.791	2109.065	2450.629
7	1387.141	1287.04	1673.211	2343.732	817.3766	783.4443	1003.651
8	2428.429	1603.59	1182.398	633.3986	1332.351	890.2479	759.3782

Year / Age	2008	2009	2010	2011	2012	2013	2014
1	266998.9	343176.4	394352.3	252205.6	291268.3	160011.3	340782.6
2	209190.4	110414.9	150843.8	167879.2	96761.07	135401.5	71825.87
3	73570.54	114233.5	57930.54	75659.63	93807.49	50312.06	72765.7
4	22719.98	43870.61	58162.73	29732.62	43521.05	49711.92	24440.58
5	11432.32	13637.79	23599.95	29673.21	17520.03	22948.32	26081.98
6	7622.045	6687.531	7524.352	12842.3	17066.97	9884.271	11766.36
7	1612.756	4243.315	3588.896	4189.765	7786.136	9178.325	5356.146
8	1054.371	1685.808	3142.268	3724.918	4451.961	6408.625	9277.988
Year / Age	2015	2016	2017	2018			
1	378889.5	208772.4	192528.6	333700.8			
2	137447.9	182955.8	99111.43	96857.88			
3	39026.65	77419.97	111190.5	66237.36			
4	40134.84	23647.2	44134.63	73570.54			
5	14033.46	22925.38	10511.24	27173.57			
6	16079.49	9018.2	14298.36	6197.492			
7	6723.741	8580.093	5092.886	9824.161			
8	8058.639	7752.728	8568.946	6461.392			

Table 7.6.3.15 Irish Sea Herring. PREDICTED CATCH NUMBERS AT AGE

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Units  :  NA

<0 x 0 matrix>
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Table 7.6.3.16 Irish Sea Herring. CATCH AT AGE RESIDUALS

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Units  :  NA

<0 x 0 matrix>
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Table 7.6.3.18 Irish Sea Herring. PREDICTED INDEX AT AGE Fleet 1

Units : NA

Year / Age	1980	1981	1982	1983	1984	1985	1986
1	3139.253	3588.322	3801.42	3012.634	2122.437	2788.503	3487.254
2	12504.83	15783.18	16854.28	16634.76	13981.36	9916.249	12678.84
3	7913.932	4537.947	7218.915	8634.318	10464.25	11387.25	6665.365
4	6554.453	2880.531	2136.299	4141.528	5816.71	7987.715	7467.309
5	1006.103	2422.875	854.204	801.961	2363.077	4085.993	4420.862
6	770.9242	453.5067	1342.193	553.9808	560.5957	1869.04	2885.461
7	334.4542	309.012	155.0473	270.3264	213.973	418.1332	1386.558
8	219.1705	249.5876	285.0544	122.2612	497.4773	790.7248	803.1568
Year / Age	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
1	4509.673	1984.595	2604.536	2309.07	1473.108	4706.736	1231.231
2	15055.67	20972.77	8451.676	12370.75	10364.79	6539.788	20165.93
3	7628.221	10073.26	13953.42	5702.557	7789.952	6165.719	3499.306
4	3957.39	4745.917	5540.389	9046.199	3537.693	5000.784	3415.195
5	4368.435	2577.435	2446.785	3306.912	5961.873	2593.102	3168.869
6	2883.73	2945.989	1447.452	1441.097	1913.616	4047.157	1635.379
7	2378.678	2907.416	2085.388	1061.523	803.9523	929.9306	2100.037

8	1424.833	2697.471	1782.781	1544.615	844.9944	559.3078	871.2161
Year / Age	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
1	3189.534	2719.709	1822.237	2644.851	3384.969	1503.574	1465.073
2	6418.245	18299.52	13771.13	10115.66	11923.54	16737.55	6579.934
3	11319.48	3127.033	9386.99	5772.959	3558.983	5600.438	8819.32
4	1935.517	5934.868	1625.336	5375.194	3100.845	1827.803	3337.275
5	2301.002	1278.113	4037.173	1163.77	3486.906	1587.729	1018.871
6	1884.146	1299.39	741.6222	2188.453	683.933	1719.708	720.3376
7	1019.023	1043.818	945.3261	687.8495	1703.108	371.8795	431.6133
8	1948.373	1467.917	1491.041	1447.597	522.2467	634.1148	234.6347
Year / Age	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
1	1951.669	1404.491	2535.13	2869.032	3400.372	6036.442	10691.67
2	7150.088	8265.372	6680.446	11187.36	10984.28	11836.82	19465.91
3	3686.6	3031.491	4088.854	4215.696	8067.589	6026.49	6389.428
4	6477.501	2153.005	1806.235	2446.638	2418.251	4549.534	3125.283
5	1977.76	3011.098	875.0053	712.8065	1085.016	929.3264	2162.348
6	645.9809	1039.838	1571.287	400.9032	368.021	477.4455	504.9402
7	462.6635	435.8334	916.6356	842.6739	264.2697	229.2172	169.8117
8	810.1343	543.1416	647.8764	227.764	430.7165	260.4576	128.4809

Year / Age	2008	2010	2011	2012	2013	2014	2015
1	5423.03	7816.952	4905.636	5485.92	2992.337	6273.126	6552.684
2	27998.33	19110.06	20820.64	11984.75	17094.46	9136.658	17495.69
3	10949.84	8024.142	10235.73	12499.7	6594.953	9276.875	4906.764
4	3703.635	8802.667	4472.309	6547.247	7296.791	3516.003	5970.524
5	1941.061	3543.995	4208.662	2361.849	2861.382	2979.349	1540.327
6	1489.313	1291.242	2117.031	2738.348	1515.848	1719.193	2339.354
7	282.8566	351.8623	566.2468	1139.232	734.5955	509.1537	1043.004
8	184.8103	308.1541	503.4629	651.3779	512.8995	881.9188	1250.251
Year / Age	**2016**	**2017**	**2018**				
1	3543.11	3257.32	5703.641				
2	23618.84	13407.51	13914.68				
3	9580.068	14269.22	8991.905				
4	3537.304	6402.732	10779.48				
5	2403.569	1067.346	2796.265				
6	1231.121	1804.358	759.7124				
7	917.6261	366.7755	239.1043				
8	829.033	617.0685	157.2458				

Table 7.6.3.19 Irish Sea Herring. INDEX AT AGE RESIDUALS Fleet 1

Units : NA

year

Year / Age	1980	1981	1982	1983	1984	1985	1986
1	0.740459	0.407608	0.350534	-0.99795	-0.71246	-0.16465	0.301742
2	1.78992	0.001082	-0.12419	-0.77564	-1.25478	0.033173	0.459891
3	2.2347	-0.86517	-0.59816	-1.07322	-0.91328	1.04091	0.27961
4	0.649561	-0.07908	0.015832	-0.95186	-1.02782	1.26034	0.335337
5	1.5618	-0.12006	-2.19404	-1.35874	-0.14304	1.30883	0.055238
6	0.382602	-0.7334	-0.43818	-0.31153	-0.897	0.806283	0.237242
7	0.169801	-0.14649	-0.23552	-0.13464	0.156572	1.07731	0.125378
8	0.111272	-0.09037	0.663205	-1.68087	-0.08731	-0.20338	0.20291
Year / Age	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
1	-0.84271	0.325391	-0.96894	0.002033	0.364145	1.13074	-0.76936
2	-0.36721	0.032535	-0.6945	0.091238	-0.15042	0.127393	-0.7938
3	-0.53508	0.696217	-0.36548	0.010161	-0.35745	0.222031	-0.3747
4	-0.68762	1.01813	-0.40321	0.172048	-0.55015	0.720764	-0.30703
5	-0.10173	1.3413	-0.6128	0.194629	-0.37474	0.525164	-0.20216
6	-0.08699	1.25877	-0.32914	0.327623	-0.5726	0.543348	-0.04181
7	-0.04968	0.244156	-0.67111	-0.04283	-0.25762	0.249164	0.087276
8	0.367648	1.02856	0.213904	0.102795	-0.08338	-0.81996	-0.0623
Year / Age	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	
1	-0.57477	0.195474	1.2814	1.53167	-0.11689	0.221256	
2	0.215608	0.37952	0.597581	1.85427	-0.00928	0.028159	
3	0.178419	0.200702	0.096774	0.668589	0.210686	0.144126	
4	-0.14426	-0.29474	-0.83536	0.771938	0.894646	-0.38286	
5	0.251458	-0.1474	-0.26248	0.792737	1.49766	-0.16676	
6	0.254599	-0.27374	0.116398	0.095553	0.944574	0.335608	
7	0.522406	-0.27628	0.037932	0.461	0.42654	0.408907	
8	0.049917	-0.02515	-0.20545	-0.02498	-0.33835	-0.04451	

Year / Age	2000	2001	2002	2003	2004	2005	2006
1	-0.21738	0.392896	-2.45733	-1.54538	0.13951	1.11952	-0.07492
2	-1.39717	1.17116	0.216672	-0.87401	-0.58522	0.597274	0.627996
3	-1.00695	1.6409	-1.16493	-0.49731	0.615471	0.665582	0.762126
4	-1.18887	1.73478	-0.35433	0.862808	-0.30747	0.760157	0.813293
5	-1.38897	1.24038	-0.52811	0.018368	-0.31066	0.623938	0.818279
6	-1.68495	0.855503	-0.20117	1.44923	-1.45895	0.277138	0.546229
7	-1.25053	0.784278	0.193662	-0.11516	-0.51867	0.2302	0.308365
8	-1.0787	-0.02042	-1.10105	-0.15795	-1.34751	-0.36304	-0.13173
Year / Age	**2007**	**2008**	**2010**	**2011**	**2012**	**2013**	**2014**
1	0.764219	0.596152	0.243598	0.499053	-0.94175	0.312647	1.75758
2	-0.15418	-0.96357	-0.20008	-0.41649	-0.53306	0.250777	0.11399
3	-0.61723	-0.94152	-0.45443	-0.32305	-0.05058	0.088908	-0.39257
4	-1.57448	-0.78646	-0.86768	-0.28759	0.478929	-0.23697	-1.401
5	-1.64031	0.161711	-0.23554	-0.31532	0.598163	0.031732	-1.21565
6	-1.01645	0.386553	-0.76951	-0.43791	0.328921	-0.06772	-1.33458
7	-0.76282	0.341595	0.115941	0.455996	0.770516	-0.37272	-0.5053
8	-0.33738	0.35975	-1.1771	-0.39084	0.0022	-0.86844	-0.13997
Year / Age	**2015**	**2016**	**2017**	**2018**			
1	-1.64218	-0.55981	-0.51682	0.402246			
2	-0.31374	-0.53057	-0.10635	1.23417			
3	-0.03394	-1.1622	-0.34395	1.37354			
4	0.523569	0.691716	-0.9251	0.339657			
5	0.106348	-0.36706	-1.29443	0.339783			
6	1.39139	0.330904	-1.21627	-0.79608			
7	1.09693	-0.05502	0.654036	1.13455			
8	-0.27035	-0.20361	0.022073	-2.64322			

Table 7.6.3.20 Irish Sea Herring. PREDICTED INDEX AT AGE Fleet 2

Units : NA

year

Year / Age	1994	1995	1996	1997	1998	1999	2000
1	185090.5	151812.3	98380.71	143028.6	191262.1	88468.34	90327.75
2	47164.65	122700.3	85093	60500.08	78503.62	122149.4	52881.03
3	62855.9	16742.24	49148.42	29413.23	18392.53	30224.25	49816.42
4	9903.366	29810.02	7886.281	24006.98	13232.48	7884.152	14331.71
5	9593.586	5210.338	15938.93	4375.342	12861.33	6200.902	4237.209
6	7202.763	4936.639	2752.432	7953.282	2446.295	6274.882	2751.799
7	3417.279	3549.919	2412.406	966.0156	3409.088	1238.108	3143.336
8	6533.839	4992.24	3805.033	2033.004	1045.364	2111.175	1708.772
Year / Age	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
1	125316.8	94968.45	168771.3	180232	202359.3	350950.3	605918
2	57907.37	73123.13	66171.16	116611.1	115254.7	130378.9	234849.5
3	20375.53	17933.04	24738.1	25670.56	51184.91	40949.71	48800.7
4	25752.84	8655.411	7295.989	10632.71	11236.58	23918.32	19492.6
5	8076.792	12815.49	3804.006	3241.917	5173.89	4873.268	13250.49
6	2403.281	3884.735	5904.441	1666.449	1600.162	2220.128	2642.023
7	1284.699	1183.688	1075.617	2091.8	767.4244	765.5925	1132.723

8	2249.538	1475.128	760.2368	565.3811	1250.789	869.9276	857.0275
Year / Age	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1	306048.8	393446.4	452118.7	289207.6	334302	183689.1	391171
2	366333.7	194172.1	266305.7	297241.4	171287.7	239043.3	126677.5
3	91253.81	142528.9	72634.84	95187.13	118302.5	63595.63	92327.75
4	25182.38	48917.97	65231.65	33382.93	48849.53	55999.61	27628.41
5	12783.75	15414.59	26932.8	34152.81	20322.42	26900.5	30878.02
6	8318.357	7394.561	8425.01	14480.53	19338.05	11283.09	13532.24
7	1809.471	4983.81	4357.44	4901.517	9004.502	11337.83	6521.502
8	1182.268	1979.639	3816.16	4358.094	5148.496	7916.227	11295.96
Year / Age	**2015**	**2016**	**2017**	**2018**			
1	435652.4	240073.4	221460.6	383540.3			
2	242292.3	322223.3	173268.9	167946.4			
3	49632.44	98567.81	140899.2	83333.01			
4	45152.46	26587.59	49826.39	82900.8			
5	16695.76	27413.75	12608.42	32552.19			
6	18503.03	10476.4	16785.15	7302.85			
7	7702.344	10324.14	6338.516	12774.55			
8	9232.914	9327.385	10664.01	8401.033			

Table 7.6.3.21 Irish Sea Herring. INDEX AT AGE RESIDUALS Fleet 2

Units : NA

year

Year / Age	1994	1995	1996	1997	1998	1999	2000
1	-1.07903	0.786881	-2.28842	-0.06786	-0.58167	0.612656	-0.1483
2	0.605701	-0.65436	-1.14096	-0.31272	-1.72765	-0.73987	1.09797
3	0.25665	-0.55385	0.518473	-1.12249	-1.3454	0.193509	1.22468
4	0.295038	-0.03126	0.207785	-1.2794	-0.58307	-0.71025	1.069
5	-0.05103	-0.21314	0.829988	-1.49859	-1.12199	0.824006	1.05464
6	0.063747	-0.4656	0.562736	-0.75515	-0.43198	1.03931	0.920656
7	0.16738	0.432753	1.21327	-0.71182	-0.56012	0.33525	0.600751
8	0.592043	0.436963	0.574169	-0.0845	-0.39643	1.47776	0.43655
Year / Age	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
1	1.19582	1.4989	0.770237	0.307782	-0.80847	0.069496	0.822046
2	0.782232	-0.02686	1.96598	-0.01523	-0.07726	-0.49031	0.110687
3	-1.13324	0.93224	0.420328	0.232648	1.04795	-1.57653	-0.07662
4	-0.63324	1.72281	-0.70748	0.605946	0.679726	-1.42995	0.129735
5	-0.07733	1.46002	0.049577	-0.73648	0.71908	-3.63053	0.739287
6	-0.7589	1.81355	-0.49739	0.435626	-0.9217	-2.42944	-1.06845
7	-0.97329	1.14416	-0.13018	-2.9425	-0.31748	-0.63769	-0.61721
8	0.008075	1.49816	0.237464	-1.16002	2.07779	-0.83639	-0.58579
Year / Age	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1	0.467119	-0.0616	0.264905	2.00891	0.104834	-0.64378	-0.2822
2	0.345135	-0.10019	1.21992	0.171917	0.185942	0.289182	0.691317
3	0.367158	0.361933	0.78978	-1.26805	0.504002	0.407999	0.526212
4	0.718992	1.04671	1.00801	-1.31143	0.082036	-0.04902	0.117848
5	1.18482	1.22011	0.396914	-0.72747	0.103021	0.695718	0.544061
6	0.972642	0.963943	0.931055	-1.125	-0.00372	0.236922	0.335816
7	1.15726	1.39247	-0.00668	-0.79977	0.400579	-0.02481	0.250668
8	-0.92049	1.68467	0.711154	-1.0825	-0.67462	-0.21055	0.135055

Year / Age	2015	2016	2017	2018
1	0.128627	-0.63743	-1.75663	-0.50611
2	-0.87602	0.544119	-1.07818	-0.54077
3	-1.1122	1.56915	-0.4959	-0.44909
4	-1.59669	2.32655	0.204908	0.475725
5	-0.78404	0.264898	-0.55042	-0.15811
6	-0.98263	0.756009	0.257192	0.061986
7	-1.90202	-0.31897	-0.49574	-0.64618
8	-1.02136	-0.38051	0.134627	-0.68824

Table 7.6.3.22 Irish Sea Herring. PREDICTED INDEX AT AGE Fleet 3

Units : NA

Year / Age	2007	2008	2009	2010	2011	2012	2013
8	19584.62	25074.33	25039.25	26542.43	26857.49	24103.2	22015.46
Year / Age	**2014**	**2015**	**2016**	**2017**	**2018**		
8	23668.49	22086.02	24374.68	22941.44	22018.1		

Table 7.6.3.23 Irish Sea Herring. INDEX AT AGE RESIDUALS Fleet 3

Units : NA

year

Year / Age	2007	2008	2009	2010	2011	2012	2013
8	1.40362	0.812138	1.77176	1.95493	1.32038	1.21793	2.60072
Year / Age	**2014**	**2015**	**2016**	**2017**	**2018**		
8	0.288037	1.58879	1.76184	0.944197	0.902875		

Table 7.6.3.25 Irish Sea Herring. FIT PARAMETERS

	name	value	std.dev
1	logFpar	0.74855	0.22053
2	logFpar	0.97627	0.16771
3	logFpar	0.62531	0.17124
4	logFpar	0.51233	0.16253
5	logSdLogFsta	-1.8965	0.57726
6	logSdLogFsta	-1.9814	0.32321
7	logSdLogFsta	-2.0027	0.46105
8	logSdLogFsta	-0.55843	0.20587
9	logSdLogN	-1.4842	0.25548
10	logSdLogObs	-0.17635	0.14484
11	logSdLogObs	-0.90691	0.12719
12	logSdLogObs	-0.83591	0.10832
13	logSdLogObs	-0.05752	0.1609
14	logSdLogObs	-0.49248	0.079939
15	logSdLogObs	-0.30198	0.0977

Table 7.6.3.26 Irish Sea Herring. NEGATIVE LOG-LIKELIHOOD

530.852

Table 7.7.1. Herring in Division 7.a North (Irish Sea). Input data for short-term forecast.

2019								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	300739.6	0.787	0.083333	0.9	0.75	0.062	0.024816	0.062
2	148157.8	0.38	0.776667	0.9	0.75	0.097	0.177433	0.097
3	54870.66	0.353	0.986667	0.9	0.75	0.122333	0.165759	0.122333
4	39077.52	0.335	1	0.9	0.75	0.138333	0.188944	0.138333
5	43596.59	0.315	1	0.9	0.75	0.151	0.127568	0.151
6	17460.32	0.311	1	0.9	0.75	0.158	0.161145	0.158
7	3895.912	0.304	1	0.9	0.75	0.161667	0.082517	0.161667
8	11677.59	0.304	1	0.9	0.75	0.181	0.082517	0.181
2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	300739.6	0.787	0.083333	0.9	0.75	0.062	0.024816	0.062
2	-	0.38	0.776667	0.9	0.75	0.097	0.177433	0.097
3	-	0.353	0.986667	0.9	0.75	0.122333	0.165759	0.122333
4	-	0.335	1	0.9	0.75	0.138333	0.188944	0.138333
5	-	0.315	1	0.9	0.75	0.151	0.127568	0.151
6	-	0.311	1	0.9	0.75	0.158	0.161145	0.158
7	-	0.304	1	0.9	0.75	0.161667	0.082517	0.161667
8	-	0.304	1	0.9	0.75	0.181	0.082517	0.181
2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	300739.6	0.787	0.083333	0.9	0.75	0.062	0.024816	0.062
2	-	0.38	0.776667	0.9	0.75	0.097	0.177433	0.097
3	-	0.353	0.986667	0.9	0.75	0.122333	0.165759	0.122333
4	-	0.335	1	0.9	0.75	0.138333	0.188944	0.138333
5	-	0.315	1	0.9	0.75	0.151	0.127568	0.151
6	-	0.311	1	0.9	0.75	0.158	0.161145	0.158
7	-	0.304	1	0.9	0.75	0.161667	0.082517	0.161667
8	-	0.304	1	0.9	0.75	0.181	0.082517	0.181

Table 7.7.2. Herring in Division 7.a North (Irish Sea). Management options table.

Rationale	Fbar (2019)	Catch (2019)	SSB (2019)	Fbar (2020)	Catch (2020)	SSB (2020)	SSB (2021)
1	0.218704	6896	23247.28	0	0	27725.76	28137.48
1	0.218704	6896	23247.28	0.1	3265.306	25408.68	26053.54
1	0.218704	6896	23247.28	0.2	6242.902	23296.36	24167.12
1	0.218704	6896	23247.28	0.3	8960.642	21370.23	22458.45
1	0.218704	6896	23247.28	0.4	11443.6	19613.45	20909.76
1	0.218704	6896	23247.28	0.5	13714.34	18010.74	19505.1
1	0.218704	6896	23247.28	0.6	15793.2	16548.19	18230.14
1	0.218704	6896	23247.28	0.7	17698.47	15213.17	17072
1	0.218704	6896	23247.28	0.8	19446.65	13994.23	16019.12
1	0.218704	6896	23247.28	0.9	21052.59	12880.95	15061.11
1	0.218704	6896	23247.28	1	22529.7	11863.86	14188.62
1	0.218704	6896	23247.28	1.1	23890.03	10934.36	13393.26
1	0.218704	6896	23247.28	1.2	25144.48	10084.62	12667.47
1	0.218704	6896	23247.28	1.3	26302.86	9307.549	12004.48
1	0.218704	6896	23247.28	1.4	27374.03	8596.675	11398.17
1	0.218704	6896	23247.28	1.5	28365.99	7946.126	10843.05
1	0.218704	6896	23247.28	1.6	29285.94	7350.56	10334.2
1	0.218704	6896	23247.28	1.7	30140.41	6805.119	9867.151
1	0.218704	6896	23247.28	1.8	30935.28	6305.384	9437.919
1	0.218704	6896	23247.28	1.9	31675.87	5847.335	9042.899
1	0.218704	6896	23247.28	2	32366.98	5427.314	8678.851

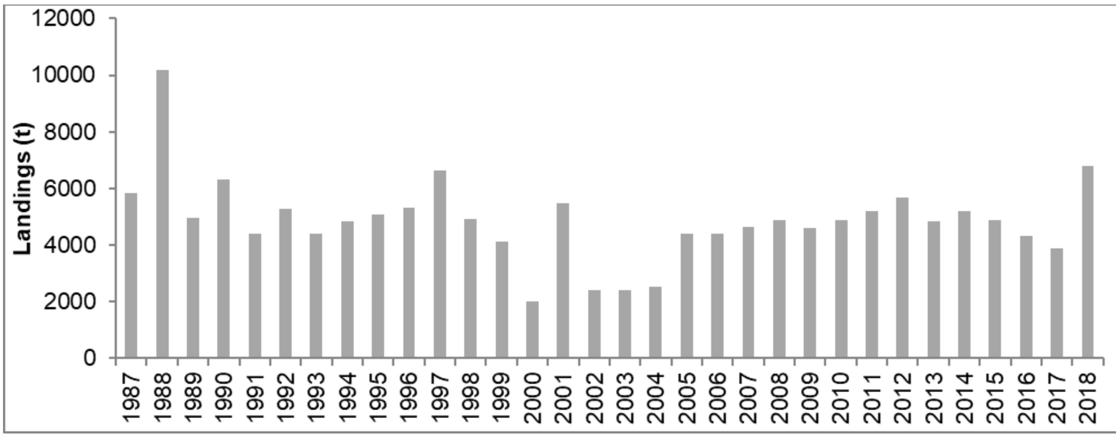


Figure 7.1.1 Herring in Division 7.a North (Irish Sea). Landings of herring from 7.a(N) from 1961 to 2018.

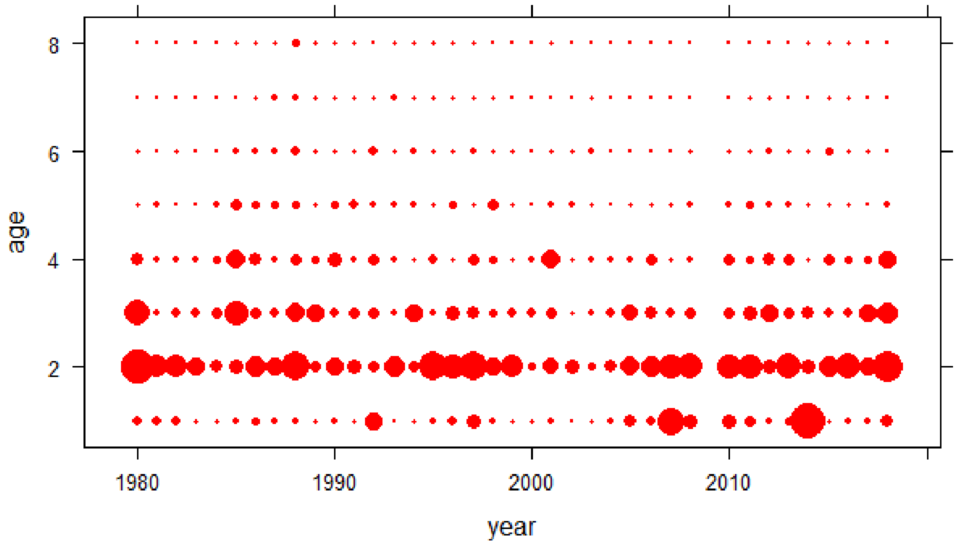


Figure 7.2.1 Herring in Division 7.a North (Irish Sea). Landings (catch-at-age) of herring from 7.a(N) from 1980 to 2018. No 2009 commercial samples.

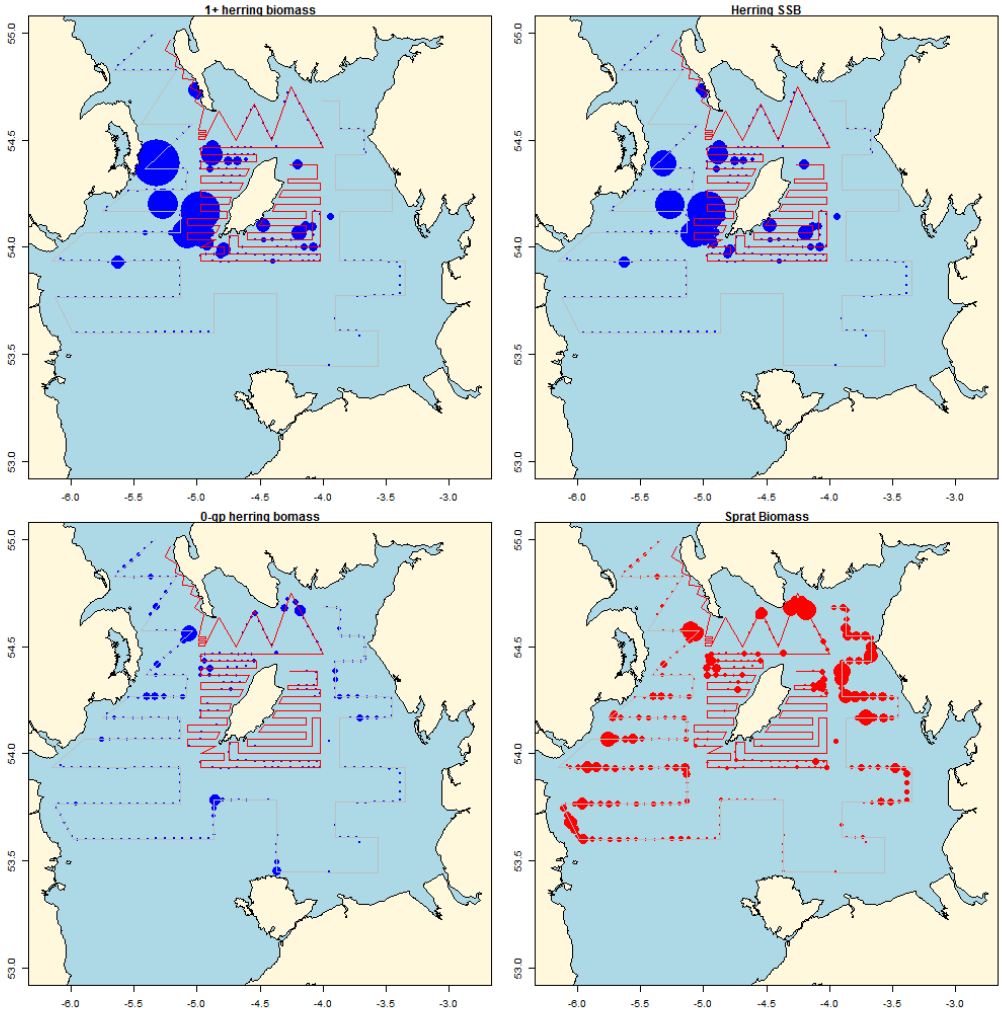


Figure 7.3.1 Herring in Division 7.a North (Irish Sea). Density distribution of 1-ring and older herring (top left panel) for the 2018 acoustic survey; SSB (top right panel); 0-ring herring (bottom left panel) and sprat biomass (bottom right panel). Note: size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval and the same scaling is used for all figures.

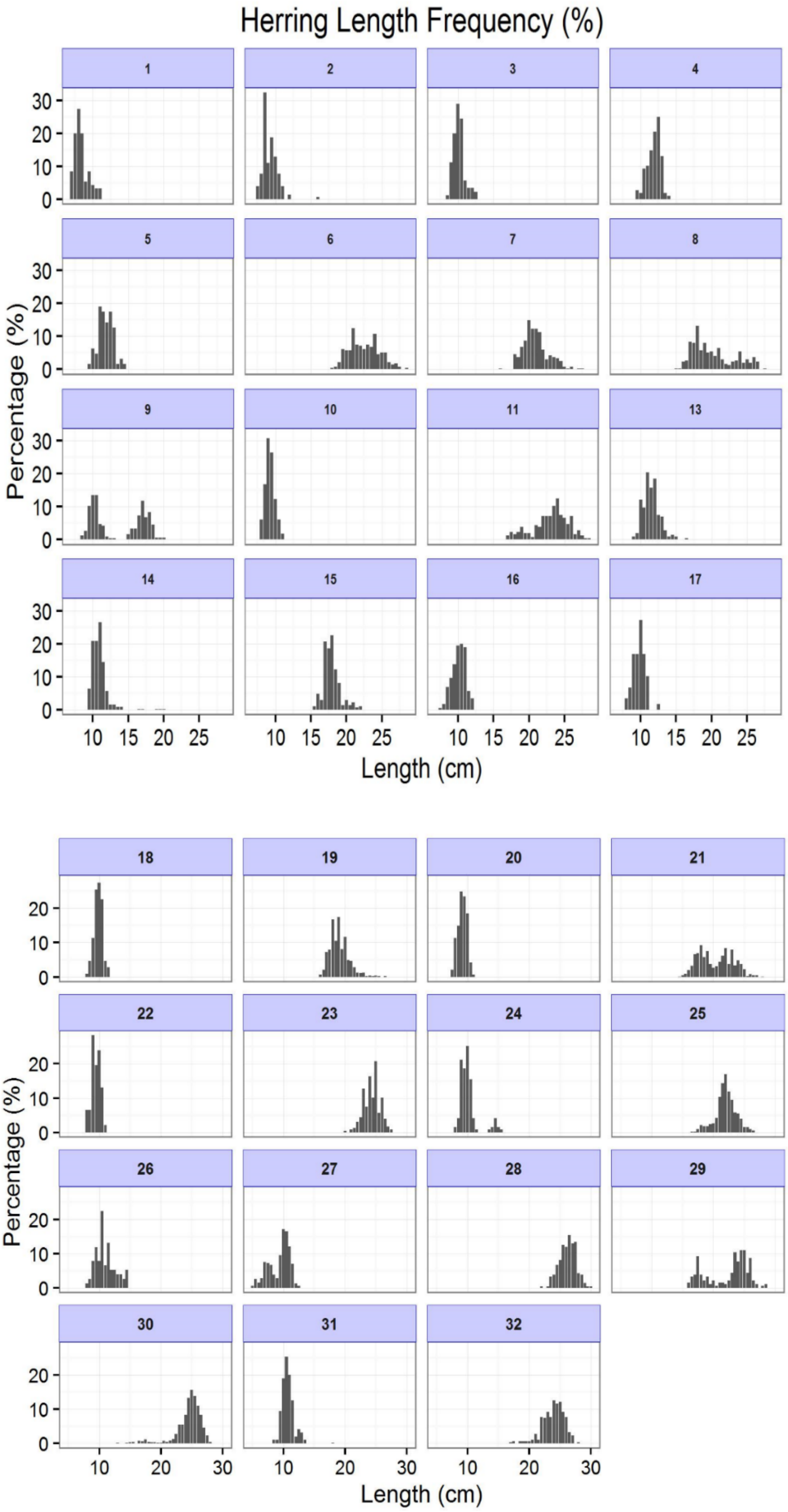


Figure 7.3.2 Herring in Division 7.a North (Irish Sea). Percentage length compositions of herring in each trawl sample in the September 2018 acoustic survey.

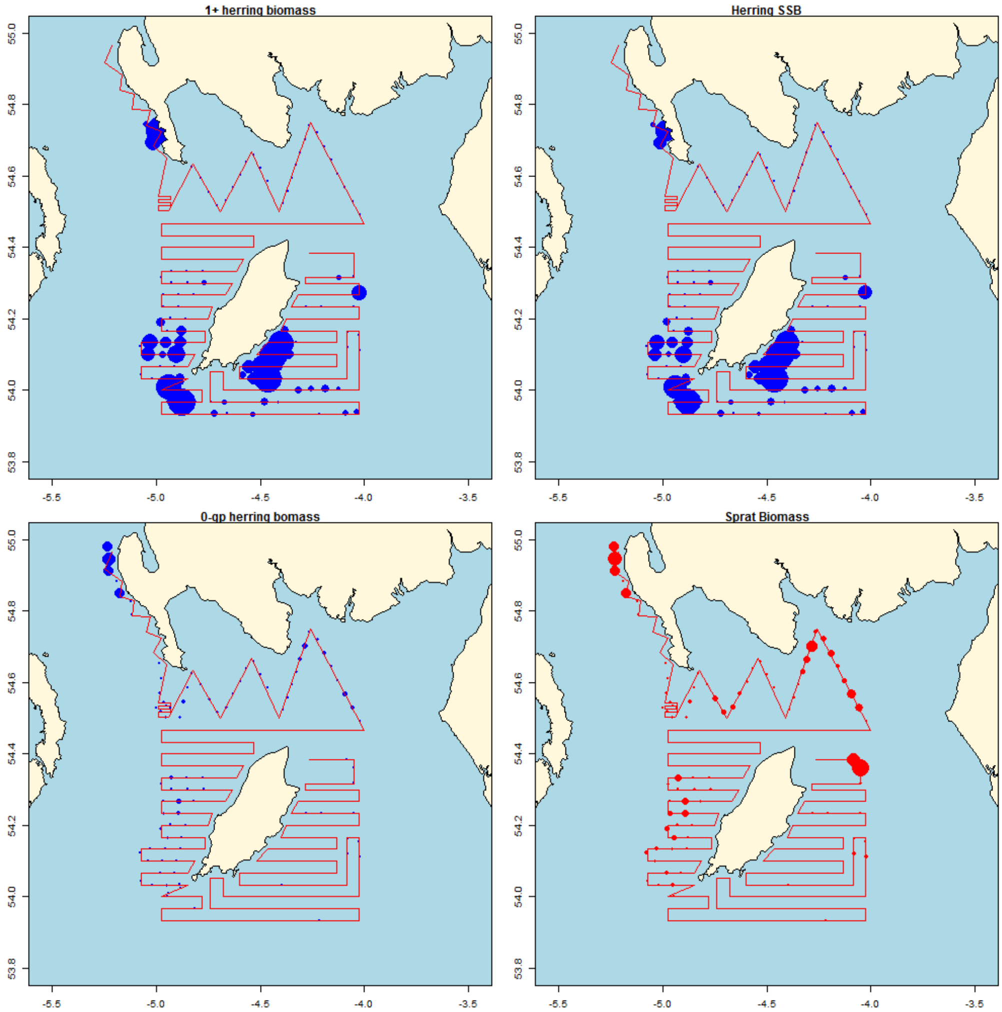


Figure 7.3.3 Herring in Division 7.a North (Irish Sea). Distribution plots for the 7.aNSpawn survey (2008–2018) (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval).

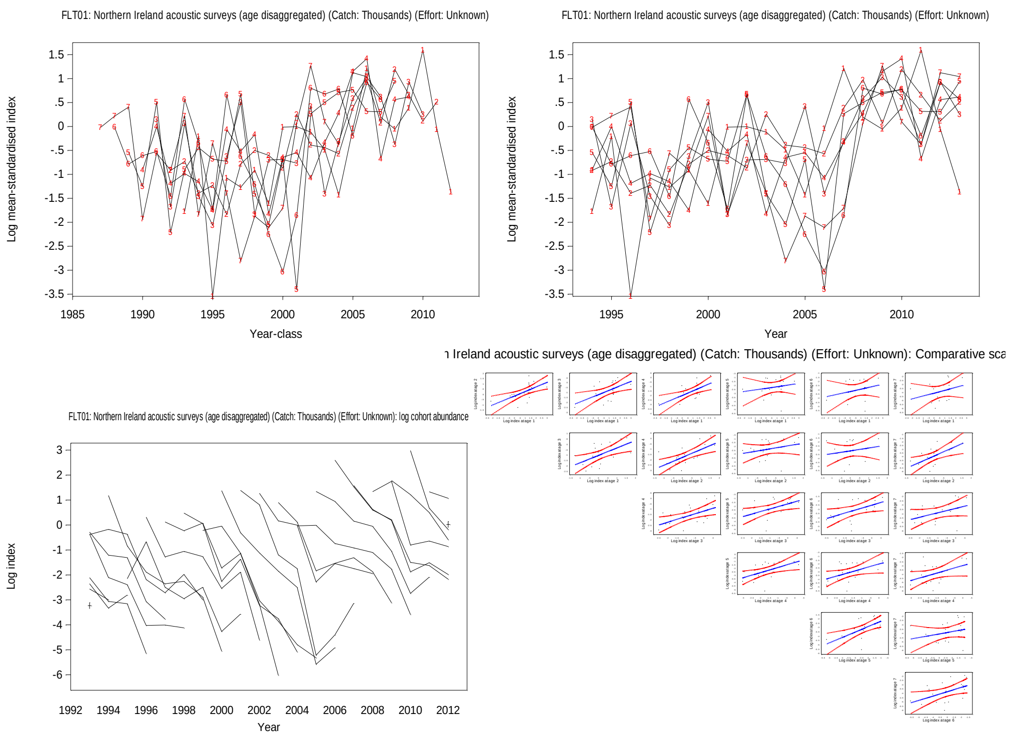


Figure 7.3.4 Herring in Division 7.a North (Irish Sea). Acoustic survey (AC(7.aN)) log mean-standardised indices by year and age class, scatter plots and catch curves.

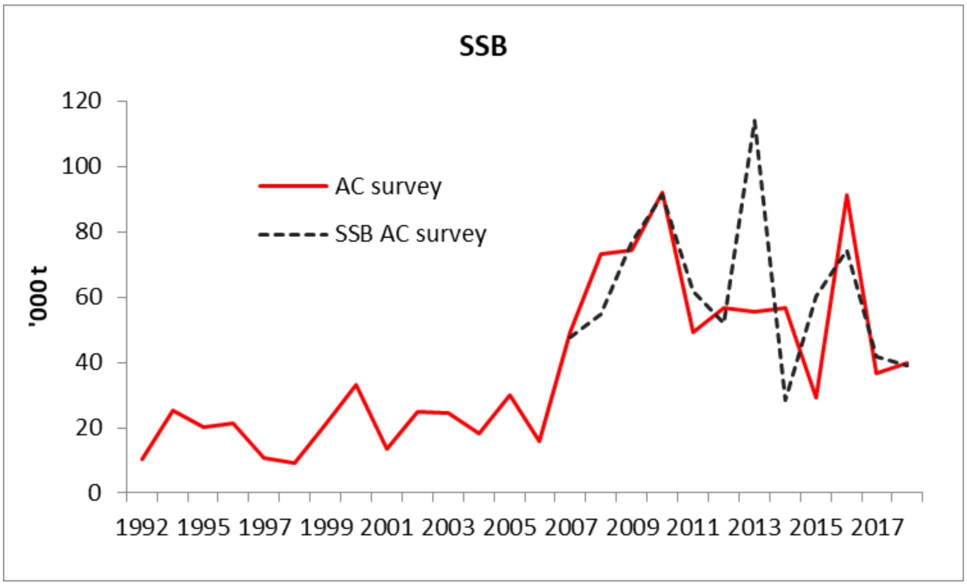


Figure 7.3.5 Herring in Division 7.a North (Irish Sea). Comparison of SSB indices from the acoustic survey estimates of SSB (red line) and the later survey 7.aNSpawn (dotted line).

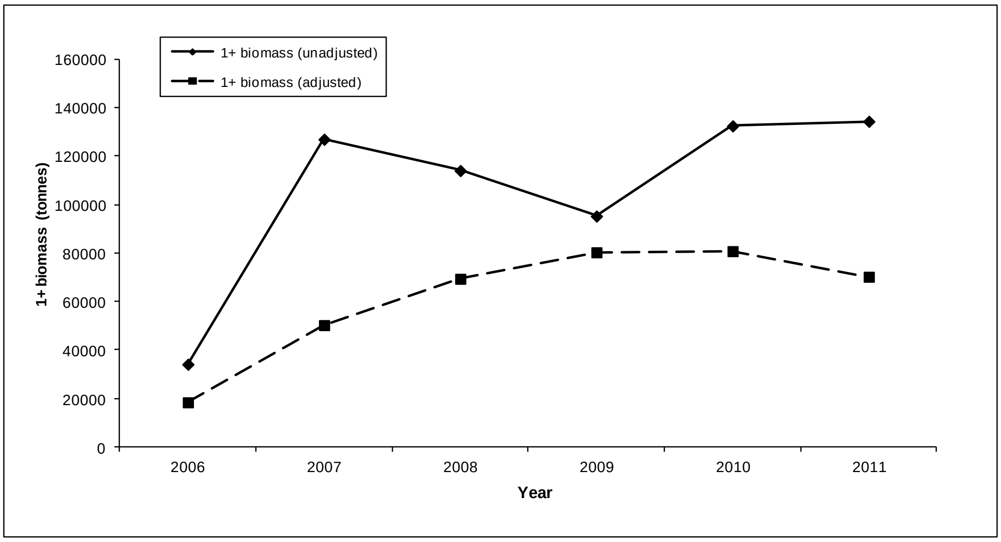


Figure 7.3.6 Herring in Division 7.a North (Irish Sea). Comparison of 1-ringer+ biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted data sets.

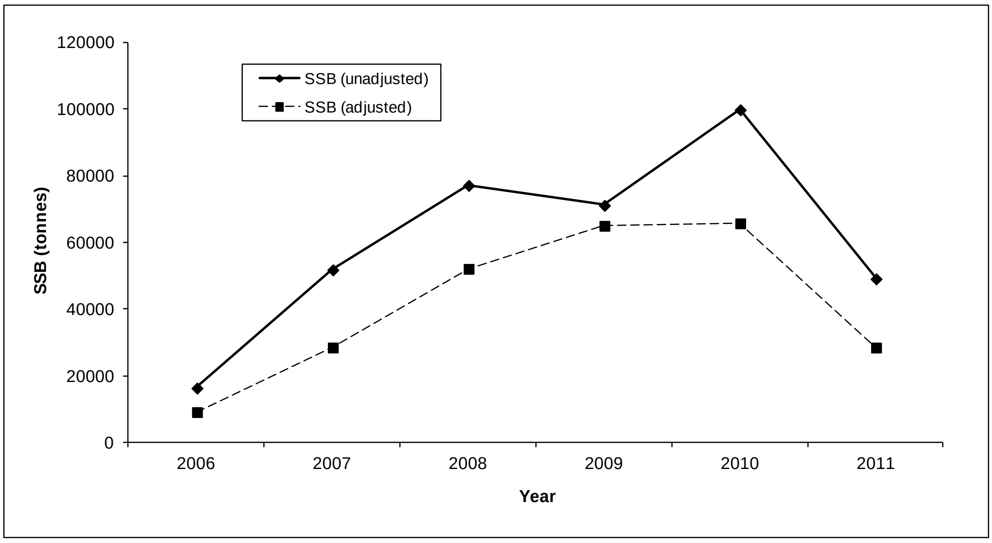


Figure 7.3.7 Herring in Division 7.a North (Irish Sea). Comparison of SSB biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted data sets.

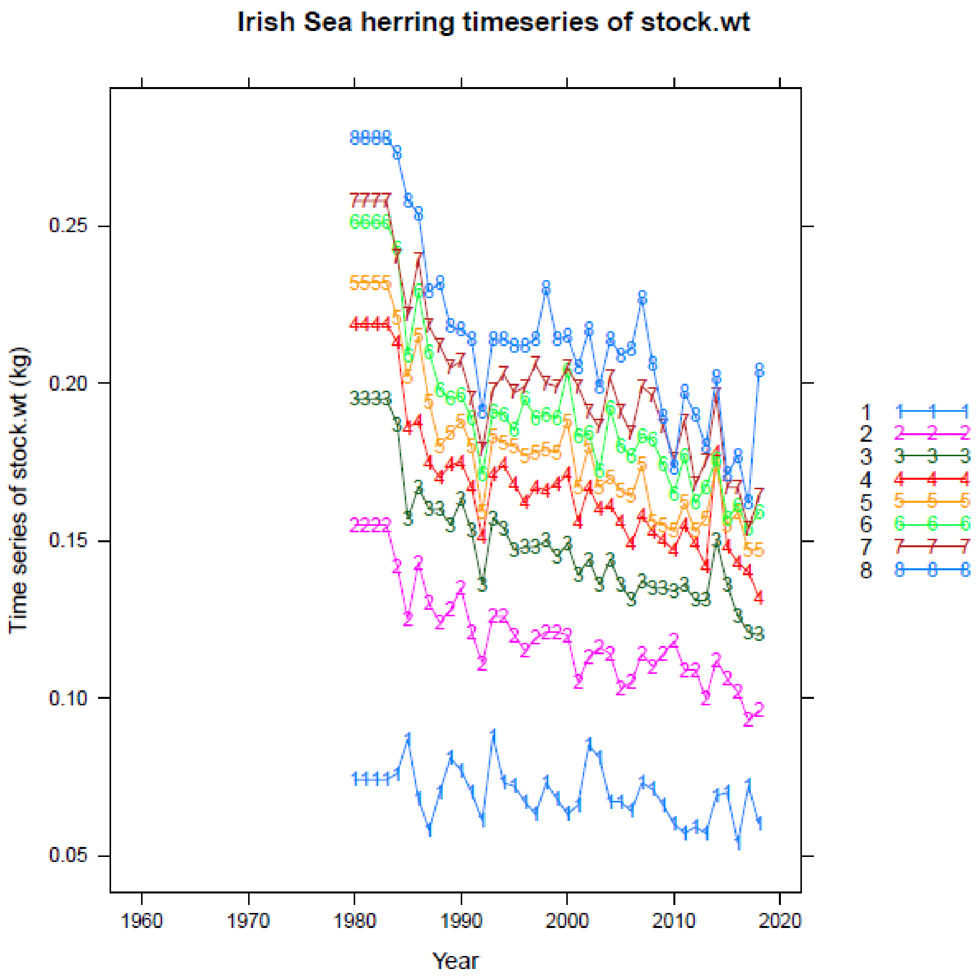


Figure 7.4.1 Herring in Division 7.a North (Irish Sea). Time series of catch weights at age.

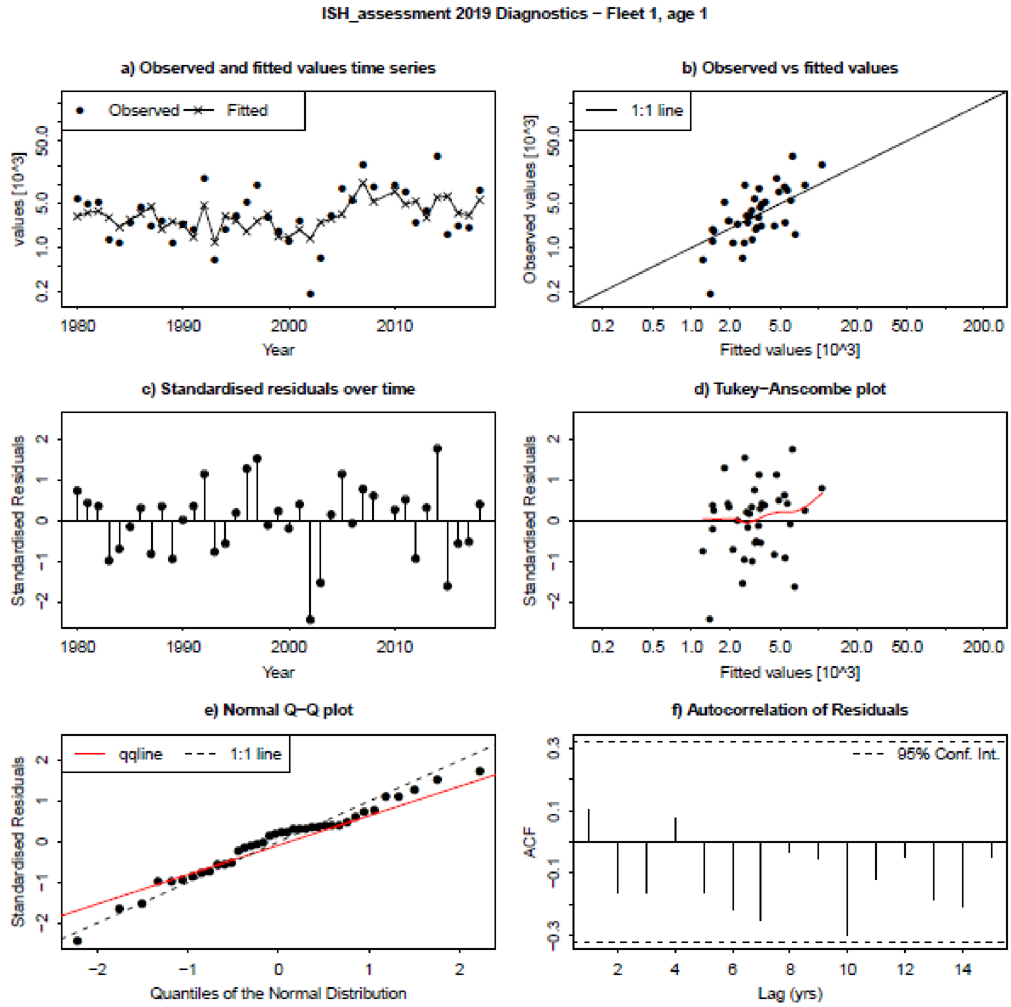


Figure 7.6.1 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age1.

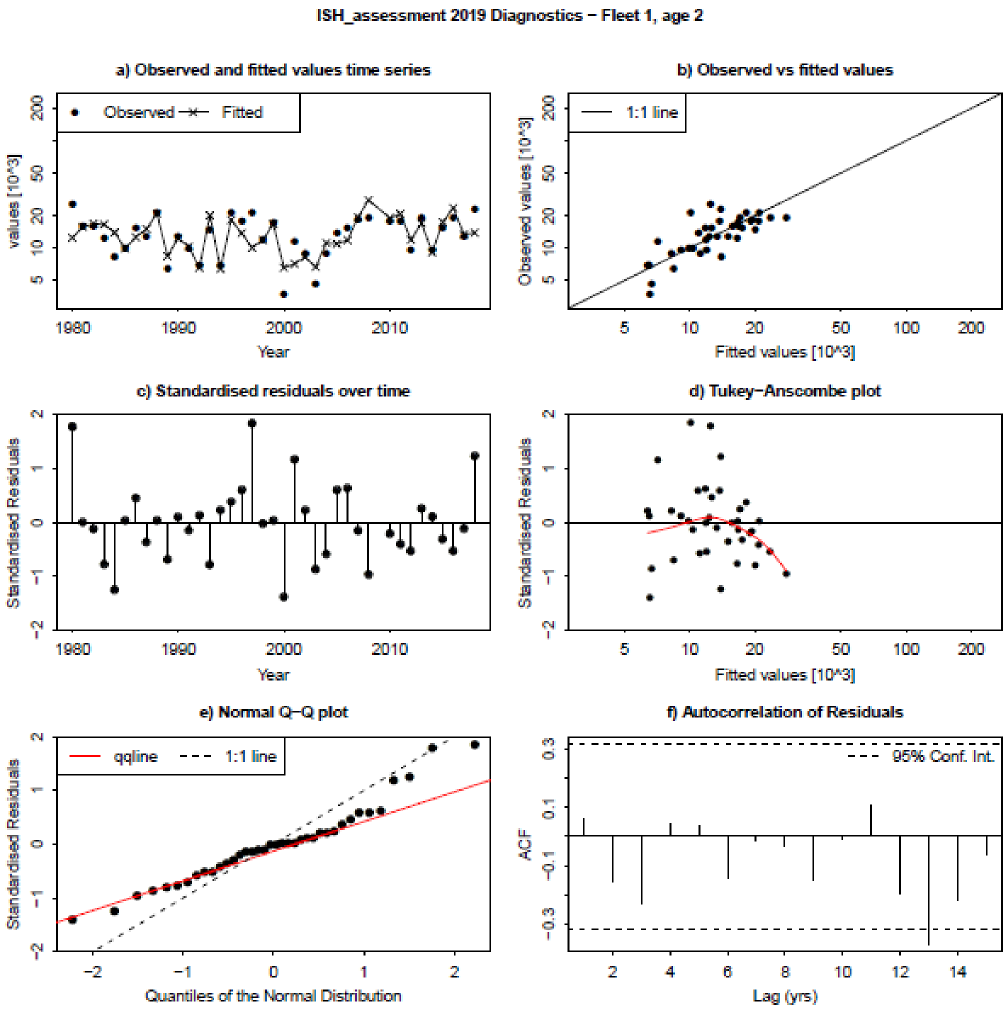


Figure 7.6.2 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age2.

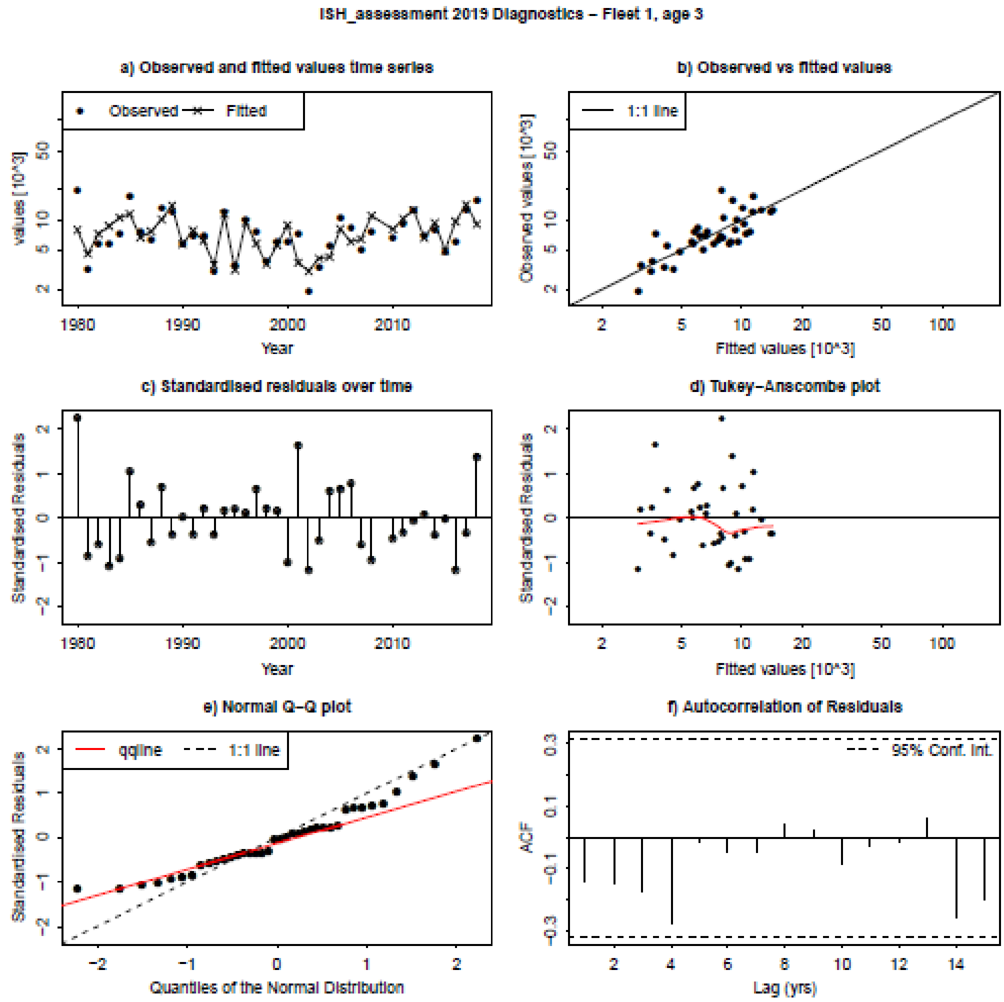


Figure 7.6.3 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age3.

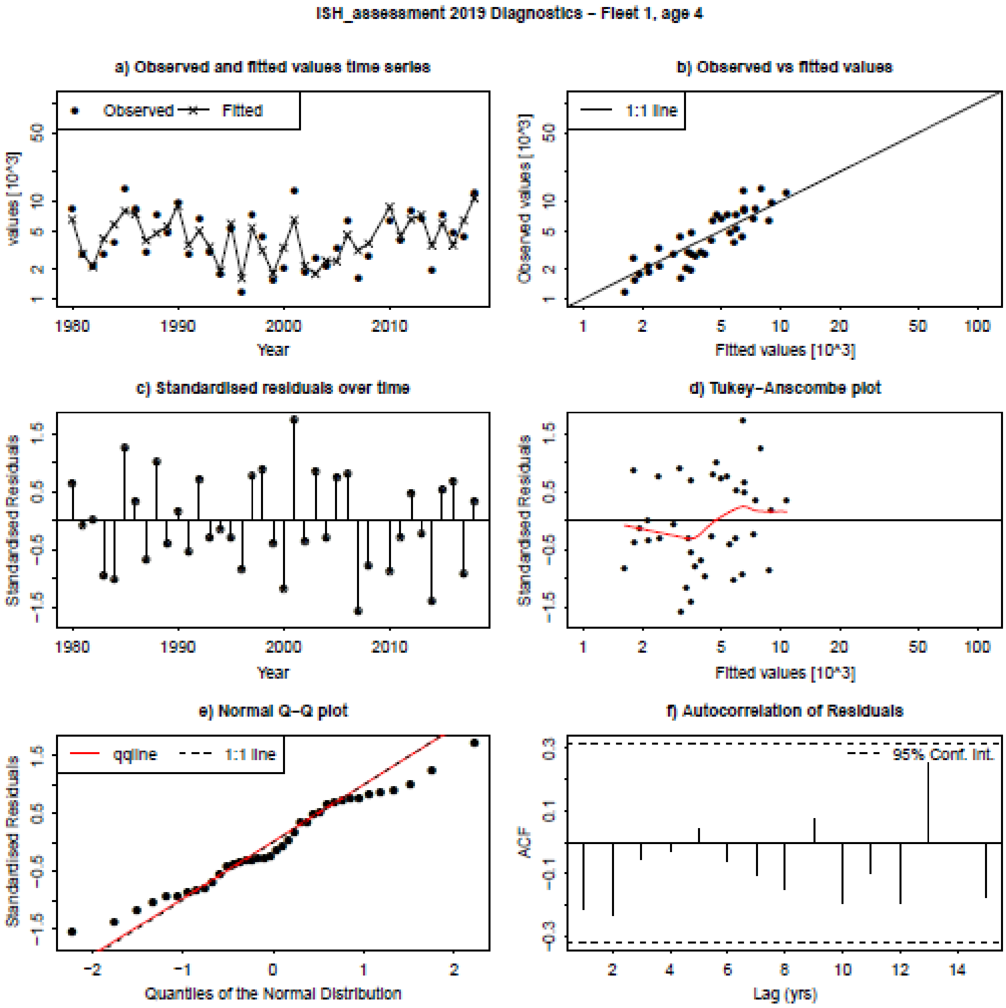


Figure 7.6.4 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age4.

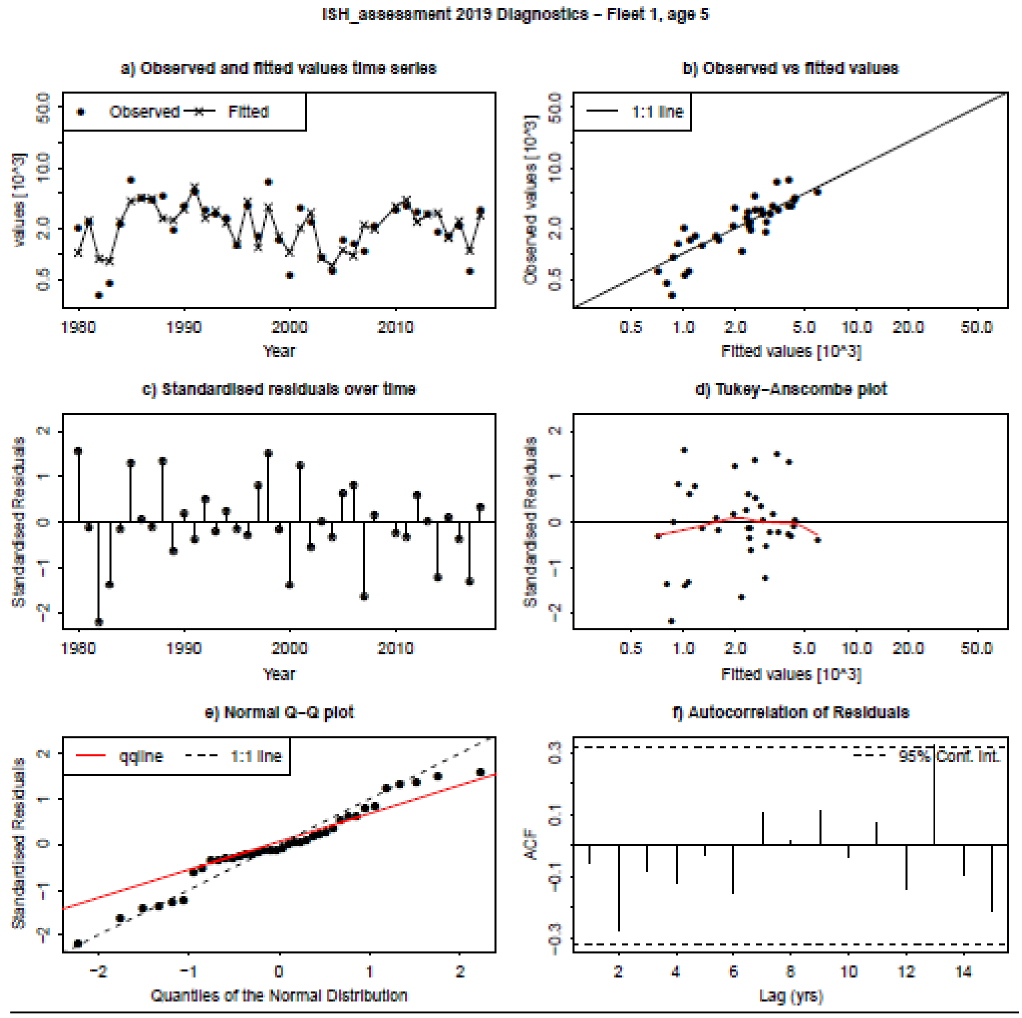


Figure 7.6.5 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age5.

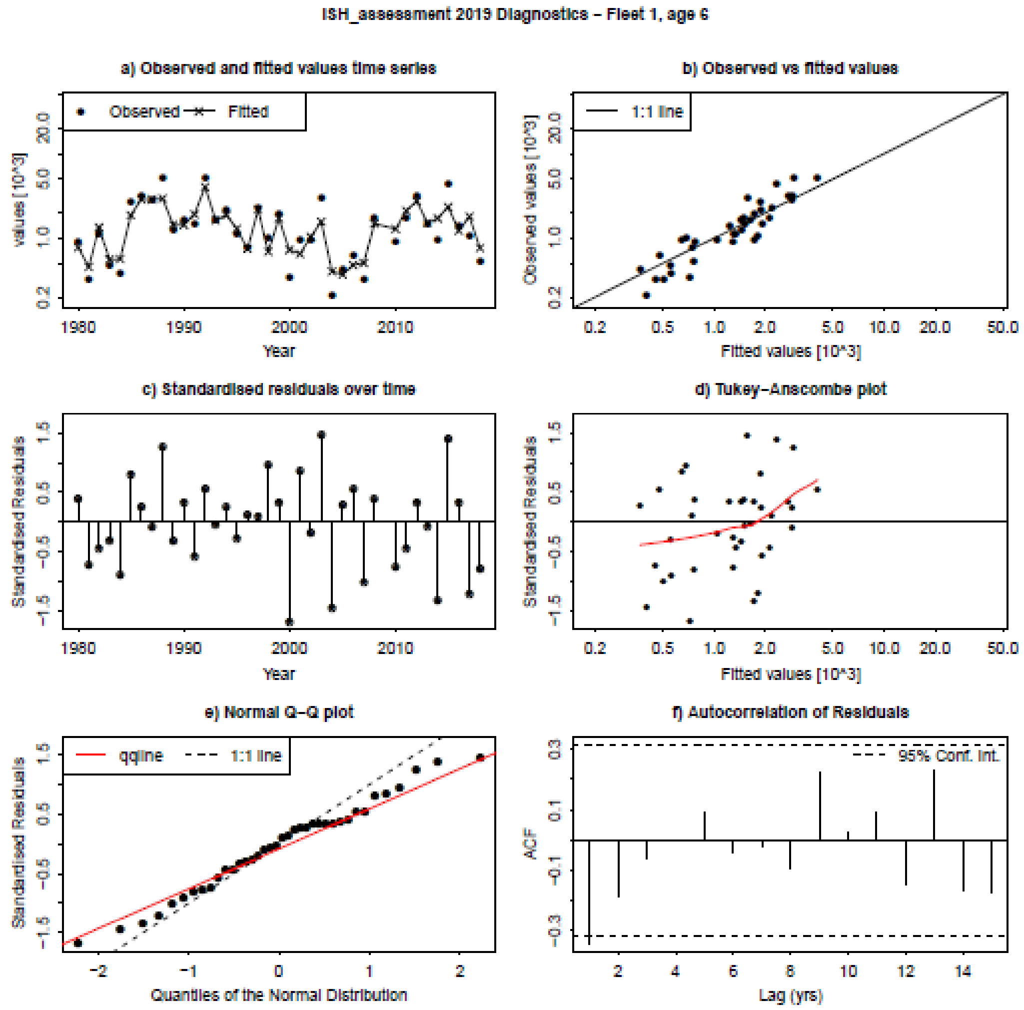


Figure 7.6.6 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age6.

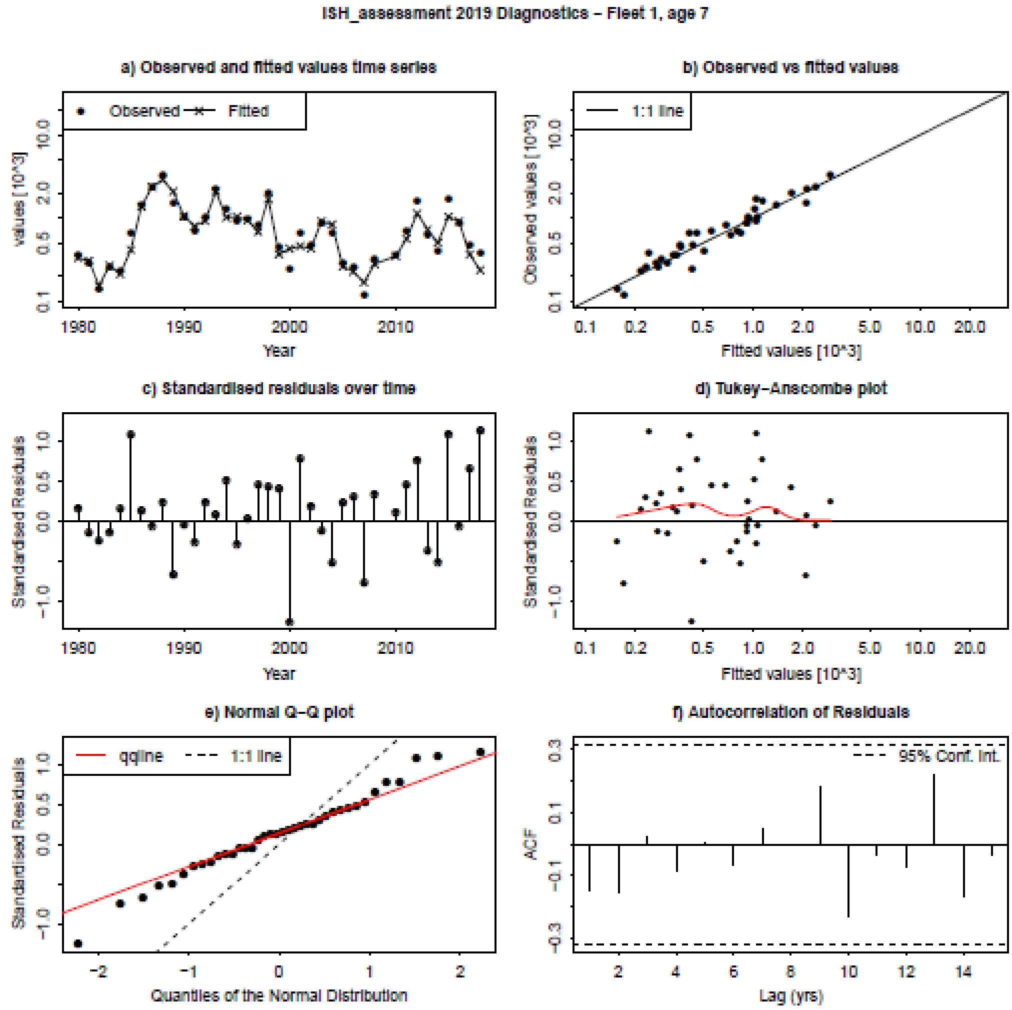


Figure 7.6.7 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age7.

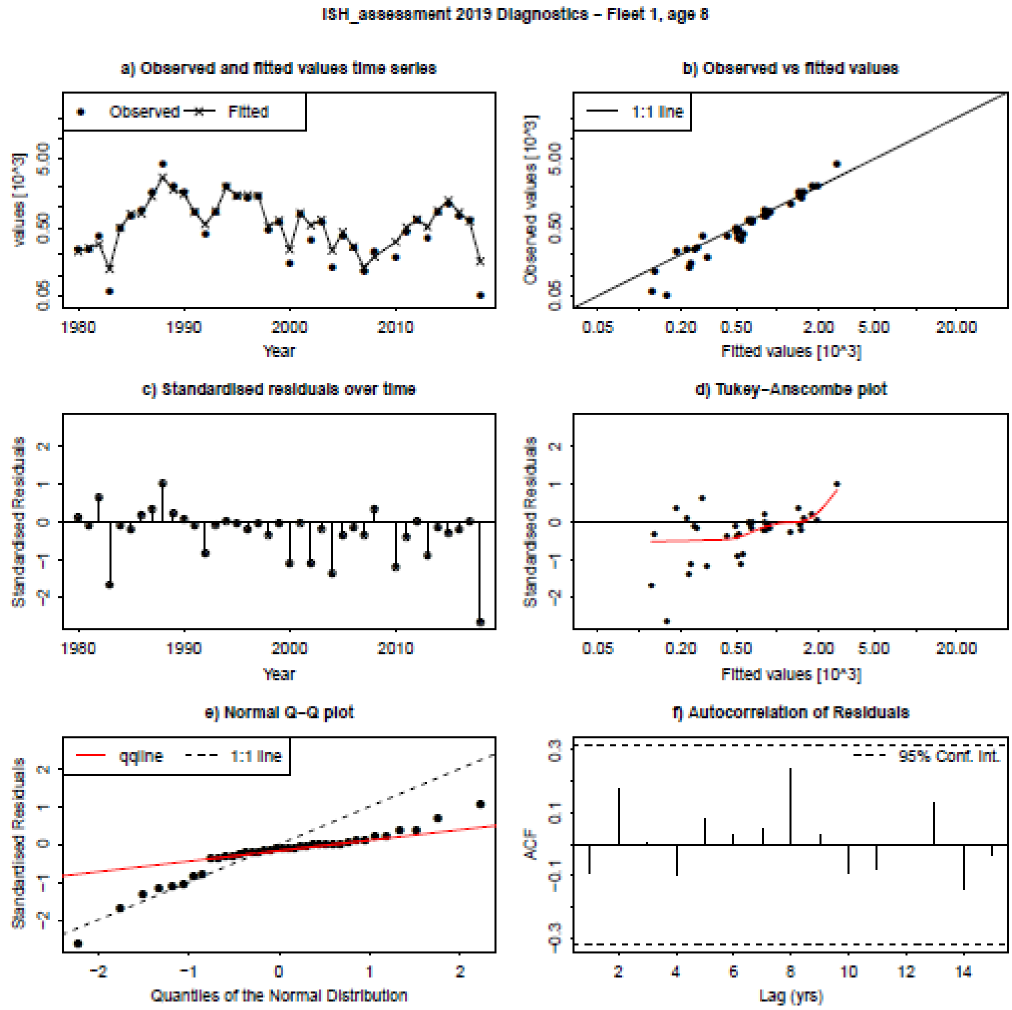


Figure 7.6.8 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age8.

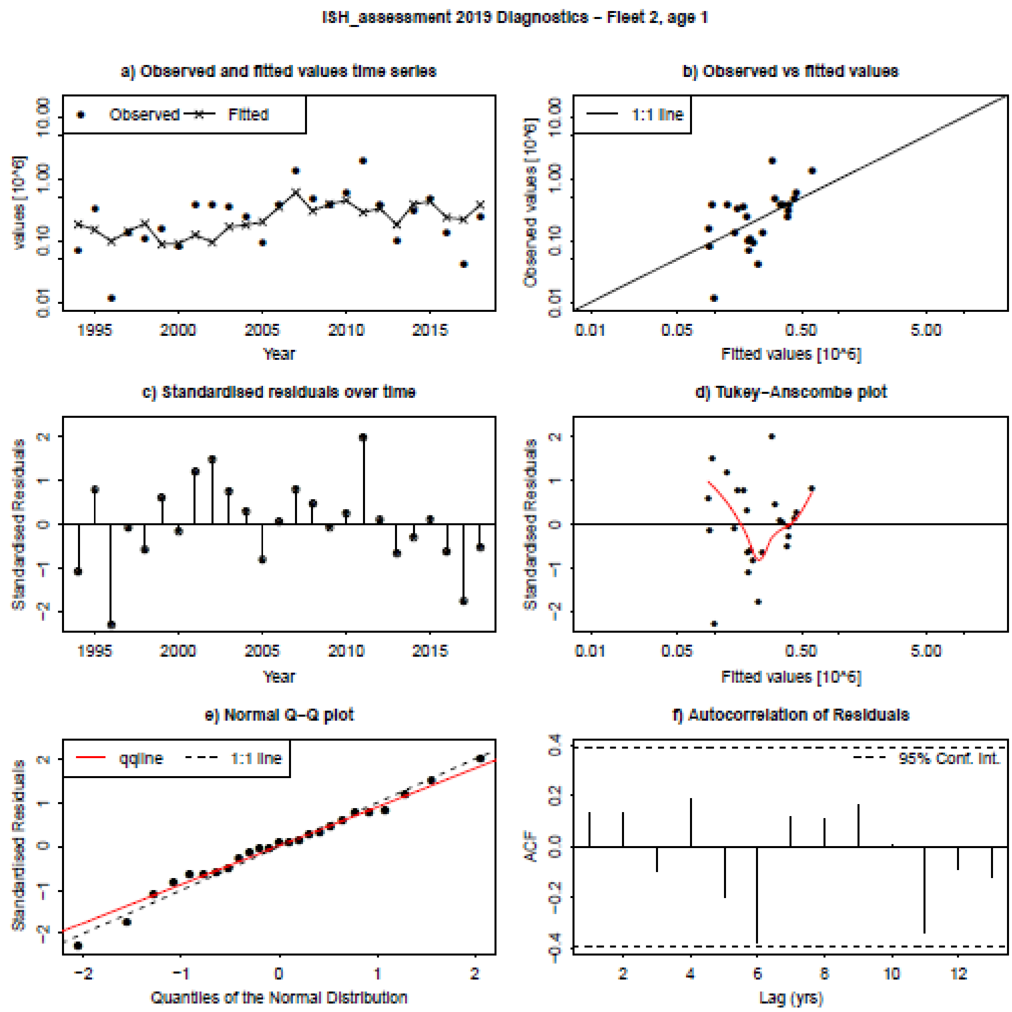


Figure 7.6.9 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age1.

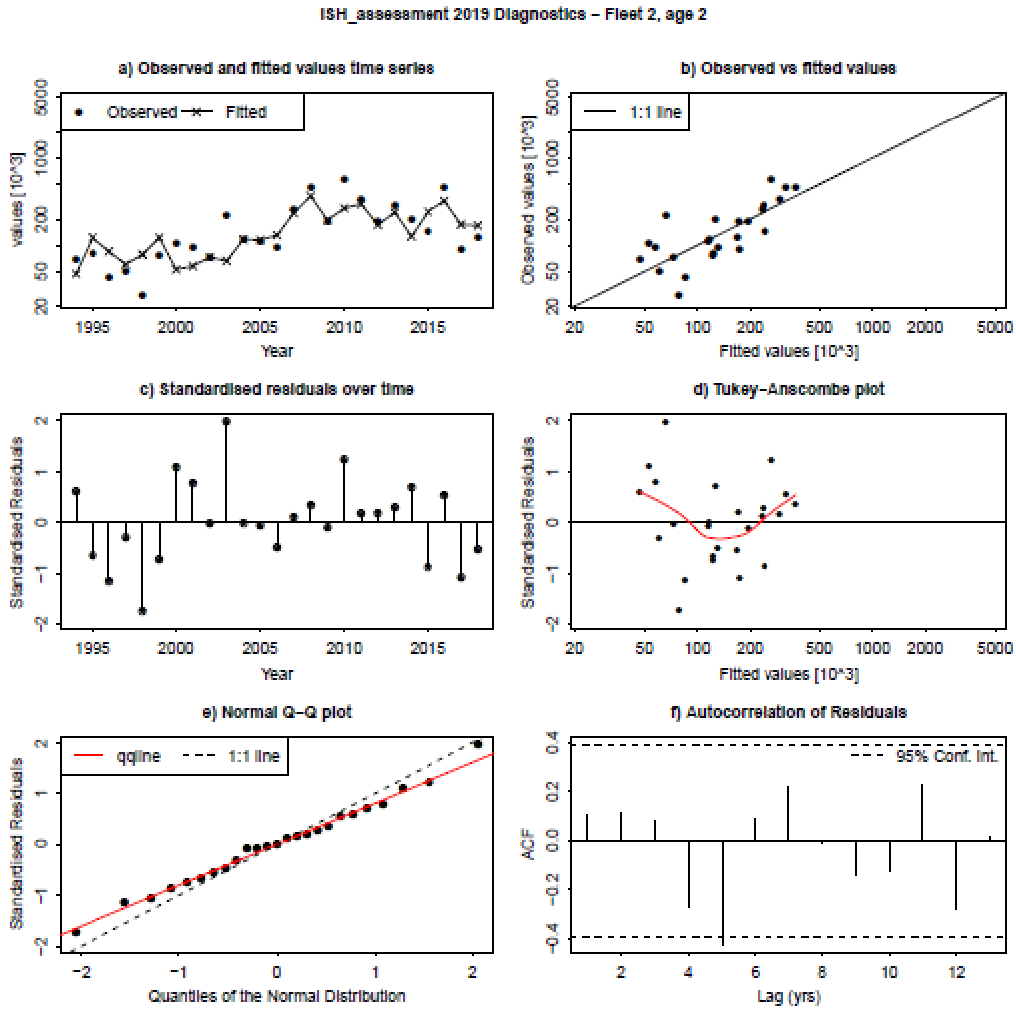


Figure 7.6.10 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age2.

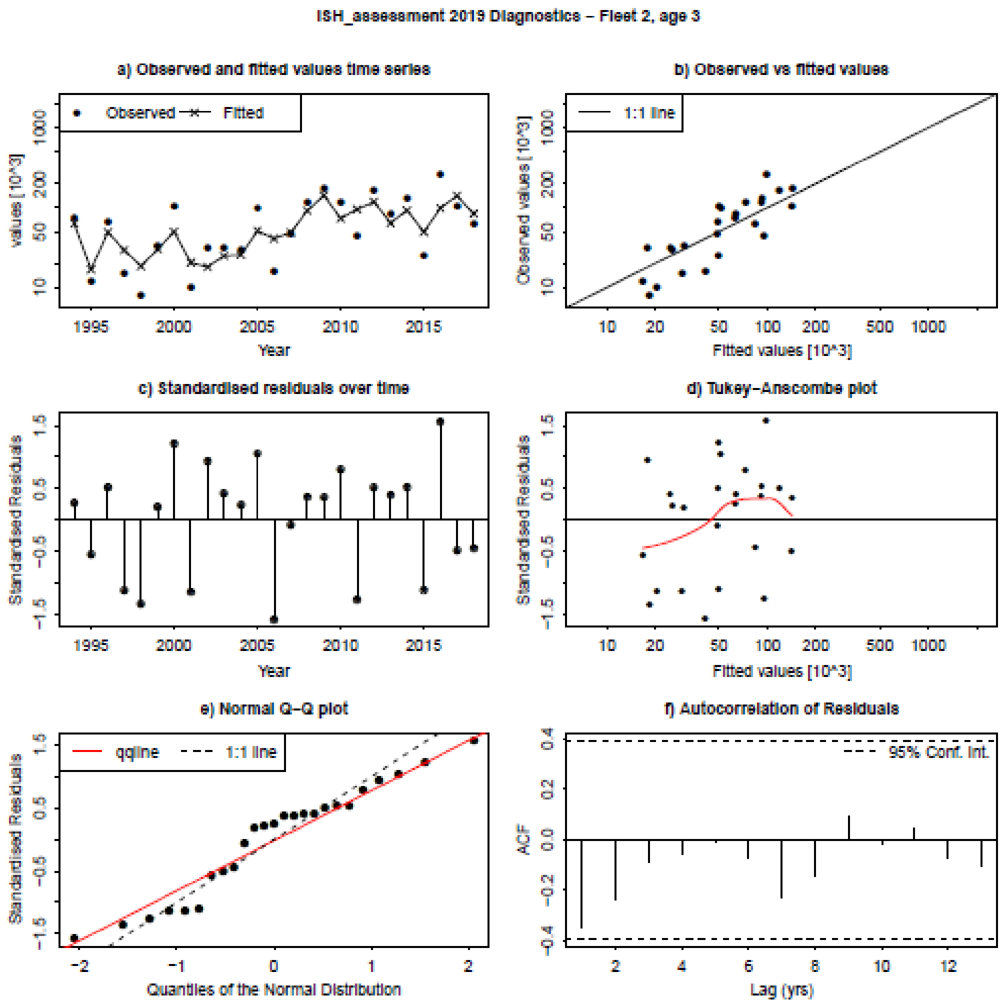


Figure 7.6.11 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age3.

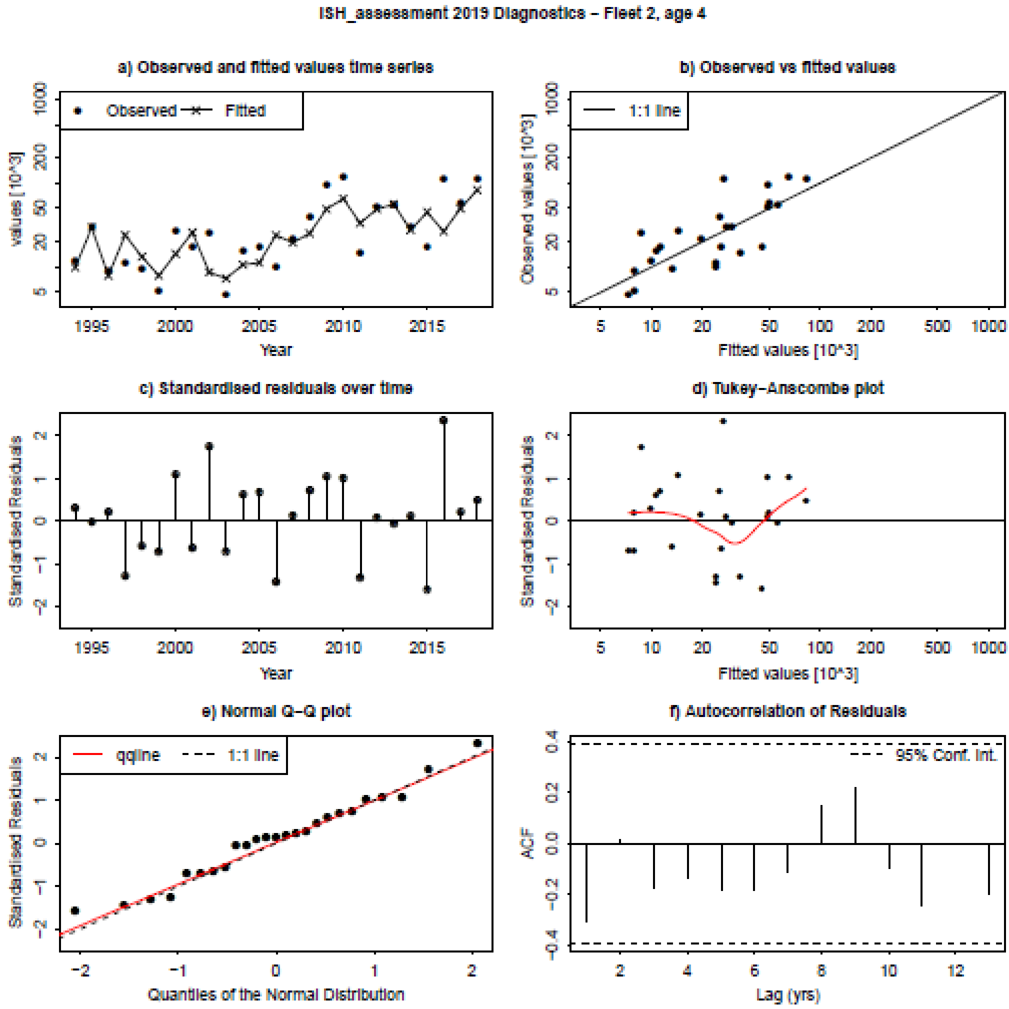


Figure 7.6.12 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age4.

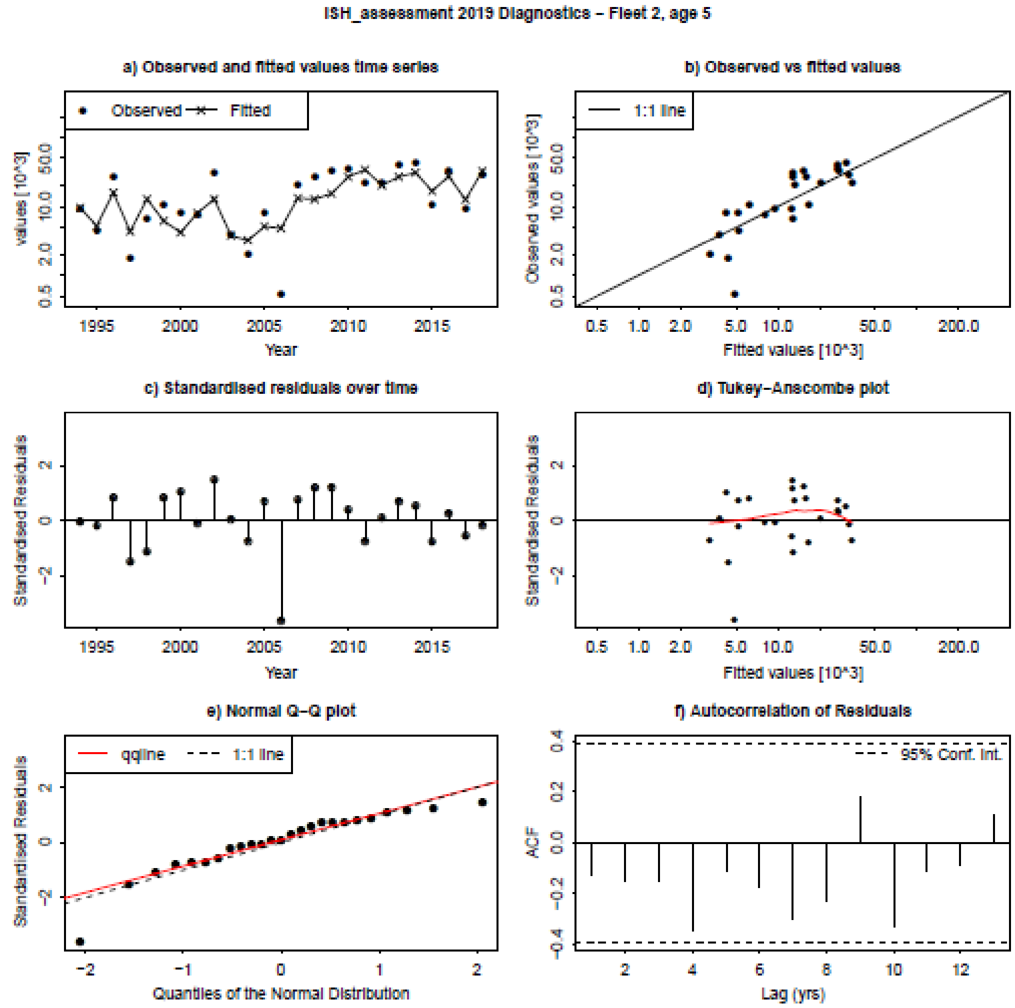


Figure 7.6.13 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age5.

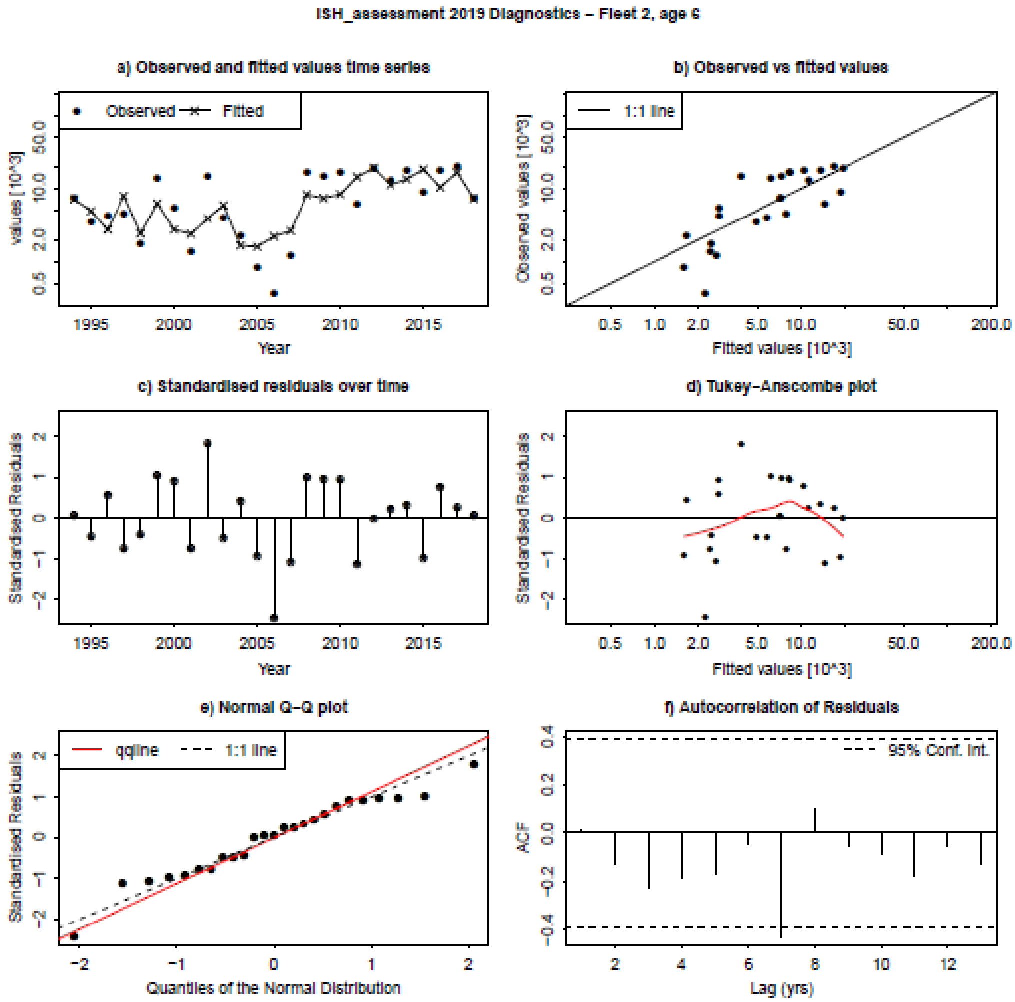


Figure 7.6.14 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age6.

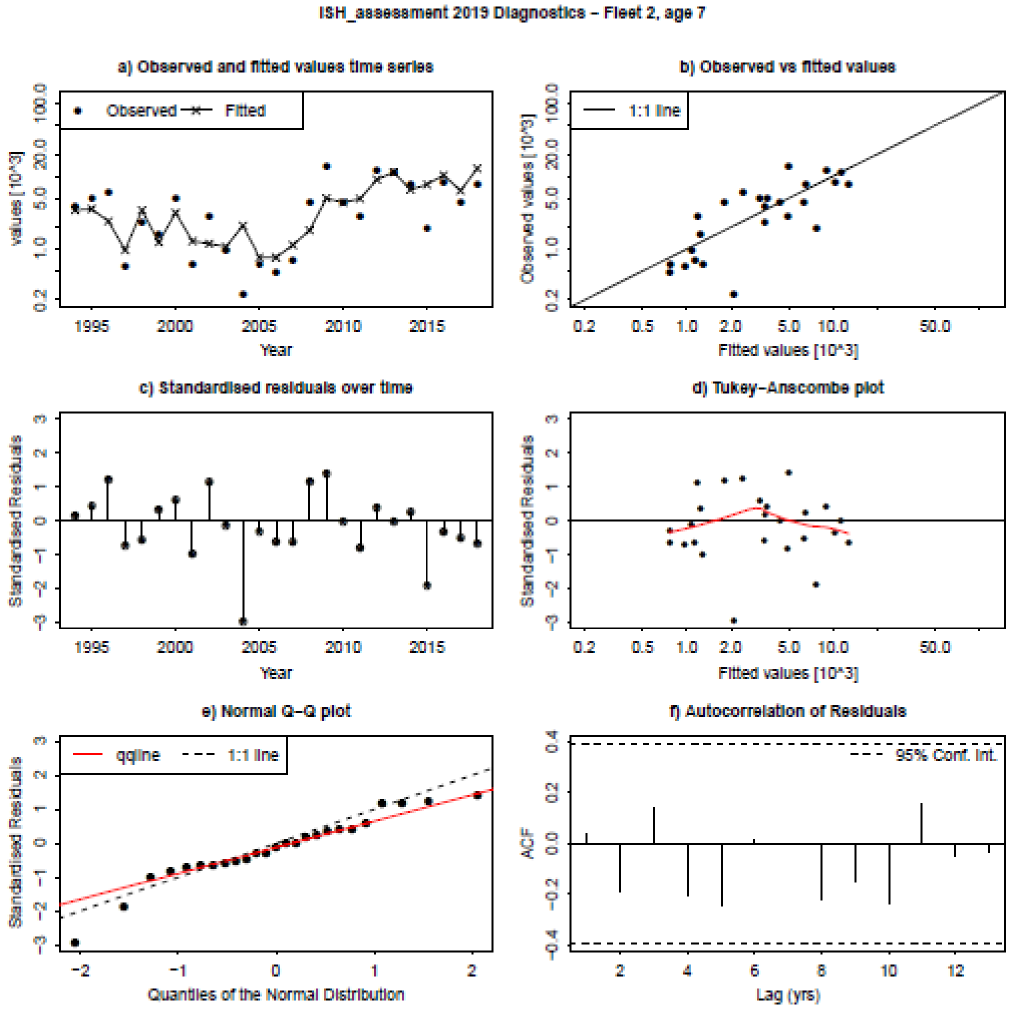


Figure 7.6.15 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age7.

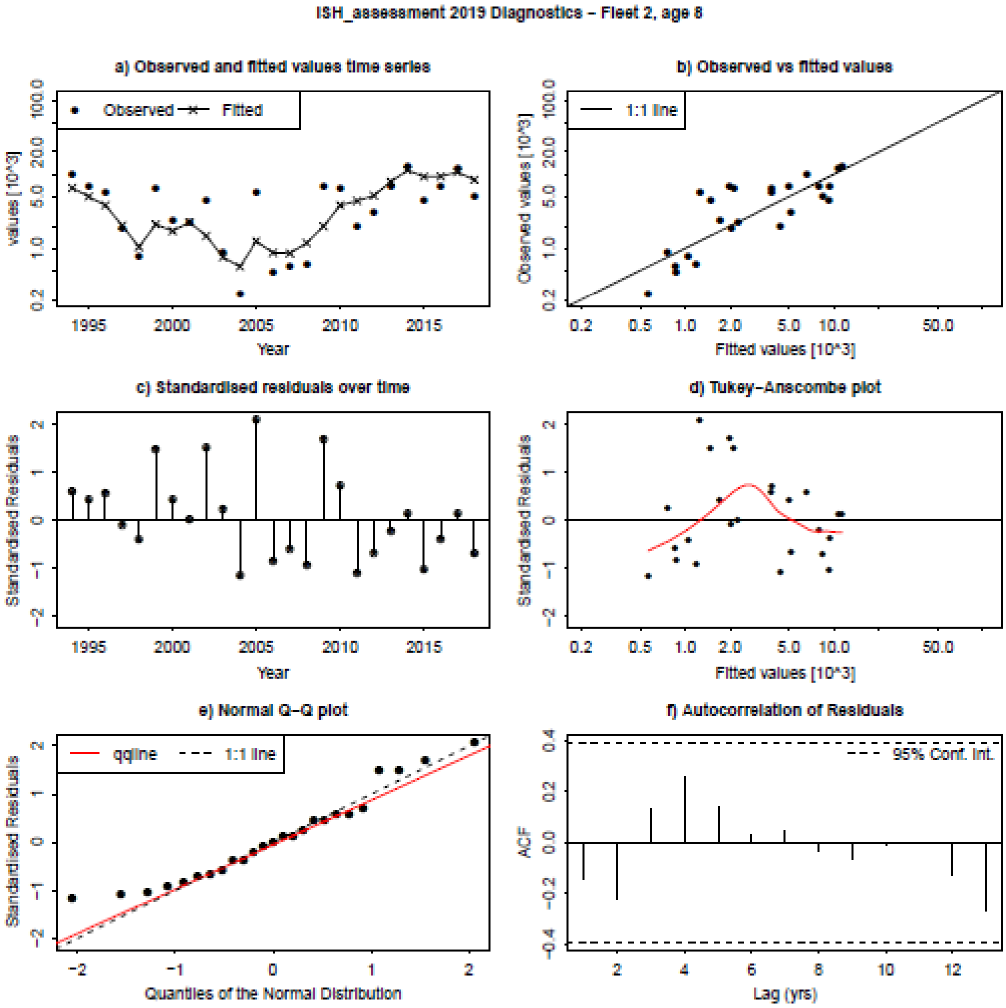


Figure 7.6.16 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age8.

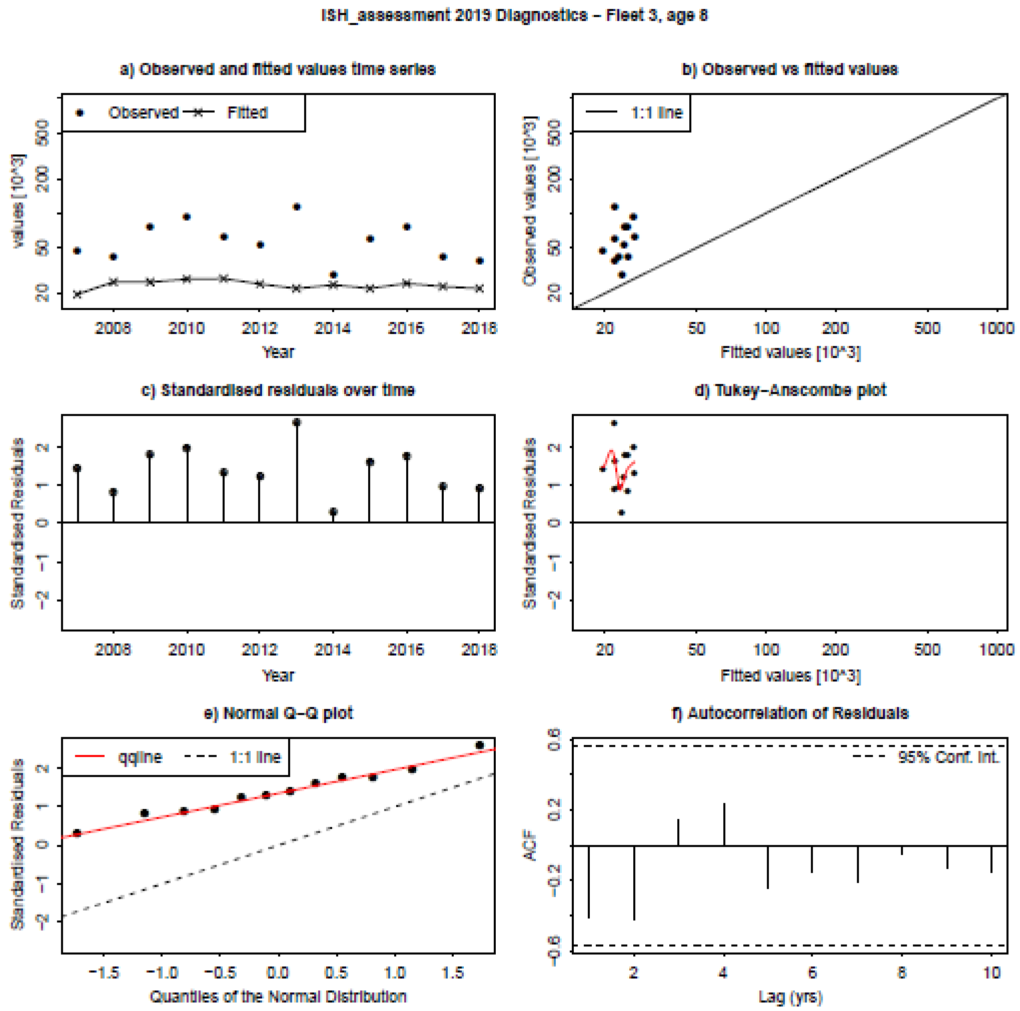


Figure 7.6.17 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the SSB acoustic survey (SSB 7.aN)).

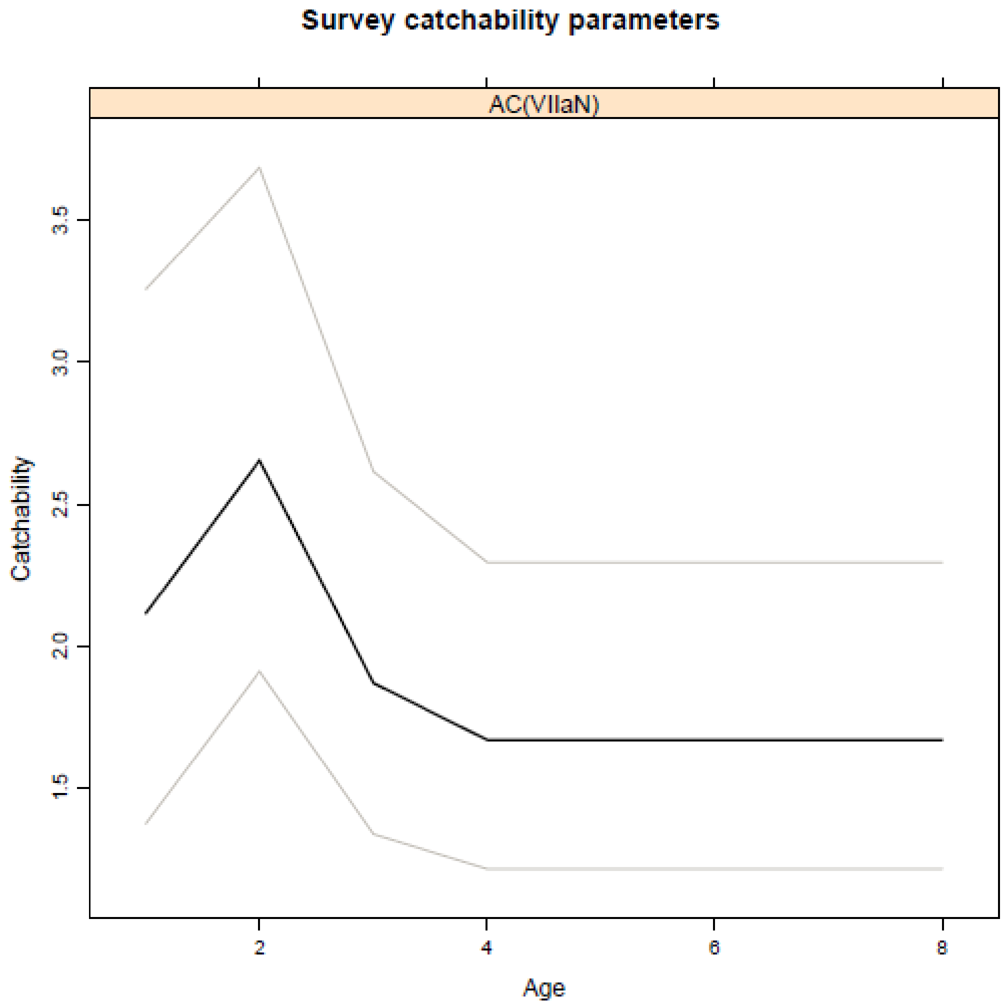


Figure 7.6.18 Herring in Division 7.a North (Irish Sea). FLSAM run output. Survey catchability parameter from the acoustic survey AC(7.aN).

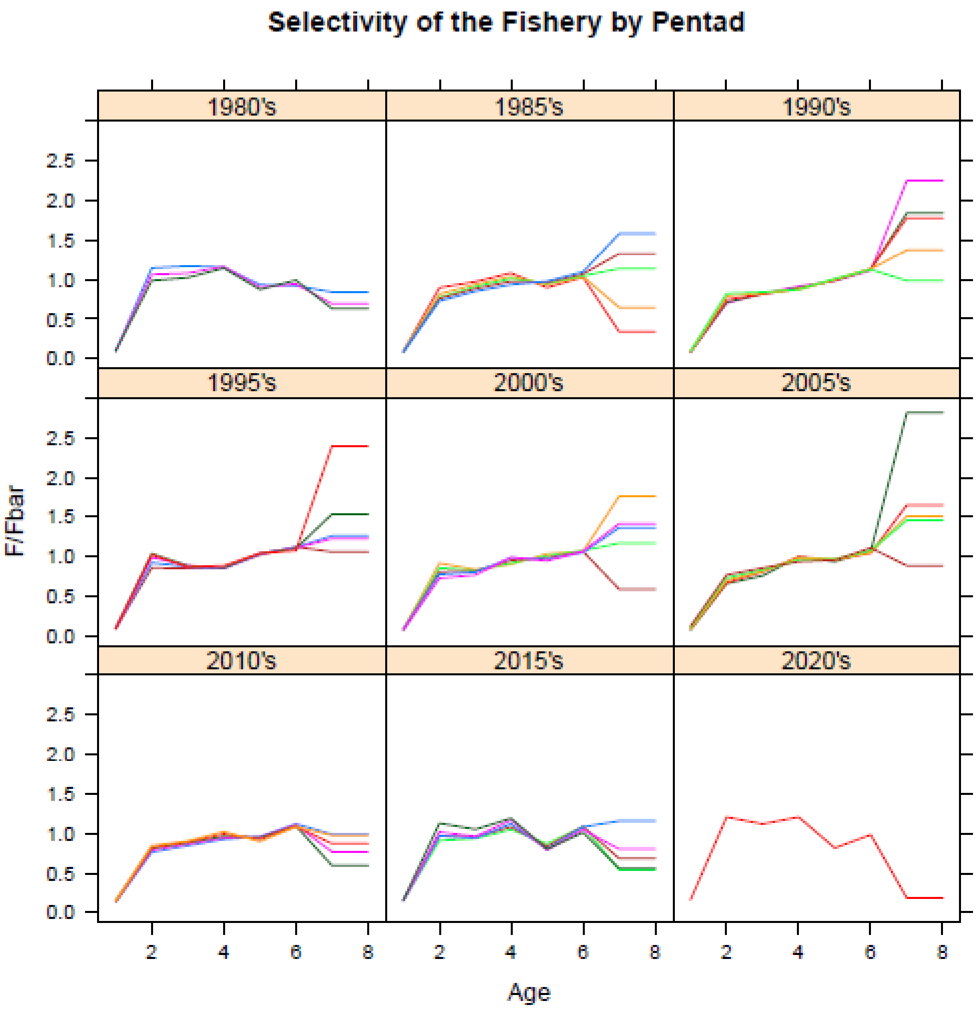


Figure 7.6.19 Herring in Division 7.a North (Irish Sea). FLSAM run output. Selectivity of the fishery by pentad.

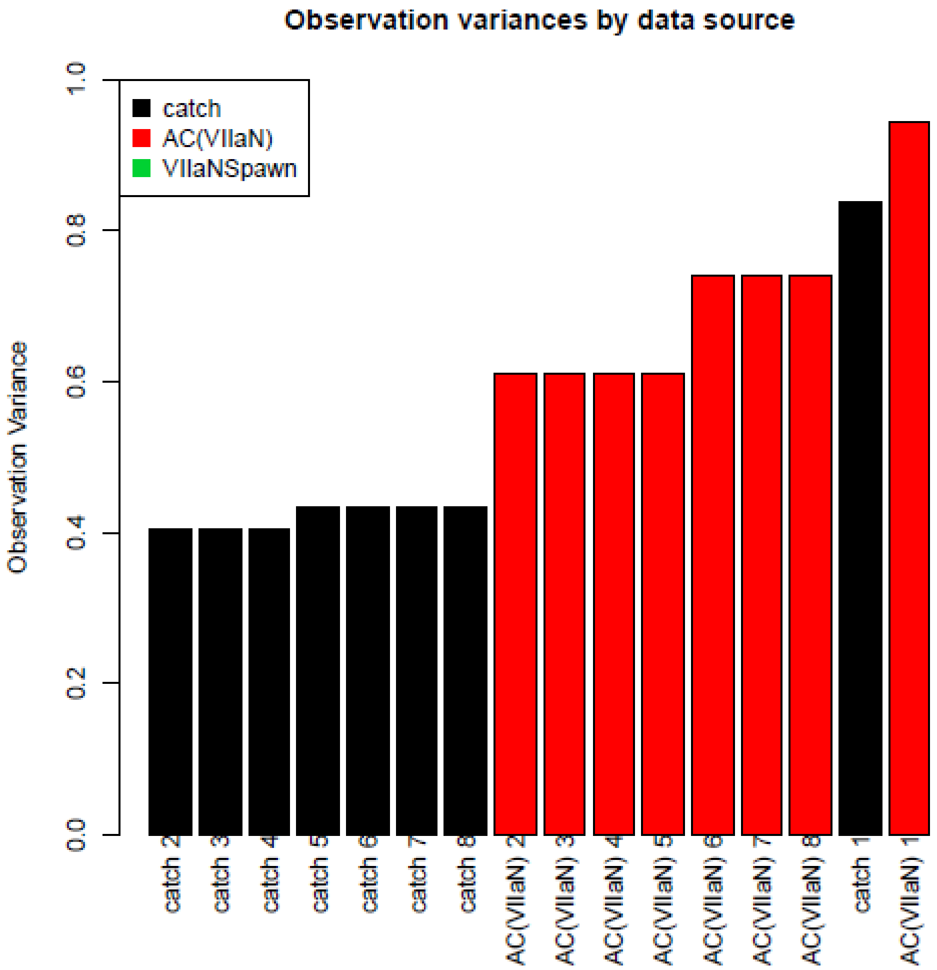


Figure 7.6.20 Herring in Division 7.a North (Irish Sea). Observation variances of all the data sources fitted in the FLSAM assessment model. The observation variance of 7.aNSpawn is fixed at 0.4

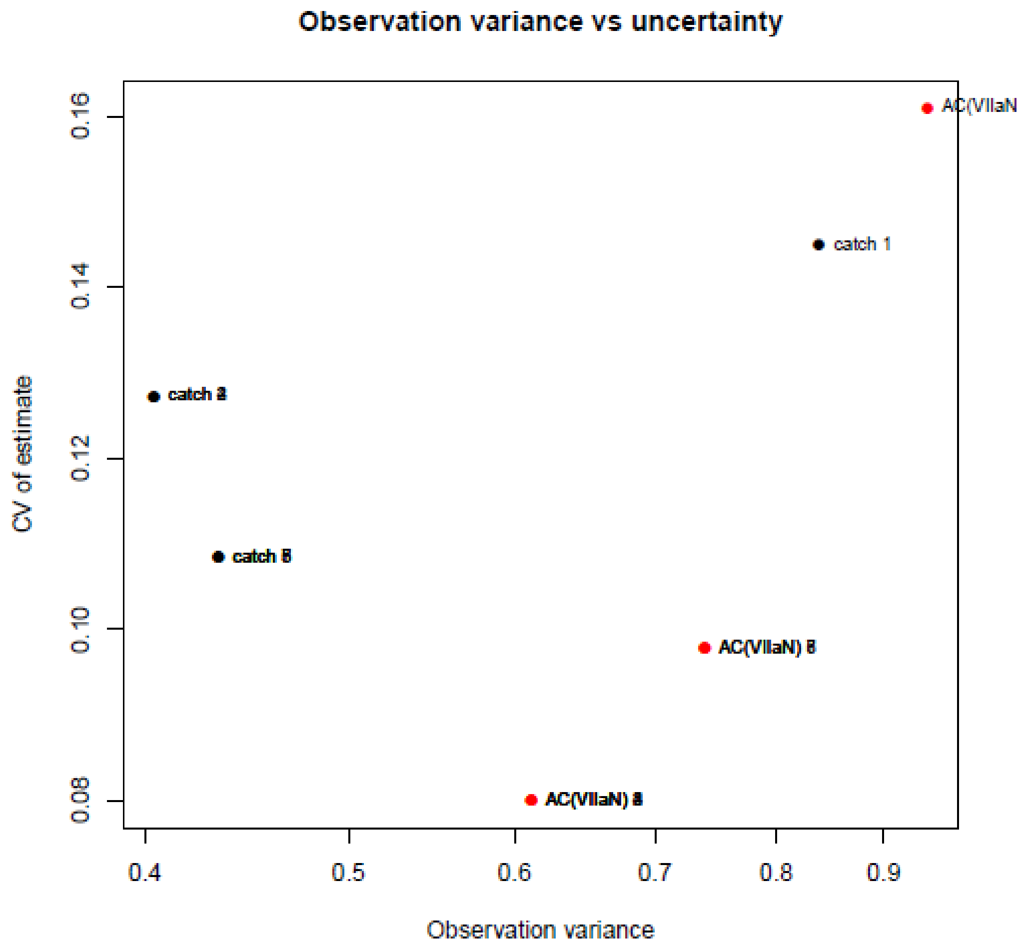


Figure 7.6.21 Herring in Division 7.a North (Irish Sea). Observation variances vs uncertainty of the data sources fitted in the FLSAM assessment model.

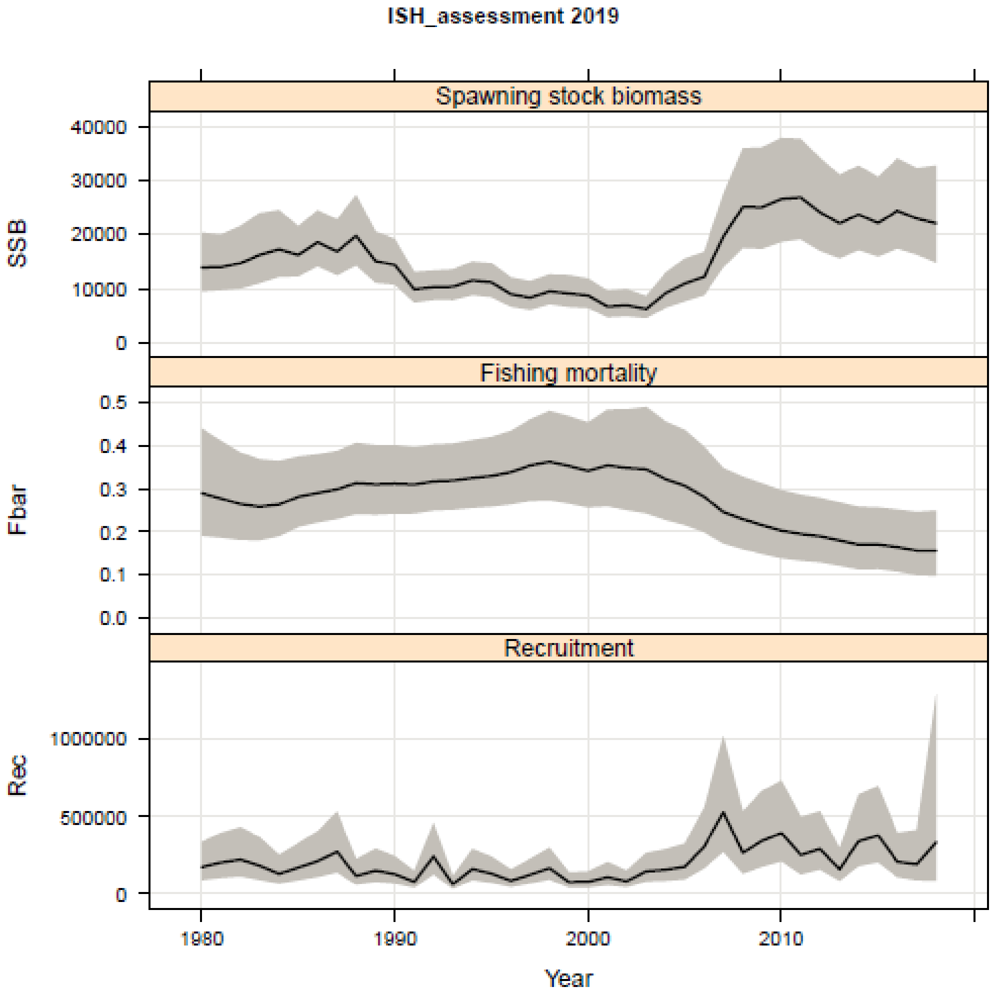


Figure 7.6.22 Herring in Division 7.a North (Irish Sea). Stock trends from the final FLSAM run, with 95% confidence intervals. Summary of estimates of spawning stock at spawning time, recruitment at 1-winter ring, mean $F_{4\text{-}6}$.

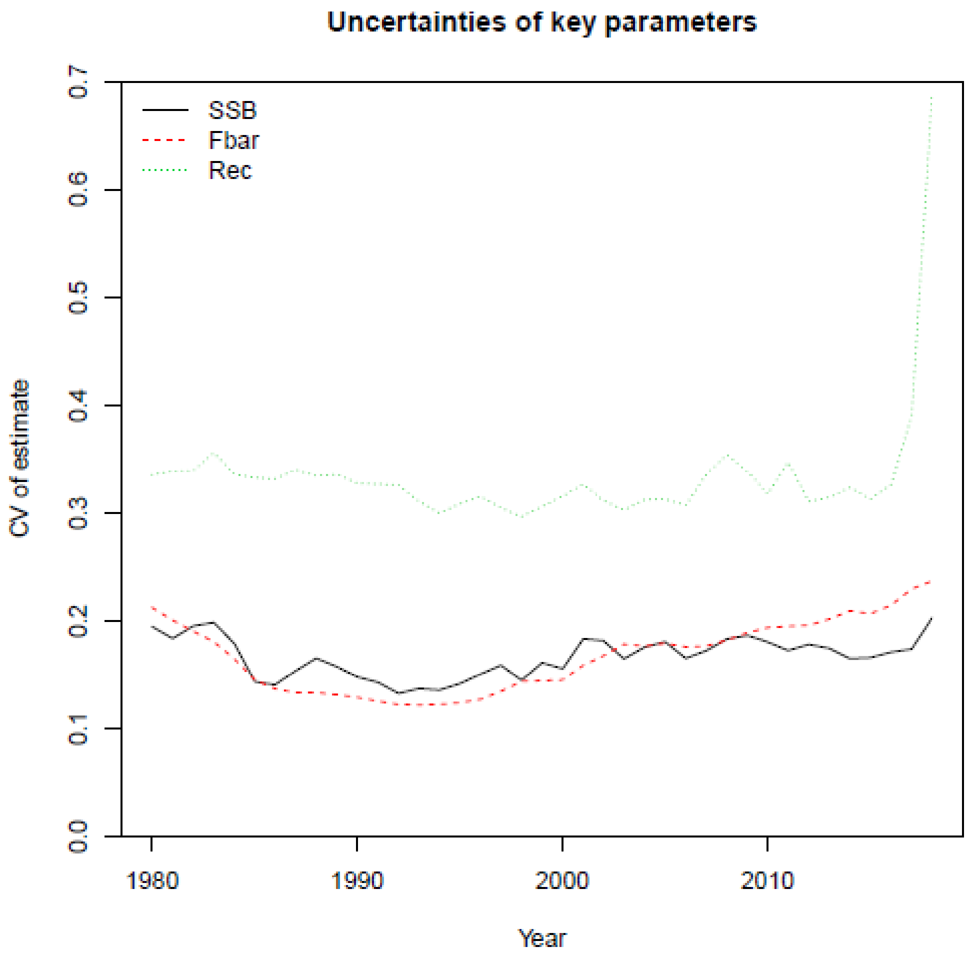


Figure 7.6.23 Herring in Division 7.a North (Irish Sea). Uncertainty of stock parameter estimates from the final FLSAM assessment. Rec = recruitment 1 winter ring.

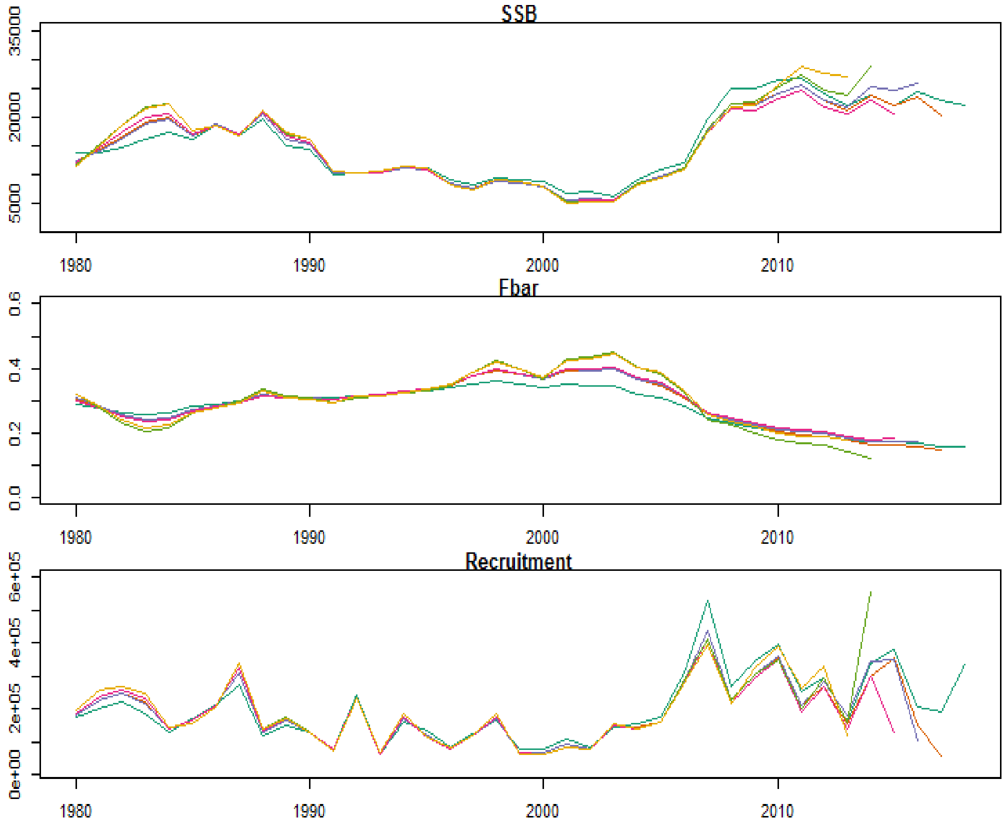


Figure 7.6.24 Herring in Division 7.a North (Irish Sea). Analytical retrospective patterns (2018 to 2013) of SSB, recruitment and mean $F_{4\text{-}6}$ from the final FLSAM assessment.

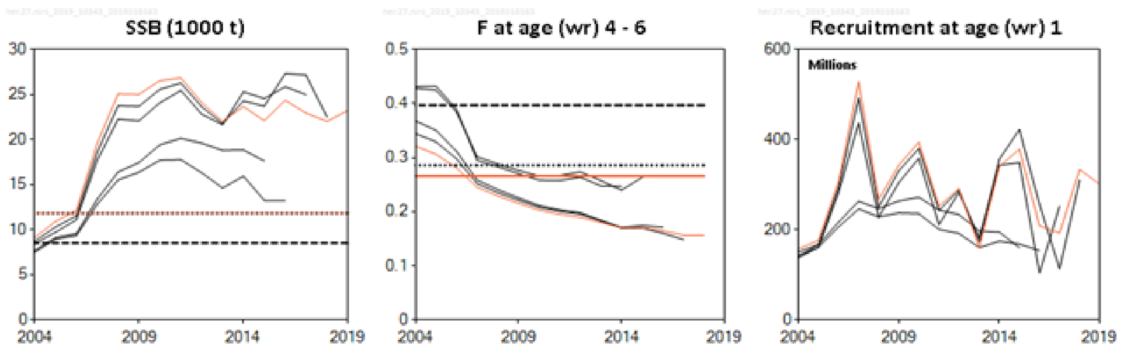


Figure 7.6.25 Herring in Division 7.a North (Irish Sea). Comparison of stock parameters between the 2018 (red line) and previous assessments.

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 6.aN (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 2018. No landings are reported in 2018 (Table 12.1).

8.2 Division 7.e,f

Figure 12.1 shows the time series of landings over the period 1974–2018 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, there was a pulse of landings in the late 1970s. Since then landings have fluctuated between 50 and 200 t in recent years, without any obvious trend. However, landings decreased in 2017 to 28 t and further down to 3 t in 2018 (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, 1959–2018. Spring and autumn-spawners combined.

Year	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
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
Year	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**
All Catches															
Total	4 061	3 664	4 139	4 847	3 862	1 951	2 081	2 135	4 021	4 361	5 770	4 800	4 650	3 612	1 923
Year	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Scotland	2 135	2 184	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
Unallocated*	208	75	18	-	-	-	-	-	-	-	-	-	-	-	-
Discards	**	**	**	**	**	**	**	-	-	-	-	-	-	-	-
Agreed TAC	3 200	2 600	2 900	2 300	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Total	2 343	2 259	731	929	853	608	586	725	846	1089	256	1	480	381	328
Year	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Scotland	-	-	+	163	54	266	-	90	119	21	0	0	0	0	0
Other UK	-	318	512	458	622	488	301	111	184	-	-	-	-	-	-
Unallocated*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Discards	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agreed TAC	1 000	1 000	1 000	800	800	800	720	720	720	648	648	583	583	583	583
Total	0	318	512	621	676	754	301	201	303	21	0	0	0	0	0

*** Calculated from estimates of weight per box and in some years estimated by-catch 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 database 2006–2016, national databases and ICES preliminary catch statistics 2017 and 2018.

Division	Country	2011	2012	2013	2014	2015	2016	2017*	2018*
7e	UK (Eng,Wal,NI,Scot,Guernsey)	218	162	274	435	268	204	22	11
7e	Denmark	-	-	-	-	-	-	-	-
7e	France	486	278	7	314	3	1	1	380
7e	Germany, Fed. Rep. Of	-	-	-	-	-	-	-	-
7e	Netherlands	6	-	-	4	0	-	-	-
	Total	**710**	**440**	**275**	**753**	**271**	**205**	**23**	**391**

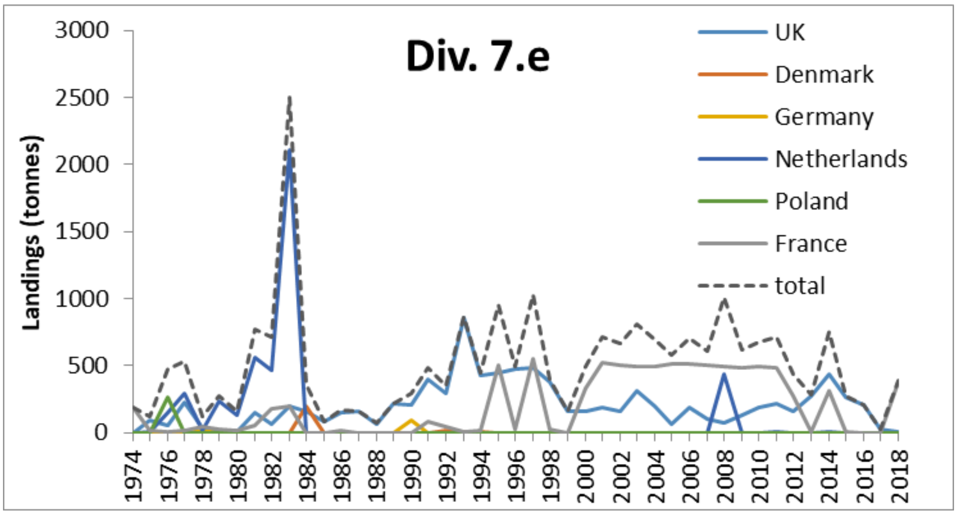
Division	Country	2011	2012	2013	2014	2015	2016	2017*	2018*
7f	UK (Eng, Wal, Scot, NI)	78	113	136	20	111	227	29	3
7f	Belgium	-	-	-	-	-	-	-	-
7f	France	26	-	-	-	-	-	-	-
7f	Netherlands	-	-	-	-	-	-	-	-
7f	Poland	-	-	-	-	-	-	-	-
	Total	**104**	**113**	**136**	**20**	**111**	**227**	**29**	**3**

* **Preliminary data**

Table 12.3. Stocks with limited data. Landings of herring in Subarea 8.

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017*	2018*
France	12	12	34	50	82	22	7	5	5	4	12	3
Netherlands	24	24	68	502	222	-	-	-	-	-	-	-
Portugal	.	.	-	-	-	-	-	-	-	-	-	-
Spain	120	131	55	38	54	2	-	-	-	-	-	-
UK	0	0	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	-	-	-	1	1
	156	167	157	590	358	24	7	5	5	4	13	4

* **Preliminary data**



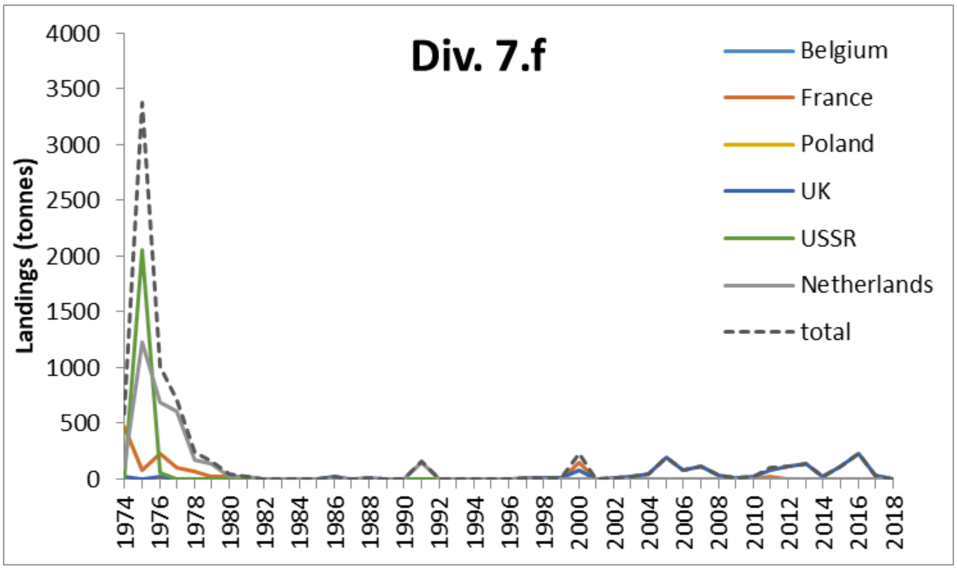


Figure 12.1. Stocks with limited data. Landings over time of herring in divisions 7.e (upper panel) and 7.f (lower panel).

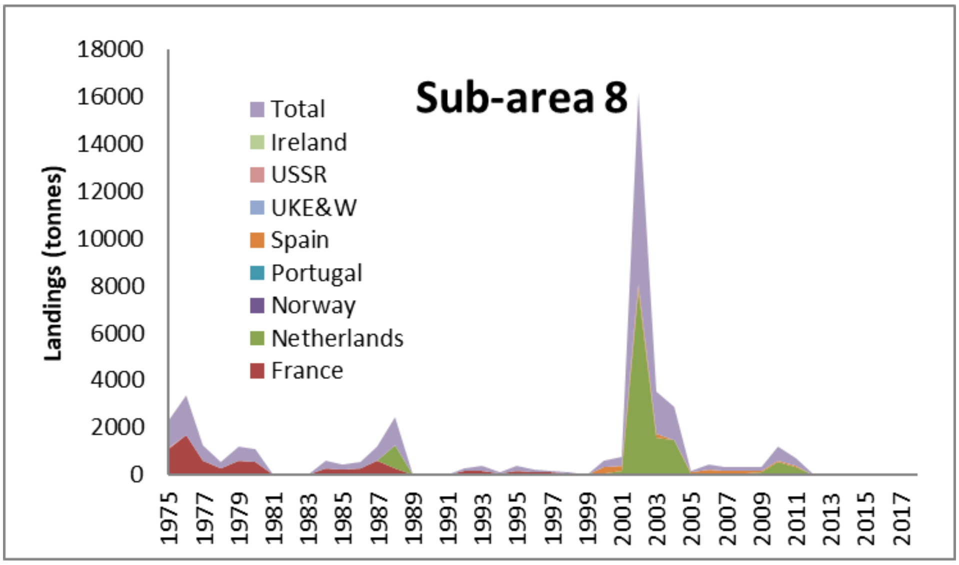


Figure 12.2. Stocks with limited data. Landings over time of herring in Subarea 8.

9 Sandeel in Division 3.a and Subarea 4

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–3r, 4 and 6). Analytical stock assessments are currently carried out in SA 1–4, 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, 2008a, 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 2018 25 vessels participated in the fishery. From 2011 to 2018, the average GRT per vessel in the Norwegian fleet increased from 1100 to 1340 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 2018 was opened 1 April and continued until the middle of July. In NEEZ the fishery opened 15 April and ended 23 June.

9.1.3 ICES Advice

ICES advised that the fishery in 2018 should be allowed only if the analytical stock assessment indicated that the stock would be above B_{pa} by 2019 (Escapement strategy). This approach resulted in an advised TAC for 2018 in SA 1r, SA 2r, SA 3r, and 4 of 134 461 t, 5000 t (monitoring catch), 108 365 t and 59 345 t, respectively. Advised catches for SA5, SA6 and SA7 for 2018 and 2019 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 2018 was given. The acoustic survey abundance estimate of age 1 was low, and the individual growth was also low, which together gave a low biomass estimate. Therefore, there was no increase in the final TAC. Fishery was allowed in the subareas 1b, 1c, 2a, 2c, 3a, 3b, 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 (see Stock Annex for details).

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 group decided to keep the practice from last year's assessment and reallocate reported catches (14 781 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 73 420 t (2016) (Figure 9.1.3).

Spatial distribution of catches

Yearly catches for the period 2000–2018 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 ~75% of the total sandeel catches in the period since 1983.

The third most important area for the sandeel fishery is SA 2r. In the period since 2003 catches from this area contributed ~17% of the total catches on average.

SA 4 has contributed about 5% 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 54 043 and 59 345 t, respectively.

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 (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 in 2016, 2017 and 2018.

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 time 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 2018 was carried out as planned and nearly all planned positions were covered in accordance with the survey protocol without notable problems related to weather or other potentially obstructive factors in areas 1r, 2r and 3r. In area 4, the northern part (Turbot bank) was not surveyed due to poor weather and hence the index only covers the Firth of Forth area. As this is the case for the majority of the time series, the lack of coverage is not expected to bias the index. 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.

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 2018, the proportion 2-group was 81% by weight, corresponding to the very high catch of the 2016 cohort in the 2016 and 2017 dredge survey (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 has generally decreased since 2017 to levels observed in 2014.

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 2017, WGSAM provided updated estimates of natural mortality at age from multi-species modelling of southern sandeel (SMS, WGSAM 2017). 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 in 2018 and it was decided that the effect on reference points was minor and all natural mortalities were therefore updated to the new values from WGSAM. The last value provided was used for all years following the latest data point. In later years, natural mortality has been historically high as a result of the increasing grey gurnard and mackerel stocks. More details are given in the Stock Annex and in WGSAM (2017). 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 2014 below long-term average. CPUE peaked again in 2016, but have decreased to levels below average in 2018.

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. This time series was not updated in 2018 due to the low catches and hence low number of samples in this time period.

CPUE data from the dredge survey (Table 9.2.4 and Figure 9.2.5) in 2018 show a increase from the second lowest observed index for age 0 and a decreased index for the 1-group to levels seen before 2017.

The internal consistency, i.e. the ability of the survey to follow cohorts, (Figure 9.2.4) still shows a low correlation between the 0-group and 1-group (i.e. $r^2 = 0.22$ on log scales). This can be a result of highly variable total mortality.

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 2018. 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 five 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 (0.36) for age 0 and moderate (0.77) for age 1. The survey residual plot (Figure 9.2.6) shows no clear patterns.

The CV of the RTM time series is moderate (0.57 and 0.59, respectively) for age 1 and age 3 and low (0.41) for age 2. 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 (0.341) for age 1 and age 2 in the first half of the year and moderate to high (> 0.57) for the remaining ages and season combinations. The catch at age residuals (Figure 9.2.7) show no alarming patterns, except for a tendency to positive residuals (observed catch is more than model catch) for age 1 in 2013–2017, followed by negative residuals in 2018.

The CV of the fitted Stock recruitment relationship (Table 9.2.5) is high (0.848), 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 except for SSB, where 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. The stability of F estimates is partly due to the assumed robust relationship between effort and F, which is rather insensitive to removal of a few years. Recruitment and SSB estimates show 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 2014 and 2019. Since 2008, SSB has been above B_{lim} but below B_{pa} in 2008, 2010, 2013 and 2015, and below B_{lim} in 2019. $F_{(1-2)}$ is estimated to have been below the long-time average since 2010. Recruitment in 2017 was estimated to be the lowest observed in the time series, whereas 2018 show average recruitment.

9.2.9 Short-term forecasts

Input

Input to the short term forecast is given in Table 9.2.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in 2019 is the geometric mean of the recruitment 1983–2017 (108 billion at age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2018. 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 2014–2018. 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 91 916 t should be set for 2019. This will leave SSB at the MSY $B_{trigger}$ of 145 000 t in 2019 and predicted F below F_{cap} (0.5). The TAC according to the escapement strategy is therefore 91 916 t in 2019.

9.2.10 Biological reference points

B_{lim} is set at 110 000 t and B_{pa} at 145 000 t. MSY $B_{trigger}$ is set at B_{pa}.

Further information about biological reference points for sandeel in 1 can be found in the Stock Annex.

9.2.11 Quality of the assessment

The quality of the present assessment has improved compared to the combined assessment for the whole of the North Sea previously presented by ICES before 2010. This is mainly due to the fact that the present division of stock assessment areas better reflects the spatial stock structure and dynamics of sandeel. Addition of fishery independent data from the dredge survey has also improved the quality of the assessment. Together with the application of the statistical assessment model SMS-effort, this has removed the retrospective bias in F and SSB for the most recent years. The model provides rather narrow confidence limits for the model estimates of F, SSB and recruitment, but a poorer fit for the oldest data.

The model uses effort as basis for the calculation of F. The total international effort is derived from Danish CPUE and total international catches. Danish catches are by far the largest in the area, but effort data from the other countries could improve the quality of the assessment.

Abundance of the 1-group, which in most years dominates the catches, is estimated on the basis of the 0-group index from the dredge survey in December of the preceding year. The model estimates a low variance on the survey index for age 0. There are indications of a retrospective pattern in recent years as older fish do not seem to appear in the catches at the expected level. This pattern can be caused by uncertainty in the selection pattern when using a relatively short period to estimate this or unallocated mortality caused by e.g. overwintering mortality increasing when fish condition is low (van Deurs *et al.*, 2011).

9.2.11.1 Status of the stock

The very high recruitment in 2016 and the restrictive F below average in 2017 resulted in an SSB above B_{pa} in 2018. As noted in last year's report (ICES, 2018), the introduction of a very low recruitment in 2018 combined with a decrease in mean weight at age led to a stock below MSY B_{lim} and $B_{trigger}$ at the beginning of 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 9.1.29–.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 2018 catch with highest proportion of 2-group in the time-series (94%). Furthermore, the proportion of age 1 is the lowest on record (1%) (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 2018 was below the historic average, reaching only 89% of the long term average for age 2.

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 2017) 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 2018 was the third lowest in the time-series and CPUE was decreased to the levels observed in 2014–2015.

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).

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 medium (0.57) for age 0 indicating a reasonable 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 (0.323) 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. However, in 2017 and 2018, the model consistently finds fewer fish in the catch of the 2014 and 2015 cohorts than it expects from the high F. The 2014 and 2015 cohorts also showed large negative residuals at ages 2+ indicating that the year classes seen in the dredge and at age 1 in the catches were less abundant than expected in the subsequent catches.

The CV of the fitted stock recruitment relationship (Table 9.3.5) is high (1.12 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 2010–2018, 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 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. However, a systematic bias like this is not expected. Possible causes suggested were:

Spatial distribution of recruitment and/or catch differs from other years: There was no indication that the spatial distribution of recruitment and catch were outside those previously observed.

Survival of older age groups is low: There was no information to assess whether predation mortality has changed. Overwintering mortality can be linked to sandeel condition at the end of the season, but there was no evidence of the weight at age 3 and 4+ being outside the historical range in the last decade.

The fishery has changed selection pattern in 2017 and 2018 as it was probably targeting the very large 2016 year class. There are historical examples of a change in selection pattern towards the most abundant year class in 1997 and 2002 where there was both a large incoming year class and a large catch. In both cases, 3 and 4+ showed negative catch residuals in the year with abundant age 1 and positive catch residuals of age 4+ in the subsequent year, indicating that the cohorts remained in the stock but were underrepresented in the catches in the year of abundant 1-group.

Based on these considerations, HAWG considered that there was not sufficient information to determine the cause of the low catch of 2+ fish in 2017 and 1 and 3+ fish in 2018 or the balance between different co-occurring effects. The problem with assuming a constant selection pattern was discussed at the benchmark in 2016, in particular the presence of density dependent catchability. Ideally, such a relationship should be considered and possibly included in the model formulation at the next benchmark of the stock. The very high CPUE and the high dredge catch of the 2016 cohort confirmed that there was a large year class this year. The downscaling of this cohort in the 2018 assessment is within the range of the downscaling of recruitment observed in the previous years and the 2019 confirms the 2018 assessment. Given that there is not sufficient information to decide whether it is most appropriate to assume that selectivity has changed, that there is a survival issue for 3+ sandeel or there is a bias in the dredge survey catches of 0-group, HAWG decided to keep the benchmarked settings for the assessment.

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 is the fifth lowest on record. SSB has been at or below B_{lim} in 1989, 2002, from 2004 to 2010 and again from 2011 to 2016 and 2019. Since 2004, SSB has been below B_{pa} in all years except 2018. $F_{1\text{–}2}$ is estimated to have been below the long-time average since 2010 with the exception of 2013 and 2017, but has dropped to the fourth lowest in the time-series in 2018.

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 2019 is the geometric mean of the recruitment in 2008–2017 (20 billion at age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2018. 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 2014–2018. Natural mortality and proportion mature are the fixed values applied in the terminal year in the assessment.

Output

The short term forecast (Table 9.3.12) shows that a SSB will be below the MSY $B_{trigger}$ of 84 000 t and B_{lim} of 55 000 t in 2020 even in the complete absence of fishing. The TAC according to the escapement strategy is therefore 0 t in 2019. A monitoring TAC at 5000 t in 2019 will lead to an SSB in 2020 at 44 435 t.

9.3.10 Biological reference points

B_{lim} is set at 56 000 t and B_{pa} at 84 000 t. MSY $B_{trigger}$ is set at B_{pa}. F_{cap} is set at 0.45 (ICES, 2016). Further information about biological reference points can be found in the Stock Annex.

9.3.11 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 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 multi-species fishery within this area (i.e. suspected to catch *Ammodytes tobianus*). The dredge survey time-series in SA2 is still short (2010–2018) and the quality of the assessment will likely improve once a longer time-series becomes available.

During the meeting, an analysis was made of the effect of having age composition and weight at age in the catch available from a monitoring fishery in years with a zero TAC. Such effect was evaluated from the monitoring fishery in 2016 by removing the age composition from the likelihood and assuming average weight at age from the previous 5 years. Not including age composition and mean weight at age from the monitoring fishery led to an estimate of SSB in the assessment following the monitoring fishery that was twice as large as that estimated when including the monitoring fishery age composition and mean weight. In following year, the availability of age composition and weight at age of catch (2017) compensated for the lack of 2016 data and the two methods provided similar results. However, this fishery was dependent on the assessment in 2017, and hence on the SSB in 2017, and an overestimation of this SSB would have led to an overestimation of the sustainable TAC.

		Value relative to 2019 assessment*		
Assessment year		N (average of 2015–2017)	SSB 2017	Mean weight at age 1 and 2 2016
2017	no monitoring in 2016	2.06	3.05	1.46
2017	monitoring in 2016	1.39	1.56	1
2018	no monitoring in 2016	1.17	1.42	1.46
2018	monitoring in 2016	1.31	1.41	1

*** a value of 1 corresponds to identical estimates**

9.3.12 Status of the Stock

A moderate F in most of the years from 2010 in combination with a low recruitment have given a slow increase in SSB since the historical low values in 2004 to 2010. F in 2017 was the highest in recent years. SSB in 2016 and 2017 are estimated below B_{lim}. Recruitment in 2016 is estimated to be the fourth highest on record while the 2017 and 2018 year classes are extremely low.

9.3.13 Management considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such as sandeel is the escapement strategy, i.e. to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Management strategy evaluations (ICES, 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 SA2r sandeel at 0.45. 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 SA3 is given in tables 9.1.2–9.1.4. Catch numbers at age by half-year is given in Table 9.4.1.

The proportions of age groups in the 2013–2015 catches are quite similar with approximately 65% 1-group, but in 2018, the 2-group provided the largest contribution to the catches similar to what has been reported in 2011 when the large 2009 year-class were 2 years old (Figure 9.4.1). The proportion of group-1 was low in 2018.

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.

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 2017, WGSAM provided updated estimates of natural mortality at age from multi-species modelling of northern sandeel (SMS, WGSAM 2017). In later years, natural mortality has been historically high as a result of the increasing grey seal population as well as grey gurnard and saithe stocks.

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.

Tuning series used in the assessments

CPUE data from the dredge survey (Table 9.4.4 and Figure 9.4.5) in 2018 show an above average recruitment in 2018 (Table 9.4.4). The internal consistency plot (Figure 9.4.4) shows medium consistency for age 0 vs. age 1 (i.e. $r^2 = 0.30$ 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 (2009–2018) 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 9.4.12. The age 1 index in 2017 and the age 2 index in 2018 is the highest observed in the time series supporting that the 2016 year class was very strong.

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 high for both age 0 (0.68) and age 1 (0.92), showing an overall poor consistency between the results from the dredge survey and the overall model results. The dredge survey residuals (Figure 9.4.6) plot shows a series of negative residuals from 2007–2011 for the 0 group followed by positive residuals, while the residuals for the 1-group are more randomly distributed. 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 0 (0.78) and age 1 (0.61), showing an overall medium consistency between the results from the dredge survey and the overall model results. The acoustic survey residuals (Figure 9.4.15) plot shows a series of positive residuals followed by a series of negative residuals for the 2-group, while the residuals for the 1-group are more randomly distributed.

The model CV of catch at age is medium (0.65) 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 (> 1.01). 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 cluster of negative or positive residuals for ages 1 and 2.

The CV of the fitted stock recruitment relationship (Table 9.4.5) is high (1.06), 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 is a large retrospective pattern in the recruitment that consistently overestimates large recruiting year-classes by more than 100%.

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, 1999–2018, 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 2013, 2014 and 2016 together with a fishing mortality below average have resulted in SSB above B_{pa} in 2015 onwards.

The estimated recruitment in 2016 is the highest in the time series, and the recruitment in 2018 is also estimated to be among the five highest recruitments.

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 2 and older. Recruitment in 2019 is the geometric mean of the recruitment 1986–2017 (105 billion at age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2018. 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 2014–2018, corresponding to a 23% decrease in mean weight at age 2 compared to the values used in the forecast for 2018. 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 133 610 t in 2019 will result in a fishing mortality of 0.29, identical to F_{cap}, and leave SSB at 262 800 t, well above MSY $B_{trigger}$ of 129 000 t, in 2020. The TAC according to the escapement strategy is therefore 133 610 t in 2019.

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 and 2016 combined with a low fishing mortality. Recruitment estimate for 2018 is fifth largest on record.

9.4.13 Management Considerations

Since 2011 the Norwegian sandeel fishery in the current SA3r has been managed according to an area-based management plan for the Norwegian EEZ and an advice provided by the IMR in Bergen.

9.5 Sandeel in SA 4

9.5.1 Catch data

Catch numbers at age by half-year from area SA 4 is given in Table 9.5.1. Total catch weight by year for SA 4 is given in tables 9.5.2–9.5.4. In 2018, age groups 1, 3 and 4 contributed almost equally to the catches (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 historical levels after the very low levels in 2001 to 2005. The second half year mean weights are affected by the very limited sampling at this time of year.

9.5.3 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 2017) 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. Effort since 2004 has been extremely low. CPUE in later years has been around the average prior to 2004.

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 2018 year-class lowest recruitment 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 (see WD01 on sandeel dredge in SA4).

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 2018. 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) for all ages. In fact, the CV of the dredge survey hits the lower bound 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 (0.70) 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 (1.29), 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 substantially above B_{pa} in 2016 to 2019. $F_{(1–2)}$ is estimated to have been very low since 2005 increasing in 2018 to the highest since 2004. Recruitment in

2014, 2016 and 2017 are estimated to be above average, whereas 2018 show the second lowest in record.

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 2019 is the geometric mean of the recruitment 1993–2017 (81 billion at age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2018. 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 2014–2018. Natural mortality and maturity are as applied in the assessment in final year. The Stock Annex gives more details about the forecast methodology.

Output

The short term forecast (Table 9.3.12) shows that a SSB will be below the MSY $B_{trigger}$ of 84 000 t and B_{lim} of 55 000 t in 2020 even in the complete absence of fishing. The TAC according to the escapement strategy is therefore 0 t in 2019. A monitoring TAC at 5000 t in 2019 will lead to an SSB in 2020 at 38 915 t.

The short-term forecast (Table 9.5.12) shows that that a SSB will be below the MSY $B_{trigger}$ of 102 000 t in 2020 even in the absence of fishing. The TAC according to the escapement strategy is therefore 0 t in 2019. A monitoring TAC at 5000 t in 2019 will lead to an SSB in 2020 at 97 744 t.

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 2019 is high (0.37). The assessment accuracy is improved compared to the 2018 assessment as catches were increased in 2018.

9.5.10.2 Status of the Stock

Recruitment in 2014, 2016 and 2017 are all above the long-term average, while 2018 is the second lowest on record. 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.

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).

9.6 Sandeel in SA 5

9.6.1 Catch data

Total catch weight by year for SA 5 is given in tables 9.1.2–9.1.4. No landings 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 SA5. 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 References

ICES. 2016. Report of the Benchmark on Sandeel (WKSand 2016), 31 October - 4 November 2016, Bergen, Norway. ICES CM 2016/ACOM:33. 301pp.

van Deurs, M., Hartvig, M., & Steffensen, J. F. (2011). Critical threshold size for overwintering sandeels (*Ammodytes marinus*). Marine biology, 158(12), 2755-2764.

WD01 Marine Scotland Science sandeel dredge survey indices for SA4.

Table 9.1.1 Sandeel. Catches ('000 t), 1955–2018. (Data provided by Working Group Members).

Year	Denmark	Germany	Faroes	Ireland	Netherlands	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
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

Year	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	Total
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	278.5	9.8	-	-	-	109	32.7	6.1	1.65	437.8
2012	51.5	1.706	-	-	-	42.46	5.652	-	-	101.4
2013	208.7	7.9	-	-	0.4	30.446	26.8	2.436	1.3	278.0
2014	148.0	5.052	-	-	-	82.499	18.815	0.03	0.825	255.2
2015	163.2	9.097	-	-	-	100.859	33.439	2	-	308.6
2016	28.9	-	-	-	-	40.867	4.139	-	-	73.9
2017	307.0	-	-	-	-	120.204	41.123	-	3.324	471.7
2018	168.6	5.905	-	-	-	69.531	16.387	1.849	-	262.2

Table 9.1.2 Sandeel. Total catch (tonnes) by area as estimated by ICES.

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	382629	156208	24828	2782	0	364	0	566810
1984	498671	133398	49111	2563	5821	791	744	691098
1985	460057	111889	20859	38122	3004	1927	0	635858
1986	382844	225581	282334	12718	628	13219	10650	927973
1987	373021	49067	395298	8154	1713	1163	0	828417
1988	422805	151543	336919	1338	0	2726	0	915330
1989	446129	227292	374252	4384	2903	909	450	1056318
1990	306302	133796	163224	3314	374	499	0	607508
1991	332204	215565	274839	41372	1168	17	2529	867694
1992	558602	184241	87022	68905	1099	4277	3455	907600
1993	144389	147964	200123	133136	586	4490	80	630768
1994	193241	244944	267281	158690	2757	3748	4	870666
1995	400759	122155	213168	52591	152274	1830	0	942776
1996	291709	186460	159304	158490	27570	1263	1	824796
1997	426414	242680	474093	58446	10772	2372	3061	1217839
1998	372604	99305	474843	58911	3010	941	5228	1014841
1999	425478	70085	193621	53338	145	0	4415	747083
2000	374724	101952	196525	37792	303	0	4371	715667
2001	540248	97210	196209	47918	1678	26	971	884260
2002	610161	120520	115207	12762	8	493	453	859604
2003	178642	56248	35365	64049	44	111	260	334718
2004	215352	116837	33658	6882	0	573	0	373302
2005	126261	34569	13994	1557	0	259	0	176640
2006	247510	37952	7094	86	0	161	0	292802
2007	110395	44069	75376	11	4	0	0	229855
2008	236069	35655	74943	1168	0	0	0	347836
2009	309712	37049	6161	0	0	0	0	352922
2010	300896	52470	60542	275	0	0	0	414183
2011	320241	24310	92450	270	0	489	0	437761
2012	45954	12672	40141	2618	0	214	0	101599
2013	214787	48172	9838	5119	0	72	0	277989
2014	99059	64707	95426	4505	0	65	0	263762
2015	162861	39492	104607	4736	0	198	0	311894
2016	15407	9569	44074	6232	0	123	0	75405
2017	242069	141314	115642	18474	0	0	0	517499
2018	132828	20569	74933	42528	0	0	0	270858
arith. mean	302806	105486	149536	30951	5996	1203	1019	596998

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	126182	20284	74352	42528	0	0	0	263346
arith. mean	273514	75451	123869	26078	5500	1097	806	506314

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	6646	285	581	0	0	0	0	7512
arith. mean	29292	30036	25668	4873	496	106	213	90684

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	2211	1416	1096	51	0	4	0	4777
2015	2046	1233	1441	43	0	5	0	4769
2016	146	429	561	79	0	6	0	1220
2017	2813	2093	1247	172	0	0	0	6324
2018	3265	561	1489	547	0	0	0	5862
arith. mean	5527	2737	3079	358	87	47	9	11844

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	2130	1344	1094	51	0	4	0	4623
2015	2046	1214	1441	43	0	5	0	4749
2016	146	413	561	79	0	6	0	1205
2017	2762	1838	1247	172	0	0	0	6018
2018	2942	555	1477	547	0	0	0	5522
arith. mean	4839	1910	2453	300	83	43	7	9635

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	81	71	2	0	0	0	0	155
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	322	6	12	0	0	0	0	340
arith. mean	688	826	626	58	5	4	2	2209

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	166	71	0	0	0	723
Sum	6206	2779	1776	850	39	71	0	11721

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
2018	91	1702	159	14567	797	975	43	343	11
arith. mean	2665	23753	1739	9291	625	2362	198	703	39

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
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	2.4	4.7	4.1	7.0	6.6	9.5	8.8	11.5	10.1
arith. mean	3.6	5.8	6.3	9.3	10.3	13.0	14.0	15.0	16.0

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 (number/hour).

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

Table 9.2.5 Sandeel Area-1r. SMS settings and statistics.

Date: 01/30/19 Start time:12:09:14 run time:2 seconds

objective function (negative log likelihood): 8.6934
Number of parameters: 77
Maximum gradient: 3.91354e-005
Akaike information criterion (AIC): 171.387
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
324	60	36	0	420

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
16.9	-8.8	12.0	0.0	0.0	0.00	20

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.05	-0.15	0.33	0.00

contribution by fleet:

RTM 2007-2017	total:	-4.737	mean:	-0.158
Dredge survey 2004-2018	total:	-4.049	mean:	-0.135

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
2010-2018:	0.000	1.000
age: 1 - 4		
1983-1988:	0.457	0.500
1989-1998:	0.470	0.500
1999-2004:	0.374	0.500
2005-2009:	0.261	0.500
2010-2018:	0.472	0.500

F, age effect:

	0	1	2	3	4
1983-1988:	0.025	0.256	0.926	1.353	1.353
1989-1998:	0.012	0.540	0.712	0.702	0.702
1999-2004:	0.069	1.054	1.151	1.127	1.127
2005-2009:	0.007	1.508	2.221	2.237	2.237
2010-2018:	0.008	0.315	0.829	1.265	1.265

Exploitation pattern (scaled to mean F=1)

	0	1	2	3	4
1983-1988 season 1:	0	0.326	1.181	1.726	1.726

season 2: 0.021 0.107 0.386 0.564 0.564

1989-1998 season 1: 0 0.829 1.094 1.079 1.079
season 2: 0.001 0.033 0.044 0.044 0.044

1999-2004 season 1: 0 0.814 0.889 0.871 0.871
season 2: 0.019 0.142 0.155 0.152 0.152

2005-2009 season 1: 0 0.754 1.111 1.119 1.119
season 2: 0.001 0.054 0.080 0.081 0.081

2010-2018 season 1: 0 0.523 1.378 2.102 2.102
season 2: 0.001 0.027 0.072 0.110 0.110

sqrt(catch variance) ~ CV:

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season

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age	1	2
0		1.610
1	0.341	0.572
2	0.341	0.572
3	0.691	0.911
4	0.691	0.911

Survey catchability:

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	age 0	age 1	age 2	age 3
RTM 2007-2017		0.863	1.681	2.133
Dredge survey 2004-2018			2.475	1.049

sqrt(Survey variance) ~ CV:

----

	age 0	age 1	age 2	age 3
RTM 2007-2017		0.57	0.41	0.59
Dredge survey 2004-2018			0.36	0.77

Recruit-SSB alfa beta recruit s2 recruit s
Area-1r 1021.404 1.100e+005 0.718 0.848

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	0.252	0.913	1.333	1.333	0.583	0.252
1984	0.285	1.032	1.507	1.507	0.659	0.285
1985	0.305	1.102	1.610	1.610	0.704	0.305
1986	0.204	0.741	1.082	1.082	0.473	0.204
1987	0.160	0.578	0.845	0.845	0.369	0.160
1988	0.221	0.801	1.170	1.170	0.511	0.221
1989	0.698	0.921	0.908	0.908	0.810	0.698
1990	0.697	0.919	0.907	0.907	0.808	0.697
1991	0.494	0.653	0.644	0.644	0.574	0.494
1992	0.721	0.951	0.938	0.938	0.836	0.721
1993	0.318	0.420	0.415	0.415	0.369	0.318
1994	0.258	0.340	0.335	0.335	0.299	0.258
1995	0.483	0.638	0.629	0.629	0.561	0.483
1996	0.451	0.595	0.587	0.587	0.523	0.451
1997	0.444	0.585	0.577	0.577	0.515	0.444
1998	0.545	0.719	0.709	0.709	0.632	0.545
1999	0.890	0.972	0.952	0.952	0.931	0.890
2000	0.719	0.785	0.768	0.768	0.752	0.719
2001	1.158	1.264	1.239	1.239	1.211	1.158
2002	0.792	0.866	0.848	0.848	0.829	0.792
2003	0.684	0.747	0.732	0.732	0.716	0.684
2004	0.694	0.757	0.742	0.742	0.726	0.694
2005	0.803	1.183	1.191	1.191	0.993	0.803
2006	0.984	1.448	1.459	1.459	1.216	0.984
2007	0.355	0.523	0.527	0.527	0.439	0.355
2008	0.673	0.991	0.998	0.998	0.832	0.673
2009	0.844	1.243	1.252	1.252	1.044	0.844
2010	0.304	0.801	1.222	1.222	0.553	0.304
2011	0.337	0.887	1.352	1.352	0.612	0.337
2012	0.062	0.164	0.250	0.250	0.113	0.062
2013	0.392	1.033	1.575	1.575	0.713	0.392
2014	0.234	0.617	0.941	0.941	0.426	0.234
2015	0.219	0.579	0.882	0.882	0.399	0.219
2016	0.015	0.041	0.062	0.062	0.028	0.015
2017	0.299	0.787	1.200	1.200	0.543	0.299
2018	0.348	0.918	1.400	1.400	0.633	0.348
arith. mean	0.482	0.792	0.939	0.939	0.637	0.482

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	0.190	0.062	0.688	0.225	1.005	0.328	1.005	0.328
1984	0.013	0.217	0.068	0.786	0.246	1.148	0.359	1.148	0.359
1985	0.014	0.232	0.073	0.839	0.263	1.225	0.385	1.225	0.385
1986	0.005	0.180	0.024	0.653	0.088	0.954	0.128	0.954	0.128
1987	0.008	0.118	0.042	0.426	0.152	0.623	0.222	0.623	0.222
1988	0.005	0.197	0.024	0.713	0.088	1.041	0.129	1.041	0.129
1989	0.001	0.671	0.027	0.885	0.036	0.873	0.035	0.873	0.035
1990	0.002	0.652	0.045	0.860	0.059	0.848	0.059	0.848	0.059
1991	0.005	0.373	0.121	0.493	0.160	0.486	0.158	0.486	0.158
1992	0.003	0.645	0.076	0.851	0.100	0.839	0.099	0.839	0.099
1993	0.001	0.284	0.034	0.375	0.045	0.370	0.045	0.370	0.045
1994	0.001	0.232	0.026	0.306	0.034	0.302	0.033	0.302	0.033
1995	0.002	0.431	0.052	0.569	0.069	0.561	0.068	0.561	0.068
1996	0.003	0.391	0.060	0.516	0.079	0.509	0.078	0.509	0.078
1997	0.005	0.325	0.119	0.429	0.156	0.423	0.154	0.423	0.154
1998	0.002	0.496	0.049	0.654	0.065	0.645	0.064	0.645	0.064
1999	0.017	0.758	0.132	0.828	0.144	0.811	0.141	0.811	0.141
2000	0.016	0.595	0.124	0.650	0.135	0.636	0.132	0.636	0.132
2001	0.050	0.774	0.384	0.845	0.419	0.828	0.411	0.828	0.411
2002	0.004	0.764	0.028	0.835	0.031	0.818	0.030	0.818	0.030
2003	0.015	0.568	0.116	0.621	0.126	0.608	0.124	0.608	0.124
2004	0.008	0.635	0.059	0.693	0.064	0.679	0.063	0.679	0.063
2005	0.001	0.749	0.054	1.103	0.080	1.111	0.080	1.111	0.080
2006	0.001	0.906	0.078	1.334	0.114	1.344	0.115	1.344	0.115
2007	0.000	0.355	0.000	0.523	0.000	0.527	0.000	0.527	0.000
2008	0.000	0.636	0.037	0.936	0.055	0.943	0.055	0.943	0.055
2009	0.001	0.768	0.076	1.131	0.112	1.139	0.113	1.139	0.113
2010	0.001	0.289	0.015	0.761	0.040	1.161	0.061	1.161	0.061
2011	0.001	0.326	0.011	0.859	0.028	1.310	0.042	1.310	0.042
2012	0.000	0.062	0.000	0.164	0.000	0.250	0.000	0.250	0.000
2013	0.000	0.392	0.000	1.033	0.000	1.575	0.000	1.575	0.000
2014	0.000	0.225	0.009	0.593	0.024	0.904	0.037	0.904	0.037
2015	0.000	0.219	0.000	0.579	0.000	0.882	0.000	0.882	0.000
2016	0.000	0.015	0.000	0.041	0.000	0.062	0.000	0.062	0.000
2017	0.000	0.293	0.006	0.772	0.015	1.177	0.023	1.177	0.023
2018	0.002	0.312	0.036	0.822	0.096	1.254	0.146	1.254	0.146
arith. mean	0.006	0.424	0.057	0.699	0.093	0.830	0.109	0.830	0.109

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	0.512	0.396	0.481	0.353	0.388	0.295	0.355	0.269	0.351
1984	0.502	0.401	0.466	0.360	0.386	0.274	0.336	0.256	0.348
1985	0.516	0.385	0.468	0.346	0.385	0.290	0.363	0.264	0.344
1986	0.531	0.376	0.478	0.342	0.412	0.282	0.380	0.267	0.361
1987	0.538	0.387	0.477	0.349	0.418	0.287	0.381	0.271	0.366
1988	0.546	0.394	0.475	0.360	0.419	0.298	0.373	0.293	0.366
1989	0.523	0.416	0.449	0.382	0.393	0.319	0.366	0.291	0.357
1990	0.543	0.402	0.476	0.343	0.404	0.292	0.368	0.285	0.368
1991	0.550	0.394	0.452	0.330	0.386	0.246	0.349	0.246	0.355
1992	0.533	0.391	0.424	0.313	0.365	0.234	0.328	0.235	0.335
1993	0.512	0.400	0.392	0.340	0.325	0.252	0.315	0.234	0.312
1994	0.512	0.378	0.435	0.324	0.355	0.253	0.327	0.229	0.320
1995	0.510	0.370	0.463	0.329	0.374	0.250	0.341	0.227	0.331
1996	0.538	0.334	0.483	0.299	0.385	0.246	0.350	0.219	0.343
1997	0.552	0.364	0.497	0.316	0.380	0.267	0.346	0.229	0.340
1998	0.591	0.409	0.525	0.344	0.377	0.299	0.343	0.244	0.336
1999	0.594	0.444	0.542	0.369	0.383	0.306	0.341	0.254	0.333
2000	0.582	0.458	0.527	0.381	0.356	0.314	0.327	0.247	0.306
2001	0.589	0.403	0.512	0.359	0.357	0.293	0.323	0.233	0.301
2002	0.645	0.445	0.549	0.416	0.445	0.347	0.353	0.277	0.332
2003	0.663	0.465	0.566	0.433	0.456	0.380	0.368	0.322	0.363
2004	0.679	0.525	0.601	0.456	0.458	0.403	0.366	0.346	0.360
2005	0.662	0.518	0.527	0.407	0.380	0.378	0.359	0.306	0.342
2006	0.695	0.543	0.551	0.417	0.399	0.329	0.355	0.277	0.338
2007	0.731	0.526	0.536	0.387	0.411	0.299	0.379	0.264	0.362
2008	0.694	0.523	0.582	0.396	0.437	0.289	0.371	0.266	0.364
2009	0.669	0.445	0.566	0.332	0.432	0.271	0.387	0.247	0.368
2010	0.675	0.451	0.624	0.344	0.453	0.281	0.413	0.246	0.384
2011	0.723	0.488	0.665	0.336	0.442	0.294	0.426	0.255	0.388
2012	0.716	0.544	0.638	0.414	0.434	0.333	0.407	0.295	0.381
2013	0.653	0.541	0.581	0.452	0.390	0.335	0.365	0.296	0.348
2014	0.635	0.473	0.524	0.439	0.348	0.297	0.327	0.278	0.319
2015	0.606	0.514	0.516	0.390	0.331	0.271	0.323	0.251	0.304
2016	0.606	0.514	0.516	0.390	0.331	0.271	0.323	0.251	0.304
2017	0.606	0.514	0.516	0.390	0.331	0.271	0.323	0.251	0.304
2018	0.606	0.514	0.516	0.390	0.331	0.271	0.323	0.251	0.304
arith. mean	0.598	0.446	0.516	0.370	0.390	0.295	0.355	0.263	0.343

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	307789	13764	53428	3205	202
1984	76138	182227	4452	10216	469
1985	518904	45492	57608	753	1286
1986	77487	305345	14299	9210	218
1987	46882	45338	106044	3207	1651
1988	205021	27161	16292	27615	1082
1989	93494	118199	9130	3357	4557
1990	132179	55351	24779	1675	1645
1991	161729	76615	11469	4680	695
1992	36290	92840	20047	2919	1556
1993	149627	21225	19966	3929	995
1994	215287	89540	6989	6740	1852
1995	54971	128926	30677	2523	3461
1996	387500	32947	34546	8028	1801
1997	60464	225590	9272	9612	3032
1998	113895	34620	61198	2573	3887
1999	150716	62937	7892	14506	1736
2000	244417	81770	9640	1408	3303
2001	405754	134449	14880	2105	1224
2002	25513	214039	16920	2053	538
2003	151085	13333	35859	3010	561
2004	67761	76681	2399	6978	821
2005	149597	34110	12429	451	1733
2006	74627	77088	5374	1735	341
2007	206138	37224	9653	558	246
2008	66094	99251	9030	2577	245
2009	479825	33017	16764	1457	539
2010	31323	245514	5164	2254	299
2011	40855	15945	61825	1044	379
2012	91537	19809	3598	11700	183
2013	51269	44716	5711	1308	4418
2014	189591	26682	9841	876	614
2015	28959	100443	7791	2417	315
2016	233749	15802	28799	2123	627
2017	20795	127551	5556	13443	1441
2018	110803	11344	33794	1230	2485
2019		60357	2860	6562	519

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	307812072	646348	476870	378795	0.583
1984	76133581	1190140	205048	498626	0.658
1985	518784950	793723	462314	437114	0.703
1986	77516393	1894430	277340	382844	0.472
1987	46875232	1533910	991526	373021	0.369
1988	205098313	795387	593623	413646	0.511
1989	93455879	753101	160332	446028	0.809
1990	132222941	656341	250196	306240	0.808
1991	161659043	950504	331042	332204	0.574
1992	36288085	1042360	286359	558599	0.836
1993	149678467	461536	262761	132024	0.370
1994	215183132	675313	180232	193241	0.299
1995	54953614	1429380	399512	400588	0.560
1996	387412277	603306	364397	265869	0.523
1997	60490688	1851450	233748	426089	0.515
1998	113919202	844877	522301	377073	0.632
1999	150729892	567762	225258	422718	0.931
2000	244322590	662828	142629	299167	0.752
2001	405649482	781692	160653	531265	1.211
2002	25520689	1428820	154972	606466	0.829
2003	151031654	342920	243531	148039	0.716
2004	67795068	478922	94278	203646	0.726
2005	149528864	356073	117243	123422	0.993
2006	74626035	530434	75584	240646	1.216
2007	206126373	308942	88345	109624	0.439
2008	66121201	758791	129314	234447	0.832
2009	479857623	386188	155127	290995	1.043
2010	31327285	1646980	119731	300508	0.552
2011	40873807	643056	452707	318840	0.612
2012	91513769	295400	163081	46117	0.113
2013	51289674	309657	97246	214359	0.712
2014	189519030	211182	73644	78830	0.426
2015	28947662	645626	93153	163381	0.399
2016	233805469	409101	270493	14613	0.028
2017	20790361	852929	183689	241916	0.543
2018	110773707	331641	231886	130460	0.633
2019			97636		
arith. mean	151612992	779751	253196	295596	0.637
geo. mean	107822833				

arith. mean for the period 1983–2018

geo. mean for the period 1983–2017

Table 9.2.11 Sandeel Area-1r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2019)	107870.298	60357.3	2860.25	6561.6	519.456
Exploitation pattern 1st half		0.312	0.822	1.254	1.254
Exploitation pattern 2nd half	0.002	0.036	0.096	0.146	0.146
Weight in the stock 1st half		5.077	7.927	10.257	12.511
Weight in the catch 1st half		5.077	7.927	10.257	12.511
weight in the catch 2nd half	3.099	5.519	8.615	11.384	13.154
Proportion mature(2019)	0.000	0.021	0.801	0.988	1.000
Proportion mature(2020)	0.000	0.021	0.801	0.988	1.000
Natural mortality 1st half		0.514	0.390	0.271	0.251
Natural mortality 2nd half	0.606	0.516	0.331	0.323	0.304

Table 9.2.12 Sandeel Area-1r. Short term forecast (000 tonnes).

Basis: Fsq = F(2018) = 0.6328; Yield(2018) = 130.461; Recruitment(2018) = 110.773707; Recruitment(2019) = geometric mean (GM 1983–2017) = 107.870298 billions; SSB(2019) = 97.636

F multiplier	Basis	F(2019)	Catch(2019)	SSB(2020)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	206.479	111 %	-100 %
1.000	Fsq*1	0.633	130.568	120.774	24 %	0 %
1.100	Fsq*1.1	0.696	139.421	115.390	18 %	7 %
1.200	Fsq*1.2	0.759	147.775	110.368	13 %	13 %
1.300	Fsq*1.3	0.823	155.675	105.674	8 %	19 %
1.400	Fsq*1.4	0.886	163.159	101.278	4 %	25 %
1.500	Fsq*1.5	0.949	170.261	97.152	0 %	31 %
1.600	Fsq*1.6	1.013	177.012	93.273	-4 %	36 %
1.700	Fsq*1.7	1.076	183.439	89.618	-8 %	41 %
0.624	MSY	0.395	91.916	145.001	49 %	-30 %

***SSB in 2020 relative to SSB in 2019**

****TAC in 2019 relative to catches in 2018**

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
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	51	0	1984	22	62	2	13	0
arith. mean	2932	7336	1545	1771	322	447	116	169	46

Table 9.3.2 Sandeel Area-2r. Individual mean weight (gram) at age in the catch and in the sea.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	3.3	5.2	9.9	10.8	16.5	12.8	22.9	15.0	27.3
1984	5.9	5.6	10.2	11.1	14.1	15.6	25.8	18.8	30.1
1985	4.5	6.7	10.7	9.9	16.8	17.5	23.3	24.1	27.5
1986	3.2	5.9	9.8	10.3	15.8	12.7	15.0	15.0	17.0
1987	2.8	5.8	8.7	11.1	12.9	16.4	21.1	14.6	19.4
1988	3.5	5.5	7.2	11.1	15.3	16.1	21.0	23.1	30.6
1989	4.8	5.7	9.4	9.1	13.4	10.1	14.4	12.1	18.0
1990	4.4	7.1	8.1	9.7	11.8	14.4	17.4	17.3	20.8
1991	3.8	7.7	5.7	12.1	11.0	35.8	32.6	21.2	20.1
1992	4.7	6.9	15.0	9.9	20.6	13.5	29.3	17.9	29.2
1993	2.8	7.7	9.3	15.1	14.8	16.9	17.5	22.3	22.0
1994	3.6	5.4	7.6	10.5	18.8	15.3	23.0	19.5	20.7
1995	5.2	7.6	8.9	12.4	13.2	16.0	17.6	19.2	21.1
1996	2.7	7.0	4.9	12.4	13.2	17.0	15.8	27.9	24.5
1997	3.2	5.3	7.1	8.0	11.2	13.1	13.8	15.9	14.9
1998	3.4	6.2	6.7	11.4	14.0	14.7	16.5	17.4	18.3
1999	5.3	8.1	9.1	11.8	12.8	15.4	15.3	19.1	19.6
2000	3.1	6.8	10.2	10.0	13.0	15.2	17.9	18.1	19.5
2001	4.0	6.0	5.0	12.9	16.1	16.6	21.7	20.4	26.2
2002	3.2	5.7	8.3	8.4	13.2	9.6	15.3	17.3	17.7
2003	5.4	6.0	8.1	11.3	16.0	15.1	21.4	18.2	27.2
2004	4.8	6.5	7.4	9.4	10.9	12.4	12.2	13.1	13.7
2005	3.4	7.5	7.4	11.8	11.9	14.4	15.4	14.8	17.5
2006	4.6	7.6	9.9	11.5	15.9	13.9	20.6	14.8	23.4
2007	5.8	6.2	6.2	12.4	12.4	15.4	15.4	17.8	17.8
2008	3.4	5.5	7.5	12.5	12.0	16.1	15.6	18.0	17.7
2009	6.0	6.1	5.0	8.7	10.9	16.5	18.6	12.2	11.0
2010	2.5	5.7	5.3	10.3	8.4	11.5	11.0	13.2	12.5
2011	3.6	6.9	7.6	11.1	12.2	13.8	15.8	14.6	18.0
2012	4.4	8.2	9.4	12.4	15.1	14.8	19.6	21.8	22.3
2013	3.9	5.9	8.8	7.9	11.5	14.2	14.4	14.1	16.5
2014	3.3	5.3	7.0	9.9	11.2	12.0	14.6	18.6	16.6
2015	5.3	6.8	11.4	12.4	18.4	15.3	23.9	17.3	27.1
2016	2.6	3.3	5.5	12.2	8.9	14.6	11.5	16.0	13.1
2017	2.9	5.5	7.8	7.8	10.7	13.1	10.8	14.8	15.5
2018	3.2	4.6	7.0	9.6	11.3	12.4	14.5	14.4	16.5
arith. mean	4.0	6.3	8.1	10.8	13.5	15.0	18.1	17.5	20.3

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 (number/hour).

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

Table 9.3.5 Sandeel Area-2r. SMS settings and statistics.

Date: 01/28/19 Start time:13:44:17 run time:0 seconds

objective function (negative log likelihood): 60.0717
Number of parameters: 71
Maximum gradient: 7.27768e-005
Akaike information criterion (AIC): 262.143
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
324	18	36	0	378

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
53.6	4.3	22.2	0.0	0.0	0.00	80

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.17	0.24	0.62	0.00

contribution by fleet:

Dredge survey 2010-2018 total: 4.283 mean: 0.238

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
2010-2018:	0.000	1.000
age: 1 -		4
1983-1988:	0.482	0.500
1989-1998:	0.668	0.500
1999-2004:	0.424	0.500
2005-2009:	0.199	0.500
2010-2018:	0.494	0.500

F, age effect:

	0	1	2	3	4
1983-1988:	0.040	0.273	0.880	1.494	1.494
1989-1998:	0.101	0.346	0.418	0.489	0.489
1999-2004:	0.041	0.600	0.738	0.739	0.739
2005-2009:	0.001	1.949	1.623	1.762	1.762
2010-2018:	0.001	0.280	0.453	0.739	0.739

Exploitation pattern (scaled to mean F=1)

		0	1	2	3	4
1983-1988	season 1:	0	0.300	0.968	1.644	1.644
	season 2:	0.051	0.173	0.558	0.948	0.948

1989-1998	season 1:		0	0.718	0.867	1.014	1.014
	season 2:	0.110	0.188	0.227		0.266	0.266
1999-2004	season 1:		0	0.307	0.377	0.378	0.378
	season 2:	0.080	0.590	0.726		0.727	0.727
2005-2009	season 1:		0	0.553	0.461	0.500	0.500
	season 2:	0.001	0.538	0.448		0.487	0.487
2010-2018	season 1:		0	0.624	1.010	1.647	1.647
	season 2:	0.001	0.140	0.226		0.369	0.369

sqrt(catch variance) ~ CV:
----

season
----

age	1	2
0		1.563
1	0.323	0.703
2	0.323	0.703
3	0.808	1.094
4	0.808	1.094

Survey catchability:
----

	age 0	age 1
Dredge survey 2010-2018	49.001	22.100

sqrt(Survey variance) ~ CV:
----

	age 0	age 1
Dredge survey 2010-2018	0.57	1.04

Recruit-SSB		alfa	beta	recruit s2	recruit s
Area-2r	1056.582	5.600e+004	1.266	1.125	

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	0.337	1.088	1.848	1.848	0.713	0.337
1984	0.286	0.925	1.571	1.571	0.606	0.286
1985	0.256	0.824	1.399	1.399	0.540	0.256
1986	0.358	1.156	1.963	1.963	0.757	0.358
1987	0.082	0.265	0.451	0.451	0.174	0.082
1988	0.277	0.893	1.515	1.515	0.585	0.277
1989	0.635	0.766	0.897	0.897	0.701	0.635
1990	0.414	0.501	0.586	0.586	0.458	0.414
1991	0.489	0.591	0.691	0.691	0.540	0.489
1992	0.482	0.583	0.681	0.681	0.533	0.482
1993	0.409	0.494	0.577	0.577	0.452	0.409
1994	0.409	0.494	0.577	0.577	0.452	0.409
1995	0.233	0.282	0.330	0.330	0.258	0.233
1996	0.400	0.483	0.565	0.565	0.442	0.400
1997	0.501	0.605	0.709	0.709	0.553	0.501
1998	0.260	0.314	0.367	0.367	0.287	0.260
1999	0.407	0.501	0.501	0.501	0.454	0.407
2000	0.489	0.603	0.604	0.604	0.546	0.489
2001	0.492	0.606	0.606	0.606	0.549	0.492
2002	0.589	0.725	0.725	0.725	0.657	0.589
2003	0.462	0.569	0.570	0.570	0.516	0.462
2004	0.808	0.995	0.996	0.996	0.902	0.808
2005	1.189	0.990	1.075	1.075	1.090	1.189
2006	1.277	1.063	1.154	1.154	1.170	1.277
2007	0.620	0.517	0.561	0.561	0.569	0.620
2008	0.735	0.611	0.664	0.664	0.673	0.735
2009	0.776	0.647	0.701	0.701	0.712	0.776
2010	0.289	0.467	0.761	0.761	0.378	0.289
2011	0.178	0.289	0.471	0.471	0.234	0.178
2012	0.100	0.162	0.264	0.264	0.131	0.100
2013	0.450	0.727	1.186	1.186	0.589	0.450
2014	0.329	0.533	0.870	0.870	0.431	0.329
2015	0.283	0.459	0.748	0.748	0.371	0.283
2016	0.122	0.198	0.322	0.322	0.160	0.122
2017	0.586	0.950	1.548	1.548	0.768	0.586
2018	0.157	0.255	0.414	0.414	0.206	0.157
arith. mean	0.449	0.615	0.819	0.819	0.532	0.449

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	0.036	0.214	0.123	0.690	0.398	1.172	0.676	1.172	0.676
1984	0.033	0.174	0.112	0.562	0.363	0.955	0.616	0.955	0.616
1985	0.022	0.182	0.074	0.585	0.239	0.994	0.405	0.994	0.405
1986	0.025	0.274	0.084	0.884	0.272	1.501	0.462	1.501	0.462
1987	0.008	0.055	0.027	0.177	0.088	0.301	0.150	0.301	0.150
1988	0.026	0.188	0.089	0.606	0.287	1.028	0.487	1.028	0.487
1989	0.077	0.503	0.132	0.607	0.159	0.711	0.186	0.711	0.186
1990	0.038	0.350	0.064	0.423	0.078	0.495	0.091	0.495	0.091
1991	0.072	0.367	0.122	0.443	0.148	0.518	0.173	0.518	0.173
1992	0.052	0.393	0.089	0.475	0.108	0.555	0.126	0.555	0.126
1993	0.082	0.269	0.140	0.325	0.169	0.380	0.197	0.380	0.197
1994	0.051	0.321	0.088	0.388	0.106	0.453	0.124	0.453	0.124
1995	0.044	0.158	0.075	0.191	0.091	0.224	0.106	0.224	0.106
1996	0.135	0.169	0.231	0.204	0.279	0.238	0.327	0.238	0.327
1997	0.085	0.356	0.145	0.430	0.175	0.504	0.205	0.504	0.205
1998	0.047	0.180	0.080	0.217	0.097	0.254	0.113	0.254	0.113
1999	0.036	0.139	0.268	0.171	0.330	0.171	0.330	0.171	0.330
2000	0.017	0.362	0.127	0.446	0.157	0.447	0.157	0.447	0.157
2001	0.036	0.224	0.268	0.276	0.330	0.276	0.330	0.276	0.330
2002	0.020	0.445	0.144	0.548	0.177	0.548	0.177	0.548	0.177
2003	0.037	0.193	0.269	0.238	0.331	0.238	0.332	0.238	0.332
2004	0.030	0.585	0.223	0.721	0.274	0.721	0.275	0.721	0.275
2005	0.001	0.603	0.586	0.502	0.488	0.545	0.530	0.545	0.530
2006	0.001	0.577	0.700	0.480	0.583	0.521	0.633	0.521	0.633
2007	0.000	0.620	0.000	0.517	0.000	0.561	0.000	0.561	0.000
2008	0.000	0.547	0.188	0.455	0.156	0.494	0.170	0.494	0.170
2009	0.000	0.403	0.373	0.336	0.311	0.364	0.337	0.364	0.337
2010	0.000	0.236	0.053	0.382	0.085	0.622	0.139	0.622	0.139
2011	0.000	0.159	0.019	0.258	0.031	0.420	0.051	0.420	0.051
2012	0.000	0.093	0.007	0.150	0.012	0.245	0.019	0.245	0.019
2013	0.000	0.395	0.055	0.639	0.088	1.042	0.144	1.042	0.144
2014	0.000	0.309	0.020	0.500	0.033	0.816	0.054	0.816	0.054
2015	0.000	0.278	0.005	0.450	0.009	0.734	0.014	0.734	0.014
2016	0.000	0.118	0.004	0.191	0.007	0.311	0.011	0.311	0.011
2017	0.001	0.514	0.072	0.833	0.117	1.358	0.190	1.358	0.190
2018	0.000	0.155	0.002	0.252	0.003	0.410	0.004	0.410	0.004
arith. mean	0.028	0.309	0.141	0.432	0.183	0.587	0.232	0.587	0.232

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
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
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	165822	16306	14367	709	32
1984	46688	63735	3647	1909	56
1985	282288	18002	14996	571	195
1986	62255	110082	4371	2595	91
1987	35120	24204	24107	542	180
1988	182143	13884	6987	7292	221
1989	86859	70719	3300	1129	788
1990	156507	32044	11752	605	376
1991	109124	60069	6636	2810	263
1992	115520	40480	11548	1450	736
1993	234965	43693	7834	2544	531
1994	108021	86295	9102	1886	826
1995	74724	40890	17976	2192	731
1996	420437	28496	10150	5350	1008
1997	15316	146350	5990	2471	1730
1998	26134	5608	27794	1290	995
1999	75890	9937	1356	8011	762
2000	43060	29162	2074	324	2540
2001	132731	16866	5602	448	761
2002	10221	51003	3233	1206	318
2003	48018	3994	8872	618	353
2004	19015	18448	788	1980	264
2005	19132	7352	2577	115	396
2006	27522	7619	702	378	85
2007	39049	10958	666	96	70
2008	24271	15562	1847	157	45
2009	82924	9670	2341	395	50
2010	12435	33031	1395	484	106
2011	12992	4953	7759	345	132
2012	56377	5177	1299	2293	143
2013	27880	22466	1469	436	894
2014	18017	11105	4493	280	197
2015	5480	7179	2504	1040	96
2016	185342	2184	1695	624	257
2017	1386	73859	606	549	306
2018	11059	552	12878	92	87
2019		4407	148	3941	57

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	165751461	249032	140225	155664	0.713
1984	46688106	425883	71682	133343	0.606
1985	282164276	283374	140225	110546	0.540
1986	62270602	724736	84881	225470	0.758
1987	35110121	420706	236570	49070	0.174
1988	182087883	276926	188528	149466	0.585
1989	86876663	456875	53960	223507	0.701
1990	156567847	356203	114462	133874	0.458
1991	109124501	647313	182225	215508	0.540
1992	115525287	428556	133786	184033	0.533
1993	234977424	509086	159692	139826	0.451
1994	108038694	604749	133519	244939	0.451
1995	74700698	584284	240386	113899	0.258
1996	420518907	444242	227521	182562	0.441
1997	15309743	880457	115036	242094	0.553
1998	26140594	387628	299839	99814	0.287
1999	75905523	234779	153123	69427	0.454
2000	43055477	270282	71898	92908	0.546
2001	132752892	195834	85050	90200	0.549
2002	10221460	332832	45342	117388	0.657
2003	48013847	139811	99409	53710	0.516
2004	19019969	154594	36534	110546	0.902
2005	19134432	92820	33894	34396	1.090
2006	27508346	72096	14354	37860	1.170
2007	39036201	78340	10895	43090	0.568
2008	24276030	112737	24173	35604	0.673
2009	82887929	85996	25135	35687	0.711
2010	12434681	209963	22675	51670	0.378
2011	12994022	127403	78984	24896	0.234
2012	56401144	95666	51328	10594	0.131
2013	27868289	162764	31101	47814	0.588
2014	18020130	110302	45252	48033	0.431
2015	5482107	97711	44356	37902	0.371
2016	185395141	40989	30516	5230	0.160
2017	1386094	426022	23813	141314	0.768
2018	11061708	128861	105345	20568	0.206
2019			55770		
arith. mean	82631198	301385	97596	103124	0.532
geo. mean	47583661				

arith. mean for the period 1983–2018

geo. mean for the period 1983–2017

Table 9.3.11 Sandeel Area-2r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2019)	20477.415	4407.14	147.917	3940.91	57.258
Exploitation pattern 1st half		0.155	0.252	0.410	0.410
Exploitation pattern 2nd half	0.000	0.002	0.003	0.004	0.004
Weight in the stock 1st half		5.103	10.386	13.482	16.195
Weight in the catch 1st half		5.103	10.386	13.482	16.195
weight in the catch 2nd half	3.469	7.760	12.086	15.070	17.762
Proportion mature(2019)	0.000	0.020	0.830	1.000	1.000
Proportion mature(2020)	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(2018) = 0.2056; Yield(2018) = 20.568; Recruitment(2018) = 11.061708; Recruitment(2019) = geometric mean (GM 2008–2017) = 20.477415 billions; SSB(2019) = 55.77

F multiplier	Basis	F(2019)	Catch(2019)	SSB(2020)	%SSB change*	%TAC change**
0	F=0	0.000	0.001	44.435	-20 %	-100 %
1	Fsq*1	0.206	18.622	32.046	-43 %	-9 %
0.24	Fsq*0.24	0.048	5.004	41.080	-26 %	-76 %
0.4	Fsq*0.4	0.082	8.248	38.915	-30 %	-60 %
0.5	Fsq*0.5	0.103	10.132	37.660	-32 %	-51 %
0.6	Fsq*0.6	0.123	11.952	36.452	-35 %	-42 %
0.7	Fsq*0.7	0.144	13.708	35.288	-37 %	-33 %
0.8	Fsq*0.8	0.164	15.403	34.166	-39 %	-25 %
0.9	Fsq*0.9	0.185	17.041	33.086	-41 %	-17 %
No conversion for calculation of MSY catch		NA	NA	NA		

***SSB in 2020 relative to SSB in 2019**

****TAC in 2019 relative to catches in 2018**

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
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	276	9	6114	44	758	2	216	1
arith. mean	3644	11266	1060	3524	98	628	31	211	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
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	3.3	5.9	6.8	9.4	10.9	14.6	14.6	18.4	15.9
arith. mean	4.6	6.9	9.4	12.4	15.9	18.2	21.2	23.1	22.9

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 (number/hour).

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

Table 9.4.5 Sandeel Area-3r. SMS settings and statistics.

Date: 01/28/19 Start time:14:20:26 run time:1 seconds

objective function (negative log likelihood): 118.007
Number of parameters: 57
Maximum gradient: 6.39117e-005
Akaike information criterion (AIC): 350.014
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
297	67	33	0	397

objective function weight:

Catch	CPUE	S/R
1.00	1.00	0.01

unweighted objective function contributions (total):

Catch	CPUE	S/R	Stom.	Stom N.	Penalty	Sum
102.3	15.5	18.3	0.0	0.0	0.00	136

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.34	0.23	0.55	0.00

contribution by fleet:

Acoustic survey	total:	7.943	mean:	0.199
Dredge survey 2004-2018	total:	7.607	mean:	0.282

F, season effect:
----

age:		0
1986-1998:	0.000	1.000
1999-2018:	0.000	1.000
age: 1 -		4
1986-1998:	0.901	0.500
1999-2018:	1.034	0.500

F, age effect:

	0	1	2	3	4
1986-1998:	0.102	0.359	0.387	0.293	0.293
1999-2018:	0.058	0.190	0.301	0.323	0.323

Exploitation pattern (scaled to mean F=1)

		0	1	2	3	4
1986-1998	season 1:	0	0.654	0.705	0.535	0.535
	season 2:	0.176	0.309	0.332	0.252	0.252
1999-2018	season 1:	0	0.535	0.847	0.909	0.909
	season 2:	0.145	0.239	0.378	0.406	0.406

sqrt(catch variance) ~ CV:
----

season
----
age 1 2

0 1.146
1 0.651 1.019
2 0.651 1.019
3 1.149 1.194
4 1.149 1.194

Survey catchability:
----
age 0 age 1 age 2 age 3 age 4
Acoustic survey 3.060 5.975 4.438 4.438
Dredge survey 2004-2018 0.779 0.779

sqrt(Survey variance) ~ CV:
----
age 0 age 1 age 2 age 3 age 4
Acoustic survey 0.65 0.65 0.84 0.84
Dredge survey 2004-2018 0.68 0.96

Recruit-SSB alfa beta recruit s2 recruit s
Area-3r 1430.788 8.000e+004 1.114 1.056

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	0.414	0.446	0.338	0.338	0.430	0.414
1987	0.570	0.613	0.466	0.466	0.592	0.570
1988	0.766	0.825	0.625	0.625	0.796	0.766
1989	0.857	0.922	0.700	0.700	0.890	0.857
1990	0.506	0.545	0.413	0.413	0.526	0.506
1991	0.602	0.648	0.492	0.492	0.625	0.602
1992	0.263	0.282	0.215	0.215	0.273	0.263
1993	0.516	0.556	0.422	0.422	0.536	0.516
1994	0.523	0.562	0.427	0.427	0.543	0.523
1995	0.415	0.446	0.339	0.339	0.431	0.415
1996	0.428	0.461	0.349	0.349	0.445	0.428
1997	0.776	0.835	0.634	0.634	0.806	0.776
1998	1.028	1.107	0.839	0.839	1.068	1.028
1999	0.832	1.316	1.413	1.413	1.074	0.832
2000	0.732	1.159	1.243	1.243	0.946	0.732
2001	0.568	0.900	0.966	0.966	0.734	0.568
2002	0.451	0.714	0.766	0.766	0.583	0.451
2003	0.259	0.410	0.440	0.440	0.335	0.259
2004	0.190	0.300	0.322	0.322	0.245	0.190
2005	0.084	0.133	0.143	0.143	0.109	0.084
2006	0.036	0.058	0.062	0.062	0.047	0.036
2007	0.218	0.345	0.370	0.370	0.282	0.218
2008	0.241	0.382	0.410	0.410	0.312	0.241
2009	0.020	0.032	0.034	0.034	0.026	0.020
2010	0.261	0.413	0.443	0.443	0.337	0.261
2011	0.166	0.262	0.281	0.281	0.214	0.166
2012	0.101	0.159	0.171	0.171	0.130	0.101
2013	0.049	0.077	0.083	0.083	0.063	0.049
2014	0.196	0.310	0.333	0.333	0.253	0.196
2015	0.258	0.409	0.439	0.439	0.334	0.258
2016	0.101	0.159	0.171	0.171	0.130	0.101
2017	0.224	0.354	0.380	0.380	0.289	0.224
2018	0.265	0.419	0.450	0.450	0.342	0.265
arith. mean	0.391	0.502	0.460	0.460	0.447	0.391

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	0.281	0.133	0.303	0.143	0.230	0.108	0.230	0.108
1987	0.001	0.568	0.002	0.611	0.002	0.464	0.002	0.464	0.002
1988	0.051	0.676	0.090	0.728	0.097	0.552	0.073	0.552	0.073
1989	0.003	0.851	0.006	0.916	0.006	0.695	0.005	0.695	0.005
1990	0.050	0.419	0.087	0.451	0.094	0.342	0.071	0.342	0.071
1991	0.039	0.533	0.069	0.573	0.075	0.435	0.057	0.435	0.057
1992	0.003	0.257	0.006	0.276	0.006	0.210	0.005	0.210	0.005
1993	0.042	0.443	0.073	0.477	0.079	0.362	0.060	0.362	0.060
1994	0.016	0.495	0.028	0.532	0.030	0.404	0.023	0.404	0.023
1995	0.007	0.402	0.013	0.433	0.013	0.329	0.010	0.329	0.010
1996	0.043	0.353	0.075	0.380	0.081	0.288	0.061	0.288	0.061
1997	0.066	0.661	0.115	0.711	0.124	0.540	0.094	0.540	0.094
1998	0.140	0.783	0.245	0.843	0.264	0.639	0.200	0.639	0.200
1999	0.156	0.575	0.257	0.910	0.406	0.977	0.436	0.977	0.436
2000	0.004	0.725	0.007	1.148	0.011	1.232	0.011	1.232	0.011
2001	0.162	0.302	0.266	0.479	0.421	0.514	0.452	0.514	0.452
2002	0.000	0.451	0.000	0.714	0.000	0.766	0.000	0.766	0.000
2003	0.021	0.224	0.035	0.354	0.056	0.380	0.060	0.380	0.060
2004	0.021	0.155	0.035	0.245	0.055	0.263	0.059	0.263	0.059
2005	0.000	0.084	0.000	0.133	0.000	0.143	0.000	0.143	0.000
2006	0.000	0.036	0.000	0.057	0.001	0.061	0.001	0.061	0.001
2007	0.000	0.218	0.000	0.345	0.000	0.370	0.000	0.370	0.000
2008	0.000	0.241	0.000	0.382	0.000	0.410	0.000	0.410	0.000
2009	0.000	0.020	0.000	0.032	0.000	0.034	0.000	0.034	0.000
2010	0.001	0.260	0.001	0.412	0.001	0.442	0.001	0.442	0.001
2011	0.000	0.166	0.000	0.262	0.000	0.281	0.000	0.281	0.000
2012	0.000	0.101	0.000	0.159	0.000	0.171	0.000	0.171	0.000
2013	0.000	0.049	0.000	0.077	0.000	0.083	0.000	0.083	0.000
2014	0.000	0.196	0.000	0.310	0.000	0.333	0.000	0.333	0.000
2015	0.000	0.258	0.000	0.409	0.000	0.439	0.000	0.439	0.000
2016	0.000	0.101	0.000	0.159	0.000	0.171	0.000	0.171	0.000
2017	0.000	0.224	0.000	0.354	0.000	0.380	0.000	0.380	0.000
2018	0.000	0.265	0.000	0.419	0.000	0.450	0.000	0.450	0.000
arith. mean	0.027	0.345	0.047	0.442	0.060	0.406	0.054	0.406	0.054

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
arith. mean	1.164	0.713	0.572	0.566	0.463	0.419	0.403	0.385	0.386

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	508628	92585	6386	245	747
1987	115398	123493	15707	1403	341
1988	361602	27585	18660	3006	514
1989	105977	73662	3530	3010	905
1990	211506	27937	9711	565	956
1991	124520	55954	5548	2430	544
1992	269677	35341	10203	1253	986
1993	196507	81772	8436	3190	985
1994	185145	60288	14851	1949	1412
1995	143194	60066	10045	3146	1108
1996	779957	51784	11252	2340	1433
1997	61168	277707	9868	2612	1276
1998	92780	23289	39659	1655	958
1999	117131	30591	2665	5333	551
2000	121434	35424	3593	260	723
2001	117009	39459	3996	353	131
2002	27690	30286	4512	430	69
2003	61734	8175	3742	550	70
2004	39343	17840	1274	637	121
2005	67318	11486	3133	262	183
2006	115686	21315	2380	810	150
2007	57000	37736	4919	712	370
2008	79747	19946	7869	1184	324
2009	129990	29632	4816	2078	449
2010	13397	48296	10059	1953	1209
2011	9867	4413	12503	2786	997
2012	78759	2942	1115	3647	1294
2013	188227	23960	770	350	1786
2014	214535	57263	6603	262	867
2015	8452	65256	13619	1780	356
2016	463596	2571	14585	3328	588
2017	19835	141036	673	4576	1408
2018	297171	6034	32639	174	1753
2019		90406	1340	7895	544

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	508512319	643843	82951	282315	0.430
1987	115409820	1013520	205253	395296	0.592
1988	361582215	473076	279847	330358	0.795
1989	106005337	548609	104715	350409	0.889
1990	211555937	331555	108445	163224	0.526
1991	124522876	576107	166209	274839	0.625
1992	269748338	362098	129444	86788	0.273
1993	196466011	690574	202805	175786	0.536
1994	185209838	652850	248948	267281	0.542
1995	143235402	493734	148747	173607	0.431
1996	780152522	721161	247212	159024	0.444
1997	61159759	1610440	187775	470670	0.806
1998	92803972	556904	352216	462081	1.067
1999	117154016	341576	118539	191253	1.074
2000	121448395	299796	56444	186837	0.946
2001	117036920	332856	60840	193684	0.734
2002	27701580	309932	60415	116298	0.583
2003	61712681	111061	56444	34673	0.334
2004	39349743	152965	25009	31285	0.245
2005	67322159	150168	52156	13991	0.108
2006	115640870	209789	48194	7094	0.047
2007	57024981	376789	87816	74972	0.281
2008	79717524	312560	130875	74933	0.311
2009	129994149	284576	91766	6261	0.026
2010	13403146	610233	219476	61241	0.338
2011	9869897	280906	211504	92452	0.214
2012	78766631	167654	135673	40116	0.130
2013	188197029	261581	48582	9844	0.063
2014	214538550	592986	101215	90876	0.253
2015	8452730	759194	196811	104631	0.334
2016	463816705	275985	223686	42845	0.130
2017	19835821	1205740	160011	115642	0.289
2018	297225004	378095	272120	74933	0.342
2019			182590		
arith. mean	163150899	487543	147203	156228	0.447
geo. mean	98542649				

arith. mean for the period 1986–2018

geo. mean for the period 1986–2017

Table 9.4.11 Sandeel Area-3r. Input to forecast. Table XXX. Area-3r Sandeel. input to forecast

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2019)	93435.991	90405.7	1339.86	7895.09	544.185
Exploitation pattern 1st half		0.265	0.419	0.450	0.450
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		6.870	11.821	17.056	24.603
Weight in the catch 1st half		6.870	11.821	17.056	24.603
weight in the catch 2nd half	3.759	7.820	12.550	16.993	18.389
Proportion mature(2019)	0.000	0.036	0.766	1.000	1.000
Proportion mature(2020)	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(2018) = 0.3421; Yield(2018) = 74.933; Recruitment(2018) = 297.225004; Recruitment(2019) = geometric mean (GM 1986–2017) = 98.516877 billions; SSB(2019) = 182.59

F multiplier	Basis	F(2019)	Catch(2019)	SSB(2020)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	340.918	87 %	-100 %
0.850	Fsq*0.85	0.290	133.610	262.800	44 %	78 %
1.000	Fsq*1	0.342	154.348	250.965	37 %	106 %
1.500	Fsq*1.5	0.513	216.496	216.044	18 %	189 %
2.000	Fsq*2	0.684	270.594	186.399	2 %	261 %
2.500	Fsq*2.5	0.855	317.819	161.186	-12 %	324 %
3.000	Fsq*3	1.026	359.162	139.705	-23 %	379 %
3.500	Fsq*3.5	1.197	395.459	121.370	-34 %	428 %
4.000	Fsq*4	1.368	427.414	105.696	-42 %	470 %
3.282	MSY	1.123	380.226	129.000	-29 %	407 %

***SSB in 2020 relative to SSB in 2019**

****TAC in 2019 relative to catches in 2018**

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=0.30940475)	16989.62 (CV=0.09694092)	79.82 (CV=0.34325033)	440.33 (CV=0.30654509)

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
2016	0	181	0	406	0	20	0	36	0
2017	0	719	0	468	0	578	0	30	0
2018	0	876	0	1259	0	349	0	1150	0
arith. mean	134	1143	182	1026	158	652	27	274	51

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
2018	4.7	5.8	7.7	9.4	12.2	13.1	16.6	18.3	19.2
arith. mean	3.8	5.6	7.9	9.4	13.7	13.2	16.5	17.2	21.7

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 (number/hour).

Year	Age 0	Age 1
1999	615	494
2000	586	3170
2001	48	2656
2002	243	404
2003	580	
2004		
2005		
2006		
2007		
2008	52	24
2009	832	87
2010	147	1032
2011	89	165
2012	95	135
2013	62	85
2014	445	43
2015	136	1044
2016	300	81
2017	346	223
2018	16	461

Table 9.5.5 Sandeel Area-4. SMS settings and statistics.

Date: 01/24/19 Start time:14:58:39 run time:1 seconds

objective function (negative log likelihood): -2.24692
Number of parameters: 45
Maximum gradient: 3.94028e-005
Akaike information criterion (AIC): 85.5062
Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
234	31	26	0	291

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
27.3	-30.5	19.6	0.0	0.0	0.00	16

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.12	-0.98	0.75	0.00

contribution by fleet:

Old Dredge survey 1999-2003 total: -9.491 mean: -1.055
New Dredge survey 2008-2018 total: -20.998 mean: -0.954

F, season effect:
----
age: 0
1993-2018: 0.000 1.000
age: 1 - 4
1993-2018: 0.579 0.500

F, age effect:

	0	1	2	3	4
1993-2018:	0.003	0.106	0.193	0.265	0.265

Exploitation pattern (scaled to mean F=1)

		0	1	2	3	4
1993-2018	season 1:	0	0.626	1.138	1.562	1.562
	season 2:	0.005	0.084	0.153	0.210	0.210

sqrt(catch variance) ~ CV:
----

season
----

age	1	2
0		2.006
1	0.700	0.382

2	0.700	0.382
3	0.730	1.270
4	0.730	1.270

Survey catchability:
----

	age 0	age 1
Old Dredge survey 1999-2003	0.763	17.355
New Dredge survey 2008-2018	0.570	2.724

sqrt(Survey variance) ~ CV:
----

	age 0	age 1
Old Dredge survey 1999-2003	0.30	0.30
New Dredge survey 2008-2018	0.30	0.30

Recruit-SSB	alfa	beta	recruit s2	recruit s
Area-4	1372.548	4.800e+004	1.655	1.287

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	0.269	0.488	0.670	0.670	0.379	0.269
1994	0.308	0.561	0.770	0.770	0.435	0.308
1995	0.086	0.156	0.215	0.215	0.121	0.086
1996	0.263	0.479	0.657	0.657	0.371	0.263
1997	0.119	0.217	0.297	0.297	0.168	0.119
1998	0.119	0.217	0.298	0.298	0.168	0.119
1999	0.168	0.306	0.420	0.420	0.237	0.168
2000	0.083	0.151	0.208	0.208	0.117	0.083
2001	0.132	0.240	0.330	0.330	0.186	0.132
2002	0.028	0.050	0.069	0.069	0.039	0.028
2003	0.215	0.391	0.537	0.537	0.303	0.215
2004	0.040	0.073	0.100	0.100	0.057	0.040
2005	0.017	0.032	0.044	0.044	0.025	0.017
2006	0.000	0.000	0.001	0.001	0.000	0.000
2007	0.000	0.000	0.001	0.001	0.000	0.000
2008	0.001	0.003	0.004	0.004	0.002	0.001
2009	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.001	0.001	0.002	0.002	0.001	0.001
2011	0.001	0.002	0.003	0.003	0.002	0.001
2012	0.013	0.024	0.033	0.033	0.019	0.013
2013	0.007	0.013	0.019	0.019	0.010	0.007
2014	0.010	0.018	0.024	0.024	0.014	0.010
2015	0.008	0.014	0.020	0.020	0.011	0.008
2016	0.015	0.028	0.038	0.038	0.022	0.015
2017	0.034	0.062	0.085	0.085	0.048	0.034
2018	0.108	0.196	0.270	0.270	0.152	0.108
arith. mean	0.079	0.143	0.197	0.197	0.111	0.079

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	0.237	0.032	0.430	0.058	0.591	0.079	0.591	0.079
1994	0.002	0.278	0.030	0.506	0.055	0.694	0.076	0.694	0.076
1995	0.000	0.086	0.000	0.156	0.000	0.214	0.001	0.214	0.001
1996	0.009	0.102	0.161	0.186	0.293	0.255	0.402	0.255	0.402
1997	0.001	0.097	0.022	0.176	0.041	0.241	0.056	0.241	0.056
1998	0.000	0.113	0.006	0.206	0.011	0.283	0.015	0.283	0.015
1999	0.000	0.168	0.000	0.306	0.000	0.420	0.000	0.420	0.000
2000	0.000	0.083	0.000	0.151	0.000	0.208	0.000	0.208	0.000
2001	0.000	0.130	0.002	0.236	0.004	0.324	0.006	0.324	0.006
2002	0.000	0.028	0.000	0.050	0.000	0.069	0.000	0.069	0.000
2003	0.001	0.203	0.012	0.369	0.022	0.507	0.030	0.507	0.030
2004	0.000	0.040	0.000	0.072	0.001	0.099	0.001	0.099	0.001
2005	0.000	0.017	0.000	0.032	0.000	0.044	0.000	0.044	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	0.001	0.000	0.001	0.000
2008	0.000	0.001	0.000	0.003	0.000	0.004	0.000	0.004	0.000
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.001	0.000	0.001	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	0.013	0.000	0.024	0.000	0.033	0.000	0.033	0.000
2013	0.000	0.007	0.000	0.013	0.000	0.019	0.000	0.019	0.000
2014	0.000	0.010	0.000	0.018	0.000	0.024	0.000	0.024	0.000
2015	0.000	0.008	0.000	0.014	0.000	0.020	0.000	0.020	0.000
2016	0.000	0.015	0.000	0.028	0.000	0.038	0.000	0.038	0.000
2017	0.000	0.034	0.000	0.062	0.000	0.085	0.000	0.085	0.000
2018	0.000	0.108	0.000	0.196	0.000	0.270	0.000	0.270	0.000
arith. mean	0.001	0.069	0.010	0.125	0.019	0.171	0.026	0.171	0.026

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
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	115583	21689	23227	7439	1561
1994	253303	36902	4260	4793	2038
1995	68529	80879	6965	818	1409
1996	371687	21917	19064	2002	812
1997	96739	117846	4327	3971	649
1998	42876	30902	26879	1172	1517
1999	229416	13708	7047	7276	900
2000	196908	73371	2977	1745	2372
2001	23448	62975	17346	860	1510
2002	85668	7498	14180	4588	772
2003	150258	27398	1874	4533	2211
2004	12750	48024	5676	426	1757
2005	8752	4078	11854	1774	901
2006	5422	2799	1029	3861	1143
2007	9747	1734	719	346	2220
2008	27273	3117	445	242	1173
2009	392249	8723	800	149	644
2010	67444	125449	2241	269	362
2011	47438	21570	32206	752	284
2012	41282	15172	5534	10802	460
2013	26934	13203	3846	1816	4793
2014	317986	8614	3367	1276	2949
2015	52262	101698	2191	1112	1871
2016	114852	16714	25923	726	1323
2017	163314	36732	4229	8475	893
2018	7625	52231	9123	1337	3797
2019		2439	12046	2520	1783

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 $F_{1\text{-}2}$
1993	115525287	576799	357182	132599	0.378
1994	253278441	560500	148153	158690	0.435
1995	68544930	827656	123500	52591	0.121
1996	371849589	417494	248948	158490	0.371
1997	96784750	877167	80660	58446	0.168
1998	42883599	503930	257816	58746	0.168
1999	229405101	294876	193300	53334	0.237
2000	196859336	372014	82454	37714	0.117
2001	23441066	347081	111190	47902	0.186
2002	85668864	169830	123130	12736	0.039
2003	150278380	199332	69982	63731	0.303
2004	12749467	262814	61267	6882	0.056
2005	8753814	114747	81961	1557	0.025
2006	5422134	101481	82951	0	0.000
2007	9742419	54635	44846	0	0.000
2008	27261881	40157	24465	0	0.002
2009	392089230	74002	21367	0	0.000
2010	67456938	673402	26265	0	0.001
2011	47441124	405289	240145	0	0.002
2012	41284596	215777	143344	2585	0.019
2013	26936694	214438	136626	5225	0.010
2014	318139333	183842	113437	4314	0.014
2015	52273494	507367	59278	4392	0.011
2016	114834211	386423	248948	6188	0.022
2017	163283743	449019	161943	18474	0.048
2018	7625436	473207	154508	42526	0.152
2019			169058		
arith. mean	112682460	357818	132091	35659	0.111
geo. mean	65857245				

arith. mean for the period 1993–2018

geo. mean for the period 1993–2017

Table 9.5.11 Sandeel Area-4. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2019)	80801.276	2438.59	12045.9	2520.43	1782.86
Exploitation pattern 1st half		0.108	0.196	0.270	0.270
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.940	10.295	14.642	19.545
Weight in the catch 1st half		5.940	10.295	14.642	19.545
weight in the catch 2nd half	4.522	7.967	12.959	17.069	20.434
Proportion mature(2019)	0.000	0.000	0.790	0.980	1.000
Proportion mature(2020)	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(2018) = 0.1522; Yield(2018) = 42.526; Recruitment(2018) = 7.625436; Recruitment(2019) = geometric mean (GM 2008–2017) = 80.801276 billions; SSB(2019) = 169.058

F multiplier	Basis	F(2019)	Catch(2019)	SSB(2020)	%SSB change*	%TAC change**
0	F=0	0.000	0.001	100.879	-40 %	-100 %
0.99	Fsq*0.99	0.150	31.408	81.351	-52 %	-26 %
0.14	Fsq*0.14	0.022	5.001	97.744	-42 %	-88 %
2.65	Fsq*2.65	0.403	72.062	56.804	-66 %	69 %
3	Fsq*3	0.456	79.026	52.708	-69 %	86 %
3.5	Fsq*3.5	0.533	88.183	47.383	-72 %	107 %
4	Fsq*4	0.609	96.495	42.618	-75 %	127 %
4.5	Fsq*4.5	0.685	104.048	38.350	-77 %	145 %
5	Fsq*5	0.761	110.918	34.528	-80 %	161 %
No conversion for calculation of MSY catch		NA	NA	NA		

***SSB in 2020 relative to SSB in 2019**

****TAC in 2019 relative to catches in 2018**

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

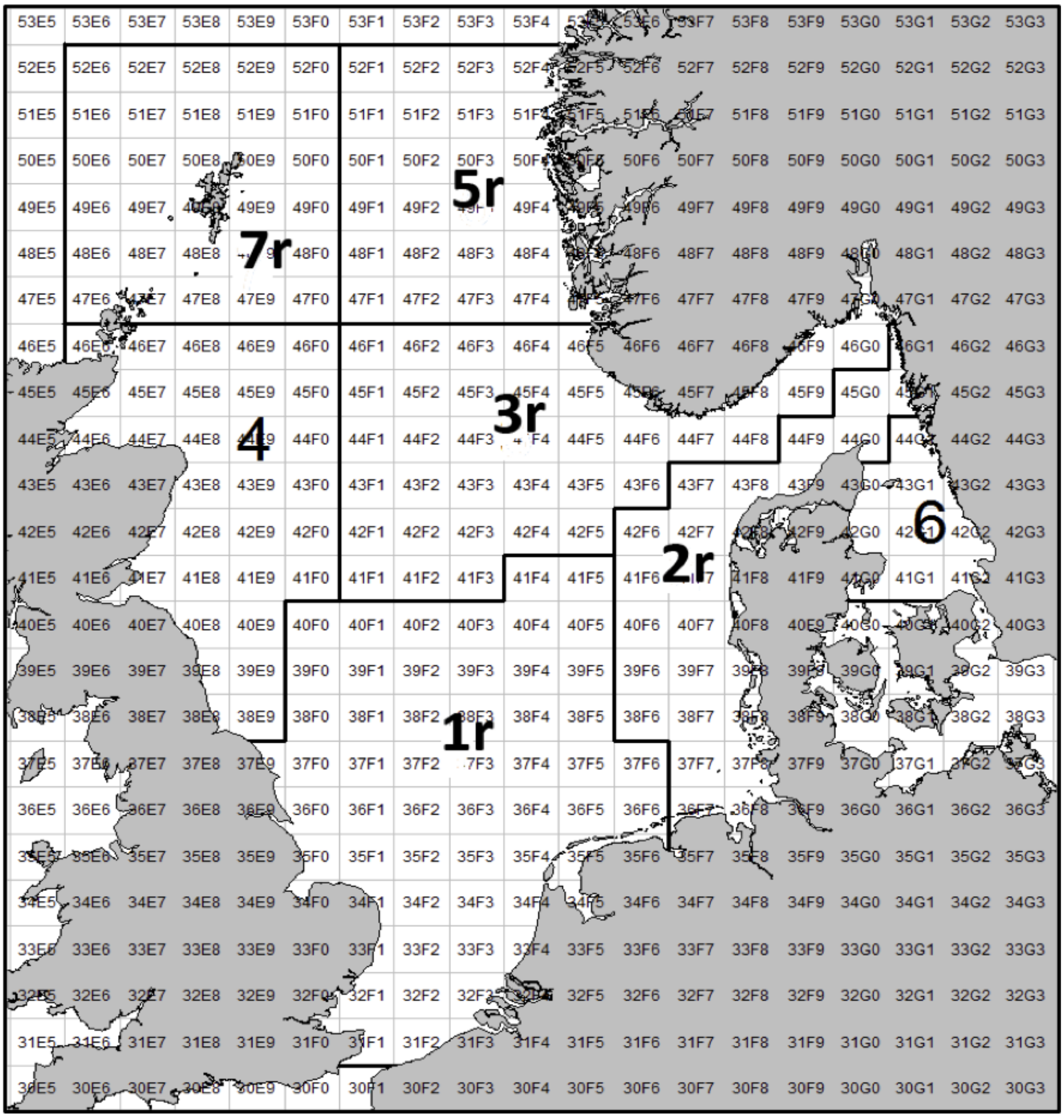


Figure 11.1.1 Sandeel in ICES Division 4 and 3.a. Sandeel management areas.

Figure 11.1.2 Sandeel in ICES Division 4 and 3.a. Catch by ICES rectangles 2003–2018. Area of the circles is proportional to catch by rectangle.

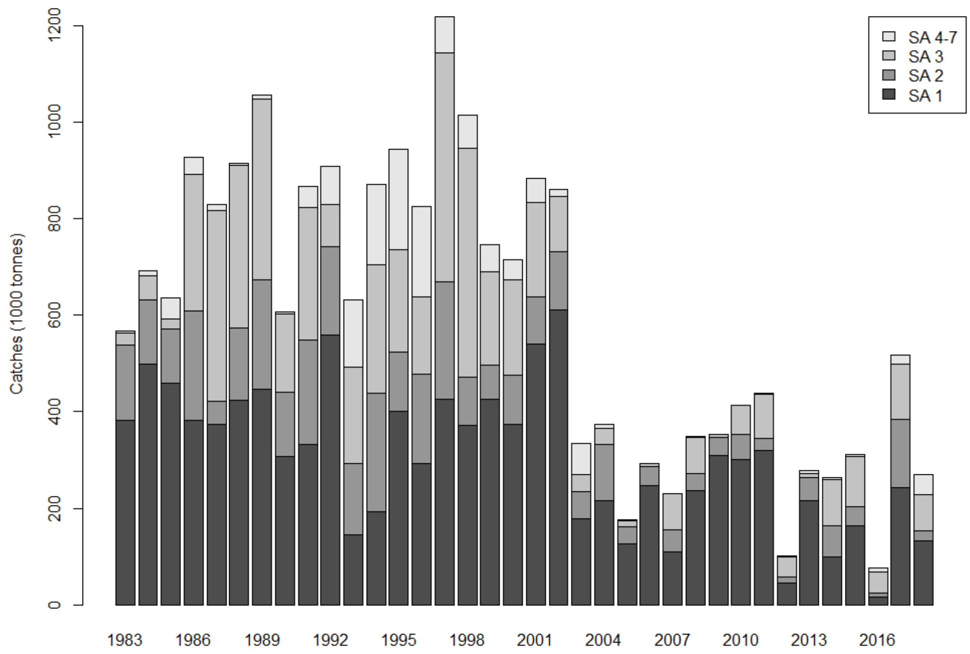


Figure 11.1.3 Sandeel in ICES Division 4 and 3.a. Total catches by year and area.

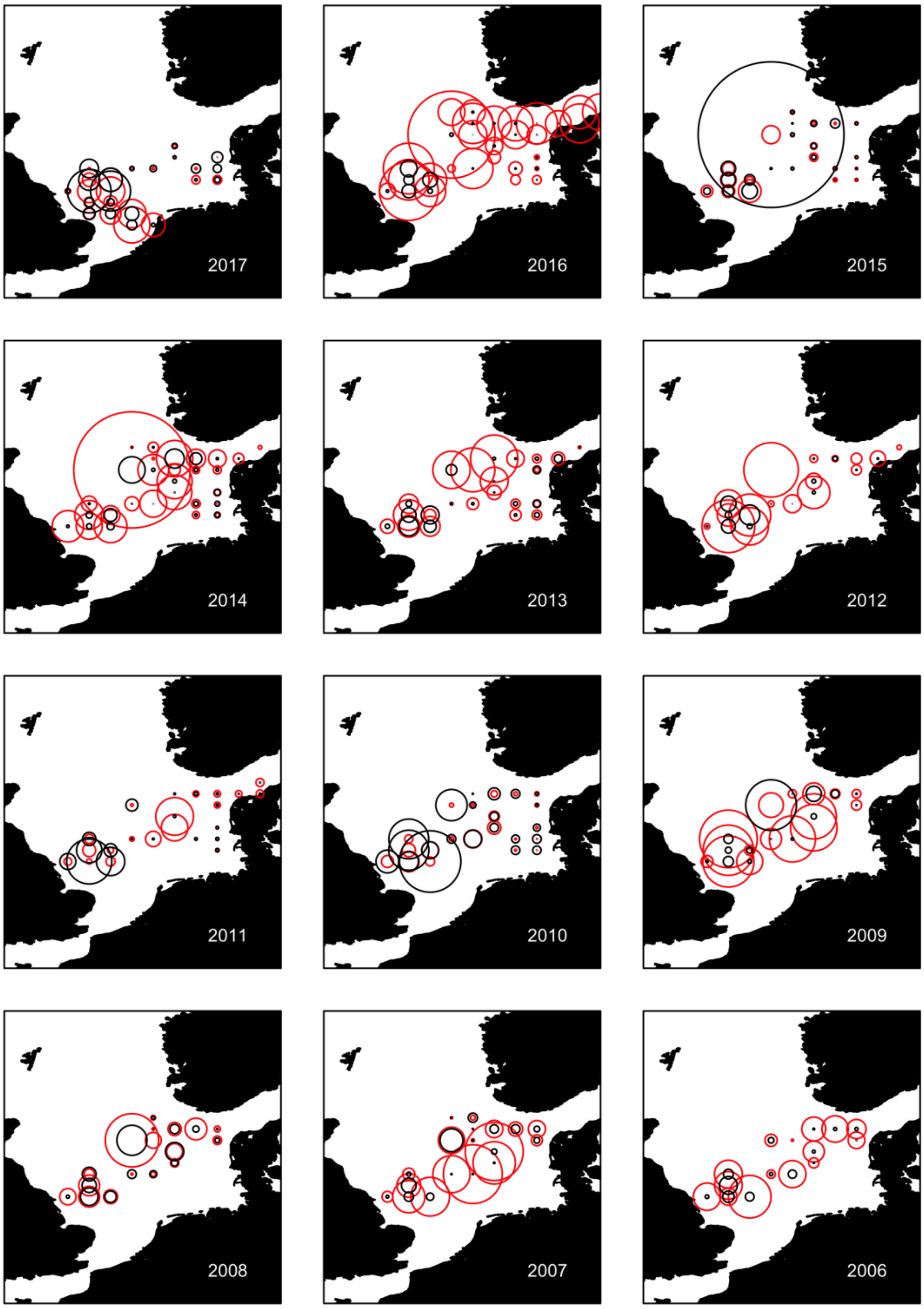


Figure 11.1.4 Sandeel in ICES Division 4 and 3.a. Danish survey indices by year and ICES rectangles. Red circles: 0-group, black circles: 1-group. Area of the circles is proportional to catch numbers by rectangle.

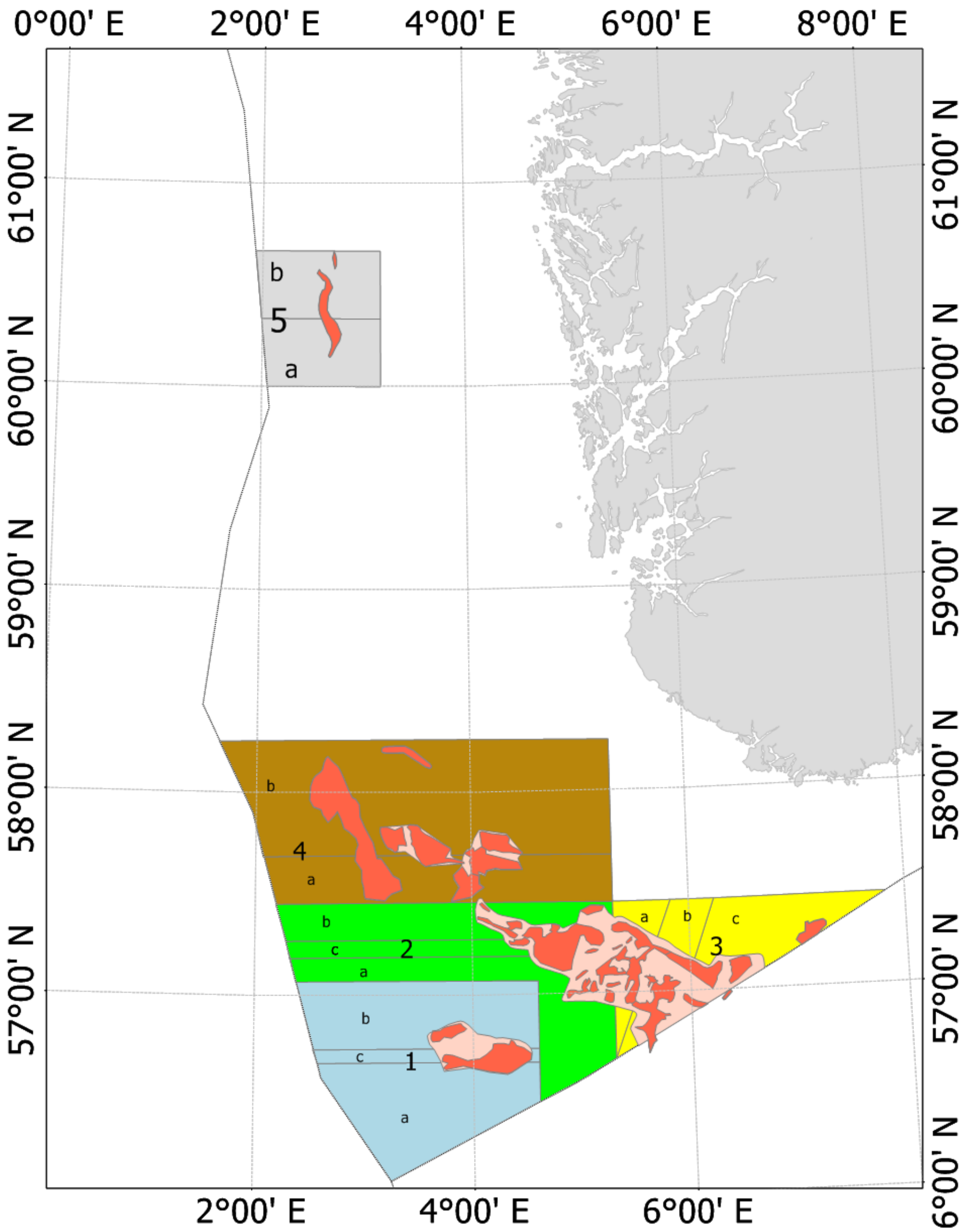


Figure 11.1.5 Map of the Norwegian sandeel management areas and sub-areas in the North Sea . Historical important fishing grounds are depicted in red, and areas with suitable sandeel habitat are depicted in pink. Areas valid from 2017.

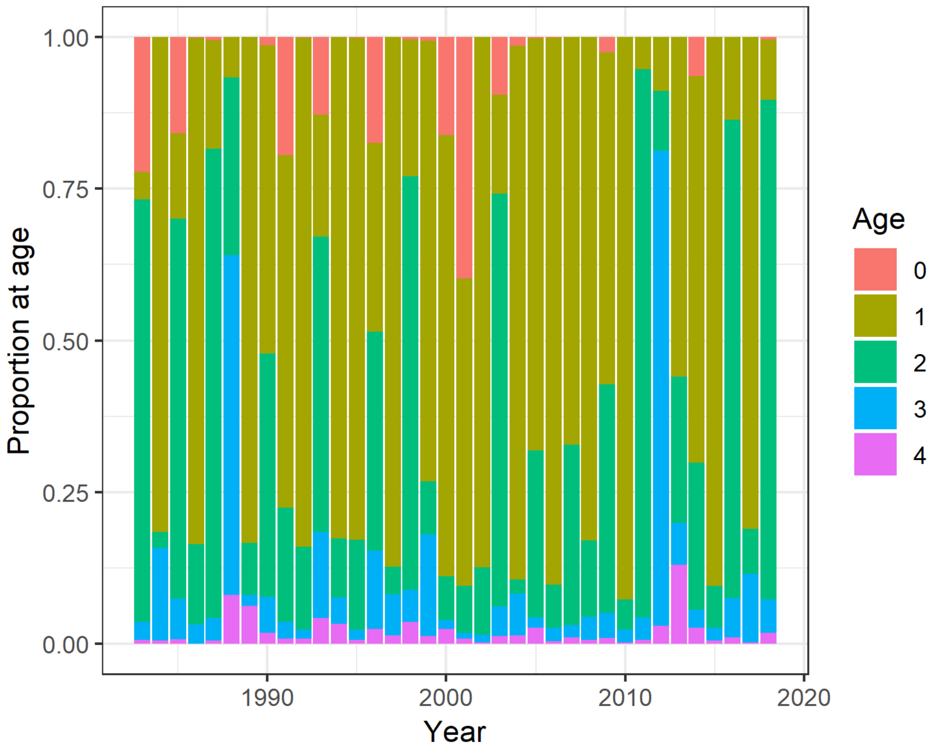


Figure 11.2.1 Sandeel Area-1r. Catch numbers, proportion at age.

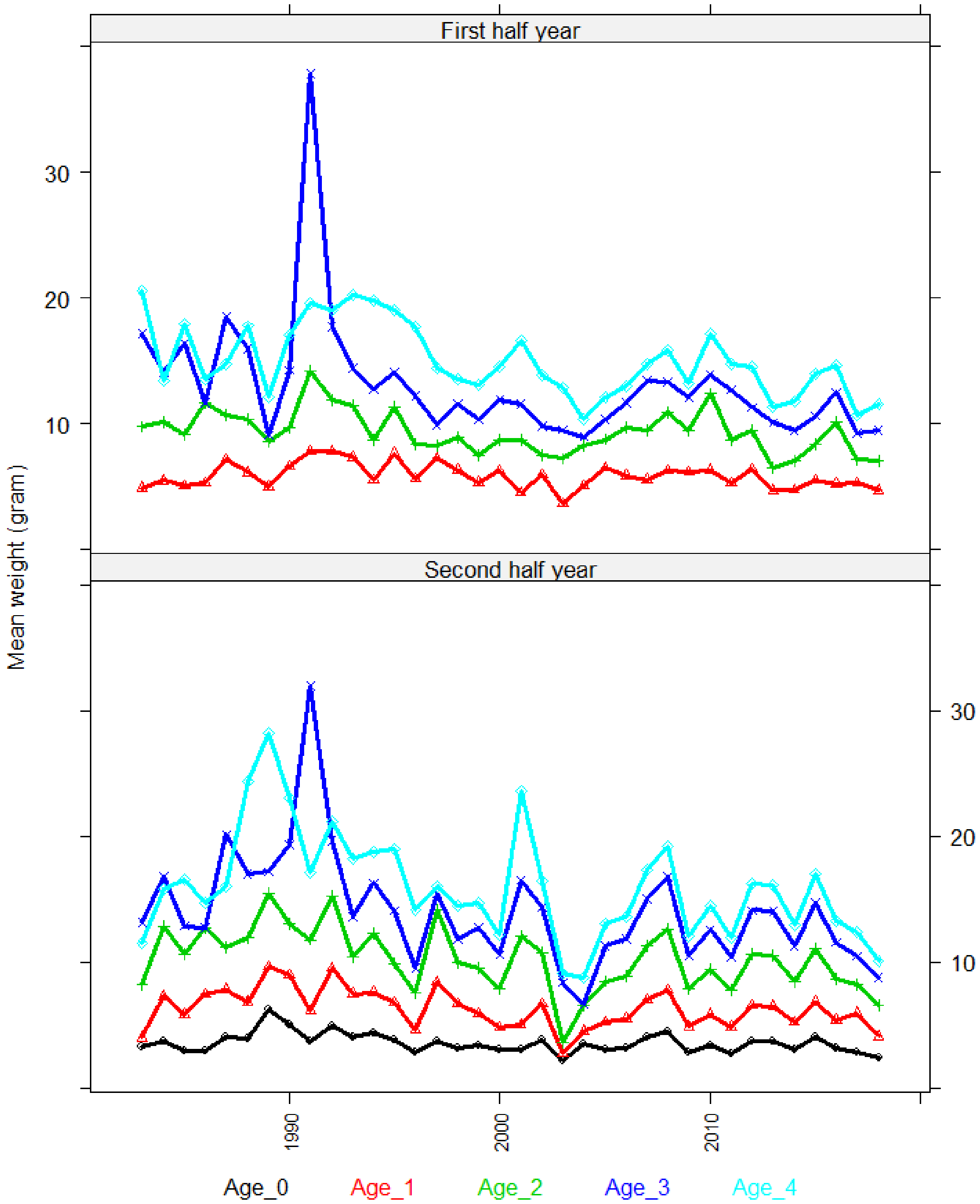


Figure 11.2.2 Sandeel Area-1r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

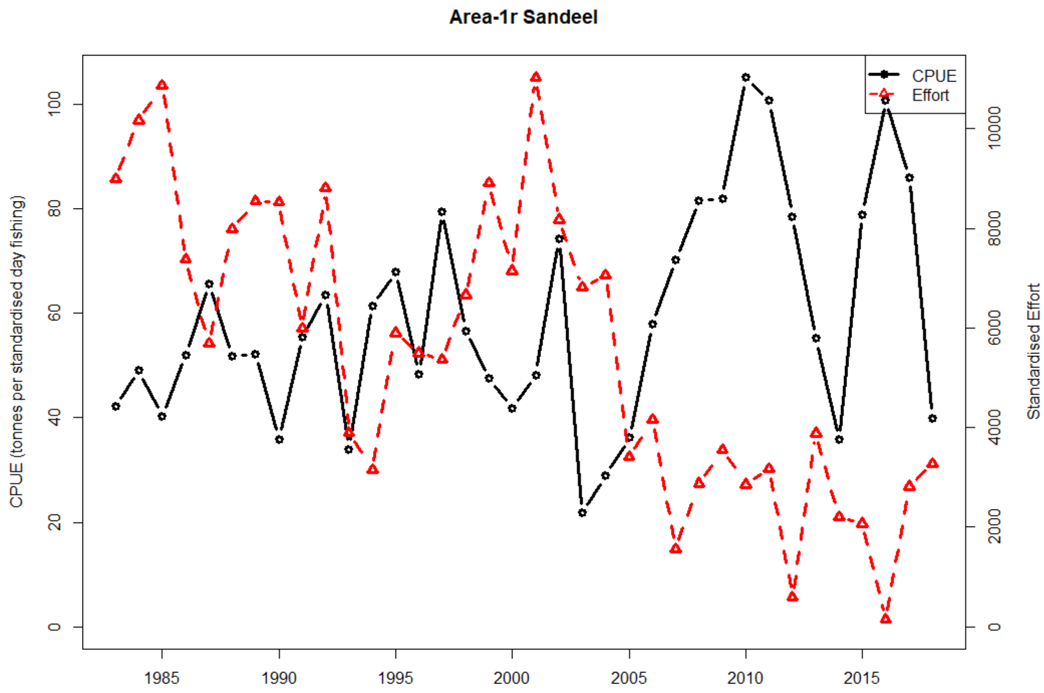


Figure 11.2.3 Sandeel Area-1r. CPUE and effort.

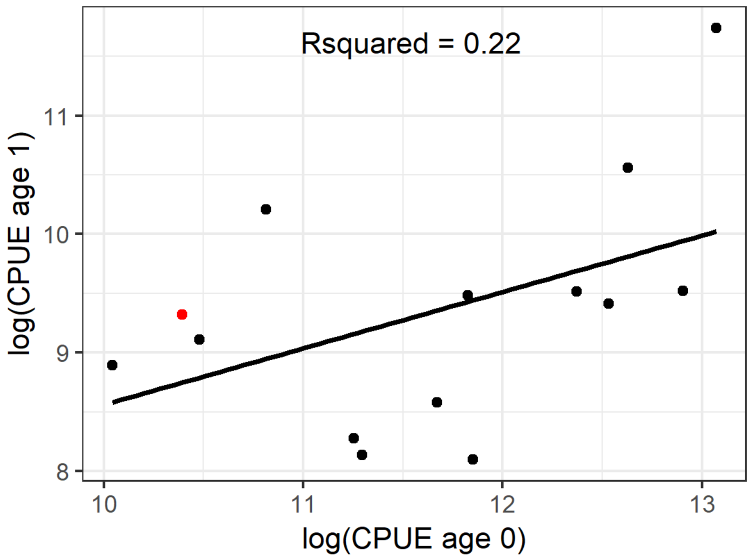


Figure 11.2.4 Sandeel Area-1r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

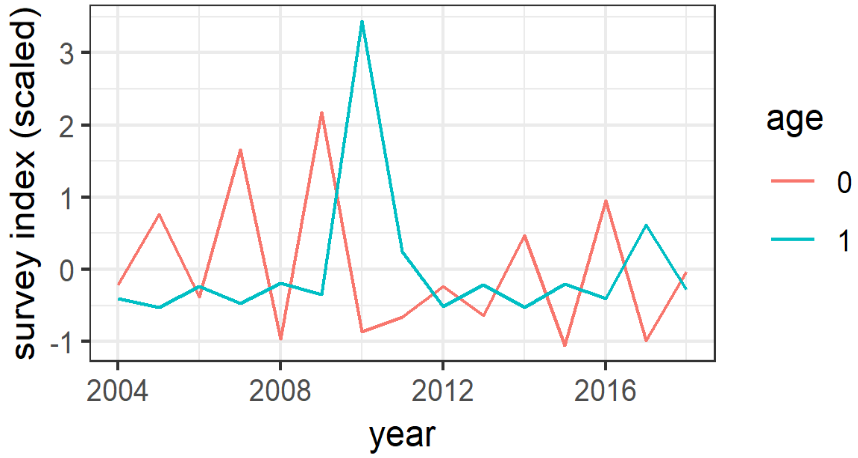


Figure 11.2.5 Sandeel Area-1r. Dredge survey index timeline.

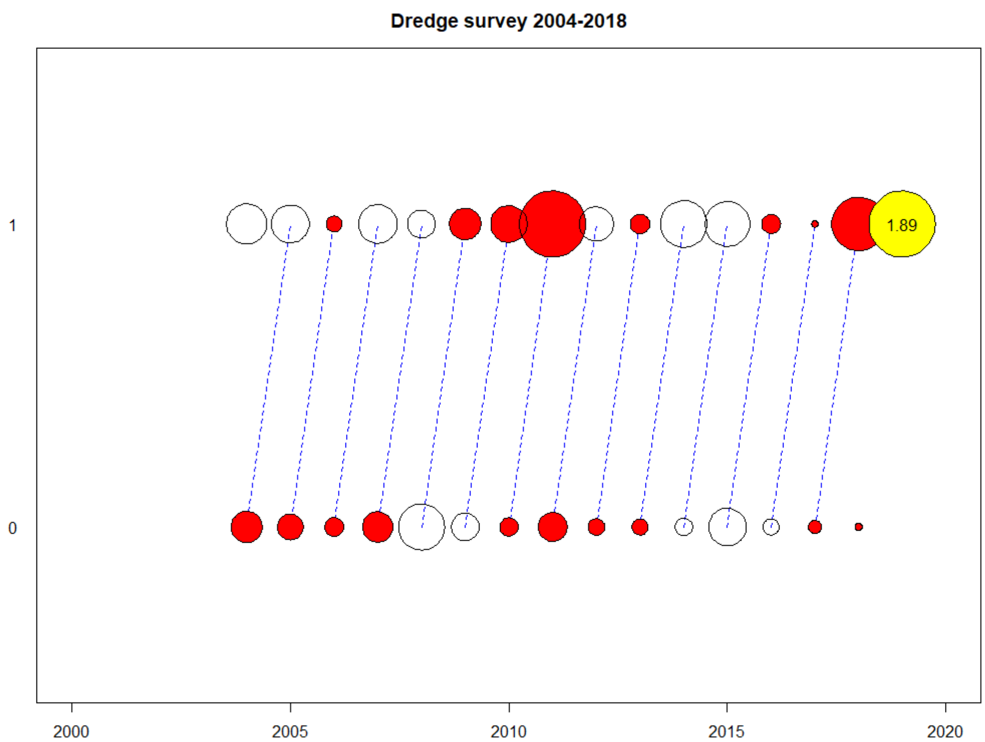


Figure 11.2.6 Sandeel Area-1r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

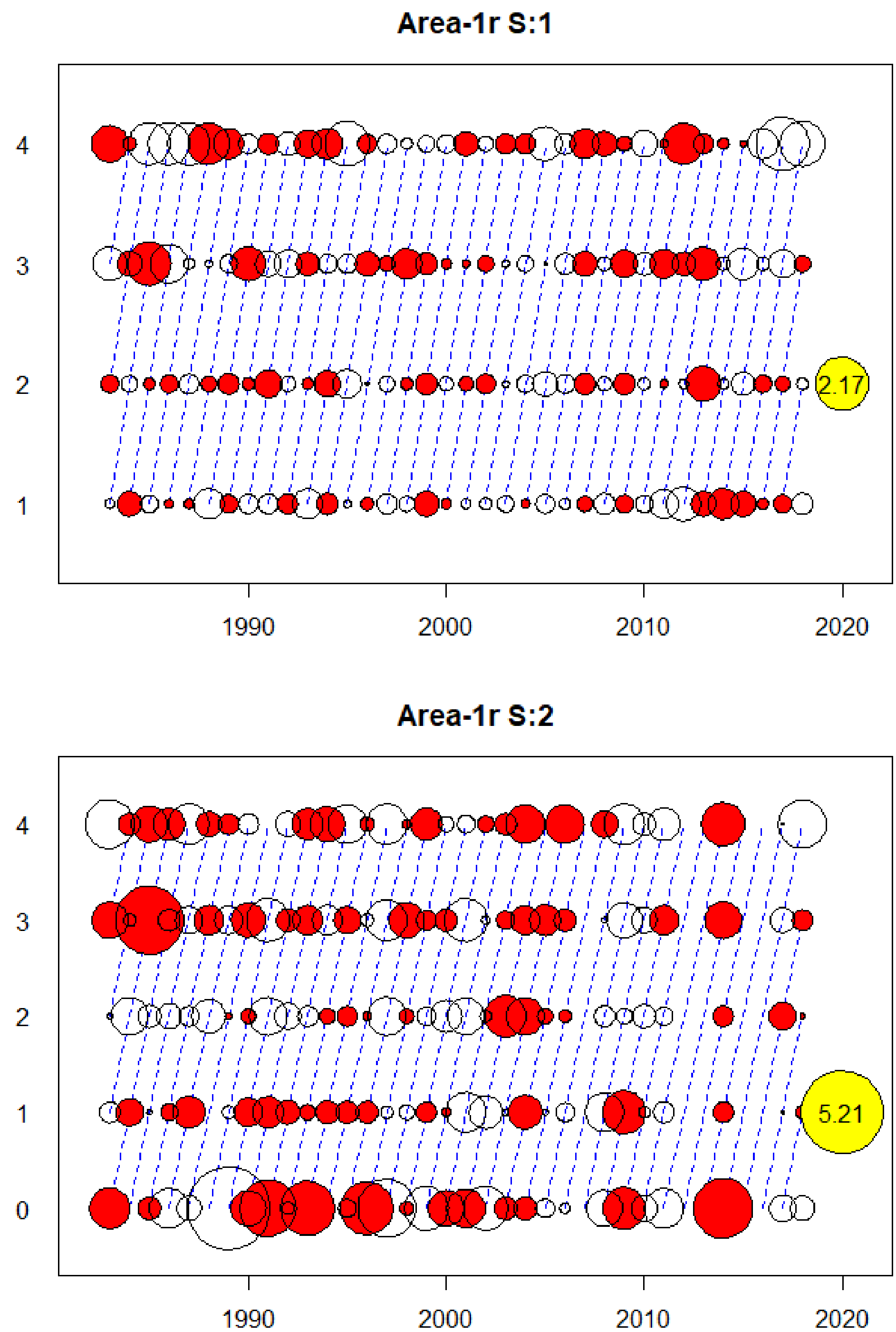


Figure 11.2.7 Sandeel Area-1r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

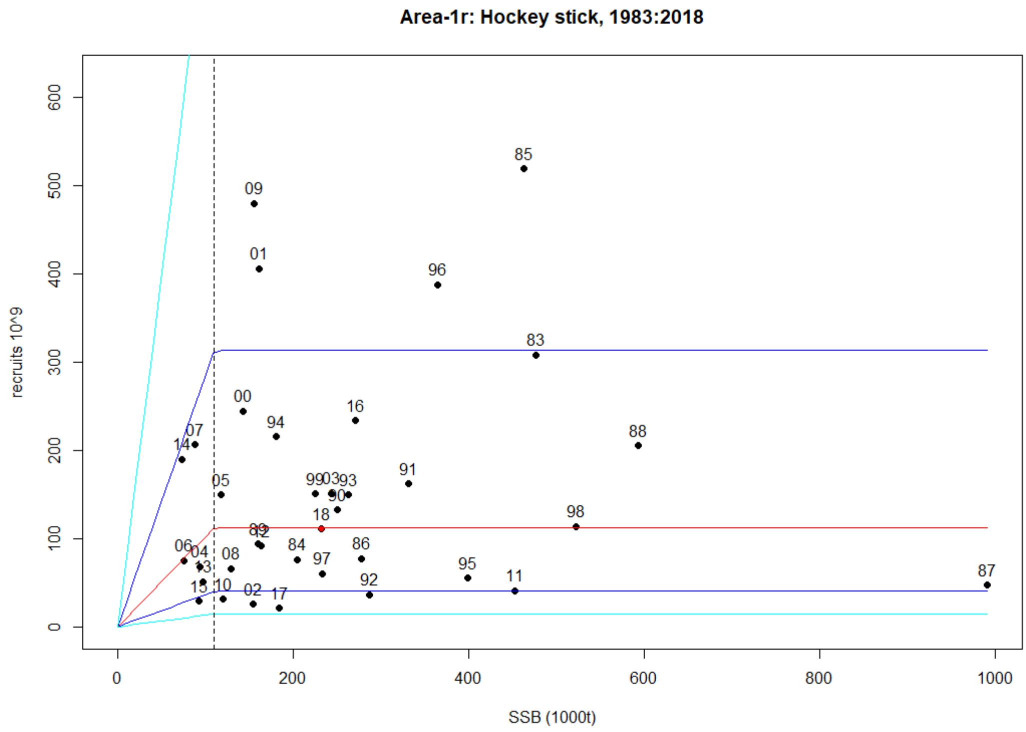


Figure 11.2.8 Sandeel Area-1r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

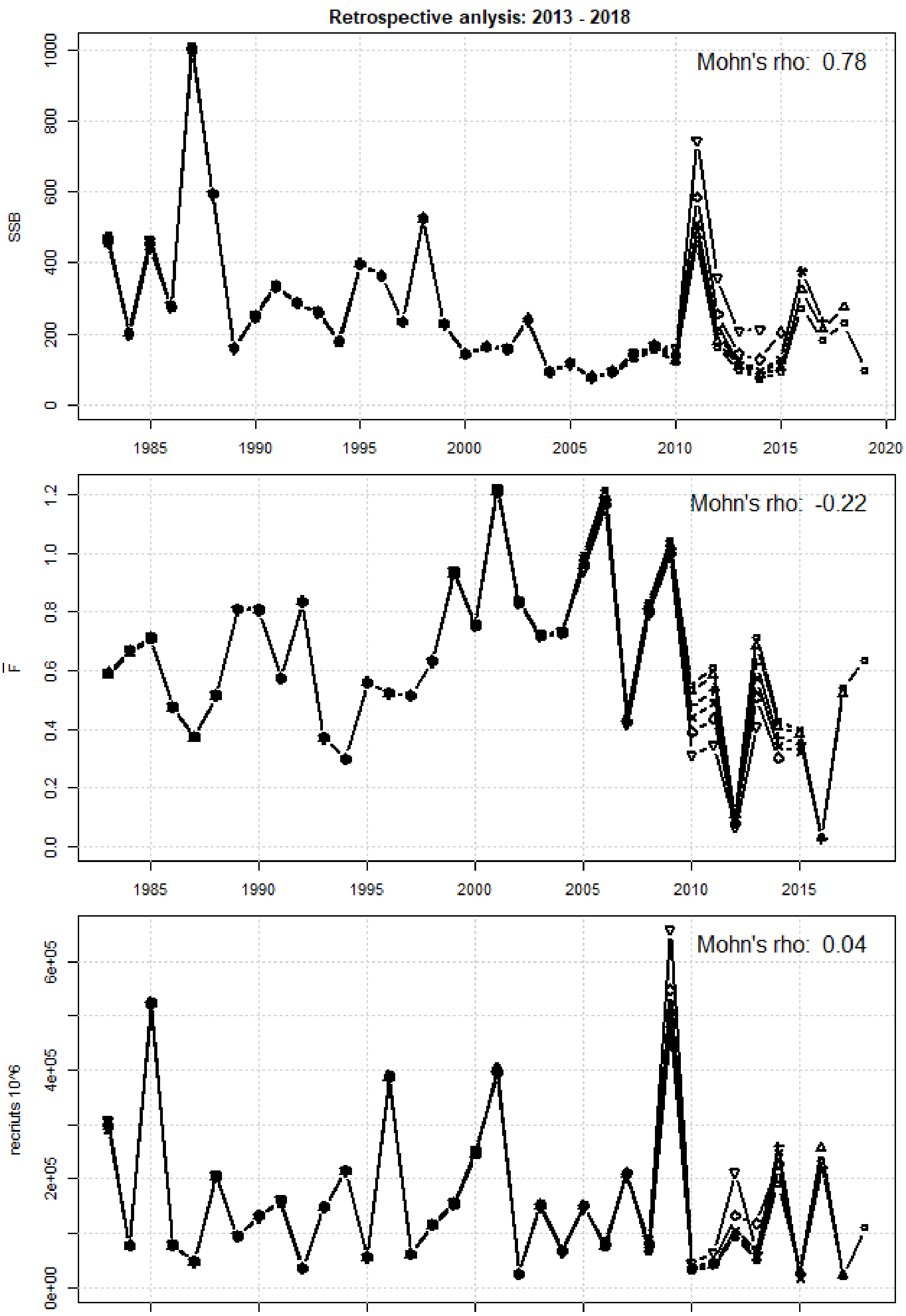


Figure 11.2.9 Sandeel Area-1r. Retrospective analysis.

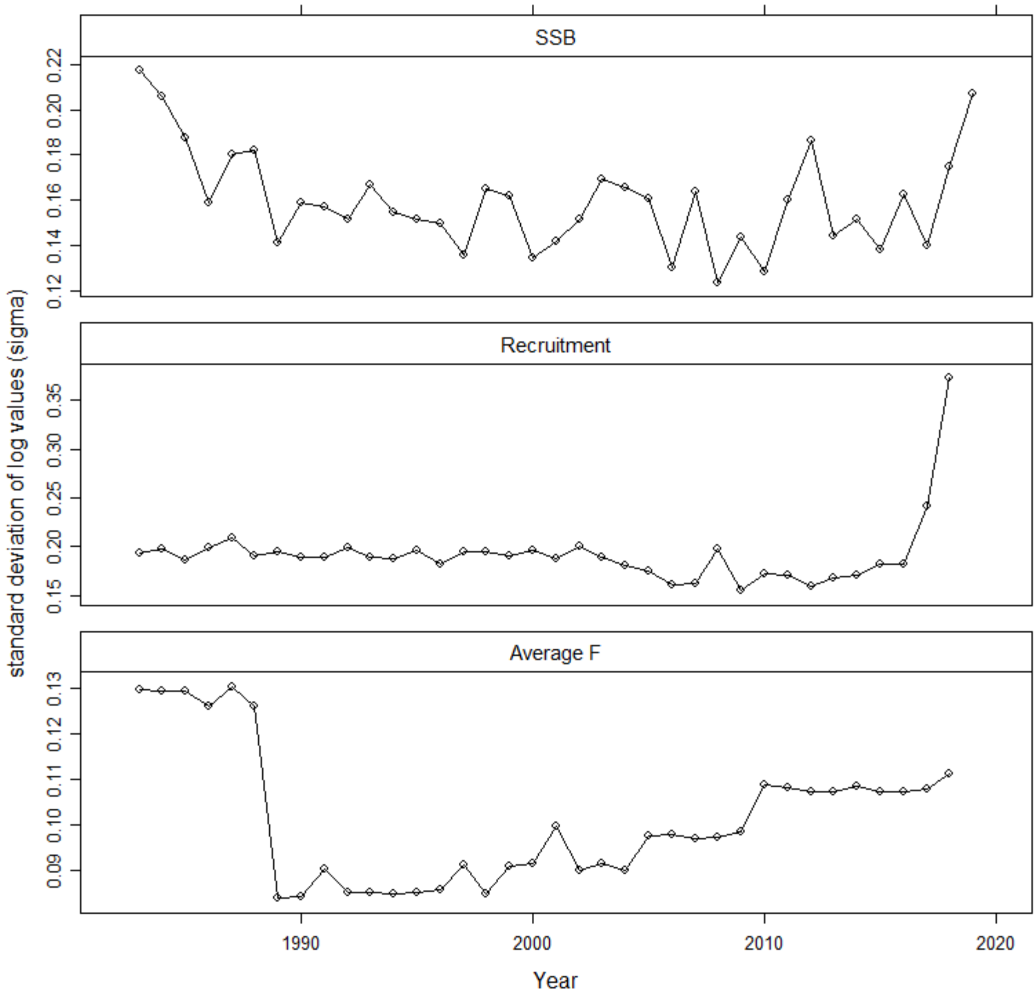


Figure 11.2.10 Sandeel Area-1r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

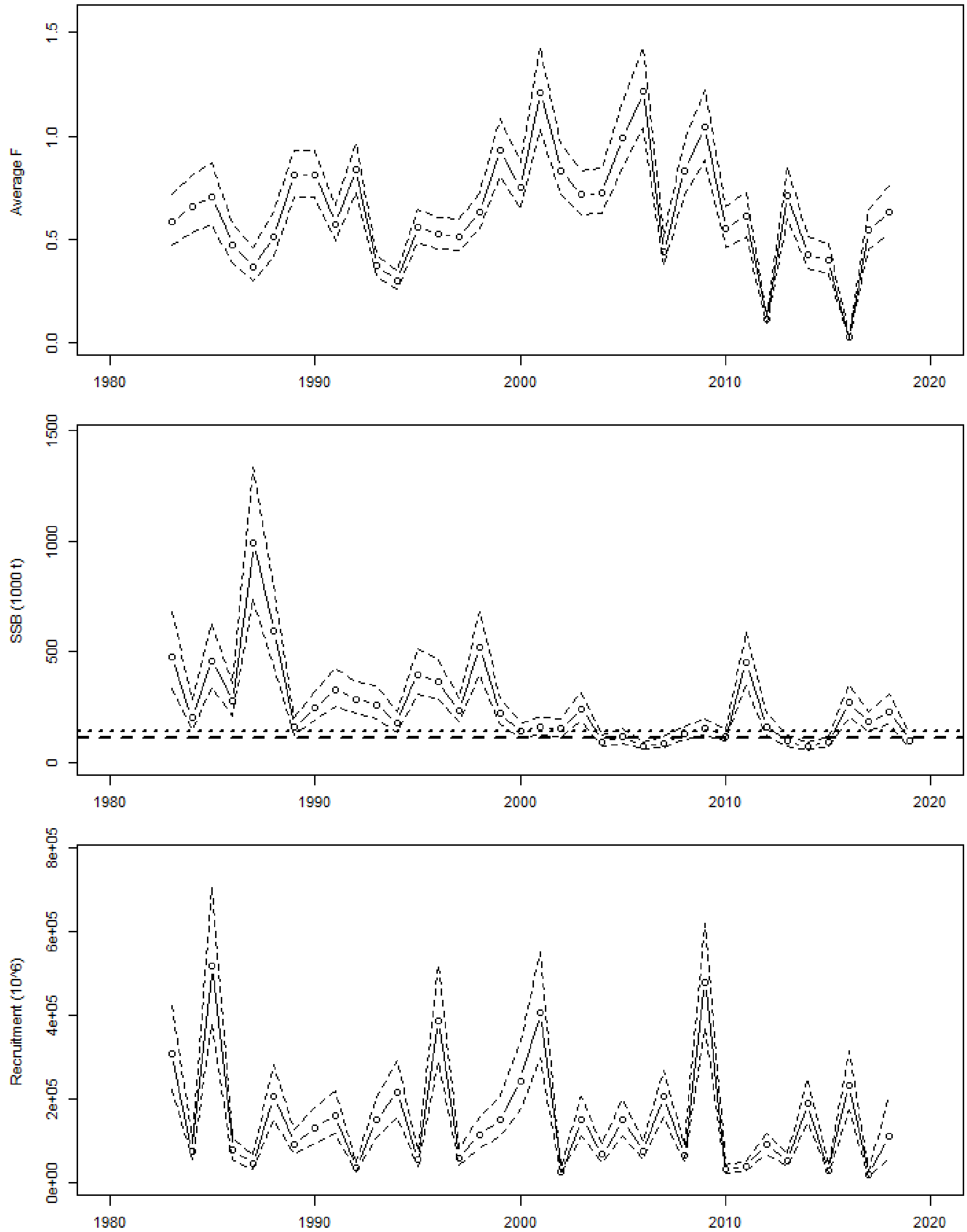


Figure 11.2.11 Sandeel Area-1r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

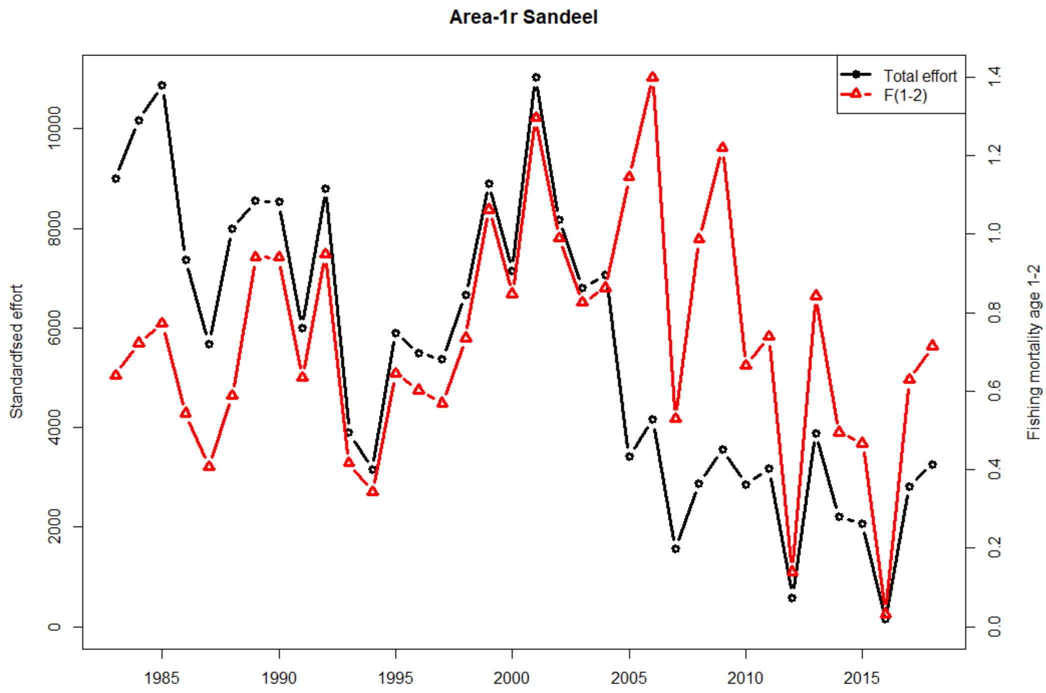


Figure 11.2.12 Sandeel Area-1r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

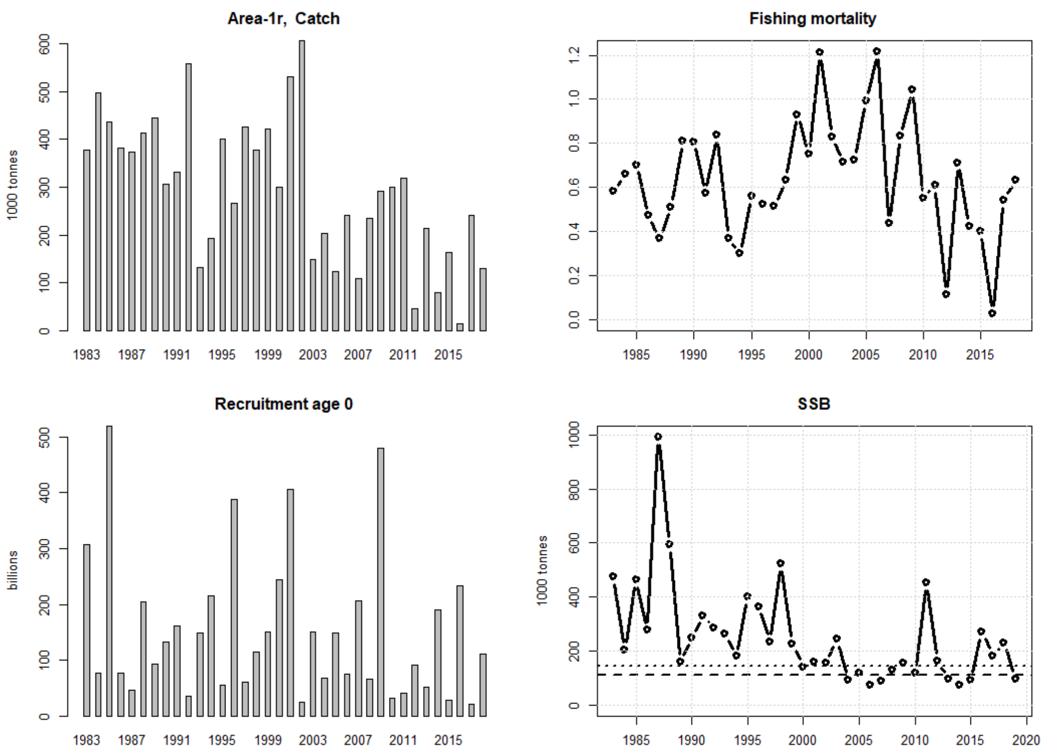


Figure 11.2.13 Sandeel Area-1r. Stock summary.

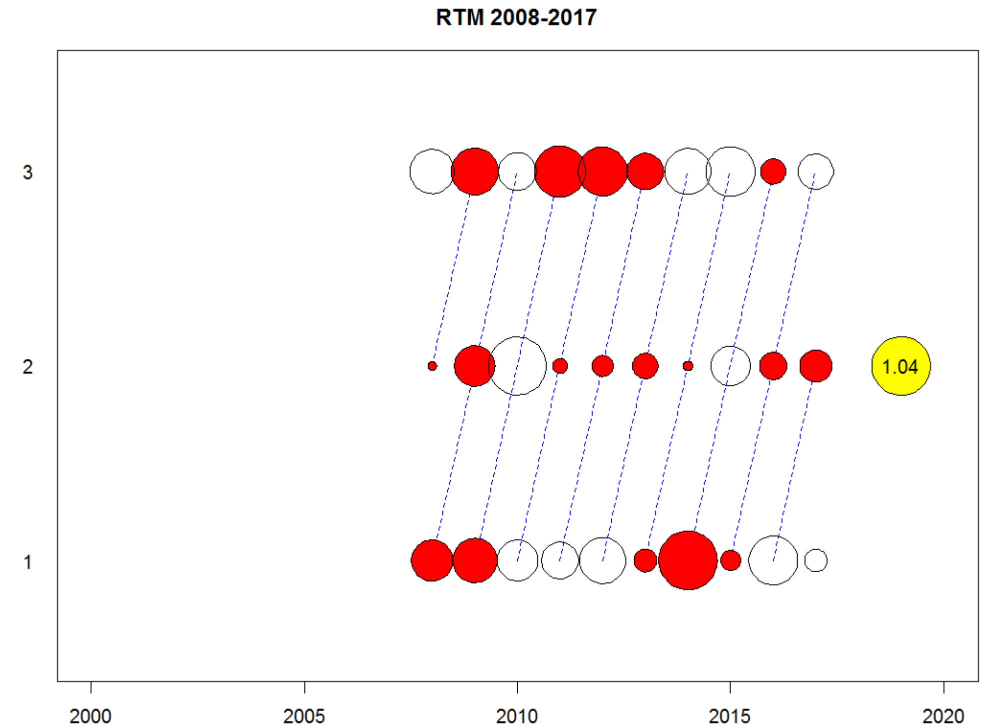


Figure 11.2.14 Sandeel Area-1r. RTM survey. Survey CPUE at age residuals (log(observed CPUE)-log(expected CPUE). "Red" dots show a positive residual.

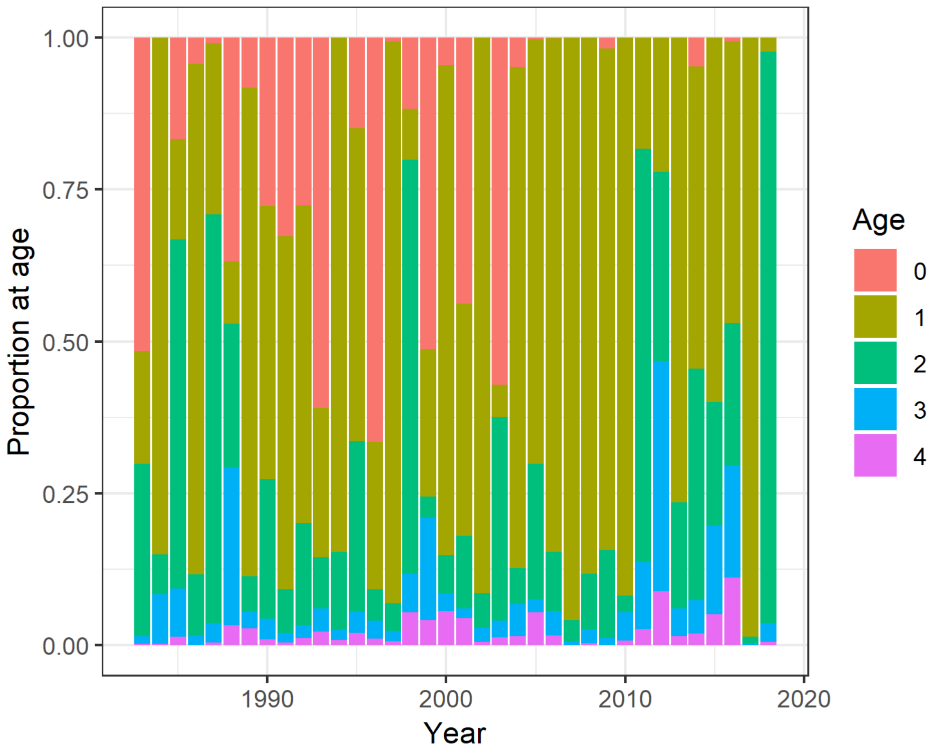


Figure 11.3.1 Sandeel Area-2r. Catch numbers, proportion at age.

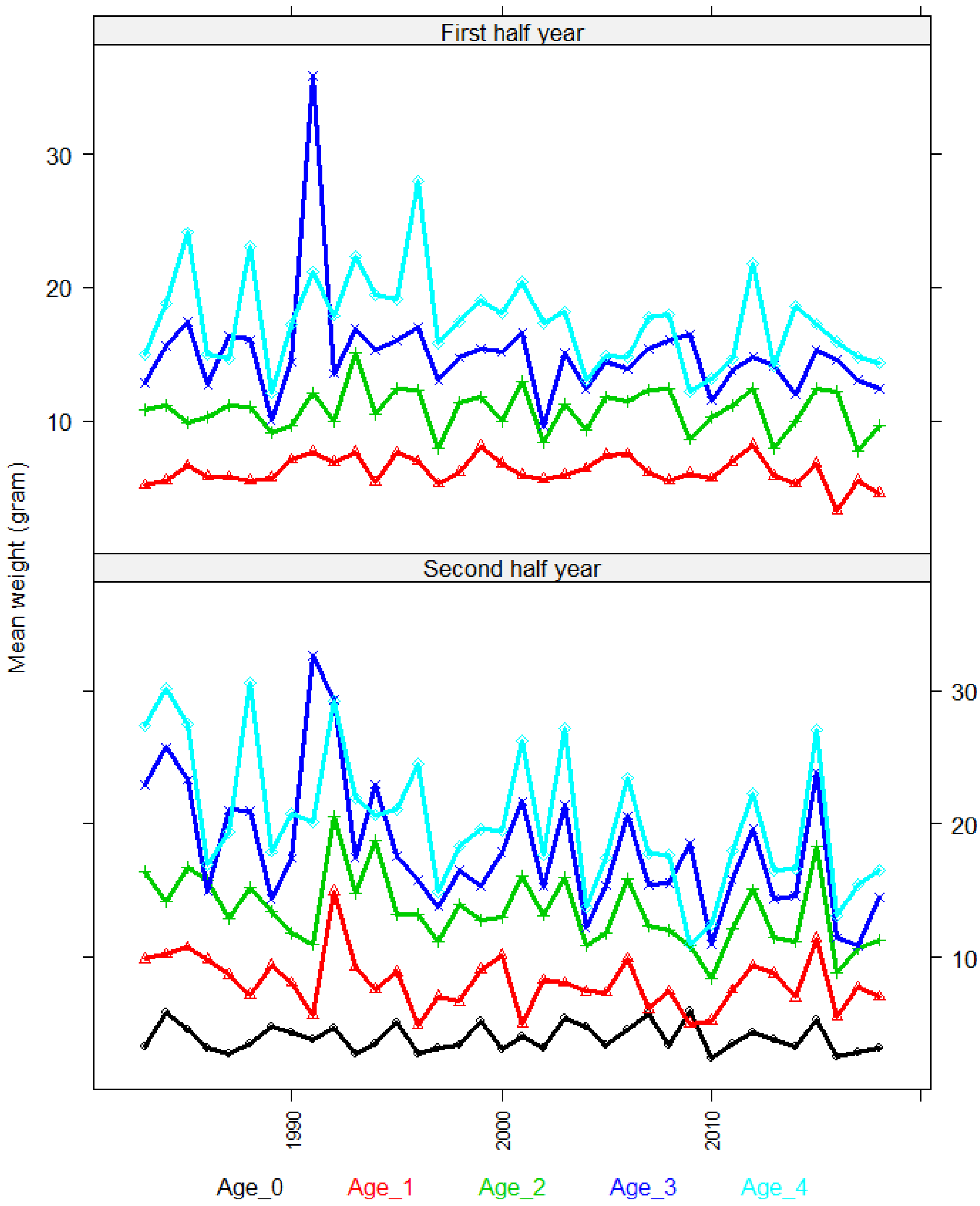


Figure 11.3.2 Sandeel Area-2r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

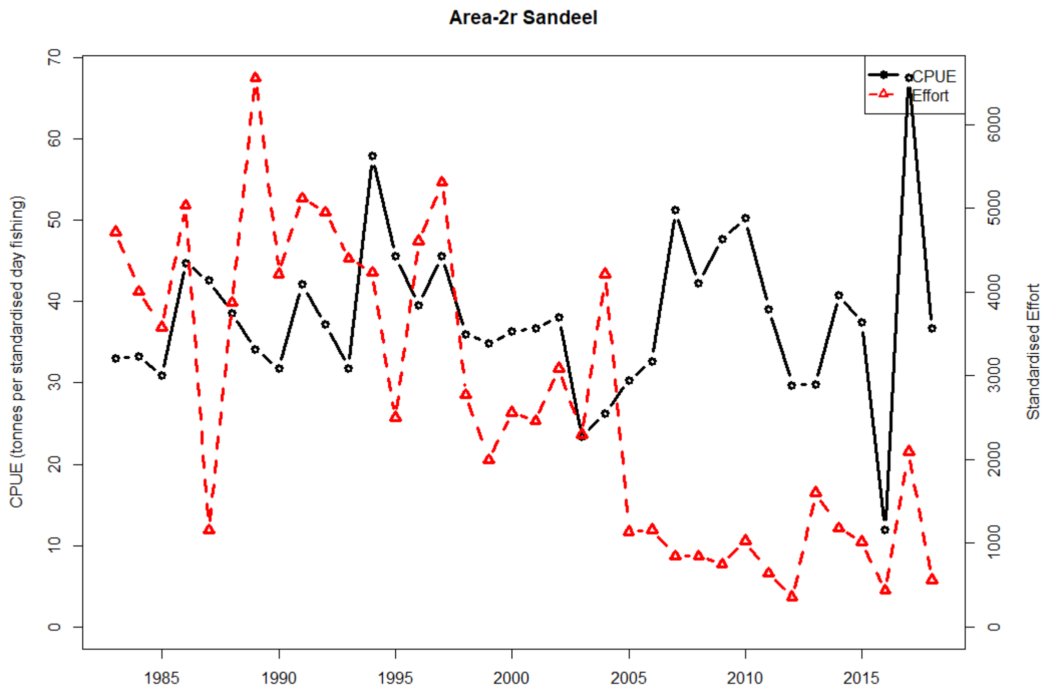


Figure 11.3.3 Sandeel Area-2r. CPUE and effort.

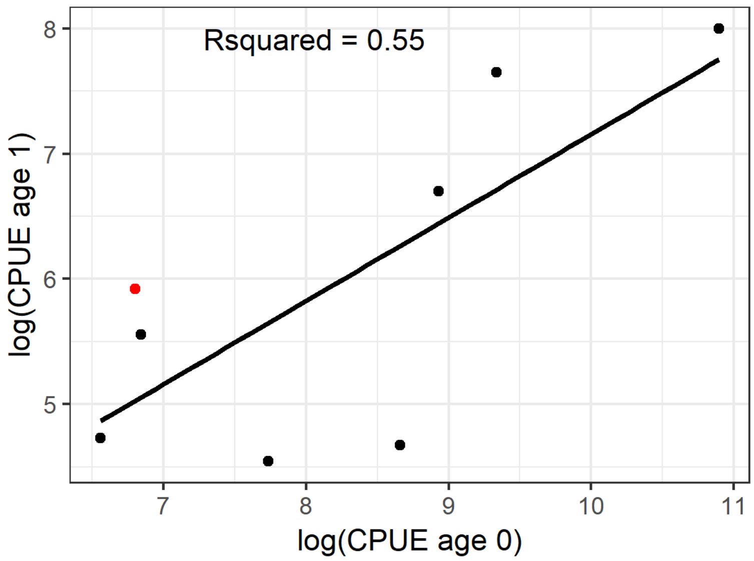


Figure 11.3.4 Sandeel Area-2r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

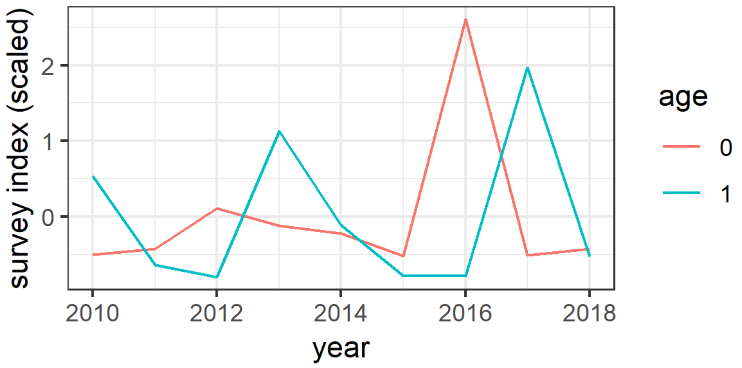


Figure 11.3.5 Sandeel Area-2r. Dredge survey index timeline.

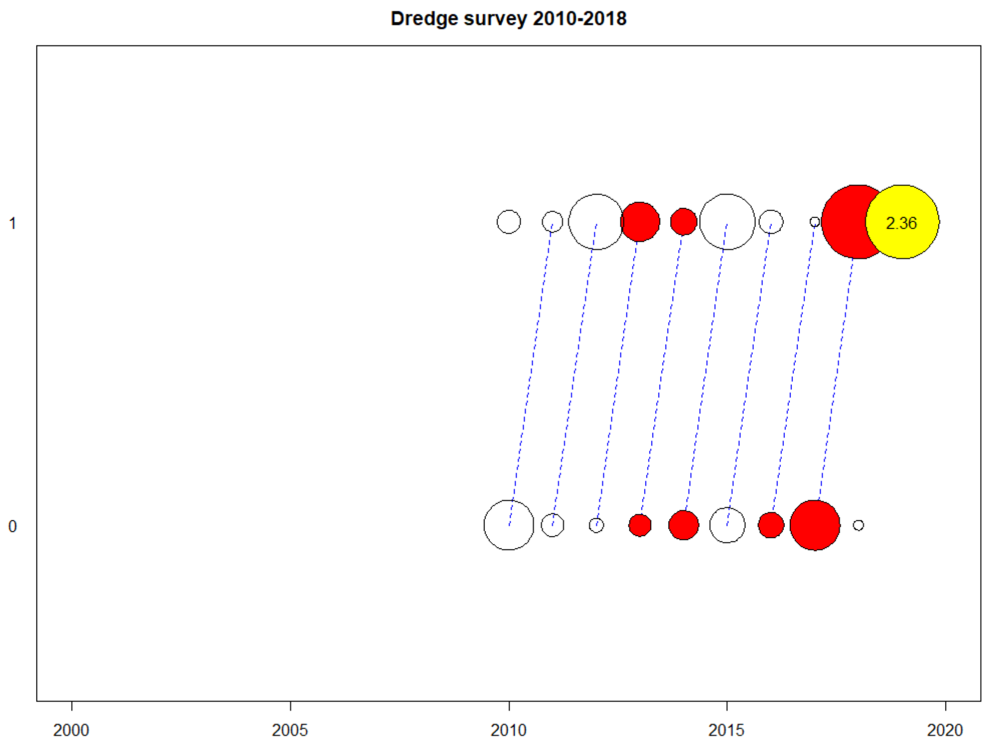
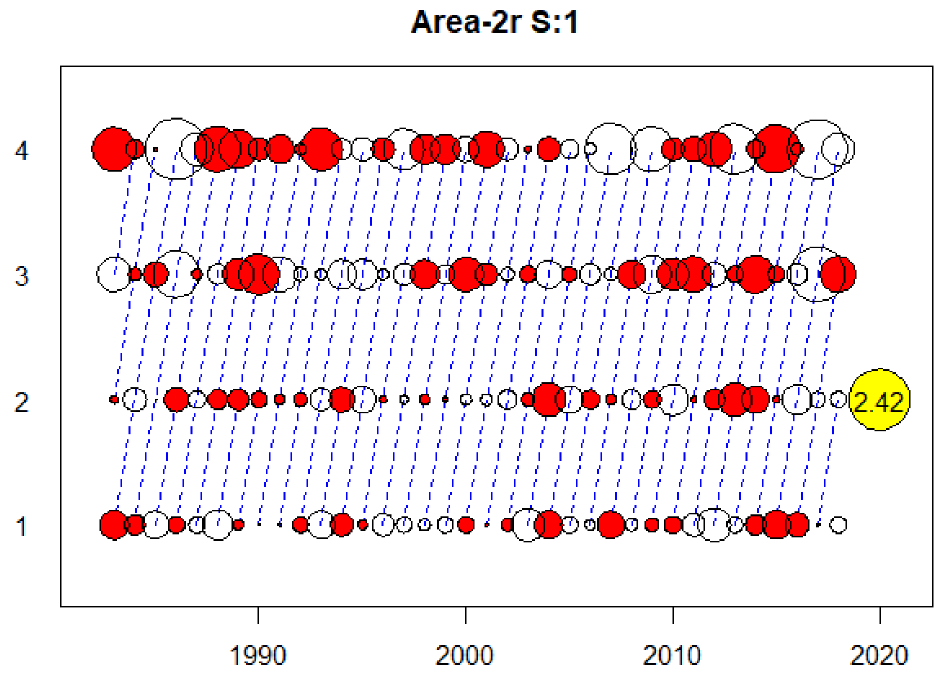


Figure 11.3.6 Sandeel Area-2r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.



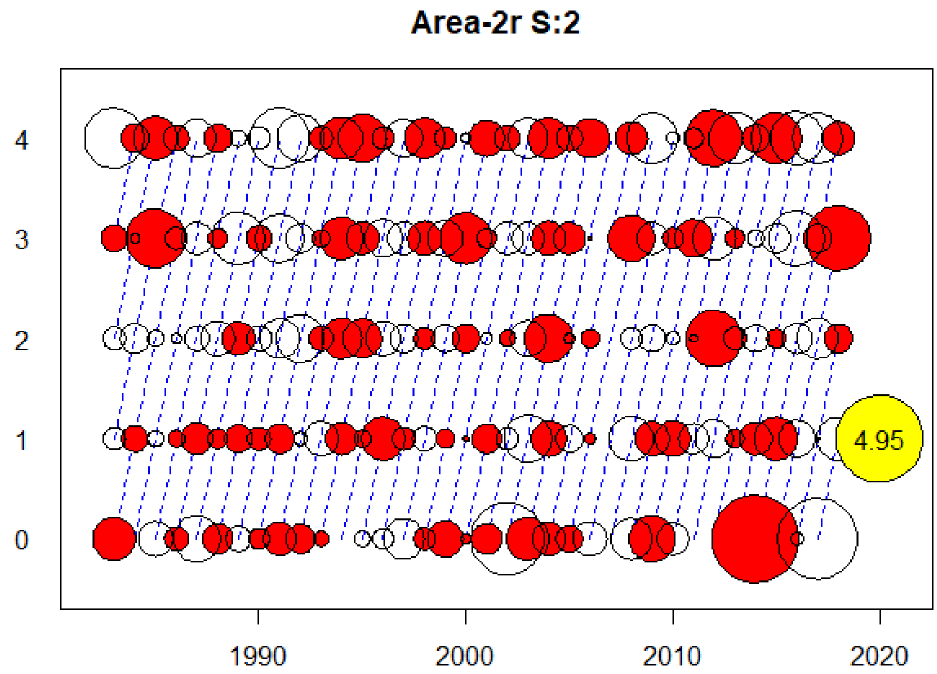


Figure 11.3.7 Sandeel Area-2r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

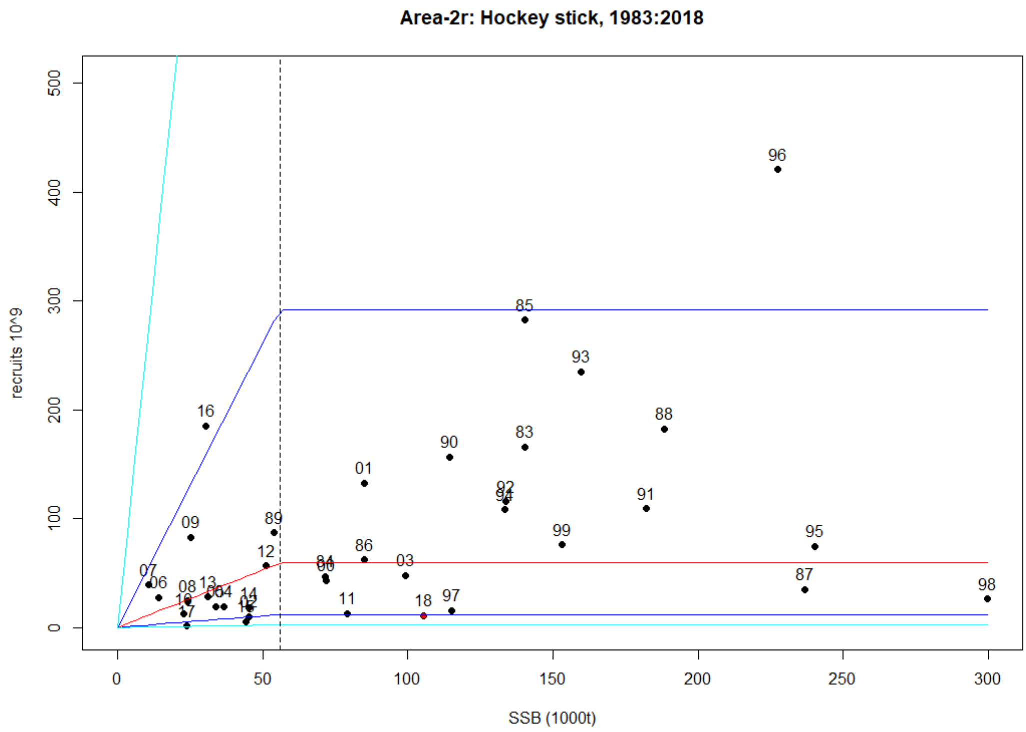


Figure 11.3.8 Sandeel Area-2r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

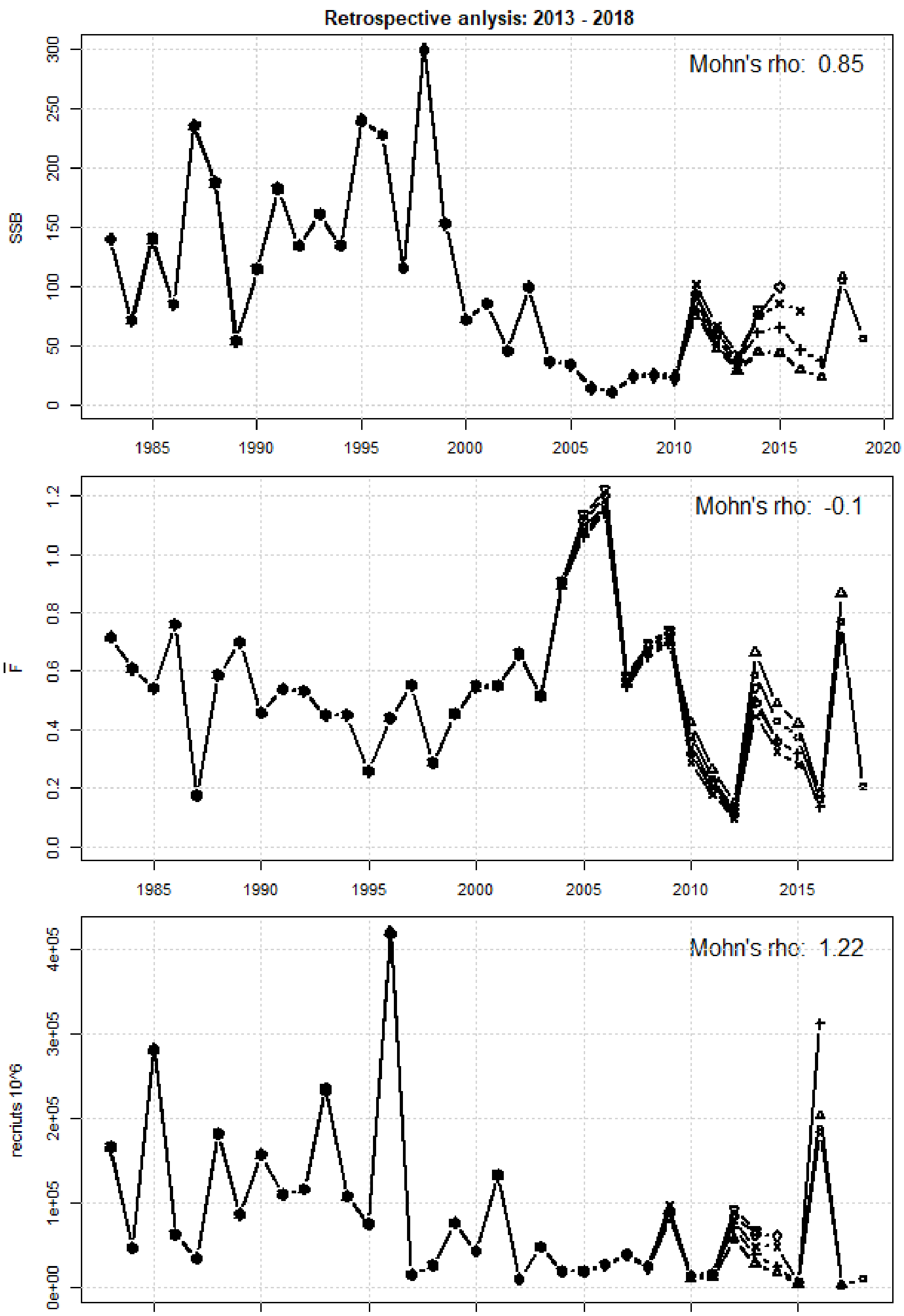


Figure 11.3.9 Sandeel Area-2r. Retrospective analysis.

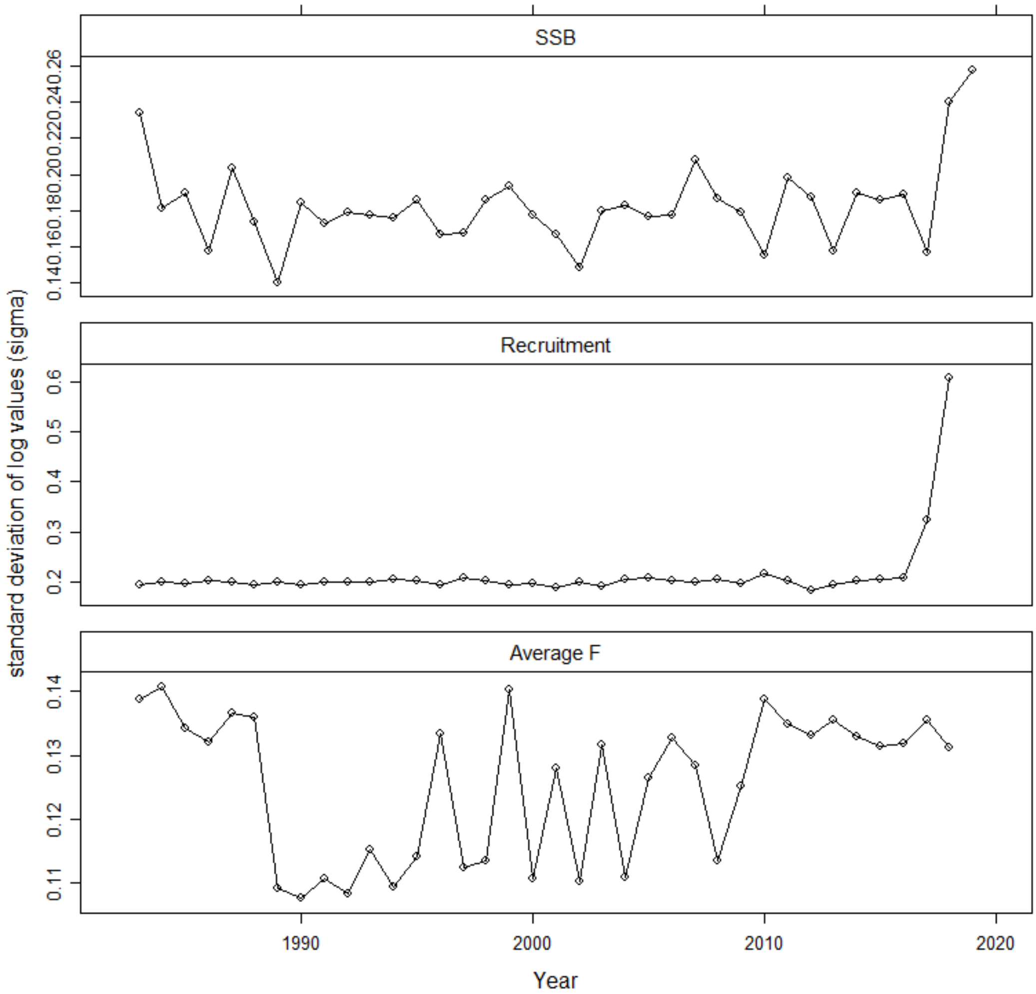


Figure 11.3.10 Sandeel Area-2r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

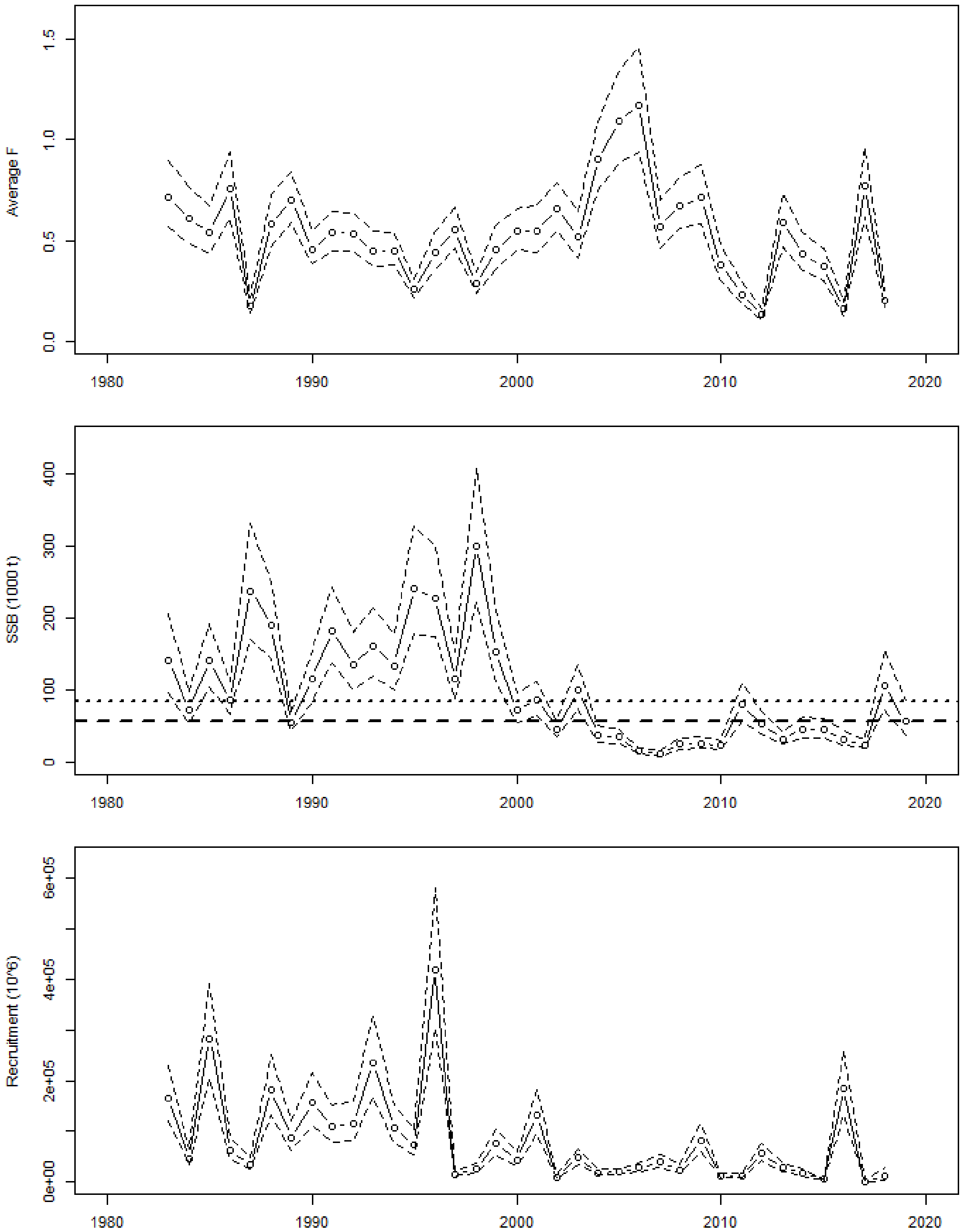


Figure 11.3.11 Sandeel Area-2r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

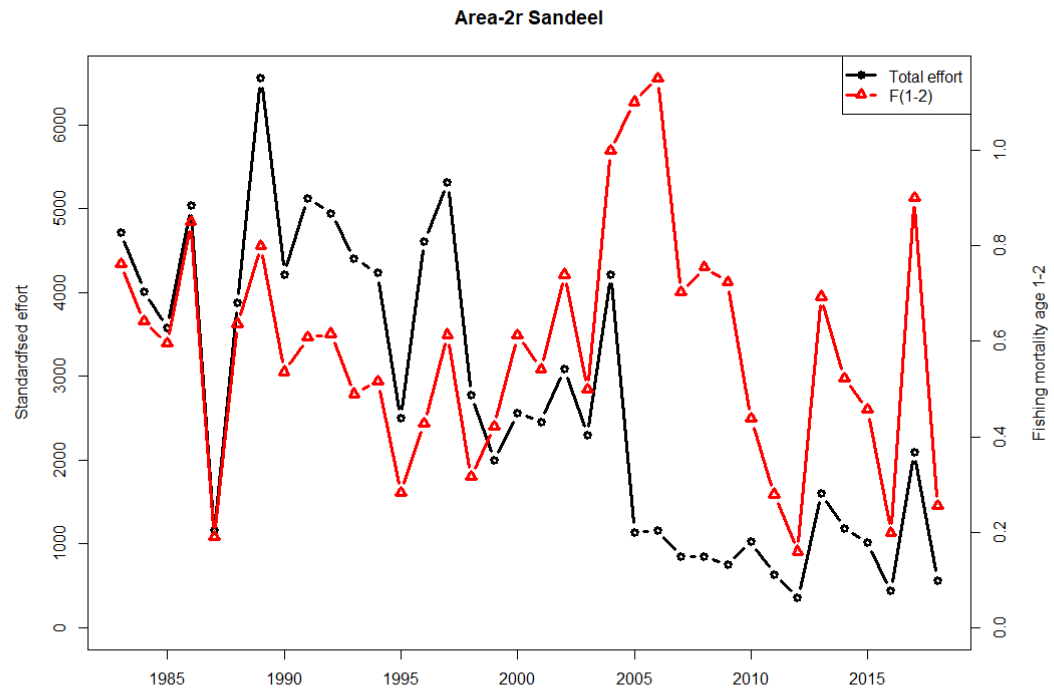


Figure 11.3.12 Sandeel Area-2r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

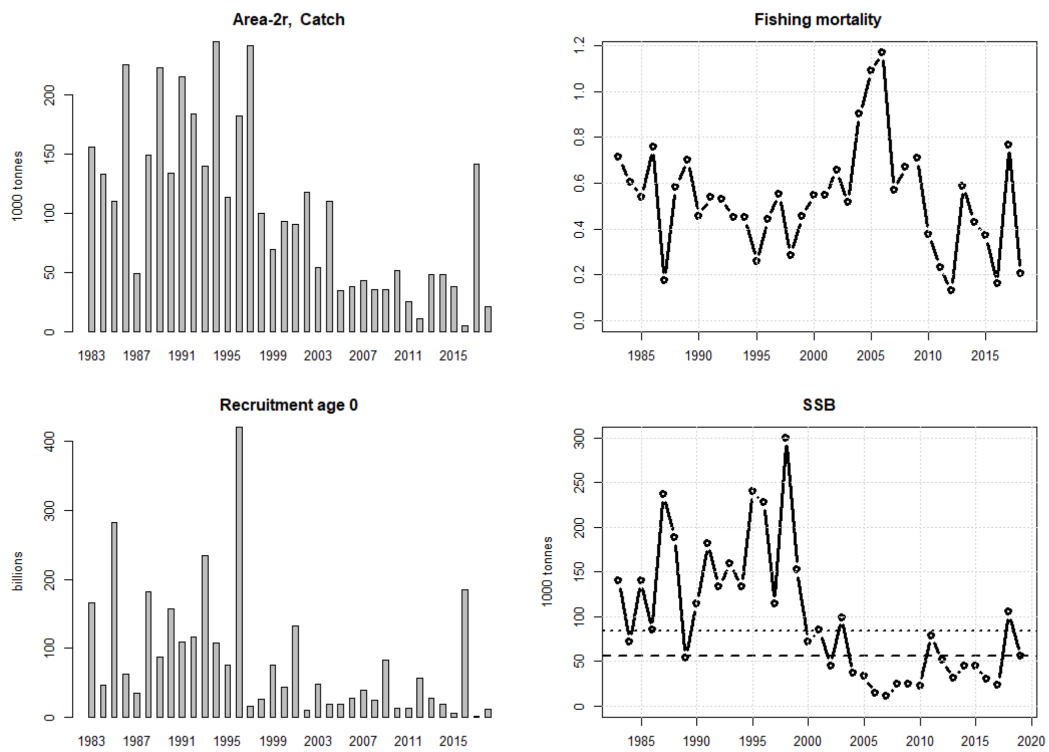


Figure 11.3.13 Sandeel Area-2r. Stock summary.

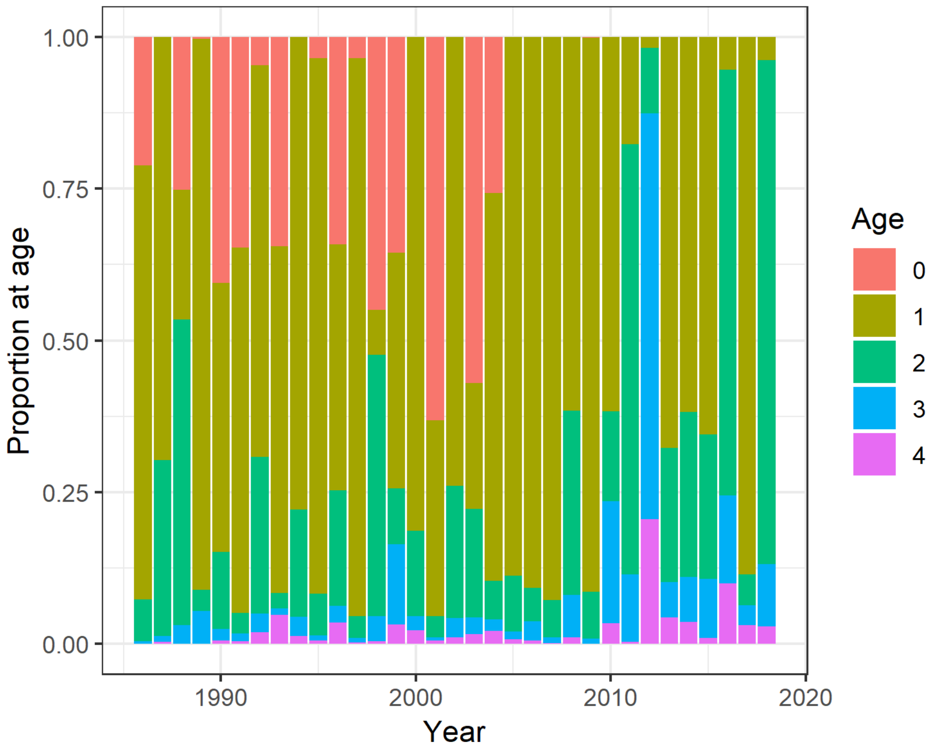


Figure 11.4.1 Sandeel Area-3r. Catch numbers, proportion at age.

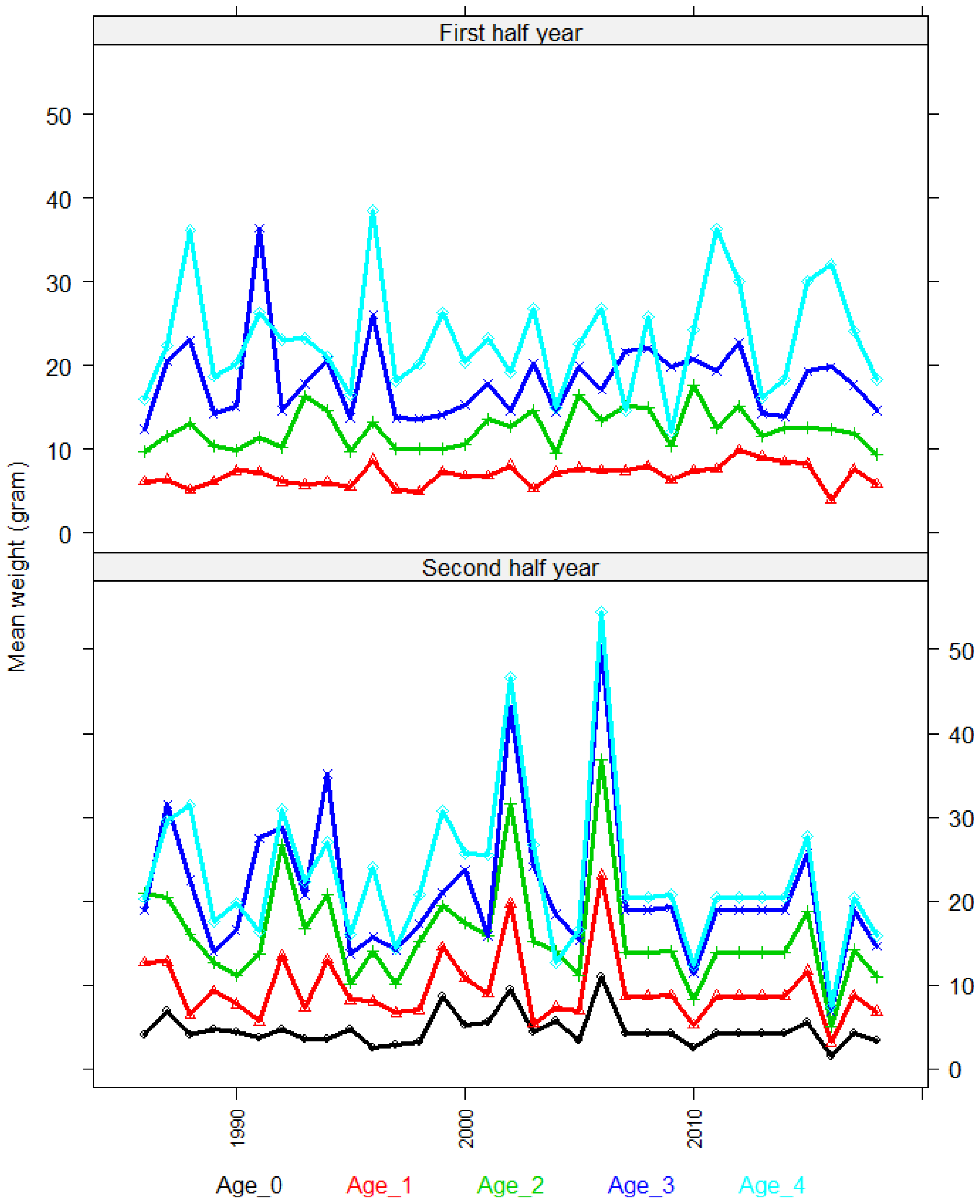


Figure 11.4.2 Sandeel Area-3r. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

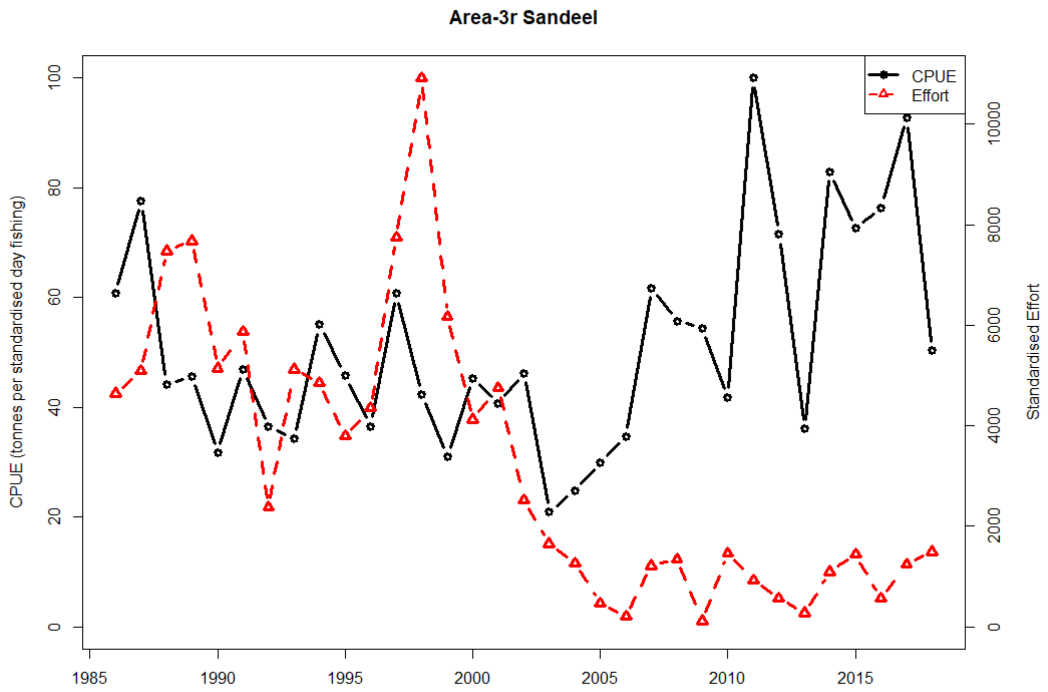


Figure 11.4.3 Sandeel Area-3r. CPUE and effort.

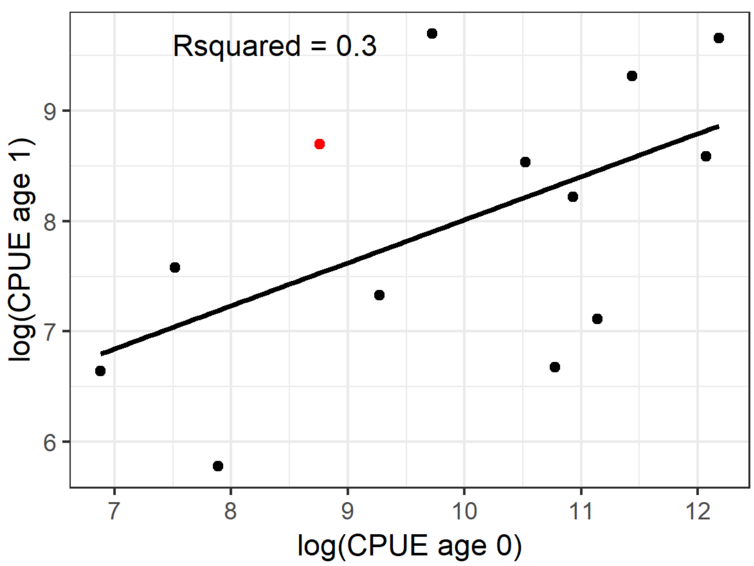


Figure 11.4.4 Sandeel Area-3r. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

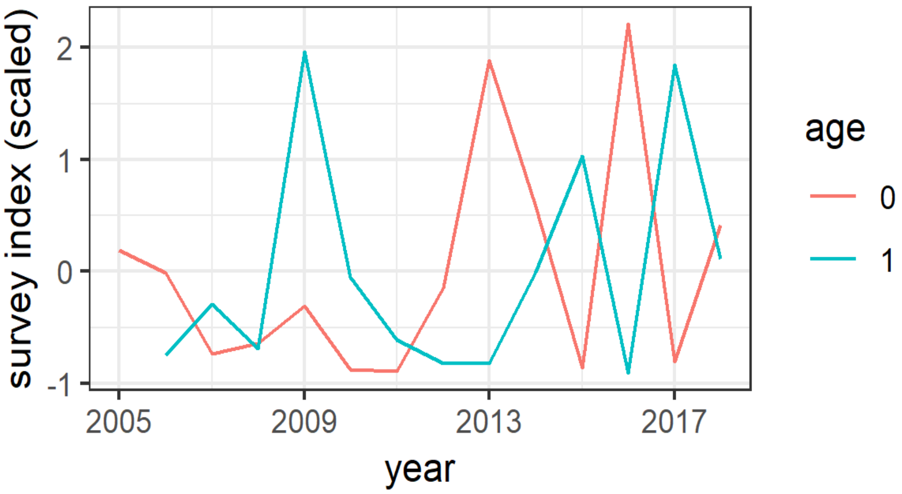


Figure 11.4.5 Sandeel Area-3r. Dredge survey index timeline.

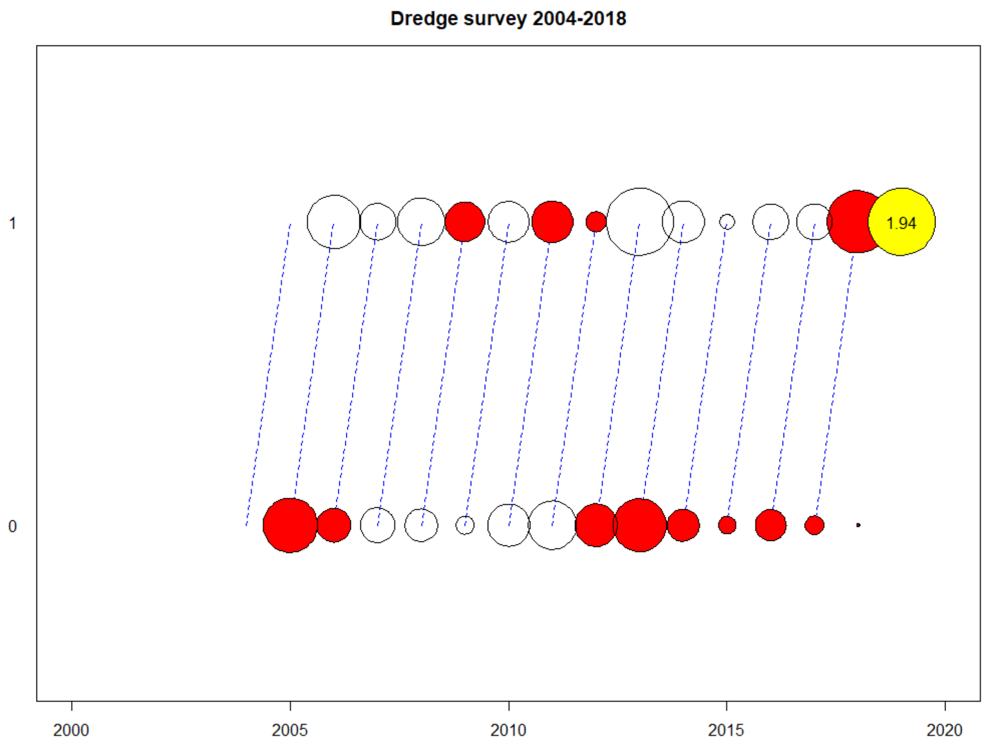


Figure 11.4.6 Sandeel Area-3r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

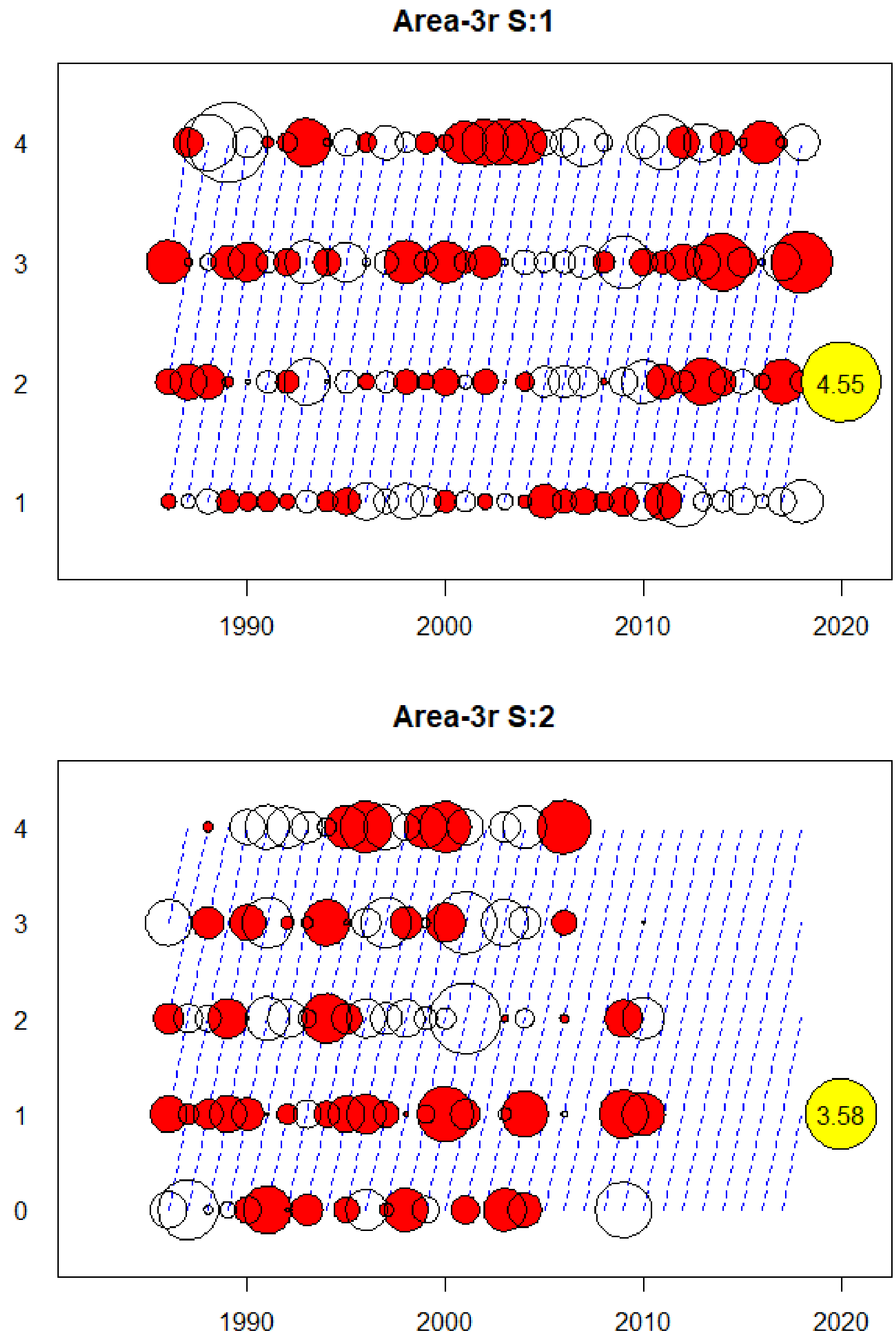


Figure 11.4.7 Sandeel Area-3r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

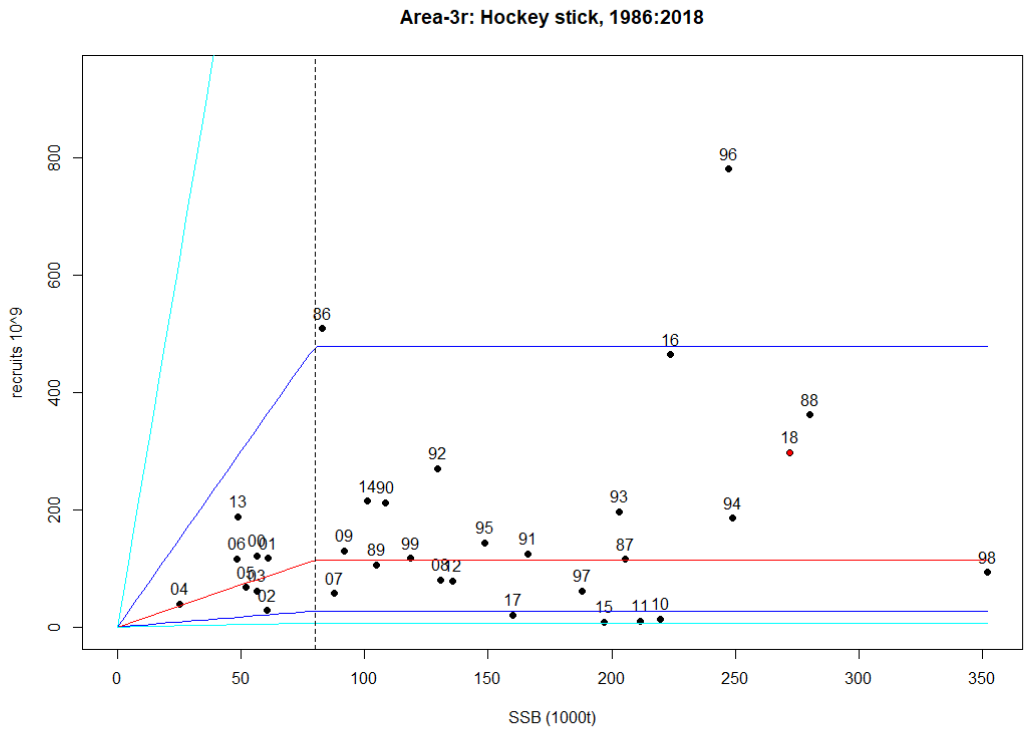


Figure 11.4.8 Sandeel Area-3r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

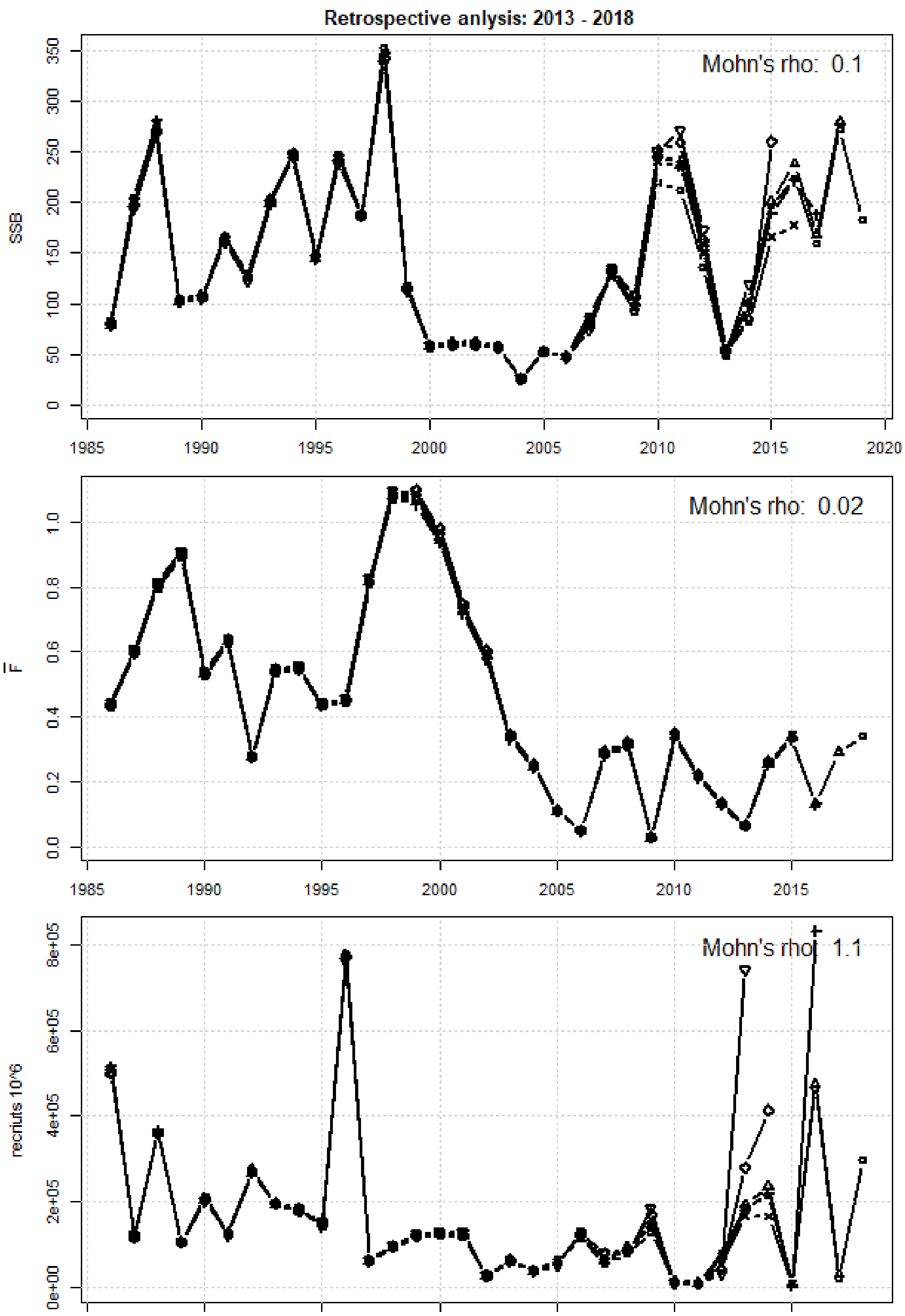


Figure 11.4.9 Sandeel Area-3r. Retrospective analysis.

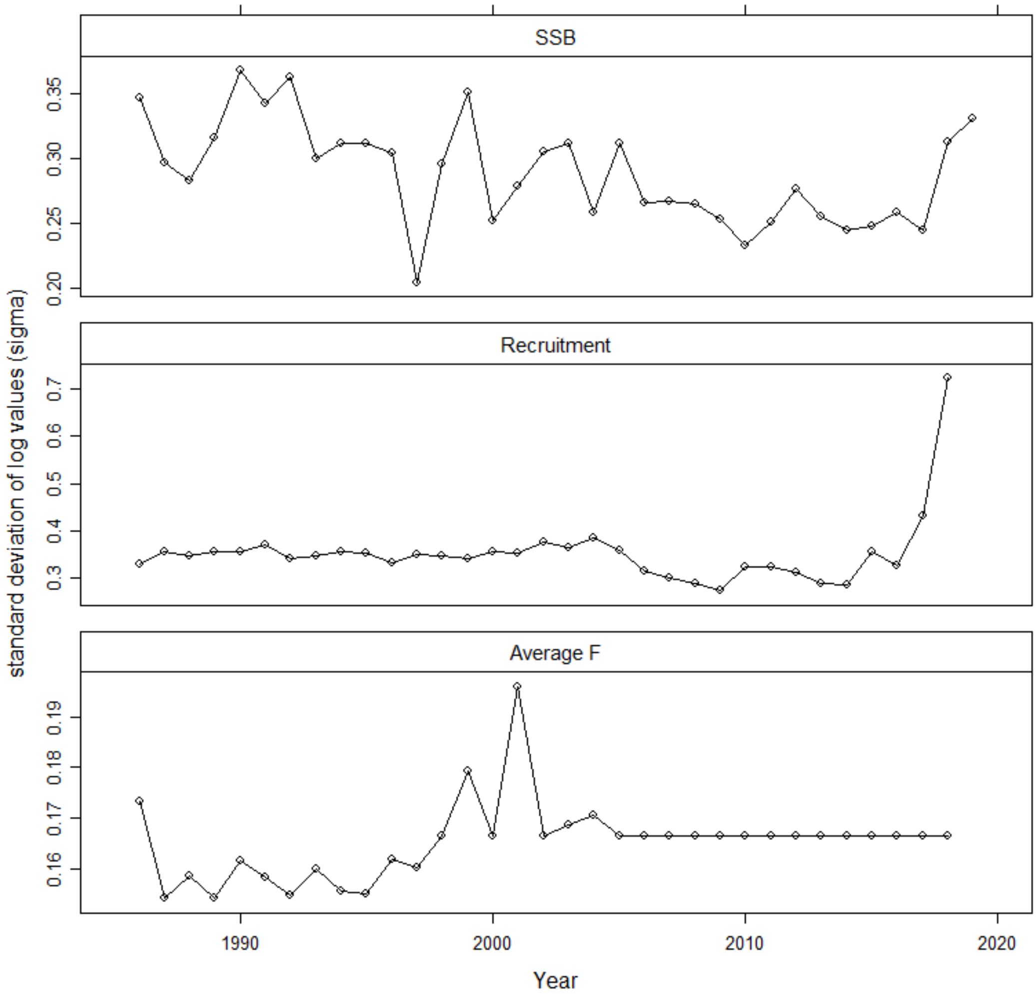


Figure 11.4.10 Sandeel Area-3r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

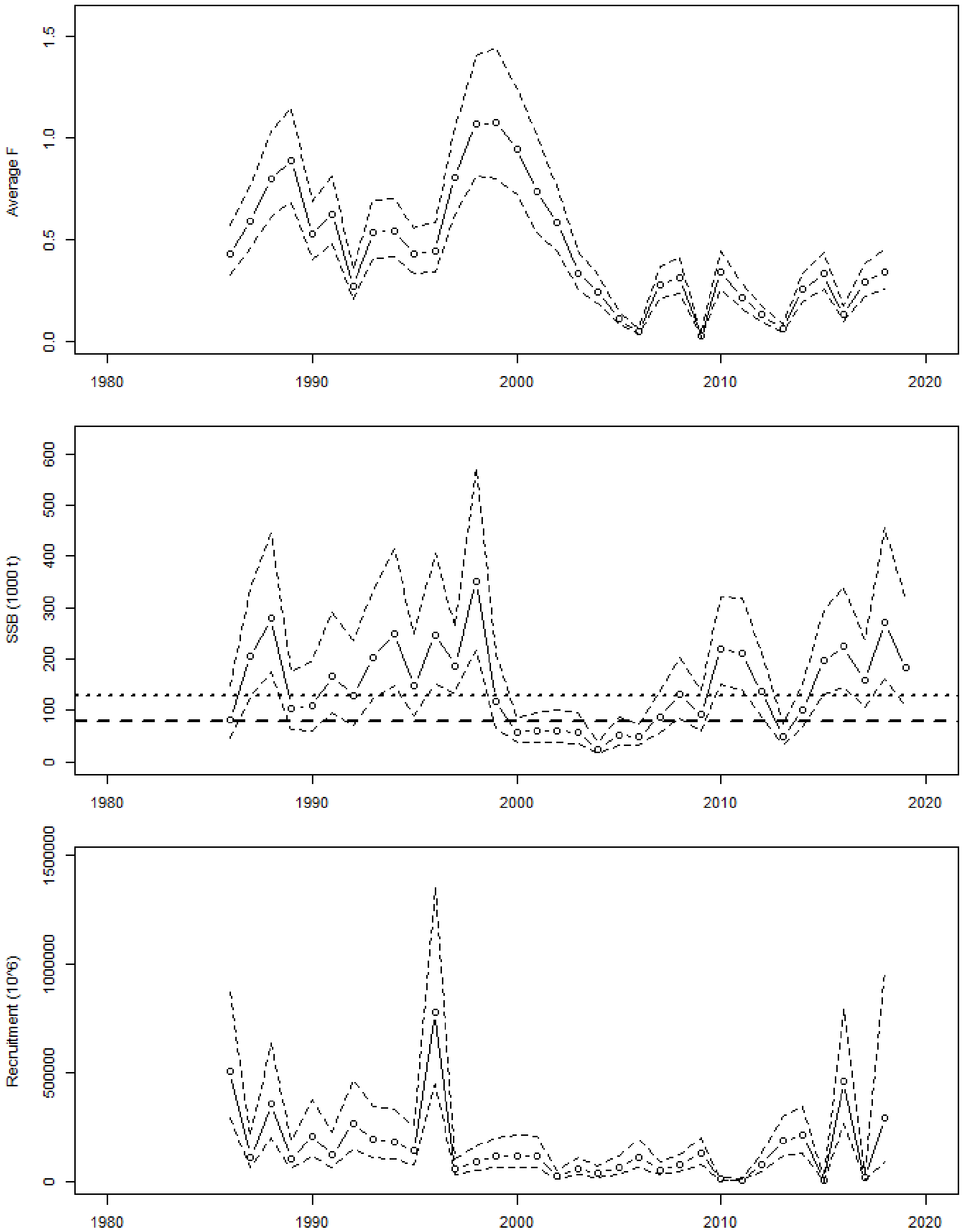


Figure 11.4.11 Sandeel Area-3r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

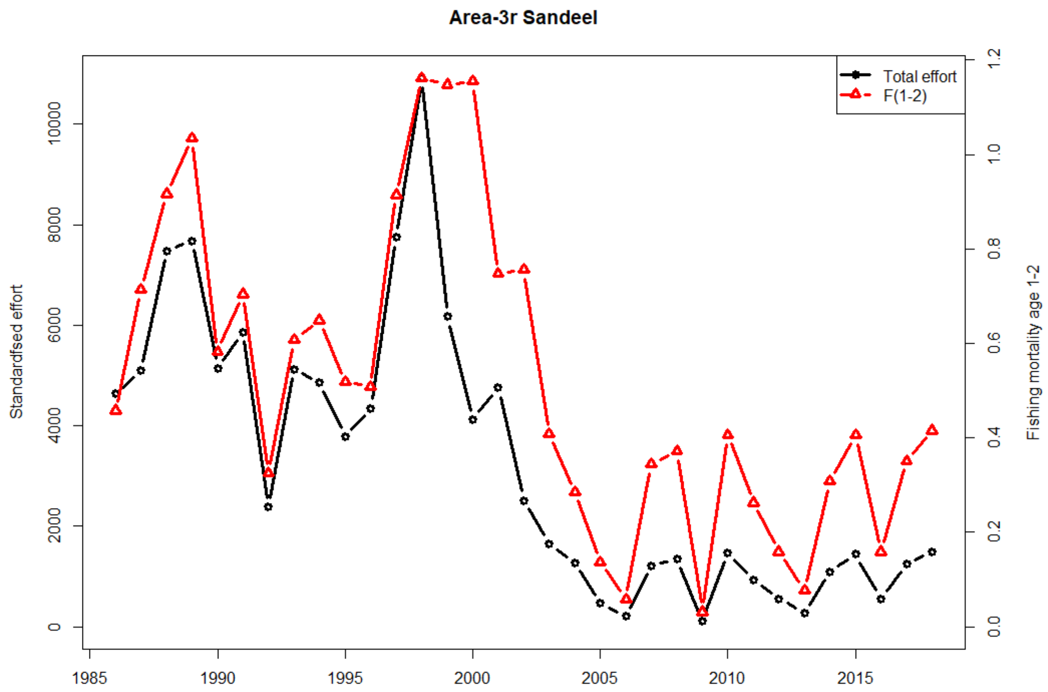


Figure 11.4.12 Sandeel Area-3r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

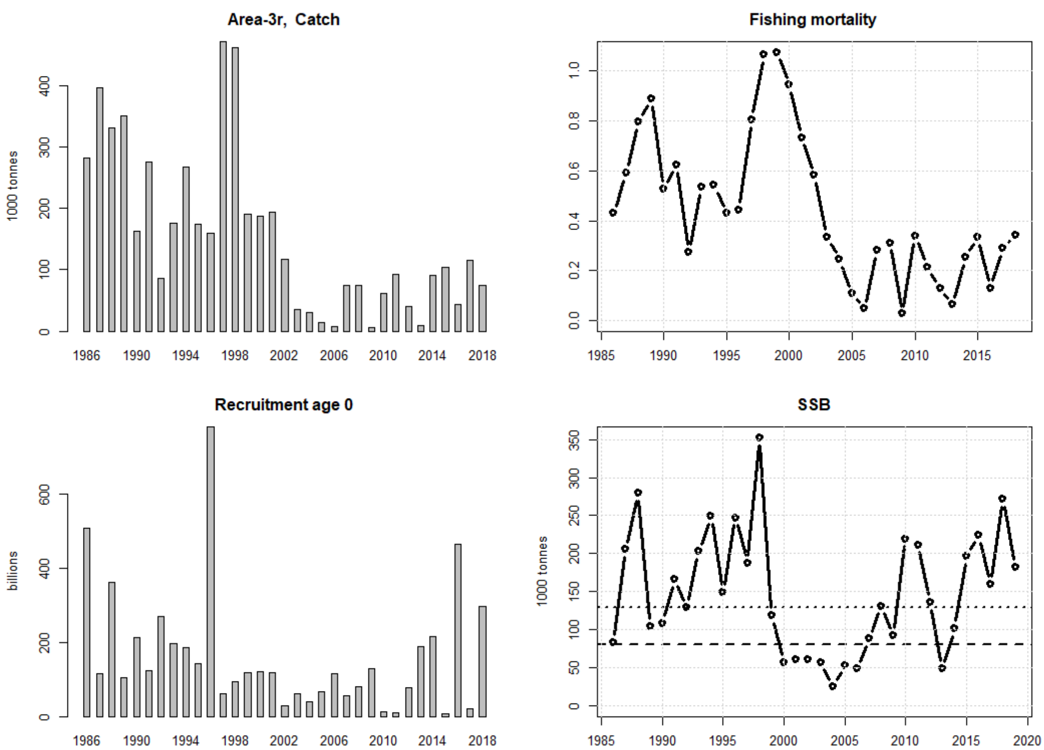


Figure 11.4.13 Sandeel Area-3r. Stock summary.

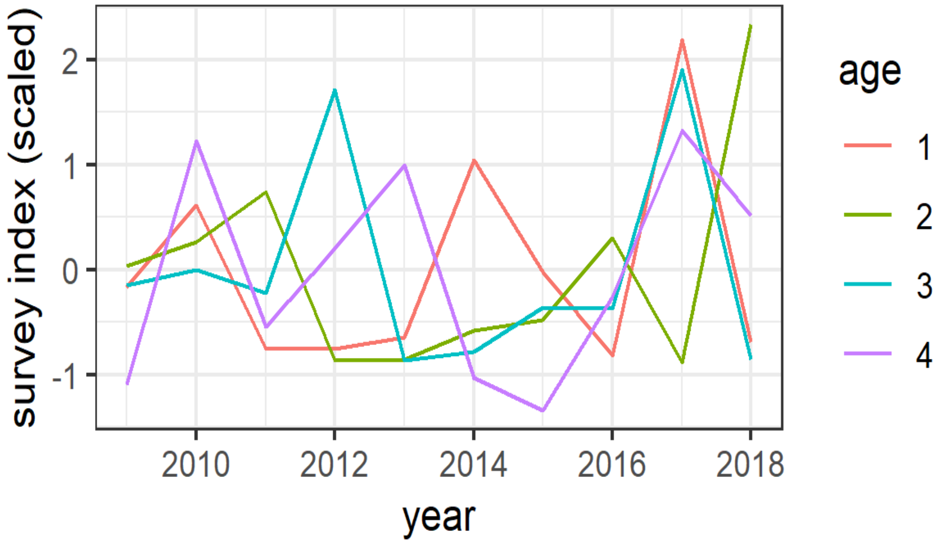


Figure 11.4.14 Sandeel Area-3r. Acoustic survey index timeline.

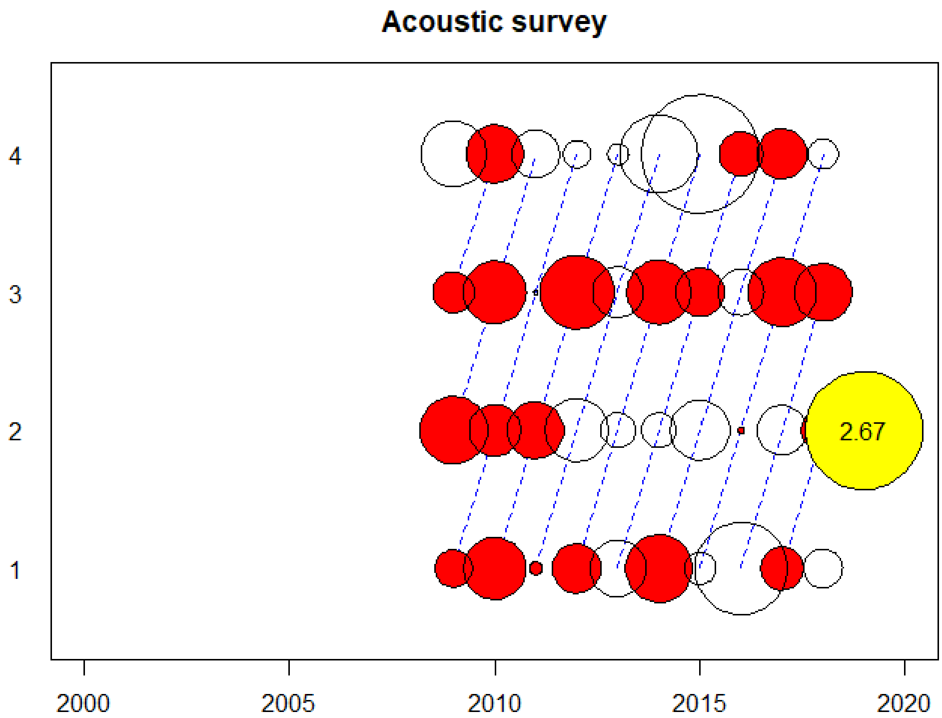


Figure 11.4.15 Sandeel Area-3r. Norwegian acoustic survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

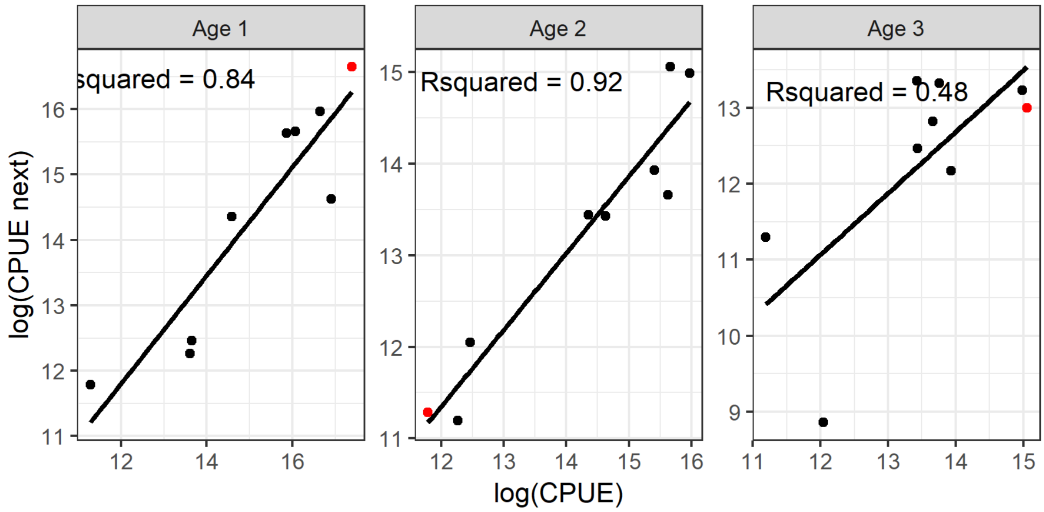


Figure 11.4.16 Sandeel Area-3r. Internal consistency by age of the acoustic survey. Red dot indicates the most recent data point.

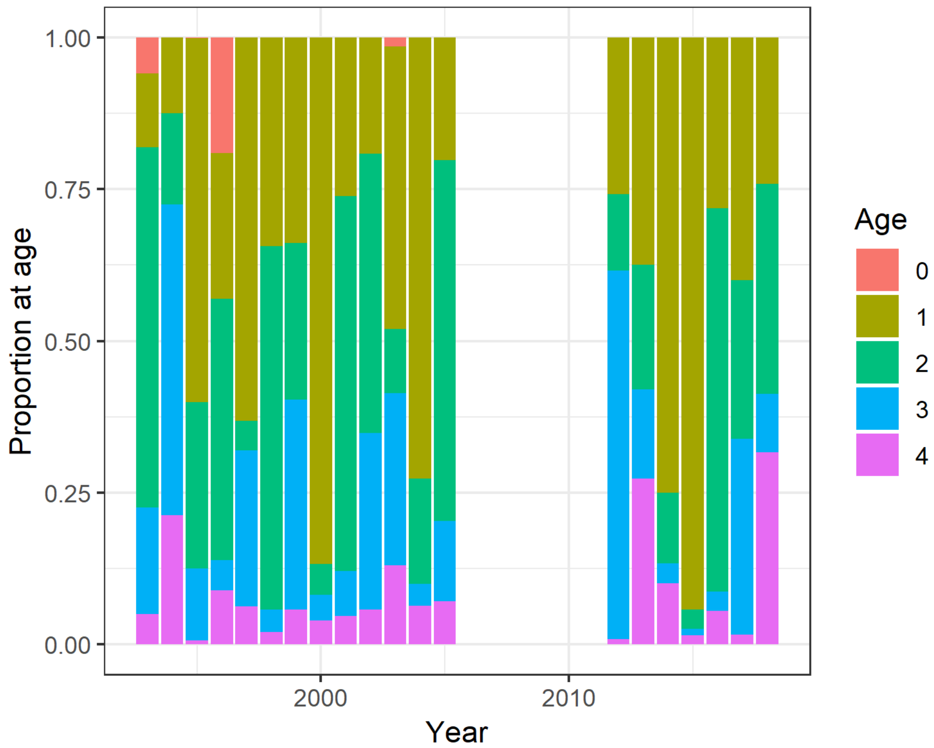


Figure 11.5.1 Sandeel Area-4. Catch numbers, proportion at age.

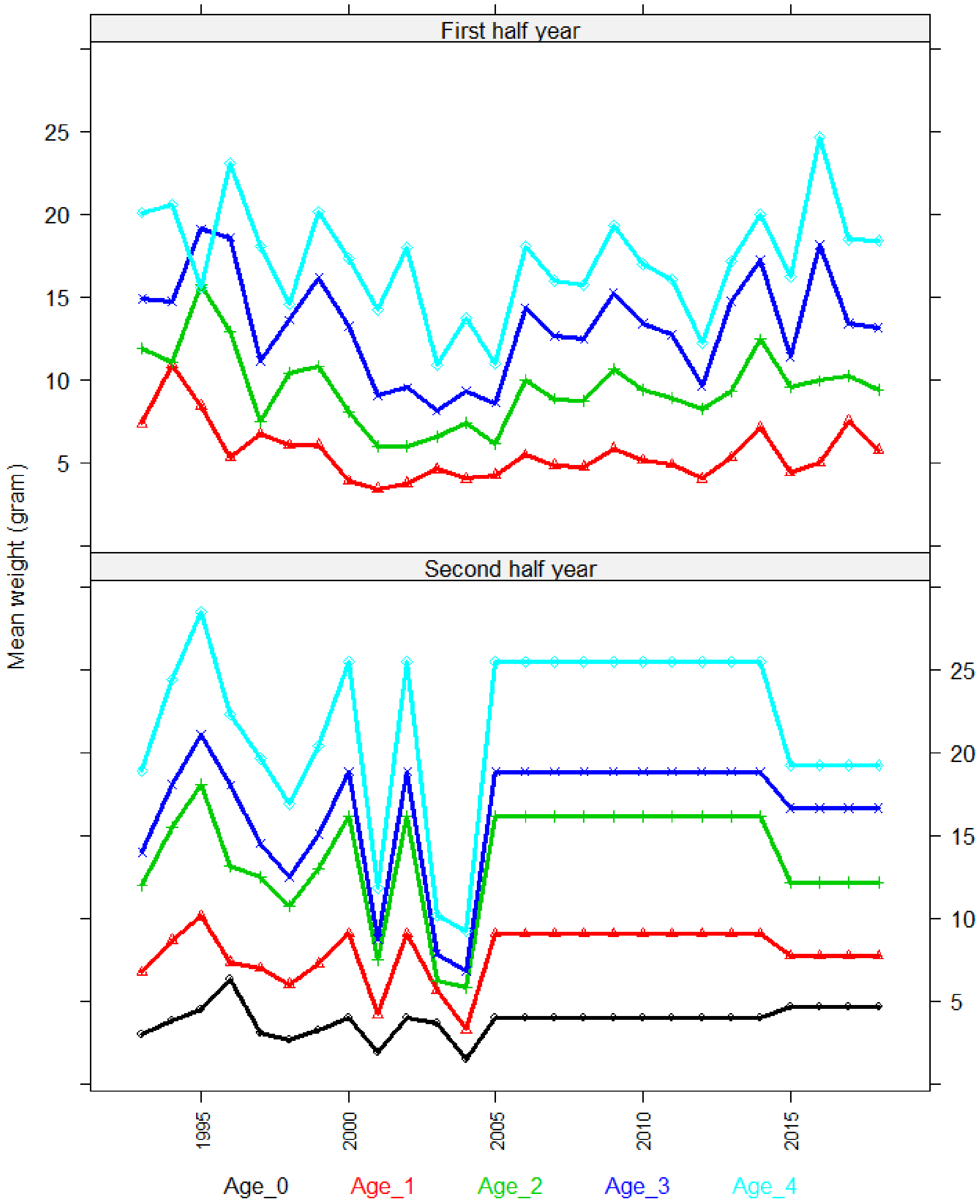


Figure 11.5.2 Sandeel Area-4. Mean weight at age in the first half year (age 1–4+) and second half year (age 0–4+).

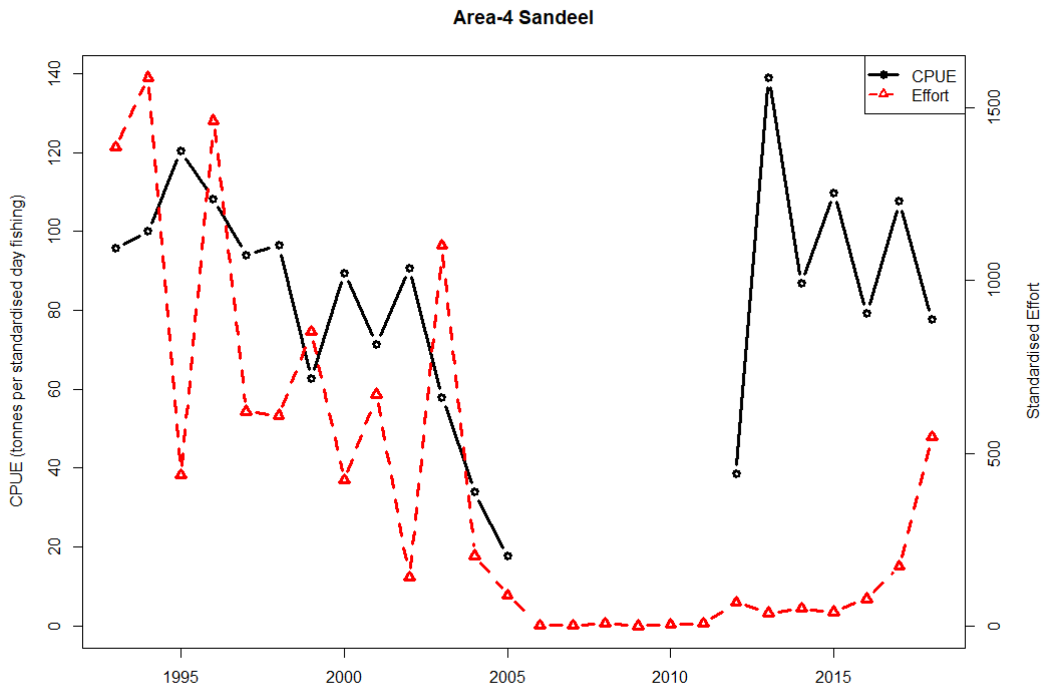


Figure 11.5.3 Sandeel Area-4. CPUE and effort.

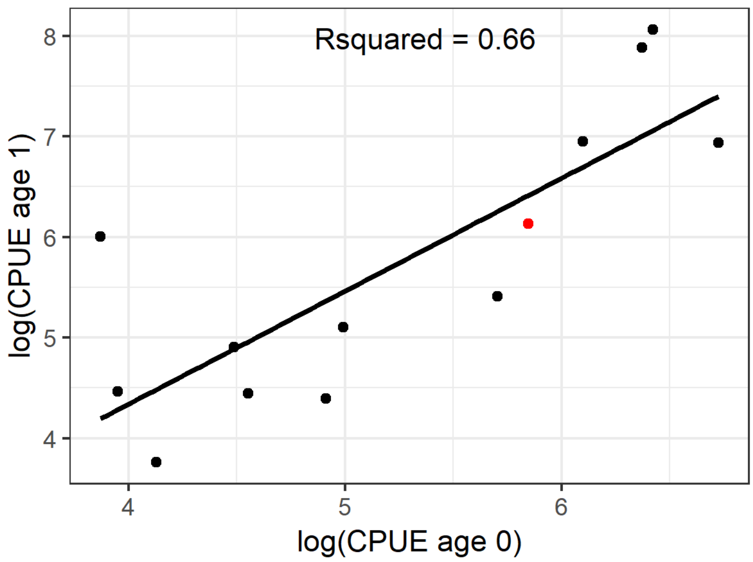


Figure 11.5.4 Sandeel Area-4. Internal consistency by age of the dredge survey. Red dot indicates the most recent data point.

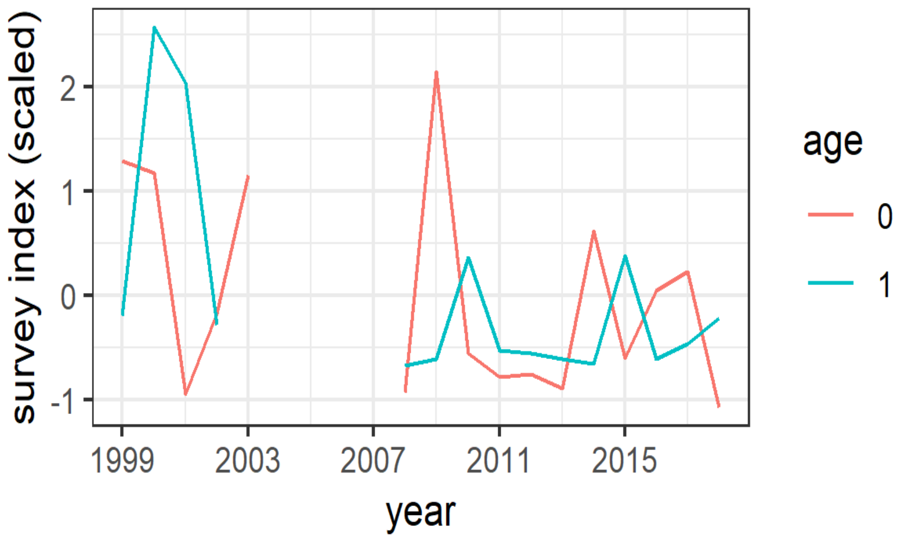


Figure 11.5.5 Sandeel Area-4. Dredge survey index timeline.

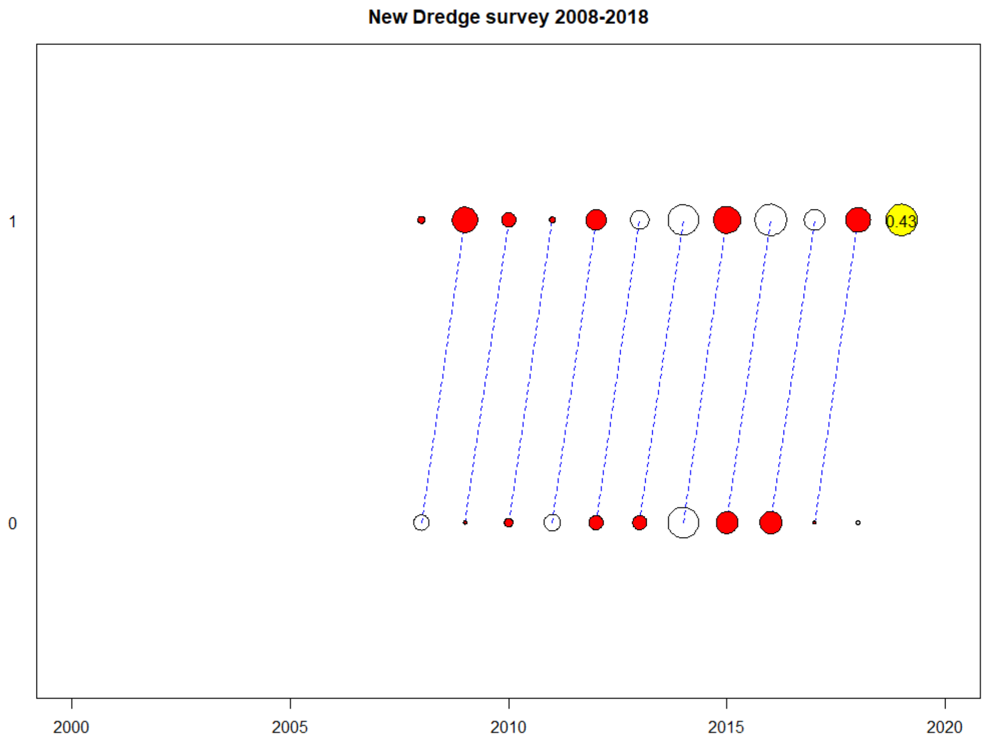


Figure 11.5.6 Sandeel Area-4. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

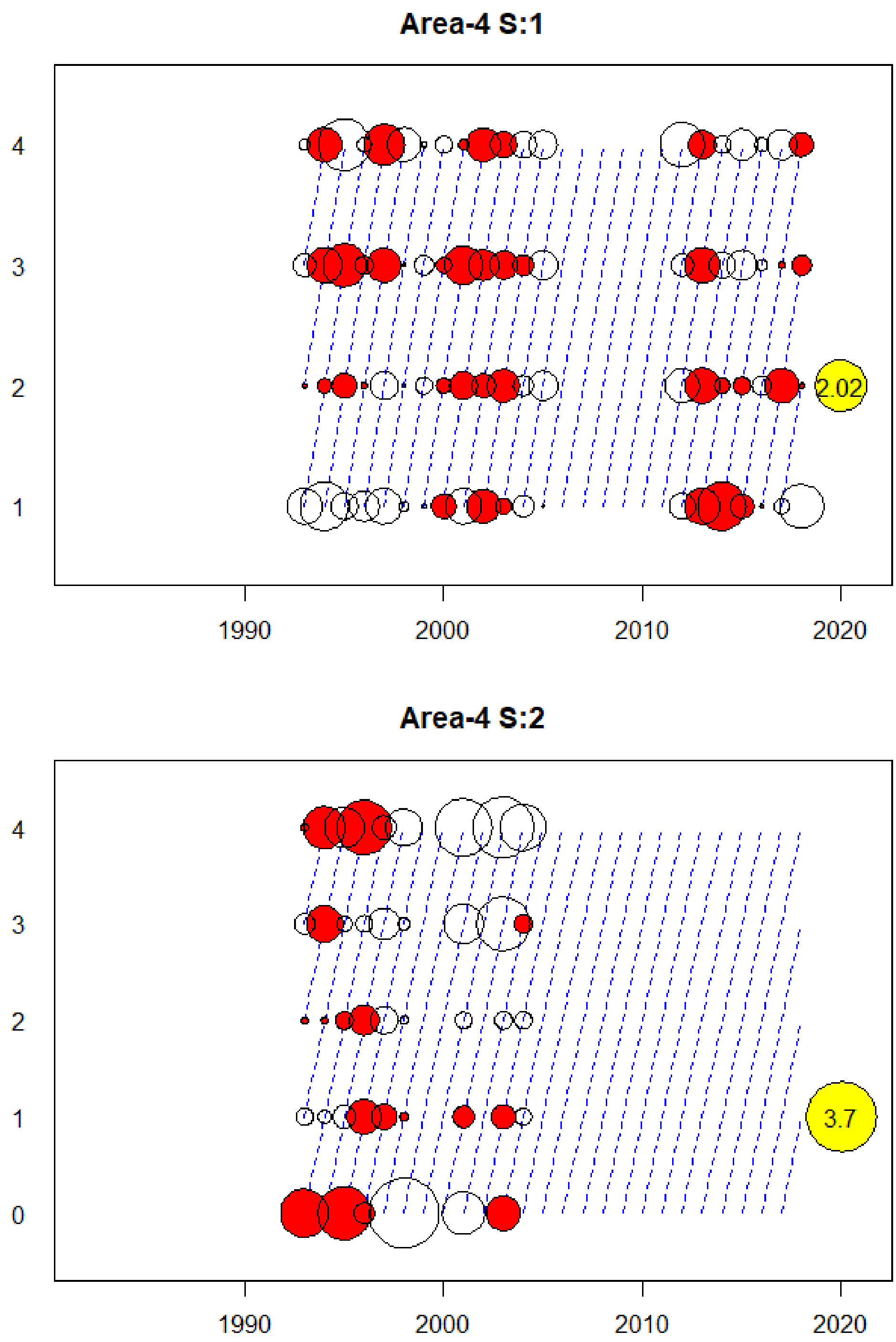


Figure 11.5.7 Sandeel Area-4. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

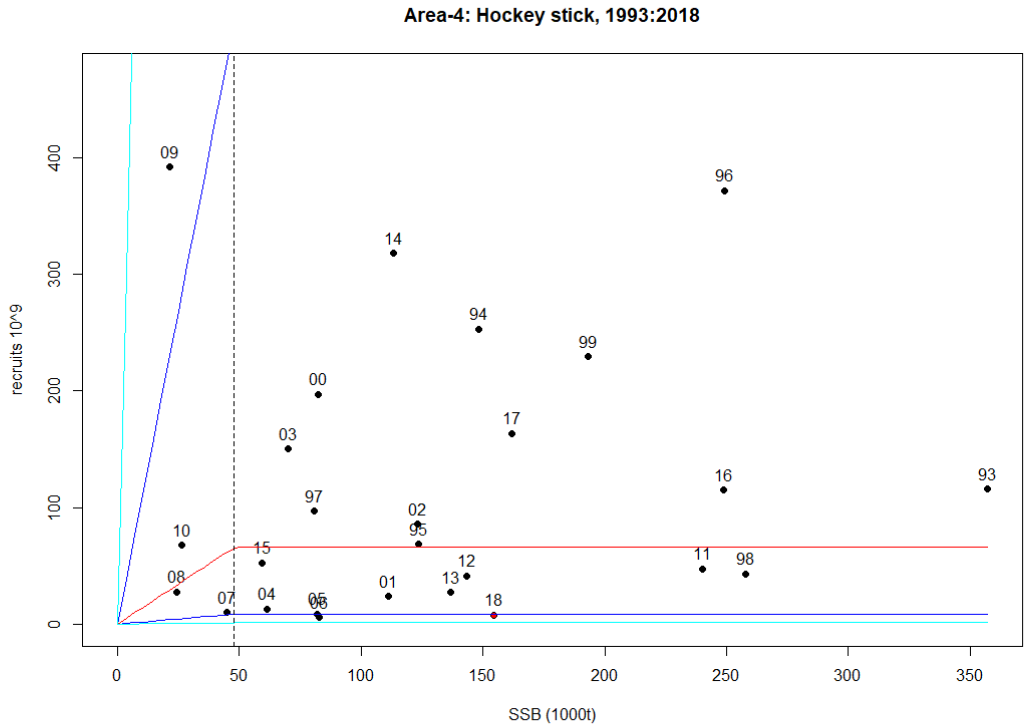


Figure 11.5.8 Sandeel Area-4. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

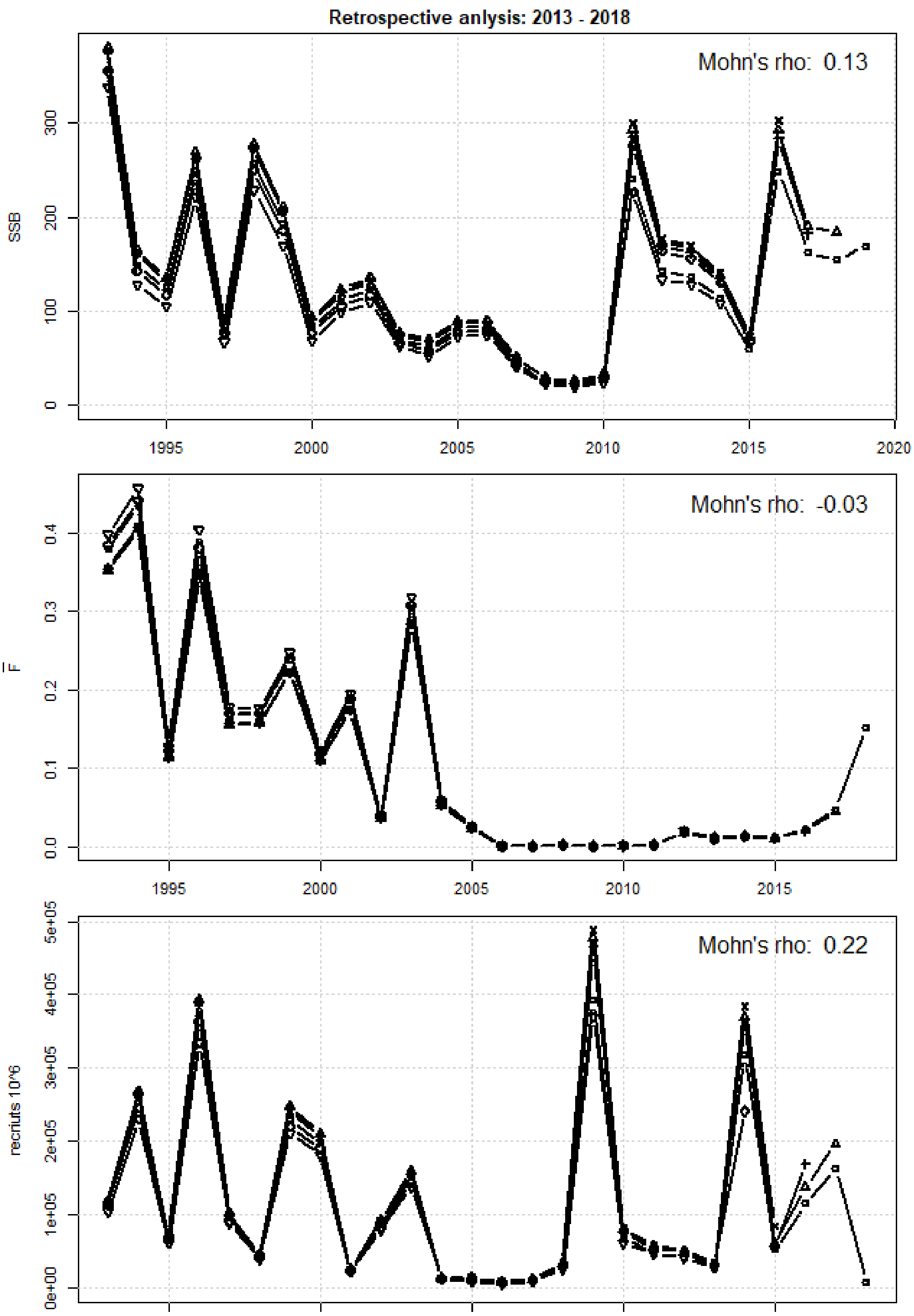


Figure 11.5.9 Sandeel Area-4. Retrospective analysis.

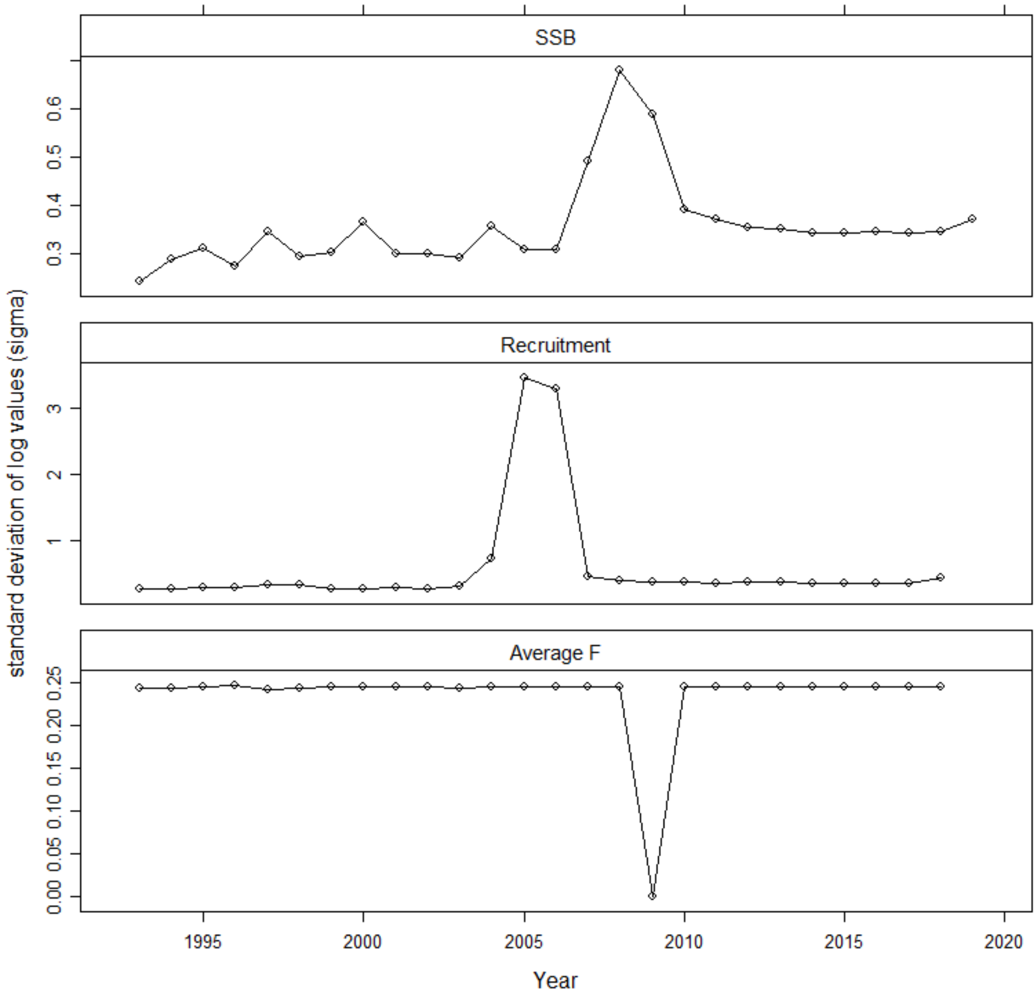


Figure 11.5.10 Sandeel Area-4. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

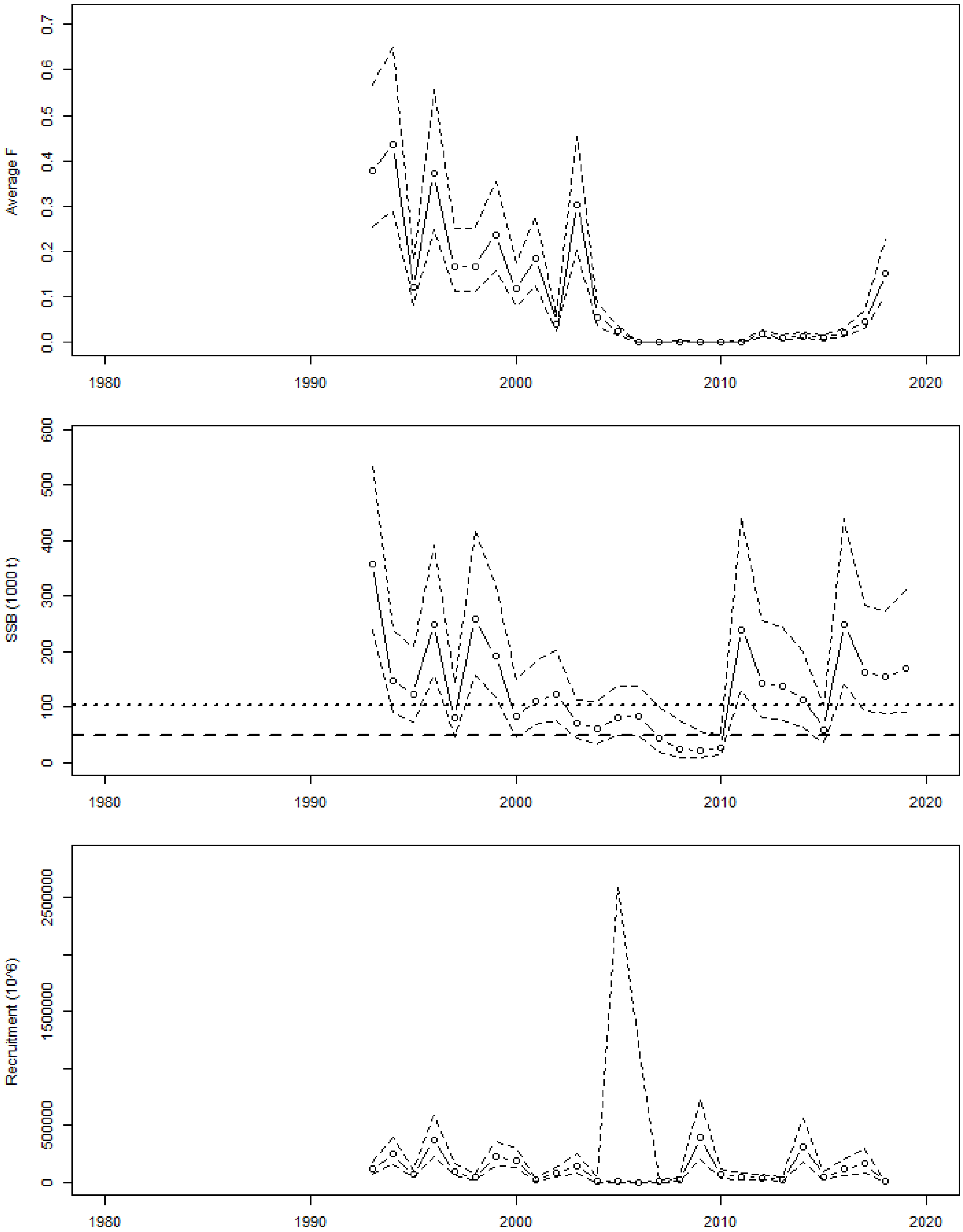


Figure 11.5.11 Sandeel Area-4. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

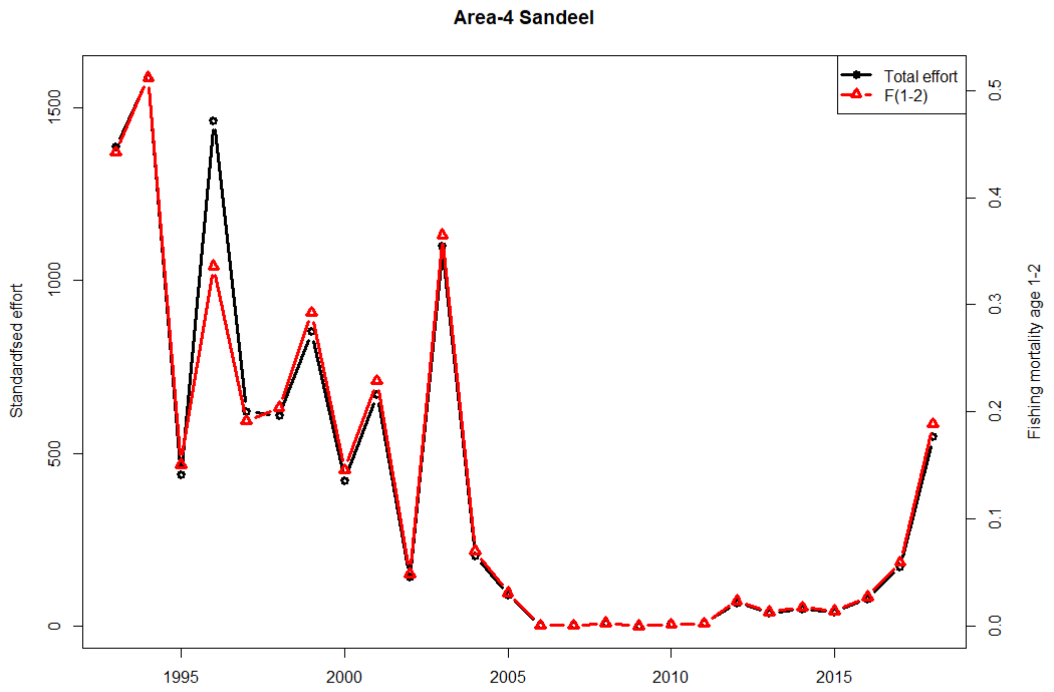


Figure 11.5.12 Sandeel Area-4. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

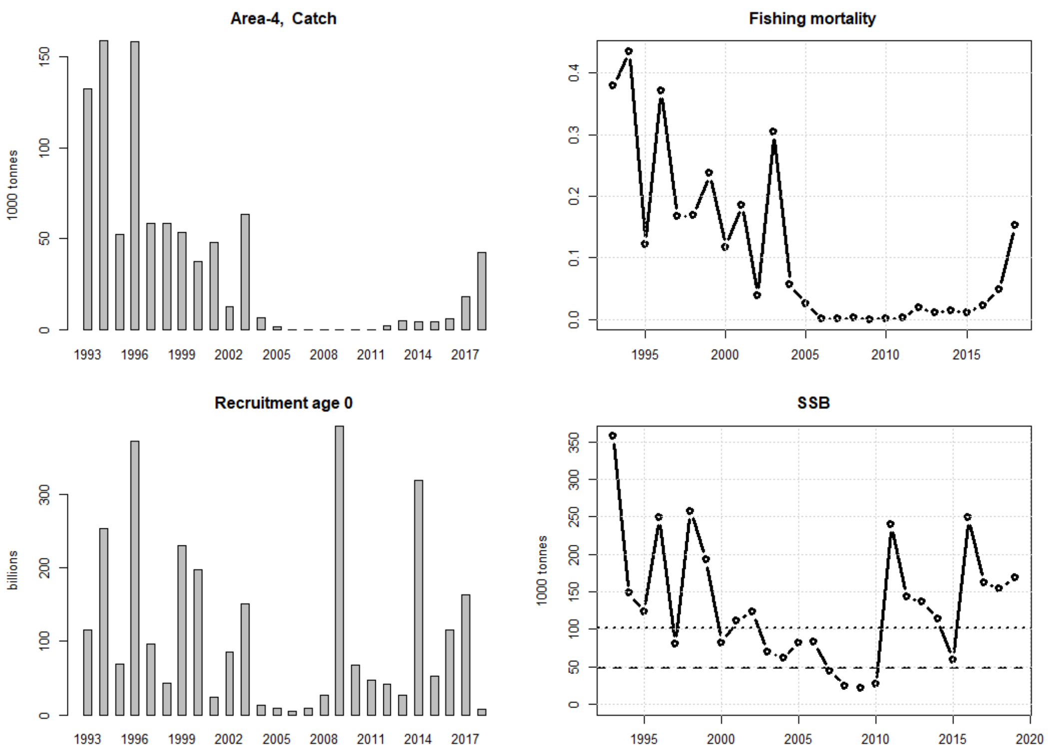


Figure 11.5.13 Sandeel Area-4. Stock summary.

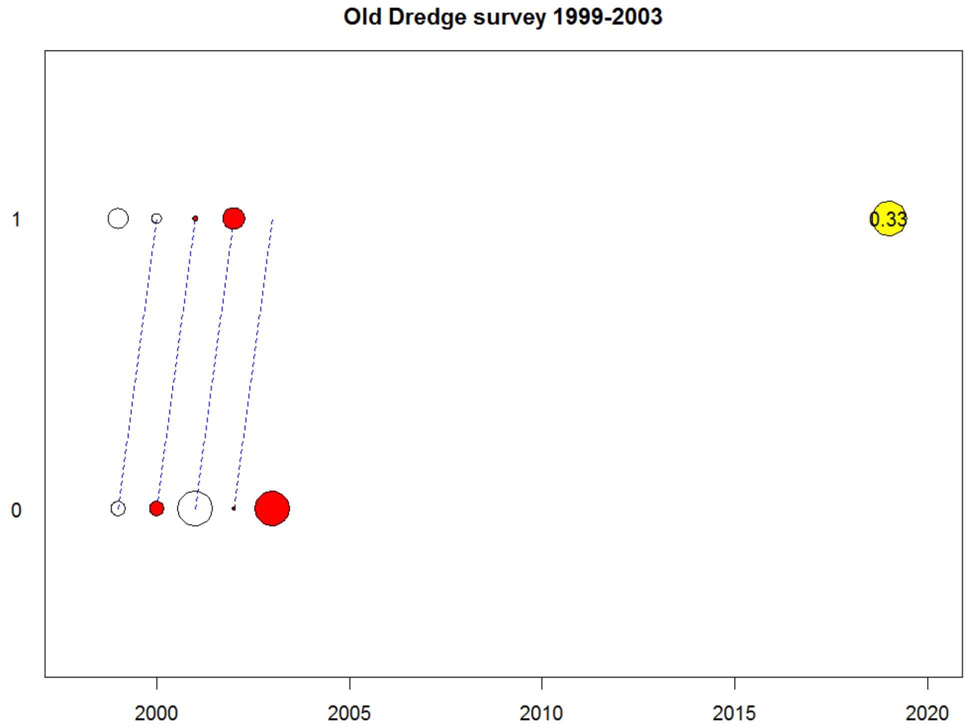


Figure 11.5.1 Sandeel Area-4. Old dredge survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

10 Sprat in Division 3.a and Subarea 4 (Skagerrak, Kattegat and North Sea)

10.1 The Fishery

10.1.1 ACOM advice applicable to 2019 and 2020

There have never been any explicit management objectives for this stock. Last year, the advised TAC (July 2018 to June 2019) was set to 177 545 t for sprat in Subarea 4 and 7506 t for Division 3.a. The 2019 herring bycatch quotas are 13 190 t for the North Sea and 6659 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 2018

Catch statistics for 1996–2018 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 2018 were 191 184 t (total official catches amounted to 190 159 t). This is a 49% increase compared to 2017, but still not far from the average for the time series. The Danish catches represent 87% of the total catches.

The spatial distribution of landings was similar to 2017 (Figure 10.1.1). As in previous years, a low percentage (12% in 2018) of the catches were landed in the first and second quarter of 2018 (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 by-catch 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 by-catch quantities. By-catches of herring are practically unavoidable except in years with high sprat abundance or low herring recruitment. By-catch 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 by-catches were expected.

ICES evaluated the effectiveness of the sprat box in 2017 (ICES, 2017). The evaluation concluded that fishing inside the sprat box would be expected to reduce unwanted catches of herring (by weight) and 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 (2018: 92% taken by trawl).

10.2 Biological composition of the catch

Only data on by-catch from the Danish fishery were available to the Working Group (Table 10.2.1). The Danish sprat fishery was conducted with a 4.4% and 7.8% by-catch of herring in 2018 in the North Sea and Division 3.a, respectively. The total amount of herring caught as by-catch in the sprat fishery has mostly been less than 10%.

The estimated quarterly landings at age in numbers for the period 1974–2018 are presented in Table 10.2.2. In the model year 2018 (1 July 2018–30 June 2019), one-year old sprat contributed 55% of the total landings, which is lower compared to the 1990–2018 average (62%) and the lowest since 2011 (45%). 2-year olds contributed 23% in 2018 (model year), which corresponds to the 1990–2018 average (23%). 0-year olds contributed 17% of the total landings, which is higher than the 1990–2018 average (9%).

Denmark, Sweden and Norway provided age data of commercial landings in 2018 (Table 10.2.4). Quarters 1, 3 and 4 were covered. The sample data were used to raise the landings data from the North Sea. The landings by the Netherlands, UK-England, UK-Scotland, Germany and Belgium were minor and 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. The sampling level in 2018 (model year) was 1.5 samples per 2000 t. The required sampling level in the EU directive for the collection of fisheries data (Commission Regulation 1639/2001) is 1 sample per 2000 tonnes (see also the Stock Annex). This level was met by Denmark, Sweden and Norway, thus the total sampling level was above the EU directive required minimum level.

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 gives the time series of IBTS indices by age (calculated using a delta-GAM model formulation; see WKSPRAT-report (WKSPRAT: ICES, 2018) for further details). The data source is the IBTS Q1 data from 1983–2019. The index for IBTS Q1 1-year olds in 2018 (age-0 in the model and the table, serving as a recruitment index) was the fifth highest in the time series, 58% of 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 2018 values were 33% lower for age-1 and 8% and 16% higher for age-2 and age-3, respectively, compared to 2017. To track changes in Subarea 4 and Division 3.a, separately, IBTS indices for roundfish areas 6–9 are shown in Figure 10.3.2a (stratified averages downloaded directly from ICES DATRAS database).

10.3.2 Acoustic Survey (HERAS)

Abundance indices were provided by WGIPS (ICES, 2019 (see Section 1.4.2)). The abundance indices for Subarea 4 and Division 3.a were summed (Table 10.3.2 and Figure 10.3.2.b). The 2018 values were 286%, 276%, and 53% (age-1, age-2, and age-3, respectively) of the 2017-values. Compared to the long-term average, the 2018 values were 283%, 69%, and 23% higher. To track changes in Subarea 4 and Division 3.a separately, IBTS indices for roundfish areas 6–9 are shown in Figure 10.3.3 (stratified averages downloaded directly from ICES DATRAS database).

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 (S1,2; quarter 3 and 4), where most of the catches are taken, show a declining trend over the past decade. In 2018, the mean weights of age-1 and age-2 fish in S1 was the lowest observed for two decades. Mean weight-at-age was also very low in S2; among the lowest observed for two decades (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

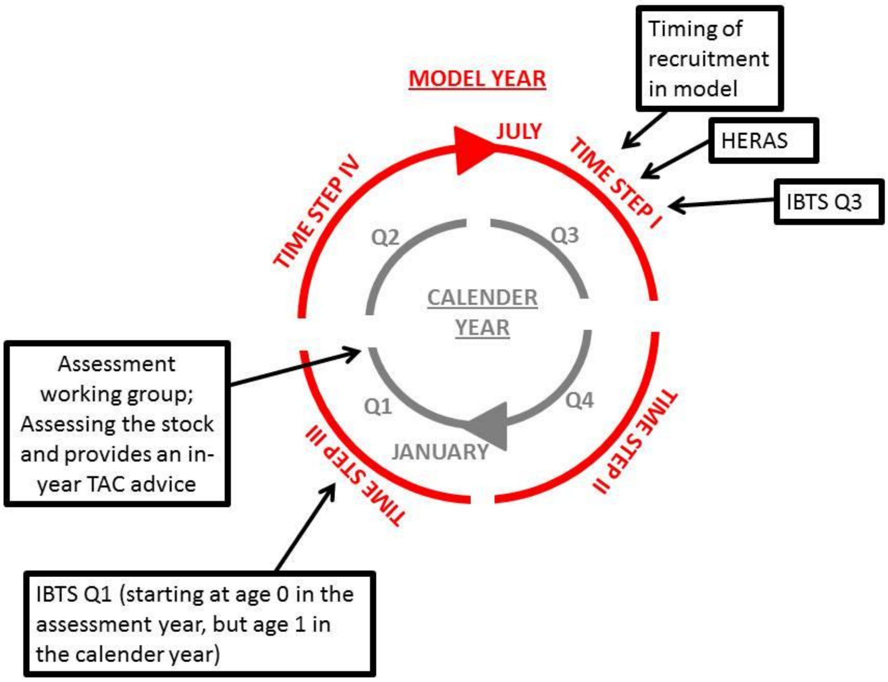
The IBTS Q1 age-1 index (age-0 in the model) (Table 10.3.1) is used as a recruitment index for this stock. The 2019 value, indicative of the 2018 recruitment, was the fifth highest in the time series, although only 58% of last year's index. The recruitment estimated by the model for 2018 is 83% of the recruitment in 2017 (after updating the 2017 recruitment) and 48% higher than the 1990–2018 average. After the latest 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 report (WKSPRAT: ICES, 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 is provided in Tables 10.1.1–2 and in Figures 10.1.13 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.

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. Note that it is 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 runs. Internal consistency in survey data and external consistency between surveys are presented in Figures 10.3.1–5.

10.6.1.4 Natural mortality

New natural mortalities were available from the 2017 North Sea key run from WGSAM (ICES, 2017). The major changes were changes to the mackerel consumption leading to a much lower M of 0-group in the second half of the year. HAWG reviewed stock recruitment plots based on the old and new M's and considered that updating the entire time series of Ms did not affect the stock recruitment plot substantially, and did not lead to a change in the perception of B_{lim}/B_{pa}. Therefore, the new M's were used. 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 10.6.2.

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 (WKSPRAT: 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 = 0.22) (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 = 0.27). However, the assessment model has been improved with this respect and mohn´s rho reduced by roughly a factor of 3 during the last benchmark.

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

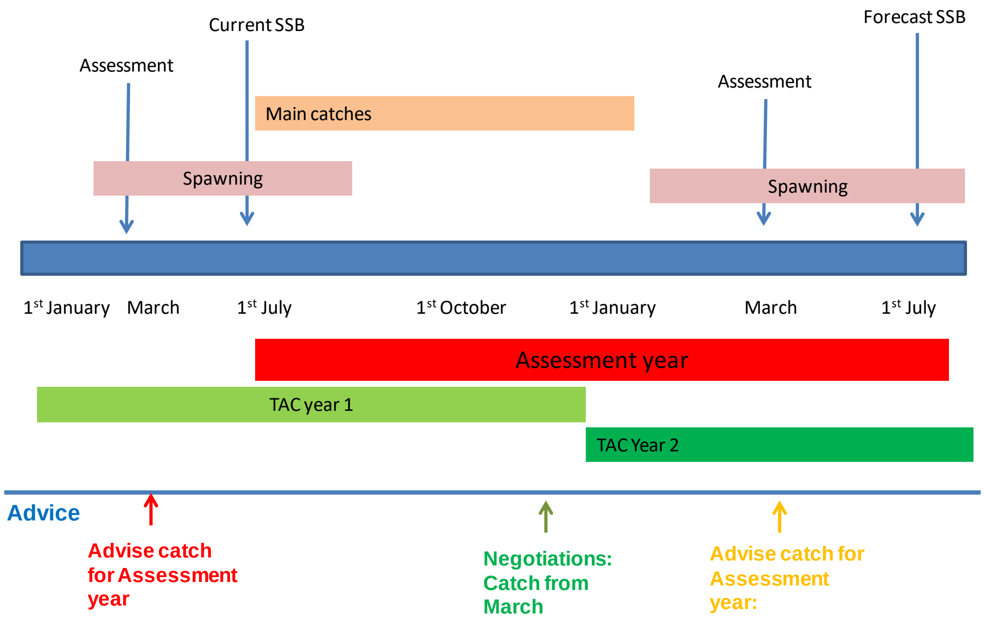
The sprat stock appears to be abundant judged by all the surveys and by the assessment output. The stock appears to have been well above B_{pa} since 2013 and above B_{lim} since 1991. The current SSB is more than twice the B_{lim}, and among the six highest since 1980. Fishing mortality has been above the long-term average for the last 4 years. 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 unprecautionary 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.

Since the catch projections are based on an assessment year from 1 July to 30 June each year rather than the calendar TAC years of 1 January to 31 December, the following figure (see below) illustrates the timing of steps in the process in relation to the spawning and fisheries of North Sea sprat.



SSB in 2019 is expected to be 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 2020 of 361 000 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 138 726 t (July 2019–June 2020), which is anticipated to result in an SSB of 271 000 t in July 2020, 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 genrally 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). There is a small retrospective bias in SSB and recruitment (5 years mohn´s rho of 0.27 and 0.22, respectively).

10.11 Management Considerations

A management plan needs to be developed. 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.

In the forecast table for North Sea herring, industrial fisheries are allocated a bycatch of 13 190 t and 6659 t of juvenile herring in 2019 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. Many of the plankton-feeding fish, including sprat, recruited strongly in 2016 (e.g. sandeel, Norway pout). This is in contrast to a previous period of poor recruitment. The implications of the environmental change for sprat and the influence of the sprat fishery on other fish species and sea birds are at present unknown.

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. 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 WKSPRAT: ICES, 2018).

Table 10.1.1. North Sea & 3.a sprat. Landings (' 000 t) 1996–2018. See ICES CM 2006/ACFM:20 for earlier data. Catch in coastal areas of western 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	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
		Division 27.4.a																					
Denmark	0.3			0.7		0.1	1.1		*		*	0.8	*	*					*	*	0.1	0.1	
Norway														*		*							
Sweden						0.1																	
UK (Scotland)																0.5						0.0	0.0
Germany																				*	*		
Netherlands																				*			
Total	0.3			0.7		0.2	1.1		*		*	0.8	*	*		0.5			*	*	0.1	0.1	0.0
		Division 27.4.b																					
Denmark	76.5	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
Norway	52.8	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
Sweden	0.5		1.7	2.1		1.4				0.0				0.3	0.6	1.1	1.8	0.1	3.9	5.5	11.7	8.1	7.6
UK(Scotland)				1.4								0.1		2.5	1.1	1.9	0.7						0.0
UK(Engl.&Wales)														*								0.0	0.0
Germany																3.3	0.5	0.6	1.5	3.1	5.4	6.0	3.7
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

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total	129.8	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
		Division 27.4.c																					
Denmark	3.9	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
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
Sweden														0.6	0.6	0.2	0.4	1.3		1.2	0.4	8.1	
UK(Scotland)													0.2			0.4					*		
UK(Engl.&Wales)	2.6	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	*	*	*	*	0.0	0.1
Germany																*	*	1.0		0.6	0.2		
Netherlands				0.2												4.2	1.0	0.7	*	1.2	0.8	0.0	0.7
Belgium																*		*	*	*	*	0.0	
France																				*		0.0	
Total	6.5	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
		Division 27.3.a																					
Denmark	10.4	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
Sweden	6.6	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
Germany																			0.0				0.0
Faroe Islands																					0.0		
Total	17.0	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

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
			Total North Sea & Skagerrak-Kattegat																				
Denmark	91.1	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
Norway	52.8	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
Sweden	7.1	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
UK(Scotland)				1.4								0.1	0.2	2.5	1.1	2.8	0.7				*	0.0	0.0
UK(Engl.&Wales)	2.6	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	*	*	*	*	0.0	0.1
Germany																3.3	0.5	1.6	1.6	3.7	5.6	6.0	3.7
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																*		*	*	*	*	0.0	
France																				*		0.0	
Total	136.6	103.4	164.3	188.4	195.9	170.2	143.6	176.5	194.3	207.7	113.7	83.8	61.1	133.1	143.5	133.6	85.6	65.9	140.4	290.4	240.7	128.7	191.2
* < 50 t										207.6	0.036												
			Total North Sea																				
Denmark	80.7	98.8	131.1	164.3	191.144	157.141	141.958	175.179	192.738	206.029	103.367	76.829	59.5854	123.774	129.295	110.968	68.929	60.1777	123.474	268.4	196.376	102.27	
Norway	52.8	3.2	31.3	18.8	2.706	9.536	*		0.056		9.807	6.673	1.266	5.83	11.121	10.0278	9.137	1.666	9.014	9.064	20.1521	9.74246	
Sweden	0.5		1.7	2.1		1.51				*				0.87	1.2	1.24	2.223	1.365	3.872	6.75715	12.094	8.1	
UK(Scotland)				1.4								0.07	0.19187	2.54943	1.07534	2.75865	0.651				*	0.00121	
UK(Engl.&Wales)	2.6	1.4	0.2	1.6	2.027	1.996	1.633	1.31022	1.48	1.60524	0.543	0.25	*	*	0.79409	0.5729	0.48503	*	*	*	*	0.04699	

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Germany																3.26	0.471	1.583	1.544	3.70483	5.55025	5.99381	
Netherlands				0.2												5.288	3.66881	1.10066	2.444	2.42085	1.76696	1.58357	
Faroe Islands																					4.711	0.9625	
Belgium																*		*	*	*	*	2.8E-05	
France																				*		1.2E-05	
Total	136.6	103.4	164.3	188.4	195.877	170.183	143.604	176.489	194.274	207.67	113.717	83.822	61.083	133.072	143.485	133.608	85.5648	65.8924	140.378	290.38	240.673	128.66	

* < 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				Total	Year	Quarter	Division				Total
		27.4.a	27.4.b	27.4.c	27.3.a				27.4.a	27.4.b	27.4.c	27.3.a	
2000	1		18 126	28 063		46 189	2010	1		10 976	17 072	1 462	29 510
	2		1 722	45		1 767		2		3 235	3	648	3 886
	3		131 306	1 216		132 522		3		14 220		3 405	17 625
	4		12 680	2 718		15 398		4		62 006	35 973	4 278	102 257
	Total		163 834	32 042		195 876		Total		90 437	53 048	9 793	153 278
2001	1	115	40 903	9 716		50 734	2011	1		3 747	21 039	3 216	28 002
	2		1 071			1 071		2		2 067	3	617	2 687
	3		44 174	481		44 655		3		22 309	451	2 311	25 072
	4	79	65 102	8 538		73 719		4	8	70 256	13 759	3 887	87 910
	Total	194	151 249	18 735		170 177		Total	8	98 380	35 252	10 031	143 671
2002	1	1 136	2 182	2 790		6 108	2012	1		81	1 649	4 668	6 399
	2		435	93		528		2		2 924	0	909	3 832
	3		70 504	647		71 151		3		26 779	307	1 631	28 717
	4		52 942	12 911		65 853		4		47 765	6 060	2 728	56 553
	Total	1 136	126 063	16 441		143 640		Total		77 549	8 016	9 936	95 501
2003	1		11 458	7 727	5 217	24 402	2013	1		1 281	3 158	1 296	5 734
	2		625	26	1 397	2 049		2		32	0	443	474

Year	Quarter	Division				Total	Year	Quarter	Division				Total
		27.4.a	27.4.b	27.4.c	27.3.a				27.4.a	27.4.b	27.4.c	27.3.a	
	3		56 207	165	1 720	58 092		3		25 577	720	211	26 509
	4		84 629	15 651	7 349	107 629		4		18 892	16 276	943	36 110
	Total		152 919	23 570	15 683	192 172		Total		45 781	20 154	2 893	68 827
2004	1		827	1 831	4 456	7 113	2014	1		59	125	384	568
	2	7	260	16	1 510	1 793		2		11 631	3	1 415	13 050
	3		54 161	496	4 138	58 794		3	1	88 457	1 428	9 622	99 507
	4		120 685	15 937	10 775	147 397		4	7	37 851	822	6 905	45 586
	Total	7	175 932	18 280	20 879	215 097		Total	8	137 999	2 378	18 327	158 711
2005	1		11 538	2 457	8 148	22 143	2015	1	*	14 816	16 972	1 442	33 230
	2		2 515	123	4 722	7 360		2		16 843	107	619	17 568
	3		107 530		19 418	126 948		3		124 512	335	6 528	131 375
	4		82 474	1 033	7 296	90 803		4	25	88 395	28 375	4 389	121 184
	Total		204 057	3 613	39 584	247 254		Total	25	244 566	45 789	12 978	303 358
2006	1	47	13 713	33 534	8 105	55 399	2016	1	68	18 487	5 969	746	25 250
	2		190	8	324	522		2		8 927	51	669	9 647
	3		40 051	8	1 440	41 499		3	*	158 522	111	4 664	163 297
	4	2	26 579	77	2 335	28 993		4	2	34 070	14 466	1 764	50 301

Year	Quarter	Division				Total	Year	Quarter	Division				Total
		27.4.a	27.4.b	27.4.c	27.3.a				27.4.a	27.4.b	27.4.c	27.3.a	
	Total	49	80 533	33 627	12 204	126 413		Total	70	220 007	20 596	7 843	248 516
2007	1		582	247	2 646	3 475	2017	1	1	3 432	1 220	92	4 745
	2		241	3	1 291	1 535		2		1 327	0	33	1 360
	3		16 603		5 357	21 960		3	0	92 885	217	227	93 329
	4	769	41 850	23 531	4 761	70 911		4	94	29 310	174	849	30 426
	Total	769	59 276	23 781	14 055	97 881		Total	95	126 954	1 611	1 200	129 860
2008	1		2 872	43	2 890	5 805	2018	1	0	8 994	1 628	168	10 790
	2		52	*	1 017	1 069		2		11 898	0	224	12 122
	3		21 787		636	22 423		3		112 361	1	1 328	113 690
	4		27 994	8 334	3 672	40 001		4		46 411	5 922	2 249	54 582
	Total		52 706	8 377	8 215	69 298		Total	0	179 664	7 551	3 969	191 184
2009	1		36	1 268	2 600	3 904							
	2		2 526	1	300	2 827							
	3	22	41 513		3 300	44 835							
	4		78 373	9 336	2 400	90 109							
	Total	22	122 448	10 604	8 600	141 675							

* < 0.5 t

Table 10.2.1. North Sea & 3.a sprat. Species composition in Danish sprat fishery in tonnes and percentage of the total catch. Left: North Sea, right: Division 3.a.

North Sea:

	Year	Sprat	Herring	Horse mack.	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
Tonnes	1998	129 315	11 817	573	673	6	220	11	2 174	1 187	145 978
Tonnes	1999	157 003	7 256	413	1 088	62	321	7	4 972	635	171 757
Tonnes	2000	188 463	11 662	3 239	2 107	66	766	4	423	1 911	208 641
Tonnes	2001	136 443	13 953	67	1 700	223	312	4	17 020	1 141	170 862
Tonnes	2002	140 568	16 644	2 078	2 537	27	715	0	4 102	801	167 471
Tonnes	2003	172 456	10 244	718	1 106	15	799	11	5 357	3 504	194 210
Tonnes	2004	179 944	10 144	474	334	0	4 351	3	3 836	1 821	200 906
Tonnes	2005	201 331	21 035	2 477	545	4	1 009	16	6 859	974	234 251
Tonnes	2006	103 236	8 983	577	343	25	905	4	5 384	576	120 033
Tonnes	2007	74 734	6 596	168	900	6	126	18	6	253	82 807
Tonnes	2008	61 093	7 928	26	380	10	367	0	23	1 735	71 563
Tonnes	2009	112 721	7 222	44	307	3	116	1	1 526	407	122 345
Tonnes	2010	112 395	4 410	11	119	2	18	0	1 236	577	118 769
Tonnes	2011	109 376	8 073	35	191	0	127	0	1 881	345	120 026
Tonnes	2012	67 263	8 573	2	354	0	246	0	93	411	76 943
Tonnes	2013	55 792	5 176	47	445	0	277	2	1	369	62 109
Tonnes	2014	123 180	11 402	0	897	0	70	16	16	1 700	137 280
Tonnes	2015	265 356	4 568	5	1 809	0	527	0	147	3 311	275 723
Tonnes	2016	192 718	11 107	18	4 223	0	439	0	46	2 093	210 643
Tonnes	2017	100 833	5 130	1	1 344	0	197	0	503	12 386	120 394
Tonnes	2018	161 536	7 528	174	716	0	366	0	24	344	170 687
Percent	1998	88.6	8.1	0.4	0.5	0.0	0.2	0.0	1.5	0.8	100.0
Percent	1999	91.4	4.2	0.2	0.6	0.0	0.2	0.0	2.9	0.4	100.0
Percent	2000	90.3	5.6	1.6	1.0	0.0	0.4	0.0	0.2	0.9	100.0
Percent	2001	79.9	8.2	0.0	1.0	0.1	0.2	0.0	10.0	0.7	100.0
Percent	2002	83.9	9.9	1.2	1.5	0.0	0.4	0.0	2.4	0.5	100.0
Percent	2003	88.8	5.3	0.4	0.6	0.0	0.4	0.0	2.8	1.8	100.0
Percent	2004	89.6	5.0	0.2	0.2	0.0	2.2	0.0	1.9	0.9	100.0
Percent	2005	85.9	9.0	1.1	0.2	0.0	0.4	0.0	2.9	0.4	100.0
Percent	2006	86.0	7.5	0.5	0.3	0.0	0.8	0.0	4.5	0.5	100.0
Percent	2007	90.3	8.0	0.2	1.1	0.0	0.2	0.0	0.0	0.3	100.0
Percent	2008	85.4	11.1	0.0	0.5	0.0	0.5	0.0	0.0	2.4	100.0
Percent	2009	92.1	5.9	0.0	0.3	0.0	0.1	0.0	1.2	0.3	100.0
Percent	2010	94.6	3.7	0.0	0.1	0.0	0.0	0.0	1.0	0.5	100.0
Percent	2011	91.1	6.7	0.0	0.2	0.0	0.1	0.0	1.6	0.3	100.0
Percent	2012	87.4	11.1	0.0	0.5	0.0	0.3	0.0	0.1	0.5	100.0
Percent	2013	89.8	8.3	0.1	0.7	0.0	0.4	0.0	0.0	0.6	100.0
Percent	2014	89.7	8.3	0.0	0.7	0.0	0.1	0.0	0.0	1.2	100.0
Percent	2015	96.2	1.7	0.0	0.7	0.0	0.2	0.0	0.1	1.2	100.0
Percent	2016	91.5	5.3	0.0	2.0	0.0	0.2	0.0	0.0	1.0	100.0
Percent	2017	83.8	4.3	0.0	1.1	0.0	0.2	0.0	0.4	10.3	100.0
Percent	2018	94.6	4.4	0.1	0.4	0.0	0.2	0.0	0.0	0.2	100.0

Division 3.a:

	Year	Sprat	Herring	Horse mack.	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
Tonnes	1998	9 143	3 385	230	467	54	0	49	7	2 866	16 202
Tonnes	1999	16 603	8 470	138	1 026	210	5	75	3 337	2 896	32 760
Tonnes	2000	12 578	8 034	5	1 062	308	8	52	13	3 556	25 617
Tonnes	2001	18 236	8 196	75	1 266	50	13	35	4 281	1 271	33 423
Tonnes	2002	11 451	12 982	21	1 164	3	6	30	606	2 280	28 541
Tonnes	2003	8 182	4 928	340	252	4	4	4	1	567	14 282
Tonnes	2004	13 374	4 620	97	976	18	24	27	116	2 155	21 408
Tonnes	2005	30 157	6 171	244	871	63	18	20	746	1 758	40 047
Tonnes	2006	6 814	2 852	215	276	13	3	45	1	232	10 451
Tonnes	2007	7 116	2 043	34	190	31	8	4	1	469	9 896
Tonnes	2008	4 805	1 948	14	285	0	0	11	462	39	7 563
Tonnes	2009	4 839	3 016	37	169	15	0	1	53	47	8 177
Tonnes	2010	2 851	2 134	25	142	6	1	2	135	171	5 466
Tonnes	2011	4 754	2 461	0	43	0	7	1	141	40	7 447
Tonnes	2012	5 707	5 495	9	149	7	10	5	0	228	11 610
Tonnes	2013	1 143	1 751	2	46	0	0	1	1	27	2 971
Tonnes	2014	16 751	3 777	5	343	1	20	5	12	888	21 801
Tonnes	2015	11 448	5 831	0	565	0	29	8	1	154	18 036
Tonnes	2016	7 001	2 140	0	335	1	19	3	0	78	9 579
Tonnes	2017	963	328	0	172	0	19	1	0	32	1 515
Tonnes	2018	2 872	257	2	150	1	11	0	0	12	3 304
Percent	1998	56.4	20.9	1.4	2.9	0.3	0.0	0.3	0.0	17.7	100.0
Percent	1999	50.7	25.9	0.4	3.1	0.6	0.0	0.2	10.2	8.8	100.0
Percent	2000	49.1	31.4	0.0	4.1	1.2	0.0	0.2	0.1	13.9	100.0
Percent	2001	54.6	24.5	0.2	3.8	0.2	0.0	0.1	12.8	3.8	100.0
Percent	2002	40.1	45.5	0.1	4.1	0.0	0.0	0.1	2.1	8.0	100.0
Percent	2003	57.3	34.5	2.4	1.8	0.0	0.0	0.0	0.0	4.0	100.0
Percent	2004	62.5	21.6	0.5	4.6	0.1	0.1	0.1	0.5	10.1	100.0
Percent	2005	75.3	15.4	0.6	2.2	0.2	0.0	0.0	1.9	4.4	100.0
Percent	2006	65.2	27.3	2.1	2.6	0.1	0.0	0.4	0.0	2.2	100.0
Percent	2007	71.9	20.6	0.3	1.9	0.3	0.1	0.0	0.0	4.7	100.0
Percent	2008	63.5	25.8	0.2	3.8	0.0	0.0	0.1	6.1	0.5	100.0
Percent	2009	59.2	36.9	0.5	2.1	0.2	0.0	0.0	0.6	0.6	100.0
Percent	2010	52.2	39.0	0.5	2.6	0.1	0.0	0.0	2.5	3.1	100.0
Percent	2011	63.8	33.0	0.0	0.6	0.0	0.1	0.0	1.9	0.5	100.0
Percent	2012	49.2	47.3	0.1	1.3	0.1	0.1	0.0	0.0	2.0	100.0
Percent	2013	38.5	58.9	0.1	1.6	0.0	0.0	0.0	0.0	0.9	100.0
Percent	2014	76.8	17.3	0.0	1.6	0.0	0.1	0.0	0.1	4.1	100.0
Percent	2015	63.5	32.3	0.0	3.1	0.0	0.2	0.0	0.0	0.9	100.0
Percent	2016	73.1	22.3	0.0	3.5	0.0	0.2	0.0	0.0	0.8	100.0
Percent	2017	63.6	21.6	0.0	11.4	0.0	1.2	0.1	0.0	2.1	100.0
Percent	2018	86.9	7.8	0.1	4.5	0.0	0.3	0.0	0.0	0.4	100.0

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

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**
1980	3	2536060	3866612	389674	8724
1980	4	0	0	0	0
1981	1	428776	12322431	1483241	130805
1981	2	40632	3540737	3025289	202048
1981	3	374254	3854059	319763	9835
1981	4	0	0	0	0
1982	1	545769	6350511	601581	64879
1982	2	818525	5021082	1070960	55333
1982	3	2530673	401839	46913	3525
1982	4	0	0	0	0
1983	1	5613728	2819244	969599	155653
1983	2	2375763	1334333	588678	91112
1983	3	1697718	596857	7271	0
1983	4	0	0	0	0
1984	1	954757	6475021	417235	2532
1984	2	521866	2535354	247654	4803
1984	3	405095	612407	10648	1053
1984	4	0	0	0	0
1985	1	0	1304457	1972027	37680
1985	2	0	576004	870780	16638
1985	3	84760	215856	150819	14916
1985	4	0	0	0	0
1986	1	0	177780	452745	347620
1986	2	0	156913	399604	306818
1986	3	580936	58710	740	0
1986	4	0	0	0	0
1987	1	2236	2250587	128512	2525

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**
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
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

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**
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

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**
2000	4	0	0	0	0
2001	1	13056	5767627	315550	7694
2001	2	550512	3967343	1528712	498496
2001	3	143017	531588	59709	13418
2001	4	0	0	0	0
2002	1	63416	6586442	594557	108679
2002	2	927294	4326530	661656	59022
2002	3	1182692	1199165	296900	65718
2002	4	0	0	0	0
2003	1	197639	4003316	594498	68144
2003	2	2785630	6826281	1115905	218400
2003	3	713229	39824	29774	26427
2003	4	0	0	0	0
2004	1	229309	4217281	731500	78913
2004	2	24806798	4735686	264373	53425
2004	3	5233945	309955	44145	15707
2004	4	0	0	0	0
2005	1	97602	13409729	479222	88858
2005	2	839944	7903545	228337	22051
2005	3	1089274	5408581	230703	38557
2005	4	0	0	0	0
2006	1	0	1987696	1401797	295158
2006	2	319709	493221	1003837	235542
2006	3	176742	129541	176585	10933
2006	4	0	0	0	0
2007	1	0	1693273	189551	67672
2007	2	609939	4186796	1681648	254768

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**
2007	3	404452	329724	19675	20964
2007	4	0	0	0	0
2008	1	11590	422430	1447939	329770
2008	2	2087187	1901763	1006626	260966
2008	3	893785	131774	41692	21858
2008	4	0	0	0	0
2009	1	0	4776947	219922	39037
2009	2	231412	8163927	554425	137328
2009	3	168362	3385107	519516	88967
2009	4	0	0	0	0
2010	1	12414	1732171	689166	90040
2010	2	349703	3105417	3011291	2157387
2010	3	298472	2412405	683264	90603
2010	4	0	0	0	0
2011	1	2469	1847215	1105017	281708
2011	2	420004	4234059	2917969	999295
2011	3	57320	250247	95834	42266
2011	4	0	0	0	0
2012	1	147896	2527701	729427	121665
2012	2	187098	3756225	1690250	281071
2012	3	78240	463743	86910	30157
2012	4	0	0	0	0
2013	1	10002	1973364	411558	72705
2013	2	462029	2176971	745578	144434
2013	3	193678	1554	2447	4794
2013	4	0	0	0	0
2014	1	2640874	9499013	627237	105519

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**
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	4350565	11667334	2940924	279993
2018	2	2025377	2923947	1574333	527760
2018	3	120913	978572	267657	6437
2018	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)

Catch 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

Catch 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**
1980	4	0.0046	0.0073	0.0105	0.0101
1981	1	0.0038	0.0099	0.0129	0.0156
1981	2	0.0082	0.0126	0.0153	0.0194
1981	3	0.0049	0.0089	0.0157	0.0194
1981	4	0.0060	0.0139	0.0191	0.0192
1982	1	0.0085	0.0089	0.0171	0.0155
1982	2	0.0071	0.0110	0.0160	0.0219
1982	3	0.0029	0.0075	0.0115	0.0174
1982	4	0.0044	0.0078	0.0114	0.0160
1983	1	0.0044	0.0092	0.0128	0.0152
1983	2	0.0042	0.0124	0.0169	0.0211
1983	3	0.0034	0.0094	0.0174	0.0163
1983	4	0.0038	0.0093	0.0127	0.0156
1984	1	0.0060	0.0081	0.0121	0.0166
1984	2	0.0053	0.0122	0.0168	0.0164
1984	3	0.0093	0.0135	0.0197	0.0197
1984	4	0.0093	0.0135	0.0197	0.0197
1985	1	0.0063	0.0093	0.0135	0.0197
1985	2	0.0051	0.0093	0.0135	0.0197
1985	3	0.0073	0.0099	0.0166	0.0166
1985	4	0.0073	0.0099	0.0166	0.0166
1986	1	0.0063	0.0073	0.0099	0.0166
1986	2	0.0051	0.0073	0.0099	0.0166
1986	3	0.0083	0.0164	0.0228	0.0163
1986	4	0.0084	0.0156	0.0208	0.0156
1987	1	0.0066	0.0086	0.0117	0.0153
1987	2	0.0060	0.0093	0.0112	0.0165

Catch 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
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
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

Catch 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
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

Catch 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**
2001	1	0.0078	0.0109	0.0118	0.0159
2001	2	0.0048	0.0116	0.0136	0.0166
2001	3	0.0062	0.0127	0.0150	0.0162
2001	4	0.0065	0.0120	0.0161	0.0181
2002	1	0.0073	0.0109	0.0141	0.0154
2002	2	0.0077	0.0122	0.0142	0.0158
2002	3	0.0047	0.0101	0.0133	0.0145
2002	4	0.0060	0.0116	0.0129	0.0155
2003	1	0.0042	0.0125	0.0146	0.0228
2003	2	0.0058	0.0108	0.0145	0.0167
2003	3	0.0049	0.0115	0.0135	0.0141
2003	4	0.0050	0.0092	0.0123	0.0139
2004	1	0.0088	0.0116	0.0139	0.0154
2004	2	0.0041	0.0094	0.0126	0.0153
2004	3	0.0030	0.0097	0.0112	0.0130
2004	4	0.0044	0.0093	0.0115	0.0129
2005	1	0.0076	0.0097	0.0130	0.0154
2005	2	0.0066	0.0103	0.0115	0.0141
2005	3	0.0055	0.0080	0.0114	0.0138
2005	4	0.0047	0.0087	0.0115	0.0130
2006	1	0.0063	0.0108	0.0133	0.0152
2006	2	0.0055	0.0143	0.0158	0.0180
2006	3	0.0041	0.0095	0.0129	0.0134
2006	4	0.0050	0.0093	0.0124	0.0139
2007	1	0.0063	0.0119	0.0131	0.0149
2007	2	0.0065	0.0101	0.0127	0.0151
2007	3	0.0045	0.0075	0.0106	0.0126

Catch 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
2007	4	0.0048	0.0089	0.0118	0.0133
2008	1	0.0088	0.0103	0.0114	0.0131
2008	2	0.0044	0.0076	0.0126	0.0142
2008	3	0.0034	0.0076	0.0082	0.0085
2008	4	0.0044	0.0068	0.0090	0.0081
2009	1	0.0063	0.0096	0.0123	0.0142
2009	2	0.0046	0.0095	0.0130	0.0160
2009	3	0.0043	0.0077	0.0103	0.0135
2009	4	0.0087	0.0096	0.0105	0.0141
2010	1	0.0066	0.0080	0.0097	0.0137
2010	2	0.0047	0.0094	0.0114	0.0148
2010	3	0.0050	0.0072	0.0094	0.0130
2010	4	0.0038	0.0071	0.0095	0.0107
2011	1	0.0052	0.0085	0.0101	0.0134
2011	2	0.0044	0.0089	0.0114	0.0145
2011	3	0.0042	0.0102	0.0128	0.0171
2011	4	0.0050	0.0092	0.0123	0.0139
2012	1	0.0085	0.0087	0.0106	0.0150
2012	2	0.0072	0.0087	0.0119	0.0152
2012	3	0.0040	0.0069	0.0113	0.0146
2012	4	0.0047	0.0087	0.0117	0.0132
2013	1	0.0061	0.0096	0.0120	0.0150
2013	2	0.0043	0.0097	0.0124	0.0156
2013	3	0.0026	0.0051	0.0071	0.0084
2013	4	0.0022	0.0094	0.0128	0.0153
2014	1	0.0086	0.0086	0.0104	0.0168
2014	2	0.0070	0.0079	0.0116	0.0139

Catch 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**
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	0.0066	0.0086	0.0123
2018	2	0.0053	0.0074	0.0097	0.0132
2018	3	0.0042	0.0066	0.0097	0.0128
2018	4	0.0076	0.0141	0.0188	0.0212

Table 10.2.4. North Sea & 3.a sprat. Sampling for biological parameters in 2018. 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	9.81	8	790	348
	2	11.90	6	762	287
	3	98.60	61	8 002	2 972
	4	45.32	47	5 351	2 312
	Total	165.62	122	14905	5919
Norway	1	0.78	1	100	50
	2				
	3	5.92	5	369	213
	4	3.07	3	305	107
	Total	9.78	9	774	370
Sweden	1	0.13	3	107	107
	2				
	3	5.92			
	4	2.62	10	840	840
	Total	8.67	13	947	947
All countries	1	10.79	12	997	505
	2	12.12	6	762	287
	3	113.69	66	8371	3185
	4	54.58	60	6496	3259
Total North Sea	Total	191.18	144	16 626	7 236

Table 10.2.5. North Sea & 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

Year	S1	S2	S3	S4
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
2012	37	88	15	3

Year	S1	S2	S3	S4
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	11	0

Table 10.3.1. North Sea sprat. Abundance indices by age from IBTS Q1

IBTS Q1 survey index (sa 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**
1982	252619	551262	574173	47111
1983	619180	553686	100186	25687
1984	374594	292408	75083	19254
1985	116338	137304	39250	9993
1986	503284	86061	25143	9769
1987	248663	789924	77117	15148
1988	744970	154929	114877	11326
1989	360108	185946	47580	21180
1990	1412224	176334	33438	7582
1991	1882139	281520	36961	9645
1992	1863182	1224852	103248	10709
1993	1195289	887347	132008	8288
1994	2258852	2257140	263386	10391
1995	604673	967027	199658	28253
1996	599335	270098	168138	27513
1997	1072937	1104108	180777	16056
1998	5183400	583736	73757	5308
1999	2017439	1164352	150449	25036

IBTS Q1 survey index (sa 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**
2000	1997862	1309083	239142	13995
2001	1191954	968965	87712	10393
2002	2493114	589410	66441	5540
2003	4084377	685280	106637	9076
2004	8918279	675529	29062	2718
2005	1230441	1416990	58676	7654
2006	1917763	1035569	162880	12506
2007	1526985	803061	47400	8526
2008	4133598	312030	34043	3833
2009	3288300	2489705	118665	17586
2010	1078333	926246	206207	47562
2011	3356603	3143308	245116	36666
2012	1137772	1116849	203191	29306
2013	3886605	443621	50655	9871
2014	7727188	3460669	317090	26651
2015	2112309	3409890	675849	37763
2016	10317128	1707447	128002	15146
2017	10440866	1547476	94598	11384
2018	6097175	2511994	226057	9585

Table 10.3.1. North Sea sprat. Abundance indices by age from IBTS Q3

IBTS Q3 survey index (sa 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
2017	18709889	3123833	200733

Table 10.3.2. North Sea & 3.a sprat. HERAS survey index.

HERAS abundance index (sa 4 and 3.a summed), data is 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

Table 10.6.1. North Sea & 3.a sprat. Natural mortality input (Model year). From multi-species SMS (WKSAM: ICES, 2015) 2015 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

Year	Season	age 0	age 1	age 2	age 3
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

Year	Season	age 0	age 1	age 2	age 3
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
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

Year	Season	age 0	age 1	age 2	age 3
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
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

Year	Season	age 0	age 1	age 2	age 3
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

Year	Season	age 0	age 1	age 2	age 3
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
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

Table 10.6.2. North Sea sprat. Assessment diagnostics.

Date: 03/15/19 Start time:16:38:31 run time:1 seconds

objective function (negative log likelihood): 266.022

Number of parameters: 137

Maximum gradient: 0.0264053

Akaike information criterion (AIC): 806.044

Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
720	268	45	0	1033

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
365.3	-100.5	11.8	0.0	0.0	0.00	277

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.51	-0.37	0.26	0.00

contribution by fleet:

IBTS Q1 total: -49.835 mean: -0.337

IBTS Q3 total: -41.144 mean: -0.508

Acoustic total: -9.508 mean: -0.244

F, season effect:

----

age: 0

1974-2018: 0.033 0.212 0.394 0.250

age: 1

1974-2018: 0.521 0.539 0.218 0.250

age: 2

1974-2018: 0.245 0.491 0.136 0.250

age: 3

1974-2018: 0.215 0.496 0.319 0.250

F, age effect:

	0	1	2	3
1974-2018:	0.038	0.417	1.480	1.480

Exploitation pattern (scaled to mean F=1)

		0	1	2	3
1974-2018	season 1:	0.001	0.189	0.315	0.277
	season 2:	0.007	0.196	0.633	0.639
	season 3:	0.013	0.079	0.176	0.412
	season 4:	0.008	0.091	0.322	0.322

sqrt(catch variance) ~ CV:

----

season

----

age	1	2	3	4
0	1.414	1.414	1.155	0.100
1	0.861	0.693	1.414	0.100
2	1.035	1.063	1.414	0.100
3	1.035	1.063	1.414	0.100

Survey catchability:

----

	age 0	age 1	age 2	age 3
IBTS Q1	0.000	1.470	2.827	4.487
IBTS Q3		0.772	0.997	0.932
Acoustic		1.045	2.333	6.072

Stock size dependent catchability (power model)

--	age 0	age 1	age 2	age 3
IBTS Q1	1.58	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	0.47	0.42	0.42	0.42
IBTS Q3		0.46	0.32	0.32
Acoustic		0.45	0.49	0.49

Recruit-SSB		alfa	beta	recruit s2	recruit s
Sprat	Hockey stick -break.:	1392.285	9.000e+004	0.621	0.788

Table 10.6.3. North Sea & 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	533667000	328875000	235319000	172346000	138012000	70385100	44432900	30828200	10746300	5006380	1948140	1336540	485584	267092	106286	55619
1975	712689000	423481000	312599000	219115000	109421000	45596200	24606900	15548000	18451300	6383020	1448740	815527	699739	314887	72750	25385
1976	330409000	202020000	144894000	98009200	136460000	57750600	30179300	18354400	9997240	3423270	731948	399113	550925	231443	50329	16791
1977	631497000	405708000	275921000	184392000	60321000	28383400	15579900	9496200	11785000	4598860	1160670	657922	273059	120807	31009	11452
1978	1033370000	684142000	479393000	322208000	113014000	60452900	37928900	24138700	6117920	2846870	1067060	701460	434619	223763	85446	42267
1979	534780000	345451000	226623000	151382000	206526000	116443000	77560800	50529400	16239200	8330960	3957680	2733000	511616	274342	132104	75735
1980	328622000	204788000	128468000	84170100	97069800	36530600	16528300	9344830	34233600	9322120	1290550	634258	1926640	598756	83726	21669
1981	94281300	57064600	37548000	25738500	55360000	26534100	15623400	10283000	6440630	2713730	900184	571346	468557	226575	77223	35885
1982	49287200	29542100	21035300	15261800	17665200	9127130	5717620	4122110	7390680	3457780	1292650	870694	464976	260023	100318	50762
1983	66959800	39231000	27634600	20018500	11104800	4923770	2613990	1809790	3125200	1160900	257741	151580	750389	341225	76568	27864
1984	33535900	19546000	13041000	9432390	14649500	7681260	4832080	3471250	1396220	725586	281622	192142	151643	91497	35957	18636
1985	23326400	13445100	8209920	5824610	6839640	3062280	1698140	1166720	2638750	1097510	310481	196274	173042	91146	26601	11533
1986	79160700	43826900	27626500	19215400	4236710	1933460	1090380	758119	891230	384686	124529	81724	176193	94570	32251	15474
1987	40836300	22491100	14007900	9752320	13743100	7783180	5201730	4042630	570443	318041	177599	135739	82060	56091	33415	22978
1988	60893000	32651900	19729300	13333700	6956140	3123930	1629070	1132460	3052250	1176030	315312	191624	131958	65750	18265	7644
1989	54629700	29865400	17615500	12279100	9290040	5202980	3469820	2680900	837769	482840	284187	213304	157917	114954	69761	47948
1990	73835200	43904700	26400500	18398600	8446340	3636000	1810980	1203860	1962720	727217	167490	93938	197178	91909	21398	7716
1991	112582000	70847800	47414200	34374200	12494900	6941390	4471330	3205800	875415	482868	220587	151345	76309	46071	21370	11937
1992	104251000	69105100	50226800	36950400	23299100	13428700	8783870	6158140	2327630	1277310	549667	372199	122524	71764	31415	16760
1993	150399000	95169800	73966900	54926500	25504900	11620100	6414900	4261430	4566470	1745690	414980	242167	296851	126945	30293	11106
1994	128713000	77807400	57739600	44133500	38804300	21109200	14272500	10706400	3238940	1744190	831909	591407	198449	111713	53804	31233
1995	36331900	21729500	16051000	12557300	32119400	14373200	8048530	5756720	8356860	3352310	869562	528148	498233	220989	57464	22700
1996	60863800	36695200	25224200	19911700	9637460	4723710	2708550	1997540	4661890	2108050	594150	380068	455689	230805	66007	28393
1997	49103400	31231700	22995800	18030300	15695400	9265190	5929210	4431900	1643930	901345	341263	231379	349417	212301	82476	41750
1998	109864000	71336600	48968100	37069100	13776800	7010460	3832230	2638020	3577060	1480310	332721	194197	230196	106922	24470	8744
1999	77583000	50844100	37734700	28274200	26976200	16457600	10979000	7913680	2064240	1158330	488975	333190	166699	99329	42360	22293
2000	73316900	48756100	33757500	25594900	20233400	10242100	5908950	4142240	6058510	2670250	715873	446259	278978	136317	36524	14907
2001	61396800	40712300	29793800	22276100	19371100	9770820	5458710	3752460	3272560	1429950	354083	209889	380576	186540	45976	17464
2002	82225000	53134800	38226500	28962100	16398800	8158960	4422480	3073410	2897880	1215670	278086	161287	183700	89144	20305	7359
2003	106874000	70149900	51684600	39112300	20974800	11998400	7073870	4982780	2365920	1176690	362314	220858	135640	74963	22963	9752
2004	188359000	121451000	90500900	69706900	26678000	13037300	6660790	4482050	3661390	1395120	263657	142258	173259	75000	14076	4385
2005	66445300	42649800	30958400	24323500	47872200	25646200	15050800	10842400	3312600	1590730	480232	302627	111011	57305	17251	7442
2006	84862900	51157500	38706300	30343500	16855200	8364420	4538870	3171110	8102270	3394780	784029	460667	247597	113392	26016	9439
2007	60934300	37622400	27838800	21995300	21079400	10639200	5801840	4169550	2403350	1054130	256226	155750	383995	185232	44644	17067
2008	140415000	86918600	65670600	52607200	16094600	8654010	5102970	3763230	3288200	1614890	482581	305066	145069	77530	23063	9854
2009	114653000	73449500	52569800	42860200	38817500	22096800	14683700	11389300	3003660	1700030	739763	520872	258635	163644	71266	39024
2010	120614000	71099600	47474800	38000000	31989500	16772500	10603800	8015450	9183040	4554560	1743150	1196510	463153	277415	106974	54881
2011	91679800	54947800	37252500	29212000	27899900	14583000	9226180	6897860	6391570	3051960	1237290	849219	1027860	628130	256428	135101
2012	72997200	43789300	29940400	23531200	20832900	9811780	5542980	4063920	5352700	2219540	625012	400794	786532	411606	116141	49862
2013	171319000	114754000	86593100	69081200	17576200	9153830	5530910	4120100	3244730	1515520	494954	327263	376562	213405	69459	32167
2014	188465000	130470000	100361000	80484300	52737100	32955200	23497300	18530400	3303640	2063630	1110610	840083	300737	214462	116448	74407
2015	101492000	70318500	54818100	43363000	61321400	31590100	18613200	13612000	14766000	6703480	1922850	1225490	761030	411571	118504	50400
2016	133857000	91534100	69562200	54278400	32842100	13738700	6535470	4394740	10876500	3496870	512233	270939	1065150	427885	62297	17123
2017	190734000	130571000	99935700	79012000	41109200	20854500	12112400	8830090	3511540	1557500	435192	275428	240482	128182	35827	14990
2018	158389000	108428000	82982800	65601000	59841900	30306600	17571700	12800900	7055540	3120640	867067	547900	242449	128913	35827	14935
2019	0				49684700				10228400				469869			

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 refers to the model year.

Year	Recruits (in 1000s)	SSB (tonnes)	F (ages 1–2)	Yield (tonnes)
1974	533516203	605615	1.148	463344
1975	713005719	605010	1.609	732312
1976	330461262	497325	1.653	628598
1977	631747281	337729	1.442	385257
1978	1033275820	388481	0.957	458804
1979	534584303	619706	0.626	463638
1980	328484431	425491	2.158	387434
1981	94300778	302549	1.049	280582
1982	49278577	180954	0.963	162357
1983	66986389	87378	1.615	115440
1984	33531639	65578	0.925	113444
1985	23324153	60355	1.269	62514
1986	79161450	23040	1.054	27520
1987	40832954	55492	0.356	53942
1988	60915609	57412	1.255	103652
1989	54624879	42531	0.296	58420
1990	73809647	41940	1.487	78180
1991	112560341	86163	0.692	125815
1992	104218478	121297	0.802	156471
1993	150428734	166542	1.564	208848
1994	128700686	135402	0.682	424206
1995	36324391	198590	1.448	446555
1996	60854724	108120	1.335	95496
1997	49081856	108662	0.983	125174
1998	109891052	134457	1.651	188907
1999	77593949	130092	0.869	243158
2000	73294784	184241	1.425	222027
2001	61404888	125492	1.498	153321

Year	Recruits (in 1000s)	SSB (tonnes)	F (ages 1–2)	Yield (tonnes)
2002	82227471	111302	1.582	174713
2003	106856781	139944	1.216	174988
2004	188385320	173338	1.848	231352
2005	66452635	228891	1.275	280275
2006	84901303	172474	1.622	78028
2007	60915609	135402	1.561	99902
2008	140399151	102539	1.318	69892
2009	114604772	187963	0.846	170934
2010	120601225	188151	0.98	145415
2011	91696980	166542	0.89	122472
2012	73002190	134592	1.35	96030
2013	171312512	108228	1.198	60207
2014	188385320	219476	0.568	190268
2015	101442227	349759	1.361	298227
2016	133819174	224583	2.203	227169
2017	190659562	174207	1.393	135824
2018	158457979	217510	1.4	190052
2019		216305		

Table 10.9.1. North Sea & 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(2019) (millions)	126950	49685	10228	470
Exploitation pattern Q1	0.002	0.292	0.487	0.428
Exploitation pattern Q2	0.011	0.302	0.978	0.987
Exploitation pattern Q3	0.020	0.122	0.272	0.636
Exploitation pattern Q4	0.000	0.002	0.008	0.008
Weight in the stock Q1 (gram)	5.042	7.552	10.003	13.592
Weight in the catch Q1 (gram)	5.04	7.55	10.00	13.59
Weight in the catch Q2 (gram)	4.72	7.53	10.45	14.66
Weight in the catch Q3 (gram)	5.23	9.09	13.15	16.42
Weight in the catch Q4 (gram)	7.60	14.07	18.76	21.17
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 & 3.a. Short-term predictions options table.

Catch options. Landings and SSB are in thousands of tonnes.					
3-year average weight-at-age was used to calculate SSB. Recruitment(2019) = geom average 2008–2017.					
Basis	F(2019)	Landings(2019)	SSB(2020)	%SSB change	%TAC change
F_{cap}	0.69	139	271	8.83%	not applicable
$F_{(status\ quo)}$	1.4	229	217	-12.95%	not applicable
F=0	0	0	361	44.94%	not applicable
F=0.1	0.1	25	344	38.35%	not applicable
F=0.2	0.2	48	329	32.30%	not applicable
F=0.3	0.3	69	315	26.73%	not applicable
F=0.4	0.4	89	303	21.60%	not applicable
F=0.5	0.5	107	291	16.86%	not applicable
F=0.6	0.6	124	280	12.49%	not applicable
F=0.7	0.7	140	270	8.43%	not applicable
F=0.8	0.8	155	260	4.68%	not applicable
F=0.9	0.9	170	252	1.19%	not applicable
F=1.0	1	183	244	-2.05%	not applicable
$B_{escapement}$ without F_{cap}	5.187	418	125	-49.76%	not applicable

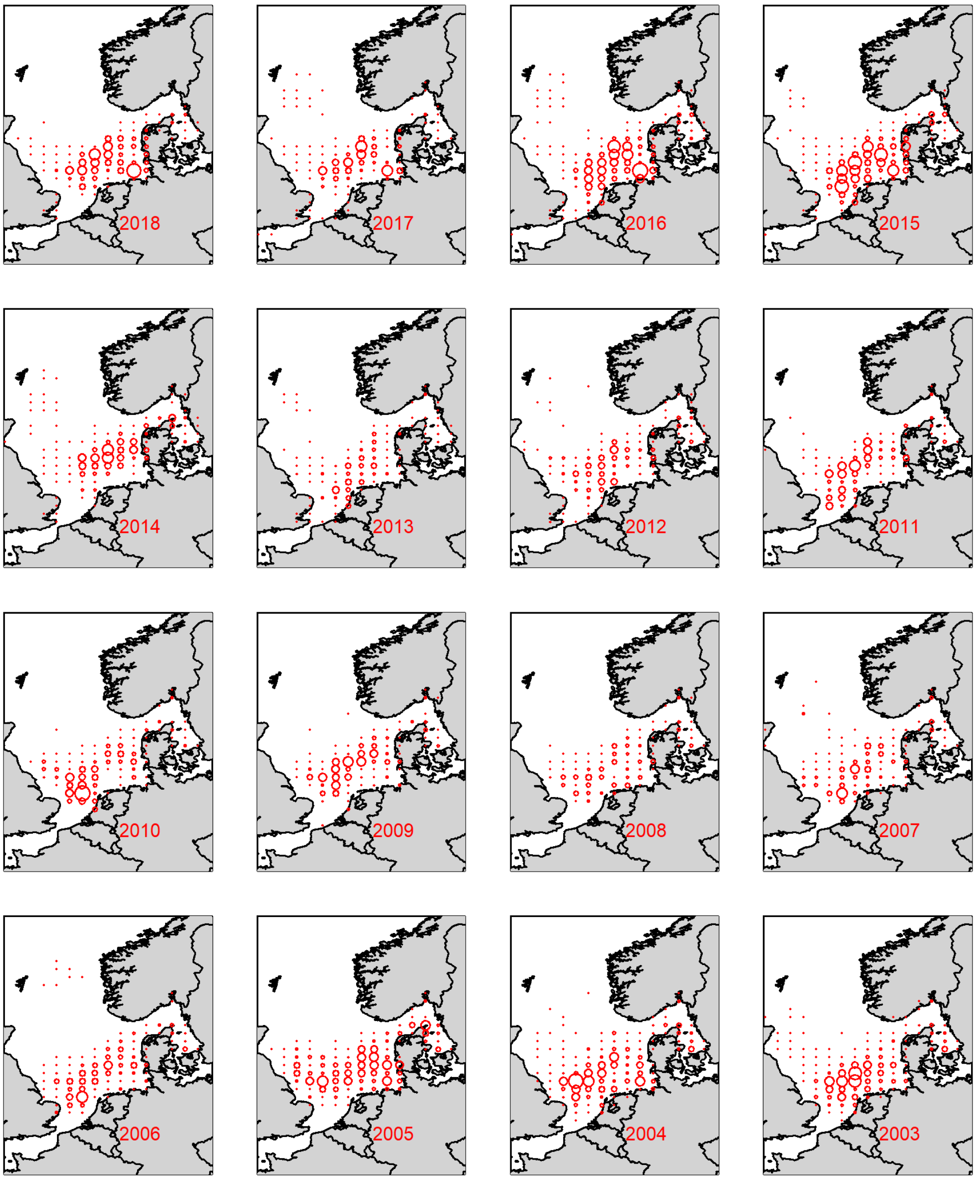


Figure 10.1.1. North Sea & 3.a sprat. Sprat catches in the North Sea and Division 3.a (in tonnes) for each calendar year by statistical rectangle.

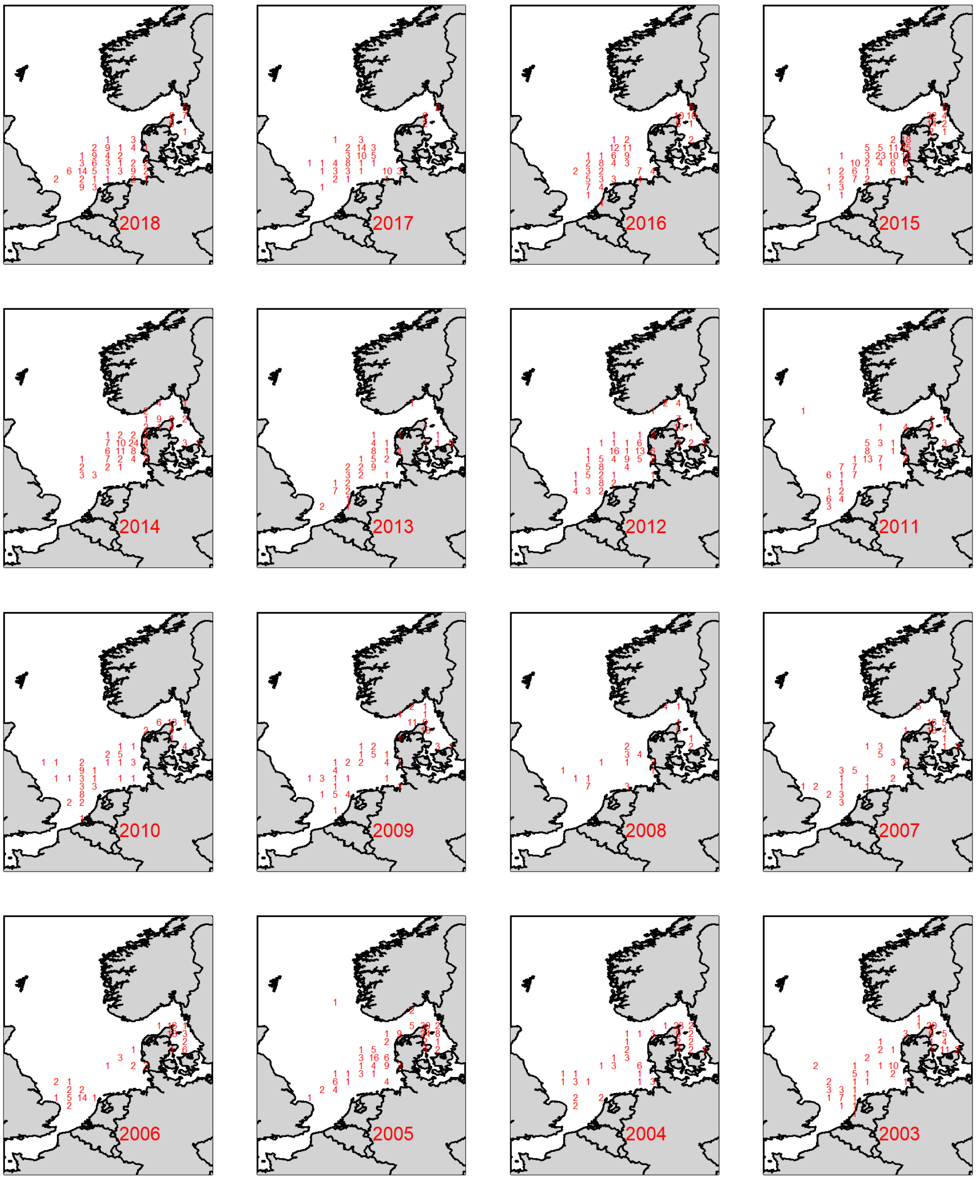


Figure 10.2.1. North Sea & 3.a sprat. Number of samples taken in the North Sea and Division 3.a for each calendar year by statistical rectangle.

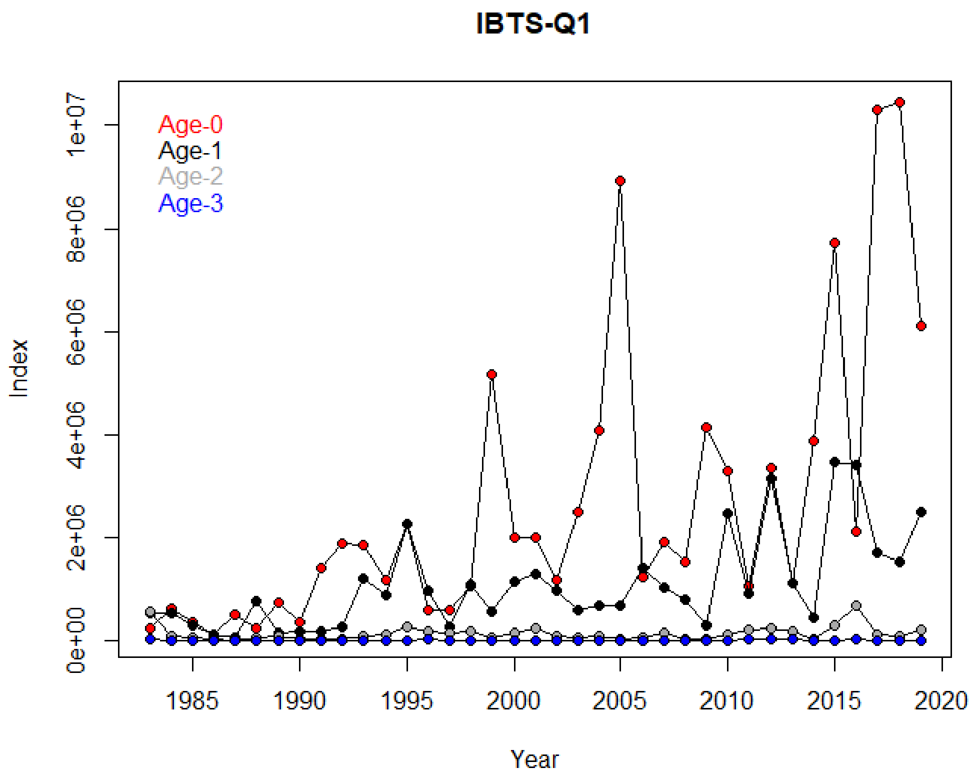


Figure 10.3.1. North Sea & 3.a sprat. IBTS Q1 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018) for details). Years refer to the calendar year.

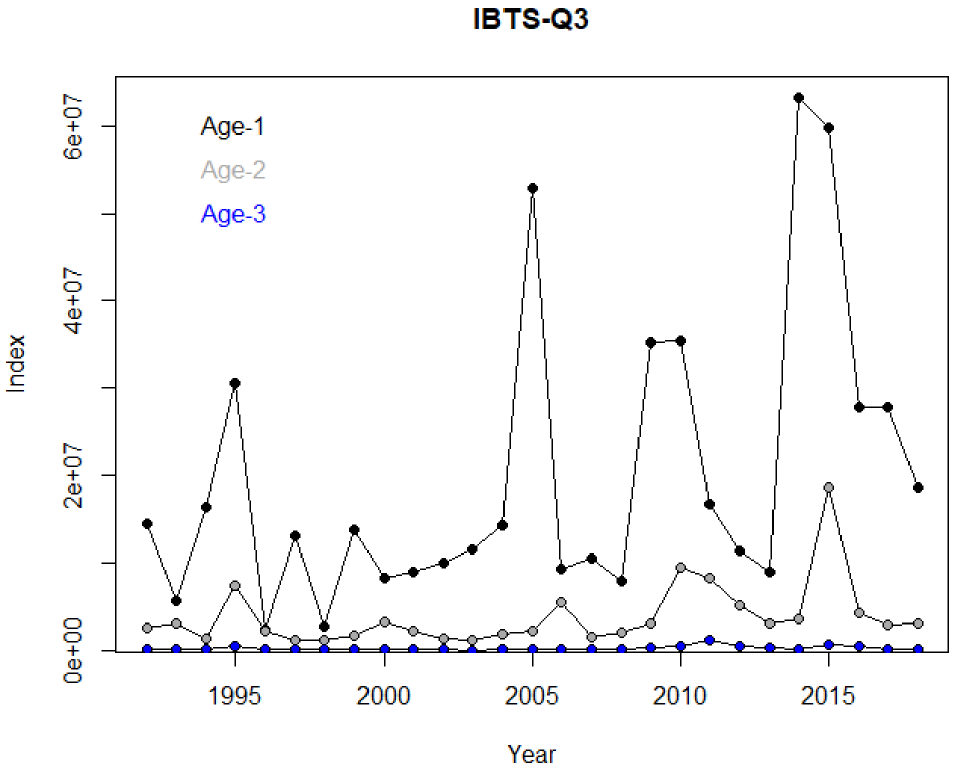


Figure 10.3.2a. North Sea & 3.a sprat. IBTS Q3 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018) for details). Years refer to the calendar year.

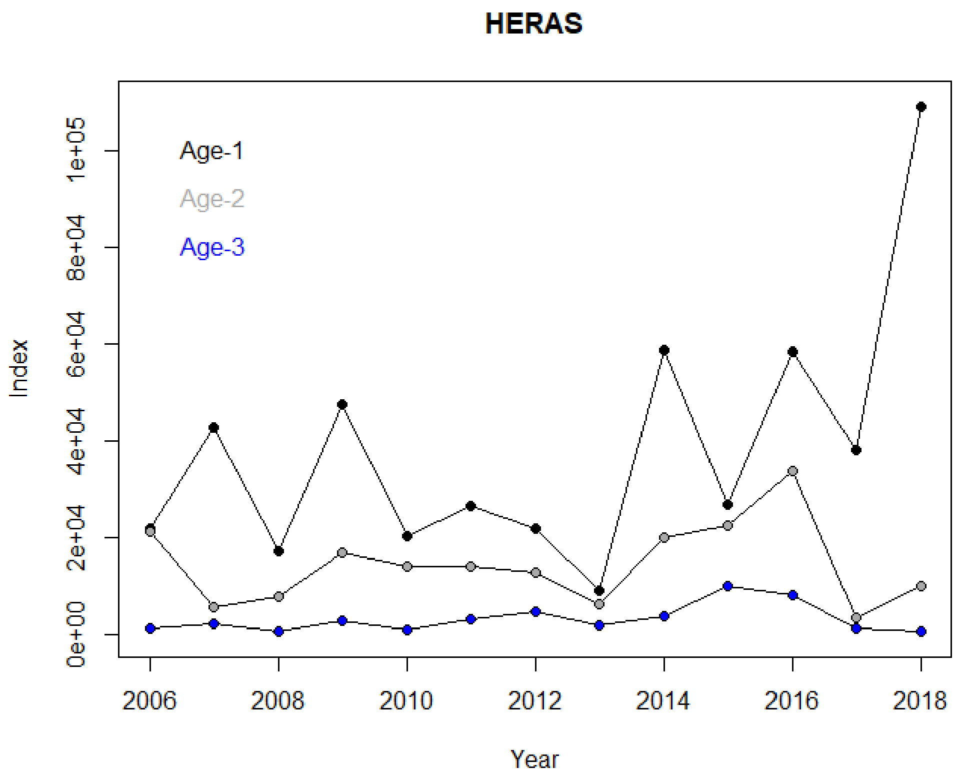
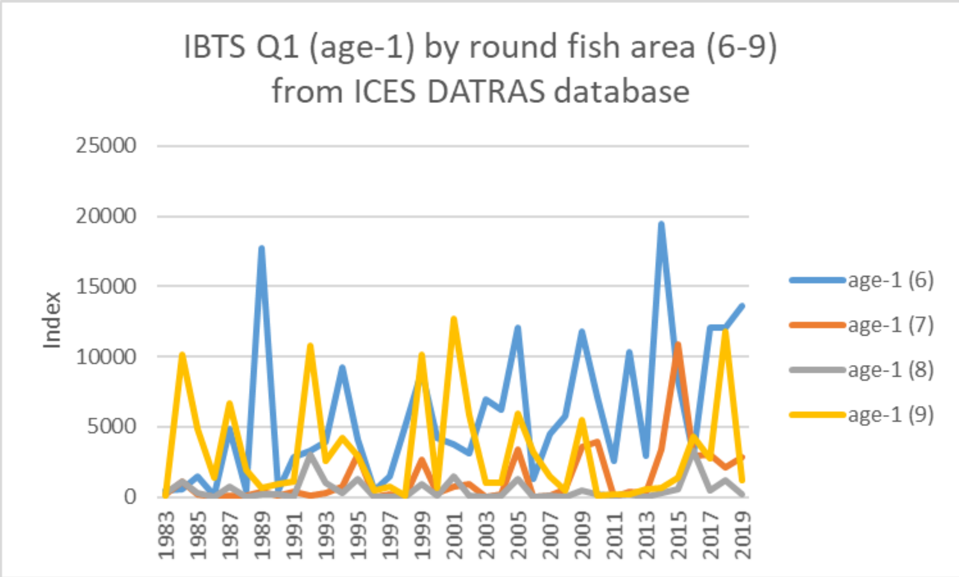


Figure 10.3.2b. North Sea & 3.a sprat. HERAS survey index for Subarea 4 and Division 3.a combined (sum of abundance indices published by WGIPS). Years refer to the calendar year.



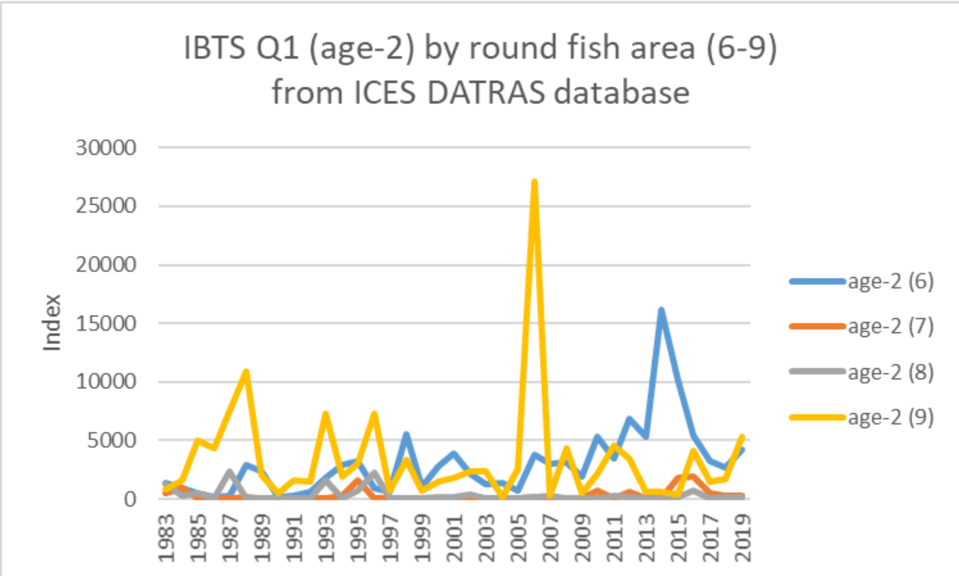
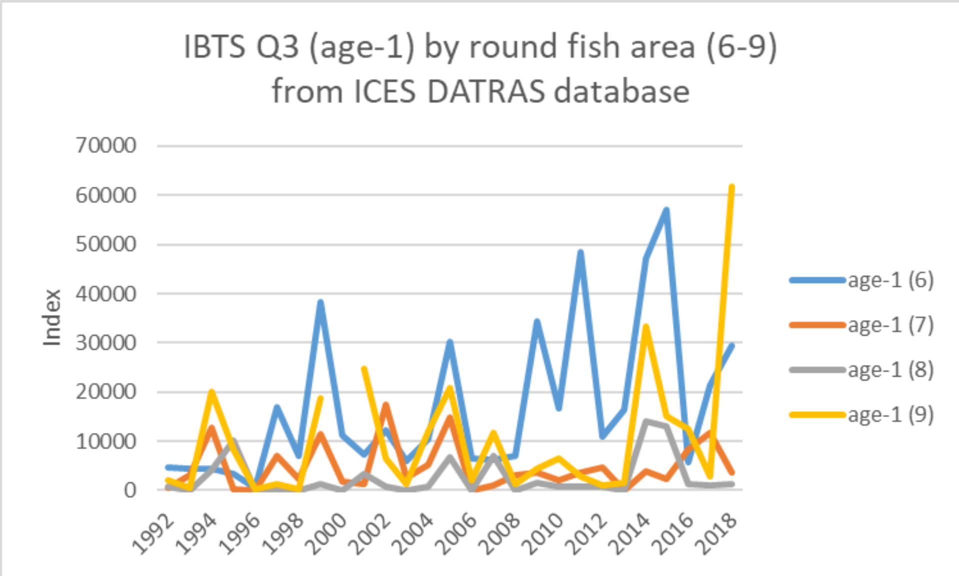


Figure 10.3.2c. North Sea & 3.a sprat. IBTS Q1 indices for round fish areas 6–9 (6 and 7 belong to Subarea 4, and 8 and 9 belongs to Division 3.a) for age 1 (top figure) and age-2 (bottom figure), respectively. Data were downloaded from the ICES DATRAS database. Years and age refer to the calendar year.



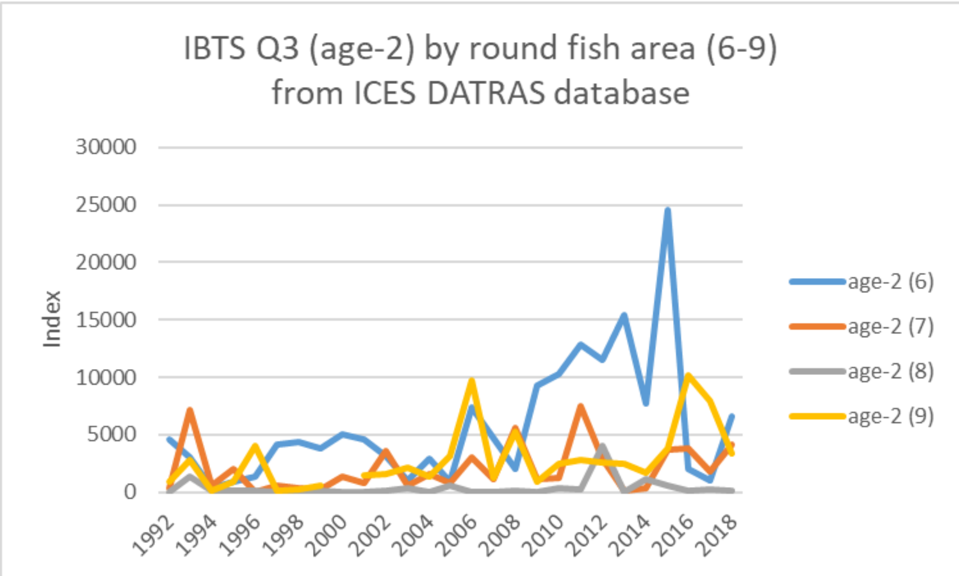


Figure 10.3.3. North Sea & 3.a sprat. IBTS Q3 indices for round fish areas 6–9 (6 and 7 belong to Subarea 4 and 8, and 9 belongs to Division 3.a) for age 1 (top figure) and age-2 (bottom figure), respectively. Data were downloaded from the ICES DATRAS database. Years and age refer to the calendar year.

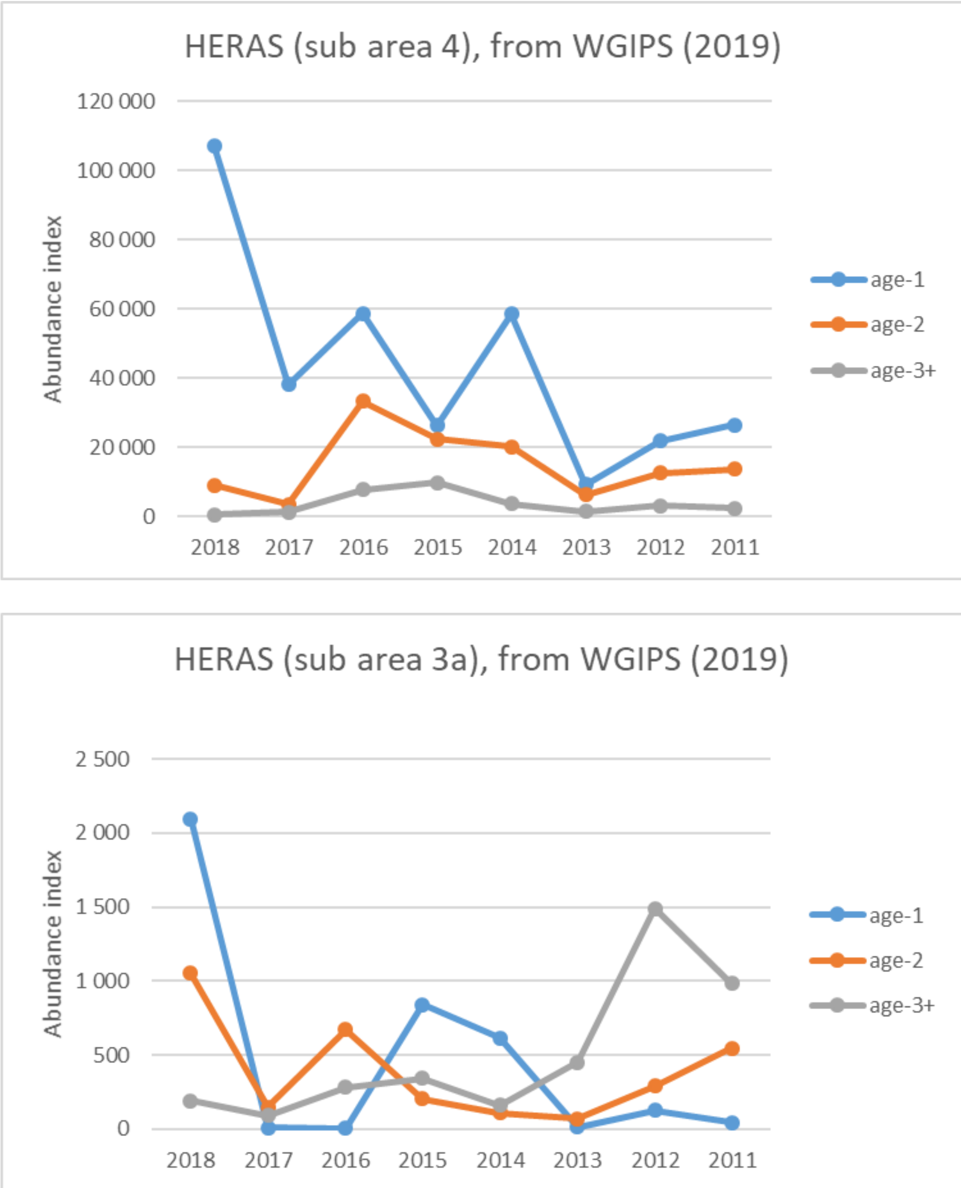


Figure 10.3.4. North Sea & 3.a sprat. HERAS survey index (abundance) for Subarea 4 and Division 3.a, respectively. Data were taken from the most recent WGIPS report.

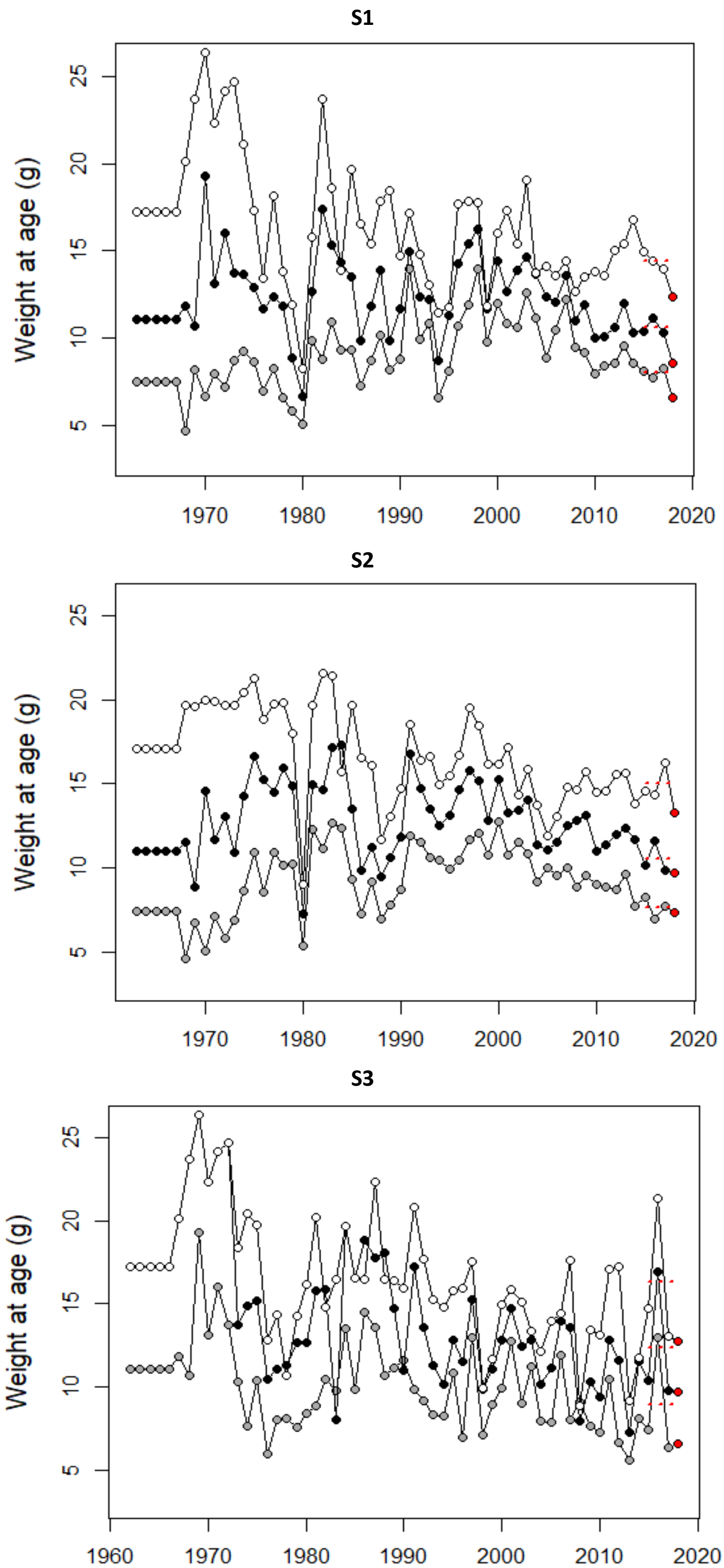


Figure 10.4.1. North Sea & 3.a sprat. Top: Mean weight at age in season 1 (years refer to the model year). Age 1 (grey), age 2 (black), age 3 (white). Red dot is the status quo weight and the red dashed line refer to the 3-year average used in the forecast last year. Middle: Mean weight at age in season 2 (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 average of the three previous years. Bottom: Mean weight at age in season 3 (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 average of the three previous years.

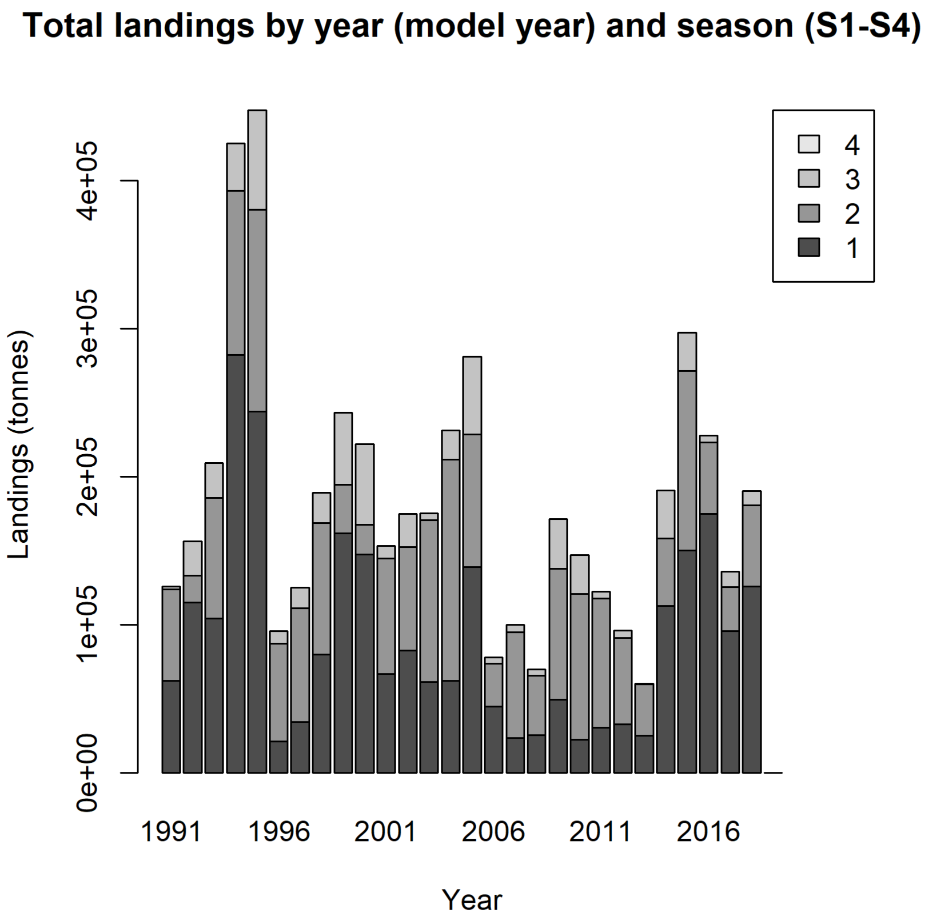


Figure 10.6.1. North Sea & 3.a sprat. Seasonal distribution of catches (Calendar year). Year and season 1-4 refer to the time steps of the model. Note that since the model year of 2018 is not yet finished, the 2018 column will be updated next year. Also note that there are no catches shown for S4, since these are moved to S1 in the following year (see WKSPRAT report (ICES, 2018) for details).

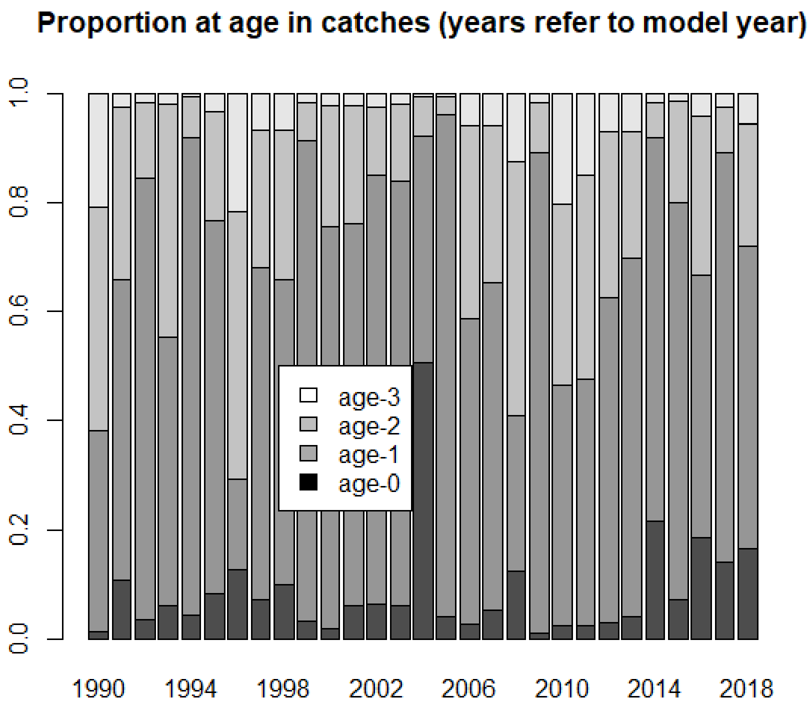


Figure 10.6.1. North Sea & 3.a sprat. Proportion of each age group in the catches. Year and age refer to the model year.

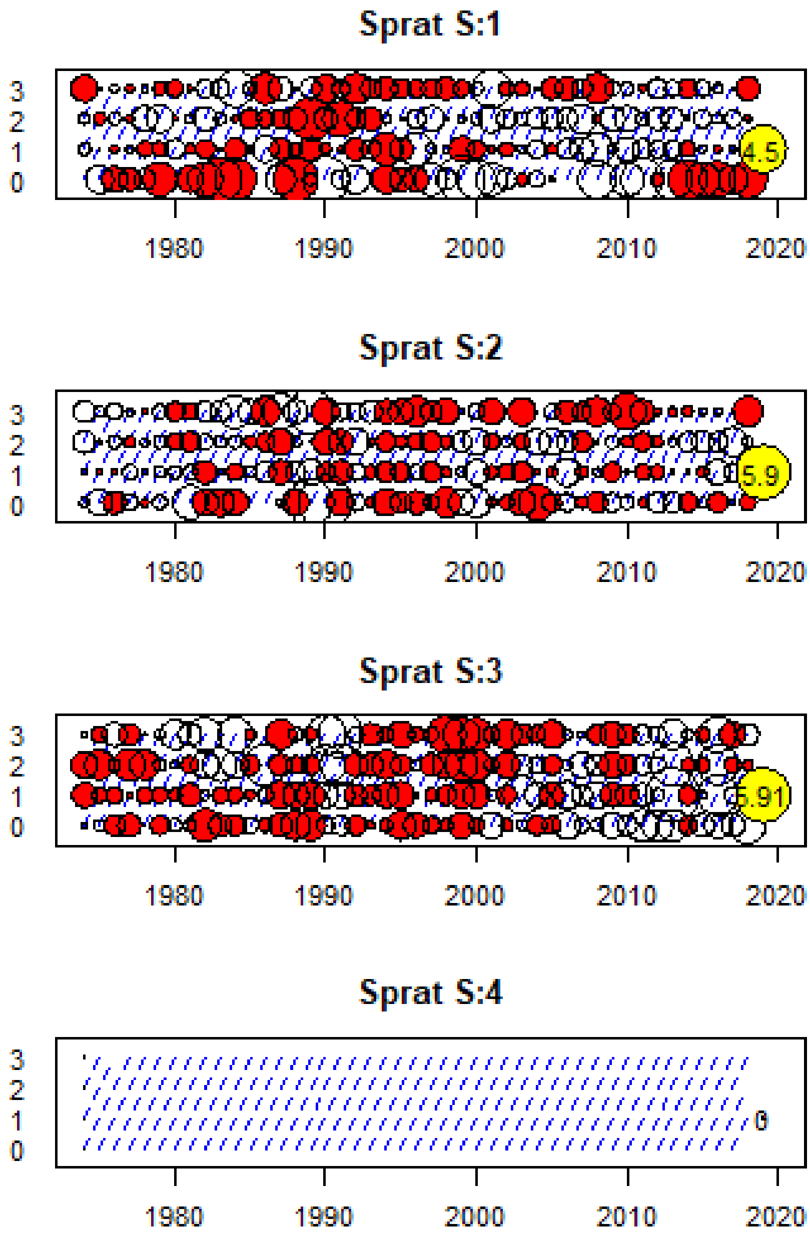


Figure 10.6.2. North Sea & 3.a sprat. Catch residuals by age. (Model year)

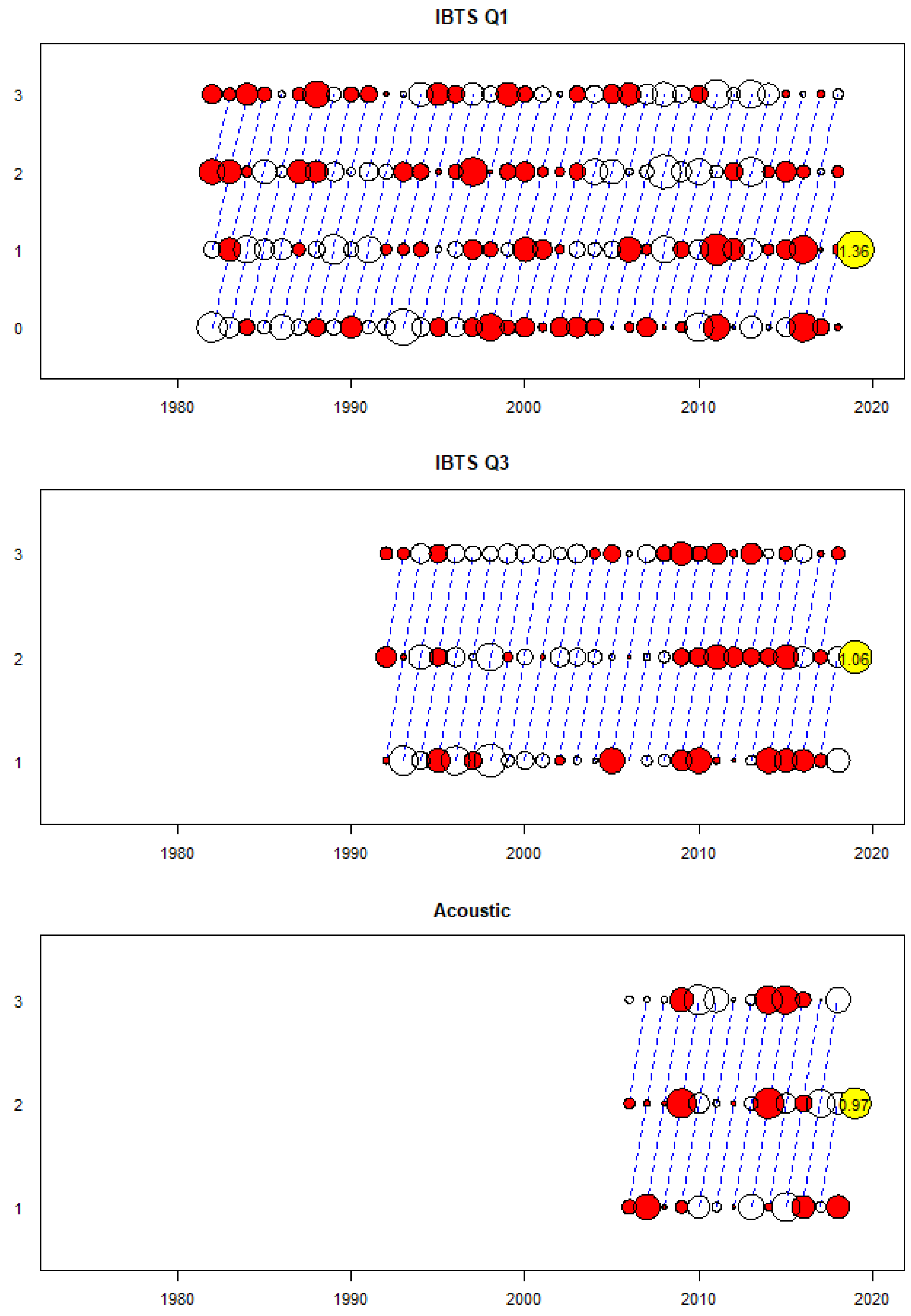


Figure 10.6.3. North Sea & 3.a sprat. Survey residuals by age. (Model year)

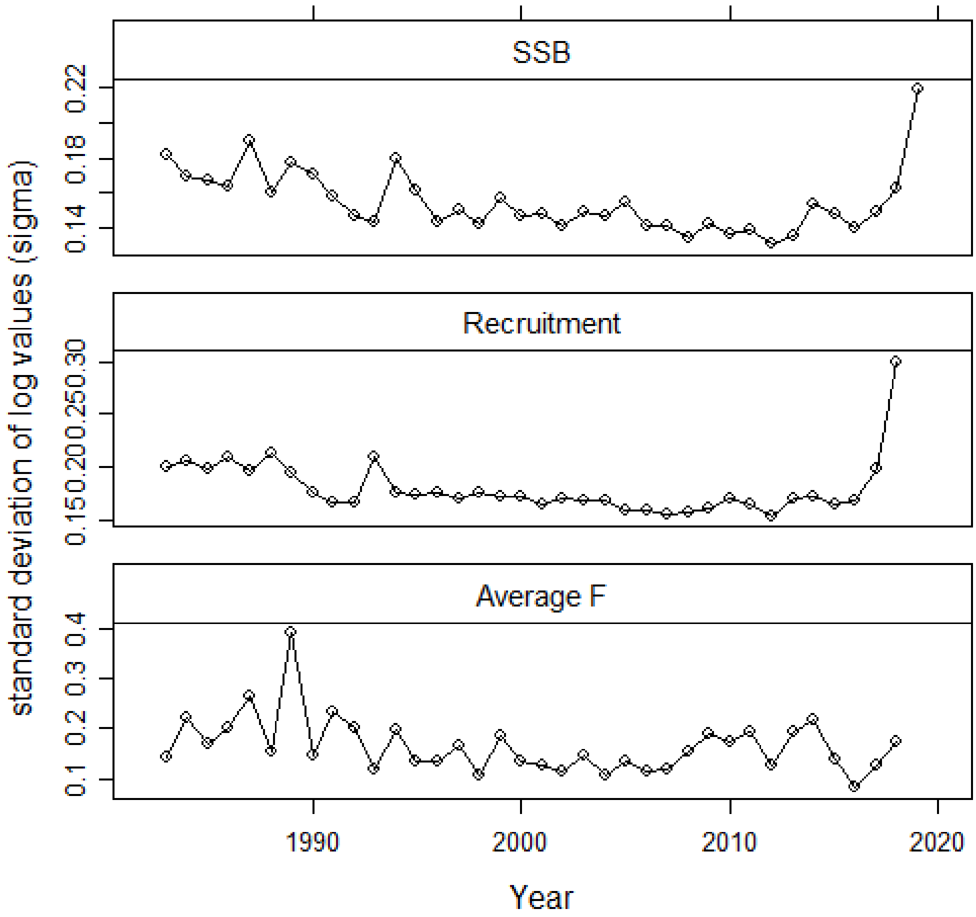


Figure 10.6.4. North Sea & 3.a sprat. Coefficients of variance (Model year).

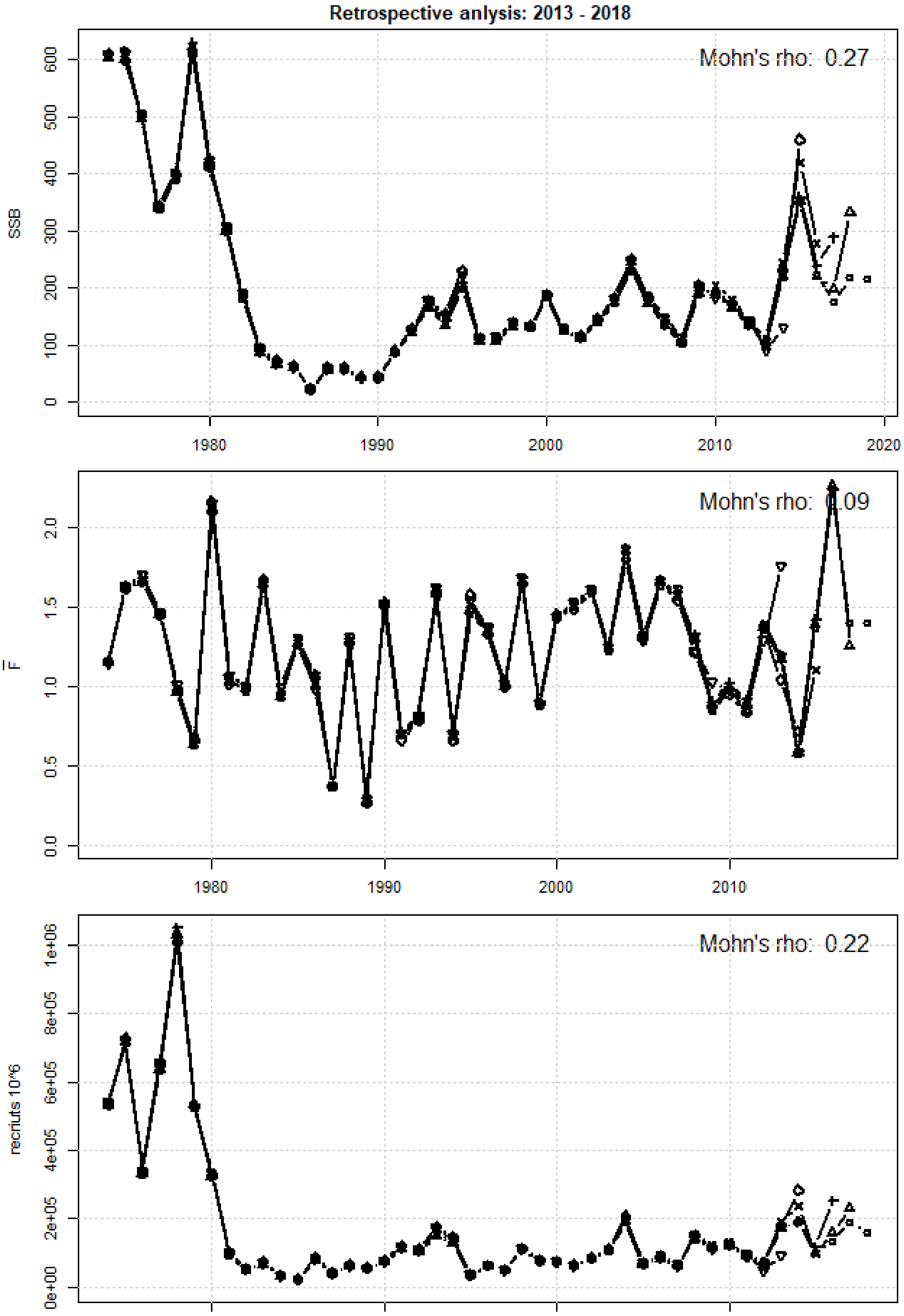


Figure 10.6.5. North Sea & 3.a sprat. Retrospective analysis (Model year)

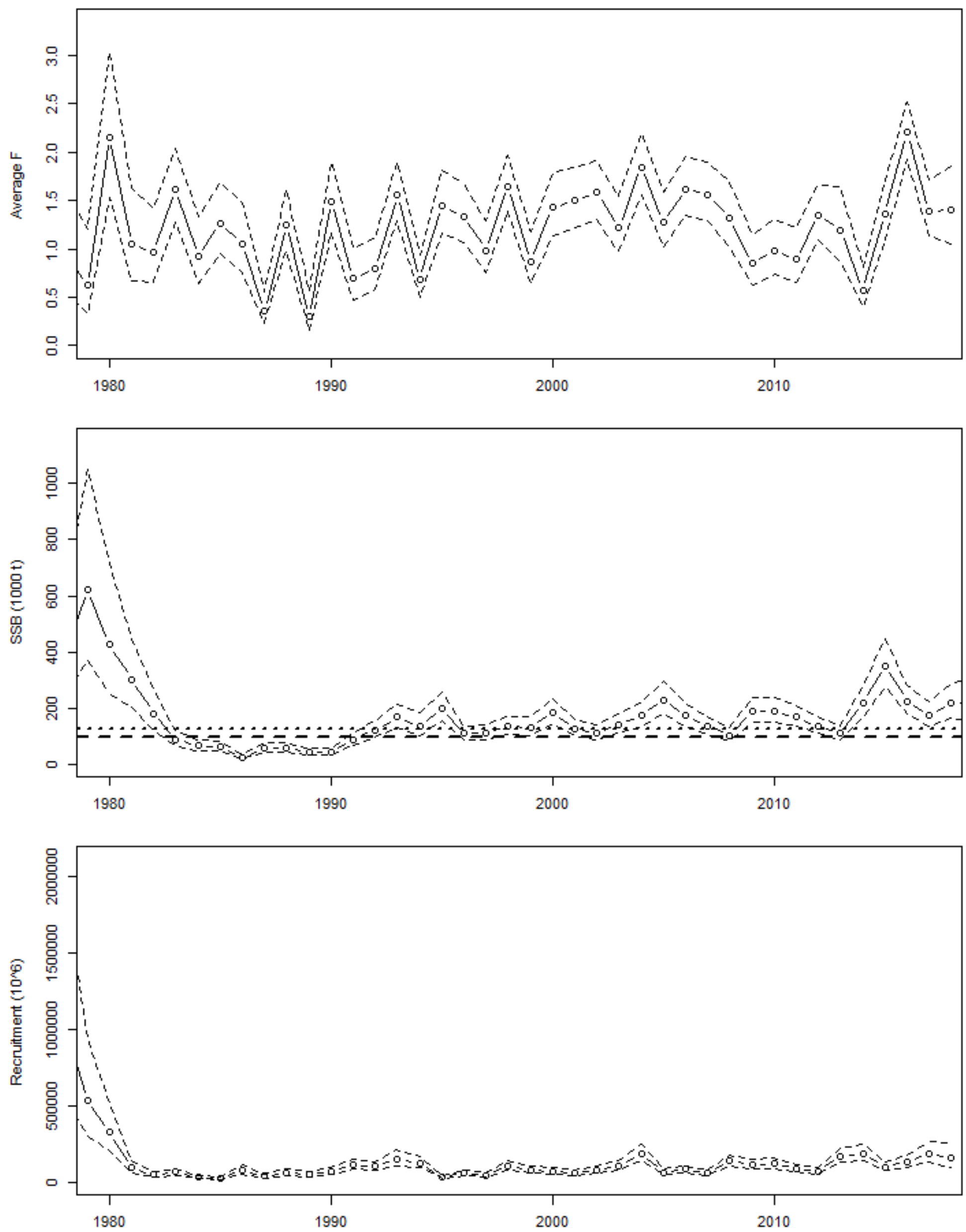


Figure 10.6.6. North Sea & 3.a sprat. Temporal development in Mean F, SSB and recruitment. Hatched lines are 95% confidence intervals (Model year).

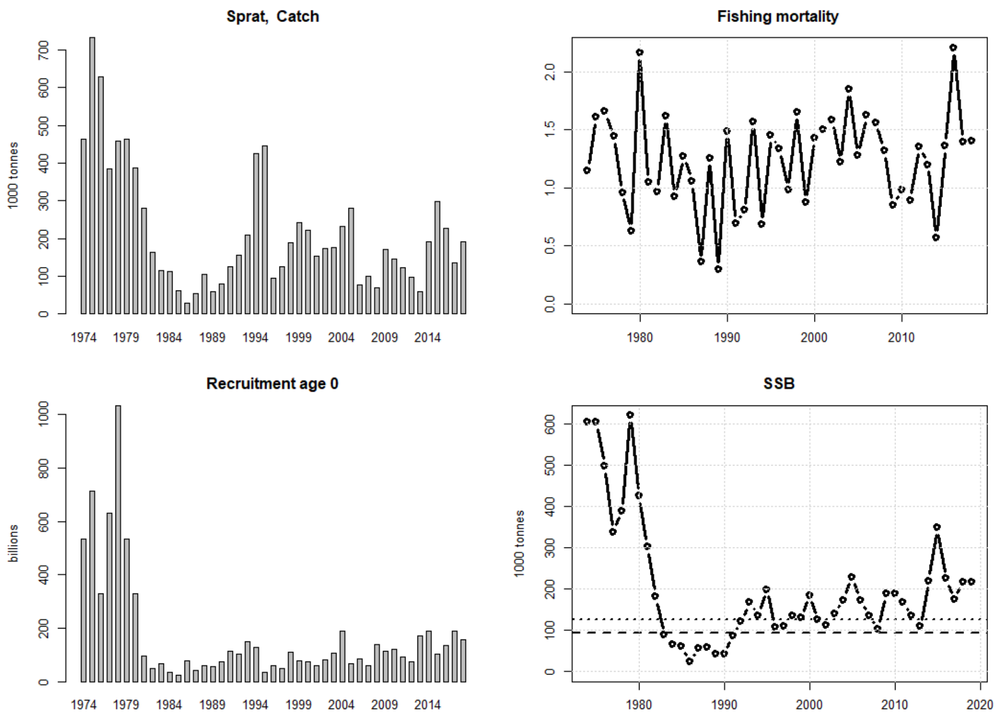


Figure 10.6.7. North Sea & 3.a sprat. Assessment summary (Model year)

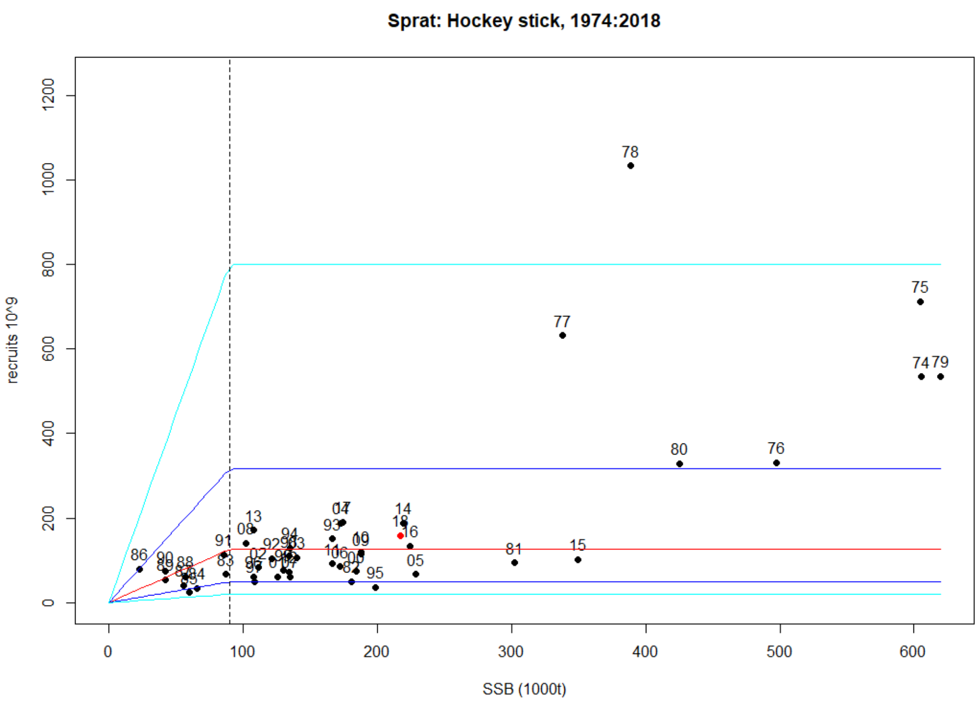


Figure 10.7.1. North Sea & 3.a sprat. Stock-recruitment relationship (Model year).

10.14 Audit of spr.27.3a4 (Sprat in the North Sea)

Working Group: **HAWG**

Stock Name: **Sprat (*Sprattus sprattus*) in Division 3.a and Subarea 4 (Skagerrak, Kattegat and North Sea)**

Date: 20/03/2019
Auditor: Henrik Mosegaard, Christophe Loots, Florian Berg

General

During the last benchmark in 2018 the stock unit was re-defined, combining division 3.a and subarea 4.

For single stock summary sheet advice:

1) **Assessment type:** Update
2) **Assessment**: Analytical assessment
3) **Forecast**: presented
4) **Assessment model**: SMS in quarterly steps. Tuning data IBTS Q1 (age 0-3), IBTS Q3 (age 1-3), HERAS (age 1-3)
5) **Data issues:** No data issues
6) **Consistency**: First assessment for the re-defined stock
7) **Stock status**: B>Bescapement, F is higher than Fcap (0.69).
8) **Management Plan**: No management plan has been developed.

Technical comments

There is no technical issue with this stock

Conclusions
The assessment has been performed correctly

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.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 is required to resolve this uncertainty.

12.1 The Fishery

12.1.1 ICES advice applicable for 2018 and 2019

The TAC for the English Channel (7.d and e) was set equal to 3296 and 2637 tonnes for 2018 and 2019, respectively.

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 the following year into February and sometimes March. 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 times series, Germany, contributing to about 11% of the reported landings. In 2018, 21% of the catches were reported from Denmark with the rest being reported by UK (England, Wales and Northern Ireland). UK has a history of taking the majority of the total landings.

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 changes such as temperature and/or salinity.

12.1.3 Fleets

In the English Channel the primary gear used for sprat is midwater trawl. Within that gear type three 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). 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 the recent period the TAC was not limiting for the sprat landing in the 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

In 2017/2018 fishing season a pilot self-sampling programme started in the South West of UK, involving sprat fisherman from Lyme bay. The skippers have been collecting length frequency distribution of the catches and they have been recording information on fishing trips. The main processors for the fishery have been engaged as well and asked to provide length-weight data from catch subsamples. The length in the fisherman samples ranged from 11 to 15 cm (Figure 12.2.1). The length structure in the processors sample are slightly smaller: few very small individuals have been measured, and the bulk of the catches start from 8 cm up to 15 (Figure 12.2.2).

Four length samples (2 in January and 2 in December) were also collected by the UK within the Data Collection Framework: The length distribution echoes those provided by the skippers within the self-sampling programme (Figure 12.2.3).

Last year was the first year that length frequency distribution for sprat in the English Channel were presented at HAWG. The sampling programme is intended to continue in the future. The data shown are raw numbers-at-length in the samples, and not yet raised to the total catches.

12.3 Fishery-independent information

PELTIC Acoustic Survey

A pelagic survey was undertaken in autumn in the English Channel and Eastern Celtic Sea to acoustically asses the biomass of the small pelagic fish community within this area (divisions 7.d–g). This survey, conducted from the RV Cefas Endeavour, is divided into three geographically separated regions: the western English Channel, the Isles of Scilly and the Bristol Channel (Figure 12.3.1). In 2017, the survey was expanded to cover the southern area of division 7.e and in 2018 was further extended in to division 7.d

Calibrated acoustic data were collected during daylight hours only over three frequencies (38, 120, 200 kHz) from transducers mounted on a lowered drop keel at 8.2 m below the surface. Pulse duration was set to 0.516 m/s for all three frequencies and the ping rate was set to 0.6 s^{-1} as the depth did not exceed 100 m. Data from 38 kHz was used to determine target species abundance for all swim bladder fish. To distinguish between organisms with different acoustic properties (echotypes) a multifrequency algorithm was developed, principally based on a threshold applied to the summed backscatter of the three frequencies, eventually resulting in separate echograms for each of the echotypes.

The acoustic data were then processed using the echoR software. The global area has been split into several strata. For each strata, energies where converted into biomass by applying catch ratio and then weighted by abundance of fish in the haul surrounded area.

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 2018 is shown in Figure 12.3.2. Sex ratio is on average skewed towards female, which contributed to 72% of the sampled fish.

FSP Acoustic Survey off the western English Channel

In October 2011 and 2012, two Fisheries Science Partnership (FSP) surveys were conducted covering the Lyme bay area, where the main sprat population is thought to be concentrated during the onset of the fishing season (September–October).

The estimated sprat biomasses were similar in both years. In 2012, both estimates (2011, and 2012) were re-computed using a new more robust Target Strength (TS) published for herring (Saunders *et al.*, 2012), which has brought down the estimates but still shows a healthy population. The revised 2011 sprat biomass estimate is 33 861 tonnes and the estimate for 2012 is 27 971 tonnes.

Biological data

Biological information from trawl catches carried out during the FSP acoustic survey where sampling information was available, suggested that most (73.1% by number) of the sprat were mature (spent), with 26.9% immature, and that the sex ratio slightly favored females (59:41). Four age classes were identified: 0, 1, 2 and 3, contributing 1.5%, 8.9%, 70.1% and 19.4% to the population by number, respectively. Low numbers of the 0 and 1 age groups may be the result of gear selectivity. The observed low numbers of sprat age 4 and older could be the result of exploitation as the fishery targets the larger fish for human consumption. However, just three of the trawl hauls contained good samples of sprat, so it is equally possible that the age 4+ sprat were under-sampled because of their different geographic distribution or behavior.

IBTS Q1 in the Eastern English Channel

Starting in 2006, the French in quarter 1 started to carry out additional tows in the Eastern English Channel as part of the standard IBTS survey. This proved successful and starting in 2007 the RV 'Thalassa' carried out 8 GOV trawls and 20 MIK stations.

During the IBTSWG in 2009, Roundfish Area 10 was created to cover these new stations fished by France and the Netherlands.

Data are stored in DATRAS database and available for the period 2007 to 2012.

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

An attempt for an analytical assessment was carried out for sprat in the English Channel (WKSPRAT, 2013) but was considered preliminary and still not suitable to be used as a basis for advice. A Landing per Unit Effort index (LPUE) based on hours at sea of between 2 and 4 vessels in the Lyme Bay area was used as basis for the assessment until 2015; in 2016 the LPUE was replaced by the PELTIC acoustic survey index, which is currently used as a basis for advice of the sprat stock in divisions 7.d–e.

The advice is based on the ICES framework for category 3 stocks using the ratio between average of the two latest values from the PELTIC acoustic survey and the average of the three preceding values multiplied by the recent ICES advised catch.

The recent workshop on management strategy evaluations (WKSpratMSE, 2018) concluded that for short lived species the “2 over 3” rule was not dynamic enough and a “1 over 2” rule was tested and found to be not precautionary. Further work is due to be carried out in the autumn of 2019 to develop a more appropriate method for providing advice for sprat and other short-lived species.

12.6.1 Data exploration

Biomass Index

A 6-years 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 carried out in partnership with the fishery. The stock identity for sprat in the Channel is still unclear. However, 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 2018 showed very low numbers of sprat, mainly 0 year old’s, in the southern area of 7.e. The transects located in the very eastern part of division 7.e seems to confirm that the sprat stock in the western English Channel do not extend in to the Eastern English Channel (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. 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 please refer to 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 the hypothesis of two different stocks.

In 2018 the biomass index from the PELTIC acoustic survey was used to provide advice on sprat in Division 7.d–e applying the “2 over 3” rule (ratio between average biomass of the last 2 years and average biomass of the previous 3 years). The index was also used to provide an indication of the current harvest rate.

The biomass, as estimated by the survey for the English Channel strata only, is stable at high levels in 2013–2014. This trend is followed by a 23% decrease in 2015 and an 85% drop in 2016 to its lowest level of the series. The estimates for 2017 resulted in an upward rescaling (by 3 times) of the biomass compared to 2016, but still remained at about half the values observed at the beginning of the time series (Table 12.6.1, Figure 12.6.2). A slight decline in biomass was observed in 2018.

Landings per Unit of Effort

A data exploration for English Channel sprat was carried out in 2013 at the benchmark workshop WKSPRAT. An LPUE time-series for English Channel sprat based on mid-water trawler data was constructed and used as the basis for advice until 2015. In 2016 the LPUE index was replaced as basis for advice by the PELTIC acoustic survey, which is deemed to provide a more accurate representation of the stock status. The index is shown here as it provides an indication of the stock development over time due to the long time series, but it is no longer used for the assessment.

The LPUE was based on data from ~three <15 m vessels that target sprat in the area: the time series was revised in 2017 to account for changes in the database and has been recalculated using days instead of hours, as this information is no longer available (Table 12.6.2 and Figure 12.6.3). Vessels considered for LPUE calculations have been making use of standard sonar technology to locate the fish throughout the period of analysis and no other major technical advances need to be factored out. Also, these vessels account for on average 95% of total landings for the area. The LPUE was computed seasonally from 1 August to 31 March. If there were no landings in August or March, the effort in those months were excluded from the computation.

The index shows an increasing trend over the time series with the highest values observed between 2010 and 2014. A slight drop is observed in 2015 stabilizing around 9000 kg/day (Figure 12.6.3), two to three times higher than that observed at the beginning of the time series.

12.7 State of the Stock

The acoustic estimates for 2017 show a three-time increase compared to the all-time low value in 2016, even though the biomass is still half of the high levels recorded in the period 2013–2015. The estimate in 2018 shows a slight decline on the 2017 value but is still twice that of the lowest level of the time series. The harvest rate index (Figure 12.7.1) has dropped from the value of 34% recorded in 2016 to less than 15% which is higher than that observed in 2013–2015.

CATCH ADVICE

Catch advice for 2019 is based on the 5 years (2014–2018) acoustic estimates. Discards occur but are believed to be negligible, therefore the advice is for catch. The advice is based on category 3.2 (WKLIFE, 2012) according to the data and analyses available and uses the "2 over 3" rule for the calculation of a catch multiplier to be applied to last year catch advice. The ratio resulting from the "2 over 3" rule is 0.47; a 20% uncertainty cap is applied, which means that a reduction of maximum 20% of last year advised catch (1883 tonnes) is recommended; hence, ICES advise that catch in 2020 should not exceed 1506 tonnes.

12.8 Short term projections

No projections are presented for this stock.

12.9 Reference Points

No precautionary reference points are defined for sprat populations in this region due to uncertainty in stock definition.

An attempt was made to estimate reference points for this stock following ICES guidelines and using the SPiCT model: convergence was achieved using only the last 5 years of the time series and, despite converging, the confidence intervals around the estimated variables were huge, indicating that the data are not informative and the results not reliable. One year of length frequency distribution is available for this stock: however, length-based reference points are not considered suitable for such short lived species. An upcoming benchmark in 2018 will discuss the issues and propose some solutions.

12.10 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.

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. The most plausible hypothesis is that the pool of young fish in the Bristol Channel contribute mainly to the Irish Sea population. Investigations are continuing to resolve this uncertainty.

12.11 Management Considerations

Sprat is a short-lived species with large inter-annual fluctuations in stock biomass. The natural inter-annual variability in 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 2990 tonnes on average. The harvest rate, estimated as the ratio between catches and the acoustic index, is low (around 10%) throughout the 5-year time series available, with the exception of 2016 value (34%). In general, however, it seems that Lyme Bay, where most of the fishery occurs, consistently hosts quite substantial level of the sprat stock: this is confirmed by the fact that even in 2016, when the estimated biomass is overall very low, Lyme Bay still contributed to 50% of the total sprat population in the Western English Channel. This is also supported by the high LPUE values observed in the last few years.

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 recovery of the stock and that the decline in sprat biomass is not to be ascribed to fishing mortality, but it is most likely caused by environmental factors.

12.12 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 chains have been collected during the PELTIC acoustic survey: these data in the future will be able to provide a substantial contribution to knowledge available in the area.

Table 12.1.1 Sprat in 7.d-e. Landings of sprat, 1985–2018.

Country	Denmark	France	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
1985	0	14	0	3 771	0	0	3 785
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

Country	Denmark	France	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
2012	6	2	8	4 458	0	0	4 474
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

Table 12.6.1. Sprat in 7.d–e. Annual sprat biomass in ICES Subdivision 7.e (Source: Cefas annual pelagic acoustic survey).

Survey	Area	Season	2011	2012	2013	2014	2015	2016	2017	2018
Partial	Lyme Bay	Oct	33 861	24 246	62 040	67 538	12 212	6 181	29 996	15 310
FSP	Lyme Bay*	Oct	33 861	27 971						
PELTIC	W Eng Ch	May	85 358							
PELTIC	W Eng Ch	Oct			70 680	85 184	65 219	9 826	32 751	17 091

*** ICES rectangles 29E6, 30E6**

Table 12.6.2. Sprat in 7.d–e. Landings per unit effort (LPUE) for 3 vessels that target sprat. The years refer to the start of the season 1 August year (y) to 31 March in year (y+1). Please note that LPUE for 2018 and 2019 is estimated as kg/day, as number of hours were not available.

Year	HAWG 2015	HAWG 2016	HAWG 2017	HAWG 2018	HAWG 2019*
1988	283	283	624	3 815	3 815
1989	668	682	395	4 432	4 432
1990	429	429	569	3 684	3 684
1991	528	528	481	4 147	4 147
1992	422	422	560	3 887	3 784
1993	630	630	850	4 779	4 737
1994	742	747	612	7 809	7 809
1995	599	599	899	5 831	5 831
1996	803	803	927	6 768	6 768
1997	868	868	601	6 845	6 808

Year	HAWG 2015	HAWG 2016	HAWG 2017	HAWG 2018	HAWG 2019*
1998	736	736	971	6 794	6 794
1999	970	970	844	8 919	8 919
2000	631	683	732	8 369	8 369
2001	508	521	944	5 976	5 976
2002	598	644	622	5 992	5 992
2003	352	375	841	4 215	4 190
2004	588	588	1 108	5 938	5 841
2005	1 050	1 050	1 388	8 820	8 820
2006	992	992	1 059	8 035	8 035
2007	1 050	1 050	945	8 241	8 241
2008	1 029	1 029	890	8 085	8 085
2009	773	773	1 388	7 474	7 474
2010	1 527	1 527	1 288	13 260	13 260
2011	1 042	1 042	1 709	9 801	9 801
2012	1 904	1 904	1 870	13 475	13 475
2013	1 933	1 933	2 225	11 398	11 398
2014	2 413	2 405	1 683	11 977	11 977
2015		2 221	1 765	8 763	8 763
2016			624	9 459	9 459
2017				9 515	9 457
2018					8 373

***provisional**

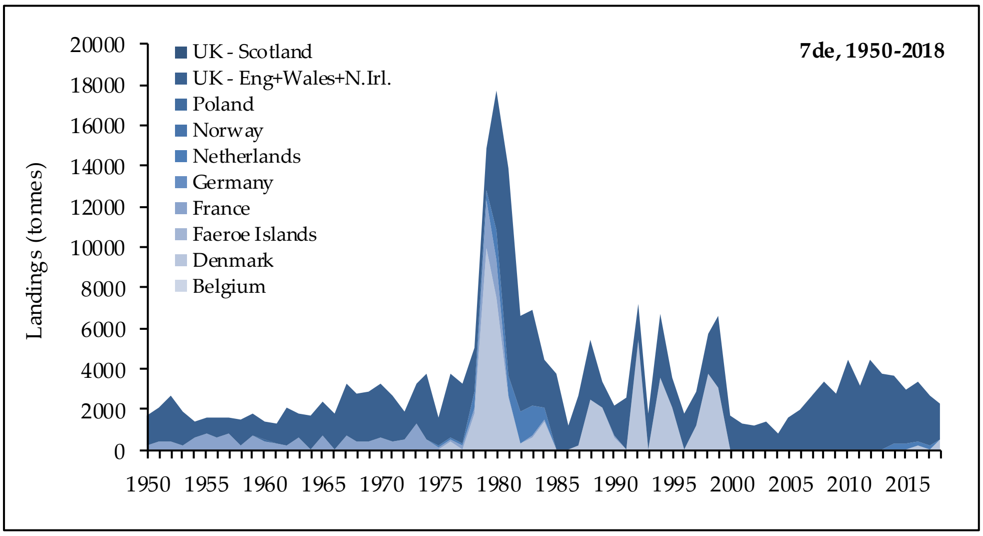


Figure 12.1.1. Sprat in 7.d-e. Landings of sprat 1950–2018.

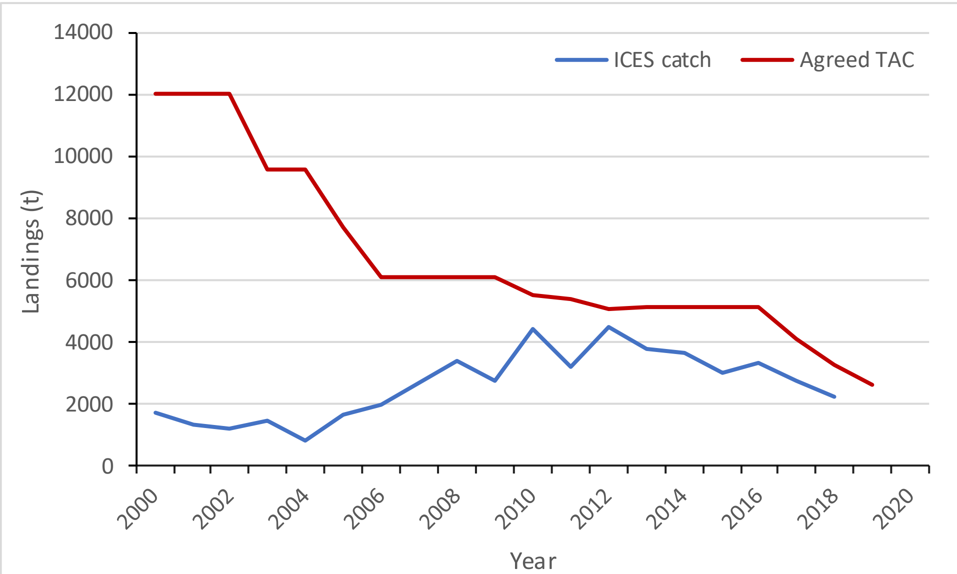


Figure 12.1.2. Sprat in 7.d-e. ICES catch (blue line) and agreed TAC (red line) from 2000 to 2019.

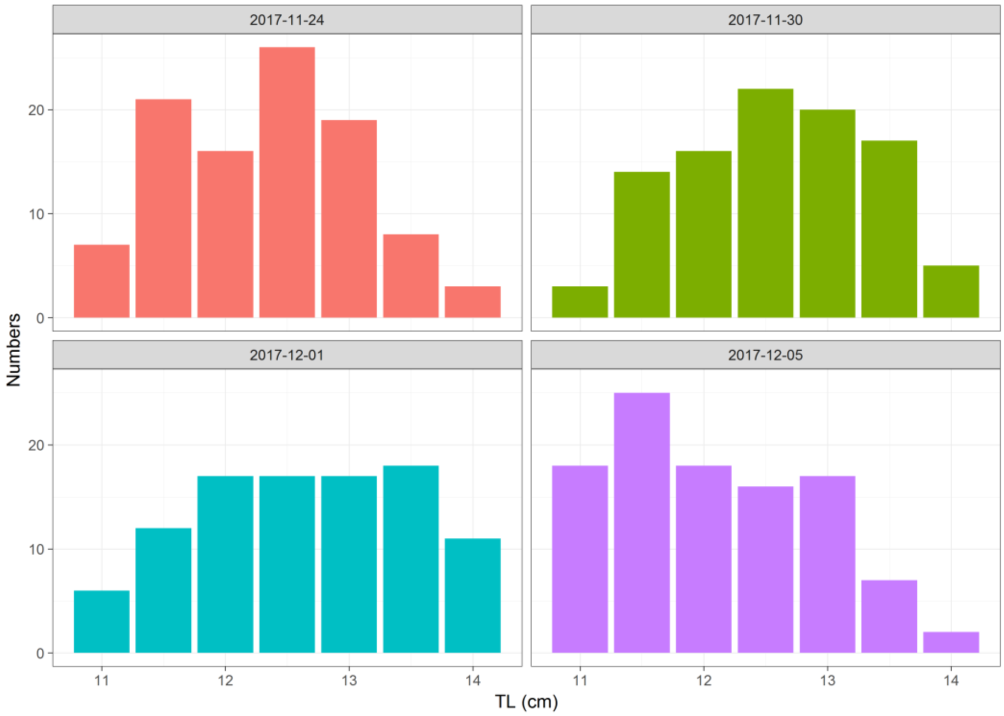


Figure 12.2.1. Sprat in 7.d-e. Length frequency distribution of sprat for 4 samples collected by one vessel from the Lyme bay area within a self-sampling programme.

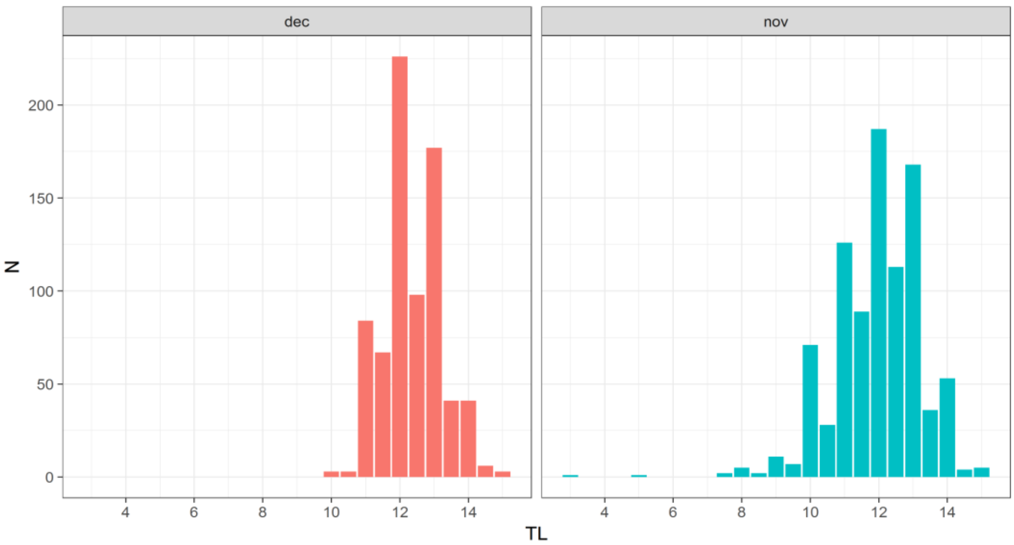


Figure 12.2.2. Sprat in 7.d–e. Length frequency distribution of sprat from samples in November (right) and December (left) collected by one processor in the Lyme Bay area within a self-sampling programme.

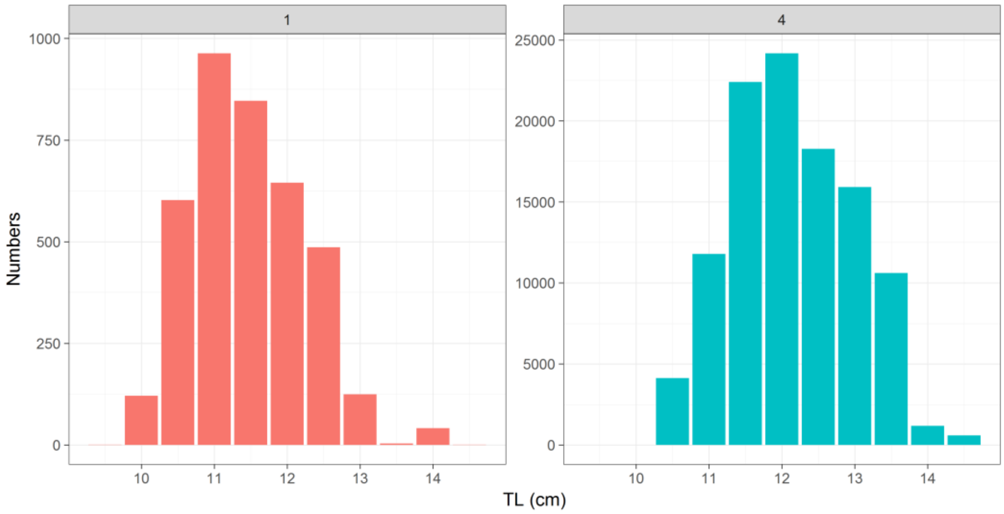


Figure 12.2.3. Sprat in 7.d-e. Length frequency distribution of sprat from samples in Quarter 1 (left) and quarter 4 (right) provided by UK within the Data Collection Framework.

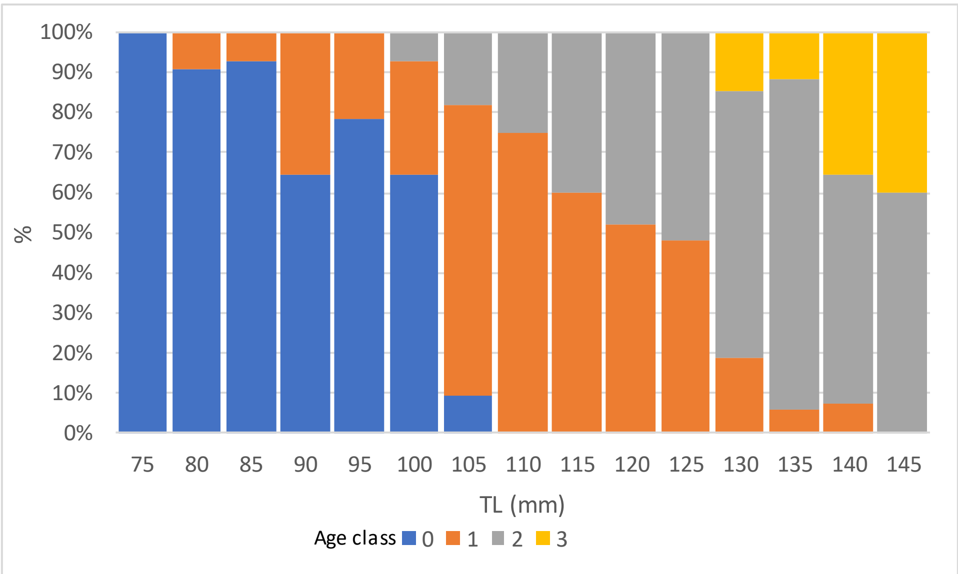


Figure 12.3.2. Sprat in 7.d-e. Proportion of numbers-at-age in the biological sample collected during the 2018 PELTIC acoustic survey

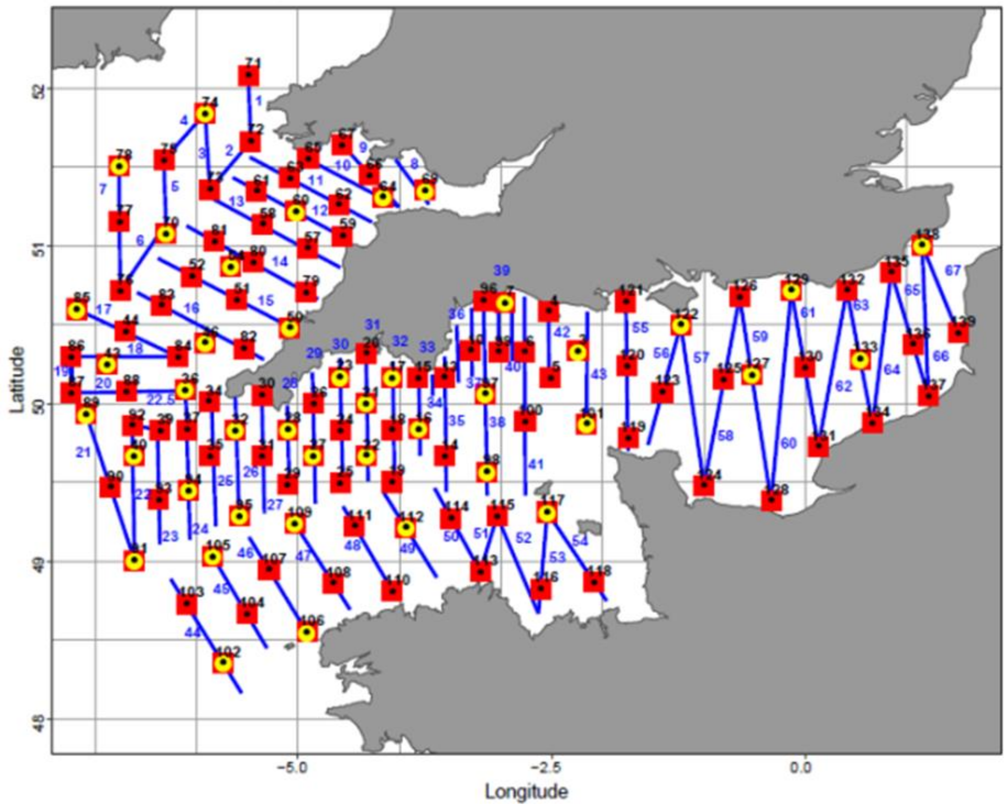


Figure 12.3.1. Sprat in 7.d–e. Survey design with acoustic transects (blue lines), zooplankton stations (red squares) and oceanographic stations (yellow circles).

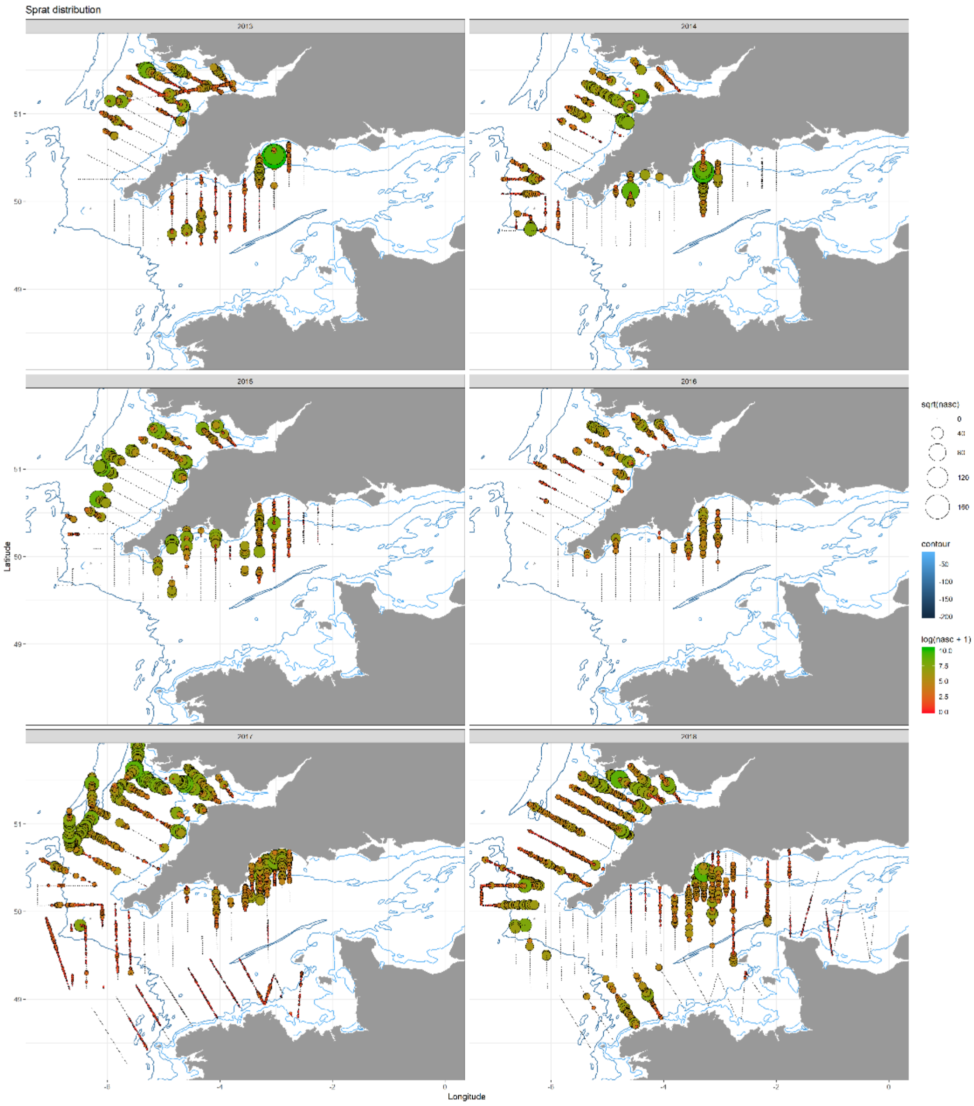


Figure 12.6.1. Sprat in 7.d–e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October.

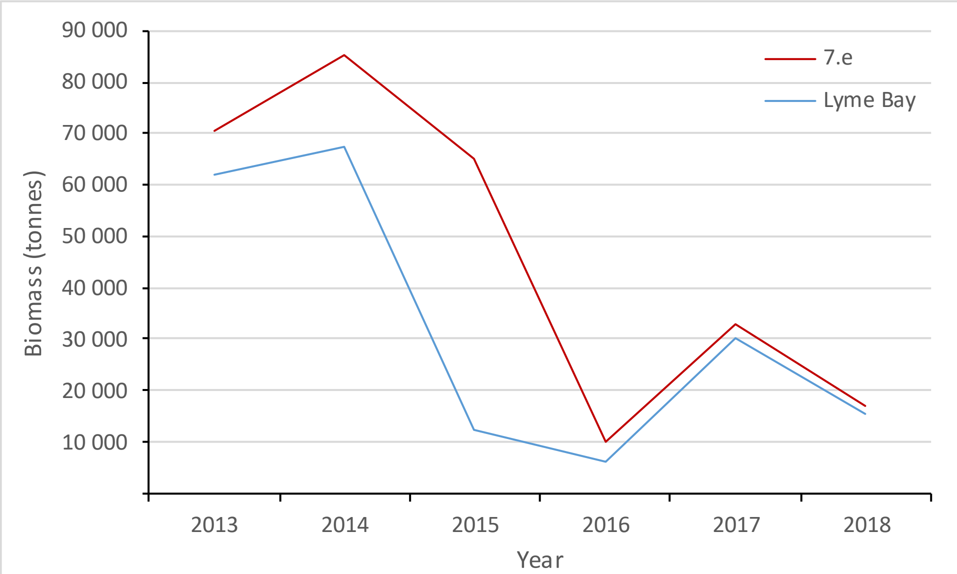


Figure 12.6.2. Sprat in 7.d-e. Biomass of sprat estimated from the PELTIC acoustic survey from 2013 to 2018 for Division 7.e (red line) and the Lyme Bay area (blue line).

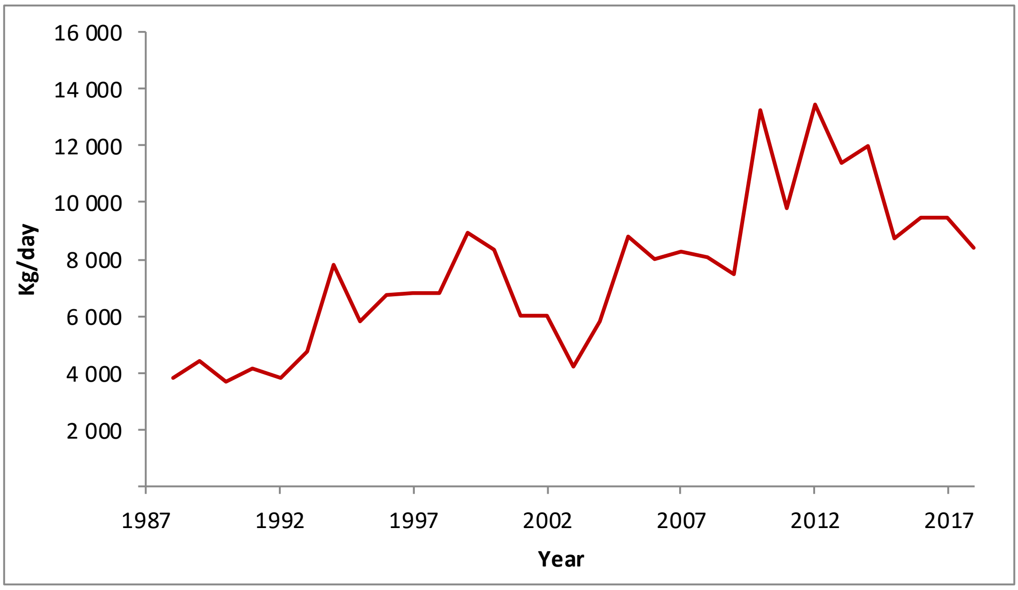


Figure 12.6.3. Sprat in 7.d–e. LPUE (kg/day). LPUE time series from 1989 to 2018.

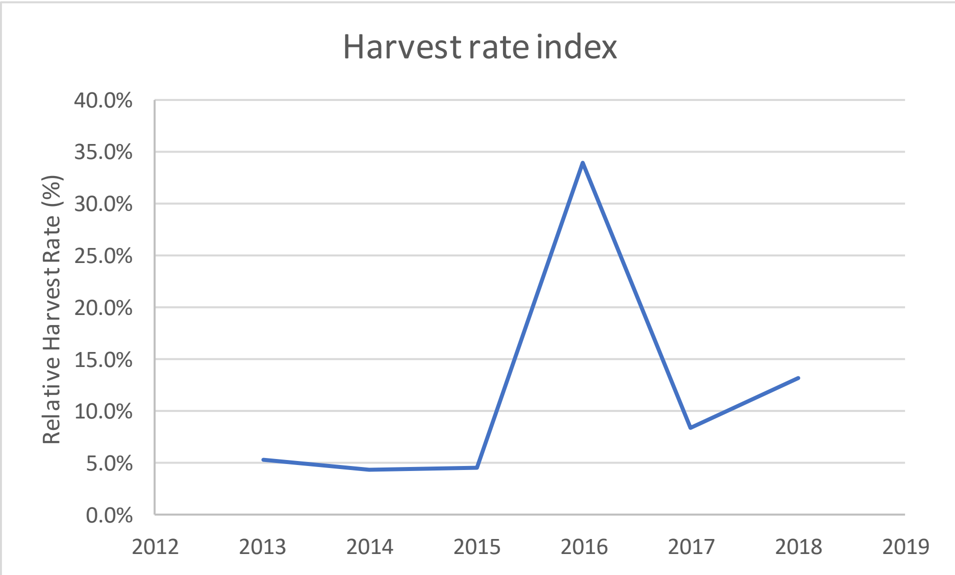


Figure 12.7.1. Sprat in 7.d-e. Harvest rate index (ratio between landings and PELTIC acoustic survey biomass estimate).

13 Sprat in the Celtic Seas (subareas 6 and 7)

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 and in the English Channel (7.d–e). 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 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 2019 and 2020

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, based on precautionary consideration, ICES advised that catches should not be allowed to increase in 2019. 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 13.1.1–13.1.8 and in figures 13.2.1–13.2.8.

Division 6.a (West of Scotland and Northwest of Ireland)

Landings have been dominated by UK-Scotland and Ireland (Table 10.1.1). 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 10.2.1). 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 much lower than that of 2017, 1 tonne in total.

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 13.2.2–3). The fishery came to an end in 1979, due to the closure of the fish meal 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 over-estimated. No landings from 7.aN were reported 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. With the exception of 2014, the last decade, Irish landings are mainly from 7.aS, predominantly from Waterford Harbour.

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 the 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 the winter of 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 most recent years. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

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 data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Divisions 7.d–e (English Channel)

Please refer to Section 12 (Sprat in subarea 7.de).

13.1.3 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 drift-net, fixed nets, lines and pots and most of the landings are sold for human consumption.

In Ireland, larger sprats are sold for human consumption whilst smaller ones for fish meal. Other countries mainly land catches for industrial purposes.

13.1.4 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 fish meal and oil. It is not clear whether bycatches of herring in sprat fisheries in Irish and Scottish waters are subtracted from quota.

13.1.5 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 (6a)

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 is 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

Celtic Sea Acoustic Survey

The Irish Celtic Sea Herring Acoustic Survey was used to calculate sprat biomass. Biomass estimates for Celtic Sea Sprat for the period November 1991 to October 2014 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 inter-annual 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 (Figure 13.3.1). Biomass in 2015 is really high, while the value for 2016 dropped down again. This 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.

Scottish Acoustic Surveys

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.

Scottish IBTS surveys

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 ground fish 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 sub area 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).

Northern Ireland Groundfish Survey

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.

AFBI Acoustic Survey

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. No further updates were provided to the working group.

PELTIC Acoustic Survey

Please refer to Section 12 (Sprat in divisions 7.d-e).

FSP Acoustic Survey off the western English Channel

Please refer to Section 12 (Sprat in divisions 7.d-e).

IBTS Q1 in the Eastern English Channel

Please refer to Section 12 (Sprat in divisions 7.d-e).

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 ground fish and acoustic surveys may provide an index of sprat recruitment in this ecoregion. However further work is required.

13.6 Stock Assessment

An analytical assessment was carried out for sprat in the English Channel at WKSPRAT 2013 and requires further development prior to its acceptance. 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 inter-annual fluctuations in stock biomass. The natural inter-annual variability in 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 by-catch ceiling limitation of herring as well as by-catch 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, 1985–2018, 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	Faeroe Islands	Ireland	Norway	UK Eng+Wales+N.Irl.	UK Scotland	Total
1985	0	0	51	557	0	2946	3554
1986	0	0	348	0	2	520	870
1987	269	0	0	0	0	582	851
1988	364	0	150	0	0	3 864	4 378
1989	0	0	147	0	0	1 146	1 293
1990	0	0	800	0	0	813	1 613
1991	0	0	151	0	0	1 526	1 677
1992	28	0	360	0	0	1 555	1 943
1993	22	0	2 350	0	0	2 230	4 602
1994	0	0	39	0	0	1 491	1 530
1995	241	0	0	0	0	4 124	4 365
1996	0	0	269	0	0	2 350	2 619
1997	0	0	1 596	0	0	5 313	6 909
1998	40	0	94	0	0	3 467	3 601
1999	0	0	2 533	0	310	8 161	11 004
2000	0	0	3 447	0	0	4 238	7 685
2001	0	0	4	0	98	1 294	1 396
2002	0	0	1 333	0	0	2 657	3 990
2003	887	0	1 060	0	0	2 593	4 540
2004	0	0	97	0	0	1 416	1 513
2005	0	252	1 134	0	13	0	1 399
2006	0	0	601	0	0	0	601
2007	0	0	333	0	0	14	347
2008	0	0	892	0	0	0	892
2009	0	0	104	0	0	70	174
2010	0	0	332	0	0	537	869
2011	0	0	468	0	248	507	1 223
2012	0	0	113	0	0	1 688	1 801

Country	Denmark	Faeroe Islands	Ireland	Norway	UK Eng+Wales+N.Irl.	UK Scotland	Total
2013	0	0	487	0	0	968	1 455
2014	0	0	3	0	0	1 540	1 543
2015	0	0	1 305	0	0	1 060	2 365
2016	0	0	431	0	0	2 177	2 608
2017	0	0	604	0	0	1 354	1 958
2018	0	0	1	0	0	0	1

Table 13.1.2 Sprat in the Celtic Seas Ecoregion. Irish landings of sprat, 1985–2018 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	1 152	1	6	0	1 159
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
2002	0	0	306	0	306
2003	0	0	592	0	592

Country	Ireland	Isle of Man	UK Eng+Wales+N.Irl.	UK Scotland	Total
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	771
2016	150	0	0	0	150
2017	150	0	0	0	150
2018	0	0	0	0	0

Table 13.1.3 Sprat in the Celtic Seas Ecoregion. Irish landings of sprat, 1985–2018 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	3 103
2004	408
2005	361
2006	114
2007	0
2008	102
2009	0
2010	433
2011	1 535
2012	6 261
2013	2 545
2014	16
2015	3659
2016	935
2017	935
2018	1 117

Table 13.1.4. Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2018, 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
2003	38
2004	68
2005	260
2006	40
2007	32
2008	1
2009	238
2010	0
2011	0
2012	23

Country	Ireland
2013	237
2014	0
2015	250
2016	0
2017	874
2018	508

Table 13.1.5 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2018, from divisions 7.d–e. (tonnes)

Country	Denmark	France	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
1985	0	14	0	3 771	0	0	3 785
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	0 836	0	0	842

Country	Denmark	France	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
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
2013	0	0	0	3 793	0	0	3 793
2014	45	0	275	3 358	0	0	3 658
2015	0	1	346	2 657	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

Table 13.1.6 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2018, 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

Country	Netherlands	UK Eng+Wales+N.Irl.	Total
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
2013	0	2	2
2014	0	1	1
2015	0	0	0
2016	0	1	1
2017	0	0	0
2018	0	0	0

Table 13.1.7 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2018, divisions 7.g–k. Irish data may be underestimated due to difficulties in quantifying the landings from vessels of less than 10 m length. (tonnes)

Country	Denmark	France	Ireland	Netherlands	Spain	UK Eng+Wales+N.Irl.	Total
1985	0	0	3 245	0	0	0	3 245
1986	538	0	3 032	0	0	2	3 572
1987	0	1	2 089	0	0	0	2 090
1988	0	0	703	1	0	0	704
1989	0	0	1 016	0	0	0	1 016
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	3 924	0	0	0	3 924
1997	0	0	461	0	0	6	467
1998	0	0	1 146	0	0	0	1 146
1999	0	0	3 263	0	0	0	3 263
2000	0	0	1 764	0	0	0	1 764
2001	0	0	306	0	0	0	306
2002	0	0	385	0	0	0	385
2003	0	0	747	0	0	0	747
2004	0	0	3 523	0	0	0	3 523
2005	0	0	4 173	0	0	0	4 173
2006	0	0	768	0	0	0	768
2007	0	0	3 380	0	1	0	3 381
2008	0	0	1 358	0	0	0	1 358
2009	0	0	3 431	0	0	0	3 431
2010	0	0	2 436	0	0	0	2 436
2011	0	0	1 767	0	0	12	1 779
2012	0	0	2 632	0	0	0	2 642

Country	Denmark	France	Ireland	Netherlands	Spain	UK Eng+Wales+N.Irl.	Total
2013	0	0	1 648	0	0	0	1 648
2014	0	0	2 311	0	0	0	2 311
2015	0	0	3 322	0	0	0	3 322
2016	0	0	3 248	0	0	0	3 189
2017	0	0	1 755	0	0	0	1 755
2018	10	0	1 955	0	0	0	1 965

Table 13.1.8 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2018. Total Landings, subareas 6 and 7. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length. (tonnes)

Country	Denmark	Faeroe Islands	France	Ireland	Isle of Man	Netherlands	Norway	Spain	UK England & Wales	UK Scotland	Other.	Total
1985	0	0	14	3 964	0	273	557	0	3 791	2 946	0	11 545
1986	553	0	0	4 532	1	0	0	0	1 173	520	0	6 779
1987	519	0	24	2 230	0	0	0	0	2 441	582	0	5 796
1988	2 893	0	2	853	0	2	0	0	2 948	3 870	0	10 568
1989	2 092	0	10	1 163	0	0	0	0	1 521	1 146	0	5 932
1990	608	0	79	1 325	0	0	0	0	1 562	813	0	4 387
1991	0	0	0	205	0	0	0	0	2 571	1 526	0	4 302
1992	5 417	0	35	508	0	0	0	0	1 791	1 555	0	9 306
1993	22	0	3	2 353	0	0	0	0	1 798	2 230	0	6 406
1994	3 572	0	1	232	0	0	0	0	3 178	1 531	0	8 514
1995	2 575	0	0	799	0	0	0	0	1 546	4 124	0	9 044
1996	0	0	2	4 214	0	0	0	0	1 789	2 350	0	8 355
1997	1 245	0	1	2 085	0	0	0	0	1 629	5 313	0	10 273
1998	3 781	0	0	1 578	0	0	0	0	2 027	3 467	0	10 853
1999	3 064	0	0	5 826	0	1	0	0	4 014	8 161	0	21 066
2000	0	0	1	6 032	0	1	0	0	2 064	4 238	0	12 336
2001	0	0	0	455	0	0	0	0	1 716	1 297	0	3 468

2002	0	0	0	1 729	0	0	0	0	1 502	2 657	0	5 888
2003	887	0	2	4 948	0	72	0	0	1 960	2 593	0	10 462
2004	0	0	6	4 096	0	0	0	0	970	1 416	0	6 488
2005	0	252	0	5 928	0	0	0	0	2 239	0	0	8 419
2006	0	0	7	1 523	0	0	0	0	2 532	0	0	4 062
2007	0	0	0	3 745	0	0	0	1	2 708	14	0	6 468
2008	0	0	0	2 353	0	0	0	0	3 369	0	0	5 722
2009	0	0	2	3 773	0	0	0	0	2 774	70	0	6 619
2010	0	0	2	3 200	0	0	0	0	4 415	537	0	8 154
2011	0	0	1	3 770	0	37	0	0	3 399	507.3	0	7 714
2012	6	0	2	9 029	0	8	0	0	4 460	1 688	0	15 193
2013	0	0	0	4 916	0	0	0	0	3 795	968	0	9 680
2014	45	0	0	2 852	0	275	0	0	3 339	1 540	0	8 050
2015	0	0	1	9 328	0	346	0	0	2 657	1 060	0	13 392
2016	185	0	7	4 763	0	231	0	0	2 868	2 177	49	10 280
2017	0	0	0	4 318	0	235	0	0	2 498	1 354	0	8 405
2018	484	0	1	3 580	0	0	0	0	1 776	0	0	5 842

Table 13.3.1. Sprat in the Celtic Seas Ecoregion. Sprat biomass by year in the Celtic Sea (Source: MI Celtic Sea Herring Acoustic Survey, ICES, 2016).

Year	Biomass (t)
Nov/Dec-91	36 880
Jan-92	15 420
Jan-92	5 150
Nov-92	27 320
Jan-93	18 420
Nov-93	95 870
Jan-94	8 035
Nov-95	75 440
2002	20 600
2003	1 395
2004	14 675
2005	29 019
2008	5 493
2009	16 229
2011	31 593
2012	35 100
2013	44 685
2014	33 728
2015	83 779
2016	28 016

Table 13.3.2. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Division 7.a (Source: AFBI annual herring 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				
2018				

Figure 13.1. Sprat in the Celtic Seas Ecoregion. Map showing areas mentioned in the text.

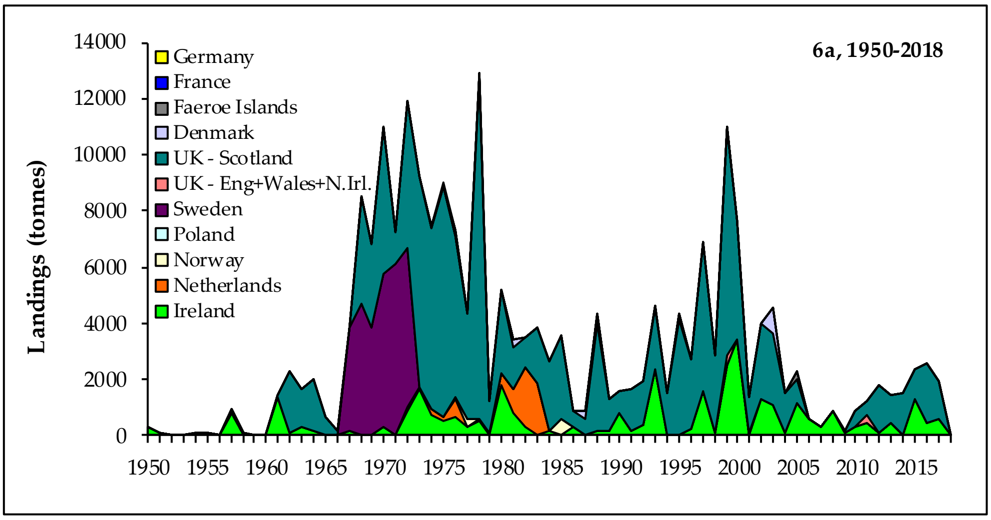


Figure 13.2.1. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2018 ICES Division 6.a.

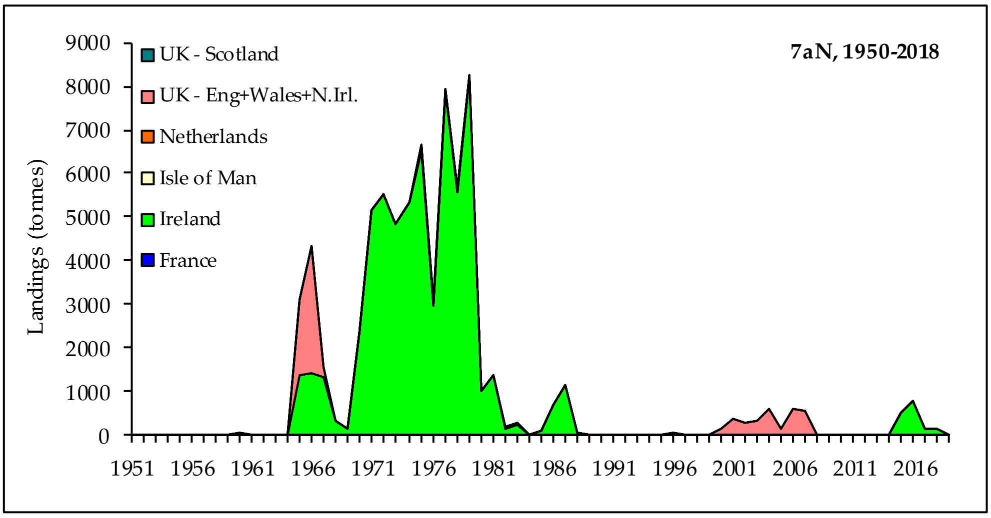


Figure 13.2.2. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2018 ICES Division 7.aN. Note: Irish landings from 1973–1995 may be from 7.aN or 7.aS.

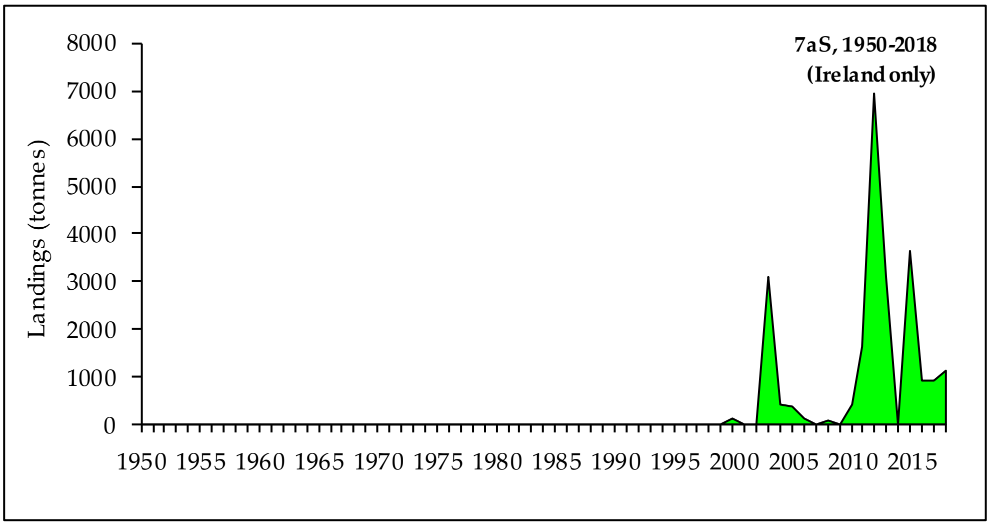


Figure 13.2.3. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2018 ICES Division 7.aS.

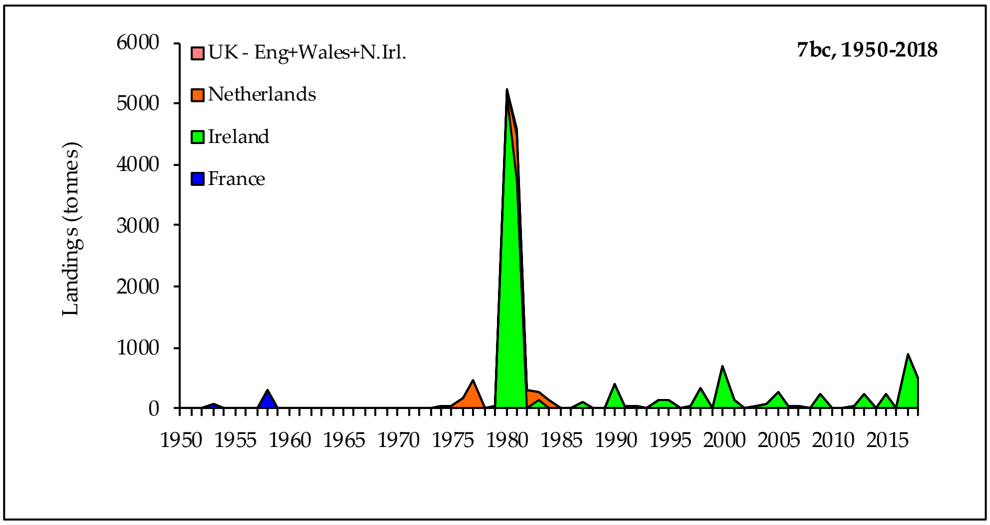


Figure 13.2.4. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2018 ICES divisions 7.b–c.

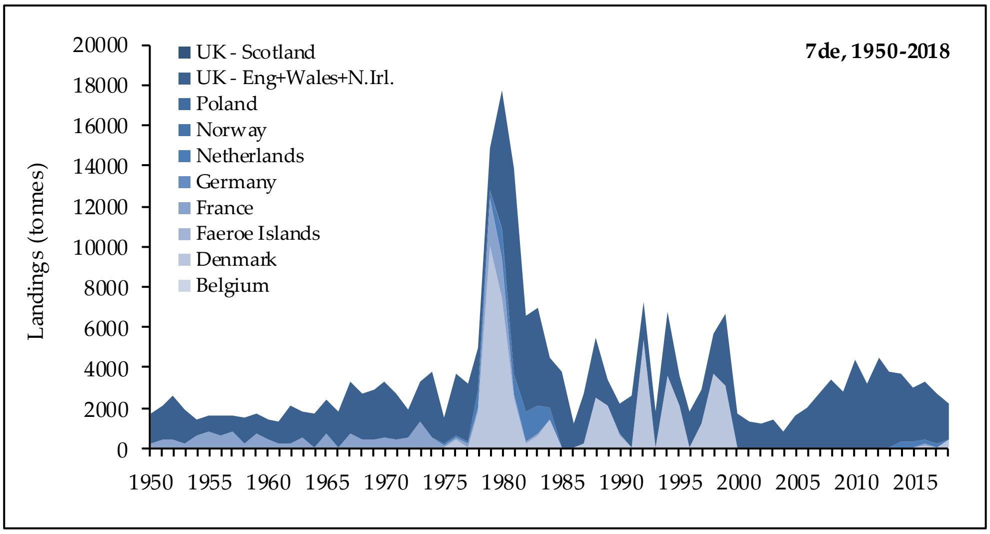


Figure 13.2.5. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2018 ICES divisions 7.d–e.

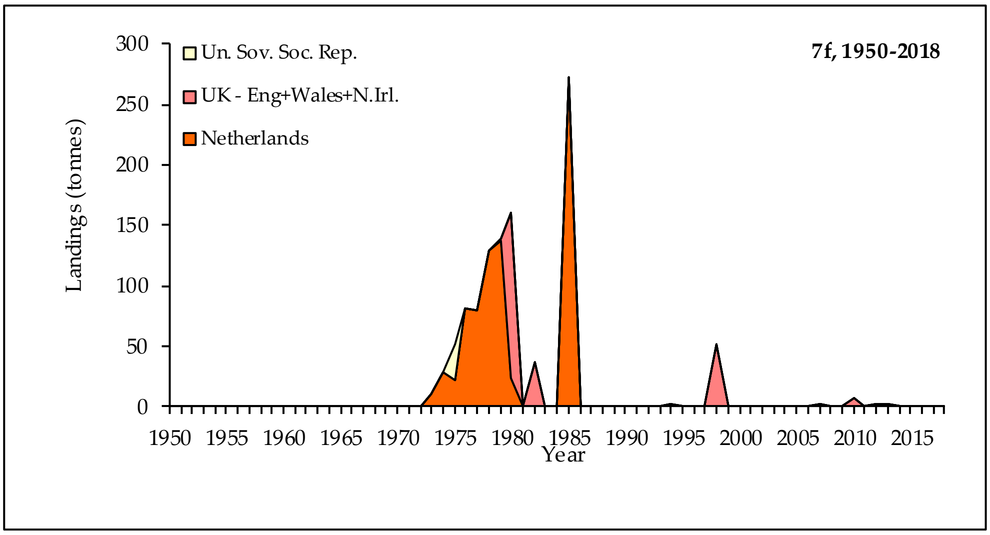


Figure 13.2.6. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2018 ICES Division 7.f.

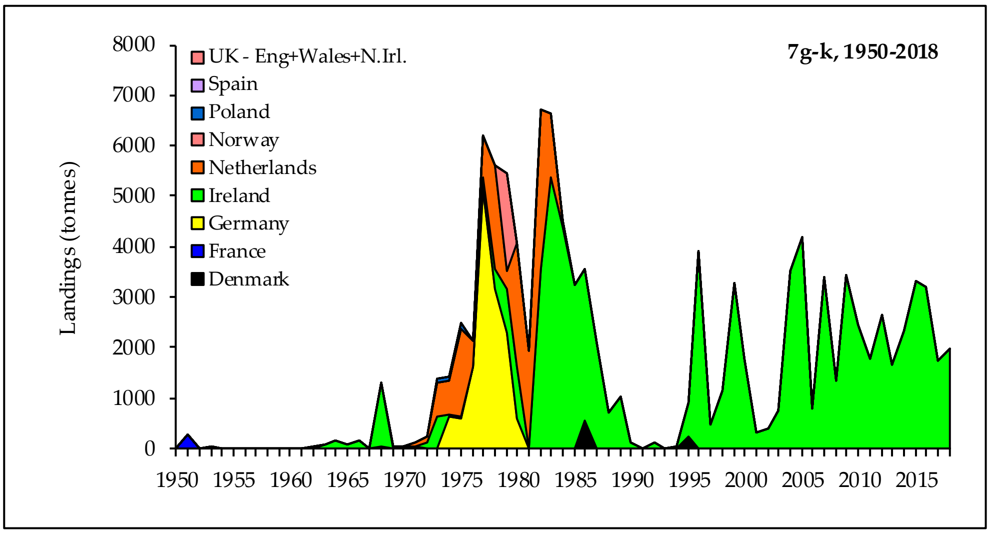


Figure 13.2.7. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2018 ICES divisions 7.g–k.

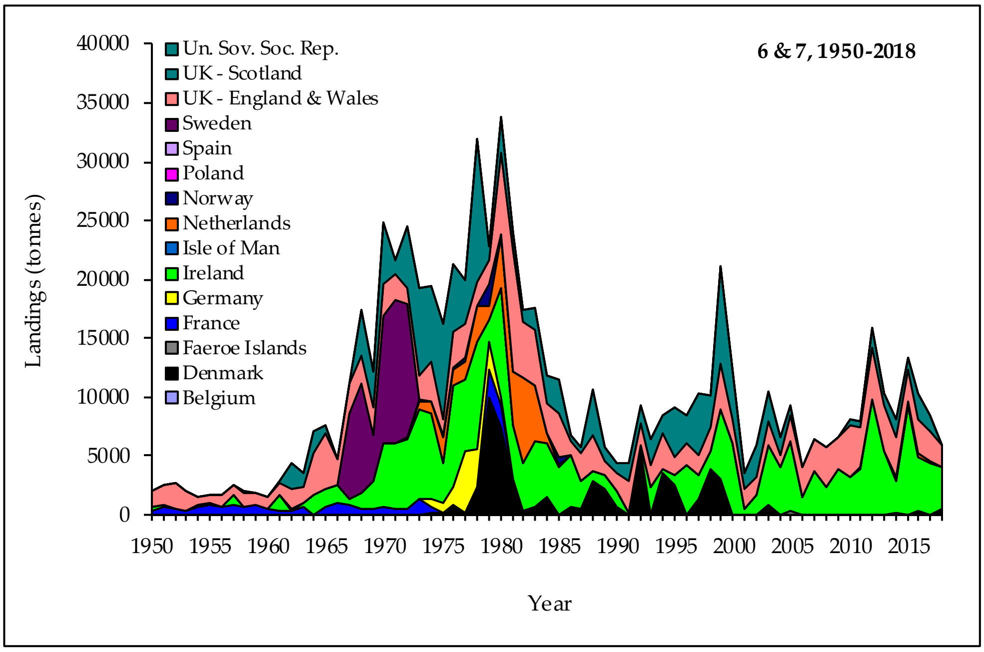


Figure 13.2.8. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2018 ICES subareas 6 and 7 (Celtic Seas Ecoregion).

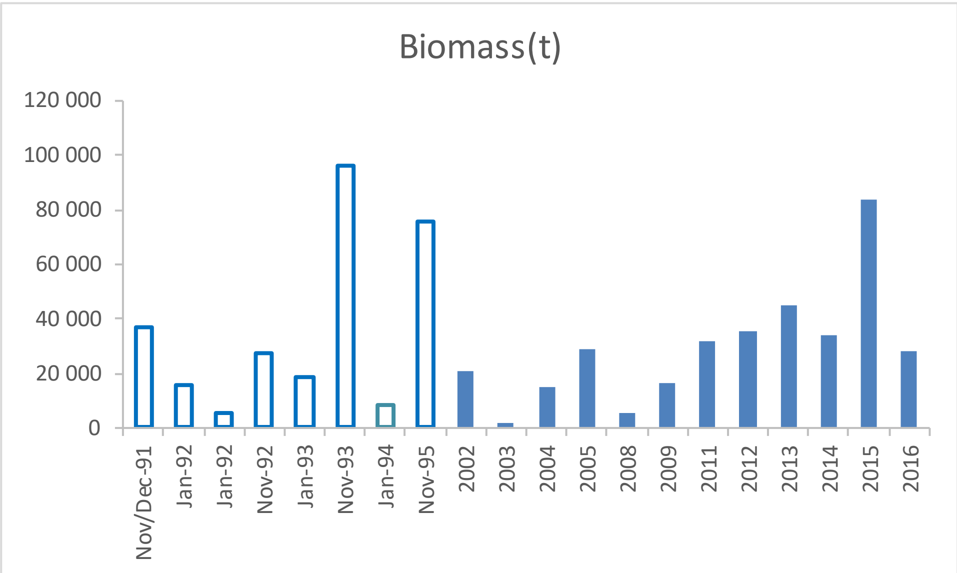


Figure 13.3.1. Sprat in the Celtic Seas Ecoregion. Estimated sprat biomass in the Celtic Sea. (Source: MI Celtic Sea Herring Acoustic Survey). Solid bars correspond to the period where the surveys are considered consistent.

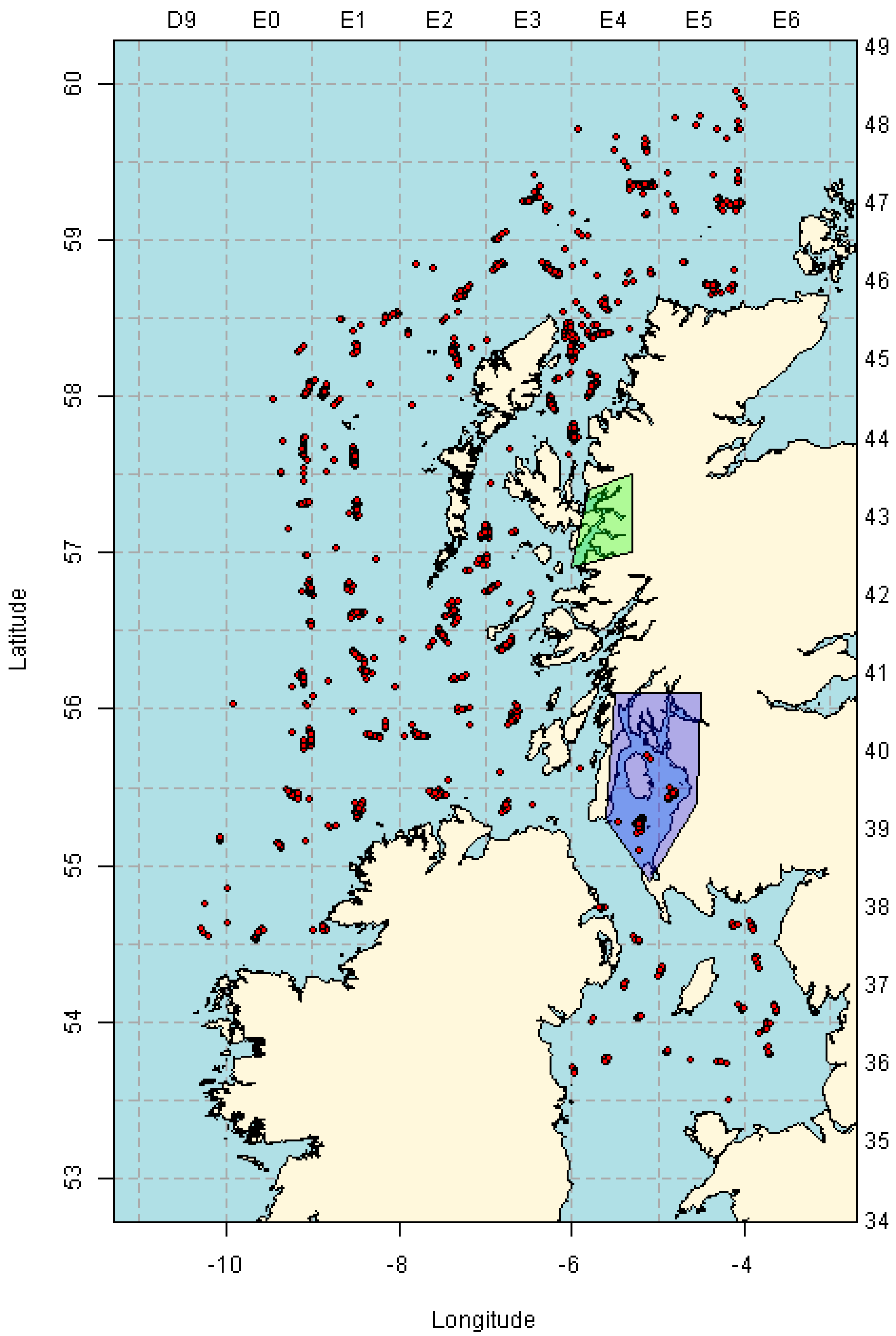


Figure 13.3.2: Extent of Scottish surveys that may provide information about sprat in 6.a. In purple is the extent of the Clyde Herring and Sprat Acoustic Surveys carried out in July between 1985 and 1989 and again in October 2012. In green is the extent of the Sea Lochs Surveys carried out annually 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.

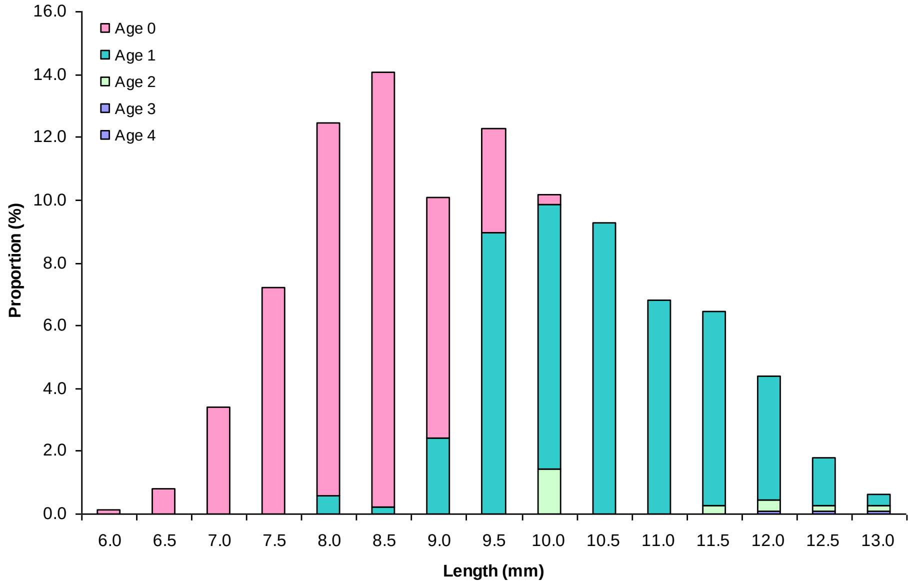


Figure 13.3.3. Length and age of sprat caught in the October 2012 Clyde Herring and Sprat Acoustic Survey. Data from six hauls were combined giving equal weight to the age and length distribution in each haul. 1442 sprat were measured and 182 were aged.

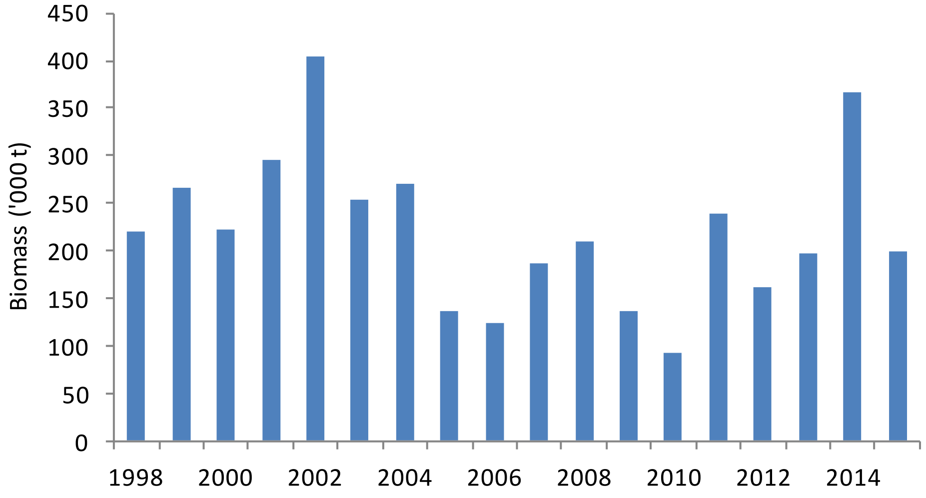


Figure 13.3.4. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Division 7.aN.

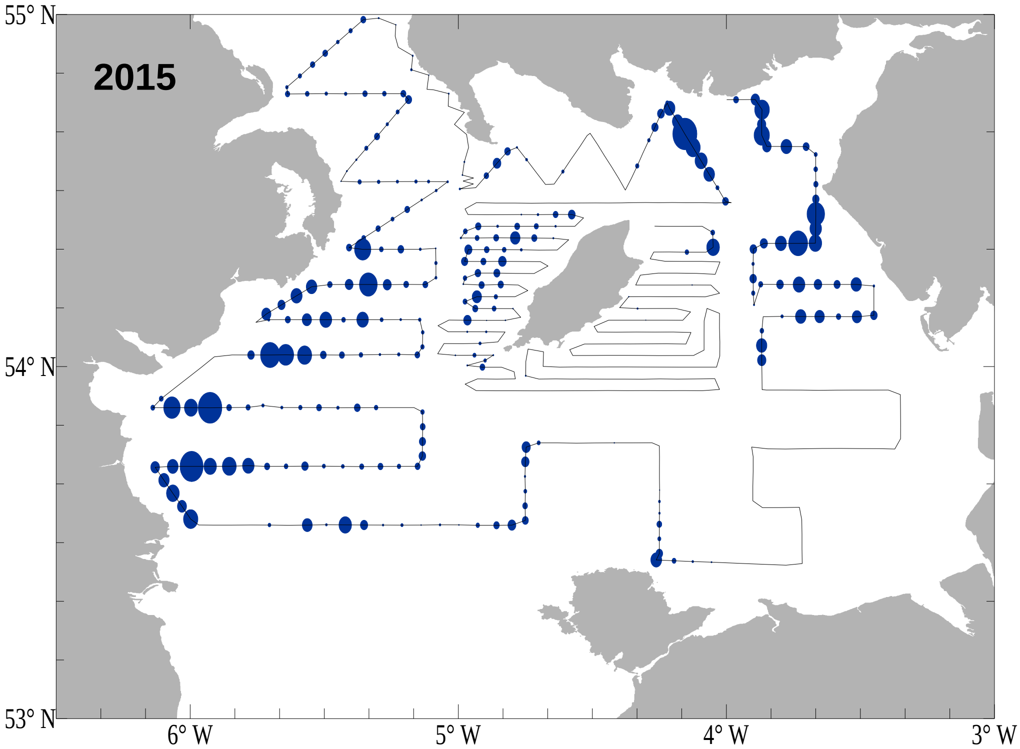


Figure 13.3.5. Sprat in the Celtic Seas Ecoregion. Sprat acoustic densities in ICES Division 7.aN. Size of ellipse is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval) for the UK (NI). September 2015 acoustic survey (AC(7.aN)) . Maximum density was 470 t n.mile^{-2}.

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Annex 3: Resolutions for next meeting

HAWG – Herring Assessment Working Group for the Area South of 62ºN

The **Herring Assessment Working Group for the Area South of 62ºN** (HAWG), chaired by Susan Lusseau, UK, and Valerio Bartolino, Sweden, will meet at ICES Headquarters:

XX-XX January 2020 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;

17-25 March 2020 to:

b) compile the catch data of North Sea and Western Baltic herring on 17–18 March;

c) address generic ToRs for Regional and Species Working Groups 19-25 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 2020 ICES data call. HAWG will report by XX February and XX April 2020 for the attention of ACOM.

Annex 4: 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 updated	Link
her.27.20-24	Herring (*Clupea harengus*) in subdivisions 20-24, spring spawners (Skagerrak, Kattegat, and western Baltic)	March 2019	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)	Feb 2015	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 2019	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 2019	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)	Feb 2019	spr.27.7de_SA

Annex 5: Working documents

Working documents HAWG 2019	
WD 01a	Marine Scotland Science sandeel dredge survey indices for SA4
WD 01b	Survey index calculations for Western Baltic spring spawning herring from IBTS and BITS data
WD 02	2018 Western Baltic spring spawning herring recruitment monitored by the Rügen herring larvae survey
WD 03	Fisheries & Stock assessment data in the Western Baltic in 2018
WD 04	PFA self-sampling report for HAWG 2015–2018

Working Document 01a, HAWG 2019 *17/12/18*

Marine Scotland Science sandeel dredge survey indices for SA4

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corresponding author *T.Regnier@marlab.ac.uk

Introduction

The Marine Scotland Science (MSS) sandeel survey of SA4, off the north east UK coast, was established in 2008 to complement the Danish dredge survey of areas 1 – 3. The survey is targeted at historically fished banks off the Firth of Forth and around Turbot bank and takes place in late November or early December to coincide with the Danish sampling. All the Firth of Forth banks sampled are within the North East UK sandeel closure, where fishing is currently limited to a monitoring TAC. This report presents the results from the survey for the years 2008 – 2018 and compares the Firth of Forth banks with data from the same stations sampled during research surveys conducted in October-November between 1999 and 2003.

Methods

Dredge hauls encompassing the major Firth of Forth banks were taken at 8 stations in 1999 – 2003; 3 stations on the Wee Bankie, 3 on Marr Bank and 2 on Berwick Bank. In 2008 – 2018, additional stations were sampled over Berwick Bank and around the Wee Bankie grounds. During 2008 – 2013, and 2015 – 2017, Turbot Bank and/or nearby patches of sandeel habitat have also been dredged. The survey in 2018 sampled from 2 stations on Wee Bankie, 3 on Marr Bank and 3 on Berwick Bank. Where possible 5 tows of 10 minute duration were made per station, although time constraints has sometimes reduced this to 3. Weather conditions were severe in 2018 so all 2018 stations were reduced to 3 tows due to time constraints and Turbot Bank was not sampled. All captured sandeels were measured and a length stratified sample was aged to produce average age-length keys for Firth of Forth grounds. Numbers caught were converted to numbers per area swept and then raised to numbers per hour based on the average area swept in one hour. Average CPUE for SA4 was calculated using the averaging method given by Christensen in Appendix A (WKSAN 2010).

Results

The total numbers of hauls by sandeel bank are given in Table 1. Due to the different requirements of surveys, sample sizes were low prior to the establishment of a dedicated recruit survey in 2008. As only sandeels ≥ 8.5 cm TL are fully selected by the gear and many 0-group are typically below this length, age 1 catches are generally higher than age 0 for a given year-class, although this was not the case for the 2012, 2013, 2015, 2016 and 2018 cohorts. Nevertheless, catch rates at age 1 were significantly correlated with age 0 and likewise between catch rates of age 1 and 2 sandeels ($P < 0.01$, Figure 1).

Incoming year-class abundance was much lower compared with last year, marking a break in the trend of increasing recruitment since 2015. This result is concerning as this year's abundance of Age 0 fish is the lowest observed throughout the time series. Age 1 fish densities were elevated, across the Firth of Forth, with capture rates the third highest observed throughout the time series. In the southerly stations, frequency distributions were dominated by 1-group fish of size 9 to 12 cm. This high age 1 abundance is consistent with last year results, seemingly as a consequence of large 0-group abundance in 2017 (Figure 2). This result suggests low recruitment to the Southern part of SA4.

Table 1. Scottish dredge survey. Number of hauls by sandeel bank and year.

Bank	Year													
	1999	2000	2001	2002	2003	2008	2009	2010	2011	2012	2013	2014	2015	2016
Wee Bankie	3	4	3	3	3	18	15	18	11	14	18	16	18	20
Marr Bank	4	5	3	3	3	8	8	9	7	7	13	10	6	11
Berwick Bank	2	5	0	2	2	6	8	8	6	6	17	14	20	16
Turbot Bank	0	0	0	0	0	3	15	16	17	20	6	0	16	35

Bank	Year													
	2017	2018												
Wee Bankie	16	7												
Marr Bank	9	9												
Berwick Bank	9	9												
Turbot Bank	24	0												

Table 2. Average CPUE by age for a) SA4 and b) Firth of Forth

a)				b)		
Year	Age 0	Age 1	Age 2	Age 0	Age 1	Age 2
1999				615	494	301
2000				586	3170	258
2001				48	2656	1561
2002				243	404	916
2003				580		
2008	52	24	18	68	24	24
2009	832	87	38	1023	174	56
2010	147	1032	67	186	1244	78
2011	89	165	407	119	220	534
2012	95	135	23	122	178	30
2013	62	85	35	82	89	45
2014	445*	43*	12*	445	43	12
2015	136	1044	14	151	1126	13
2016	300	81	90	163	98	105
2017	346	223	40	438	235	50
2018	16*	461*	91*	16	461	91

*Adverse weather conditions in 2014 and 2018 precluded any sampling of SA4 stations outside the Firth of Forth region, hence CPUE estimates are identical.

Figure 1: Internal consistency plot. Average CPUE of consecutive ages from the same year-class for Firth of Forth samples. Symbols coloured in red indicate 2018 points.

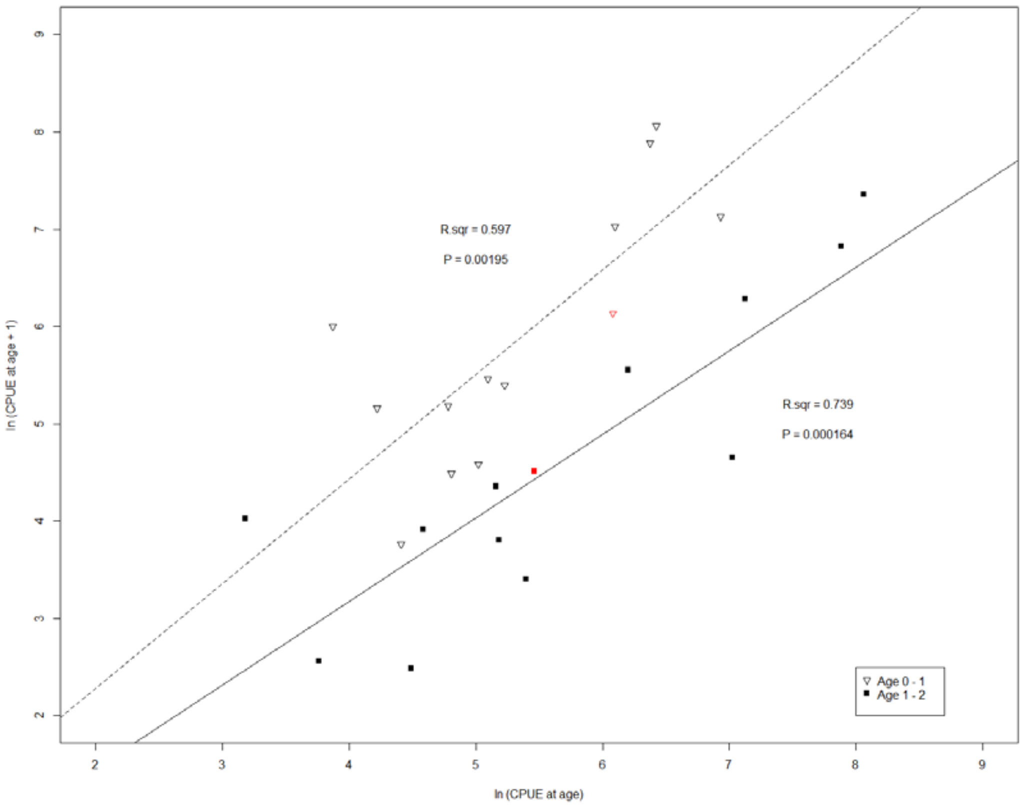
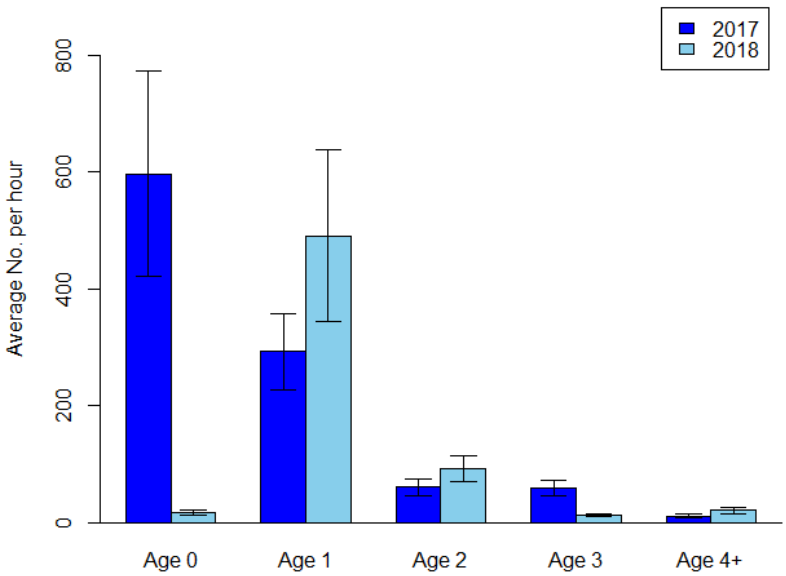


Figure 2: Average catch per hour per age-class in the Southern (Firth of Forth) region compared to last year (2017). Whiskers indicate standard deviation around the mean.



WD 01b

Survey Index Calculations for Western Baltic Spring Spawning Herring from IBTS and BITS data

Casper W. Berg

March 14, 2019

1 Introduction

This document describes the calculation of standardized survey indices of abundance for Western Baltic Spring Spawning Herring using combined IBTS and BITS data and the methodology of [2]. There is however two extra modelling steps needed for this stock, which consist of splitting the survey length and age data by stock using subsamples of stock-identified individuals.

2 Data Exploration / Filtering

Only data from the year 2002 and onwards are considered, because the data-series for stock splitting from IBTS starts in 2002.

2.1 IBTS

All IBTS data in IIIa with “HaulVal” code “V” and “StdSpecRecCode” equal to 1 are used.

2.2 BITS

All data from areas 20–24, only hauls with “HaulVal” code “V”, “A” and “C” are included in the analysis, and also only hauls with “StdSpecRecCode” equal to 1 or 3. The “TVL” gear is excluded also since there are few hauls with this gear type in the area of interest.

3 Stock splitting

3.1 Lengths

Length distributions from IIIa (north of 56 degrees latitude) are split into spring-, autumn-, and winter spawners using split samples from IBTS, and only the spring spawners are used in the further analysis. Longitude and latitude coordinates were unfortunately not directly available in the data

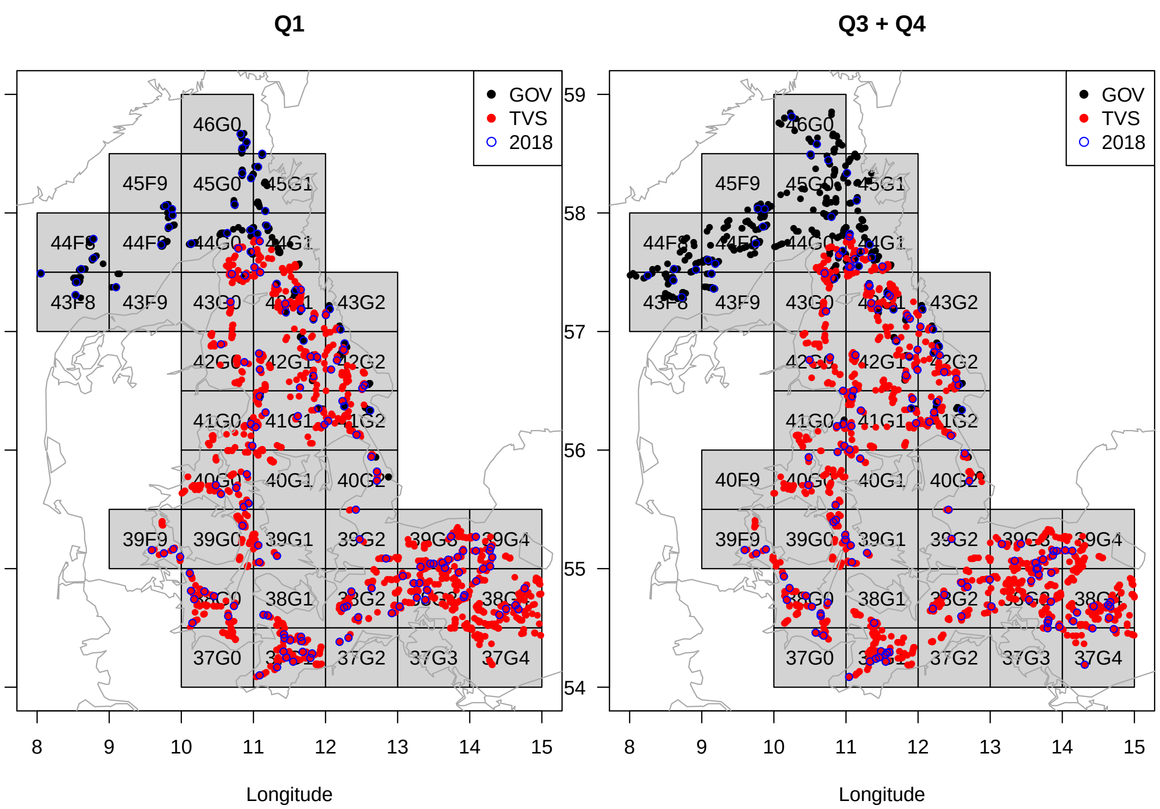


Figure 1: All hauls used in the analysis colored by gear type

set used, but ICES rectangle was, so the midpoint of the ICES rectangle was used instead. Length distributions south of IIIa are assumed to be 100% spring spawners, because there were no split samples from the BITS survey available for the analysis. The probability of belonging to one of the three stock types is modelled as a smooth 4D function of time, spatial coordinates, and length of the fish using a multinomial likelihood

$$stock \sim f(time, lon, lat, length)$$

. The probabilities are calculated by haul and the length distributions are multiplied with the probability of being a spring spawner. In Q1 44% of the total numbers-at-length are estimated to be spring-spawners. In Q3+Q4 it is 39%. See appendix for some predictions from the model.

	4	9	12
4	0.78	0.18	0.04
9	0.23	0.71	0.06
12	0.42	0.05	0.53

Table 1: Cross-classification table

3.2 Ages

The age-samples are also split by stock, using a similar model, although here the model utilizes age and cohort effects as well, since these additional variables are useful for classification, i.e.

$$stock \sim Age + Year + f(time, lon, lat, length) + f(cohort) + f(Year : Age)$$

where Age is truncated to age 5+ to reduce the number of parameters. The first 4D smoother is a tensor product spline of continuous variables, whereas the last two are categorical variables such that a smooth implies Gaussian random effects with mean zero. Each age sample is weighted with the probability of being a spring spawner prior to estimation of ALKs and the age-conversion described in the following section.

	4	9	12
4	0.86	0.10	0.04
9	0.13	0.81	0.06
12	0.41	0.09	0.50

Table 2: Cross-classification table, age specific model

4 ALKs

Smooth age length keys are estimated using the methodology described in [1] using an assumption of a spatially constant relationship, but estimated separately for each combination of year and quarters. The assumption of spatial homogeneity was made because age samples of herring are only available in the IBTS data but not in the BITS data. This implies that the ALK must be extrapolated to the southern part of the assessment area which is only covered by BITS. Numbers-at-age are then calculated using the observed numbers-at-length and the estimated ALKs. The estimated ALKs are shown in the appendix.

5 Survey Indices

Survey indices by age and area are calculated using the methodology described in [2].

The following equation describes the model considered for both the presence/absence and positive parts of the Delta-Lognormal model:

$$\begin{aligned} g(\mu_i) =& \text{Year(i)} + \text{Gear(i)} + f_1(\text{lon}_i, \text{lat}_i) \\ &+ f_2(\text{Depth}_i) + f_3(\text{time}_i) + \log(\text{HaulDur}_i) \end{aligned}$$

where Gear(i) and Year(i) maps the ith haul to categorical gear/year effects for each age group. An offset is used for the effect of haul duration ($HaulDur$), i.e. the coefficient is not estimated but taken to be 1. f_1 is a 2D thin-plate spline for space, f_2 is a 1-dimensional thin plate spline for the effect of bottom depth, and f_3 is a cyclic cubic regression spline on the time of day (i.e. with same start end end point).

The function g is the link function, which is taken to be the logit function for the binomial model. Each combination of quarter age group are estimated separately. The fitted models are then used to sum the expected catches over a fine grid by year and age to obtain the survey index. Nuisance variable such as gear, time-of-day and haul duration are corrected for in this process.

The whole procedure consists of the following steps:

1. Fit a multinomial model to predict probability of WBSS given time, position, and length using individual samples of stock from IBTS.
2. Multiply observed length distributions by haul with predicted stock probabilities to filter out all but WBSS.
3. Fit a multinomial model to predict probability of WBSS given same data and predictors as in step 1, but also include age and cohort.
4. Fit ALK using aged individuals, but weight each age sample with probability of being WBSS using the model from step 3.
5. Apply ALK to WBSS specific length distributions from step 2 and fit survey index standardization model for numbers-at-age by age and quarter
6. Select grid of haul positions
7. Predict abundance on grid by year (using reference vessel, time-of-day etc).
8. Sum of grid points = index

Steps 1 and 2 splits the *length* distributions by haul into WBSS / non-WBSS. Step 3 and 4 splits the individual *age* samples into WBSS / non-WBSS. This is gives us the stock-specific ALK which we can use to convert the split length distributions from steps 1 & 2 into numbers-at-age by haul.

6 Results

The results show that the youngest (immature) age groups are distributed in Kattegat and the Danish Belts, whereas older herring are more predominant in the Sound (Øresund) and the Arcona Basin in the south-east. The distributions are similar in both quarters, although a slightly more north-eastern distribution in Q3 and Q4 compared to Q1. The internal and external consistencies (a measure between 0 and 1 of how well we can "follow the cohorts" within and between surveys under the assumption of constant mortality) are fairly good up to and including age 3, but poor hereafter. This is not surprising considering that the older age groups are mainly distributed in the area south of Kattegat where there are no age samples. I recommend that only indices for ages 0–3 are used in the assessment. It could be considered to obtain commercial age (and split) samples from the areas not covered by the IBTS samples to supplement the ALK estimation. This could potentially improve the indices of the older herring.

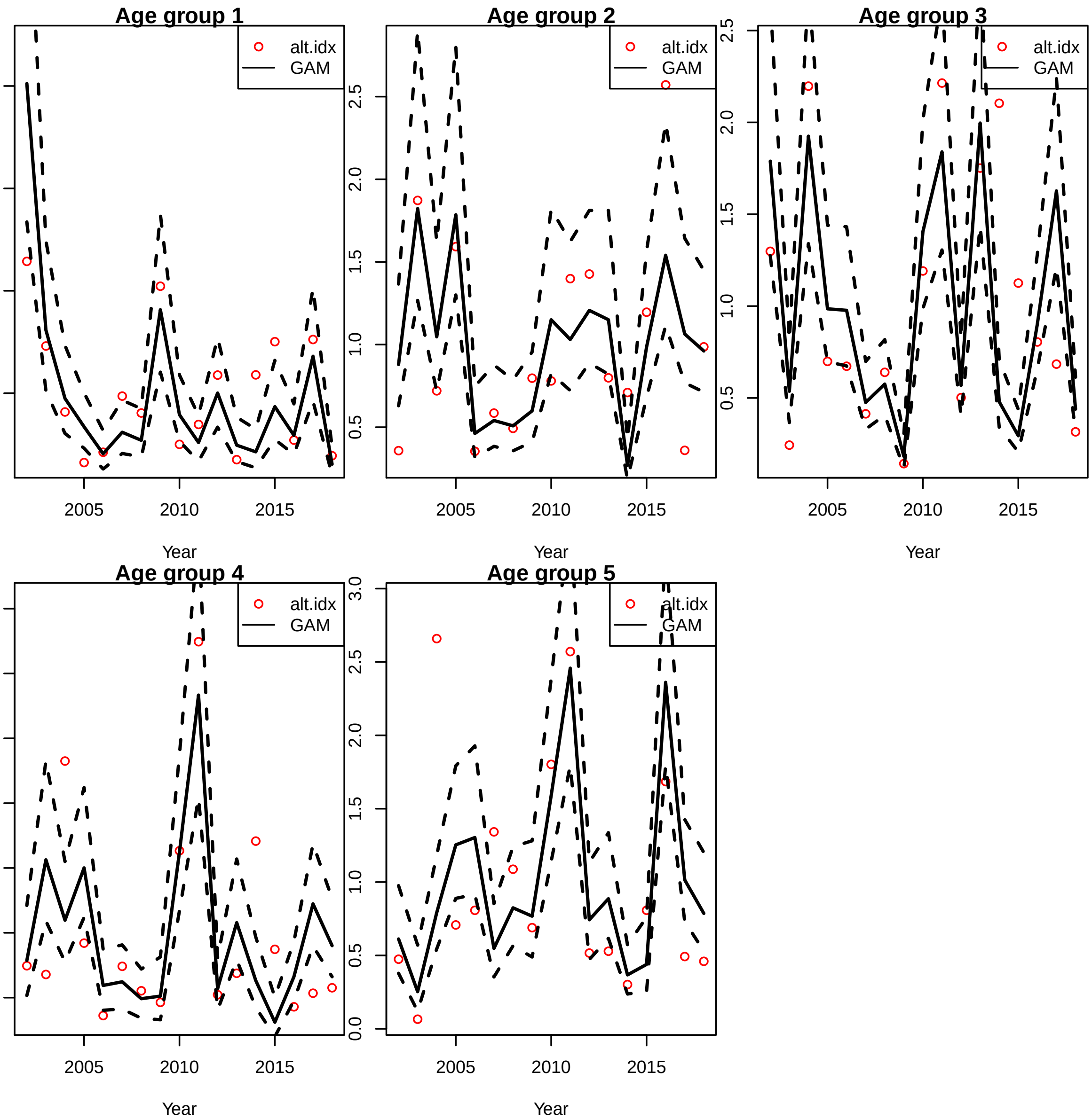


Figure 2: Q1 scaled indices (divided by their mean) by age group (which is the same as age in Q1). Stratified mean method is shown in red.

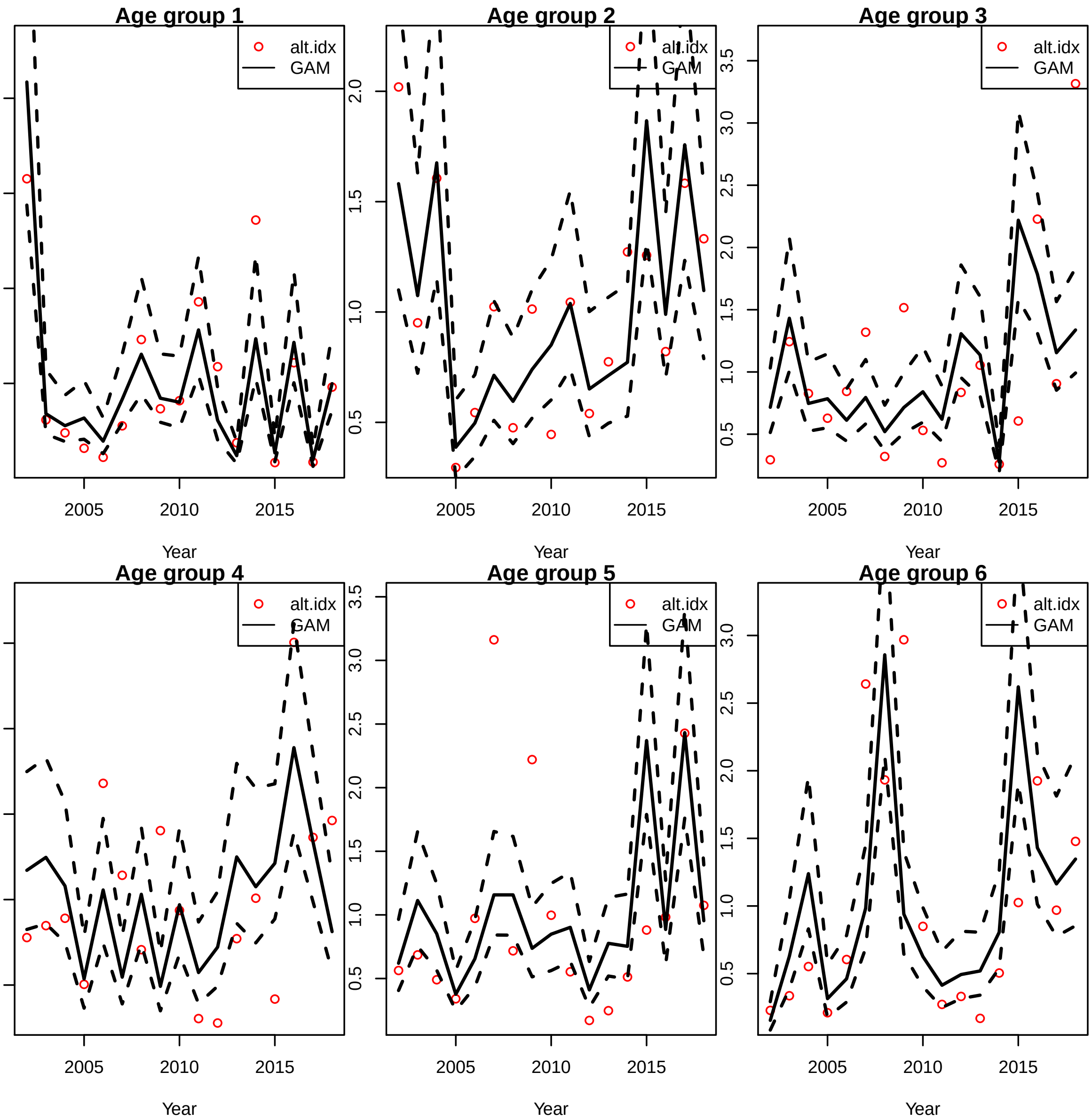


Figure 3: Q3 + Q4 scaled indices (divided by their mean) by age group (which is age - 1 in Q3+Q4 because first age group is 0). Stratified mean method is shown in red.

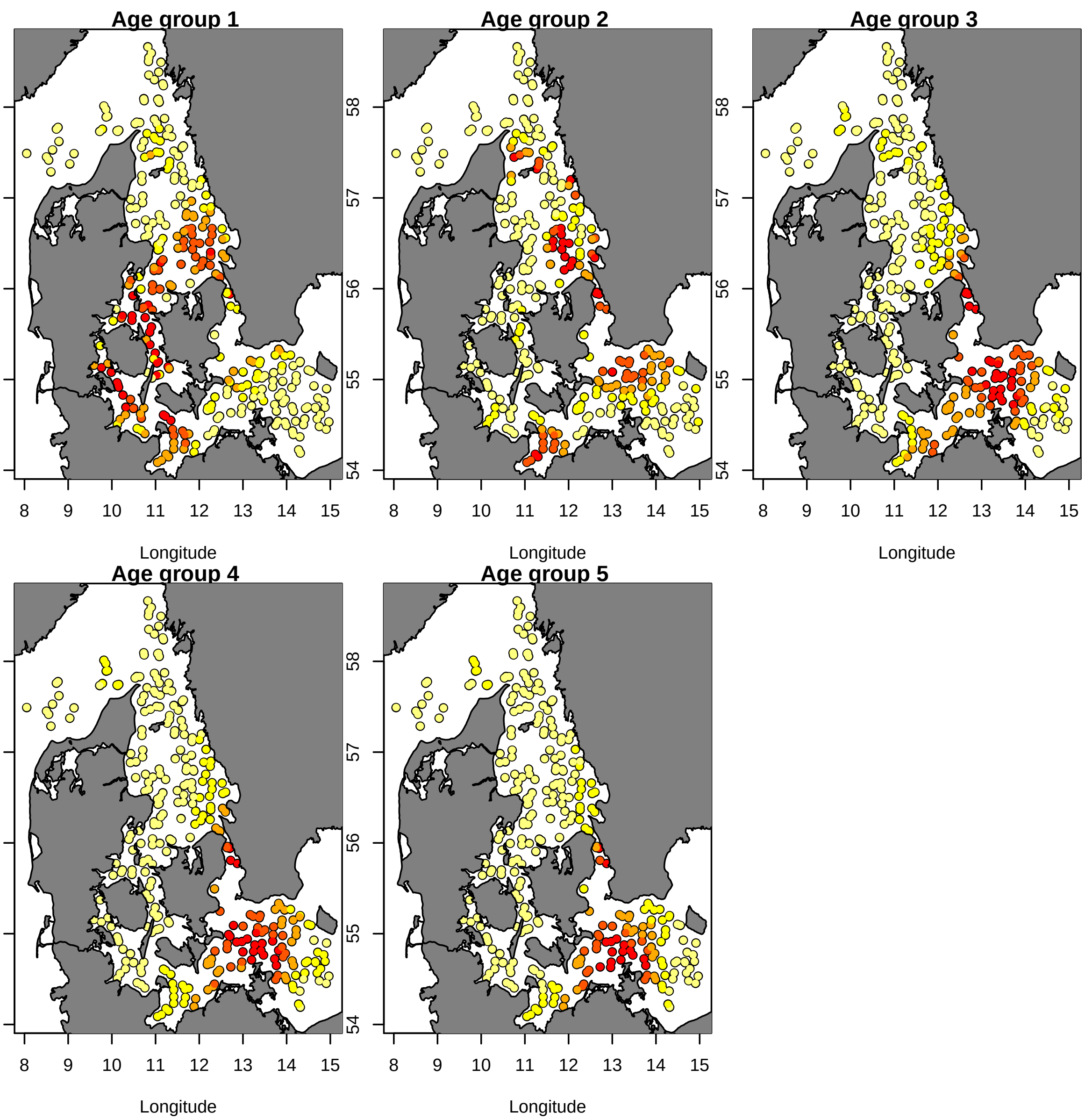


Figure 4: Distribution maps by age group Q1.

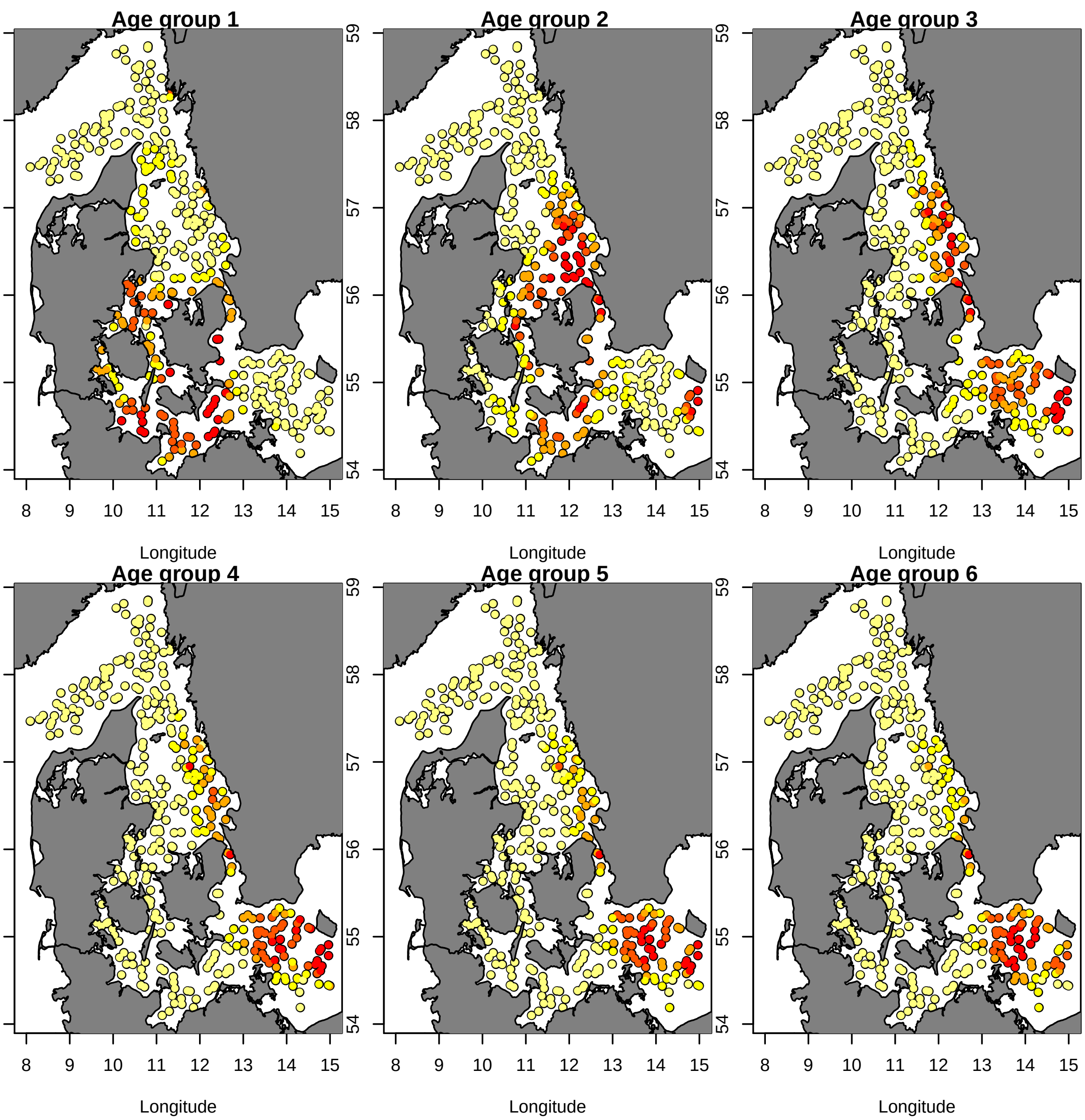


Figure 5: Distribution maps by age group Q3+Q4 (note that age group 1 is age 0).

6.1 Internal and external consistencies

```
> cat("IC Q1:\n")
IC Q1:

> internalCons(SI$idx)
Age  1  vs  2  :  0.5742609
Age  2  vs  3  :  0.6571229
Age  3  vs  4  :  0.1727792
Age  4  vs  5  :  -0.05646259
[1]  0.57426092  0.65712294  0.17277920 -0.05646259

> cat("IC Q3+Q4:\n")
IC Q3+Q4:

> internalCons(SIQ34$idx)
Age  1  vs  2  :  0.2144529
Age  2  vs  3  :  0.4708503
Age  3  vs  4  :  0.4816305
Age  4  vs  5  :  0.4195899
Age  5  vs  6  :  0.4817922
[1] 0.2144529 0.4708503 0.4816305 0.4195899 0.4817922

> cat("EC Q1 vs Q34 same age:\n")
EC Q1 vs Q34 same age:

> externalCons(SI$idx, SIQ34$idx[,-1])
Survey 1 Age  1  vs Survey 2  1  :  0.4312561
Survey 1 Age  2  vs Survey 2  2  :  0.7210529
Survey 1 Age  3  vs Survey 2  3  :  0.3088495
Survey 1 Age  4  vs Survey 2  4  :  -0.152079
Survey 1 Age  5  vs Survey 2  5  :  -0.1277546
[1]  0.4312561  0.7210529  0.3088495 -0.1520790 -0.1277546

> cat("EC Q34 vs Q1 a+1:\n")
EC Q34 vs Q1 a+1:

> externalCons(SIQ34$idx[-nrow(SIQ34$idx),1:5], SI$idx[-1,1:5])
Survey 1 Age  1  vs Survey 2  1  :  0.8028965
Survey 1 Age  2  vs Survey 2  2  :  0.7144539
Survey 1 Age  3  vs Survey 2  3  :  0.5950734
Survey 1 Age  4  vs Survey 2  4  :  0.1321415
Survey 1 Age  5  vs Survey 2  5  :  0.2309258
[1] 0.8028965 0.7144539 0.5950734 0.1321415 0.2309258

> sink()
```

7 Appendix

7.1 Figures

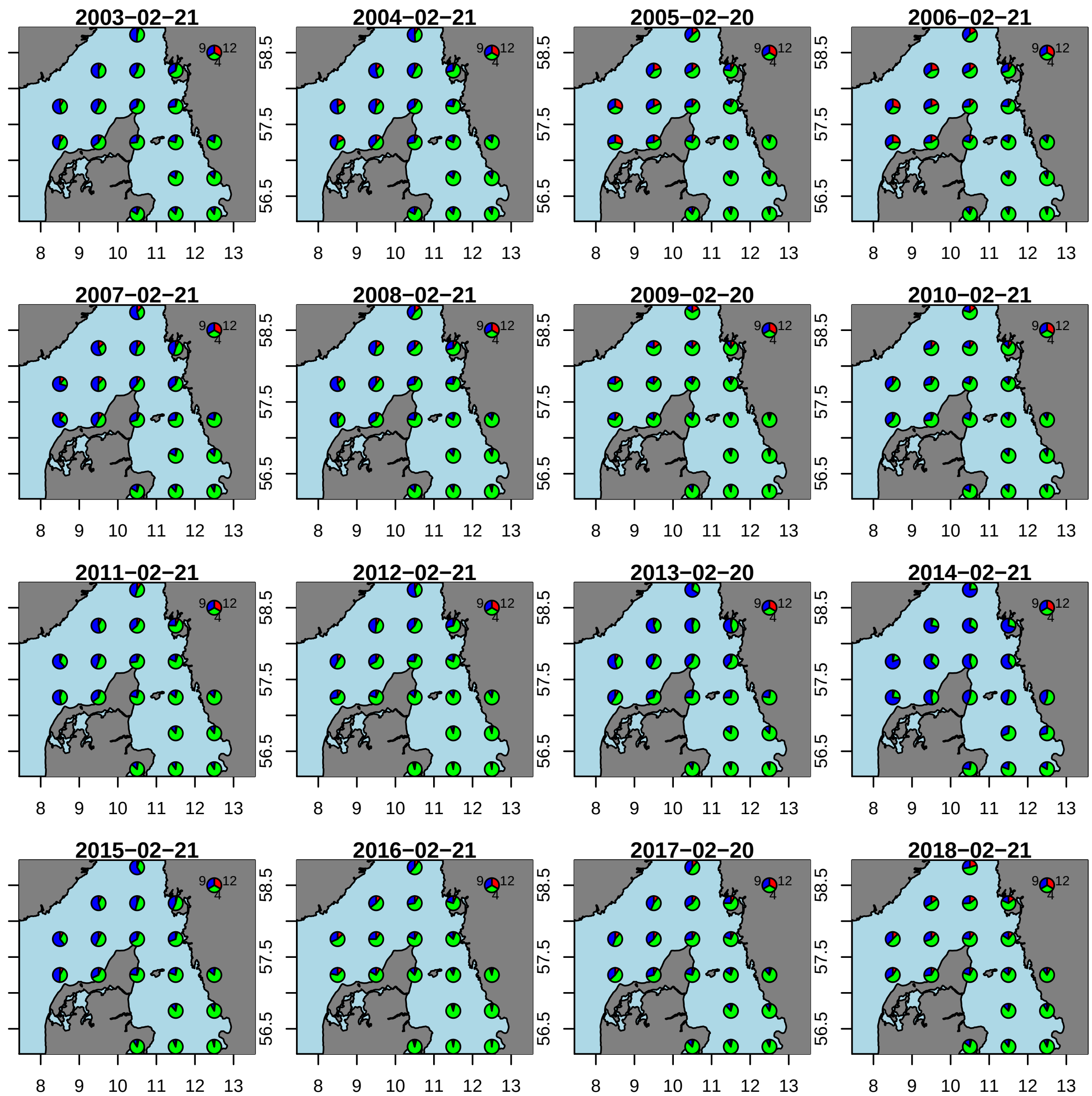


Figure 6: Fitted stock proportions for a 21.5 cm herring (median) by ICES rectangle Q1. Colors denote hatch-month – green is spring-spawners.

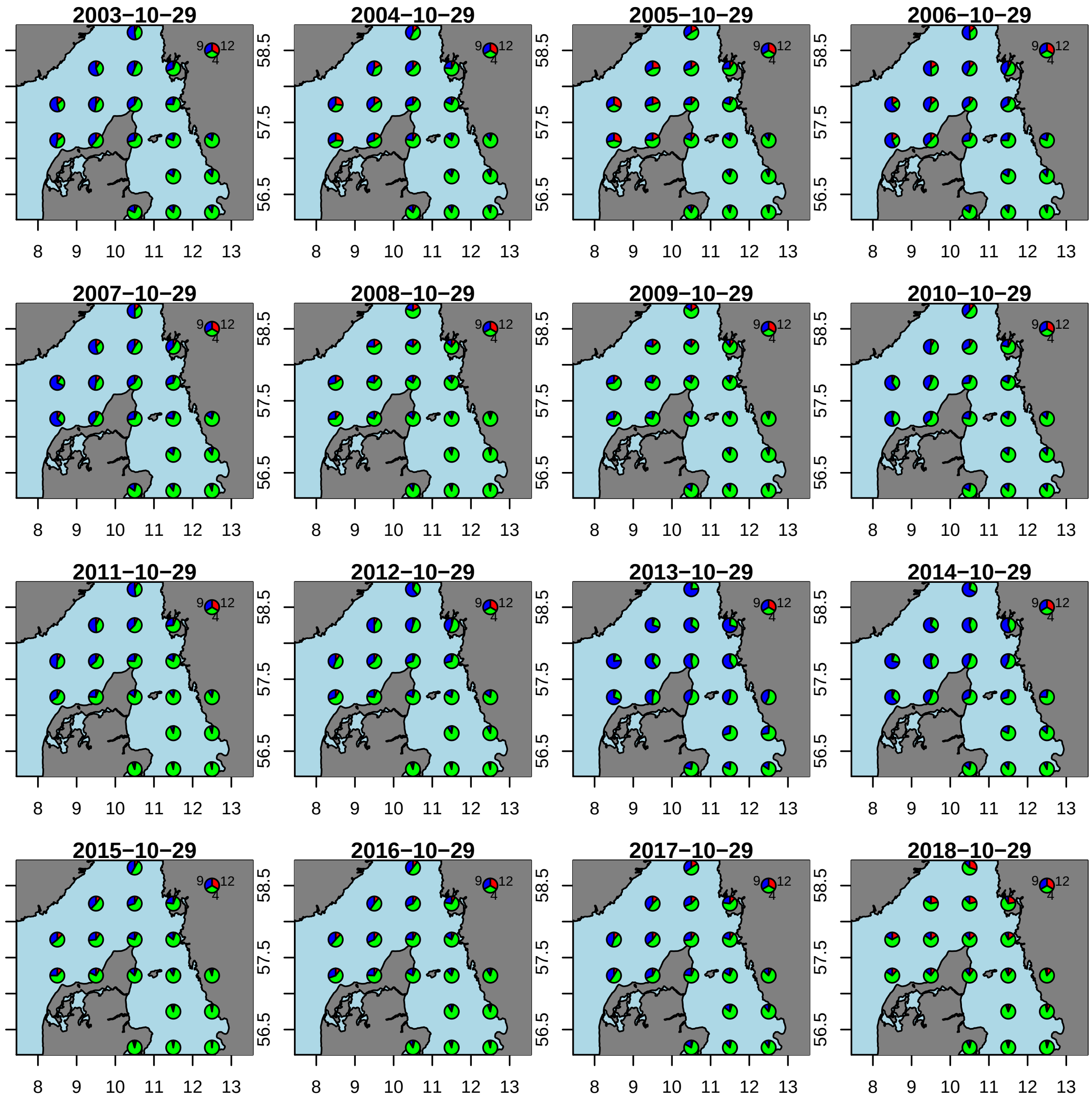


Figure 7: Fitted stock proportions for a 21.5 cm herring (median) by ICES rectangle Q3 + Q4

References

[1] Casper W Berg and Kasper Kristensen. Spatial age-length key modelling using continuation ratio logits. *Fisheries Research*, 129:119–126, 2012.

[2] Casper W Berg, Anders Nielsen, and Kasper Kristensen. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. *Fisheries Research*, 151:91–99, 2014.

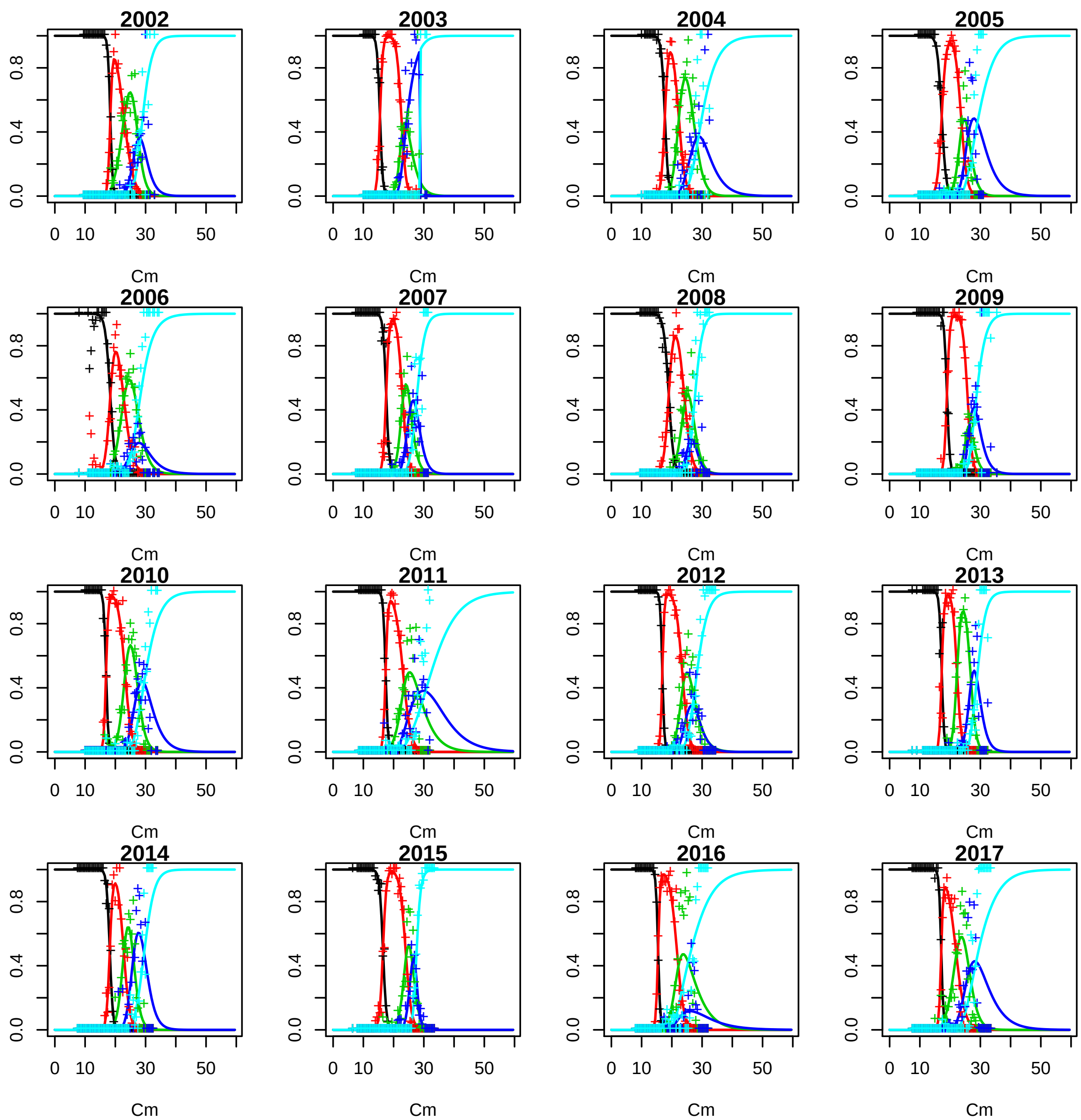


Figure 8: Fitted ALK Q1

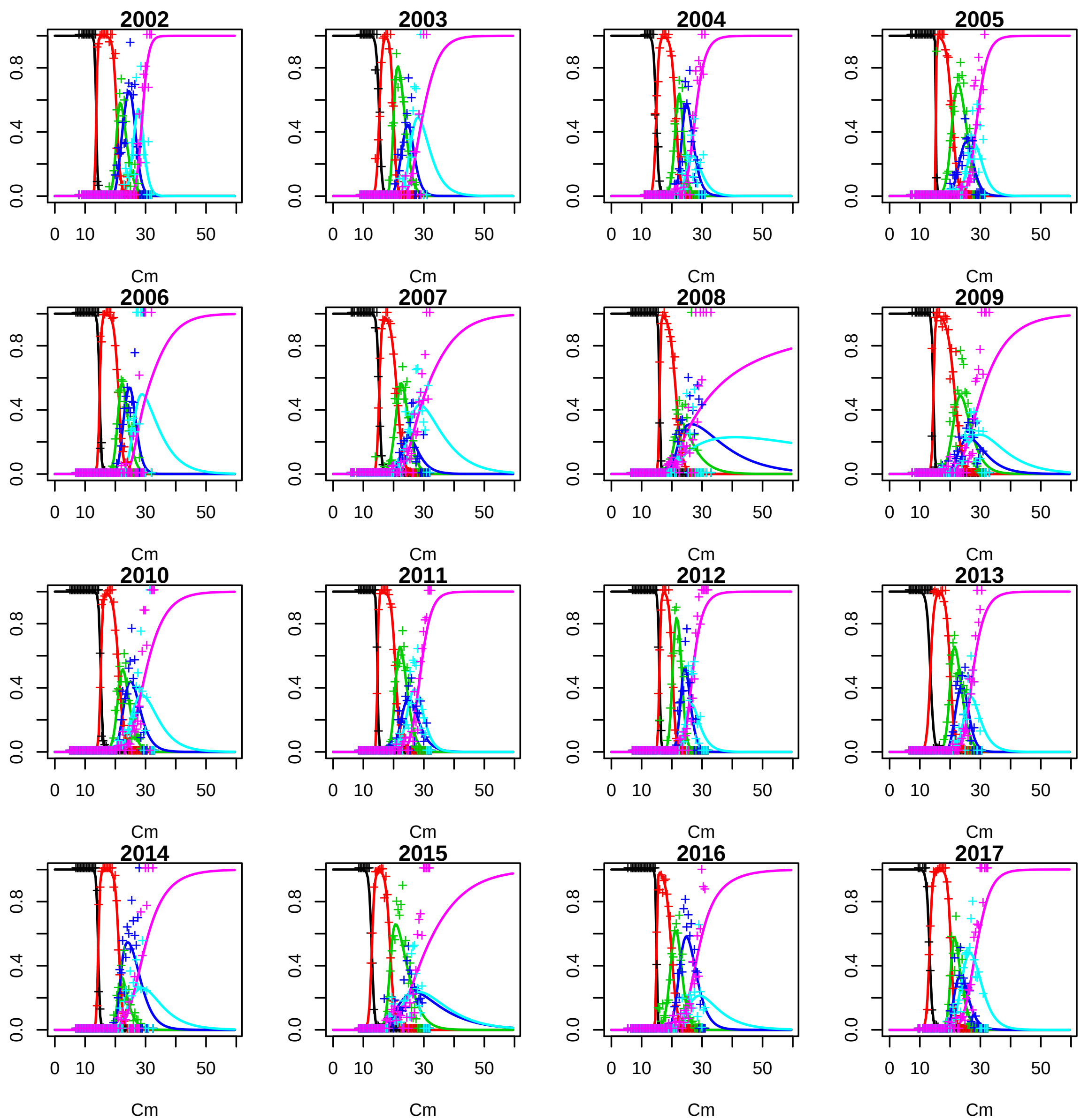


Figure 9: Fitted ALK Q3 + Q4

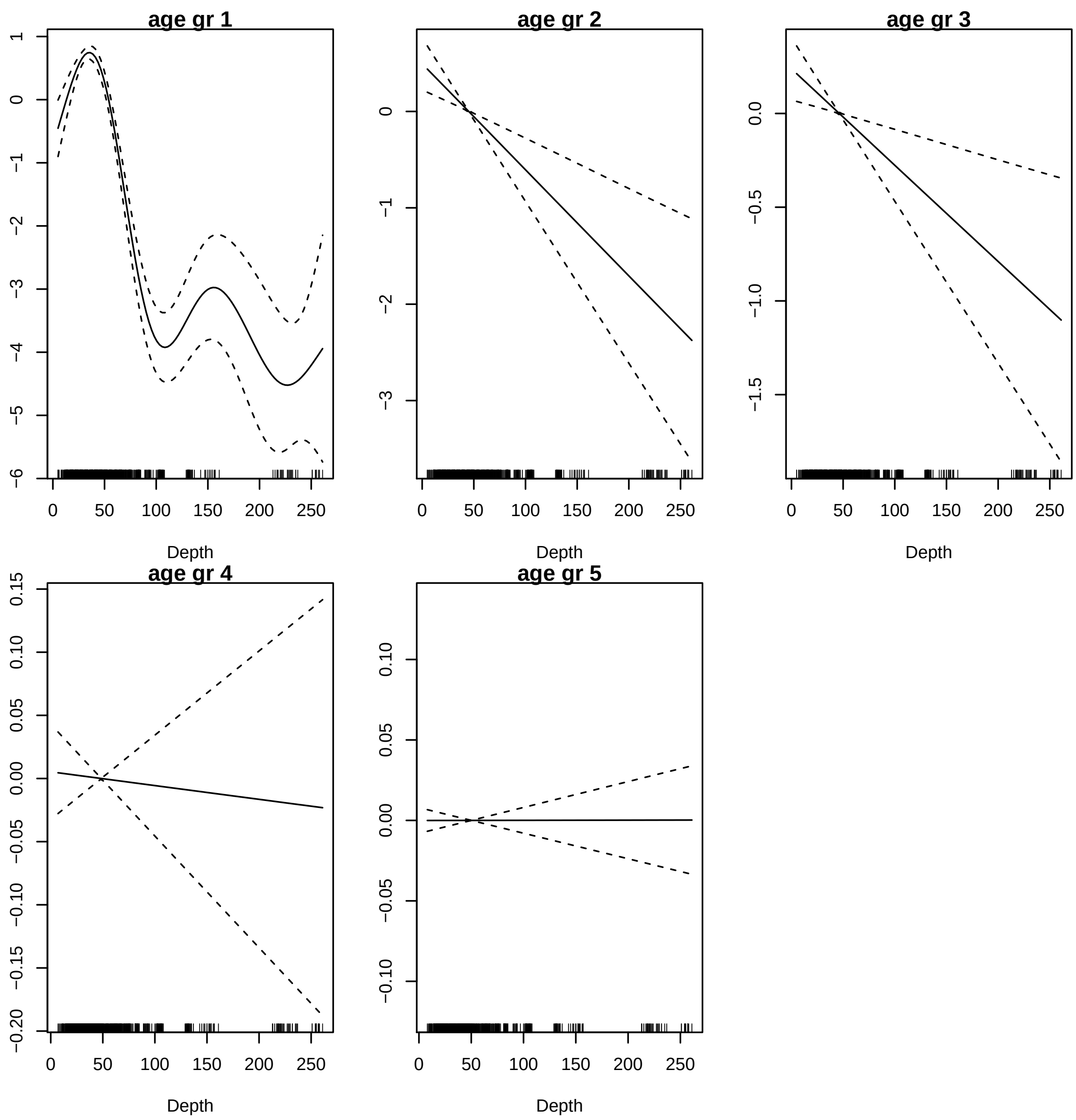


Figure 10: Estimated depth effects Q1

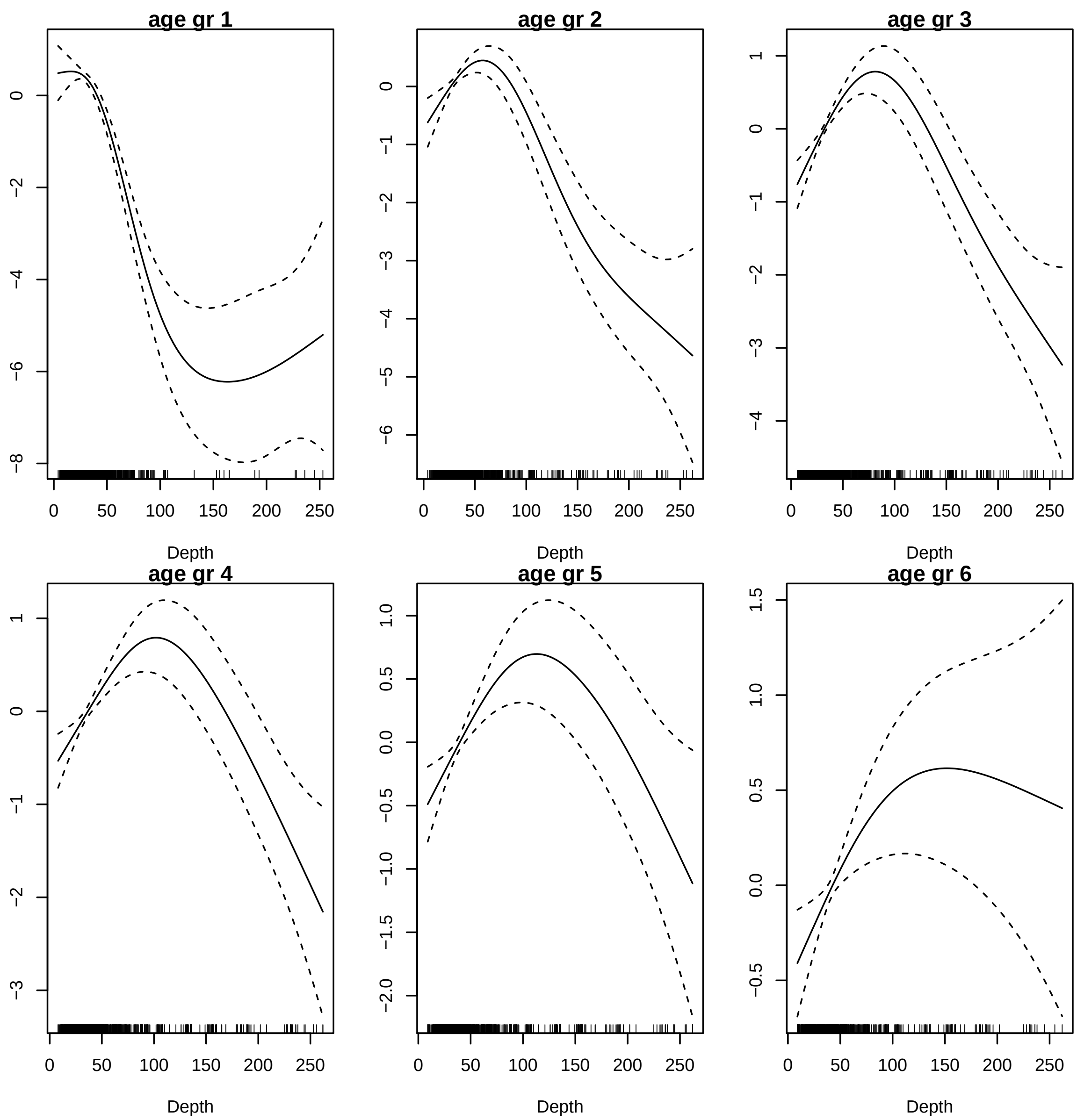


Figure 11: Estimated depth effects Q3+Q4

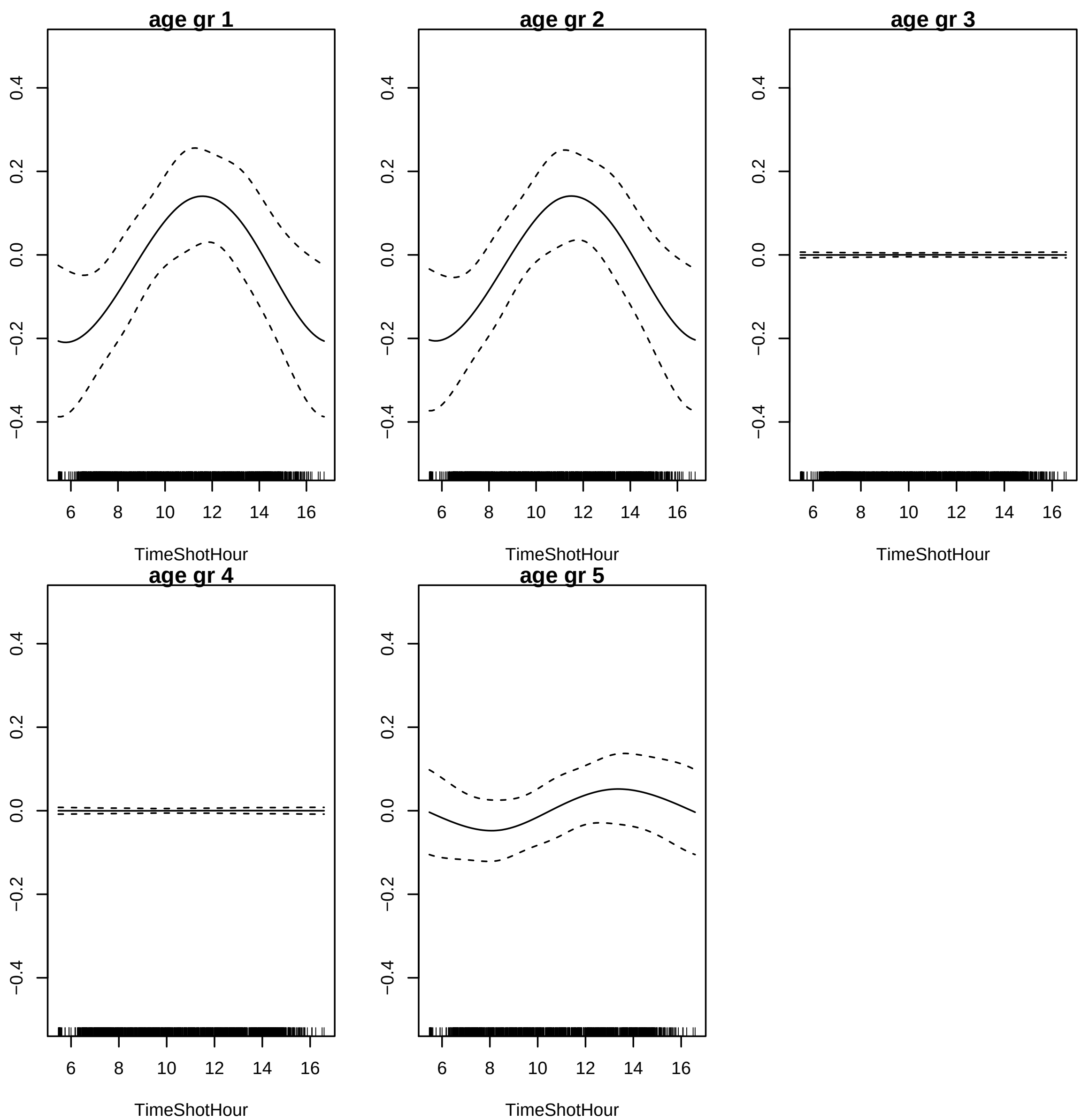


Figure 12: Estimated time of day effects Q1

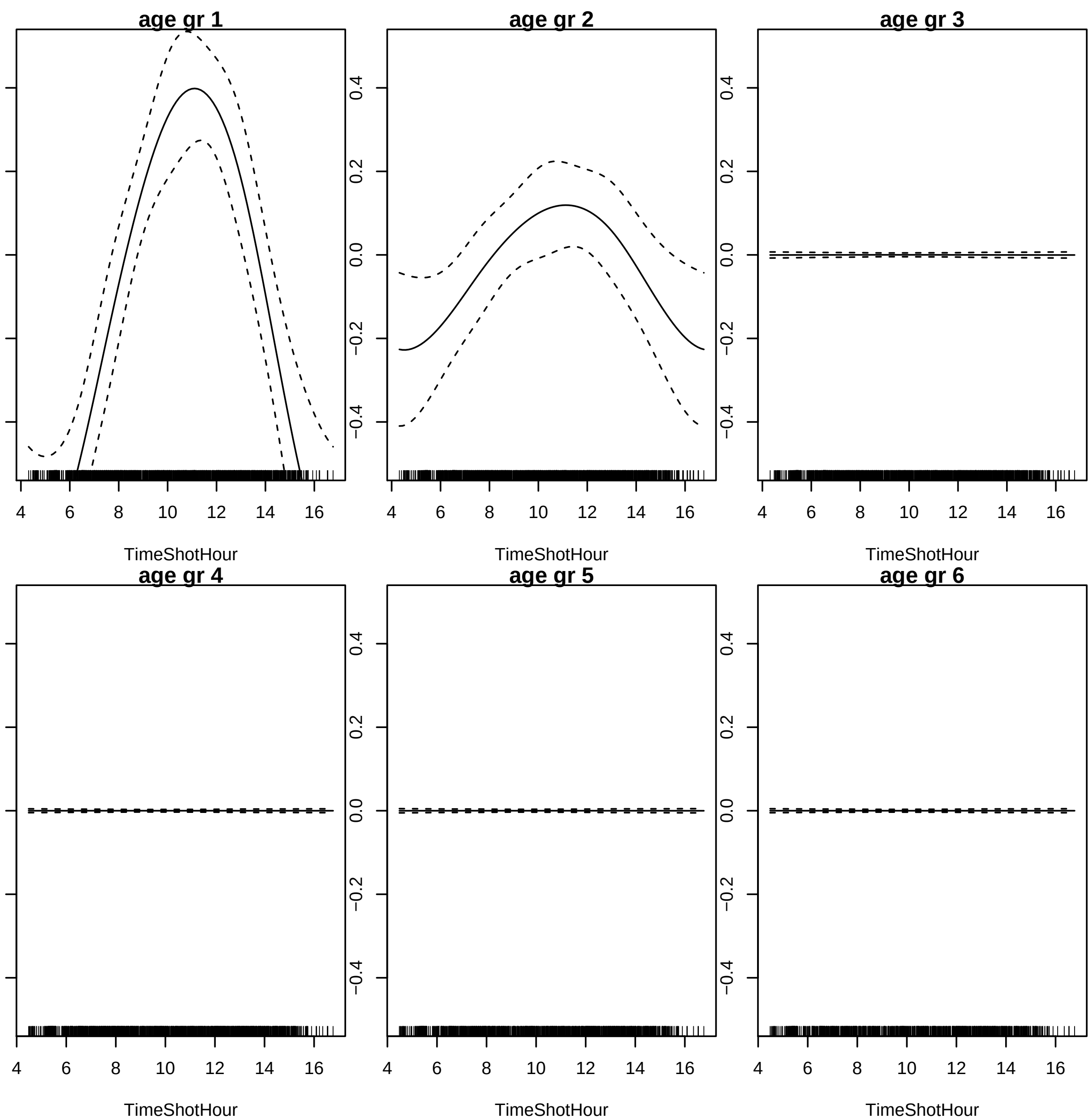


Figure 13: Estimated time of day effects Q3+Q4

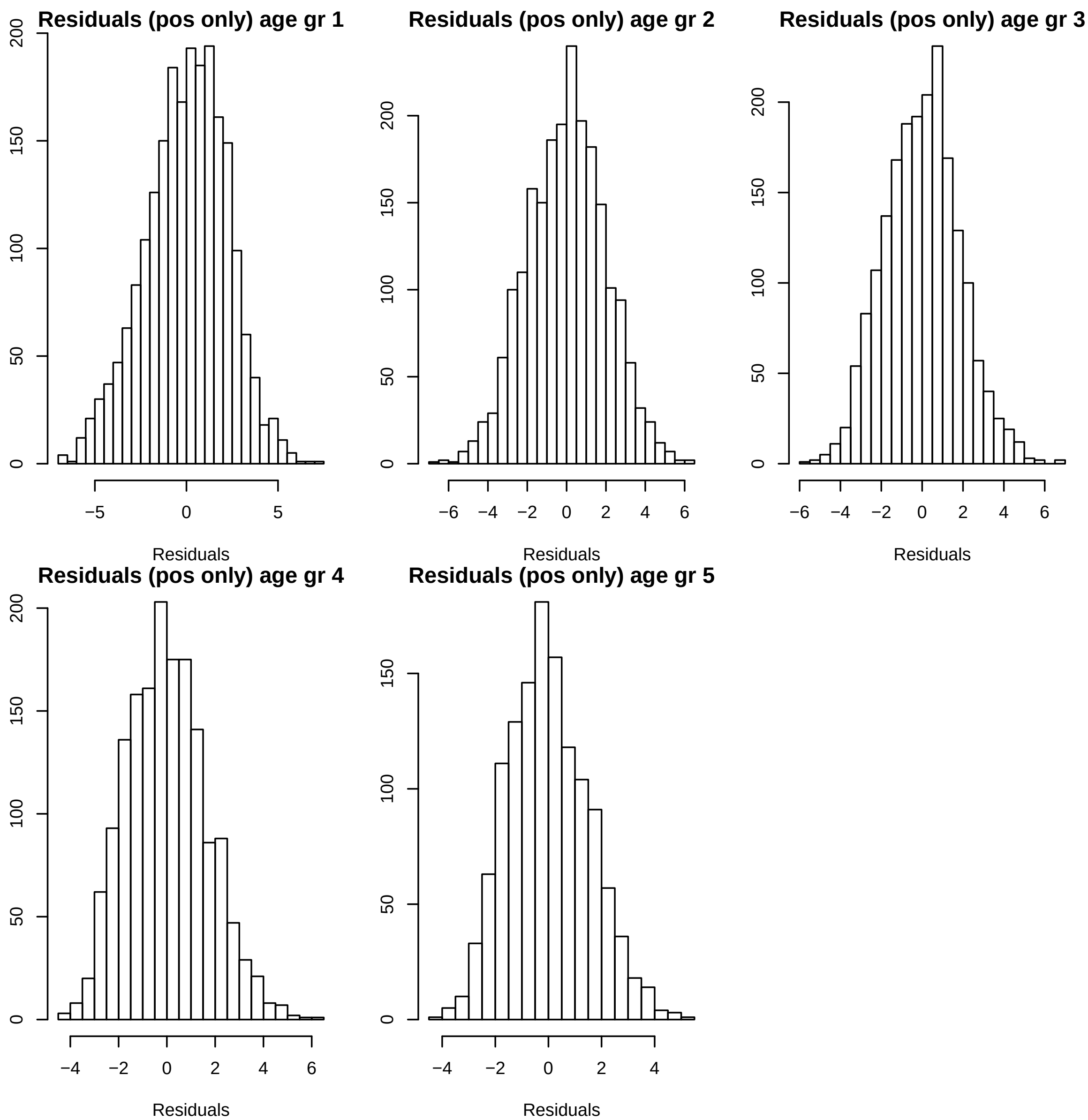


Figure 14: residuals Q1

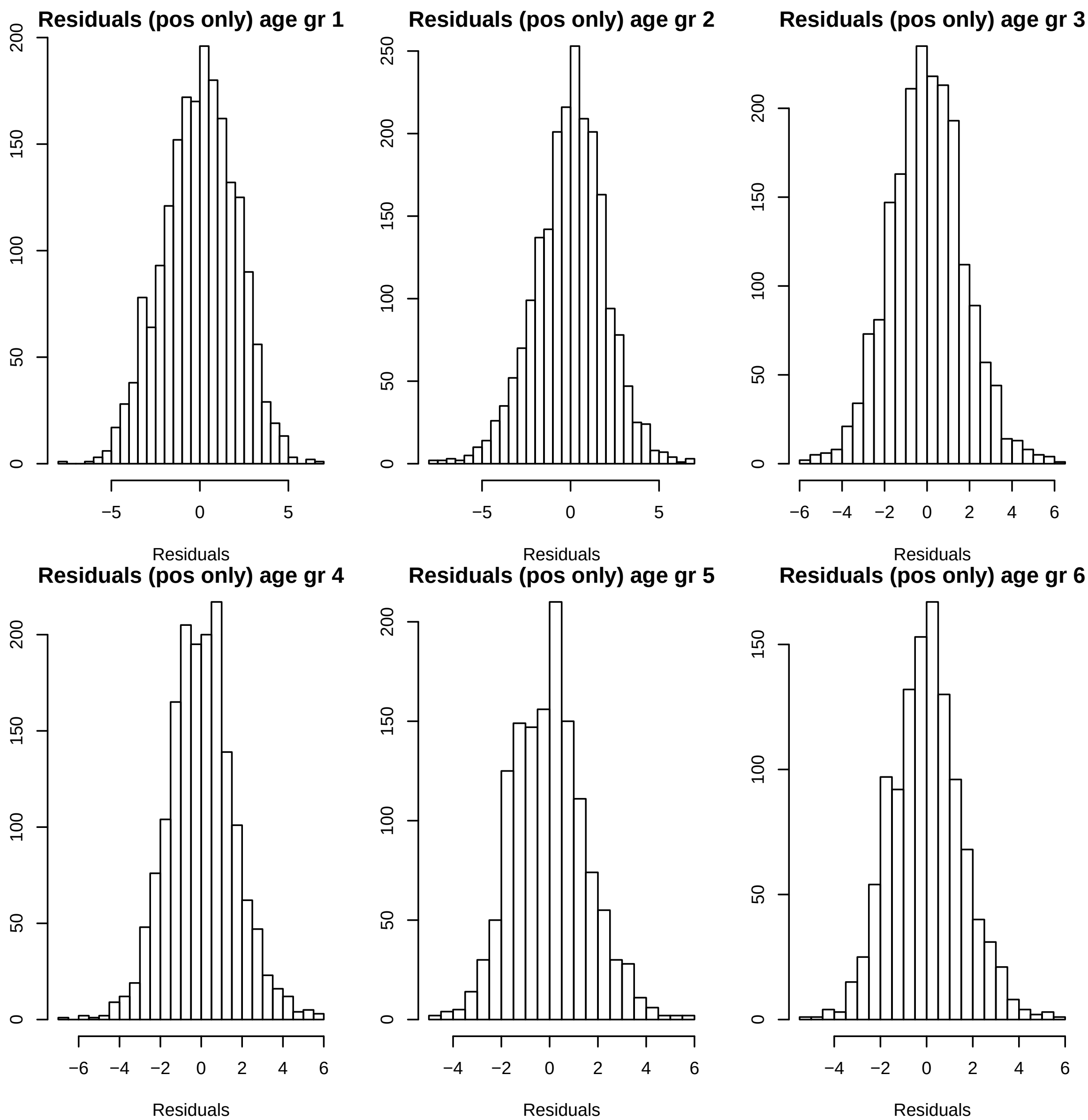


Figure 15: residuals Q3+Q4

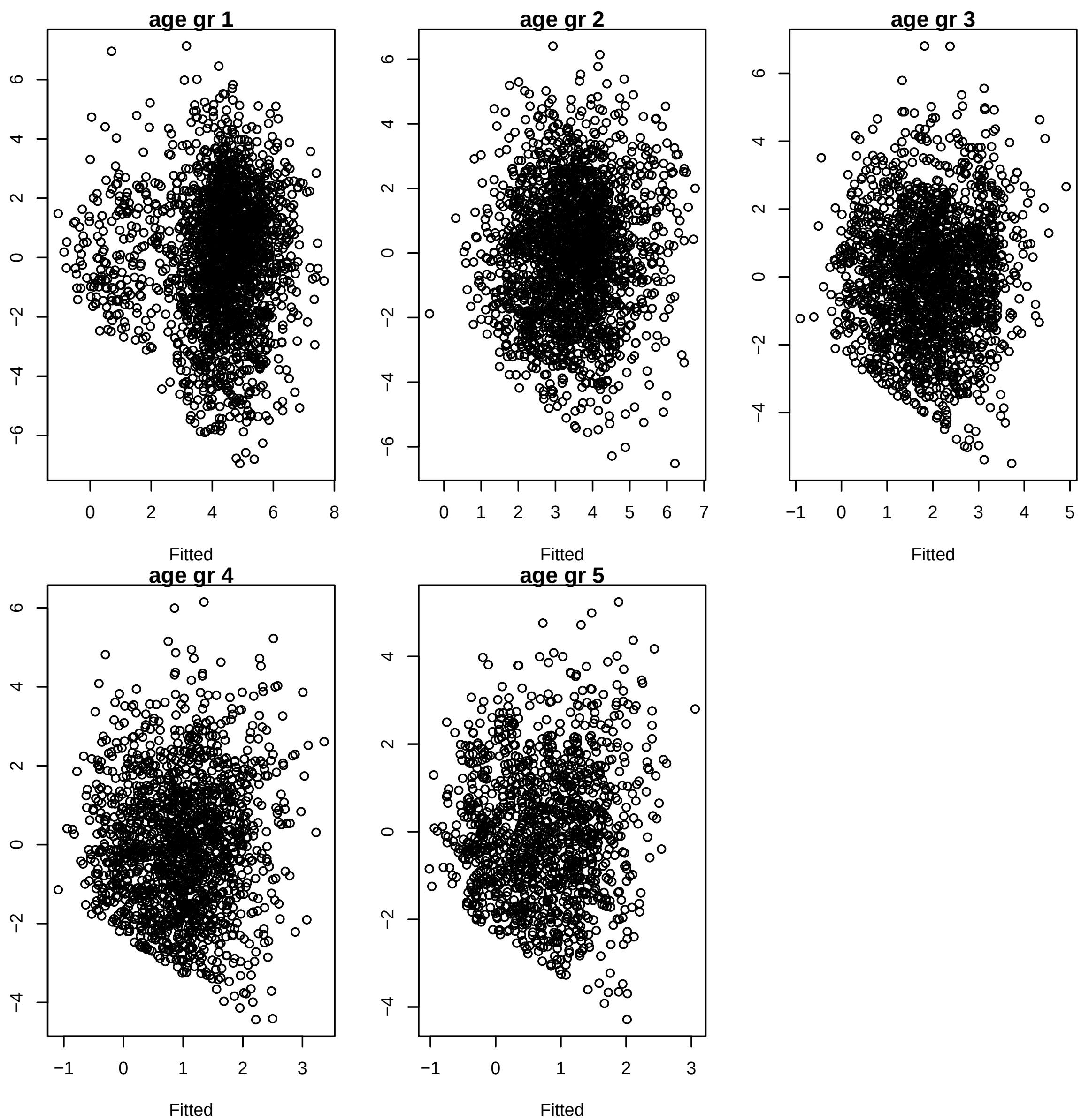


Figure 16: fitted versus residuals Q1

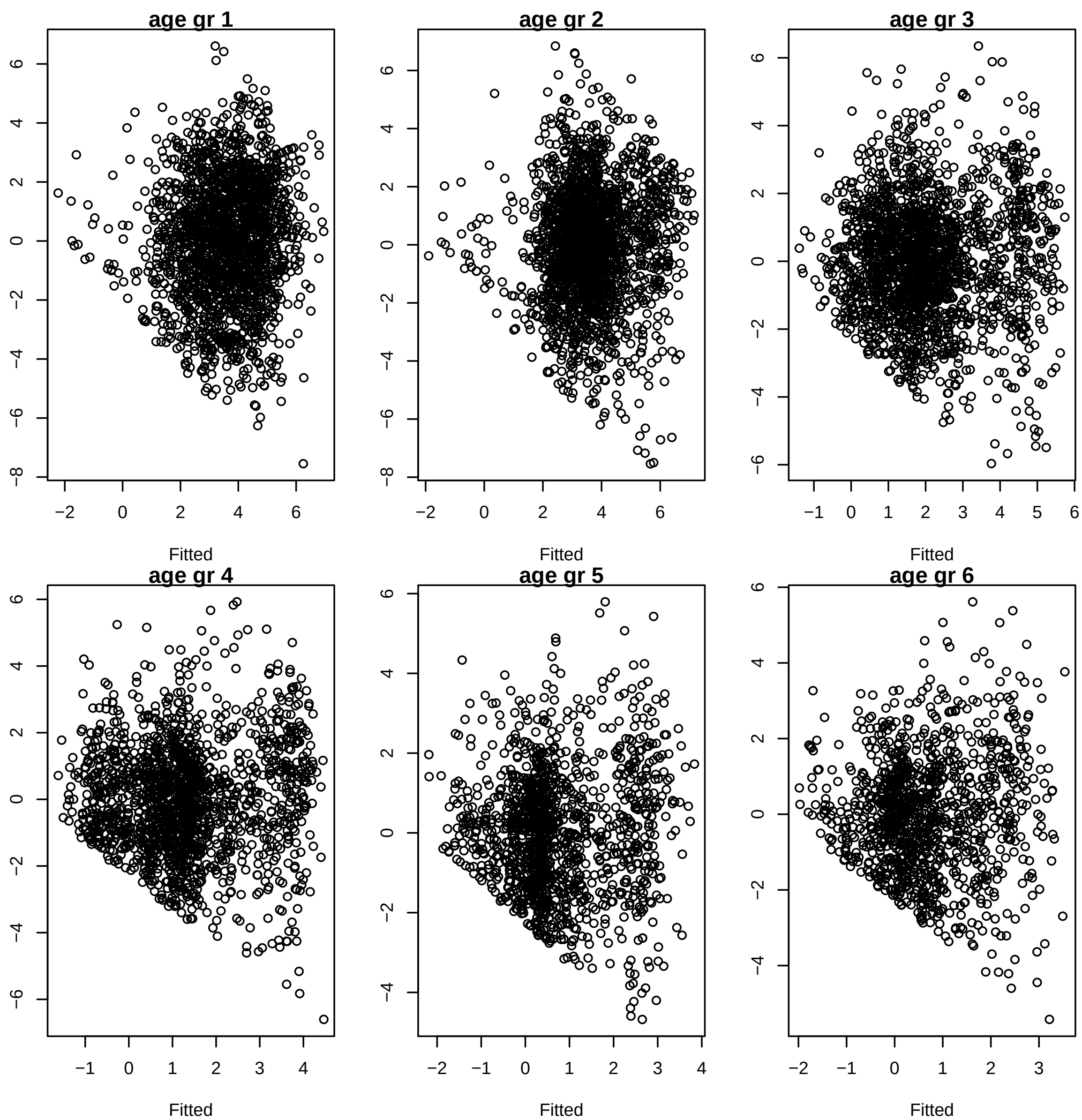


Figure 17: fitted versus residuals Q3+Q4

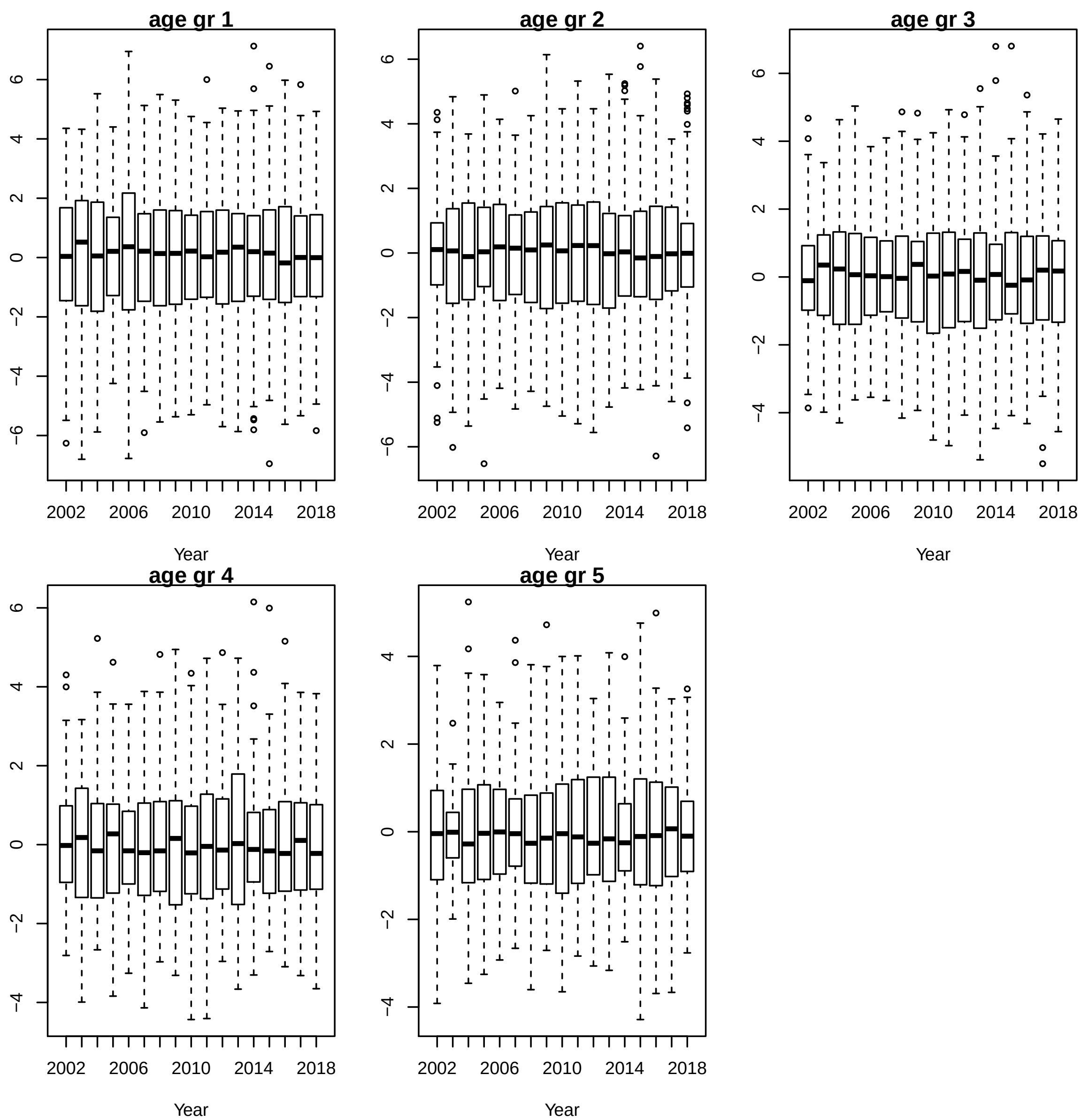


Figure 18: residuals by year Q1

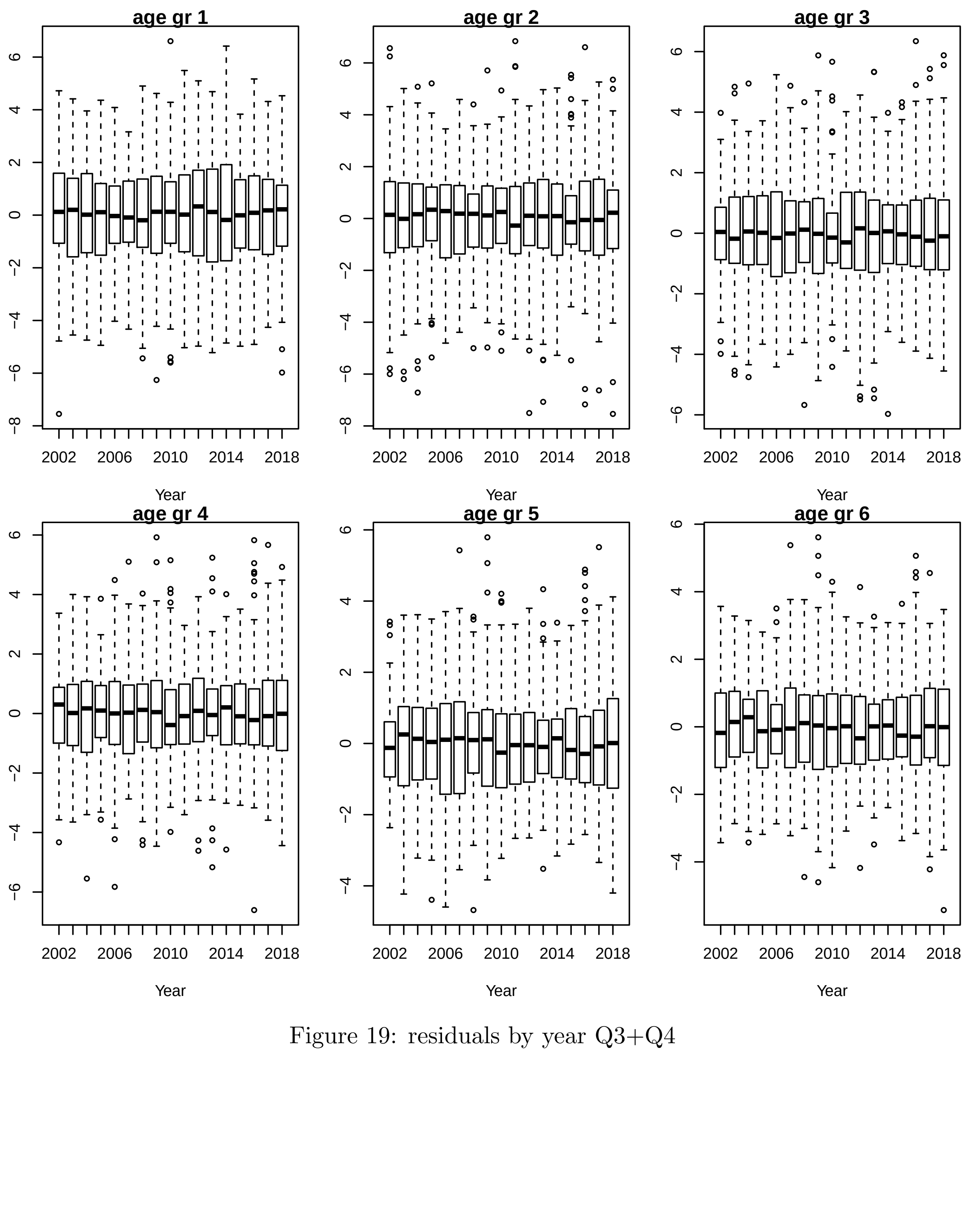


Figure 19: residuals by year Q3+Q4

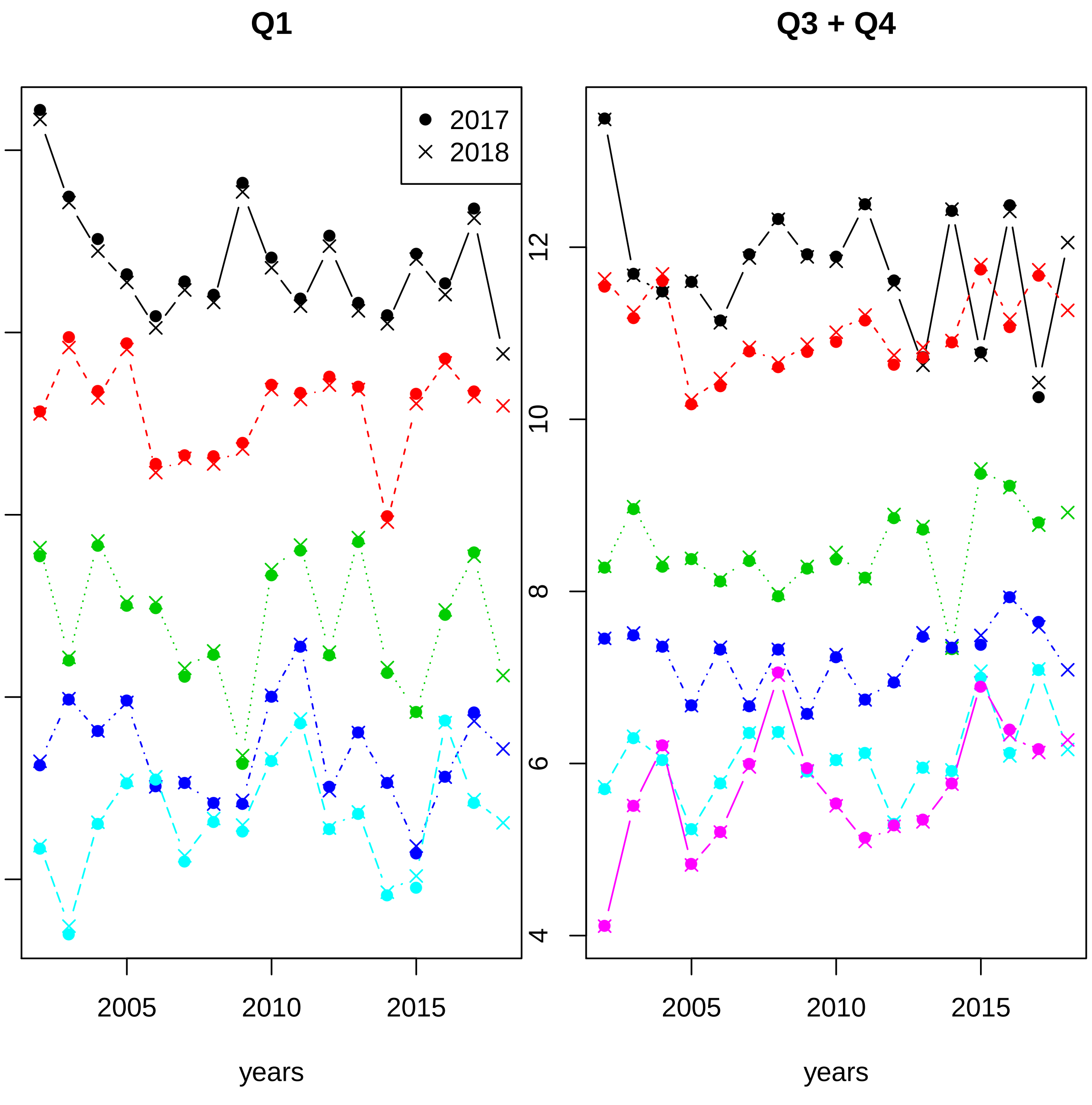


Figure 20: Comparison with last year's indices

WD 02

2018 Western Baltic spring spawning herring recruitment monitored by the Rügen Herring Larvae Survey

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The waters of Greifswald Bay (ICES area 24) are considered a major spawning area of Western Baltic spring spawning (WBSS) herring. The German Thünen Institute of Baltic Sea Fisheries (TI-OF), Rostock, and its predecessor monitors the density of herring larvae as a vector of recruitment success since 1977 within the framework of the Rügen Herring Larvae Survey (RHLS). It delivers a unique high-resolution dataset on the herring larvae ecology in the Western Baltic, both temporally and spatially. Onboard the research vessel "FFS Clupea" a sampling grid including 35 stations is sampled weekly using ichthyoplankton gear (Bongo-net, mesh sizes 335 µm; 780 µm) during the main reproduction period from March to June. The weekly assessment of the entire sampling area is conducted within two days (detailed description of the survey design can be found in Polte 2013 (WD in ICES CM 2013/ACOM: 4). The collected data provide an important baseline for detailed investigations of spawning and recruitment ecology of WBSS herring spawning components. As a fishery-independent indicator of stock development, the recruitment index is incorporated into the assessment of the ICES Herring Assessment Working Group.
The rationale for the *N20* recruitment index is based on regular and strong correlations between the amount of larvae reaching a length of 20 mm (TL) in Greifswald Bay and abundance data of juveniles (1wr and 2wr fish) as determined by acoustic surveys in the Arkona and Belt Seas (GERAS).
Those recurring correlations (N20/GERAS, 1-wr; 1992-2018 R^2=0.74) support the underlying hypotheses that i) major variability of natural mortality occurs at early life stages before larvae reach a total length of 20 mm and ii) larval herring production in Greifswald Bay is an adequate proxy for annual recruitment strength of the WBSS herring stock.
The *N20* recruitment index is calculated every year based on data obtained from the RHLS. This is done by estimating weekly growth of larvae for seasonal temperature change and taking the sum of larvae reaching 20 mm by every survey week until the end of the investigation period. On the spatial scale, the 35 sampling stations are assigned to 5 strata and mean values of stations for each stratum are extrapolated to the strata area (for details see Oeberst et. al 2009). The sum of *N20* larvae caught over the investigation period in the entire area results in the *N20* recruitment index for those herring that enter the fishery as adults two to three years later.
Calculation procedures have been reviewed and re-established in 2007 and the recalculated index for the time series from 1992 onwards is used by HAWG since 2008 as 0-group recruitment index for the assessment of Western Baltic Spring Spawning herring.

2018 N20 index results:

With an estimated product of **1563 million** larvae, the 2018 *N20* recruitment index is in similar dimensions as the previous year and more than double as high as the record low of 2016 (Table 1, Figure 1). However, the value is only in the range of about 1/5 of the time series mean thus not countering the decreasing trend of larval production observed in the system during the past two decades.

The spawning process in spring 2018 took place under a quite special winter regime. The course of winter-water temperatures remained quite mild (Figure 2) until mid- February. When the first cruise (RHLS-winter control) started on February 2nd, the first spawning fishes were observed in own gill net samples in Greifswald Bay. About a week later a severe cold period started and water temperatures quickly dropped to 2 -0 °C. This temperature is considered below the critical temperature for vital embryonic development (Peck et al. 2012). Since herring in full spawning condition remained in the aggregation area in Pommeranian Bay for the entire period Greifswald Bay was ice covered, many individuals with abnormal ovaries were found in scientific as well as commercial samples. When the spawning process in Greifswald Bay continued in March, steep spring temperatures lead to rapid warming of the water and spawning ended early in the end of April (instead early May as usual). All these observations point on severe consequences of current phenology shifts on larval production and-survival. The trawl net fishery on pre-spawner aggregations in the Pommeranian Bay started on January 2nd. The gill net fishery on ripe fish on the spawning ground started on February 18th but then stopped due to the cold period (ice cover) and took up fishery again on Mar 12th. This fishery ended on Apr. 23rd.

Due to extended ice cover the regular Rügen-herring larvae Survey started late on March 23nd (10 days later than 2017) and was conducted until June 26th, over a 15 weeks period. Additionally on two dates in February (start Feb. 2nd) and November (start Nov 5th) control surveys were conducted testing for winter and autumn larvae respectively. During both controls a limited number of post-flexion larvae were observed in the system.

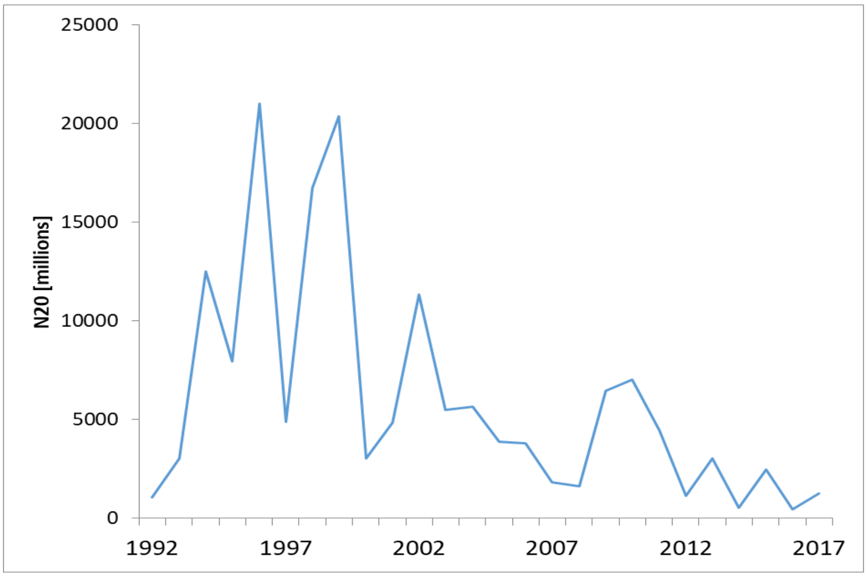

Figure 1 Validated RHLS time series with N20 index data presented as annual sum of 20 mm larvae in millions.

Table 1 *N20* larval herring index for spring spawning herring of the Western Baltic Sea (WBSS), generated by RHLS data.

Year	N20 (Millions)
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**

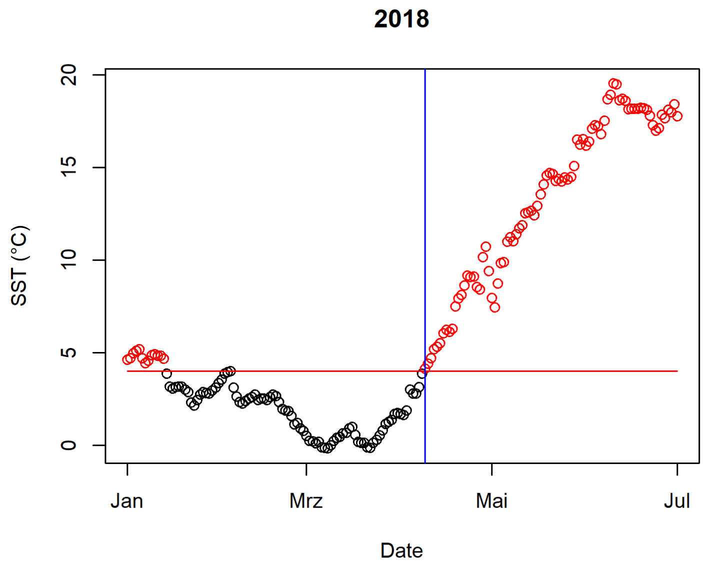

Figure 2 Daily mean sea surface temperature (SST) slope (*NASA Earth Observation project (http://neo.sci.gsfc.nasa.gov/)*) in central Greifswald Bay 2018. Red line indicates a 4°C threshold for initial spawning activity. On both positions where SST reached this line, spawning activity was observed. The blue line indicates the beginning of the spring temperature curve covering egg development, larval hatch and larval growth/survival.

Revision of the relation between N20 and GERAS 1-wr herring after years with low larvae production

After the record low N20 in 2016 the relation with the 1-group juveniles as monitored by the German hydroacoustic survey (GERAS) after the one-year growth phase was re-evaluated to see if the recent years with extremely low larvae production results affect the former correlation with 1-wr juveniles on the scale of the western Baltic Sea. The results indicate no influence on the correlation between N20 and GERAS 1-wr juveniles. The low N20 years resulted in correspondingly low GERAS indices for the 1-wr juveniles (Fig. 3).

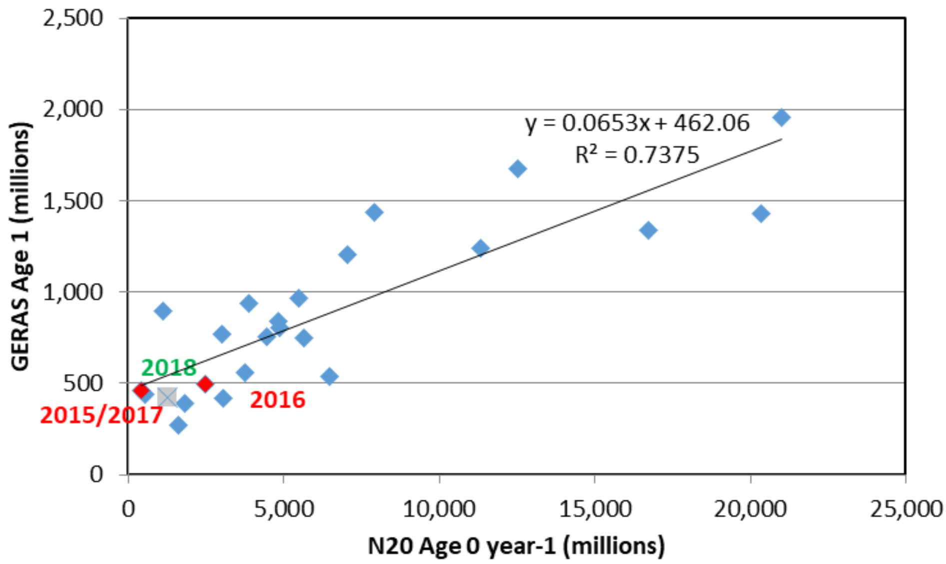

Figure 3 Correlation of N20 larvae index (1992-2017) with the 1-wr herring from GERAS (1993-2018). Note: The one-year lag phase between indices. E.g. the exceptionally low N20 year 2016 is represented by the GERAS 1-wr index 2017.

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Peck, M.A., Kanstinger, P., Holste, L., Martin, M. (2012).Thermal windows supporting survival of the earliest life stagesof Baltic herring (*Clupea harengus*). ICES Journal of Marine Science, 69: 529–536.

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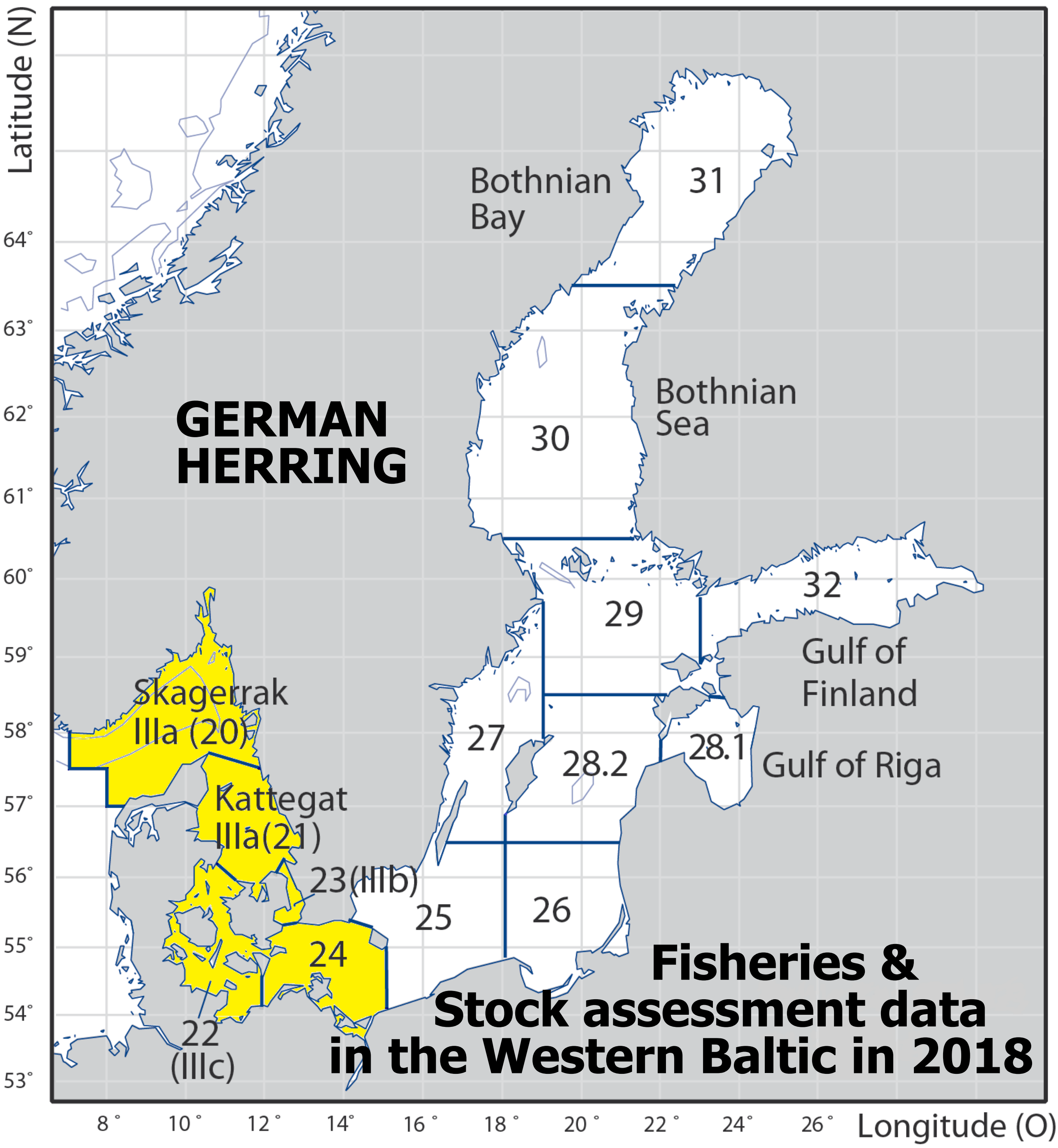

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1 German herring fisheries in 2018

1.1 Fisheries

In 2018 the total German herring landings from the Western Baltic Sea in Subdivisions (SD) 22 and 24 amounted to 11,304, which represents a decrease of 23 % compared to the landings in 2017 (14,694 t). This decrease was caused by a decrease of the TAC/quota (German quota for SDs 22 and 24 in 2018: 9,551 t + quota-transfer of 2,434 t). The German quota in 2018 was only used by 94 % (2017: 88 %, 2016: 98). The fishing activities in one of the main fishing areas, the Greifswald Bay (SD 24), which started already in mid-February, had to be suspended at the end of February until mid-March due due to a cold period with ice coverage. The main German fishery stopped their activities at the end of April.

As in previous years some herring was also caught in the Skagerrak/Kattegat area (Division IIIa):

Year	Landings (t)
2005	751
2006	556
2007	454
2008	352 + 1,214 misreported from area SD 23
2009	887
2010	146
2011	54
2012	629
2013	195 (= 46 % of GER quota (>32 mm) of 421 t
2014	84 (= 27 % of GER quota (>32 mm) of 310 t
2015	128 (= 44 % of GER quota (>32 mm) of 289 t
2016	125 (= 37 % of GER quota (>32 mm) of 339 t
2017	85 (= 25 % of GER quota (> 32 mm) of 339 t*
2018	.206 (= 43 % of GER quota (>32 mm) of 358 t*

*Including a quota transfer of 1 t in 2017 and 34 t in 2018.

The landings (t by quarter and Sub-Division including information about the fraction of landings in foreign ports (**given as minus values**)) are shown in the table below:

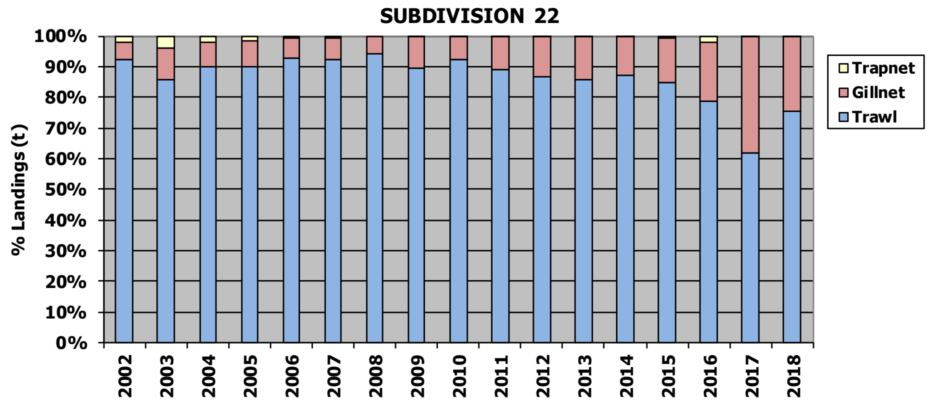
Quarter	Skag./Katteg. (t)	Subdiv. 22 (t)	Subdiv. 24 (t)	TOTAL (t)	TOTAL (%)
I		114.932	7,521.311	**7,636.243**	**66.3**
			-0.950	**-0.950**	**0.0**
II		13.538	2,471.531	**2,485.069**	**21.6**
			-1.500	**-1.500**	**0.0**
III	104.347	0.477	0.145	**104.969**	**0.9**
	-104.347			**-104.347**	**-0.9**
IV	101.534	7.375	1,174.924	**1,283.833**	**11.2**
			-0.440	**-0.440**	**0.0**
TOTAL	**205.881**	**136.322**	**11,167.911**	**11,510.114**	**100.0**
	-104.347	**0.000**	**-2.890**	**-107.237**	**-0.9**

Source: Federal Centre for Agriculture and Food (BLE). Since 2008 the obligation to report via logbooks changed to vessels >8 m (until 2007 for vessels >10 m)

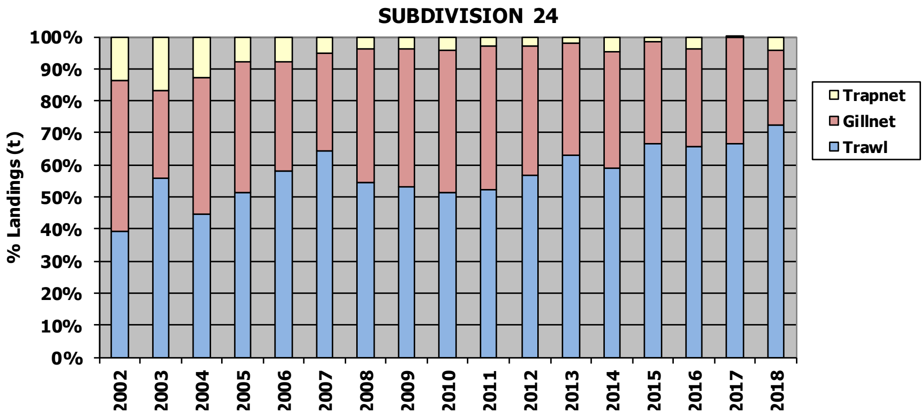
Landings = Total landings
-Landings = Fraction landed abroad

Just as in former years the main fishing season was during the first and second quarter. About 88 % of the herring in 2018 was caught between January and April (2017: 86 %, 2016 : 84 %, 2015: 84 %). As in last years, the main fishing area was located in Subdivision 24 (2016-2018: 97 %; 2015: 96 %, 2014: 93 %). The overall fishing pattern during the last years was rather stable in the Baltic area of Subdivisions 22 and 24. Until 2000, the dominant part of herring was caught in the passive fishery by gillnets and trapnets around the Island of Rügen. Since 2001, the activities in the trawl fishery have increased. They reached the highest contribution in 2018 of 72 % (2017: 66 %, 2017: 66 %). The trawl fishery was mostly carried out in Subdivision 24 (2016-2018: 98 %, 2015: 96 %, 2014: 91 %; 2013: 94). The change in fishing pattern since 2001 was caused by the perspective of a new fish processing factory on the Island of Rügen, which finally started the production in autumn 2003. This factory intends to process 50,000 t fish annually. The figure below shows the share of the different gear types in the German herring fishery for the years 2002-2018 in Subdivisions 22 and 24.

SD 22 (t)	Trawl	Gillnet	Trapnet	Total	SD 22 (%)	Trawl	Gillnet	Trapnet
2002	3,871.716	253.710	78.838	4,204.264	2002	92.1%	6.0%	1.9%
2003	3,147.054	382.678	150.007	3,679.739	2003	85.5%	10.4%	4.1%
2004	2,282.844	196.963	55.674	2,535.481	2004	90.0%	7.8%	2.2%
2005	1,700.627	162.795	29.312	1,892.734	2005	89.9%	8.6%	1.5%
2006	2,977.731	215.366	14.372	3,207.469	2006	92.8%	6.7%	0.4%
2007	1,922.914	139.321	16.395	2,078.630	2007	92.5%	6.7%	0.8%
2008	2,086.175	124.471	0.000	2,210.646	2008	94.4%	5.6%	0.0%
2009	1,436.082	171.106	0.910	1,608.098	2009	89.3%	10.6%	0.1%
2010	1,565.826	125.609	3.381	1,694.816	2010	92.4%	7.4%	0.2%
2011	1,040.724	124.015	3.073	1,167.812	2011	89.1%	10.6%	0.3%
2012	729.236	109.950	3.315	842.501	2012	86.6%	13.1%	0.4%
2013	610.485	99.970	2.708	713.163	2013	85.6%	14.0%	0.4%
2014	572.074	80.422	2.660	655.156	2014	87.3%	12.3%	0.4%
2015	404.439	70.548	2.382	477.369	2015	84.7%	14.8%	0.5%
2016	193.125	48.061	4.593	245.779	2016	78.6%	19.6%	1.9%
2017	190.689	117.481	0.004	308.174	2017	61.9%	38.1%	0.0%
2018	103.078	32.903	0.341	136.322	2018	75.6%	24.1%	0.3%



SD 24 (t)	Trawl	Gillnet	Trapnet	Total	SD 24 (%)	Trawl	Gillnet	Trapnet
2002	7,155.192	8,529.682	2,480.824	18,165.698	2002	39.4%	47.0%	13.7%
2003	8,425.517	4,162.634	2,508.141	15,096.292	2003	55.8%	27.6%	16.6%
2004	6,912.896	6,599.784	1,960.868	15,473.548	2004	44.7%	42.7%	12.7%
2005	9,863.481	7,761.212	1,522.218	19,146.911	2005	51.5%	40.5%	8.0%
2006	11,393.038	6,744.164	1,525.095	19,662.297	2006	57.9%	34.3%	7.8%
2007	14,449.006	6,937.814	1,117.411	22,504.231	2007	64.2%	30.8%	5.0%
2008	11,196.706	8,636.140	789.005	20,621.851	2008	54.3%	41.9%	3.8%
2009	7,617.179	6,232.206	523.088	14,372.473	2009	53.0%	43.4%	3.6%
2010	5,415.716	4,679.209	448.801	10,543.726	2010	51.4%	44.4%	4.3%
2011	3,654.547	3,177.875	186.600	7,019.022	2011	52.1%	45.3%	2.7%
2012	5,865.995	4,142.744	318.993	10,327.732	2012	56.8%	40.1%	3.1%
2013	8,742.420	4,833.203	301.719	13,877.342	2013	63.0%	34.8%	2.2%
2014	5,656.314	3,482.558	447.064	9,585.936	2014	59.0%	36.3%	4.7%
2015	8,517.972	4,112.581	181.151	12,811.704	2015	66.5%	32.1%	1.4%
2016	9,301.364	4,314.489	564.965	14,180.818	2016	65.6%	30.4%	4.0%
2017	9,585.798	4,781.359	19.100	14,386.257	2017	66.6%	33.2%	0.1%
2018	8,082.664	2,630.414	454.833	11,167.911	2018	72.4%	23.6%	4.1%



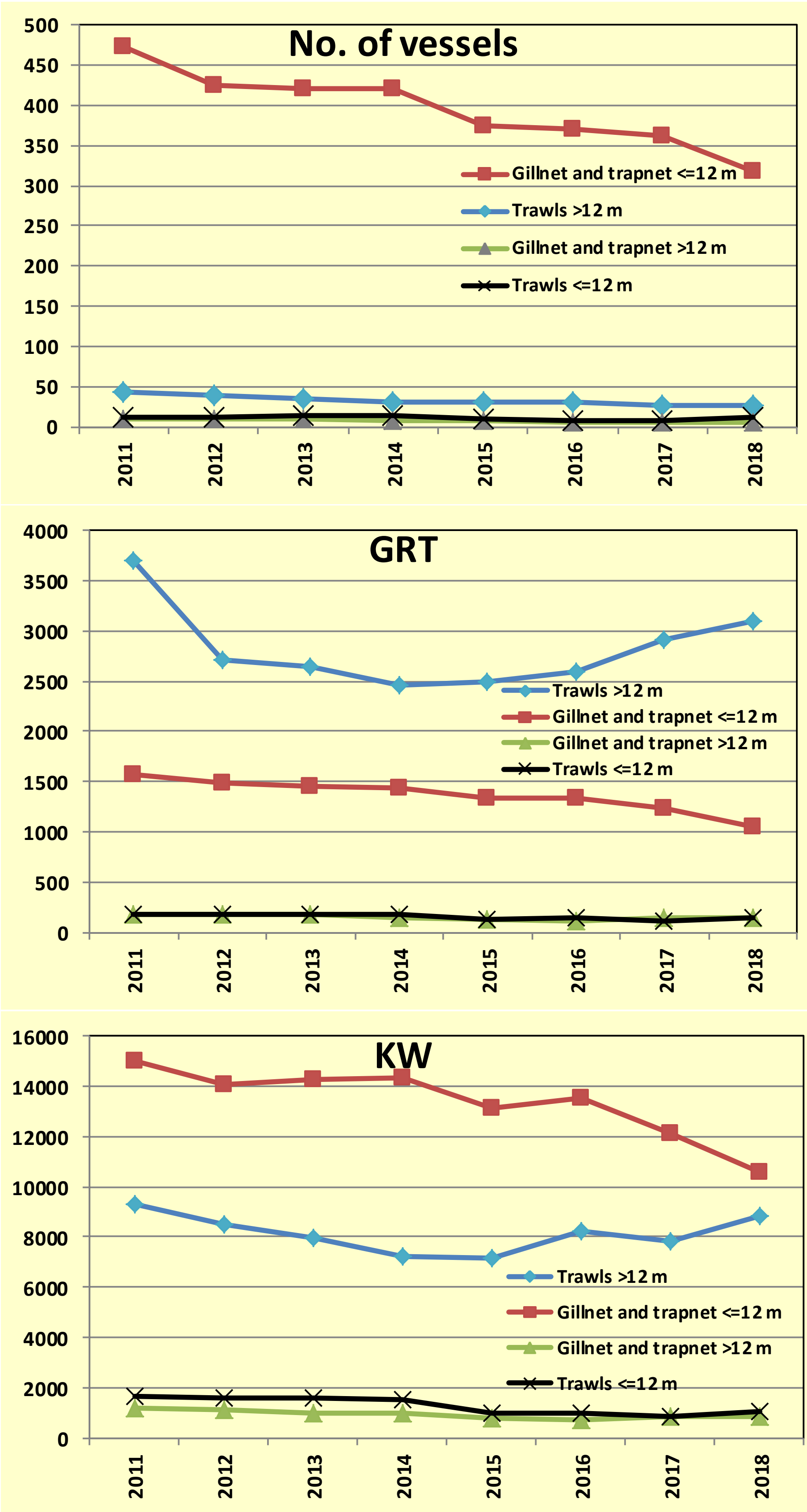
1.2 Fishing fleet

The German fishing fleet in the Baltic Sea consists of two parts where all catches for herring are taken in a directed fishery:

- coastal fleet with undecked vessels (rowing/motor boats <=10 m, engine power <=100 HP)
- cutter fleet with decked vessels and total lengths between 12 m and 30 m.

In the years from 2011 until 2018 the following types of fishing vessels carried out the herring fishery in the Baltic (only referring to vessels, which are contributing to the overall total landings per year with more than 20 %):

Year	Type of gear	Vessel length (m)	No. of vessels	GRT	kW
2011	Fixed gears	<=12	473	1,566	15,020
	(gillnet and trapnet)	>12	10	185	1,215
	Trawls	<=12	12	171	1,666
		>12	43	3,710	9,325
	TOTAL		**538**	**5,632**	**27,226**
2012	Fixed gears	<=12	426	1,485	14,105
	(gillnet and trapnet)	>12	9	184	1,125
	Trawls	<=12	12	170	1,573
		>12	38	2,712	8,480
	TOTAL		**485**	**4,551**	**25,283**
2013	Fixed gears	<=12	421	1,459	14,289
	(gillnet and trapnet)	>12	9	186	1,005
	Trawls	<=12	14	173	1,557
		>12	35	2,638	7,960
	TOTAL		**479**	**4,456**	**24,811**
2014	Fixed gears	<=12	421	1,443	14,351
	(gillnet and trapnet)	>12	8	149	970
	Trawls	<=12	13	170	1,502
		>12	31	2,469	7,205
	TOTAL		**473**	**4,231**	**24,028**
2015	Fixed gears	<=12	375	1,341	13,163
	(gillnet and trapnet)	>12	7	133	802
	Trawls	<=12	9	122	991
		>12	31	2,503	7,148
	TOTAL		**422**	**4,099**	**22,104**
2016	Fixed gears	<=12	371	1,341	13,532
	(gillnet and trapnet)	>12	5	103	699
	Trawls	<=12	8	137	997
		>12	30	2,599	8,205
	TOTAL		**414**	**4,180**	**23,433**
2017	Fixed gears	<=12	362	1,237	12,158
	(gillnet and trapnet)	>12	6	148	874
	Trawls	<=12	8	113	872
		>12	27	2,910	7,816
	TOTAL		**403**	**2,910**	**21,720**
2018	Fixed gears	<=12	319	1,049	10,572
	(gillnet and trapnet)	>12	6	148	874
	Trawls	<=12	11	143	1,080
		>12	26	3,093	8,815
	TOTAL		**362**	**4,433**	**21,341**


No. of vessels
500
450
400
350
300
250
200
150
100
50
0
Gillnet and trapnet <=12 m
Trawls >12 m
Gillnet and trapnet >12 m
Trawls <=12 m
2011
2012
2013
2014
2015
2016
2017
2018
GRT
4000
3500
3000
2500
2000
1500
1000
500
0
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m
KW
16000
14000
12000
10000
8000
6000
4000
2000
0

1.3 Species composition of landings

The catch composition from gillnet and trapnet consists of nearly 100 % of herring.

The results from the species composition of German trawl catches, which were sampled in **Subdivision 24** of quarter 1 and 4 in 2018, are given below:

SD 24/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
January	1	57.4	0.0	0.0	0.0	57.4	100.0	0.0	0.0	0.0
	2	61.5	0.0	0.0	0.0	61.5	100.0	0.0	0.0	0.0
	3	53.6	0.0	0.0	0.0	53.6	100.0	0.0	0.0	0.0
	Mean	57.5	0.0	0.0	0.0	57.5	100.0	0.0	0.0	0.0
February	1	69.7	0.0	0.0	0.0	69.7	100.0	0.0	0.0	0.0
	2									
	3									
	Mean	69.7	0.0	0.0	0.0	69.7	100.0	0.0	0.0	0.0
March	1	43.7	0.0	0.0	0.0	43.8	100.0	0.0	0.0	0.0
	2	50.2	0.0	0.0	0.0	50.2	100.0	0.0	0.0	0.0
	3	56.9	0.1	0.0	0.0	56.9	99.9	0.1	0.0	0.0
	Mean	50.3	0.0	0.0	0.0	50.3	100.0	0.0	0.0	0.0
Q I	Mean	59.2	0.0	0.0	0.0	59.2	100.0	0.0	0.0	0.0

SD 24/Quarter IV		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
Octob.	1									
	2									
	3									
	Mean									
Novemb.	1									
	2									
	3									
	Mean									
Decemb.	1	60.580	0.419	0.000	0.000	60.999	99.3	0.7	0.0	0.0
	2									
	3									
	Mean	60.580	0.419	0.000	0.000	60.999	99.3	0.7	0.0	0.0
Q IV	Mean	60.580	0.419	0.000	0.000	60.999	99.3	0.7	0.0	0.0

The officially reported total trawl landings of herring in Subdivison 24 (see 2.1) in combination with the detected mean species composition in the samples (see above) results in the following differences:

Subdiv.	Quarter	Trawl landings (t)	Mean Contribution of Herring (%)	Total Herring corrected (t)	Difference (t)
24	I	**6,740**	100.0	6,740	0
	IV	**1,122**	99.3	1,115	-8

The officially reported trawl landings in Subdivision 24 (see 2.1) and the referring assessment input data (see 2.2 and 2.3) were as in last years not corrected since the results would only result in overall small changes of the official statistics (total trawl landings in Subdivision 22 and 24 of 8186 t – 8 t -> 0.1 % difference).

1.4 Logbook registered discards/BMS landings

No BMS landings (both new catch categories since 2015) of herring have been reported in the German herring fisheries in 2018 (no BMS landing have been reported since 2015). A total amount logbook registered discards of 14.507 t (quarter 1: 3.133 t; quarter 2: 11.374) were recorded by the German fisherman (as predation by seals?) in the gillnet fisheries in SD 24 in 2018. Neither discards nor logbook registered discards have been reported before 2018.

1.5 Central Baltic herring

In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring Spawning herring (WBSSH) and the Central Baltic herring (CBH) overlap. German autumn acoustic survey (GERAS) 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). 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 based on baseline samples of WBSSH and CBH support the applicability of SF in 2011-2018 (Oeberst et al., 2013, WD Oeberst et al., 2014, WD Oeberst et al., 2015; WD Oeberst et al., 2016; WD Oeberst et al., 2017; WD Gröhsler, T. and Schaber, M., 2018, WD Gröhsler, T. and Schaber, M., 2019). SF (slightly modified by commercial samples) was employed in the years 2005-2016 to identify the fraction of Central Baltic Herring in German commercial herring landings from SD 22 and 24 (WD Gröhsler et al., 2013; ICES, 2018). Results showed a rather low share of CBH in landings from all métiers but indicated that the actual degree of mixing might be underrepresented in commercial landings as German commercial fisheries target pre-spawning and spawning aggregations of WBSSH.

1.6 References

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2 Stock assessment data in 2018

2.1 Landings (tons) and sampling effort

Gear	Quarter	SKAGERRAK (DIVISION IIIaN/SD 20)				KATTEGAT (DIVISION IIIaS/SD21)			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	no landings	-	-	-	no landings	-	-	-
	Q 2	no landings	-	-	-	no landings	-	-	-
	Q 3	104.347	0	0	0	no landings	-	-	-
	Q 4	101.534	0	0	0	no landings	-	-	-
	Total	205.881	0	0	0	0.000	0	0	0
GILLNET	Q 1	no landings	-	-	-	no landings	-	-	-
	Q 2	no landings	-	-	-	no landings	-	-	-
	Q 3	no landings	-	-	-	no landings	-	-	-
	Q 4	no landings	-	-	-	no landings	-	-	-
	Total	0.000	0	0	0	0.000	0	0	0
TRAPNET	Q 1	no landings	-	-	-	no landings	-	-	-
	Q 2	no landings	-	-	-	no landings	-	-	-
	Q 3	no landings	-	-	-	no landings	-	-	-
	Q 4	no landings	-	-	-	no landings	-	-	-
	Total	0.000	0	0	0	0.000	0	0	0
TOTAL	Q 1	**0.000**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
	Q 2	**0.000**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
	Q 3	**104.347**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
	Q 4	**101.534**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
	Total	**205.881**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**

Gear	Quarter	SUBDIVISION 22				SUBDIVISION 24			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	102.877	0	0	0	6,739.938	7	2,924	726
	Q 2	0.201	0	0	0	220.305	0	0	0
	Q 3	0.000	-	-	-	0.000	-	-	-
	Q 4	0.000	-	-	-	1,122.421	1	349	119
	Total	103.078	0	0	0	8,082.664	8	3,273	845
GILLNET	Q 1	11.953	1	339	70	757.373	6	2,124	343
	Q 2	13.324	3	1,217	169	1,820.398	6	2,324	350
	Q 3	0.464	0	0	0	0.145	0	0	0
	Q 4	7.162	0	0	0	52.498	0	0	0
	Total	32.903	4	1,556	239	2,630.414	12	4,448	693
TRAPNET	Q 1	0.102	0	0	0	24.000	0	0	0
	Q 2	0.013	1	321	49	430.828	2	798	198
	Q 3	0.013	0	0	0	0.000	-	-	-
	Q 4	0.213	0	0	0	0.005	0	0	0
	Total	0.341	1	321	49	454.833	2	798	198
TOTAL	Q 1	**114.932**	**1**	**339**	**70**	**7,521.311**	**13**	**5,048**	**1,069**
	Q 2	**13.538**	**4**	**1,538**	**218**	**2,471.531**	**8**	**3,122**	**548**
	Q 3	**0.477**	**0**	**0**	**0**	**0.145**	**0**	**0**	**0**
	Q 4	**7.375**	**0**	**0**	**0**	**1,174.924**	**1**	**349**	**119**
	Total	**136.322**	**5**	**1,877**	**288**	**11,167.911**	**22**	**8,519**	**1,736**

Gear	Quarter	TOTAL (DIV. IIIa & SUBDIV. 22+24)			
		Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	6,842.815	7	2,924	726
	Q 2	220.506	0	0	0
	Q 3	104.347	0	0	0
	Q 4	1,223.955	1	349	119
	Total	8,391.623	8	3,273	845
GILLNET	Q 1	769.326	7	2,463	413
	Q 2	1,833.722	9	3,541	519
	Q 3	0.609	0	0	0
	Q 4	59.660	0	0	0
	Total	2,663.317	16	6,004	932
TRAPNET	Q 1	24.102	0	0	0
	Q 2	430.841	3	1,119	247
	Q 3	0.013	0	0	0
	Q 4	0.218	0	0	0
	Total	455.174	3	1,119	247
TOTAL	Q 1	7,636.243	14	5,387	1,139
	Q 2	2,485.069	12	4,660	766
	Q 3	104.969	0	0	0
	Q 4	1,283.833	1	349	119
	Total	11,510.114	27	10,396	2,024

2.2 Catch in numbers (millions)

		SUBDIVISION 20				SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
TRAWL	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												0.126				0.126
	1					0.001	0.0000			0.069	0.002		0.272	0.070	0.002		0.272
	2					0.005	0.0000			0.302	0.010		1.928	0.307	0.010		1.928
	3					0.155	0.0003			10.133	0.331		2.465	10.288	0.332		2.465
	4					0.106	0.0002			6.934	0.227		0.613	7.040	0.227		0.613
	5					0.328	0.0006			21.496	0.703		2.481	21.824	0.703		2.481
	6					0.095	0.0002			6.220	0.203		0.538	6.315	0.204		0.538
	7					0.049	0.0001			3.221	0.105		0.341	3.271	0.105		0.341
	8+					0.026	0.0000			1.673	0.055			1.698	0.055		
	Sum					0.764	0.0015			50.048	1.636		8.763	50.812	1.637		8.763
GILLNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0																
	1																
	2																
	3					0.002	0.0005	0.0000	0.000		0.033	0.0000	0.001	0.002	0.033	0.000	0.001
	4					0.006	0.002	0.0001	0.001	**0.148**	0.433	0.0000	0.012	0.154	0.435	0.000	0.014
	5					0.006	0.021	0.0007	0.011	**2.082**	5.272	0.0004	0.152	2.089	5.293	0.001	0.163
	6					0.008	0.030	0.0011	0.016	**0.928**	2.491	0.0002	0.072	0.937	2.522	0.001	0.088
	7					0.027	0.020	0.0007	0.011	**0.878**	1.955	0.0002	0.056	0.905	1.975	0.001	0.067
	8+					0.017	0.009	0.0003	0.005	**0.301**	0.973	0.0001	0.028	0.319	0.982	0.000	0.033
	Sum					0.067	0.083	0.0029	0.045	**4.338**	11.157	0.0009	0.322	4.405	11.240	0.004	0.367
TRAPNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0																
	1					0.000	0.000	0.0000	0.0004					0.000	0.000	0.0000	0.0004
	2					0.001	0.0002	0.0002	0.0025	0.002	0.036		0.00000	0.003	0.036	0.0002	0.0025
	3					0.0003	0.0000	0.0000	0.0006	0.070	1.264		0.00001	0.071	1.264	0.0000	0.0006
	4					0.0001	0.0000	0.0000	0.0003	0.044	0.788		0.00001	0.044	0.788	0.0000	0.0003
	5									0.087	1.568		0.00002	0.087	1.568		0.0000
	6									0.016	0.289		0.00000	0.016	0.289		0.0000
	7									0.013	0.235		0.00000	0.013	0.235		0.0000
	8+									0.004	0.074		0.00000	0.004	0.074		0.0000
	Sum					0.0018	0.000	0.0002	0.0038	0.237	4.253		0.00005	0.239	4.253	0.0002	0.0039
TOTAL	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												0.126				0.126
	1					0.001	0.000	0.000	0.0004	0.069	0.002		0.272	0.070	0.002	0.000	0.272
	2					0.0058	0.000	0.000	0.0025	0.304	0.046		1.928	0.310	0.046	0.000	1.931
	3					0.157	0.001	0.000	0.0009	10.204	1.628	0.000	2.466	10.361	1.628	0.000	2.467
	4					0.112	0.003	0.000	0.0016	7.126	1.447	0.000	0.625	7.238	1.450	0.000	0.627
	5					0.334	0.021	0.001	0.0112	23.665	7.543	0.000	2.633	24.000	7.564	0.001	2.644
	6					0.103	0.031	0.001	0.0164	7.165	2.984	0.000	0.609	7.268	3.014	0.001	0.626
	7					0.076	0.020	0.001	0.0107	4.112	2.295	0.000	0.398	4.189	2.315	0.001	0.408
	8+					0.043	0.009	0.000	0.0051	1.978	1.102	0.000	0.028	2.021	1.111	0.000	0.033
	Sum					0.833	0.085	0.003	0.0486	54.623	17.046	0.001	9.085	55.456	17.131	0.004	9.133

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	1, 2	24	Trawl	1	Trawl	2	24	Trawl	1
Gillnet	3, 4	22	Gillnet	2	Gillnet	3, 4	24	Gillnet	2
Trapnet	1, 3, 4	22	Trapnet	2	Trapnet	1, 4	24	Trapnet	2

2.3 Mean weight (grammes) in the catch

	W-rings	SUBDIVISION 20				SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0												17.9				17.9
	1					19.6	19.6			19.6	19.6		49.6	19.6	19.6		49.6
	2					49.1	49.1			49.1	49.1		79.7	49.1	49.1		79.7
	3					93.0	93.0			93.0	93.0		110.7	93.0	93.0		110.7
	4					112.7	112.7			112.7	112.7		142.9	112.7	112.7		142.9
	5					147.4	147.4			147.4	147.4		167.9	147.4	147.4		167.9
	6					157.3	157.3			157.3	157.3		196.2	157.3	157.3		196.2
	7					166.5	166.5			166.5	166.5		207.2	166.5	166.5		207.2
	8+					189.4	189.4			189.4	189.4			189.4	189.4		
	Sum					134.7	134.7			134.7	134.7		128.1	134.7	134.7		128.1
GILLNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0																
	1																
	2																
	3					153.5	101.9	101.9	101.9		111.1	111.1	111.1	153.5	111.0	103.1	109.0
	4					138.5	150.1	150.1	150.1	160.4	142.9	142.9	142.9	159.5	142.9	147.9	143.5
	5					149.5	149.6	149.6	149.6	167.6	158.7	158.7	158.7	167.6	158.6	153.0	158.1
	6					182.7	159.9	159.9	159.9	177.9	164.2	164.2	164.2	177.9	164.2	160.6	163.4
	7					185.1	165.4	165.4	165.4	182.7	168.4	168.4	168.4	182.8	168.3	166.0	167.9
	8+					190.0	176.3	176.3	176.3	196.0	185.0	185.0	185.0	195.7	185.0	178.0	183.7
	Sum					177.4	159.9	159.9	159.9	174.6	163.2	163.2	163.2	174.6	163.1	160.6	162.8
TRAPNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0																
	1					45.5	45.5	45.5	45.5					45.5	45.5	45.5	45.5
	2					55.0	55.0	55.0	55.0	47.6	47.6		47.6	50.4	47.7	55.0	55.0
	3					62.5	62.5	62.5	62.5	74.9	74.9		74.9	74.9	74.9	62.5	62.8
	4					60.9	60.9	60.9	60.9	95.6	95.6		95.6	95.5	95.6	60.9	61.9
	5									117.8	117.8		117.8	117.8	117.8		117.8
	6									116.2	116.2		116.2	116.2	116.2		116.2
	7									128.4	128.4		128.4	128.4	128.4		128.4
	8+									145.4	145.4		145.4	145.4	145.4		145.4
	Sum					55.6	55.6	55.6	55.6	101.3	101.3		101.3	101.0	101.3	55.6	56.1
TOTAL	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												17.9				17.9
	1					23.8	43.6	45.5	45.5	19.6	19.6		49.6	19.7	19.9	45.5	49.6
	2					50.3	54.6	55.0	55.0	49.1	47.9		79.7	49.1	48.0	55.0	79.7
	3					93.8	97.1	75.7	75.2	92.9	79.3	111.1	110.7	92.9	79.4	77.3	110.6
	4					114.1	146.4	133.0	132.2	113.6	112.4	142.9	142.9	113.6	112.5	135.6	142.8
	5					147.4	149.6	149.6	149.6	149.0	149.1	158.7	167.3	149.0	149.1	153.0	167.3
	6					159.4	159.9	159.9	159.9	159.9	159.1	164.2	192.5	159.9	159.1	160.6	191.6
	7					173.1	165.4	165.4	165.4	169.9	164.2	168.4	201.7	169.9	164.2	166.0	200.8
	8+					189.6	176.3	176.3	176.3	190.3	182.6	185.0	185.0	190.3	182.5	178.0	183.7
	Sum					138.0	159.1	152.1	151.7	137.7	145.0	163.2	129.3	137.7	145.1	154.5	129.5

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	1, 2	24	Trawl	1	Trawl	2	24	Trawl	1
Gillnet	3, 4	22	Gillnet	2	Gillnet	3, 4	24	Gillnet	2
Trapnet	1, 3, 4	22	Trapnet	2	Trapnet	1, 4	24	Trapnet	2

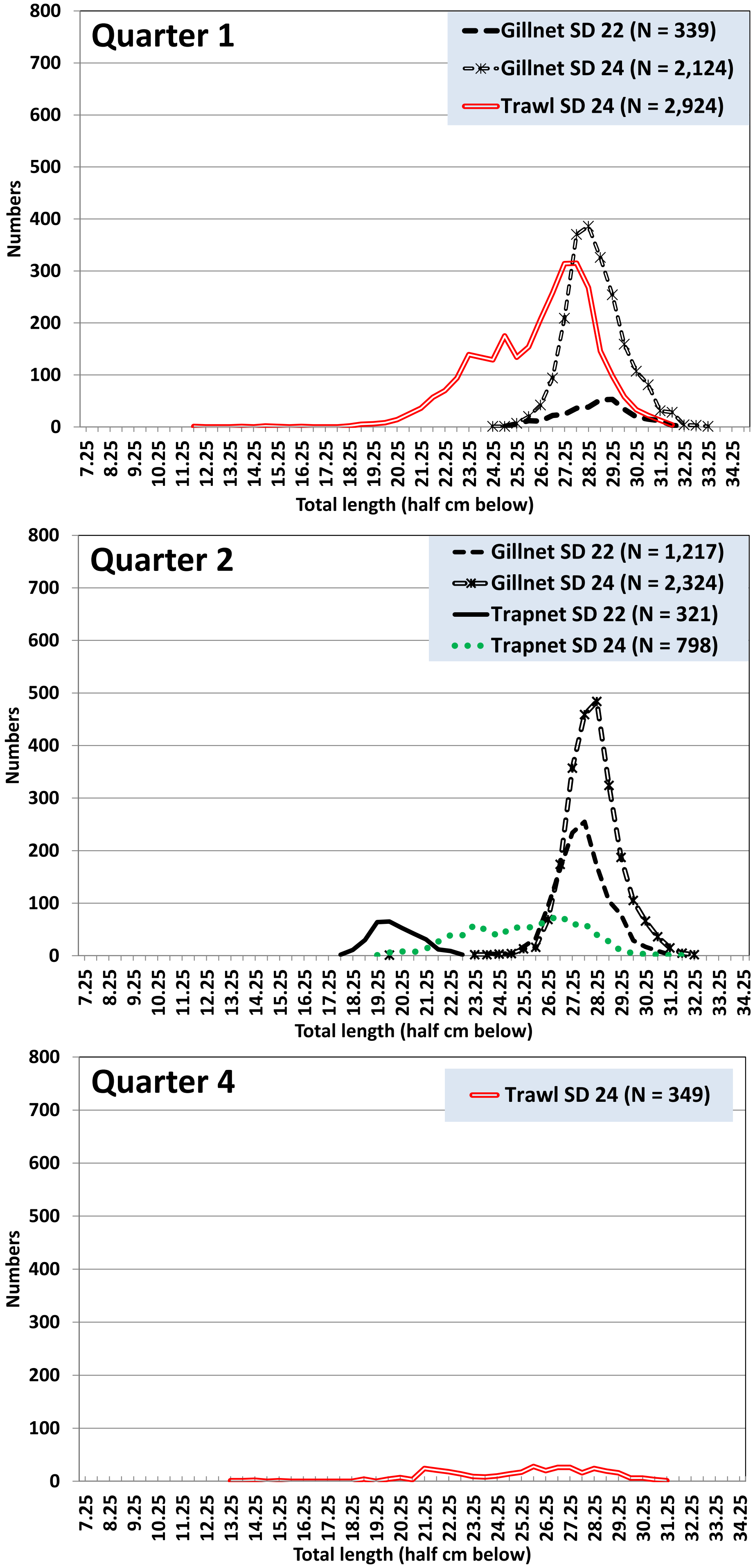
2.4 Mean length (cm) in the catch

		SUBDIVISION 20				SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0												14.2				14.2
	1					14.6	14.6			14.6	14.6		19.6	14.6	14.6		19.6
	2					19.2	19.2			19.2	19.2		22.4	19.2	19.2		22.4
	3					23.5	23.5			23.5	23.5		24.5	23.5	23.5		24.5
	4					24.8	24.8			24.8	24.8		26.4	24.8	24.8		26.4
	5					27.0	27.0			27.0	27.0		27.7	27.0	27.0		27.7
	6					27.6	27.6			27.6	27.6		28.9	27.6	27.6		28.9
	7					28.2	28.2			28.2	28.2		29.6	28.2	28.2		29.6
	8+					29.6	29.6			29.6	29.6			29.6	29.6		
	Sum					26.1	26.1			26.1	26.1		25.2	26.1	26.1		25.2
GILLNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0																
	1																
	2																
	3					26.9	24.6	24.6	24.6		24.1	24.1	24.1	26.9	24.1	24.6	24.2
	4					26.2	27.1	27.1	27.1	27.4	26.7	26.7	26.7	27.4	26.7	27.0	26.7
	5					26.8	26.9	26.9	26.9	28.0	27.8	27.8	27.8	28.0	27.8	27.3	27.8
	6					28.9	27.6	27.6	27.6	28.8	28.2	28.2	28.2	28.8	28.2	27.7	28.1
	7					29.0	28.0	28.0	28.0	29.2	28.5	28.5	28.5	29.2	28.5	28.1	28.4
	8+					29.4	28.8	28.8	28.8	30.3	29.6	29.6	29.6	30.2	29.6	29.0	29.5
	Sum					28.6	27.7	27.7	27.7	28.5	28.1	28.1	28.1	28.5	28.1	27.8	28.1
TRAPNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0																
	1					18.6	18.6	18.6	18.6					18.6	18.6	18.6	18.6
	2					20.0	20.0	20.0	20.0	19.8	19.8		19.8	19.9	19.8	20.0	20.0
	3					20.8	20.8	20.8	20.8	23.1	23.1		23.1	23.1	23.1	20.8	20.9
	4					21.0	21.0	21.0	21.0	24.9	24.9		24.9	24.9	24.9	21.0	21.1
	5									26.7	26.7		26.7	26.7	26.7		26.7
	6									26.5	26.5		26.5	26.5	26.5		26.5
	7									27.6	27.6		27.6	27.6	27.6		27.6
	8+									28.9	28.9		28.9	28.9	28.9		28.9
	Sum					20.0	20.0	20.0	20.0	25.3	25.3		25.3	25.3	25.3	20.0	20.1
TOTAL	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												14.2				
	1					15.3	18.3	18.6	18.6	14.6	14.6		19.6	14.6	14.7	18.6	19.6
	2					19.3	19.9	20.0	20.0	19.2	19.7		22.4	19.2	19.7	20.0	22.4
	3					23.6	23.8	22.1	22.0	23.5	23.2	24.1	24.4	23.5	23.2	22.2	24.4
	4					24.8	26.5	25.9	25.8	24.8	25.4	26.7	26.4	24.8	25.4	26.1	26.4
	5					26.9	27.8	26.9	26.9	27.0	27.5	27.8	27.7	27.0	27.5	27.3	27.7
	6					27.7	28.2	27.6	27.6	27.7	28.0	28.2	28.8	27.7	28.0	27.7	28.8
	7					28.5	28.5	28.0	28.0	28.4	28.4	28.5	29.5	28.4	28.4	28.1	29.4
	8+					29.5	29.6	28.8	28.8	29.7	29.5	29.6	29.6	29.7	29.5	29.0	29.5
	Sum					26.3	28.1	27.1	27.0	26.3	27.2	28.1	25.3	26.3	27.2	27.3	25.3

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	1, 2	24	Trawl	1	Trawl	2	24	Trawl	1
Gillnet	3, 4	22	Gillnet	2	Gillnet	3, 4	24	Gillnet	2
Trapnet	1, 3, 4	22	Trapnet	2	Trapnet	1, 4	24	Trapnet	2

2.5 Sampled length distributions by Subdivision, quarter and type of gear



PFA self-sampling report for HAWG 2015-2018

Martin Pastoors, 20/03/2019 17:18:46

1 Introduction

The Pelagic Freezer-trawler Association (PFA) is an association that has ten member companies that together operate 19 (in 2017) freezer trawlers in six European countries (www.pelagicfish.eu). In 2015, the PFA has initiated a self-sampling programme that expands the ongoing monitoring programmes on board of pelagic freezer-trawlers by the specialized crew of the vessels. The primary objective of that monitoring programme is to assess the quality of fish. The expansion in the self-sampling programme consists of recording of haul information, recording the species compositions per haul and regularly taking random length-samples from the catch. The self-sampling is carried out by the vessel quality managers on board of the vessels, who have a long experience in assessing the quality of fish, and by the skippers/officers with respect to the haul information. The scientific coordination of the self-sampling programme is carried out by Martin Pastoors (PFA chief science officer) with support of Floor Quirijns (contractor).

2 Overview of self-sampling methodology

The self-sampling programme is designed in such a way that it follows as closely as possible the working practices on board of the different vessels and that it delivers the information needed for the SPRFMO Science Committee. The following main elements can be distinguished in the self-sampling protocol:

- haul information (date, time, position, weather conditions, environmental conditions, gear attributed, estimated catch, optionally: species composition)
- batch information (total catch per batch=production unit, including variables like species, average size, average weight, fat content, gonads y/n and stomach fill)
- linking haul and batch information (how much of a batch is caught in which of the hauls) or estimating species proportion per haul
- length frequency measurements, either by batch or by haul

The self-sampling information is collected using standardized Excel worksheets. Each participating vessel will send in the information collected during a trip by the end of the trip. The data will be checked and added to the database by Floor Quirijns and/or Martin Pastoors, who will also generate standardized trip reports (using RMarkdown) which will be sent back to the vessel within one or two days. The compiled data for all vessels is being used for specific purposes, e.g. reporting to expert groups, addressing specific fishery or biological questions and supporting detailed biological studies. The PFA publishes an annual report on the self-sampling programme.

An important feature of the PFA self-sampling programme is that it is tuned to the capacity of the vessel-crew to collect certain kinds of data. Depending on the number of crew and the space available on the vessel, certain types of measurements can or cannot be carried out. That is why the programme is essentially tuned to each vessel separately. And that is also the reason that the totals presented in this report can be somewhat different dependent on which variable is used. For example the estimate of total catch is different from the sum of the catch per species because not all vessels have supplied data on the species composition of the catch on all trips.

Because the self-sampling programme has been under development over the years, different numbers of vessels have been participating in the programme over different years. Results should not be interpreted as a census of the PFA fleet, but rather as an indicator of relative distributions and samples of catch and catch compositions.

3 Results

3.1 Vessels, fisheries, trips and catch in all areas

An overview of all the self-sampling trips in 2015-2018 (and the beginning of 2019) and in which the total catch of herring and sprat was at least 250 tonnes, is shown in the table below. Overall, an expansion of the number of participating vessels in the self-sampling has lead to larger number of trips and higher catches being included in the sampling. The selected trips equated to 5.910^{4} tonnes of catch in 2015 and increased to 2.0610^{5} tonnes in 2018.

year	nvessels	ntrips	ndays	nhauls	catch	nlength

2015	4	19	338	837	58,892	57,559
2016	9	38	549	1,426	135,098	50,445
2017	11	38	551	1,415	123,091	62,993
2018	16	68	1,040	2,537	205,579	102,750
(all)	.	163	2,478	6,215	522,660	273,747

year	catch/trip	catch/day	catch/haul
2015	3,099	174	70
2016	3,555	246	94
2017	3,239	223	86
2018	3,023	197	81
(all)	.	.	.

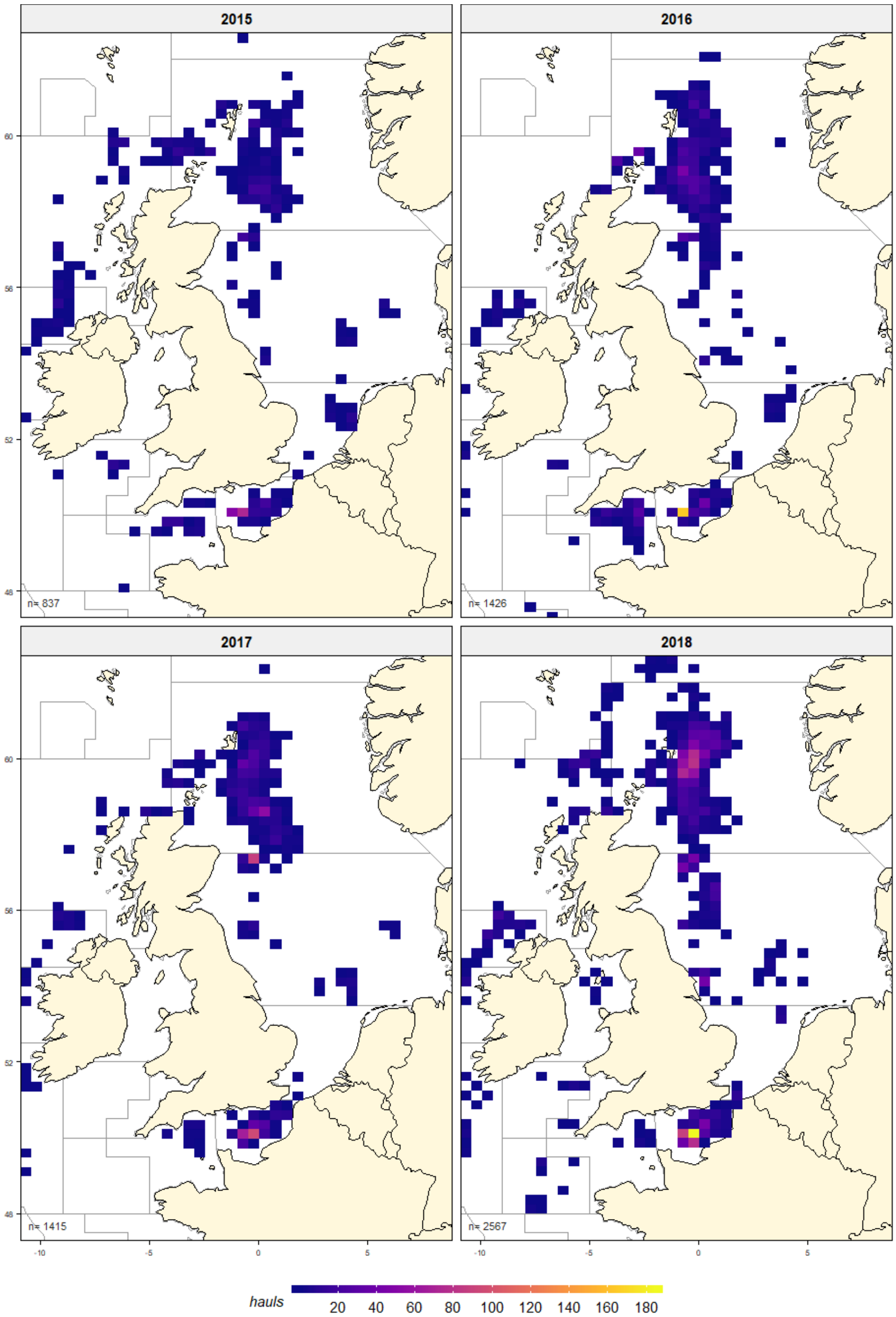
Table 1.1.1: PFA selfsampling summary of herring and sprat trips (>250 ton) with the number of days, hauls, trips, vessels, catch (tonnes), number of fish measured and average catch rates (ton/trip, ton/day, ton/haul). The asterisk indicates a partial year.

Species compositions in self-sampled fisheries.

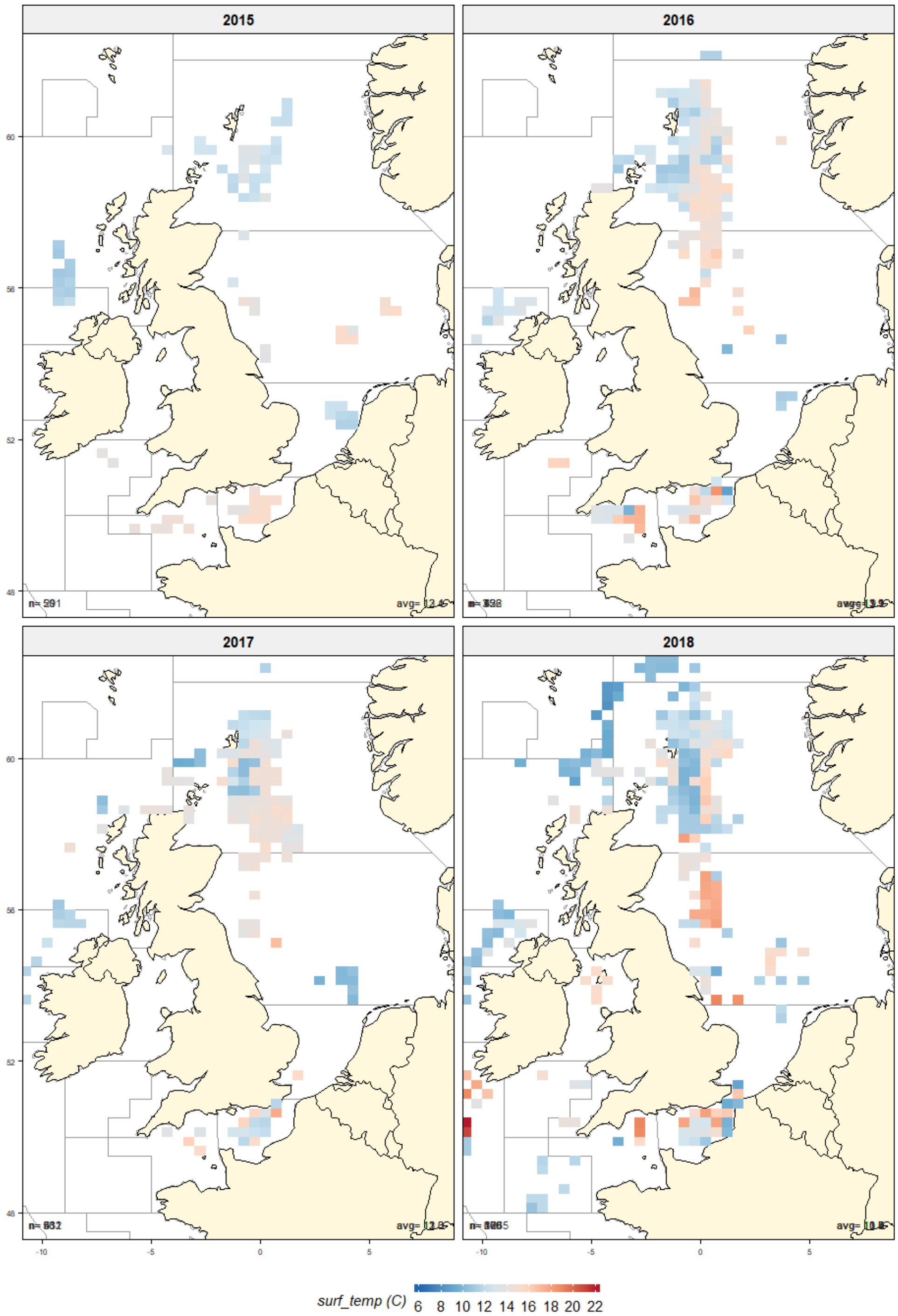
species	englishname	scientificname	2015	2016	2017	2018	all
her	herring	Clupea harengus	36,143	80,535	79,790	157,485	353,953
spr	sprat	Sprattus sprattus	1,570	139	1,059	1,013	3,782
oth	NA	NA	13,747	17,559	14,234	40,477	86,017
(all)	(all)	(all)	51,461	98,233	95,084	198,975	443,753

Table 2.1.1: Total catch (tonnes) by species in PFA self-sampled fisheries. Target species and other species. The asterisk indicates a partial year

An overview of all self-sampled hauls during trips when a certain amount of herring and sprat were caught during a trip (>250 tonnes).



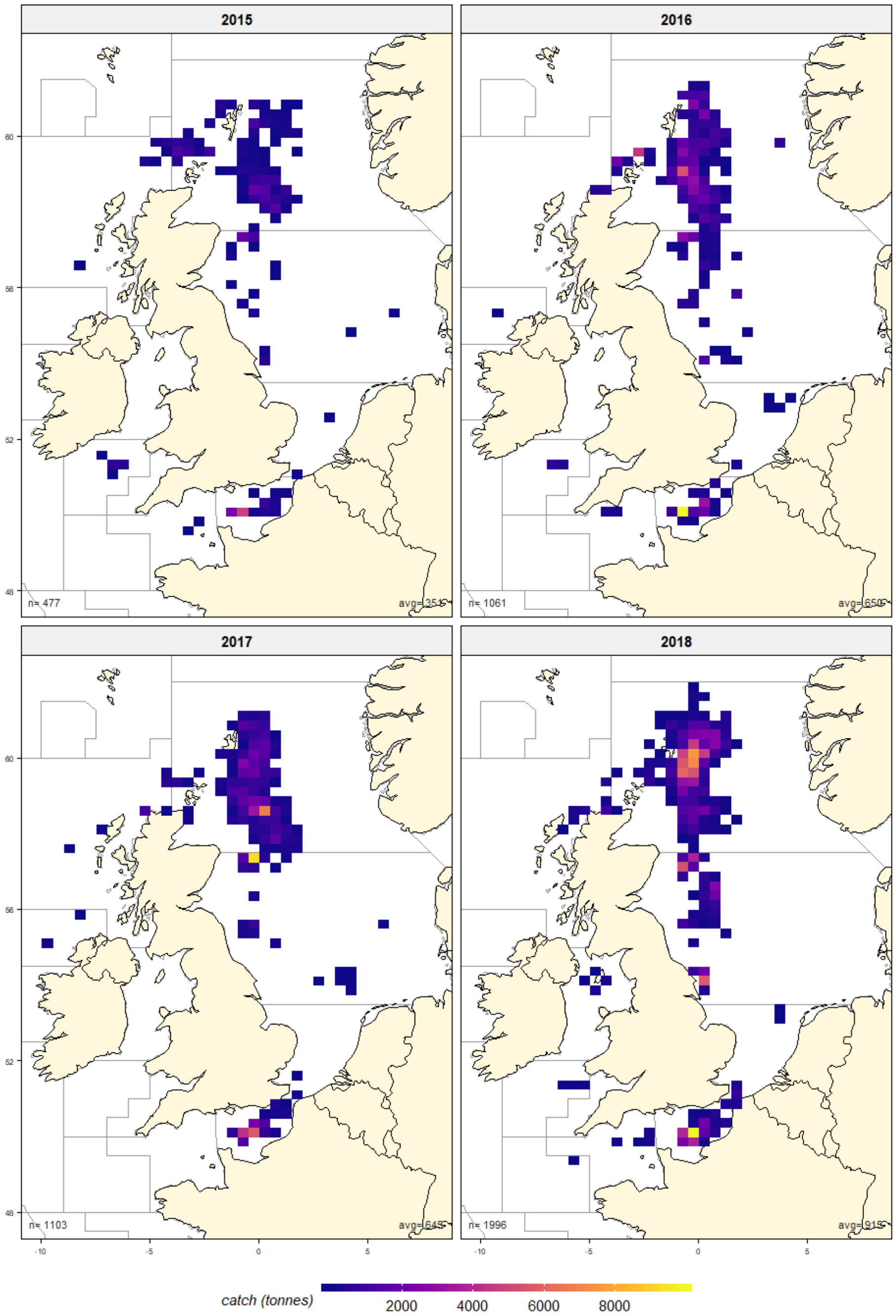
Haul positions in PFA self-sampled fisheries for herring and sprat.


2015
2016
2017
2018
surf_temp (C) 6 8 10 12 14 16 18 20 22

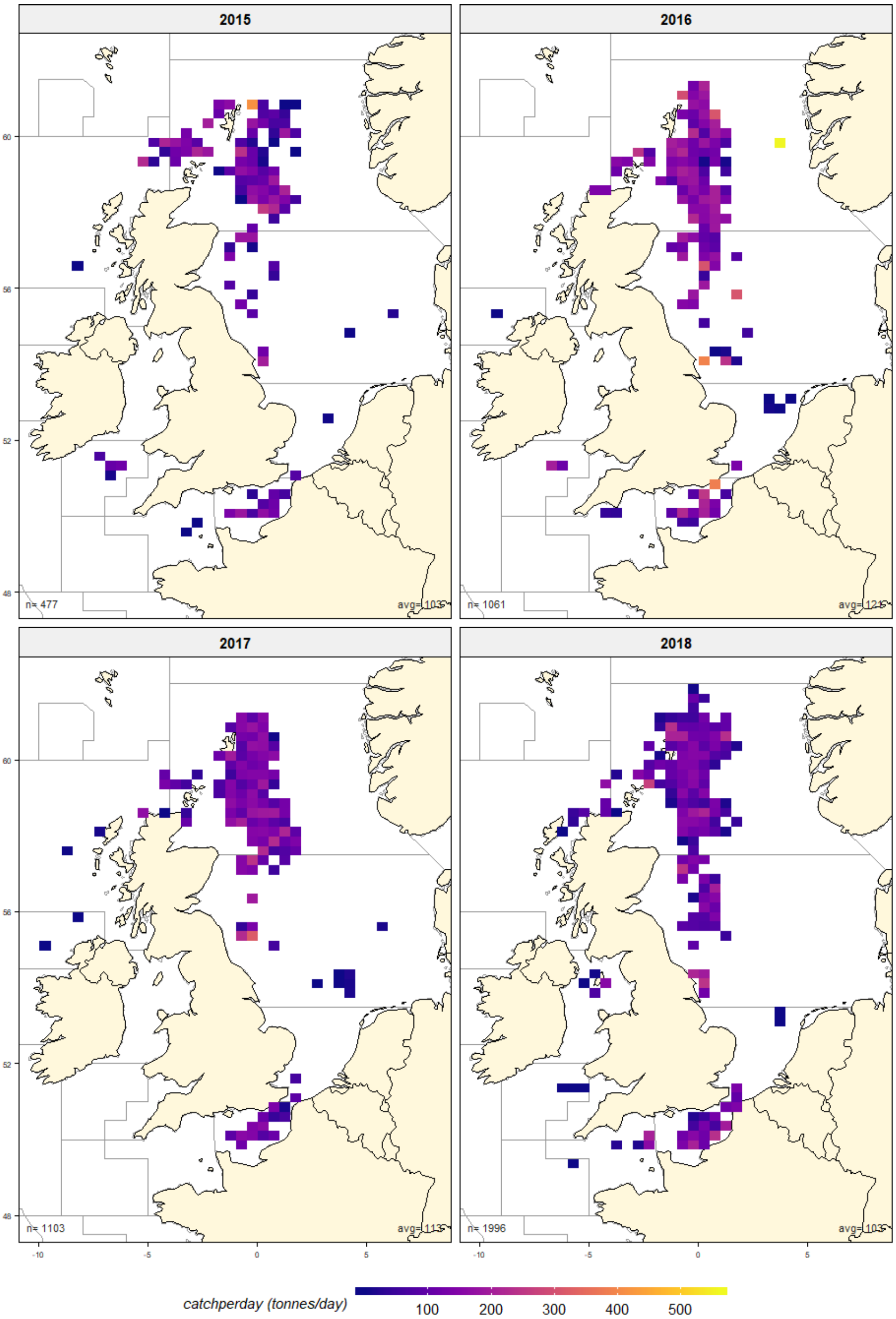
Herring (Clupea harengus) in area 27

year	nvessels	ntrips	ndays	nhauls	catch	nlength
2015	4	18	195	478	38,834	39,223
2016	9	38	419	1,063	105,665	37,484
2017	11	38	422	1,106	99,624	48,885
2018	16	68	747	1,971	163,973	82,234
(all)	.	162	1,783	4,618	408,096	207,826

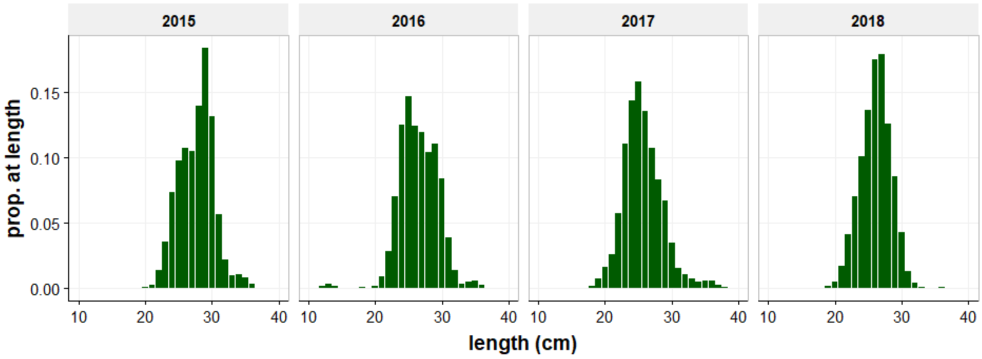
Herring catch by year



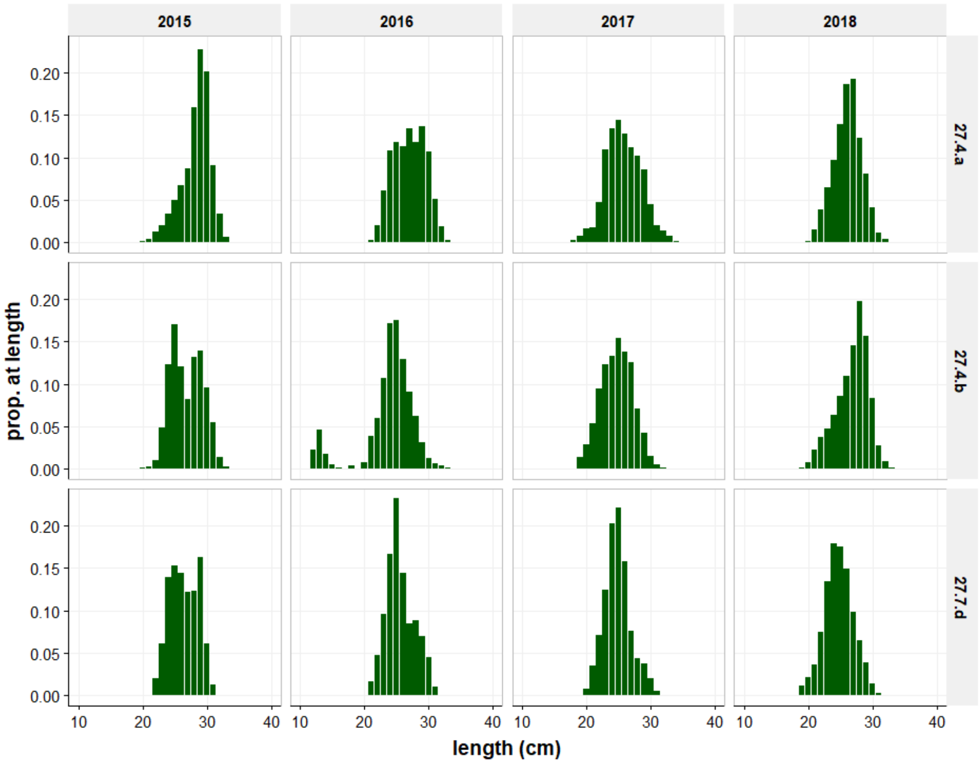
Herring catch/day by year



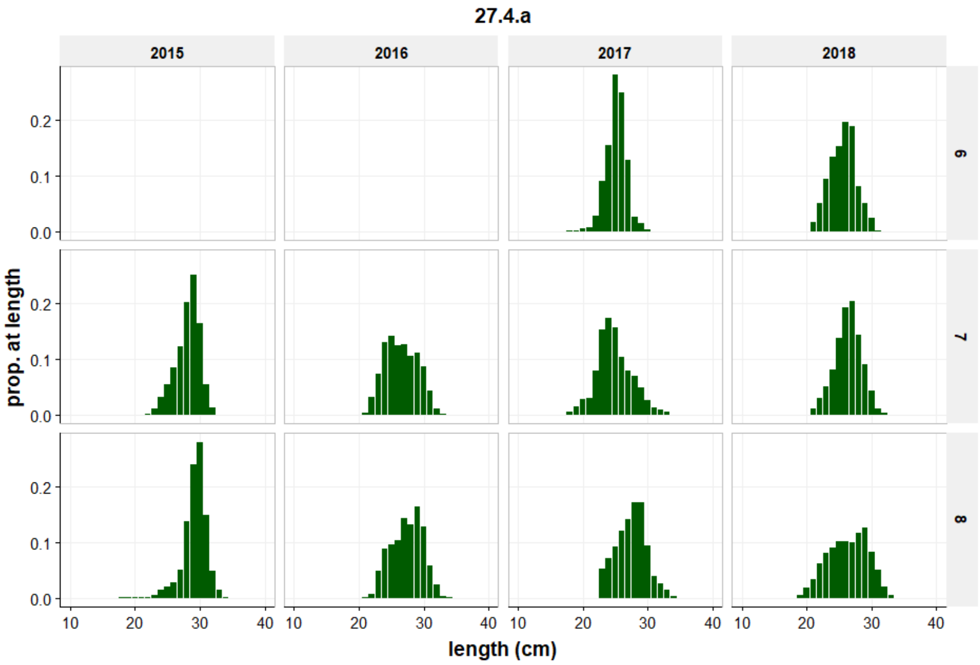
Herring length compositions by year



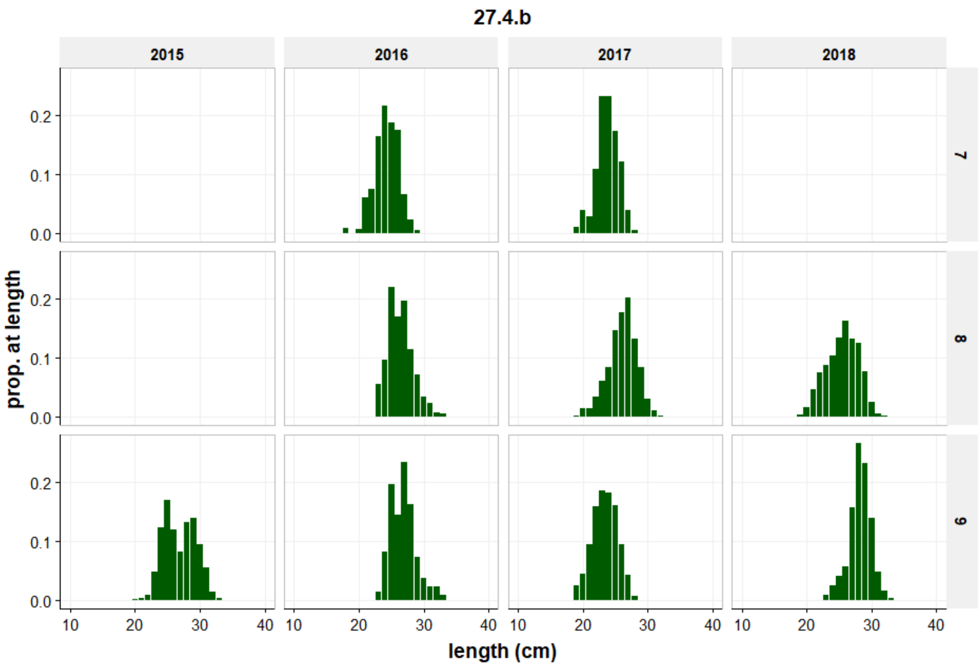
Herring length compositions by division and year



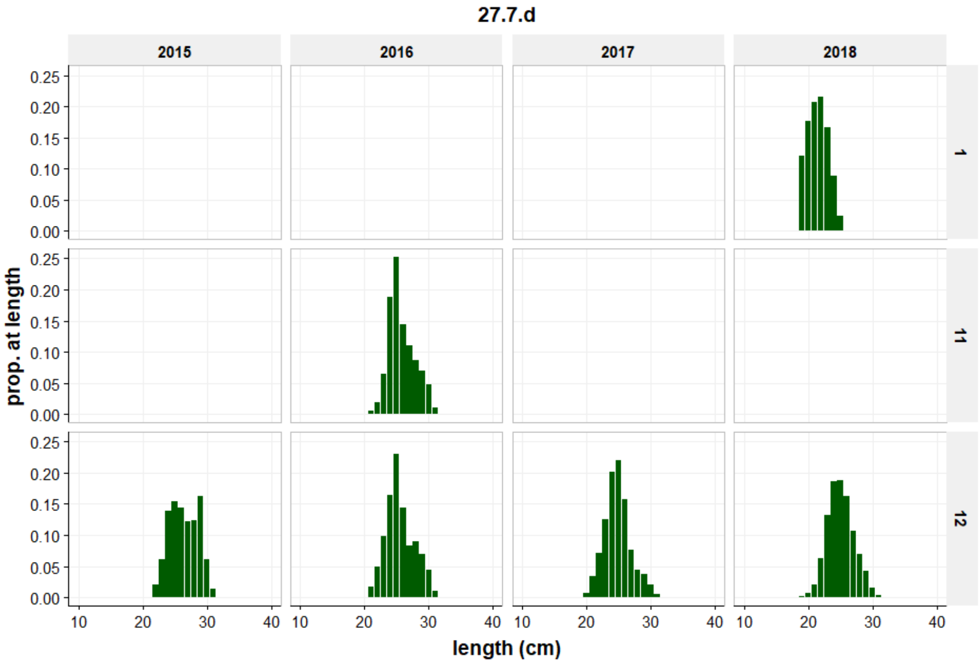
Herring length composition year and month for division 27.4.a in months 6, 7 and 8.



Herring length composition year and month for division 27.4.b in months 7, 8 and 9,



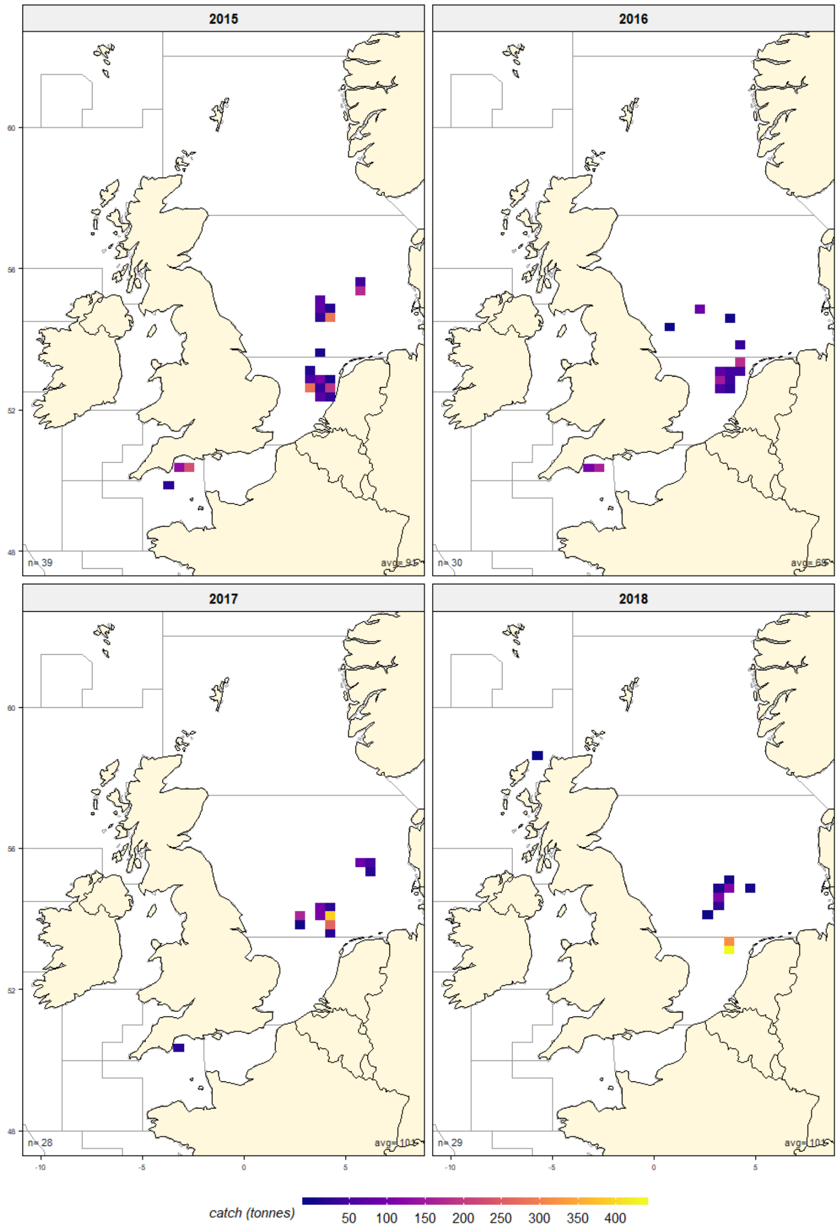
Herring length composition year and month for division 27.7.d in months 1, 11 and 12,


27.7.d
2015
2016
2017
2018
1
11
12
prop. at length
0.00
0.05
0.10
0.15
0.20
0.25
10
20
30
40
length (cm)

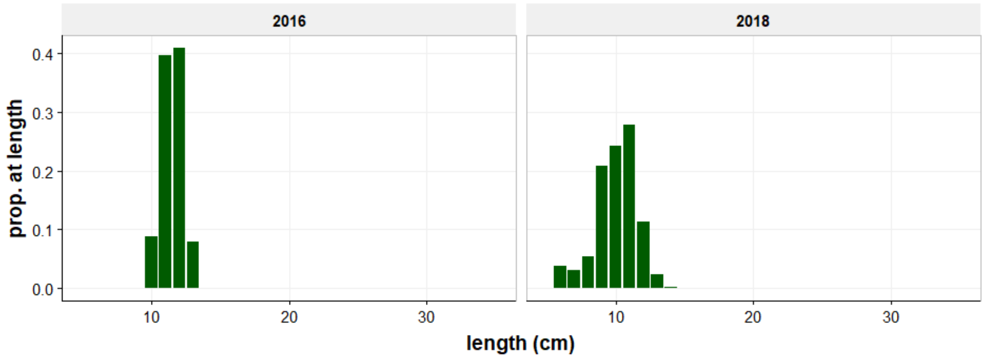
Sprat (Sprattus sprattus) in area 27

year	nvessels	ntrips	ndays	nhauls	catch	nlength
2015	3	6	21	39	1,828	0
2016	3	6	15	30	978	156
2017	3	3	11	28	1,221	0
2018	4	5	11	29	1,011	2,318
(all)	.	20	58	126	5,038	2,474

Sprat catch by year



Sprat length compositions by year (limited length sampling available)



4 Discussion and conclusions

By the end of 2018, 16 vessels had been participating in the PFA self-sampling programme in the Northeast Atlantic in one way or another. This is about 89% of the freezer-trawler fleet. Although the programme does not consist of a random selection of vessels – because the instructions to the vessel benefit from a continued application of data collection on the participating vessels – the overall fishing pattern does appear to represent the fisheries of the PFA vessels.

The information in this report is only supplied for the fisheries that targetted herring or sprat, where the total catch of herring and sprat was at least 250 tonnes per trip.

In this year's report, the focus is more on the length compositions by year, area and month. Ideally, and for the future, one could expect that links will be generated between the age-length sampling that is part of the European data collection programme and the PFA self-sampling programme.

We believe that the direct communication of the results of the self-sampling programme with the participating crews and vessels is a key element of the programme. Maintaining engagement with the fishermen at sea is an essential requisite for the programme to work. Direct communication involves an almost instantaneous return of the trip report after finishing a trip.

Overall the self-sampling programme demonstrates the feasibility of self-documenting catches of this fleet and providing links between environmental parameters and catches.

5 Acknowledgements

The skippers, officers and the quality managers of many of the PFA vessels have put in a lot of effort to make the PFA the self-sampling work. Without their efforts, there would be no self-sampling.

6 More information

Please contact Martin Pastoors (mpastoors@pelagicfish.eu) if you would have any questions on the PFA self-sampling programme or the specific results presented here.

Annex 6: Summaries of presentations from Stock ID mini symposium

A6.1 Genetic Stock Identification of 6a/7bc Herring

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Commercially important seasonal fisheries for Atlantic Herring (*Clupea harengus*) take place in many different areas around the coasts of Ireland and Britain. The definition of these western stocks has changed considerably over the last five decades (see ICES 2015) and the putative stocks are currently recognised as: 6aN; 6aS/7bc; Irish Sea; Celtic Sea & 7j (ICES 2014). This separation is largely based on information from commercial fisheries and the recognition of temporal and spatial differences in spawning season and grounds (ICES, 2015); the 6aN and Irish Sea herring spawn in Autumn (Sept/Oct), the 6aS/7bc and Celtic Sea herring in winter (Nov-Jan) and there are small groups of herring (6aN and the Clyde) that spawn in spring (Feb-May). However, herring from separate stocks are believed to form mixed aggregations on common feeding grounds (Hatfield et al., 2005). Potentially mixed stock fisheries and surveys operate in these areas and the inability to assign catches to their stock of origin prevents accurate assessment, and has hampered the development and implementation of effective management strategies.

In an effort to resolve this issue a genetic stock identification project was initiated in 2016 at University College Dublin, Ireland. The project was funded by a collaboration of the Irish, Scottish and Dutch industries and the Irish Marine Institute and Marine Scotland Science. In December 2018 the project partners secured funding from the European Commission's Executive Agency for Small and Medium Enterprises (EASME) to extend the project until December 2020 and to also include morphometric analyses. The primary objectives of the project are to assess the genetic population structure of herring stocks in ICES 6a/7bc and to develop genetic baselines of the 6aN and 6aS/7bc stocks, which can be used to discriminate mixed aggregations of non-spawning herring in area 6a.

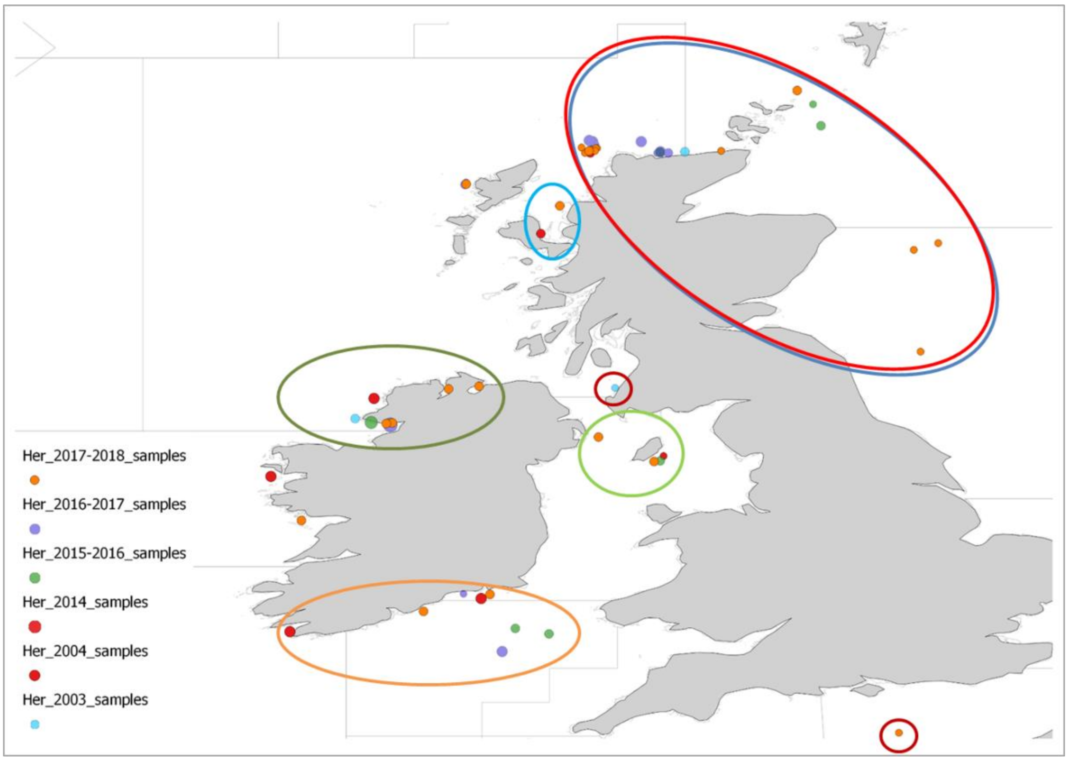

Figure 1. Baseline spawning samples analysed to date. The clustering of samples is indicated by the coloured circles.

To date, baseline spawning samples from 6 spawning seasons, comprising 56 samples and c.4,442 herring have been genotyped at 38 SNPs and 38 microsatellite markers (Figure 1). Results indicated that the 6aN autumn spawners and 6aS/7bc winter spawners represent at least 2 genetically distinct populations. No genetic differentiation has been found between the 6aN autumn and North Sea autumn spawners and the samples from these areas indicated a high degree of temporal stability. The 6aN spring spawning samples from the Minch and the Clyde areas were genetically distinct from the other 6a populations. The 6aS, Celtic Sea and Irish Sea samples all showed significant genetic differentiation between each other and were more significantly different to 6aN samples than they were from each other. Though more similar to each other than to the surrounding populations, the 6aS samples displayed a higher level of genetic variation among themselves than the other populations did. This is not unexpected as it has been well documented than the spawning time in 6aS has changed from being dominated by spring spawning in the 1920’s, to autumn spawning from 197-1994 and to winter spawning from 1995 onwards (ICES, 2015). This appears to be reflected in the genetic diversity of the herring in this area. In order to improve the baseline dataset and increase the accuracy of future assignment testing of mixed samples, an additional year of baseline samples were collected (Figure 2) and are currently being analysed with the same marker panel as the previous samples.

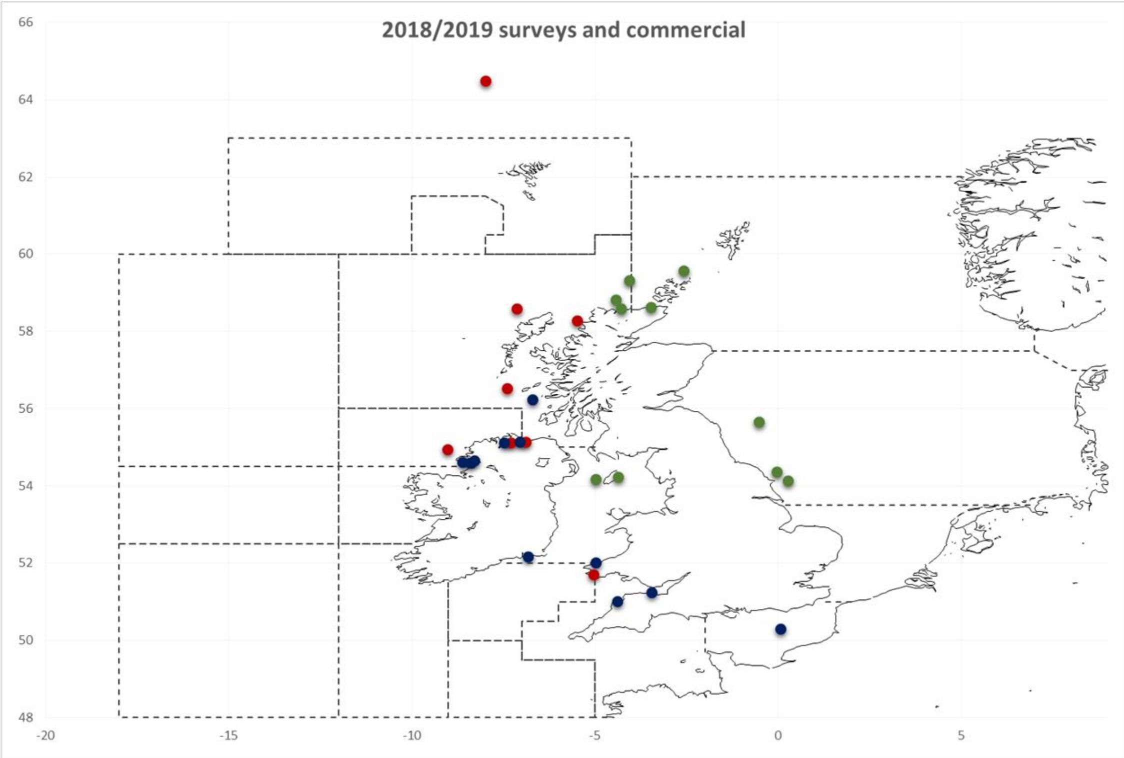

Figure 2. Baseline spawning samples analysed to date. The clustering of samples is indicated by the coloured circles.

In addition to the extra baseline samples, the marker panels being used to genotype the herring samples are also being further analysed. Collaborations are underway with DTU-Aqua and also the GENSINC project to determine if there are additional informative SNP markers that many be useful for discrimination the herring population west of Ireland and Britain from each other and from surrounding populations. Once the these analyses are completed and the additional baseline samples analysed the project aims to discriminate the samples collected during the Malin Shelf Herring Acoustic Survey (MSHAS) using both genetic methods, for samples 2014-2018 (Figure 3), and morphometric methods, for samples collected 2010-2018. The combined analyses will provide separate survey indices for the herring in 6aN and 6aS/7bc, thus enabling separate assessments to be performed on these stocks.

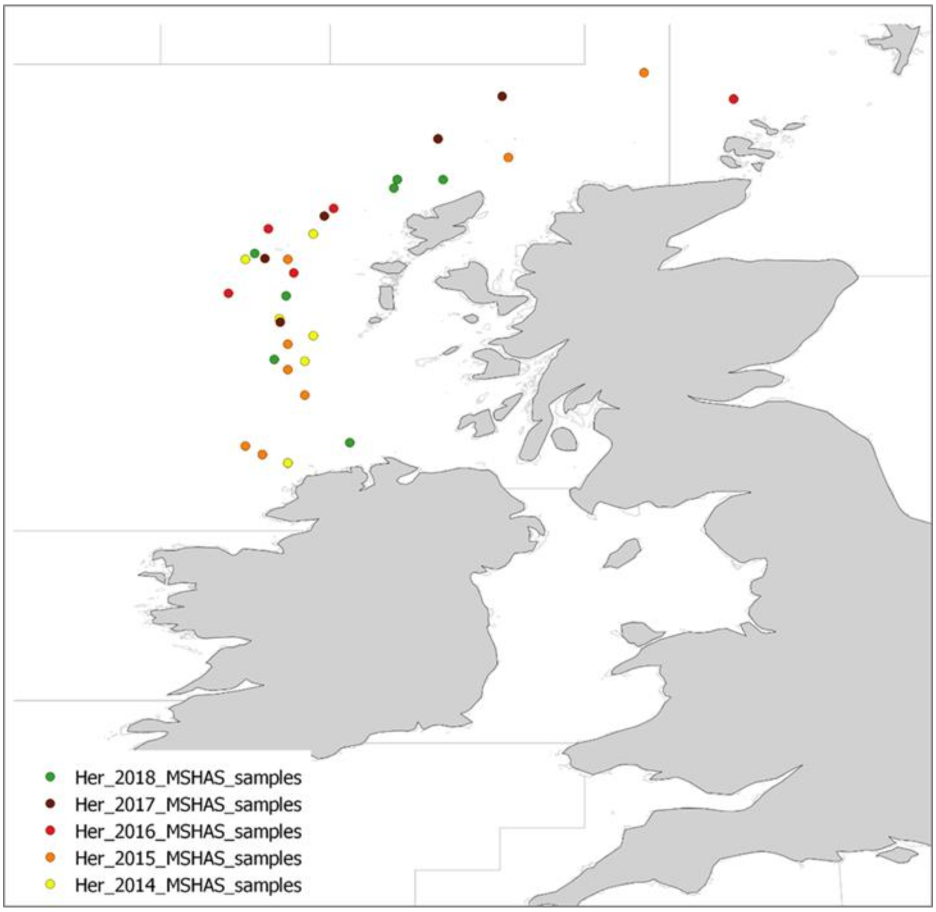

Figure 3. The genetic samples collected on the MSHAS from 2014-2018.

References

Hatfield, E.M.C., Zuur, A.F., Boyd, J., et al. (2005) WESTHER: a multidisciplinary approach to the identification of herring (*Clupea harengus* L.) stock components west of the British Isles using biological tags and genetic markers. ICES CM 2005/K:01.

ICES. 2014. Report of the Herring Assessment Working Group for the Area South of 62ºN (HAWG), 11-20 March 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:06. 1257 pp.

ICES. 2015. Report of the Benchmark Workshop on West of Scotland herring (WKWEST 2015). 2–6 February 2015, Marine Institute, Dublin, Ireland.

A6.2 Genetic stock determination in Atlantic herring: New possibilities for accurate stock discrimination

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DTU Aqua

Genetic marker based methods to determine biologically coherent units of herring and to classify individuals in mixed samples have undergone a paradigm shift since the first genetic study by Andersson et al. (1981). Application of newly developed genomic resources for herring (e.g. Bekkevold et al. 2015; Lamichhaney et al. 2012; Barrio et al. 2016) has enabled a much improved understanding of the degree of reproductive separation among stocks and of the local selective pressures acting on them. Validation of improved accuracy marker panels to trace individuals in time and space is in development but for a number of stocks genetic methods are fully available for use within a routine monitoring framework. A Single Nucleotide Polymorphism (SNP) marker classification tool is thus applicable for distinguishing, at high statistical accuracy, among major stocks and sub-stocks mixing in areas SA4, SA3a and DIV22-25. Extended sample analyses are required to compare information from genetic markers with morphological traits.

Cited literature:

Andersson et al. 1981. Genetic variability in Atlantic herring (*Clupea harengus harengus*): Description of protein loci and population data. Hereditas 95:69–78.

Barrio et al. 2016. The genetic basis for ecological adaptation of the Atlantic herring revealed by genome sequencing. eLife e12081

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Lamichhaney et al. 2012. Population-scale sequencing reveals genetic differentiation due to local adaptation in Atlantic herring. Proceedings of the National Academy of Sciences of the United States of America 109:19345–19350.

A6.3 Tools to split herring populations

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University of Bergen

Discrimination and splitting of mixed stocks are essential for 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). However, the splitting is limited to Danish and Swedish samples from commercial landings and scientific surveys in division 3.a, Norwegian samples from scientific surveys, and samples from commercial landings in the "transfer area" in subarea 4. Further, applied splitting methods are not consistent between labs and countries.

One of the used splitting methods to separate NSASH and WBSSH is otolith shape analysis. In recent years, the use of otolith shape analysis to discriminate fish stocks increased rapidly. Open-access packages like shapeR (Libungan and Pálsson, 2015) allow scientist to easily extract otolith outlines for further analysis. Otolith shape analysis of Atlantic herring reveal clear differences between populations in the north-eastern Atlantic (Libungan *et al*., 2015). Further, there is a clear genetic effect on the otolith shape of Atlantic herring (Berg *et al*., 2018). Using otolith shape analyses also allow to discriminate more than two stocks and assign individual fish to one of the discriminated stocks. In the greater North Sea ecoregion, there is evidence that Norwegian spring spawning herring (NSSH) might occur in this management area and can even migrate into the Skagerrak (Eggers *et al*., 2014, Berg *et al*., 2017). It is also debated if herring from division 6.a migrate into subarea 4 and mix with NSASH. Furthermore, comparisons of historical vertebral counts demonstrate that WBSSH occur outside of the "transfer area" (Berg *et al*., 2017).

In a preliminary analysis, a baseline was build-up including otoliths from herring collected at spawning grounds as well as herring of all three stocks (NSASH, WBSSH, and NSSH) and samples from spawning herring in division 6.a. Spawning herring representing NSASH were collected on spawning grounds near Shetland. NSSH were collected during the spawning survey along the western Norwegian coastline. Otoliths of WBSSH were sampled at the main spawning ground in Greifswalder Bodden. In addition, otoliths assigned as spring (WBSSH) and autumn (NSASH) spawning herring from the Skagerrak and Kattegat based on otolith microstructure were included. Ideally, this baseline should be updated by annual samples, instead of rebuilding it from year to year.

The otolith shape of herring was transformed into 64 wavelet coefficients for further testing. There were no differences between otoliths from NSASH and spawning herring in division 6.a. Therefore, these herring were merged for the following analyses. Monte-Carlo and k-fold cross-validations, provided by the assignPOP package in R (Chen *et al*., 2018), were conducted on this baseline using support vector machine as classification method. In addition to the wavelet coefficient, length data was included as an extra variable in the analysis. Analyses were conducted on a cohort basis comparing only individual of similar age. In general, the overall assignment accuracy was relatively high (>80%). The miss classifications occurred mainly between NSASH and WBSSH. These results indicate that our baseline is suitable for assignment of individuals from unknown catches.

Unknown catches were collected during the Norwegian part of the Herring Acoustic (HERAS) survey in the North Sea where the proportion of spring and autumn spawning herring is currently calculated based on vertebral counts. The benefit using the otolith shape is an individual assignment, while only proportions are estimated on mean values using vertebral counts. Comparing the assignment of the same data demonstrate that both methods results in similar assignments.

Such an individual assignment will be also beneficial for the stock assessment since more reliable data as weight-at-age can be estimated than using only proportions. Another advantage is the incorporation of NSSH as a third component. Using the vertebral counts, only to groups can be separated. The most western station resulted e.g. in 100% NSASH that means the vertebral counts were higher than the overall mean for NSASH. The same stations also indicate the occurrence of some NSSH which could explain the high mean vertebral counts, because the overall mean of NSSH is even higher. Consequently, the use of otolith shape can provide a better and more accurate assignment of individual on the stock levels than using vertebral counts.

In addition to otolith shape and vertebral counts, genetic samples were collected for two station outside the "transfer area" during the HERAS 2018. The general trend for all the methods was, that the northern station consisted mainly of NSASH, while the southern station included mainly WBSSH. The individual assignment based on otolith shape and genetics allowed for more detailed comparison. Overall, >70% of the herring were assigned to the identical stock using genetics and otolith shape (Table 1). The biggest discrepancy is that some herring were assigned as NSSH using otolith shape analysis. However, the genetics did not assign a single herring as NSSH. This discrepancy needs to be further investigated.

All in all, otolith shape analysis provide a useful tool to discriminate and assign unknown herring catches to a given stock. Further, the preliminary results indicate that the geographical boundaries, not only for stocks, but also for the "transfer area", should be discussed. Potential readjustments or the implementation of splitting several stocks might improve the assessment and advice of herring stocks in the greater North Sea ecoregion.

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Libungan, L. A., and Pálsson, S. 2015. ShapeR: An R package to study otolith shape variation among fish populations. PLoS ONE, 10: e0121102.

Table 1. Assignment results of individual herring to one of the three stocks (NSASH = North Sea autumn spawning herring, WBSSH = Western Baltic spring spawning herring, NSSH = Norwegian spring spawning herring) occurring in the greater North Sea ecoregion based on otolith shape analysis and genetic markers.

		Genetics	
		NSASH	WBSSH
Otolith shape	NSASH	34.4% (n = 52)	14.6% (n = 22)
	NSSH	6.6% (n = 10)	2.7% (n = 4)
	WBSSH	5.3% (n = 8)	36.4% (n = 55)

A6.4 Herring otolith microstructure – analysis and calibration

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Herring otolith microstructure (OM) analysis is carried out at DTU Aqua (Denmark) and SLU (Sweden) on samples from commercial landings in ICES areas 4.a, 4.db, 3.aN, 3.aS, SD22, SD23 and SD24 and from scientific surveys in ICES areas 3.aN and 3.aS. The aim is to determine the spawning type or stock ID's of the fish; North Sea autumn spawners (NSAS or 9's), Downs winter spawners (Downs or 12's) and Western Baltic spring spawners (WBSS or 4's). The samples form the baseline for the otolith shape/stock ID analysis conducted on the combined commercial catches from Denmark and Sweden prior to the annual stock splitting of the WBSS component from the North Sea component in the 3.a and 4.a.E. and 4.b.E "transfer area" and the Danish HERAS samples. Calibration exercises have been ongoing since 1999 to ensure consistency in agreement between readers and laboratories and for training new readers.

The 2019 exchange utilised samples with genetically assigned stock ID. The genetic methods applied have a very high statistical power for stock assignment using SNP markers (> 95% of fish classified correctly) with the added possibility to identify likely sub stocks (Rügen, Kattegat, Skagerrak, Central Baltic autumn and spring spawners). Readers results were compared against the genetically validated stock ID for each sample and the percentage agreement (PA) and a comparison matrix of each reader versus validated ID was calculated, DK01 and DK02 reached a PA of 87%, SWE01 reached a PA of 84% and SWE02 reached a PA of 80%. These results show a huge improvement from the 2016 workshop and the 2018 exchange where there were few samples where all 4 readers were in agreement. The correct identification of the Down winter spawning component was problematic is all recent calibration events. In the 2018 exchange, the inclusion of a subset of genetically validated samples provided the opportunity to calibrate against material with known stock ID. Following the exchange images were discussed with the readers and guidelines agreed upon based on these validated samples. This material has certainly contributed enormously to the improved 2019 results.

It is likely that there has been a change in increment width (IW) patterns observed in the otoliths of herring caught in this area overtime considering otolith microstructure is under the influence of growth, spawning time variation and environment. In addition, other sub stocks of herring (Rügen, Kattegat, Skagerrak, Central Baltic autumn and spring spawners) caught in this area are amongst the samples being analysed. An updated baseline set of samples is needed so that guidelines for IW measurements and an image library can be included in an updated OM reader protocol. This requires that samples from both spawning fish and 0-group fish covering the three main stock ID's plus the sub stocks are collected for combined genetic, OM and otolith shape analysis. These samples can potentially be used in the future to test the validity of the various stock identification and splitting methods and be used for quality assurance exercises within and between national laboratories.

A6.5 Herring otolith classification

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Background

The separation of different herring stock components is an issue in several of the surveys coordinated in WGIPS. Recently concerns have been raised by the survey groups for the International ecosystem surveys in the Nordic Seas (IESNS and IESSNS) on mixing issues between Norwegian spring-spawning herring (NSSH) and other herring stocks (e.g. Icelandic summer-spawning ISSH, Faroese autumn-spawning FASH and North Sea type autumn-spawning herring NASH) might have occurred in some of the fringe regions in the Norwegian Sea. Up to date fixed cut lines have been used to exclude herring of presumed other types than NSSH, however this simple procedure is thought to introduce some contamination of the stock indices of the target NSSH.

Summary

Havstovan (the Faroe Marine Research Institute) uses a combination of maturation stage and otolith microstructure (nucleus or hatch type and otolith shape/growth pattern) to separate autumn-spawning herring from the Norwegian spring-spawning herring. The nucleus (hatch) type and the width of first winter ring/summer growth (L_1) combined with maturity stage (GSI) apparently gives a high degree of separation power if employed by experienced personnel.

Method

Mixing of herring occurs in the Faroese area and neighbouring areas during the IESNS and IESSNS. The NSS herring is found feeding in the northern part of the Faroese EEZ, usually north of 62°N. However, in this fringe area NSSH is found mixed with the local Faroese herring (FASH). Similarly east of the Faroes and into the northern part of the EU EEZ, herring of the autumn-spawning type is found mixed with NSSH to a varying degree. In the Faroe zone they are believed to be autumn-spawning herring of Faroese origin while further east they might originate from the northern North Sea (IVa or VIa north).

There are many ways to classify herring e.g. by

observing the spawning site

otolith microstructure, e.g. nucleus type (opaque or hyaline) or shape analysis, intercirculi spacing in otoliths (and scales)

morphological (fenotypical) differentiations of the herring such as gillraker spacing, vertebrae counts, maturity stage at time of capture

genetic methods (microsatellite or SNPs)

chemical and fatty acids analysis.

The current method used by the Faroese Marine Research Institute to split herring samples into NSSH and other herring types consists of two parts: otolith micro structures (nucleus type and annual growth patterns) together with gonad development indices.

The measurement is the growth in the first year (L_1 radius from centre to first winter zone or diameter D_1). The L_1 measure has been reported in literature (Geffen 1982, Husebø et al. 2005). The observed smaller width of the first winter ring in the opaque type NSSH might be attributed to the nursery area in northern Norway/Barents Sea, i.e. in colder environment than the herring grown up on the Faroe Plateau of further south in the northern North Sea. Thus the hyaline types have a wider diameter to the first winter ring compared to the NSSH. A further indication is the hyaline nucleus in the autumn-spawning herring, where the transparent nucleus indicate that the larvae was spawned the autumn before (with poor growth as larvae during winter) prior to the first years growth. Geffen (1982) found a positive relationship between herring growth rate and daily ring deposition rate in herring. Husebø et al. (2005) also used otolith microstructure and gonad development indices to demonstrate spawning season fidelity in autumn- and spring-spawning herring in mixed overwintering aggregations.

Initially otoliths from herring of both types (NSSH and FASH) were photographed and measured (L_1) to determine their origin. This analysis showed a clear separation between the two types of herring. This method is time consuming and cumbersome, however, it appeared that it was relatively easy to distinguish the two otolith types by visual inspection only by trained personnel.

Visual discrimination:

Opaque (spring-spawning) type: shorter, shorter rostrum, wider appearance, more square winter zones, L_1 (or D_1) shorter than for hyaline otoliths

Hyaline (autumn-spawning) type: opposite to above.

The L_1 measurements and nucleus type together with maturity stage transformed to gonosomatic index GSI (gonad weight in relation to body weight) apparently gives a very high degree of separation power if employed by experienced personnel.

Examples of L_1 measurements from a Faroese sample in May 2008 in the northernmost part of the EU zone (where mixed concentrations of herring was found). Most likely the opaque type herring were NSSH and the hyaline types with larger first summer growth were FASH or NASH: Hyaline type L_1 = 0.71 mm and Opaque type L_1 = 0.50 mm (small sample in the ppt presentation). The method has been tested by comparison of "known" samples of NSSH and FASH.

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A6.6 Morphometric discrimination of herring in 6a,7bc

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Identifying stocks is one of the primary prerequisites to perform an assessment. In the divisions 6a and 7bc, ICES recognise that two stocks of herring are assessed as one. As both stocks are not the same size and have different dynamics, using one fishing mortality for both could lead to the overfishing of one stock. In December 2017, an EASME funded project led by University College Dublin with the Marine Institute and Marine Science Scotland as partners started. The objective of the project is first to develop tools that enable the identification of the herring stocks that occur in the ICES divisions 6a and 7bc and second to use the developed tools to identify the origin of fish sampled in a putative mix. The stock identification will be based on genetics, body morphometrics and otolith shape. The objective of the presentation is to give the HAWG an update about the work undertaken on body morphometrics and otolith shape. Regarding body morphometrics, 20 landmark points were digitised and enabled the derivation of 40 body morphometric measurements. Among these, 8 were excluded due to correlation with maturity stages. Regarding otolith shape, each otolith was photographed and the R package ShapeR (Libungan and Palsson, 2015) used to derive either the coordinates of the Fourrier ellipses or the wavelet coefficients. Both of them can describe the shape of an otolith and can be used to identify fish of different stocks. Baseline data collection started in 2003–2005 as part of the WESTHER project and further samples were collected in 2014 and 2016–2017. In total, 1900 fish were sampled for baseline morphometrics. Regarding mix samples, from 2010 to 2018, 9,700 fish were sampled on mix aggregations. Some preliminary cross validation tests using the R package AssignPOP (Chen et al., 2017) showed 87% success in allocation. Although morphometric data are more labour intensive than genetic data to collect, the work continues as the time series is longer (time series on the mix starts in 2010 for morphometrics vs 2014 for genetics). The data collection will carry on until the end of the project in 2020. Comparisons between morphometric and genetic tools will be made to choose the most efficient and less costly method that will be used on the long term to monitor the mix aggregations.

References

Chen, K-Y, Marschall, EA, Sovic, MG, Fries, AC, Gibbs, HL, Ludsin, SA, 2017. assignPOP: An r package for population assignment using genetic, non-genetic, or integrated data in a machine-learning framework. Methods Ecol Evol. 2018; 9:439–446. https://doi.org/10.1111/2041-210X.12897

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Annex 7: Special Request - Evaluation of a sentinel TAC for Celtic Sea Herring

This annex was added to the report in October 2019.

Evaluation report of the proposal for a monitoring TAC for the Celtic Sea Herring

Background

The 2019 assessment of Celtic Sea herring estimated that the stock has decreased significantly since 2011 and has been below B_{lim} since 2017 (ICES, 2019). ICES advised that there should be no catch on this stock in 2020. Given this context, ICES is requested to

→ provide advice on the minimum level of catches (tonnage) required in a sentinel TAC, which would provide sufficient data for ICES in order to continue providing scientific advice on the state of this stock.

Ireland is the main participant in the Celtic Sea herring fishery and has 86% of the TAC. The Irish Celtic Sea herring fleet is composed of two components; The "Sentinel fleet" defined as the fleet of vessels <17 m LOA that operate in ICES Division 7.aS and receives an allocation of the Irish quota. In this document "sentinel TAC" was replaced by "monitoring TAC" to avoid any confusion with the Irish sentinel fleet.

Methodology

The procedure adopted aims to determine the number of individual samples required to meet an acceptable level of precision within the resulting catch-at-age matrix (Campbell, 2016). To determine an appropriate level of precision Irish sampling data from 2013–2017 was examined. Ireland is the only country sampling Celtic Sea herring.

Sampling precision was calculated using a bootstrap technique:

1. Set N = total number of available age samples
2. Randomly sample with replacement the complete dataset. Quality is considered equivalent across samples and equivalent weight is attributed to all the samples
3. An ALK is constructed using the age data from the bootstrapped samples,
4. Numbers–at–age are generated by passing the whole dataset through the ALK
5. Steps 2–4 are repeated 1000 times
6. Calculate a weighted CV from the 1000 iterations
7. Set N = N-1 and repeat steps 2–6, continuing until N = 2

As background, the DCF reporting structure defines the level of precision for ageing as follows

Level	CV (%)
0	20+
1	12.5-20
2	2.5-12.5
3	0-2.5

A precision level of 2 is the target for group 1 and group 2 species for landings data, from a stock such as Celtic Sea herring (Commission Decision 2010/93/EU).

Data

Length frequency data from Irish port sampling is plotted in Figure 1. In 2013 smaller fish were sampled in 7.g but a similar mode can be seen in both areas. Lengths sampled were similar in both areas in 2015 and 2016. In 2014, two modes can be seen in 7.aS from the sentinel fleet that did not appear in the main fleet. In 2017, two clear modes are evident in the main fleet operating in 7.g. This is less defined in 7.aS.

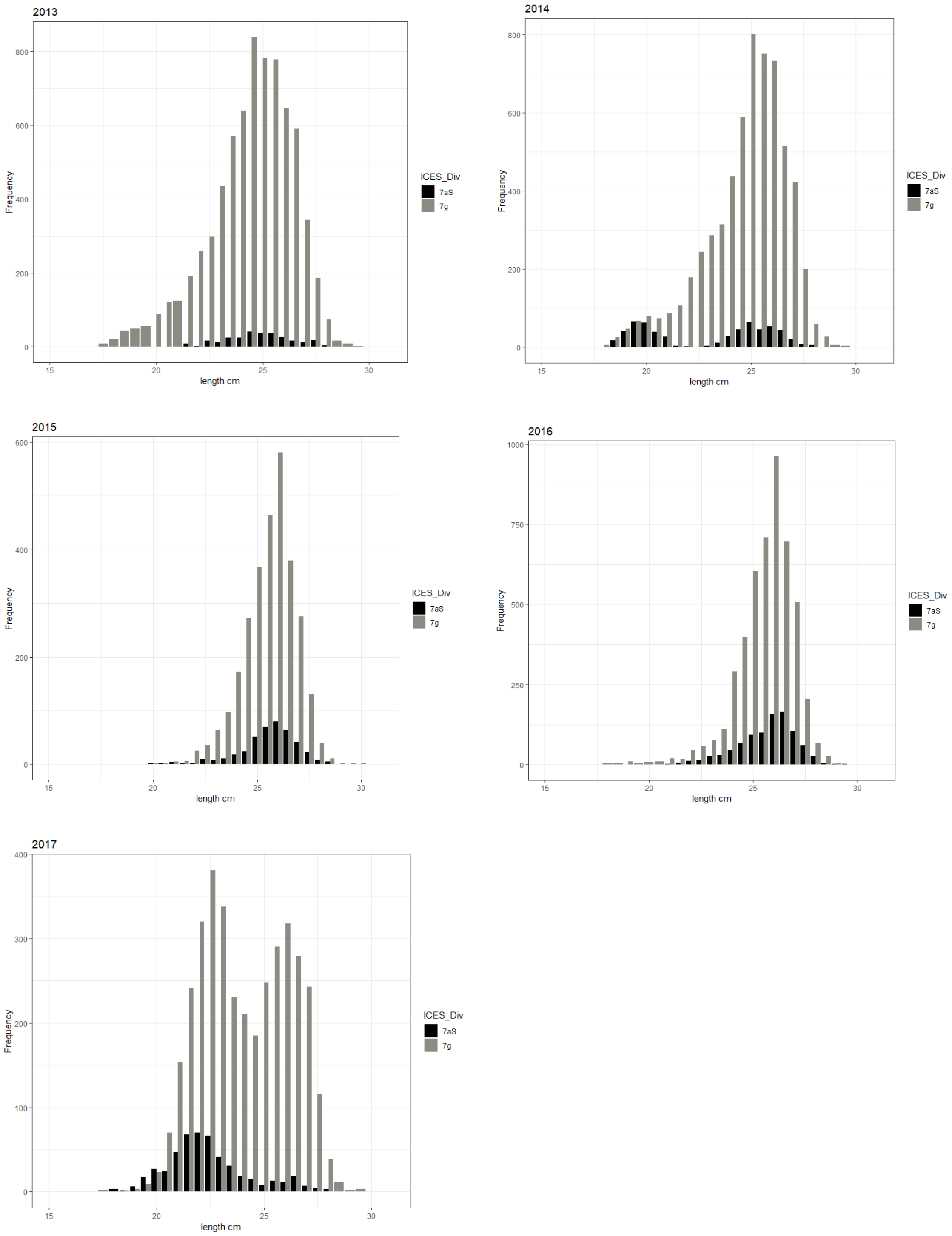

Figure 1: Length frequency of samples collected from landings of the main fleet 7.g (grey) and the sentinel fleet 7.aS (black) 2013–2017.

Results

Sampling precision

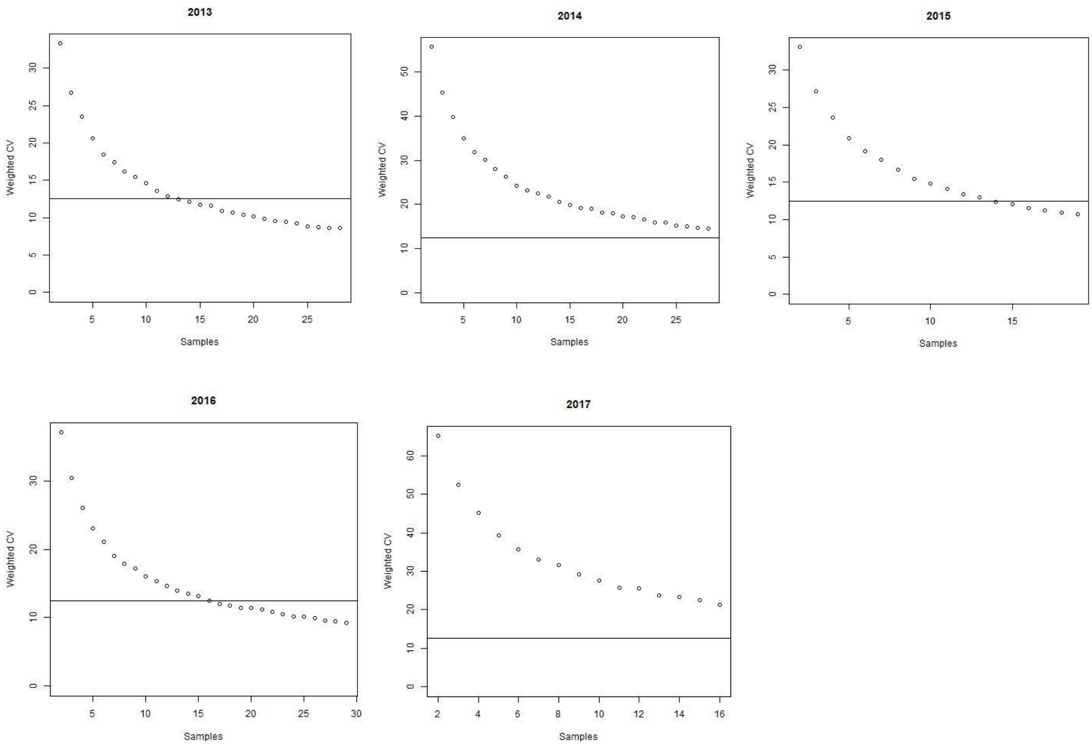

Figure 2: Weighted CV vs number of samples collected per year from 2013 to 2017

The number of samples required to reach a sampling precision <12.5% ranged from 14 to 17 samples in 2013, 2015 and 2016. The threshold was not reached for samples collected in 2014 and 2017 although 28 and 16 samples were aged respectively (Table 1).

Table 1: Number of samples collected per year and number of samples required to reach a sampling precision <12.5%

Year	N samples	N of samples required
2013	28	14
2014	28	NA
2015	19	15
2016	29	17
2017	16	NA

Estimation of the Monitoring TAC

To estimate the level of catches which would provide a sufficient number of samples, the average haul size from each fleet, provided by the Irish Industry (Celtic Sea Herring Management Advisory committee) was used.

- Main fleet: Average size of a haul is 65 t.
- Sentinel fleet: Average size of a haul is 6 t.

An analysis of the 2013–2017 Irish sampling data was conducted. 2016 was chosen as the reference year because the fishery was not constrained by quota, the age structure included both strong and weak year classes, and there was good distribution of samples in both 7.aS and 7.g. The analysis was confined to quarter 4 because it is indicative of the winter fishery for which monitoring is required. In total, 29 samples were taken in 7.g and 7.aS combined, with an average of 186 fish measured and 50 fish aged per sample.

Based on sampling data in 2016, it is possible to attain a precision of 12.5% with 17 samples. The highest level of sampling should be in the main fishery (13 samples) where the majority of the quota is. The sentinel fishery should provide 4 samples. These proportions are based on the sampling levels that have been attained from this fishery in the past.

Table 2: Sampling of the main fishery

Basis	CV%	No of samples	Catch assuming 65 t hauls
DCF Level 2	2.5–12.5	13	845 t

Table 3: Sampling of the sentinel fishery

Basis	CV%	No of samples	Catch assuming 6 t hauls
DCF Level 2	2.5–12.5	4	24 t

Total proposed monitoring TAC = 869 t

The Celtic Sea Herring TAC is shared between Germany, France, UK, the Netherlands and Ireland (Council Regulation (EU) 2019/124). The percentages are given in Table 4 with the greatest proportion of the TAC allocated to Ireland.

Table 4: Percentage of Celtic Sea Herring TAC by country and the proposed monitoring TAC.

Country	Percentage	TAC (t)
Germany	1.1%	10
France	6.2%	54
UK	0.1%	1
Ireland	86.4%	751
Netherlands	6.2%	54
Total		869

Evaluation of the impact of the proposed monitoring TAC on the recovery of the stock

To evaluate the impact of the monitoring TAC on the recovery of the stock, a shortcut Management Strategy Evaluation was run using SimpSim which is a version of EqSim, the ICES software to calculate reference points that works at non–equilibrium. SimpSim was used in the evaluation of the blue whiting management strategies (ICES, 2016).

Operating Model (OM)

The Operating Model (OM) was based on the 2019 assessment (ICES, 2019). The stock–recruitment relationship is a segmented regression model with a breakpoint at B_{lim} (34 000 t). The 2019 catch was assumed to be 5320 t which is the same figure used by HAWG for the short term forecast (see Section 6 of this report).

Implementation Model

Three scenarios were considered in the implementation model.

1. No Catch.
2. The proposed monitoring TAC (869 t).
3. The Irish proportion of the proposed monitoring TAC (751 t).

Performance statistics

The second and third scenarios described above were compared to the zero catch scenario to highlight the impact of the proposed monitoring TAC on the recovery of the stock. The year of recovery was defined as the year when the risk to B_{lim} falls below 5%. For each scenario, the realised F, the year of recovery and the risk to B_{lim} in 2023 and 2024 were tabulated (Table 5).

Table 5: Performance statistics (range of F over the years 2021–2026 derived from the Management Strategy Evaluation simulating 3 scenarios, i.e. no catch, proposed monitoring TAC fully caught, Irish portion of the proposed monitoring TAC only.

Scenario	Range of Realised F	Recovery Year	Risk to B_{lim} in 2023	Risk to B_{lim} in 2024
No catch	0	2023	3.5%	1.2%
Total TAC = 869 t	0.04–0.01	2024	5.1%	2.8%
Irish quota = 751 t	0.03–0.01	2023	4.7%	2.6%

Conclusions

Based on sampling data in 2016, it is possible to attain a precision level of 12.5% in the Celtic Sea herring fishery with approximately 17 samples and these could be obtained with a monitoring TAC of 869 t.

The length composition of catches from the main fleet and the sentinel fleet exhibited differences in some years. It is recommended to keep sampling both fleets to ensure any differences in length compositions are monitored.

The simulations show that with no fishing in 2020 recovery is expected in 2023. The proposed monitoring TAC of 869 t will delay this recovery by one year until 2024. If only the Irish portion of the TAC (751 t) is taken the recovery year remains at 2023.

References

Campbell, A. 2016. Sampling Precision in the 6.a, 7.b, and 7.c Herring Fishery. ICES CM 2016/ACOM:51. 16 pp.

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.

Review on the Evaluation report of the proposal for monitoring TAC for the Celtic Sea Herring.

Reviewer 1

ICES is requested advice on the minimum level of catches (tonnage) 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. The expert report proposes a monitoring TAC of 869 t (845 t from the main fishery and 24 t from the sentinel fishery) based on sampling precision of <12.5% and 2016 as reference year as the basis of the calculations.

The analysis conducted is appropriate for determining the number of samples required to reach a sampling precision of <12.5% (following also Campbell, 2016). This level of precision for ageing is taken from the Commission Decision 2010/93/EU section B.B 2.4. Please see the document for comments in the text.

The major concern for this stock, as I see it, is to keep the mortality of the stock at a minimum level. The proposed monitoring TAC of 869 t will delay this recovery of the stock by one year until 2024 according to the shortcut Management Strategy evaluation that was run. So the proposed numbers for the sampling do not seem to be the best option. Instead of catching this much, would it not be a possibility to use the fishery independent acoustic samples?

Response: The short–cut MSE was run with 3 different scenarios, (i) no catch, (ii) full uptake of the monitoring TAC, (iii) only the Irish quota. In case (ii) the risk to B_{lim} in 2023 is 5.1% and falls to 2.8% in 2024. The risk in 2023 is only marginally higher than 5%. As other countries have quota but do not have a targeted fishery on this stock, their quota might not be fished. In this case, the risk to B_{lim} would fall below 5% in 2023 and the recovery year would be the same as in the no catch scenario. With the proposed monitoring TAC of 869 t (80% lower than the lowest TAC for that stock), the fishing mortality would be 0.04 in 2020 (30% lower than the lowest fishing mortality in the time series).

Below, I list some of the issues that I think needs more clarification and thorough elaboration from the experts:

1. Using the Acoustic survey - There is a fishery independent acoustic survey that is also used in the assessment in years 2002–2018 (excluding years 2004 and 2017). Is it not possible to use the acoustic survey results to assess the state of the stock by using the existing correlation between the acoustic survey results and the correlated SSB found in the assessment? If possible, it would be enough in the rebuilding phase of the stock to only perform the acoustic survey and from that draw inferences about the SSB development. I would like the experts to elaborate if this is feasible or not.
2. In addition, the acoustic survey provides data on the size and length distribution of the fish. For instance, the acoustic survey in 2018 October provided 9788 t and 213 491 individuals which were provided from 15 trawl hauls. 529 herring were aged and 1668 length measured and 807 length-weights recorded. Can the experts give reasons why the age/length information obtained from the acoustic survey is not sufficient to obtain the required information on the state of the stock?

Response: (1) and (2): The Celtic Sea Herring assessment is a full analytical category 1 assessment. Two data series are used in the age–disaggregated model, the catch–at–age matrix (fishery dependent) and the survey index (fishery independent) to tune the model. Using only the survey data in the assessment will increase the uncertainty on the SSB estimation. The survey is carried out over a three week period in October. The survey follows a parallel transect design standard across all acoustic surveys and in a pre-defined survey area for this stock. Sampling levels vary on the acoustic survey and rely on the survey encountering herring marks along the survey track. When the stock is low estimates from acoustic surveys in general are uncertain. For instance, in 2018 the CV for the survey was 50% and could not be calculated on the 2017 survey due to the fact that only one biological sample was collected. The survey does not guarantee adequate biological or acoustic sampling at low stock sizes. Sufficient information on age structure may not be available to the assessment if the acoustic survey is the only data source. The monitoring fishery would cover a period 6 weeks and would provide a better sampling coverage of the fishing grounds.

3. When the estimation for the monitoring TAC is made the experts indicate that the average haul size is 65 t for the main fleet. Is it possible to shorten the trawl time of the hauls thereby reducing the tonnage obtained in the catch? Can the experts show evidence why a reduced haul time/size is not sufficient to meet the requirements of precision for a representative age/length distribution.

Response (3): Herring is a pelagic schooling fish. Fish density in aggregations could be high. As opposed to demersal fishing, reducing the time of trawling does not necessarily reduce the catch. We are reducing the risk of not collecting enough samples by using average haul sizes provided by fishermen (65 t in the main fleet). The monitoring TAC would help to maintain a commercial catch–at–age matrix consistent with fleet behaviour in years when commercial TAC is available.

4. It looks as the sentinel fleet is catching the same size distribution as the main fleet, why not only use the data from the sentinel fleet? Can the experts provide arguments for not using only the sentinel fleet?

Response (4): In the CSH fishery, the sentinel fleet (vessels <17 m LOA) is confined to 7.aS and fishes primarily inshore in two ICES rectangles. The main fleet (larger vessels) fishes primarily in 7.g and cover a much larger area than the sentinel fleet. In Figure 1 of the report, length frequencies from 2013 to 2017 are presented. In 2013, 2014 and 2017, differences in catch composition appear. The 7.g component of the stock would not be sampled if only the sentinel fleet participates the fishery.

5. Are all the hauls going to be sampled or what is meaning of "the sampling level of 2016"? For example, is it every third haul or every third trip etc.? Maybe it is possible to reduce the total catch by increasing the intensity of the sampling. Can the experts elaborate on this?

Response (5): In this fishery, like in the 6.a, 7.b–c herring fishery, vessels that prosecute the fishery will be requested to take a 25 kg sample of unsorted catch at every haul directly from the net and arrange to deliver the samples to the Marine Institute. Upon availability, the vessel will be requested to carry an observer on board who will take and process the sample.

Reviewer 2

This is a review of the report supporting the ICES response for a special request from the European Commission asking for advice on the minimum level of catches (tonnage) required in a monitoring TAC, which would provide sufficient data for ICES in order to continue providing scientific advice on the state of Herring in Division 7.a South of 52°30'N, 7.g-h and 7.j-k.

The ICES response to this request provides a monitoring TAC, defined as the product of the number of samples that allows achieving a sampling precision <12.5% and the average haul tonnage. It also provides a short-cut MSE to evaluate the impact of the proposed monitoring TAC on the recovery of the stock compared to a zero catch situation.

Reviewer's Comments

The methodology conducted by Gras and Egan is appropriate to answer this request. They followed the approach described in Campbell (2016) to calculate sampling precision and monitoring TAC, and then an MSE was implemented. However, for the first part, the methodology differs in a technical issue that is of particular significance, and it is about the choice of the year selected as a baseline for the analysis.

While in Campbell (2016), the analysis just starts defining the baseline year, in the evaluation report, the analysis starts calculating the sampling precision for the yearly data available from 2013 to 2017, and after that, 2016 is decided as the baseline year. This sampling precision analysis developed for some years in the report provides important information related to other years different to 2016 and it is never used again in the posterior results.

This additional analysis shows that for the year 2014 there was almost the same number of samples as for the year 2016 but the desired sampling precision was not achieved. This also indicates that the sampling precision not only depends on the number of samples available. Thus, it is necessary to understand what the particular circumstances are that prevent the desired precision level from being obtained when there is a high number of samples available. This understanding should determine also additional constraints on the recommended monitoring TAC. In case it is not possible to diagnose the reasons for not achieving the sampling precision with almost the same aged samples available, I suggest to calculate the number of samples required for all the years analysed, even if that number is higher than the samples available, then, choose the two highest numbers of samples required to calculate the monitoring TAC and decide among them using the MSE short-cut approach.

In summary, the report should take into account the possibility of a monitoring TAC providing 17 samples but with similar sampling properties as the one in 2014.

On the other hand, it is assumed that it is necessary to have enough samples with a <12.5% sampling precision level to provide scientific advice using an analytical assessment but that was not the case in years 2014 and 2017. Therefore, it would be helpful in terms of consistency if ICES could suggest to the HAWG to check the precision level of aged samples before the assessment and to analyse the consequences on the advice of not having the required precision level.

Some minor issues are also included as comments in the main document.

Response of the authors

The year 2016 was chosen using the same criteria as Campbell (2016), i.e. the catch was not limited by the quota. For transparency purposes, other years were also presented.

The difference in 2014 is the appearance of a cohort <20 cm that was not observed in 2013, 2015 and 2016 in catch samples. That small cohort in 2014 might be at the origin of a higher value in precision level. In 2014, although the number of samples went up to 28, the threshold of 12.5% was not reached. When two distinct modes are present in the length frequency data, a very high level of sampling would be required to reach the sampling precision level of 12.5%. Increasing the number of samples to ensure the precision threshold is reached in any circumstances would imply increasing the level of catches and delay further the recovery of the stock. Collecting 17 samples would ensure that the precision level of 12.5% would be reached in non-exceptional circumstances and would ensure a low impact on the recovery of the stock as shown in the MSE.