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 on an interactive virtual platform for eight days in March 2020 to assess the state of five herring stocks and three sprat stocks. HAWG also provided advice for four 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 a data limited assessment (ICES category 3) was conducted for English Channel sprat (spr.27.7de).

The **North Sea autumn spawning herring (her.27.3a47d)** SSB in 2019 was estimated at 1.7 mill tonnes while $F_{2\text{–}6}$ in 2019 was estimated at 0.18, which is below F_{MSY}. Recruitment in 2019 is comparable to the 2018 value and remains within the low recruitment regime observed since 2015. Year classes since 2002 are estimated to be consistently weak with year classes 2014 and 2016 some of the weakest on record. ICES considers that the stock is still in a low productivity phase.

The **Western Baltic spring-spawning herring (her.27.20-24)** assessment was updated. The SSB and recruitment in 2019 are record low. SSB is estimated to be around 56 600 tonnes which is below both B_{pa} and B_{lim}. Recruitment has been low since 2006 and it has been further deteriorating with time. Fishing mortality has decrease in 2019 to 0.382 but is still well above F_{MSY} (0.31). The stock has decreased consistently during the second half of the 2000s and given the continued low recruitments the stock is not able to recover above B_{lim} unless a drastic reduction in fishing effort is applied.

The **Celtic Sea autumn and winter spawning stock (her.27.irls)** is estimated to be at a very low level. SSB is currently estimated to be at the lowest level in the time-series and has been below B_{lim} (34 000 t) since 2016. Mean $F_{(2\text{–}5 \text{ rings})}$ was estimated at 0.49 in 2019, having decreased from the peak of 1.15 in 2017. Recruitment has been consistently below average from 2013-2018. Recruitment in 2019 is estimated to be above average.

The assessment of the combined stocks of herring in **6.aN and 6.aS/7.b, c (her.27.6a7bc)** went through an interbenchmark procedure in 2019 and the advice is based on trends from an analytical assessment. SSB 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 2019 compared to previous years at around 24 700 tonnes. The stock has experienced large incoming year classes in recent years. Fishing mortality ($F_{4\text{–}6}$) is estimated at 0.18, 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 the TAC in recent years.

North Sea and 3.a Sprat (spr.27.3a4) were combined into a single assessment unit during the 2018 benchmark. Perception of the status of the stock is dominated by the dynamics in Subarea 4 where most of the catches occur. Despite the fact that fishing mortality in the last years has fluctuated at high levels between 0.6–2.2, recruitments slightly but consistently above the average during recent years have contributed to an increase in SSB well above MSY $B_{escapement}$. The estimates for 2020 show an SSB of 266 000 t which is more than 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 (2013–2019). The acoustic biomass has fluctuated over time and the 2019 biomass has increased from the 2018 estimate.

The HAWG reviewed the assessments performed on four 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 to small pelagic fish were discussed.

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

ii Expert group information

Expert group name	Herring Assessment Working Group for the Area South of 62° N (HAWG)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chair(s)	Afra Egan, Ireland
	Valerio Bartolino, Sweden
Meeting venue(s) and dates	HAWG Sandeel: 22-24 January 2020, Copenhagen, Denmark (6 participants)
	HAWG: 17-24 March 2020, virtual meeting (26 participants)

1 Introduction

1.1 HAWG 2020 work in relation to the generic ToR

In light of the disruptions caused by COVID 19 in 2020, the 17th-25th March meeting, which was initially planned at the ICES Headquarters, was conducted using virtual meetings and based on re-prioritized generic ToRs (see Annex 2).

1.2 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.

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

As usual, WGCHAIRS met in January in preparation for the new year of advice and science working group activities. Activities of working groups in 2019 were reviewed. Progress made on issues that were highlighted last year were summarized.

Under the ICES strategy, activities of advisory working groups such as HAWG are conducted under the umbrella of the Fisheries Resources Steering Group (FRSG) which became operational in 2019. Advisory expert groups maintain their prerogative of “closed groups” in the sense that members will be still nominated at a national level.

The newly published ICES advisory plan was introduced which aims to keep advice resilient to future challenges. It aims to enhance credibility and transparency of advice, following FAIR (Findable, Accessible, Interoperable, Reusable) and TAF (Transparent Assessment Framework) principles. It facilitates the move towards ecosystem advice and will better utilize the science and data available in ICES (ICES 2019). The plan also aims to improve sharing and communicating advice to meet the stakeholders/requestors needs.

Six priority areas for development are identified in the plan:

1. Assuring quality
2. Incorporating innovation
3. Highlighting benefits
4. Sharing Evidence
5. Evolving advice
6. Identifying needs

The different channels for publications were discussed including in house publication such as the Cooperative Research Report CRR for reference publications and the Techniques in Marine Environmental Sciences TIMES for practical guidelines. ID Leaflets can be published on specific topics. Scientific advice is published through the ICES scientific reports and the ICES advice. Peer reviewed scientific work is published in the ICES journal of Marine Science. Other communication channels that can be utilized include social media, ICES news, annual reports and fact-sheets.

Overall, the format of the advice had no major changes in January. 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 by assigning at least two members as auditors for each stock. After the WGCHAIRS meeting and in light of the Covid-19 disruption the format of the ICES advice changed and HAWG adopted these changes.

1.2.2 Working Group for International Pelagic Surveys (WGIPS)

The Working Group of International Pelagic Surveys (WGIPS) met in Bergen, Norway on 14–18 January 2020. 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 2020 surveys.

Results of the surveys covered by WGIPS and coordination plans for the 2020 pelagic acoustic surveys are available from the WGIPS report (WGIPS, ICES 2020). The following text refers only to the surveys of relevance to HAWG.

Review of larvae surveys in 2019: These surveys are no longer dealt with in WGIPS. From 2019 the planning, analysis and reporting on larvae surveys will fall under WGSINS. The results from the larvae surveys can be found in the HAWG report, Section 2.3.2 and for 2018/19 onwards they will be coordinated and reported on in WGEGGS2.

North Sea, West of Scotland and Malin Shelf summer herring acoustic surveys in 2019: Six surveys were carried out during late June and July covering most of the continental shelf in the North Sea, West of Scotland, Malin Shelf, West of Ireland and Celtic Sea.

The estimate of **North Sea autumn spawning herring** spawning-stock biomass is lower than previous year at 1.9 million tonnes (2018: 2.3) due to a decrease in the number of fish (2018: 12 315 mill. fish, 2019: 10 295). The mean weight of mature fish is similar to last year at 186.4 g and the decrease in biomass follows directly from a decrease in numbers. The spawning stock is dominated by young fish of age 3 and 5 wr, which is in accordance with the strongest year classes in the 2018 survey.

The 2019 estimate of **Western Baltic spring-spawning herring** 3+ group is 74 000 tonnes and 574 million. This is a decrease of 31 and 23%, respectively, compared to the 2018 estimates of 107 000 tonnes and 574 million fish.

The **West of Scotland** estimate (6.a.N) of SSB is 76 000 tonnes and 406 million individuals, a large decrease compared to the 152 000 tonnes and 875 million herring estimate in 2018.

The 2019 SSB estimate for the **Malin Shelf area (6.a and 7.b,c)** is 128 000 tonnes and 740 million individuals, a decrease compared to the 159 000 tonnes and 925 million herring estimate in 2018 and the second lowest level in the time-series. In 2019 there was a larger proportion of herring distributed south of 56°N compared to previous years. This is due to a combination of decreased abundance in the 6aN part and increased abundance in the 6aS part.

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 2019 was estimated at 124 999 million individuals and the biomass at 880 000 tonnes. This is at the same level as the historic high in the time-series (2016) in terms of abundance and the second highest in terms of biomass. Compared to the 2016 estimate, abundance and biomass is 0.3% higher and 21% lower, respectively. The stock was dominated by 1- and 2-year-old sprat (92% of biomass). The 2019, as the 2014-2016 and 2018, sprat biomass estimates are all well above the long-term average for the survey time-series, whereas the 2017 estimate is 24% lower.

In for **sprat in Division 3.a**, the abundance in 2019 is estimated at 2645 million individuals and the biomass at 38 400 tonnes. This is the second highest estimate of the time-series in terms of biomass, and well above the long-term average both in terms of abundance (52%) and biomass (39%). The stock is dominated by 2-year-old sprat.

Irish Sea Acoustic Survey: The herring abundance for the Irish Sea and North Channel (7.a.N) during 28th August–13th September was reported by Northern Ireland. In 2019 the estimate was 39 319 tonnes, similar to that observed in 2018. The biomass estimate of 68 078 t for 1+ ringers is a further 25% increase on last year's biomass estimate. A large proportion of the 1+biomass estimate was seen to the west of the Isle of Man and in North Channel close to the Scottish coast. The western and northern Irish Sea are areas of mixed size fish. Sampling intensity was high during the 2019 survey with 30 successful trawls completed. Sprat and 0-group herring were distributed around the periphery of the Irish Sea. Highest abundance of 1+ herring targets in 2019 were observed on both the western sides of the Isle of Man and on the Scottish coast of the North Channel. Local high areas of high abundance of herring were also observed on the known spawning banks toward the county Down coast. 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 examined at WKHASS in 2019 and recommended for inclusion the Acoustic Survey manual. The results of the survey are reported in the WGIPS 2019 report (ICES, 2019). The survey is included in the assessment as a SSB index. The SSB in 2019 was estimated 44 428t. The herring were distributed primarily to the southeast of the Isle of Man on the inshore sections of survey transects, associated with known spawning areas. The estimate of herring SSB from the 2019 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 2019 was reported by the Marine Institute, Ireland. The Celtic Sea herring stock was considered to have been contained within the survey area in 2019 for the main grounds in the Celtic Sea and saw increased acoustic sampling effort as compared to 2018 (25%). The spawning-stock biomass (SSB) estimate in 2019 was the lowest in the time-series. The CV on the survey estimate was high (0.55) in 2019. 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 CSHAS 2018 and the WESPAS summer survey in June 2019 showed potential of a recruiting year class. However, recruiting herring were not observed in the numbers expected during this year's survey.

The biomass and abundance of sprat in 2019 was higher than in 2018. Overall, the standing stock of sprat remains relatively consistent within the survey time-series. One important caveat within the sprat time-series is that the survey is conducted over 24 hrs and not during daylight hours only. The latter survey design being best suited to measuring sprat abundance due day/night behavioural effects and the availability of targets to the acoustic equipment.

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 2019. This year, for the third year running, the survey was extended beyond the area covered between

2012 and 2016. The extended survey coverage included the French waters of western Channel (ICES 7e). The pelagic fish objectives of the survey were successfully completed. In total just under 1800 nautical miles of acoustic sampling units were collected and supplemented with 38 valid trawls. The results indicated that sprat was found to be more widespread than in recent years, although combined sprat biomass for the whole survey area was comparable to 2018.

The biomass in Lyme Bay, which is relevant to the stock assessment of sprat in 7de, was up from 2018, to 36,789 t.

1.2.3 Working Group on Baltic International Fish Survey (WGBIFS)

The Working Group on Baltic International Fish Survey plans, coordinates, and implements both demersal trawl surveys and hydroacoustic surveys for the Baltic Sea. All the acoustic indices used by HAWG are provided by WGIPS with the exception of the GerAs index which is derived from the Baltic International Acoustic Survey (BIAS).

Baltic International Acoustic Survey (BIAS): This survey is conducted throughout the Baltic Sea during the months of September-October with participation of the different Baltic countries. Germany is responsible for the survey covering the western Baltic and the Kattegat (SD21-24), from which the GerAs index is derived for Western Baltic Spring-spawning herring (WBSSH). Mixing with the adjacent central Baltic herring stock generally occurs in SD 24 and in 2019 also in SD21,23. The index is routinely adjusted to account for the mixing of the two stocks based on growth parameters. The 2019 GerAs index for the WBSSH was 2.3 x 10^9 individuals and 51.6 x 10^3 tonnes which is the lowest biomass value on record.

1.2.4 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 prioritization system. WGBIOP has a close working relationship with WGSMART (The Working Group on SmartDots Governance) and in cooperation will further develop the SmartDots tool as a platform for supporting the provision of quality assured data to the end-users.

The last WGBIOP (October 2019) reviewed the following activities falling within its remit and of interest for HAWG:

- No exchanges or workshops were held during the previous year for herring (*Clupea harengus*) and sprat (*Sprattus sprattus)* stocks assessed by HAWG.
- A workshop on the identification of clupeid larvae (WKIDCLUP2) is scheduled on 31 August – 4 September 2020 to be held in Bremerhaven, Germany.
- There was a Sandeel (*Ammodytes marinus*) small otolith exchange during 2019 focused on samples from SA1, SA3 and SA5 (available at https://smartdots.ices.dk/ViewEvent?key=219). Results show a weighted average percentage agreement (PA) based on modal ages for all advanced readers of 81 % (71% based on all readers) and the weighted average coefficient of variation (CV) is 24 % (26% based on all readers). At modal age 0, the PA calculated across all readers is 78%. At modal ages 1 and 2 the PA increases to 80% and 89% respectively. From modal ages 3 to 8 the PA is between 75 and 50% and at modal age 9 it is 83%. At modal age 1 the overall CV is high at 41% and no reader achieving a CV below 27%. CV decreases with an increase in age. At modal age 0, 1 and 2 the overall bias, calculated across all age readers, is 0.28, 0.12 and 0.05 respectively, indicating an overestimation compared with modal age (as with modal age 6). At modal ages 3-5 and 7-9 the overall negative bias indicates underestimation compared with modal age. Three stocks were included in this exchange. PA is highest for san.sa.1r (SA1), followed by san.sa.3r (SA3) and san.sa.5r (SA5). The CV is the highest for san.sa.1r followed by san.sa.3r and san.sa.5r. Again, the overall relative bias indicates overestimation at modal ages 0, 1 and 2 and underestimation at modal age 3 and 4. In comparison, the highest bias is seen in san.sa.3r and san.sa.5r respectively.

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 datasets can be weighted in an assessment model according to their relative quality.

WGCATCH 2019 finalized best practice guidelines for sampling of the small-scale fleet and best practice guidelines for provision of frequency data for AWG's, when number of samples are limited. The group started documenting current estimations methods used when providing commercial catch data, developing methods for evaluating the completeness of declarative data in respect to the small sale fleet and continued the close relation to WGBYC by reviewing sampling protocols for protected, endangered and threatened species (PETS) and the inclusion of relevant PETS data in the RDBES.

1.2.5 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 2020 HAWG assessments.

1.2.6 MIK surveys

Down's herring recruitment information

In 2016, WKHERLARS evaluated the North Sea herring larvae surveys (ICES, 2016), and concluded that the current IBTS-MIK recruitment index does not contain information on the Downs spawning component. It was recommended to investigate the possibility to collect data to include information on Down's recruitment. In 2017, the effect of omitting one of the three IHLS surveys, carried out on the Downs component, from the herring assessment was investigated. The omission resulted in a negligible effect and it was, thus, decided to drop the Dutch IHLS participation in the second half of January. The vessel time and budget of this survey was instead used to conduct a Downs Recruitment Survey (DRS) in 2018.

The DRS was carried out in April 2018 and 2019, 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. A survey was also planned for April 2020, but due to COVID-19 measures this survey was cancelled. In April 2021 the survey will continue, provided the COVID-19 measures are released. HAWG has a positive view on the continuation of the Downs Recruitment Survey (DRS), but cannot include the survey in the advice based on only two years of a survey. HAWG foresees potential future use of the combined IBTS0-DRS-index for a complete NSAS recruitment index for the advice if the surveys are continued. Thus HAWG supports the continuation of the exploratory surveys in April and have had a positive response from several laboratories. HAWG recommends that WGSINS investigate calculation of a Downs and combined North Sea herring recruitment index based on the combination of the IBTS-MIK and DRS data.

1.2.7 Stock separation of herring in surveys and catches

The mixing of herring stocks in surveys and catches is an issue in many of the stock assessments carried out in HAWG. Currently only the mixing between North Sea herring and Western Baltic Spring-spawning herring (in the catches, in the HERAS and IBTS surveys) and between Western Baltic Spring-spawning herring and Central Baltic herring (limited to the GerAS survey) are routinely quantified and accounted for in the assessments. The development of operational methods to enable estimation of proportion contribution from different stock in catches and survey indices throughout the management areas for herring assessed by HAWG is a topic that HAWG continues to have high on the list of issues to solve to improve upon assessments. Several ICES workshops have been held to progress this topic, most recently WKMIXHER in 2018 and WKSIDAC in 2017. During HAWG 2019 a mini symposium was arranged to facilitate exchange of ideas and foster collaboration of researchers working on different aspects and methods. An update on progress of those projects dealing with stock identification and mixing of relevance to HAWG is provided below.

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

Atlantic herring west of Scotland and Ireland comprise at least two reproductively isolated biological populations. The 6aN herring spawn off Cape Wrath in northwest Scotland in Autumn (September/October) and the 6aS/7bc herring spawn off Donegal in northwest Ireland in winter (November to January). The stocks are believed to form mixed feeding aggregations west of the Hebrides in summer, where they are targeted by the Malin Shelf Herring Acoustic Survey (MSHAS), conducted annually by the Marine Institute and Marine Scotland. The MSHAS survey index is a primary input into the stock assessments of these two stocks. It is not currently possible to separate the data from the MSHAS into population/stock of origin, therefore only a combined index is available and hence a combined assessment (ICES, 2015). Based on the combined assessment, ICES provides combined advice for the two areas and stocks and has recommended a zero

TAC for the last five years. Scientific samples are obtained during the scientific monitoring fisheries in 6aS/7bc and 6aN.

The 6a/7bc herring stock identification project is developing three stock identification methods; genetics, body morphometrics and otolith shape analysis, to distinguish between herring stocks in ICES areas 6a, 7b and 7c. The aims of the project are to assess the identity of herring stocks in 6a/7bc using genetics, body morphology and/or otolith shape analysis; to provide a breakdown of the stocks captured during the MSHAS as far back as the data collection will allow; contribute to the achievement of MSY assessment of the stocks; provide advice on data collection required to distinguish between the stocks going forward.

Data being analysed during this project were collected between 2010 and 2019 for baseline samples and mixed samples. Some archive samples from the WESTHER project (2003-2005) are also available, inclusion of which will increase the temporal scale of the analyses.

Body morphology and otolith shape analysis data have been collected by the Marine Institute and Marine Scotland during the MSHAS from 2010 to present (ICES SGHERWAY, 2010). This 10 year period of data collection has resulted in over 10,000 fish with biological, body morphology and otolith shape data recorded during the time of year that herring stocks in this area are believed to form mixed aggregations. A focus on collecting baseline spawning data began in 2014, when two samples of spawning fish were collected from both 6aS and 6aN during the commercial fisheries in these areas. Between 2016, 2017 and 2019, 11 more baseline spawning samples were collected from commercial fisheries (5 samples from 6aS and 6 samples from 6aN). No spawning samples were collected in 2015 or 2018 despite a continued effort to do so.

Genetic sample collection began in 2014 for both mixed and baseline spawning samples. From 2014 onwards all fish that were sampled for body morphormetrics and otolith shape during the MSHAS also had a tissue sample collected for genetic analyses. Tissue samples have also been collected from additional baseline spawning samples in 6aN, 6aS/7bc and from surrounding stocks, including the Irish Sea, Celtic Sea and North Sea. In total 177 samples comprising over 12,500 herring have been analysed with a panel of genetic markers that have been shown to discriminate between the target populations.

The data collected from herring in 6a/7bc are being analysed using a combination of R scripts written by project partners and various packages available to perform tasks and analysis specific to stock identification and multivariate data.

R scripts written in-house are being used to calculate body morphometric measurements, including truss measurements across the body. The R package geomorph (Adams & Otárola-Castillo, 2013) is also being explored as another method of describing the shape of the body using geometric morphometrics. The R package ShapeR (Libungan & Pálsson, 2015) is being used to extract the outline of each otolith in order to describe its shape. Both elliptic Fourier analysis and Wavelet transform are calculated by this package so data from both methods of shape description have been recorded. Genotype data for all samples have been generated using a modified genotyping by sequencing approach (see Farrell et al. 2016). The R package adegenet (Jombart, 2008) is being used to explore the data and undertake standard genetic analyses including summary statistics, Hardy-Weinberg Equilibrium (HWE) tests and *F* statistics. Multivariate analyses, including discriminant analysis of principle components (dapc), of both the genetic and morphometric data are also being undertaken using adegenet to identify and visualize the clusters found within the datasets. Preliminary results from the genetic analyses conclude that the 6aN and

6aS/7bc herring stocks represent at least two genetically distinct populations, and this result appears to be stable over time. The 6aN samples are indistinguishable from the North Sea samples analysed and both are relatively temporally stable at the molecular markers analysed. The 6aS, Celtic Sea and Irish Sea samples all showed strong population differentiation between each other and the samples from 6aN and NS.

To ensure that all three stock identification methods are working independently before comparing and combining them, data analyses are being conducted separately to fine tune each dataset. The R package assignPOP (Chen et al., 2018) works with genetic, morphometric and integrated (genetic and morphometric) datasets to perform population assignments using machine learning classification algorithms. The package is currently being used to evaluate the baseline datasets of each stock identification method and will later be used on an integrated baseline dataset. This dataset will then be used to predict source populations of the mixed MSHAS samples, all within assignPOP.

The project is now in its final year and the project partners are currently conducting data analyses and comparison work between the three stock identification methods. All three methods are demonstrating a strong ability to distinguish between 6aS and 6aN herring, with self-classification rates of 70-95%. Further analyses are underway to fine tune the baselines and to ensure that both the genetic and morphometric methods are in agreement. This is essential as all methods will be used to split the 2014-2019 MSHAS samples into population of origin. There is no genetic data available for the MSHAS samples collected from 2010 to 2013 so the morphometric data will be analysed in an effort to provide a retrospective split of the survey data for these 4 years.
Further information on this project is available from Ed Farrell (edward.d.farrell@gmail.com) and Emma White (emma.white@marine.ie).

Updates on tools to split herring populations

Discrimination and splitting of mixed stocks are essential to stock assessment and advice. Herring stocks assessed by HAWG are mainly separated based on a priori assumptions that fish stocks rigidly follow artificial geographical boundaries. Currently, splitting methods are only applied for the separation of North Sea autumn spawning herring (NSASH, her.27.3a47d) and western Baltic spring-spawning herring (WBSSH, her.27.20-24). 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 northeastern Atlantic (Libungan *et al*., 2015). Further, there is a clear genetic effect on the otolith shape of Atlantic herring (Berg *et al*., 2018). In the meantime, Smoliński et al. (2020) have compared the assignment performance of different statistical classifiers, including traditional and machine learning classifiers. Their study provides a solid reference guideline for otolith shape analysis.

Results of preliminary otolith shape analysis and other splitting methods have been reported in Annex 6.3 of the last HAWG report (ICES, 2019). Here, new results of follow-up studies will be presented based on the same and updated material from last year (Berg et al. 2019). Shortly, 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). As suggested, this baseline was updated with annual samples and not rebuilt for the current year. The otolith shape of herring was transformed into 64 wavelet coefficients for further testing. Cross-validation was performed following the guidelines of Smoliński et al. (2020). In general, the overall assignment accuracy was relatively high (>80%) indicating that our baseline is suitable for assignment of individuals from unknown catches. While Smoliński et al. (2020) focused on the validation of the baseline, our aim was to assign unknown herring for mixed catches to their original stock. Unknown catches were collected during several scientific surveys in the greater North Sea ecoregion and adjacent areas (Figure 1.2.7.1). We applied several classifiers, provided by the assignPOP package in R (Chen *et al*., 2018), to assign unknown otoliths and compared their results. During the assignment each otolith receives a probability for each of the three stocks (Figure 1.2.7.2). Otoliths were not assigned if the difference in assignment probability between the two most likely stocks was <20%.

Our results demonstrate that otolith shape analysis can, combined with machine learning techniques, be used to assign individuals of unknown origin to one of these stocks (~82.5% assigned, ~17.5% not assigned). Similar to Smoliński et al. (2020), estimations of the level of mixing are sensitive to the machine learning technique applied (Figure 1.2.7.2). A disadvantage is that stocks not included in the baseline, that appear in mixed catches, cannot be assigned. Further, the fixed threshold (<20%) used to not assign individuals needs to be evaluated, especially regarding to the statistical power needed for sustainable assessment and management. More analyses to estimate the extent of mixing and potential effects on stock biomass/catches are encouraged, also in combination with other discrimination methods like genetics. Since last year, 2019, genetic samples were collected on Norwegian scientific surveys, in addition to the standard sampling including otoliths. The collection of genetic material will be continued and extended this year, and genetic analyses will be started. This allows for a larger comparison of assignments based on different discrimination methods comparable to the results presented in the last HAWG report (ICES 2019).

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

All in all, discrimination methods used for the splitting and assignment of unknown individuals need to be further developed and adjusted. Also, our 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. Further information on this work is available from florian.berg@hi.no.

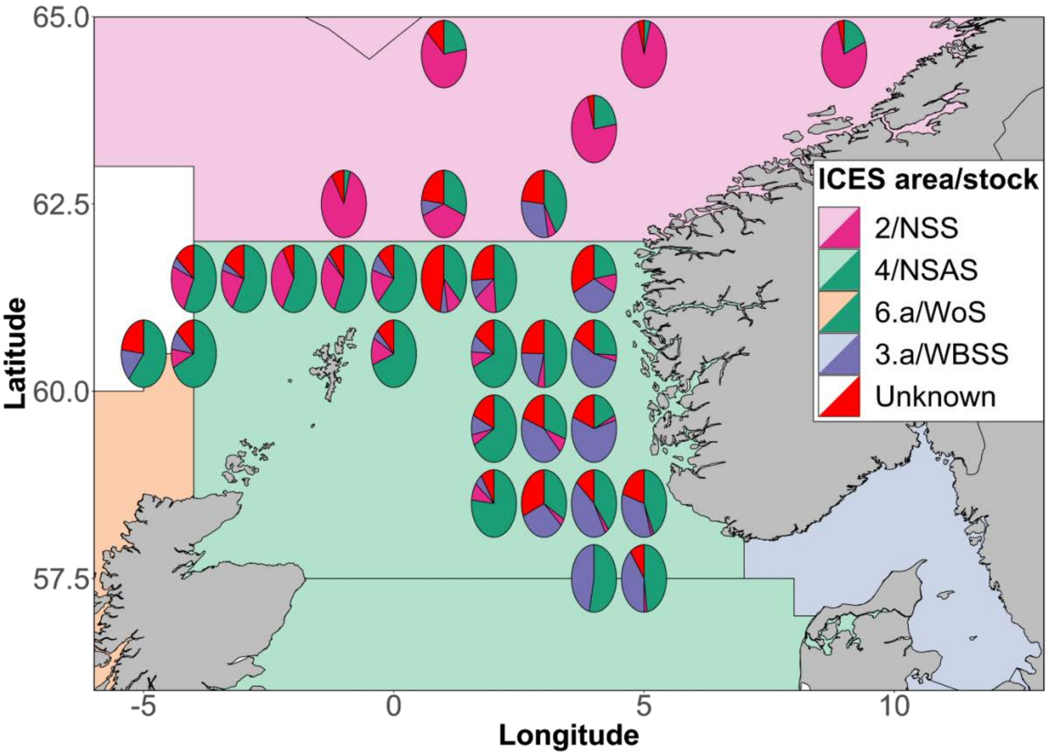

Figure 1.2.7.1: Map of the greater North Sea ecoregion indicating geographical boundaries of four different herring stocks. Assignment results of individual fish of unknown origin to one of these stocks using otolith shape analysis and machine learning techniques, in this case support vector machine (SVM).

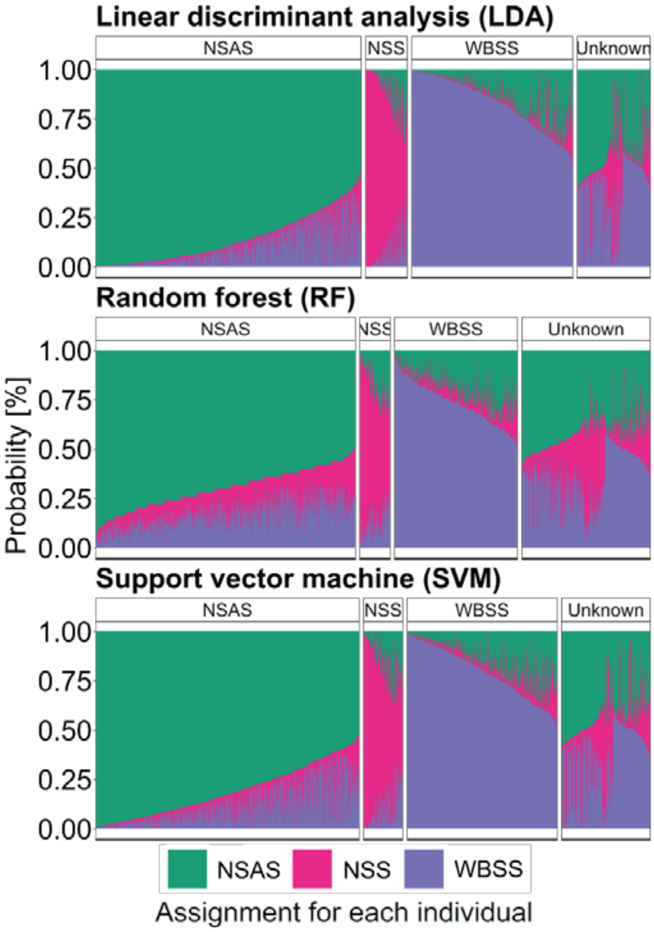

Figure 1.2.7.2: Assignment results for individuals of unknown origin to their potential stocks based on different machine learning techniques.

Updates on the analyses of the WKMixHer sample

The 2018 workshop on mixing of western and central Baltic herring stocks (WKMixHer) was concluded with a recommendation and proposal for coordinated sampling of Spring-spawning herring with the objective to further evaluate mixing of herring stocks in the western-central Baltic and implement operational methods for their separation.

Accordingly, Spring-spawning herring were collected by Sweden, Germany, Poland and Lithuania during the 2019 spawning peak on 7 coastal spawning grounds in the Hanö Bay, Bay of Lübeck, Greifswald Bay, Pomeranian Bay, Kolozbreg, Vistula Lagoon and Klaipéda (Figure 1.2.7.3).

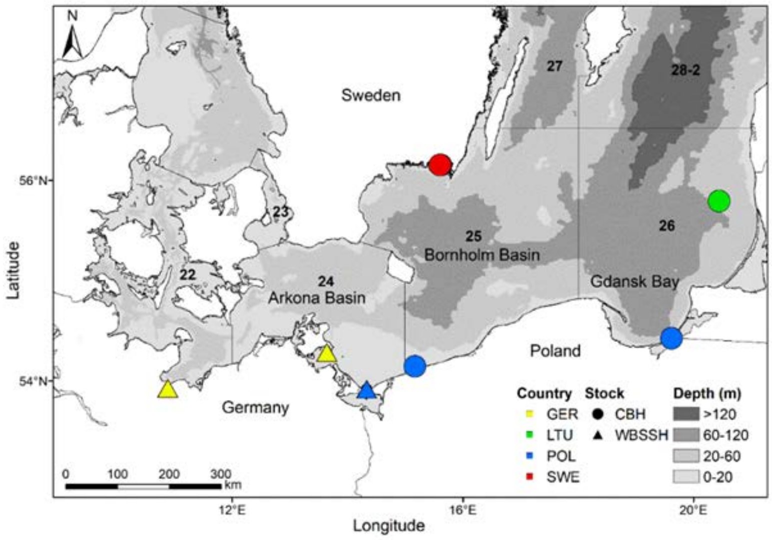

Figure 1.2.7.3. Map with sampling locations of spawning herring during Spring 2019.

Herring was collected at spawning time on spawning aggregations, resulting in samples covering the period between late March and early May as the spawning peak showed a seasonal progression throughout the region. Sampling was restricted to ripe and running individuals corresponding to maturity stages between 5 and 7. The sample comprised 399 individuals from which otolith shapes were extracted and preliminary analyses conducted.

A Canonical Analysis of Principal Coordinates performed on the standardized wavelet coefficients showed that herring from the sampled locations group into two well distinct clusters, with a clear geographical longitudinal separation (Figure 1.2.7.4). Based on the 2019 samples the two clusters approximate the Western and the Central Baltic herring stocks, but Polish samples from the western part of SD25 (station "SWI-31") group with the western Baltic cluster. A wide geographical gap in the 2019 sampling did not allow other inference on the level of otolith differentiation along the southern Baltic coast.

Among the classifiers tested (both traditional techniques and machine learning algorithms) Random Forest (with k-fold cross validation) provided the best overall accuracy in the discrimination between the two clusters with overall promising assignment accuracy of approx. 70%.

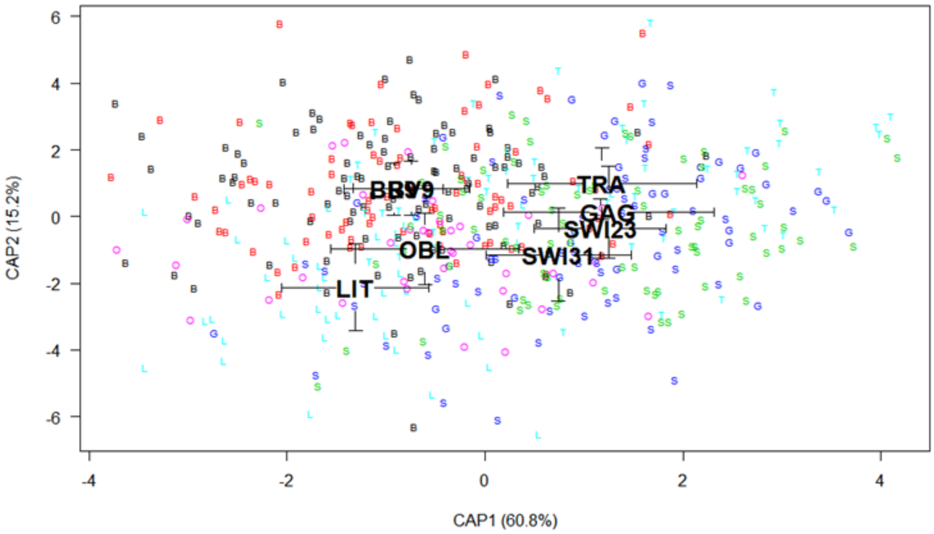

Figure 1.2.7.4. Plot of the first and second Principal Components from the analysis of standardized Wavelet coefficients. The black labels show the centroid for each spawning location.

Further work is in progress to:

- improve the level of accuracy in the assignment of mixed samples by combining otolith shape and growth data;
- collect samples of spawning herring from the central part of the Polish coast to evaluate gradient of differentiation along the southern Baltic coast.

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

1.2.8 WKFORBIAS

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

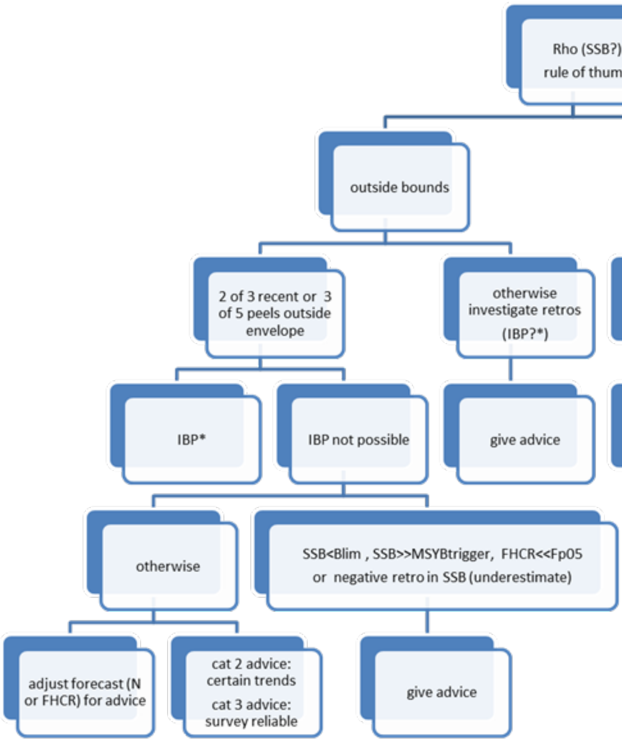

Figure 1.2.8.1: Decision tree for handling assessments with retrospective patterns produced by WKFORBIAS.

General recommendations from WKFORBIAS include:

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

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

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

1.2.9 WKREBUILD

The Workshop on guidelines and methods for the evaluation of rebuilding plans (WKREBUILD) chaired by Vanessa Trijoulet (Denmark) and Martin Pastoors (Netherlands) met from 24 to 28 February 2020. The workshop attracted 27 participants from the US, Canada, Europe and FAO.

When stocks are estimated to be below Blim and there is no perceived possibility of rebuilding above Blim within the time frame of a short term forecast, ICES has regularly recommended zero catch in combination with the development of a rebuilding plans.

A review was carried out on the international experience on the development, evaluation and implementation of rebuilding plans for fisheries management in the Northeast Atlantic and in other fora around the world. In the Northeast Atlantic, rebuilding plans have been implemented in the past (e.g. the cod recovery plans of the early 2000s) but ICES has played a limited role in evaluating the performance of such recovery plans and does not have the tools or criteria to evaluate such plans. Recently, when a rebuilding plan for herring in 6a7bc was submitted to ICES for evaluation, ICES refrained from providing such an evaluation. In the US and Canadian approaches, the legal framework determines the triggering and required elements of rebuilding plans. Such a legal imperative does not exist in the Northeast Atlantic. Nevertheless, the US and Canadian experiences provided useful elements that could be included in the ICES approach to rebuilding plans.

Several case studies were presented on application of potential tools for the evaluation of rebuilding plans. Particular attention was given to the harvest control rule options of such a plan. The tools focused mostly on short to medium term explorations of the probability of achieving a re-building of stocks. Because rebuilding plan evaluations can be expected to be needed on relatively short time frames, it was concluded that relatively standardized tools (i.e. packages or com-piled code) to carry out such evaluations would be preferable over custom-made evaluation tools. In addition, certain modelling considerations were highlighted as important such as the probability of achieving a rebuilding of stocks and realistic assumptions of productivity, uncertainty, bias in assessments and implementation error.

Criteria for the acceptability of rebuilding plans will require agreed reference points for triggering a rebuilding plan (e.g. Blim), definition of rebuilding fishing mortality or biomass targets, time frames and probabilities of achieving the rebuilding targets, taking into account realistic levels of uncertainty and being consistent with international best (scientific) practices. Although it was recognized that Blim would be the most likely candidate for triggering a rebuilding plan, the current basis for Blim in ICES was questioned during the workshop because it requires a more or less subjective classification of the stock-recruitment pairs into different types. In other regions, the Limit Reference Point (LRP) is often set as a certain proportion of Bmsy (e.g. 40% Bmsy). If changes in productivity have been experienced in recent years, the proportion of Bmsy approach would likely lead to greater changes in the estimated value of Blim than the current procedures, which rely on stock-recruitment pairs or Bloss. This could have a large impact on the rebuilding target for stocks that show signs of low productivity regimes. Some concerns were raised regard-ing the relatively small distance between Blim and MSY Btrigger compared with the distance between trigger and limit in other jurisdictions. MSY Btrigger could therefore represent a late trigger to start decreasing fishing mortality when SSB is decreasing. The workshop recommend-ed a future workshop on the revision of the procedure to estimate reference points within the ICES framework.

The minimum time (Tmin) by which rebuilding may be expected, could be calculated by assuming zero catch. This should be used as baseline for comparison with other rebuilding scenarios. The maximum time for rebuilding in the US and Canadian jurisdictions is set to Tmax = 2 * Tmin or to Tmin plus one generation time. While the workshop did not arrive at an overall agreement on a default value for Tmax, it was suggested that Tmax = 2 * Tmin could be explored as a potential bounding on the rebuilding period, although this should be subject to scientific analysis on potential effects.

The workshop generated a guidance table summarizing the best practices for evaluation of rebuilding plans against the potential criteria of acceptability. The guidance table includes elements such as estimation of reference points, time frames for rebuilding, rebuilding targets, handling uncertainties and bias, probability of achieving rebuilding targets and visualizing results. The workshop recommended that a follow-up workshop (WKREBUILD2) be organized for testing the guidelines with actual test cases. This should enable to narrow down and refine the guidelines i.e. learning by doing.

Some of the elements that were discussed in the workshop but that have not (yet) entered the guidelines for evaluation of rebuilding plans are socio-economic trade-offs (e.g. between fast and slow rebuilding), mixed fisheries aspects (e.g. unavoidable bycatch due to mixed fisheries) and elements in rebuilding plans other than the HCR part (e.g. monitoring to improve the knowledge base).

Most of the discussion at WKREBUILD was centred on stocks with analytical assessments (Category 1+2). Identifying when a data limited stock is in need of rebuilding (or has rebuilt) and how to evaluate rebuilding plan options for such stocks would likely require a separate process.

1.2.10 WKDLSSLS

The Workshop on Data Limited Stocks of Short-Lived Species (WKDLSSLS) aimed to provide guidelines on the estimation of MSY proxy reference points for category 3–4 short-lived species and to evaluate the management procedures currently in use and their appropriateness for short-lived species by means of Long-Term Management Strategy Evaluations (LT-MSE). A number of stock were examined including Sprat in 7d and e.

WKDLSSLS 2019 investigated the use of SPICT, length based indicators and two-stage biomass models for developing biological and MSY proxy reference point and application of the existing advice rules to category 3 and 4, short lived data limited species using long-term management strategy evaluation. Index based HCR were tested using MSE with a range of operating models. In year advice was found to result in larger catches and reduced risk in all tests due to the reduced lag between observation, advice and management when tested against annual advice. The principle cause of risk in simulations was historical exploitation (trend), HCR and the uncertainty cap. A 1o2 advice rule was found to outperform the current 2o3 rule for short lived stocks, 1o2 was tested with a range of uncertainty caps and biomass safeguard such as Imin (minimum observed abundance index) and Itrigger (1.4*Imin). Investigation of the uncertainty cap and biomass safeguards is currently ongoing and will be resolved at WKDLSSLS 2020. Rule 1-over-2 with symmetrical 80% Uncertainty cap might be preferred as a compromise between moderate risks and catches though it can lead to major reduction of catches in the long term.

1.2.11 IBSANDEEL

The sandeel advice is largely influenced by the most recent recruitment, which is informed by the recent age-0 survey index. During the sandeel assessment and advice meeting (held on 22nd-24th January 2020 at the ICES HQ as part of HAWG), a retrospective bias was observed by the expert group for both area 2r and 3r in both recruitment (R) and spawning-stock biomass (SSB). This triggered an inter-benchmark IBPSANDEEL with the aim to evaluate the use of a density-dependent survey catchability model to reduce retrospective patterns in the assessment of sandeel in area 2r and 3r. IBPSANDEEL concluded that the method proposed is appropriate and can be applied to provide advice on these two stocks.

The sandeel advice on fishing opportunities is highly influenced by good incoming year classes. High uncertainty is usually associated with estimation of high recruitments, which justified the implementation of an Fcap strategy. However, sandeel assessments in 2r and 3r have also strong retrospective patterns in recruitment (i.e. the model has a tendency to overestimate recruitment in the terminal year) which are not properly accounted by the current Fcap.

Sandeel recruitment in 2019 is estimated to be high throughout the entire North Sea, including areas 2r and 3r. For this reason an adjustment to the assessment model was proposed to provide more reliable estimates of recruitment in the terminal year. A power function was implemented in the assessment of sandeel 2r and 3r to capture density-dependency catchability of age 0 fish in the survey. The adjusted models provided downward correction of the terminal year recruitment which is considered more reliable as suggested by the reduced Mohn's rho statistic, while estimates of stock dynamics (SSB and R) remained highly consistent with the previous assessment.

1.2.12 WKHASS

The Workshop on Herring Acoustic Spawning Surveys (WKHASS) reviewed the methodology (survey design, timing, identification of the sources of uncertainties and how to address them, among other issues), and abundance estimates (including CV) from acoustic surveys carried out in 6aN, 6aS/7b and 7a on commercial vessels. The results will be used by WGIPS to establish survey protocols to be included in future in the Manual for International Pelagic Surveys (SISP 9). Analyses carried out during this workshop showed that both the 6aN and 6aS/7bc industry-led surveys are not yet sufficiently developed for them to be included in the SISP 9 survey manual because they are still undergoing regular changes as they learn from testing different designs regarding the issues and the solutions proposed to address them. WKHASS recommends that:

- the acoustic and biological data from the herring acoustic spawning surveys in 6aN, 6aS/7b and 7a are uploaded to and hosted on the ICES Acoustic trawl surveys database. This is recommended to ensure transparency in the calculation of survey indices and allow for comparison with standard methods (e.g. StoX).
- a workshop is held on scrutinising of acoustic data from the herring acoustic spawning surveys in 6aN, 6aS,7bc and 7.a. It is important that all scientists responsible for the scrutinisation of an acoustic survey follow mutually agreed and documented procedures for each survey and that these agreed procedures are developed specifically for the survey. This is particularly important when surveys are carried out on board commercial vessels, resulting in some differences in the acoustic equipment used (e.g. different transducer frequencies and/or hull or towed body mounted).
- the 7a survey in the Irish Sea is included in the SISP 9 manual for pelagic acoustic surveys, because this survey is already used as a biomass index in the Irish Sea herring assessment and thus transparency is required in the calculation of survey indices.

1.2.13 WKIRISH

The WKIrish workshop series was a multiyear process focusing on improving single-species stock assessments (principally cod, haddock, whiting, plaice, herring), incorporating a mixed fisheries model, and developing the integration of ecosystem aspects and working towards an integrated assessment and advice. The final Workshop (WKIrish 6) set out to operationalize an Ecosystem Based Approach to Fishery Management for the Irish Sea. WKIrish defined a framework to incorporate ecosystem information into the ICES single-species stock assessment process. The series initiated independent ecosystems models. Of these, an Ecopath with Ecosim (EwE) model, reviewed by the ICES Working Group on Multispecies Assessment Methods (WGSAM), is the most developed. WKIrish propose to use relevant ecosystem indicators to inform the F_{MSY} within established F ranges ($F_{MSYLower}$ to $F_{MSYUpper}$). This F_{IND} uses indicators of current ecosystem suitability for individual stocks to refine the F target values within these precautionary ranges. F_{IND} is based on finding ecosystem indicators which are positively related to the stock development over the model tuning range, and where the likely underlying mechanisms for this link are likely to continue acting in the short to medium term. In essence the value of the indicator is used to explore if the ecosystem is in a favorable state for the stock and consequently F in the upper range may be advised. Conversely, where the indicator suggests the ecosystem may be in an unfavorable state, F should be in the lower range. In this framework in no case does the proposed F target lie outside the ranges defined as being precautionary and thus the system proposed here remains according to the ICES principles.

The EwE model was used to provide ecosystem indicator(s) for individual stocks (cod, whiting, haddock, sole, plaice, herring, and *Nephrops*). Management Strategy Evaluation simulations were applied for Irish Sea herring testing resilience of the stock to fishing at the extremes of the F range. The selection of the indicator aimed to cover a range of possible ecosystem processes on each stock. Through this approach, WKIrish has identified a route by which ecosystem information can be incorporated into the current single species assessment process. However, the approach can be developed further; a potential frame-work for a more complete Ecosystem Based Fishery Management is described. This framework suggests the use of ecosystem descriptors to inform decision-making within assessment benchmarking processes. This may involve, exploring productivity change across the assessment time-series, examining trends in aspects of population dynamics such as natural mortality and recruitment success, and input into the definition of reference points.

1.2.14 Other activities relevant to HAWG

Industry-Science survey of herring in 6.a, 7b–c. in 2019.

(see Section 06 for additional details).

In 2019, 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 (EU2019/124), 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 2016-2018 surveys.

Biological samples taken during the survey and subsequent commercial catches were used to construct a catch-at-age used in the 2020 stock assessment. Acoustic surveys on the biomass of the spawning components (ICES, 2020) provide a third set of data points in a spawning stock time-series. Genetic data from spawning fish will continue to contribute to the new baseline data required to assess separately the stocks in 6.aN and 6.aS, 7.b–c, during the benchmark scheduled for 2022.

Pelagic fish fat as ecosystem indicator

A presentation was made to HAWG on behalf of Susan Kenyon, a PhD student at Aberdeen University, whose research title is ‘Fats as ecosystem indicators: Revealing the ecological value of industry data on Atlantic herring (*Clupea harengus*) and Atlantic mackerel (*Scomber scombrus*) fat content’. The PhD accesses historical data on fish fat measurements recorded by Scottish pelagic processing factories and onboard pelagic freezer trawler vessels. The premise of the research is that as a direct indicator of body condition, fat content measurements are relevant to understanding changes in survival, growth, recruitment of pelagic fish. Linking changes in fat content to changes in environmental conditions could help serve as an early warning indicator of changes in stock productivity. Key research questions are:

- Do industry and scientific data on two different condition indices for Atlantic herring show similar interannual variation?

- Is there interannual spatial and temporal variation in Atlantic herring and Atlantic mackerel fat content in the Northeast Atlantic?
- Is interannual variation in Atlantic herring and Atlantic mackerel fat content impacted by variation in food availability and temperature?

While the research is still in its early stages, focused on gathering and standardization of data, initial data exploration show clearly temporal and seasonal changes among different herring stocks (Figure 1.2.14.1)

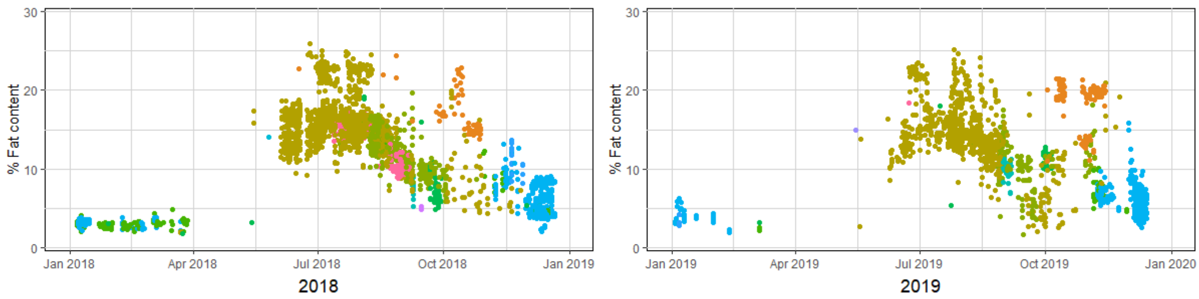

Figure 1.2.14.1. Example of herring fat content data from freezer trawler vessels. (different colours represent different ICES statistical areas)

Data from the herring processing industry (her.27.20-24)

A time-series of herring catch composition data in industrial samples taken during production process in a herring factory in Germany back until 2004 was provided by the industry (processing approx. 1/3 of WBSS SD22-24 TAC landings). The dataset is currently being processed and might contribute to a higher resolution of commercial catch sampling as well as closer cooperation and improved communication between fisheries and science in Germany.

First results reveal high correspondence between scientific and factory sampling of the catches, whereby the industry only records weight data, resulting in some complications regarding comparability and usability of data. However, industrial data of the last 5 years reveal a general shift of the catch composition towards a smaller proportion of light fish and within the individual spawning seasons, no changes in the weight distribution of the prespawning aggregations become apparent.

Ichthyophonus

Ichthyophonus hoferi is a parasite found in fish. It has a low host-specificity, has been observed in more than 80 fish species, mostly marine, and is common in herring, haddock and plaice. *Ichthyophonus* belong to the Class Mesomycetozoea, a group of micro-organisms residing between the fungi and animals (McVivar and Jones, 2013). Epidemics associated with high mortality have been reported several times for Atlantic herring: in 1991–1994 for herring in the North Sea, Skagerrak, Kattegat and the Baltic Sea (Mellergaard and Spanggaard, 1997), and in 2008–2010 for Icelandic summer-spawning herring (Óskarsson and Pálsson, 2011). A time-series of the Norwegian data on *Ichthyophonus* was presented at HAWG 2017. The occurrence is usually below 1%, except for the beginning of the 1990s, but high occurrences (22%) were again observed again in the Norwegian IBTSQ1 2017 which is carried on in the North Sea (Figure 1.2.14.2). Because of the high lethal level of this parasite and episodic outburst, HAWG 2017 decided to continue monitoring the level of *Ichthyophonus* infestation in the following years and Sweden extended the coverage of the sampling to the Skagerrak and Kattegat since IBTSQ3. In the 2018-2020 IBTSQ1 surveys, the occurrences of *Ichthyophonus* in the Norwegian part were again fairly low: 4.4%, less than 1% and 1.2%, respectively. In the Kattegat-Skagerrak, the IBTS data suggests levels of incidence generally < 3% but with areas of > 20% infestation in some recent years 2017-2018 and with a peak around 50% in 45G0 in 2018, although the sample was rather small. In 2019, the infection was generally lower in IBTS Q3 (Figure 1.2.14.3) and comparable to previous years in Q1. In contrast to the IBTS samples and the commercial samples from previous years, of the >3300 individuals collected in 2019 in 3a in the Swedish commercial samples none was infected based on visual inspection. It is relevant that all countries continue to screen herring for *Ichthyophonus* during the IBTS surveys (both Q1 and Q3) and HERAS, as well as for the commercial sampling.

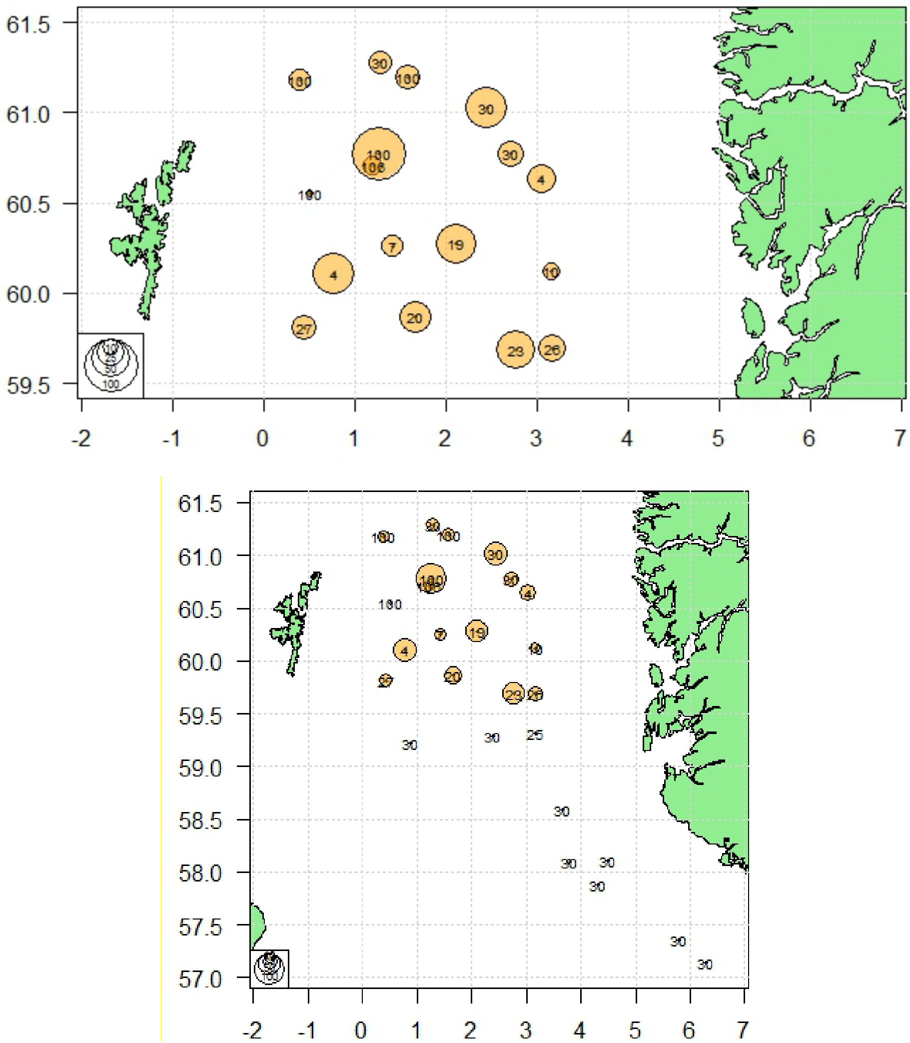

Figure 1.2.14.2 Occurrence of *Ichthyophonus hoferi* in the Norwegian part of the IBTSQ1 2017. Bubble size show the percentage of diseased herring, whereas the numbers show the number of herring examined. The upper figure shows the details of the area with infection.

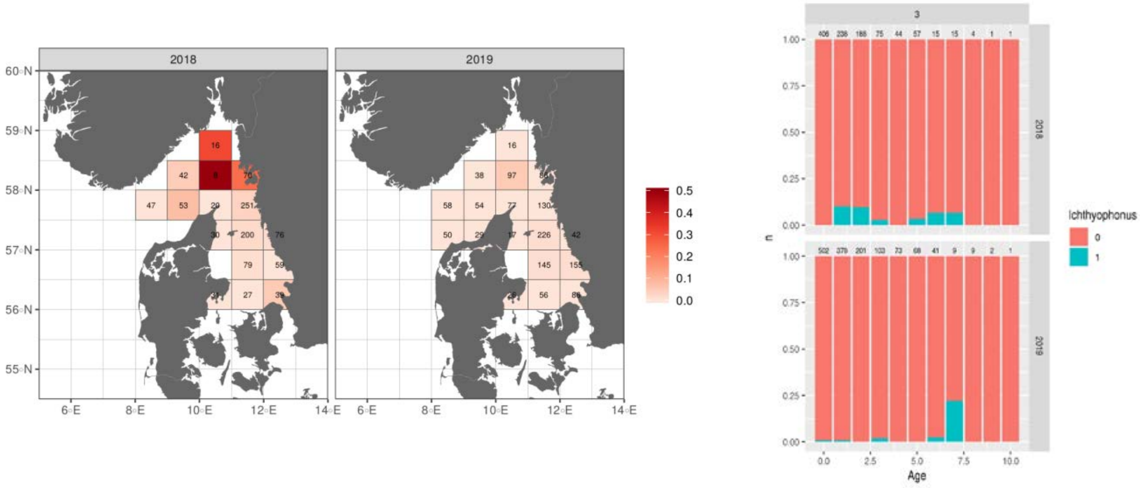

Figure 1.2.14.3 Occurrence of *Ichthyophonus hoferi* in the Kattegat-Skagerrak from Swedish samples collected during the IBTSQ3 2018-2019. Left map with distribution of the proportion of infested herring and number of samples in each rectangle; right distribution of infestation among ages.

HAWG's feedbacks to RDBES

Regional Database and Estimation System (RDBES)

The RDBES is still under development, but is now ready for the first major upload of data, so this year the first data call will be launched late spring / early summer, requesting data from sampling schemes covering a small group of stocks, spr.27.22-32, cod.27.21, whb.27.1-91214, YFT (Yellowfin tuna (tropical)), sol.27.7fg, mur.27.67a-ce-k89a, mon.27.78abd, mon.27.8c9a, ank.27.78abd, ank.27.8c9a, mac.27.nea. The stocks have been chosen to ensure that most countries will be involved in this first major test of the system. None of the stocks are covered by HAWG, but all counties have been encouraged to submit more stocks.

In 2020, three workshops will be held in relation to the RDBES, WKRDB-POP 2 – Second Workshop on Populating the RDBES data model, WKRDB-EST2 – Second Workshop on Estimation with the RDBES data model and WKRDB-RAISE&TAF - support migrating of present estimation routines to TAF. In 2021, a data call requesting upload of all stock will be launched.

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

1.3 Commercial catch data collation, sampling, and terminology

1.3.1 Commercial catch and sampling: data collation and handling

Input spreadsheet and initial data processing

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

Since 2015, ICES requested relevant countries within a data call to submit the national catches into InterCatch or to accessions@ices (via the standard exchange files). National catch data submission was due by 3rd March 2020. Not all countries delivered their data in due time. With regards to the North Sea herring assessment, some reported with a delay of more than one week and hindered the overall catch data preparation for the assessment until the very last day.

"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.

1.3.2 Sampling

Quality of sampling for the whole area

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

Area	Official Catch	Sampled Catch	Age Readings	Age Readings per 1000t
4.a(E)	64692	64589	1062	16
4.a(W)	25486	215739	5073	24
4.b	86325	66602	1245	19
4.c	2583	0	0	0
7.d	37170	24266	401	17
7.a(N)	6377	5400	1529	240
6.a(N)	1739	1522	569	101
3.a	14918	12646	4036	271
SD22-24	9831	9003	4285	436
Celtic, 7.j	1841	1803	1280	710
6.a(S), 7.b and 7.c	1690	1625	2350	1446

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

1.3.3 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.

1.4 Methods Used

1.4.1 SAM

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

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.

1.4.2 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.

1.4.3 SMS

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

1.4.4 Short-term predictions

Short-term predictions for the North Sea used a code developed in R. The method was developed in 2009 and intensively compared to the MFDP approach. Celtic Sea herring and Irish Sea herring forecast used the standard projection routines developed under FLR package FLCore (version 2.6.0.20170228). For sprat in the North Sea, a forecast using the FLR framework is in use. North Sea herring is assessed using a fleet-wise projection method using native R and FLR routines (some maintenance of the code has been done this year mainly to improve readability and documentation).

The Western Baltic Spring-spawning herring uses an R-based multifleet forecast routine available at www.stockassessment.org.

1.4.5 Reference Points

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

For sprat in the North Sea (Division 4) and sandeel in management area 1–4, the ICES guide for setting management reference points for category 1 stocks is used to find B_{lim}. MSY $B_{escapement}$ is equal to B_{pa} and is calculated as $B_{lim} \times e^{\sigma \times 1.645}$. An upper level on the fishing mortality is implemented (F_{cap}) if the difference between B_{lim} and MSY $B_{escapement}$ is not compatible with the ICES F_{MSY} criteria (i.e. that the average probability in the long-term of getting below B_{lim} should be no more than 5% per year). F_{cap} is calculated/optimized using a management strategy evaluation framework (MSE).

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

1.4.6 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.

1.5 Ecosystem overview and considerations

General ecosystem overviews for the areas relevant to herring, sprat and sandeel stocks covered by the Herring Assessment Working Group for herring stocks south of 62°N (HAWG) are given for the Greater North Sea and Celtic Seas Ecoregions (ICES, 2019a, 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 of the biology and ecology of species and populations (including biological and environmental drivers), and disease.

It should be pointed out that while numerous studies have greatly improved our understanding on the effects of environmental forcing on the herring stock productivity and dynamics, further work is still required to move beyond simple correlative understanding and elucidate the underlying mechanisms. One specific case is the persistent decrease in mean weight-at-age for many of the herring stocks in the region. A subgroup has been tasked to look in to this phenomenon over the next year and report back to the 2021 HAWG. Furthermore, mechanisms to incorporate this understanding into the provision of management advice are limited. ICES could therefore benefit greatly from developments that unify these two aspects of its community.

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

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

1. Stock assessments (weight-at-age [in stock or catch], length distribution, maturity, sex ratio)
2. Forecasts (recruitment over recent years – reflecting productivity changes, recent weight-at-age, maturity, natural mortality)
3. Natural mortality (predation, diseases, parasites) assessed and included as variable by year (including smoothed)
4. Stock distribution (changes caused by year class strength, predators, prey, habitat suitability/quality)
5. Mixed fisheries (catch and bycatch of target/non-target species)
6. Climate change (is this considered and how?)

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

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

Stock code	Stock assessment variable w@a	length dis-tribution	variable mat@a	estimated variable nat mort	estimated variable sex ratio	Short-term forecast 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	1	1	0	1	0	0
her.27.nirs						0	1	1	1	0	0	0	0
san.sa.1r	0	3	0	0	0	3	0	1	0	0	0	0	1
san.sa.2r	0	3	0	0	0	3	0	1	0	0	0	0	0
san.sa.3r	0	3	0	0	0	3	0	1	0	0	0	0	0
san.sa.4	0	3	0	0	0	3	0	1	0	0	0	0	0
san.sa.5r						0	0	0	0	0	0	0	0
san.sa.6						0	0	0	0	0	0	0	0
san.sa.7r						0	0	0	0	0	0	0	0
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

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

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

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

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

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

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

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

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

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

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

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

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

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

Herring in 6.a North (part of her-6.a):

Herring are an important prey species in the ecosystem and also one of the dominant planktivorous fish. Herring fisheries tend to be clean with little bycatch of other fish. Herring represent an important prey item for many predators including cod and other large gadoids, dog-fish and sharks, marine mammals and seabirds. Because of the trophic importance of herring puts its stocks under immense pressure from constant exploitation**.**

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

Herring in 6.a South and 7.b and 7.c (part of her-6.a):

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

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

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

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

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

Stock discrimination techniques, tagging, and otolith microstructure and shape show that juveniles originating in the Celtic Sea are present in the Irish Sea. The majority of mixing between these populations occurs at 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 these foodweb interactions. It is uncertain how many sprat migrate into and out of adjacent management areas, i.e. the English Channel (7.d and 7.e) and the western Baltic and the Sound (SD22–24), or how this may vary annually. Uncertain is also the boundary with local populations occurring along the Scandinavian Skagerrak coasts. While genetic information has supported the exclusion of sprat along the Norwegian coasts from the current assessment unit, similar information was insufficient for the Swedish coasts despite the fact that local populations likely exist. Young herring as a bycatch is acknowledged for this fishery with bycatch regulations in force. The bycatch of marine mammals and birds is considered to be very low (undetectable using observer programs).

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

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

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

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

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

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

Sandeel is targeted by a highly seasonal industrial fishery which has experienced a progressive change towards fewer larger vessels owing most of the quota since the introduction of ITQ in

2004. Time 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 foodweb as they are a high quality, lipid-rich food resource for many predatory fish, seabirds and marine mammals. Concerns of local depletion exist, especially for those sandeel aggregations occurring at less than 100 km from seabird colonies as some bird species (i.e. black-legged kittiwake and sandwich tern) may be particularly affected whereas more mobile marine mammals and fish are likely to be less vulnerable to local sandeel depletion.

1.7 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.

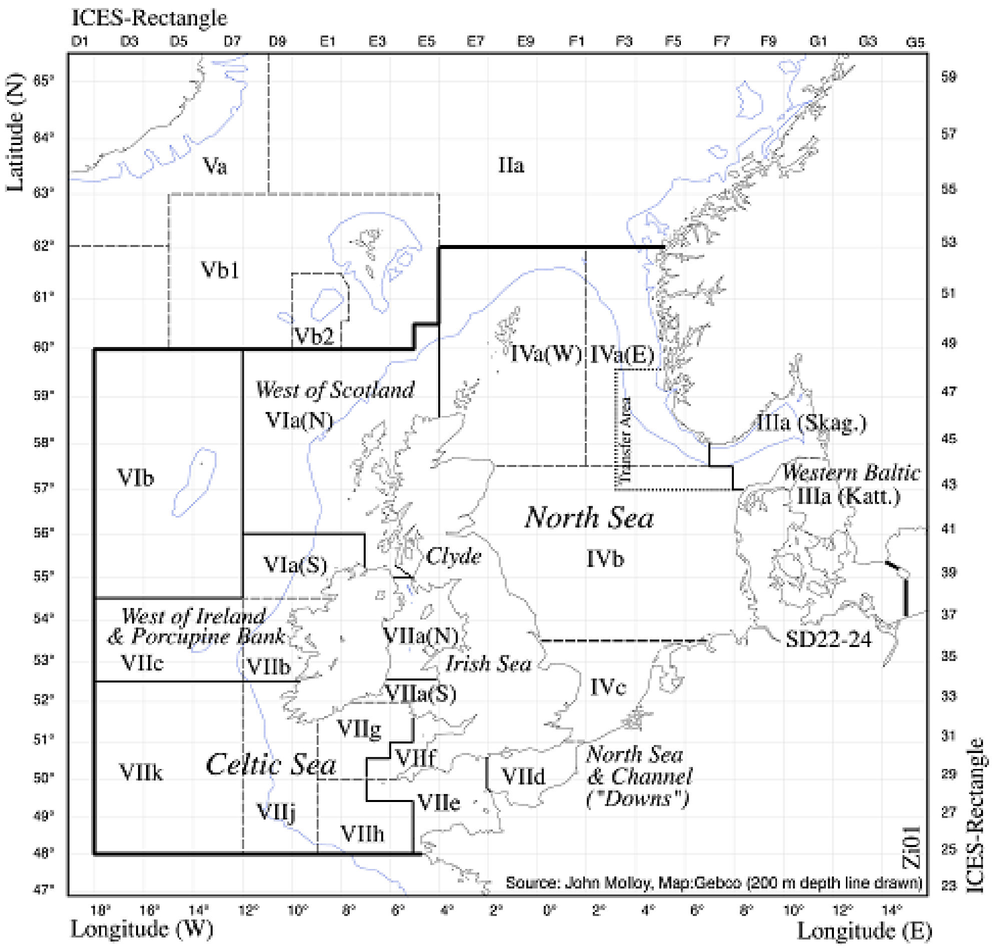

Figure 1.7.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North 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. Since 2019, no management plan is in place and the advice is based on the F_{MSY} advice rule. The spawning stock at spawning time in 2019 is estimated at 1.7 million tonnes. Recruitment in 2019 is comparable to the 2018 value and remains within the low recruitment regime observed since 2015. The strongest recruitment remains the one observed back in 2014. Mean $F_{2\text{–}6}$ in 2019 is estimated at approximately 0.18, which is below F_{MSY}. The SSB for the stock from the 2020 assessment has been further revised upward for a number of years.

Given the agreed TACs, the 2020 SSB is expected to decrease to ~1.3 million tonnes. Under most scenarios, SSB is predicted to decrease in 2021. Based on the present advice SSB in 2021 is estimated to approx. 1.2 million tonnes which is well above B_{pa} (0.9 million tonnes).

Western Baltic Spring Spawners (her.27.20-24) is the only spring-spawning stock assessed within this WG. It is distributed in the eastern part of the North Sea, the Skagerrak, the Kattegat and the subdivisions 22, 23 and 24. Within the northern area, the stock mixes with North Sea autumn spawners, and recently mixing with Central Baltic herring stock has been reported in the western Baltic area. The stock has decreased consistently during the second half of the 2000s. The 2019 SSB (56 621 t) and recruitment (778 899 thousands) are record low. The estimate of SSB in 2019 is considered low, below both B_{pa} and B_{lim}. Fishing mortality ($F_{3\text{–}6}$) was reduced from 0.51 in 2009 to 0.37 in 2011. It had then remained stable above F_{MSY} (0.31) until 2014 (~0.38) but showed an increase in 2015-2018 with an estimated $F_{3\text{-}6}$ above 0.42. The 2019 $F_{3\text{–}6}$ has decreased (0.382) but is still well above F_{MSY}. The 2021 advised catch of WBSS is 0 t, which if applied by managers, will result in an increase in SSB from 57 124 t in 2020 to 66 824 t in 2021. The zero catch will not allow the stock to rebuild above B_{lim} (120 000 t) by 2022 (87 890 t). A medium-term forecast to 2023 showed that SSB can increased to 111 745 t if F=0 in 2021-2022 but will still remain below B_{lim}.

Herring in the Celtic Sea and 7.j (her.27.irls): The herring fisheries to the south of Ireland in the Celtic Sea and in Division 7.j have been considered to exploit the same stock. For the purpose of stock assessment and management, these areas have been combined since 1982. The stock has fluctuated over time. Low stock size was observed from the mid-70s to the early 80s. The SSB increased again before declining in the late 90s. From 2005 the stock increased when several strong cohorts (2004, 2008, 2009, 2010 and 2013) entered the fishery and as they gained weight, they maintained the stock at a high level. The SSB has decreased since its peak in 2011 and is estimated to be around 12 000 t in 2019, which is well below B_{pa} (at 54 000 t) and B_{lim} (34 000 t). Recruitment has been below average from 2013-2018. An increase in recruitment can be seen in 2019. Fishing mortality ($F_{2\text{–}5}$) declined between 2003 and 2009 but started to rise again in 2010 due to increased catches. F decreased in 2019 in line with reduced catches. This year assessment estimates a fishing mortality, $F_{2\text{–}5}$ of 0.49 in 2019 which is a decrease from the high F in 2018 (1.10) but is still above the F_{MSY} (0.26) and F_{lim} (0.45). Short-term projections predict SSB to increase to around 17 500 t in 2020.

Herring in 6.a: The stock was much larger in the 1960s when the productivity of the stock was higher. The stock experienced a heavy fishery in the mid-1970s following closure of the North Sea fishery. The fishery was closed before the stock collapsed. It was opened again along with the North Sea. In the mid-1990s there was substantial area misreporting of catch into this area and sampling of catch deteriorated. Area misreporting was reduced to a very low level and information on catch has improved; in recent years misreporting has remained relatively low. The assessment is a combination of two herring stocks, one residing in 6.aS, 7.b and 7.c, and one in

6.aN. It is currently not possible to separate the two stocks for assessment purposes and therefore stock size is a combined estimate. SSB and recruitment have been declining since around 2000 and are currently predicted to be at the lowest level in the time-series. Fishing mortality has reduced since 2016 when catches have been limited to a scientific monitoring TAC.

Herring in the Irish Sea (her.27.nirs): comprises two spawning groups (Manx and Mourne). This stock complex experienced a decline during the 1970s. In the mid-1980s the introduction of quotas resulted in a temporary increase, but the stock continued its decline from the late 1980s up to the early 2000s. During this time period the contribution of the Mourne spawning component declined. An increase in activity on the Mourne spawning area has been observed since 2006. In the past decade there have been problems in assessing the stock, partly as a consequence of the variability of spawning migrations and mixing with the Celtic Sea stock. A benchmark in 2017 resulted in a substantial revision of SSB perception leading to an increased SSB in the most recent period compared to pre-benchmark perceptions. In 2019, SSB and recruitment have been estimated at 24 785 t and 343 863 thousand respectively, estimates of SSB in recent years appear to be relatively stable. F_{4-6} is estimated at 0.18 in 2019. Under the MSY approach the stock is expected to show minor decline to 21 973 t in 2021.

North Sea and 3a Sprat (spr.27.3a4): The catches are dominated by age 1–2 fish. Due to the short life cycle and early maturation, most of the stock consists of mature fish. To undertake the assessment and fit with the natural life cycle of sprat the assessment model is shifted by six months so that an assessment year and advice runs from 1 July to 30 June each year, and thus provide in-year advice. Since the last benchmark (ICES 2018), sprat in Division 3.a and Subarea 4 are combined into a single assessment unit. The advice is based on the MSY escapement strategy with an additional precautionary F_{cap}. The F_{cap} of 0.69 is used to ensure that after the fishery has been conducted, escapement biomass is preserved above B_{lim} with high probability. 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 2020 show an SSB of 266 000 t which is more than double of B_{pa} (125 000 t). The ICES advise for the period 1 July 2020–30 June 2021 indicates that catches of sprat should not exceed 207 807 t which represents a 50% increase on the last year advice.

Sprat in the English Channel (7.d and 7.e) (spr.27.7de): Consists of a small midwater trawl fleet targeting sprat primarily in the vicinity of Lyme Bay, western English Channel. The stock identity of sprat in the English Channel relative to sprat in the North Sea and Celtic Sea is unknown. This year, ICES has provided catch advice for sprat in divisions 7.d and 7.e (primarily in the vicinity of Lyme Bay) based on criteria for data limited stocks. Data available are catches, a time-series of LPUE (1988–2016) and one acoustic survey that has been carried out since 2013 in the area where the fishery occurs and further offshore, also including the waters north off the Cornish Peninsula and, from 2017, the French part of the Western English Channel. The advice provided is based on the biomass estimates from the acoustic survey which in 2019 remained at low level in relation to the estimates for 2013–2015. The advised catch for 2021 is 4% lower compared to last year (applying the 1 over 2 rule with the uncertainty cap and the precautionary buffer).

Sprat in the Celtic Seas (spr.27.67a-cf-k): The stock structure of sprat populations in this ecoregion (subareas 6 and 7 (excluding 7.d and 7.e)) is not clear, and further work for the identification of management units for sprat is required. Most sprat in the Celtic Seas ecoregion are caught by small pelagic vessels that also target herring, mainly Irish and Scottish vessels. The quality of information available for sprat is heterogeneous across this composite area. There is evidence from different survey sources of significant interannual variation in sprat abundance. Landed biomass, but not biological information on the catch, is available from 1970s in some areas (i.e. 6.a and 7.a), while Irish acoustic surveys started in 1991, with some gaps in the time-series provide sprat estimates but their validity to provide a reliable sprat index is questionable because they do not always cover the core of sprat distribution in the area. Acoustic estimates in the Irish Sea are more reliable. The state of the stock of sprat in the Celtic Seas ecoregion is uncertain. ICES advice a catch of no more than 2800 tonnes for 2020 and 2021 in this ecoregion 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 subpopulations. A decline in the sandeel population in recent years concurrent with a marked change in distribution has increased the concern about local depletion, of which there has been some evidence. Since 2010 this has been accounted for by dividing the North Sea into 7 management areas. Denmark and Norway are responsible for most of the fishery of sandeel in the North Sea. The catches are largely represented by age 1 fish. Analytical assessments are performed in four of the management areas (A1r–4) where most of the fishery takes place and data are available. Note that a benchmark in 2016 revised most of the area definitions.

A1: SSB has been above B_{pa} (145 000 t) in 2016-2018, and dropped to 68 000 t in 2019. SSB increased to 85 000 t in 2020 but it remains still below B_{lim} (110 000 t). Recruitment in 2019 was above the geometric mean of the time-series, and higher than in 2018. Fishing mortality (F) has fluctuated, showing a declining trend since the mid-2000s followed by an increase in 2017 to approximately the long-term average where it has remained for the last two years. The 2019 year class is large enough to contribute both to an increase in SSB and the catch advice.

A2: SSB has been below B_{lim} (56 000 t) since 2004, with few exceptions. SSB increased in 2018 above B_{pa} as the result of the exceptionally high 2016 year class but decreased again in 2019 and further in 2020 to set at 47 000 t. Recruitment has been low since 2000, with the exception of the 2016 year class. The 2019 yearclass is estimated to be just above the long-term average. Fishing mortality was low in 2019 due to the monitoring TAC.

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 360 000 t in 2018 and is estimated 221 000 t in 2020. The recruitments in 2016 and 2019 were among the five highest on record which contributes to explain the 16% increase in the advised catch. Fishing mortality (F) declined in the early 2000s and has been low since then. F has increased in the last 3 years but it is still below the long-term average

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

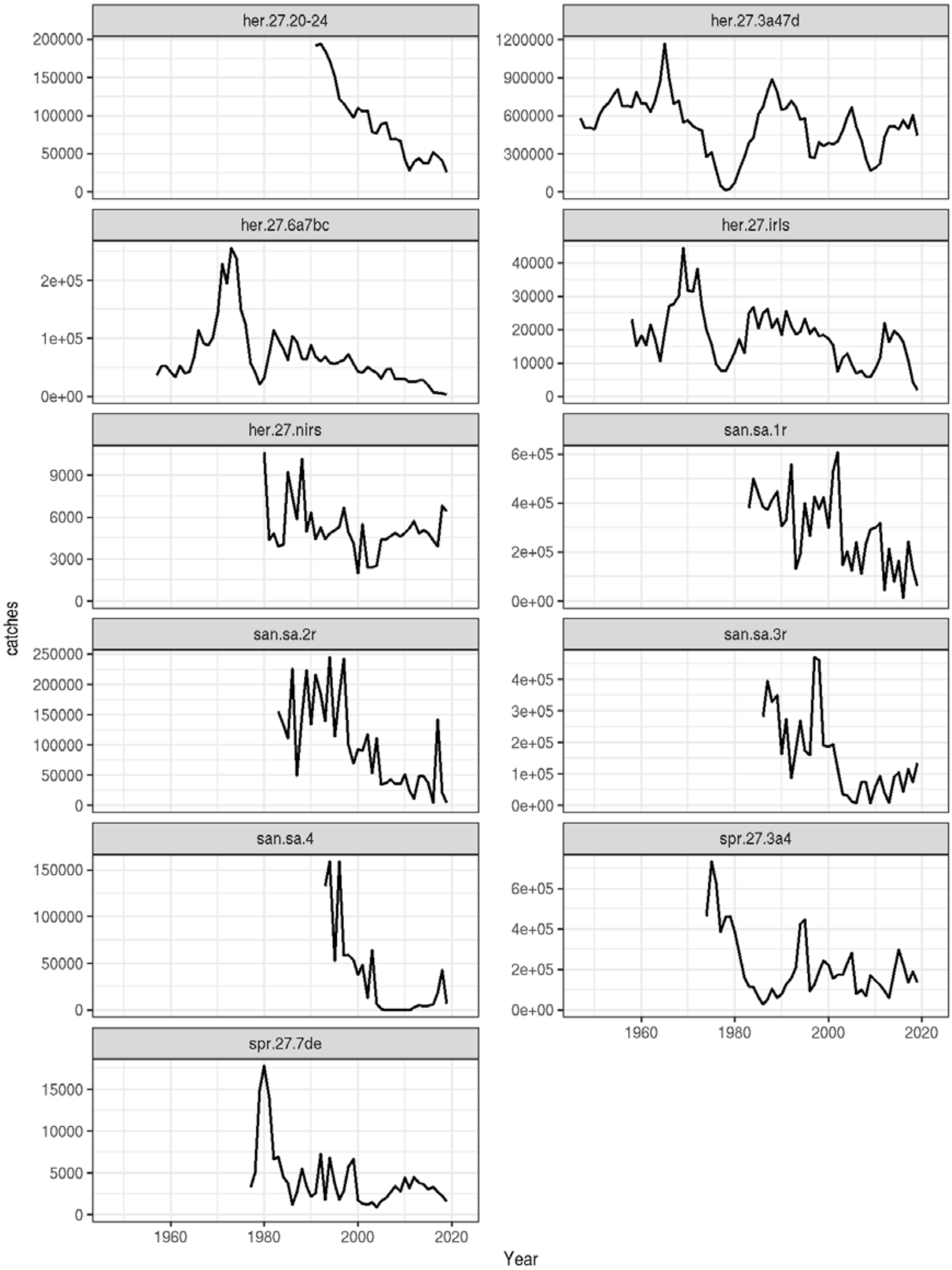

Figure 1.7.2 WG estimates of catch/landings (yield) of the herring, sprat and sandeel stocks presented in HAWG 2020.

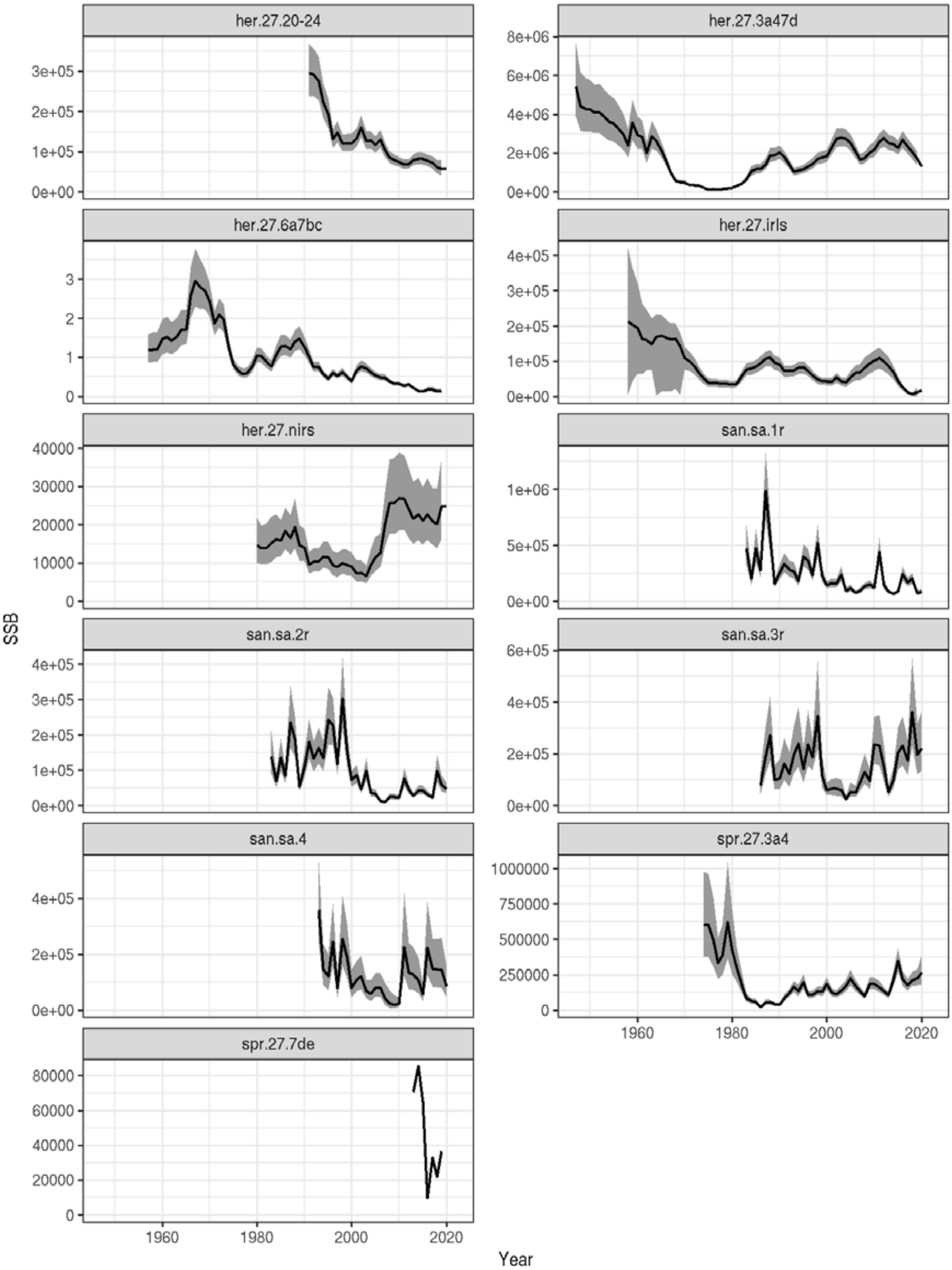

Figure 1.7.3 Spawning-stock biomass estimates for the sprat, herring and sandeel stocks presented in HAWG 2020.

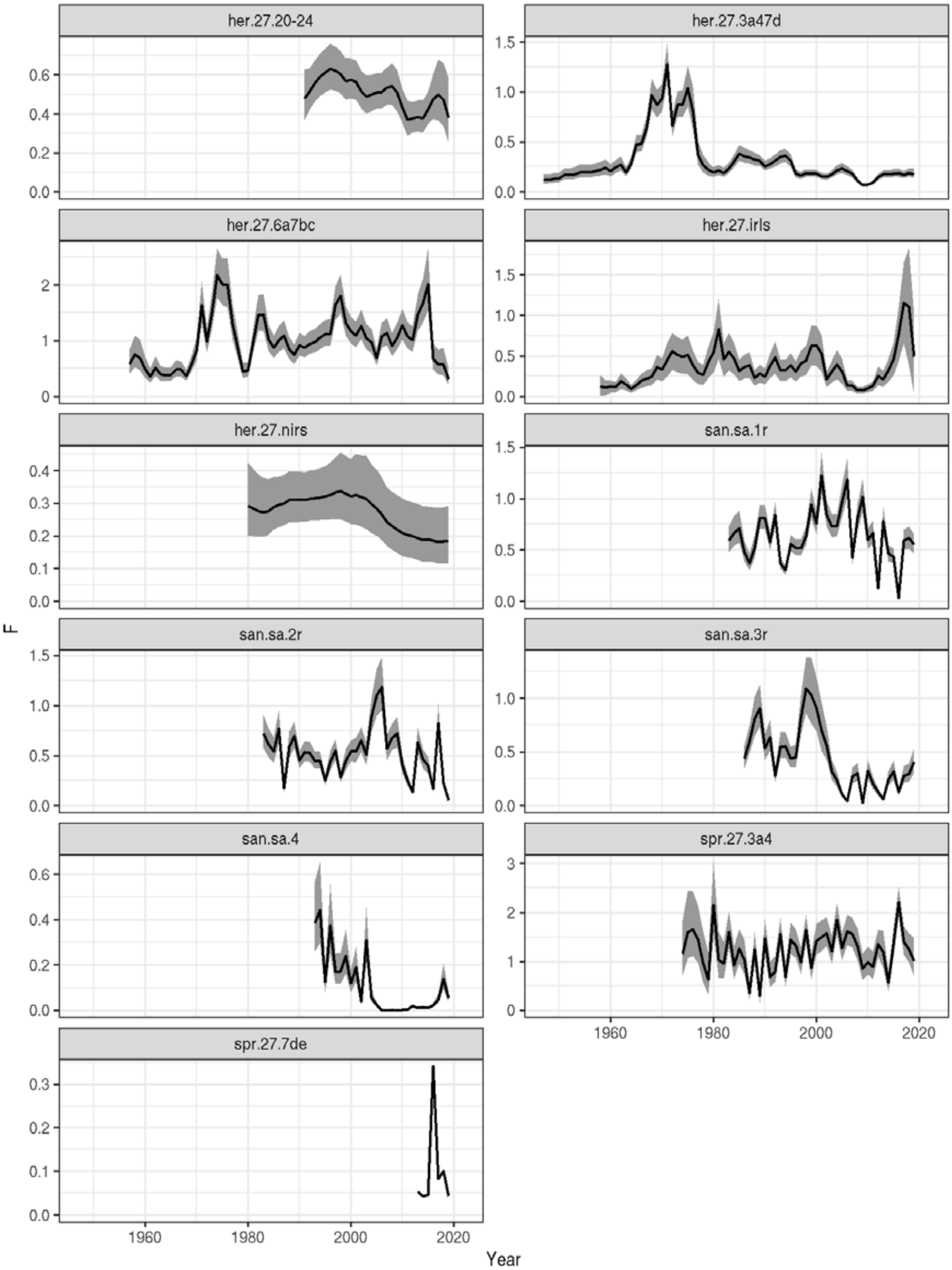

Figure 1.7.4 Estimates of mean F for the sprat, herring and sandeel stocks presented in HAWG 2020.

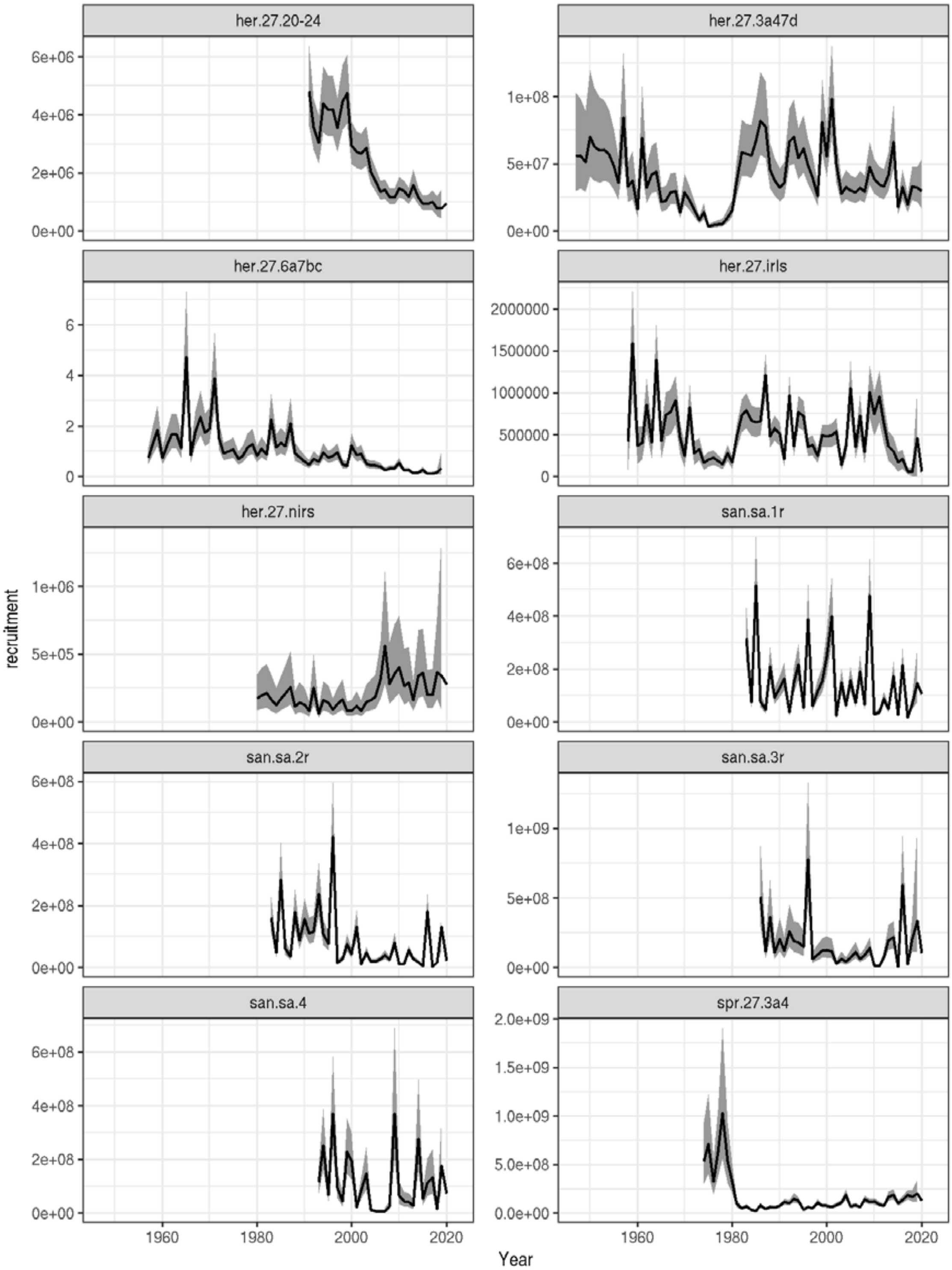

Figure 1.7.5 Estimates of recruitment for the sprat, herring and sandeel stocks presented in HAWG 2020.

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

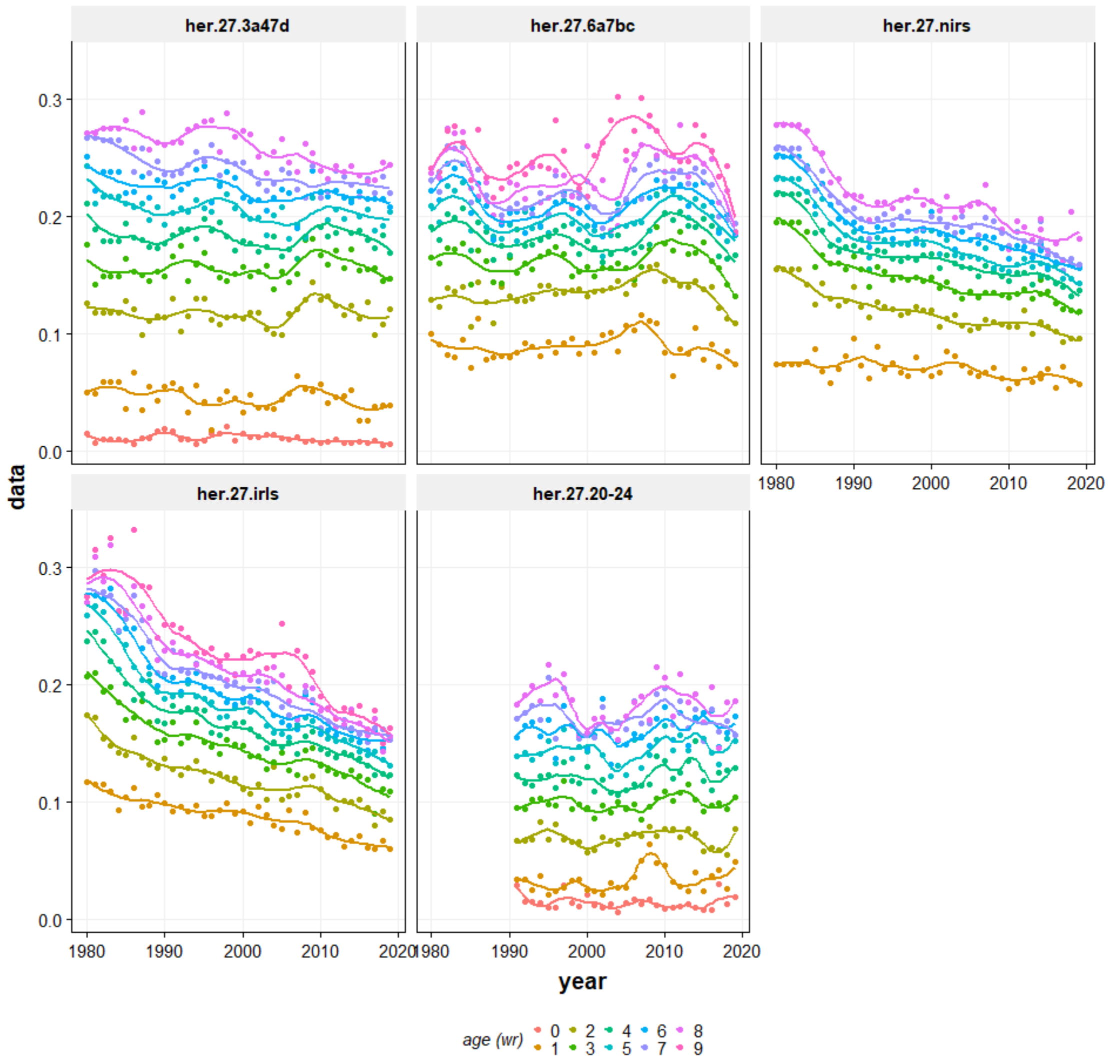

Figure 1.7.6 Time-series of herring mean individual weight in the catch.

1.8 Mohn's rho and retrospective patterns in the assessments

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

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

* 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

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

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 are truncated to have terminal year 2016 (T-i).

Mohn's rho values have been uploaded at https://community.ices.dk/ExpertGroups/Lists/Retrobias2020/Allitems.aspx and they are included in this report in Table 1.8.1.

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.27.20-24	2019	5	-0.178	No	0.247	No	0.016
her.27.3a47d	2020	5	-0.123	No	0.115	No	0.03
her.27.6a7bc	2019	5	0.161	No	-0.203	No	0.242
her.27.irls	2019	5	-0.356	No	1.104	No	2.797
her.27.nirs	2019	5	-0.158	Yes	0.088	No	-0.262
san.sa.1r	2019	5	-0.200	No	0.670	No	0.200
san.sa.2r	2019	5	-0.160	No	0.570	No	0.520
san.sa.3r	2019	5	0.030	No	-0.060	No	0.130
san.sa.4	2019	5	-0.05000	No	0.25000	No	0.19000
spr.27.3a4	2019	5	0.02000	No	0.35000	No	0.31000

1.9 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 preprocessed. 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.

1.10 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 2020) there are no plans to benchmark stocks assessed by HAWG. An Interbenchmark is recommended for Sprat in 7d,e in Spring 2021.

Stock	Ass status	Latest benchmark	Benchmark next 12 months	Planning Year +2	Further planning	Comments
NSAS	Update	2018	No	No		Issue list available
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 available, likely need for an interbenchmark to revisit reference points
6.a, 7.bc	Update	2015, interbenchmark in 2019	No	2022*	Splitting of survey and new assessment, explore new indices, reference points, MSE	Issue list available
Celtic Sea	Update	2015, Interbenchmark in 2018	No	No	Mixing with Irish Sea herring, recruitment signal	Issue list available
7.aN	Update	2017	No	No	Explore stock mixing, recruitment signal and F in the assessment	Issue list available
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	IBP recommended for 2021	No	Consider stock components, review advice guidance for short lived species	Issue list available
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 available

*** Provisional, timeline to be decided**

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

2.1 Introduction

The WG noted that the use of "age", "winter rings", "rings" and "ringers" still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using "rings", "ringers", "winter ringers" or "wr" instead of "age" throughout this section. However, if the word "age" is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks, there is a difference of one year between "age" and "rings", which is not the case for spring spawners. Further elaboration on the rationale behind this, specific to the North Sea autumn spawners, Western Baltic spring spawners and the mixed stock catches, can be found in the Stock Annexes. It is the responsibility of any user of age based data for any of these herring stocks to consult the relevant annex and if in doubt consult a relevant member of the Working Group.

2.1.1 ICES advice and management applicable to 2019 and 2020

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

There is currently no agreed EU-Norway management plan (Anon, 2019) although a Working Group has been set up by Norway and the European Union to recommend an a way of optimally and sustainably utilizing the North Sea autumn spawning herring stock. This working group needs to report by September 2020. 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 2019 was 398 198 tonnes for Area 4 and Division 7.d, where no more than 42 351 t should be caught in Division 4.c and 7.d. For 2020, the TAC for the A-fleet is the same amount (385 008 t for the A-Fleet), including a TAC of 42 351 t for Division 4.c and 7.d.

The bycatch TAC for the B-Fleet in the North Sea (and Division 2.a) was 13 190 t in 2019 and has decreased by 32% to 8954 t in 2020. 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 2019

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 445 631 t in 2019. Official catches by the human consumption fishery were 440 470 t, corresponding to a substantial overshoot of 14% of the TAC for the human consumption fishery (385 008 t).

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 39 754 t. The separate TAC for this area was 42 351 t, so 8% of the TAC remains in Division 4.c and 7.d (but due to catch regulations, 50% of the TAC could have been taken in Division 4.b).

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

Landings of herring taken as bycatch in the small-meshed fishery were 5161 tonnes in 2019. The bycatch ceiling for the B-Fleet was 13 190 t. Since the introduction of yearly bycatch 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 2014 to 2019 are shown in the table below (adapted from Table 2.1.6).

Year	2014	2015	2016	2017	2018	2019
TAC HC (‘000 t)	470	445	518	482	601	385
“Official” landings HC (‘000 t) *	490	472	545	485	594	439
Working Group catch HC (‘000 t)	493	474	545	485	594	440
Excess of landings over TAC HC (‘000 t)	23	28	27	3	-7	55
Bycatch ceiling (‘000 t) **	13	16	13	11	10	13
Reported bycatches (‘000 t) ***	14	8	15	7	8	5
Working Group catch North Sea (‘000 t)	507	482	560	492	602	442

HC = human consumption fishery

*** Landings might be provided by WG members to HAWG before the official landings become available; they may then differ from the official catches and cannot be used for management purposes. Norwegian bycatches included in this figure.**

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

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

2.1.3 Regulations and their effects

In 2019, the following quota had been set initially and modified through swaps and banking and borrowing (source: FIDES + Norway). This is compared with the officially reported catches and the calculated percentage uptake. Note that the officially reported catches of herring are not necessarily identical to the WG estimates of catches.

year	Fleet	Area	Init Quota	Final Quota	Official catch	% Uptake
2019	A-fleet	4AB.	342 657	377 389	374,753	99%
		4CXB7D	42 351	45 378	43 963	97%
	A-fleet Total		385 008	422 767	418 717	99%
	B-fleet	2A47DX	13 190	14 281	5365	38%
	B-fleet Total		13 190	14 281	5365	38%
2019 Total			398 198	437 048	424 082	97%

In 2020, half of the EU quota for Division 3.a (HER/03A.) can be taken in the North Sea (HER/*04-C.). Based on correspondence with the Pelagic AC, HAWG notes that this transfer is expected to be 50%. Norway can take up to 50% of its quota for Division 3.a in the North Sea (Subarea 4).

In the North Sea, Norway can take up to 50 000 tonnes of its quota in EU-waters in divisions 4.a and 4.b (HER/*4AB-C). 50 000 tonnes of the EU-quota can be taken within Norwegian waters south of 62°N (HER/*04N-).

Half of the EU quota for divisions 4.c and 7.d can be taken in Division 4.b (HER/*04B.). In 2019 the quota transfer from 4.c and 7.d to 4.b has been around 54% (source: FIDES).

In 2014, an agreed record between EU and Norway was applied, enabling an interannual quota flexibility of 10% of the TAC. Each party could transfer non-utilized quota of up to 10% of its quota into the next year, where it is added to the quota allocated to the party concerned in the following year (or borrow 10% of the TAC, to be subtracted the following year). This interannual flexibility was changed in 2015 due to the Russian embargo on EU fishing products, so that 25% of the TAC could be transferred into the next year, while up to 10% coud be borrowed. Subsequent year, the quota flexibility has been set to 10% again.

HAWG 2020 had access to the EU FIDES data for 2015-2019 and some national statistics on quota and catches. Unfortunately there is, however, still no complete coverage of whether countries have applied the annual quota flexibility.

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

2.1.4 Changes in fishing technology and fishing patterns.

There have been no major changes to fishing technology of the fleets that target North Sea herring.

The fishery concentrated in the northwestern part of the North Sea, around the Fladen Ground area (figures 2.1.1 a–e). In line with the TAC, catches in 2019 decreased. The majority of catches is taken in Subdivision 4.aW, in the order of 57% of the total. Subdivision 4.aE provided 15% of the catches in 2019 and catches in Division 4.b contributed 19%.

The utilization of catches in divisions 4.c and 7.d has decreased since 2010. Since 2014, catches in the southern North Sea contributed less than 10% to the total catch, while they were in the range of 15% for the period before 2010. The TAC in this Division is not fully taken since 2012. Catches in Division 4.c were only 2583 t in 2019 (<1%).

As in former years, most of the catches in the B-Fleet are taken in Division 4.b (70%). The bycatch ceiling for this fleet has not fully been taken in 2019.

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

2.2 Biological composition of the catch

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

Biological information on the NSAS caught in Division 3.a was obtained using splitting procedures described in Section 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 2009–2018.

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 2.83 billion fish and NSAS amounts to 2.87 billion fish in 2019. The proportion of 0- and 1-ringers of herring taken in the North Sea is 21% of the total catch in numbers in 2019 (Table 2.2.5), compared to 31% in 2018. Most of these young herring are still taken in the B-Fleet in Division 4.b. Here, 0- and 1-ringers amount to 53% of the total catch in numbers.

The proportion of 3+ winter ring herring is 76% of the total catch in numbers taken in the North Sea (compared to 65% in 2018). The 5 and 6 winter ring herring contributed most to the catches in 2019, 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 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 2004–2019. After splitting the herring caught in the North Sea and 3.a between stocks, the total catch of North Sea Autumn spawners amounts to 442 886 tonnes.

Area	Allocated	Unallocated	BMS/Discard	Total
4.a West	254 860			254 860
4.a East	64 692			64 692
4.b	85 525		800	86 325
4.c/7.d	38 924		830	39 754
	Total catch in the North Sea			445 631
	Autumn spawners caught in Division 3.a (SOP)			6087
	Baltic spring spawners caught in the North Sea (SOP)			-8832
	Total catch NSAS used for the assessment			442 886

2.2.2 Other Spring-spawning herring in the North Sea

Norwegian spring spawners and local fjord-type spring-spawning herring are taken in Division 4.a (East) close to the Norwegian coast under a separate TAC. These catches are not included in the Norwegian North Sea catch figures given in tables 2.1.1–2.1.6, but are listed separately in the respective catch tables. Along with the reduction in biomass of these spring-spawning herring in recent years, the catches have decreased in recent years and amount to only 5 t in 2019.

Blackwater herring are caught in the Thames estuary under a separate quota and included in the catch figure for England and Wales. In recent years, these catches have been relatively small. At the time of HAWG, no catch figure for 2019 was available.

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

2.2.3 Data revisions

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

2.2.4 Quality of catch and biological data

Annual misreporting and unallocation of catches are meanwhile regarded as a minor issue in the North Sea herring fishery. In 2019, no unallocated catches were reported.

Since 2015, a landing obligation is in place for pelagic fleets operating in the North Sea and the Baltic. All catches have to be landed into port. Reported catches in the BMS category (below minimum landing size, including any fish lost or damaged during processing procedures) were 800 tonnes in 2019. 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 2019 North Sea herring fishery. However, discards occurred in demersal fisheries not targeting on herring. These discards sum to 830 tonnes in 2019.

The sampling of commercial landings covers 83% of the total catch.

More important than a sufficient overall sampling level is an appropriate spread of sampling effort over the different métiers (here defined as each combination of fleet/nation/area and quarter). Of 104 different reported métiers, 293 were sampled in 2019. The sampling level of more than 1 sample per 1000 t catch has been met for only 11 métiers. With regards to age readings, 8 métiers appear to be sampled sufficiently (>25 fish aged per 1000 t catch).

However, some of the métiers yielded very little catch. In 59 métiers the catch is below 1000 t. The total catch in these métiers sums to 9938 t, so the remaining 45 métiers represent 435 694 t of the working group catch (98%). Of these 45 métiers, 27 were sampled. Only 8 métiers have more than 1 sample per 1000 t catch and only 5 more than 25 age readings per 1000 t catch.

According to the DCF regulations, some catches of UK (England and Wales) were landed into and sampled by other nations.

The WG recommends that all métiers with substantial catch should be sampled (including by-catches in the industrial fisheries), and that catches landed abroad should be sampled 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 national surveys were carried out during late June and July covering most of the continental shelf in the North Sea, West of Scotland and the Malin Shelf. The survey methods and full results are given in the report of the Working Group for International Pelagic Surveys (WGIPS; ICES CM 2020/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 for the assessment.

The estimate of North Sea autumn spawning herring SSB (spawning-stock biomass) is estimated to be lower than in 2018, at 1.9 million tonnes (2018: 2.3) and at similar level to 2017. This is due to a decrease in the number of fish (2018: 12,315 mill. fish, 2019: 10,295). The mean weight of mature fish is similar to last year at 186.4 g and the decrease in biomass follows directly from a decrease in numbers. The spawning stock is dominated by fish of age 3 and 5 wr, which is in accordance with the strongest year classes in the 2018 survey.

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

Distribution of herring in the North Sea area is similar to that seen in 2017 and 2018 though it did not extend as far south as in the years prior to 2017. Abundance of NSAS herring was slightly lower compared to recent surveys in the North Sea area. Particularly the abundance of age 2 winter ring herring was very low this year and the maturity level of this age class is still low although it is higher than in 2018.

The abundance of immature fish in the stock has decreased by 25% since last year from 20 290 million in 2018 to 15 265 million this year. This is influenced by the small number of 2 wr fish.

Maturity of 2 winter ringers was at an all-time low at 37% in 2018. This year the proportion mature at 2 winter rings were higher at 59%, but still low when compared to the long-term picture. Maturities for ages 3 and above were comparable to the long-term average, with 97% of 3 winter ringers and 99% 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)

Six survey areas were covered within the framework of the International Herring Larval Surveys in the North Sea during the sampling period 2019-2020. They monitored the abundance and distribution of newly hatched herring larvae in the Orkney/Shetlands area, in the Buchan area and the central North Sea (CNS) in September and in the southern North Sea (SNS) in December 2019 and January 2020 (Figure 2.3.2.1).

The survey around the Orkneys revealed relatively small numbers of newly hatched larvae, while in the Buchan area and the central North Sea, quantities were much higher, in the same order of magnitude as in preceding years.

The two surveys in the southern North Sea showed a peak in abundance in December. The abundance of newly hatched larvae in the southern North Sea is strikingly high in the first survey of the most recent sampling period. Newly hatched larvae occurred only in the western part of the survey area. However, the overall distribution of larvae and thus the main spawning area used by herring is not obviously different from preceding years. The abundance of young larvae is high when hatching started in December, but their spatial distribution is limited. With progressing spawning season also the spatial distribution gets broader.

No survey was planned for the second half of January 2020. Instead, an additional MIK sampling was undertaken in March-April 2020 in the German Bight and Skagerrak/Kattegat area. This sampling should shade light on the foraging and recruitment of herring larvae originating in the Downs stock component. Results of this survey are described in section 2.11.

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

2.3.3 International Bottom Trawl Survey (IBTS-Q1)

The total abundance of 0-ringers in the survey area is used as a recruitment index for the stock. This year, 576 depth-integrated hauls were completed with the MIK-net, which is 61 MIK hauls less than in 2019. Several issues hampered MIK sampling during the Q1 IBTS: in particular the permit to work in UK waters was not issued for the German participation and other nations had to step in. Their sampling, however, was severely affected by prevailing bad weather with strong winds and high waves. The coverage of the survey area was, however, still good with at least 2 hauls in most of ICES rectangles in the North Sea as well as in Kattegat and Skagerrak.

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

Larvae measured between 5 and 38 mm standard length (SL). Again, and as in most years, the smallest larvae <10 mm were the most numerous. Larger larvae >18 mm SL were rarer and were caught in slightly higher 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 in both, the western and eastern parts of the North Sea. In the southeastern and eastern part of the North Sea, the potential nurseries, abundance of large herring larvae was much higher than last year.

The newly proposed rule was applied to the MIK herring larvae data time-series from 1992 onwards, where because of data quality issues all French data before 2008 were excluded. The results of the calculation can be found in Table 2.3.3.1.2. The 2020 index is 62.4.

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

The 1-ringer recruitment estimate (IBTS-1 index) is based on GOV catches in the entire survey area. The time-series for year classes 1991 to 2018 is shown in Table 2.3.3.2. The index from the 2020 survey is 1021 which is below 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 2018, 2019 and 2020. For the 2018 year class, the majority of the 1-ringers were found in the Kattegat/Skagerrak area, while in the North Sea, the 1-ringer abundance was low and more dispersed than in previous years. The few rectangles in the Kattegat/Skagerrak area contributing the most to the index for this year. It appears noteworthy, that the trajectories for six recent 1-ringer abundances (year classes 2013–2018) correspond very well to the trajectories of their 6 respective 0-ringer indices (Figure 2.3.3.4).

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 2019 for comparison. The data for 2019 were sourced from tables 2.3.1.2. and 2.2.2. In the third quarter most fish are approaching their peak weights just prior to spawning.

The mean weights in the acoustic survey in 2019 were lighter for groups 1 to 5-wr and 9+ wr compared to those in the catch (Table 2.4.1.1).

However, the general trend towards smaller mean weight at age observed in recent years in the acoustic survey and, but less pronounced, in the catch in the 3rd quarter (Figure 2.4.1.1), seems to be continued in 2019. Only 2-wr in the acoustic survey had higher mean weight at age compared to 2018, while all other ages had the same or lower mean weight. In the 3rd quarter catch, all aged were lighter expect of 1, 2 and 5-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 2019 were estimated from the North Sea acoustic survey (Table 2.4.2.1). The method and justification for the use of values derived from a single year's data were described fully in ICES (1996/ACFM:10). While 5+ group herring were considered fully mature in the period prior to 2015, WGIPS reported maturity stage for all groups up to 7+ separately in the most recent years.

Maturity of 2 winter ringers was at an all-time low in 2018 at 37%. In 2019, the proportion mature at 2 winter rings was at 59%, still low when compared to the long term. Maturities for winter ringers 3 (97%) and 4 (99%) are comparable to the long-term average. 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.

Because no update from SMS model key run was available, the 2020 assessment used the natural mortality from the 2017 SMS model key run (ICES WGSAM, 2018) which provides M at age from 1974 to 2016. Natural mortality outside this year range is computed using a three year moving average.

2.5 Recruitment

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

2.5.1 Relationship between 0-ringer and 1-ringer recruitment indices

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

The time-series of 0- and 1-ringer abundance from the Q1 IBTS survey exists since the 1977 year class. For more than a decade until the mid-1990s, there has been very good agreement between the indices in their description of temporal trends in recruitment, with the 0-ringer index explaining more than 70% of the variability of the respective 1-ringer abundance. It has to be borne in mind that the IBTS 0-ringer (or MIK) index only reflects recruitment in autumn spawning components. Hence, once the contribution of 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 31 % 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 2.3.3.4).

2.6 Assessment of North Sea herring

2.6.1 Data exploration and preliminary results

The tool for the assessment of North Sea herring is FLSAM, an implementation of the State-space assessment model (www.stockassessment.org), 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. As for the 2019 assessment, a somewhat high and one-directional retrospective was observed. This was further explored and results are presented in 2.10.1

The proportion mature of 2, 3 and 4-wr individuals are 59%, 97%, and 99% respectively. The historical proportion mature at age are given in Table 2.6.3.5 and plotted in Figure 2.6.1.1. The maturity for age has substantially increased compared to 2018 (37%). This is following a consistent decrease of proportion mature at this age since 2015. The tracking of each cohort can be observed in the catch-at-age presented Figure 2.6.1.2. The 2013 year class is particular high in the catches. Time-series of natural mortality-at-age built from the 2017 SMS key run (ICES WGSAM, 2018) 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), especially for age 5 and 6. The internal consistency of the acoustic survey remains high, as it has been for a long period (Figure 2.6.1.5). Though, an exploration of the assessment results revealed that the consistency is variable in time with a significant drop in the last years for age 6-7 (see Section 2.10.1). Following the revision of the index generation during the 2018 benchmark (ICES, WKPELA 2018), the internal consistency for the IBTS-Q3 is also at a considerable high levels (Figure 2.6.1.6).

The SAM model fits the catch and the surveys well and residuals are random and small for all ages (figures 2.6.1.7–2.6.1.42). A small block of positive residuals can be observed for age 7 catch data over the years 2000–2006, while at age 8 for catch data, a similar block of negative residuals can be observed (figures 2.6.1.13 and 2.6.1.14). This likely indicates a trade-off in model fit to either the age 7 or age 8+ catch information. There is a methodological need however to link age 7 and age 8+ together in the stock assessment model. The residuals are very small and are not considered an issue for the performance of the assessment. The fitting of the LAI index is poor due to the intrinsic noise to the larvae survey (figures 2.6.1.32–2.6.1.42). This survey is the only one able to provide information on the strength of the different spawning components. Given the low impact of this survey on the overall assessment, this is not considered an issue. All other surveys fit well inside the model. Further visualization 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 dataset (see Figure 2.6.1.47). Overall, all data sources are associated with low observation variances. The catch-at-ages 1–5 stands out as the most precise data source while the LAI indices, IBTSQ3 age 0 and HERAS age 1 to be the noisiest data. The uncertainty associated with the parameter estimated is low for most data sources where only the CV of the catch-at-age 0 is somewhat high (Figure 2.6.1.48). However, the CV quantities do not indicate a lack of convergence of the assessment model.

The analytical retrospective pattern is similar to the 2019 assessment. The SSB has been revised upward with very similar perception in F and recruits (Figure 2.6.1.49). The mean mohn's rho with a 5-year period for the peel is similar to those from 2019: -12.2% (F_{bar}), 2.9% (rec), and 11.5% (SSB). A specific analysis of the analytical retrospective is presented in Section 2.10.1.

Figure 2.6.1.49 shows the model uncertainty plot, representing the parametric uncertainty of the fit of the assessment model in terminal F and SSB.

Further data screening of the input data on mature – immature biomass ratios, survey CPUEs, proportion of catch numbers- and weights-at-age and proportion of IBTS and acoustic survey ages have been executed, as well as correlation coefficient analyses for the acoustic and IBTS survey and assessment parameters (Figure 2.6.1.50-51).

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. It is important to note that fleet B and D are combined because of their similarity. More details on the model configuration exploration is provided in the 2018 benchmark report (ICES WKPELA, 2018). Tables for the multifleet assessment and results (including fleet wise fishing mortalities) are given in Table 2.6.2.2 to 2.6.2.41.

Of particular relevance when running the SAM model using a multifleet configuration is the fishing mortality-at-age that is outputted for each fleet. The subsequent catch residuals for each fleet is shown in Figure 2.6.2.1 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 analytical retrospective for SSB, F_{bar} and the recruitment is shown in Figure 2.6.2.7. Similar pattern to the single fleet can be observed, i.e. one directional bias with increased peels. With respect to SSB, F_{bar} and recruitment, the multifleet assessment yields very similar results to the single fleet assessment (figures 2.6.2.8-10).

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 2.6.3.13–2.6.3.35, 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.

The spawning stock at spawning time in 2019 is estimated at approximately 1.68 million tonnes, which is a decrease of 18% compared with 2018.

The abundance of 0-wr fish in 2020 (2019 year class) is estimated to be at approximately 29 billion, which is 10% below the 10-year weighted mean (33 billion, see Table 2.6.3.14).

Mean $F_{2\text{–}6}$ in 2019 is estimated at approximately 0.18.

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).

The SSB in autumn 2019 was estimated at 1.68 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 2020 remains low (23 billion, 10% lower than the 10-years weighted mean).

Similarly to recent years' assessments, fishing mortality on older ages remains high in recent years. As for the 2019 assessment, the fishing mortality-at-age 7 is estimated around 0.42 in 2019, 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 2020, 2021, and 2022 were done with code developed in the R programming language. During HAWG 2019, a modification to the code was made because the 2015 EU-Norway management rule is no longer in force and because the ICES advice for WBSS herring resulted in a zero catch advice. During HAWG 2020 a further modification to the code was made to allow for a combined scaling of the A and B fleets (see below).

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

In the short-term predictions, recruitment is assumed constant at 33 billion for the years 2021 and 2022 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 2019 year class, obtained from the assessment served as the estimate for 2020.

For the intermediate year (2020), no overshoot for the A fleet was assumed. Previous negotiations between the EU and Norway resulted in the allowance of 50% of the C-fleet TAC in the Kattegat-Skagerrak area to be taken in the North Sea. Because a TAC for the C-fleet had been agreed for 2020, 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 50% in 2020. 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 6071 t) in the intermediate year. In the projected year 2021, for most of the scenarios, the C and D fleet outtake was set to 0 in agreement with the 0-catch advice for WBSS for 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. In HAWG 2019, a fixed fishing mortality was assumed across all scenarios. In HAWG 2020, this assumption has been changed. In the new forecast, the combined selection pattern for the A and B fleets are scaled together to achieve the different targets of the forecast scenarios. Therefore the fishing mortalities of the A and B fleets are both variable across the scenarios. In addition, three scenarios are presented in which 1) a fixed target fishing mortality for the B-fleet is used and 2) and 3) the TACs of the C and D fleet are the same as in 2020 (with and without transfer of the C fleet to the North Sea).

All predictions are for North Sea autumn spawning herring only.

2.7.1 Comments on the short-term projections

Although the SSB is expected to decrease between 2020 and 2022, due to a series of weak year-classes recruiting to the fishery, the projection still estimates a higher catch compared to the projection that was carried out in HAWG 2018 and HAWG 2019. The main reasons for the higher predicted catch were:

8. a higher estimate of stock size due to a retrospective bias in the assessment (see Section 2.10),
9. a relatively large contribution of older fish in the population (year classes 2012 and 2013, age 7 and 8 wr in 2020), and
10. a high selection on the oldest ages in the population.

The large proportion of age 7 and 8 in the forecast year (2021) is shown in figures 2.7.2.1 and 2.7.2.2. This leads to a projection where the estimated catch (in tonnes) in 2021 consists for around 42% of fish that are age 7 (WR) and older, and that the average fishing mortality on ages 7 and 8 (WR) is around 0.58.

The predicted total catch of NSAS herring according to the MSY Advice Rule for 2021 is 365.792 tonnes which implies a 15% decrease compared to the advice for 2020. The calculated catch for the A fleet in 2020 is based on a number of assumption about the distribution of fishing mortalities and catches between fleets. Using these assumption, the estimated catch of the A fleet in 2021 would be 359 367 tonnes which represents a 14% decrease compared to the calculated A fleet catch in HAWG 2019 (418 649 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 2020 again carried out and extended short-term projection using the MSY AR projection, using the same (low) recruitment and the same fishing patterns by fleet for the years 2022–2026 (Figure 2.7.2.3). This resulted in a further decline in the total catch of autumn spawning herring to around 300 000 tonnes in 2022 and catches slowly increasing to 320 000 tonnes by 2026 while SSBs would be between 1 200 000 and 1 300 000 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.

2.8 Medium term predictions and HCR simulations

No medium-term prediction or HCR simulations were carried out during the Working Group. A new management strategy evaluation was carried out in 2019 (ICES WKNSMSE, 2019), following an EU-Norway request (EU–Norway, 2018[2]). However, to date there is no agreement of management plan.

2.9 Precautionary and Limit Reference Points and 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 tables 2.9.1 and 2.9.2 respectively. Overall, in light of the 2020 assessment, the fishing pressure remains below F_{MSY} while the SSB is below MSY $B_{Trigger}$. For 2020, the F_{MSY} advice rule is applied. This management procedure consists of applying a fishing mortality F_{bar} (over ages 2-6) of F_{MSY} if the SSB in the forecast year is above MSY $B_{Trigger}$ and conversely decrease F_{bar} linearly. This is exemplified in Figure 2.9.1.1 with the current estimation of SSB in the intermediate and forecast years. Following the linear decrease of F_{bar} due to having SSB_{2021} below MSY $B_{Trigger}$, the applicable F_{bar} in the forecast year is of 0.22. 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 2020 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 of North Sea herring. The time-series are those from the latest 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

[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.

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 2020 assessment has decreased the estimates of the 2017–2019 recruitments by 1.5% compared to the 2019 assessment. The SSB has been increased by 10.1% over the 2017-2019 period and the fishing mortality is estimated to be lower by around 12.1% (see text table below and discussion in Section 2.6.4 and 2.7).

	2019 Assessment				2020 Assessment				% change 2020/2011			
Year	Rec	SSB	Catch	$F_{2–6}$	Rec	SSB	Catch	$F_{2–6}$	Rec	SSB	Catch	$F_{2–6}$
2017	22	2.2	495	0.22	20	2.3	492	0.21	-13.9	5.9	-0.4	-6.3
2018	36	1.8	567	0.27	33	2.1	556	0.24	-8.7	10.6	-2.0	-11.0
2019	26	1.5	432	0.34	32	1.7	437	0.23	18.1	13.7	1.1	-18.9

2.10.1 Analysing the retrospective pattern

Given the continuous one-directional retrospective pattern in the assessment, the following extra analyses were undertaken to find the source and potential solution for the retrospective pattern:

11. Leave-one-out analyses including retrospective analyses. If the retrospective pattern was due to substantial pattern in any of the surveys, a leave-one-out analyses would have resulted in a model lacking a retrospective as the cause of the problem would have been eliminated. The results however did not indicate it was only one of the surveys causing the problem, suggesting the catch data plays an important role as well.
12. Changing settings and parameter bindings of the assessment model. In some occasions, not allowing for enough free parameters results in retrospective patterns. For that reason, all settings were carefully screened. Results indicate that no setting could be found that solved the problem or substantially reduced the retrospective pattern.
13. Change in plus-group. An analyses was undertaken increasing the plus-group to age 9+ to investigate the effect on the retrospective pattern. Updating the model settings and parameter bindings was part of this analyses. Increasing the plus-group did however not result in a reduced retrospective pattern.
14. Analyse the change in internal consistency of the data used in the assessment. A 10-year moving window was used to estimate the internal consistency of the catch and survey data. In this analyses, a window of 10 years was used to estimate the linear relationship between e.g. age-pairs 4-5 within a cohort. The results showed that in the catch-at-age data the internal consistency in the age-pairs 7-8+ was very low around 2010 and increased since (Figure 2.10.1.1). The results furthermore showed that the internal consistency in the HERAS-at-age data for age-pairs 6-7 has declined substantially and is now close to 0 (random noise) (Figure 2.10.1.2). The improved consistency at older ages in the catch together with the reduced consistency at older ages in the HERAS data results in a change in weight of the catch and HERAS data (observation variance for catch down, for HERAS up (Figure 2.10.1.3). This ultimately results in the change in perception from year to year.

2.11 North Sea herring spawning components

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

2.11.1 International Herring Larval Survey

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

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

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

2.11.2 IBTS0 Larval Index

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

2.11.3 Component considerations

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

2.12 Ecosystem considerations

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

2.13 Changes in the environment

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

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

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

The North Sea Autumn Spawning herring stock has, since 2002, produced a series of below average year classes, a situation which has not been observed previously (Payne *et al.*, 2009): the most recent year class also appears to represent a continuation of this trend. This low recruitment has occurred despite a spawning-stock biomass that is well above the B_{lim} of 800 000 tonnes (where impaired recruitment is expected to set in) (Figure 2.13.1).

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

Year-class strength in this stock is determined during the larvae phase (Dickey-Collas and Nash, 2005; Payne *et al*., 2009). Updating these analyses with the most recent datasets suggests that the trend of reduced larval survival between the early (as indicated by the SSB/LAI index) and the late (as indicated by the IBTS0 index) larval stages has continued in the most recent years (Figure 2.13.3). (It should be noted that the switch from the SCAI calculation to the LAI calculation inside the assessment model, has caused a higher variability of the larvae survival relationship between SSB/LAI and IBTS0 indices). The most recent observation continues the trend of relatively poor survival.

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

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

Table 2.1.1. Herring caught in the North Sea. Total catch (tonnes) by country, 2015–2019. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2015	2016	2017	2018	2019
Belgium	18	26	13	32	60
Denmark *	113 481	133 962	110 318	132 231	91 680
Faroe Islands	981	833	442	497	614
France	30 269	35 177	28 801	31 505	25 288
Germany	44 377	44 231	43 707	51 636	37 699
Netherlands	70 076	98 859	84 914	111 302	79 465
Norway	134 349	150 183	134 132	162 594	128 614
Sweden	13 184	16 625	18 518	19 408	13 184
Ireland	183	127	868	515	3
UK (England)	18 897	20 485	16 997	19591	12 685
UK (Scotland)	48 332	59 240	49 514	66005	50 771
UK (N.Ireland)	5948	-	3469	6916	3938
Unallocated landings	1516	8	0	0	0
Total landings	481 611	559 756	491 693	602 232	444 001
Discards/BMS	-	170	-	96	1630
Total catch	481 611	559 926	491 693	602 328	445 631
Estimates of the parts of the catches which have been allocated to spring-spawning stocks					
WBSS	2204	1839	632	2164	8832
Thames estuary **	10	1	0	0	-
Norw. Spring Spawners ***	2191	216	83	310	5

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

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

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

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

Country	2015	2016	2017	2018	2019
Denmark *	68017	81080	76277	90763	54820
Faroe Islands	981	811	405	496	611
France	13401	15073	11064	14745	13344
Germany	32253	27926	32736	35884	19851
Netherlands	44309	66740	55832	56990	44071
Norway	47010	57056	57744	78647	53254
Sweden	10388	9933	12447	14132	8557
Ireland	183	127	868	515	3
UK (England)	12249	13010	12072	12313	5640
UK (Scotland)	46931	58557	49012	64424	50771
UK (N. Ireland)	4878	-	3469	5582	3938
Unallocated landings **	1939	0	0	0	0
Total Landings	282539	330313	311926	374491	254860
Discards/BMS	-	100	-	-	-
Total catch	282539	330413	311926	374491	254860

*** Including any bycatches 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	2015	2016	2017	2018	2019
Denmark *	16739	16305	3928	751	-
Faroe Islands	-	-	-	-	-
France	-	-	-	-	-
Germany	-	-	-	-	-
Netherlands	-	-	-	-	100
Norway	67254	78125	74216	73452	64592
UK (Scotland)	1369	-	-	-	-
Sweden	570	3985	705	377	-
Unallocated landings**	-423	0	0	0	0
Total landings	85509	98415	78849	74580	64692
Discards/BMS	-	-	-	-	-
Total catch	85509	98415	78849	74580	64692
Norw. Spring Spawners ***	2191	216	85	310	5

*** 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	2015	2016	2017	2018	2019
Denmark*	28551	36149	30045	4067	36750
Faroe Islands	-	22	37	1	3
France	6342	6225	7423	6090	1359
Germany	107	3419	2048	4964	8568
Netherlands	10606	17233	15739	34491	20700
UK (N. Ireland)	1070	-	-	1334	-
Norway	20077	15002	2172	10495	10768
Sweden*	2226	2705	5366	4899	4627
UK (England)	3484	3820	2435	3262	2750
UK (Scotland)	32	683	502	1581	-
Unallocated landings	0	0	0	0	0
Total landings	72495	85258	65767	107794	85525
Discards	-	-	-	1	800
Total catch	72495	85258	65767	107795	86325

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

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

Country	2015	2016	2017	2018	2019
Belgium	18	26	13	32	60
Denmark*	174	428	68	40	110
France	10526	13879	10314	10670	10585
Germany	12017	12886	8923	10788	9280
Netherlands	15161	14886	13343	19821	14594
Norway	8	-	-	-	-
Sweden	-	2	-	-	-
UK (England)	3164	3655	2490	4016	4295
UK (Scotland)	-	-	-	-	-
Unallocated landings	0	8	0	0	0
Total landings	41068	45770	35151	45367	38924
Discards/BMS	-	70	-	95	830
Total catch	41068	45840	35151	45462	39754
Coastal spring spawners included above**	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	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Subarea 4 and Division 7.d: TAC (4 and 7.d)												
Agreed Divisions 4.a,b	147.4	149.0	173.5	360.4	427.7	418.3	396.3	461.2	428.7	534.5	342.7	342.7
Agreed Div. 4.c, 7.d	23.6	15.3	26.5	44.6	50.3	51.7	49.0	57.0	53.0	66.0	42.4	42.4
Bycatch ceiling in the small mesh fishery *	16.0	13.6	16.5	17.9	14.4	13.1	15.7	13.4	11.4	9.7	13.2	9.0
CATCH (4 and 7.d)												
National catch Divisions 4.a,b **	145.0	148.1	191.7	387.2	453.8	465.9	439	514.0	456.5	556.9	405.1	
Unallocated catch Divisions 4.a,b	-1.1	0.0	0.0	-3.0	0.0	3.3	1.5	0.0	0.0	0.0	0.0	
Discard/slipping Divisions 4.a,b ***	0.1	0.0	-	-	-	0.0	-	0.1	-	0.0	0.8	
Total catch Divisions 4.a,b #	143.9	148.1	191.7	384.2	453.9	469.2	440.5	514.1	456.5	556.9	405.9	
National catch Divisions 4.c, 7.d **	21.5	26.5	26.7	37.1	44.7	38.2	41.1	45.8	35.2	45.4	38.9	
Unallocated catch Divisions 4.c,7.d	0.4	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0	
Discard/slipping Divisions 4.c, 7.d ***	-	-	-	-	-	-	-	0.1	-	0.1	0.8	
Total catch Divisions 4.c, 7.d	21.9	26.5	26.7	40.4	44.7	38.2	41.1	45.8	35.2	45.5	39.8	
Total catch 4 and 7.d as used by ICES #	165.8	174.6	218.4	424.6	498.5	507.5	481.6	559.9	491.7	602.3	445.6	
CATCH BY FLEET/STOCK (4 and 7.d) ##												
North Sea autumn spawners directed fisheries (Fleet A)	152.1	164.8	209.2	411.8	489.9	490.5	471.5	543.6	484.1	591.7	440.5	
North Sea autumn spawners industrial (Fleet B)	9.8	9.1	8.9	10.6	8.1	14.0	7.9	14.5	7.0	8.5	5.2	

Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
North Sea autumn spawners in 4 and 7.d total	161.9	173.9	218.1	422.5	498.1	504.5	479.4	558.1	491.1	600.2	436.8	
Baltic-3.a-type spring spawners in 4	3.9	0.8	0.3	2.1	0.5	3.0	2.2	1.8	0.6	2.2	8.8	
Coastal-type spring spawners	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Norw. Spring Spawners caught under a separate quota in 4 ###	44.6	56.9	12.2	9.6	3.2	2.3	2.2	0.2	0.1	0.3	0.0	
Division 3.a: TAC (3.a)												
Agreed herring TAC	37.7	33.9	30.0	45.0	55.0	46.8	43.6	51.1	50.7	48.4	29.3	24.5
Bycatch ceiling in the small mesh fishery	8.4	7.5	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
CATCH (3.a)												
National catch	38.8	37.3	20.0	27.7	31.2	28.9	27.8	29.9	26.8	23.3	14.9	
Catch as used by ICES	38.8	37.3	20.0	27.7	31.2	28.9	27.8	29.9	26.8	23.3	14.9	
CATCH BY FLEET/STOCK (3.a) ##												
Autumn spawners human consumption (Fleet C)	5.1	12.0	6.6	7.8	11.8	9.5	10.2	4.1	7.4	3.2	5.8	
Autumn spawners mixed clupeoid (Fleet D)	1.5	1.8	1.8	4.4	1.6	3.3	4.4	1.4	0.2	0.2	0.3	
Autumn spawners in 3.a total	6.5	13.8	8.4	12.2	13.4	12.8	14.7	5.5	7.6	3.4	6.1	
Spring spawners human consumption (Fleet C)	29.4	23.0	10.8	14.5	16.6	15.4	11.3	23.3	19.0	19.7	8.8	
Spring spawners mixed clupeoid (Fleet D)	2.9	0.5	0.8	1.0	1.3	0.6	1.8	1.1	0.2	0.2	0.0	
Spring spawners in 3.a total	32.3	23.5	11.6	15.5	17.9	16.1	13.1	24.4	19.2	19.9	8.8	
North Sea autumn spawners Total as used by ICES	168.4	187.6	226.5	434.6	511.4	517.3	494.1	563.6	498.7	603.5	442.9	

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 2019. 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	**23.7**	**0.0**	**5.3**	**0.0**	**100.7**	**403.2**	**14.2**	**0.0**	**503.9**	**14.2**	**541.8**	**518.1**
1	**101.3**	**2.4**	**30.6**	**0.0**	**20.2**	**42.2**	**1.2**	**0.0**	**62.5**	**1.2**	**164.9**	**66.0**
2	**19.8**	**21.2**	**53.0**	**0.0**	**40.7**	**17.5**	**0.4**	**7.3**	**58.2**	**7.7**	**85.7**	**87.1**
3	**4.6**	**36.3**	**16.2**	**20.1**	**168.6**	**39.3**	**8.2**	**55.5**	**228.0**	**63.7**	**296.3**	**307.9**
4	**0.1**	**17.9**	**5.5**	**12.4**	**115.3**	**26.7**	**2.3**	**40.2**	**154.4**	**42.5**	**197.0**	**202.4**
5	**0.1**	**97.5**	**2.5**	**95.0**	**454.9**	**119.9**	**5.5**	**64.9**	**669.8**	**70.5**	**740.4**	**742.7**
6	**0.1**	**81.1**	**1.4**	**79.7**	**311.6**	**115.6**	**2.2**	**33.1**	**506.9**	**35.3**	**542.3**	**543.6**
7	**0.0**	**25.8**	**0.3**	**25.4**	**67.6**	**38.3**	**0.2**	**8.1**	**131.3**	**8.3**	**139.6**	**140.0**
8	**0.0**	**20.1**	**0.1**	**20.0**	**47.4**	**11.2**	**0.3**	**6.5**	**78.6**	**6.8**	**85.4**	**85.4**
9+	**0.0**	**23.7**	**0.0**	**23.7**	**75.1**	**25.7**	**0.9**	**12.8**	**124.6**	**13.7**	**138.3**	**138.3**
Sum	**149.8**	**325.9**	**114.9**	**276.4**	**1402.2**	**839.6**	**35.3**	**228.5**	**2518.2**	**263.9**	**2931.8**	**2831.5**
Quarter: 1												
0	0.0	0.0	0.0	0.0	3.6	2.9	12.4	0.0	6.5	12.4	**18.9**	**18.9**
1	38.4	0.0	2.3	0.0	0.3	0.2	1.0	0.0	0.5	1.0	**40.0**	**1.6**
2	17.9	0.0	22.0	0.0	0.6	0.5	0.0	0.0	1.1	0.0	**19.0**	**1.1**
3	3.4	0.0	5.8	0.0	3.8	0.8	0.8	11.0	4.6	11.9	**19.8**	**16.5**
4	0.1	0.0	1.4	0.0	2.7	0.3	0.2	3.5	3.1	3.7	**6.9**	**6.8**
5	0.0	0.0	0.5	0.0	16.3	1.3	0.4	6.7	17.6	7.1	**24.8**	**24.7**
6	0.0	0.0	0.3	0.0	13.1	1.3	0.1	1.6	14.4	1.7	**16.1**	**16.1**
7	0.0	0.0	0.0	0.0	2.8	0.5	0.0	0.9	3.3	0.9	**4.2**	**4.2**
8	0.0	0.0	0.0	0.0	1.1	0.3	0.0	0.0	1.4	0.0	**1.4**	**1.4**
9+	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.3	1.4	0.3	**1.7**	**1.7**
Sum	**59.8**	**0.0**	**32.3**	**0.0**	**45.8**	**8.2**	**15.0**	**24.0**	**54.1**	**39.0**	**152.9**	**93.1**
Quarter: 2												
0	0.0	0.0	0.0	0.7	6.5	165.0	1.8	0.0	0.2	0.1	**174.1**	**173.4**
1	9.6	2.4	0.7	1.7	0.6	13.8	0.2	0.0	16.1	0.2	**25.9**	**17.0**
2	0.2	21.2	0.9	20.3	18.6	0.2	0.0	0.0	39.1	0.0	**39.3**	**40.0**
3	0.1	31.6	0.5	31.1	39.7	0.2	0.0	0.1	70.9	0.1	**71.1**	**71.6**
4	0.0	13.7	0.3	13.4	15.2	0.0	0.0	0.0	28.7	0.0	**28.7**	**29.0**
5	0.0	51.1	0.3	50.9	58.8	0.7	0.0	0.0	110.3	0.1	**110.4**	**110.7**
6	0.0	51.3	0.2	51.1	52.1	0.5	0.0	0.0	103.7	0.0	**103.7**	**103.9**
7	0.0	18.2	0.1	18.0	13.8	0.2	0.0	0.0	32.0	0.0	**32.0**	**32.2**
8	0.0	13.4	0.0	13.4	10.7	0.1	0.0	0.0	24.2	0.0	**24.2**	**24.2**
9+	0.0	2.4	0.0	2.4	0.6	0.2	0.0	0.0	3.3	0.0	**3.3**	**3.3**
Sum	**9.8**	**205.4**	**3.1**	**203.0**	**216.7**	**180.9**	**2.1**	**0.2**	**428.6**	**0.5**	**612.7**	**605.2**
Quarter: 3												
0	16.0	0.0	0.0	0.0	14.2	132.7	0.0	0.0	146.9	0.0	**163.0**	**146.9**
1	36.1	0.0	7.9	0.0	1.5	9.5	0.0	0.0	11.1	0.0	**47.2**	**11.1**
2	0.6	0.0	22.0	0.0	15.8	15.9	0.0	0.0	31.7	0.0	**32.3**	**31.7**
3	0.8	4.4	7.9	0.0	108.1	25.0	0.0	0.0	133.1	0.0	**133.8**	**137.5**
4	0.0	3.7	2.9	0.0	86.6	18.0	0.0	0.0	104.6	0.0	**104.6**	**108.3**
5	0.1	39.6	1.2	0.0	334.4	92.5	0.0	0.0	426.9	0.0	**427.0**	**466.6**
6	0.0	24.1	0.9	0.0	199.6	85.1	0.0	0.0	284.7	0.0	**284.8**	**308.8**
7	0.0	5.9	0.2	0.0	42.6	27.5	0.0	0.0	70.1	0.0	**70.1**	**76.0**
8	0.0	4.4	0.0	0.0	31.9	8.6	0.0	0.0	40.5	0.0	**40.5**	**44.9**
9+	0.0	19.6	0.0	0.0	40.7	19.2	0.0	0.0	59.9	0.0	**59.9**	**79.5**
Sum	**53.6**	**101.9**	**43.0**	**0.0**	**875.4**	**434.1**	**0.0**	**0.0**	**1309.4**	**0.0**	**1363.1**	**1411.3**
Quarter: 4												
0	7.7	0.0	5.3	0.0	76.3	102.6	0.0	0.0	178.9	0.0	**186.6**	**178.9**
1	17.2	0.0	19.7	0.0	17.7	18.6	0.0	0.0	36.4	0.0	**53.6**	**36.4**
2	1.2	0.0	8.1	0.0	5.8	0.8	0.4	7.3	6.6	7.7	**15.5**	**14.3**
3	0.4	0.2	2.0	0.0	17.1	13.3	7.3	44.4	30.4	51.7	**82.5**	**82.3**
4	0.0	0.4	0.8	0.0	10.7	8.3	2.1	36.7	19.1	38.8	**57.8**	**58.2**
5	0.0	6.8	0.5	6.3	45.3	25.4	5.1	58.2	76.9	63.3	**140.3**	**140.7**
6	0.0	5.7	0.1	5.7	46.8	28.7	2.1	31.5	81.2	33.6	**114.8**	**114.8**
7	0.0	1.7	0.0	1.7	8.3	10.1	0.2	7.2	20.1	7.4	**27.6**	**27.6**
8	0.0	2.2	0.0	2.2	3.7	2.2	0.3	6.5	8.1	6.8	**14.8**	**14.9**
9+	0.0	1.7	0.0	1.7	32.5	6.3	0.9	12.5	40.5	13.4	**53.9**	**53.9**
Sum	**26.5**	**18.7**	**36.5**	**17.5**	**264.3**	**216.3**	**18.3**	**204.4**	**498.1**	**222.6**	**747.2**	**721.9**

Table 2.2.2. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2019. 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	**0.012**	**0.000**	**0.020**	**0.009**	**0.006**	**0.003**	**0.000**	**0.006**	**0.003**	**0.006**	**0.006**
1	**0.041**	**0.071**	**0.048**	**0.047**	**0.034**	**0.027**	**0.000**	**0.039**	**0.027**	**0.038**	**0.039**
2	**0.062**	**0.134**	**0.080**	**0.134**	**0.144**	**0.118**	**0.119**	**0.136**	**0.118**	**0.162**	**0.135**
3	**0.085**	**0.155**	**0.107**	**0.154**	**0.149**	**0.098**	**0.130**	**0.153**	**0.126**	**0.149**	**0.148**
4	**0.116**	**0.173**	**0.128**	**0.174**	**0.171**	**0.116**	**0.155**	**0.173**	**0.153**	**0.170**	**0.169**
5	**0.118**	**0.212**	**0.128**	**0.205**	**0.215**	**0.136**	**0.168**	**0.208**	**0.165**	**0.204**	**0.204**
6	**0.164**	**0.204**	**0.156**	**0.206**	**0.222**	**0.166**	**0.186**	**0.210**	**0.185**	**0.208**	**0.208**
7	**0.202**	**0.209**	**0.178**	**0.220**	**0.229**	**0.196**	**0.196**	**0.220**	**0.196**	**0.219**	**0.219**
8	**0.159**	**0.220**	**0.162**	**0.246**	**0.242**	**0.203**	**0.203**	**0.239**	**0.203**	**0.236**	**0.236**
9+	**0.000**	**0.250**	**0.000**	**0.248**	**0.259**	**0.211**	**0.223**	**0.251**	**0.223**	**0.248**	**0.248**
Quarter: 1											
0	0.000	0.000	0.000	0.003	0.003	0.003	0.000	0.000	0.000	**0.003**	**0.003**
1	0.027	0.071	0.027	0.027	0.027	0.027	0.000	0.027	0.027	**0.027**	**0.027**
2	0.060	0.134	0.061	0.142	0.150	0.000	0.000	0.146	0.000	**0.034**	**0.146**
3	0.072	0.149	0.078	0.119	0.146	0.088	0.090	0.123	0.000	**0.102**	**0.100**
4	0.122	0.164	0.111	0.125	0.155	0.103	0.107	0.129	0.107	**0.118**	**0.117**
5	0.087	0.180	0.097	0.144	0.173	0.113	0.125	0.146	0.125	**0.141**	**0.140**
6	0.137	0.188	0.101	0.163	0.186	0.130	0.162	0.165	0.161	**0.165**	**0.164**
7	0.000	0.202	0.000	0.172	0.186	0.172	0.172	0.174	0.000	**0.173**	**0.173**
8	0.000	0.209	0.000	0.185	0.212	0.000	0.000	0.191	0.000	**0.191**	**0.191**
9+	0.000	0.213	0.000	0.185	0.222	0.169	0.169	0.186	0.169	**0.182**	**0.182**
Quarter: 2											
0	0.000	0.000	0.000	0.003	0.003	0.003	0.000	0.000	0.000	**0.003**	**0.003**
1	0.032	0.071	0.032	0.035	0.027	0.027	0.000	0.034	0.000	**0.033**	**0.034**
2	0.060	0.134	0.061	0.142	0.148	0.000	0.000	0.138	0.000	**0.139**	**0.138**
3	0.079	0.149	0.078	0.145	0.163	0.088	0.088	0.147	0.088	**0.147**	**0.146**
4	0.090	0.164	0.101	0.155	0.163	0.103	0.103	0.159	0.103	**0.160**	**0.159**
5	0.049	0.180	0.118	0.174	0.210	0.113	0.113	0.177	0.113	**0.177**	**0.177**
6	0.000	0.188	0.138	0.188	0.229	0.129	0.129	0.188	0.129	**0.188**	**0.188**
7	0.000	0.202	0.149	0.184	0.251	0.000	0.000	0.194	0.000	**0.195**	**0.194**
8	0.000	0.209	0.166	0.210	0.244	0.000	0.000	0.209	0.000	**0.209**	**0.209**
9+	0.000	0.213	0.000	0.234	0.253	0.169	0.169	0.219	0.169	**0.219**	**0.219**
Quarter: 3											
0	0.009	0.000	0.000	0.006	0.006	0.000	0.000	0.006	0.000	**0.006**	**0.006**
1	0.054	0.000	0.053	0.050	0.038	0.000	0.000	0.040	0.000	**0.050**	**0.040**
2	0.095	0.000	0.097	0.130	0.145	0.000	0.000	0.138	0.000	**0.222**	**0.138**
3	0.135	0.196	0.134	0.159	0.148	0.000	0.000	0.158	0.000	**0.160**	**0.158**
4	0.097	0.201	0.143	0.179	0.174	0.000	0.000	0.179	0.000	**0.180**	**0.179**
5	0.155	0.253	0.153	0.213	0.221	0.000	0.000	0.218	0.000	**0.218**	**0.218**
6	0.180	0.233	0.180	0.214	0.228	0.000	0.000	0.219	0.000	**0.220**	**0.219**
7	0.202	0.225	0.202	0.237	0.235	0.000	0.000	0.235	0.000	**0.235**	**0.235**
8	0.000	0.250	0.159	0.259	0.244	0.000	0.000	0.255	0.000	**0.255**	**0.255**
9+	0.000	0.255	0.000	0.266	0.264	0.000	0.000	0.263	0.000	**0.263**	**0.263**
Quarter: 4											
0	0.018	0.000	0.020	0.010	0.010	0.000	0.000	0.010	0.000	**0.010**	**0.010**
1	0.049	0.000	0.049	0.048	0.037	0.000	0.000	0.042	0.000	**0.042**	**0.042**
2	0.078	0.078	0.083	0.115	0.120	0.118	0.119	0.116	0.118	**0.148**	**0.117**
3	0.095	0.217	0.096	0.148	0.150	0.099	0.140	0.149	0.135	**0.141**	**0.140**
4	0.097	0.211	0.112	0.166	0.165	0.118	0.160	0.166	0.158	**0.161**	**0.161**
5	0.078	0.217	0.101	0.209	0.194	0.138	0.173	0.205	0.170	**0.190**	**0.189**
6	0.093	0.221	0.093	0.205	0.209	0.168	0.188	0.207	0.186	**0.201**	**0.201**
7	0.000	0.229	0.000	0.210	0.215	0.196	0.199	0.214	0.199	**0.210**	**0.210**
8	0.159	0.230	0.159	0.252	0.238	0.203	0.203	0.242	0.203	**0.224**	**0.224**
9+	0.000	0.249	0.000	0.230	0.244	0.212	0.225	0.233	0.224	**0.231**	**0.231**

Table 2.2.3. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2019. Mean length-at-age (cm) in the catch, by quarter and division.

WR	3.a NSAS	4.aE all	4.aW WBSS	4.aW	4.b	4.c	7.d	4.a & 4.b all	4.c & 7.d	Herring caught in the North Sea
Quarters: 1-4										
0	**n.d.**	**0.0**	**n.d.**	**10.7**	**9.2**	**7.7**	**0.0**	**9.5**	**7.7**	**9.5**
1	**n.d.**	**19.2**	**n.d.**	**17.8**	**16.2**	**15.0**	**0.0**	**16.8**	**15.0**	**16.8**
2	**n.d.**	**22.8**	**n.d.**	**24.1**	**24.2**	**23.6**	**23.7**	**23.8**	**23.7**	**23.8**
3	**n.d.**	**24.4**	**n.d.**	**25.3**	**25.3**	**23.8**	**24.9**	**25.2**	**24.8**	**25.1**
4	**n.d.**	**25.6**	**n.d.**	**26.6**	**26.8**	**25.2**	**26.5**	**26.5**	**26.4**	**26.5**
5	**n.d.**	**27.4**	**n.d.**	**28.0**	**28.3**	**26.0**	**26.8**	**28.0**	**26.8**	**27.8**
6	**n.d.**	**27.3**	**n.d.**	**27.9**	**28.8**	**27.4**	**27.6**	**28.0**	**27.6**	**28.0**
7	**n.d.**	**27.5**	**n.d.**	**28.6**	**29.3**	**28.0**	**28.5**	**28.6**	**28.5**	**28.6**
8	**n.d.**	**28.5**	**n.d.**	**29.5**	**29.7**	**28.2**	**28.8**	**29.3**	**28.7**	**29.2**
9+	**n.d.**	**29.5**	**n.d.**	**30.6**	**30.5**	**29.4**	**29.4**	**30.4**	**29.4**	**30.3**
Quarter: 1										
0	n.d.	0.0	n.d.	7.7	7.7	7.7	0.0	0.0	0.0	**7.7**
1	n.d.	19.2	n.d.	15.0	15.0	15.0	0.0	15.0	15.0	**15.0**
2	n.d.	22.8	n.d.	23.7	23.9	0.0	0.0	23.8	0.0	**23.8**
3	n.d.	24.1	n.d.	24.5	24.2	23.5	23.6	24.5	0.0	**23.8**
4	n.d.	25.2	n.d.	25.2	25.1	24.9	24.9	25.2	24.9	**25.0**
5	n.d.	26.0	n.d.	26.7	25.7	25.5	25.8	26.6	25.8	**26.4**
6	n.d.	26.6	n.d.	27.8	26.4	27.1	28.0	27.7	28.0	**27.7**
7	n.d.	27.2	n.d.	28.1	26.8	28.3	28.3	28.0	0.0	**28.0**
8	n.d.	28.0	n.d.	28.6	27.7	0.0	0.0	28.4	0.0	**28.4**
9+	n.d.	28.5	n.d.	29.6	28.6	29.5	29.5	29.6	29.5	**29.6**
Quarter: 2										
0	n.d.	0.0	n.d.	7.7	7.7	7.7	0.0	0.0	0.0	**7.7**
1	n.d.	19.2	n.d.	15.9	15.0	15.0	0.0	15.6	0.0	**15.6**
2	n.d.	22.8	n.d.	23.9	24.3	0.0	0.0	23.3	0.0	**23.3**
3	n.d.	24.1	n.d.	24.6	25.6	23.5	23.5	24.4	23.5	**24.4**
4	n.d.	25.2	n.d.	25.3	25.6	24.9	24.9	25.3	24.9	**25.3**
5	n.d.	26.0	n.d.	26.1	28.2	25.5	25.5	26.1	25.5	**26.1**
6	n.d.	26.6	n.d.	26.7	29.0	27.1	27.1	26.7	27.1	**26.7**
7	n.d.	27.2	n.d.	26.8	29.9	0.0	0.0	27.0	0.0	**27.0**
8	n.d.	28.0	n.d.	27.7	30.0	0.0	0.0	27.9	0.0	**27.9**
9+	n.d.	28.5	n.d.	29.1	30.5	29.5	29.5	28.7	29.5	**28.7**
Quarter: 3										
0	n.d.	0.0	n.d.	9.5	9.5	0.0	0.0	9.5	0.0	**9.5**
1	n.d.	0.0	n.d.	18.0	16.3	0.0	0.0	16.6	0.0	**16.6**
2	n.d.	0.0	n.d.	24.6	24.3	0.0	0.0	24.4	0.0	**24.4**
3	n.d.	26.4	n.d.	25.6	25.4	0.0	0.0	25.6	0.0	**25.6**
4	n.d.	26.7	n.d.	26.9	27.2	0.0	0.0	27.0	0.0	**27.0**
5	n.d.	28.9	n.d.	28.3	28.7	0.0	0.0	28.4	0.0	**28.4**
6	n.d.	28.2	n.d.	28.1	29.2	0.0	0.0	28.4	0.0	**28.4**
7	n.d.	28.0	n.d.	29.2	29.8	0.0	0.0	29.3	0.0	**29.3**
8	n.d.	29.0	n.d.	30.1	29.9	0.0	0.0	29.9	0.0	**29.9**
9+	n.d.	29.4	n.d.	30.5	30.8	0.0	0.0	30.3	0.0	**30.3**
Quarter: 4										
0	n.d.	0.0	n.d.	11.3	11.3	0.0	0.0	11.3	0.0	**11.3**
1	n.d.	0.0	n.d.	17.9	17.0	0.0	0.0	17.5	0.0	**17.5**
2	n.d.	21.0	n.d.	23.4	23.3	23.6	23.7	23.3	23.7	**23.6**
3	n.d.	27.7	n.d.	25.3	25.2	23.8	25.2	25.2	25.0	**25.1**
4	n.d.	27.6	n.d.	26.4	26.0	25.2	26.7	26.2	26.6	**26.5**
5	n.d.	29.2	n.d.	28.4	27.1	26.0	26.9	28.0	26.9	**27.5**
6	n.d.	29.7	n.d.	28.4	27.7	27.4	27.6	28.3	27.6	**28.1**
7	n.d.	29.7	n.d.	28.7	28.0	27.9	28.5	28.5	28.5	**28.5**
8	n.d.	30.5	n.d.	29.9	28.8	28.2	28.8	29.8	28.7	**29.3**
9+	n.d.	31.6	n.d.	30.8	29.5	29.4	29.4	30.6	29.4	**30.3**

Table 2.2.4. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2019. 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	0.3	0.0	0.1	0.0	0.9	2.3	0.0	0.0	3.2	0.0	3.4	3.3
1	4.1	0.2	1.5	0.0	0.9	1.4	0.0	0.0	2.4	0.0	5.2	2.6
2	1.2	2.8	4.2	0.0	5.5	2.5	0.0	0.9	8.0	0.9	8.7	11.7
3	0.4	5.6	1.7	3.9	25.9	5.8	0.8	7.2	35.7	8.0	44.1	45.4
4	0.0	3.1	0.7	2.4	20.0	4.6	0.3	6.2	27.0	6.5	33.5	34.2
5	0.0	20.7	0.3	20.4	93.3	25.7	0.8	10.9	139.4	11.7	151.1	151.4
6	0.0	16.5	0.2	16.3	64.3	25.7	0.4	6.2	106.3	6.5	112.9	113.1
7	0.0	5.4	0.1	5.3	14.8	8.8	0.0	1.6	28.9	1.6	30.6	30.6
8	0.0	4.4	0.0	4.4	11.6	2.7	0.1	1.3	18.8	1.4	20.1	20.1
9+	0.0	5.9	0.0	5.9	18.7	6.7	0.2	2.9	31.3	3.1	34.3	34.3
Sum	6.1	64.7	8.8	58.7	256.0	86.3	2.6	37.2	400.9	39.8	444.0	446.8
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
1	1.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
2	1.1	0.0	1.4	0.0	0.1	0.1	0.0	0.0	0.2	0.0	0.0	0.2
3	0.2	0.0	0.5	0.0	0.5	0.1	0.1	1.0	0.6	1.1	1.4	1.6
4	0.0	0.0	0.2	0.0	0.3	0.1	0.0	0.4	0.4	0.4	0.6	0.8
5	0.0	0.0	0.1	0.0	2.3	0.2	0.0	0.8	2.6	0.9	3.4	3.5
6	0.0	0.0	0.0	0.0	2.1	0.2	0.0	0.3	2.3	0.3	2.6	2.6
7	0.0	0.0	0.0	0.0	0.5	0.1	0.0	0.2	0.6	0.2	0.7	0.7
8	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.3	0.0	0.3	0.3
9+	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.3	0.1	0.3	0.3
Sum	2.4	0.0	2.1	0.0	6.3	0.9	0.2	2.7	7.2	2.9	10.5	10.1
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.5	0.5
1	0.3	0.2	0.0	0.1	0.0	0.4	0.0	0.0	0.5	0.0	0.9	0.6
2	0.0	2.8	0.1	2.8	2.6	0.0	0.0	0.0	5.5	0.0	5.5	5.5
3	0.0	4.7	0.0	4.7	5.7	0.0	0.0	0.0	10.4	0.0	10.4	10.5
4	0.0	2.3	0.0	2.2	2.4	0.0	0.0	0.0	4.6	0.0	4.6	4.6
5	0.0	9.2	0.0	9.2	10.2	0.2	0.0	0.0	19.6	0.0	19.6	19.6
6	0.0	9.6	0.0	9.6	9.8	0.1	0.0	0.0	19.5	0.0	19.5	19.6
7	0.0	3.7	0.0	3.6	2.5	0.0	0.0	0.0	6.2	0.0	6.2	6.3
8	0.0	2.8	0.0	2.8	2.2	0.0	0.0	0.0	5.1	0.0	5.1	5.1
9+	0.0	0.5	0.0	0.5	0.2	0.0	0.0	0.0	0.7	0.0	0.7	0.7
Sum	0.3	35.8	0.2	35.6	35.8	1.3	0.0	0.0	72.7	0.0	73.0	72.9
Quarter: 3												
0	0.1	0.0	0.0	0.0	0.1	0.8	0.0	0.0	0.9	0.0	1.0	0.9
1	1.9	0.0	0.4	0.0	0.1	0.4	0.0	0.0	0.4	0.0	2.0	0.4
2	0.1	0.0	2.1	0.0	2.1	2.3	0.0	0.0	4.4	0.0	2.3	4.4
3	0.1	0.9	1.1	0.0	17.2	3.7	0.0	0.0	20.9	0.0	20.8	21.8
4	0.0	0.7	0.4	0.0	15.5	3.1	0.0	0.0	18.7	0.0	19.0	19.4
5	0.0	10.0	0.2	9.8	71.3	20.4	0.0	0.0	101.5	0.0	101.5	101.7
6	0.0	5.6	0.2	0.0	42.8	19.4	0.0	0.0	62.1	0.0	67.6	67.7
7	0.0	1.3	0.0	1.3	10.1	6.5	0.0	0.0	17.8	0.0	17.8	17.9
8	0.0	1.1	0.0	1.1	8.3	2.1	0.0	0.0	11.5	0.0	11.5	11.5
9+	0.0	5.0	0.0	5.0	10.8	5.1	0.0	0.0	20.9	0.0	20.9	20.9
Sum	2.3	24.7	4.4	17.3	178.1	63.7	0.0	0.0	259.1	0.0	264.4	266.5
Quarter: 4												
0	0.1	0.0	0.1	0.0	0.8	1.0	0.0	0.0	1.8	0.0	1.8	1.8
1	0.8	0.0	1.0	0.0	0.8	0.7	0.0	0.0	1.5	0.0	1.4	1.5
2	0.1	0.0	0.7	0.0	0.7	0.1	0.0	0.9	0.8	0.9	1.1	1.7
3	0.0	0.0	0.2	0.0	2.5	2.0	0.7	6.2	4.5	7.0	11.4	11.5
4	0.0	0.1	0.1	0.0	1.8	1.4	0.2	5.9	3.1	6.1	9.3	9.4
5	0.0	1.5	0.0	1.4	9.5	4.9	0.7	10.1	15.8	10.8	26.6	26.6
6	0.0	1.3	0.0	1.3	9.6	6.0	0.3	5.9	16.8	6.3	23.1	23.1
7	0.0	0.4	0.0	0.4	1.7	2.2	0.0	1.4	4.3	1.5	5.8	5.8
8	0.0	0.5	0.0	0.5	0.9	0.5	0.1	1.3	2.0	1.4	3.3	3.3
9+	0.0	0.4	0.0	0.4	7.5	1.5	0.2	2.8	9.4	3.0	12.4	12.4
Sum	1.1	4.2	2.1	4.0	35.8	20.3	2.3	34.5	60.1	36.9	96.2	97.2

Table 2.2.5. North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2019. Percentage age composition (based on numbers, 3+ group summarized), by quarter and division.

WR	3.a NSAS	4.aE all	4.aE WBSS	4.aE NSAS only	4.aW	4.b	4.c	7.d	4.a & 4.b NSAS	4.c & 7.d	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	15.8%	0.0%	4.6%	0.0%	7.2%	48.0%	40.2%	0.0%	20.0%	5.4%	18.5%	18.3%
1	67.7%	0.7%	26.7%	0.0%	1.4%	5.0%	3.3%	0.0%	2.5%	0.4%	5.6%	2.3%
2	13.2%	6.5%	46.1%	0.0%	2.9%	2.1%	1.0%	3.2%	2.3%	2.9%	2.9%	3.1%
3	3.0%	11.1%	14.1%	7.3%	12.0%	4.7%	23.2%	24.3%	9.1%	24.2%	10.1%	10.9%
4	0.1%	5.5%	4.8%	4.5%	8.2%	3.2%	6.5%	17.6%	6.1%	16.1%	6.7%	7.1%
5	0.1%	29.9%	2.2%	34.4%	32.4%	14.3%	15.7%	28.4%	26.6%	26.7%	25.3%	26.2%
6	0.0%	24.9%	1.2%	28.8%	22.2%	13.8%	6.1%	14.5%	20.1%	13.4%	18.5%	19.2%
7	0.0%	7.9%	0.3%	9.2%	4.8%	4.6%	0.7%	3.5%	5.2%	3.2%	4.8%	4.9%
8	0.0%	6.2%	0.0%	7.2%	3.4%	1.3%	0.7%	2.9%	3.1%	2.6%	2.9%	3.0%
9+	0.0%	7.3%	0.0%	8.6%	5.4%	3.1%	2.6%	5.6%	4.9%	5.2%	4.7%	4.9%
Sum 3+	3.3%	92.8%	22.6%	100.0%	88.5%	44.9%	55.4%	96.8%	75.2%	91.3%	73.0%	76.3%
Quarter: 1												
0	0.0%	0.0%	0.0%	0.0%	7.9%	35.3%	82.5%	0.0%	12.1%	31.7%	12.4%	20.3%
1	64.3%	1.2%	7.0%	0.0%	0.7%	2.9%	6.9%	0.0%	1.0%	2.6%	26.2%	1.7%
2	29.9%	10.3%	68.0%	0.0%	1.3%	6.5%	0.0%	0.0%	2.1%	0.0%	12.4%	1.2%
3	5.6%	15.4%	18.0%	0.0%	8.3%	9.7%	5.6%	46.0%	8.5%	30.5%	13.0%	17.7%
4	0.1%	6.7%	4.4%	0.0%	6.0%	4.2%	1.5%	14.5%	5.7%	9.5%	4.5%	7.3%
5	0.1%	24.9%	1.6%	0.0%	35.7%	15.7%	2.8%	27.8%	32.6%	18.2%	16.2%	26.6%
6	0.0%	25.0%	0.9%	0.0%	28.7%	15.8%	0.6%	6.5%	26.7%	4.3%	10.5%	17.3%
7	0.0%	8.8%	0.0%	53.3%	6.2%	5.6%	0.0%	3.8%	6.1%	2.3%	2.8%	4.5%
8	0.0%	6.6%	0.0%	39.6%	2.4%	4.1%	0.0%	0.0%	2.7%	0.0%	0.9%	1.6%
9+	0.0%	1.2%	0.0%	7.0%	2.9%	0.2%	0.2%	1.3%	2.5%	0.9%	1.1%	1.8%
Sum 3+	5.8%	88.5%	24.9%	100.0%	90.1%	55.2%	10.6%	100.0%	84.8%	65.6%	49.0%	76.8%
Quarter: 2												
0	0.0%	0.0%	0.0%	0.3%	3.0%	91.2%	88.7%	0.0%	0.0%	27.0%	28.4%	28.6%
1	97.6%	1.2%	22.9%	0.8%	0.3%	7.6%	7.4%	0.0%	3.8%	28.3%	4.2%	2.8%
2	1.8%	10.3%	30.1%	10.0%	8.6%	0.1%	0.0%	0.0%	9.1%	0.0%	6.4%	6.6%
3	0.6%	15.4%	17.2%	15.3%	18.3%	0.1%	2.0%	52.5%	16.6%	23.5%	11.6%	11.8%
4	0.0%	6.7%	10.1%	6.6%	7.0%	0.0%	0.5%	13.9%	6.7%	6.2%	4.7%	4.8%
5	0.0%	24.9%	8.5%	25.1%	27.1%	0.4%	1.0%	25.9%	25.7%	11.6%	18.0%	18.3%
6	0.0%	25.0%	5.7%	25.2%	24.1%	0.3%	0.2%	5.9%	24.2%	2.6%	16.9%	17.2%
7	0.0%	8.8%	4.7%	8.9%	6.4%	0.1%	0.0%	0.0%	7.5%	0.0%	5.2%	5.3%
8	0.0%	6.5%	0.7%	6.6%	4.9%	0.1%	0.0%	0.0%	5.6%	0.0%	3.9%	4.0%
9+	0.0%	1.2%	0.0%	1.2%	0.3%	0.1%	0.1%	1.9%	0.8%	0.8%	0.5%	0.5%
Sum 3+	0.6%	88.5%	47.0%	88.8%	88.1%	1.0%	3.9%	100.0%	87.1%	44.7%	61.0%	61.9%
Quarter: 3												
0	29.9%	0.0%	0.0%	0.0%	1.6%	30.6%	#DIV/0!	0.0%	11.2%	#DIV/0!	12.0%	10.4%
1	67.3%	0.0%	18.4%	0.0%	0.2%	2.2%	#DIV/0!	0.0%	0.8%	#DIV/0!	3.5%	0.8%
2	1.1%	0.0%	51.1%	0.0%	1.8%	3.7%	#DIV/0!	0.0%	2.4%	#DIV/0!	2.4%	2.2%
3	1.4%	4.4%	18.3%	0.0%	12.3%	5.8%	#DIV/0!	0.0%	10.2%	#DIV/0!	9.8%	9.7%
4	0.0%	3.6%	6.7%	0.0%	9.9%	4.2%	#DIV/0!	0.0%	8.0%	#DIV/0!	7.7%	7.7%
5	0.1%	38.9%	2.8%	0.0%	38.2%	21.3%	#DIV/0!	0.0%	32.6%	#DIV/0!	31.3%	33.1%
6	0.1%	23.6%	2.1%	0.0%	22.8%	19.6%	#DIV/0!	0.0%	21.7%	#DIV/0!	20.9%	21.9%
7	0.0%	5.8%	0.4%	0.0%	4.9%	6.3%	#DIV/0!	0.0%	5.4%	#DIV/0!	5.1%	5.4%
8	0.0%	4.4%	0.0%	0.0%	3.6%	2.0%	#DIV/0!	0.0%	3.1%	#DIV/0!	3.0%	3.2%
9+	0.0%	19.3%	0.0%	0.0%	4.6%	4.4%	#DIV/0!	0.0%	4.6%	#DIV/0!	4.4%	5.6%
Sum 3+	1.7%	100.0%	30.4%	0.0%	96.4%	63.6%	#DIV/0!	0.0%	85.5%	#DIV/0!	82.2%	86.6%
Quarter: 4												
0	29.0%	0.0%	14.6%	0.0%	28.9%	47.4%	0.0%	0.0%	35.9%	0.0%	25.0%	24.8%
1	64.9%	0.0%	54.1%	0.0%	6.7%	8.6%	0.0%	0.0%	7.3%	0.0%	7.2%	5.0%
2	4.5%	0.0%	22.1%	0.0%	2.2%	0.4%	2.0%	3.6%	1.3%	3.4%	2.1%	2.0%
3	1.4%	1.1%	5.4%	0.0%	6.5%	6.2%	40.0%	21.7%	6.1%	23.2%	11.0%	11.4%
4	0.1%	2.3%	2.3%	0.0%	4.1%	3.8%	11.3%	18.0%	3.8%	17.4%	7.7%	8.1%
5	0.1%	36.1%	1.3%	35.9%	17.1%	11.7%	27.9%	28.5%	15.4%	28.4%	18.8%	19.5%
6	0.0%	30.7%	0.1%	32.5%	17.7%	13.3%	11.3%	15.4%	16.3%	15.1%	15.4%	15.9%
7	0.0%	8.9%	0.0%	9.6%	3.2%	4.7%	1.3%	3.5%	4.0%	3.3%	3.7%	3.8%
8	0.0%	11.9%	0.1%	12.5%	1.4%	1.0%	1.4%	3.2%	1.6%	3.0%	2.0%	2.1%
9+	0.0%	8.9%	0.0%	9.5%	12.3%	2.9%	4.8%	6.1%	8.1%	6.0%	7.2%	7.5%
Sum 3+	1.6%	100.0%	9.2%	100.0%	62.2%	43.6%	98.0%	96.4%	55.5%	96.6%	65.8%	68.2%

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

2018	**Fleet A**		**Fleet B**		**Fleet C**		**Fleet D**		**TOTAL**	
Winter		Mean		Mean		Mean		Mean		Mean
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										

2019	**Fleet A**		**Fleet B**		**Fleet C**		**Fleet D**		**TOTAL**	
Winter		Mean		Mean		Mean		Mean		Mean
rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0	0.0	0.000	526.2	0.006	6.2	0.022	17.5	0.008	550.0	0.007
1	6.7	0.057	57.0	0.032	95.4	0.042	5.9	0.027	165.0	0.039
2	66.1	0.192	0.0	0.000	19.5	0.062	0.3	0.039	85.9	0.162
3	292.5	0.150	0.0	0.000	4.5	0.085	0.1	0.065	297.1	0.149
4	197.5	0.170	0.0	0.000	0.1	0.116	0.0	0.000	197.6	0.170
5	742.4	0.204	0.0	0.000	0.1	0.118	0.0	0.000	742.5	0.204
6	543.8	0.208	0.0	0.000	0.1	0.165	0.0	0.000	543.8	0.208
7	140.0	0.219	0.0	0.000	0.0	0.202	0.0	0.000	140.0	0.219
8	85.6	0.236	0.0	0.000	0.0	0.159	0.0	0.000	85.6	0.236

2019	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Winter		Mean		Mean		Mean		Mean		Mean
rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
9+	138.7	0.248	0.0	0.000	0.0	0.000	0.0	0.000	138.7	0.248
TOTAL	2'213.3		583.2		125.9		23.8		2'946.2	
SOP catch		440.5		5.2		5.8		0.3		451.7
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, 2004–2019.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
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
2019	513	35	34	292	197	740	542	140	85	138	2717

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, 2004–2019.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
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
2019	5.3	30.6	53.0	16.2	5.5	2.5	1.4	0.3	0.1	0.0	114.9

Table 2.2.9. Catch-at-age (numbers in millions) of NSAS taken in 3.a, and transferred to the assessment of NSAS, 2004–2019.

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

Year/rings	0	1	2	3	4	5	6	7	8+	Total
2013	0.9	86.2	85.8	2.4	0.4	0.3	0.0	0.0	0.0	175.9
2014	284.7	61.1	80.2	5.9	0.5	0.5	0.2	0.0	0.1	433.3
2015	30.7	169.6	97.6	7.0	1.3	4.9	1.1	1.2	0.4	313.6
2016	133.3	23.3	47.6	6.0	0.5	0.3	0.2	0.0	0.1	211.3
2017	0.1	76.0	34.4	6.9	3.0	1.2	0.1	0.0	0.0	121.8
2018	14.5	19.2	28.5	1.1	1.8	1.0	0.2	0.1	0.1	66.5
2019	23.7	101.3	19.8	4.6	0.1	0.1	0.1	0.0	0.0	0.0

Table 2.2.10. Catch-at-age (numbers in millions) of the total NSAS stock 2004–2019.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
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
2019	537	137	54	296	197	740	542	140	85	138	2866

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 2009–2019

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
3.a	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	-
	2019	0.062	0.085	0.116	0.118	0.164	0.202	0.159	-
4.a(E)	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
	2019	0.134	0.155	0.173	0.212	0.204	0.209	0.220	0.250
4.a(W)	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
	2014	0.143	0.172	0.184	0.215	0.212	0.227	0.246	0.242

Division	Year	Age (Rings) 2	3	4	5	6	7	8	9+
	2015	0.124	0.158	0.198	0.211	0.233	0.228	0.239	0.252
	2016	0.138	0.161	0.189	0.215	0.227	0.242	0.233	0.250
	2017	0.120	0.160	0.177	0.192	0.218	0.226	0.236	0.236
	2018	0.114	0.156	0.188	0.193	0.220	0.241	0.250	0.258
	2019	0.134	0.154	0.174	0.205	0.206	0.220	0.246	0.248
4.b	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
	2019	0.148	0.163	0.163	0.210	0.229	0.251	0.244	0.253

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 2009–2019.

Division	Year	Age (Rings) 2	3	4	5	6	7	8	9+
4.a & 4.b	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

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
	2017	0.116	0.159	0.176	0.190	0.217	0.223	0.231	0.230
	2018	0.117	0.152	0.187	0.195	0.220	0.238	0.245	0.254
	2019	0.136	0.153	0.173	0.208	0.210	0.220	0.239	0.251
4.c & 7.d	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
	2019	0.118	0.126	0.153	0.165	0.185	0.196	0.203	0.223
Total	2009	0.145	0.181	0.216	0.216	0.239	0.243	0.248	0.273
North Sea	2010	0.138	0.167	0.192	0.222	0.219	0.217	0.234	0.245
Catch	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
	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
	2019	0.135	0.148	0.169	0.204	0.208	0.219	0.236	0.248

Table 2.2.12. Sampling of commercial landings of North Sea herring (Division 4 and 7.d) in 2019 by quarter. Sampled catch means the proportion of the reported catch to which sampling was applied. Métiers are each reported combination of nation/fleet/area/quarter.

Country (fleet)	Q	Métiers (n)	Métiers sampled	Sam. Catch (%)	Official Catch	Samples	Fish aged	Fish measured	>1 sample per 1 kt catch
Belgium	1	2	0	0%	7	0	0	0	n
	2	1	0	0%	0	0	0	0	n
	3	1	0	0%	0	0	0	0	n
	4	2	0	0%	52	0	0	0	n
total		**6**	**0**	**0%**	**60**	**0**	**0**	**0**	**n**
Denmark (A)	1	3	1	99%	5450	3	81	360	y
	2	2	1	94%	4819	1	29	112	y
	3	2	2	100%	58076	37	1036	4217	y
	4	2	2	100%	18268	9	252	948	y
total		**9**	**6**	**100%**	**86612**	**50**	**1398**	**5637**	**y**
Denmark (B)	1	3	0	0%	104	0	0	0	n
	2	3	1	95%	938	3	23	47	y
	3	3	1	90%	1023	42	382	798	y
	4	2	1	57%	3004	16	92	99	y
total		**11**	**3**	**70%**	**5069**	**61**	**497**	**944**	**y**
UK(E&W)	1	3	1	81%	483	4	100	339	y
	2	4	1	100%	1061	24	599	4553	y
	3	4	1	62%	7177	21	524	2387	y
	4	4	0	0%	3964	0	0	0	n
total		**15**	**3**	**46%**	**12686**	**49**	**1223**	**7279**	**y**
France	1	2	0	0%	1285	0	0	0	n
	2	5	0	0%	1596	0	0	0	n
	3	4	0	0%	10496	0	0	0	n
	4	5	0	0%	12741	0	0	0	n
total		**16**	**0**	**0%**	**26119**	**0**	**0**	**0**	**n**
Germany	2	2	1	100%	5045	25	118	7913	y

Country (fleet)	Q	Métiers (n)	Métiers sampled	Sam. Catch (%)	Official Catch	Samples	Fish aged	Fish measured	>1 sample per 1 kt catch
	3	2	1	71%	20341	19	155	7214	y
	4	3	1	75%	12313	44	176	14282	y
total		**7**	**3**	**76%**	**37700**	**88**	**449**	**29409**	**y**
Ireland	1	1	0	0%	3	0	0	0	n
total		**1**	**0**	**0%**	**3**	**0**	**0**	**0**	**n**
Netherlands	1	1	1	100%	1021	1	25	289	y
	3	2	2	100%	56315	55	1372	6774	y
	4	4	1	61%	22128	4	100	598	y
total		**7**	**4**	**89%**	**79464**	**60**	**1497**	**7661**	**y**
Norway	1	2	0	0%	848	0	0	0	n
	2	3	2	100%	56633	22	944	1342	y
	3	3	3	100%	51641	15	544	868	y
	4	3	3	100%	19492	5	190	257	y
total		**11**	**8**	**99%**	**128613**	**42**	**1678**	**2467**	**y**
UK(Scotland)	1	1	0	0%	13	0	0	0	n
	2	1	1	100%	1473	5	199	744	y
	3	1	1	100%	46692	21	840	3057	y
	4	1	0	0%	2593	0	0	0	n
total		**4**	**2**	**95%**	**50771**	**26**	**1039**	**3801**	**y**
Sweden	1	1	0	0%	876	0	0	0	n
	2	1	0	0%	1371	0	0	0	n
	3	3	0	0%	9660	0	0	0	n
	4	2	0	0%	1985	0	0	0	n
total		**7**	**0**	**0%**	**13892**	**0**	**0**	**0**	**n**
Sweden (B)	2	1	0	0%	15	0	0	0	n
	3	1	0	0%	72	0	0	0	n
	4	2	0	0%	5	0	0	0	n

Country (fleet)	Q	Métiers (n)	Métiers sampled	Sam. Catch (%)	Official Catch	Samples	Fish aged	Fish measured	>1 sample per 1 kt catch
total		**4**	**0**	**0%**	**92**	**0**	**0**	**0**	**n**
Faroese	1	1	0	0%	6	0	0	0	n
	3	2	0	0%	251	0	0	0	n
	4	1	0	0%	357	0	0	0	n
total		**4**	**0**	**0%**	**613**	**0**	**0**	**0**	**n**
UK(NI)	3	1	0	0%	3777	0	0	0	n
	4	1	0	0%	161	0	0	0	n
total		**2**	**0**	**0%**	**3939**	**0**	**0**	**0**	**n**
grand total		**104**	**29**	**83%**	**445633**	**376**	**7781**	**57198**	**n**
Period total	**1**	18	5	68%	10095	8	206	988	n
Period total	**2**	23	6	95%	72951	80	1912	14711	y
Period total	**3**	32	13	88%	265522	210	4853	25315	n
Period total	**4**	30	9	64%	97064	78	810	16184	n
Total 2019		**104**	**29**	**83%**	**445633**	**376**	**7781**	**57198**	**n**
Human Cons. only		92	28	83%	440471	315	7284	56254	n
Total 2017		100	27	84%	491694	326	7783	58280	n
Total 2018		103	33	83%	602328	394	8868	63991	n
Human Cons. only		92	28	84%	593851	326	8354	63030	n

2.3.1.1. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June–July 2019. Vessels, areas and cruise dates.

Vessel	Period	Contributing to Stocks	Strata
Celtic Explorer (IRL) EIGB	4 – 24 July	MSHAS, WoS	2, 3, 4, 5, 6
Scotia (SCO) MXHR6	27 June – 19 July	MSHAS,WoS, NSAS, Sprat NS	1, 91 (north of 58°30'N), 111, 121
Johan Hjort (NOR) LDGJ	29 June – 16 July	NSAS, WBSS, Sprat NS	11, 141
Tridens (NED) PBVO	1 – 18 July	NSAS, Sprat NS	81, 91 (south of 58°30'N), 101
Solea (GER) DBFH	28 June – 18 July	NSAS, Sprat NS	51, 61, 71, 131
Dana (DEN) OXBH	25 June – 09 July	NSAS, WBSS, Sprat NS, Sprat 3.a	21, 31, 41, 42, 151, 152

Table 2.3.1.2. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June–July 2019. 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	4,573	15	0.00	3.3	7.7
1	10,146	384	0.01	37.8	16.6
2	1,303	137	0.59	105.1	22.8
3	2,345	339	0.97	144.5	25.2
4	1,212	196	0.99	161.8	26.1
5	3,506	718	1.00	204.8	27.8
6	1,657	374	1.00	225.8	28.6
7	395	95	1.00	240.3	29.3
8	252	65	1.00	258.0	30.1
9+	172	44	1.00	255.8	30.1
Immature	15,265	448		29.3	14.1
Mature	10,295	1,919		186.4	27.0
Total	25,560	2,366	0.40	92.6	19.3

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

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
1986	1639	3206	1637	833	135	36	24	6	8	7542	942
1987	13736	4303	955	657	368	77	38	11	20	20165	817
1988	6431	4202	1732	528	349	174	43	23	14	13496	897
1989	6333	3726	3751	1612	488	281	120	44	22	16377	1637
1990	6249	2971	3530	3370	1349	395	211	134	43	18262	2174
1991	3182	2834	1501	2102	1984	748	262	112	56	12781	1874
1992	6351	4179	1633	1397	1510	1311	474	155	163	17173	1545
1993	10399	3710	1855	909	795	788	546	178	116	19326	1216
1994	3646	3280	957	429	363	321	238	220	132	13003	1035
1995	4202	3799	2056	656	272	175	135	110	84	11220	1082
1996	6198	4557	2824	1087	311	99	83	133	206	18786	1446
1997	9416	6363	3287	1696	692	259	79	78	158	22028	1780
1998	4449	5747	2520	1625	982	445	170	45	121	16104	1792
1999	5087	3078	4725	1116	506	314	139	54	87	15107	1534
2000	24735	2922	2156	3139	1006	483	266	120	97	34928	1833
2001	6837	12290	3083	1462	1676	450	170	98	59	26124	2622
2002	23055	4875	8220	1390	795	1031	244	121	150	39881	2948
2003	9829	18949	3081	4189	675	495	568	146	178	38110	2999
2004	5183	3415	9191	2167	2590	317	328	342	186	23722	2584
2005	3113	1890	3436	5609	1211	1172	140	127	107	16805	1868
2006	6823	3772	1997	2098	4175	618	562	84	70	20199	2130
2007	6261	2750	1848	898	806	1323	243	152	65	14346	1203
2008	3714	2853	1709	1485	809	712	1749	185	270	20355	1784
2009	4655	5632	2553	1023	1077	674	638	1142	578	31526	2591
2010	14577	4237	4216	2453	1246	1332	688	1110	1619	43705	3027
2011	10119	4166	2534	2173	1016	651	688	440	1207	25524	2431

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
2012	7437	4718	4067	1738	1209	593	247	218	478	23641	2269
2013	6388	2683	3031	2895	1546	849	464	250	592	36484	2261
2014	11634	4918	2827	2939	1791	1236	669	211	250	61339	2610
2015	6714	9495	2831	1591	1549	926	520	275	221	24508	2280
2016	9034	12011	5832	1273	822	909	395	220	146	51686	2648
2017	3054	1761	6095	3142	787	365	298	153	140	30055	1943
2018	9938	4254	1692	5150	2440	719	529	293	111	32606	2337
2019	10146	1303	2345	1212	3506	1657	395	252	172	25560	1919

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		
2019	2488		5654	3794		10605		14082	5258	

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 2019 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	**Northwest**	**Northeast**	**Central west**	**Central east**	**Southwest**	**Southeast**	**Division 3.a**	**South'Bight**	**IBTS-0 index**
Area $m^2 \times 10^9$	83	34	86	102	37	93	31	31	
Year class									no. in 10^9
1991	0.227	0.074	0.364	0.444	0.466	0.329	0.330	0.259	164.0
1992	0.191	0.037	0.576	0.387	0.638	0.300	0.359	0.871	195.8
1993	0.574	0.231	0.545	0.178	0.117	0.140	0.223	0.322	155.1
1994	0.131	0.023	0.438	0.359	0.360	0.174	0.503	1.277	170.5
1995	0.222	0.053	0.644	0.069	0.246	0.015	0.015	0.424	107.0
1996	0.026	0.003	0.878	0.099	0.443	0.298	0.040	0.034	134.5
1997	0.039	0.021	0.295	0.059	0.181	0.035	0.021	0.186	51.7
1998	0.095	0.054	1.074	0.543	0.994	0.296	0.242	0.839	255.5
1999	0.042	0.011	0.725	0.149	0.316	0.141	0.105	0.043	111.1
2000	0.237	0.005	0.764	0.161	0.813	0.790	0.065	4.354	342.0
2001	0.076	0.018	0.528	0.456	0.487	0.301	0.261	NA	152.9
2002	0.117	0.031	0.241	0.030	0.127	0.058	0.003	0.841	70.9
2003	0.044	0.004	0.248	0.068	0.119	0.019	0.036	0.145	43.9
2004	0.016	0.008	0.205	0.097	0.511	0.228	0.053	0.399	83.3
2005	0.013	0.018	0.315	0.079	0.291	0.154	0.011	0.068	64.5

Area	Northwest	Northeast	Central west	Central east	Southwest	Southeast	Division 3.a	South'Bight	IBTS-0 index
Area m² x 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
2019	0.017	0.002	0.159	0.141	0.166	0.244	0.065	0.066	62.4

Table 2.3.3.2. North Sea herring. Indices of 1-ringers from the IBTS 1st Quarter for the 1995 to 2018 year classes (the data for the 1977 to 1994 year classes can be found in the stock annex). Estimation of the small sized component (possibly Downs herring) in different areas. " North Sea" = total area of sampling minus 3.a.

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

Year class	Year of sampling	All 1-ringers in total area (IBTS-1 index) (no/hour)	Small<13cm 1-ringers in total area (no/hour)	Proportion of small in total area vs. all sizes	Small<13cm 1-ringers in North Sea (no/hour)	Proportion of small in North Sea vs. all sizes	Proportion of small in 3.a vs.small in total area
2001	2003	2837	664	0.23	180	0.06	0.75
2002	2004	979	665	0.68	710	0.73	0.01
2003	2005	1015	341	0.34	357	0.35	0.02
2004	2006	900	115	0.13	121	0.13	0.02
2005	2007	1322	303	0.23	304	0.23	0.07
2006	2008	1792	417	0.23	444	0.25	0.01
2007	2009	2339	734	0.31	623	0.27	0.21
2008	2010	1206	279	0.23	286	0.24	0.05
2009	2011	2939	1331	0.45	1407	0.48	0.02
2010	2012	1353	279	0.21	288	0.21	0.04
2011	2013	1665	747	0.45	796	0.48	0.01
2012	2014	2615	1297	0.5	1245	0.48	0.11
2013	2015	3918	1808	0.46	1105	0.28	0.43
2014	2016	783	368	0.47	364	0.47	0.08
2015	2017	2396	1306	0.54	1008	0.42	0.28
2016	2018	778	406	0.52	424	0.55	0.03
2017	2019	1543	432	0.28	397	0.26	0.15
2018	2020	1021	168	0.16	150	0.15	0.17

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

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
2002	45	50	138	140	172	177	194	200	224	224	247	244	261	252	280	281	249	298
2003	46	65	104	119	185	177	209	198	214	210	243	236	281	247	290	272	307	282
2004	35	45	116	125	139	159	206	203	231	234	253	250	262	264	279	262	270	299
2005	43	53	135	124	171	177	181	201	229	234	248	249	253	261	274	287	295	270
2006	45	61	127	139	158	163	188	192	188	205	225	242	243	257	244	260	265	285
2007	66	75	123	153	155	171	171	183	204	215	198	211	218	252	247	263	233	273
2008	62	67	141	151	180	192	183	207	194	211	230	240	217	243	268	276	282	312
2009	56	56	148	166	208	217	236	242	232	259	240	261	266	274	249	274	263	292
2010	38	74	138	150	183	190	229	222	245	245	233	239	237	248	252	265	251	271
2011	35	86	151	155	171	176	210	201	242	227	258	244	249	246	252	253	275	267
2012	48	61	125	142	192	198	194	205	212	223	232	223	242	251	239	256	243	268
2013	38	48	131	149	161	170	221	217	210	207	236	222	257	252	249	254	252	265
2014	44	49	130	142	177	191	195	208	225	239	218	233	225	243	250	264	246	266
2015	49	33	121	134	146	168	183	212	200	226	220	253	205	243	210	255	229	276
2016	37	31	112	141	158	169	187	200	223	227	235	241	243	259	232	244	236	263
2017	43	47	100	109	156	167	178	187	198	207	225	235	233	242	237	254	230	252
2018	40	45	92	126	145	163	192	202	224	211	228	235	240	254	272	262	273	270
2019	38	51	105	137	145	158	162	179	205	218	226	219	240	235	258	255	256	263

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 2019. 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

Year \ Ring	2	3	4	5	6	7+
1995	72.6	95.4	100	100	100	100
1996	60.5	97.5	100	100	100	100
1997	64.0	94.2	100	100	100	100
1998	64.0	89.0	100	100	100	100
1999	81.0	91.0	100	100	100	100
2000	66.0	96.0	100	100	100	100
2001	77.0	92.0	100	100	100	100
2002	86.0	97.0	100	100	100	100
2003	43.0	93.0	100	100	100	100
2004	69.8	64.9	100	100	100	100
2005	76.0	97.0	96.0	100	100	100
2006	66.0	88.0	98.0	100	100	100
2007	71.0	92.0	93.0	100	100	100
2008	86.0	98.0	99.0	100	100	100
2009	89.0	100	100	100	100	100
2010	45.0	90.0	100	100	100	100
2011	87.0	84.0	99.0	100	100	100
2012	91.0	99.0	100	100	100	100
2013	83.0	96.0	98.0	100	100	100
2014	85.0	100	100	100	100	100
2015	70.0	90.0	96.0	98.0	99.0	100
2016	71.0	89.0	95.0	97.0	98.0	100
2017	55.0	96.0	97.0	98.0	98.0	100
2018	37.0	91.0	98.0	100	100	100
2019	59.0	97.0	99.0	100	100	100

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	1972–2019	1973–2019
IBTS 1st Quarter (Trawl survey)	1 wr	1971–2020	1984–2020
IBTS 3rd Quarter (Trawl survey)	0-5 wr	1991–2019	1998–2019
Acoustic (+trawl)	1 wr	1995–2019	1997–2019
	2-9+ wr	1984–2019	1989–2019
IBTS0	0wr	1977–2020	1992–2020

Table 2.6.2.1. North Sea Herring multifleet assessment. CATCH IN NUMBER

```
Units  :  thousands
, , area = A

   year
age   1997    1998    1999   2000   2001   2002   2003       2004
  0      0       0     900  14300      0      0   1700       0.00
  1  18400   19200   36900  93500  35600  77500  59200    2742.34
  2 445900 1024600  479700 486700 682400 427200 952900  252943.50
  3 419500  497300 1004700 470400 469200 874300 502000 1298647.98
  4 245600  252700  280700 587200 258200 281500 799100  510566.17
  5  85900  157300  130900 183000 293000 131400 240500  714620.51
  6  22800   81500   66600  77700  70200 159700 104700  168564.45
  7  10800   15100   25800  27800  39700  46000 118800   99086.33
  8  17900   18900   11800  18700  41000  40400  45100   91784.49
   year
age       2005        2006       2007       2008       2009       2010
  0     370.83    7626.329   20518.61   66326.54   39555.07       0.00
  1   42294.69   14317.025   21000.11   78367.74   20895.89   49098.41
  2  196263.51  334087.797  142145.56  259696.77  240765.77  237386.41
  3  469506.01  308175.624  412754.88  182805.52  108033.06  229567.90
  4 1313016.96  471796.256  284048.94  198652.09   96475.11  123132.74
  5  477572.01 1012566.583  307418.28  137305.38   87559.66   79783.41
  6  573577.13  257502.800  628121.13  118211.91   39482.25   57479.29
  7  114689.37  253325.080  146819.94  215029.23   57601.93   34204.88
  8  146939.01  109356.448  156120.28  117158.05  146172.09  115361.78
   year
age      2011      2012     2013      2014      2015      2016       2017
  0      0.01    964.83      0.0  51827.64      0.00      0.00       0.03
  1  10953.93  42583.90 220314.1 123489.43  22069.38   2266.73   11429.50
  2 306229.46 404364.31 218399.5 301326.88 454232.46 556167.33   74276.48
  3 270916.44 667132.00 481777.5 377968.23 240596.59 807104.45 1072939.39
  4 217634.40 402719.28 569285.6 612183.09 281558.31 292667.90  834803.34
  5 129485.21 305311.44 421526.1 482925.60 456147.89 281288.52  221588.33
  6  62683.39 149493.78 326237.7 282534.63 430922.75 368010.60  145439.64
  7  51767.93 104341.73 144913.5 190210.26 270074.10 308001.17  175489.28
  8 125119.00 197582.57 312128.9 212506.33 337460.94 360221.01  221268.20
   year
```

```
age       2018      2019
  0       0.04      0.00
  1    8556.77   6686.63
  2  175851.85  66073.41
  3  199400.70 292527.33
  4 1176811.03 197463.35
  5  847919.28 742358.54
  6  223453.20 543779.12
  7  144881.43 140033.26
  8  332397.32 224359.57

, , area = BD

   year
age   1997   1998    1999    2000    2001   2002   2003       2004
  0 448300 242990 1522300 1031400 1816600 787100 365500 702371.337
  1 259500 337250  112500  589900   47000 574500 390300 185134.240
  2  78300  54910   38400   28800   31000  83000 109400  71603.232
  3   9000   2980   22400    5400    9100  24000   2600  15440.534
  4   1100   5610    4700    6000   10700   1800   4600   4504.390
  5   2800   1120    1200     800    1100   1600    400   2897.281
  6    200    600     800     300    4800   1400    500    977.078
  7      0    100     300     300     500    200    500    299.094
  8      0    200       0    1300     100    200    100    512.507
   year
age        2005        2006       2007       2008       2009       2010
  0 1003835.615 864978.971 586298.647 727620.103 609519.988 643205.527
  1  498688.950 114605.971  64277.477  97442.846 105416.413 111048.081
  2   43321.434  28405.157  17371.465  19427.299  13252.754  10588.055
  3    3737.874   3859.262    209.353    194.806    435.122   3799.599
  4     620.600   4620.192     99.051     15.738      4.254   1093.668
  5     234.316   5962.889     79.327      0.893      0.000   3626.372
  6     327.427    147.662    102.353      0.402    201.157   5612.243
  7     198.327     87.525     12.457      0.356      0.000      0.000
  8       0.000    522.397      2.512      1.507      0.052      0.000
   year
age       2011       2012      2013        2014     2015        2016
  0 776665.373 771659.094 460672.00 1336408.279 536231.8 1583567.508
  1 129136.779 171619.280 128349.36  196353.428 322104.5   96041.970
  2   1747.186  14766.265  37946.21   20507.573  19630.0   28404.041
  3    157.498   4258.114    715.72    1816.481     90.0    9714.031
  4      0.000      0.000   1476.07    1632.259      0.0    1204.270
  5      0.000    732.084    466.07    2421.874     20.0      86.382
  6      0.000   1449.227    663.62     837.241      0.0     793.000
  7      0.000      0.000    349.61     808.671      0.0       0.000
  8      0.000    418.334    863.24    1187.871      0.0       0.000
   year
age      2017       2018   2019
  0 462000.31 1337301.27 543700
  1 122289.22   47122.62  62900
  2   7683.74    2180.96    300
  3      2.04      10.15    100
  4      0.00       0.00      0
```

5	0.00	0.00	0
6	0.00	0.00	0
7	0.00	0.00	0
8	0.00	0.00	0

, , area = C

age \ year	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	8900	18800	42000	63100	16100	10200	1900	13224.659	11348.035
1	249000	649500	180600	485400	344000	201000	167500	18781.670	174563.971
2	156000	141200	129300	105800	140900	51500	142100	114216.281	115852.028
3	67300	25600	50200	21400	16600	5100	12400	12034.393	12432.805
4	11800	18200	13000	19800	1400	700	16000	4433.049	4734.859
5	5500	2700	6000	7500	300	200	1800	8716.986	2142.120
6	1700	3100	1200	2900	500	100	1100	1608.338	1946.357
7	700	1200	400	300	0	0	1200	1857.617	276.878
8	900	500	400	100	0	0	200	848.599	160.680

age \ year	2006	2007	2008	2009	2010	2011
0	6031.506	14188.186	4338.255	967.532	63.893	2261.893
1	93313.152	150276.724	59212.038	49610.797	120464.527	19413.633
2	42052.087	59524.312	52575.827	6432.312	39362.171	59715.483
3	7329.826	1862.450	1683.228	343.800	284.818	3058.037
4	2417.487	346.167	234.935	217.338	144.577	277.768
5	2109.206	1362.359	146.281	0.000	99.120	171.243
6	416.577	158.925	56.015	0.000	16.488	117.299
7	290.241	620.013	330.892	0.000	59.490	93.709
8	129.495	16.100	63.793	102.543	13.971	18.963

age \ year	2012	2013	2014	2015	2016	2017	2018	2019
0	617.894	900	261.842	2000	0.000	148.46	102.51	6200
1	70566.848	64340	50303.335	50700	10846.292	75638.58	17581.87	95400
2	35450.808	68520	60071.599	77940	42121.171	26745.53	28198.77	19500
3	1822.980	2280	4985.472	6870	5877.935	6912.92	1115.21	4500
4	1140.440	340	544.423	1250	531.712	2967.48	1794.09	100
5	189.311	280	497.966	4870	213.924	1201.98	1041.36	100
6	195.812	0	173.621	1110	221.875	72.12	183.59	100
7	111.160	0	26.221	1200	34.396	45.37	122.36	0
8	29.343	0	55.559	350	63.288	28.42	89.75	0

Table 2.6.2.2. North Sea Herring multifleet assessment. WEIGHTS AT AGE IN THE CATCH

Units : kg

, , area = A

age \ year	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      2019
  0 0.0000000 0.0000000
  1 0.0890300 0.0574700
  2 0.1175900 0.1923500
  3 0.1453400 0.1498000
  4 0.1838400 0.1700300
  5 0.1914100 0.2041100
  6 0.2151200 0.2081100
  7 0.2342400 0.2190000
  8 0.2455873 0.2434669

, , 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        2019
  0 0.008428322 0.00700000 0.00890000 0.005449234 0.006064374
  1 0.020214437 0.02126004 0.02636988 0.026532076 0.031531002
  2 0.055000000 0.05212731 0.02479000 0.029537017 0.039000000
  3 0.095000000 0.08397668 0.07500000 0.048000000 0.065000000
  4 0.000000000 0.09300000 0.00000000 0.000000000 0.000000000
  5 0.147000000 0.07800000 0.00000000 0.000000000 0.000000000
  6 0.000000000 0.14600000 0.00000000 0.000000000 0.000000000
  7 0.000000000 0.00000000 0.00000000 0.000000000 0.000000000
  8 0.000000000 0.00000000 0.00000000 0.000000000 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
   year
age  2019
  0 0.022
  1 0.042
  2 0.062
  3 0.085
  4 0.116
  5 0.118
  6 0.165
  7 0.202
  8 0.000
```

Table 2.6.2.3. North Sea Herring multifleet assessment. WEIGHTS AT AGE IN THE STOCK

```
Units  :  kg
, , area = A

   year
age       1997        1998       1999        2000       2001        2002
  0 0.00500000 0.005666667 0.00600000 0.005666667 0.00600000 0.006333333
  1 0.04866667 0.047333333 0.05066667 0.051333333 0.05066667 0.047333333
  2 0.12333333 0.116000000 0.11600000 0.115666667 0.12166667 0.128000000
  3 0.18333333 0.187333333 0.17933333 0.183666667 0.17166667 0.171666667
  4 0.23033333 0.241333333 0.22633333 0.221333333 0.21000000 0.205333333
  5 0.23733333 0.264333333 0.25600000 0.248333333 0.23266667 0.228333333
  6 0.25666667 0.283666667 0.27333333 0.278666667 0.25533333 0.248333333
  7 0.28033333 0.286666667 0.27600000 0.286000000 0.27466667 0.270333333
  8 0.31004007 0.308339011 0.27811880 0.284171183 0.27449422 0.286521182
   year
age        2003        2004        2005        2006       2007       2008
  0 0.006666667 0.006666667 0.005666667 0.006666667 0.00600000 0.00800000
  1 0.047000000 0.042000000 0.041333333 0.041000000 0.05133333 0.05766667
  2 0.123000000 0.119333333 0.118000000 0.125666667 0.12800000 0.13033333
  3 0.173000000 0.165333333 0.164333333 0.155333333 0.16066667 0.16433333
  4 0.202333333 0.202666667 0.198000000 0.191000000 0.17966667 0.18066667
  5 0.222000000 0.223000000 0.224666667 0.216000000 0.20700000 0.19533333
  6 0.242333333 0.247666667 0.248000000 0.242000000 0.22366667 0.21766667
  7 0.265666667 0.267666667 0.265000000 0.252333333 0.23800000 0.22600000
  8 0.284946134 0.280490193 0.284851772 0.270150625 0.25639104 0.25556215
   year
age        2009        2010        2011       2012       2013        2014
  0 0.007333333 0.007333333 0.006666667 0.00600000 0.00600000 0.005666667
  1 0.061333333 0.052000000 0.043000000 0.04033333 0.04033333 0.043333333
  2 0.137333333 0.142333333 0.145666667 0.13800000 0.13566667 0.128666667
  3 0.181000000 0.190333333 0.187333333 0.18200000 0.17466667 0.176666667
  4 0.196666667 0.216000000 0.225000000 0.21133333 0.20866667 0.203666667
  5 0.210000000 0.223666667 0.239666667 0.23300000 0.22133333 0.215666667
  6 0.222666667 0.234333333 0.243666667 0.24100000 0.24200000 0.228666667
```

```
  7 0.233666667 0.240000000 0.250666667 0.24266667 0.24933333 0.241333333
  8 0.255734029 0.260650879 0.257270953 0.25251076 0.25179433 0.246572539
   year
age        2015       2016        2017        2018       2019
  0 0.005333333 0.00500000 0.004166667 0.004566667 0.00400000
  1 0.043666667 0.04333333 0.042866667 0.039966667 0.04023333
  2 0.127333333 0.12100000 0.110866667 0.101300000 0.09900000
  3 0.161333333 0.16033333 0.153166667 0.152966667 0.14846667
  4 0.200000000 0.18866667 0.182966667 0.185766667 0.17736667
  5 0.211666667 0.21600000 0.207100000 0.215033333 0.20896667
  6 0.224666667 0.22433333 0.226533333 0.229200000 0.22613333
  7 0.229000000 0.22433333 0.227066667 0.238766667 0.23786667
  8 0.239358137 0.23372066 0.229232697 0.246755779 0.25411003

, , area = BD

   year
age       1997        1998       1999        2000       2001        2002
  0 0.00500000 0.005666667 0.00600000 0.005666667 0.00600000 0.006333333
  1 0.04866667 0.047333333 0.05066667 0.051333333 0.05066667 0.047333333
  2 0.12333333 0.116000000 0.11600000 0.115666667 0.12166667 0.128000000
  3 0.18333333 0.187333333 0.17933333 0.183666667 0.17166667 0.171666667
  4 0.23033333 0.241333333 0.22633333 0.221333333 0.21000000 0.205333333
  5 0.23733333 0.264333333 0.25600000 0.248333333 0.23266667 0.228333333
  6 0.25666667 0.283666667 0.27333333 0.278666667 0.25533333 0.248333333
  7 0.28033333 0.286666667 0.27600000 0.286000000 0.27466667 0.270333333
  8 0.31004007 0.308339011 0.27811880 0.284171183 0.27449422 0.286521182
   year
age        2003        2004        2005        2006       2007       2008
  0 0.006666667 0.006666667 0.005666667 0.006666667 0.00600000 0.00800000
  1 0.047000000 0.042000000 0.041333333 0.041000000 0.05133333 0.05766667
  2 0.123000000 0.119333333 0.118000000 0.125666667 0.12800000 0.13033333
  3 0.173000000 0.165333333 0.164333333 0.155333333 0.16066667 0.16433333
  4 0.202333333 0.202666667 0.198000000 0.191000000 0.17966667 0.18066667
  5 0.222000000 0.223000000 0.224666667 0.216000000 0.20700000 0.19533333
  6 0.242333333 0.247666667 0.248000000 0.242000000 0.22366667 0.21766667
  7 0.265666667 0.267666667 0.265000000 0.252333333 0.23800000 0.22600000
  8 0.284946134 0.280490193 0.284851772 0.270150625 0.25639104 0.25556215
   year
age        2009        2010        2011       2012       2013        2014
  0 0.007333333 0.007333333 0.006666667 0.00600000 0.00600000 0.005666667
  1 0.061333333 0.052000000 0.043000000 0.04033333 0.04033333 0.043333333
  2 0.137333333 0.142333333 0.145666667 0.13800000 0.13566667 0.128666667
  3 0.181000000 0.190333333 0.187333333 0.18200000 0.17466667 0.176666667
  4 0.196666667 0.216000000 0.225000000 0.21133333 0.20866667 0.203666667
  5 0.210000000 0.223666667 0.239666667 0.23300000 0.22133333 0.215666667
  6 0.222666667 0.234333333 0.243666667 0.24100000 0.24200000 0.228666667
  7 0.233666667 0.240000000 0.250666667 0.24266667 0.24933333 0.241333333
  8 0.255734029 0.260650879 0.257270953 0.25251076 0.25179433 0.246572539
   year
age        2015       2016        2017        2018       2019
  0 0.005333333 0.00500000 0.004166667 0.004566667 0.00400000
  1 0.043666667 0.04333333 0.042866667 0.039966667 0.04023333
```

```
  2 0.127333333 0.12100000 0.110866667 0.101300000 0.09900000
  3 0.161333333 0.16033333 0.153166667 0.152966667 0.14846667
  4 0.200000000 0.18866667 0.182966667 0.185766667 0.17736667
  5 0.211666667 0.21600000 0.207100000 0.215033333 0.20896667
  6 0.224666667 0.22433333 0.226533333 0.229200000 0.22613333
  7 0.229000000 0.22433333 0.227066667 0.238766667 0.23786667
  8 0.239358137 0.23372066 0.229232697 0.246755779 0.25411003

, , area = C

   year
age       1997        1998       1999        2000       2001        2002
  0 0.00500000 0.005666667 0.00600000 0.005666667 0.00600000 0.006333333
  1 0.04866667 0.047333333 0.05066667 0.051333333 0.05066667 0.047333333
  2 0.12333333 0.116000000 0.11600000 0.115666667 0.12166667 0.128000000
  3 0.18333333 0.187333333 0.17933333 0.183666667 0.17166667 0.171666667
  4 0.23033333 0.241333333 0.22633333 0.221333333 0.21000000 0.205333333
  5 0.23733333 0.264333333 0.25600000 0.248333333 0.23266667 0.228333333
  6 0.25666667 0.283666667 0.27333333 0.278666667 0.25533333 0.248333333
  7 0.28033333 0.286666667 0.27600000 0.286000000 0.27466667 0.270333333
  8 0.31004007 0.308339011 0.27811880 0.284171183 0.27449422 0.286521182
   year
age        2003        2004        2005        2006       2007       2008
  0 0.006666667 0.006666667 0.005666667 0.006666667 0.00600000 0.00800000
  1 0.047000000 0.042000000 0.041333333 0.041000000 0.05133333 0.05766667
  2 0.123000000 0.119333333 0.118000000 0.125666667 0.12800000 0.13033333
  3 0.173000000 0.165333333 0.164333333 0.155333333 0.16066667 0.16433333
  4 0.202333333 0.202666667 0.198000000 0.191000000 0.17966667 0.18066667
  5 0.222000000 0.223000000 0.224666667 0.216000000 0.20700000 0.19533333
  6 0.242333333 0.247666667 0.248000000 0.242000000 0.22366667 0.21766667
  7 0.265666667 0.267666667 0.265000000 0.252333333 0.23800000 0.22600000
  8 0.284946134 0.280490193 0.284851772 0.270150625 0.25639104 0.25556215
   year
age        2009        2010        2011       2012       2013        2014
  0 0.007333333 0.007333333 0.006666667 0.00600000 0.00600000 0.005666667
  1 0.061333333 0.052000000 0.043000000 0.04033333 0.04033333 0.043333333
  2 0.137333333 0.142333333 0.145666667 0.13800000 0.13566667 0.128666667
  3 0.181000000 0.190333333 0.187333333 0.18200000 0.17466667 0.176666667
  4 0.196666667 0.216000000 0.225000000 0.21133333 0.20866667 0.203666667
  5 0.210000000 0.223666667 0.239666667 0.23300000 0.22133333 0.215666667
  6 0.222666667 0.234333333 0.243666667 0.24100000 0.24200000 0.228666667
  7 0.233666667 0.240000000 0.250666667 0.24266667 0.24933333 0.241333333
  8 0.255734029 0.260650879 0.257270953 0.25251076 0.25179433 0.246572539
   year
age        2015       2016        2017        2018       2019
  0 0.005333333 0.00500000 0.004166667 0.004566667 0.00400000
  1 0.043666667 0.04333333 0.042866667 0.039966667 0.04023333
  2 0.127333333 0.12100000 0.110866667 0.101300000 0.09900000
  3 0.161333333 0.16033333 0.153166667 0.152966667 0.14846667
  4 0.200000000 0.18866667 0.182966667 0.185766667 0.17736667
  5 0.211666667 0.21600000 0.207100000 0.215033333 0.20896667
  6 0.224666667 0.22433333 0.226533333 0.229200000 0.22613333
  7 0.229000000 0.22433333 0.227066667 0.238766667 0.23786667
```

```
  8 0.239358137 0.23372066 0.229232697 0.246755779 0.25411003
```

Table 2.6.2.4. North Sea Herring multifleet assessment. NATURAL MORTALITY

```
Units  :  NA
, , area = A

   year
age      1997      1998      1999      2000      2001      2002      2003
  0 0.8714153 0.8809581 0.8953693 0.9138225 0.9303382 0.9462271 0.9636406
  1 0.6323094 0.6414736 0.6612056 0.6887892 0.7089131 0.7237124 0.7391891
  2 0.4175451 0.4218480 0.4291405 0.4376797 0.4447908 0.4528783 0.4623603
  3 0.3407633 0.3411658 0.3447208 0.3494167 0.3550605 0.3641446 0.3756800
  4 0.3158974 0.3144479 0.3140061 0.3129517 0.3144011 0.3206260 0.3294129
  5 0.2949494 0.2944949 0.2949689 0.2952192 0.2974189 0.3032716 0.3111539
  6 0.2744636 0.2745619 0.2760781 0.2779683 0.2811793 0.2871590 0.2949874
  7 0.2684613 0.2687931 0.2699709 0.2713117 0.2737630 0.2783370 0.2843214
  8 0.2610349 0.2620768 0.2649014 0.2687185 0.2727170 0.2774175 0.2830219
   year
age      2004      2005      2006      2007      2008      2009      2010
  0 0.9778611 0.9924404 1.0051537 1.0126169 1.0176157 1.0160229 1.0077651
  1 0.7458320 0.7351250 0.7212731 0.7089871 0.6927028 0.6815790 0.6742762
  2 0.4675825 0.4670940 0.4651993 0.4606177 0.4534194 0.4486089 0.4455843
  3 0.3842515 0.3917235 0.3982069 0.3992761 0.3979235 0.3972307 0.3969625
  4 0.3371511 0.3469816 0.3567311 0.3614871 0.3648674 0.3680856 0.3710640
  5 0.3182483 0.3270457 0.3358458 0.3408919 0.3449711 0.3487946 0.3522990
  6 0.3020598 0.3098954 0.3176953 0.3228500 0.3272613 0.3316144 0.3358301
  7 0.2900766 0.2964710 0.3030145 0.3082212 0.3132112 0.3182143 0.3231951
  8 0.2882408 0.2937930 0.2992683 0.3031155 0.3064383 0.3102376 0.3144489
   year
age      2011      2012      2013      2014      2015      2016      2017
  0 0.9945248 0.9758610 0.9522143 0.9234139 0.8891311 0.8495409 0.8873620
  1 0.6682724 0.6657074 0.6645925 0.6661190 0.6716350 0.6800092 0.6725878
  2 0.4427270 0.4410072 0.4395108 0.4388913 0.4398892 0.4419012 0.4402272
  3 0.3960316 0.3949324 0.3931928 0.3911678 0.3893188 0.3873211 0.3892692
  4 0.3734170 0.3753545 0.3766790 0.3775302 0.3781232 0.3783272 0.3779935
  5 0.3552698 0.3578357 0.3598761 0.3615013 0.3628765 0.3639009 0.3627596
  6 0.3397322 0.3434756 0.3469157 0.3501437 0.3532930 0.3562775 0.3532380
  7 0.3281086 0.3330175 0.3378633 0.3426801 0.3475198 0.3523502 0.3475167
  8 0.3187356 0.3232706 0.3278875 0.3326709 0.3377392 0.3430125 0.3378075
   year
age      2018      2019
  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

, , area = BD

   year
age      1997      1998      1999      2000      2001      2002      2003
  0 0.8714153 0.8809581 0.8953693 0.9138225 0.9303382 0.9462271 0.9636406
  1 0.6323094 0.6414736 0.6612056 0.6887892 0.7089131 0.7237124 0.7391891
  2 0.4175451 0.4218480 0.4291405 0.4376797 0.4447908 0.4528783 0.4623603
  3 0.3407633 0.3411658 0.3447208 0.3494167 0.3550605 0.3641446 0.3756800
  4 0.3158974 0.3144479 0.3140061 0.3129517 0.3144011 0.3206260 0.3294129
  5 0.2949494 0.2944949 0.2949689 0.2952192 0.2974189 0.3032716 0.3111539
  6 0.2744636 0.2745619 0.2760781 0.2779683 0.2811793 0.2871590 0.2949874
  7 0.2684613 0.2687931 0.2699709 0.2713117 0.2737630 0.2783370 0.2843214
  8 0.2610349 0.2620768 0.2649014 0.2687185 0.2727170 0.2774175 0.2830219
   year
age      2004      2005      2006      2007      2008      2009      2010
  0 0.9778611 0.9924404 1.0051537 1.0126169 1.0176157 1.0160229 1.0077651
  1 0.7458320 0.7351250 0.7212731 0.7089871 0.6927028 0.6815790 0.6742762
  2 0.4675825 0.4670940 0.4651993 0.4606177 0.4534194 0.4486089 0.4455843
  3 0.3842515 0.3917235 0.3982069 0.3992761 0.3979235 0.3972307 0.3969625
  4 0.3371511 0.3469816 0.3567311 0.3614871 0.3648674 0.3680856 0.3710640
  5 0.3182483 0.3270457 0.3358458 0.3408919 0.3449711 0.3487946 0.3522990
  6 0.3020598 0.3098954 0.3176953 0.3228500 0.3272613 0.3316144 0.3358301
  7 0.2900766 0.2964710 0.3030145 0.3082212 0.3132112 0.3182143 0.3231951
  8 0.2882408 0.2937930 0.2992683 0.3031155 0.3064383 0.3102376 0.3144489
   year
age      2011      2012      2013      2014      2015      2016      2017
  0 0.9945248 0.9758610 0.9522143 0.9234139 0.8891311 0.8495409 0.8873620
  1 0.6682724 0.6657074 0.6645925 0.6661190 0.6716350 0.6800092 0.6725878
  2 0.4427270 0.4410072 0.4395108 0.4388913 0.4398892 0.4419012 0.4402272
  3 0.3960316 0.3949324 0.3931928 0.3911678 0.3893188 0.3873211 0.3892692
  4 0.3734170 0.3753545 0.3766790 0.3775302 0.3781232 0.3783272 0.3779935
  5 0.3552698 0.3578357 0.3598761 0.3615013 0.3628765 0.3639009 0.3627596
  6 0.3397322 0.3434756 0.3469157 0.3501437 0.3532930 0.3562775 0.3532380
  7 0.3281086 0.3330175 0.3378633 0.3426801 0.3475198 0.3523502 0.3475167
  8 0.3187356 0.3232706 0.3278875 0.3326709 0.3377392 0.3430125 0.3378075
   year
age      2018      2019
  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

, , area = C

   year
age      1997      1998      1999      2000      2001      2002      2003
```

```
  0 0.8714153 0.8809581 0.8953693 0.9138225 0.9303382 0.9462271 0.9636406
  1 0.6323094 0.6414736 0.6612056 0.6887892 0.7089131 0.7237124 0.7391891
  2 0.4175451 0.4218480 0.4291405 0.4376797 0.4447908 0.4528783 0.4623603
  3 0.3407633 0.3411658 0.3447208 0.3494167 0.3550605 0.3641446 0.3756800
  4 0.3158974 0.3144479 0.3140061 0.3129517 0.3144011 0.3206260 0.3294129
  5 0.2949494 0.2944949 0.2949689 0.2952192 0.2974189 0.3032716 0.3111539
  6 0.2744636 0.2745619 0.2760781 0.2779683 0.2811793 0.2871590 0.2949874
  7 0.2684613 0.2687931 0.2699709 0.2713117 0.2737630 0.2783370 0.2843214
  8 0.2610349 0.2620768 0.2649014 0.2687185 0.2727170 0.2774175 0.2830219
   year
age      2004      2005      2006      2007      2008      2009      2010
  0 0.9778611 0.9924404 1.0051537 1.0126169 1.0176157 1.0160229 1.0077651
  1 0.7458320 0.7351250 0.7212731 0.7089871 0.6927028 0.6815790 0.6742762
  2 0.4675825 0.4670940 0.4651993 0.4606177 0.4534194 0.4486089 0.4455843
  3 0.3842515 0.3917235 0.3982069 0.3992761 0.3979235 0.3972307 0.3969625
  4 0.3371511 0.3469816 0.3567311 0.3614871 0.3648674 0.3680856 0.3710640
  5 0.3182483 0.3270457 0.3358458 0.3408919 0.3449711 0.3487946 0.3522990
  6 0.3020598 0.3098954 0.3176953 0.3228500 0.3272613 0.3316144 0.3358301
  7 0.2900766 0.2964710 0.3030145 0.3082212 0.3132112 0.3182143 0.3231951
  8 0.2882408 0.2937930 0.2992683 0.3031155 0.3064383 0.3102376 0.3144489
   year
age      2011      2012      2013      2014      2015      2016      2017
  0 0.9945248 0.9758610 0.9522143 0.9234139 0.8891311 0.8495409 0.8873620
  1 0.6682724 0.6657074 0.6645925 0.6661190 0.6716350 0.6800092 0.6725878
  2 0.4427270 0.4410072 0.4395108 0.4388913 0.4398892 0.4419012 0.4402272
  3 0.3960316 0.3949324 0.3931928 0.3911678 0.3893188 0.3873211 0.3892692
  4 0.3734170 0.3753545 0.3766790 0.3775302 0.3781232 0.3783272 0.3779935
  5 0.3552698 0.3578357 0.3598761 0.3615013 0.3628765 0.3639009 0.3627596
  6 0.3397322 0.3434756 0.3469157 0.3501437 0.3532930 0.3562775 0.3532380
  7 0.3281086 0.3330175 0.3378633 0.3426801 0.3475198 0.3523502 0.3475167
  8 0.3187356 0.3232706 0.3278875 0.3326709 0.3377392 0.3430125 0.3378075
   year
age      2018      2019
  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 2.6.2.5. North Sea Herring multifleet assessment. PROPORTION MATURE

```
Units  :  NA
, , area = A

   year
age 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
```

```
  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 0.64 0.64 0.69 0.67 0.77 0.87 0.43 0.70 0.76 0.66 0.71 0.86 0.89 0.45
  3 0.94 0.89 0.91 0.96 0.92 0.97 0.93 0.65 0.96 0.88 0.92 0.98 1.00 0.90
  4 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 0.96 0.98 0.93 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 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 2011 2012 2013 2014 2015 2016 2017 2018 2019
  0 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
  2 0.87 0.91 0.83 0.85 0.70 0.71 0.55 0.37 0.59
  3 0.84 0.99 0.96 1.00 0.90 0.89 0.96 0.91 0.97
  4 1.00 1.00 0.98 1.00 0.96 0.95 0.97 0.98 0.99
  5 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
  7 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

, , area = BD

   year
age 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  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 0.64 0.64 0.69 0.67 0.77 0.87 0.43 0.70 0.76 0.66 0.71 0.86 0.89 0.45
  3 0.94 0.89 0.91 0.96 0.92 0.97 0.93 0.65 0.96 0.88 0.92 0.98 1.00 0.90
  4 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 0.96 0.98 0.93 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 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 2011 2012 2013 2014 2015 2016 2017 2018 2019
  0 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
  2 0.87 0.91 0.83 0.85 0.70 0.71 0.55 0.37 0.59
  3 0.84 0.99 0.96 1.00 0.90 0.89 0.96 0.91 0.97
  4 1.00 1.00 0.98 1.00 0.96 0.95 0.97 0.98 0.99
  5 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
  7 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

, , area = C

   year
age 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  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 0.64 0.64 0.69 0.67 0.77 0.87 0.43 0.70 0.76 0.66 0.71 0.86 0.89 0.45
```

```
  3 0.94 0.89 0.91 0.96 0.92 0.97 0.93 0.65 0.96 0.88 0.92 0.98 1.00 0.90
  4 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 0.96 0.98 0.93 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 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 2011 2012 2013 2014 2015 2016 2017 2018 2019
  0 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
  2 0.87 0.91 0.83 0.85 0.70 0.71 0.55 0.37 0.59
  3 0.84 0.99 0.96 1.00 0.90 0.89 0.96 0.91 0.97
  4 1.00 1.00 0.98 1.00 0.96 0.95 0.97 0.98 0.99
  5 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
  7 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
```

Table 2.6.2.6. North Sea Herring multifleet assessment. FRACTION OF HARVEST BEFORE SPAWNING

```
Units  :  NA
, , area = A

   year
age 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 2011 2012 2013 2014 2015 2016 2017 2018 2019
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  1 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
  3 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
  5 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
  7 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

, , area = BD

   year
age 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
```

```
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 2011 2012 2013 2014 2015 2016 2017 2018 2019
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  1 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
  3 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
  5 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
  7 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

, , area = C

   year
age 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 2011 2012 2013 2014 2015 2016 2017 2018 2019
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  1 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
  3 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
  5 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
  7 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
```

Table 2.6.2.7. North Sea Herring multifleet assessment. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

```
Units  :  NA
, , area = A

   year
age 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 2011 2012 2013 2014 2015 2016 2017 2018 2019
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  1 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
  3 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
  5 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
  7 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

, , area = BD

   year
age 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 2011 2012 2013 2014 2015 2016 2017 2018 2019
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  1 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
  3 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
  5 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
  7 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
```

```
, , area = C

   year
age 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 2011 2012 2013 2014 2015 2016 2017 2018 2019
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  1 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
  3 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
  5 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
  7 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
```

Table 2.6.2.8. North Sea Herring multifleet assessment. SURVEY INDICES

HERAS - Configuration

```
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) (16/Mar/2020) . Imported
from VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
     1.00      8.00      8.00   1989.00   2019.00      0.54      0.56
Index type : number

HERAS - Index Values

Units  :  NA
   year
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
   year
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
   year
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
   year
age    2013     2014    2015     2016    2017    2018     2019
  1 6388000 11634000 6714000  9034000 3054000 9938000 10146000
  2 2683000  4918000 9495000 12011000 1761000 4254000  1303000
  3 3031000  2827000 2831000  5832000 6095000 1692000  2345000
  4 2895000  2939000 1591000  1273000 3142000 5150000  1212000
  5 1546000  1791000 1549000   822000  787000 2440000  3506000
  6  849000  1236000  926000   909000  365000  719000  1657000
  7  464000   669000  520000   395000  298000  529000   395000
  8  842000   461000  496000   366000  293000  404000   424000
```

IBTS-Q1 - Configuration

```
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) (16/Mar/2020) . Imported
from VPA file.
         min          max    plusgroup      minyear      maxyear
   1.0000000    1.0000000           NA 1984.0000000 2020.0000000
      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 957324 1473183 1662159 3221178 1464182 1677569 768368.2 1085666
   year
age    1992    1993    1994    1995    1996    1997    1998     1999
  1 1147216 1838663 2812005 2266363 1277320 1350215 1804583 698806.6
   year
age    2000    2001    2002    2003     2004     2005     2006     2007
  1 2096596 1605575 1820055 1426762 771457.8 925583.4 717821.2 883302.7
   year
age     2008     2009     2010    2011     2012     2013    2014    2015
```

```
  1 774710.1 732798.5 916572.8 1613673 824527.6 505955.1 1645682 1943846
   year
age   2016    2017     2018     2019    2020
  1 558363 1361551 689636.3 970111.9 1145081
```

IBTS0 - Configuration

```
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) (16/Mar/2020) . Imported
from VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      0.00        NA   1992.00   2020.00      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     2020
  0 113.7963 21.76008 81.69031 27.83202 102.1129 51.62587 62.41121
```

IBTS-Q3 - Configuration

```
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) (16/Mar/2020) . Imported
from VPA file.
         min          max    plusgroup      minyear      maxyear
   0.0000000    5.0000000           NA 1998.0000000 2019.0000000
      startf         endf
   0.6084662    0.6084662
Index type : number

IBTS-Q3 - Index Values

Units  :  NA
   year
age      1998       1999       2000       2001       2002      2003
  0 707529.29 4233846.75 1620038.45 1714578.46 2055109.72 833224.14
  1 415995.22  290830.27  763292.82  317776.68 1940710.52 467668.41
  2 281888.09  205967.99  256000.32  219364.82  438205.77 557140.92
  3  90723.61  122047.54  115690.52   93775.23  341437.92 145835.21
  4  24717.72   49316.26   66902.87   41645.09   79278.42 109662.86
  5  10726.45   17602.24   17044.41   25305.84   31226.51  18512.78
   year
age       2004       2005      2006       2007      2008       2009
  0 1970515.25 1005504.45 962447.25 2086570.65 524669.09 2654058.23
```

```
  1  384254.10  382307.62 288008.48  132097.51 150256.12  199023.94
  2  281709.01  112453.04 192018.99   92766.30 112671.15   93460.99
  3  411046.51   81907.19  77885.34   97733.80  58448.44   61031.71
  4   93091.92   96320.65  45055.96   48852.73  34431.66   25875.50
  5   48867.94   30631.40  51266.22   29610.43  18428.13   11714.79
   year
age       2010      2011      2012       2013       2014      2015
  0 1236261.22 765326.25 730383.60 1692837.79 6751020.89 486178.94
  1  503511.61 312408.38 204328.24  256455.03  433998.02 714517.44
  2  172333.79 173233.15  89601.62  139602.35  191263.38 348475.49
  3   79991.16  97020.29  64651.12  119332.48   85553.69 123410.84
  4   35528.12  48163.41  36532.75   81910.09   75575.16  64702.78
  5   14991.30  20709.64  21092.99   38385.03   42936.54  43663.74
   year
age       2016      2017       2018       2019
  0 1581744.08 796376.86 1761034.92 1400298.87
  1  169323.28 275389.01  324256.82  136400.79
  2  359009.05  76519.79  113537.58   70812.24
  3  206745.55 193058.61   47077.15   39172.62
  4   64513.46 123311.33   83658.56   24716.52
  5   40839.27  39288.74   37960.22   34846.04
```

LAI-ORSH - Configuration

```
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      1.00      1.00   1972.00   2019.00      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 2019
  0    -1    -1   -1   -1   -1   -1   -1 2488
  1 19552 21282 6604 9631   -1   -1  102   -1
```

LAI-BUN - Configuration

```
      min       max plusgroup   minyear   maxyear    startf      endf
```

```
     0.00      1.00      1.00   1972.00   2019.00      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 2019
  0   -1   -1   -1   -1   -1 5654
  1 5033 3496 3872 5833 1740 3794
```

LAI-CNS - Configuration

```
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      3.00      3.00   1972.00   2019.00      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  2019
```

```
  0   -1   -1   -1   -1   -1   -1    -1
  1 7354 1149 3424 3288 3965 1509 10605
  2   -1   -1   -1   -1   -1   -1    -1
  3   -1   -1   -1   -1   -1   -1    -1
```

LAI-SNS - Configuration

```
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      2.00      2.00   1972.00   2019.00      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  2019
  0    5   -1 2011 20710 10553 1140 14082
  1 9314   -1 1200  1442  5880   -1  5258
  2 2957 1851  645  1545    -1   -1    -1
```

Table 2.6.2.9. North Sea Herring multifleet assessment. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1997      2019         2         6
```

Table 2.6.2.10. North Sea Herring multifleet assessment. sam CONFIGURATION SETTINGS

```
name           : North Sea herring multifleet
desc            : Imported from a VPA file. ( ./data/index.txt ).  Tue Mar 24 12:15:33
2020
range          :       min       max plusgroup   minyear   maxyear   minfbar   maxfbar
range          :         0         8         8      1947      2020         2         6
fleets         :  catch A catch BD  catch C    HERAS  IBTS-Q1    IBTS0  IBTS-Q3 LAI-ORSH
```

```
fleets         :        0        0        0        2        2        2        2        6
fleets         :  LAI-BUN  LAI-CNS  LAI-SNS sumFleet
fleets         :        6        6        6        7
plus.group     : TRUE
states         :           age
states         : fleet       0  1  2  3  4  5  6  7  8
states         :   catch A  -1  0  1  2  3  4  5  6  6
states         :   catch BD  7  8  9 10 10 10 -1 -1 -1
states         :   catch C  -1 11 12 13 14 14 14 -1 -1
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
states         :   sumFleet -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 A  -1 -1 -1 -1 -1 -1 -1 -1 -1
catchabilities :   catch BD -1 -1 -1 -1 -1 -1 -1 -1 -1
catchabilities :   catch C  -1 -1 -1 -1 -1 -1 -1 -1 -1
catchabilities :   HERAS    -1  2  3  4  4  4  4  4  4
catchabilities :   IBTS-Q1  -1  0 -1 -1 -1 -1 -1 -1 -1
catchabilities :   IBTS0     1 -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
catchabilities :   sumFleet -1 -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 A  -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :   catch BD -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps :   catch C  -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
power.law.exps :   sumFleet -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 A  -1  0  0  0  0  0  1  1  1
f.vars         :   catch BD  2  3  3  3  3  3 -1 -1 -1
f.vars         :   catch C  -1  4  5  6  6  6  6 -1 -1
```

```
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
f.vars         :   sumFleet -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 A  -1  0  1  1  1  1  2  2  2
obs.vars       :   catch BD  3  4  5  5  5  5 -1 -1 -1
obs.vars       :   catch C  -1  6  7  8  8  8  8 -1 -1
obs.vars       :   HERAS    -1  9 10 10 10 10 10 11 11
obs.vars       :   IBTS-Q1  -1 12 -1 -1 -1 -1 -1 -1 -1
obs.vars       :   IBTS0    13 -1 -1 -1 -1 -1 -1 -1 -1
obs.vars       :   IBTS-Q3  14 15 16 16 16 16 -1 -1 -1
obs.vars       :   LAI-ORSH 17 -1 -1 -1 -1 -1 -1 -1 -1
obs.vars       :   LAI-BUN  17 -1 -1 -1 -1 -1 -1 -1 -1
obs.vars       :   LAI-CNS  17 -1 -1 -1 -1 -1 -1 -1 -1
obs.vars       :   LAI-SNS  17 -1 -1 -1 -1 -1 -1 -1 -1
obs.vars       :   sumFleet -1 -1 -1 -1 -1 -1 -1 -1 -1
srr            : 0
scaleNoYears   : 0
scaleYears     : NA
scalePars      :
cor.F          : 2 2 2
cor.obs        : NA NA NA -1 -1 -1 0 -1 -1 -1 -1 -1 NA NA NA NA -1 -1 0 -1 -1 -1 -1 -1 NA
NA NA NA -1 -1 0 -1 -1 -1 -1 -1 NA NA NA NA -1 -1 0 -1 -1 -1 -1 -1 NA NA NA NA -1 -1 0 -
1 -1 -1 -1 -1 NA NA NA NA -1 -1 -1 -1 -1 -1 -1 NA NA NA NA -1 -1 -1 -1 -1 -1 -1 -1 NA
NA NA NA -1 -1 -1 -1 -1 -1 -1 -1
cor.obs.Flag   : ID ID ID ID ID ID AR ID ID ID ID NA
biomassTreat   : -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
timeout        : 3600
likFlag        : LN LN LN LN LN LN LN LN LN LN LN LN
fixVarToWeight : FALSE
simulate       : FALSE
residuals      : TRUE
sumFleets      : A BD C
```

Table 2.6.2.11. North Sea Herring multifleet assessment. FLR, R SOFTWARE VERSIONS

```
FLSAM.version                       2.1.0
FLCore.version                     2.6.14
R.version      R version 3.6.3 (2020-02-29)
platform                x86_64-w64-mingw32
run.date              2020-03-24 12:34:49
```

Table 2.6.2.12. North Sea Herring multifleet assessment. STOCK SUMMARY

Year	Recruitment Age 0 thousands	Low thousands	High thousands	TSB	Low	High	SSB	Low	High	Fbar (Ages 2-6) f	Low f	High f	Landings tonnes	Landings SOP
1947	52991791	28959058	96968966	10182377	7558234	13717598	6004208	4224937	8532794	0.1098	0.0758	0.1591	264313	0.7395
1948	51205504	29578664	88645099	8722658	6540741	11632440	4863393	3458677	6838624	0.1057	0.0743	0.1504	391628	0.7829
1949	44906588	26215653	76923569	8233940	6258653	10832645	4512407	3260996	6244048	0.1277	0.0907	0.1799	363163	0.8691
1950	62694268	37276080	105444865	8024248	6179703	10419362	4355691	3208857	5912400	0.1315	0.0952	0.1815	388157	0.8133
1951	59766910	35837309	99674991	8074743	6290607	10364893	3996319	2976375	5365776	0.1644	0.1210	0.2234	374065	0.7886
1952	57849822	34969560	95700429	7889542	6162276	10100955	3908720	2914714	5241712	0.1823	0.1343	0.2475	394709	0.8206
1953	62201288	38790782	99740196	7605773	5953404	9716758	3686851	2740498	4960000	0.1879	0.1382	0.2555	482281	0.9027
1954	58957444	37088914	93720192	7401781	5806772	9434909	3387762	2494386	4601106	0.2265	0.1651	0.3108	587698	0.9074
1955	49110768	31172925	77370588	7067425	5540572	9015044	3422641	2528820	4632387	0.1971	0.1440	0.2696	663813	0.9223
1956	36514524	23219020	57423202	6481474	5107127	8225663	3249030	2406238	4387013	0.2024	0.1488	0.2752	514597	0.9662
1957	83883083	53001531	132757894	6369278	5052514	8029211	2913990	2162317	3926963	0.2199	0.1619	0.2986	406482	0.9390
1958	35484096	22725988	55404460	6380864	5053619	8056688	2436269	1814392	3271290	0.2031	0.1513	0.2728	257870	0.9259
1959	39390387	24676953	62876588	6952901	5561109	8693019	3575962	2686718	4759527	0.2477	0.1857	0.3305	168443	0.9364
1960	16313220	10272494	25906188	5799946	4659964	7218805	3072850	2325315	4060699	0.2025	0.1531	0.2678	187611	0.8779
1961	75349457	47446872	119661012	5959766	4851340	7321445	3038371	2342057	3941706	0.2246	0.1734	0.2908	226478	0.9146
1962	36030060	23316838	55675012	5543974	4526510	6790143	2055679	1572195	2687845	0.2737	0.2119	0.3534	434710	0.9534
1963	41920335	27641073	63576203	6313396	5201838	7662478	3322441	2614466	4222130	0.1600	0.1270	0.2017	511416	0.9583
1964	42741114	28272819	64613396	5977794	5119467	6980026	2868973	2344414	3510901	0.2531	0.2076	0.3086	517356	0.9474
1965	21402505	14157529	32355026	5190566	4546099	5926394	2152434	1794092	2582350	0.4910	0.4108	0.5867	494099	0.9548
1966	22140466	14810753	33097590	3881532	3414914	4411910	1737658	1459292	2069123	0.4531	0.3820	0.5375	563610	0.9672
1967	28941643	19385217	43209146	2938348	2608794	3309533	1018483	866856	1196632	0.6478	0.5558	0.7551	498437	0.9715
1968	28882628	19242058	43353275	2478060	2166903	2833898	544234	461874	641280	1.0303	0.8993	1.1803	603536	0.9821
1969	14738320	9692645	22410609	1922551	1647326	2243759	496825	402606	613094	0.8544	0.7409	0.9852	442138	0.9962
1970	28538403	18979149	42912380	1874355	1611684	2179835	484859	391164	600997	0.9086	0.7875	1.0484	264313	0.0715
1971	22366928	15035107	33274088	1724896	1462461	2034425	303814	247069	373591	1.3591	1.1944	1.5466	391628	0.0522
1972	15371473	10340777	22849556	1560332	1331761	1828134	377045	305239	465743	0.5507	0.4694	0.6460	363163	0.0658

1973	8232281	5519746	12277820	1233858	1074732	1416544	302463	248704	367843	0.8840	0.7663	1.0197	388157	0.0772
1974	13675474	9021594	20730107	886037	764575	1026795	209290	172993	253201	0.8314	0.7177	0.9633	374065	0.0742
1975	3346609	2166095	5170499	709983	590380	853815	117124	94603	145007	1.0855	0.9154	1.2871	394709	0.0788
1976	4495132	2808463	7194758	548019	446078	673256	174443	128265	237247	0.7402	0.5612	0.9762	482281	0.0426
1977	5607178	3425443	9178505	409324	319547	524326	139645	99138	196702	0.2607	0.1851	0.3670	587698	0.0411
1978	6170981	3707256	10272018	488006	374391	636100	168359	122609	231179	0.1817	0.1084	0.3048	663813	0.0471
1979	10986797	6850244	17621230	640962	503683	815656	222744	168467	294510	0.1492	0.0891	0.2497	514597	0.0301
1980	16504934	10971576	24828961	863837	695986	1072169	254619	199342	325223	0.1351	0.1040	0.1757	406482	0.0256
1981	34408394	23129535	51187263	1397145	1128109	1730340	334338	262817	425322	0.2101	0.1644	0.2685	257870	0.0427
1982	55482702	37690139	81674683	2114055	1708635	2615671	477993	380443	600555	0.1550	0.1234	0.1948	168443	0.0588
1983	54151411	37385004	78437209	2808494	2315367	3406646	655858	527099	816070	0.2285	0.1850	0.2822	187611	0.0580
1984	55874003	38585393	80908967	3643777	3064708	4332259	1021553	821733	1269962	0.3112	0.2551	0.3798	226478	0.0458
1985	67628119	46368088	98635995	4186184	3548802	4938044	1105111	899104	1358318	0.4014	0.3295	0.4892	434710	0.0347
1986	82502703	56417845	120647927	4792784	4039818	5686091	1160239	948461	1419304	0.3730	0.3054	0.4557	511416	0.0192
1987	74143208	50875740	108051800	4860334	4128607	5721748	1426414	1164893	1746646	0.3369	0.2767	0.4104	517356	0.0347
1988	46380904	31939638	67351679	4725075	4051856	5510149	1849838	1515166	2258433	0.3225	0.2663	0.3906	494099	0.0245
1989	37800213	25961645	55037196	4200862	3664696	4815472	1906032	1604067	2264841	0.3109	0.2595	0.3724	563610	0.0278
1990	33113193	22653210	48403009	4224824	3681285	4848616	2084211	1756968	2472403	0.2446	0.2029	0.2948	498437	0.0151
1991	36340449	24980554	52866252	4033996	3518114	4625525	1854577	1569569	2191338	0.2609	0.2167	0.3141	603536	0.0143
1992	64886378	46426840	90685519	4060745	3529258	4672270	1433654	1206595	1703442	0.3068	0.2541	0.3704	442138	0.0120
1993	69218686	49053652	97673188	3783664	3249829	4405190	1032400	858900	1240948	0.3584	0.2953	0.4350	264313	0.1274
1994	56623356	39884189	80387857	3698973	3129445	4372150	1095452	913896	1313076	0.3589	0.2962	0.4348	391628	0.1494
1995	60132094	42274047	85534009	3622192	3066873	4278062	1157811	958865	1398034	0.3245	0.2656	0.3963	363163	0.0863
1996	49202715	34880132	69406479	3618899	3061167	4278248	1361588	1130285	1640227	0.1566	0.1276	0.1923	388157	0.0957
1997	40897657	28727869	58222849	3627940	3090961	4258206	1520407	1269411	1821033	0.1410	0.1151	0.1727	374065	0.0961
1998	26097797	18678175	36464752	3930170	3370618	4582613	1731007	1457380	2056008	0.1806	0.1484	0.2198	394709	0.0430
1999	82296940	58675493	115427858	3957639	3407932	4596014	1814787	1526066	2158131	0.1720	0.1419	0.2084	482281	0.0502
2000	52967526	38074554	73685926	4862836	4147638	5701359	1858523	1565784	2205992	0.1706	0.1407	0.2069	587698	0.0229
2001	103526184	72804840	147210965	5405738	4623221	6320702	2392285	2015120	2840043	0.1443	0.1184	0.1760	663813	0.0345
2002	50643694	36275387	70703140	6465567	5498968	7602074	2827762	2383165	3355303	0.1345	0.1106	0.1635	514597	0.0226
2003	26880540	19308585	37421873	6848854	5859560	8005176	2901026	2458386	3423365	0.1583	0.1306	0.1919	406482	0.0404
2004	32082787	22989814	44772230	5635108	4865534	6526403	2781992	2360573	3278644	0.1913	0.1578	0.2320	257870	0.0359

2005	29512069	21291659	40906263	4692038	4082992	5391933	2508143	2120417	2966765	0.2386	0.1967	0.2895	168443	0.0299
2006	29168218	20968570	40574294	4042890	3515191	4649808	2076919	1756956	2455151	0.2158	0.1776	0.2621	187611	0.0635
2007	34859596	24673960	49249957	3345195	2897726	3861763	1625697	1372055	1926227	0.1888	0.1550	0.2299	226478	0.0292
2008	30976399	21918072	43778361	3487659	2992184	4065179	1739228	1468404	2060000	0.1140	0.0937	0.1387	434710	0.0177
2009	48658402	34740116	68152913	4118124	3517964	4820670	2169060	1826299	2576151	0.0625	0.0512	0.0764	511416	0.0230
2010	39880153	28682660	55449064	4900119	4193367	5725988	2276098	1911261	2710578	0.0622	0.0510	0.0759	517356	0.0184
2011	34377544	24721636	47804909	4863130	4195675	5636765	2688053	2289857	3155494	0.0827	0.0684	0.1000	494099	0.0207
2012	32187823	23079811	44890140	4732003	4103769	5456411	2757176	2348553	3236894	0.1515	0.1255	0.1830	563610	0.0072
2013	42409242	30137771	59677398	4561058	3972548	5236751	2507560	2139319	2939185	0.1772	0.1468	0.2141	498437	0.0149
2014	65013622	45783068	92321710	4964611	4312835	5714887	2500227	2130852	2933632	0.1715	0.1418	0.2074	603536	0.0052
2015	17311934	12270662	24424359	5267635	4539817	6112135	2349471	2000668	2759086	0.1797	0.1481	0.2179	442138	0.0131
2016	32077307	23065028	44610985	5209596	4474858	6064973	2745638	2320700	3248385	0.1986	0.1635	0.2413		
2017	19757648	14016840	27849692	4403858	3785983	5122570	2446245	2053316	2914365	0.1647	0.1358	0.1999	264313	0.7395
2018	33481370	23323890	48062400	4105874	3533190	4771382	2126005	1771859	2550935	0.1945	0.1590	0.2380	391628	0.7829
2019	32355791	21764990	48100055	3370357	2857605	3975115	1750201	1429110	2143435	0.1704	0.1346	0.2157	363163	0.8691
2020	29721206	16312145	54152908	3043156	2426383	3816709	1407211	1048360	1888896	0.1704	0.0788	0.3682	388157	0.8133

Table 2.6.2.13. North Sea Herring multifleet assessment. ESTIMATED FISHING MORTALITY

```
Units  :  f
, , area = A

   year
age        1947        1948       1949        1950        1951        1952
  0 0.000000000 0.000000000 0.00000000 0.000000000 0.000000000 0.000000000
  1 0.001191938 0.001164389 0.00143109 0.001849824 0.002824751 0.003415827
  2 0.036413130 0.035271910 0.04434182 0.058412382 0.091761175 0.111916450
  3 0.083940748 0.083828114 0.09866455 0.115439723 0.158458577 0.166385124
  4 0.097078133 0.098205470 0.11535596 0.130810401 0.174239599 0.179617084
  5 0.127567209 0.125973280 0.14562958 0.148834883 0.180538424 0.193234881
  6 0.202791843 0.184112708 0.23284002 0.201122672 0.213221589 0.255406534
  7 0.226493841 0.206773311 0.27369395 0.217205749 0.208870106 0.284997966
  8 0.226493841 0.206773311 0.27369395 0.217205749 0.208870106 0.284997966
   year
age        1953        1954        1955        1956        1957
  0 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.004023518 0.005078631 0.005434346 0.006253664 0.006657265
  2 0.132736834 0.169854963 0.181439952 0.210059221 0.223445436
  3 0.179836383 0.214714272 0.205329380 0.215787431 0.225425585
  4 0.181970074 0.206385464 0.184007519 0.184996065 0.196787801
  5 0.193994438 0.223542229 0.190766053 0.188574680 0.210137273
  6 0.245044318 0.310991417 0.215463807 0.204095330 0.234403979
  7 0.268295977 0.337778627 0.195506869 0.203730127 0.229441681
  8 0.268295977 0.337778627 0.195506869 0.203730127 0.229441681
   year
age        1958        1959        1960        1961        1962
  0 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.007025144 0.008113512 0.006895489 0.007543924 0.007441785
  2 0.235737401 0.274530107 0.229016556 0.251754394 0.246725873
  3 0.227380659 0.260681393 0.210487355 0.241162823 0.278021164
  4 0.188120714 0.223182935 0.179691893 0.209502151 0.257293157
  5 0.189805719 0.224336084 0.181160717 0.202608319 0.261975152
  6 0.165677853 0.246125379 0.202192563 0.208997055 0.316686162
  7 0.141543084 0.244574129 0.228444944 0.199241824 0.300345024
  8 0.141543084 0.244574129 0.228444944 0.199241824 0.300345024
   year
age        1963        1964       1965       1966      1967       1968
  0 0.000000000 0.000000000 0.00000000 0.00000000 0.0000000 0.00000000
  1 0.005676455 0.008348186 0.01416961 0.01290248 0.0153944 0.02659002
  2 0.182415429 0.275605823 0.48753762 0.43804677 0.5280325 0.95284878
  3 0.188301708 0.292193120 0.54537737 0.51364056 0.6848348 1.20259972
  4 0.155818884 0.249895479 0.47757385 0.45284489 0.6239498 0.95158491
  5 0.150293852 0.240023672 0.46579107 0.45807028 0.6503287 0.90569195
  6 0.114295600 0.196050381 0.46679452 0.39073511 0.7384280 1.12432186
  7 0.125084786 0.190822382 0.47616580 0.47898144 0.9060044 1.16564974
  8 0.125084786 0.190822382 0.47616580 0.47898144 0.9060044 1.16564974
   year
age      1969      1970      1971       1972       1973       1974
  0 0.0000000 0.0000000 0.0000000 0.00000000 0.00000000 0.00000000
  1 0.0197390 0.0217371 0.0235931 0.01672614 0.02352954 0.02194995
```

```
  2 0.6843785 0.7568328 0.8220630 0.56219414 0.81144253 0.74967043
  3 0.8607365 0.9529927 1.0495348 0.64078563 0.95226792 0.87849765
  4 0.7733037 0.8627114 1.0280000 0.54102898 0.81055759 0.77761854
  5 0.8039119 0.8154818 1.1025377 0.49801409 0.81212966 0.84257645
  6 1.1357973 1.1400400 2.7753113 0.49156360 1.01346957 0.88976378
  7 1.0132827 0.8737571 1.6734414 0.28903101 0.67023465 0.78815596
  8 1.0132827 0.8737571 1.6734414 0.28903101 0.67023465 0.78815596
   year
age       1975       1976        1977        1978        1979        1980
  0 0.00000000 0.00000000 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.02654755 0.01862278 0.006593931 0.005404257 0.005122789 0.005248562
  2 0.91874873 0.62322470 0.200371961 0.160646730 0.150939588 0.154412179
  3 1.14656368 0.85443780 0.302146490 0.223268644 0.195318369 0.187256729
  4 1.01136888 0.73745894 0.266569748 0.192040073 0.158802718 0.144258232
  5 1.11779071 0.78104049 0.315375180 0.211978367 0.161295661 0.131264139
  6 1.21381567 0.69007138 0.205902738 0.107277766 0.065128759 0.043287384
  7 1.52549927 0.98045350 0.341319136 0.186014891 0.113723757 0.073345665
  8 1.52549927 0.98045350 0.341319136 0.186014891 0.113723757 0.073345665
   year
age        1981        1982        1983        1984        1985
  0 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.006018653 0.005179098 0.006125715 0.007316947 0.009247042
  2 0.178229880 0.150587678 0.179897434 0.217249551 0.278817911
  3 0.230008553 0.193135757 0.237943490 0.299572448 0.384000061
  4 0.213481012 0.167911303 0.240420177 0.331982095 0.429097306
  5 0.227845167 0.152251786 0.240664275 0.334924118 0.417278268
  6 0.181989060 0.090925672 0.220467567 0.347468361 0.468547541
  7 0.323584442 0.129949409 0.299353865 0.448937121 0.530579815
  8 0.323584442 0.129949409 0.299353865 0.448937121 0.530579815
   year
age        1986        1987        1988        1989        1990
  0 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.008724336 0.008273282 0.007765702 0.007992528 0.007031221
  2 0.260601670 0.245094631 0.227937933 0.234555187 0.203425989
  3 0.338116989 0.300354311 0.271115951 0.266718952 0.218830640
  4 0.384494901 0.351720441 0.331621950 0.323073962 0.253111190
  5 0.389035210 0.360350841 0.351306192 0.332705489 0.256902852
  6 0.459788895 0.388233841 0.385921970 0.349513850 0.238973184
  7 0.519443994 0.394143229 0.403156779 0.359363754 0.256256404
  8 0.519443994 0.394143229 0.403156779 0.359363754 0.256256404
   year
age        1991        1992       1993       1994        1995        1996
  0 0.000000000 0.000000000 0.00000000 0.00000000 0.000000000 0.000000000
  1 0.008430622 0.009279709 0.01049272 0.01028126 0.007957184 0.003749499
  2 0.247472456 0.274203846 0.31289762 0.30584421 0.230642967 0.101240031
  3 0.251310389 0.289856445 0.35756584 0.38649894 0.332828263 0.157526920
  4 0.266075085 0.309679621 0.37632891 0.40441255 0.352537701 0.165790520
  5 0.251532814 0.289734378 0.32591866 0.32141268 0.313063246 0.158287269
  6 0.229834441 0.305462237 0.34781642 0.30532261 0.315284734 0.120764389
  7 0.212835404 0.294012706 0.33261535 0.26369146 0.262609408 0.090579733
  8 0.212835404 0.294012706 0.33261535 0.26369146 0.262609408 0.090579733
   year
age        1997        1998        1999        2000        2001
```

```
  0 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.003098475 0.003964822 0.003733941 0.003514785 0.002647492
  2 0.082112477 0.106003466 0.096808461 0.088623864 0.063763742
  3 0.138202694 0.180028107 0.178529165 0.170521639 0.132946008
  4 0.148380306 0.188781008 0.186371064 0.190483202 0.163609187
  5 0.144572561 0.188281325 0.182793923 0.190203608 0.179000600
  6 0.114474552 0.173493566 0.153563549 0.156565822 0.158098890
  7 0.090995687 0.115211277 0.095808808 0.102671027 0.140015613
  8 0.090995687 0.115211277 0.095808808 0.102671027 0.140015613
   year
age        2002        2003        2004        2005        2006
  0 0.000000000 0.000000000 0.000000000 0.000000000 0.000000000
  1 0.002350023 0.002304553 0.002203403 0.002634719 0.002841691
  2 0.054856080 0.052659070 0.049634266 0.058340139 0.061731832
  3 0.115991049 0.118436160 0.119668528 0.136457357 0.135764760
  4 0.152025197 0.170764841 0.188235709 0.221247839 0.210729218
  5 0.172833028 0.213106642 0.254939065 0.303775711 0.274885702
  6 0.156290330 0.204333931 0.311498715 0.442461165 0.373363037
  7 0.143905963 0.177071648 0.268852541 0.460263047 0.424102110
  8 0.143905963 0.177071648 0.268852541 0.460263047 0.424102110
   year
age        2007        2008       2009        2010       2011        2012
  0 0.000000000 0.000000000 0.00000000 0.000000000 0.00000000 0.000000000
  1 0.002737504 0.002608284 0.00187046 0.001983688 0.00227582 0.003238007
  2 0.057520744 0.053011642 0.03645613 0.038531799 0.04477842 0.065030379
  3 0.124596244 0.090111450 0.05326192 0.057881513 0.07502344 0.124534959
  4 0.188972273 0.122564764 0.06905716 0.068959768 0.09176226 0.159956898
  5 0.241421502 0.148403273 0.08363991 0.080799109 0.10771430 0.190877344
  6 0.317593208 0.145710933 0.06227512 0.056945589 0.08397856 0.204946630
  7 0.372555553 0.183280571 0.08774562 0.069133850 0.09097336 0.217294716
  8 0.372555553 0.183280571 0.08774562 0.069133850 0.09097336 0.217294716
   year
age        2013        2014        2015       2016        2017        2018
  0 0.000000000 0.000000000 0.000000000 0.00000000 0.000000000 0.000000000
  1 0.002849793 0.002639797 0.002049917 0.00198796 0.001621964 0.001689365
  2 0.056258362 0.053032413 0.041937556 0.04191324 0.034013815 0.035897811
  3 0.120974677 0.119080730 0.101062894 0.11636226 0.109761746 0.120792173
  4 0.175155036 0.176452678 0.162292301 0.18305879 0.172016932 0.199590205
  5 0.227436240 0.225655279 0.234260093 0.25645550 0.221502184 0.265382580
  6 0.294449967 0.270441386 0.341154471 0.38377671 0.274018045 0.340673488
  7 0.339656602 0.329147107 0.472903426 0.57555081 0.403690278 0.493117012
  8 0.339656602 0.329147107 0.472903426 0.57555081 0.403690278 0.493117012
   year
age        2019        2020
  0 0.000000000 0.000000000
  1 0.001353414 0.001353396
  2 0.028408060 0.028407709
  3 0.102631450 0.102630286
  4 0.169035474 0.169033714
  5 0.238837695 0.238835413
  6 0.305324360 0.305319904
  7 0.447185055 0.447179065
  8 0.447185055 0.447179065
```

```
, , area = BD

   year
age         1947         1948         1949         1950         1951
  0 0.0004254691 0.0004057721 0.0007496947 0.0012983618 0.0021474644
  1 0.0006236132 0.0005664338 0.0019677105 0.0059968307 0.0166401784
  2 0.0001596298 0.0001503870 0.0003184482 0.0006257946 0.0011663822
  3 0.0002230317 0.0002153825 0.0003369227 0.0005041291 0.0007306202
   year
age         1952        1953        1954        1955        1956
  0 0.0029737922 0.003704661 0.004617573 0.004916170 0.004485667
  1 0.0322038739 0.050300257 0.071459417 0.101809938 0.104915711
  2 0.0017383400 0.002266006 0.002785317 0.003451984 0.003522532
  3 0.0009153046 0.001064992 0.001194180 0.001345343 0.001344339
   year
age        1957        1958        1959        1960        1961
  0 0.005162996 0.005494037 0.009062819 0.014309740 0.014723436
  1 0.128637649 0.118994757 0.144103315 0.158428212 0.112822994
  2 0.003943895 0.003764828 0.004187979 0.004379081 0.003550911
  3 0.001428313 0.001382809 0.001450255 0.001457796 0.001287938
   year
age        1962        1963        1964        1965        1966
  0 0.009135413 0.012962161 0.016623988 0.015504825 0.021955649
  1 0.078525696 0.118912506 0.209404018 0.202545839 0.225066163
  2 0.002780829 0.003549529 0.004982881 0.004883634 0.005158329
  3 0.001115287 0.001280505 0.001590605 0.001592814 0.001661627
   year
age        1967        1968        1969        1970        1971
  0 0.028921219 0.030999598 0.022085615 0.035301627 0.049707655
  1 0.279992795 0.296404469 0.259564807 0.311145348 0.491395254
  2 0.005798923 0.006034370 0.005546661 0.006187814 0.008102060
  3 0.001793051 0.001843874 0.001754345 0.001881205 0.002207203
   year
age        1972        1973        1974        1975        1976
  0 0.064959730 0.071182267 0.092586031 0.114665270 0.084138440
  1 0.558725560 0.561475494 0.467446346 0.438398174 0.188659621
  2 0.008833681 0.008823322 0.007863606 0.007496529 0.004431910
  3 0.002337408 0.002343405 0.002193530 0.002139386 0.001561401
   year
age        1977        1978        1979        1980        1981
  0 0.075950802 0.094162224 0.116188179 0.143357570 0.314505543
  1 0.110822965 0.100556114 0.094066240 0.086459527 0.179157589
  2 0.003131091 0.002995307 0.002932628 0.002853071 0.004365784
  3 0.001262257 0.001225452 0.001208038 0.001187061 0.001502701
   year
age        1982        1983        1984        1985        1986
  0 0.313315313 0.310395074 0.191454602 0.128128711 0.101927053
  1 0.172865698 0.202185994 0.182303846 0.227673500 0.236135187
  2 0.004343858 0.004891074 0.004763584 0.005721029 0.006180265
  3 0.001495961 0.001605099 0.001593940 0.001787428 0.001863019
   year
age        1987        1988        1989        1990        1991
```

```
  0 0.133901676 0.128329096 0.115342063 0.094992145 0.118512594
  1 0.315495279 0.393209165 0.316793609 0.270778057 0.224790747
  2 0.007833976 0.009519714 0.009202201 0.009346684 0.009727777
  3 0.002144970 0.002401882 0.002346308 0.002350455 0.002400390
   year
age        1992        1993        1994       1995        1996        1997
  0 0.195380970 0.211421648 0.140936945 0.13216858 0.067881163 0.024526968
  1 0.262797263 0.240225767 0.121103687 0.10707732 0.066965226 0.023329534
  2 0.011975573 0.012860003 0.009716907 0.01015923 0.008776931 0.005766687
  3 0.002730617 0.002893165 0.002490202 0.00259376 0.002377326 0.001873694
   year
age        1998        1999        2000        2001        2002
  0 0.021394465 0.024595204 0.029347917 0.020269044 0.026071202
  1 0.022637230 0.017197492 0.018403510 0.006978742 0.016543792
  2 0.006290206 0.006023339 0.006427652 0.003866011 0.006474955
  3 0.001933940 0.001899925 0.001765649 0.001222338 0.001289424
   year
age        2003         2004        2005         2006         2007
  0 0.028391870 0.0360621807 0.050843770 0.0409406078 0.0289817697
  1 0.024657707 0.0294634360 0.039006448 0.0197926438 0.0106197951
  2 0.007312579 0.0080335357 0.008139999 0.0051658312 0.0025269984
  3 0.000971650 0.0008266217 0.000572396 0.0003833313 0.0001364983
   year
age          2008         2009         2010         2011         2012
  0 0.03037552674 0.0253415705 0.0263188196 0.0306942632 0.0340106867
  1 0.01085909179 0.0106473355 0.0102415520 0.0119213011 0.0173176398
  2 0.00190778057 0.0019012095 0.0022059916 0.0020703886 0.0030044718
  3 0.00007777724 0.0001001045 0.0001916648 0.0001815494 0.0002588558
   year
age         2013         2014         2015          2016          2017
  0 0.0257010496 0.0327145627 0.0444153416 0.05791078362 0.04391751108
  1 0.0145494689 0.0152157593 0.0165222572 0.01933276144 0.01242271982
  2 0.0028647232 0.0027030016 0.0020082267 0.00195367683 0.00098327138
  3 0.0002376307 0.0002068359 0.0001065275 0.00009283426 0.00003386248
   year
age          2018          2019          2020
  0 0.04311169413 0.03105075007 0.03105442223
  1 0.00901278844 0.00706593160 0.00706556329
  2 0.00064187832 0.00049502582 0.00049501031
  3 0.00002393186 0.00002168145 0.00002168104
```

Table 2.6.2.14. North Sea Herring multifleet assessment. ESTIMATED POPULATION ABUNDANCE

```
Units  :  NA
   year
age     1947     1948     1949     1950       1951     1952     1953
  0 52991791 51205504 44906588 62694268 59766909.5 57849822 62201288
  1 19603408 23568649 22930723 18909009 28933887.8 26393449 25276879
  2 16125281  9961607 14055611 11757343  9078741.3 14450339 12642029
  3  6305835  9256383  7917733 11052838  7566301.3  5008093  7429502
  4  8499678  4056669  4635135  5828798  8065479.2  4377636  3281081
```

```
  5  5278194  5749311  2532781  2633192  4116934.4  4464080  2549119
  6  4659903  3420660  3597453  1583815  1658444.3  2436111  2588666
  7  2479580  2585793  2144457  1981642   904453.3  1049006  1377989
  8  7535805  5739955  4887660  3608416  3011548.0  2486357  1954032
   year
age     1954       1955       1956       1957       1958       1959
  0 58957444 49110768.2 36514524.3 83883083.0 35484096.4 39390387.3
  1 28179604 25358002.4 21961507.9 14787926.7 45114205.5 15203606.2
  2 11854652 13871470.8 10931602.1 10137142.0  5868277.4 23914069.1
  3  6735301  6541095.1  7598508.2  4644371.3  5496718.8  2618355.3
  4  3910473  3381307.2  3595625.1  4352131.8  2310565.9  2810129.6
  5  2087415  2235294.1  1824035.8  2072409.6  2731466.0  1326791.8
  6  1477089  1275422.8  1288353.5  1137735.8  1138934.2  1393291.0
  7  1479510   799722.5   688744.5   795596.9   666976.4   671703.6
  8  1935821  1605495.6  1671418.3  1398831.9  1191288.7  1461702.1
   year
age       1960       1961       1962       1963       1964       1965
  0 16313220.3 75349457.2 36030059.7 41920334.5 42741114.1 21402504.9
  1 19266566.2  5217574.9 37152450.2 16053052.7 17814332.0 19995568.8
  2  6413813.2  8916978.0  1896188.9 19940493.4  7569030.1  6719341.5
  3 12903377.6  2911571.5  3721905.7  1176620.8 10881682.2  3730671.9
  4  1277755.5  8493491.7  1611121.2  1463739.0   755625.6  5959007.0
  5  1382455.0   792074.2  5122661.5   787479.2   834244.9   434097.1
  6   721352.0   952818.9   490624.3  2643776.9   573141.6   463410.1
  7   725997.5   405165.0   619144.7   233242.9  1746950.4   353352.8
  8  1343962.5  1014065.7   815065.3   831226.1   610959.7  1513091.8
   year
age       1966       1967       1968        1969        1970        1971
  0 22140466.1 28941642.5 28882628.3 14738319.81 28538402.93 22366928.41
  1  9421482.8  9073891.0 12433894.0 12332169.18  6512009.90 12601064.64
  2  8442248.2  3902507.2  3277775.0  4653168.47  4515177.86  2539003.07
  3  2309796.2  3391624.3  1911788.9   693207.36  1583955.78  1288272.97
  4  1488802.8   903589.1  1219842.4   320283.35   218489.26   393110.79
  5  2531747.1   702895.9   306810.0   370822.50   102496.66    55230.28
  6   189464.4   924791.5   264761.6    81513.41   117138.93    31156.86
  7   201056.9   113395.8   284288.1    70616.10    16656.34    32885.34
  8   929414.1   492674.3   173951.5    98214.93    45612.24    17921.99
   year
age         1972        1973         1974        1975        1976
  0 15371472.543 8232280.983 13675474.377 3346609.160 4495131.809
  1  9760675.252 6372129.011  3234487.059 6485883.085 1088321.899
  2  3759269.057 2847391.323  1715527.379 1010480.283 2155195.663
  3   819297.196 1240277.844   789230.958  470889.585  237062.792
  4   335723.276  314757.477   285242.032  250716.751  105025.682
  5   101356.352  129570.709   104878.718   87637.869   70443.601
  6    15344.762   48555.821    42491.287   29889.703   16309.359
  7     1092.367    8276.329    11635.547   12554.724    7348.432
  8     7083.188    4726.784     5861.691    6335.749    2712.283
   year
age        1977        1978         1979         1980        1981
  0 5607178.266 6170980.660 10986797.455 16504933.726 34408394.13
  1 1883959.285 2412460.552  2379250.310  4431757.506  6375025.45
  2  382023.470  852991.442  1080345.965   971267.979  2089085.17
```

```
  3  755669.202  283338.074   484121.645   574733.308   404198.46
  4   62683.755  318142.327   219729.328   273539.882   262428.55
  5   30720.279   39659.984   155967.996   184886.541   161809.85
  6   23771.478   14461.058    27151.343    79592.484   137485.73
  7    5911.798   12891.623     8544.550    21895.374    67271.85
  8    2764.274    4360.629     9413.479     9609.708    24819.97
   year
age        1982        1983        1984        1985        1986
  0 55482701.53 54151411.36 55874003.49 67628118.77 82502703.09
  1 10278728.22 17877200.62 15565619.41 18515283.34 25870961.54
  2  2430632.24  3950262.20  7058015.60  6437858.14  6341655.54
  3  1283203.34  1290099.29  2081212.43  3994948.11  3323339.12
  4   241577.04   603183.00   782220.44  1131034.11  1753154.84
  5   141798.43   146360.19   312757.26   407059.57   489173.08
  6    90087.02   116743.39    90485.79   139436.10   190112.55
  7    80354.97    58668.83    75715.29    53501.09    59953.44
  8    47231.20    95652.34    91030.59    83278.89    70947.79
   year
age        1987        1988       1989       1990       1991       1992
  0 74143207.72 46380904.21 37800213.3 33113192.8 36340449.2 64886378.5
  1 33989243.61 25347551.37 16653928.1 13273011.5 13378517.2 13041706.4
  2 10571710.99 12338650.76  8267781.1  5523511.6  5005253.1  5651842.3
  3  3011904.74  5427872.37  6676780.5  4619645.8  2812380.3  2145493.4
  4  1766115.01  1558257.66  3095328.5  4338552.3  2735449.1  1595582.1
  5   894728.71   939699.55   820684.7  1854677.9  2583287.7  1601084.8
  6   255136.77   453627.32   472813.6   450727.1  1056012.7  1560463.3
  7    86617.72   129860.79   228996.9   261557.4   251798.0   639165.6
  8    57840.36    78273.42   106264.8   195884.3   237318.5   288601.3
   year
age       1993       1994       1995       1996       1997       1998
  0 69218686.3 56623356.0 60132093.7 49202714.8 40897657.2 26097797.4
  1 20794011.2 21390275.3 19179640.2 19154913.9 19026842.0 16655682.1
  2  4755376.0  7177996.8  7813677.0  7203636.3  7871162.9 11051047.2
  3  2385481.0  1782875.1  3143839.3  3763675.4  3803307.4  3832355.9
  4  1135910.6  1007647.1   895972.6  1371061.4  2003352.7  1861249.4
  5   886846.7   495462.5   452775.5   429497.5   803213.1  1063490.6
  6   895132.5   419825.6   247882.2   193911.3   255885.8   544104.6
  7   766530.5   404707.4   207682.5   122603.8   120942.8   160760.6
  8   497004.2   573579.7   459356.0   314174.1   250868.5   205415.2
   year
age       1999       2000        2001       2002       2003       2004
  0 82296940.5 52967525.6 103526184.0 50643694.1 26880539.5 32082787.2
  1 10884069.3 32535094.7  19168571.4 42687746.8 18851329.3  9604961.4
  2  6812872.9  6652042.9  15045003.5  9598590.9 23308135.5  7356937.6
  3  6444545.7  3604262.8   4314975.7  9646844.5  5471842.5 13242433.0
  4  2013363.5  3769181.8   2044016.6  2297133.2  5977499.2  3521779.6
  5   931392.3  1201427.8   2039146.1  1111349.0  1274146.9  3592817.6
  6   521932.0   591021.6    608086.3  1252826.5   693465.3   660943.5
  7   292368.5   321915.2    330242.0   367531.3   768940.2   446612.0
  8   175823.7   252606.4    337000.0   361922.9   370137.6   542935.7
   year
age       2005       2006       2007       2008       2009     2010
  0 29512068.9 29168217.9 34859596.2 30976398.7 48658402.4 39880153
```

age						
1	13471816.2	9731981.5	10031115.8	12156629.7	11926198.4	17388617
2	4496159.0	6553136.3	4086608.9	5597466.2	7169232.8	7246084
3	4619161.2	2992680.9	3653104.3	2634611.6	3202859.7	4780453
4	7673925.9	2894624.3	1825475.1	2060908.2	1718837.2	2397377
5	2066881.1	4869001.6	1633222.8	1171454.2	1355825.6	1310852
6	1898849.6	1009639.7	2559942.9	1017733.0	810386.1	1166125
7	334716.2	860408.1	530136.5	1641429.3	755739.1	607639
8	473677.2	351768.7	570568.1	714789.5	1899361.6	2041410

age \ year	2011	2012	2013	2014	2015	2016
0	34377544.2	32187822.7	42409241.5	65013622.3	17311933.6	32077307.1
1	15560276.5	12376768.9	11652527.7	19045480.7	26511598.2	6862656.6
2	8518624.8	7745926.9	5567522.9	7003327.2	12830786.1	15935208.3
3	4534023.3	6146468.5	5164757.9	3898877.9	3661076.0	8686387.6
4	2995344.8	3201818.6	4183416.9	4070930.2	2368778.3	2239299.6
5	1500900.6	2022290.7	2354242.2	2767635.4	2497871.8	1440314.3
6	890647.6	952656.6	1389079.3	1485657.3	1627936.8	1379542.8
7	737694.5	578180.5	587083.9	811058.3	840597.7	817099.1
8	1706356.1	1324078.5	1201893.4	890386.6	971260.0	875323.0

age \ year	2017	2018	2019	2020
0	19757648.5	33481370.0	32355791.5	29721206.3
1	12543650.6	8143814.0	11970602.7	13858645.1
2	3172483.7	5819277.6	3217313.6	5986455.9
3	10328975.5	2281480.9	3342160.8	1996459.5
4	5853404.7	7019756.4	1612034.4	2046692.1
5	1465106.6	3949758.9	4039923.0	932395.3
6	712954.9	940573.3	2347313.1	2210799.7
7	642427.2	460625.2	481131.3	1211135.7
8	734053.9	851380.6	665940.5	518460.7

Table 2.6.2.15. North Sea Herring multifleet assessment. PREDICTED CATCH-AT-AGE 1947-1996 (summed fleets)

Units : NA

age \ year	1947	1948	1949	1950	1951	1952
0	15425.94	14216.00	23030.77	55671.69	87748.16	117573.3
1	27776.07	31914.66	59132.92	109917.17	410184.89	677210.0
2	473655.96	283621.34	501754.97	550311.32	656955.95	1266151.0
3	422740.90	619692.05	620132.36	1005976.75	927030.61	642490.2
4	663200.58	320004.80	426393.23	604246.50	1092061.05	610025.2
5	537628.05	578702.80	292225.60	310349.26	580424.08	670143.0
6	730990.09	491335.95	639160.49	246592.59	272242.20	469955.1
7	430886.50	413915.11	440803.93	331632.76	146106.90	223396.0
8	1309950.31	919108.74	1005005.02	604073.10	486648.30	529663.1

age \ year	1953	1954	1955	1956	1957	1958	1959
0	157436.9	185925.7	164867.4	111867.7	295706.4	133090.76	243335.7
1	979391.2	1521981.6	1892065.4	1696169.7	1375136.3	3925862.25	1579586.7
2	1302578.0	1534616.0	1912767.1	1718685.7	1686573.6	1022972.98	4766532.4
3	1024286.4	1090901.3	1018362.8	1237007.4	786496.8	937869.23	504331.9
4	463030.8	618921.0	482708.7	515807.9	660550.4	336603.54	477611.2

```
  5  384304.1  357724.2  332345.0  268372.0  336341.7  404336.22  228329.2
  6  481371.1  338413.5  211353.7  203280.4  203356.0  148461.74  260103.9
  7  278341.9  364720.1  121662.2  108777.4  139866.2   75301.53  125013.8
  8  394824.1  477358.4  244324.3  264062.5  245994.6  134540.44  272131.7
   year
age      1960       1961      1962       1963       1964      1965
  0  158759.3  754362.90  224352.9  369761.25  482746.12  225565.2
  1 2162032.3  435504.59 2255413.7 1386019.76 2576013.60 2880554.6
  2 1093554.0 1646890.23  343333.3 2776133.95 1520636.88 2156605.9
  3 2055252.1  523288.83  757643.3  169341.21 2316237.63 1324862.0
  4  178615.6 1363105.38  310248.5  179407.36  142051.86 1931006.2
  5  196236.2  124322.77 1010074.6   94107.19  152536.80  138948.6
  6  112854.2  153607.34  114174.6  243440.54   87188.27  148798.9
  7  127133.6   62708.58  137999.9   23448.56  259953.29  115552.1
  8  235425.0  157000.91  181726.2   83592.97   90942.85  494958.6
   year
age       1966      1967      1968       1969       1970       1971
  0  329506.08  565705.5  604522.2  220626.96  679131.17  744441.92
  1 1477019.98 1722138.9 2551577.2 2231667.78 1371589.85 3810567.36
  2 2492287.74 1334619.3 1693480.1 1927156.75 2007150.84 1195922.71
  3  783242.04 1426300.9 1151252.6  341019.95  831663.11  717840.55
  4  462515.27  359285.2  646955.1  148306.52  108845.17  218642.80
  5  799760.18  290176.4  158813.9  177530.54   49547.49   32220.19
  6   52644.63  418758.6  156590.4   48489.42   69835.05   26561.12
  7   66056.74   58993.1  171965.8   39379.14    8466.31   23768.16
  8  305450.85  256382.1  105251.7   54784.91   23191.06   12956.44
   year
age         1972        1973       1974        1975       1976        1977
  0  664517.0281  389258.817 831034.574  250342.202 250464.059 283128.6560
  1 3215425.2531 2120680.925 945317.591 1803392.399 150445.789 154710.6027
  2 1355914.3813 1329804.294 761013.292  511018.227 833027.432  58383.0074
  3  328592.2539  650819.887 394128.066  275939.926 115783.265 164928.4338
  4  120023.1647  150503.019 132707.010  138020.995  47021.456  12450.3762
  5   34241.3085   62490.214  51820.398   51527.959  33077.276   7125.2245
  6    5133.4439   27030.201  21786.924   18454.472   7051.734   3793.7157
  7     235.4946    3509.146   5517.412    8714.109   4024.092   1475.8501
  8    1527.4947    2004.747   2780.335    4398.680   1485.709    690.3348
   year
age        1978        1979         1980        1981         1982
  0 383033.7266 832312.7858 1520612.6152 6451481.265 10322818.047
  1 180312.8001 167810.9618  292542.7411  793839.015  1242332.219
  2 107666.9500 129560.6844  119297.7990  294113.337   298255.862
  3  47407.8938  71884.0173   82282.4762   69867.337   190373.816
  4  47192.2764  27432.9970   31307.6772   43076.617    32004.178
  5   6496.4687  19960.9059   19595.9114   28440.523    17352.719
  6   1261.1296   1470.8414    2909.0121   19758.973     6781.677
  7   1884.7278    791.0757    1334.7418   16162.891     8485.488
  8    637.7789    871.9291     586.1178    5966.748     4990.886
   year
age       1983       1984       1985       1986       1987       1988
  0 9909526.78 6561831.42 5428387.93 5303120.93 6164688.48 3709647.45
  1 2498103.24 2021479.03 2940878.71 4263621.36 7133915.12 6370048.76
  2  569097.94 1199096.05 1359831.78 1280464.38 2057618.55 2293778.50
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  3  231708.77  459043.60 1092426.28  823845.35  680748.98 1131316.76
  4  110741.20  190557.95  342483.19  488600.44  459823.08  387770.15
  5   27151.84   77427.91  121411.11  138487.56  238923.30  246583.79
  6   20065.17   23183.77   45790.89   61743.29   72507.37  128629.25
  7   13235.30   24018.41   19407.71   21458.92   24915.30   38117.32
  8   21595.09   28901.87   30231.99   25406.70   16644.22   22984.63
   year
age       1989       1990       1991       1992      1993       1994
  0 2741891.24 2000377.25 2718675.27 7778041.23 8939452.0 5031301.37
  1 3553438.76 2509282.93 2215385.96 2472706.42 3723308.5 2294872.24
  2 1581639.97  949159.38 1009480.12 1242801.32 1161220.8 1708217.34
  3 1379488.12  810038.95  558249.36  480630.07  636106.3  506262.54
  4  755708.61  862322.99  568280.89  376462.59  314700.8  295412.64
  5  206383.26  375372.92  514715.75  360120.20  220390.0  121606.85
  6  123824.35   85414.20  194027.32  366673.34  234858.5   98901.71
  7   61177.74   52251.61   42611.54  143848.44  191671.2   82744.27
  8   28402.03   39157.81   40211.14   65081.97  124592.8  117645.51
   year
age       1995        1996
  0 5037781.48 2172246.206
  1 1879097.88 1320131.044
  2 1497755.00  740298.191
  3  795773.24  519268.384
  4  235222.33  190195.504
  5  108898.45   57826.342
  6   60124.85   20492.678
  7   42292.45    9326.977
  8   93890.63   23990.854
```

Table 2.6.2.16. North Sea Herring multifleet assessment. CATCH-AT-AGE RESIDUALS 1947-1996 (summed fleets)

```
Units  :  NA
   year
age           1947          1948       1949       1950       1951
  0 0.000000000000  0.0000000000  0.0000000  0.0000000  0.0000000
  1 0.000000000000  1.6763948031  0.0000000  0.0000000  3.6366445
  2 0.003803974062  3.2149192903  2.2582415  0.3324272 -1.0052863
  3 5.976998589785  3.3741468336  1.4162999  0.7310880  0.1393934
  4 0.000005463472  1.4732163080 -0.6229474  1.4378079  1.6526802
  5 1.564537141025  0.2653490235  0.1980542 -1.0284663  0.9664654
  6 2.510224904974  1.6523708665  0.5072678 -0.4168431 -0.6349659
  7 0.194678529914 -0.0238804705  1.4103571 -0.1013004 -0.0280305
  8 1.796274565982 -0.0002728092  0.1860118 -0.2827679 -0.1162220
   year
age       1952        1953       1954       1955        1956        1957
  0  0.0000000  1.92197765  0.4980945 -0.2463143 -0.66557749  1.08072803
  1  0.9361980  0.28172796  0.1649020  0.3417575  0.15512982 -0.16235529
  2 -0.7104467 -0.59338276 -0.1774475  0.0579161 -0.36057612  0.02008057
  3 -1.7261917 -1.49618601 -0.9475774 -1.1194200 -0.82377845 -1.82075765
  4 -0.2069229  0.07417182 -1.1508716 -1.3242056 -0.46124017  0.18604213
  5  0.1477315 -0.08793209  0.6617736 -0.4581783 -0.82999823  0.29859205
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  6  0.9860945  0.28048870  0.5558783  0.4458254  0.12354010  0.67245982
  7  1.7465168  0.23305533  0.3714273 -0.8705319 -0.01881574  0.37339666
  8  1.4638036  0.65244392  1.0314145 -0.7864980  1.97320216  0.31868785
   year
age       1958        1959        1960        1961       1962       1963
  0 -0.9969680  0.00000000  0.59294817  2.19263575 -1.9213173  0.8888631
  1  1.1348238 -0.34269383  0.12445034 -3.26019274  0.8706540  0.2522296
  2 -0.3165291  1.63865349 -0.98519962  0.09898932 -2.2305273  1.2191723
  3 -0.1031804 -1.50783614 -0.13907656 -0.62775999  0.4618362 -0.2774421
  4 -1.2266307 -0.22088927 -0.95592060  1.48426039  0.7521476 -3.4366544
  5  0.3390807 -0.34878433 -1.42977109  0.03040965  0.8509634 -2.2877694
  6 -0.8815083  0.08337111  0.75580947  0.30126834  0.9591278 -0.4522460
  7 -0.7232912  0.48902276 -0.03228896 -1.13643036  0.7591513 -0.8183902
  8 -0.5959134  2.30948535  1.33744636 -1.58720684 -0.5448990  0.3562401
   year
age       1964       1965        1966        1967        1968       1969
  0  0.2807665 -1.2943144  0.71494213  0.77633379  0.46843176 -2.1778808
  1  0.6352091  0.6199451 -0.48152923 -0.50686763 -0.21222361  0.4125877
  2  0.6148288 -0.2295986 -0.05910311 -0.14438621  0.23888529 -0.4857211
  3  0.6956751  0.8898955 -1.64441266  0.09025701  1.83993958 -3.2426407
  4  1.4126585  1.0417597 -0.60994447 -0.37638159 -1.28910394 -1.3110973
  5 -0.2137682  0.7614785  0.01389934  0.19459690 -1.65314126 -0.3960823
  6  0.4662358 -0.2997487 -0.75007106 -0.38427924  0.07182717  1.0006679
  7 -0.2401305  0.8193296  0.28409651  1.57536080 -1.90820252 -0.3977047
  8 -1.7241223  0.1941150  0.81243312 -0.83758348  1.06824728 -2.4592983
   year
age        1970        1971        1972       1973       1974       1975
  0  1.96244668  0.06459975  0.07813457 -1.0618464  1.2323408 -1.2394871
  1 -0.39405211  0.65068852 -0.15670411 -0.2379243 -1.3641628  0.7743102
  2 -0.13752770  0.45837634 -0.89651984 -0.7303104 -1.2087360  0.3084954
  3 -0.62559411 -1.25675488 -0.09194488  0.2971076 -0.3324684  0.2057770
  4 -0.27758426 -0.30150314 -0.76375221  1.1066073 -1.0294155  0.8669649
  5 -0.78621722 -1.37617354 -1.12236225  1.1920224  1.4200970  0.3610135
  6 -0.26464763  1.67360640 -1.20135567  2.4123122 -0.3146951 -1.3117772
  7 -2.40596010  0.59329791 -3.36301836  2.4851822  0.8393524  2.0302863
  8  0.02179797 -0.61543412  0.43194856  0.9515379  2.0028497  0.2554176
   year
age        1976        1977 1978 1979       1980       1981        1982
  0 -0.39720198  0.18456185    0    0  1.5004697  2.5803550  0.75680763
  1 -2.97829126 -0.84187845    0    0 -0.7270726  0.2338973 -0.80361011
  2 -0.02033085 -3.19618578    0    0 -0.3531468  0.6888490 -0.86027391
  3  0.30546021 -0.09254521    0    0 -0.3086987 -1.6776056  1.20388500
  4 -0.10261852 -1.90312197    0    0  0.3302685 -0.1251313 -0.09389326
  5  0.23999193 -1.01253340    0    0  2.3465755  0.5497252 -0.07041632
  6 -2.44241985  0.60661544    0    0 -2.9898950  4.1703654 -0.45944011
  7  1.24062689 -0.10678048    0    0  1.1546882  2.6803179 -1.55238027
  8 -1.96670357 -0.54066870    0    0 -2.2382041  1.6283252 -0.50467080
   year
age       1983        1984        1985       1986        1987        1988
  0  0.3267254 -0.65794949 -0.78750424 -0.4479547  0.59804284 -0.86714212
  1  0.3855354  0.01122359  0.90868539  0.9585942  0.10573915  1.08264931
  2  0.1468757  0.07897868  0.52893675 -0.4322631  0.43819939 -0.08413128
  3  0.1330117  0.50671740  1.17735519  0.2242003 -0.81610968 -0.35452297
```

```
  4  0.5642239  0.97600989  0.26157358 -0.7201860  0.23171377 -0.10310364
  5  0.6072250  0.30275083 -0.06541379 -0.5541213  0.28295333  0.45931763
  6  2.7253943  0.11468472 -0.88862637  0.2721526 -0.08466497 -0.01603100
  7 -0.2062706  0.89396013  0.68290588 -0.5505951 -0.90763580  0.10099968
  8  1.2001074  0.66124175  0.58218589  1.8060508 -0.31469374  0.47545142
   year
age        1989        1990       1991       1992        1993        1994
  0 -0.32034324 -0.91505079  0.4076556  1.6178646  0.27249104 -0.87442019
  1 -0.82119496  0.55421949 -0.5081002 -0.6717247 -0.42124865 -1.67135126
  2  0.08362139 -0.02074785  1.0429712  0.1201875 -0.09408469 -1.28660912
  3 -0.13095163 -0.06067437 -0.2016389 -0.0855467  0.43782081 -0.20124847
  4  0.44577753  0.01441010 -0.7270860  0.2802363  0.25701740  1.02361739
  5 -0.24642253  0.26266629 -0.6073259  0.3305923 -0.18133099 -1.77051246
  6 -0.45148115 -0.31237084  0.2969924  0.4163068 -0.21391929 -1.07795238
  7 -0.08808912  0.38549002 -1.4699110  0.7473954 -0.21205029 -1.24029031
  8 -0.24997048  0.24904134 -0.4461709 -0.3966554  0.51817582 -0.09823056
   year
age       1995       1996
  0  0.3992745 -1.2270276
  1 -0.7936420  0.1649295
  2 -1.7582367 -3.0836756
  3  0.5132602 -0.3289446
  4 -0.3955713 -1.6543327
  5  0.8349952 -0.1658593
  6 -0.2767952  0.9370553
  7 -0.3417235 -1.0589785
  8  0.2271525 -1.8503770
```

Table 2.6.2.17. North Sea Herring multifleet assessment. PREDICTED INDEX AT AGE LAI-ORSH

```
Units  :  NA
   year
age     1972     1973      1974     1975      1976     1977     1978
  0 2308.509 1851.873 1099.8760 647.1364 1130.1374 824.7905 935.7554
  1 1340.271 1075.158  638.5645 375.7136  656.1337 478.8558 543.2796
   year
age      1979      1980     1981     1982     1983     1984    1985
  0 1328.9290 1685.0382 2114.563 2639.262 2609.570 3587.944 4085.63
  1  771.5478  978.2973 1227.670 1532.299 1515.061 2083.084 2372.03
   year
age     1986     1987     1988     1989     1990     1991     1992
  0 4698.965 5699.942 6697.169 7566.462       NA 3934.495 936.7481
  1 2728.119 3309.265 3888.233 4392.926 4200.856 2284.284 543.8560
   year
age     1993     1994     1995     1996     1997     1998     1999
  0       NA 890.6409       NA       NA       NA       NA       NA
  1 480.1602 517.0871 1857.296 4792.451 6047.581 6885.936 7540.132
   year
age     2000     2001     2002     2003     2004     2005     2006
  0       NA       NA       NA       NA       NA       NA 6171.387
  1 7760.599 8910.746 8847.299 6517.756 5215.365 4579.375 3582.976
```

```
   year
age     2007     2008     2009     2010     2011    2012     2013    2014
  0       NA 4484.478       NA       NA       NA      NA       NA      NA
  1 2362.441 2603.592 2787.197 2876.017 3786.828 4195.17 3875.385 3568.47
   year
age     2015     2018     2019
  0       NA       NA 1657.107
  1 3073.761 733.8047       NA
```

Table 2.6.2.18. North Sea Herring multifleet assessment. INDEX AT AGE RESIDUALS LAI-ORSH

```
Units  :  NA
   year
age     1972        1973       1974       1975       1976        1977
  0 1.356885  0.11026241 -0.9668326 -0.4861022  0.2737448  1.03433601
  1 1.367649 -0.08988364 -0.4221544 -1.5346186 -0.7959615 -0.06648087
   year
age      1978     1979        1980       1981        1982        1983
  0  1.935566 1.628796  0.95401482  0.5124014  0.11854758 -0.05923156
  1 -1.184158 1.546439 -0.03681079 -1.1559506 -0.06445275 -0.50860767
   year
age       1984      1985        1986       1987      1988      1989
  0 -0.1817556 0.5301445 -0.08274676  0.4305656 0.2934881 0.7100293
  1  0.2796557 0.4210527 -0.18980539 -0.3254024 0.7556194 0.4487689
   year
age      1990       1991      1992      1993      1994     1995
  0        NA -1.2794985 -1.974920        NA -1.654097       NA
  1 0.6643821 -0.1016824  1.350135 -1.072055  2.056072 2.311549
   year
age        1996       1997      1998       1999       2000      2001
  0          NA         NA        NA         NA         NA        NA
  1 -0.05731425 -0.1879486 0.2437372 -0.2851473 -0.4784196 0.1322101
   year
age       2002       2003      2004        2005       2006       2007
  0         NA         NA        NA          NA  0.1724099         NA
  1 -0.3968978 -0.8636024 0.1728643 -0.05879057 -0.2454789 -0.1221582
   year
age      2008      2009        2010      2011     2012     2013      2014
  0 0.3755036        NA          NA        NA       NA       NA        NA
  1 0.9223481 0.8225126 -0.01853485 0.3701493 1.617641 1.648724 0.4689029
   year
age      2015      2018      2019
  0        NA        NA 0.6722727
  1 0.8238508 -1.868202        NA
```

Table 2.6.2.19. North Sea Herring multifleet assessment. PREDICTED INDEX AT AGE LAI-BUN

Units : NA

year

age	1972	1973	1974	1975	1976	1977	1978
0	21.98895	17.639413	112.56698	71.10465	NA	63.87924	NA
1	NA	6.871859	43.85318	NA	9.480862	24.88570	46.11013

year

age	1979	1980	1981	1982	1983	1984	1985
0	64.57884	16.361221	28.96267	352.8857	1755.3748	2806.064	2538.8399
1	25.15825	6.373909	11.28311	137.4752	683.8486	1093.170	989.0664

year

age	1986	1987	1988	1989	1990	1991	1992
0	2285.6042	2683.862	4654.798	4166.211	5322.421	NA	NA
1	890.4123	1045.563	1813.389	1623.048	2073.478	3362.952	4470.28

year

age	1993	1996	1997	1998	1999	2000	2001
0	NA	NA	NA	NA	NA	195.4298	NA
1	3030.147	561.3765	169.6535	317.8413	154.9747	76.1344	229.2309

year

age	2002	2003	2004	2005	2006	2007	2008	2009
0	NA	NA	NA	NA	NA	NA	NA	NA
1	737.4687	1486.623	1760.861	1278.497	729.099	796.5325	723.8967	1349.674

year

age	2010	2011	2012	2013	2014	2015	2016	2017
0	NA	NA	NA	NA	NA	NA	NA	NA
1	1445.598	2123.744	2672.923	3405.019	3408.105	3126.4	3779.307	3813.705

year

age	2018	2019
0	NA	5786.572
1	4486.16	2254.299

Table 2.6.2.20. North Sea Herring multifleet assessment. INDEX AT AGE RESIDUALS LAI-BUN

Units : NA

year

age	1972	1973	1974	1975	1976	1977	1978
0	-0.3264201	-1.37589458	1.325944	0.622026	NA	1.4553941	NA
1	NA	0.06862822	1.960361	NA	-2.361647	0.4196813	1.499903

year

age	1979	1980	1981	1982	1983	1984
0	0.3949763	-0.8655318	-0.9863637	1.549464	1.4031931	0.2137484
1	-1.1829569	-1.8334456	1.0586190	1.224382	0.3411073	0.6185063

year

age	1985	1986	1987	1988	1989	1990
0	0.1592201	0.0351558	0.02743315	0.7760330	0.5267477	0.1983381
1	0.5137552	-0.9483379	-0.29681866	0.9654793	-0.5550519	0.1813717

year

age	1991	1992	1993	1996	1997	1998	1999
0	NA	NA	NA	NA	NA	NA	NA
1	0.0168791	-0.4791295	-2.66928	-2.170667	-2.172867	1.260456	-0.6610685

age	2000	2001	2002	2003	2004	2005	2006
0	-1.6626597	NA	NA	NA	NA	NA	NA
1	0.9805759	0.373644	0.8969661	0.5462103	0.7492309	-0.132851	-0.8443287

age	2007	2008	2009	2010	2011	2012	2013
0	NA	NA	NA	NA	NA	NA	NA
1	0.6683741	-0.06879095	1.412438	0.07470418	0.559806	1.234073	1.489342

age	2014	2015	2016	2017	2018	2019
0	NA	NA	NA	NA	NA	-0.05898927
1	0.630779	0.4631181	0.1962898	0.6764039	-0.3624391	0.28628254

Table 2.6.2.21. North Sea Herring multifleet assessment. PREDICTED INDEX AT AGE LAI-CNS

Units : NA

age	1972	1973	1974	1975	1976	1977
0	445.44351	357.33226	292.2692	NA	167.823189	152.673488
1	637.45201	511.36039	NA	206.666530	240.163403	218.483419
2	304.06796	243.92160	199.5083	98.581022	NA	104.217740
3	21.07354	16.90507	NA	6.832193	7.939567	7.222848

age	1978	1979	1980	1981	1982	1983	1984
0	187.358341	217.13796	174.958170	245.5113	394.43224	566.0686	1126.8546
1	268.119184	310.73532	250.373917	351.3390	564.45232	810.0726	1612.5854
2	127.894260	148.22238	119.429675	167.5906	269.24673	386.4089	769.2117
3	8.863758	10.27261	8.277117	NA	18.66024	NA	53.3105

age	1985	1986	1987	1988	1989	1990
0	1328.87745	1388.25682	1735.03209	2008.39905	1682.25013	1766.877
1	1901.69029	1986.66515	2482.91796	2874.11978	2407.38432	2528.490
2	907.11627	947.64972	1184.36492	1370.97025	1148.33498	1206.103
3	62.86802	65.67721	82.08284	95.01559	79.58577	NA

age	1991	1992	1993	1994	1995	1996	1998
0	1059.3509	210.7562	NA	NA	NA	NA	299.487
1	1515.9843	301.6027	255.7366	218.1349	NA	509.9525	428.581
2	723.1325	143.8661	121.9877	104.0515	166.5079	NA	NA
3	NA	NA	NA	NA	NA	NA	NA

age	1999	2000	2001	2002	2003	2004	2005
0	NA	NA	NA	NA	NA	NA	NA
1	470.5192	621.2461	1398.746	NA	3517.319	3377.813	3098.388
2	224.4401	NA	NA	1280.481	1677.779	NA	NA
3	NA	NA	NA	NA	NA	NA	NA

age	2006	2007	2008	2009	2010	2011	2012	2013
0	NA	NA	NA	NA	NA	NA	NA	NA
1	2308.591	1584.296	1908.633	2218.818	2294.108	2940.826	2628.094	2576.56
2	NA	NA	NA	NA	NA	NA	NA	NA

```
  3       NA       NA       NA       NA       NA       NA       NA      NA
   year
age     2014     2015     2016     2017     2018     2019
  0       NA       NA       NA       NA       NA       NA
  1 2576.088 2727.119 3224.211 2723.233 1895.266 2317.251
  2       NA       NA       NA       NA       NA       NA
  3       NA       NA       NA       NA       NA       NA
```

Table 2.6.2.22. North Sea Herring multifleet assessment. INDEX AT AGE RESIDUALS LAI-CNS

```
Units  :  NA
   year
age       1972      1973      1974       1975       1976       1977
  0 -0.6693743 0.8605067 -1.397317         NA -0.1774154  1.1604566
  1 -0.6951781 0.7782469        NA -1.1368018 -0.1029398  0.1125024
  2  0.3854345 1.4874278  1.211713 -0.1545739         NA -0.1720578
  3  0.8938121 1.7137540        NA -0.1083896  0.6920744 -0.7112215
   year
age       1978       1979       1980       1981       1982       1983
  0  2.0589068  1.0952232  0.2826112  1.0872244 -1.2264681  0.7766191
  1 -0.7794670 -0.6316490 -0.4494097 -0.4370122 -1.4578253 -0.9085009
  2  0.8435063  1.0964964 -2.1470262 -0.3215225  1.5422474 -1.3269801
  3 -1.0245974 -0.3216698  0.5433821         NA  0.3862391         NA
   year
age      1984       1985        1986       1987      1988       1989
  0 0.3233399 -1.5009691  0.01418682 -0.4460174 0.8338163 -0.2780413
  1 0.9185467  2.0238112  0.76158351  0.7486980 0.1264993  0.4470916
  2 0.4973354  0.7375073 -1.49839994  0.5049523 0.1653246  0.3849029
  3 2.0112036  1.0775885 -0.51464399  0.2809607 0.4751496 -3.1785501
   year
age       1990        1991        1992       1993      1994      1995
  0  1.9112935  0.84802477 -3.70384979         NA        NA        NA
  1 -0.8263592 -0.24731040 -0.63833366  0.9029948  1.306217        NA
  2 -0.3430863 -0.05999216  0.06218255 -0.3740906 -1.104236 -1.440604
  3         NA          NA          NA         NA        NA        NA
   year
age       1996       1998       1999      2000     2001     2002      2003
  0         NA -0.8528587         NA        NA       NA       NA        NA
  1 -0.4096517 -1.6331706 -0.6245100 0.3309796 1.037871       NA 1.4563061
  2         NA         NA  0.3111583        NA       NA 1.536102 0.6878248
  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 0.5555259 0.6108599 -0.1501593 -1.208608 1.745884 0.6784587 0.08491009
  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 1.620018 -1.162974 1.281183 -0.357214 0.6134334 0.401049 0.7197233
```

```
  2       NA        NA       NA        NA        NA       NA        NA
  3       NA        NA       NA        NA        NA       NA        NA
   year
age        2018     2019
  0          NA       NA
  1 -0.01007814 1.488977
  2          NA       NA
  3          NA       NA
```

Table 2.6.2.23. North Sea Herring multifleet assessment. PREDICTED INDEX AT AGE LAI-SNS

```
Units  :  NA
   year
age     1972     1973     1974     1975     1976     1977     1978
  0 8.123406       NA       NA 3.544383       NA 7.315533 20.45746
  1 6.478209       NA 5.530888 2.826555 4.173166       NA 16.31430
  2       NA 2.179489       NA       NA       NA       NA       NA
   year
age     1979     1980      1981      1982      1983     1984     1985
  0       NA 97.60609 172.59537 263.92757 246.84743 327.5158 363.8064
  1 52.02520 77.83837        NA 210.47552 196.85454 261.1855 290.1263
  2 21.81895 32.64478  57.72528  88.27173  82.55921 109.5391 121.6766
   year
age     1986     1987     1988      1989     1990     1991     1992
  0 336.1940 510.6707 770.3123 1284.7200 1782.419 1663.196 618.1749
  1 268.1061 407.2469 614.3044 1024.5314 1421.434 1326.356 492.9787
  2 112.4415 170.7961 257.6343  429.6802       NA       NA       NA
   year
age     1993     1994     1995      1996      1997      1998      1999
  0 608.3666 466.7524 613.3552 1059.2507 1201.8013 1223.6555 1149.3403
  1 485.1569 372.2232 489.1352  844.7255  958.4059  975.8341  916.5696
  2       NA       NA 205.1393  354.2710  401.9477  409.2570  384.4019
   year
age      2000      2001      2002     2003     2004     2005     2006
  0 1121.2941 1980.5096 2644.6111 3968.281 4561.195 4730.823 5002.229
  1  894.2035 1579.4059 2109.0100 3164.603 3637.437 3772.711 3989.150
  2  375.0217  662.3901  884.5018 1327.209 1525.512 1582.245 1673.017
   year
age     2007     2008     2009     2010     2011     2012      2013
  0 4332.971 4531.484 5658.289 5986.108 5634.472 4957.176 2608.8973
  1 3455.434 3613.743 4512.342 4773.769 4493.348 3953.221 2080.5291
  2 1449.181 1515.575 1892.440 2002.080 1884.474 1657.949  872.5571
   year
age     2014      2015     2016     2017     2018     2019
  0       NA 2938.7817 4439.718 4357.999 3094.607 3713.480
  1       NA 2343.6035 3540.562 3475.393       NA 2961.406
  2 986.4992  982.8884 1484.883       NA       NA       NA
```

Table 2.6.2.24. North Sea Herring multifleet assessment. INDEX AT AGE RESIDUALS LAI-SNS

```
Units  :  NA
   year
age      1972      1973      1974        1975      1976       1977
  0 -0.407725        NA        NA -0.91026219        NA -0.5922436
  1  1.945232        NA 0.2679241  0.05826303 0.6773998         NA
  2        NA -1.080158        NA          NA        NA         NA
   year
age       1978      1979      1980        1981       1982        1983
  0  1.9874495        NA 1.5779778  1.89905975  0.4507975 -1.44879137
  1 -0.2241189 2.133298 0.8041784          NA -0.2089477  0.01323085
  2         NA 1.954288 0.3954561 -0.04049521 -0.7447951 -0.41562105
   year
age       1984        1985       1986        1987       1988      1989
  0  0.1315237  1.20593487  0.3904131  0.77624278  0.8204243 0.8677289
  1 -0.5088826 -0.05312096 -0.9110326 -0.10778823 -0.9592801 1.0703794
  2 -0.9291847 -1.19292840 -1.5194422  0.03316116 -0.3918890 0.4398310
   year
age       1990       1991       1992      1993        1994       1995
  0 0.64781453  0.9871800 -0.6534687 0.6948230 -0.22494273 -1.9284074
  1 0.09882312 -0.3114381  1.2954622 0.4268258  0.07794644 -0.3239541
  2         NA         NA         NA        NA          NA  0.1495582
   year
age       1996       1997       1998       1999      2000       2001
  0 -0.7998581  1.6789086 -0.1526622 -0.3471826  1.373349 -0.3149120
  1  0.1233771 -0.3417850 -0.3026442  0.2383089 -1.103821  1.2233445
  2  0.7383102 -0.3330206 -0.8920718 -0.1393250 -1.096827  0.2638078
   year
age       2002       2003       2004       2005       2006         2007
  0 -0.2680782 1.31052487  0.6560517 -1.3542074  0.9979426  0.351323139
  1 -1.5834968 0.17607647 -0.1946849  0.6593912 -0.1010296 -0.009190141
  2  0.3478074 0.02017891  1.0624956  1.3548046  0.3925295  1.031920422
   year
age       2008       2009      2010        2011      2012      2013
  0  0.8253177 1.17670104 0.2981831 -0.05005143 1.3143837 -5.002596
  1 -0.1281609 1.19136016 0.8847806  0.21804678 0.7520391  1.913030
  2  1.0152856 0.04084318 1.1042146 -0.41261476 0.3964274  1.325283
   year
age      2014        2015       2016      2017       2018      2019
  0        NA -0.01618142  1.7064957 1.1348075 -0.8044394 1.4162582
  1        NA -0.24473466 -0.5159889 0.6378617         NA 0.5582267
  2 0.7890399 -0.01592103  0.2845567        NA         NA        NA
```

Table 2.6.2.25. North Sea Herring multifleet assessment. PREDICTED INDEX AT AGE IBTS-Q1

```
Units  :  NA
   year
age    1984    1985    1986    1987    1988    1989     1990    1991
  1 1162859 1377449 1924647 2510590 1859168 1231812 987100.4 1000424
   year
```

```
age      1992    1993    1994    1995    1996    1997    1998     1999
  1 972751.6 1555750 1621146 1456792 1461092 1456912 1274482 831755.9
   year
age    2000    2001    2002    2003     2004    2005     2006     2007
  1 2479514 1461254 3247576 1429861 727690.2 1020759 740018.6 764659.9
   year
age      2008     2009    2010    2011     2012     2013    2014    2015
  1 928386.8 912044.8 1330858 1191218 947082.9 892069.2 1457647 2027216
   year
age      2016     2017     2018     2019    2020
  1 524331.2 959691.7 623136.8 915908.3 1060368
```

Table 2.6.2.26. North Sea Herring multifleet assessment. INDEX AT AGE RESIDUALS IBTS-Q1

```
Units  :  NA
   year
age       1984      1985      1986     1987      1988      1989       1990
  1 -0.1613603 0.9053539 0.9559064 1.824686 -1.089489 0.5896949 -0.8288632
   year
age      1991     1992       1993      1994      1995      1996      1997
  1 0.8967076 -0.13328 -0.2789059 0.5525326 0.4238923 -1.179383 0.2576232
   year
age     1998      1999       2000      2001      2002       2003      2004
  1 1.005488 0.1115111 -0.9557553 0.6960816 -1.845754 -0.5548838 0.4485724
   year
age      2005       2006      2007       2008       2009      2010
  1 0.3113187 -0.3339794 0.1883438 -0.5160011 0.01654388 -1.435548
   year
age     2011       2012      2013     2014     2015      2016     2017
  1 1.363569 -0.5960683 -1.536668 1.188785 0.434221 0.1828247 1.272208
   year
age      2018       2019      2020
  1 0.3074688 -0.6474979 0.4344462
```

Table 2.6.2.27. North Sea Herring multifleet assessment. PREDICTED INDEX AT AGE HERAS

```
Units  :  NA
   year
age       1989      1990      1991      1992      1993       1994
  1 7274946.63 5972795.8 6203294.8 5963503.1 9669014.5 10671619.3
  2 4524533.04 3079291.2 2717441.9 3009534.9 2469868.6  3737157.2
  3 4414995.96 3137943.2 1872004.0 1392700.0 1486888.7  1091705.4
  4 2023564.93 2949096.8 1841124.3 1043392.2  713436.9   621666.0
  5  536964.50 1266174.3 1766363.4 1069136.5  579252.8   323840.1
  6  308848.62  313157.5  736933.5 1043199.7  583955.2   280139.3
  7  149641.44  181076.4  178496.3  432836.0  507804.5   278352.4
  8   69478.81  135718.5  168482.0  195913.2  330275.8   396020.3
   year
age      1995       1996        1997      1998      1999       2000
```

```
  1 9683768.4 9897434.63 10039575.89 8755862.6 5681164.6 16730385.3
  2 4223271.7 4175640.27  4610746.18 6378654.2 3938759.3  3846265.1
  3 1977783.0 2606753.47  2664926.53 2629417.3 4420232.5  2479051.3
  4  567309.1  962509.91  1422727.30 1295062.5 1403676.3  2624752.6
  5  296670.0  306497.39   578240.17  748350.7  657474.8   844970.2
  6  164338.7  143096.29   189606.75  390669.3  378711.5   427882.1
  7  142861.9   92723.27    91485.49  119974.3  220390.3   241570.5
  8  317400.0  238655.11   190542.63  153867.0  132907.7   189830.6
   year
age      2001       2002       2003      2004      2005      2006
  1 9872027.6 21743032.5  9445932.1 4782618.4 6711934.7 4943644.2
  2 8837336.1  5643472.0 13601385.7 4285890.9 2607763.8 3808210.4
  3 3035634.7  6821005.0  3834203.5 9229482.4 3177644.7 2053862.8
  4 1446891.8  1631318.4  4179143.7 2428489.3 5169765.8 1951670.0
  5 1444707.7   787731.3   879093.0 2413189.6 1345296.2 3205665.8
  6  440007.8   904746.1   485321.1  434385.1 1156377.4  636135.0
  7  242453.8   268577.2   549940.8  302730.5  203495.3  531687.8
  8  247557.7   264612.7   264909.2  368394.1  288403.1  217823.2
   year
age      2007      2008      2009      2010      2011      2012      2013
  1 5165042.0 6322427.4 6249376.0 9152143.4 8200891.8 6507228.0 6141681.2
  2 2393426.9 3304080.2 4285726.1 4334307.4 5081388.4 4569499.9 3303606.2
  3 2522981.4 1856314.6 2304047.3 3430618.9 3224434.9 4255720.2 3586537.0
  4 1242838.6 1452802.2 1245687.5 1734622.3 2137411.6 2198137.7 2846110.2
  5 1092636.0  823102.3  985151.1  952087.0 1072303.2 1378163.1 1570714.6
  6 1658853.2  723193.0  601480.9  866054.8  650273.2  649418.6  899743.4
  7  336053.7 1151494.5  557232.2  451404.4  540015.8  393774.3  372819.9
  8  362700.4  503310.1 1406621.6 1523840.9 1255562.8  906621.3  767445.8
   year
age       2014       2015      2016      2017      2018      2019
  1 10023426.4 13883469.9 3578005.6 6588930.5 4280350.6 6290148.5
  2  4162861.7  7659993.5 9519509.5 1905021.8 3492095.4 1939440.9
  3  2712983.1  2573704.3 6066605.2 7230880.6 1588675.5 2352468.8
  4  2766238.4  1621358.9 1515543.7 3986285.4 4708396.3 1099590.9
  5  1846634.3  1657205.6  943686.5  979146.6 2576025.4 2673023.2
  6   973319.2  1023824.2  846323.9  465349.2  591355.7 1503646.2
  7   516667.0   493461.2  452134.0  391761.6  267059.1  285704.9
  8   570332.5   573240.0  486845.5  450033.6  496211.3  397484.3
```

Table 2.6.2.28. North Sea Herring multifleet assessment. INDEX AT AGE RESIDUALS HERAS

```
Units  :  NA
   year
age        1989       1990       1991       1992       1993        1994
  1  0.00000000  0.0000000  0.0000000  0.0000000  0.0000000  0.00000000
  2 -0.11874064 -0.4059424  0.2974545  0.8704575 -0.1498163 -1.34298622
  3 -0.19170587  0.9353845 -0.9179751 -0.9275820 -0.6210491 -2.05241108
  4 -0.33497245  1.5509561  0.2264361  0.3502018  0.4021498 -2.33519520
  5 -0.22205363  1.0976058  0.3543215  0.3073934  0.6668151 -0.15083886
  6 -0.32856988  1.1348560 -0.4368060  0.6911248  0.7399364  0.08047269
  7 -0.37906198  0.6102984  0.3474899 -0.3742082 -0.4379814 -0.09484917
```

```
  8  0.09869623  0.9729327 -0.7755563 -0.1389064 -0.6368146 -0.73020695
   year
age        1995        1996       1997        1998        1999       2000
  1  0.00000000  0.00000000  0.2820532 -1.59667207  0.07738851  0.4889217
  2 -1.62978060 -1.01298444  0.6597337 -0.59513590 -1.48022284 -0.2023720
  3  0.39241755  0.49466545 -0.5335664 -0.70621972 -0.41456064 -0.2272438
  4  0.88221425 -0.04636895 -0.6115774  0.01564264 -1.71023797  0.5497475
  5 -0.35767043 -0.00910169 -0.1037536  0.17665291 -2.02489554  0.3475362
  6  0.02077646 -1.99668068 -0.1308173 -0.32174783 -1.74308963  0.1735635
  7 -0.86076710 -0.54755206 -2.7337707  0.51529490 -2.25526250 -0.3667508
  8 -1.93494007  0.37460393  0.3661156 -0.44601389 -0.29564945 -0.2168363
   year
age       2001        2002       2003       2004       2005        2006
  1 -0.3678063 -0.09351437 -0.2946054  0.3563208 -1.3117805  0.57059406
  2  1.9276151 -0.35333855  2.0504830 -1.1048423 -0.9068999  0.09664043
  3  0.1334064  1.10376621 -0.9387558  0.0155205  1.0614367  0.40142350
  4 -0.1397731 -1.24689061 -0.4221984 -0.4545732  0.5339229  0.61410614
  5  0.2926679 -0.14397849 -2.2204395 -0.2255769 -0.4256296  1.57657796
  6 -0.6505012  0.21985087 -0.2369499 -2.3939530 -0.1595502 -0.12451915
  7 -2.0368821 -0.91283235 -0.5742123 -0.2502230 -1.8732297 -0.16918675
  8 -2.1221360 -0.43803857  0.1218045  0.5880648 -1.1117933 -1.36414634
   year
age        2007       2008        2009      2010        2011        2012
  1  0.24389252 -1.2569664 -0.01922671 0.8277066  0.87977695  0.15587503
  2  0.33675066 -0.7918537  1.91211473 0.5767235 -0.62568702  0.64287186
  3 -1.70264358  0.6332765  1.40311980 1.1303004 -1.13759123 -0.03025288
  4 -0.85160000  1.0750008 -0.16513615 2.1306008 -0.06996681 -0.83824478
  5 -0.73422966  1.3632459  1.33277917 1.6612231 -0.53869609 -0.42210799
  6 -0.05981671  1.4734725  1.46240995 2.6681173 -0.10335746 -0.41925883
  7 -0.52227966  2.3893391  1.12560248 1.7459682  0.58651376 -1.73354897
  8 -0.99640170  0.2632209  1.30787413 2.0502350  0.66401380 -0.84735559
   year
age       2013       2014       2015       2016        2017       2018
  1  0.1325736  1.2192370 -1.0812560  2.2761912 -1.53454820  2.0830172
  2 -0.1241144  1.8938068  2.3084922  2.0445876  0.33414217  1.0147727
  3  0.2019091  0.8169574  0.8270987 -0.3024453 -0.83856388  1.1303080
  4  0.8779830  1.0739012  0.1845438 -0.6169223 -0.84706898  0.6152317
  5  0.7161770  0.5132299 -0.2797019 -0.1714042 -0.08624817  0.2152084
  6  0.5509172  1.9057709 -0.2879403  0.7962655 -0.26997562  1.9836082
  7  0.8819543  0.8781296  0.3125970 -0.2236355 -0.18066235  2.9248565
  8  0.2951848 -0.7279682 -0.3615709 -0.6244992 -0.58346308 -0.2795280
   year
age       2019
  1  0.3442492
  2 -1.9286151
  3 -0.4518098
  4  1.3703263
  5  1.5682391
  6  0.8992208
  7  1.3011879
  8  0.2658163
```

Table 2.6.2.29. North Sea Herring multifleet assessment. PREDICTED INDEX AT AGE IBTS0

```
Units  :  NA
   year
age     1992     1993     1994     1995     1996     1997     1998
  0 137.2187 146.1867 120.7308 128.4192 105.8834 88.41192 56.37263
   year
age     1999     2000     2001     2002     2003     2004     2005
  0 177.3748 113.8304 222.2773 108.4408 57.41614 68.34074 62.63446
   year
age     2006     2007     2008     2009     2010     2011     2012
  0 61.88295 73.99929 65.70359 103.2942 84.73639 73.12556 68.59922
   year
age     2013     2014     2015     2016     2017     2018     2019
  0 90.74503 139.4921 37.24917 69.24453 42.52353 72.23033 70.08059
   year
age     2020
  0 64.37422
```

Table 2.6.2.30. North Sea Herring multifleet assessment. INDEX AT AGE RESIDUALS IBTS0

```
Units  :  NA
   year
age      1992      1993       1994      1995      1996     1997       1998
  0 0.8634374 0.2977856 -0.3770855 0.1467973 -0.361059 1.765499 -0.2242101
   year
age     1999       2000     2001      2002        2003       2004
  0 1.568518 -0.7115297 1.031604 0.3321442 -0.03366296 -0.7765319
   year
age      2005       2006       2007      2008    2009       2010
  0 0.2852178 -0.2703188 -0.4992696 -1.207378 1.14574 -0.4628993
   year
age       2011      2012      2013        2014      2015      2016
  0 -0.3445791 -0.115152 0.5447876 -0.05881465 -2.665633 0.4272633
   year
age      2017      2018       2019       2020
  0 -1.048075 0.6158523 -0.3167163 -0.1116502
```

Table 2.6.2.31. North Sea Herring multifleet assessment. CATCH-AT-AGE catch A

```
Units  :  NA
   year
age       1997      1998      1999      2000      2001      2002      2003
  1  42672.620  47656.49  29161.49  81077.56  36024.99  70586.97  30173.56
  2 501845.975 898557.50 506578.46 452849.90 746588.61 410098.07 950014.26
  3 413892.350 533861.44 890035.30 476550.89 453232.56 887787.12 510319.51
  4 236713.961 275069.40 294235.20 562443.20 265582.74 278087.94 802288.46
  5  93534.152 158231.20 134894.53 180500.11 290087.18 152709.81 211079.56
```

age							
6	24176.791	75866.82	64988.10	74887.81	77770.47	158132.01	111465.81
7	9244.458	15379.93	23459.91	27574.53	37866.20	43142.54	109067.86
8	19242.644	19713.94	14141.89	21664.03	38659.90	42502.37	52532.50

year						
age	2004	2005	2006	2007	2008	2009
1	14625.98	24541.13	19417.57	19489.92	22685.82	16056.78
2	282242.45	202007.14	312043.22	182493.58	231871.51	206397.14
3	1242307.59	488803.19	314461.18	354127.00	187809.87	137320.62
4	515102.54	1294085.63	465243.67	265229.38	199905.14	96147.19
5	696419.34	465261.86	1001102.08	298814.73	137209.20	92057.47
6	153772.93	590117.31	272080.38	600295.48	118149.18	41712.24
7	91984.17	108062.13	259303.80	143253.19	237125.53	54503.25
8	111916.17	153104.61	106188.52	154528.46	103582.08	137491.09

year							
age	2010	2011	2012	2013	2014	2015	2016
1	24916.90	25608.43	28924.31	24014.85	36315.42	39098.57	9780.285
2	220599.21	300687.34	393418.71	245821.66	291911.38	424458.79	527136.625
3	222283.48	271192.86	596785.77	488323.85	363478.10	292145.85	793742.539
4	133730.48	219756.65	396498.15	563039.11	551408.61	296882.57	313631.181
5	85951.48	129388.69	297023.72	404873.65	472263.44	440430.07	275191.470
6	54915.11	60965.14	150272.27	301891.54	299315.95	400265.54	374050.803
7	34747.61	54822.87	96622.92	144841.70	194398.83	271219.23	306434.243
8	117215.85	127364.98	222257.06	297841.07	214365.01	314706.76	329572.453

year				
age	2017	2018	2019	2020
1	14673.14	9927.02	11687.68	13530.92
2	85534.86	165496.36	72682.68	135239.06
3	892057.15	215879.52	271121.17	161954.08
4	774332.30	1064052.00	209833.94	266409.55
5	245729.36	778011.48	724638.19	167241.68
6	145097.18	230879.11	524249.54	493754.38
7	182353.32	153467.76	148129.22	372876.69
8	209250.32	284827.73	205861.15	160269.20

Table 2.6.2.32. North Sea Herring multifleet assessment. CATCH-AT-AGE RESIDUALS catch A

Units : NA

year					
age	1997	1998	1999	2000	2001
1	0.19117128	-0.046732853	0.5022327	0.101248403	-0.25724349
2	-1.67108526	1.720567438	-1.2094012	0.625568362	-1.22800385
3	-0.02135837	-0.664342159	1.2976824	-0.731181157	0.70654762
4	-0.13615777	-0.970594059	-0.3733700	0.324133136	-0.03277064
5	-0.11903493	-0.008932506	-0.5672356	0.051392350	0.01462688
6	0.60343835	1.233588861	-0.3653788	0.008170969	-0.33448276
7	1.04877723	-0.561781759	-0.0809600	0.075743896	1.37500414
8	-0.70585716	-1.008345229	-1.5744847	-1.458725581	0.53080432

year					
age	2002	2003	2004	2005	2006
1	0.10974318	0.46579543	-1.4654061	0.99530278	-0.172095877
2	-0.30921956	0.14594932	-0.9375283	0.25903895	0.667235633

```
  3  0.03837181 -0.25659052  0.7431691  0.07928973  0.028736068
  4 -0.37528676  0.47393060  0.9806952  0.07509347 -0.183734810
  5 -0.76212565  0.64701583  0.7805658  0.22686140 -0.023709299
  6  0.63800199 -0.04017316  0.6946529  0.04029303 -0.972600980
  7  0.41728677  0.16874583  1.0234002  0.99853132 -0.009192591
  8 -0.74712712 -1.50745145 -1.7668753 -0.54584193 -0.266781857
   year
age        2007        2008       2009       2010       2011        2012
  1  0.18727008  1.13702333  0.3212917  0.5739283 -0.4880246  0.54093981
  2 -1.15289344  0.71973783  0.3918287  0.8790095  0.2906002  0.46093659
  3  0.58378356 -1.64910259 -2.8296286  0.1708823  0.9972157  2.14067725
  4  0.32607686 -1.58697577 -0.7283485 -0.5722790  0.3539109  0.98674003
  5 -0.15807605 -0.59544847 -0.6996133 -0.2430846  0.2564670  0.70236638
  6 -0.02038223 -0.69125821 -0.3234408  0.3541184  0.3381088  0.03763611
  7  0.29637752 -0.09805633  0.4795683 -1.0324712 -0.6877159  0.48144559
  8 -0.27878233  0.89191111  0.7526137 -0.4218023 -0.1854891 -1.27912643
   year
age       2013        2014       2015         2016       2017        2018
  1  1.5700167  1.02185038 -1.0557443 -1.388074803 -0.6583027 -0.09738641
  2 -1.7119614  0.29487144  0.7391440  0.929336133 -1.2564181 -0.13967752
  3  0.8640904  0.27104674 -1.6732364  0.985188982  1.6925551  0.59738662
  4  1.0467658  1.01005732  0.0320078 -0.516791109  0.6035522  0.97034174
  5  1.4479252 -0.09695185  0.9277162  0.005951604 -0.3651044  0.98397974
  6  0.8514255 -0.87987950  1.0151680 -0.389819086 -1.0526740 -0.37257478
  7  0.3184374  0.06559848  0.6564248  0.207332233 -0.6169038  0.18822959
  8  0.2214316 -0.73724512  0.7982889  0.672483264  0.5244503  1.36297797
   year
age       2019 2020
  1 -0.9472896    0
  2 -1.7078296    0
  3  0.6216123    0
  4  0.5236779    0
  5  0.4712831    0
  6  0.6773821    0
  7 -0.2498768    0
  8  0.9763276    0
```

Table 2.6.2.33. North Sea Herring multifleet assessment. CATCH-AT-AGE catch BD

```
Units  :  NA
   year
age       1997       1998        1999        2000        2001       2002
  0 662552.854 367787.852 1323349.945 1006374.834 1354230.222 844362.015
  1 321297.480 272095.645  134309.682  424524.289   94961.264 496921.101
  2  35244.199  53320.064   31518.875   32843.993   45265.845  48406.057
  3   5611.379   5734.971    9471.842    4934.397    4167.131   9869.161
  4   2989.140   2817.909    2999.525    5213.463    1984.191   2358.644
  5   1212.224   1625.279    1402.068    1675.572    1980.913   1139.295
   year
age        2003       2004        2005        2006        2007
  0 484038.0009 727109.173 931561.4485 740512.5651 627660.6449
```

1	322843.9236	195575.495	363326.2545	135245.2199	75608.6345
2	131925.1342	45682.247	28185.3624	26112.3407	8017.2985
3	4186.6602	8581.357	2050.3768	887.8799	387.9551
4	4565.0122	2262.031	3347.9624	846.3110	191.5803
5	962.4076	2258.090	876.6798	1396.0484	168.9481

age \ year	2008	2009	2010	2011	2012
0	583017.64335	766145.4112	654116.8821	660031.2857	689154.2570
1	94448.07013	91400.9863	128643.0802	134143.1903	154694.1616
2	8344.58132	10763.7361	12629.5685	13902.6725	18176.3577
3	162.10296	258.0908	736.0538	656.2602	1240.4666
4	126.85594	139.3739	371.6866	434.7832	641.6469
5	71.91049	110.1791	203.8868	218.0810	402.8048

age \ year	2013	2014	2015	2016	2017
0	695390.9800	1369440.8420	499826.2350	1220975.44469	564586.24757
1	122606.5771	209321.6721	315133.1375	95112.52426	112382.42270
2	12517.4462	14878.3903	20325.6835	24571.10543	2472.64185
3	959.2152	631.3392	307.9426	633.25084	275.20761
4	763.8684	646.3553	194.8716	159.05119	152.43158
5	423.0215	432.8773	200.2813	99.61649	37.56625

age \ year	2018	2019	2020
0	946728.23131	667957.11415	613639.99781
1	52960.79204	61019.27918	70639.77754
2	2959.19237	1266.53513	2356.56906
3	42.77098	57.27582	34.21342
4	127.58516	26.91449	34.17092
5	70.16009	65.78194	15.18189

Table 2.6.2.34. North Sea Herring multifleet assessment. CATCH-AT-AGE RESIDUALS catch BD

Units : NA

age \ year	1997	1998	1999	2000	2001	2002
0	-2.2338978	-1.2173768	1.8945286	-0.23066508	0.7018663	-0.7042538
1	-1.6676367	0.5517446	-1.1175752	0.38990531	-3.0551599	2.0293559
2	1.6634701	0.2894075	0.2387934	0.12213286	0.0760979	0.5864213
3	0.8725409	-0.3371259	0.5279568	-0.04148314	0.5765680	0.2774891
4	-0.3180687	0.5795621	0.1538951	-0.05820375	0.9472848	-0.6621953
5	0.9318854	-0.2485978	-0.3273518	-0.64045231	-0.7944831	-0.1226341

age \ year	2003	2004	2005	2006	2007
0	-1.07111556	0.55039064	0.57819288	-0.06560139577	-0.3156524
1	1.08146412	0.03674465	1.05528497	-1.62636219978	-1.1663108
2	0.04102094	0.37569703	0.08949261	-0.00007533975	0.1126135
3	-0.77145936	0.01421565	-0.24101830	0.79181267036	-1.5831977
4	-0.36809962	0.11314145	-1.74070699	0.74673967354	-1.1823362
5	-1.05567348	-0.25940645	-1.20588224	0.48638366599	-1.0148592

age \ year	2008	2009	2010	2011	2012	2013

```
  0  0.17371503  0.003962201 -0.2032756  0.2924428 0.1200079 -0.6333048
  1 -0.09081403  0.561601411 -0.3870525  0.4099251 0.7143843 -0.1471741
  2  0.11188650 -0.114940170  0.0619682 -1.5748904 0.2162077  0.9372812
  3 -0.52778260  0.783811042  2.0708523 -0.8935280 1.1593766 -0.1780247
  4 -1.88697144 -2.002196700  1.3700835  0.0000000 0.0000000  0.4456840
  5 -2.98638060  0.000000000  2.3037429  0.0000000 0.4529423  0.0141358
   year
age       2014       2015        2016       2017       2018       2019
  0 0.95804198 -0.9897339  1.48385602 -1.2055012  1.1166937 -0.8316170
  1 0.06080789  0.2853898 -0.02229664 -0.3828464 -0.8387408 -0.2966789
  2 0.18928762 -0.2034036  0.01118471  0.2508922 -0.6950100 -1.1683360
  3 0.55736383 -1.5162035  1.44713509 -4.3011879 -1.0184948  0.4602191
  4 0.34423542  0.0000000  0.67623589  0.0000000  0.0000000  0.0000000
  5 0.77443684 -1.9532747 -0.85473491  0.0000000  0.0000000  0.0000000
   year
age 2020
  0    0
  1    07
  2    0
  3    0
  4    0
  5    0
```

Table 2.6.2.35. North Sea Herring multifleet assessment. CATCH-AT-AGE catch C

```
Units  :  NA
   year
age       1997       1998       1999       2000        2001        2002
  1 367238.281 289394.067 179260.728 497394.212 149081.0326 209754.7637
  2 145903.338 186293.067 110941.622 103279.055 138938.8471  62512.1089
  3  53342.861  40765.823  61393.825  29815.683   7184.1483   5621.8604
  4  12840.596   9042.311   8678.427  13822.670   1431.1102    564.6595
  5   5207.411   5215.312   4056.556   4442.513   1428.7458    272.7472
  6   1699.915   2713.713   2326.326   2239.155    433.6774    312.3257
   year
age        2003       2004       2005      2006       2007       2008
  1 173106.3155 88379.7735 121035.600 72323.365 53654.4941 47971.5657
  2 250783.9310 79868.1849  47606.859 59080.602 28384.4422 30751.8076
  3  15034.6113 37303.9046  11868.491  4698.798  2557.2085   926.0459
  4   7068.2204  4196.2511   7695.749  1684.466   455.1898   254.1944
  5   1490.1404  4188.9408   2015.168  2778.643   401.4163   144.0945
  6    820.6901   756.9957   1754.810   555.997   613.0033   126.3707
   year
age        2009        2010       2011       2012       2013       2014
  1 33687.24248 43565.15852 56790.7634 50651.9514 45732.3282 84404.8420
  2 30618.58622 28308.10803 45185.9710 44961.7793 31653.1683 44387.5891
  3   536.69552   619.25350  1548.1601  2857.5978  2289.8013  2515.6062
  4   102.58737   107.72625   344.3048   489.1085   581.3575   809.4085
  5    81.09825    59.09268   172.6983   307.0463   321.9491   542.0774
  6    49.35315    53.56964   104.3706   144.6789   185.4244   286.6680
   year
```

age	2015	2016	2017	2018	2019	2020
1	170795.804	28743.0264	63019.7843	35161.2801	39083.0415	45244.40253
2	110861.500	98614.2714	22610.7166	36733.0537	16290.2579	30309.76763
3	6338.746	5516.1213	9905.0946	1504.4842	1105.2593	660.13434
4	1284.835	433.6510	1661.3619	1291.2517	137.8067	174.93811
5	1320.503	271.6031	409.4370	710.0695	336.8146	77.72376
6	824.058	246.6969	195.4285	164.1472	190.6115	179.49974

Table 2.6.2.36. North Sea Herring multifleet assessment. CATCH-AT-AGE RESIDUALS catch C

Units : NA

year

age	1997	1998	1999	2000	2001	2002
1	3.8361788	1.5108319	0.41373202	-0.03841227	0.42059316	-0.69862253
2	0.3707909	-0.6320655	0.08018703	0.34592077	-0.58510427	-0.50468661
3	-0.6165594	-1.4731386	0.78158195	-0.54770270	-0.63817584	-0.79977701
4	1.6972901	0.9688745	0.55243991	0.49293492	-1.63556202	-0.03494368
5	0.6301093	-1.0920019	0.25984147	0.47912290	-3.03719575	-0.61633603
6	0.1991686	0.3112789	-1.23956540	0.01999718	-0.09087732	-1.58480858

year

age	2003	2004	2005	2006	2007	2008
1	0.4013119	-1.6294710	0.6832039	0.1509166	0.8427183	-0.4600293
2	0.2493790	1.0128187	1.2819073	-0.8304439	0.4888763	0.1950539
3	0.8164989	-0.8348399	-0.4287030	0.3887045	-1.6533302	0.1452721
4	2.0643903	1.0061560	-1.2908720	-0.2477728	-0.8975900	-0.8713763
5	0.2058373	1.3507850	-0.1500310	-0.8873638	1.3166807	-0.2558488
6	0.4910979	0.7365310	-0.1523493	-0.7904986	-2.3909518	-1.1781328

year

age	2009	2010	2011	2012	2013	2014
1	0.1145871	0.8345365	-0.77125552	0.296620427	0.1583190	-0.2026716
2	-2.8718846	0.4221191	1.12848963	-0.148997461	1.3168608	1.0257444
3	-0.1075765	-1.3692351	1.73865288	0.002968461	-0.2631215	1.0679634
4	1.2030686	0.4658981	-0.33823973	1.344324729	-1.0280401	-0.7767343
5	0.0000000	0.5554369	0.01141888	-0.878192197	-0.1267821	-0.1652431
6	0.0000000	-1.6756246	0.24143484	0.340128473	0.0000000	-0.5126119

year

age	2015	2016	2017	2018	2019	2020
1	-1.1523205	-1.36401543	0.4237810	-0.615206801	0.6006021	0
2	0.5222302	-1.16840833	0.6543007	-0.348408432	-0.2620157	0
3	1.5346031	0.04385775	-0.2706928	0.005871081	0.5130766	0
4	0.7017707	-0.02326144	0.7876699	0.200716576	-1.7922231	0
5	2.0336278	-0.53760015	1.3286988	0.240011790	-2.3668417	0
6	0.1461137	-0.14464269	-1.8473221	0.155180391	-0.8767829	0

Table 2.6.2.37. North Sea Herring multifleet assessment. PREDICTED INDEX AT AGE IBTS-Q3

Units : NA

age	1998	1999	2000	2001	2002	2003
0	1003511.69	3130748.96	1986744.48	3865603.55	1866210.18	978719.7
1	387843.05	251458.28	739340.27	436330.16	959884.03	416281.6
2	256420.36	158364.44	154647.64	355920.56	227311.62	547408.5
3	82402.28	138519.16	77710.47	95386.19	214445.72	120428.0
4	34608.72	37519.16	70148.92	38736.86	43689.40	111738.6
5	15827.51	13910.18	17870.01	30577.51	16673.28	18553.8

age	2004	2005	2006	2007	2008	2009
0	1152677.23	1041541.47	1027647.58	1231529.05	1090094.09	1719261.94
1	210628.75	295614.93	218183.24	228282.67	279733.79	276722.65
2	172461.32	104885.40	153199.57	96364.41	133140.05	172928.44
3	289722.08	99610.96	64367.05	79122.06	58338.89	72569.92
4	64835.84	137680.98	51981.38	33136.40	38877.93	33433.68
5	50786.71	28217.93	67321.59	22985.32	17405.76	20906.96

age	2010	2011	2012	2013	2014	2015
0	1415353.51	1226663.73	1159305.46	1557440.12	2419426.80	653162.22
1	405448.13	363358.95	288242.92	272122.55	444043.11	614719.67
2	174900.01	204986.19	184119.06	133194.84	167869.60	309036.03
3	108025.46	101435.30	133497.48	112541.10	85148.44	80864.98
4	46548.43	57272.68	58658.40	75876.70	73737.87	43252.97
5	20204.40	22715.70	29048.85	33032.89	38835.86	34831.03

age	2016	2017	2018	2019
0	1229614.61	746465.59	1279540.74	1260726.84
1	158349.50	291833.59	189595.22	278610.58
2	384083.13	76904.03	140963.00	78325.76
3	190478.22	227091.04	49865.23	73923.72
4	40381.69	106284.96	125335.44	29323.02
5	19807.96	20595.62	54044.38	56165.23

Table 2.6.2.38. North Sea Herring multifleet assessment. INDEX AT AGE RESIDUALS IBTS-Q3

Units : NA

age	1998	1999	2000	2001	2002	2003
0	-0.5319871	0.4382924	-0.5389602	-1.7773159	-0.2850552	-0.6550294
1	0.1697082	0.4600631	0.3625995	0.2709578	2.3360805	0.3689644
2	0.4949172	0.7344169	2.5137427	-1.3767920	1.4558371	0.1315090
3	-0.1146639	-1.2438998	0.3755835	0.9095560	0.2844281	0.9527303
4	-1.9731533	1.3168361	-1.4165273	0.2222596	1.0206529	-0.6412237
5	-1.1769922	0.2828997	-0.3783274	-0.9742384	1.0023609	-0.2256467

age	2004	2005	2006	2007	2008	2009
0	1.4169169	-0.42912598	-0.2754433	1.3808140	-0.79396854	1.2234575
1	0.8689586	1.29857911	0.7750000	-2.3751048	-0.81610394	-1.0736188

```
  2  1.0084027 -0.02985815  0.4747271  0.4814713  0.09834225 -2.0118996
  3  0.2683086 -0.87305171  0.4544809  1.1469451  0.81194092  0.8677124
  4  0.7627222 -0.98299555 -0.9737971  1.5699587 -0.29706831 -0.2342632
  5 -1.0941226  1.11960735 -0.7400861  0.4877228  0.84772713 -1.4654522
   year
age       2010        2011        2012       2013       2014        2015
  0 -0.1626475 -1.03452037 -0.73735160  1.0198372  2.0969218 -0.51441334
  1  0.8276759  0.23726850 -0.40580086 -0.1975468 -0.8947261  1.27735806
  2 -0.1795734  0.06240037 -1.69726345  0.5426707  0.4358756  0.32370236
  3 -1.4339401  0.16095116 -1.12274988  0.3930024 -0.1804619  1.12146489
  4 -0.4809372 -0.68757305 -0.00474729  0.1720030  0.2262338  0.75174660
  5 -0.6259399 -0.10015297 -0.12762649  0.5592569  0.3796617  0.03661339
   year
age          2016       2017       2018       2019
  0  0.2999762654  0.4777058  0.1700705  0.6003140
  1 -0.0994992967 -0.4944303  1.1051089 -2.6086108
  2 -0.0004989331  0.5770191 -1.6199971  1.0919038
  3  0.2568964090 -0.5948991  0.5691664 -2.4736768
  4  1.6973410443  1.0494052 -1.4845296  0.9432827
  5  1.8408781115  2.4869017 -0.3935654 -1.5682065
```

Table 2.6.2.40. North Sea Herring multifleet assessment. FIT PARAMETERS

	name	value	std.dev
1	logFpar	-2.50042513	0.07619125
2	logFpar	-12.93258371	0.09596781
3	logFpar	-0.26234433	0.12336523
4	logFpar	-0.24370270	0.07376331
5	logFpar	-0.08143628	0.07131696
6	logFpar	-2.70929435	0.13472608
7	logFpar	-3.33875484	0.11486926
8	logFpar	-3.42508284	0.09581572
9	logFpar	-3.51295170	0.09640774
10	logFpar	-3.67374703	0.09821500
11	logFpar	-3.90885624	0.09977047
12	logFpar	-4.30220521	0.11306072
13	logSdLogFsta	-1.14050379	0.08910760
14	logSdLogFsta	-0.63094227	0.08897742
15	logSdLogFsta	-0.77452881	0.21618826
16	logSdLogFsta	-0.57634463	0.13205794
17	logSdLogFsta	-0.95416656	0.26757757
18	logSdLogFsta	-1.20281019	0.31682413
19	logSdLogFsta	-0.09933670	0.18228095
20	logSdLogN	-0.58426996	0.11912042
21	logSdLogN	-1.69260945	0.08029379
22	logSdLogP	0.15417136	0.09780270
23	logSdLogP	-0.28279112	0.15810216
24	logSdLogP	-0.18418958	0.12999604
25	logSdLogObs	0.12419966	0.16680633
26	logSdLogObs	-1.97269091	0.15653544

27	logSdLogObs	-1.90443268	0.23985001
28	logSdLogObs	-0.98355853	0.24790734
29	logSdLogObs	-1.15323340	0.25786648
30	logSdLogObs	0.33623418	0.09224168
31	logSdLogObs	-0.27186708	0.18165574
32	logSdLogObs	-0.55042599	0.16235490
33	logSdLogObs	-0.40234823	0.09724154
34	logSdLogObs	-0.71929386	0.15731771
35	logSdLogObs	-1.60459829	0.08459151
36	logSdLogObs	-1.13986464	0.12251844
37	logSdLogObs	-1.26543086	0.15116908
38	logSdLogObs	-1.08871490	0.17650365
39	logSdLogObs	-0.66544140	0.17850503
40	logSdLogObs	-0.85554579	0.17211397
41	logSdLogObs	-1.13705798	0.09896621
42	logSdLogObs	0.17326675	0.04423975
43	transfIRARdist	-0.21469877	0.27273366
44	itrans_rho	1.57474999	0.13027383
45	itrans_rho	0.69470363	0.21700983
46	itrans_rho	2.59088483	1.60282761
47	rhop	0.50339732	0.22247981
48	logAlphaSCB.LAI-ORSH	-0.54372997	0.31452374
49	logAlphaSCB.LAI-BUN	-0.94270105	0.34421565
50	logAlphaSCB.LAI-CNS	0.35840855	0.33794283
51	logAlphaSCB.LAI-CNS	-0.38181921	0.35356482
52	logAlphaSCB.LAI-CNS	-3.05105221	0.40858591
53	logAlphaSCB.LAI-SNS	-0.22630540	0.25057211
54	logAlphaSCB.LAI-SNS	-1.09525478	0.27271399

Table 2.6.2.41. North Sea Herring multifleet assessment. NEGATIVE LOG-LIKELIHOOD

1565.36538008841

Table 2.6.3.1. North Sea Herring single fleet assessment. 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

	year							
age	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

	year									
age	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

	year							
age	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

	year							
age	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	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	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	2016	2017	2018	2019
0	1583568	462148	1337404	649197
1	109135	209356	73260	172202
2	625483	108706	206232	105505
3	818585	1079854	200527	307520
4	293372	837770	1178604	198443
5	280451	222790	848961	730016
6	367844	145511	223637	528327
7	307347	175533	144999	133409
8	359076	221296	332482	217686

Table 2.6.3.2. North Sea Herring single fleet assessment. 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
   year
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
   year
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
   year
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	2019
0	0.0071000	0.0090000	0.0054000	0.0064000
1	0.0265000	0.0380000	0.0394000	0.0395000
2	0.1267000	0.0990000	0.1085000	0.1210000
3	0.1549000	0.1560000	0.1451000	0.1465000
4	0.1803000	0.1730000	0.1838000	0.1688000
5	0.2059000	0.1880000	0.1914000	0.2036000
6	0.2151000	0.2150000	0.2151000	0.2081000
7	0.2313000	0.2200000	0.2342000	0.2195000
8	0.2299244	0.2305184	0.2455776	0.2434812

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

Units : kg

	year						
age	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

	year						
age	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
   year
age      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
   year
age      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
   year
age      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
  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
   year
age        2014        2015       2016        2017        2018       2019
  0 0.005666667 0.005333333 0.00500000 0.004166667 0.004566667 0.00400000
  1 0.043333333 0.043666667 0.04333333 0.042866667 0.039966667 0.04023333
  2 0.128666667 0.127333333 0.12100000 0.110866667 0.101300000 0.09900000
  3 0.176666667 0.161333333 0.16033333 0.153166667 0.152966667 0.14846667
  4 0.203666667 0.200000000 0.18866667 0.182966667 0.185766667 0.17736667
  5 0.215666667 0.211666667 0.21600000 0.207100000 0.215033333 0.20896667
  6 0.228666667 0.224666667 0.22433333 0.226533333 0.229200000 0.22613333
  7 0.241333333 0.229000000 0.22433333 0.227066667 0.238766667 0.23786667
  8 0.246572539 0.239358137 0.23372066 0.229232697 0.246755779 0.25411003
```

Table 2.6.3.4. North Sea Herring single fleet assessment. NATURAL MORTALITY

Units : NA

age	1947	1948	1949	1950	1951	1952	1953
0	0.8135307	0.8135307	0.8135307	0.8135307	0.8135308	0.8135307	0.8135307
1	0.6750149	0.6750149	0.6750149	0.6750149	0.6750148	0.6750149	0.6750150
2	0.4424777	0.4424777	0.4424777	0.4424777	0.4424777	0.4424777	0.4424778
3	0.3894577	0.3894577	0.3894577	0.3894577	0.3894577	0.3894577	0.3894577
4	0.3617534	0.3617534	0.3617534	0.3617534	0.3617534	0.3617534	0.3617534
5	0.3443683	0.3443683	0.3443683	0.3443683	0.3443683	0.3443683	0.3443683
6	0.3347824	0.3347824	0.3347824	0.3347824	0.3347824	0.3347824	0.3347824
7	0.3290872	0.3290872	0.3290872	0.3290872	0.3290872	0.3290872	0.3290872
8	0.3283752	0.3283752	0.3283752	0.3283752	0.3283752	0.3283752	0.3283752

age	1954	1955	1956	1957	1958	1959	1960
0	0.8135308	0.8135307	0.8135307	0.8135312	0.8135302	0.8135307	0.8135326
1	0.6750146	0.6750151	0.6750152	0.6750136	0.6750167	0.6750153	0.6750087
2	0.4424777	0.4424778	0.4424778	0.4424774	0.4424782	0.4424778	0.4424761
3	0.3894576	0.3894578	0.3894578	0.3894574	0.3894581	0.3894578	0.3894563
4	0.3617534	0.3617534	0.3617534	0.3617533	0.3617536	0.3617534	0.3617529
5	0.3443683	0.3443683	0.3443683	0.3443683	0.3443683	0.3443682	0.3443683
6	0.3347824	0.3347824	0.3347824	0.3347826	0.3347822	0.3347823	0.3347832
7	0.3290872	0.3290871	0.3290871	0.3290874	0.3290869	0.3290871	0.3290882
8	0.3283752	0.3283752	0.3283751	0.3283754	0.3283749	0.3283751	0.3283762

age	1961	1962	1963	1964	1965	1966	1967
0	0.8135272	0.8135323	0.8135383	0.8135110	0.8135475	0.8135563	0.8134293
1	0.6750260	0.6750113	0.6749888	0.6750778	0.6749675	0.6749210	0.6753448
2	0.4424807	0.4424767	0.4424709	0.4424945	0.4424646	0.4424536	0.4425652
3	0.3894602	0.3894567	0.3894521	0.3894717	0.3894464	0.3894382	0.3895306
4	0.3617544	0.3617529	0.3617514	0.3617588	0.3617487	0.3617467	0.3617810
5	0.3443682	0.3443682	0.3443687	0.3443678	0.3443680	0.3443702	0.3443650
6	0.3347812	0.3347827	0.3347856	0.3347752	0.3347872	0.3347944	0.3347440
7	0.3290854	0.3290876	0.3290915	0.3290772	0.3290940	0.3291034	0.3290342
8	0.3283735	0.3283756	0.3283796	0.3283652	0.3283820	0.3283915	0.3283220

age	1968	1969	1970	1971	1972	1973	1974
0	0.8136569	0.8135827	0.8130484	0.8143397	0.8133599	0.8114455	0.8182138
1	0.6746366	0.6747816	0.6766161	0.6725121	0.6752167	0.6821197	0.6601998
2	0.4423750	0.4424207	0.4429001	0.4418043	0.4425576	0.4443383	0.4385170
3	0.3893704	0.3894136	0.3898078	0.3888898	0.3895430	0.3909907	0.3861357
4	0.3617183	0.3617408	0.3618839	0.3615302	0.3618081	0.3623135	0.3604690
5	0.3443688	0.3443769	0.3443493	0.3443803	0.3444012	0.3442663	0.3444733
6	0.3348231	0.3348162	0.3345928	0.3350602	0.3347955	0.3339227	0.3364625
7	0.3291444	0.3291317	0.3288263	0.3294753	0.3290936	0.3279101	0.3314221
8	0.3284324	0.3284201	0.3281136	0.3287636	0.3283831	0.3271940	0.3307138

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	2019
0	0.8873620	0.8693360	0.8495409
1	0.6725878	0.6758221	0.6800092
2	0.4402272	0.4408952	0.4419012
3	0.3892692	0.3883200	0.3873211
4	0.3779935	0.3782252	0.3783272
5	0.3627596	0.3633887	0.3639009
6	0.3532380	0.3547852	0.3562775
7	0.3475167	0.3499350	0.3523502
8	0.3378075	0.3403759	0.3430125

Table 2.6.3.5. North Sea Herring single fleet assessment. PROPORTION MATURE

Units : NA

	year													
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

	year													
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

	year													
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
   year
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
   year
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 2019
  0 0.00 0.00 0.00
  1 0.00 0.00 0.00
  2 0.55 0.37 0.59
  3 0.96 0.91 0.97
  4 0.97 0.98 0.99
  5 1.00 1.00 1.00
  6 1.00 1.00 1.00
  7 1.00 1.00 1.00
  8 1.00 1.00 1.00
```

Table 2.6.3.6. North Sea Herring single fleet assessment. FRACTION OF HARVEST BEFORE SPAWNING

```
Units  :  NA
   year
age 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
```

```
  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
   year
age 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 2017 2018 2019
  0 0.67 0.67 0.67
  1 0.67 0.67 0.67
  2 0.67 0.67 0.67
  3 0.67 0.67 0.67
  4 0.67 0.67 0.67
  5 0.67 0.67 0.67
```

```
  6 0.67 0.67 0.67
  7 0.67 0.67 0.67
  8 0.67 0.67 0.67
```

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

```
Units  :  NA
   year
age 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
   year
age 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
  0 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  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
  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
  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
  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
  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
  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
  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
  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
```

year

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
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
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
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
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
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
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
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
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

year

age	2017	2018	2019
0	0.67	0.67	0.67
1	0.67	0.67	0.67
2	0.67	0.67	0.67
3	0.67	0.67	0.67
4	0.67	0.67	0.67
5	0.67	0.67	0.67
6	0.67	0.67	0.67
7	0.67	0.67	0.67
8	0.67	0.67	0.67

Table 2.6.3.8. North Sea Herring single fleet assessment. SURVEY INDICES

HERAS - Configuration

Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) (16/Mar/2020) . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	8.00	8.00	1989.00	2019.00	0.54	0.56

Index type : number

HERAS - Index Values

Units : NA

year

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

year

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
   year
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
   year
age    2013     2014    2015     2016    2017    2018     2019
  1 6388000 11634000 6714000  9034000 3054000 9938000 10146000
  2 2683000  4918000 9495000 12011000 1761000 4254000  1303000
  3 3031000  2827000 2831000  5832000 6095000 1692000  2345000
  4 2895000  2939000 1591000  1273000 3142000 5150000  1212000
  5 1546000  1791000 1549000   822000  787000 2440000  3506000
  6  849000  1236000  926000   909000  365000  719000  1657000
  7  464000   669000  520000   395000  298000  529000   395000
  8  842000   461000  496000   366000  293000  404000   424000
```

IBTS-Q1 - Configuration

Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) (16/Mar/2020) . Imported from VPA file.

```
        min          max    plusgroup      minyear      maxyear
   1.0000000    1.0000000           NA 1984.0000000 2020.0000000
      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 957324 1473183 1662159 3221178 1464182 1677569 768368.2 1085666
   year
age    1992    1993    1994    1995    1996    1997    1998     1999
  1 1147216 1838663 2812005 2266363 1277320 1350215 1804583 698806.6
   year
age    2000    2001    2002    2003     2004     2005     2006     2007
  1 2096596 1605575 1820055 1426762 771457.8 925583.4 717821.2 883302.7
   year
age     2008     2009     2010    2011     2012     2013    2014    2015
  1 774710.1 732798.5 916572.8 1613673 824527.6 505955.1 1645682 1943846
   year
age   2016    2017     2018     2019    2020
```

```
  1 558363 1361551 689636.3 970111.9 1145081
```

IBTS0 - Configuration

```
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) (16/Mar/2020) . Imported
from VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      0.00        NA   1992.00   2020.00      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     2020
  0 113.7963 21.76008 81.69031 27.83202 102.1129 51.62587 62.41121
```

IBTS-Q3 - Configuration

```
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) (16/Mar/2020) . Imported
from VPA file.
         min          max    plusgroup      minyear      maxyear
   0.0000000    5.0000000           NA 1998.0000000 2019.0000000
      startf         endf
   0.6084662    0.6084662
Index type : number
```

```
IBTS-Q3 - Index Values

Units  :  NA
   year
age       1998       1999       2000       2001       2002      2003
  0 707529.29 4233846.75 1620038.45 1714578.46 2055109.72 833224.14
  1 415995.22  290830.27  763292.82  317776.68 1940710.52 467668.41
  2 281888.09  205967.99  256000.32  219364.82  438205.77 557140.92
  3  90723.61  122047.54  115690.52   93775.23  341437.92 145835.21
  4  24717.72   49316.26   66902.87   41645.09   79278.42 109662.86
  5  10726.45   17602.24   17044.41   25305.84   31226.51  18512.78
   year
age       2004       2005      2006       2007      2008       2009
  0 1970515.25 1005504.45 962447.25 2086570.65 524669.09 2654058.23
  1  384254.10  382307.62 288008.48  132097.51 150256.12  199023.94
  2  281709.01  112453.04 192018.99   92766.30 112671.15   93460.99
  3  411046.51   81907.19  77885.34   97733.80  58448.44   61031.71
```

```
  4   93091.92   96320.65  45055.96   48852.73  34431.66   25875.50
  5   48867.94   30631.40  51266.22   29610.43  18428.13   11714.79
   year
age       2010      2011      2012       2013       2014      2015
  0 1236261.22 765326.25 730383.60 1692837.79 6751020.89 486178.94
  1  503511.61 312408.38 204328.24  256455.03  433998.02 714517.44
  2  172333.79 173233.15  89601.62  139602.35  191263.38 348475.49
  3   79991.16  97020.29  64651.12  119332.48   85553.69 123410.84
  4   35528.12  48163.41  36532.75   81910.09   75575.16  64702.78
  5   14991.30  20709.64  21092.99   38385.03   42936.54  43663.74
   year
age       2016      2017       2018       2019
  0 1581744.08 796376.86 1761034.92 1400298.87
  1  169323.28 275389.01  324256.82  136400.79
  2  359009.05  76519.79  113537.58   70812.24
  3  206745.55 193058.61   47077.15   39172.62
  4   64513.46 123311.33   83658.56   24716.52
  5   40839.27  39288.74   37960.22   34846.04
```

LAI-ORSH - Configuration

```
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      1.00      1.00   1972.00   2019.00      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 2019
  0    -1    -1   -1   -1   -1   -1   -1 2488
  1 19552 21282 6604 9631   -1   -1  102   -1
```

LAI-BUN - Configuration

```
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      1.00      1.00   1972.00   2019.00      0.67      0.67
Index type : partial
```

LAI-BUN - Index Values

Units : NA

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

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

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

age	2014	2015	2016	2017	2018	2019
0	-1	-1	-1	-1	-1	5654
1	5033	3496	3872	5833	1740	3794

LAI-CNS - Configuration

min	max	plusgroup	minyear	maxyear	startf	endf
0.00	3.00	3.00	1972.00	2019.00	0.67	0.67

Index type : partial

LAI-CNS - Index Values

Units : NA

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

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

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

age	2013	2014	2015	2016	2017	2018	2019
0	-1	-1	-1	-1	-1	-1	-1
1	7354	1149	3424	3288	3965	1509	10605
2	-1	-1	-1	-1	-1	-1	-1

```
  3   -1   -1   -1   -1   -1   -1    -1
```

LAI-SNS - Configuration

```
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      2.00      2.00   1972.00   2019.00      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  2019
  0    5   -1 2011 20710 10553 1140 14082
  1 9314   -1 1200  1442  5880   -1  5258
  2 2957 1851  645  1545    -1   -1    -1
```

Table 2.6.3.9. North Sea Herring single fleet assessment. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2019         2         6
```

Table 2.6.3.10. North Sea Herring single fleet assessment. sam CONFIGURATION SETTINGS

```
name           : North Sea Herring
desc            : Imported from a VPA file. ( ./data/index.txt ).  Tue Mar 24 09:11:22
2020
range          :       min       max plusgroup   minyear   maxyear   minfbar   maxfbar
range          :         0         8         8      1947      2020         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 single fleet assessment. FLR, R SOFTWARE VERSIONS

```
FLSAM.version                        2.1.0
FLCore.version                      2.6.14
R.version      R version 3.6.3 (2020-02-29)
platform                 x86_64-w64-mingw32
run.date                2020-03-24 09:15:37
```

Table 2.6.3.12 North Sea Herring single fleet assessment. STOCK SUMMARY

Year	Recruitment Age 0	Low	High	TSB	Low	High	SSB	Low	High	Fbar (Ages 2-6) f	Low f	High f	Landings tonnes	Landings SOP
1947	55442046	29905600	102784111	9514194	7132890	12690492	5444829	3877739	7645220	0.1215	0.0818	0.1805	581760	1.4609
1948	55876843	31678907	98558375	8292207	6245114	11010320	4418539	3167651	6163396	0.1213	0.0842	0.1747	502100	1.3326
1949	51265908	29304331	89686173	8128234	6166702	10713700	4278054	3105900	5892574	0.1333	0.0931	0.1910	508500	1.4502
1950	69958768	40885165	119706726	8144604	6229709	10648101	4242634	3118227	5772492	0.1401	0.0997	0.1969	491700	1.3073
1951	62903205	37225495	106293100	8422471	6485542	10937869	4079525	3013172	5523258	0.1682	0.1220	0.2318	600400	1.3238
1952	59789405	35869796	99659694	8217604	6333240	10662634	4092850	3011779	5561967	0.1708	0.1231	0.2369	664400	1.2720
1953	60169912	37252432	97186094	7874106	6093926	10174319	3876624	2837935	5295474	0.1779	0.1279	0.2475	698500	1.1979
1954	57435650	36226606	91061632	7652489	5948217	9845065	3638878	2647526	5001434	0.1984	0.1418	0.2777	762900	1.2509
1955	48441248	30871961	76009245	7168764	5590532	9192537	3534030	2583230	4834787	0.1958	0.1406	0.2725	806400	1.0598
1956	35839655	22928560	56020999	6477457	5080423	8258652	3271684	2395037	4469207	0.1973	0.1439	0.2705	675200	1.2712
1957	84393829	53743758	132523637	6389720	5062191	8065384	2951670	2170723	4013573	0.2103	0.1538	0.2876	682900	1.1575
1958	33238126	21470586	51455185	6291604	4999854	7917088	2399474	1765576	3260962	0.2194	0.1624	0.2965	670500	1.1674
1959	37425200	23562576	59443652	6833037	5475176	8527651	3561458	2670354	4749924	0.2391	0.1782	0.3208	784500	1.5186
1960	16309280	10293621	25840529	5580295	4501905	6917004	2942338	2218904	3901634	0.2101	0.1589	0.2779	696200	1.1830
1961	68959229	44079793	107881069	5635841	4613327	6884988	2839855	2186584	3688300	0.2444	0.1898	0.3147	696700	1.1348
1962	32094128	20835020	49437586	5171682	4242577	6304256	1986885	1512947	2609287	0.2743	0.2120	0.3548	627800	1.1705
1963	42338883	28117982	63752123	5696068	4712187	6885379	2858685	2234934	3656521	0.1967	0.1539	0.2514	716000	0.8602
1964	43973249	29328388	65930887	5689208	4876663	6637137	2619620	2126733	3226737	0.2862	0.2350	0.3487	871200	1.0656
1965	21743710	14486180	32637238	5124826	4484932	5856018	2129513	1772629	2558248	0.4717	0.3917	0.5682	1168800	1.1496
1966	22643104	15291380	33529357	3795288	3349181	4300814	1625507	1362186	1939730	0.4837	0.4092	0.5718	895500	1.0707
1967	28845442	19560752	42537194	2937456	2609701	3306374	1027011	871844	1209794	0.6416	0.5469	0.7527	695500	1.1757
1968	29481027	19939176	43589110	2528519	2216655	2884259	576056	486737	681765	0.9683	0.8258	1.1354	717800	1.2551
1969	14134725	9379871	21299914	1916117	1655703	2217489	495333	400313	612906	0.8715	0.7436	1.0215	546700	0.9674
1970	28850402	19492289	42701281	1866904	1617880	2154258	476378	383355	591972	0.9344	0.8066	1.0826	563100	0.9657
1971	22558603	15477360	32879676	1724932	1480088	2010279	327573	266883	402065	1.2760	1.0961	1.4853	520100	1.0747
1972	15707167	10795289	22853958	1529936	1323719	1768278	332372	270122	408967	0.6639	0.5603	0.7866	497500	0.9197
1973	8018521	5468988	11756594	1218960	1072152	1385870	297388	244949	361054	0.8717	0.7536	1.0083	484000	0.9575

1974	13791442	9230751	20605460	870463	759173	998067	199525	165832	240063	0.8749	0.7514	1.0186	275100	0.9680
1975	3264700	2130559	5002570	698534	585950	832749	114693	93525	140652	1.0410	0.8568	1.2647	312800	0.9343
1976	4153767	2630144	6560011	507034	422916	607884	153552	115065	204911	0.8068	0.6192	1.0514	174800	0.9530
1977	4990994	3076853	8095941	348921	278580	437024	102379	74363	140950	0.3719	0.2745	0.5037	46000	1.1979
1978	5407630	3240377	9024400	422003	328595	541962	135459	99364	184667	0.2686	0.1939	0.3720	11000	1.2152
1979	10142908	6303246	16321526	558623	442807	704731	179619	136591	236201	0.2195	0.1604	0.3006	25100	1.0056
1980	15498007	10452150	22979791	757271	611860	937240	197292	155315	250615	0.1932	0.1521	0.2455	70764	1.0936
1981	36679638	25515603	52728358	1362055	1103291	1681510	297000	233182	378283	0.2144	0.1701	0.2704	174879	1.0081
1982	58184169	40921789	82728484	2082564	1690256	2565927	416142	329984	524797	0.1902	0.1517	0.2384	275079	0.9786
1983	57260462	41018772	79933171	2866889	2366341	3473317	635887	506650	798089	0.2355	0.1901	0.2918	387202	1.0771
1984	55842014	39396147	79153186	3724869	3136726	4423291	1064208	848447	1334837	0.3037	0.2472	0.3730	428631	1.0543
1985	67199646	46641412	96819378	4268595	3631456	5017521	1166105	945081	1438818	0.3808	0.3084	0.4703	613780	1.0419
1986	81773211	56509183	118332238	4806198	4072134	5672590	1185654	970009	1449239	0.3584	0.2920	0.4400	671488	1.1373
1987	77668232	54103878	111495785	4885070	4165325	5729183	1413250	1155157	1729008	0.3441	0.2826	0.4190	792058	1.0173
1988	45701177	31814546	65649140	4759542	4090252	5538349	1859715	1522375	2271806	0.3244	0.2676	0.3932	887686	1.1641
1989	37952843	26465288	54426701	4190995	3660448	4798439	1910569	1607009	2271471	0.3102	0.2585	0.3721	787899	1.0335
1990	32037356	22125556	46389442	4122992	3606755	4713119	2017634	1703382	2389861	0.2557	0.2118	0.3086	645229	1.0515
1991	35723373	24843479	51367982	3927476	3434785	4490838	1786189	1512483	2109425	0.2794	0.2325	0.3358	658008	1.0197
1992	66560766	48399794	91536247	4007349	3489135	4602530	1398218	1179429	1657592	0.3094	0.2564	0.3734	716799	0.9950
1993	70049041	50309297	97534024	3768205	3237566	4385817	1022493	855330	1222325	0.3485	0.2883	0.4211	671397	1.0231
1994	54139051	38358082	76412498	3687108	3112017	4368473	1092977	912441	1309233	0.3608	0.2984	0.4363	568234	1.0498
1995	61319615	43621562	86198087	3600618	3042707	4260827	1170736	968505	1415195	0.3117	0.2544	0.3820	579371	1.0084
1996	48824437	34833350	68435152	3505379	2968291	4139649	1287777	1068417	1552176	0.1810	0.1436	0.2280	275098	0.9987
1997	39938479	28175720	56611939	3525246	3005729	4134557	1452361	1210393	1742700	0.1645	0.1329	0.2036	264313	1.0006
1998	26090257	18741413	36320714	3873979	3325036	4513550	1699792	1430809	2019343	0.1878	0.1534	0.2299	391628	1.0018
1999	80759705	57900426	112643902	3873549	3342118	4489483	1758435	1480030	2089209	0.1805	0.1482	0.2199	363163	1.0000
2000	55531856	40127669	76849394	4760640	4073717	5563393	1823680	1537571	2163027	0.1813	0.1488	0.2209	388157	1.0004
2001	97988382	69561405	138032334	5340967	4573804	6236807	2307837	1945659	2737432	0.1580	0.1287	0.1940	374065	0.9901
2002	49897731	35819044	69510050	6250728	5331710	7328157	2744745	2313868	3255858	0.1477	0.1200	0.1818	394709	0.9974
2003	27756693	19989852	38541257	6675942	5716293	7796696	2797505	2372501	3298643	0.1736	0.1419	0.2124	482281	1.0153
2004	32539335	23393141	45261487	5641907	4875208	6529180	2738275	2322859	3227983	0.2170	0.1747	0.2694	587698	0.9985
2005	30341243	21987477	41868880	4721140	4106046	5428377	2522543	2131386	2985487	0.2344	0.1895	0.2900	663813	1.0033

2006	28560875	20629973	39540701	4010397	3489736	4608739	2056338	1740569	2429393	0.2082	0.1684	0.2574	514597	0.9950
2007	32181373	22918150	45188673	3375327	2923425	3897084	1671401	1412628	1977576	0.1796	0.1451	0.2222	406482	1.0056
2008	29370465	20953710	41168088	3409745	2934219	3962336	1744565	1476202	2061715	0.1131	0.0925	0.1382	257870	1.0040
2009	47186986	33818802	65839459	3860774	3307411	4506720	2043585	1723917	2422529	0.0666	0.0531	0.0834	168443	1.0023
2010	38620068	27832658	53588474	4664752	3997838	5442921	2164868	1816068	2580660	0.0706	0.0573	0.0869	187611	1.0034
2011	34472022	24881021	47760109	4710111	4068498	5452908	2583386	2202054	3030754	0.0917	0.0750	0.1121	226478	0.9938
2012	32914796	23663891	45782150	4721549	4093586	5445843	2746510	2340231	3223322	0.1477	0.1206	0.1807	434710	1.0109
2013	41542187	29566909	58367729	4573351	3984606	5249085	2517682	2150321	2947802	0.1744	0.1422	0.2139	511416	1.0014
2014	65896564	46534664	93314462	4893654	4255212	5627887	2450220	2090493	2871848	0.1774	0.1450	0.2171	517356	1.0029
2015	17736871	12601389	24965232	5154993	4441281	5983399	2275326	1939378	2669467	0.1840	0.1474	0.2297	494099	1.0017
2016	32774160	23656048	45406807	5116067	4392400	5958960	2684887	2271643	3173307	0.1887	0.1514	0.2353	563610	1.0000
2017	19642967	13967300	27624963	4281553	3688036	4970585	2331184	1957019	2776887	0.1700	0.1380	0.2094	498437	1.0013
2018	33126846	23178025	47346048	3992167	3433000	4642412	2051917	1707248	2466170	0.1911	0.1538	0.2373	603536	1.0015
2019	32308000	21801982	47876695	3281463	2784090	3867692	1684747	1375154	2064039	0.1784	0.1380	0.2305	442138	1.0023
2020	29574086	16262013	53783415	2966665	2368327	3716167	1363402	1038042	1790741	0.1784	0.1100	0.2893		

Table 2.6.3.13. North Sea Herring single fleet assessment. ESTIMATED FISHING MORTALITY

Units : f

year

age	1947	1948	1949	1950	1951
0	0.0038680829	0.0038679739	0.0038691764	0.003864836	0.003866312
1	0.0002239749	0.0002239749	0.0009512344	0.004040284	0.017135085
2	0.0426527964	0.0326619890	0.0410732110	0.053848670	0.079867185
3	0.0925967990	0.1062577792	0.1100013071	0.122802788	0.145432327
4	0.0999162464	0.1101941341	0.1181905290	0.146493763	0.199125694
5	0.1356282788	0.1441350842	0.1511065372	0.150983882	0.199919910
6	0.2366595951	0.2132587228	0.2463473728	0.226295673	0.216599842
7	0.2440899274	0.2364311185	0.3057133066	0.241456868	0.216433270
8	0.2440899274	0.2364311185	0.3057133066	0.241456868	0.216433270

year

age	1952	1953	1954	1955	1956	1957
0	0.003867015	0.00386692	0.005201551	0.004868157	0.004152742	0.004727644
1	0.034706648	0.05386228	0.075341142	0.114120418	0.118392601	0.146789554
2	0.110907085	0.13304112	0.159856273	0.191088893	0.239155033	0.230929315
3	0.131116945	0.16005581	0.201269970	0.204954717	0.211378376	0.216556482
4	0.173802713	0.16824426	0.171507840	0.173133250	0.182550927	0.189628278
5	0.191057176	0.18745364	0.201420404	0.176898180	0.166631121	0.210495003
6	0.247038551	0.24088270	0.258182287	0.232682393	0.186773703	0.203864224
7	0.301866584	0.28307951	0.326278007	0.179081260	0.202183694	0.210056552
8	0.301866584	0.28307951	0.326278007	0.179081260	0.202183694	0.210056552

year

age	1958	1959	1960	1961	1962	1963
0	0.004806232	0.008867736	0.01649044	0.02142176	0.008565914	0.0141900
1	0.140422584	0.167206865	0.17196207	0.10302471	0.097699476	0.1290354
2	0.253577574	0.284941669	0.28516726	0.31304004	0.199851072	0.2361116
3	0.247118418	0.247582857	0.21274163	0.24153377	0.320019110	0.2375260
4	0.183247145	0.219930362	0.18228463	0.23132823	0.279661344	0.1867872
5	0.233210631	0.215791481	0.16148631	0.21046195	0.259634146	0.1697214
6	0.179960746	0.227130972	0.20897164	0.22571318	0.312145531	0.1532115
7	0.132615409	0.232926986	0.25008981	0.19822441	0.270870456	0.1601679
8	0.132615409	0.232926986	0.25008981	0.19822441	0.270870456	0.1601679

year

age	1964	1965	1966	1967	1968	1969
0	0.01560181	0.01250797	0.02308514	0.03178558	0.03543563	0.01623076
1	0.22883465	0.23708690	0.22577586	0.28020263	0.30557688	0.32066742
2	0.30956232	0.47956817	0.47345324	0.46582817	0.90359534	0.70816658
3	0.31415537	0.49850449	0.51715025	0.68768339	1.33107073	0.80818672
4	0.28786493	0.48414056	0.46960200	0.65545978	0.79612131	0.75405519
5	0.26892804	0.46419967	0.58619767	0.68898052	0.87129158	0.83650042
6	0.25064214	0.43230815	0.37202195	0.70999470	0.93941586	1.25069159
7	0.20480209	0.46378764	0.55868589	0.94723604	1.14961107	1.01261159
8	0.20480209	0.46378764	0.55868589	0.94723604	1.14961107	1.01261159

year

age	1970	1971	1972	1973	1974	1975
0	0.03988314	0.04680556	0.06606864	0.06110913	0.1003303	0.1183654
1	0.31814656	0.55860720	0.58591215	0.64078316	0.4912970	0.5126066

```
  2 0.76997225 0.74483094 0.70525858 0.81756914 0.8529715 0.9859528
  3 0.98920814 0.92658297 0.73062679 0.97429426 0.8288543 1.0725248
  4 0.96402217 0.94603094 0.68386006 0.77988677 0.7918424 0.9642941
  5 0.83630437 0.75527961 0.55709691 0.76652254 0.9717513 1.2490066
  6 1.11266327 3.00708314 0.64259909 1.02014155 0.9289947 0.9330231
  7 0.96004239 1.38803804 0.34763522 0.60037670 0.8058348 1.5165573
  8 0.96004239 1.38803804 0.34763522 0.60037670 0.8058348 1.5165573
   year
age       1976       1977      1978      1979       1980      1981
  0 0.08979959 0.08211371 0.1023754 0.1211176 0.14665013 0.3714641
  1 0.21211189 0.13117132 0.1190915 0.1131976 0.10153572 0.1904366
  2 0.69231303 0.19500848 0.1969874 0.2066268 0.21982673 0.1979118
  3 0.94878168 0.52141605 0.3357090 0.2861474 0.25486016 0.2106100
  4 0.87034345 0.32547662 0.2594957 0.2025664 0.18660939 0.2079270
  5 0.90128299 0.48012449 0.3495067 0.2913117 0.23626768 0.2443671
  6 0.62147552 0.33737194 0.2012013 0.1110705 0.06852648 0.2113438
  7 0.98317164 0.41361571 0.3471277 0.2500760 0.14645930 0.4515270
  8 0.98317164 0.41361571 0.3471277 0.2500760 0.14645930 0.4515270
   year
age      1982      1983      1984      1985       1986      1987      1988
  0 0.3483109 0.3638179 0.2036645 0.1067077 0.08319026 0.1467448 0.1164089
  1 0.1736471 0.1941902 0.1864053 0.2699901 0.28605776 0.3266187 0.4476051
  2 0.1793502 0.1941049 0.2107741 0.2607228 0.27734583 0.2778675 0.2470355
  3 0.2691160 0.2377726 0.2842357 0.3820670 0.33899270 0.3000505 0.2698402
  4 0.2034892 0.2560871 0.3501622 0.4315465 0.36889906 0.3586031 0.3373308
  5 0.1557290 0.2345160 0.3538798 0.4061233 0.36265957 0.3771442 0.3765551
  6 0.1431913 0.2551817 0.3192234 0.4236266 0.44423007 0.4066723 0.3910402
  7 0.2110252 0.3714081 0.5153423 0.5309270 0.52397231 0.3849345 0.4001062
  8 0.2110252 0.3714081 0.5153423 0.5309270 0.52397231 0.3849345 0.4001062
   year
age      1989       1990      1991      1992      1993      1994      1995
  0 0.1177832 0.07481728 0.1124450 0.2256546 0.2272392 0.1491976 0.1642005
  1 0.3440432 0.34621957 0.2631865 0.2779383 0.2649990 0.1412992 0.1313707
  2 0.2572841 0.23893578 0.3241013 0.3366275 0.3585454 0.3447147 0.2446519
  3 0.2611064 0.22916537 0.2622181 0.2882686 0.3610112 0.3783847 0.3459168
  4 0.3453813 0.27154767 0.2674560 0.3023210 0.3771384 0.4899821 0.3403387
  5 0.3431195 0.29286521 0.2661286 0.2938289 0.3124079 0.2960403 0.3536538
  6 0.3439351 0.24582932 0.2772455 0.3261736 0.3331872 0.2949729 0.2741884
  7 0.3546437 0.27660749 0.2151725 0.3083250 0.3589400 0.2768337 0.2492684
  8 0.3546437 0.27660749 0.2151725 0.3083250 0.3589400 0.2768337 0.2492684
   year
age       1996       1997       1998       1999       2000       2001
  0 0.06824782 0.02010162 0.01710940 0.02749881 0.02998868 0.02832624
  1 0.10678339 0.04582281 0.07007496 0.04376473 0.05020245 0.04135639
  2 0.13255780 0.11687763 0.14197034 0.12040924 0.11605383 0.07879771
  3 0.20334406 0.17097074 0.18085448 0.21349314 0.16970618 0.15135998
  4 0.18207497 0.19007170 0.19700750 0.19021137 0.21652642 0.17904074
  5 0.19211332 0.17930471 0.20872672 0.19670842 0.21855087 0.19630878
  6 0.19466019 0.16517620 0.21045695 0.18182553 0.18548841 0.18453950
  7 0.09468741 0.12663256 0.11661242 0.10496887 0.11045069 0.12097941
  8 0.09468741 0.12663256 0.11661242 0.10496887 0.11045069 0.12097941
   year
age       2002       2003       2004       2005       2006       2007
```

age						
0	0.02359840	0.02286972	0.03443633	0.04988162	0.04725590	0.03399506
1	0.03260610	0.04284341	0.03440938	0.06085923	0.03509362	0.03360672
2	0.07676871	0.07133892	0.07676463	0.09326507	0.08068351	0.06721923
3	0.13376075	0.12471031	0.13192191	0.13291468	0.13312427	0.13893300
4	0.17516003	0.18896961	0.19922403	0.21981197	0.21178621	0.18835224
5	0.17166373	0.26671083	0.29384666	0.30426155	0.27135908	0.23655073
6	0.18095905	0.21636685	0.38309024	0.42178102	0.34418331	0.26683826
7	0.15829278	0.18212846	0.27552723	0.51348026	0.46086493	0.37199490
8	0.15829278	0.18212846	0.27552723	0.51348026	0.46086493	0.37199490

age \ year	2008	2009	2010	2011	2012	2013
0	0.03898757	0.02438180	0.02513088	0.03408032	0.03395498	0.02074963
1	0.02936033	0.02331364	0.02210483	0.01693434	0.03018870	0.04197958
2	0.07543715	0.05547104	0.05666934	0.05869877	0.07288504	0.07162221
3	0.08630566	0.04748275	0.06594732	0.08303756	0.13163691	0.12088964
4	0.12227184	0.07541091	0.07156391	0.09733345	0.15408323	0.17641750
5	0.14315147	0.08801687	0.08861189	0.11647419	0.18650019	0.22658454
6	0.13820968	0.06653357	0.07017152	0.10292931	0.19315960	0.27661675
7	0.17710827	0.09230044	0.06886223	0.09230063	0.21790346	0.33103819
8	0.17710827	0.09230044	0.06886223	0.09230063	0.21790346	0.33103819

age \ year	2014	2015	2016	2017	2018	2019
0	0.03201914	0.04633756	0.06352935	0.04128708	0.05376825	0.03313218
1	0.02816071	0.02144750	0.02112709	0.02144111	0.01405297	0.01931502
2	0.06896242	0.05761163	0.05040058	0.04226940	0.04572393	0.03933860
3	0.12201793	0.08989165	0.12109327	0.13481219	0.11238816	0.13022234
4	0.19364502	0.15826746	0.16799159	0.19559705	0.21969740	0.16247072
5	0.24041218	0.25313575	0.24533834	0.20814904	0.28196502	0.25552430
6	0.26219612	0.36122015	0.35878137	0.26928587	0.29551746	0.30420072
7	0.34136996	0.49309649	0.61022659	0.44695910	0.45631062	0.41558463
8	0.34136996	0.49309649	0.61022659	0.44695910	0.45631062	0.41558463

age \ year	2020
0	0.03314350
1	0.01930452
2	0.03933860
3	0.13022234
4	0.16247072
5	0.25552430
6	0.30420072
7	0.41558463
8	0.41558463

Table 2.6.3.14. North Sea Herring single fleet assessment. ESTIMATED POPULATION ABUNDANCE

Units : NA

age \ year	1947	1948	1949	1950	1951	1952	1953
0	55442046	55876843	51265908	69958768	62903205	59789404.8	60169912
1	19949359	24461284	24926861	21683248	32323262	27609843.8	26238621
2	14105671	10154918	14719731	12809339	10531794	15533627.0	13095187

```
  3  5750546  7943109  7458694 10806877  8202762  5874945.9  8215995
  4  8074177  3713686  4319440  5384520  7700511  4604420.5  3643508
  5  4921163  5252745  2389821  2531423  3874962  4419945.9  2685772
  6  4103861  3104701  3298410  1473084  1608925  2355400.5  2621045
  7  2316068  2289597  1877187  1829326   852452   978977.8  1340589
  8  7019262  5246020  4374225  3293152  2904955  2326537.3  1839569
   year
age     1954       1955       1956       1957       1958       1959
  0 57435650 48441247.8 35839654.7 84393828.7 33238125.5 37425199.8
  1 27657594 24612020.7 21441895.4 14436111.7 44579173.1 14027745.0
  2 12437926 13676175.3 10455477.1  9918345.2  5702277.5 23618412.3
  3  7138735  6697804.3  7647809.2  4638696.3  5353582.0  2633818.5
  4  4457812  3612314.7  3660873.6  4366515.1  2352877.4  2847676.4
  5  2259996  2474753.9  1987565.6  2097395.7  2543771.8  1373424.9
  6  1618396  1284512.1  1433856.4  1239723.7  1144902.4  1363797.0
  7  1505340   894129.2   707644.3   865124.8   728305.8   684637.6
  8  1851321  1715807.4  1689141.0  1446859.1  1316588.3  1439243.4
   year
age       1960       1961       1962       1963       1964       1965
  0 16309280.0 68959228.6 32094128.3 42338883.5 43973249.2 21743709.8
  1 18228143.9  5353693.9 33035793.1 14864546.9 18106577.3 20032393.8
  2  5729892.5  8049777.2  2001573.1 17309454.0  7192229.5  6819583.9
  3 12634052.1  2732565.1  3301554.4  1074893.4 10015339.6  3769648.4
  4  1252949.0  8181118.4  1507914.8  1243654.5   694933.5  5753166.0
  5  1427886.3   759983.0  5089895.7   684795.7   746159.7   429826.2
  6   739077.9   934412.0   444696.7  2521731.2   476806.0   426649.0
  7   722434.1   416642.7   586227.8   210253.0  1646443.5   300777.8
  8  1248670.2  1031648.4   841649.7   756320.3   578575.3  1439023.6
   year
age       1966       1967       1968        1969        1970        1971
  0 22643103.7 28845441.8 29481026.5 14134725.13 28850402.00 22558603.46
  1  9676876.8  9283151.0 12376281.4 12336211.16  6409150.79 12493711.28
  2  8253205.6  4093868.3  3380306.8  4623071.32  4461355.93  2579122.73
  3  2297504.9  3352377.9  2033286.1   704278.87  1579268.39  1277635.44
  4  1478449.0   896602.7  1260415.3   311328.13   225845.77   386867.69
  5  2337465.7   689058.0   307638.7   391178.91   101621.16    58007.53
  6   195834.0   877549.9   258365.9    83846.06   120558.87    30439.34
  7   190726.5   106979.1   291172.3    73820.70    16258.07    30962.44
  8   849223.0   452647.0   161779.8    99968.95    45531.93    17282.28
   year
age          1972        1973         1974        1975        1976
  0 15707166.6178 8018520.733 13791441.690 3264700.448 4153766.523
  1  9854241.7225 6416375.867  3157075.608 6449343.231 1045004.289
  2  3520325.0405 2854897.795  1644904.704  989046.154 1977778.983
  3   816009.8956 1178680.988   789084.025  447044.224  219348.952
  4   325167.3003  309532.596   277530.337  251584.206   97362.403
  5    96845.5384  124809.444   102930.114   87595.623   65424.221
  6    18121.8850   44244.763    41990.784   28072.460   16011.929
  7      968.8523    7988.478    11406.302   12036.372    7709.393
  8     7874.4239    4826.749     5610.632    5885.323    2700.281
   year
age        1977        1978         1979         1980        1981
  0 4990993.599 5407629.510 10142908.340 15498007.356 36679638.41
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  1 1741674.030 2150218.858  2053168.322  4086494.419  6140470.44
  2  367929.437  794637.406   961865.394   824909.574  1940686.51
  3  565701.529  255987.763   442611.895   486243.599   381947.20
  4   50788.224  219437.953   163632.927   228786.826   245098.99
  5   22849.918   29096.038   114603.403   121446.674   143737.01
  6   17567.335    9542.686    16657.981    58554.726    91138.45
  7    5728.173    8676.562     5360.726    12302.954    46937.14
  8    2644.830    3946.956     6136.444     5868.998    14358.93
   year
age        1982        1983        1984        1985        1986
  0 58184169.30 57260462.40 55842014.14 67199646.38 81773211.47
  1 10369889.81 18619471.49 15892859.60 18400794.33 25789801.25
  2  2303883.21  4004044.24  7492663.11  6867564.05  6325636.04
  3  1106083.66  1261074.87  2142443.32  4156523.44  3425214.23
  4   221496.73   552937.10   774374.05  1163600.73  1789065.74
  5   130473.05   144250.30   304773.32   414135.47   502899.83
  6    74374.31    99607.39    91488.26   144498.48   195987.80
  7    56767.81    49522.31    64543.72    53356.67    65325.71
  8    30219.64    66252.27    70767.39    70308.35    62432.32
   year
age        1987        1988       1989       1990       1991       1992
  0 77668232.24 45701177.12 37952843.2 32037356.0 35723373.2 66560765.7
  1 34205224.40 25948749.07 16335543.8 13057391.0 13058886.6 12939764.4
  2 10383259.80 12493909.01  8275478.8  5357871.3  4743887.1  5419783.1
  3  3030161.35  5415159.04  6774988.3  4570819.0  2795387.4  2111904.6
  4  1770113.05  1558545.38  3044878.8  4240670.3  2726793.3  1610885.5
  5   891862.31   919847.49   821941.1  1746728.5  2503255.9  1606415.9
  6   257431.66   446900.15   461413.7   461352.3   969710.2  1503848.1
  7    91303.46   129525.36   223222.5   253370.2   266058.4   573376.1
  8    57618.69    78654.33   106119.4   190834.8   232889.9   294279.3
   year
age       1993       1994       1995       1996        1997       1998
  0 70049041.3 54139051.0 61319615.4 48824436.7 39938479.35 26090256.7
  1 20848276.5 21440885.7 18532898.8 19133785.5 18408527.58 16646830.6
  2  4707499.3  7185225.4  7909036.0  6785729.9  7992222.76 10664230.5
  3  2336124.0  1805997.1  3133870.8  3551588.4  3475435.80  3917821.9
  4  1135668.7   973403.6   904509.3  1324724.7  1919685.88  1798480.3
  5   909493.7   508601.4   419806.8   409484.5   787797.61  1055288.4
  6   908856.1   439891.5   260192.6   162468.7   257484.08   499886.6
  7   746494.5   424232.6   219646.2   127043.8    91693.85   163510.7
  8   460165.8   545381.2   449199.2   341228.3   276964.50   212557.3
   year
age       1999       2000       2001       2002       2003       2004
  0 80759704.5 55531856.0 97988382.4 49897730.6 27756693.4 32539335.4
  1 10773922.1 30975773.1 20976319.2 39957619.7 18921089.7 10092494.5
  2  6812845.2  6616141.4 14422188.4  9669648.9 22486639.8  7700748.8
  3  6131393.7  3569519.3  4086413.7  9258632.7  5484065.2 13175685.0
  4  2022989.0  3687432.7  2027806.9  2161381.1  5646669.4  3532207.2
  5   898661.6  1220643.9  2074253.1  1116305.5  1168568.6  3399920.1
  6   514900.1   559125.3   637847.5  1271943.9   692258.8   579163.8
  7   258883.0   315972.2   317690.9   364612.1   761433.3   430751.3
  8   191071.3   244728.4   274920.5   359980.6   403688.0   609564.5
   year
```

age	2005	2006	2007	2008	2009	2010
0	30341243.3	28560875.3	32181373.4	29370464.8	47186985.8	38620068.3
1	13535081.0	9992767.3	9753415.0	10996504.6	10823393.4	16868391.2
2	4743493.7	6413888.5	4371789.0	5333975.7	6206534.8	6586639.1
3	4684678.8	3010112.2	3627882.2	2655207.3	3154694.7	4415017.0
4	7703194.8	2841922.6	1878293.0	2043817.4	1621056.1	2288709.4
5	2091314.4	4859058.9	1631339.3	1209361.8	1285186.6	1209883.4
6	1832498.4	1021826.0	2712682.5	1024147.8	819632.3	1128632.3
7	282575.2	842326.2	519791.5	1840326.1	720589.5	622353.6
8	476571.0	312832.1	520665.7	644854.9	1908067.9	2101455.4

year

age	2011	2012	2013	2014	2015	2016
0	34472022.1	32914796.4	41542187.2	65896563.7	17736871.0	32774160.3
1	15349994.1	12472014.9	11748473.4	18555620.3	26730537.4	7231212.2
2	8152849.5	7729916.0	5776897.3	6936117.4	12176901.7	15594653.2
3	4282297.9	6058111.0	5156027.3	3864075.8	3769693.0	8360525.3
4	2868059.5	3194086.9	4153555.7	3965957.0	2383655.5	2288604.1
5	1438607.3	2031779.7	2380509.9	2675476.1	2399459.8	1495923.1
6	800276.4	940046.1	1360928.8	1520567.6	1524771.6	1346313.9
7	749053.9	505305.7	591344.8	812147.6	840890.5	761903.2
8	1778549.0	1402411.3	1173744.7	862291.6	897043.6	785438.5

year

age	2017	2018	2019	2020
0	19642966.8	33126845.7	32307999.7	29574086.3
1	12499279.1	8351984.9	11680453.8	13806386.3
2	3354906.4	5535803.3	3453792.2	5804262.7
3	9858235.1	2356908.3	2978775.0	2134501.2
4	5539876.8	6690358.6	1637735.3	1775298.7
5	1478295.5	3806497.1	3874659.5	953626.2
6	766882.1	967431.7	2268738.5	2085549.9
7	629709.5	514085.1	519202.2	1172039.9
8	634840.6	729185.0	635240.4	538392.0

Table 2.6.3.15. North Sea Herring single fleet assessment. CATCH-AT-AGE catch unique

Units : NA

year

age	1947	1948	1949	1950	1951	1952
0	146508.53	147653.352	135511.10	184714.80	166149.1	157953.1
1	3248.79	3983.565	17234.88	63590.71	399703.3	686182.2
2	476702.05	264010.584	479379.79	543718.80	655195.8	1323102.8
3	422498.49	665496.291	645816.68	1038509.82	923923.9	600501.6
4	646151.20	326215.501	405463.61	618395.04	1173630.2	619604.9
5	530089.61	598947.285	284767.85	301413.13	597421.0	653867.1
6	739814.38	509732.646	616248.49	255122.56	267886.3	441161.0
7	430294.93	413461.291	424858.52	336599.21	142202.6	219158.4
8	1304506.38	947645.328	990321.79	606141.19	484749.8	520995.3

year

age	1953	1954	1955	1956	1957	1958	1959
0	158954.5	203982.0	161034.9	101665.4	272472.0	109092.02	226238.2
1	1003513.8	1465716.5	1942508.3	1752400.5	1444927.7	4280210.42	1585318.8

```
  2 1324654.0 1493578.1 1935808.5 1812942.4 1666729.1 1041704.81 4781704.7
  3 1011711.8 1084979.9 1034880.7 1215180.4  753352.7  978649.12  482273.8
  4  475821.0  592574.8  484375.1  515374.1  636494.5  332393.67  474865.2
  5  390468.0  350809.9  341169.1  259316.6  338838.0  450636.93  226916.1
  6  480016.6  315206.1  228081.4  208678.7  195406.0  161047.98  236977.4
  7  283814.0  360293.3  125535.3  110992.3  140471.6   77357.24  121994.8
  8  389577.1  443242.2  240977.1  265023.6  235004.9  139887.84  256540.0
   year
age      1960       1961      1962       1963       1964       1965
  0  182736.6 1001574.62  187432.4  408611.79  466329.41  185107.22
  1 2114277.9  383303.72 2248206.8 1317966.71 2727481.63 3115588.10
  2 1160859.0 1768499.73  295147.2 2967215.80 1564917.49 2136326.78
  3 2019166.0  489452.83  756666.1  189679.40 2259132.91 1245457.31
  4  176153.0 1427583.71  311277.2  178798.79  147122.09 1879608.69
  5  180969.4  122759.16  991961.7   90873.33  149995.24  136831.55
  6  119135.1  161456.50  102209.1  305719.92   90460.30  128791.70
  7  137145.2   64185.51  119410.6   26631.73  261274.09   96318.55
  8  237120.9  158981.30  171493.3   95830.78   91843.91  460963.36
   year
age      1966       1967      1968       1969        1970       1971
  0  354150.1  618902.86  704001.0  155892.15  774132.051  707866.85
  1 1440161.0 1675219.71 2410513.0 2505319.39 1291751.330 4013767.56
  2 2559107.4 1252954.30 1678641.1 1944984.73 1990081.510 1124716.70
  3  781236.0 1411321.73 1291545.6  331780.61  847572.392  658437.11
  4  471461.9  368825.67  594380.7  141458.58  120598.309  204194.32
  5  891820.7  295956.62  155112.8  192027.85   49878.153   26574.79
  6   52236.8  386579.81  137211.2   52591.67   70885.432   26419.24
  7   70626.5   57240.54  174769.7   41149.73    8772.833   20530.93
  8  314565.0  242263.06   97131.1   55741.03   24575.890   11462.70
   year
age        1972        1973       1974        1975       1976        1977
  0  690293.294  326902.519 905199.197  251700.661 246420.130 271747.8585
  1 3281051.544 2280107.715 921125.632 1928346.655 145227.921 153936.2109
  2 1476625.102 1325983.026 787781.524  518580.590 816295.930  52804.5984
  3  358610.031  626382.850 378583.209  251746.757 114457.626 192938.4139
  4  137917.396  143902.635 130465.387  134325.829  48675.000  11944.0052
  5   35551.709   57765.663  55615.029   54706.883  33722.627   7477.7373
  6    7431.151   24727.285  22129.800   14849.532   6416.212   4327.6438
  7     244.730    3124.610   5490.293    8331.691   4228.930   1678.3712
  8    1989.690    1888.505   2701.392    4074.897   1481.647    775.2177
   year
age       1978       1979         1980        1981         1982
  0 363655.701 799311.846 1458614.2315 7937791.806 11865332.548
  1 172555.051 156405.539  280003.8745  759267.065  1177776.591
  2 115001.687 145351.751  131906.7188  282466.434   306918.280
  3  60891.590  91755.383   91135.3129   60453.405   218396.034
  4  42390.071  25337.712   32914.9516   38978.386    34613.952
  5   7345.218  24774.119   21856.2745   26699.176    16111.033
  6   1492.878   1501.929    3328.0198   14981.272     8562.365
  7   2201.034   1025.169    1447.5211   14869.476     9377.727
  8   1001.650   1174.049     690.8858    4551.413     4995.342
   year
age        1983       1984       1985       1986       1987       1988
```

```
  0 12020593.82 6941321.64 4532530.56 4323758.30 7039633.03 3332226.41
  1  2350592.65 1939449.54 3149501.96 4663493.87 6971226.59 6920746.32
  2   574820.15 1162608.19 1294393.75 1265418.10 2088941.57 2272867.20
  3   223866.32  447046.35 1121462.32  840156.17  672081.28 1097521.83
  4   106485.06  196149.61  352006.71  478202.74  463900.91  388763.08
  5    25934.33   78565.07  120116.96  133323.76  245068.26  252938.19
  6    19454.38   21764.28   43671.20   61754.96   75695.54  127463.78
  7    13420.93   22832.07   19365.08   23539.32   25754.90   37782.38
  8    17968.47   25055.19   25536.27   22507.89   16259.58   22952.83
   year
age       1989       1990       1991       1992      1993       1994
  0 2808366.59 1537310.03 2542124.41 9101046.41 9660531.6 5074996.33
  1 3506616.10 2827840.85 2237242.44 2340874.45 3632115.5 2109490.41
  2 1565753.49  950762.90 1098356.03 1293008.12 1182362.2 1741724.99
  3 1336350.68  803583.18  553398.29  453114.02  606582.2  487218.32
  4  776122.94  879131.35  556785.17  364679.69  309403.4  327315.26
  5  209387.49  388838.28  512187.37  357715.30  213244.0  113680.85
  6  118387.95   88537.60  206872.30  368853.75  226861.4   98862.56
  7   58976.49   54131.16   45470.28  134449.35  199066.6   90515.91
  8   28049.95   40797.57   39851.15   69142.85  123023.0  116735.43
   year
age       1995       1996       1997       1998       1999       2000
  0 6297581.83 2166852.33 531276.477  294576.45 1450154.32 1077841.25
  1 1707800.90 1447851.02 612542.325  834655.23  338354.50 1099295.98
  2 1418651.81  692685.53 723613.311 1157264.95  631111.94  589599.28
  3  783284.11  556468.24 465090.911  551999.49 1003119.27  472549.12
  4  225261.59  189688.71 286352.213  277364.33  302225.71  619899.85
  5  109098.55   62216.20 112482.716  173080.75  139642.80  208614.18
  6   54850.05   25226.30  34413.056   83360.98   75116.08   82997.96
  7   42715.74   10083.55   9592.086   15822.89   22661.45   29010.33
  8   87683.34   27185.79  29073.994   20633.90   16765.35   22496.54
   year
age       2001      2002       2003       2004       2005     2006
  0 1785242.47 753801.53  403534.48  704685.88  939985.76 834756.8
  1  610227.44 914046.00  562373.60  241106.48  567998.01 246022.3
  2  884705.07 576299.25 1243087.87  455868.33  338691.43 398793.6
  3  485306.99 975514.28  538106.39 1357735.41  484505.14 310856.2
  4  286566.89 298501.61  832665.95  544639.51 1292535.17 459082.8
  5  321360.18 152547.39  236722.22  747194.04  471810.89 988314.3
  6   94101.03 183804.39  117257.73  160614.85  548142.86 257241.1
  7   31755.22  46765.28  110828.49   90645.32   99445.71 271448.7
  8   27493.47  46190.94   58793.02  128380.71  167912.70 100978.7
   year
age     2007      2008      2009      2010      2011      2012     2013
  0 678259.0 706994.33 715122.97 605155.83 733822.97 703581.04 551087.4
  1 231347.0 229940.55 181076.61 268586.31 188169.35 271267.15 353660.2
  2 228330.7 312497.08 270423.41 293429.84 376353.06 440545.93 323943.0
  3 389777.8 181644.99 120919.89 233066.94 282532.28 619980.09 487354.0
  4 272141.7 197821.41  98737.37 132345.38 222654.17 382117.25 562833.6
  5 293153.9 136981.08  91648.83  86697.20 133583.75 292215.63 408091.9
  6 546855.0 113172.00  44985.01  65092.35  66557.41 140519.08 280109.8
  7 140281.3 257634.40  54550.01  35453.74  56444.37  84657.57 142736.6
  8 140836.1  90557.18 144982.57 120204.80 134607.14 235999.92 284574.8
```

age	2014	2015	2016	2017	2018	2019	2020
0	1358931.3	533823.1	1365268.7	528277.9	1162968.74	711046.6	651097.0
1	376743.6	413562.6	109814.7	193244.6	84787.45	162297.7	191733.8
2	375065.4	552695.1	620706.3	112496.3	200416.17	107844.5	181237.8
3	368797.3	269224.0	793633.9	1034390.0	208383.42	302814.2	216987.6
4	585076.7	291980.1	296219.8	824605.3	1106336.63	205525.4	222788.7
5	483270.3	453468.1	274837.5	234448.0	790850.61	738040.6	181645.6
6	298145.4	393569.6	345077.4	153728.0	210192.75	505113.6	464328.3
7	200796.1	280444.2	298544.4	194201.3	161035.36	150612.3	339990.2
8	214143.0	300435.9	308979.9	196612.1	229364.04	185026.6	156817.6

Table 2.6.3.16. North Sea Herring single fleet assessment. CATCH-AT-AGE RESIDUALS catch unique

Units : NA

age	1947	1948	1949	1950	1951	1952
0	0.000000	0.0000000000	0.00000000	0.000000000	0.0000000	0.00000000
1	0.000000	2.8832033218	0.00000000	0.000000000	3.8769942	0.87083043
2	1.097482	2.4424555752	1.37021062	0.305184502	-1.0593214	-0.76738153
3	1.802188	0.0009453391	1.33464305	-0.009204868	-0.7377701	-1.93740559
4	1.834505	-2.1421437271	-0.38416878	1.466578168	0.7326447	-1.59889670
5	1.212864	-0.0674503073	0.06771728	-0.465422581	1.3537031	-0.86684152
6	1.290966	0.0441693664	0.38789394	-0.238013141	-0.1612865	0.08730906
7	1.682250	-0.5807154416	0.88113933	-0.455577697	-0.1662658	0.59680402
8	3.009605	0.0457949197	0.59750088	-0.084192020	-0.1650082	0.65865082

age	1953	1954	1955	1956	1957	1958
0	2.1683420	0.4843715	-0.30385382	-0.65947884	1.21126278	-1.15470918
1	0.3317291	0.2403704	0.26546967	-0.04415264	0.08014454	0.83392133
2	-0.7029759	-0.3461986	-0.08244043	-0.49615387	-0.05136530	-0.50435305
3	-1.0887679	-0.2720175	-0.56752783	-0.35470263	-1.20823873	0.53381675
4	-0.8845216	-1.3434794	-1.06999879	-0.27872598	-0.19648543	-0.95757495
5	-0.7690977	-0.3030141	-1.38204146	-1.05097723	0.11211578	0.02620409
6	-0.4397990	-0.1715649	-0.64214605	-0.89156152	-0.01898035	-0.89141114
7	-0.4393625	-0.0895876	-1.35722540	-0.42823327	-0.08244099	-1.06676585
8	0.1283936	0.5321395	-0.87729050	0.68178808	0.02508006	-0.89858802

age	1959	1960	1961	1962	1963	1964
0	0.0000000	0.6159650	2.25326500	-2.41234357	1.15391889	0.2269763
1	-0.5663171	0.2420977	-2.62828097	0.98348016	0.56256165	0.6394982
2	1.4925161	-1.1215787	-0.05605497	-2.16887974	1.66586801	0.5446396
3	-0.5140454	0.1319635	-0.45264053	-0.18842224	0.00711036	1.0499512
4	0.3124137	-0.9693705	1.34313548	-0.01872995	-2.55382142	2.2700243
5	-0.4445715	-1.5305648	0.79359395	0.93314756	-2.29862045	1.0346162
6	0.1011952	-0.4043915	0.36241461	0.60991897	-1.95140126	1.2193659
7	0.4386064	-0.6868843	-0.48952028	1.22993424	-1.61352519	0.8544300
8	1.1876315	0.6162918	-0.95267654	-0.79509527	-0.46803115	-0.7937002

age	1965	1966	1967	1968	1969	1970
0	-1.3483420	0.9207074	0.7202777	0.37016371	-2.35725918	2.27665052

```
  1  0.1467123 -0.4491644 -0.2932713  0.06605356 -0.03365013  0.05669455
  2 -0.2331901  0.1200882 -0.3180198  0.14901267 -0.40328724 -0.12828687
  3  0.6746464 -1.7742268  0.5055107  1.71227741 -3.52940329  0.98644695
  4  1.3446173 -1.4469184 -0.4817876  0.13991680 -2.66484292  0.59403045
  5  1.7938470 -0.7283121 -0.2209769 -1.09180461 -1.10347656 -1.41105868
  6  0.6890629 -0.9792595 -0.1045814  0.02584878 -1.12457353 -0.72413170
  7  1.8133363 -0.8090265  0.6763125 -1.48265451 -0.82893123 -1.49286252
  8  0.1821773  0.2932368 -0.6480995 -0.44471594 -2.41562171 -1.37697877
   year
age       1971        1972       1973       1974        1975       1976
  0 -0.1399224  0.09557667 -1.1281649  1.3899520 -1.47902537 -0.2482292
  1  0.5760924 -0.19422415 -0.5350807 -1.0055401  0.66114953 -3.0825204
  2  0.3920462 -1.07425759 -0.1578942 -0.8101895  0.05587998 -0.4397002
  3 -0.5036371 -0.19912448  0.1144856 -0.9721944 -0.21210055 -0.4276307
  4 -0.4733747 -0.66649347  1.1410487 -1.1775735  0.56073699 -0.6853313
  5 -1.1260166 -0.92868655  1.4878051  0.3432772 -0.09354304 -0.5682454
  6  0.1987195 -1.80940614  1.8036795 -0.4494357 -0.45399651 -1.3335654
  7  1.0335166 -3.56356445  2.9196604 -0.1584540  0.52147570 -0.6479570
  8 -2.7239335 -1.43774835  1.8880223  1.5297076  0.90543273 -1.4161607
   year
age        1977 1978 1979       1980       1981       1982        1983
  0  0.07597696    0    0  1.3283809  2.6249341  0.5187393  0.19825435
  1 -0.23855554    0    0 -0.2462839  1.0740464 -0.5396140  0.71896516
  2 -2.76867757    0    0 -0.9089759  0.7226391 -0.9791483 -0.09711704
  3  0.23409772    0    0 -1.5817105 -0.7945850  1.1110091 -0.51002740
  4 -1.17981597    0    0 -1.1904637 -0.6033173  0.1977047 -0.15244324
  5 -1.22930555    0    0  1.9154171 -1.1429949 -1.7937485  0.98447033
  6 -0.29576788    0    0 -0.7196302  3.7767712 -1.4499989  1.84015248
  7 -0.99234594    0    0  1.6689785  2.7357989 -1.2550714  0.57587829
  8 -0.92205949    0    0 -0.2268339  4.1761216  0.2548988  2.82197531
   year
age       1984        1985        1986        1987         1988
  0 -0.7923819 -0.69629763 -0.20981987  0.94942664 -1.079191614
  1 -0.2704149  1.01274655  0.97777649  0.69591555 -0.087284042
  2  0.3847517  1.09031252  0.05003559  0.87128079 -0.588560642
  3  0.1435733  1.16832090 -0.06581243 -0.43317956 -0.044758462
  4  1.3512606  0.60552650 -0.82035448  0.28409207 -0.222805151
  5  0.5720777  0.68049271 -0.88991019  0.15287683  0.176235936
  6  0.1829367 -0.31759747 -0.12988267 -0.22306671 -0.205463000
  7  1.1527903 -0.04867301 -1.46669146 -0.85347208  0.001931288
  8  1.9409946  1.71018445  1.83841049 -0.01553572  0.212411215
   year
age        1989        1990        1991       1992         1993
  0 -0.13486482 -1.04072119  0.64547592  1.8312858  0.149833864
  1 -0.75121650 -0.12010274 -0.07233381 -0.3107737 -0.157092191
  2  0.11996513 -0.99927038  1.20636266  0.4280025 -0.283280396
  3  0.10125638 -0.47114420  0.15613760 -0.2777385 -0.002821862
  4  0.44111869 -0.29839956 -0.04012197  0.3352401  0.352011702
  5 -0.05294658  0.03386583 -0.12235399  0.3582504  0.248120780
  6 -0.14288358 -0.54599686  0.22810952  0.4005843  0.180770653
  7 -0.23680667 -0.38698205 -0.66838437  0.9636609 -0.121950832
  8 -0.18666007 -0.03594834 -0.36515872 -0.3976679  0.320249297
   year
```

```
age        1994       1995       1996       1997        1998       1999
  0 -1.01539784  0.4939821 -1.3742176 -2.1563211 -0.88834251  2.1207717
  1 -1.34920799 -0.1314740 -0.3193201 -1.4641466  0.84089892 -0.6823736
  2 -0.63960151 -1.9816428 -2.8619811 -0.8058620  1.48190947 -1.0979078
  3 -0.60763548 -0.6330188 -1.9717610 -0.9913479 -0.36516460  0.7558231
  4  0.03586815 -0.7180212 -2.4440392 -0.1856058 -0.45938307 -0.4783784
  5 -0.75779594  0.8116308 -1.8910604 -0.4159811 -0.03243927 -0.7275245
  6 -0.56102053 -0.2046261 -1.4011193 -0.2679850  0.55006687 -0.7752285
  7 -1.07141015 -0.3984453 -2.2350392  0.6952947 -0.13019736 -0.1657221
  8 -0.13357967 -0.2266866 -1.2064461 -0.7897695 -0.51670799 -1.5581429
   year
age        2000        2001        2002       2003        2004       2005
  0 -0.32054345  0.63931686 -1.09575152 -0.8653205  0.76395240  0.5346996
  1 -0.01688250 -0.30569519 -0.41072217  0.3908034 -0.67352415  1.6797352
  2  0.88036288 -1.27228618 -0.15563923  0.4442276 -0.31753797  0.7405728
  3 -0.96133985  0.03737684  0.03422035 -0.2602042  0.05304423  0.1964495
  4  0.66768168 -0.62647477 -0.44125533  0.3550985  0.33831439  0.2475762
  5  0.33875187 -0.30868612 -0.96719124  0.8661768  0.43866355  0.1637642
  6  0.09486309 -0.26492034 -0.04346561  0.1361076  0.75596632  0.2753387
  7  0.52726668  0.40468157  0.34757893  0.3725920  1.17891088  1.4051500
  8 -1.60327618 -1.65744327 -0.11362717 -0.9396057 -1.22318414 -0.7079332
   year
age        2006         2007       2008        2009         2010
  0 -0.10316315 -0.410668293  0.2087393 -0.16987205 -0.268561809
  1 -1.37813385  0.006060442 -0.4312757 -0.13165719 -0.169352648
  2 -0.27539712 -0.835890892  0.9320637 -0.26890280  0.736398507
  3  0.37639412  0.141480999 -1.1844506 -1.87590693  1.457694000
  4 -0.01419789 -0.029367569 -1.3662832 -1.49629440 -0.008982707
  5  0.20963612 -0.164088570 -1.0349389 -1.45908009  0.217555957
  6 -0.50975916 -0.143386604 -1.0516869 -1.48816708  0.631091734
  7 -0.41449654 -0.240514156 -1.1192945 -1.02706467 -0.391761058
  8 -0.06727062 -0.144390219  0.4012754 -0.05909933 -0.035330412
   year
age        2011        2012        2013       2014       2015       2016
  0  0.36693496  0.05219968 -0.60121593  1.2071315 -1.0855840 1.36345904
  1 -0.39233652  1.08045031  0.89831009 -0.2620766 -0.8468485 0.05700013
  2 -0.05431880  0.47091281 -0.42679240  0.6796029  0.5485179 0.22158185
  3  0.81740705  2.01190833 -0.06702044  0.4098810 -1.3233749 1.42057656
  4  0.94537257  1.98280462  0.77016081  1.2438507 -0.5655943 0.02591196
  5  0.57735607  1.83982432  1.39419331  0.5739212  0.4426095 0.15959932
  6  0.65202441  1.43169817  1.26441815  0.0685338  0.8370904 0.15973285
  7  0.38746291  1.93049912  0.95338388  0.4136070  0.5478256 0.43305945
  8  0.05498913 -0.54295811  0.48157490 -0.4374307  0.7168706 0.55098635
   year
age        2017       2018       2019 2020
  0 -1.37606164  1.1813020 -0.8101466    0
  1 -0.02170378 -0.5844188  0.4212925    0
  2 -0.88219535 -0.2068544 -1.1972133    0
  3  0.41325217 -0.3450561 -0.2165400    0
  4  0.69533306  0.8361862 -0.6182608    0
  5 -0.13233876  1.6468654 -0.1585924    0
  6 -0.66845525  0.3344147  0.4508528    0
  7 -0.94635000  0.3384592 -0.3978370    0
```

8	0.50387035	1.4431848	0.8157804	0

Table 2.6.3.17. North Sea Herring single fleet assessment. PREDICTED INDEX AT AGE LAI-ORSH

Units : NA

age \ year	1972	1973	1974	1975	1976	1977	1978
0	2078.709	1859.917	1071.6491	639.3247	988.6126	584.4691	726.8124
1	1212.539	1084.915	625.1074	372.9267	576.6711	340.9287	423.9595

age \ year	1979	1980	1981	1982	1983	1984	1985
0	1050.9661	1288.2055	1872.809	2298.352	2563.957	3917.453	4583.129
1	613.0428	751.4277	1092.435	1340.660	1495.591	2285.103	2673.401

age \ year	1986	1987	1988	1989	1990	1991	1992
0	5108.988	5988.752	7121.143	7952.690	NA	3974.483	935.0999
1	2980.142	3493.320	4153.859	4638.912	4280.549	2318.370	545.4564

age \ year	1993	1994	1995	1996	1997	1998	1999	2000
0	NA	889.2645	NA	NA	NA	NA	NA	NA
1	486.9211	518.7200	1817.445	4663.239	5993.355	7043.149	7617.41	7942.8

age \ year	2001	2002	2003	2004	2005	2006	2007
0	NA	NA	NA	NA	NA	6372.363	NA
1	8970.269	9000.354	6623.344	5419.745	4868.978	3717.085	2539.809

age \ year	2008	2009	2010	2011	2012	2013	2014	2015
0	4674.879	NA	NA	NA	NA	NA	NA	NA
1	2726.920	2731.293	2835.73	3790.761	4326.598	4014.665	3609.938	3082.043

age \ year	2018	2019
0	NA	1665.323
1	740.0799	NA

Table 2.6.3.18. North Sea Herring single fleet assessment. INDEX AT AGE RESIDUALS LAI-ORSH

Units : NA

age \ year	1972	1973	1974	1975	1976	1977
0	0.9535755	-0.4331756	-0.5470099	-0.7729207	0.2907140	1.9140522
1	1.5462093	-0.6940832	-0.5240960	-1.7717666	-0.8428187	0.7894143

age \ year	1978	1979	1980	1981	1982	1983
0	2.7866719	2.089468	1.4269047	0.8279461	0.2997620	-0.1303186
1	-0.4829522	1.880516	0.4036348	-0.8920931	0.0911671	-0.5902602

age \ year	1984	1985	1986	1987	1988	1989
0	-0.6928827	0.1935109	-0.1240551	0.3790471	0.2459064	0.6768771
1	-0.1896217	0.1387613	-0.2357463	-0.3702661	0.7210795	0.4178133

year

age	1990	1991	1992	1993	1994	1995
0	NA	-1.3039662	-1.990612	NA	-1.718993	NA
1	0.6657413	-0.1328554	1.341458	-1.072811	2.026868	2.309325

year

age	1996	1997	1998	1999	2000	2001
0	NA	NA	NA	NA	NA	NA
1	-0.03060965	-0.09489708	0.2464663	-0.2712274	-0.4909325	0.1289649

year

age	2002	2003	2004	2005	2006	2007
0	NA	NA	NA	NA	0.1549671	NA
1	-0.4167859	-0.8906661	0.1345411	-0.1015886	-0.2640056	-0.1467729

year

age	2008	2009	2010	2011	2012	2013	2014
0	0.3818619	NA	NA	NA	NA	NA	NA
1	0.9232668	0.8425737	-0.01609682	0.3508849	1.571298	1.613169	0.4483023

year

age	2015	2018	2019
0	NA	NA	0.6720086
1	0.8073867	-1.873082	NA

Table 2.6.3.19. North Sea Herring single fleet assessment. PREDICTED INDEX AT AGE LAI-BUN

Units : NA

year

age	1972	1973	1974	1975	1976	1977	1978
0	20.50907	18.350411	115.13275	76.97981	NA	61.52865	NA
1	NA	6.897641	43.27665	NA	9.739586	23.12769	45.13309

year

age	1979	1980	1981	1982	1983	1984	1985
0	64.06644	16.067074	29.51972	353.1653	1872.5835	3116.229	2809.693
1	24.08160	6.039369	11.09602	132.7495	703.8757	1171.343	1056.121

year

age	1986	1987	1988	1989	1990	1991	1992
0	2430.6123	2770.515	4922.271	4402.593	5400.473	NA	NA
1	913.6303	1041.395	1850.207	1654.868	2029.956	3278.634	4441.607

year

age	1993	1996	1997	1998	1999	2000	2001
0	NA	NA	NA	NA	NA	200.95614	NA
1	3062.242	577.9594	169.8615	327.6576	155.8421	75.53636	226.0276

year

age	2002	2003	2004	2005	2006	2007	2008
0	NA	NA	NA	NA	NA	NA	NA
1	736.9592	1464.692	1774.975	1312.619	732.5742	836.1728	738.9656

year

age	2009	2010	2011	2012	2013	2014	2015
0	NA	NA	NA	NA	NA	NA	NA
1	1302.442	1402.346	2092.716	2755.129	3575.947	3467.948	3128.666

year

age	2016	2017	2018	2019
0	NA	NA	NA	5859.822

```
  1 3789.257 3705.555 4438.791 2202.618
```

Table 2.6.3.20. North Sea Herring single fleet assessment. INDEX AT AGE RESIDUALS LAI-BUN

```
Units  :  NA
   year
age      1972        1973     1974      1975      1976      1977     1978
  0 -0.191631 -1.44588453 1.388216 0.3982158        NA 2.0437767       NA
  1        NA  0.04277676 2.035321        NA -2.325967 0.8371231 2.005365
   year
age       1979       1980       1981     1982      1983       1984
  0  0.5484755 -0.7214317 -0.9940804 1.585509 1.3564361 -0.3110575
  1 -1.0785510 -1.7673845  1.0788221 1.288662 0.3458204  0.2551603
   year
age       1985        1986        1987      1988       1989      1990
  0 -0.2246693 -0.02266447 -0.04929623 0.7580446  0.4763926 0.1938788
  1  0.2747409 -0.96674286 -0.31853908 0.9832198 -0.5658200 0.2038427
   year
age       1991       1992      1993      1996      1997     1998
  0         NA         NA        NA        NA        NA       NA
  1 0.01725587 -0.4575776 -2.672574 -2.167859 -2.231831 1.230628
   year
age       1999      2000      2001      2002      2003      2004
  0         NA -1.691022        NA        NA        NA        NA
  1 -0.6752219  0.995908 0.3916406 0.9016488 0.5389952 0.7283112
   year
age       2005       2006     2007        2008     2009       2010
  0         NA         NA       NA          NA       NA         NA
  1 -0.1674563 -0.8528227 0.652732 -0.06835265 1.441677 0.08212025
   year
age      2011     2012    2013      2014     2015      2016     2017
  0        NA       NA      NA        NA       NA        NA       NA
  1 0.5403415 1.187902 1.44848 0.6144584 0.450272 0.1840641 0.706288
   year
age       2018        2019
  0         NA -0.07128237
  1 -0.3265473  0.30024432
```

Table 2.6.3.21. North Sea Herring single fleet assessment. PREDICTED INDEX AT AGE LAI-CNS

```
Units  :  NA
   year
age      1972      1973     1974       1975       1976       1977
  0 427.77653 382.75146 298.8926         NA 175.105271 133.091849
  1 606.84508 542.97237       NA 220.757752 248.404863 188.804497
  2 291.76587 261.05642 203.8603 106.138419         NA  90.775570
  3  20.16503  18.04259       NA   7.335623   8.254317   6.273839
   year
age       1978       1979      1980     1981      1982     1983       1984
```

```
  0 175.062179 203.817198 163.30623 250.4716 377.36901 570.9355 1201.23518
  1 248.343733 289.135689 231.66671 355.3198 535.33681 809.9308 1704.07583
  2 119.401520 139.013940 111.38335 170.8347 257.38531 389.4077  819.30493
  3   8.252286   9.607774   7.69812       NA  17.78886       NA   56.62523
   year
age       1985       1986      1987       1988       1989     1990
  0 1429.65290 1446.50930 1760.3173 2066.41975 1735.63668 1771.334
  1 2028.10990 2052.02244 2497.1914 2931.42927 2462.17941 2512.820
  2  975.09771  986.59465 1200.6280 1409.40585 1183.79457 1208.142
  3   67.39265   68.18725   82.9799   97.40931   81.81647       NA
   year
age      1991     1992     1993     1994     1995     1996     1998
  0 1053.2779 205.9345       NA       NA       NA       NA 310.6755
  1 1494.1833 292.1392 250.9830 212.2946       NA 509.1886 440.7253
  2  718.3904 140.4580 120.6704 102.0694 165.5879       NA       NA
  3        NA       NA       NA       NA       NA       NA       NA
   year
age     1999     2000     2001     2002     2003     2004     2005
  0       NA       NA       NA       NA       NA       NA       NA
  1 479.9638 644.5049 1410.289       NA 3474.050 3405.456 3211.039
  2 230.7625       NA       NA 1295.082 1670.293       NA       NA
  3       NA       NA       NA       NA       NA       NA       NA
   year
age     2006     2007     2008     2009    2010     2011     2012     2013
  0       NA       NA       NA       NA      NA       NA       NA       NA
  1 2358.895 1674.884 1979.662 2149.928 2242.04 2922.401 2708.989 2670.613
  2       NA       NA       NA       NA      NA       NA       NA       NA
  3       NA       NA       NA       NA      NA       NA       NA       NA
   year
age     2014     2015    2016     2017     2018     2019
  0       NA       NA      NA       NA       NA       NA
  1 2609.894 2735.123 3249.73 2659.405 1846.896 2290.383
  2       NA       NA      NA       NA       NA       NA
  3       NA       NA      NA       NA       NA       NA
```

Table 2.6.3.22. North Sea Herring single fleet assessment. INDEX AT AGE RESIDUALS LAI-CNS

```
Units  :  NA
   year
age       1972      1973      1974       1975       1976        1977
  0  0.4094250 0.6808418 -1.271201         NA -0.7105600  2.06895207
  1 -0.5616920 0.6675048        NA -1.3120079 -0.4221469  0.93833119
  2  0.4522500 1.4077830  1.307900 -0.6149444         NA  0.54665931
  3  0.9557141 1.6620297        NA -0.4055627  0.4410501 -0.08690838
   year
age       1978       1979       1980       1981       1982       1983
  0  2.5973905  1.1855376  0.4631526  1.1683491 -1.1501172  0.8107628
  1 -0.3272384 -0.5522346 -0.2971534 -0.3557173 -1.4425265 -0.8779766
  2  1.2386800  1.1581421 -2.0700896 -0.2684134  1.5499451 -1.3311597
  3 -0.6823458 -0.2677323  0.5924481         NA  0.4099752         NA
   year
```

```
age       1984       1985        1986       1987      1988       1989
  0 0.07307588 -1.7278924 -0.01879499 -0.4904083 0.8718847 -0.3122096
  1 0.72496854  1.8485064  0.74460521  0.7213273 0.1672609  0.4249005
  2 0.32605817  0.5651472 -1.52601928  0.4773790 0.1955668  0.3580716
  3 1.86480637  0.9235538 -0.53980150  0.2596103 0.5064601 -3.2042479
   year
age       1990        1991        1992       1993      1994      1995
  0  1.9362377  0.85059141 -3.67700030         NA        NA        NA
  1 -0.8029704 -0.24435850 -0.59668027  0.9335421  1.289282        NA
  2 -0.3272440 -0.06340403  0.08804795 -0.3643129 -1.125871 -1.456915
  3         NA          NA          NA         NA        NA        NA
   year
age     1996       1998       1999      2000     2001     2002      2003
  0       NA -0.9031206         NA        NA       NA       NA        NA
  1 -0.38556 -1.6632010 -0.6372284 0.3062514 1.039785       NA 1.4701151
  2       NA         NA  0.2968803        NA       NA 1.538291 0.6907551
  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 0.5476612 0.5895621 -0.1563043 -1.217358 1.757325 0.7112674 0.0970424
  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 1.60476 -1.211525 1.240947 -0.3710008 0.5998923 0.385868 0.7498335
  2      NA        NA       NA         NA        NA       NA        NA
  3      NA        NA       NA         NA        NA       NA        NA
   year
age       2018     2019
  0         NA       NA
  1 0.03135325 1.503866
  2         NA       NA
  3         NA       NA
```

Table 2.6.3.23. North Sea Herring single fleet assessment. PREDICTED INDEX AT AGE LAI-SNS

```
Units  :  NA
   year
age     1972     1973     1974     1975     1976     1977     1978
  0 7.757547       NA       NA 3.667798       NA 6.273394 19.44135
  1 6.169737       NA 5.580891 2.917075 4.164247       NA 15.46210
  2       NA 2.296887       NA       NA       NA       NA       NA
   year
age     1979     1980      1981      1982      1983     1984     1985
  0       NA 95.80040 183.37074 258.61689 247.05128 339.2755 378.9276
  1 51.15811 76.19203        NA 205.68332 196.48495 269.8327 301.3689
  2 21.28568 31.70170  60.67996  85.57997  81.75275 112.2710 125.3925
   year
age     1986     1987     1988      1989     1990     1991     1992
```

```
  0 337.2216 505.5960 775.0096 1318.7338 1787.042 1671.832 616.8307
  1 268.1993 402.1109 616.3811 1048.8161 1421.271 1329.642 490.5781
  2 111.5914 167.3088 256.4616  436.3876       NA       NA       NA
   year
age     1993     1994     1995      1996      1997      1998      1999
  0 619.6249 465.2831 602.3138 1053.2151 1221.9502 1247.3447 1157.6376
  1 492.8004 370.0492 479.0325  837.6436  971.8421  992.0388  920.6929
  2       NA       NA 199.3141  348.5237  404.3605  412.7639  383.0786
   year
age      2000      2001      2002     2003     2004     2005     2006
  0 1141.0885 1979.1417 2616.7390 3933.553 4615.033 4887.587 5156.933
  1  907.5311 1574.0520 2081.1463 3128.435 3670.430 3887.199 4101.415
  2  377.6023  654.9259  865.9158 1301.668 1527.179 1617.372 1706.502
   year
age     2007     2008     2009     2010     2011     2012      2013
  0 4644.777 4739.972 5567.922 5970.090 5625.430 5104.573 2613.5732
  1 3694.086 3769.797 4428.282 4748.135 4474.020 4059.771 2078.6284
  2 1537.022 1568.523 1842.504 1975.587 1861.534 1689.175  864.8682
   year
age     2014      2015     2016     2017     2018     2019
  0       NA 2901.0223 4488.028 4326.980 3082.015 3740.706
  1       NA 2307.2426 3569.421 3441.336       NA 2975.060
  2 970.4205  959.9891 1485.152       NA       NA       NA
```

Table 2.6.3.24. North Sea Herring single fleet assessment. INDEX AT AGE RESIDUALS LAI-SNS

```
Units  :  NA
   year
age       1972      1973      1974        1975      1976      1977
  0 -0.3427024        NA        NA -1.09966967        NA -0.122797
  1  1.9570593        NA 0.3554103 -0.05827156 0.5504391        NA
  2         NA -0.981504        NA          NA        NA        NA
   year
age       1978     1979      1980         1981       1982        1983
  0  2.1241547       NA 1.5339842  1.921165675  0.4642515 -1.50273354
  1 -0.1510828 1.989533 0.7869420           NA -0.1972692 -0.02810629
  2         NA 1.850739 0.3923725 -0.004450729 -0.7415594 -0.44241447
   year
age        1984      1985       1986        1987       1988      1989
  0 -0.02066625  1.063179  0.3827616  0.77977683  0.8794208 0.8486109
  1 -0.61660314 -0.170285 -0.9153303 -0.10739805 -0.9167366 1.0493762
  2 -1.00204789 -1.274815 -1.5123297  0.03979381 -0.3499619 0.4233212
   year
age      1990       1991       1992      1993        1994       1995
  0 0.6659292  0.9678321 -0.6371519 0.6771811 -0.27091905 -1.9248803
  1 0.1106190 -0.3314678  1.3099527 0.4121662  0.05220974 -0.3046369
  2        NA         NA         NA        NA          NA  0.1710631
   year
age       1996       1997       1998       1999      2000       2001
  0 -0.7717289  1.6333220 -0.1890268 -0.3514135  1.349848 -0.3055415
  1  0.1487525 -0.3822350 -0.3263633  0.2385508 -1.125585  1.2326754
```

```
  2  0.7635507 -0.3575459 -0.9024997 -0.1340797 -1.103369  0.2729501
   year
age       2002       2003       2004      2005       2006        2007
  0 -0.2684102 1.31259070  0.6302191 -1.386830  0.9838430  0.32394742
  1 -1.5776202 0.17140393 -0.2176641  0.642873 -0.1181533 -0.03315693
  2  0.3651386 0.02150892  1.0492041  1.341054  0.3838816  1.01555147
   year
age       2008       2009      2010        2011      2012      2013
  0  0.8326610 1.21354639 0.3034594 -0.07466079 1.2650268 -5.017390
  1 -0.1238748 1.22137344 0.8897982  0.19736654 0.7029443  1.935466
  2  1.0264273 0.07115313 1.1131054 -0.42624241 0.3548591  1.336432
   year
age      2014         2015       2016      2017      2018      2019
  0        NA -0.016557299  1.6921383 1.1550109 -0.809484 1.4169246
  1        NA -0.242878362 -0.5352618 0.6509457        NA 0.5542497
  2 0.8093776 -0.007132457  0.2762174        NA        NA        NA
```

Table 2.6.3.25. North Sea Herring single fleet assessment. PREDICTED INDEX AT AGE IBTS-Q1

```
Units  :  NA
   year
age    1984    1985    1986    1987    1988    1989     1990     1991
  1 1197631 1376001 1927211 2548067 1911269 1216869 973272.9 982739.9
   year
age     1992    1993    1994    1995    1996    1997    1998     1999
  1 973754.1 1572622 1639217 1419305 1468759 1420993 1280682 829414.5
   year
age    2000    2001    2002    2003     2004    2005     2006     2007
  1 2376458 1607472 3060194 1445338 771081.6 1032460 765302.3 748009.4
   year
age   2008     2009    2010    2011     2012     2013    2014    2015
  1 845092 833229.5 1299713 1184054 961018.6 904292.9 1430018 2060279
   year
age     2016     2017     2018     2019    2020
  1 556899.5 963300.7 643944.6 899714.6 1063471
```

Table 2.6.3.26. North Sea Herring single fleet assessment. INDEX AT AGE RESIDUALS IBTS-Q1

```
Units  :  NA
   year
age       1984        1985      1986     1987      1988      1989
  1 -0.6814719 0.007299283 0.2128674 1.052921 -1.439817 0.9545864
   year
age       1990      1991        1992        1993     1994      1995
  1 -0.7946957 0.8817327 -0.09942406 -0.09257319 1.404788 0.8484396
   year
age       1996      1997     1998     1999       2000      2001    2002
  1 -0.8413866 0.5483171 1.157205 0.121766 -0.8981147 0.3975064 -1.1898
   year
```

```
age       2003        2004      2005       2006     2007        2008
  1 -0.3790905 -0.02182093 0.4026958 -0.3527853 0.363503 -0.01961185
   year
age      2009      2010     2011       2012      2013     2014      2015
  1 0.4529398 -1.256323 1.293813 -0.7594924 -1.639071 1.238104 0.2756952
   year
age       2016     2017     2018       2019      2020
  1 -0.3058115 1.228658 0.217914 -0.6510676 0.3848971
```

Table 2.6.3.27. North Sea Herring single fleet assessment. PREDICTED INDEX AT AGE HERAS

```
Units  :  NA
   year
age       1989       1990       1991       1992       1993       1994
  1 7203269.86 5777163.3 6087309.1 6031060.8 9843806.0 10894055.0
  2 4612163.41 3022527.9 2550562.0 2885109.7 2469619.3  3787655.3
  3 4607846.06 3167515.7 1899822.2 1410477.5 1495649.6  1143708.9
  4 2012554.45 2921423.6 1878557.0 1083911.6  731048.8   587522.5
  5  547290.70 1196961.0 1739296.8 1096836.4  613653.4   345684.6
  6  309039.47  326514.4  674451.3 1017095.1  611881.4   302308.4
  7  149257.46  177026.3  192240.2  393169.0  497455.4   295642.6
  8   70995.96  133439.4  168524.3  202280.9  307603.6   381533.8
   year
age      1995       1996       1997      1998      1999       2000
  1 9504282.7 9938614.30 9857436.37 8751744.1 5684708.1 16040950.4
  2 4391521.3 4000836.62 4746040.93 6231203.4 4012168.5  3887371.7
  3 2017866.2 2474261.81 2467496.55 2765890.4 4243304.6  2524016.1
  4  591602.7  945900.51 1367270.58 1277084.2 1442235.7  2592585.0
  5  276008.8  294364.35  570971.57  752751.7  645110.7   865665.2
  6  180785.9  117987.92  190203.38  360163.8  376554.9   407650.6
  7  155337.1   97837.55   69414.21  124442.5  198164.4   240958.0
  8  319103.4  263944.47  210526.22  162368.8  146665.7   186894.5
   year
age       2001       2002       2003      2004      2005      2006
  1 10795515.2 20495986.0  9569147.9 5109206.7 6792903.4 5125585.3
  2  8615549.0  5757253.5 13358610.2 4548061.1 2776943.4 3784843.6
  3  2909771.2  6623648.8  3917955.3 9331685.3 3302515.0 2114214.1
  4  1454263.7  1548060.8  3994400.2 2474045.2 5305991.3 1955672.7
  5  1487339.4   808760.9   800028.3 2284249.8 1390289.1 3273370.0
  6   464467.6   924982.3   491593.9  373788.7 1152802.8  667975.3
  7   240545.4   269785.1   554237.4  296897.5  170274.1  520594.6
  8   208280.7   266492.8   294049.4  420569.8  287595.3  193742.7
   year
age      2007      2008      2009      2010      2011      2012      2013
  1 5040855.3 5747859.8 5711054.8 8942514.4 8187726.5 6613608.1 6193457.8
  2 2605530.6 3177199.5 3747665.6 3981179.3 4930092.3 4642400.9 3474734.1
  3 2538496.5 1913883.9 2323877.8 3219896.5 3095469.6 4266197.2 3655961.0
  4 1305896.4 1470835.6 1194936.1 1687892.4 2082691.2 2245770.0 2882620.1
  5 1117111.0  869848.1  950844.8  893115.8 1044098.9 1416891.4 1622063.8
  6 1845125.7  745865.3  619437.8  849288.4  590182.2  658337.4  908611.7
  7  336381.8 1322078.4  540894.6  471922.5  559209.3  351108.4  385076.2
```

8	337895.0	464988.5	1438546.4	1601189.8	1334645.7	979694.3	768532.8

year

age	2014	2015	2016	2017	2018	2019
1	9848348.1	14196509.3	3823501.4	6634875.9	4443546.4	6182194.9
2	4179522.5	7379381.0	9477650.9	2049969.8	3374916.3	2111852.0
3	2741234.5	2724720.2	5946669.3	6951797.8	1683540.8	2108129.7
4	2725191.6	1669556.9	1594252.0	3801650.7	4530118.0	1144323.3
5	1807623.3	1608617.1	1006621.6	1015953.9	2511054.5	2592731.3
6	1021461.8	968313.2	854726.3	512285.9	636456.6	1484234.1
7	524472.3	498229.3	422141.4	382693.7	310409.3	320174.8
8	559928.4	534366.9	437422.1	387877.7	442609.5	393748.7

Table 2.6.3.28. North Sea Herring single fleet assessment. INDEX AT AGE RESIDUALS HERAS

Units : NA

year

age	1989	1990	1991	1992	1993	1994
1	0.00000000	0.0000000	0.0000000	0.00000000	0.0000000	0.0000000
2	-0.33109729	0.1342259	-0.3324343	0.75568235	-0.2434258	-1.4930398
3	-0.21722190	0.9123344	-0.6624366	-0.69101851	-0.7211828	-2.1053788
4	-0.42760016	1.5409407	0.3665909	0.13590263	0.2318488	-2.4541036
5	-0.08058128	1.2158772	0.4839243	0.10346593	0.5443316	-0.1094745
6	-0.27779890	1.1588734	-0.3039943	0.66790618	0.6376346	-0.4758571
7	-0.57707099	0.7887160	0.3367163	-0.29674049	-0.2731180	-0.4399182
8	0.11135166	1.0278587	-0.9820768	0.08422129	-0.6415672	-1.1455874

year

age	1995	1996	1997	1998	1999	2000
1	0.0000000	0.0000000	0.55881904	-1.44049944	0.17605210	0.5397438
2	-0.9802560	0.2561582	0.40407666	-0.10822059	-1.34505330	-0.1243992
3	-0.0636435	0.6254653	0.22412282	-1.15258081	0.08068883	-0.4580321
4	1.0109067	0.6881709	-0.23203476	0.01940235	-1.48781560	0.6643593
5	-0.3118327	0.3022888	0.17867755	0.13907342	-1.57912817	0.3026302
6	-0.1235038	-1.8772447	0.49858339	0.43151535	-1.56662846	0.4779964
7	-1.0548534	-1.1141162	-2.15255654	0.64589443	-2.36167878	-0.4998831
8	-2.1187398	0.4626908	0.03685231	-0.65423645	-0.71001945	-0.1087765

year

age	2001	2002	2003	2004	2005	2006
1	-0.62226828	0.4673469	-0.14029589	-0.07811619	-1.28744514	0.56281473
2	1.81080272	-0.5700131	1.95836339	-1.57547627	-1.08602970	0.43978256
3	0.58478619	1.1653885	-0.96818405	-0.11963320	0.55607932	0.27902357
4	0.06774052	-0.8626656	-0.07663189	-0.33947017	0.05394396	0.48057560
5	0.22398173	-0.2548230	-1.72060809	0.18175695	-0.53070617	1.33383475
6	-0.85892390	0.2888180	-0.20422153	-1.56714876	-0.11749943	-0.50553929
7	-2.15482351	-0.9526022	-0.60435119	-0.31322686	-1.53001229	0.01736275
8	-1.58941757	-0.3617884	-0.10508434	0.13759682	-1.29104456	-1.09965326

year

age	2007	2008	2009	2010	2011	2012
1	0.4365392	-0.8307808	0.4002927	0.9858851	0.8534677	-0.04027331
2	0.1609209	0.1835235	2.7735581	1.0728182	-0.6991617	-0.31040180
3	-1.2373473	0.4908123	1.2996464	1.2704239	-0.6976411	-0.06876807
4	-0.7816012	0.7723571	0.2507247	1.9470924	-0.1275233	-0.81098975

```
  5 -0.6721077  1.1353863 1.4257706 1.8837241 -0.5476063 -0.68606984
  6 -0.5223087  1.1342321 1.3065928 2.8298084  0.1891591 -0.54192540
  7 -0.6393129  2.6386227 1.4501638 1.8165585  0.4224784 -1.81619414
  8 -0.9477690  0.6716720 1.5334099 2.1914774  0.4305702 -1.45593862
   year
age        2013       2014        2015        2016        2017       2018
  1 -0.01955081  1.2598518 -1.27729881  1.87169868 -1.63827736 1.98175955
  2 -1.02475184  1.5652840  2.27745445  1.57916448 -0.47723329 0.27359394
  3  0.02352608  0.6471721  0.29279431 -0.02363008 -0.42321539 0.74310290
  4  0.59514640  1.1811499  0.25992203 -0.86284544 -0.35461727 0.84373930
  5  0.57807838  0.4985809  0.09370738 -0.29947146 -0.09568668 0.34170600
  6  0.31363304  1.3735652 -0.12114882  0.49368867 -0.91946203 1.23315372
  7  0.81794003  1.0255202  0.23910285  0.03394881 -0.25266848 3.16928348
  8  0.22226480 -0.8569851 -0.27741437 -0.40127791 -0.31705352 0.07944698
   year
age       2019
  1  0.3027102
  2 -2.3853838
  3 -0.1585027
  4  1.1642505
  5  1.4942242
  6  0.9425431
  7  1.1800735
  8  0.3821976
```

Table 2.6.3.29. North Sea Herring single fleet assessment. PREDICTED INDEX AT AGE IBTS0

```
Units  :  NA
   year
age     1992     1993     1994     1995     1996     1997     1998
  0 141.0904 148.5562 116.0239 131.2342 105.7108 86.91747 56.73333
   year
age     1999     2000     2001     2002     2003     2004     2005
  0 175.0686 120.0657 211.4681 107.5339 59.69341 69.75373 64.79809
   year
age     2006     2007     2008     2009     2010    2011     2012     2013
  0 60.91899 68.69111 62.61298 100.7988 82.57595 73.7463 70.58049 89.49184
   year
age     2014     2015     2016     2017     2018     2019     2020
  0 142.2684 38.38898 71.13397 42.55071 71.80933 70.38915 64.43271
```

Table 2.6.3.30. North Sea Herring single fleet assessment. INDEX AT AGE RESIDUALS IBTS0

```
Units  :  NA
   year
age       1992      1993      1994       1995      1996    1997       1998
  0 -0.1589054 0.2819204 0.4564294 0.01319253 0.5799452 2.13428 -0.4788656
   year
age     1999       2000     2001      2002       2003      2004      2005
```

```
  0 1.566193 -0.7090051 1.585146 0.3614282 -0.3060995 -1.083525 0.1175646
   year
age       2006        2007       2008      2009       2010       2011
  0 0.04779008 -0.08826931 -1.052652 1.273616 -0.3056007 -0.4216103
   year
age       2012       2013       2014       2015       2016       2017
  0 -0.2786536 0.4802185 -0.2252901 -2.694451 0.3988866 -0.8445323
   year
age      2018       2019       2020
  0 0.7642688 -0.218975 -0.1257349
```

Table 2.6.3.31. North Sea Herring single fleet assessment. PREDICTED INDEX AT AGE IBTS-Q3

```
Units  :  NA
   year
age       1998       1999       2000       2001       2002       2003
  0 1012581.76 3087399.39 2096071.15 3665332.49 1853831.45 1020817.61
  1  386970.04  251453.64  708134.90  476258.69  903888.30  421372.61
  2  249708.82  160917.55  155874.15  346071.96  231177.19  536275.56
  3   86815.57  132907.00   79237.06   91415.03  208195.95  123132.12
  4   34152.57   38585.47   69259.48   38931.79   41437.13  106777.44
  5   15918.19   13651.15   18294.65   31469.74   17130.91   16844.26
   year
age       2004       2005       2006       2007       2008       2009
  0 1178079.95 1078612.28 1009108.37 1141045.41 1035068.15 1679426.07
  1  225004.91  298878.18  226041.51  222483.94  253993.10  252620.19
  2  182466.30  111305.55  151832.70  104633.74  127583.40  150709.16
  3  293002.43  103643.24   66324.69   79602.77   60205.73   73272.14
  4   66066.10  141437.72   52125.60   34844.80   39389.95   32082.94
  5   47997.78   29180.64   68801.32   23520.89   18410.64   20185.42
   year
age       2010       2011       2012       2013       2014      2015
  0 1380816.24 1235729.69 1193474.11 1540456.60 2469764.17 672891.99
  1  395755.99  362589.24  292697.24  273931.69  435897.72 628395.66
  2  160116.81  198290.20  186583.10  139675.84  168038.83 296869.65
  3  101415.77   97404.68  133871.49  114806.31   86086.13  85737.65
  4   45320.66   55829.31   59994.65   76901.34   72624.72  44583.27
  5   18955.36   22119.89   29890.60   34134.72   38005.28  33793.31
   year
age       2016      2017       2018       2019
  0 1260430.15 748303.11 1266239.26 1265697.26
  1  169164.16 293670.54  196726.46  273549.43
  2  381398.15  82541.87  135857.99   85039.80
  3  186802.18 218176.25   52908.75   66187.15
  4   42547.65 101297.41  120536.28   30549.74
  5   21155.16  21399.19   52661.01   54456.40
```

Table 2.6.3.32. North Sea Herring single fleet assessment. INDEX AT AGE RESIDUALS IBTS-Q3

```
Units  :  NA
   year
age       1998       1999       2000         2001       2002         2003
  0 -0.6079410  0.4239333 -0.5223004 -1.550185170 -0.2758412 -0.737206094
  1  0.3407494  0.4946526  0.4092968 -0.007235645  2.8024917  0.572682257
  2  0.6918239  0.6527600  2.6243025 -1.352834268  1.1765222 -0.021763840
  3 -0.4198515 -1.0789138  0.3244650  1.144053476  0.2846599  0.903877201
  4 -1.8811539  1.2023946 -1.3262973  0.274559623  1.2096109 -0.476421659
  5 -1.2881866  0.4959110 -0.5245998 -1.087789837  0.8289420 -0.005994824
   year
age       2004        2005       2006      2007       2008        2009
  0  1.2849681 -0.47997010 -0.1551811  1.496371 -0.7098103  1.23365567
  1  0.6713514  1.43840823  0.6878134 -2.475976 -0.6037853 -0.89545042
  2  0.8940183 -0.06112766  0.7468905  0.217727  0.5714927 -1.66675162
  3  0.2725392 -1.13726607  0.3445437  1.469080  0.5675961  0.51152053
  4  0.7890420 -1.18520100 -0.9987558  1.539509 -0.3728624  0.09251306
  5 -0.9651728  1.13425498 -0.9359083  0.557987  0.8103991 -1.49667659
   year
age       2010        2011        2012        2013       2014       2015
  0 -0.1061452 -1.03633921 -0.77848828  0.96902864  1.9952276 -0.4983280
  1  0.9323347  0.19044984 -0.44365675 -0.17906894 -0.8897695  1.1744950
  2  0.1555620  0.01280361 -2.18871889  0.14121163  0.3592439  0.4814975
  3 -1.4455695  0.45527020 -0.99218680  0.55202617 -0.1654180  0.7976202
  4 -0.6545255 -0.82845442  0.04770058  0.09540425  0.3387516  0.9072813
  5 -0.4460209 -0.11100424 -0.24392290  0.56126461  0.4018069  0.2282090
   year
age       2016       2017       2018       2019
  0  0.2864098  0.5409983  0.2180309  0.6250593
  1 -0.3801736 -0.6453650  1.0272739 -2.7025268
  2 -0.1002694  0.1315924 -1.8947714  0.9081196
  3  0.5272568 -0.1666771  0.4863981 -2.0546342
  4  1.5441613  1.2290846 -1.1746782  0.7393533
  5  1.8940767  2.3868285 -0.2943493 -1.5126475
```

Table 2.6.3.34. North Sea Herring single fleet assessment. FIT PARAMETERS

```
                   name        value    std.dev
1               logFpar -12.92645214 0.09497463
2               logFpar  -0.25161514 0.12200976
3               logFpar  -0.22722562 0.07403482
4               logFpar  -0.06106206 0.07140616
5               logFpar  -2.49308454 0.07482621
6               logFpar  -2.70261495 0.13673416
7               logFpar  -3.32867462 0.11328128
8               logFpar  -3.41129054 0.09340551
9               logFpar  -3.49187339 0.09413935
10              logFpar  -3.65265623 0.09608322
11              logFpar  -3.88791344 0.09815626
```

```
12             logFpar  -4.26241945 0.11210760
13         logSdLogFsta  -0.61678992 0.12013332
14         logSdLogFsta  -1.15565916 0.09789931
15         logSdLogFsta  -0.67773017 0.09894372
16           logSdLogN  -0.58218224 0.11798400
17           logSdLogN  -1.69255577 0.08910093
18           logSdLogP   0.15399024 0.09812735
19           logSdLogP  -0.29667564 0.16251112
20           logSdLogP  -0.17878134 0.12723327
21         logSdLogObs  -1.43136417 0.38829527
22         logSdLogObs  -2.15088059 0.43454047
23         logSdLogObs  -1.40226232 0.18168369
24         logSdLogObs  -0.72968039 0.15759612
25         logSdLogObs  -1.54717802 0.08796857
26         logSdLogObs  -1.27577232 0.14486896
27         logSdLogObs  -1.28140274 0.15327222
28         logSdLogObs  -1.09227735 0.17506179
29         logSdLogObs  -0.63810752 0.18160095
30         logSdLogObs  -0.87075346 0.17511818
31         logSdLogObs  -1.17779644 0.10452888
32         logSdLogObs   0.17147975 0.04415029
33      transfIRARdist  -0.32673749 0.27901979
34                rhop   0.47631042 0.22413638
35 logAlphaSCB.LAI-ORSH  -0.53903047 0.31070830
36  logAlphaSCB.LAI-BUN  -0.97847252 0.34547267
37  logAlphaSCB.LAI-CNS   0.34967259 0.33787136
38  logAlphaSCB.LAI-CNS  -0.38264929 0.35330871
39  logAlphaSCB.LAI-CNS  -3.05465097 0.40786009
40  logAlphaSCB.LAI-SNS  -0.22901006 0.25061291
41  logAlphaSCB.LAI-SNS  -1.10589650 0.27271184
```

Table 2.6.3.35. North Sea Herring single fleet assessment. NEGATIVE LOG-LIKELIHOOD

```
1337.12613222629
```

Table 2.7.1. North Sea herring. Intermediate year (2020) assumptions for the stock.

Variable	Value	Notes
Fages (wr) 2–6 (2020)	0.20	Based on estimated catch 2020
SSB (2020)	1 287 790	Calculated based on catch constraint (in tonnes)
Rage (wr) 0 (2020)	29 574 086	Estimated by assessment model (in thousands)
Rage (wr) 0 (2021)	32 850 653	Weighted mean over 2010–2019 (in thousands)
Total catch (2020)	400 387	Estimated realized catch of autumn spawning herring derived from agreed TACs for A-D fleets, the proportion of NSAS herring in the catch (for A, C and D fleets), the transfer of TAC to the North Sea (C fleet) and the uptake of the by-catch quota (for B and D fleets).

Table 2.7.1. (cont.) North Sea herring. Intermediate year (2020), fleet wise assumptions for the catches and the fishing mortality. Weights are in tonnes

	Field	Value	Note
TACs	A-fleet TAC	385008	
	B-fleet TAC	8954	
	C-fleet TAC	24258	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	0.015	Value from terminal year
	B-fleet uptake	0.63	Average over the last 3 years (2017-2019)
	C-fleet transfer	0.50	Value for the Intermediate year
	C-fleet NSAS/WBSS split	0.27	Average over the last 3 years (2017-2019)
	D-fleet NSAS/WBSS split	0.66	Average over the last 3 years (2017-2019)
	D-fleet uptake	0.05	Average over the last 3 years (2017-2019)
F by fleet and total	$F_{(wr)\ 2–6}$ A-fleet	0.20	
	$F_{(wr)\ 0–1}$ B-fleet	0.02	
	$F_{(wr)\ 0–1}$ C-fleet	0.002	
	$F_{(wr)\ 0–1}$ D-fleet	0.0008	
	$F_{(wr)\ 2–6}$	0.20	
	$F_{(wr)\ 0–1}$	0.02	
NSAS catches by fleet	Catches A-fleet	391200	Includes C-fleet transfer and split of WBSS/NSAS in the north sea

	Field	Value	Note
	Catches B-fleet	5615	Includes fleet uptake
	Catches C-fleet	3330	Includes TAC transfer to the A fleet and WBSS/NSAS split.
	Catches D-fleet	241	Includes WBSS/NSAS split and fleet uptake

Table 2.7.2. North Sea herring. Reference points including results from management plan evaluation 2019 (ICES, 2019).

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)

Framework^	Reference point	Value	Technical basis	Source
		$F_{ages\ (wr)0–1}$ = 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)

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

Basis	F values by fleet and total						NSAS catches by fleet				Total stock catch	Biomass*				% Advice change ^
	A-fleet	B-fleet	C-fleet	D-fleet	$F_{ages\ (wr)\ 2–6}$	$F_{ages\ (wr)\ 0–1}$	A-fleet	B-fleet	C-fleet#	D-fleet#		SSB 2021	SSB 2022 **	%SSB change ***	A-fleet ****	
MSY approach^^	0.22	0.02	0	0	0.22	0.02	359367	6425	0	0	365792	1185977	1180568	-7.91	-6.66	-15.14
F = F_{MSY}	0.26	0.02	0	0	0.26	0.02	412470	7570	0	0	420040	1151509	1124228	-10.58	7.13	-2.56
F = 0	0	0	0	0	0.00	0.00	0	0	0	0	0	1410558	1622539	9.53	-100.00	-100.00
No change in A-fleet TAC	0.24	0.02	0	0	0.24	0.02	385008	6970	0	0	391978	1169374	1153096	-9.20	0.00	-9.07

Basis	F values by fleet and total						NSAS catches by fleet				Total stock catch	Biomass*				% Advice change ^
	A-fleet	B-fleet	C-fleet	D-fleet	$F_{ages\ (wr)\ 2–6}$	$F_{ages\ (wr)\ 0–1}$	A-fleet	B-fleet	C-fleet#	D-fleet#		SSB 2021	SSB 2022 **	%SSB change ***	A-fleet ****	
A-fleet TAC reduction of 15%	0.20	0.02	0	0	0.20	0.02	327257	5761	0	0	333018	1206661	1215687	-6.30	-15.00	-22.74
A-fleet TAC increase of 15%	0.28	0.03	0	0	0.28	0.03	442759	8251	0	0	451010	1131707	1093041	-12.12	15.00	4.63
$F = F_{2020}$	0.20	0.02	0	0	0.20	0.02	328563	5788	0	0	334351	1205822	1214243	-6.37	-14.66	-22.44
F_{pa}	0.30	0.03	0	0	0.30	0.03	462984	8717	0	0	471701	1118429	1072590	-13.15	20.25	9.43
F_{lim}	0.34	0.03	0	0	0.34	0.03	510788	9860	0	0	520648	1086870	1025413	-15.60	32.67	20.78
$SSB_{2021} = B_{pa}$	0.62	0.06	0	0	0.62	0.06	787754	17831	0	0	805585	900000	781185	-30.11	104.61	86.88
$SSB_{2021} = B_{lim}$	0.82	0.07	0	0	0.82	0.08	933742	23240	0	0	956982	800000	669586	-37.88	142.53	122.01
SSB_{2021} = MSY $B_{trigger}$	0.01	0.00	0	0	0.01	0.00	17454	268	0	0	17722	1400000	1598468	8.71	-95.47	-95.89
MSY approach^^ with F_{01}=0.05 target	0.22	0.05	0	0	0.22	0.05	359114	15557	0	0	374671	1185986	1178000	-7.91	-6.73	-13.08
MSY approach with C- and D-fleets catches and C-fleet TAC transfer##	0.23	0.02	0.002	0.001	0.23	0.02	368119	6346	3330	241	378036	1179238	1166898	-8.43	-4.39	-12.30
MSY approach with C- and D-fleets catches and no C-fleet TAC transfer###	0.22	0.02	0.004	0.001	0.22	0.03	355855	6346	6661	241	369103	1186084	1175799	-7.90	-7.57	-14.37

* 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 2021 as in 2020.

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

**** A-fleet catches (2021) relative to TAC 2020 for the A-fleet (385 008 tonnes).

^ Advice value 2021 relative to advice value 2020, using catches for all fleets (431 062 tonnes).

^^ Following the MSY advice rule $F_{MSY} \times SSB_{2021}$/MSY $B_{trigger}$ (ICES, 2016).

The catch for C- and D-fleets are set to zero because of the zero catch advice given for 2021 for the western Baltic spring-spawning herring stock.

Following the MSY advice rule $F_{MSY} \times SSB_{2021}$/MSY $B_{trigger}$ (ICES, 2016), assuming same catches as in 2020 for the C- and D-fleet and a 50% C-fleet TAC transfer to the A-fleet.

Following the MSY advice rule $F_{MSY} \times SSB_{2021}$/MSY $B_{trigger}$ (ICES, 2016), assuming same catches as in 2020 for the C- and D-fleet and no C-fleet TAC transfer to the A-fleet.

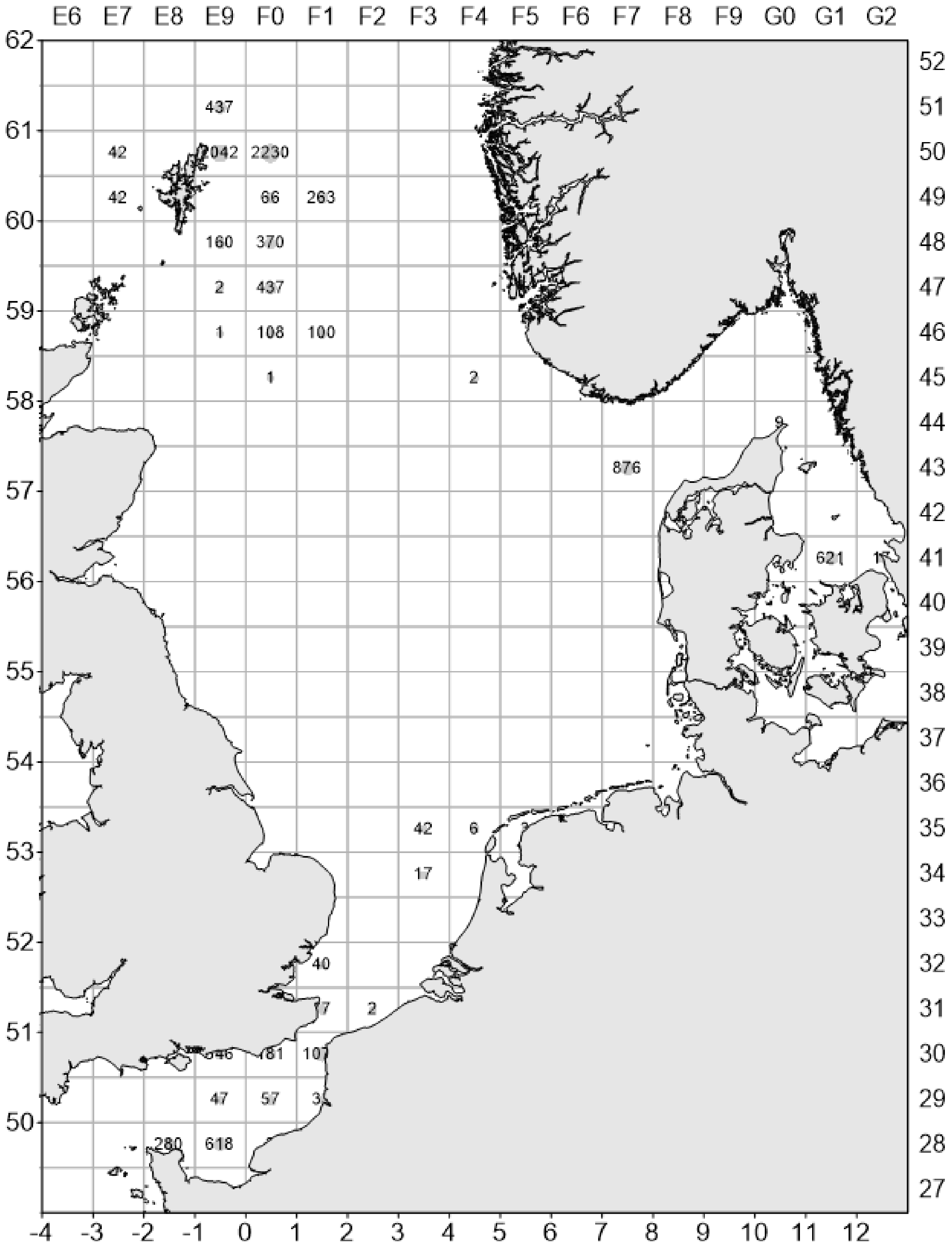


Figure 2.1.1a. Herring catches in the North Sea in the 1st quarter of 2019 (in tonnes) by statistical rectangle.

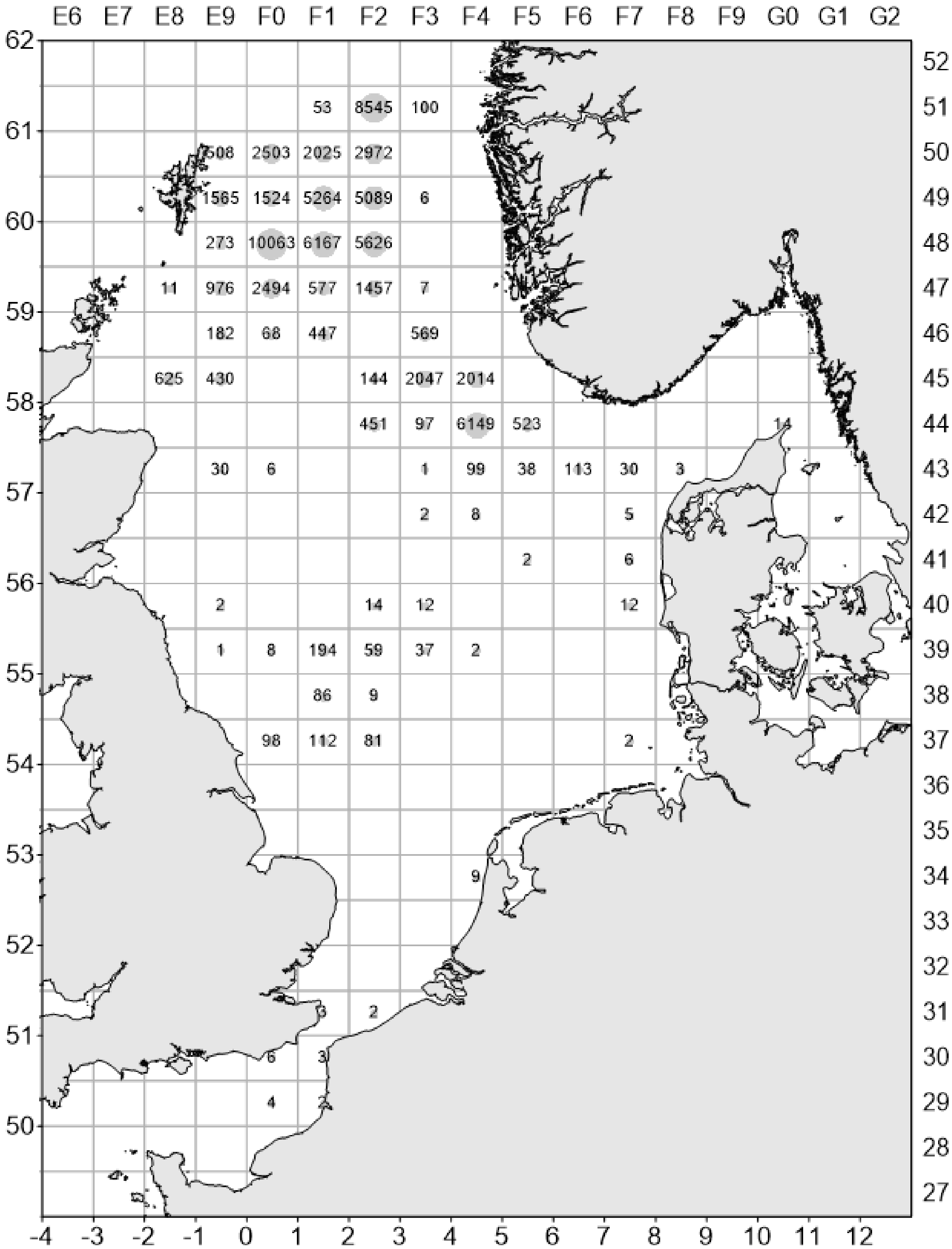


Figure 2.1.1b. Herring catches in the North Sea in the second quarter of 2019 (in tonnes) by statistical rectangle.

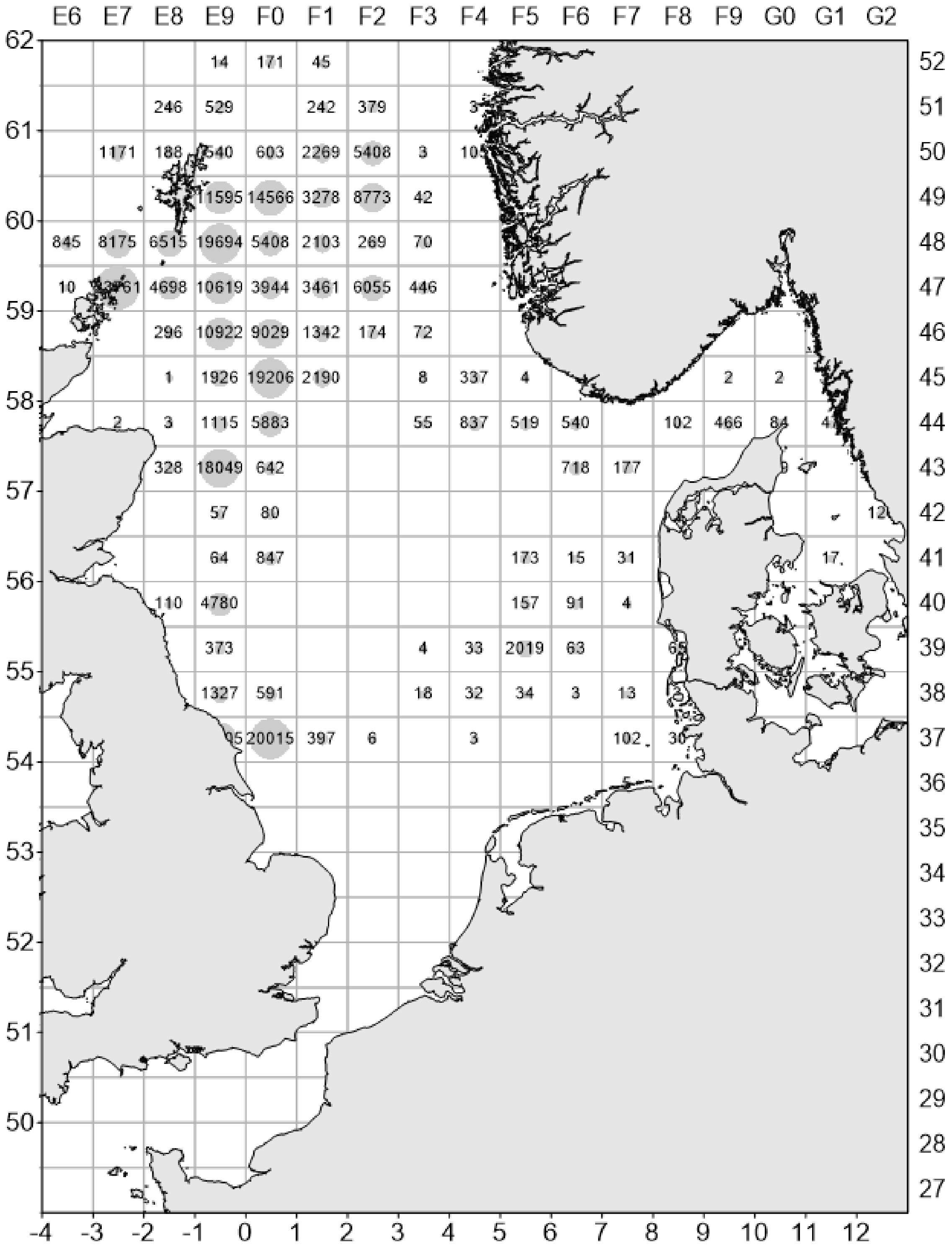


Figure 2.1.1c. Herring catches in the North Sea in the 3rd quarter of 2019 (in tonnes) by statistical rectangle.

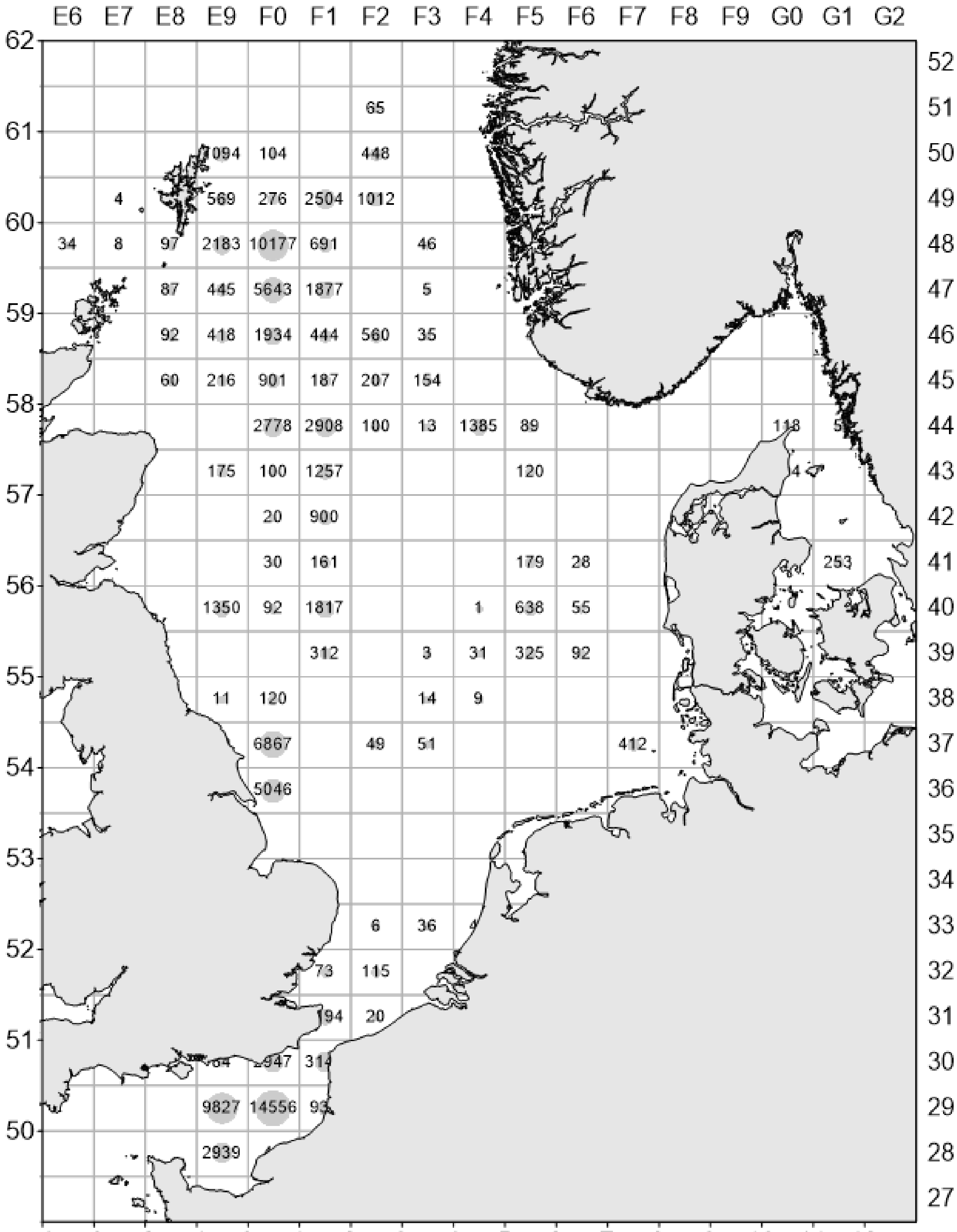


Figure 2.1.1d. Herring catches in the North Sea in the 4th quarter of 2019 (in tonnes) by statistical rectangle.

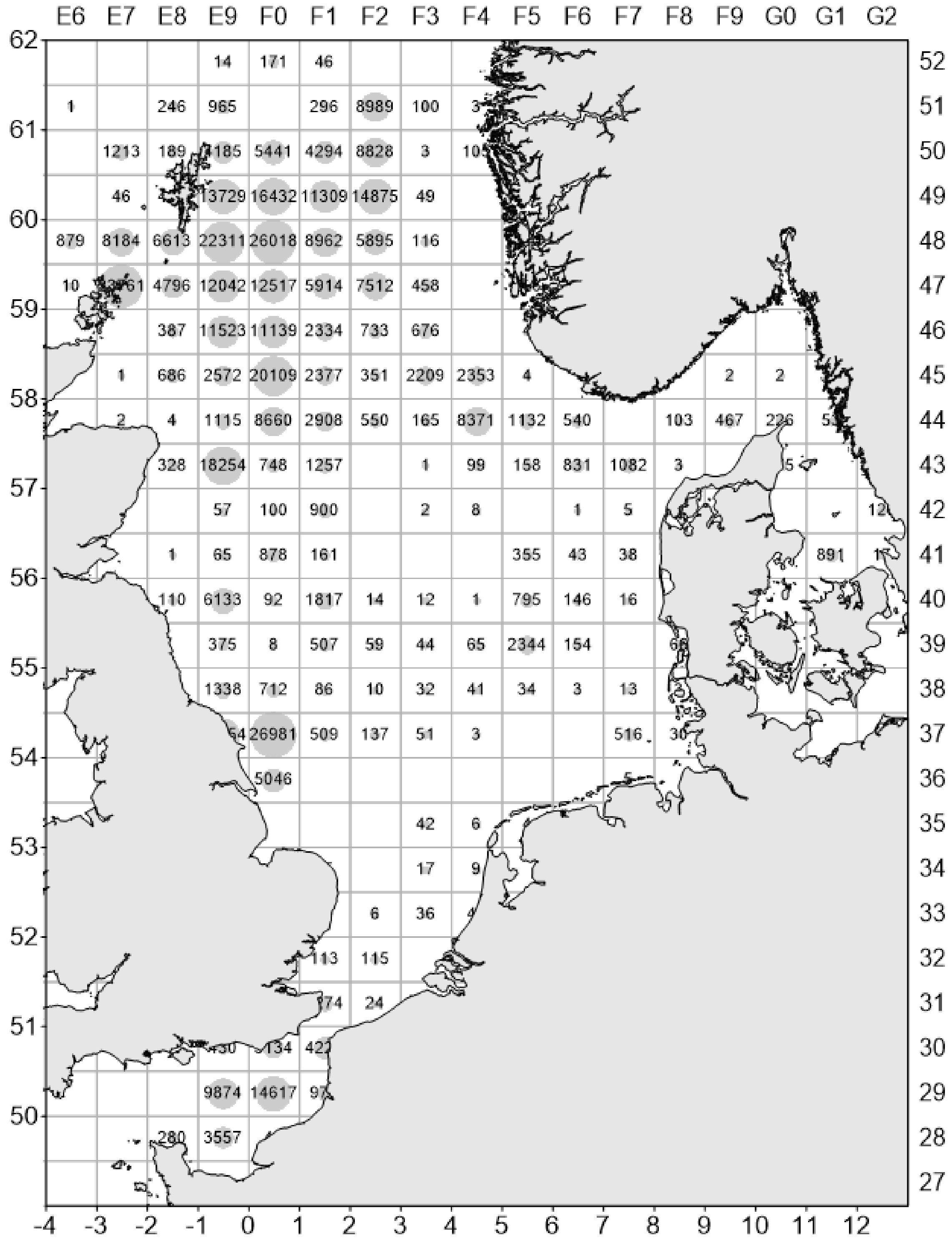


Figure 2.1.1e. Herring catches in the North Sea in all quarters of 2019 (in tonnes) by statistical rectangle.

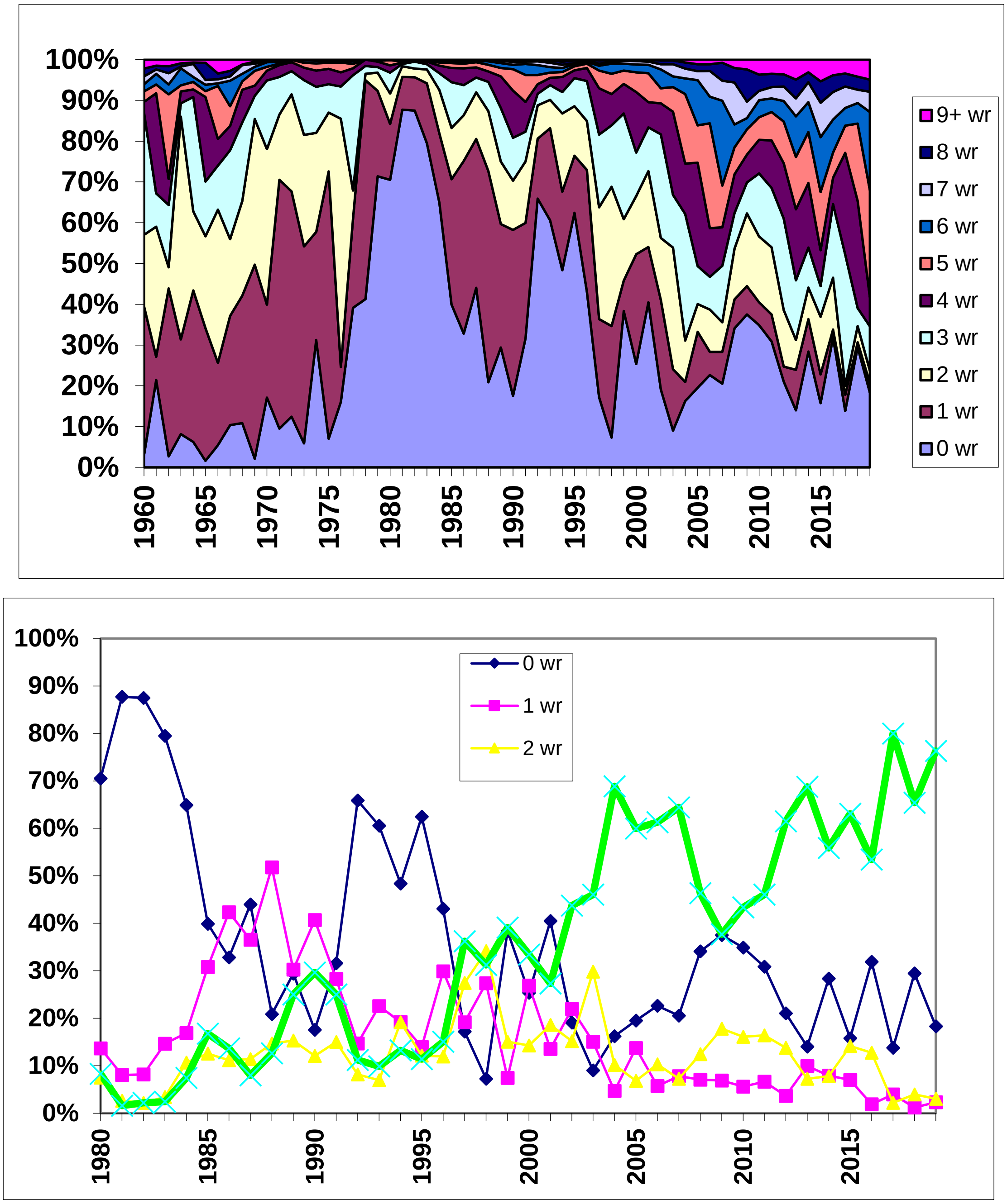


Figure 2.2.1. Proportions of age groups (numbers) in the total catch of herring caught in the North Sea (upper, 1960–2019, and lower panel, 1980–2019).

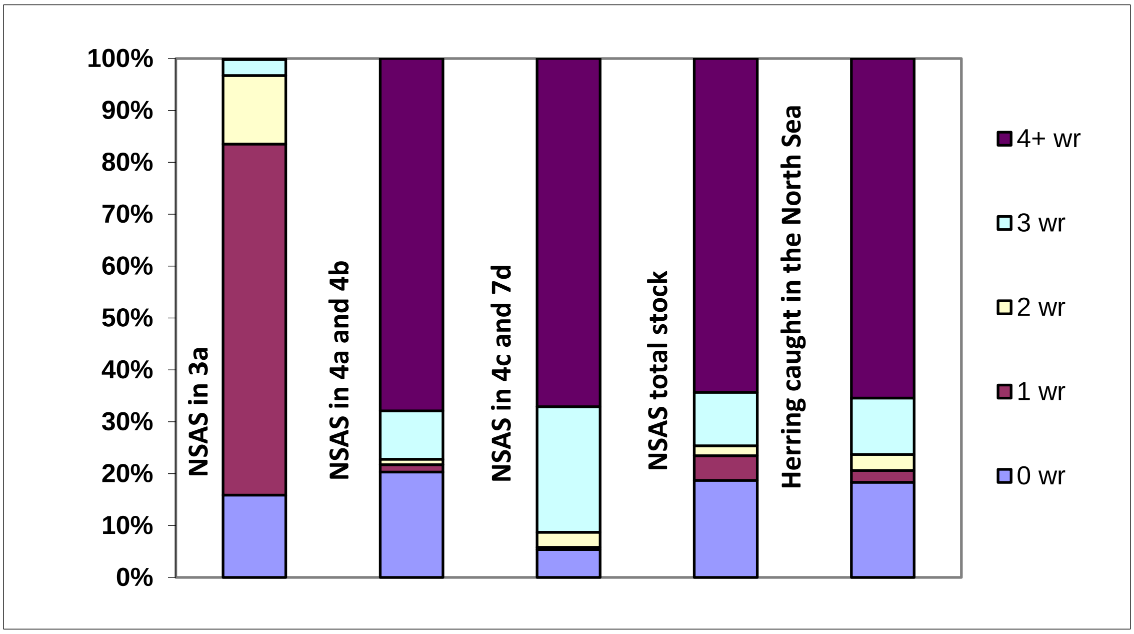


Figure 2.2.2. Proportion of age groups (numbers) in the total catch of NSAS and herring caught in the North Sea in 2019.

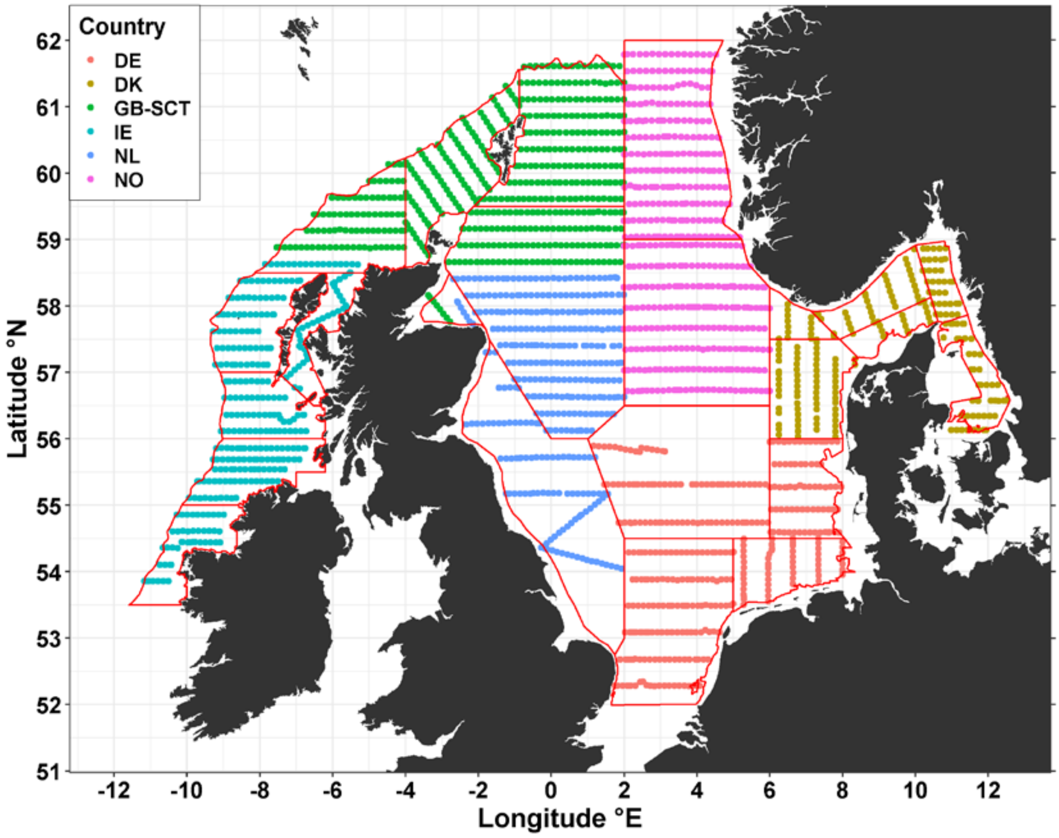


Figure 2.3.1.1. Cruise tracks and survey area coverage in the HERAS acoustic surveys in 2019 by nation.

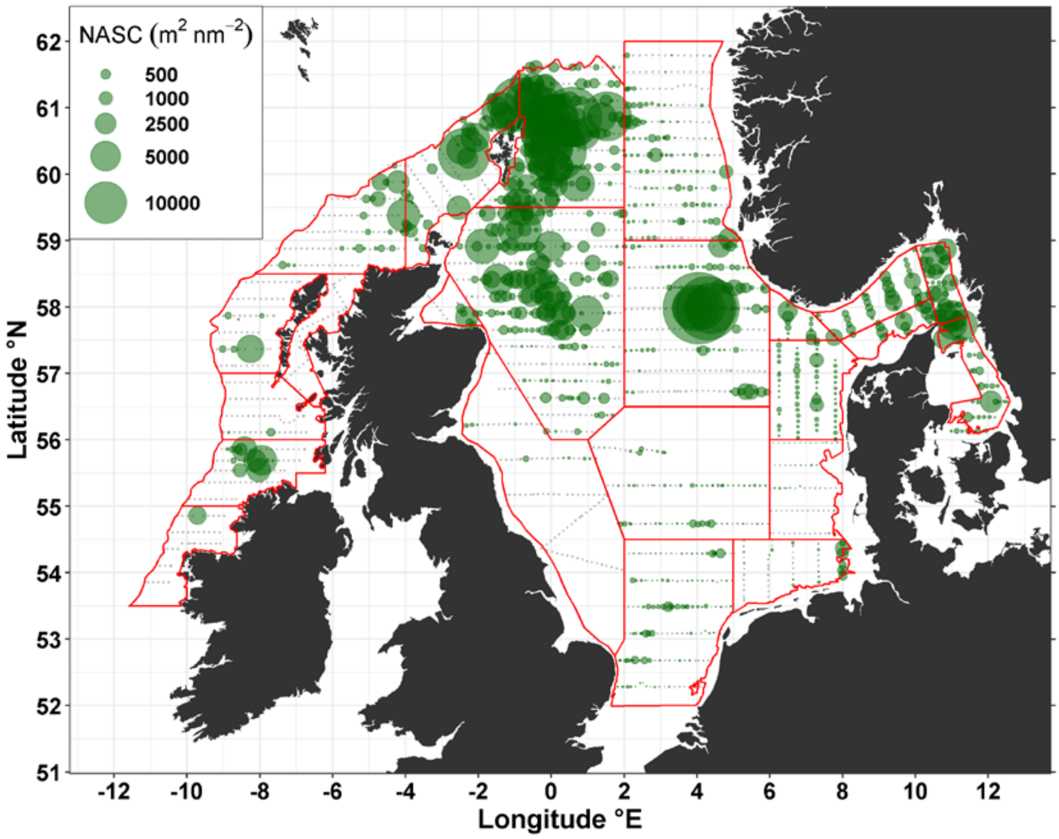


Figure 2.3.1.2. Distribution of NASC attributed to herring in HERAS in 2019. Acoustic intervals represented by light grey dot with green circles representing size and location of herring aggregations. NASC values are resampled at 5 nmi intervals along the cruise track. The red lines show the strata system.

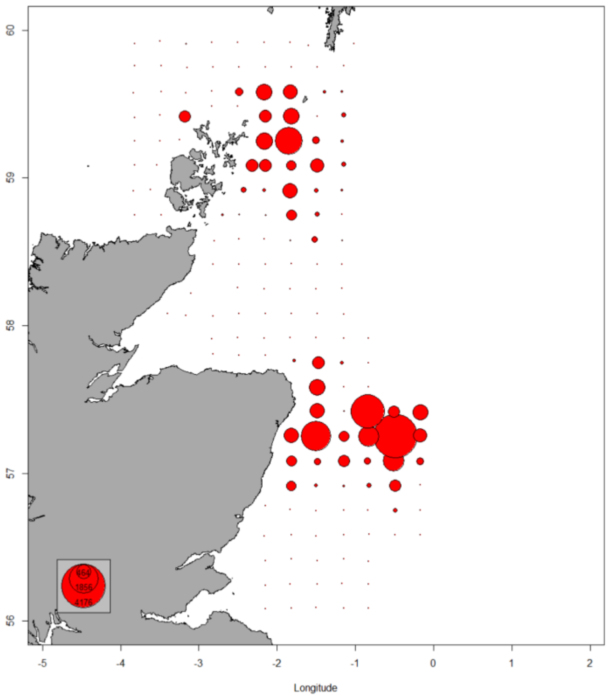


Figure 2.3.2.1. North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Orkney/Shetlands and Buchan area, first half of September 2019 (maximum circle size = 4176 n/m²).

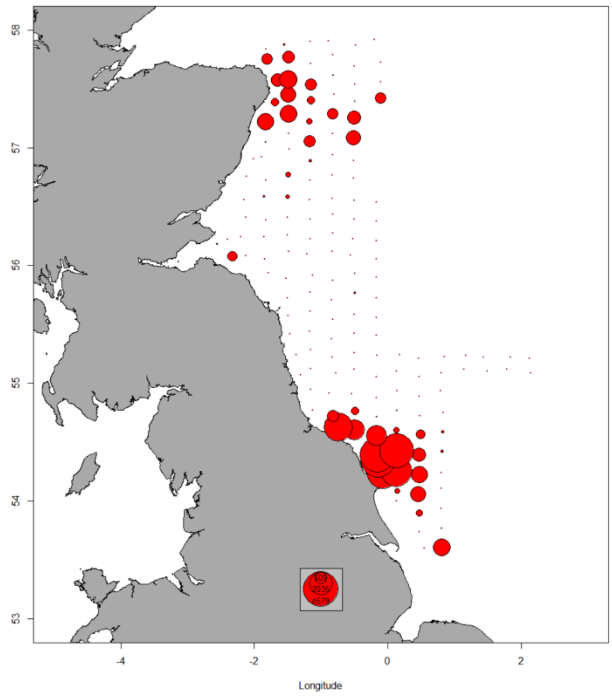


Figure 2.3.2.2: North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Buchan and central North Sea area, second half of September 2019 (maximum circle size = 4579 n/m²).

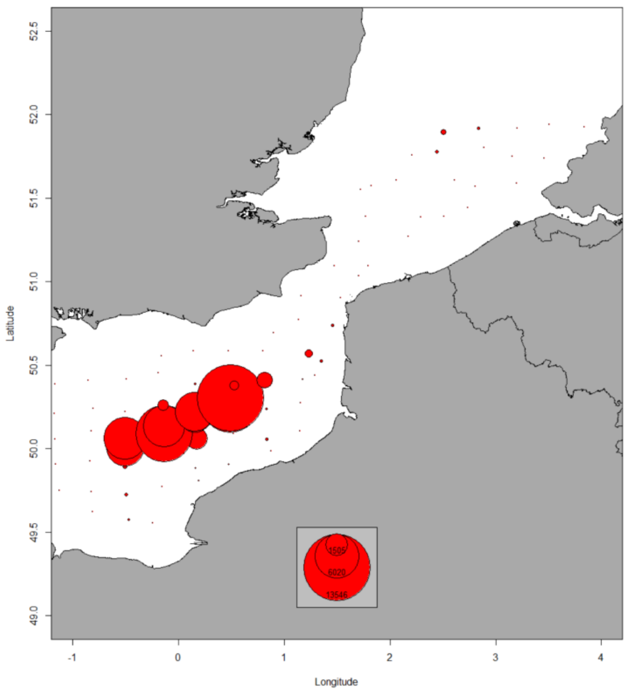


Figure 2.3.2.3. North Sea herring - Abundance of larvae <11 mm (n/m²) in the Southern North Sea and English Channel, second half of December 2019 (maximum circle size = 13 546 n/m²).

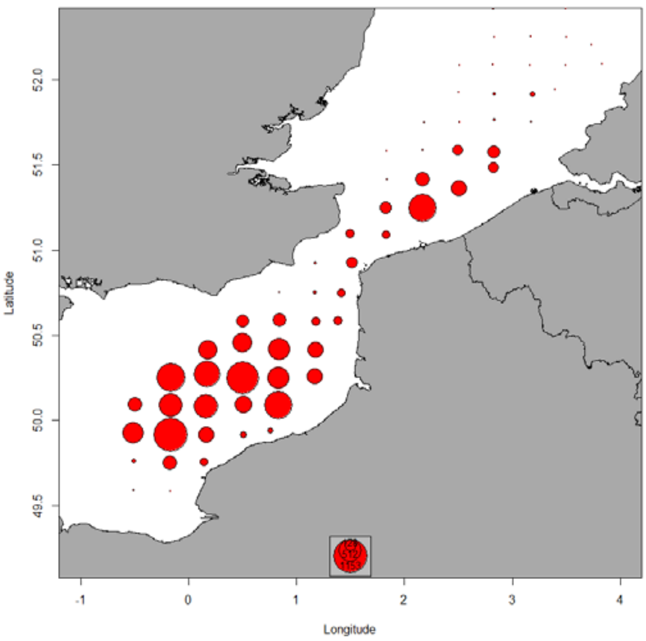


Figure 2.3.2.3. North Sea herring - Abundance of larvae <11 mm (n/m²) in the Southern North Sea and English Channel, first half of January 2020 (maximum circle size = 1153 n/m²).

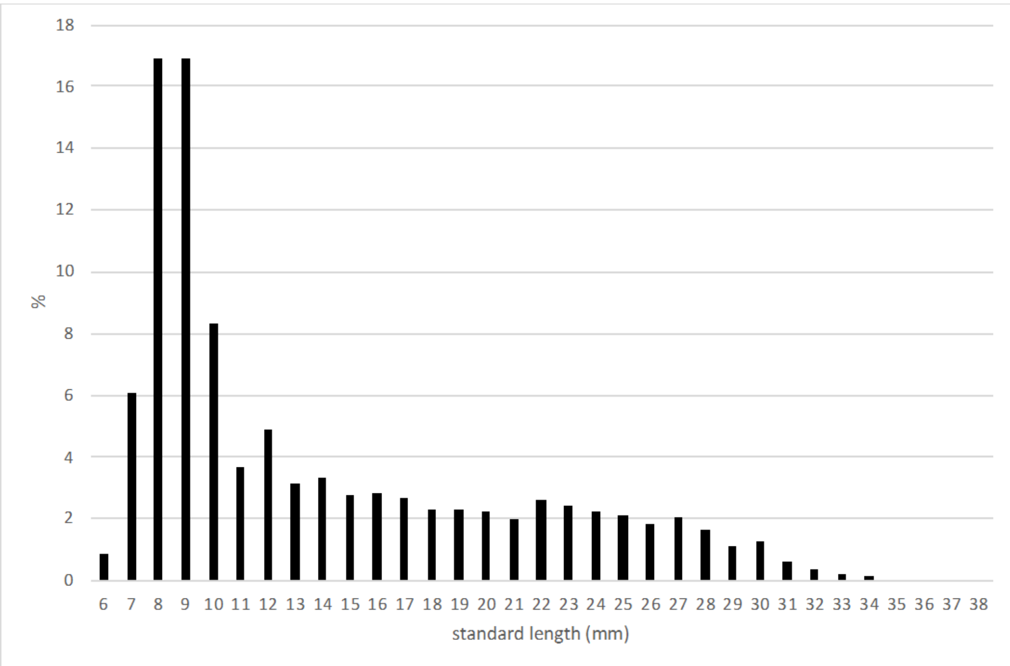


Figure 2.3.3.1. North Sea herring. Length distribution of all herring larvae caught during the 2020 Q1 IBTS.

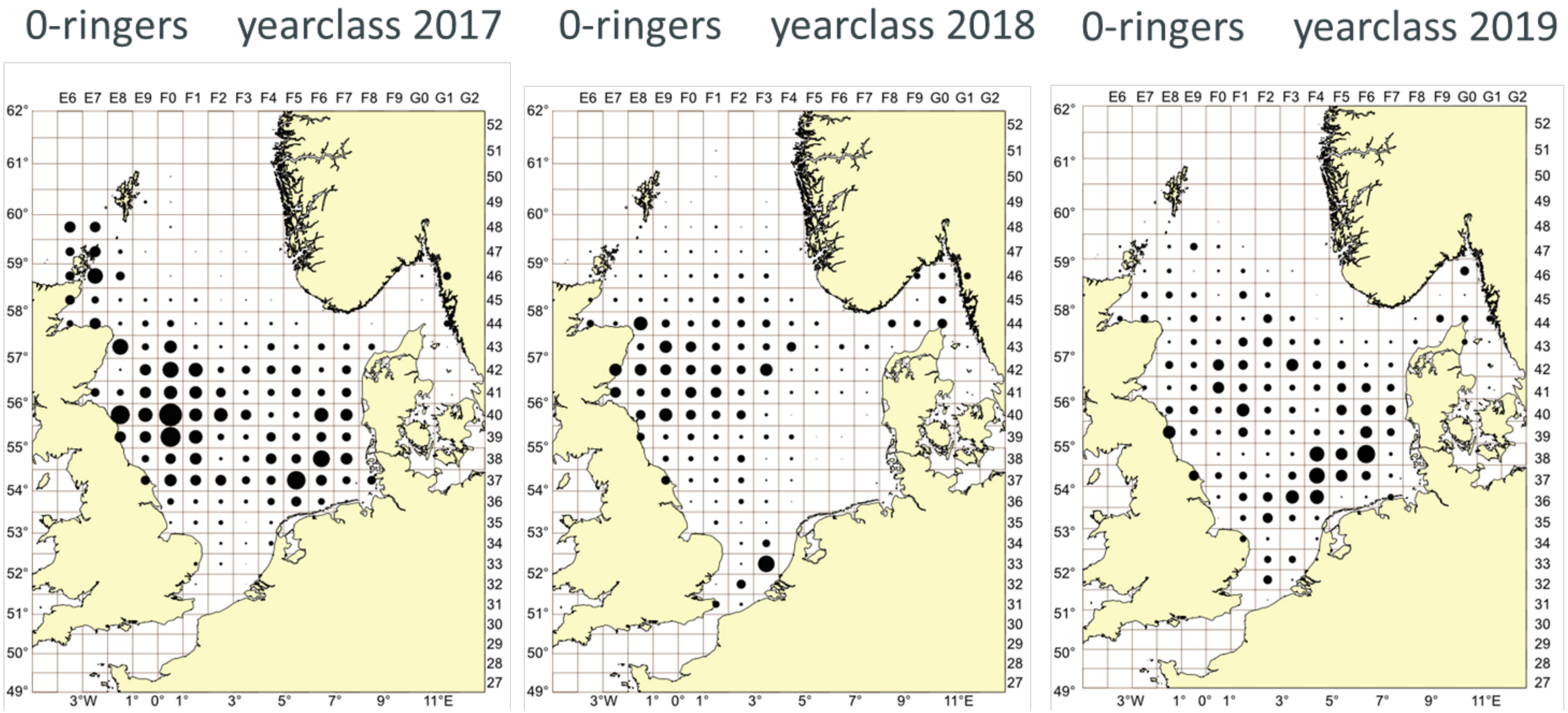


Figure 2.3.3.2. North Sea herring. Distribution of 0-ringer herring, year classes 2017–2019. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in January/February 2018–2020. Areas of filled circles illustrate densities in no m^{-2}, the area of the 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.

1-ringers yearclass 2016 1-ringers yearclass 2017 1-ringers yearclass 2018

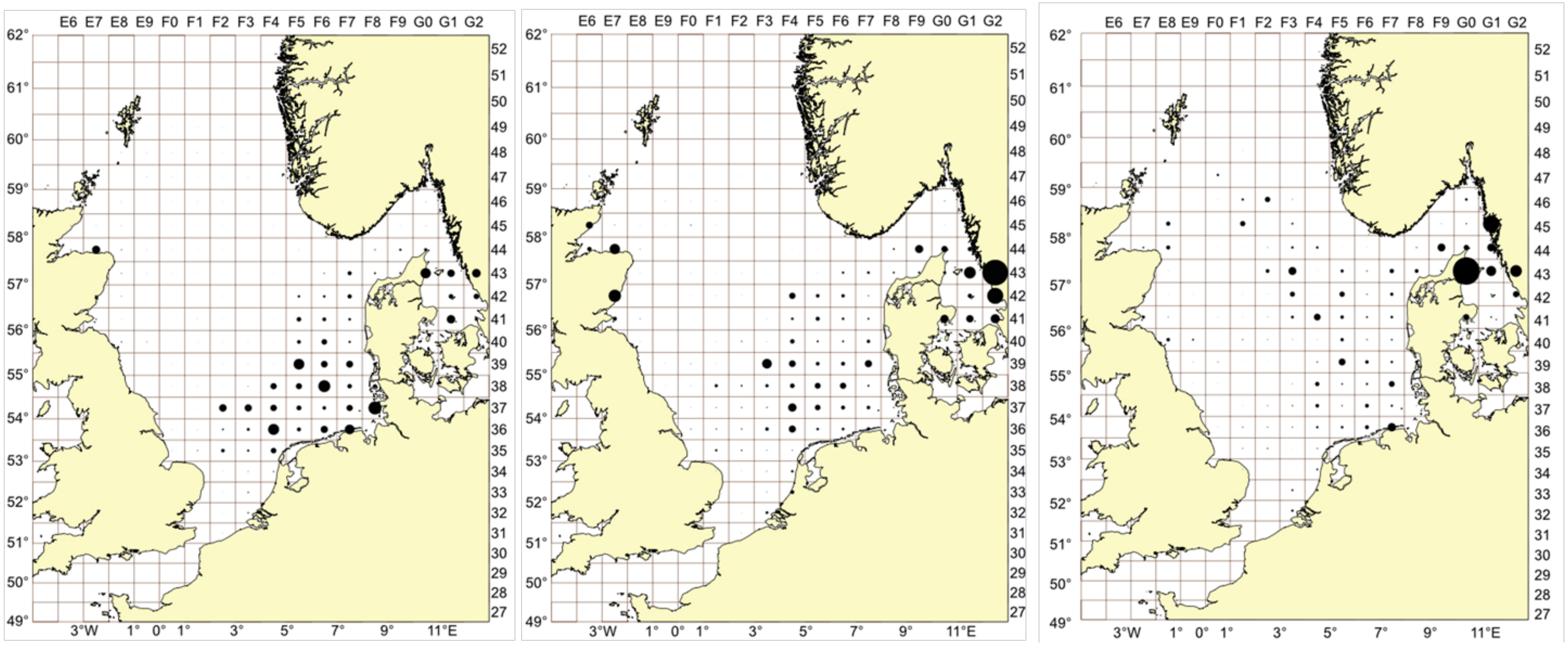


Figure 2.3.3.3. North Sea herring. Distribution of 1-ringer herring, year classes 2016–2018. Density estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in January/February 2018–2020. Areas of filled circles illustrate numbers per hour, scaled proportionally 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}.

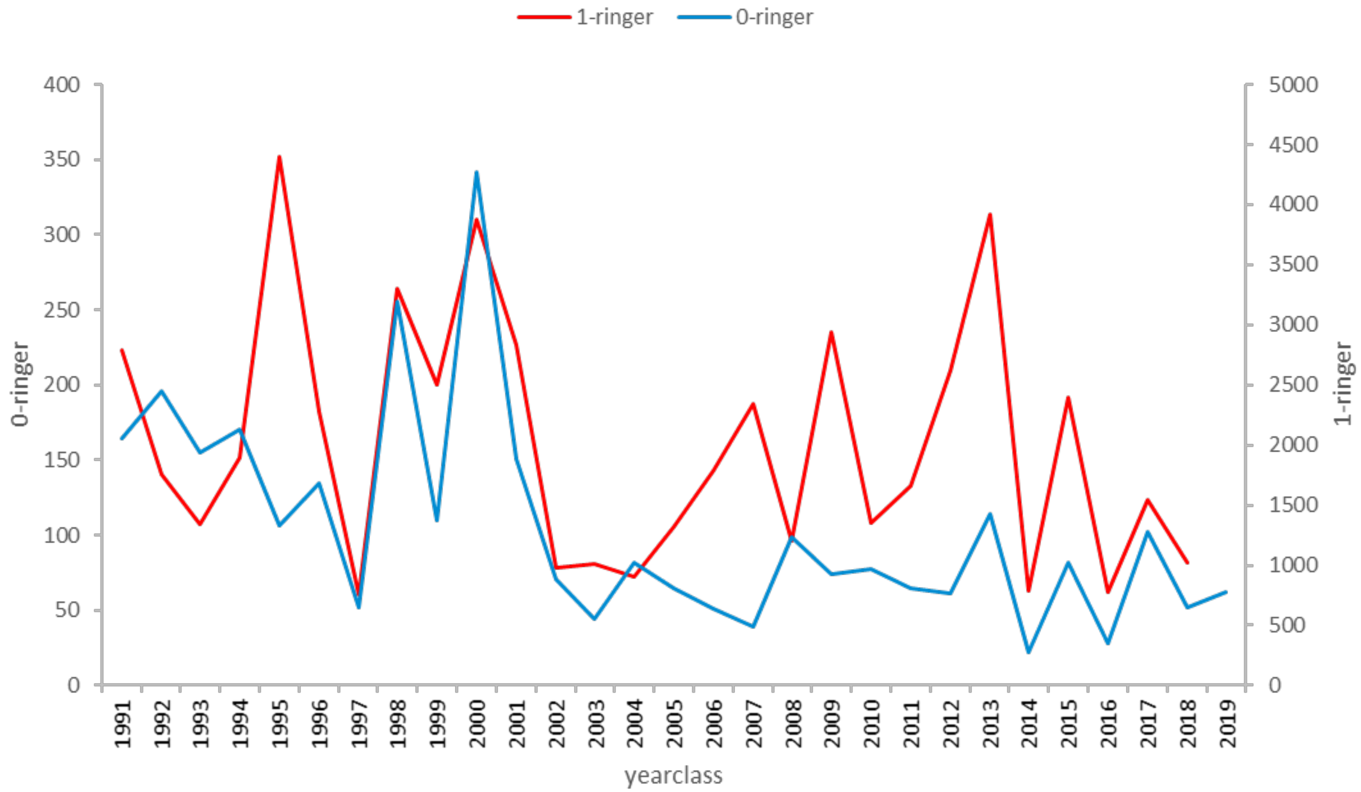
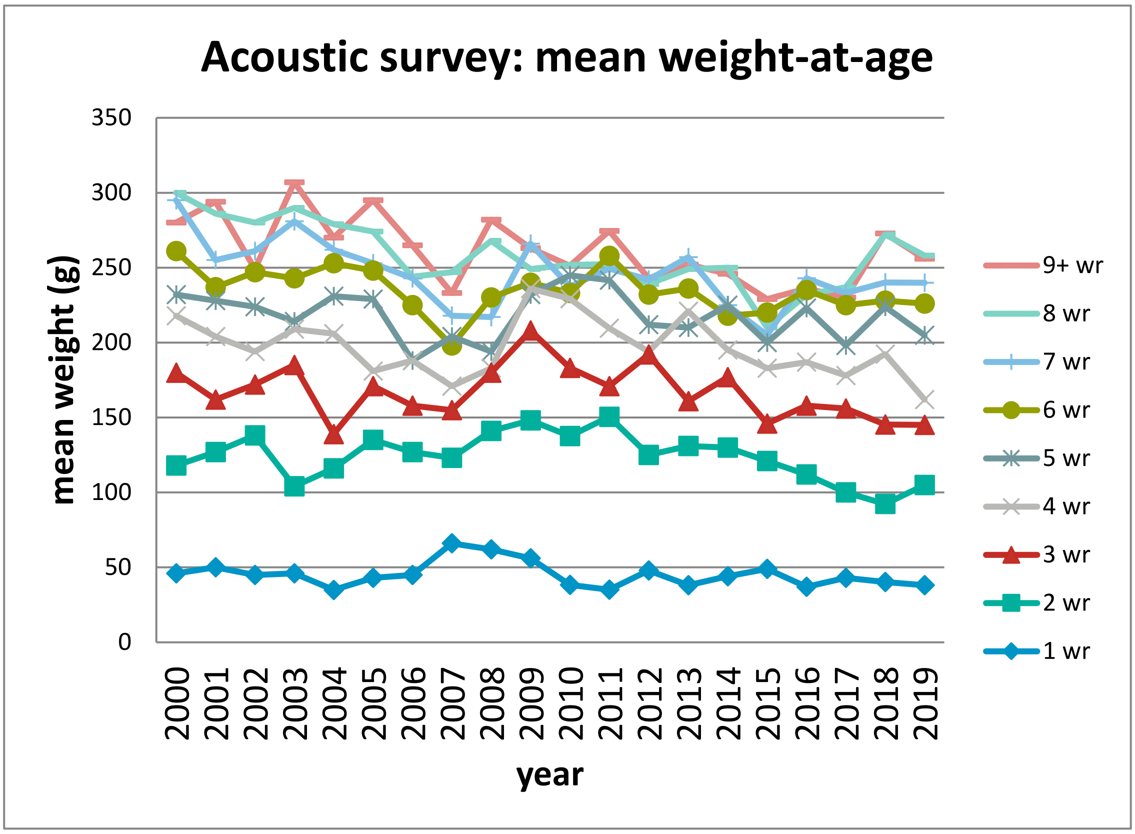


Figure 2.3.3.4. North Sea herring. Time-series of 0-ringer, and 1-ringer indices (red). Year classes 1991 to 2019 for 0-ringers, year classes 1991–2018 for 1-ringers. The new 0-ringer index only covers the 1991–2019 year classes


Acoustic survey: mean weight-at-age
mean weight (g)
350
300
250
200
150
100
50
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
year
9+ wr
8 wr
7 wr
6 wr
5 wr
4 wr
3 wr
2 wr
1 wr

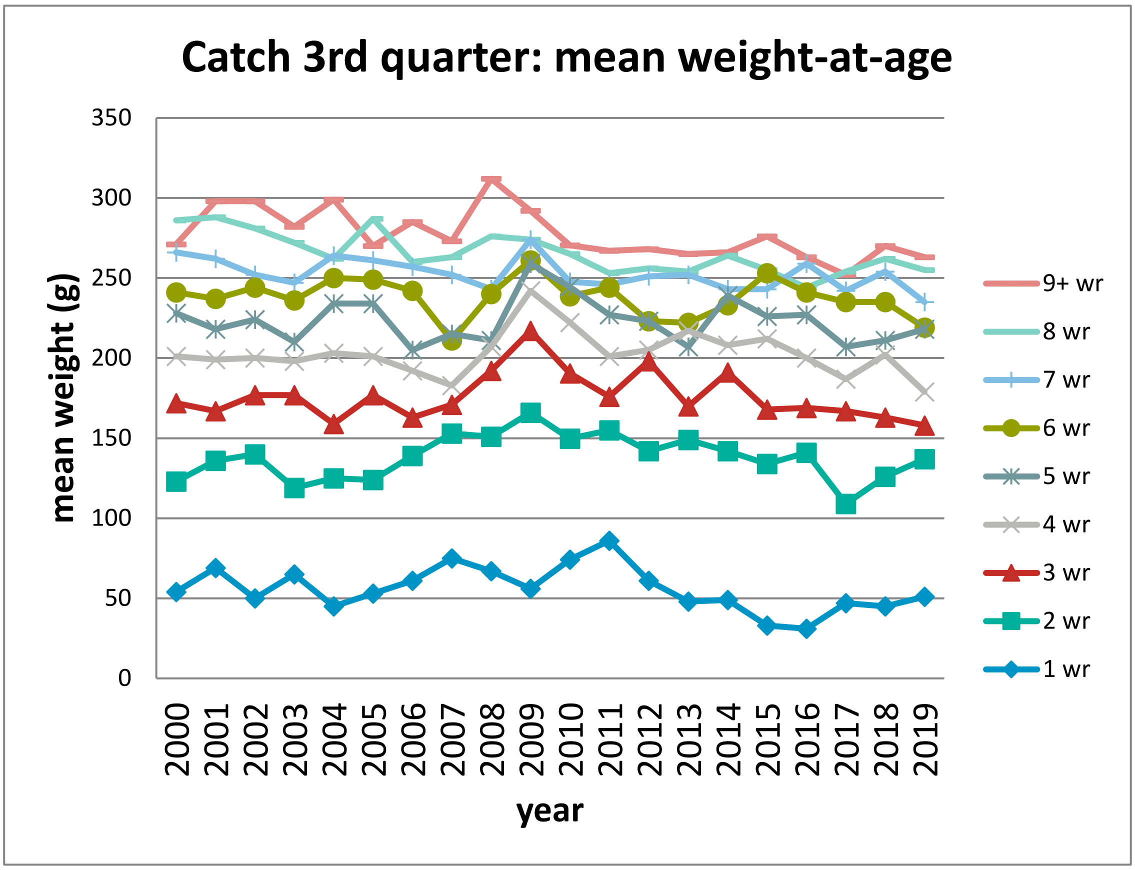

Catch 3rd quarter: mean weight-at-age
mean weight (g)
350
300
250
200
150
100
50
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
year
9+ wr
8 wr
7 wr
6 wr
5 wr
4 wr
3 wr
2 wr
1 wr

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.

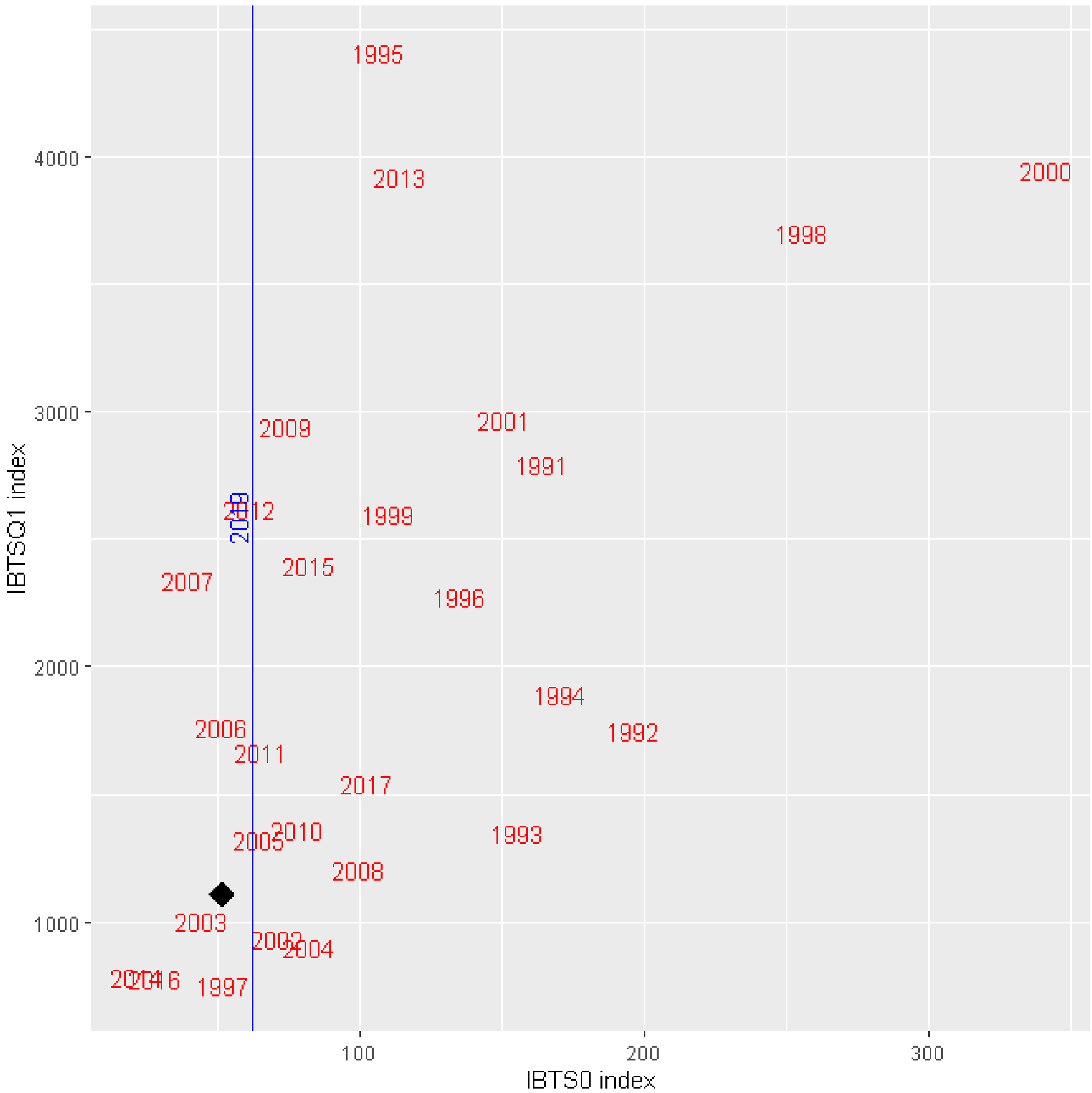


Figure 2.5.1.1 North Sea herring. Relationship between indices of 0-ringers (IBTS0) and 1-ringers (IBTS-Q1 age 1) for year classes 1991 to 2019. The diamond marker is the data point for 2018. The solid blue vertical line is where the 2019 data point will fall.

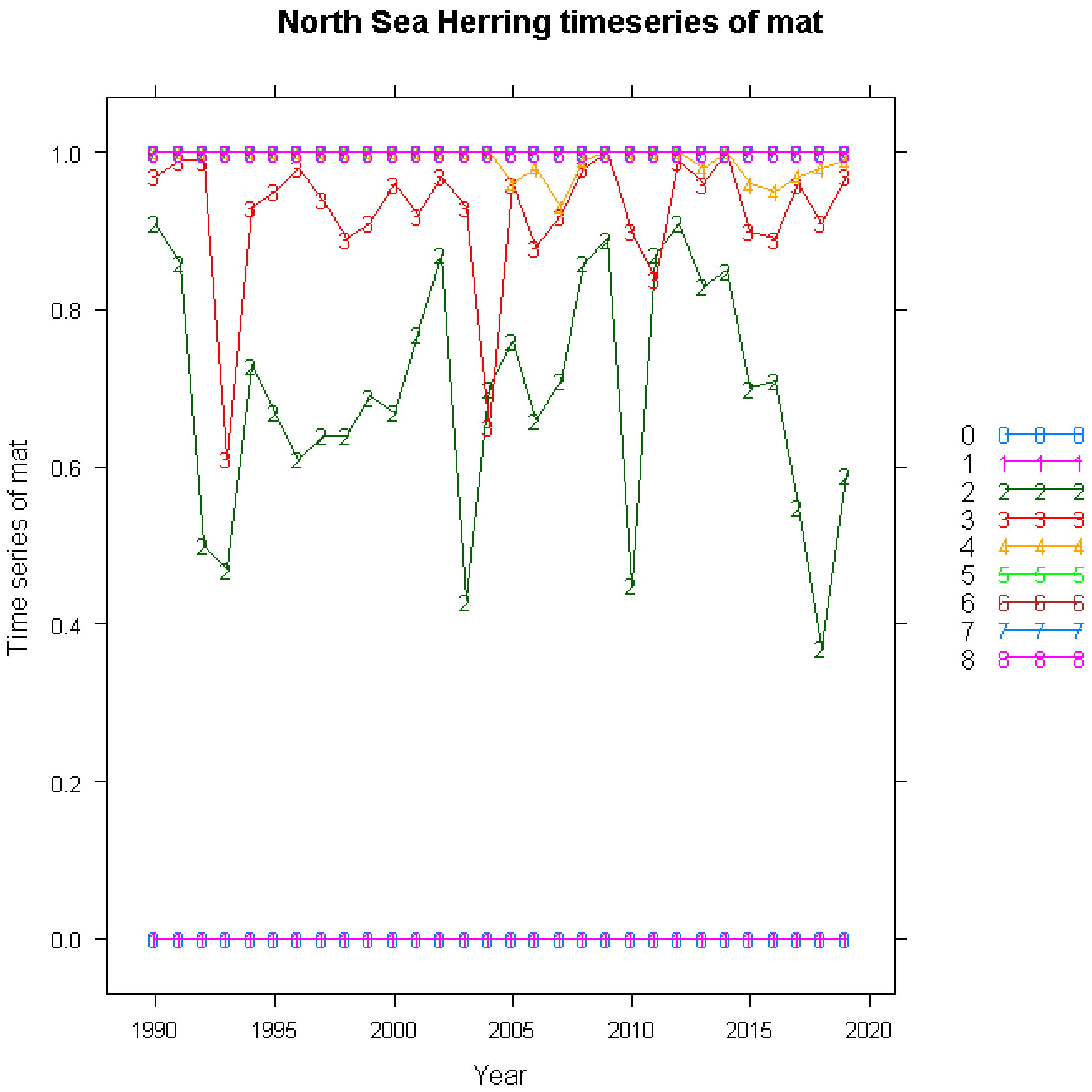


Figure 2.6.1.1. North Sea Herring. Time-series of proportion mature at ages 0 to 8+ as used in the North Sea herring assessment.

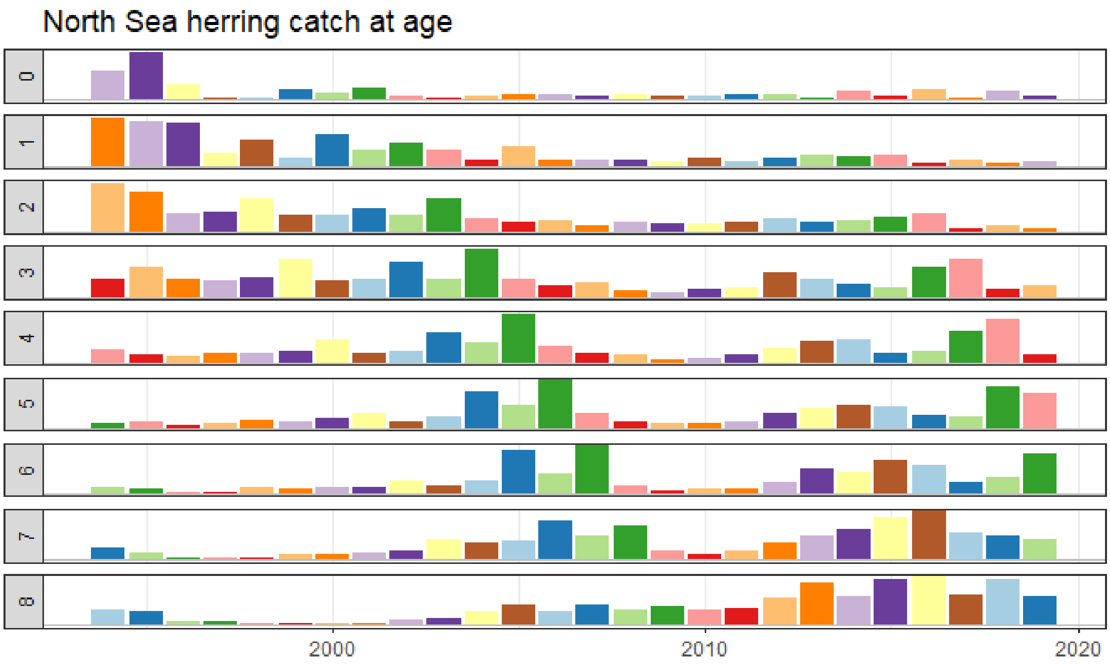


Figure 2.6.1.2. North Sea Herring. Time-series of catch-at-age proportion at ages 0–8+ as used in the North Sea herring assessment. Colours indicate year-classes. All ages are scaled independently and therefore the size of the bars can only be compared within an age.

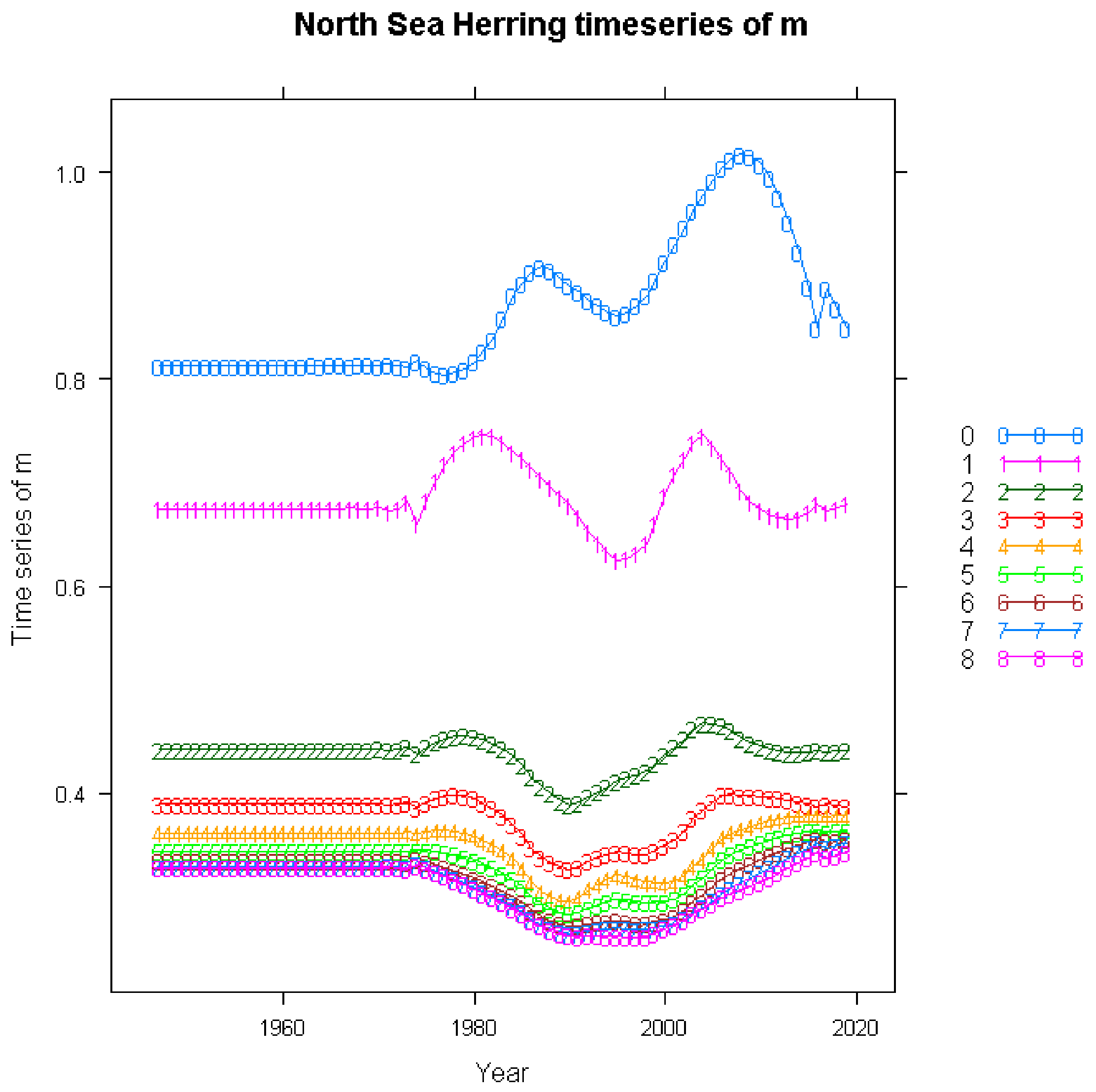


Figure 2.6.1.3. North Sea Herring. Time-series of absolute natural mortality values at age 0–8+ as used in the North Sea herring assessment. Natural mortality values are based on the 2017 North Sea key-run (ICES WGSAM, 2018).

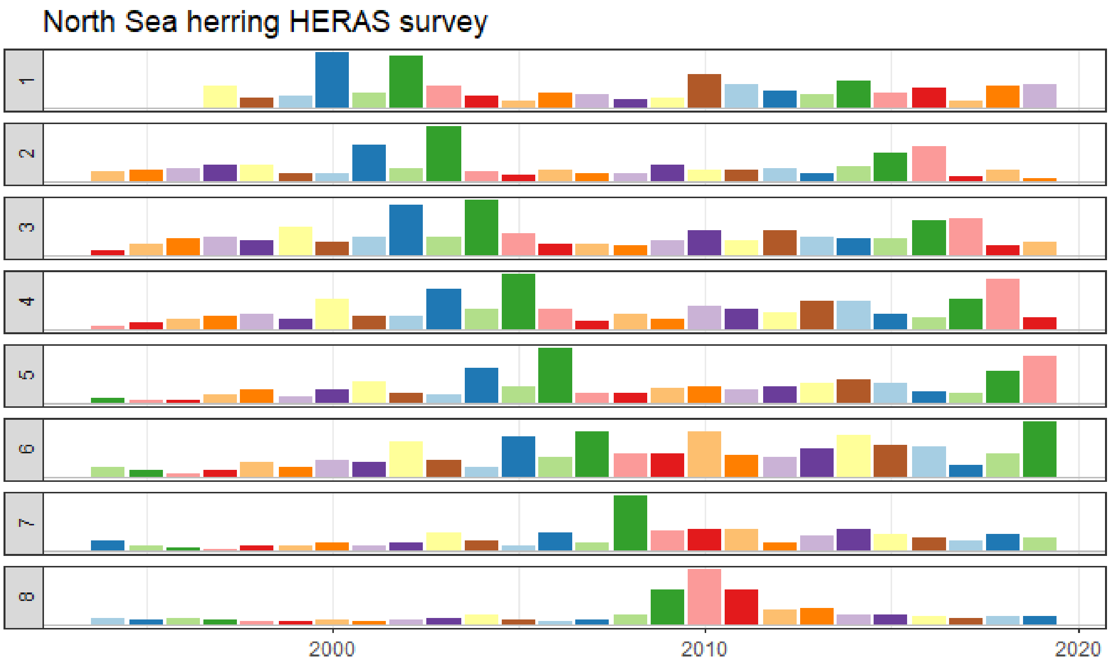


Figure 2.6.1.4. North Sea Herring. Time-series of the HERAS acoustic index by age 1–8+. Colours indicate year classes. All ages are scaled independently and cannot be compared between ages.

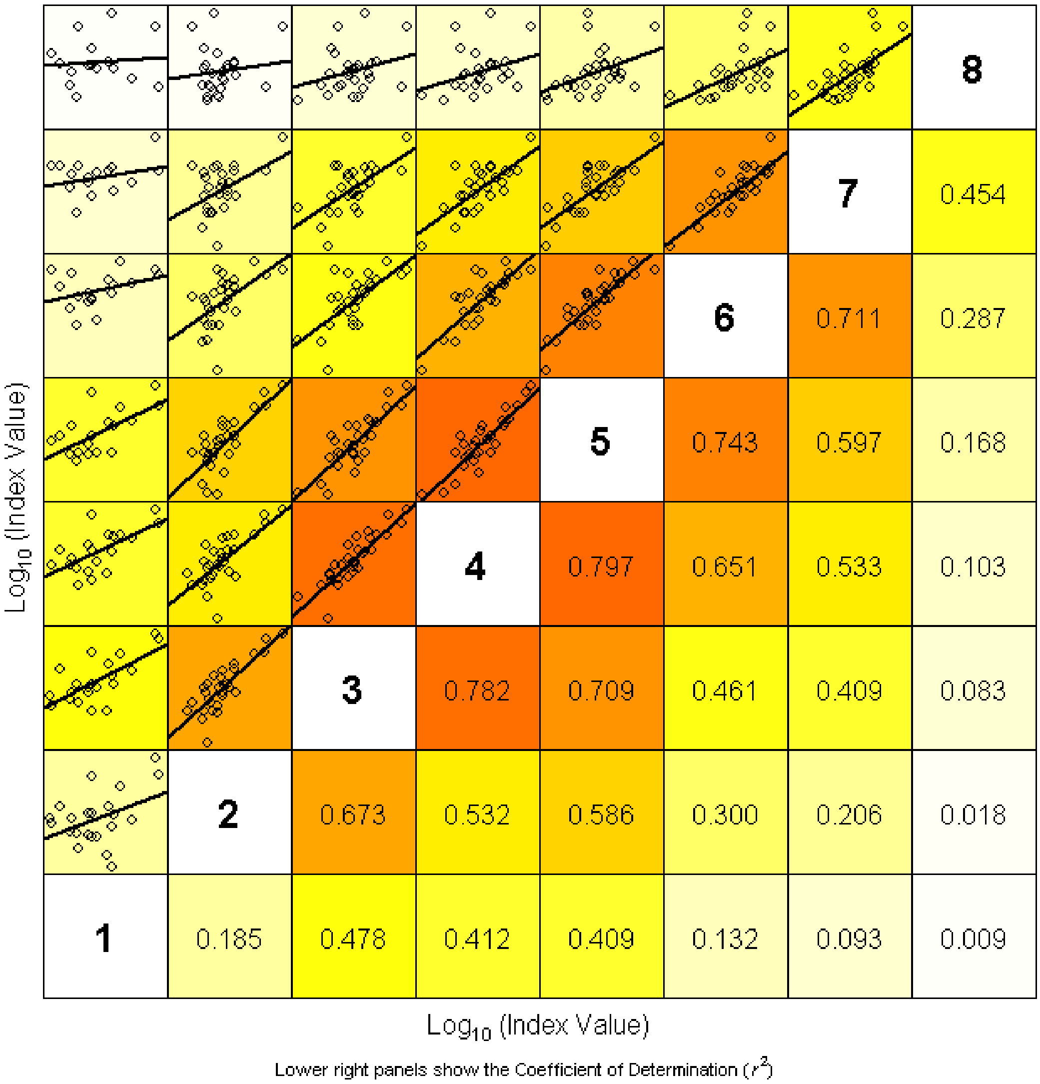


Figure 2.6.1.5. North Sea herring. Internal consistency plot of the acoustic survey (HERAS). Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r^2 value that is associated with the linear regression is given.

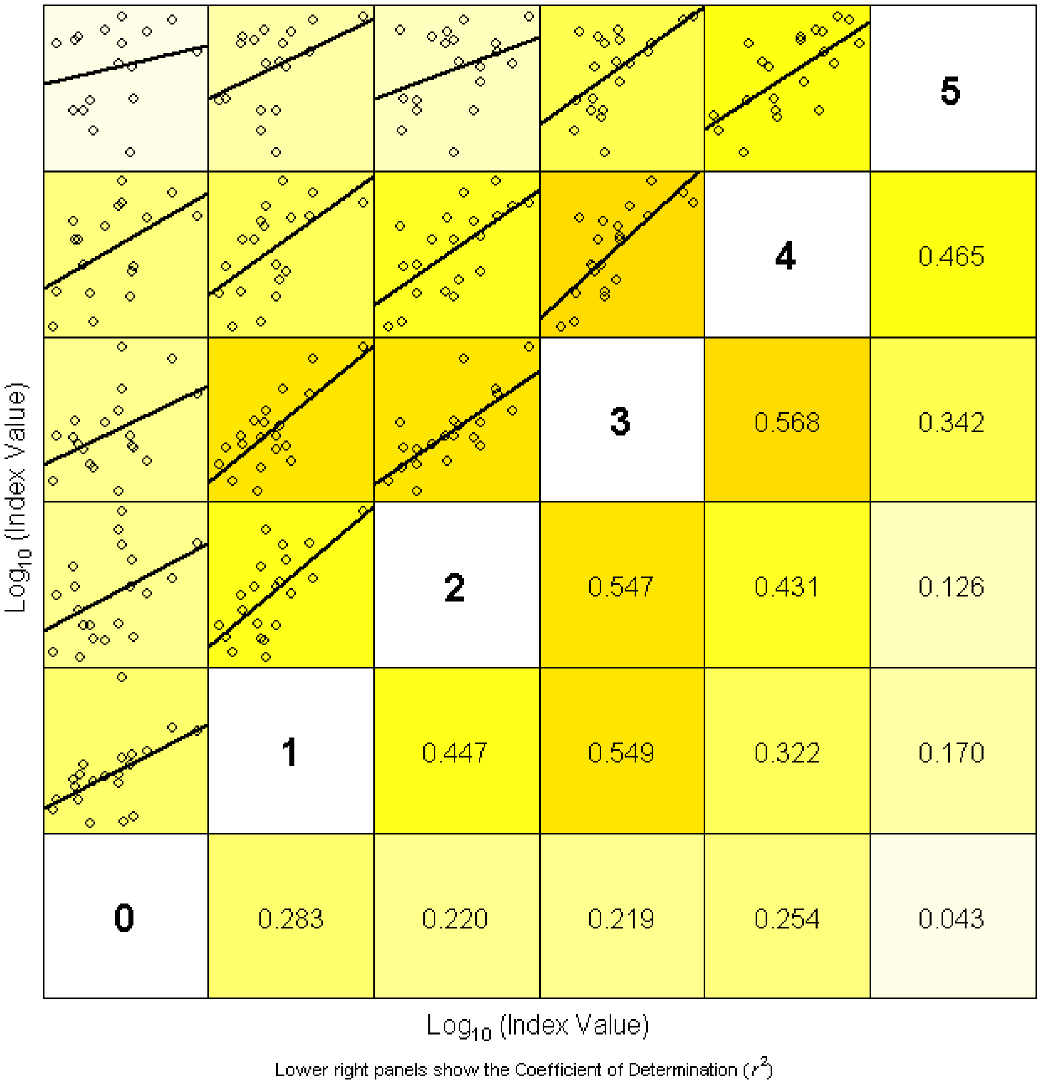


Figure 2.6.1.6. North Sea herring. Internal consistency plot of the IBTS in quarter 3. Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r² value that is associated with the linear regression is given.

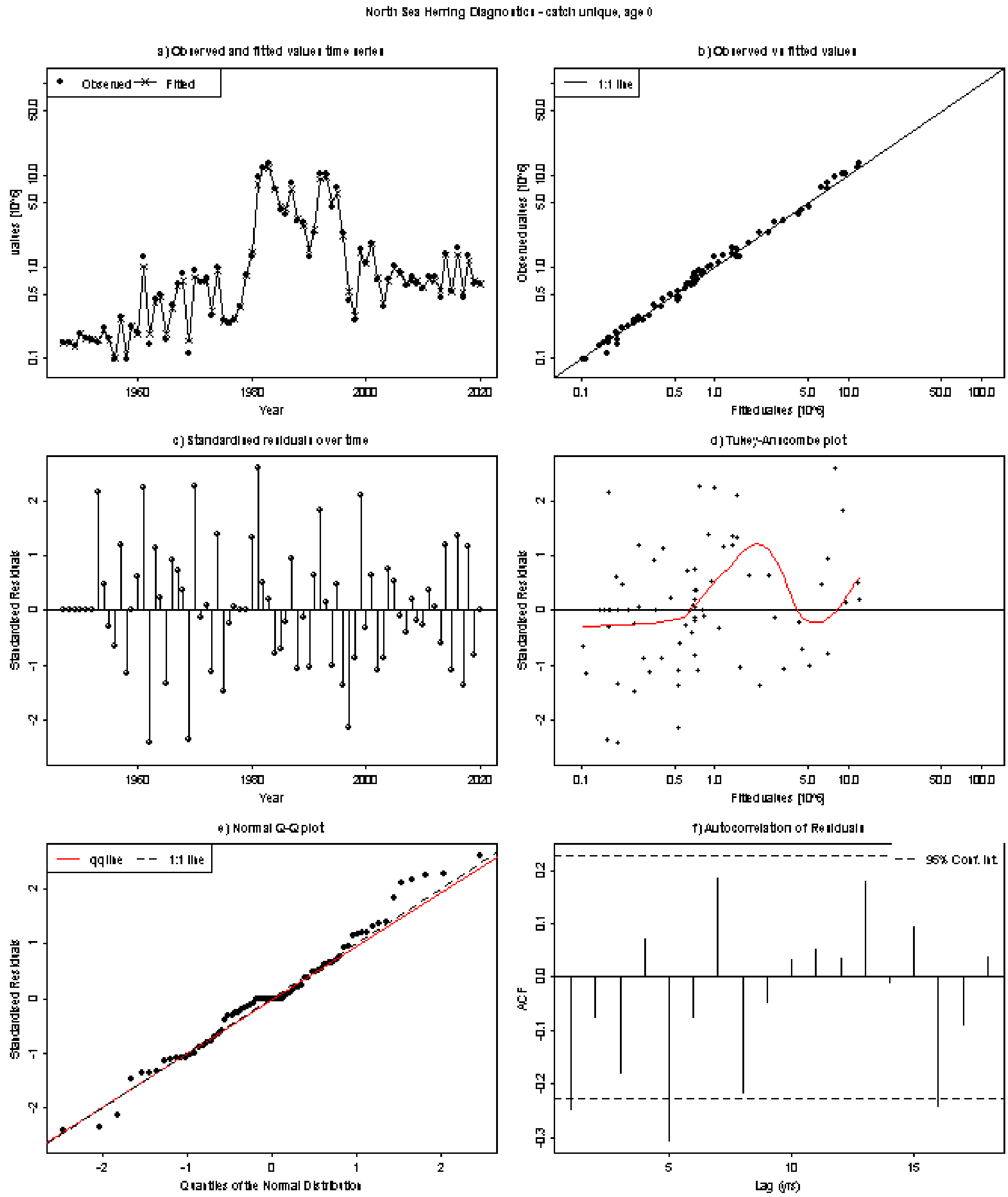
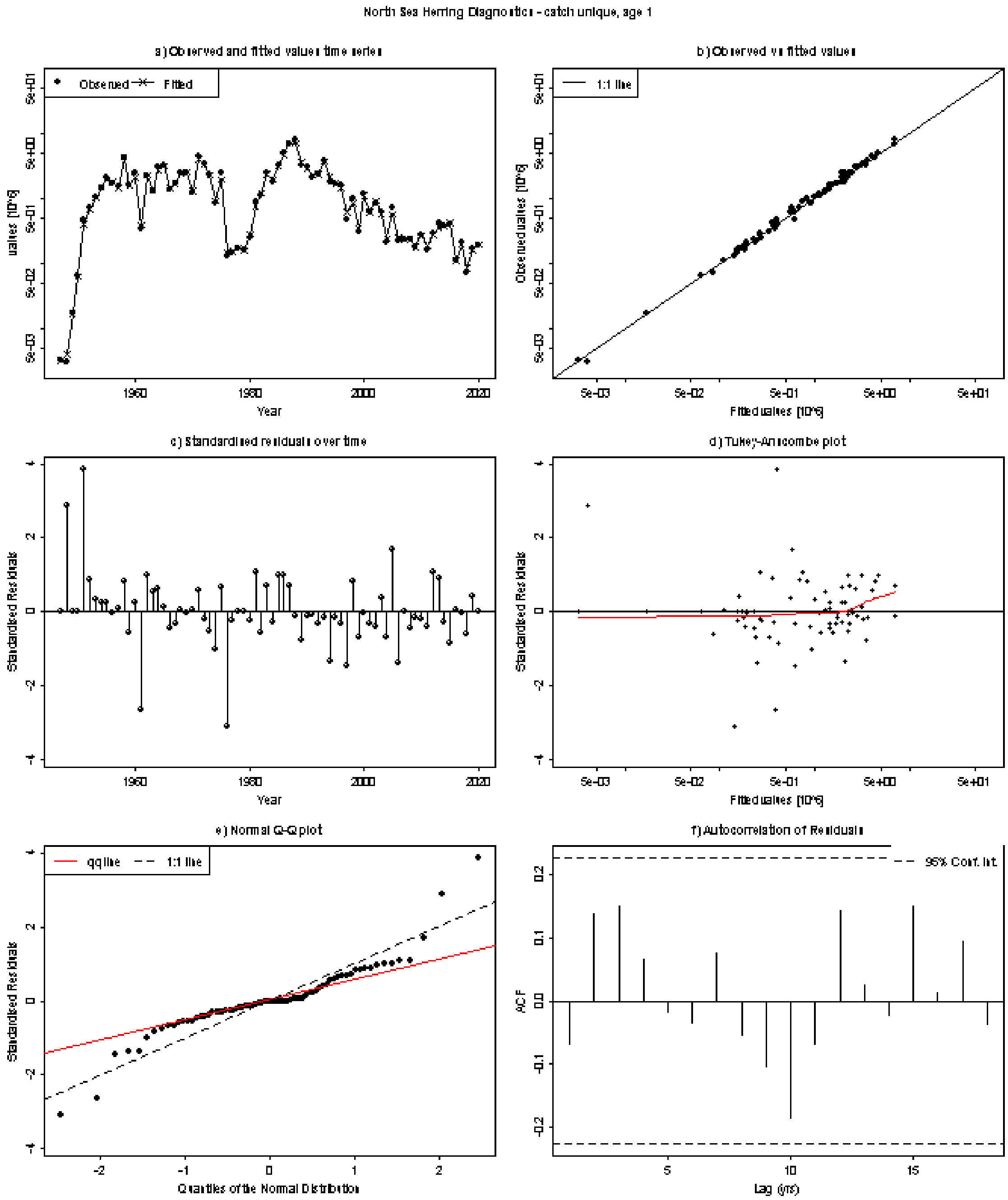


Figure 2.6.1.7 North Sea herring. Diagnostics of the assessment model fit to the catch-at-age 0 time-series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from catch abundance at 0 wr. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: catch observation vs. 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.


North Sea Herring Diagnostics - catch unique, age 1
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

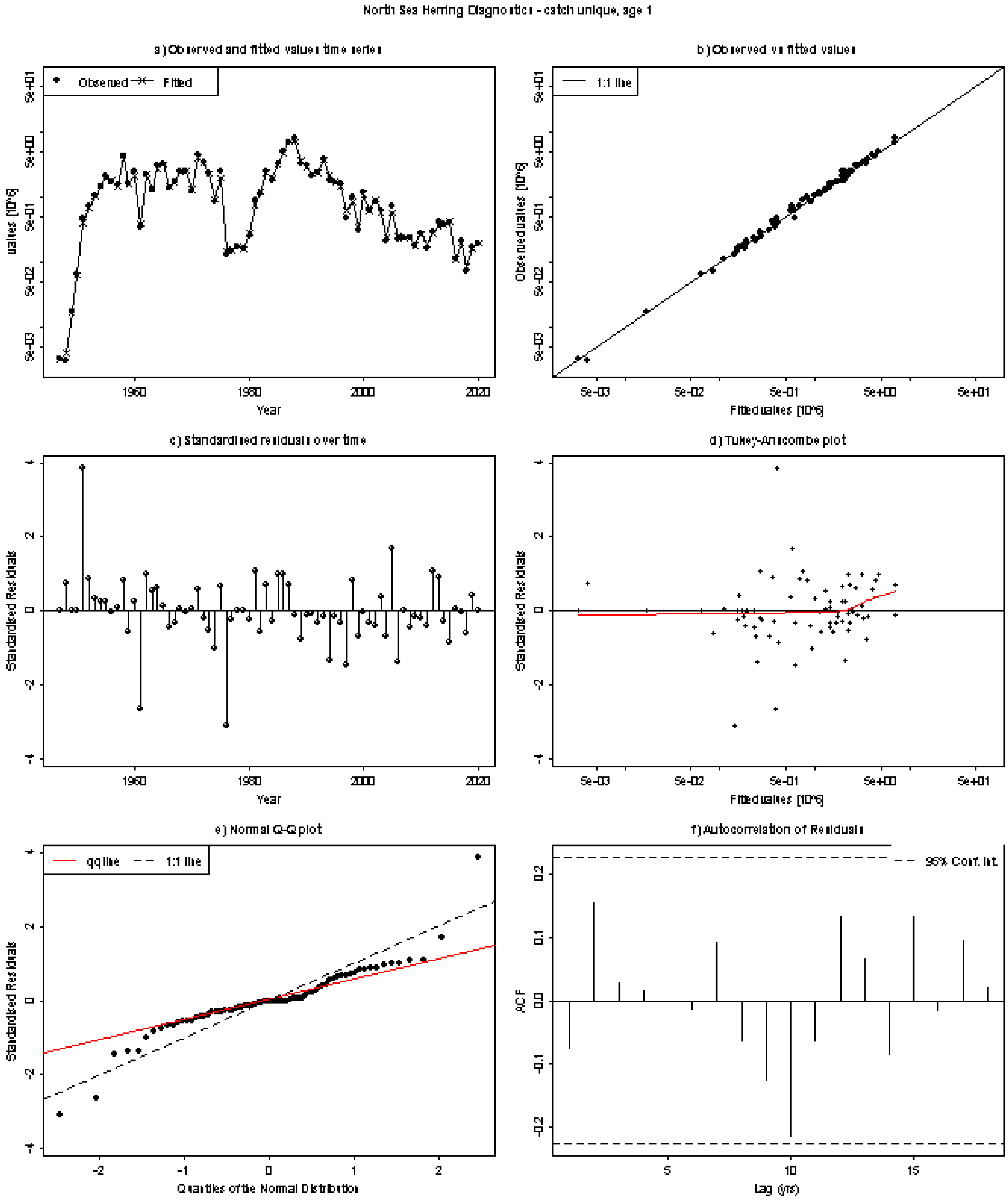
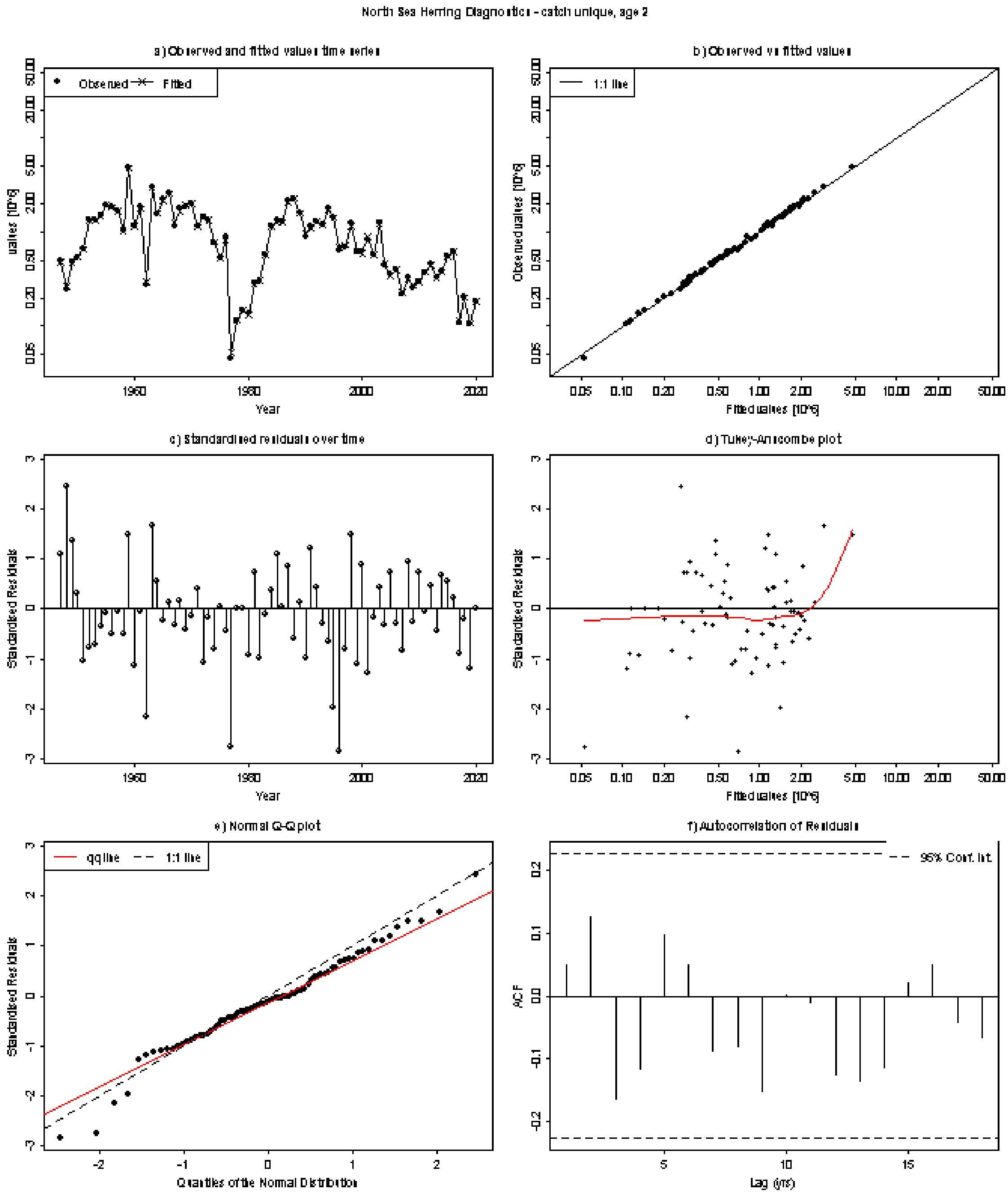


Figure 2.6.1.8. North Sea herring. Diagnostics of the assessment model fit to the catch-at-age 1 time-series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from catch abundance at 1 wr. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: catch observation vs. 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.


North Sea Herring Diagnostics - catch unique, age 2
a) Observed and fitted values time series
b) Observed vs fitted values
c) Standardised residuals over time
d) Tukey-Anscombe plot
e) Normal Q-Q plot
f) Autocorrelation of Residuals
Observed
Fitted
1:1 line
qq line
95% Conf. Int.
values [10^6]
Observed values [10^6]
Fitted values [10^6]
Year
Standardised Residuals
Quantiles of the Normal Distribution
ACF
Lag (yrs)

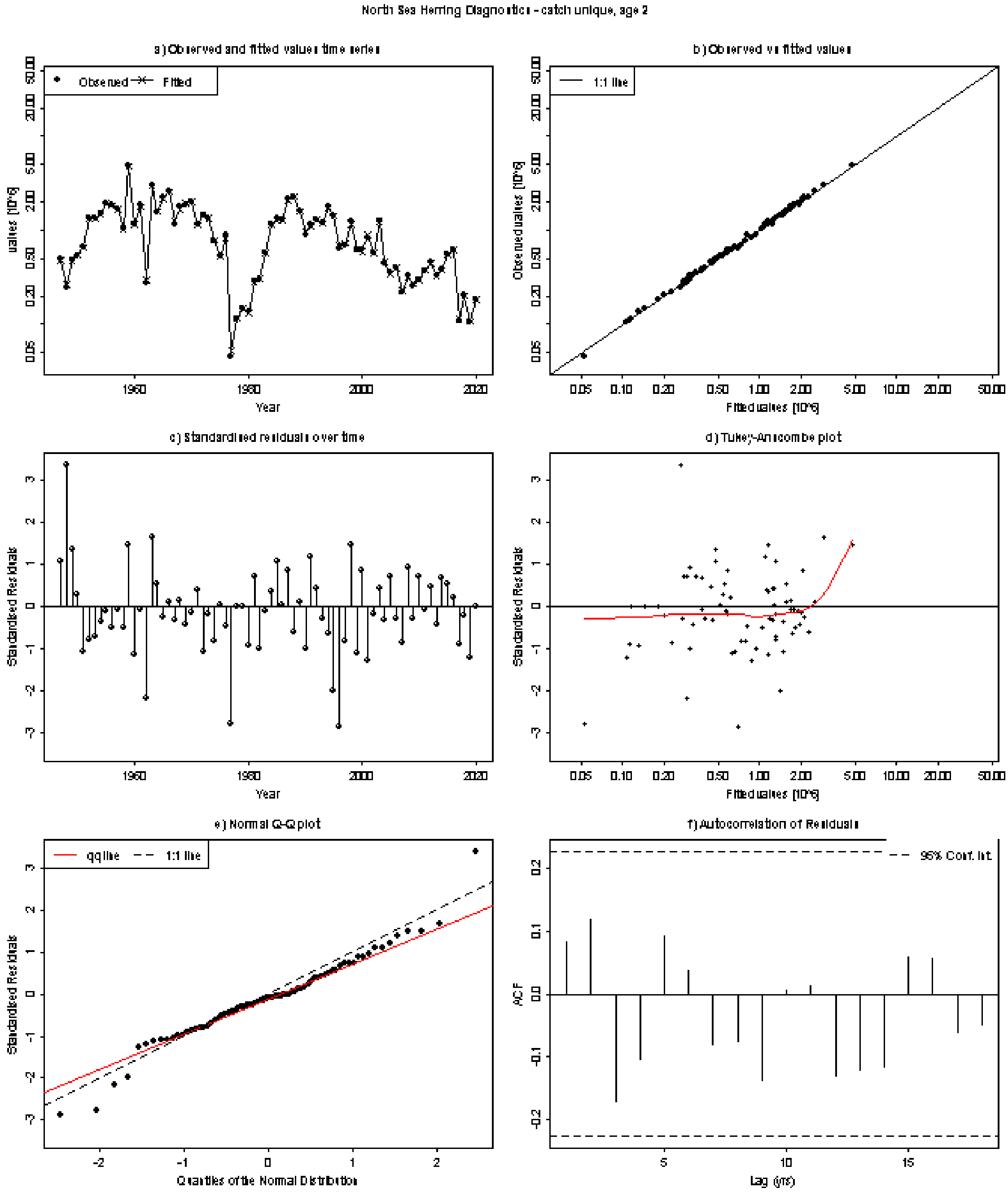
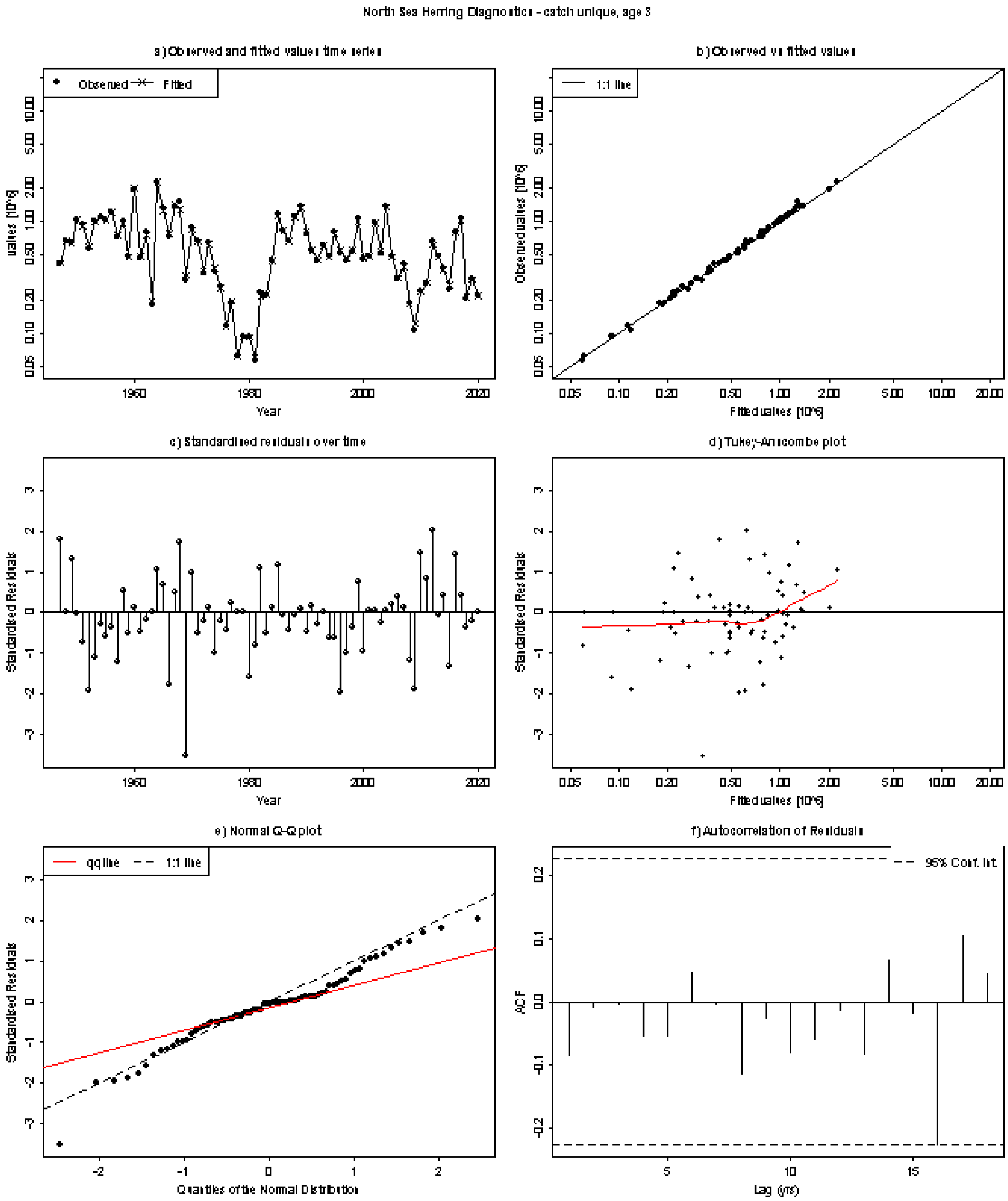


Figure 2.6.1.9. North Sea herring. Diagnostics of the assessment model fit to the catch-at-age 2 time-series. Top left: Estimates of numbers at 2 wr (line) and numbers predicted from catch abundance at 2 wr. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: catch observation vs. 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.



North Sea Herring Diagnostics - catch unique, age 3
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

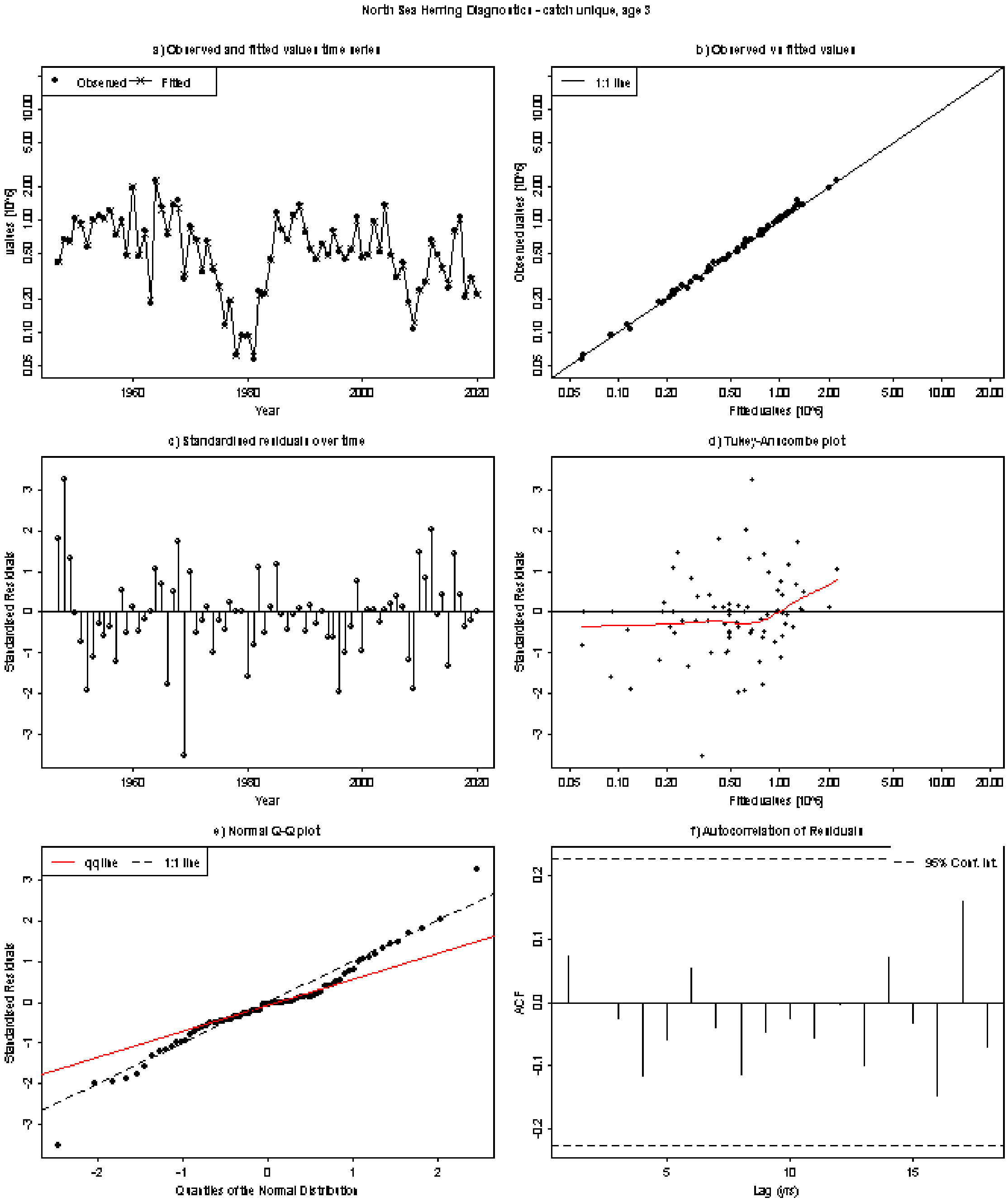
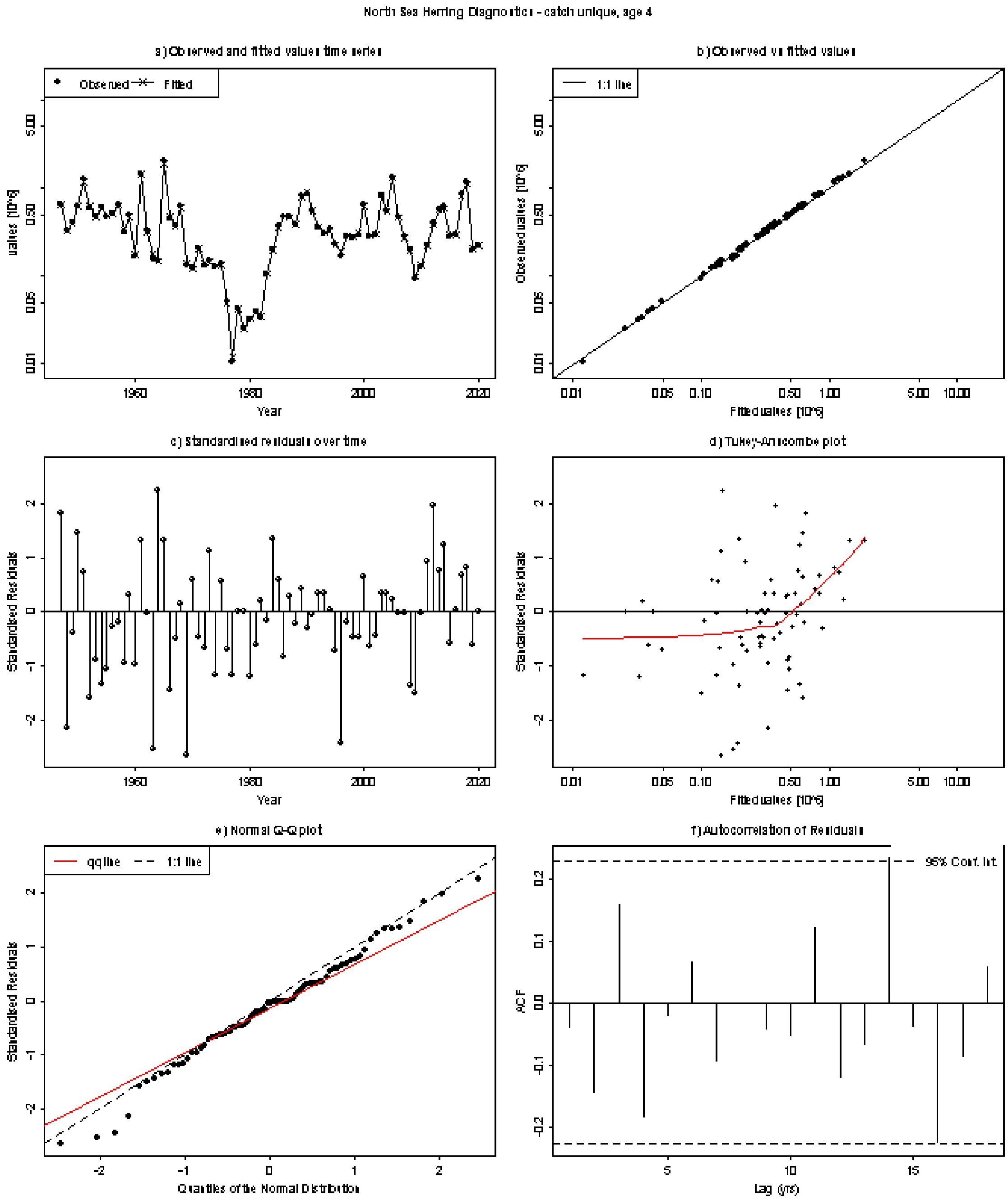


Figure 2.6.1.10. North Sea herring. Diagnostics of the assessment model fit to the catch-at-age 3 time-series. Top left: Estimates of numbers at 3 wr (line) and numbers predicted from catch abundance at 3 wr. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: catch observation vs. 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.


North Sea Herring Diagnostics - catch unique, age 4
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

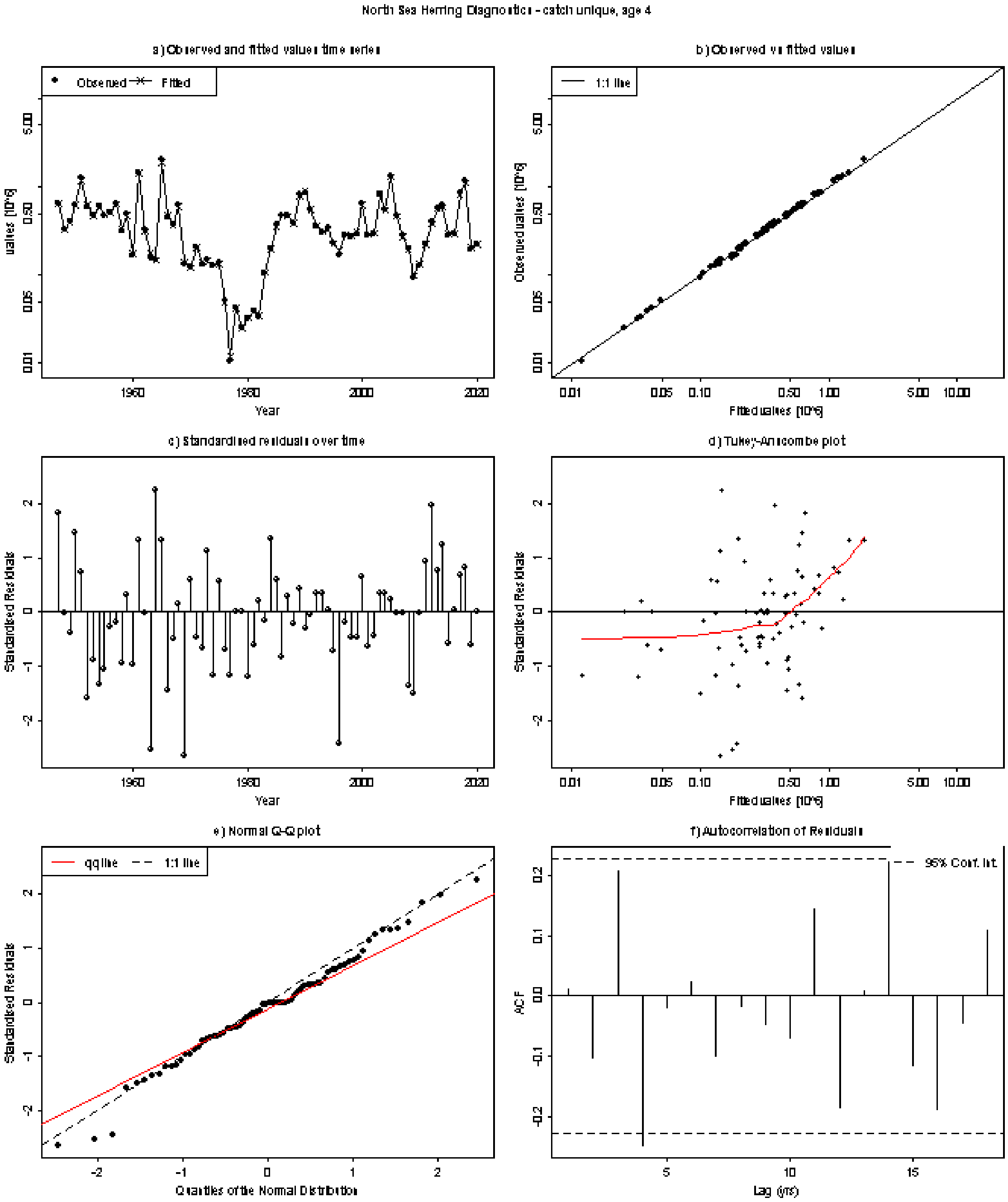
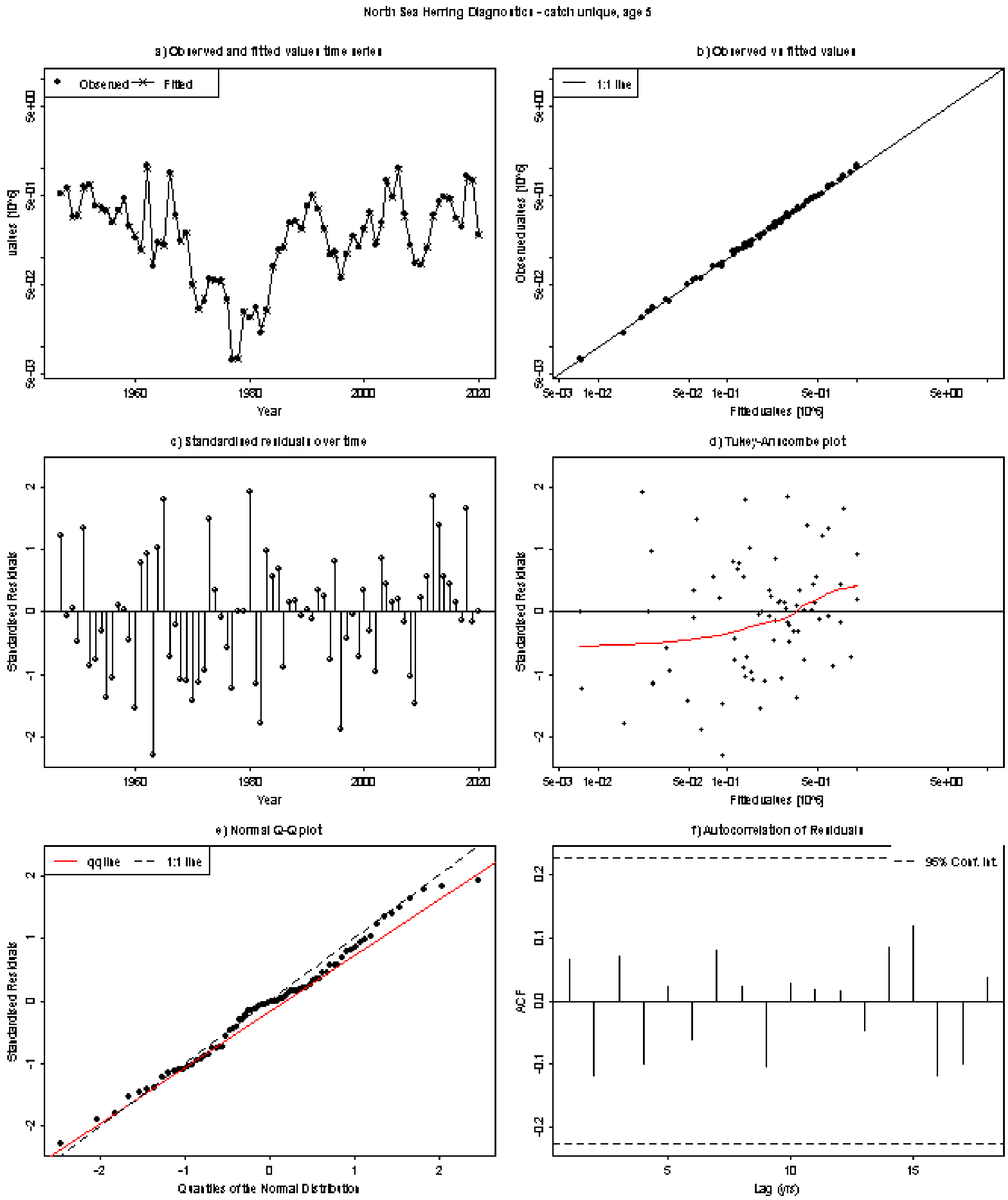


Figure 2.6.1.11. North Sea herring. Diagnostics of the assessment model fit to the catch-at-age 4 time-series. Top left: Estimates of numbers at 4 wr (line) and numbers predicted from catch abundance at 4 wr. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: catch observation vs. 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.


North Sea Herring Diagnostics - catch unique, age 5
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

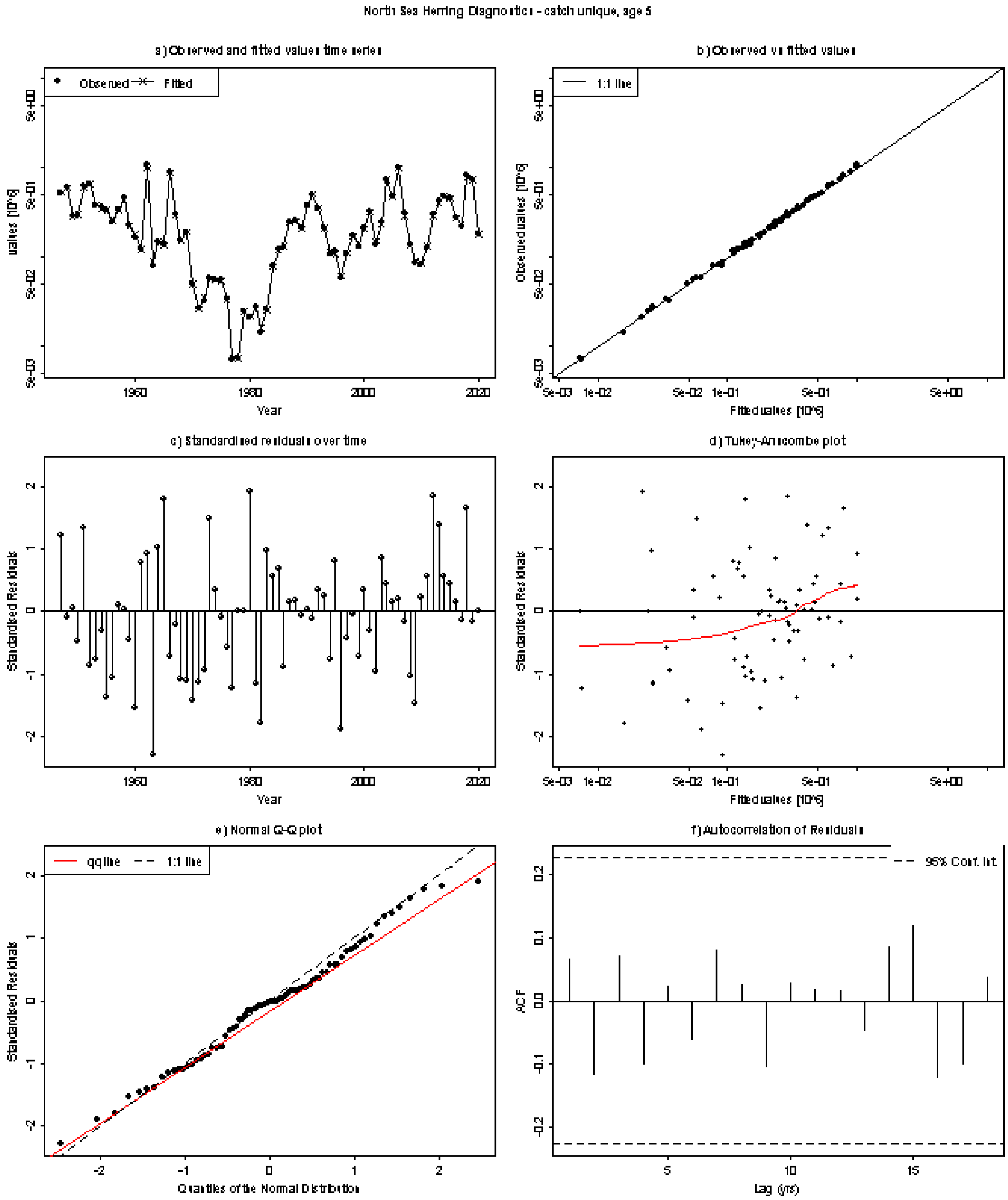
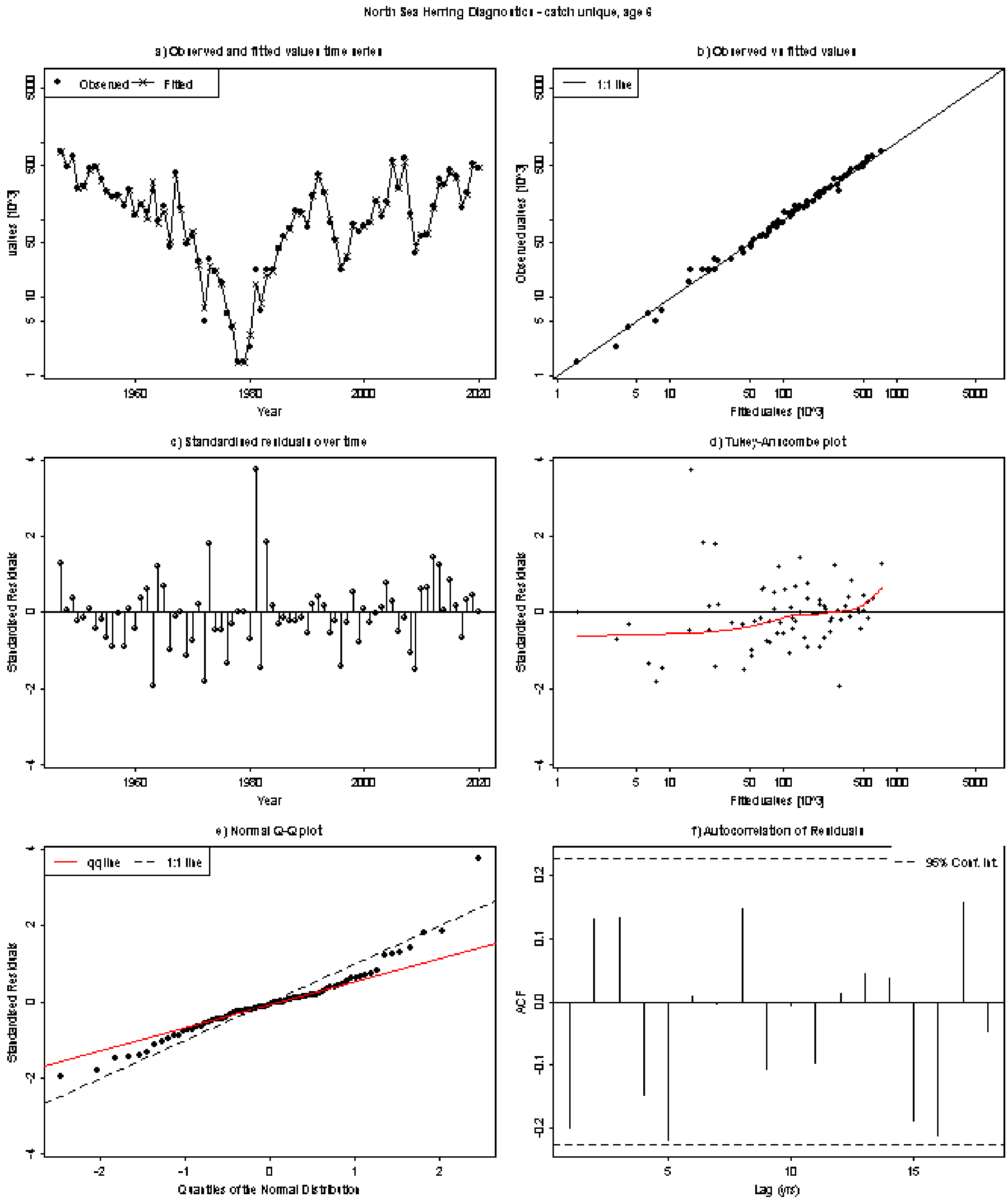


Figure 2.6.1.12. North Sea herring. Diagnostics of the assessment model fit to the catch-at-age 5 time-series. Top left: Estimates of numbers at 5 wr (line) and numbers predicted from catch abundance at 5 wr. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle right: catch observation vs. 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.


North Sea Herring Diagnostics - catch unique, age 6
a) Observed and fitted values time series
Observed
Fitted
Year
b) Observed vs fitted values
1:1 line
Fitted values [10^3]
Observed values [10^3]
c) Standardised residuals over time
Standardised Residuals
d) Tukey-Anscombe plot
e) Normal Q-Q plot
qq line
1:1 line
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

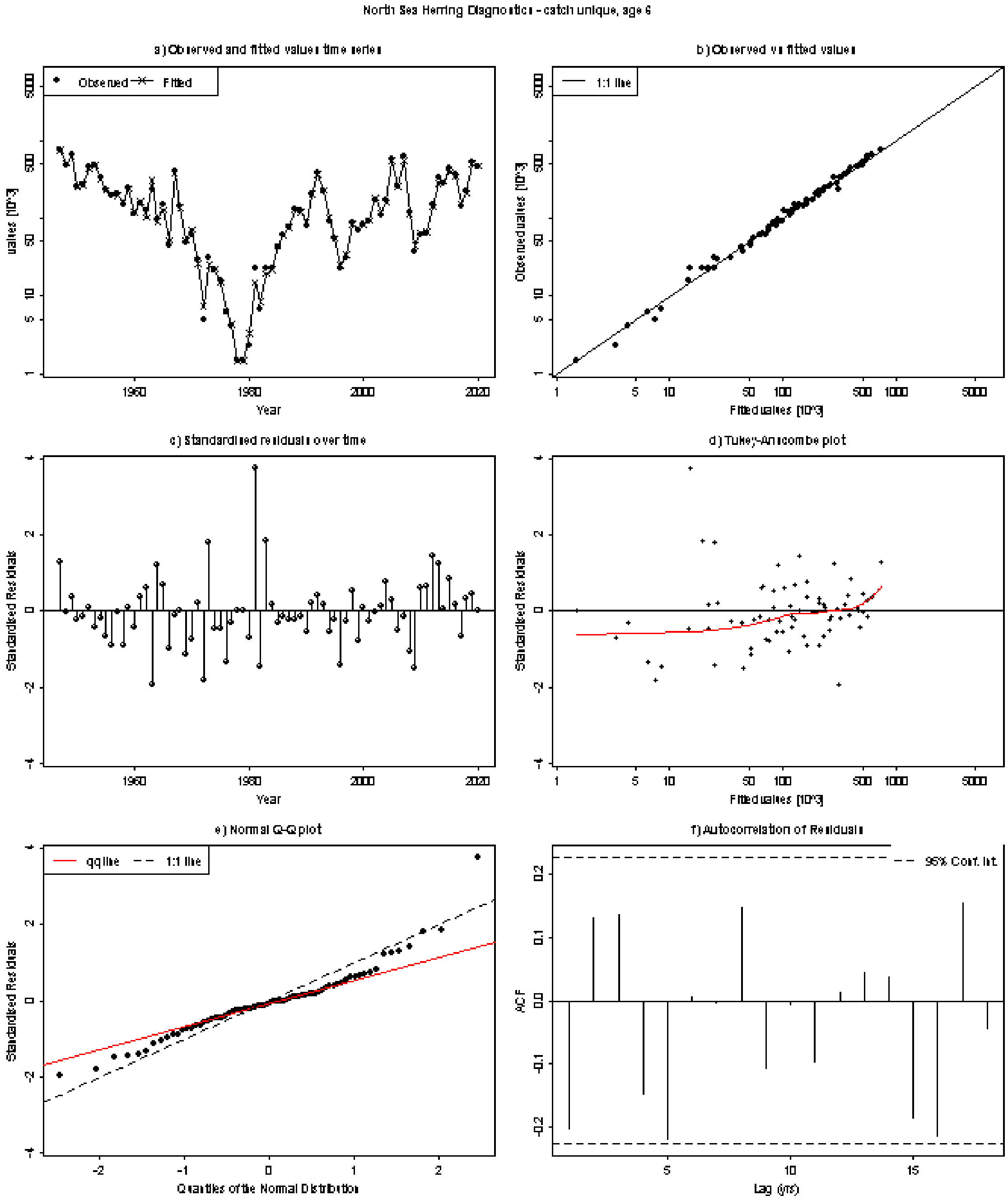
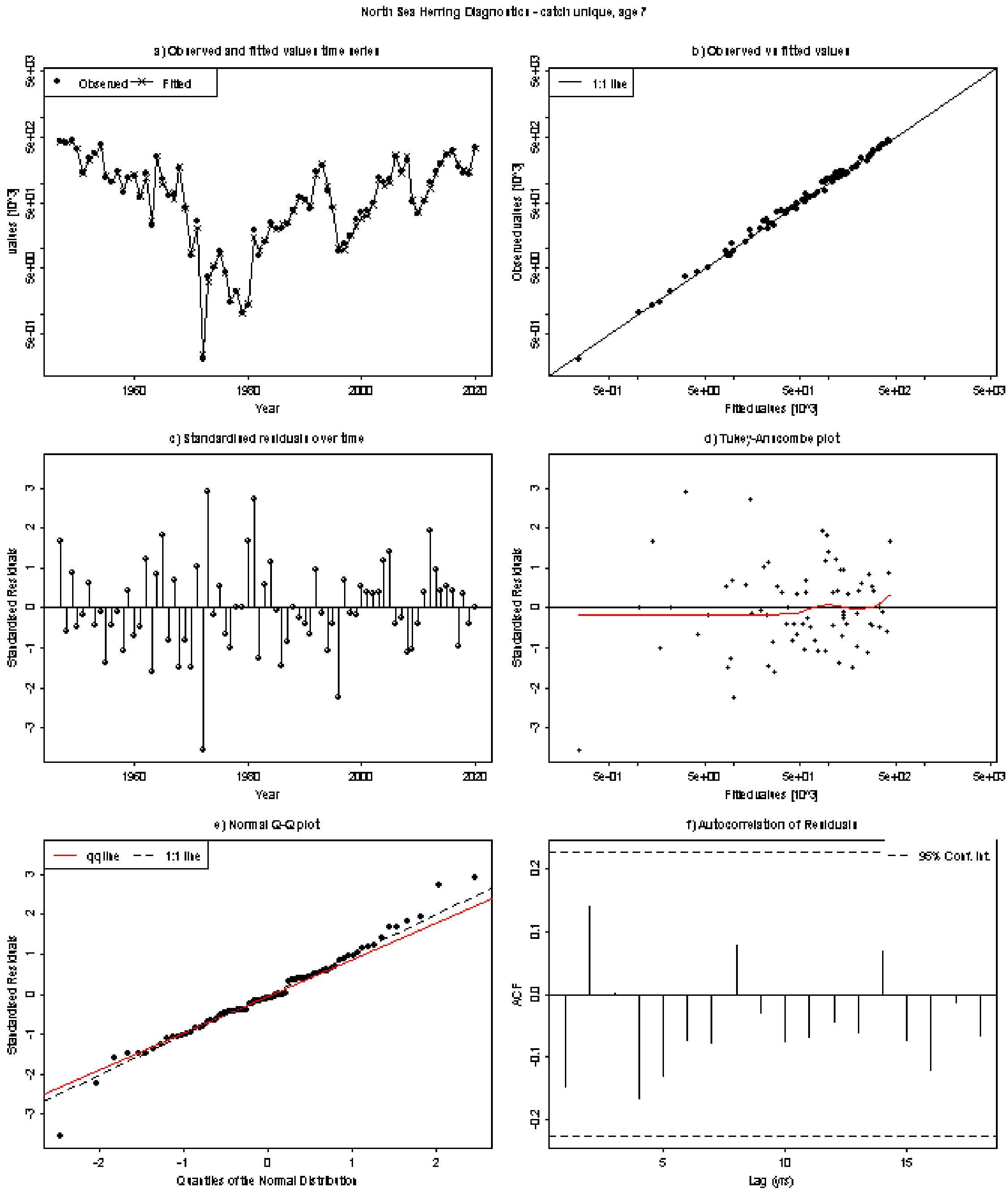


Figure 2.6.1.13. North Sea herring. Diagnostics of the assessment model fit to the catch-at-age 6 time-series. Top left: Estimates of numbers at 6 wr (line) and numbers predicted from catch abundance at 6 wr. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle right: catch observation vs. 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.


North Sea Herring Diagnostics - catch unique, age 7
a) Observed and fitted values time series
Observed
Fitted
values [10^3]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^3]
Fitted values [10^3]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^3]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

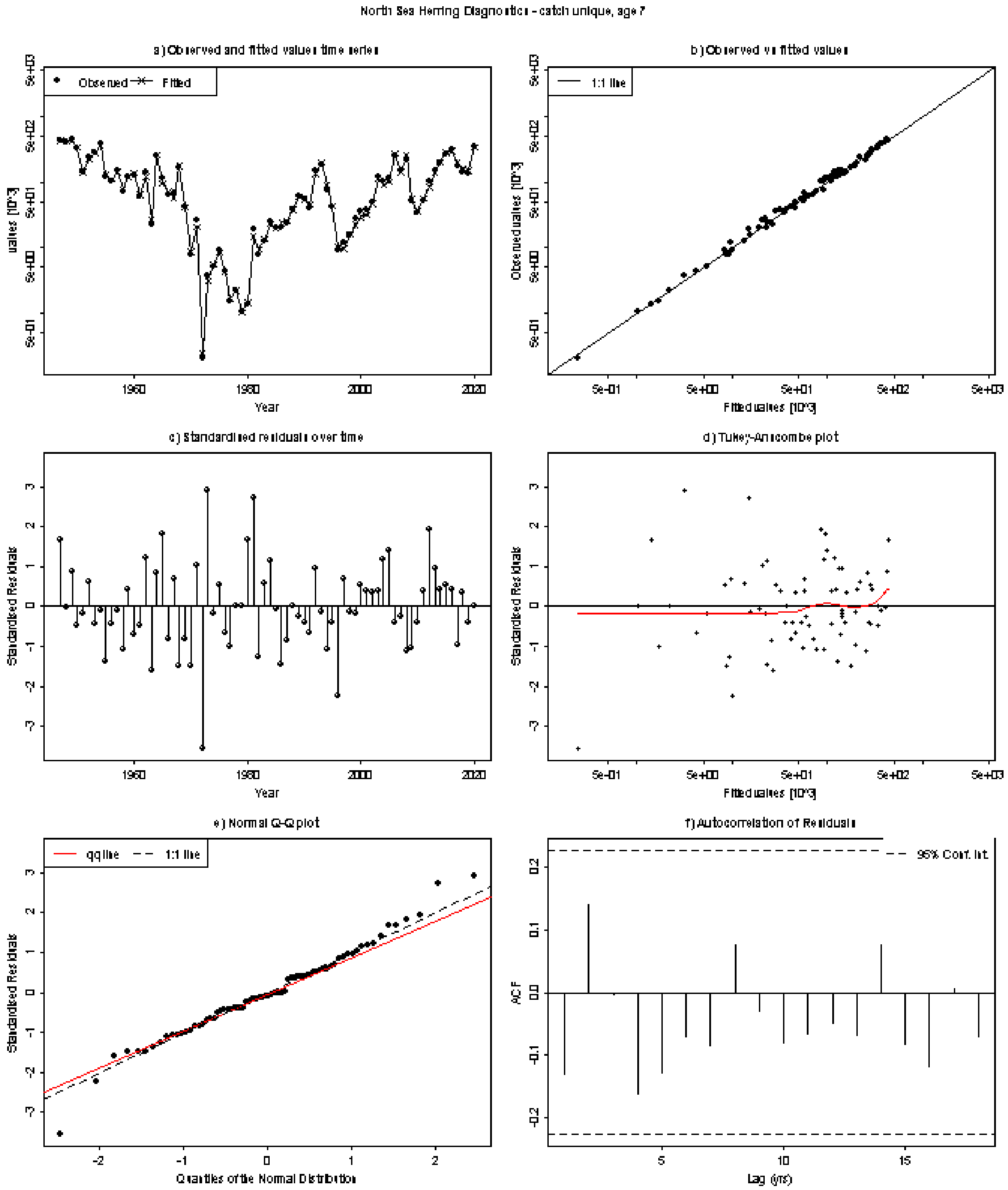
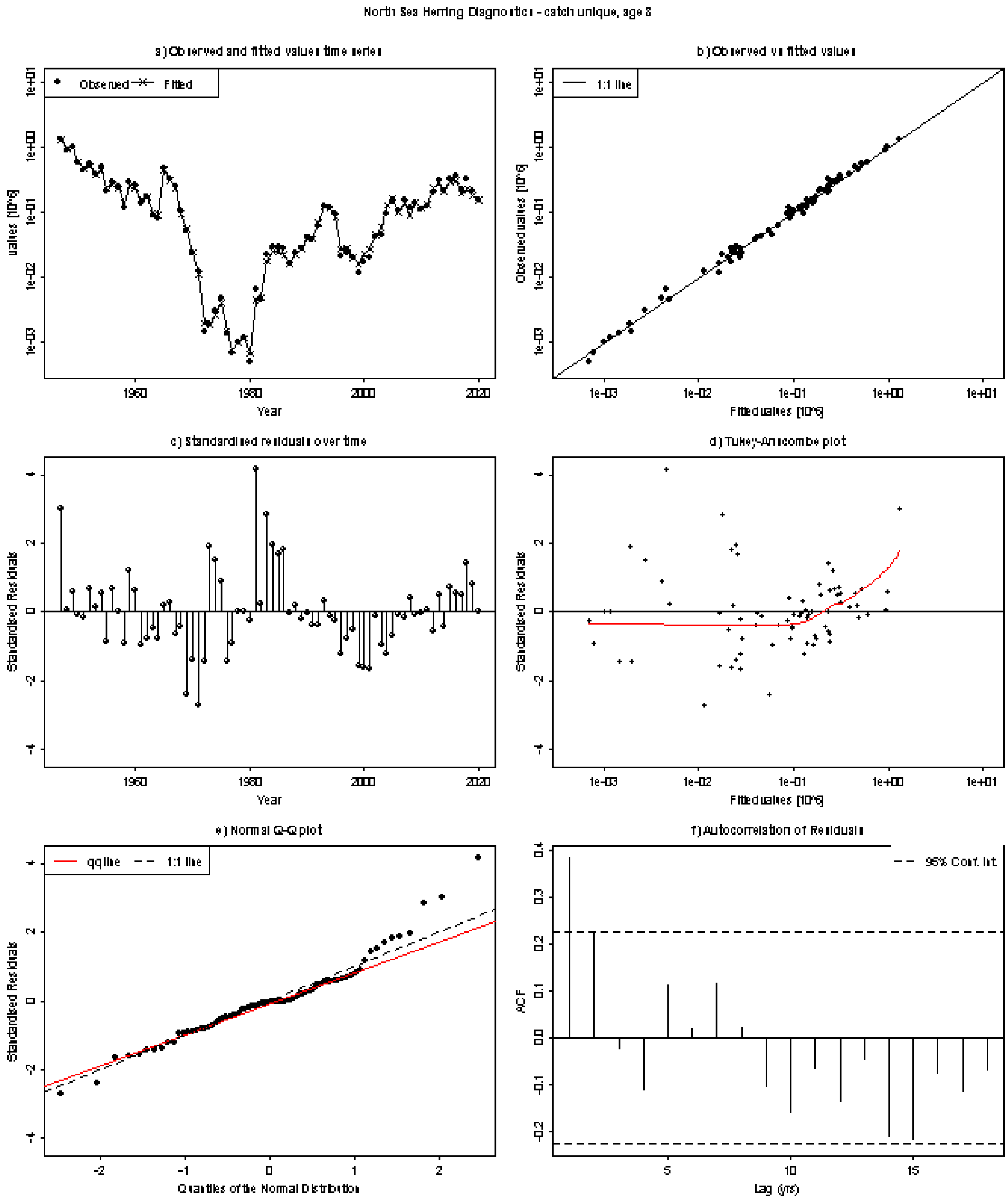


Figure 2.6.1.14. North Sea herring. Diagnostics of the assessment model fit to the catch-at-age 7 time-series. Top left: Estimates of numbers at 7 wr (line) and numbers predicted from catch abundance at 7 wr. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle right: catch observation vs. 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.


North Sea Herring Diagnostics - catch unique, age 8
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

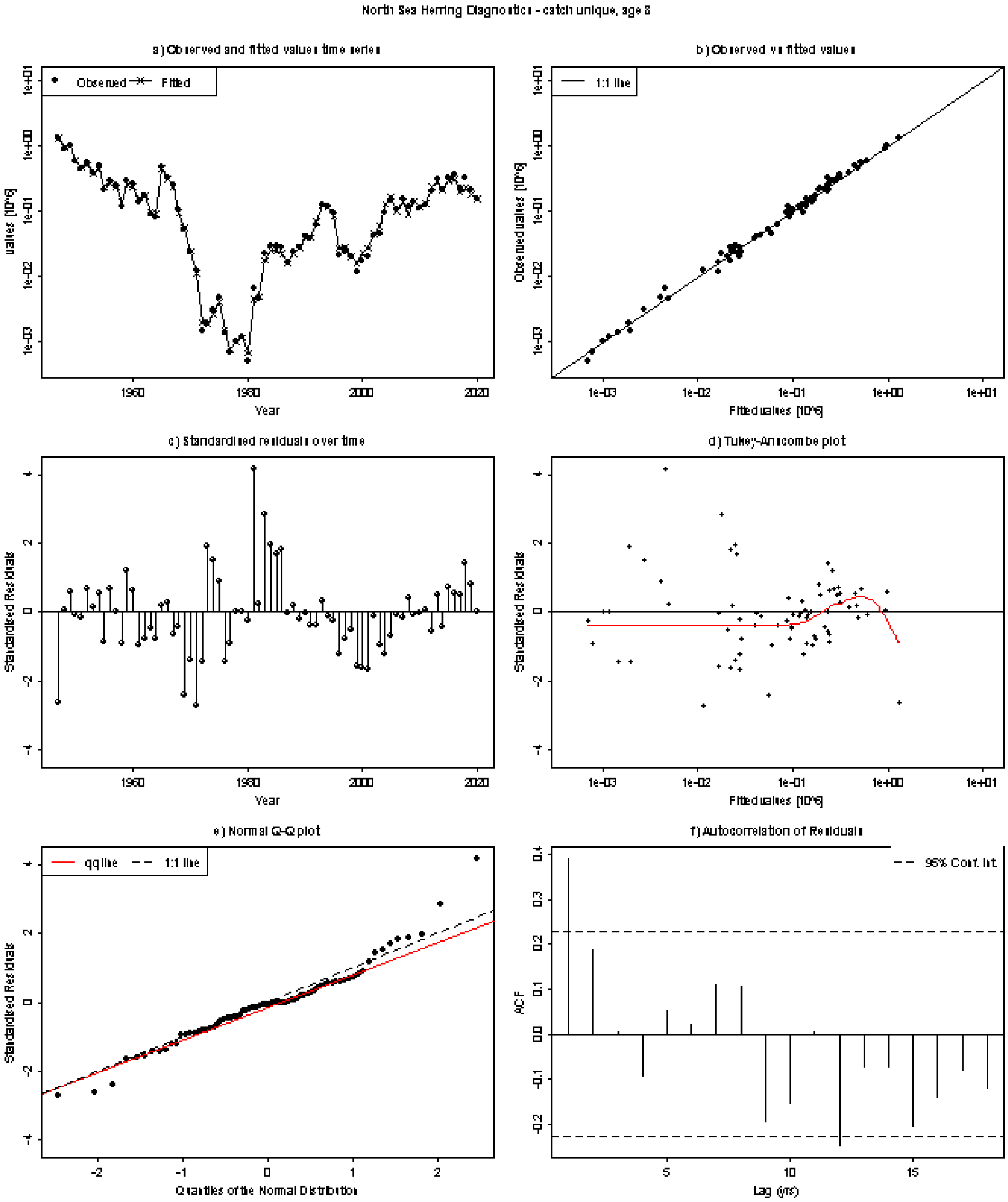
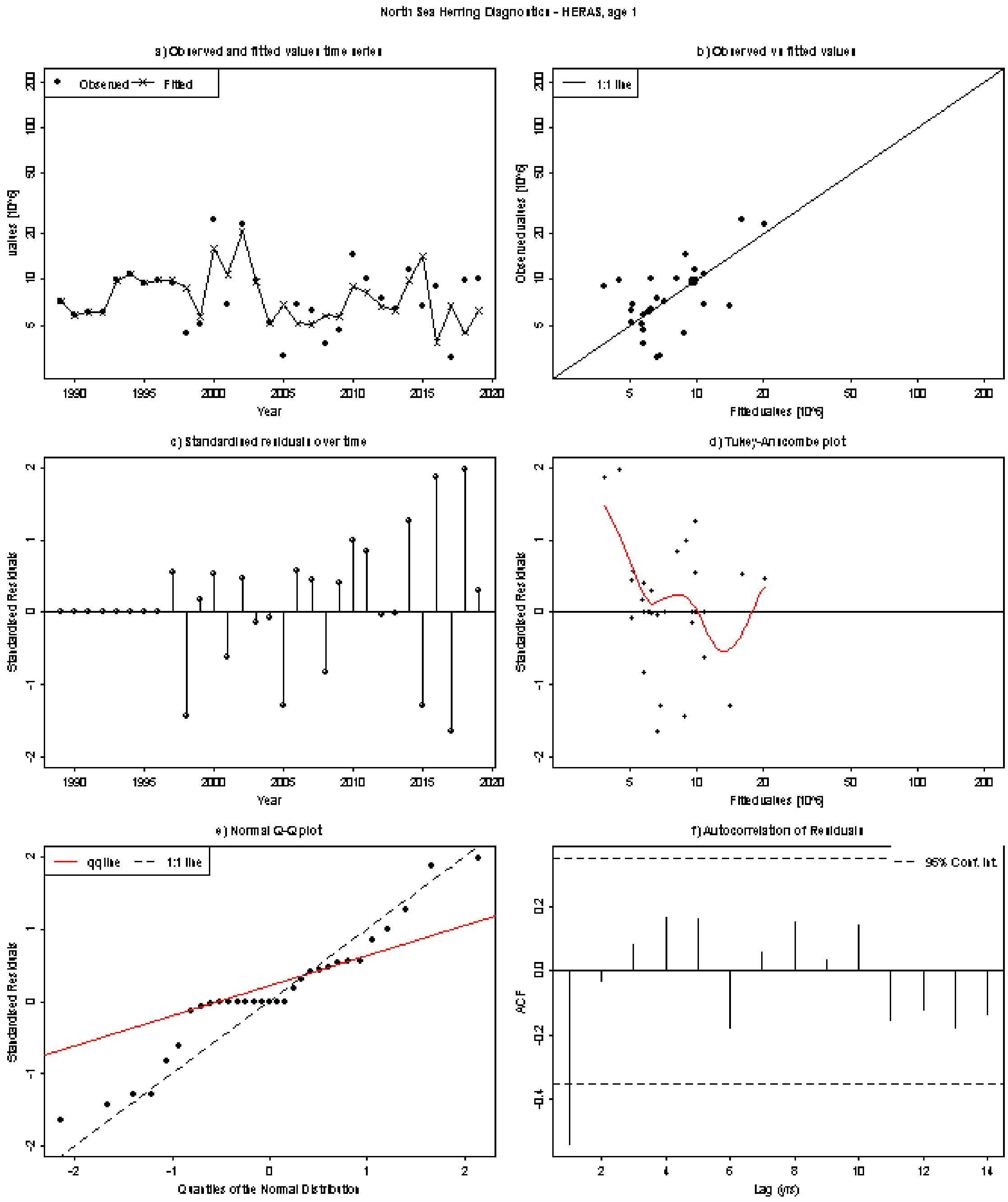


Figure 2.6.1.15. North Sea herring. Diagnostics of the assessment model fit to the catch-at-age 8+ time-series. Top left: Estimates of numbers at 8+ wr (line) and numbers predicted from catch abundance at 8+ wr. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 8+ wr with the best-fit catchability model (linear function). Middle right: catch observation vs. 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.


North Sea Herring Diagnostics - HERAS, age 1
a) Observed and fitted values time series
Observed
Fitted
Year
b) Observed vs fitted values
1:1 line
Fitted values [10^6]
Observed values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Fitted values [10^6]
Standardised Residuals
e) Normal Q-Q plot
qq line
1:1 line
Quantiles of the Normal Distribution
Standardised Residuals
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

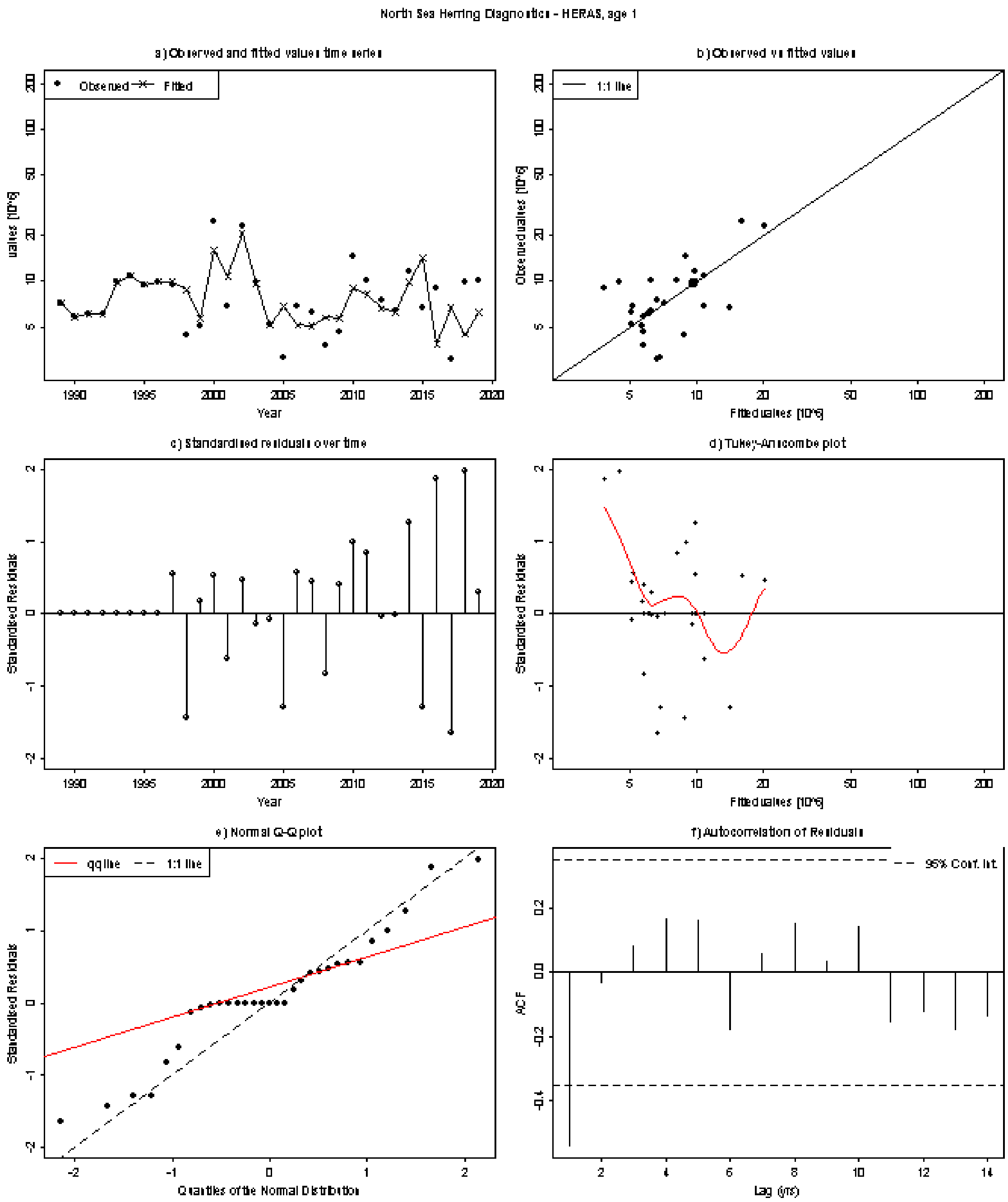
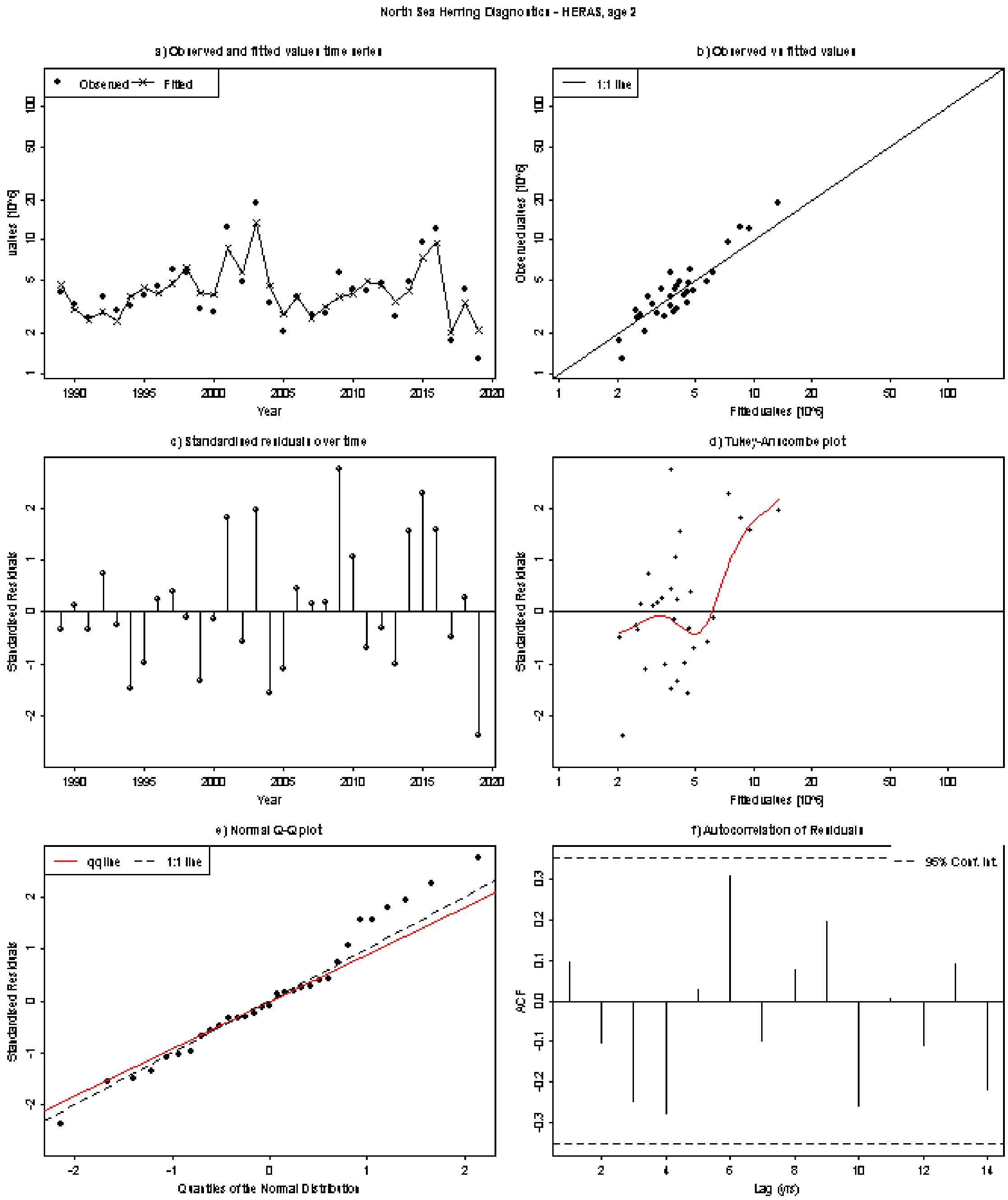


Figure 2.6.1.16. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 1 wr time-series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - HERAS, age 2
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

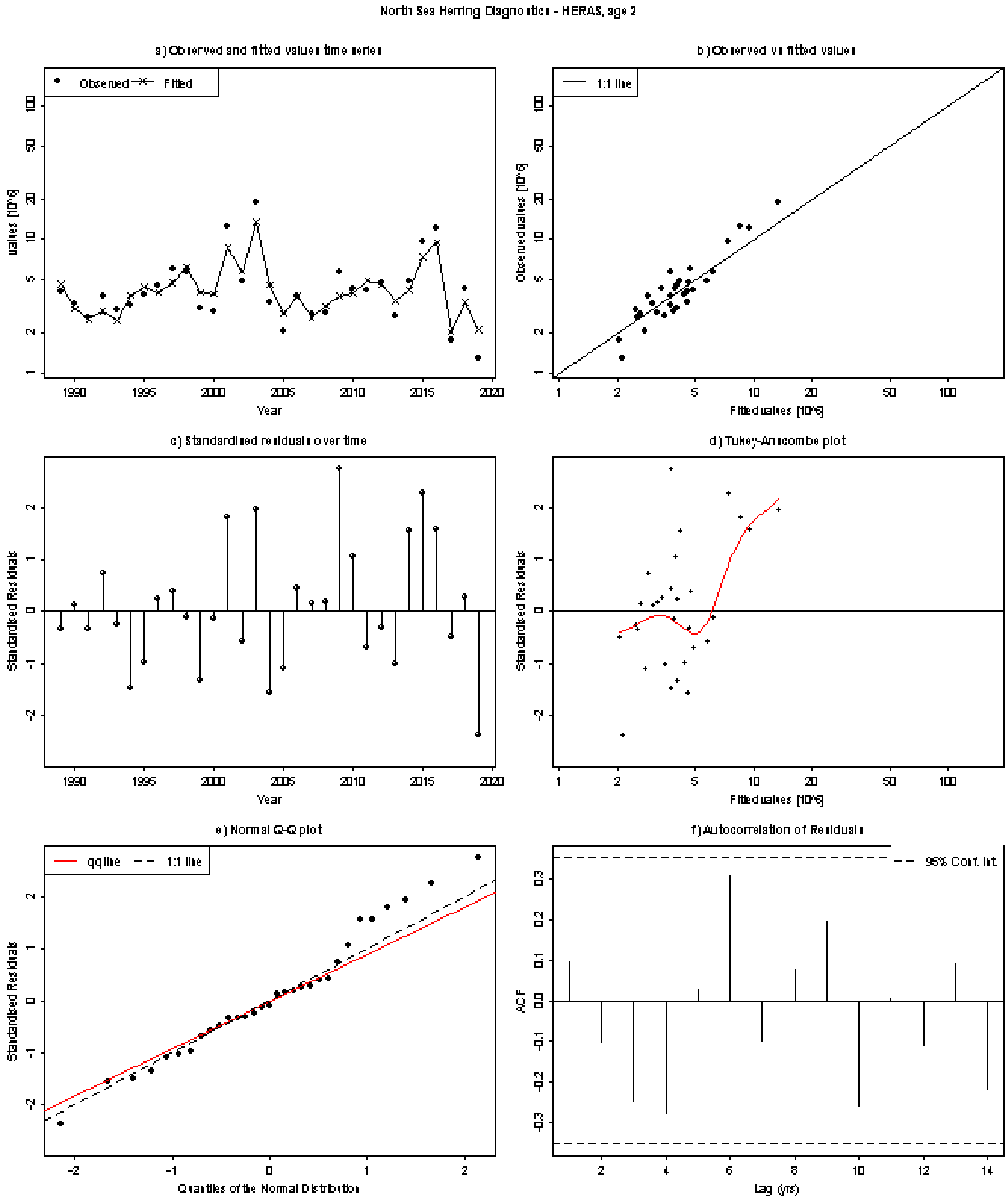
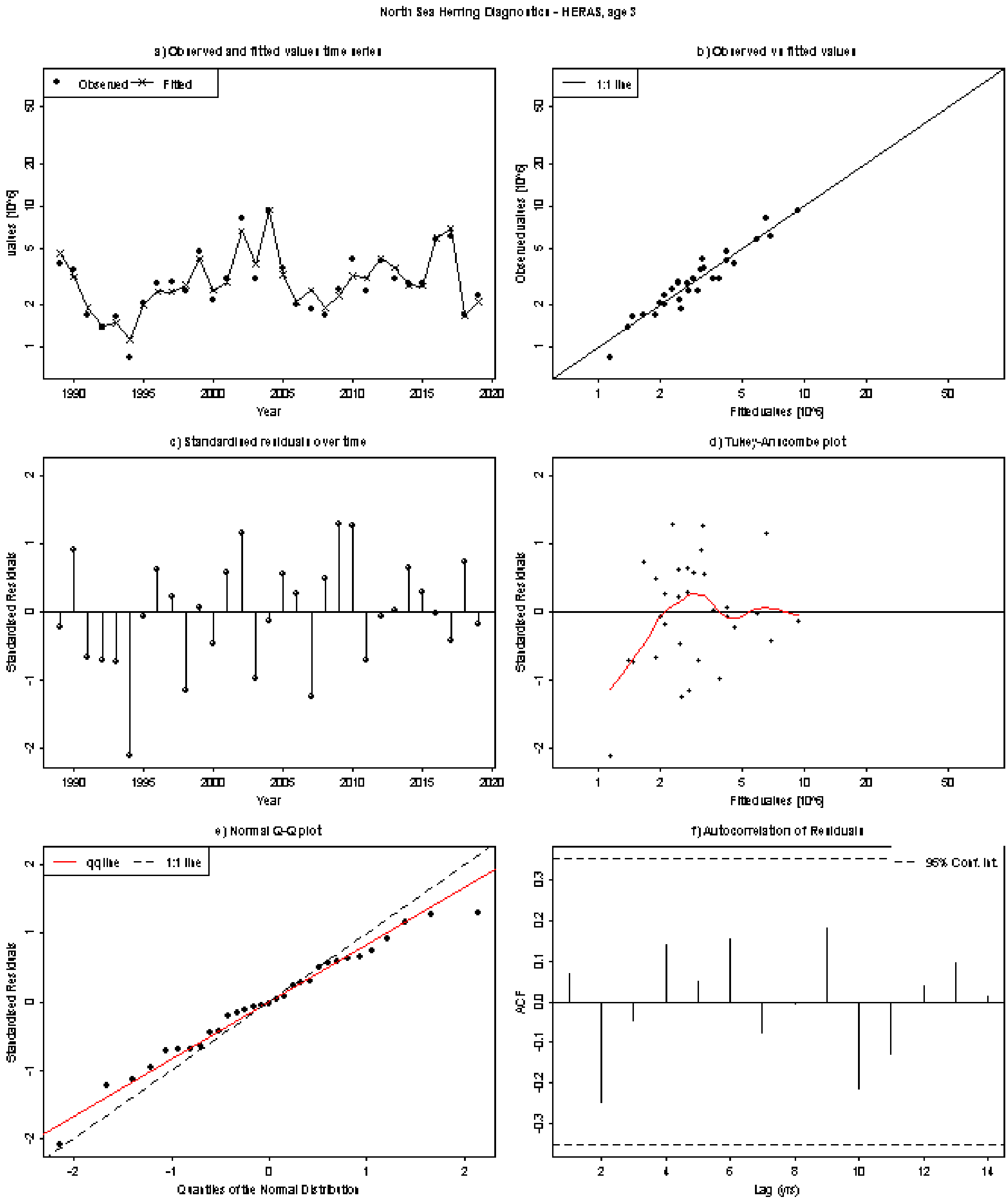


Figure 2.6.1.17. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 2 wr time-series. Top left: Estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - HERAS, age 3
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

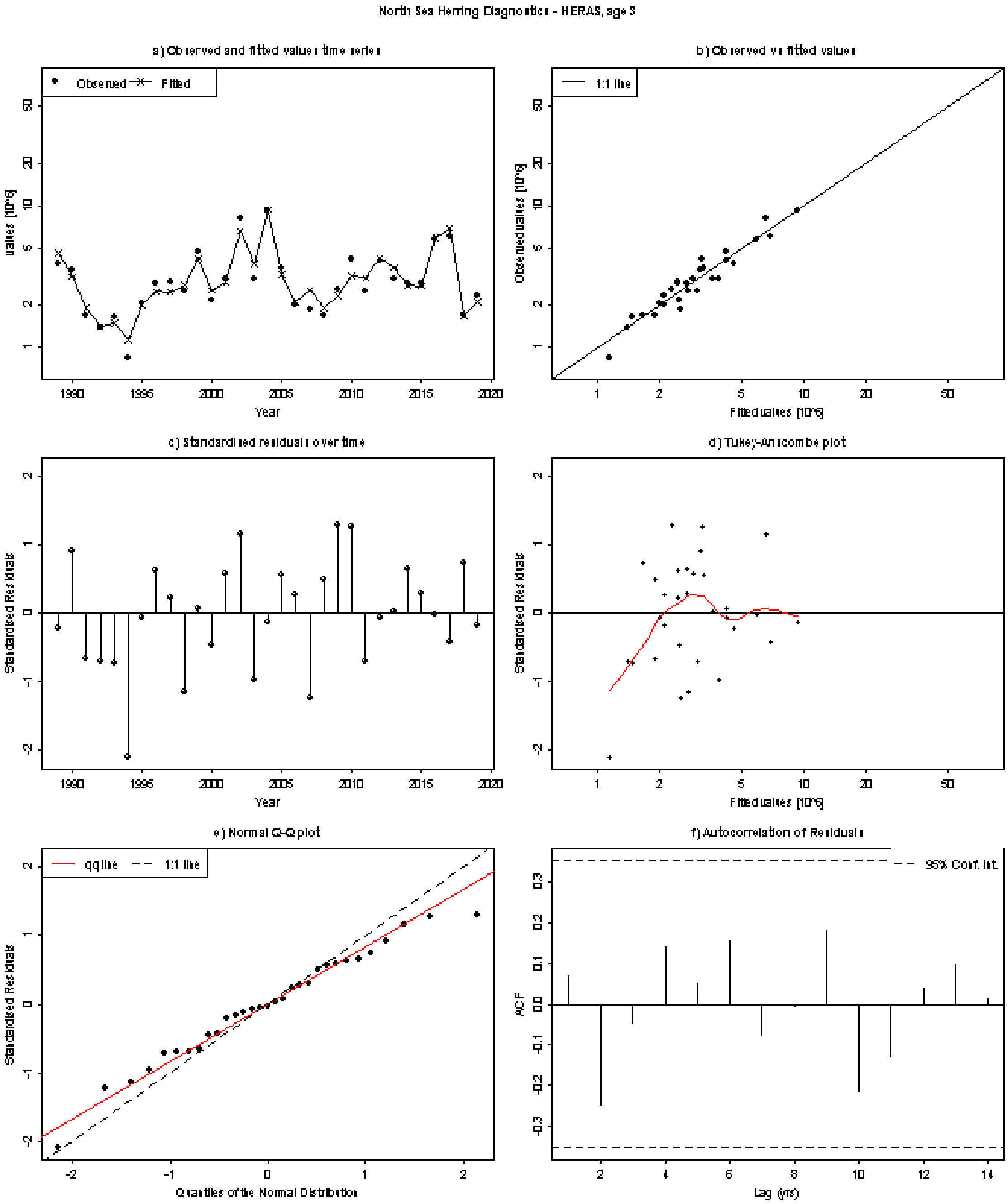
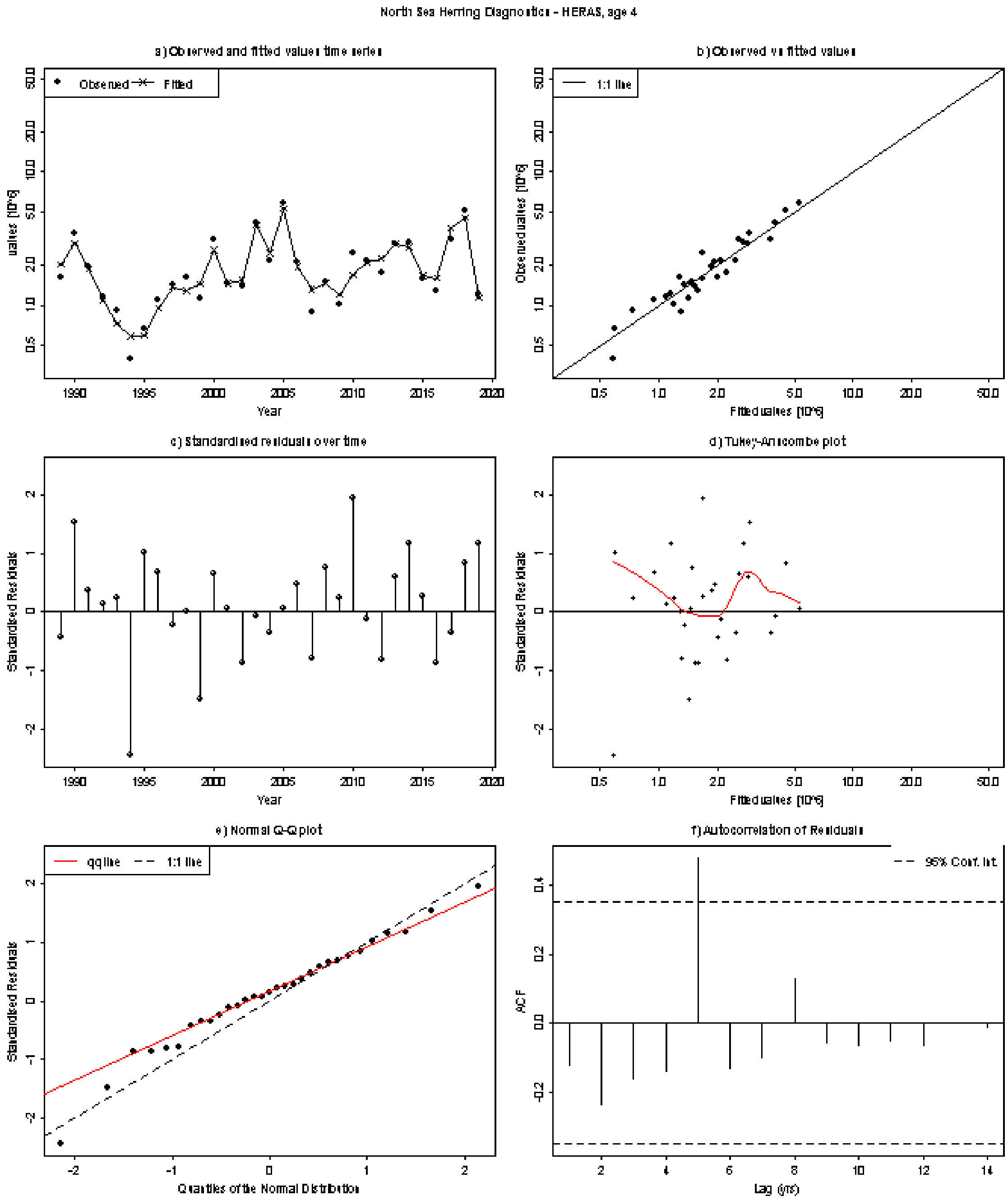


Figure 2.6.1.18. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 3 wr time-series. Top left: Estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - HERAS, age 4
a) Observed and fitted values time series
Observed
Fitted
Year
b) Observed vs fitted values
1:1 line
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

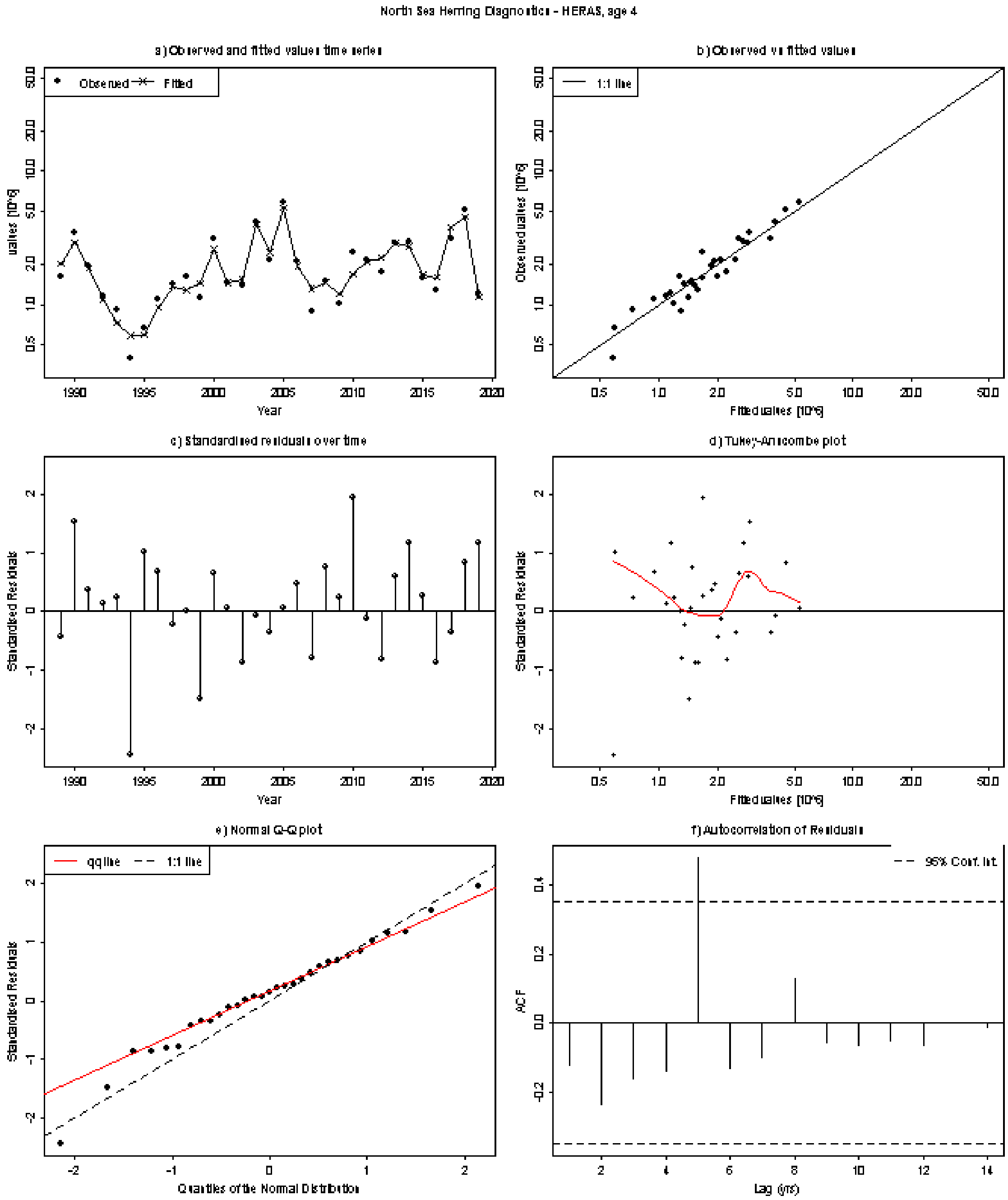
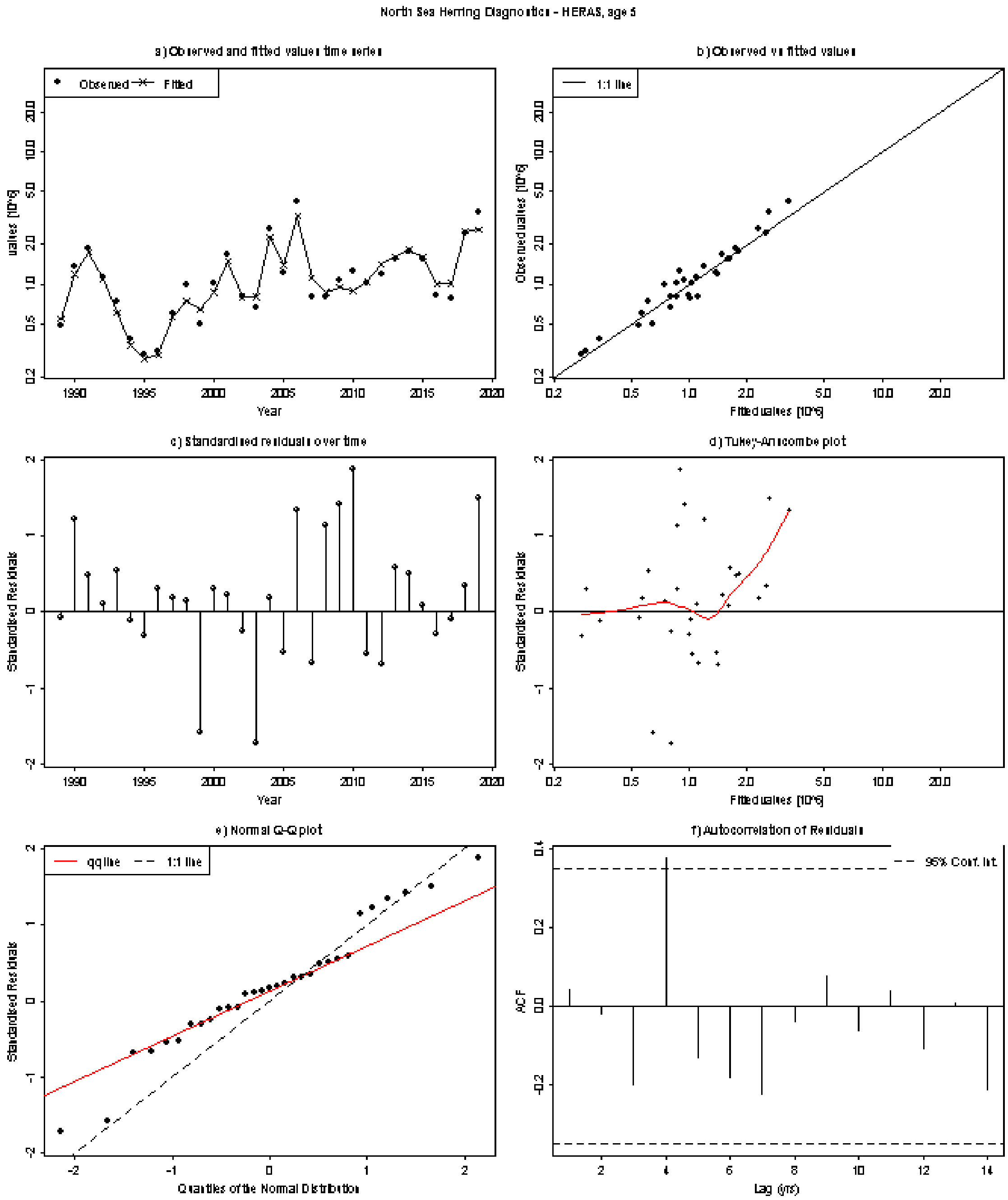


Figure 2.6.1.19. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 4 wr time-series. Top left: Estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - HERAS, age 5
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

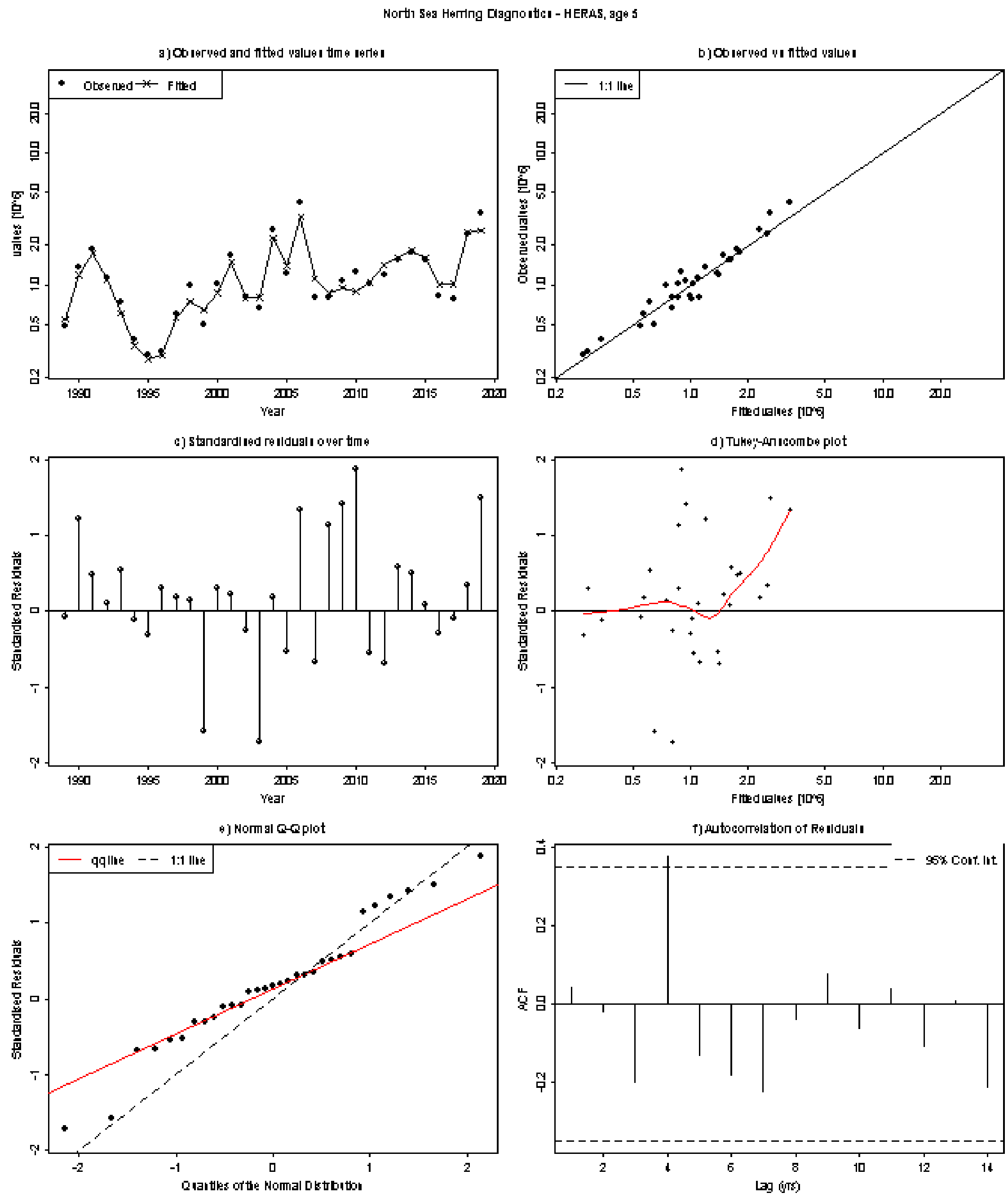
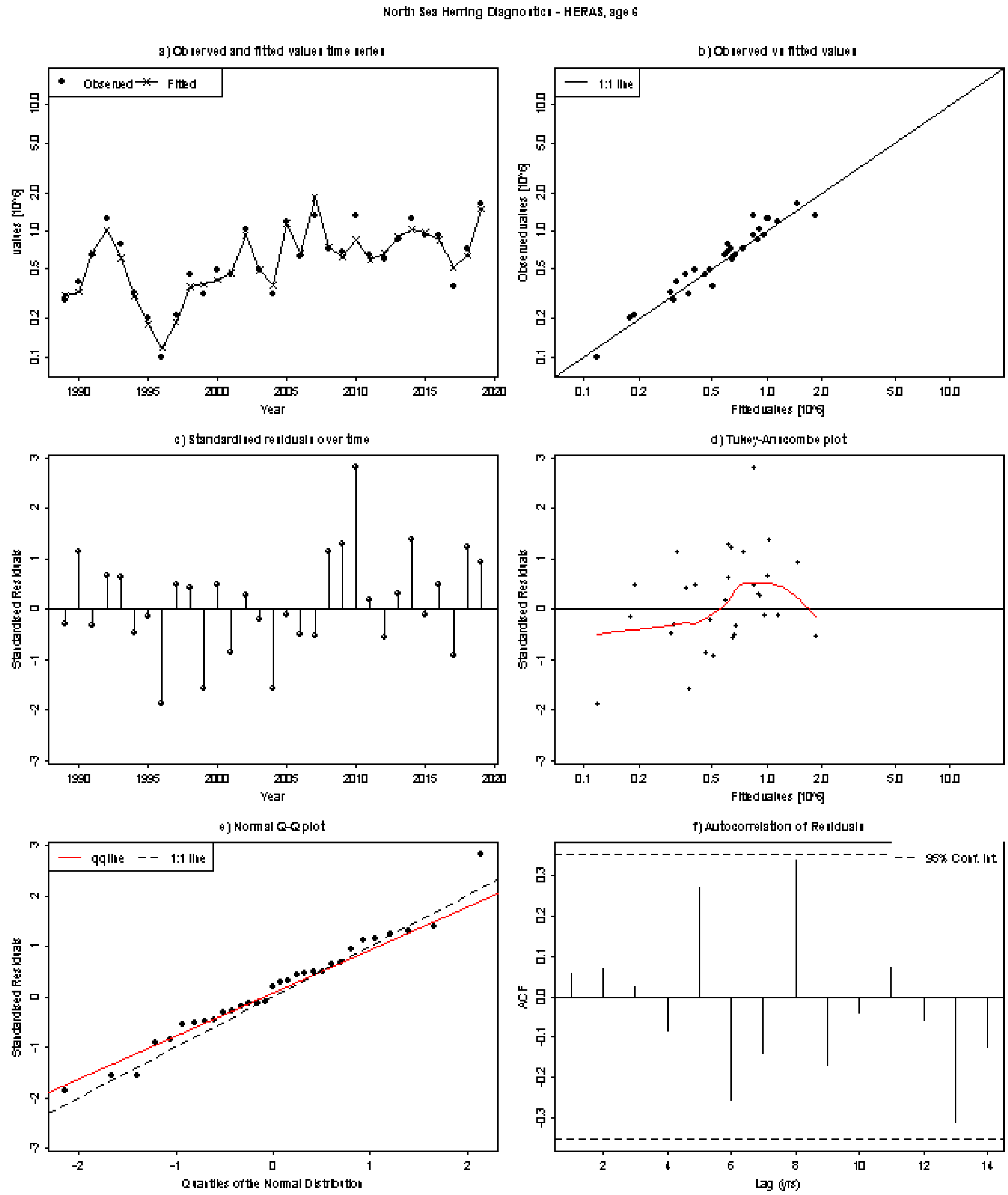


Figure 2.6.1.20. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 5 wr time-series. Top left: Estimates of numbers at 5 wr (line) and numbers predicted from index abundance at 5 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - HERAS, age 6
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

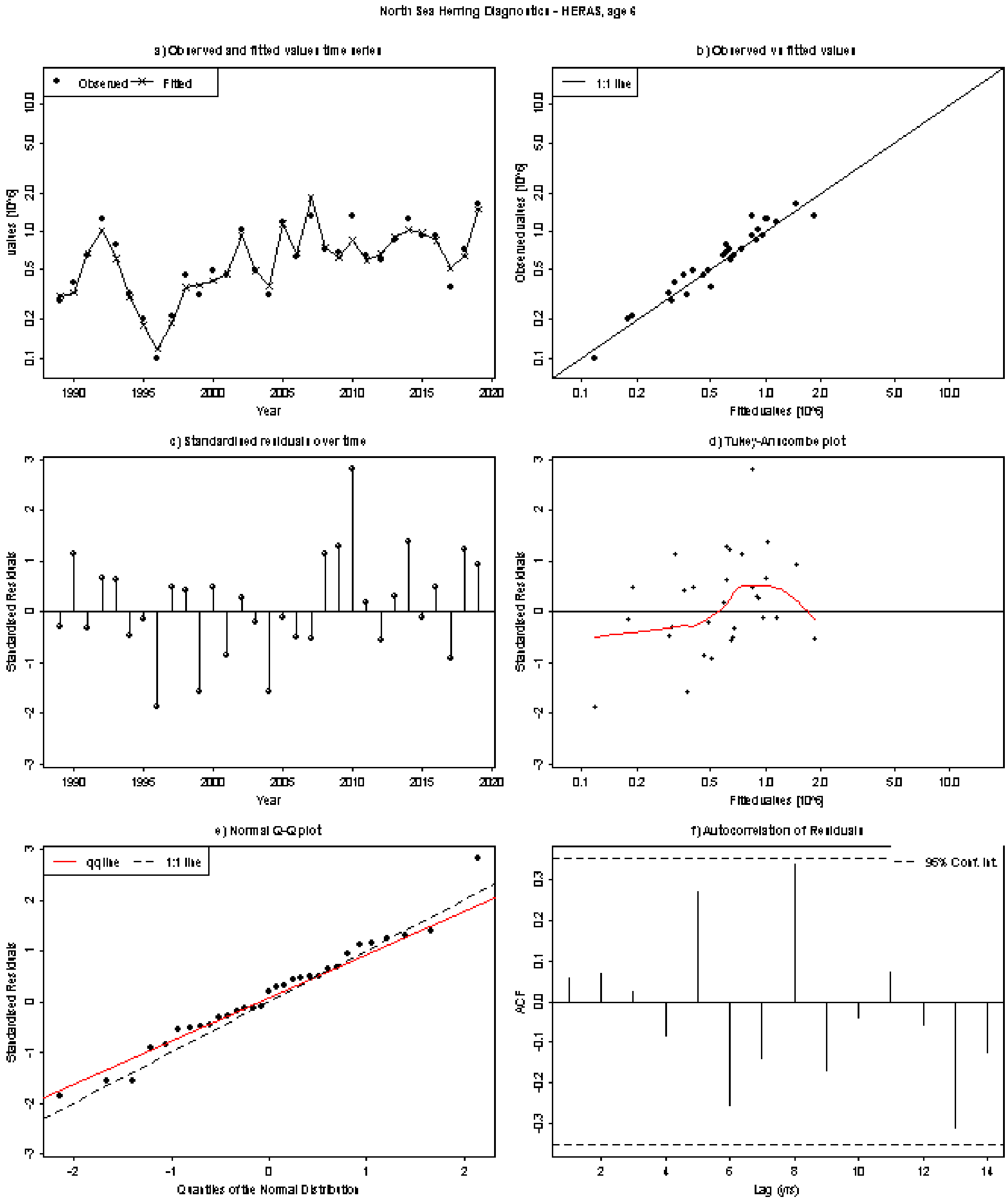
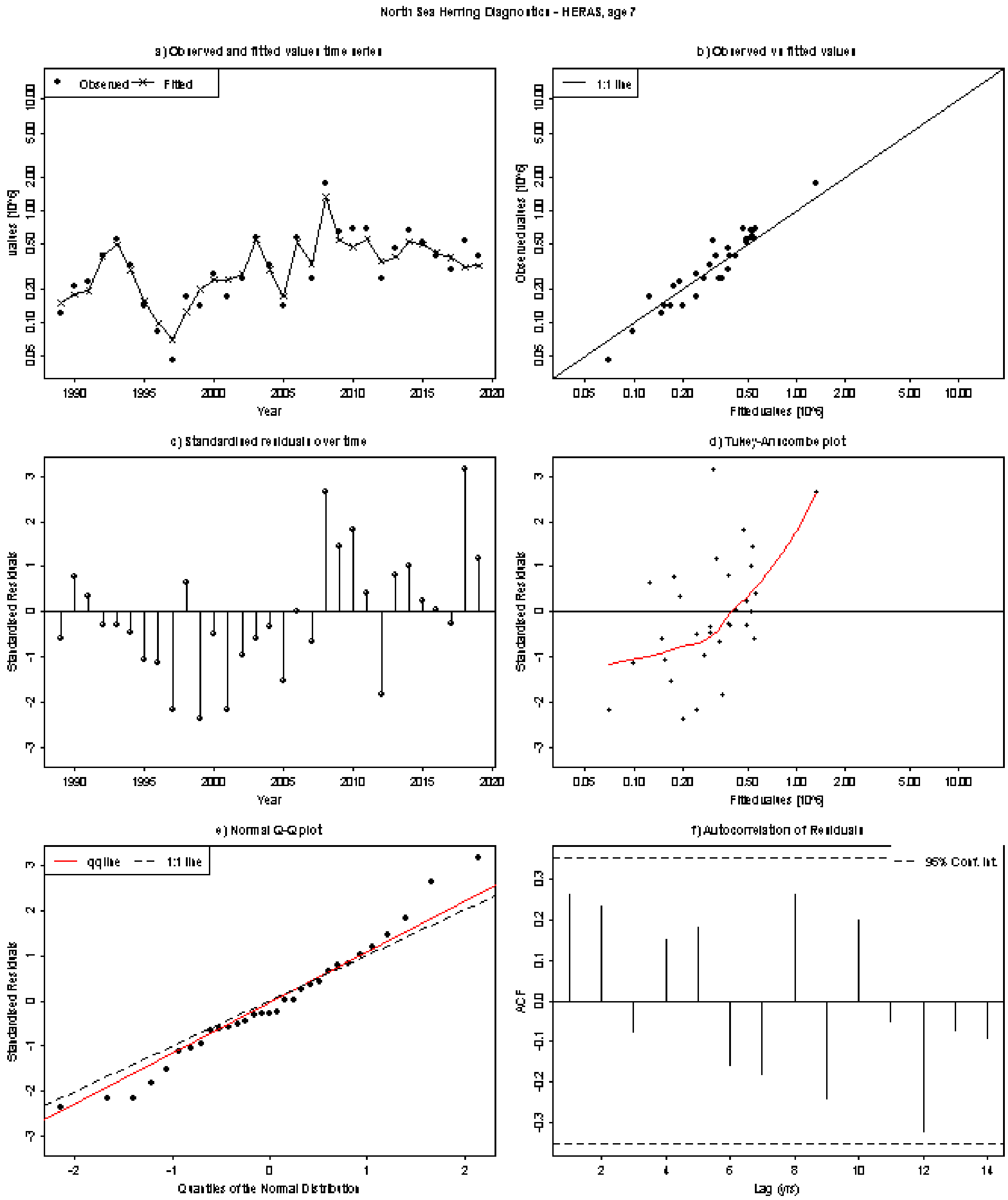


Figure 2.6.1.21. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 6 wr time-series. Top left: Estimates of numbers at 6 wr (line) and numbers predicted from index abundance at 6 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - HERAS, age 7
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

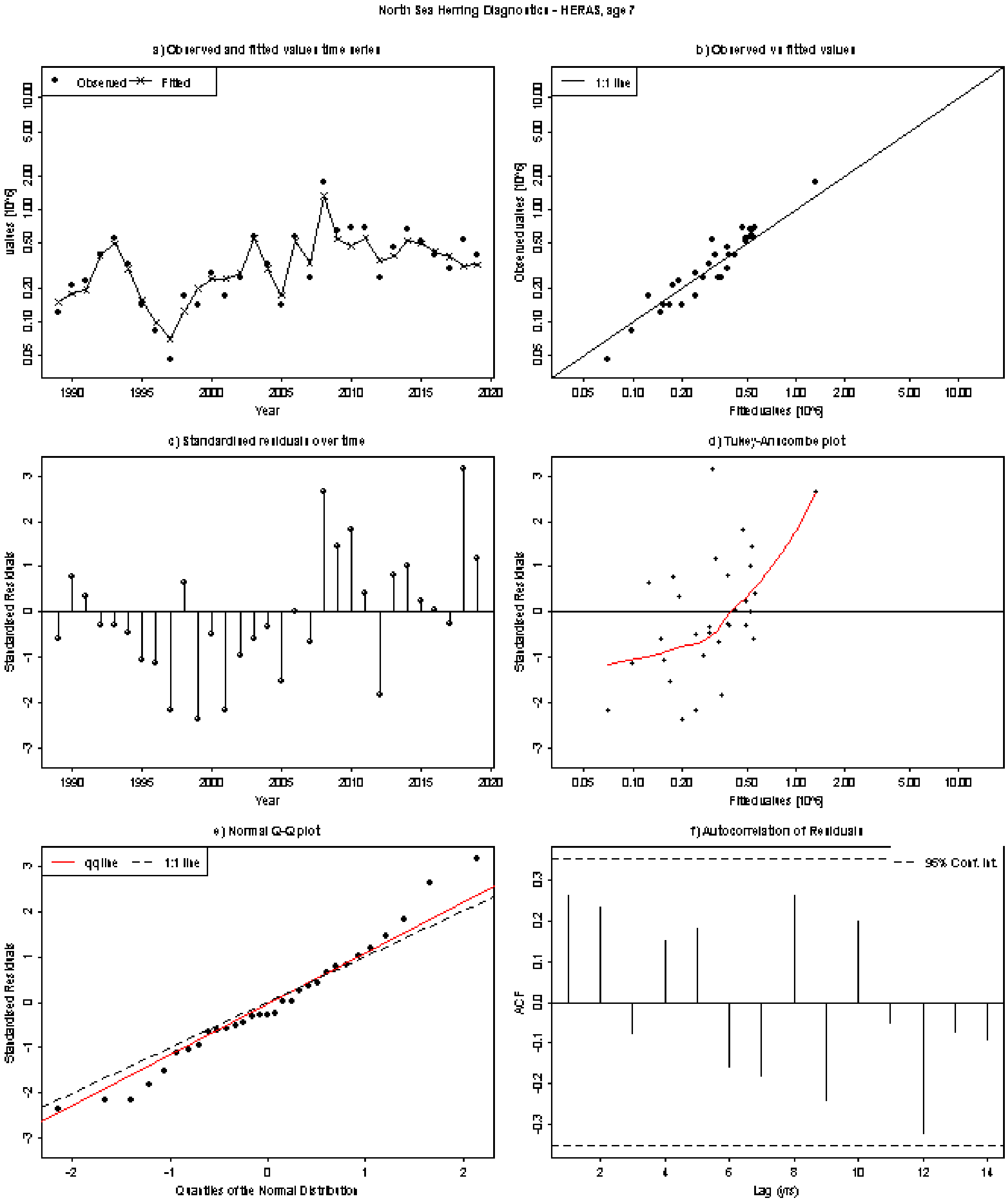
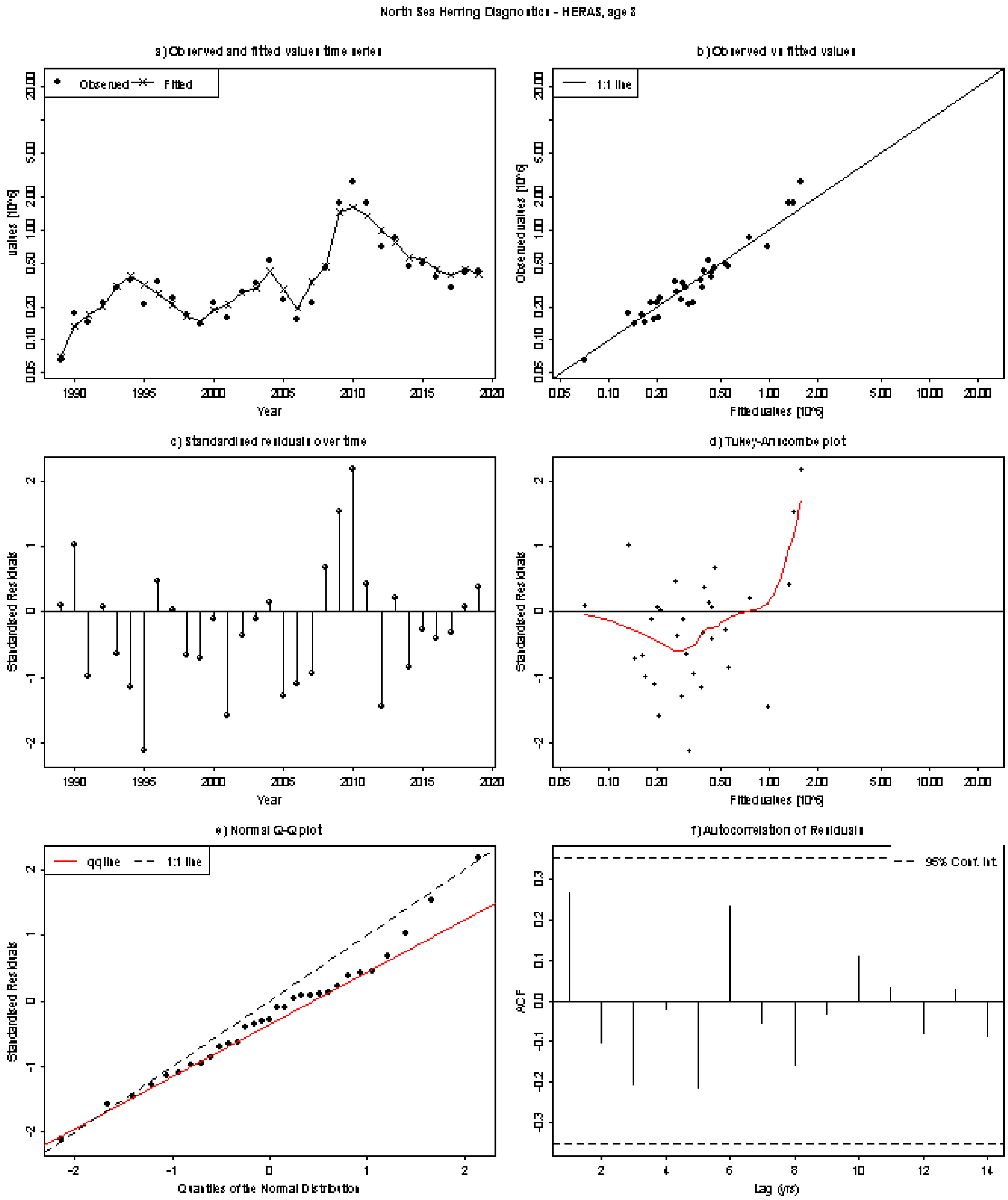


Figure 2.6.1.22. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 7 wr time-series. Top left: Estimates of numbers at 7 wr (line) and numbers predicted from index abundance at 7 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - HERAS, age 8
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

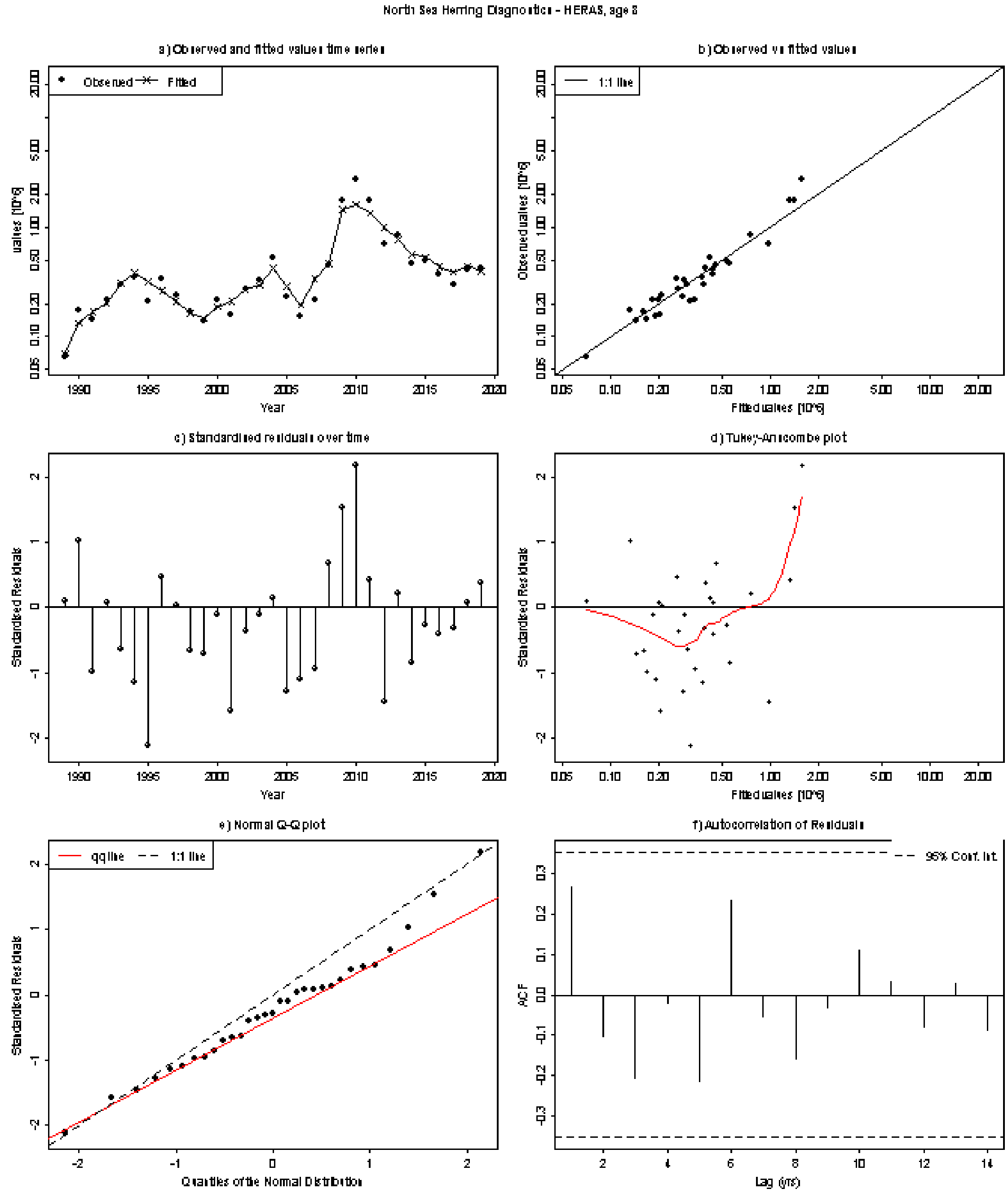
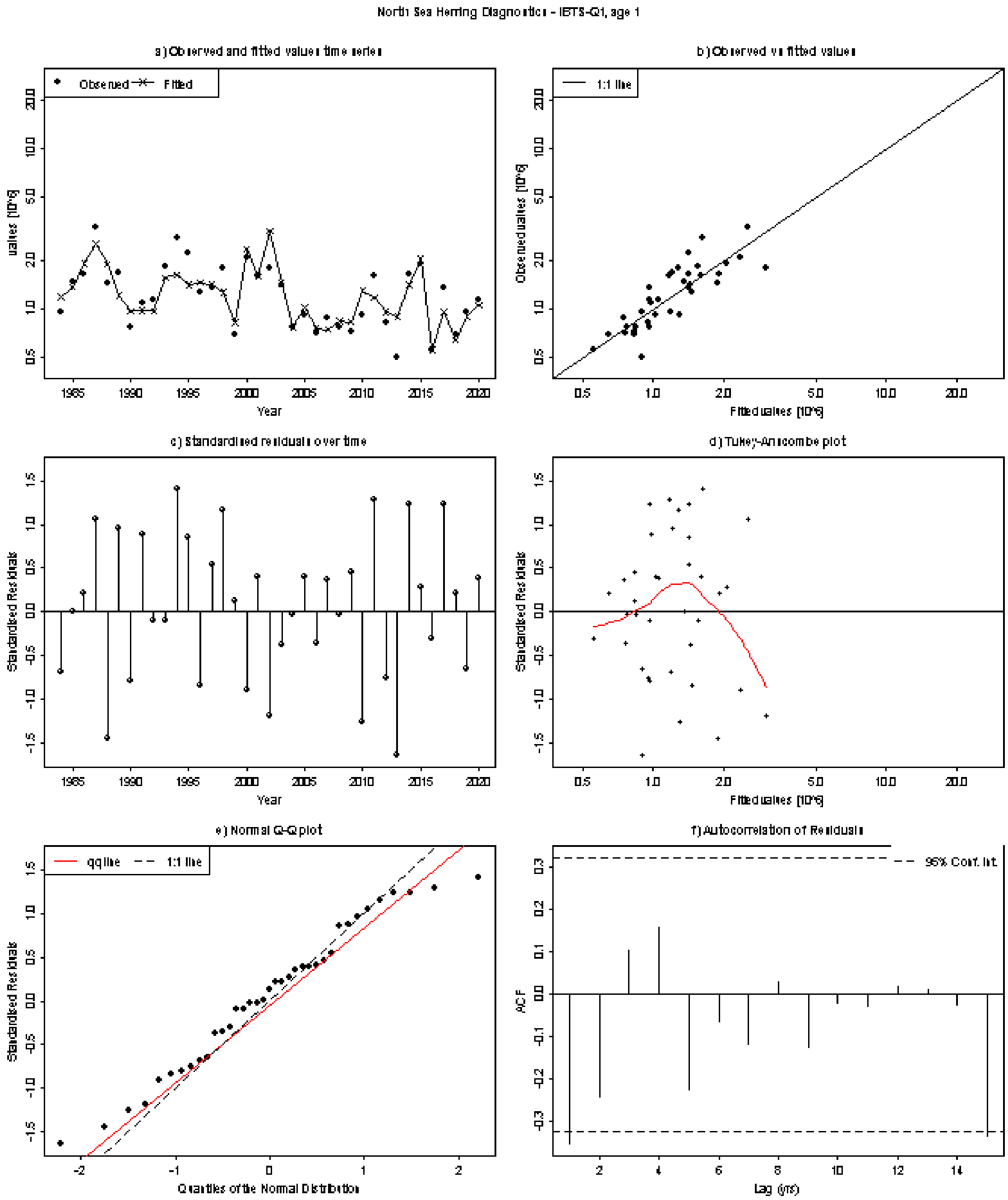


Figure 2.6.1.23. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 8+ wr time-series. Top left: Estimates of numbers at 8+ wr (line) and numbers predicted from index abundance at 8+ wr. Top right: scatter-plot of index observations vs. assessment model estimates of numbers at 8+ wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - IBTS-Q1, age 1
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

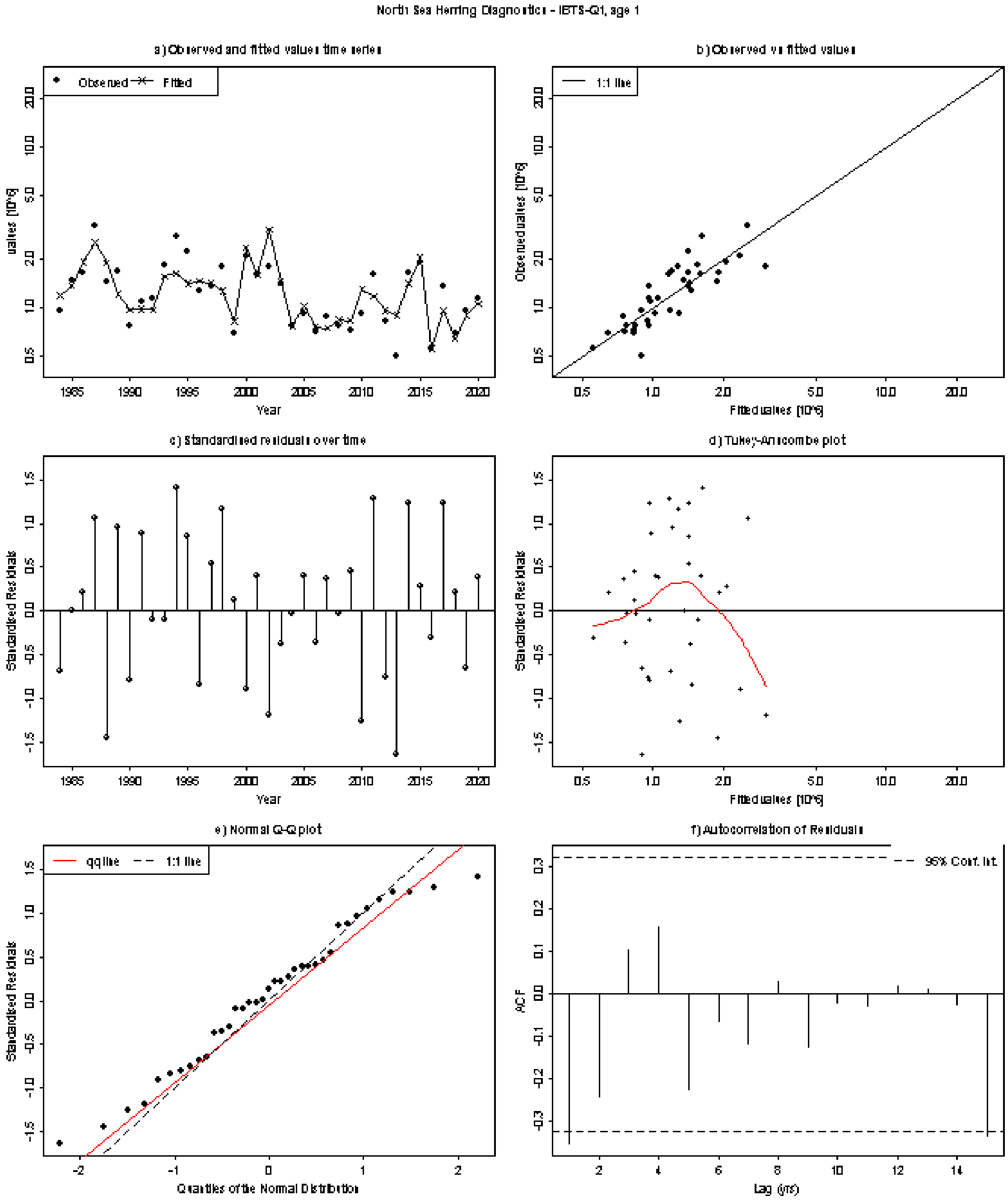
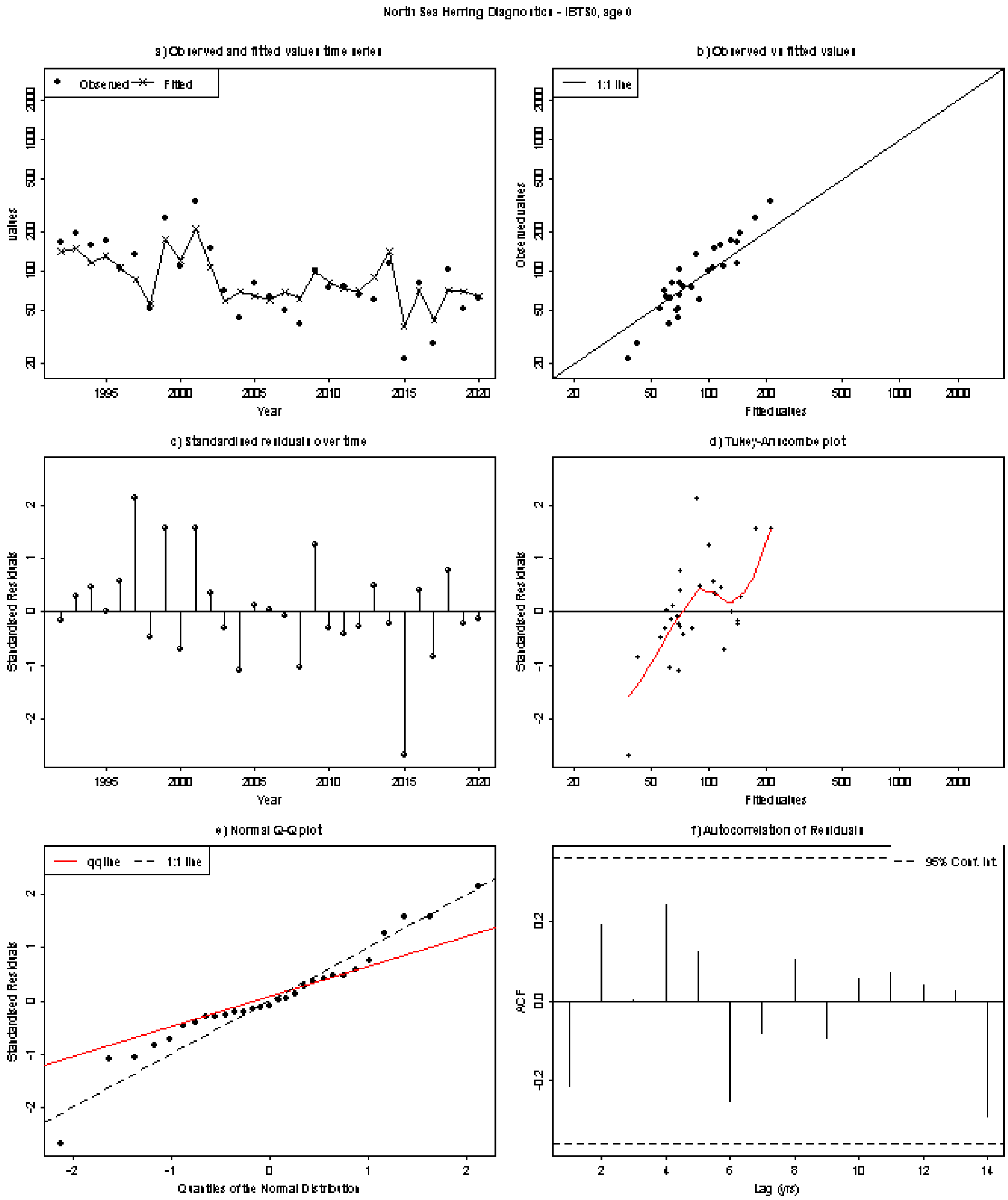


Figure 2.6.1.24. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q1 index at age 1 wr time-series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - IBTS0, age 0
a) Observed and fitted values time series
Observed
Fitted
values
Year
b) Observed vs fitted values
1:1 line
Observed values
Fitted values
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

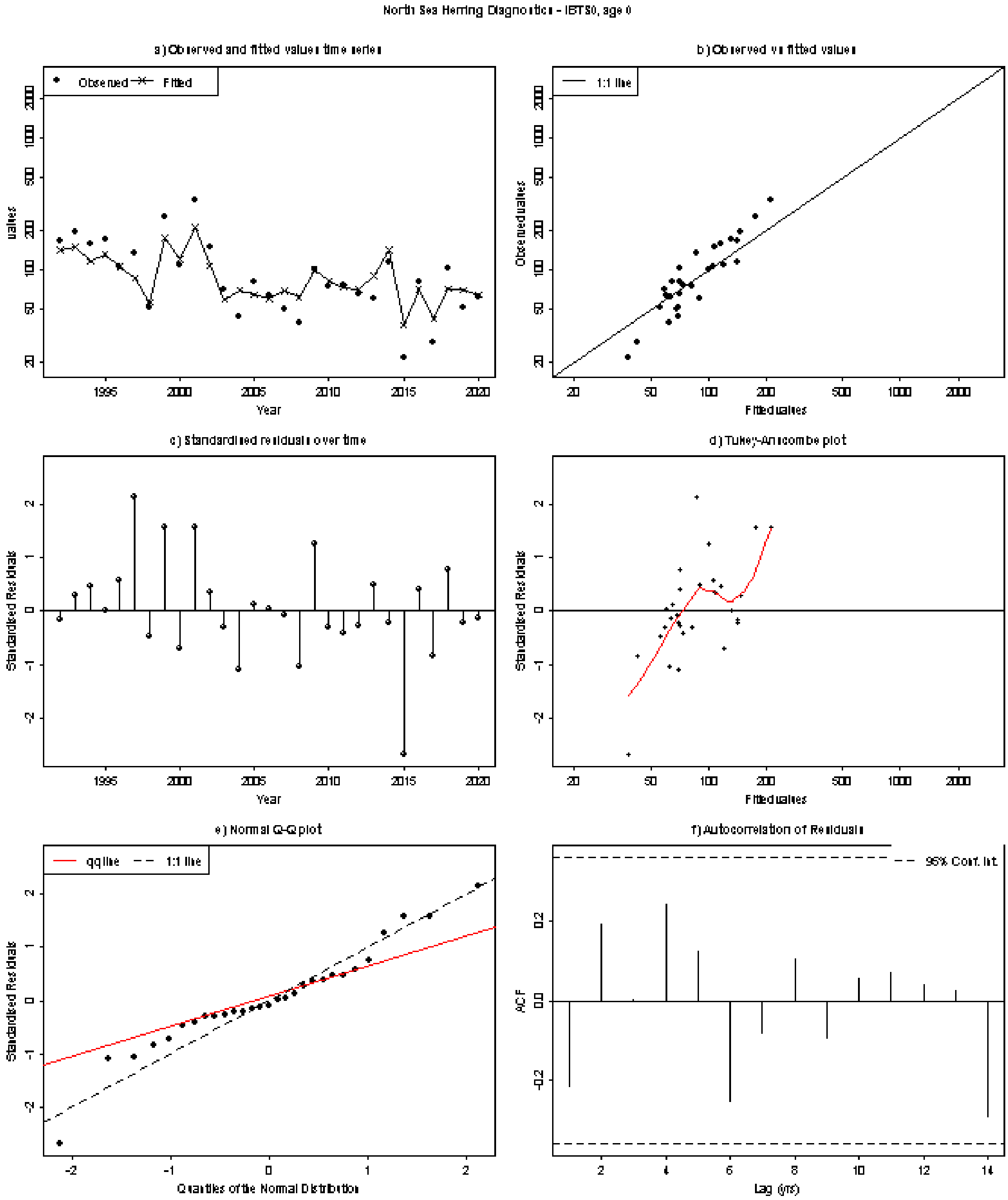


Figure 2.6.1.25. North Sea herring. Diagnostics of the assessment model fit to the IBTS0 index at age 0 wr time-series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.

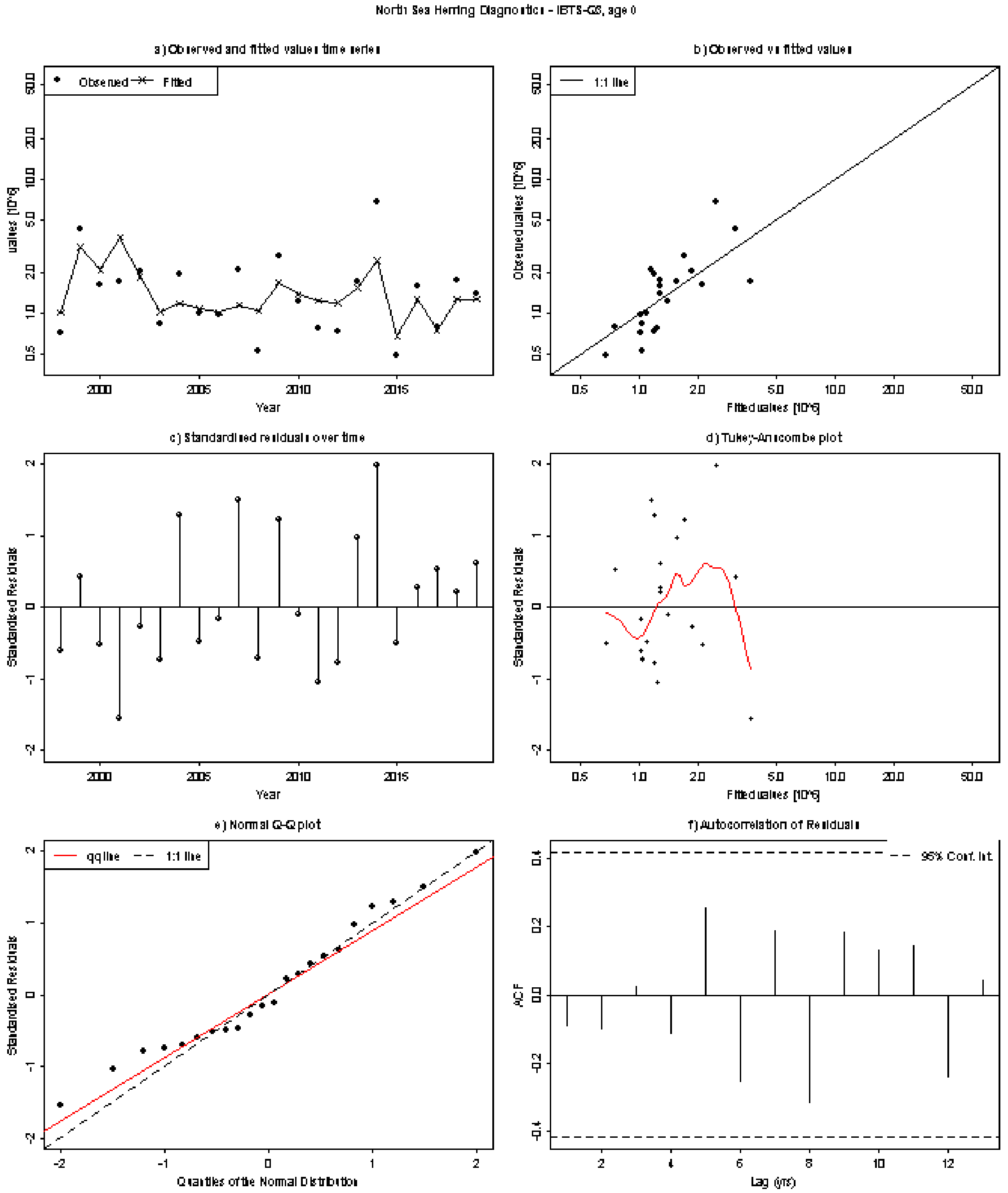


Figure 2.6.1.26. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q3 index at age 0 wr time-series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers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

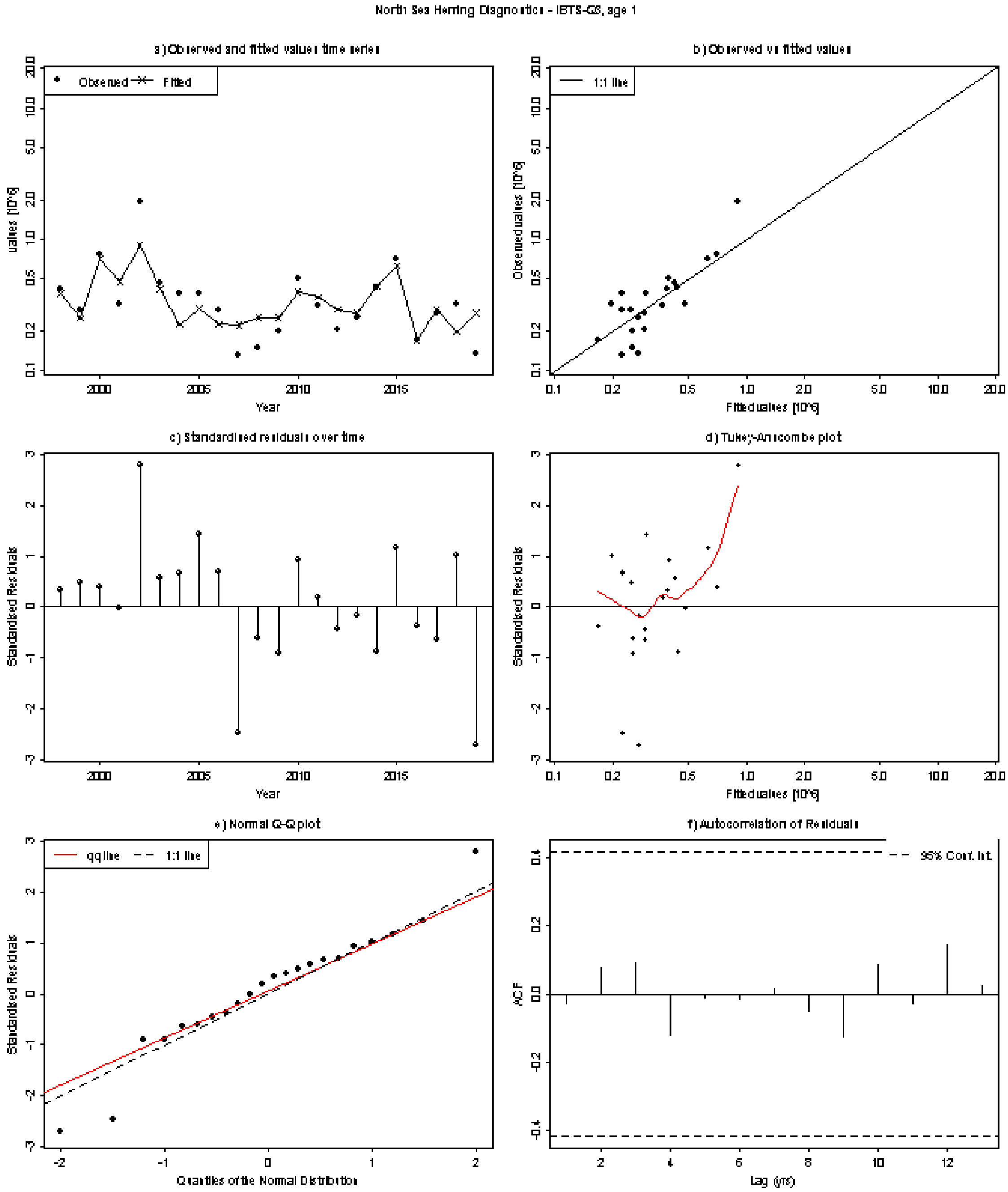


Figure 2.6.1.27. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q3 index at age 1 wr time-series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.

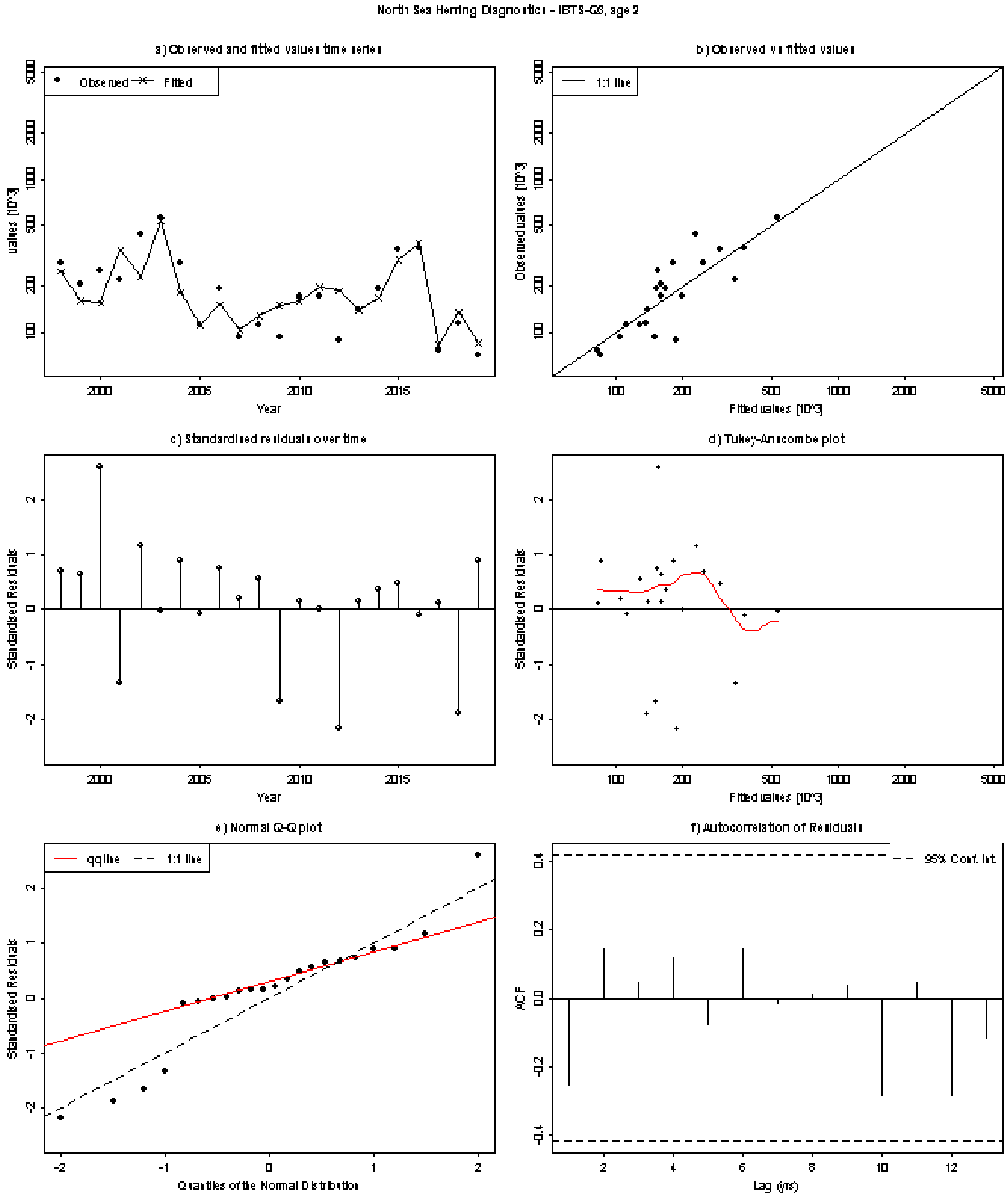


Figure 2.6.1.28. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q3 index at age 2 wr time-series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.

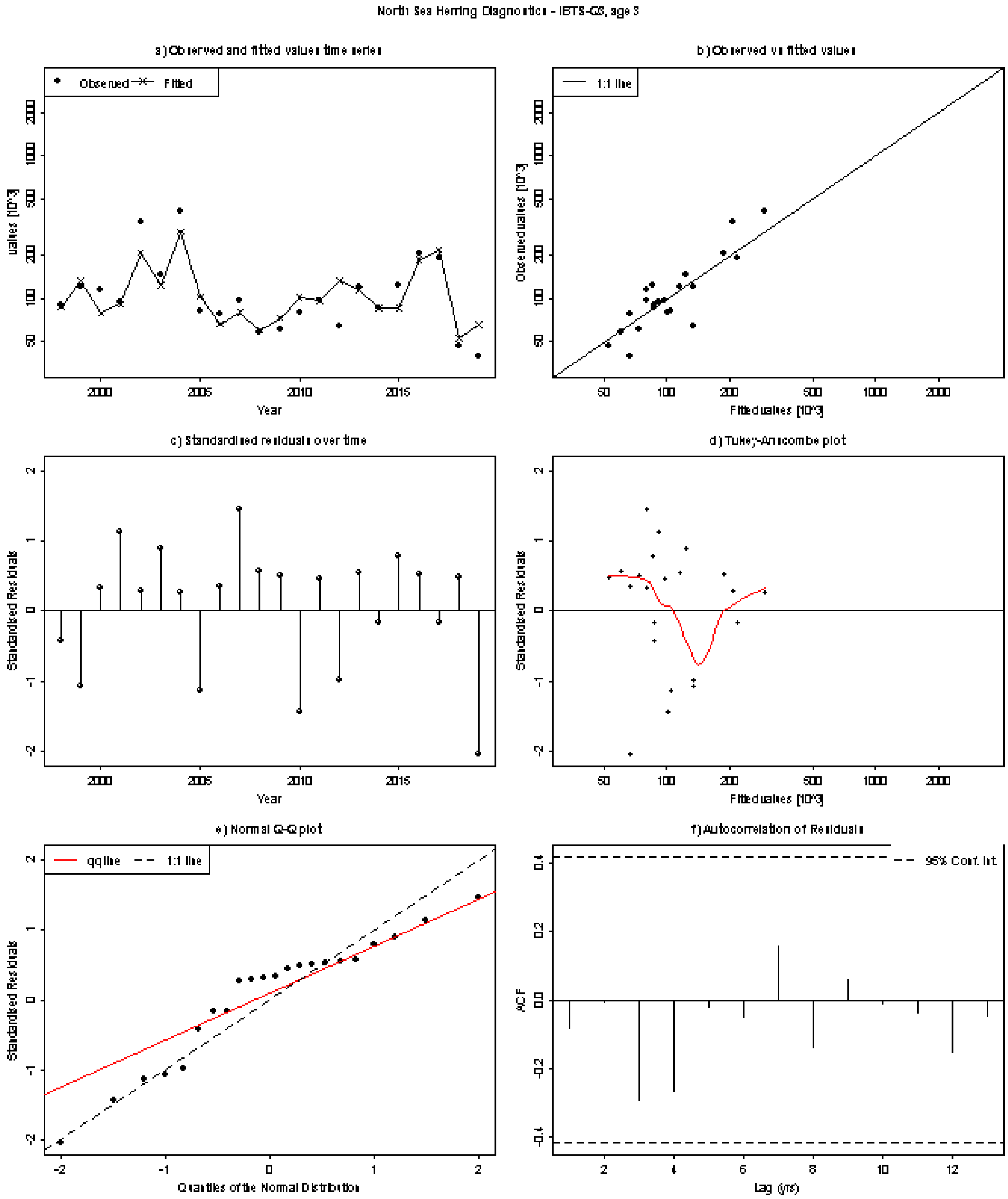


Figure 2.6.1.29. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q3 index at age 3 wr time-series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.

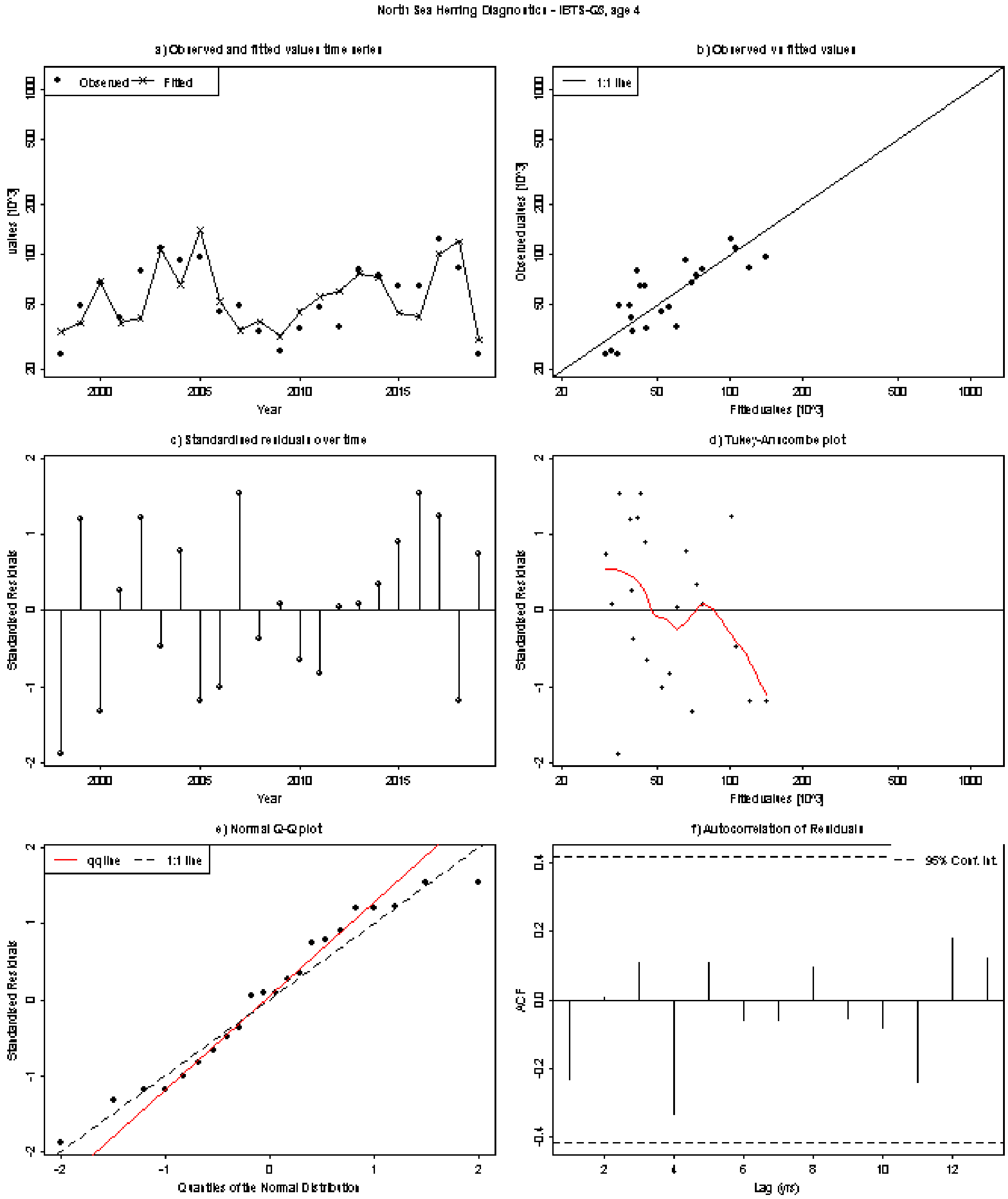


Figure 2.6.1.30. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q3 index at age 4 wr time-series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.

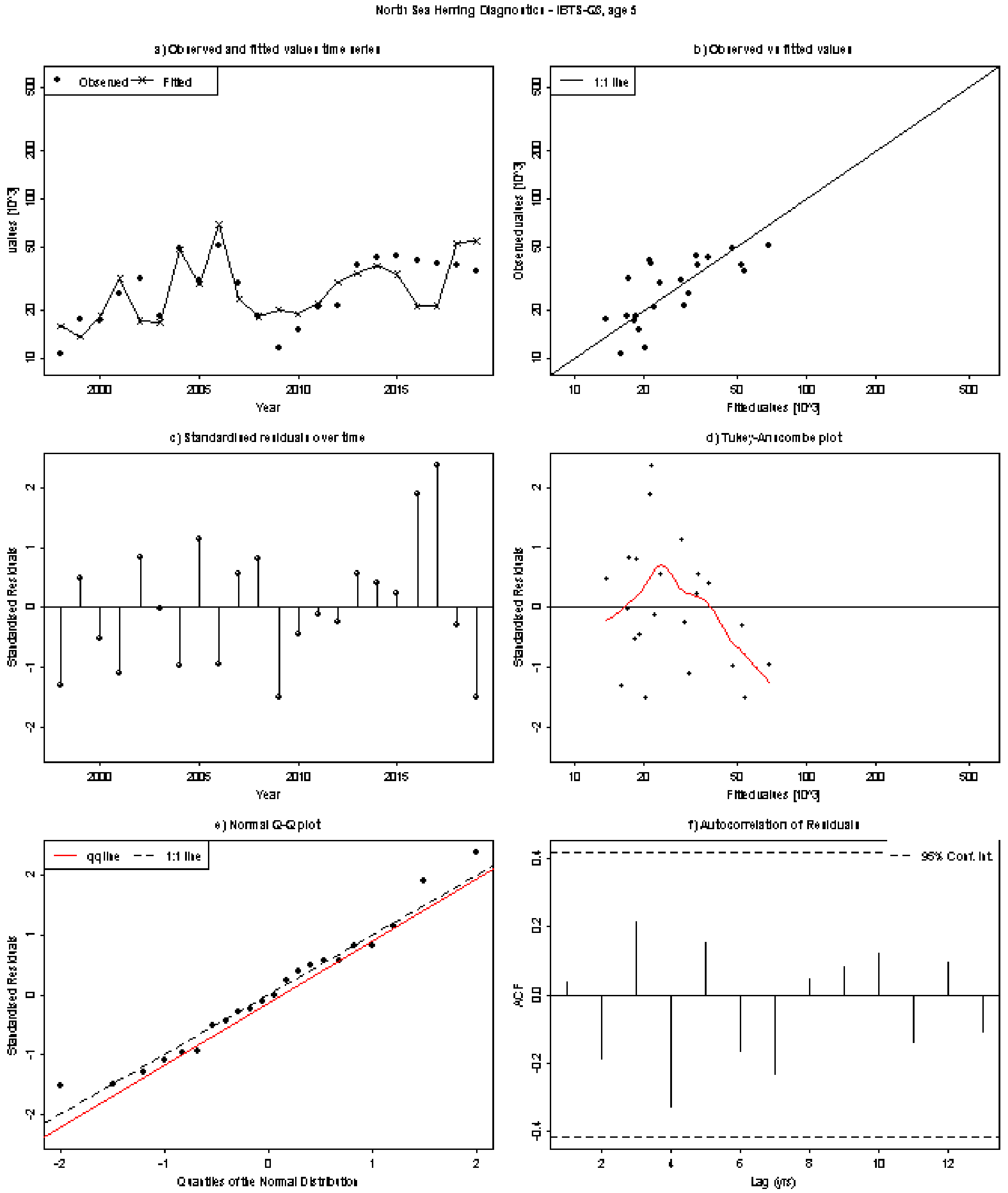
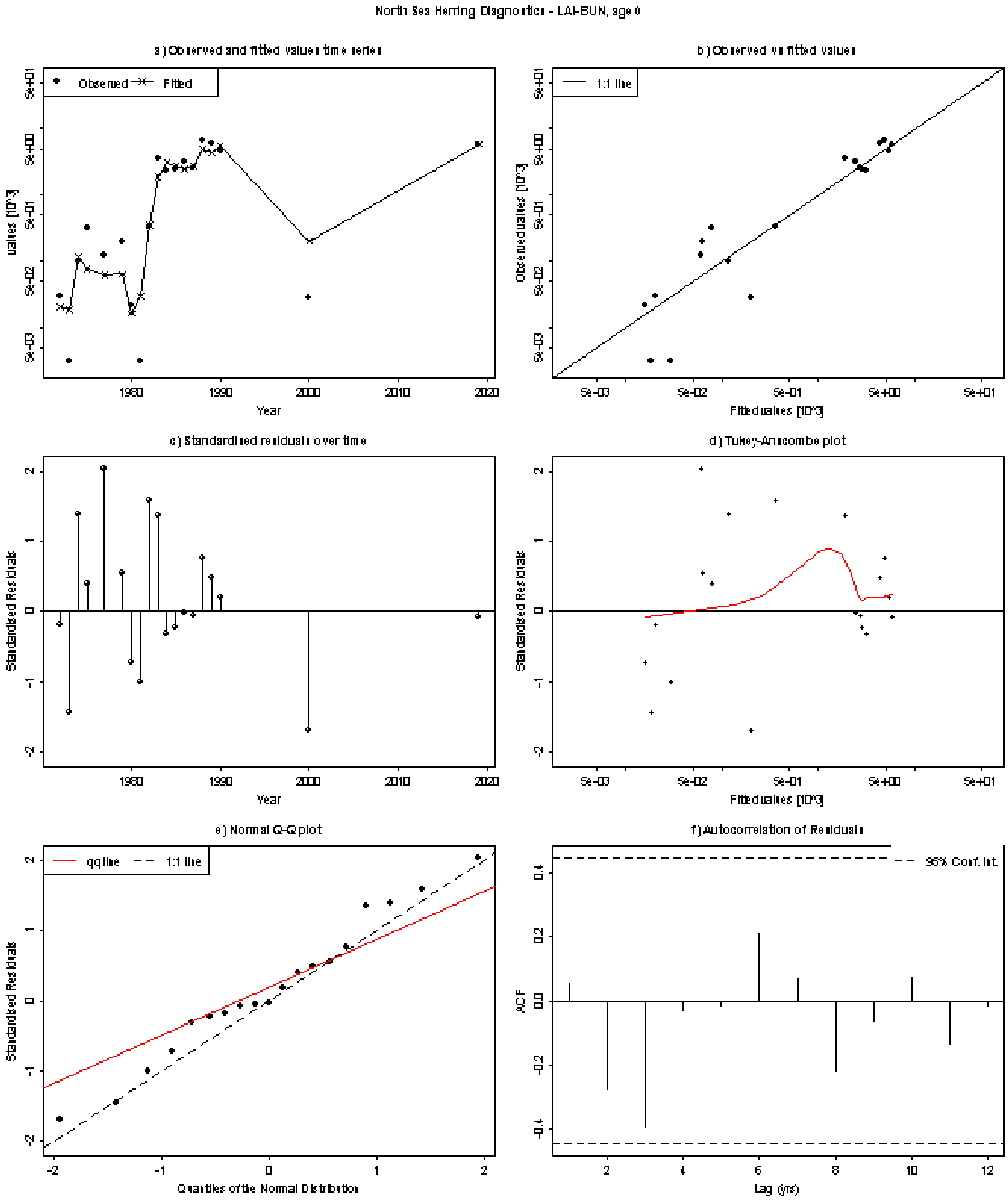


Figure 2.6.1.31. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q3 index at age 5 wr time-series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - LAI-BUN, age 0
a) Observed and fitted values time series
Observed
Fitted
values [10^3]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^3]
Fitted values [10^3]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^3]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

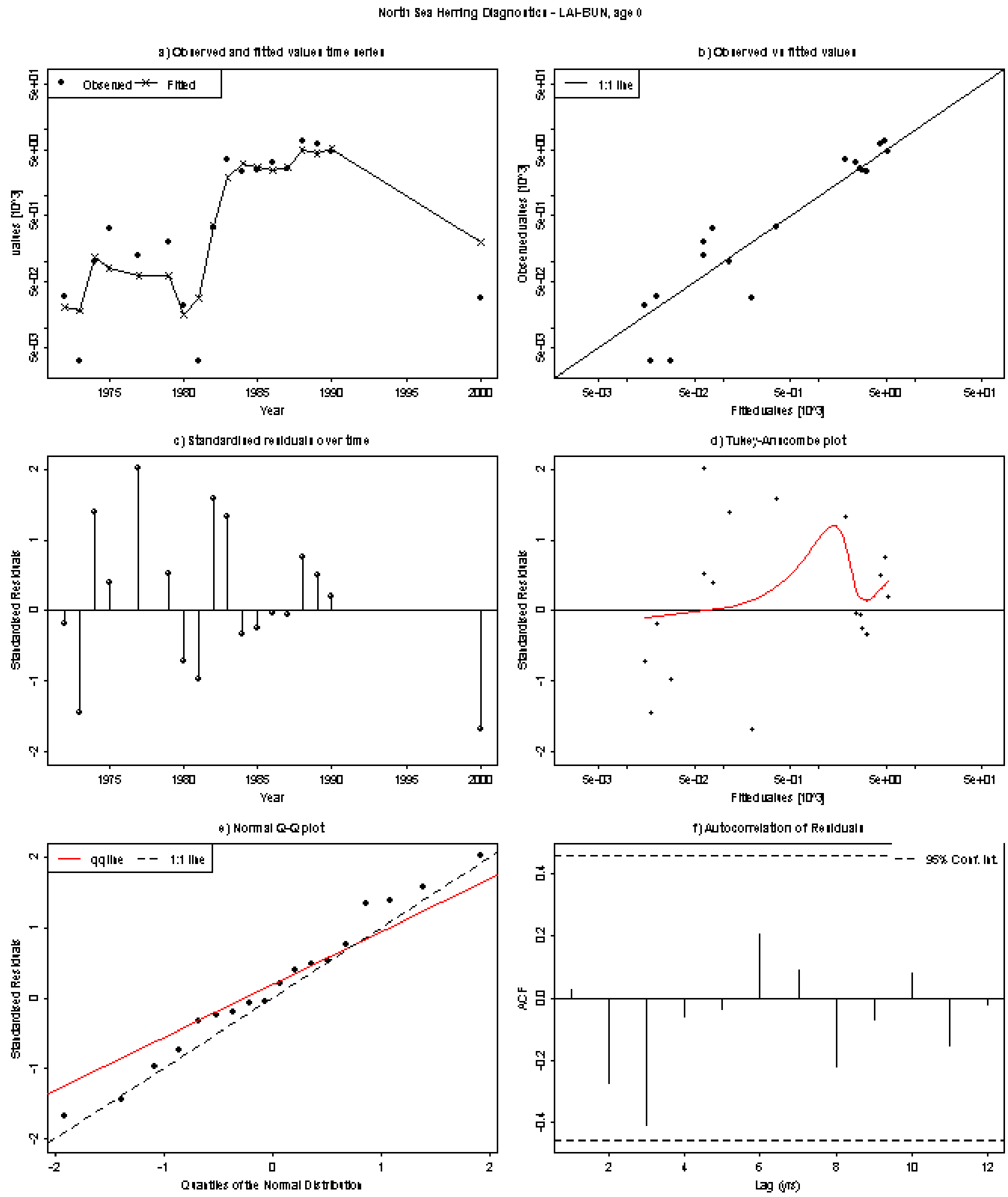
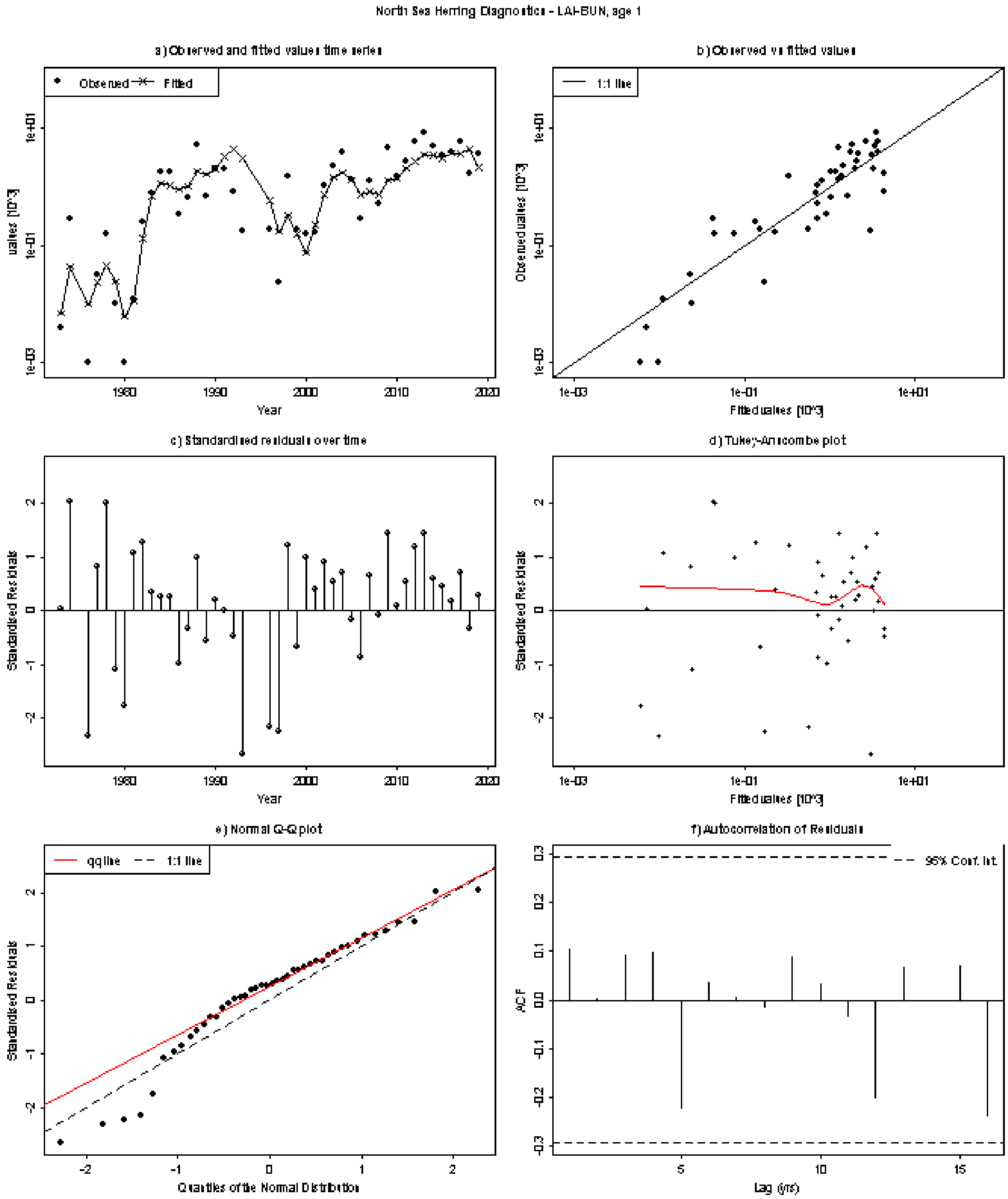


Figure 2.6.1.32. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Buchan area for the first week time-series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index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


North Sea Herring Diagnostics - LAI-BUN, age 1
a) Observed and fitted values time series
Observed
Fitted
b) Observed vs fitted values
1:1 line
c) Standardised residuals over time
d) Tukey-Anscombe plot
e) Normal Q-Q plot
qq line
1:1 line
f) Autocorrelation of Residuals
95% Conf. Int.
Year
Fitted values [10^3]
Observed values [10^3]
Standardised Residuals
Quantiles of the Normal Distribution
Lag (yrs)
ACF

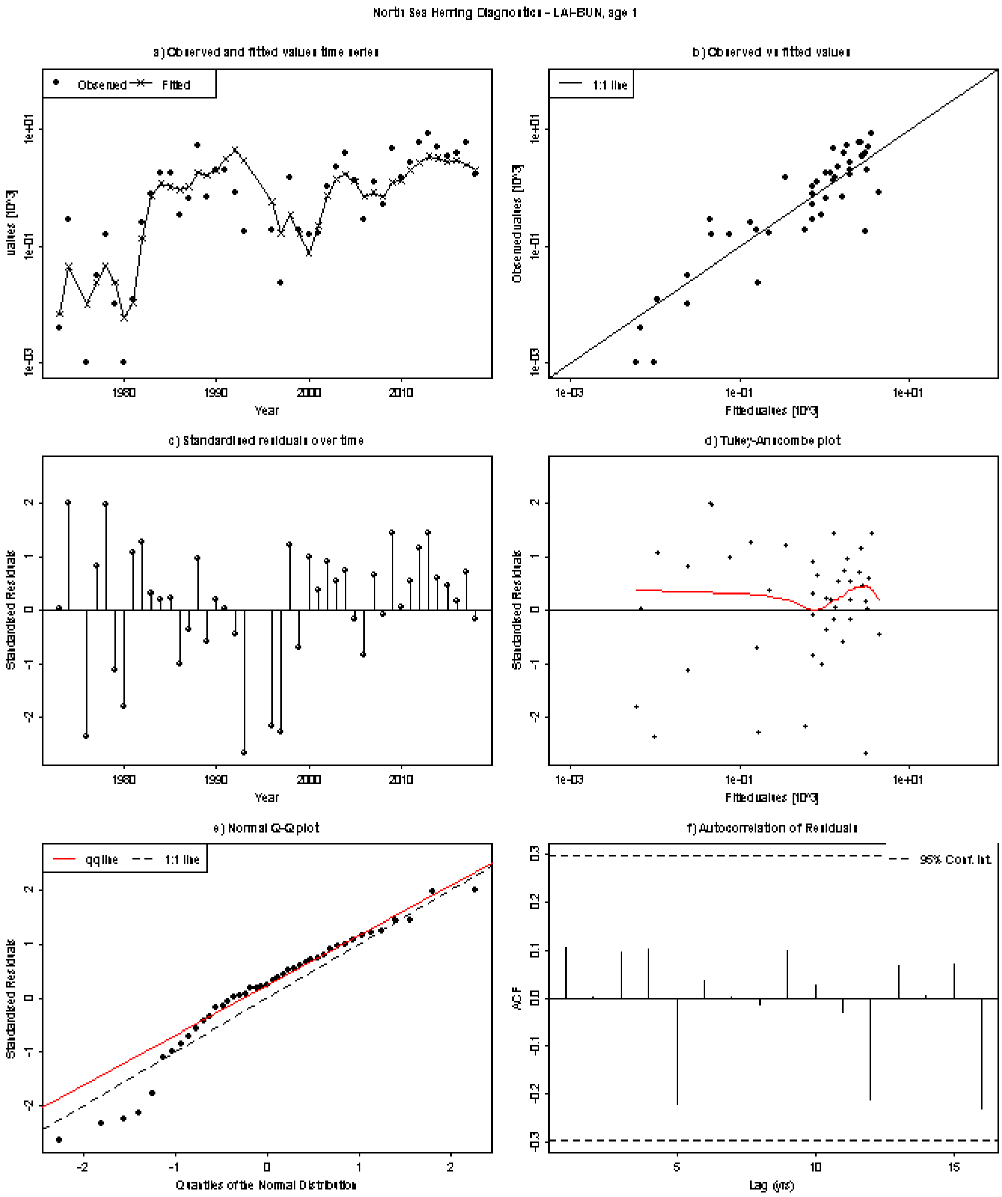
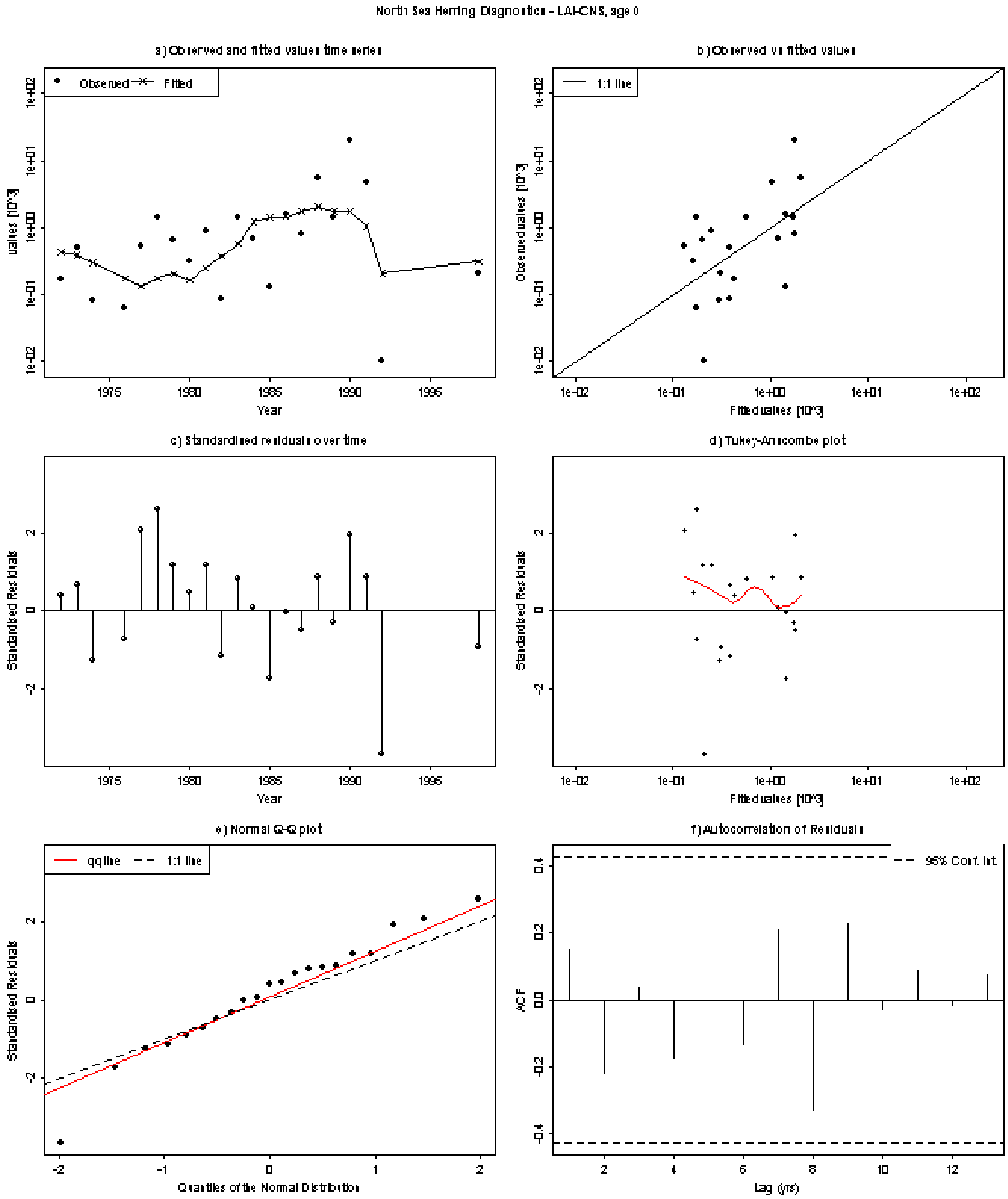


Figure 2.6.1.33. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Buchan area for the second week time-series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - LAI-CNS, age 0
a) Observed and fitted values time series
b) Observed vs fitted values
c) Standardised residuals over time
d) Tukey-Anscombe plot
e) Normal Q-Q plot
f) Autocorrelation of Residuals
Observed
Fitted
1:1 line
qq line
95% Conf. Int.
Year
Fitted values [10^3]
Observed values [10^3]
Standardised Residuals
Quantiles of the Normal Distribution
Lag (yrs)
ACF

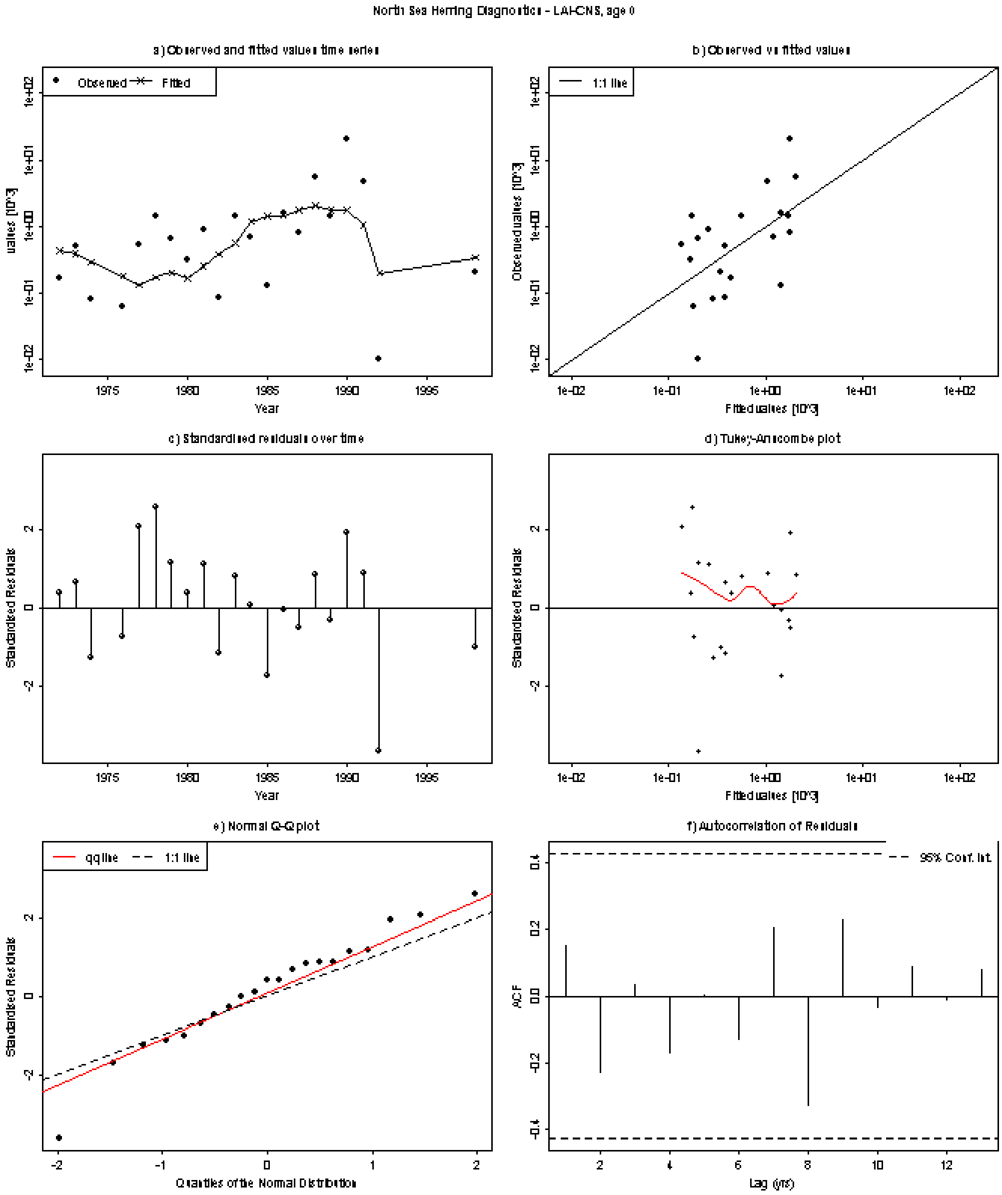
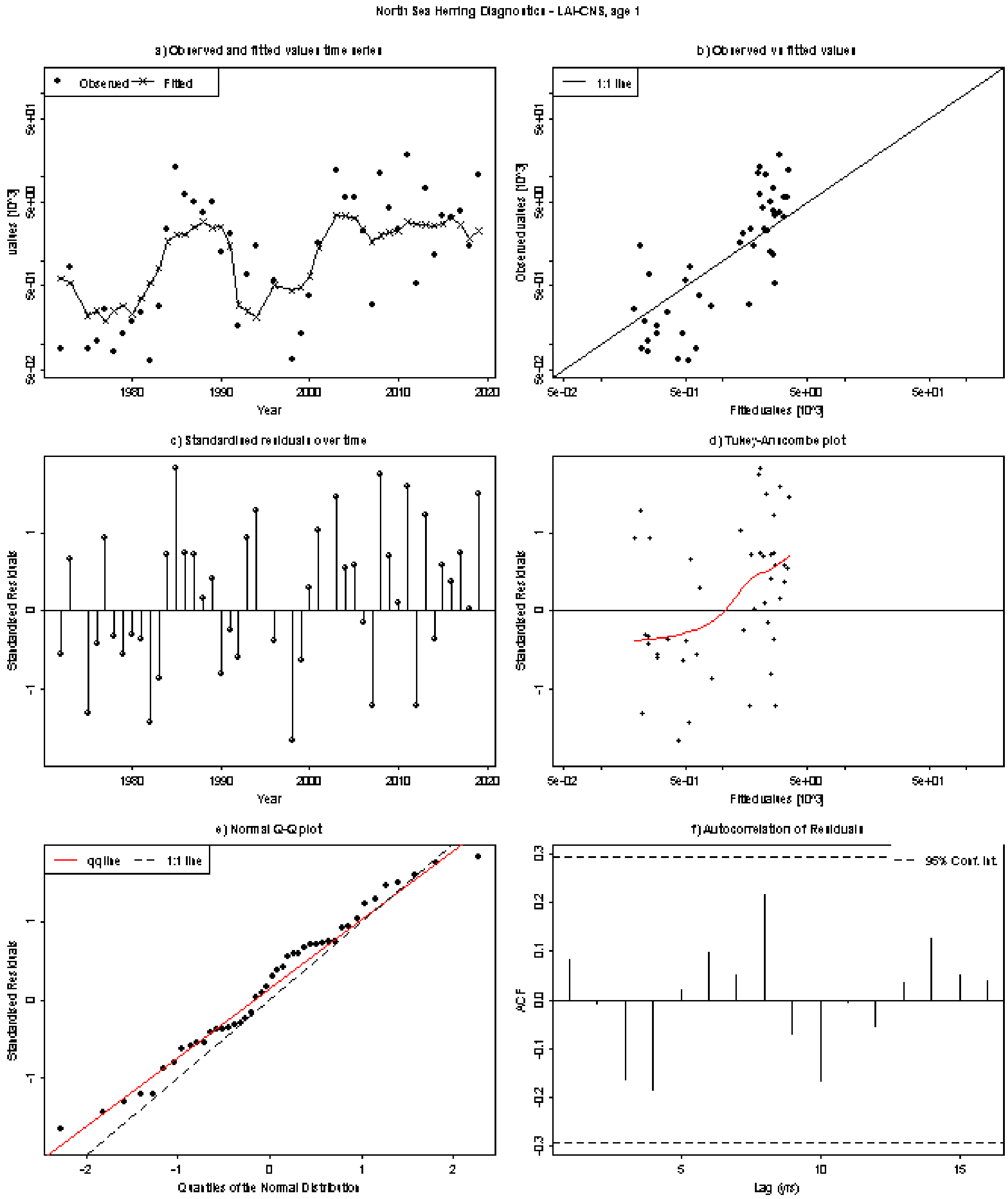


Figure 2.6.1.34. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Banks area for the first week time-series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index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


North Sea Herring Diagnostics - LAI-CNS, age 1
a) Observed and fitted values time series
Observed
Fitted
Year
b) Observed vs fitted values
1:1 line
Observed values [10^3]
Fitted values [10^3]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^3]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

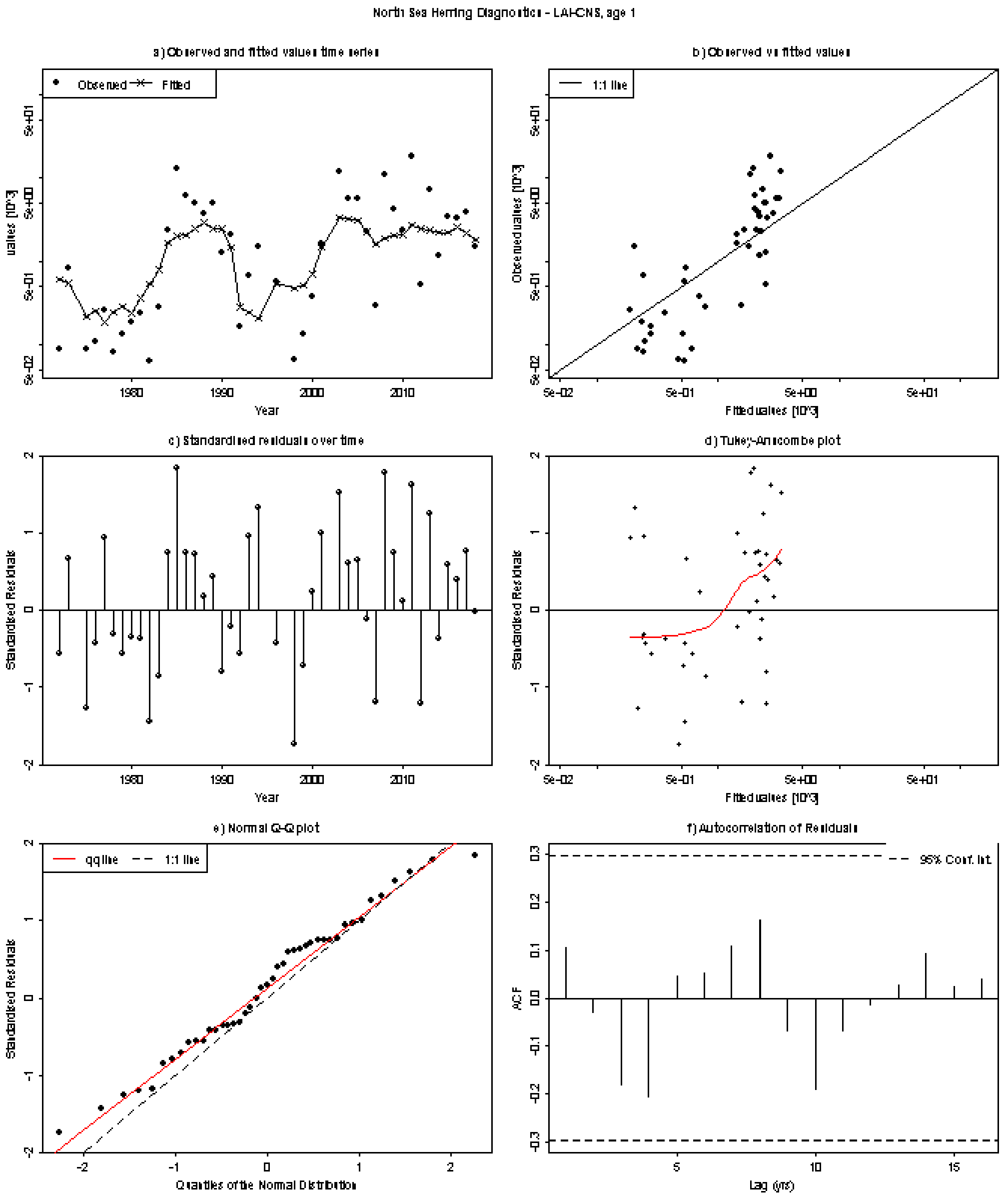
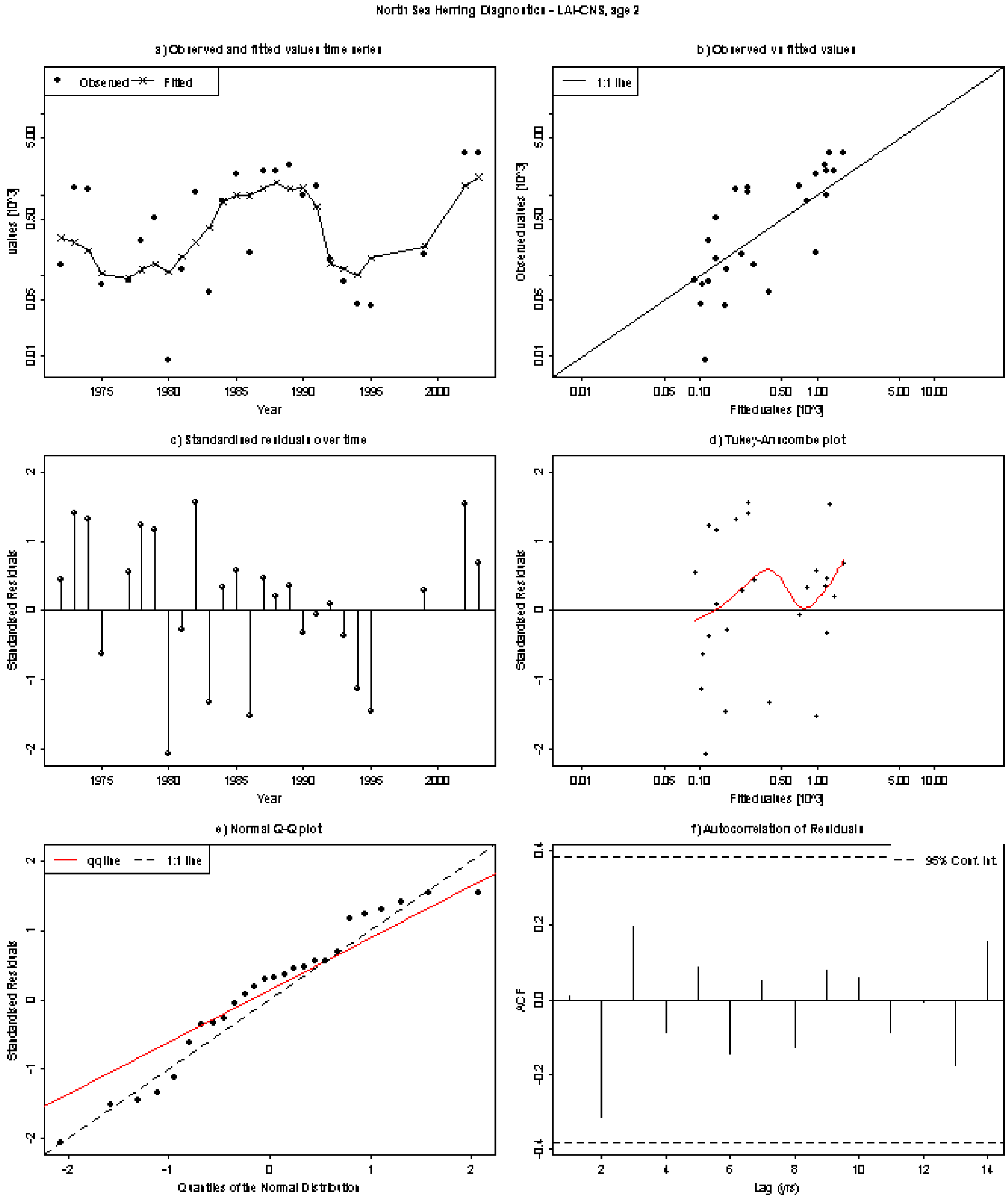


Figure 2.6.1.35. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Banks area for the second week time-series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index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


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

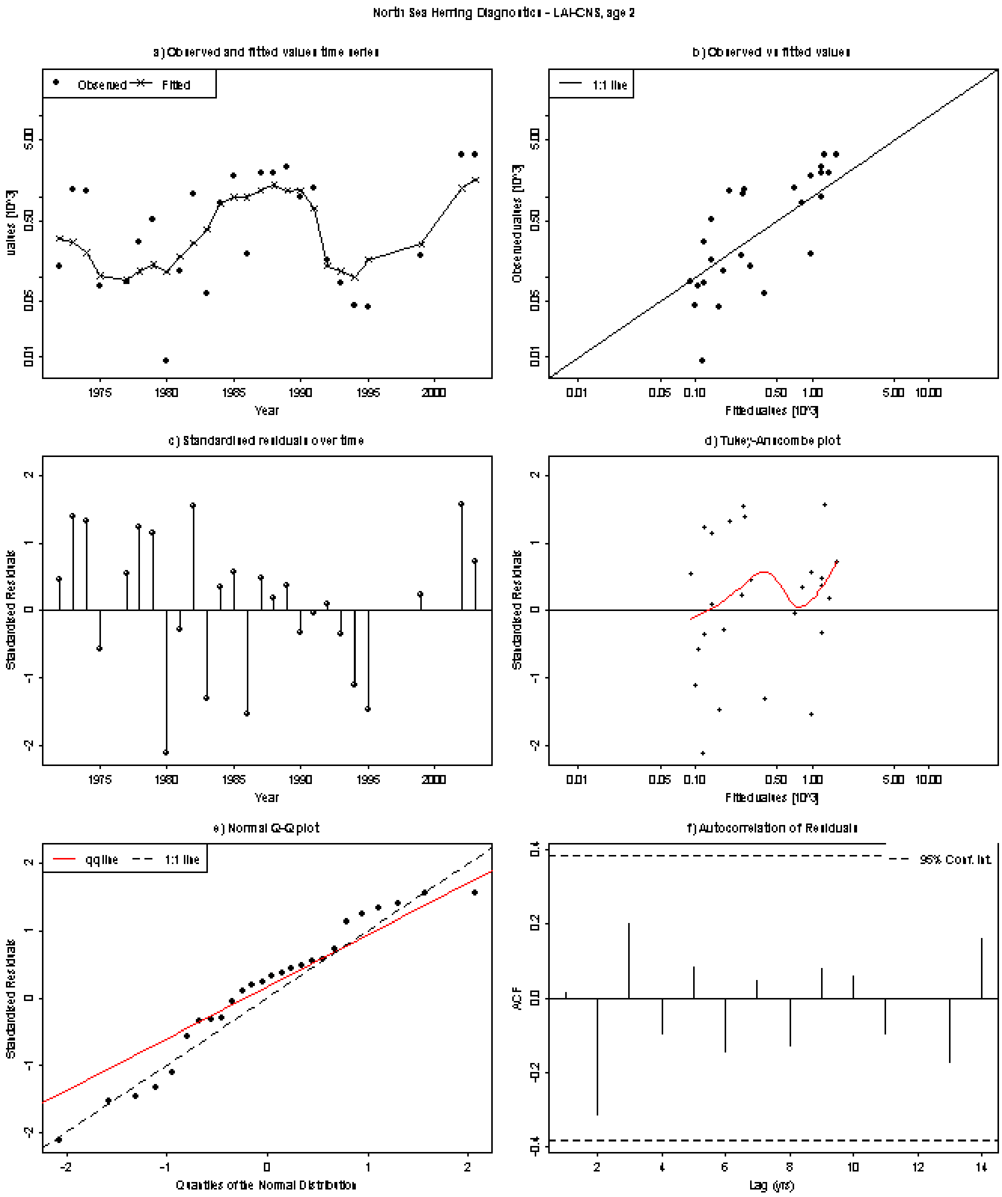
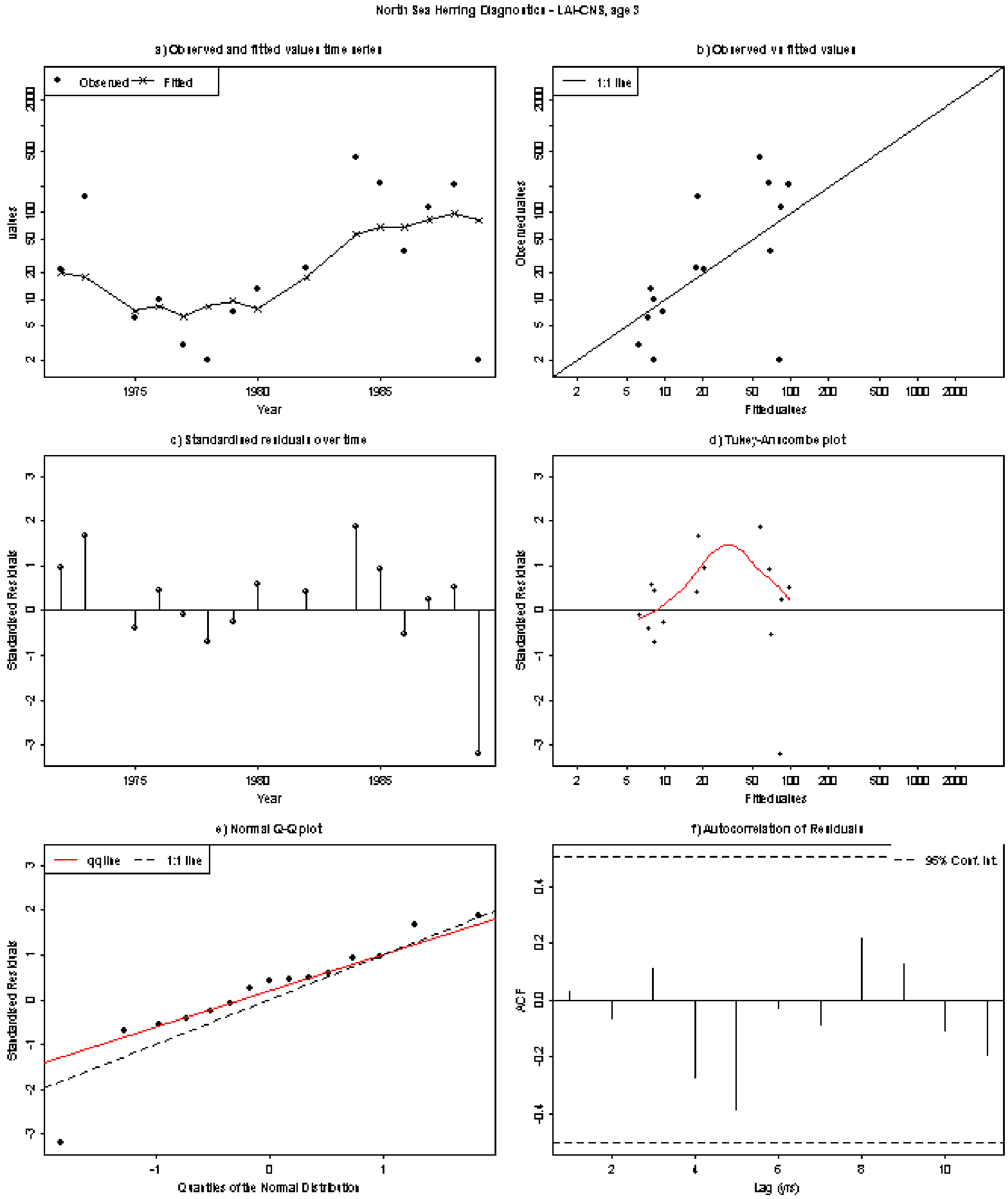


Figure 2.6.1.36. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Banks area for the third week time-series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index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



North Sea Herring Diagnostics - LAI-CNS, age 3
a) Observed and fitted values time series
Observed
Fitted
values
Year
b) Observed vs fitted values
1:1 line
Observed values
Fitted values
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

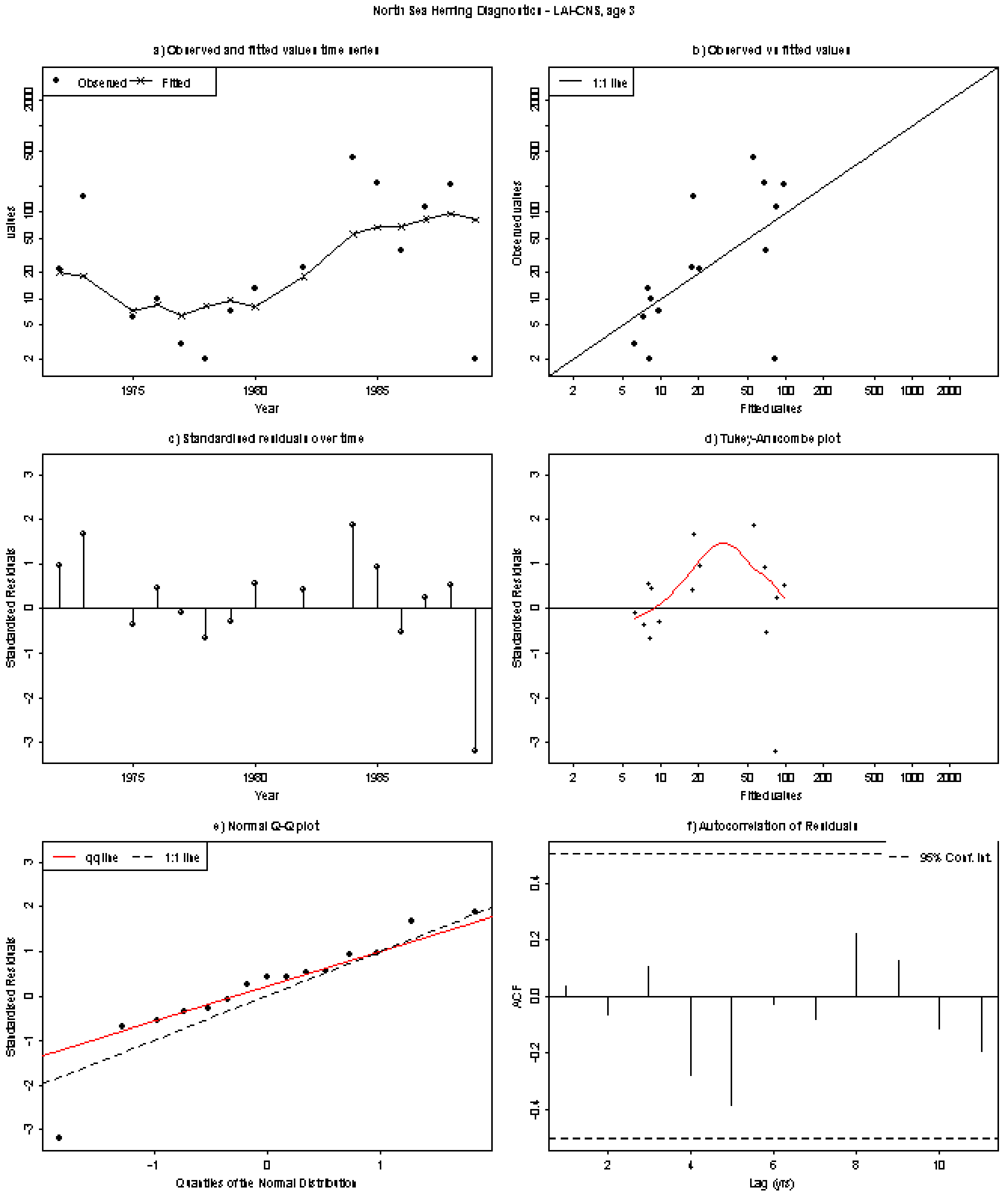
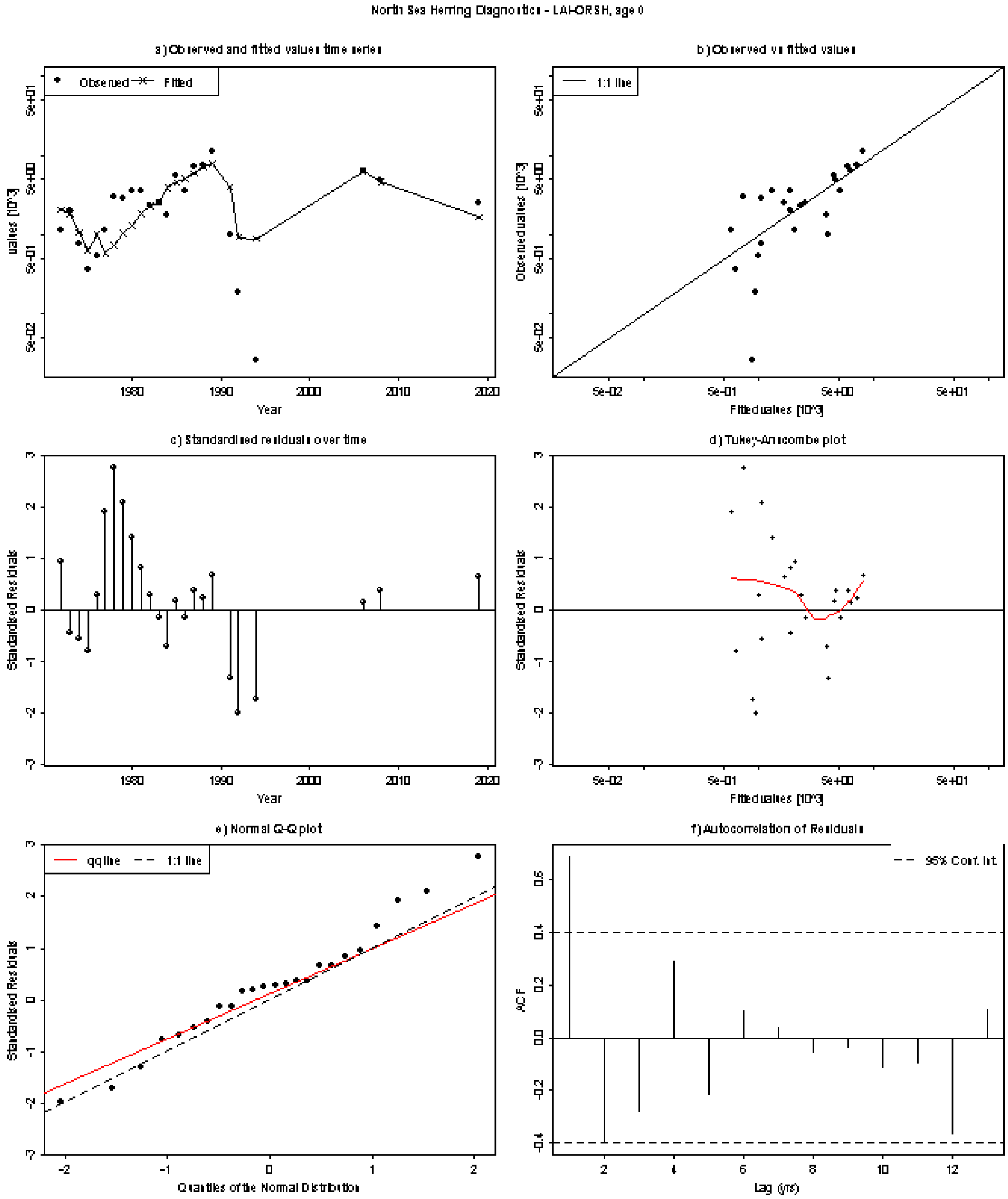


Figure 2.6.1.37. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Banks area for the fourth week time-series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - LAI-ORSH, age 0
a) Observed and fitted values time series
Observed
Fitted
values [10^3]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^3]
Fitted values [10^3]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^3]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

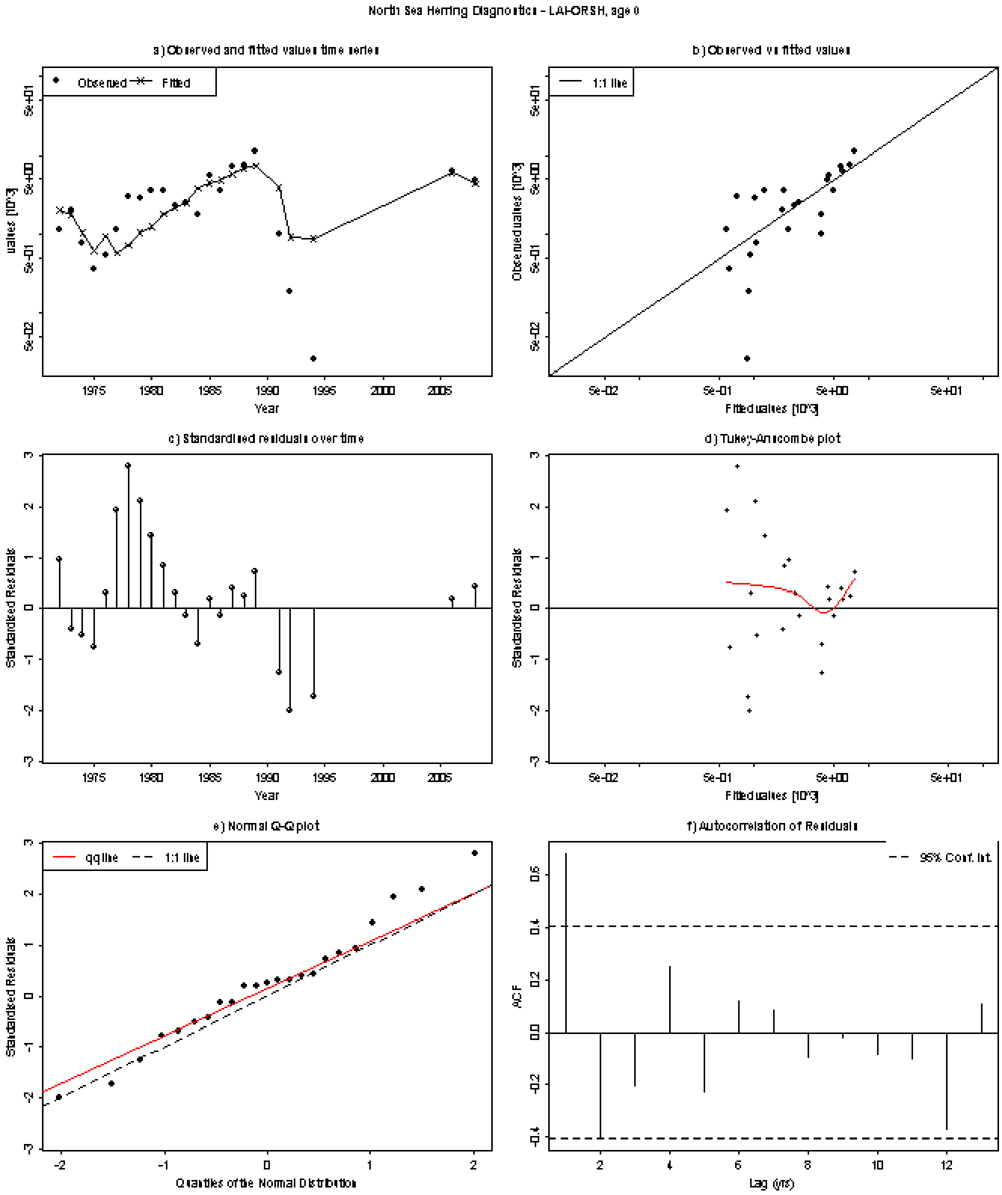
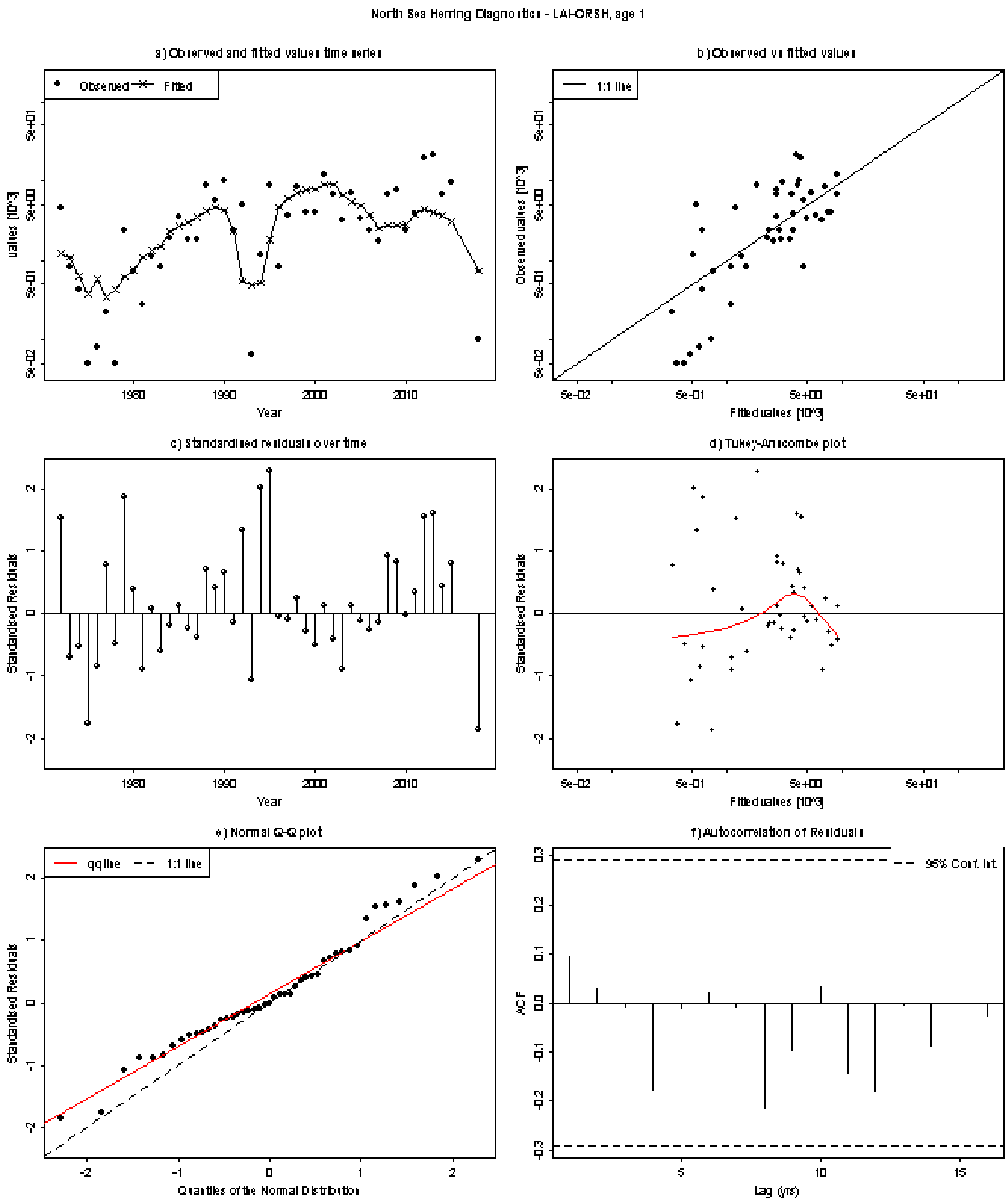


Figure 2.6.1.38. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Orkney/Shetland area for the first week time-series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot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


North Sea Herring Diagnostics - LAI-ORSH, age 1
a) Observed and fitted values time series
Observed
Fitted
values [10^3]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^3]
Fitted values [10^3]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^3]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

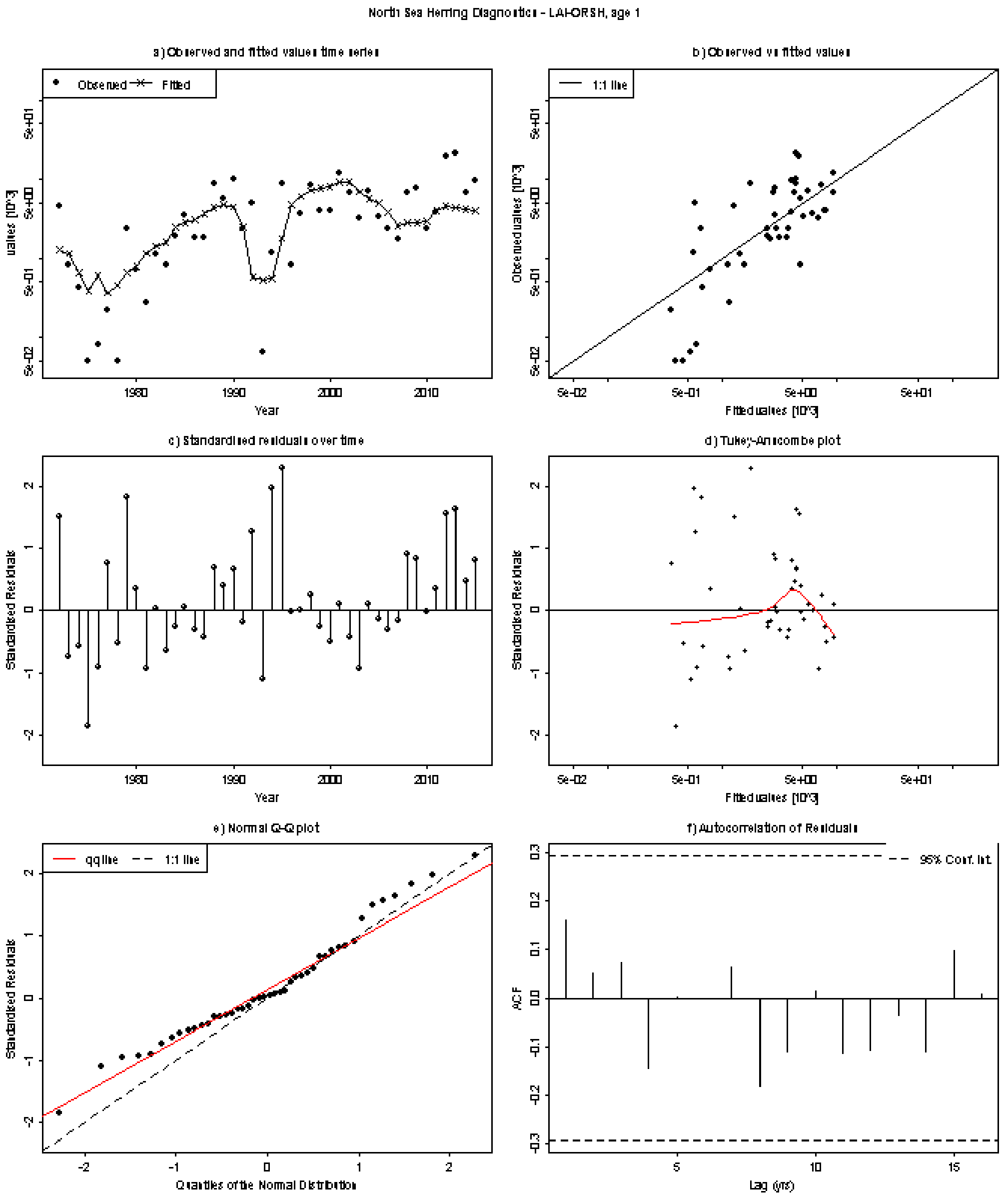
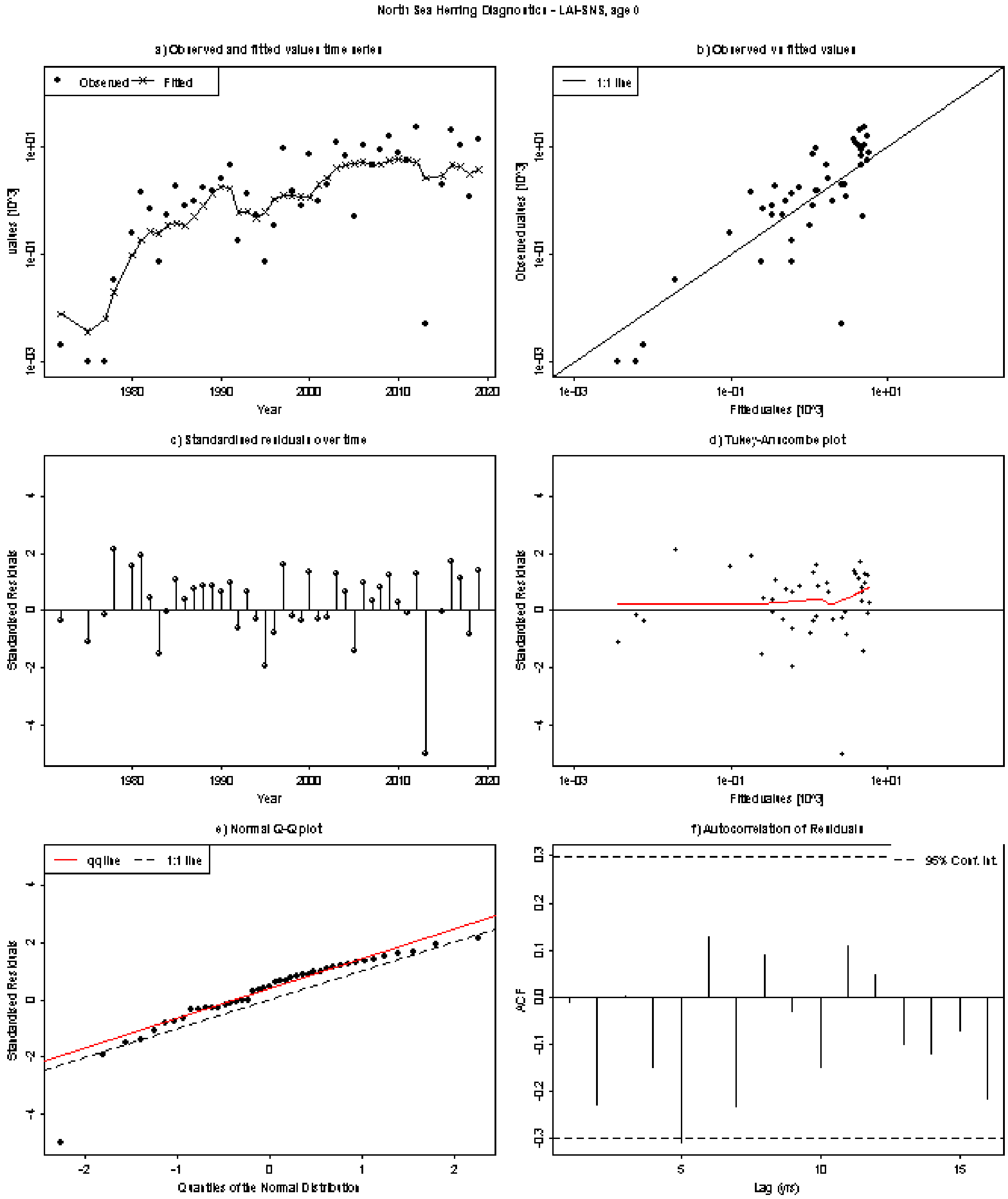


Figure 2.6.1.39. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Orkney/Shetland area for the second week time-series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.


North Sea Herring Diagnostics - LAI-SNS, age 0
a) Observed and fitted values time series
Observed Fitted
values [10^3]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^3]
Fitted values [10^3]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^3]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

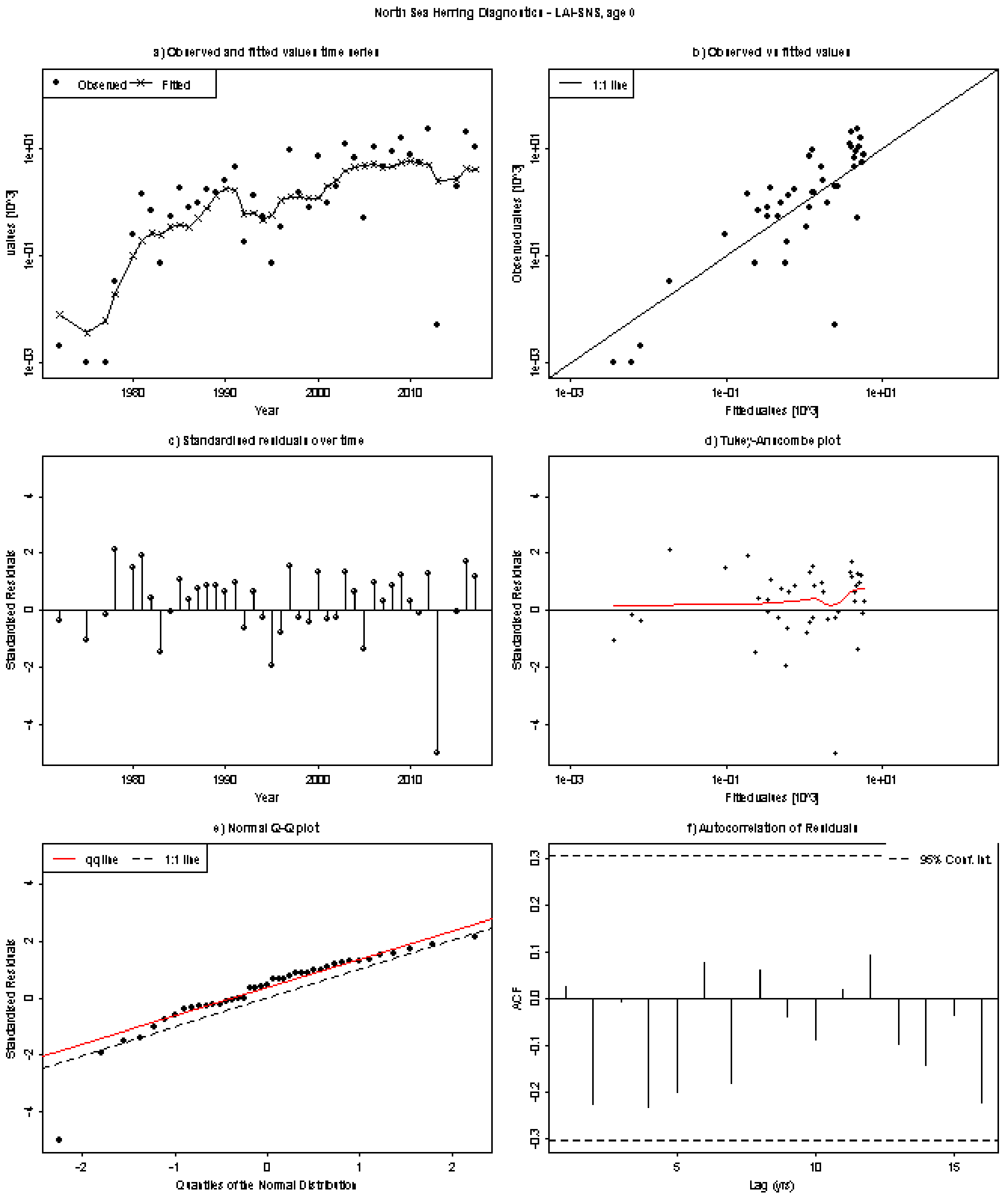
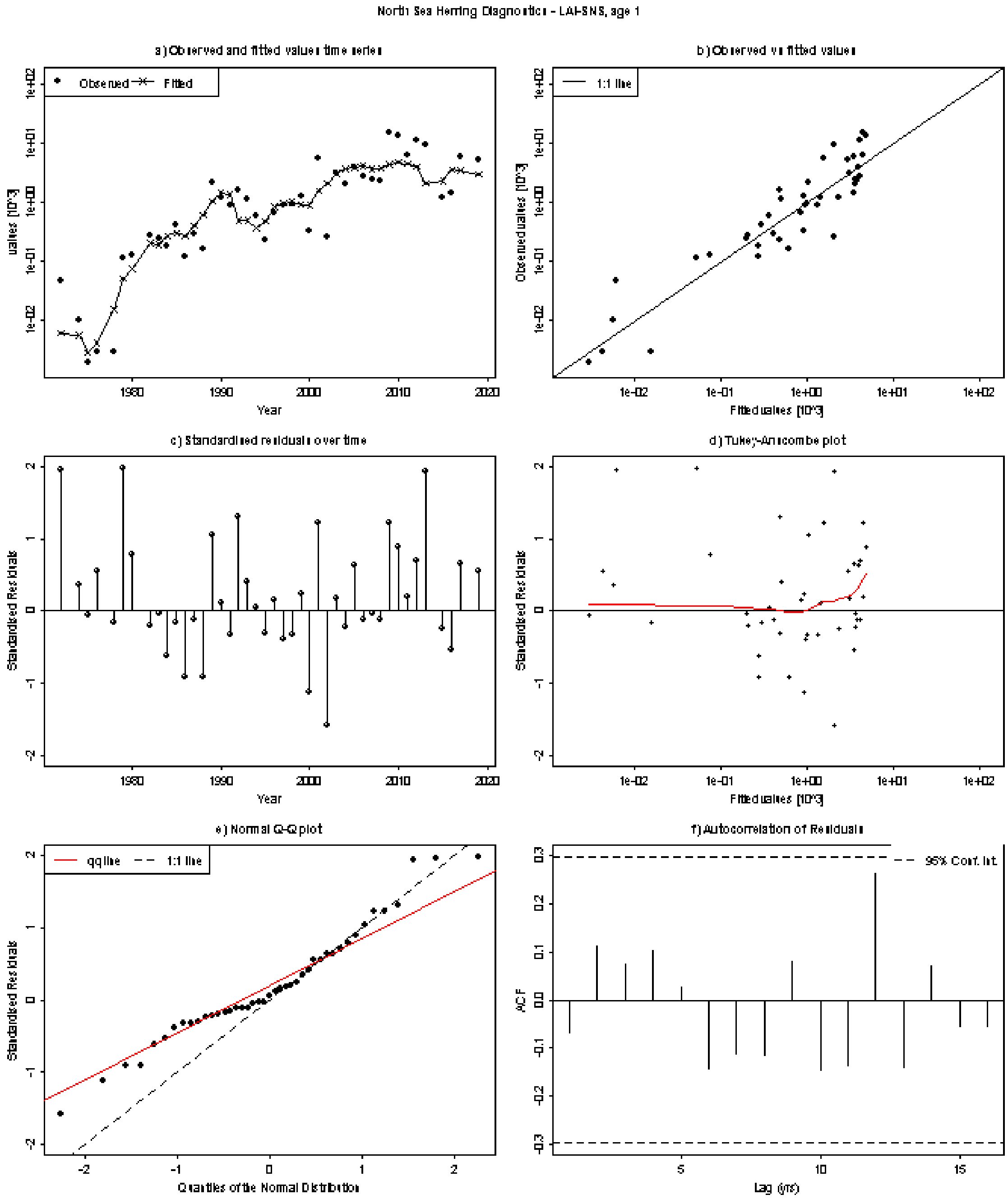


Figure 2.6.1.40. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Downs area for the first week time-series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index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


North Sea Herring Diagnostics - LAI-SNS, age 1
a) Observed and fitted values time series
Observed
Fitted
values [10^3]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^3]
Fitted values [10^3]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey-Anscombe plot
Standardised Residuals
Fitted values [10^3]
e) Normal Q-Q plot
qq line
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

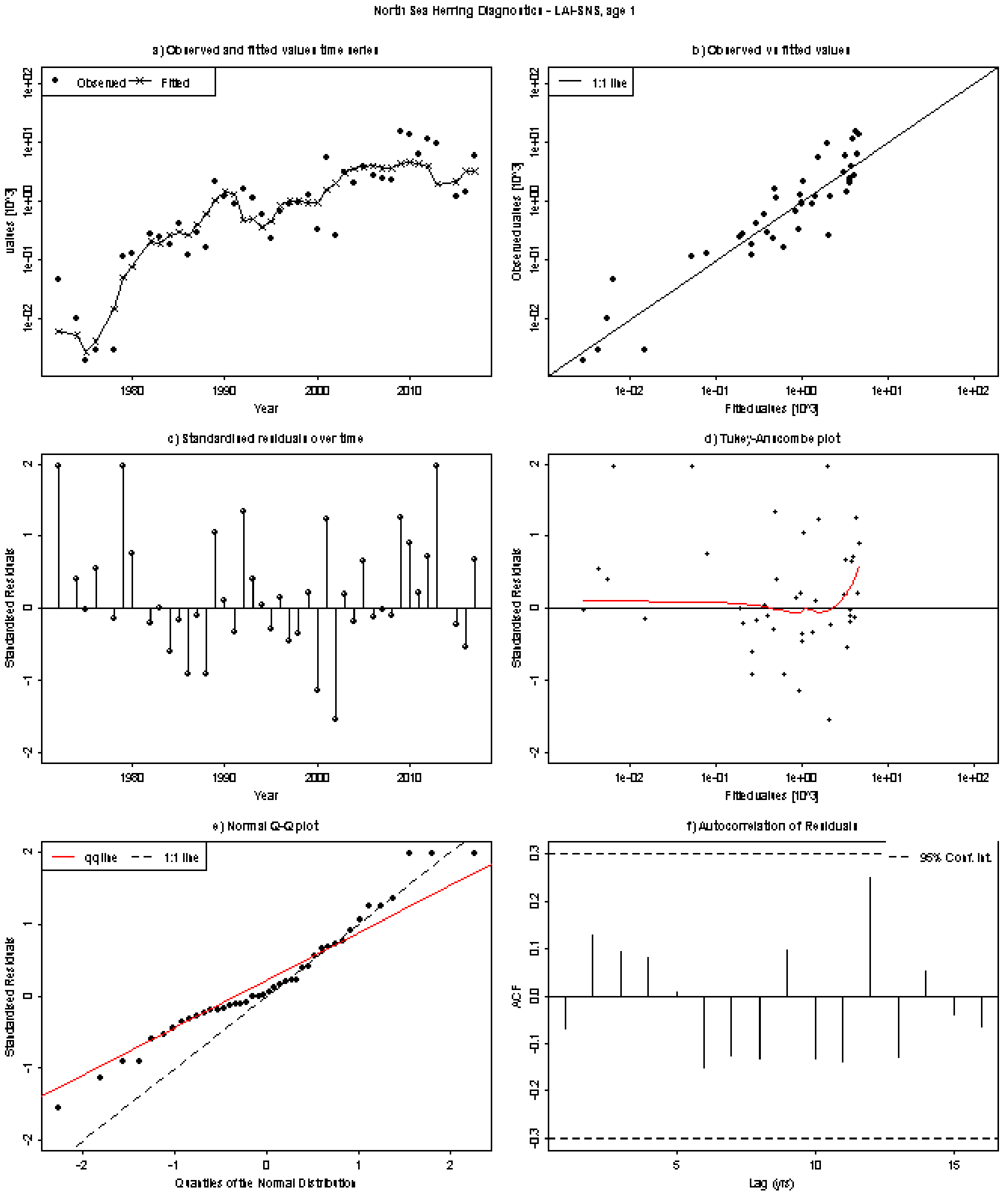
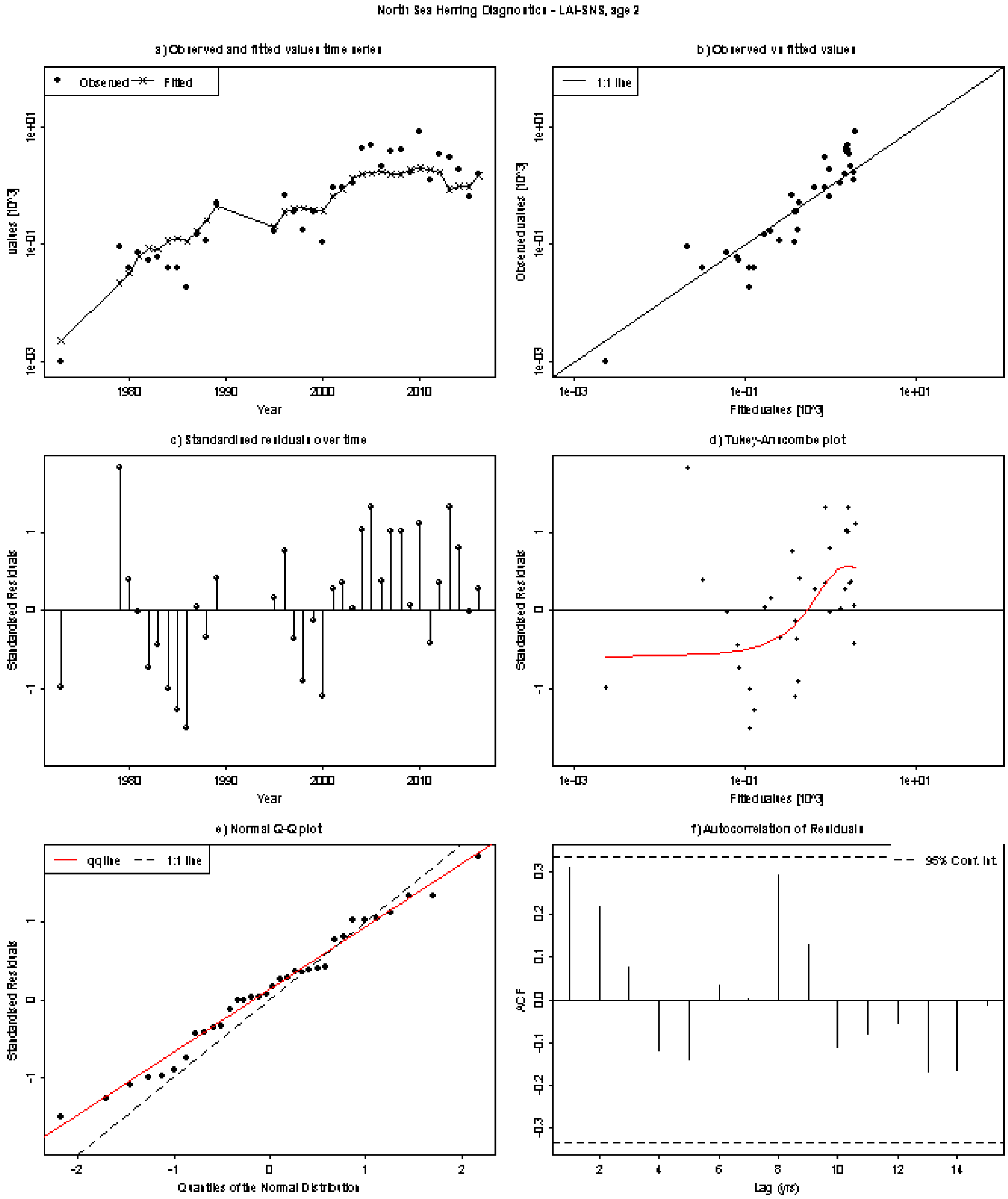


Figure 2.6.1.41. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Downs area for the second week time-series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index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


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

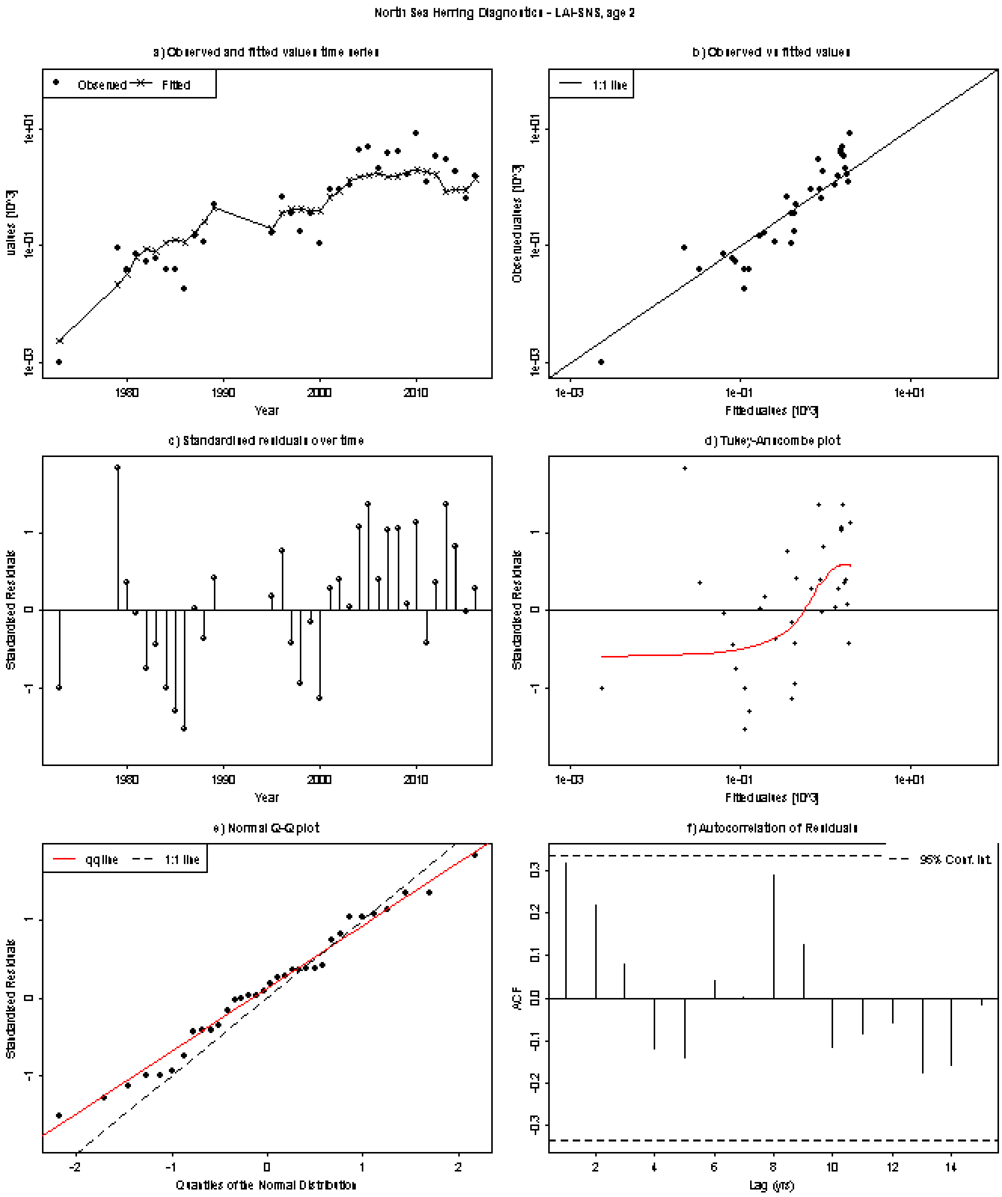


Figure 2.6.1.42. North Sea herring. Diagnostics of the assessment model fit to the LAI index in the Downs area for the third week time-series available for this component. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation vs. 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.

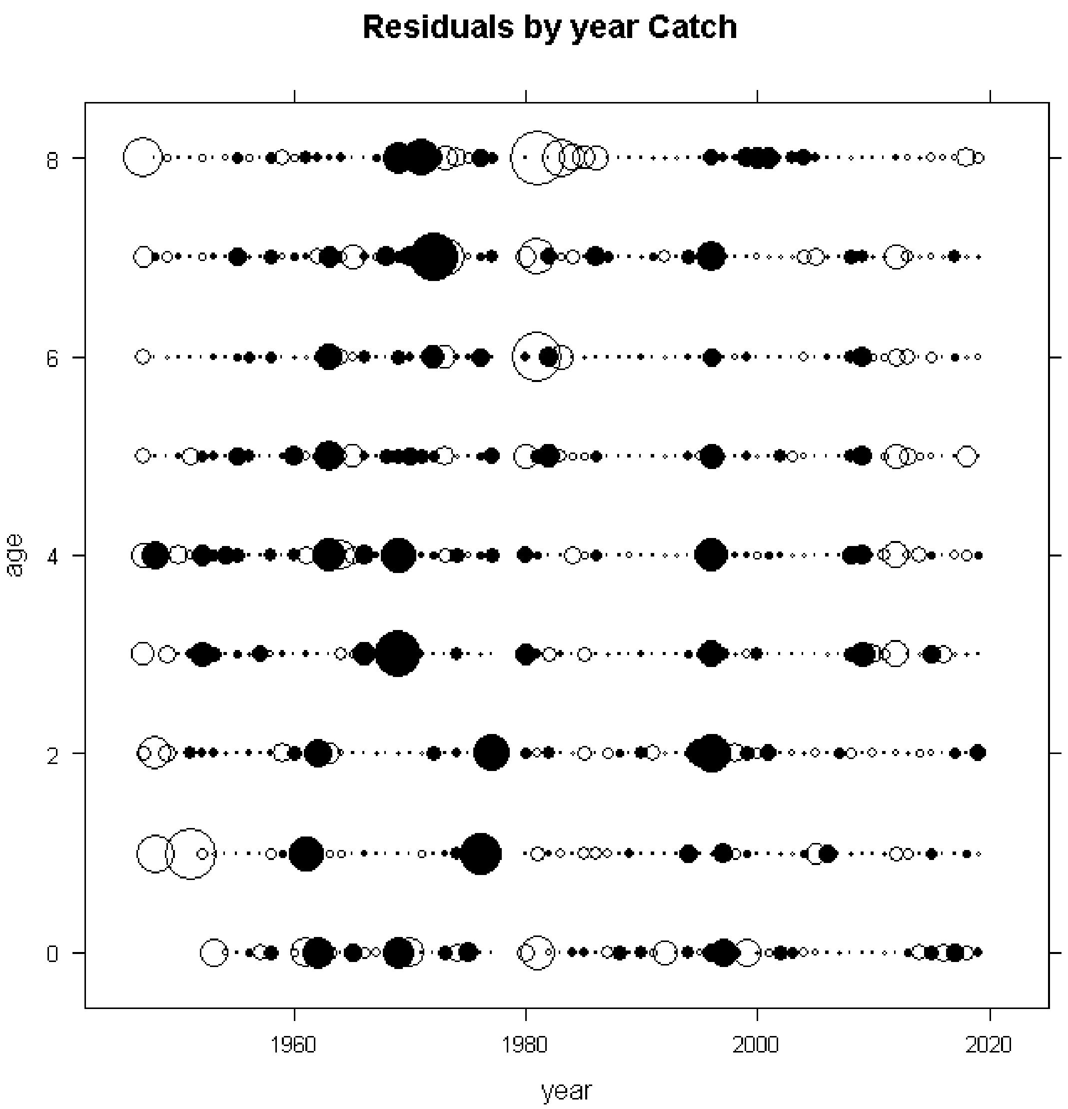


Figure 2.6.1.43. North Sea herring. Bubble plot of standardized catch residual.

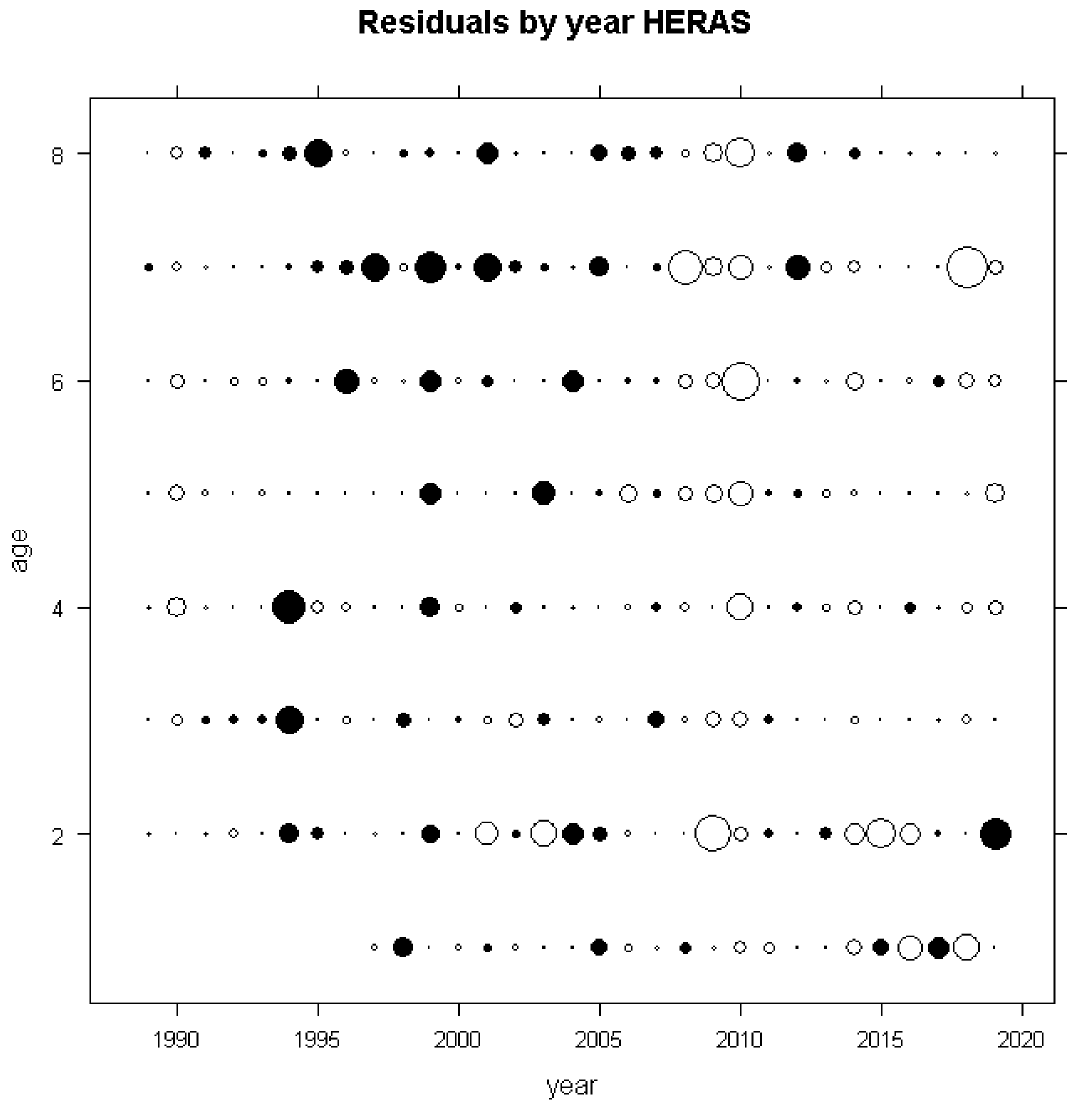


Figure 2.6.1.44. North Sea herring. Bubble plot of standardized acoustic survey residuals.

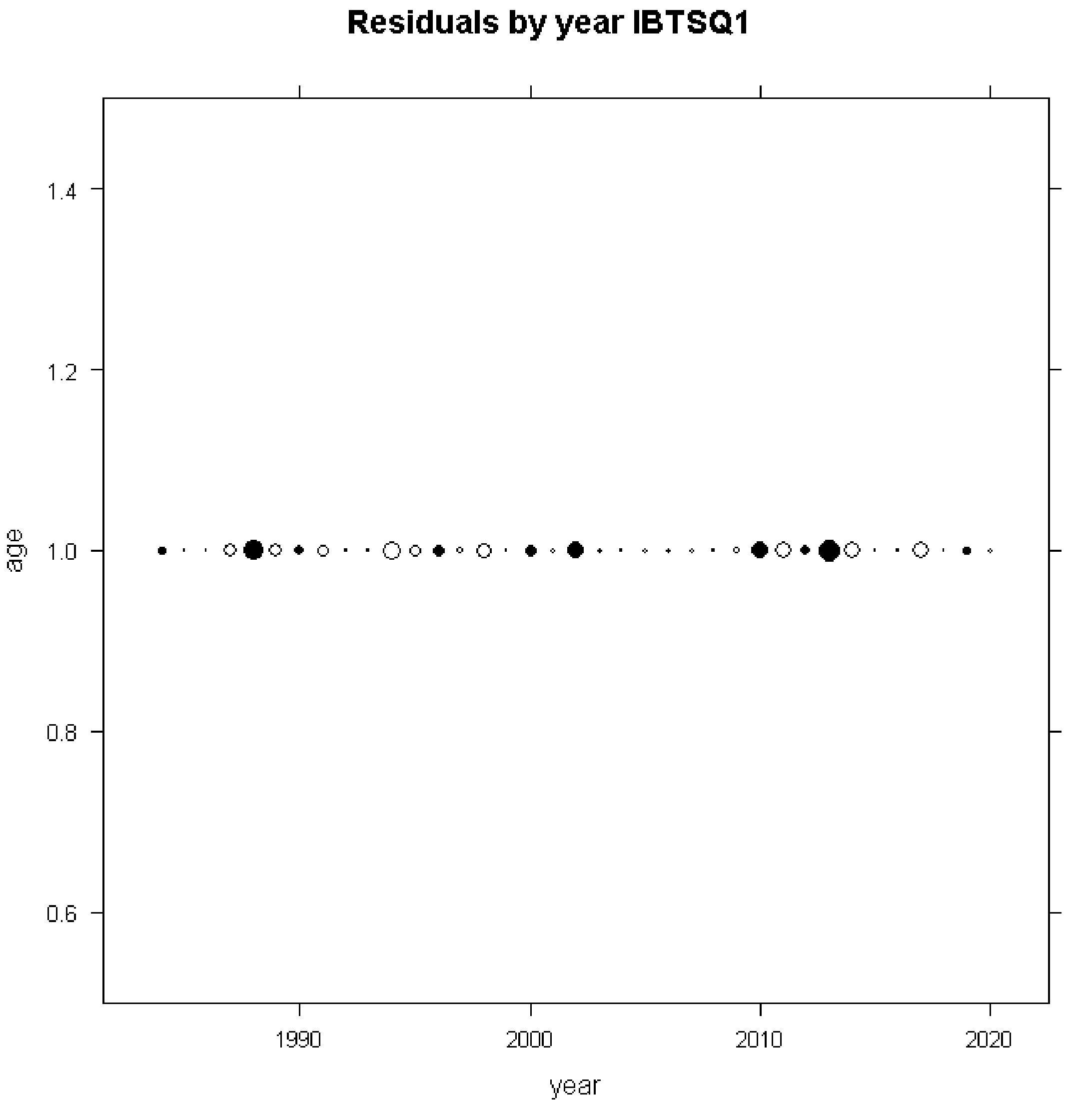


Figure 2.6.1.45. North Sea herring. Bubble plot of standardized IBTSQ1 residuals.

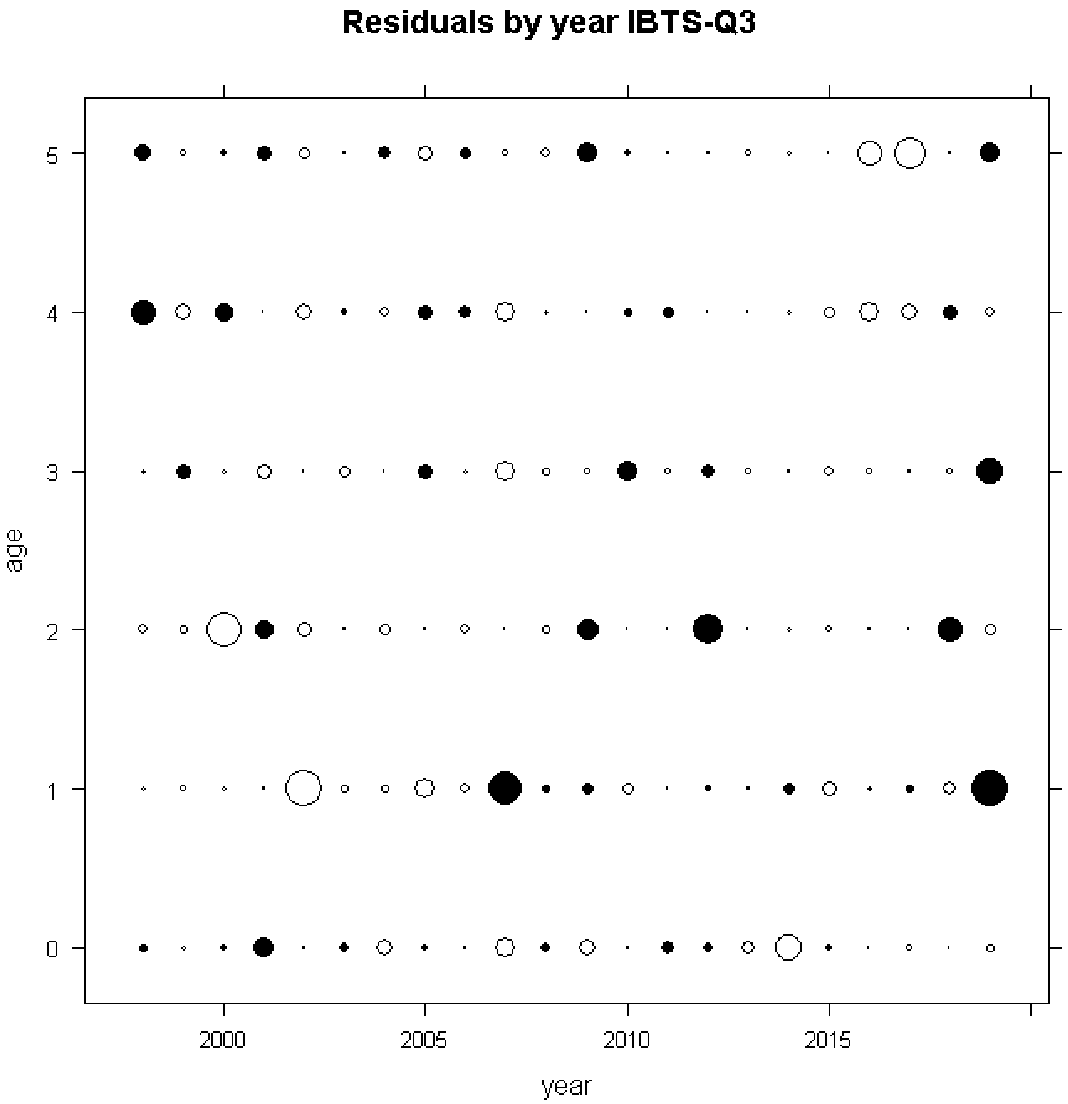


Figure 2.6.1.46. North Sea herring. Bubble plot of standardized IBTSQ3 residuals.

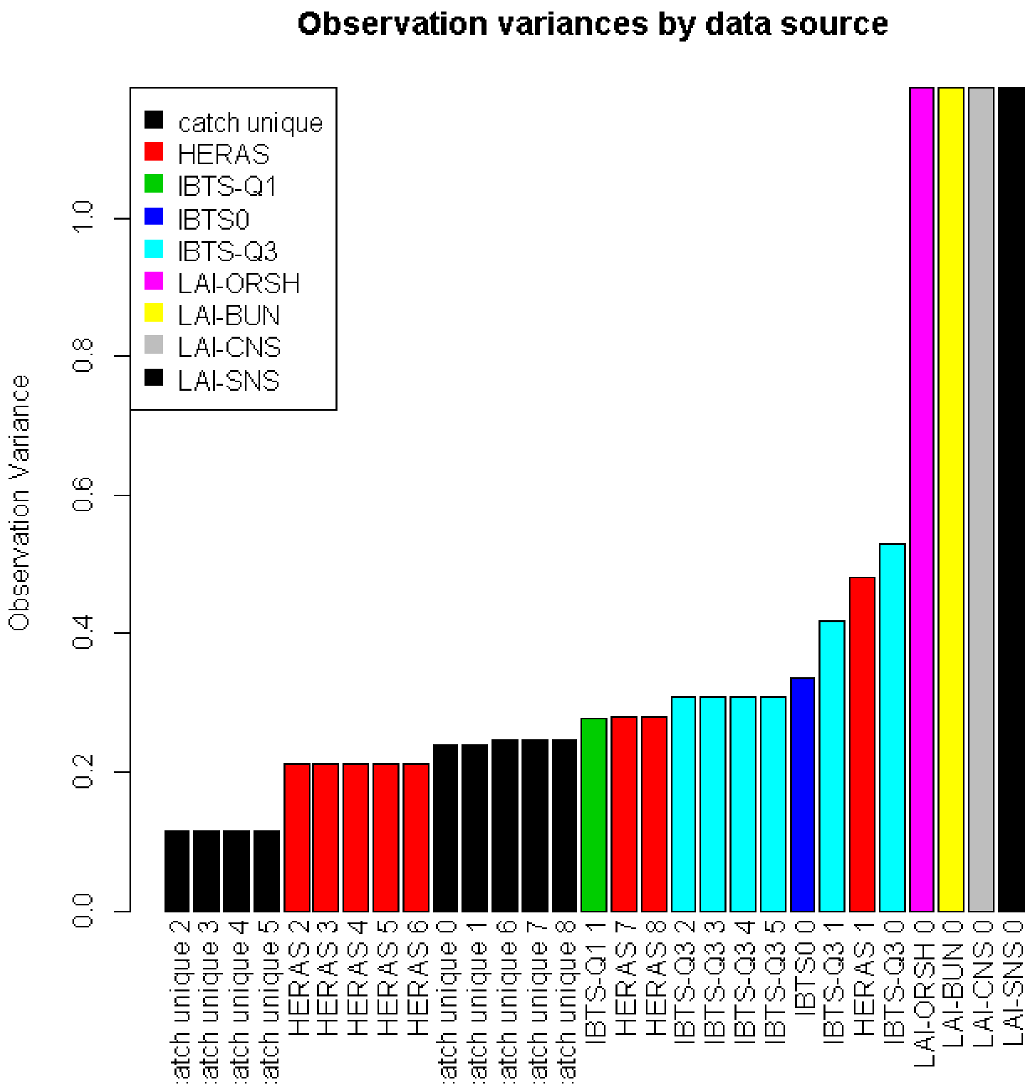


Figure 2.6.1.47. North Sea herring. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for each data source thereby reducing the parameters needed to be estimated in the assessment model. In these cases of parameter bindings, observation variances have equal values.

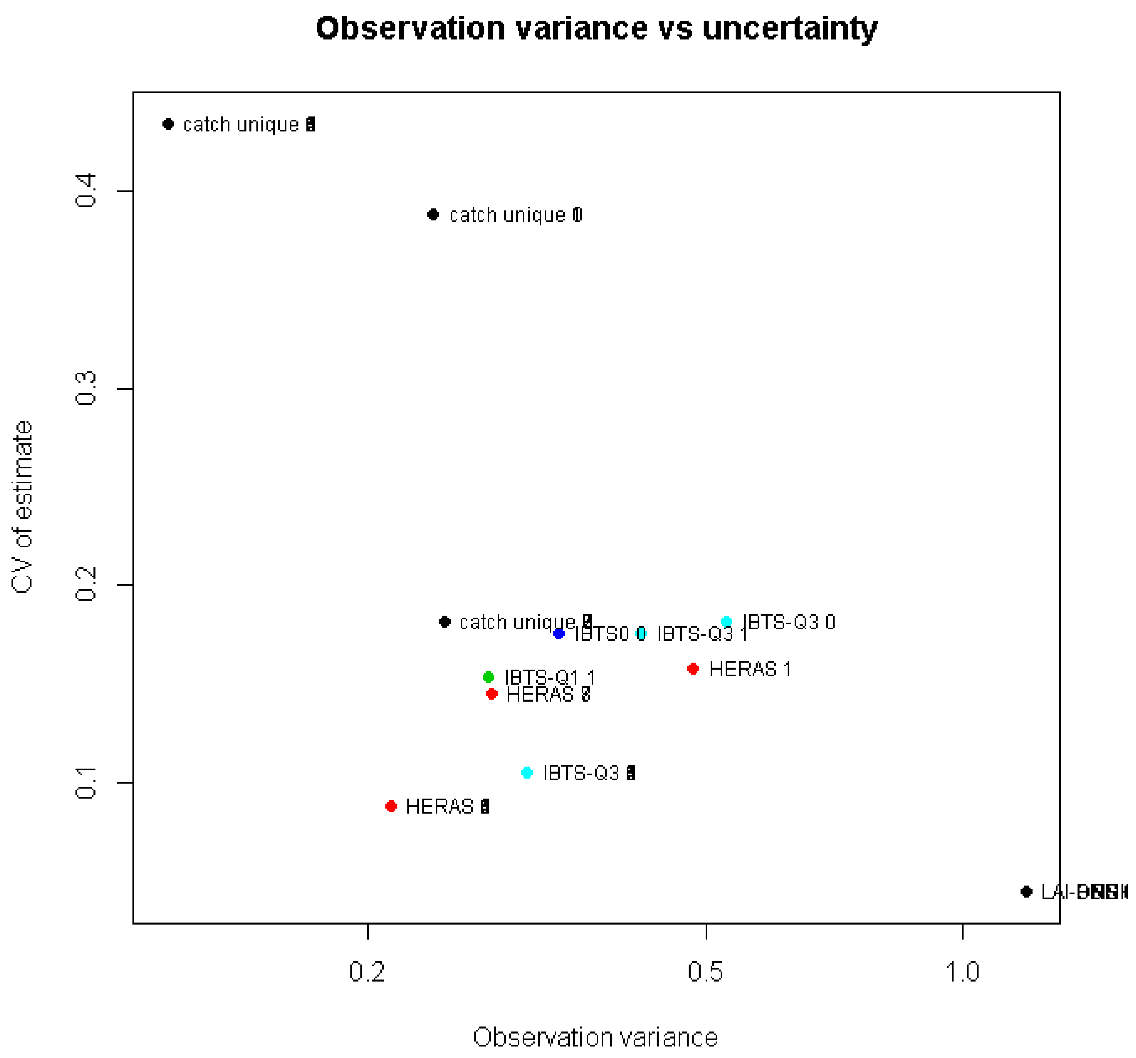


Figure 2.6.1.48. North Sea herring. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

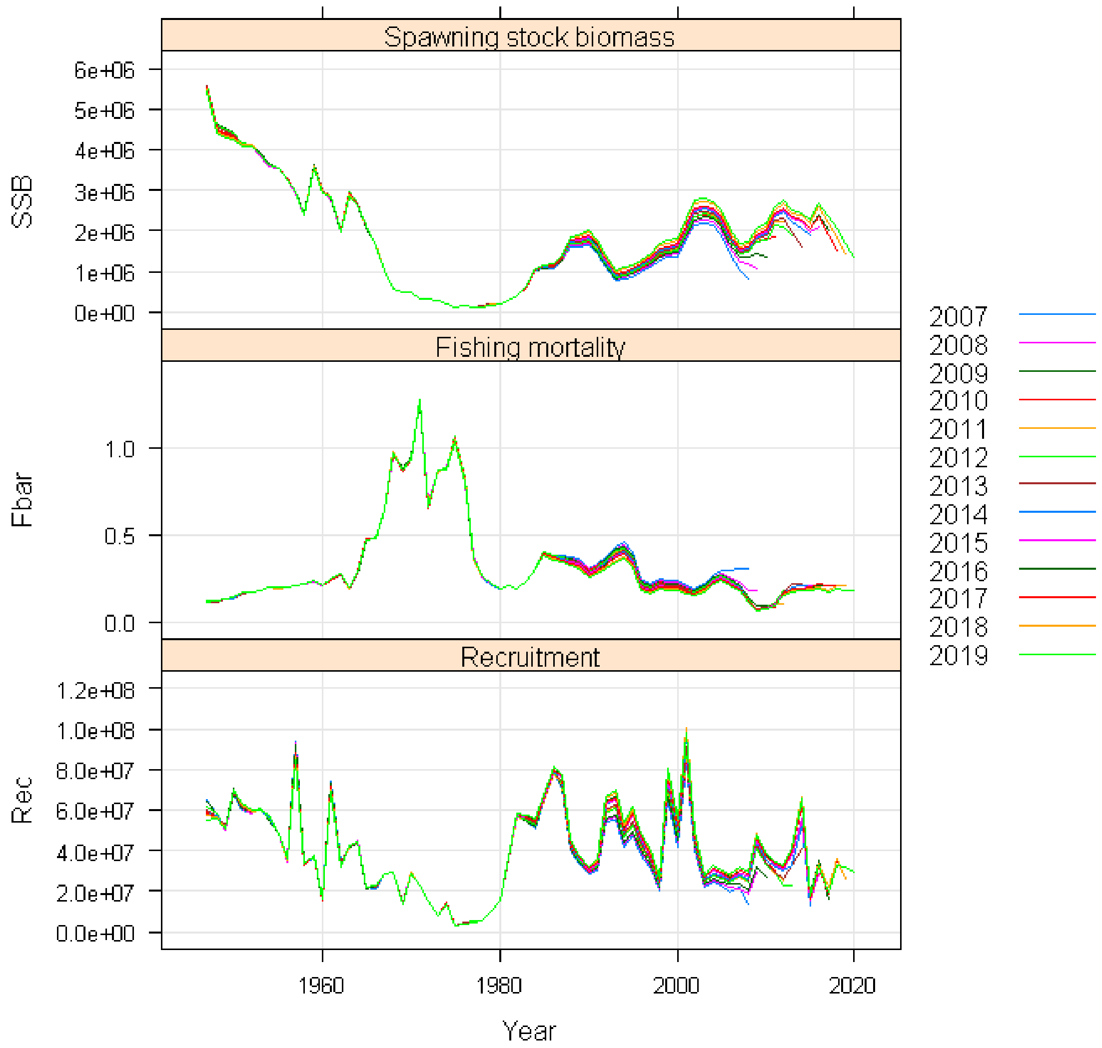


Figure 2.6.1.49. North Sea herring. Assessments retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel) from 2011 to 2018.

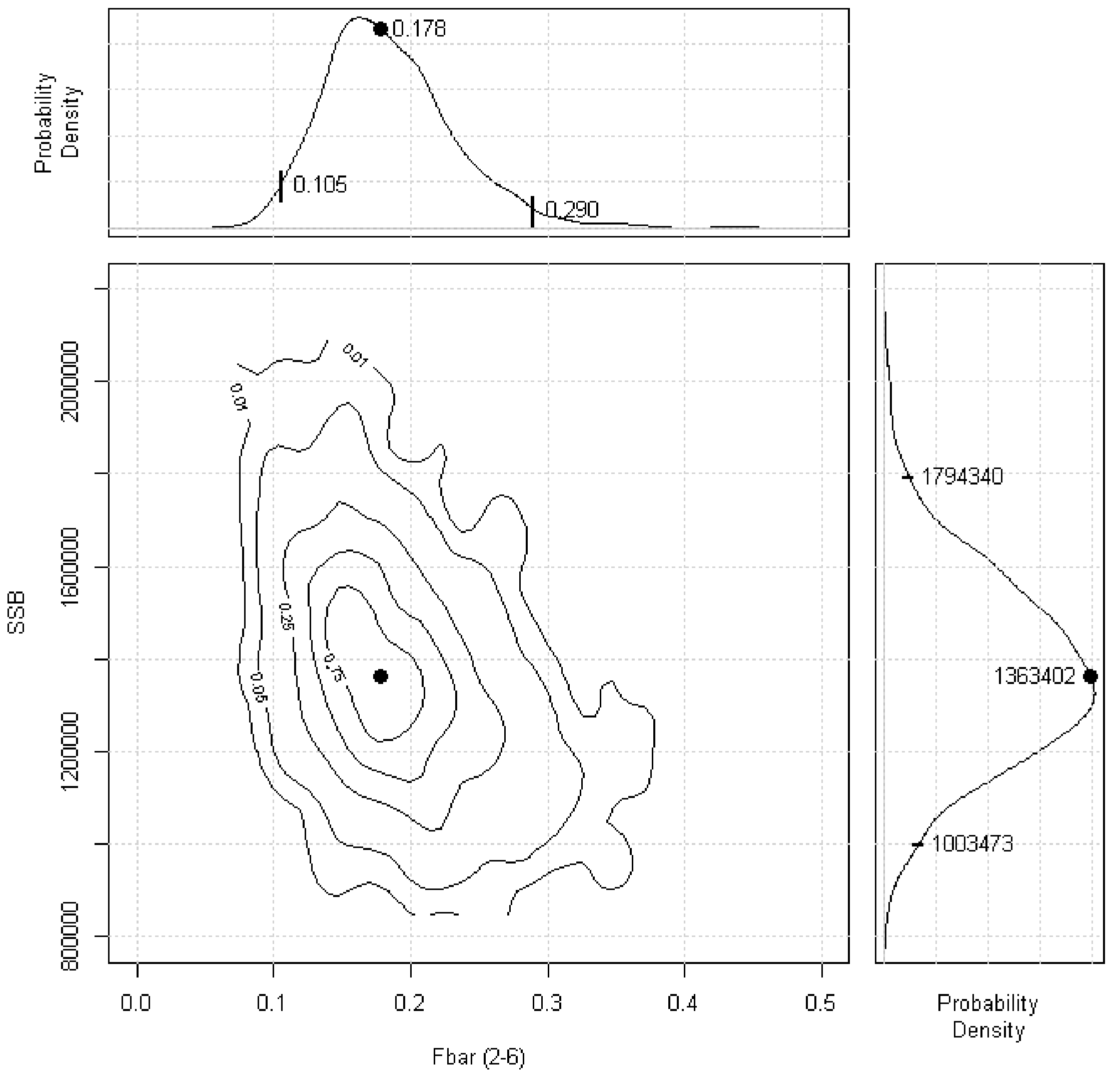


Figure 2.6.1.50. North Sea herring. Model uncertainty; distribution and quantiles of estimated SSB and $F_{2\text{-}6}$ in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLSAM estimated variance / covariance estimates from the model.

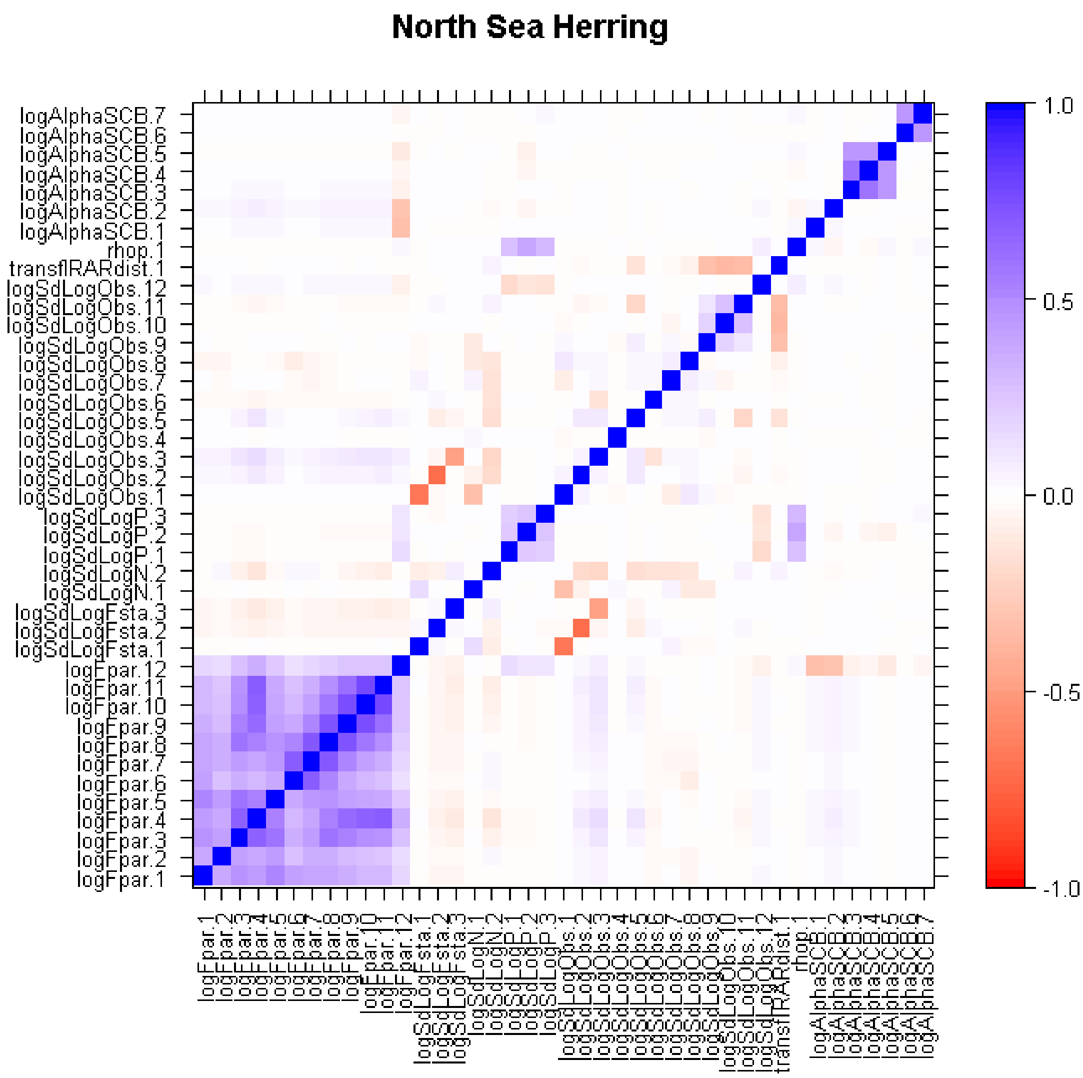


Figure 2.6.1.51. North Sea herring. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

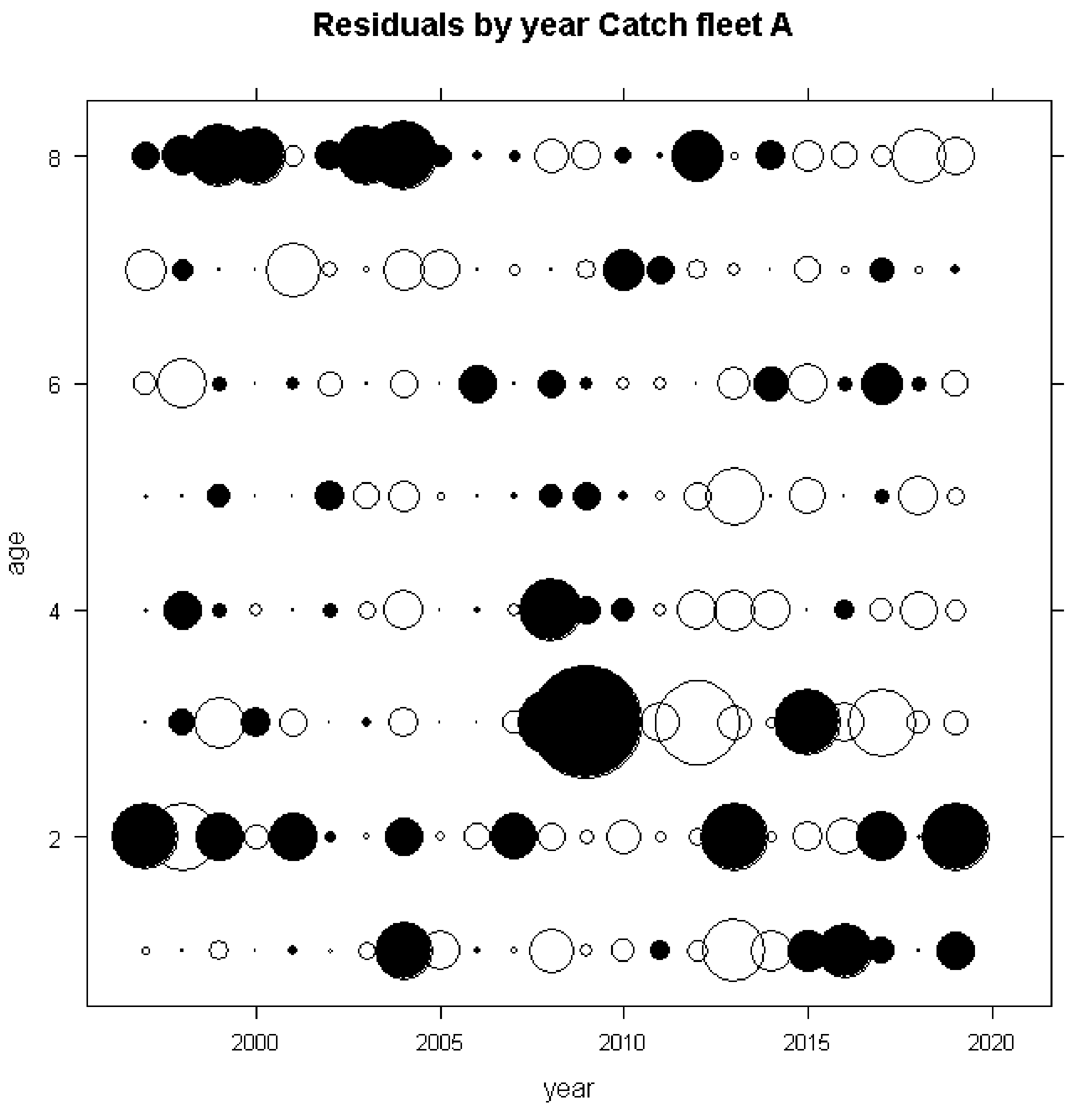


Figure 2.6.2.1. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet A.

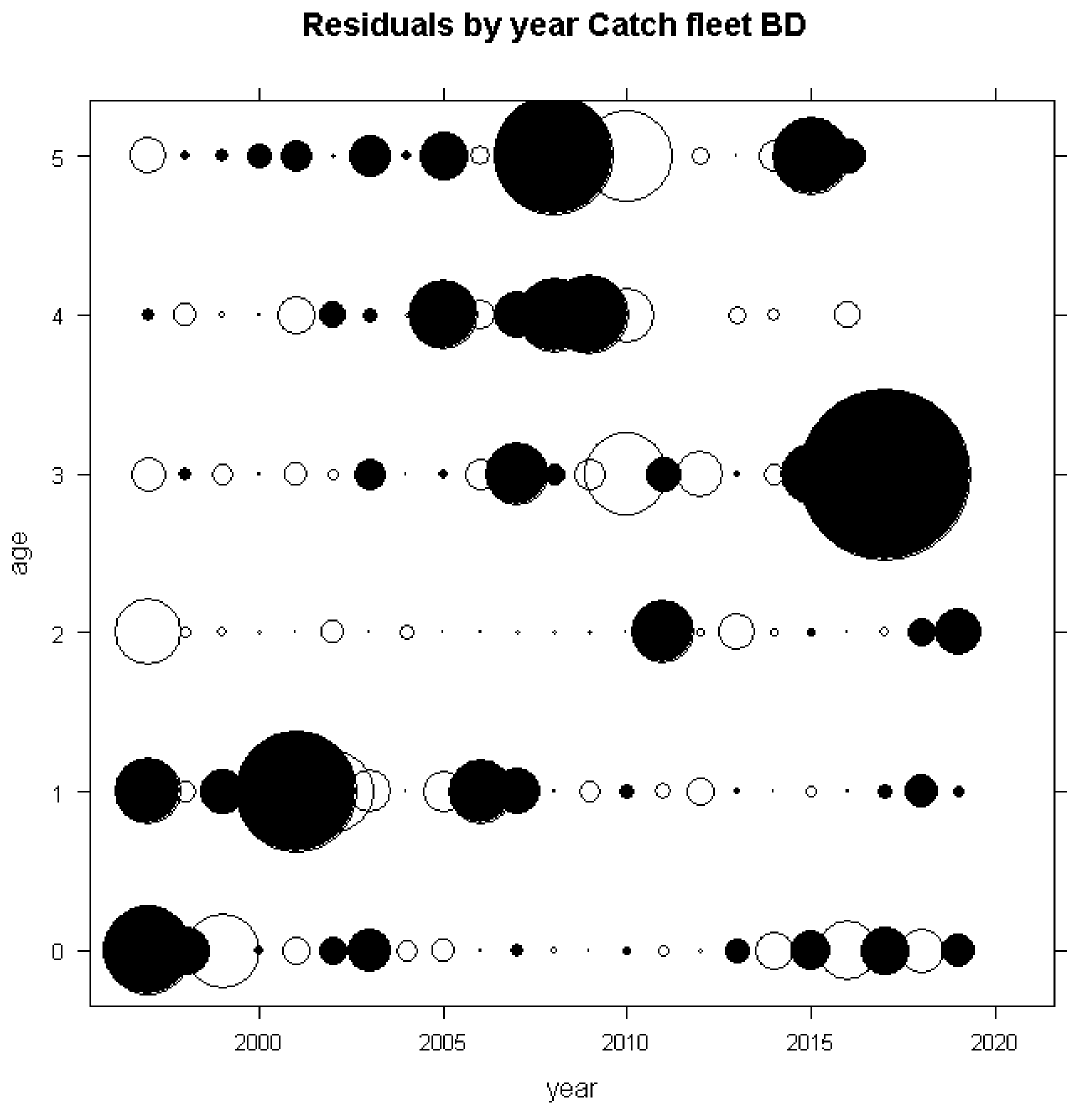


Figure 2.6.2.2. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet B&D.

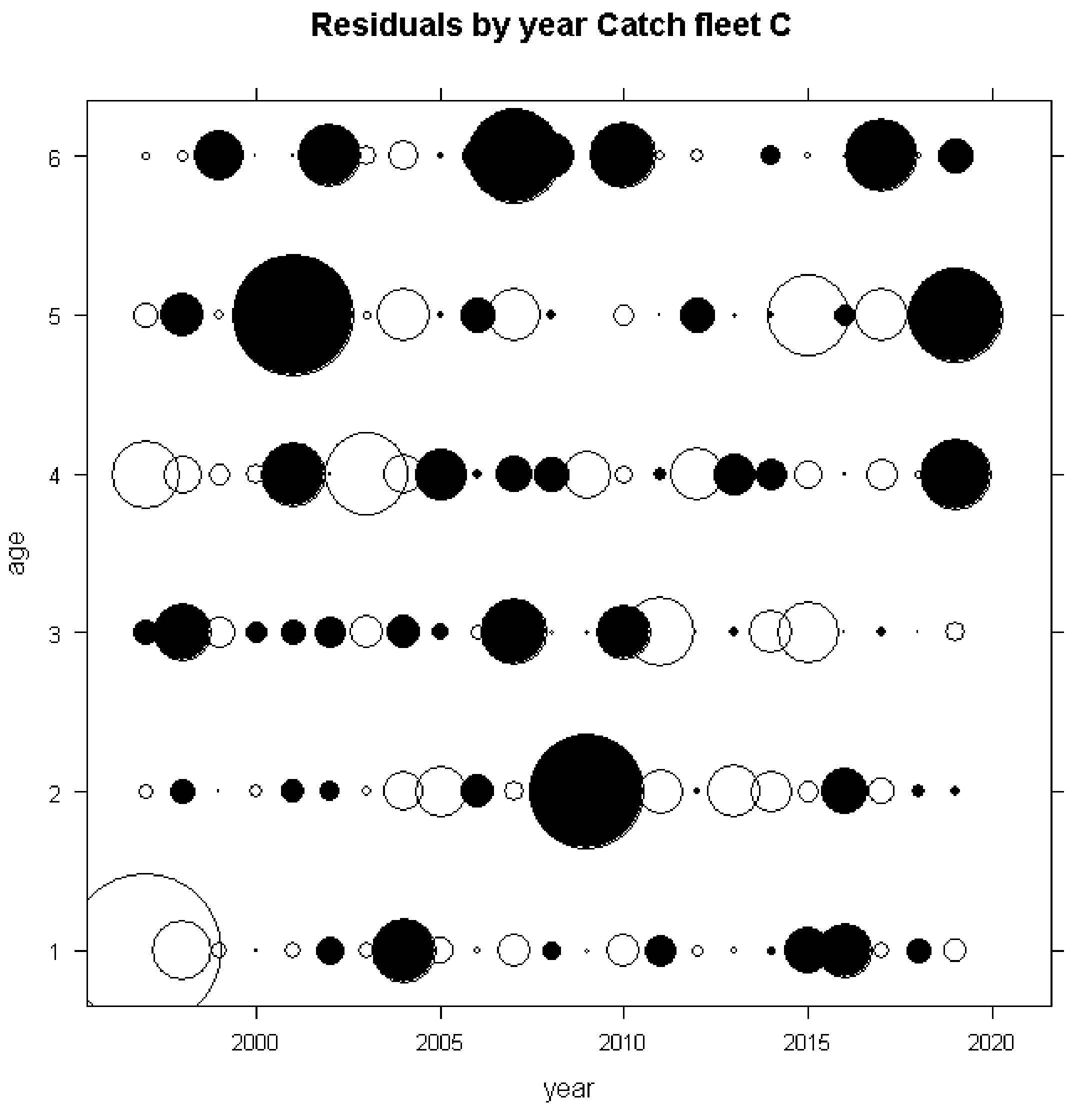


Figure 2.6.2.3. North Sea herring multifleet assessment model. Bubble plot of standardized residuals for catches of fleet C.

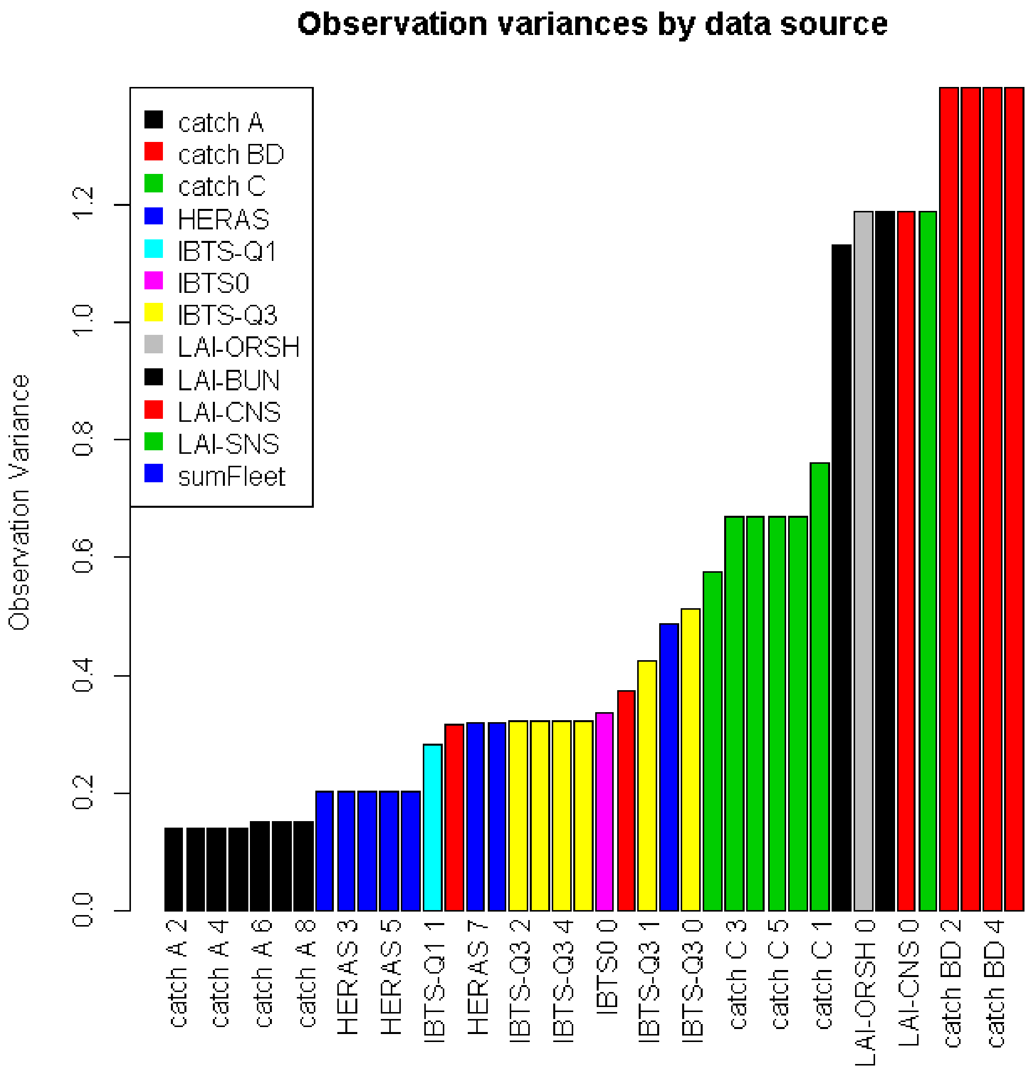


Figure 2.6.2.4. North Sea herring multifleet assessment model. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for each data source thereby reducing the parameters needed to be estimated in the assessment model. In these cases of parameter bindings, observation variances have equal values.

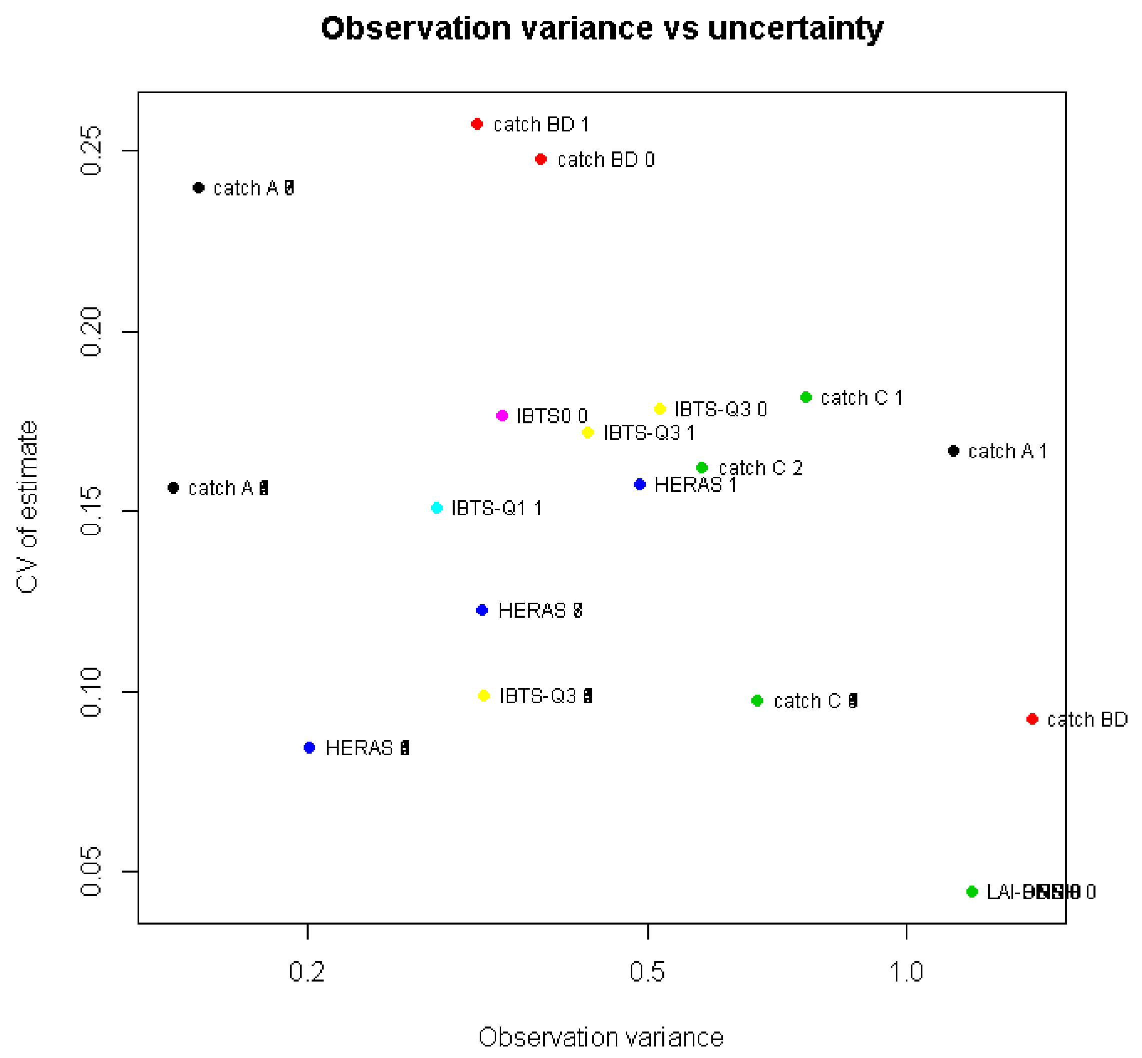


Figure 2.6.2.5. North Sea herring multifleet assessment model. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

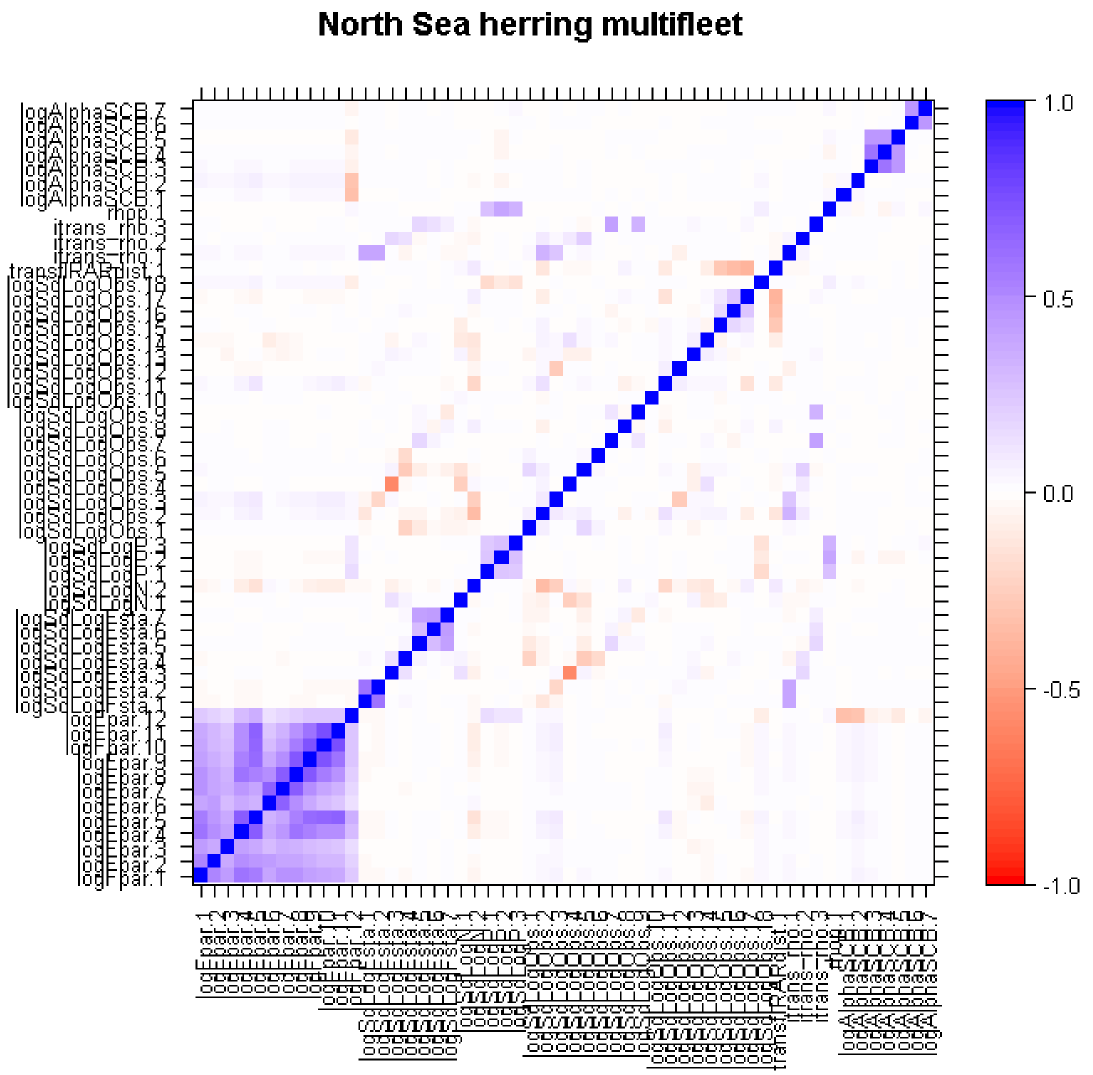


Figure 2.6.2.6. North Sea multifleet assessment model. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

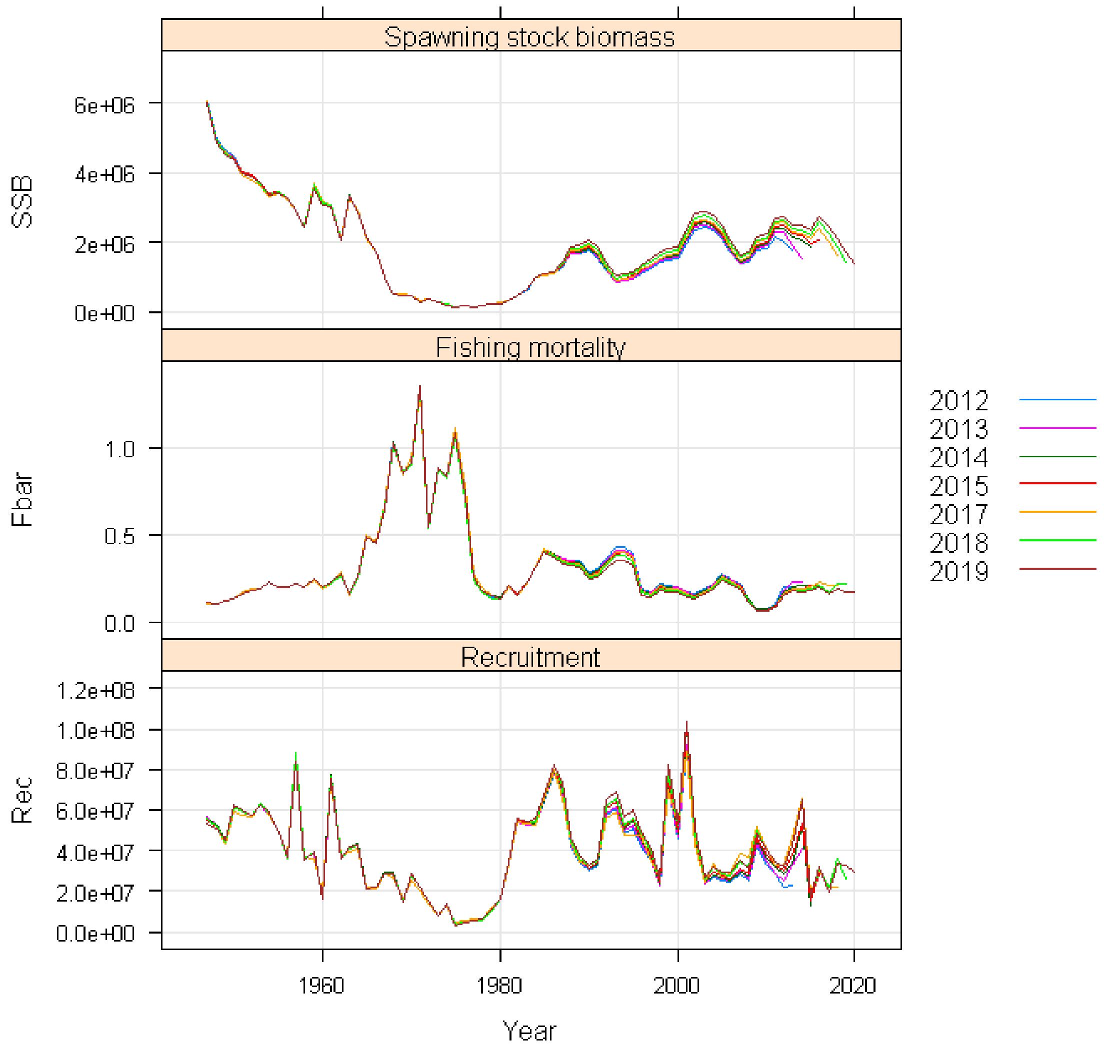


Figure 2.6.2.7. North Sea herring multifleet assessment model. Assessments retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel) from 2006 to 2018.

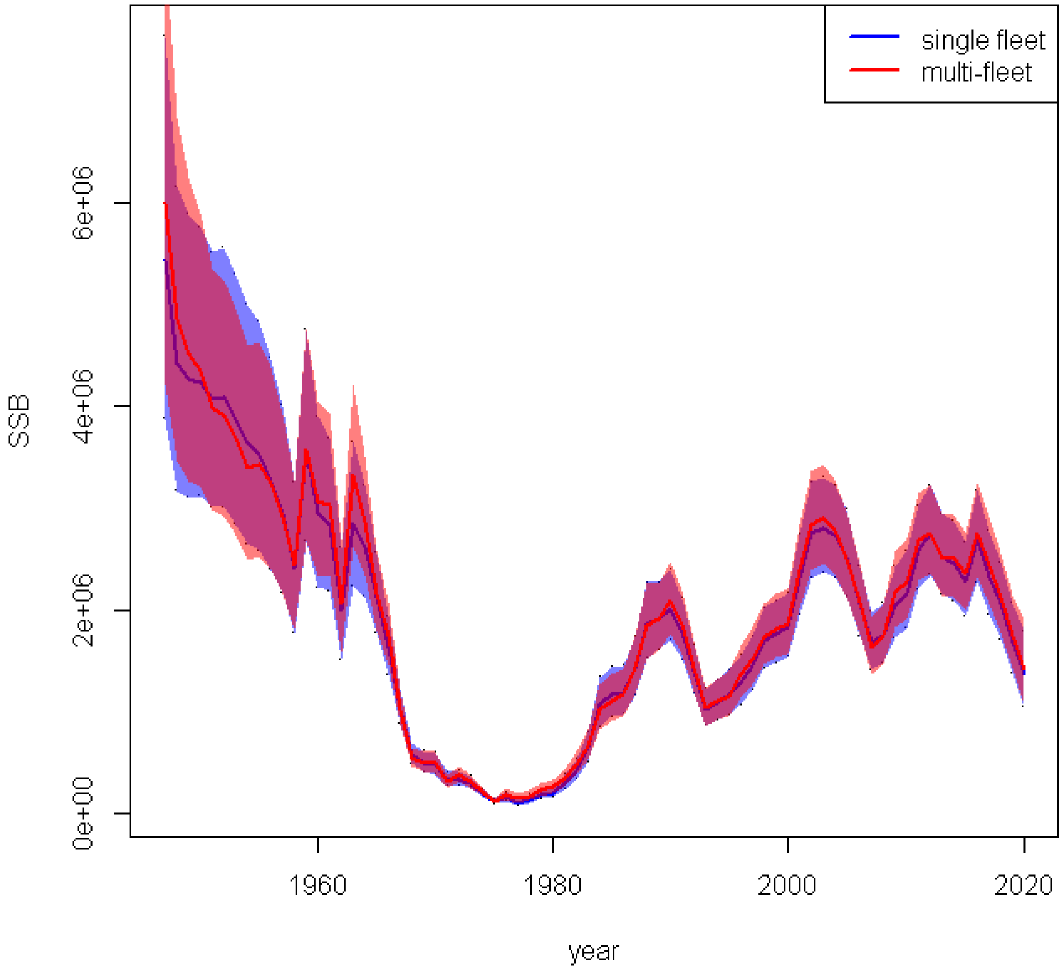


Figure 2.6.2.8. North Sea herring multifleet assessment model. Comparison of SSB for multifleet and single fleet assessment model outputs.

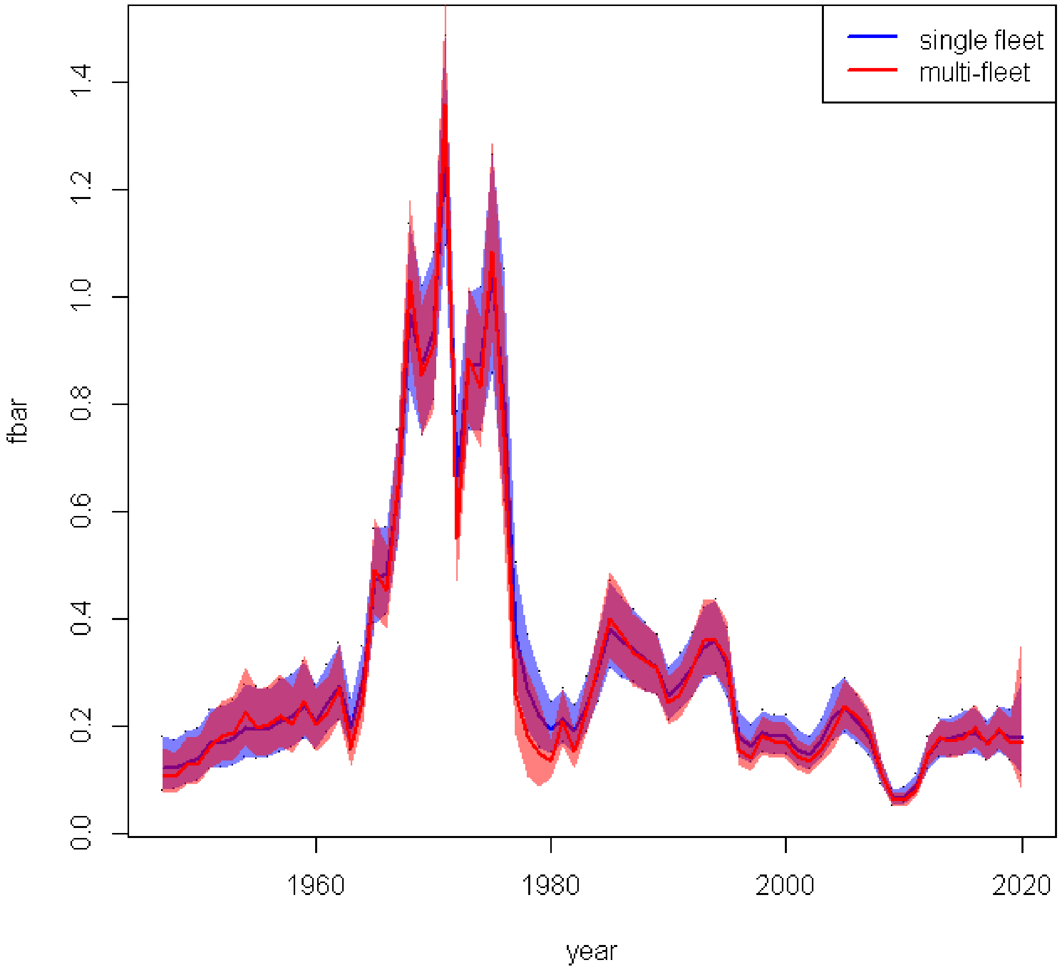


Figure 2.6.2.9. North Sea herring multifleet assessment model. Comparison of F_{bar} (across age 2 to 6) for multifleet and single fleet assessment model outputs.

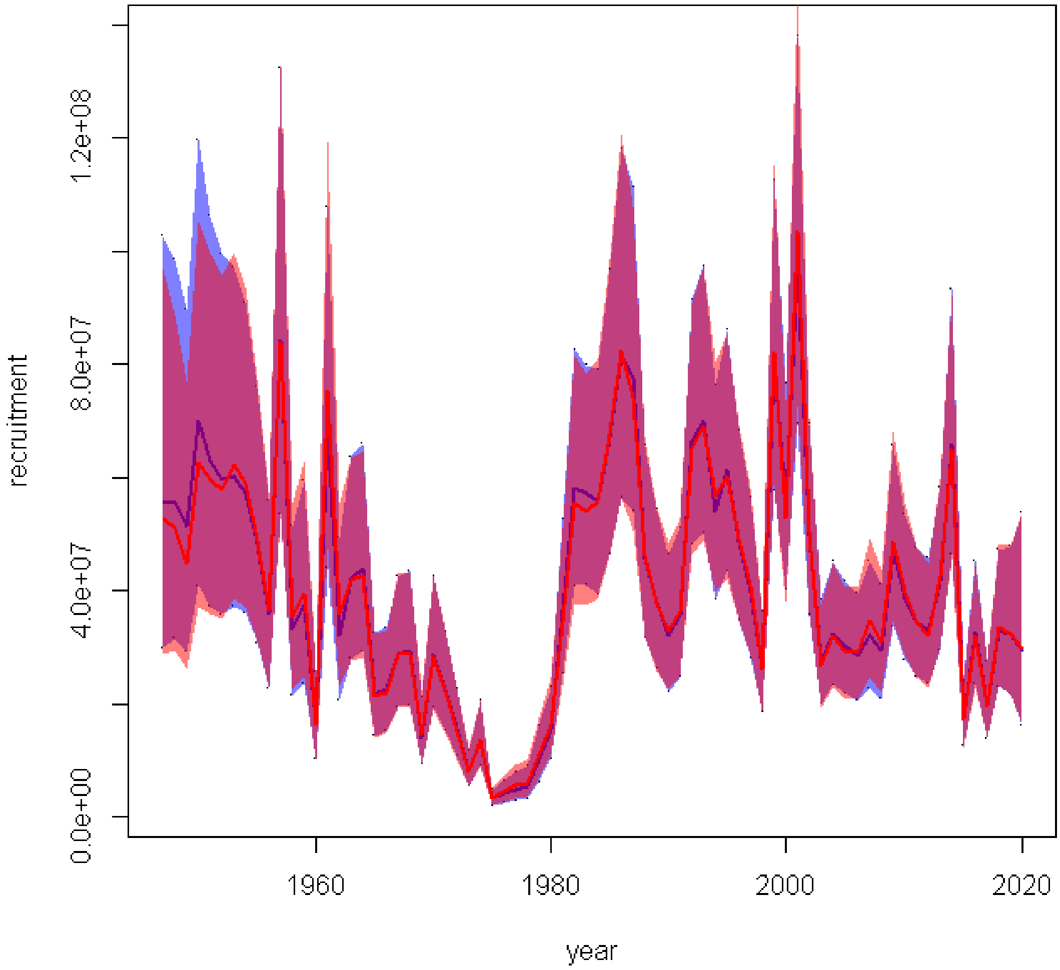


Figure 2.6.2.10. North Sea herring multifleet assessment model. Comparison of recruitment trajectories for multifleet and single fleet assessment model outputs.

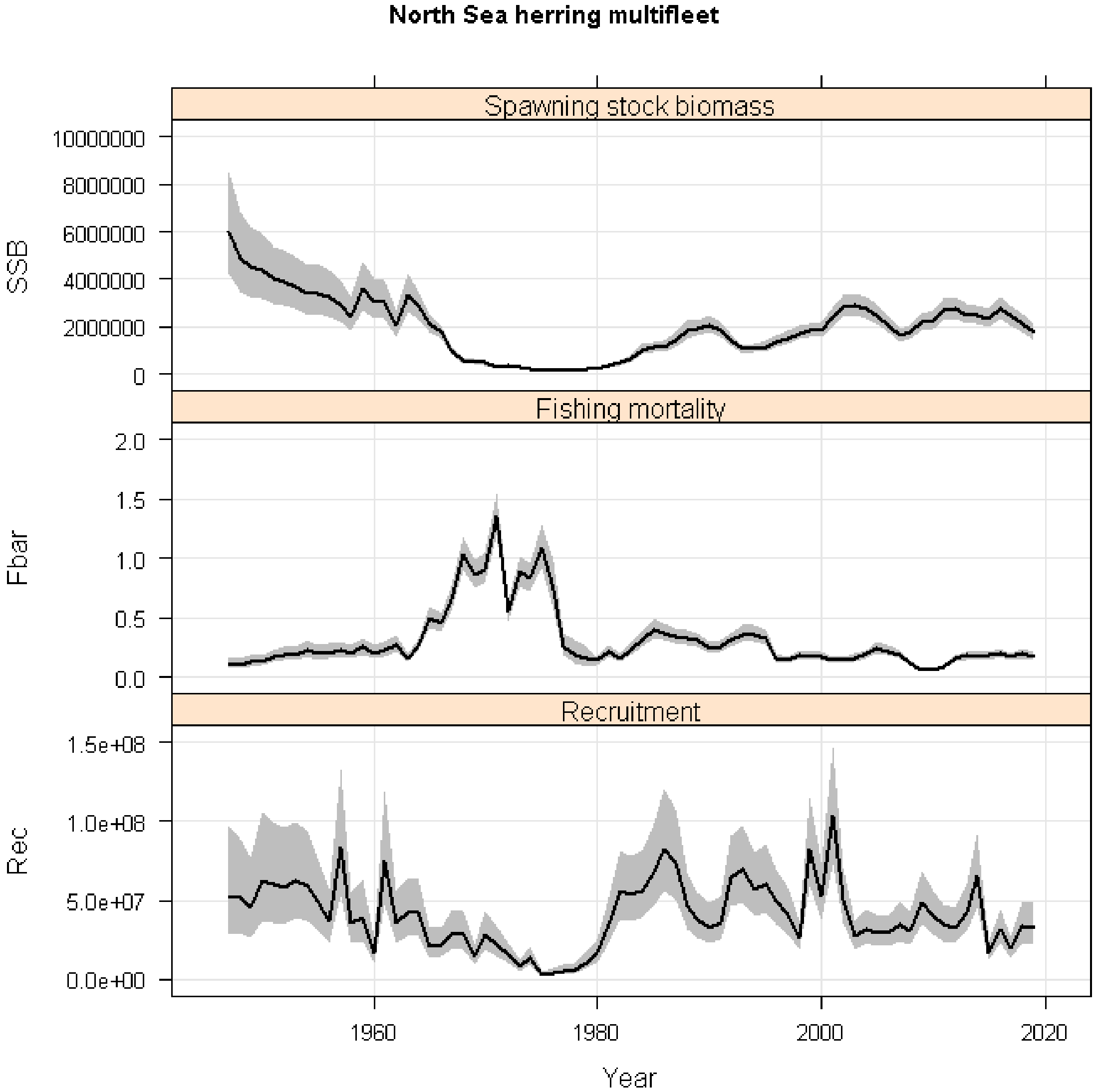


Figure 2.6.3.1 North Sea herring. Stock summary plot of North Sea herring with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

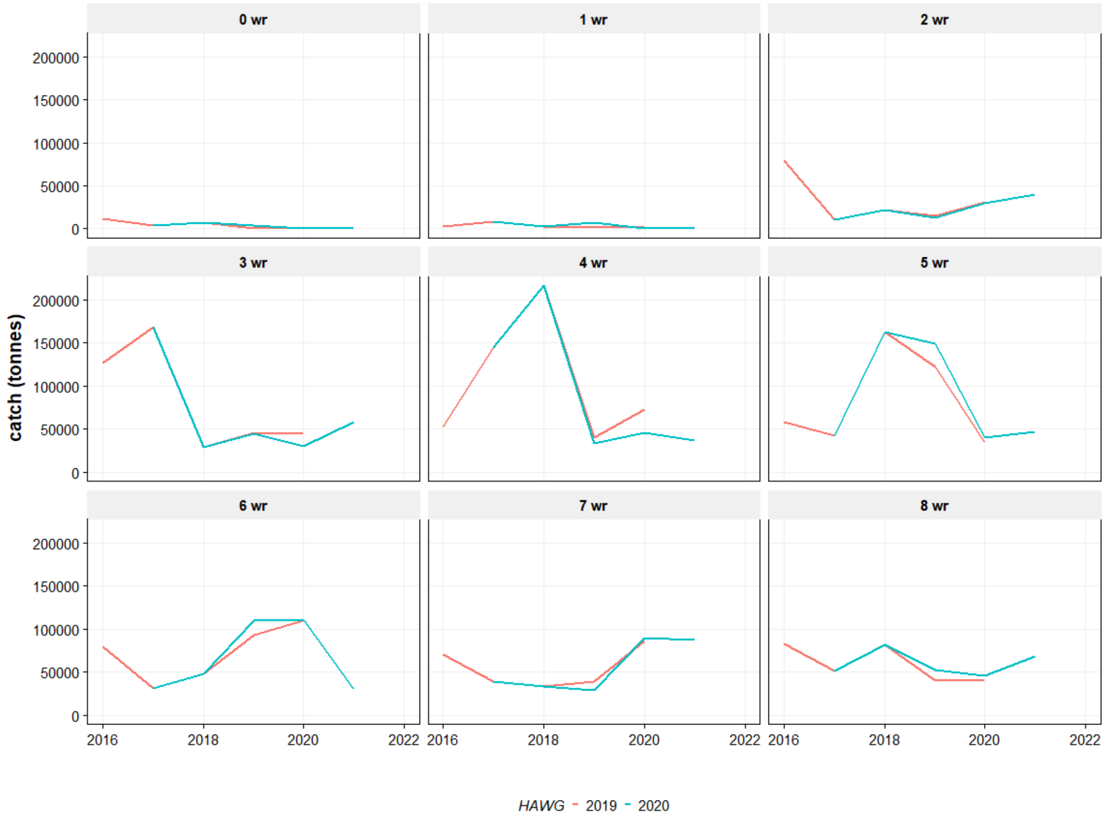


Figure 2.7.2.1. North Sea Herring. Realized and projected catch (in weight) by age (wr) between 2019 assessment (2020 as forecast year), 2020 assessment (2021 as forecast year).

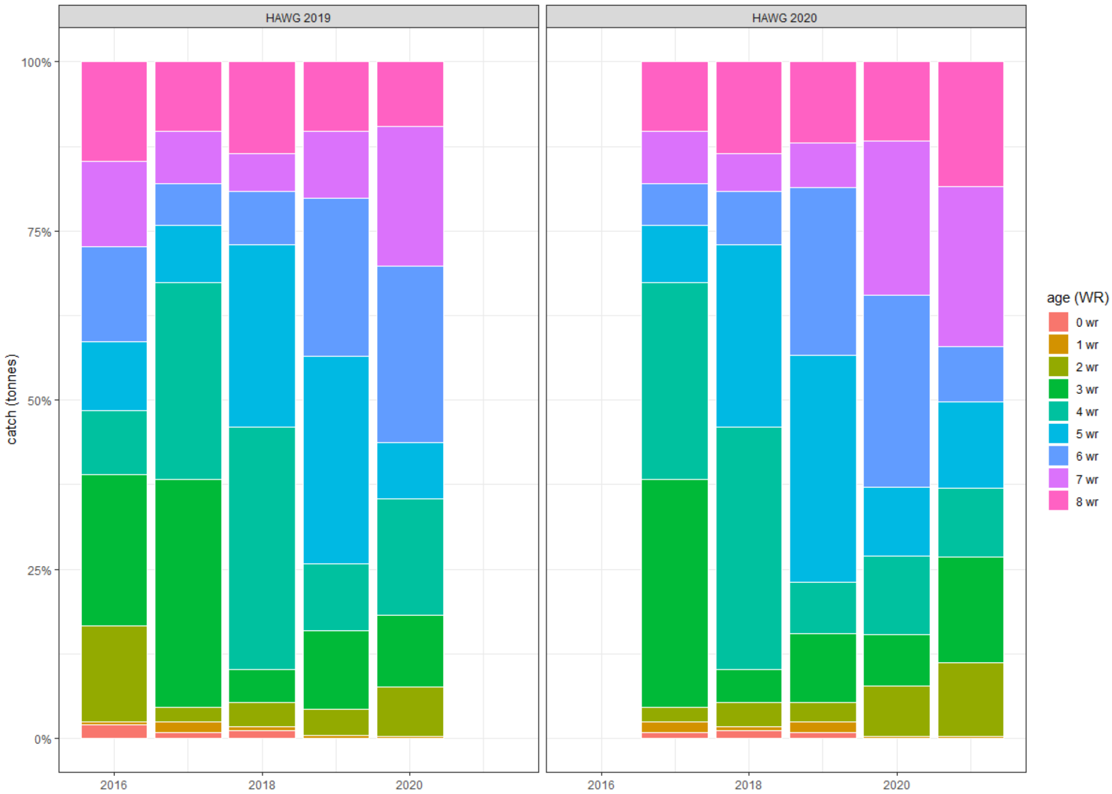


Figure 2.7.2.2. North Sea Herring. Catch proportions for the different ages between the 2019 short-term forecast (2020 as forecast year) and the 2020 short-term forecast (2012 as forecast year).

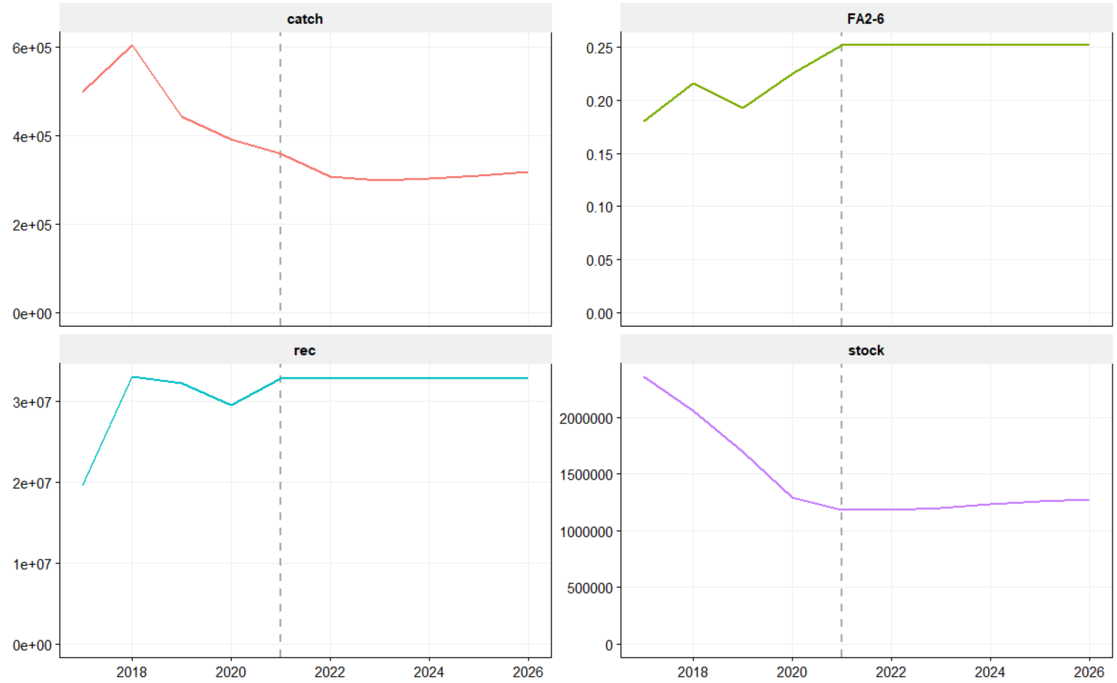


Figure 2.7.2.3. North Sea Herring. Short-term projections using an F status quo from TAC year (i.e. advice year). Intermediate year is in 2019 and the TAC year is 2020.

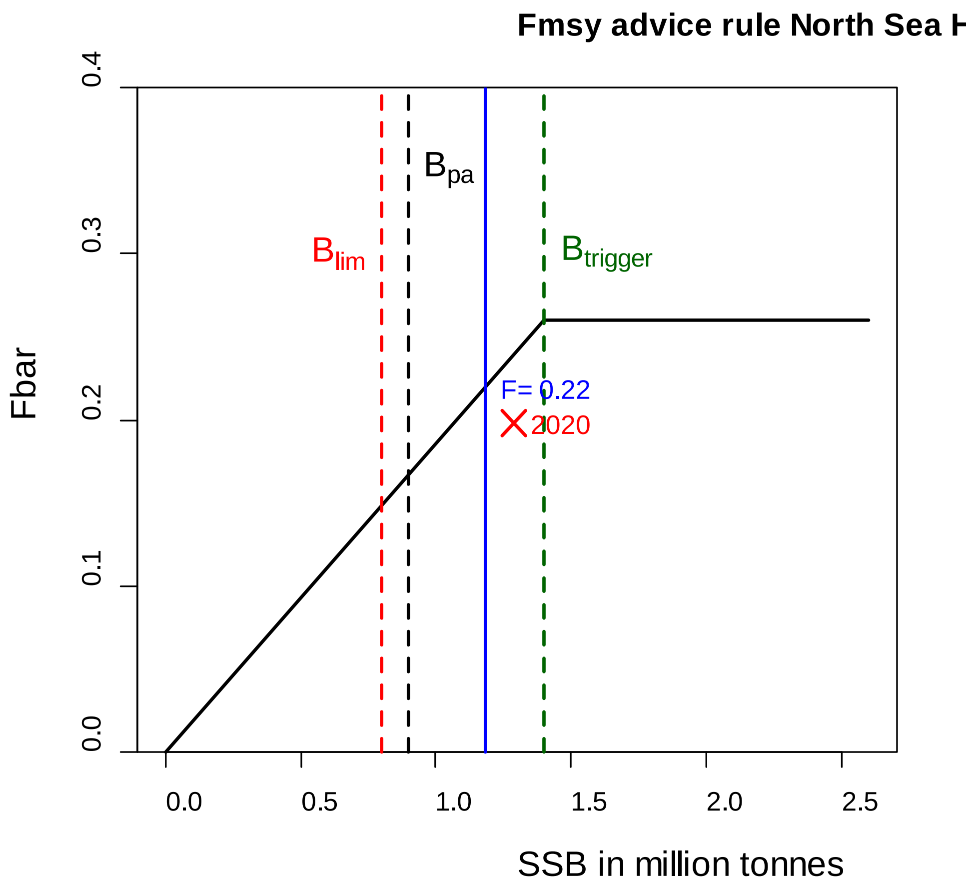


Figure 2.9.1.1. North Sea Herring. State of the stock in light of the MSY advice rule. The estimated SSB for 2021 is below MSYBtrigger (1.18 M tonnes, vertical blue line), leading to an applicable fishing mortality over age 2-6 (Fbar) of 0.22. The estimated SSB and Fbar for the intermediate year is depicted as a red cross marker.

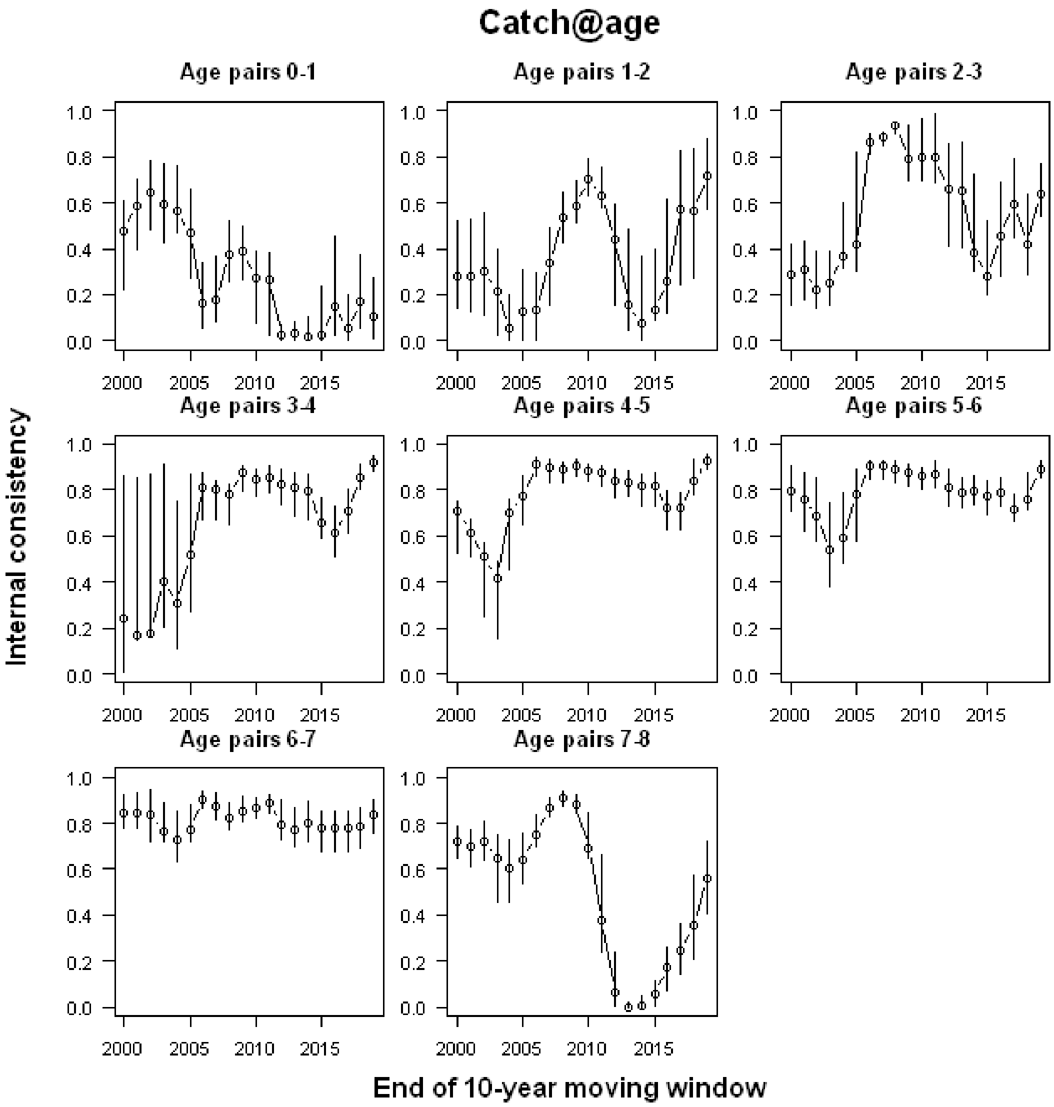


Figure 2.10.1.1. Internal consistency (R^2 of the log10-log10 linear relationship between consecutive ages in a cohort) of the catch-at-age data with a moving window of 10 years where the end-year (x-axis) denotes the last year for which data were used. Error bars show the variability of the estimate when one of the data-points is dropped (repeated 10 times without replacement).

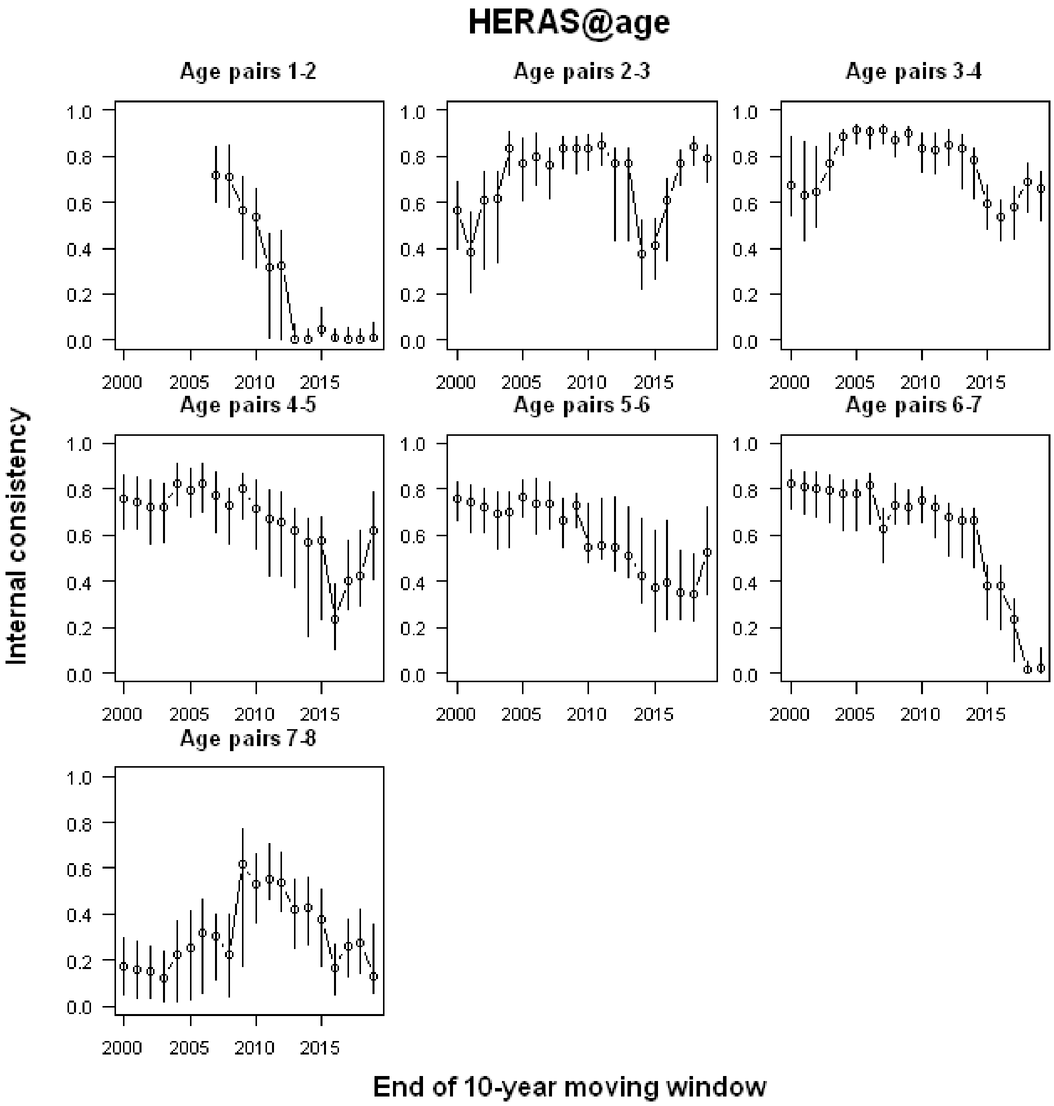


Figure 2.10.1.2. Internal consistency (R^2 of the log10-log10 linear relationship between consecutive ages in a cohort) of the HERAS-at-age data with a moving window of 10 years where the end-year (x-axis) denotes the last year for which data were used. Error bars show the variability of the estimate when one of the data-points is dropped (repeated 10 times without replacement).

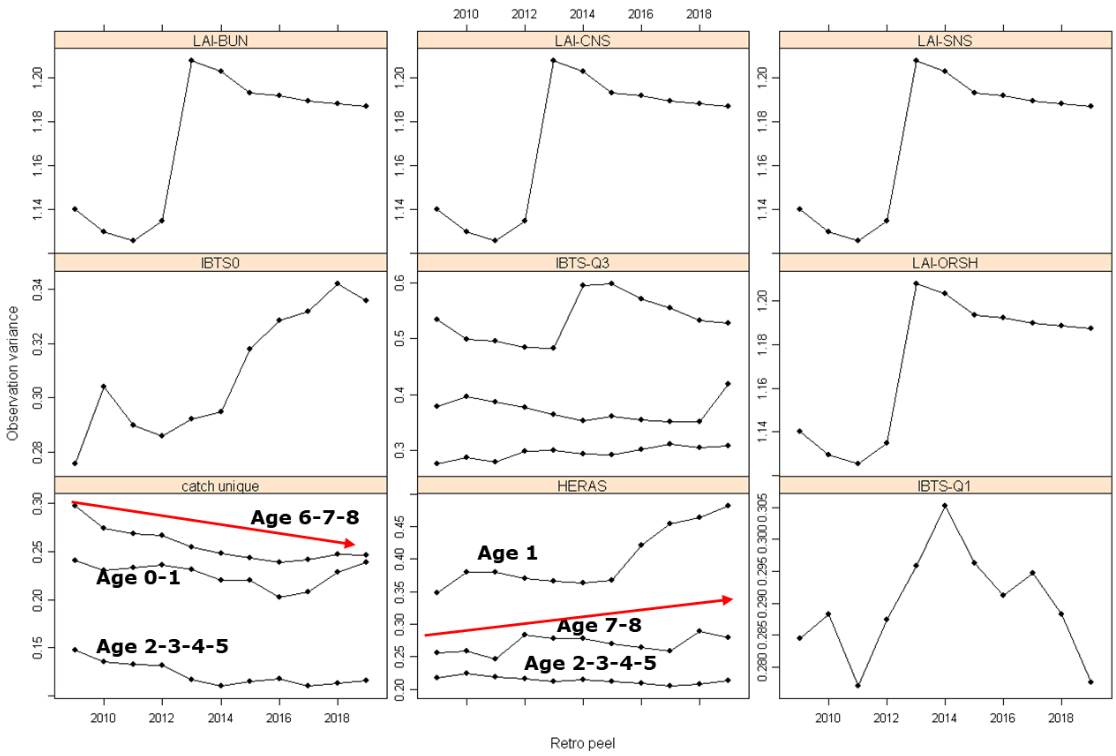
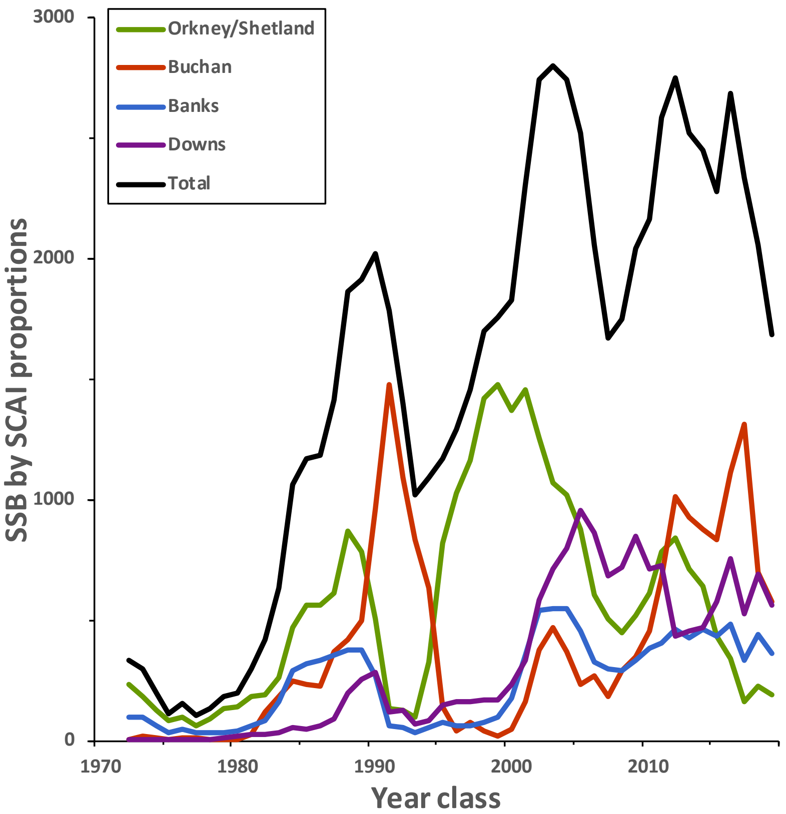


Figure 2.10.1.3. Change in observation variance for 10 retrospective peels. Patterns in the catch and in the HERAS survey are highlighted.


Orkney/Shetland
Buchan
Banks
Downs
Total
SSB by SCAI proportions
3000
2000
1000
0
1970
1980
1990
2000
2010
Year class

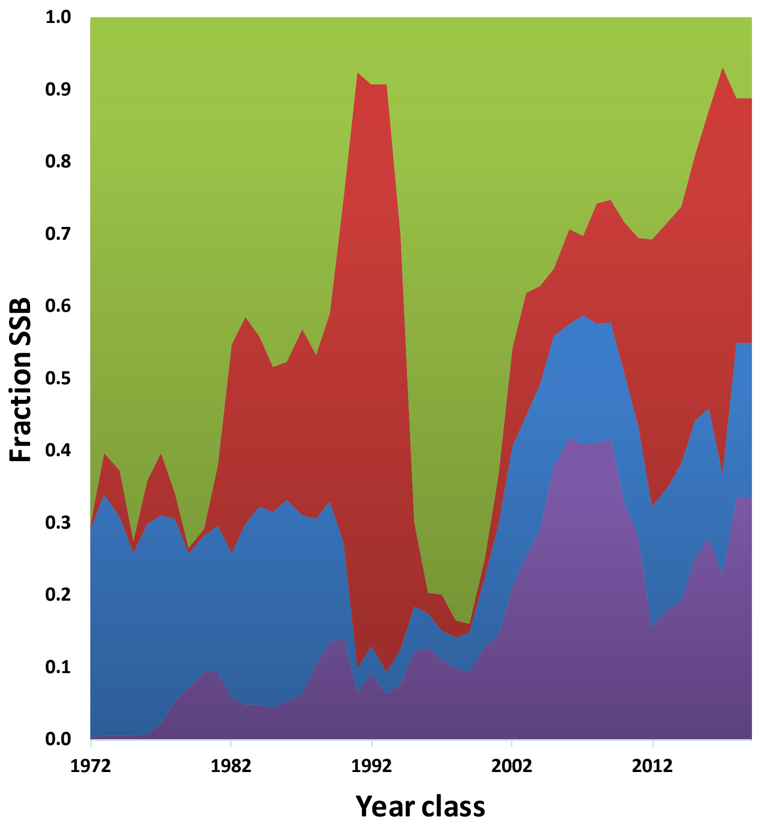

Fraction SSB
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1972
1982
1992
2002
2012
Year class

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

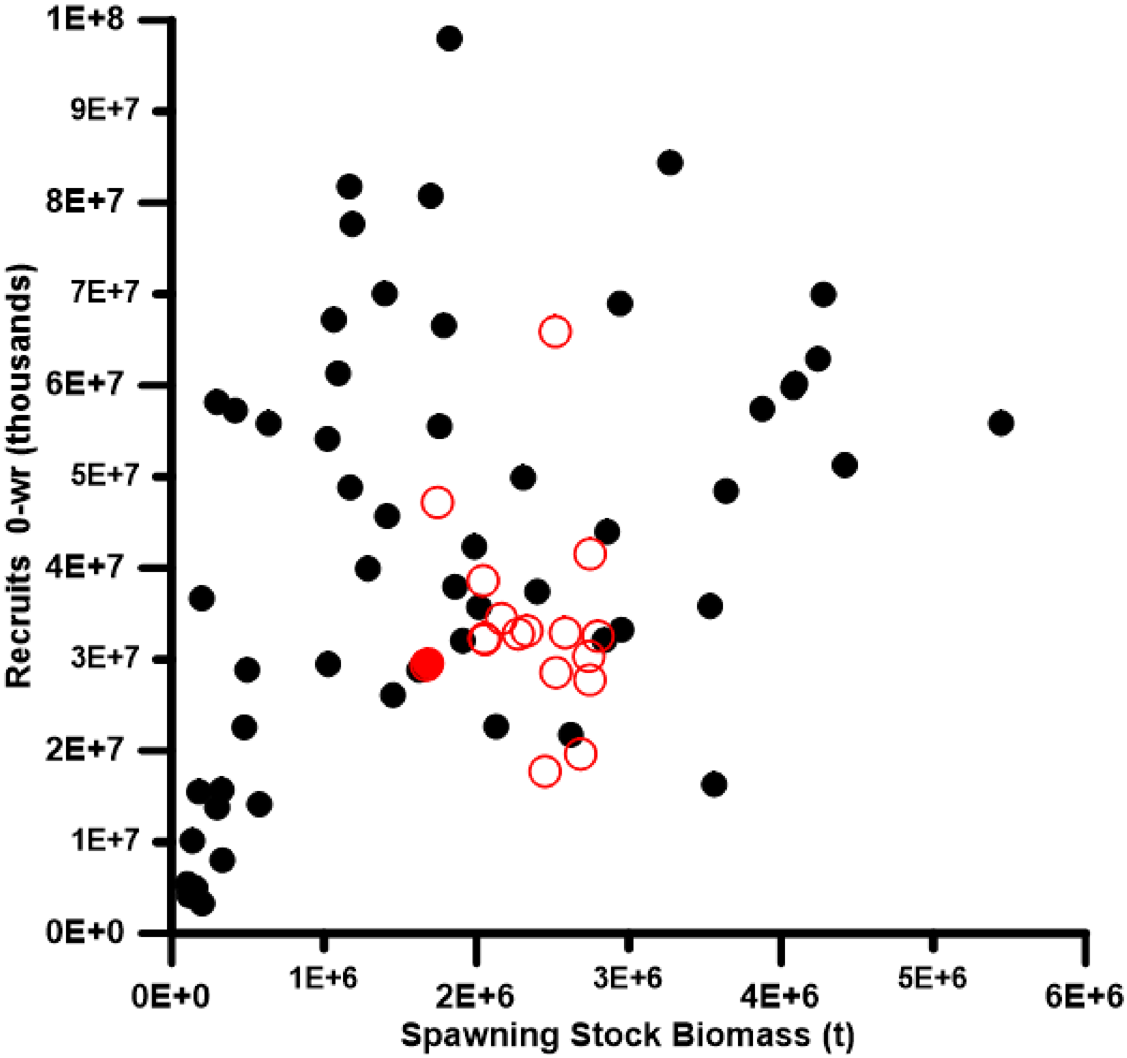


Figure 2.13.1. North Sea Autumn Spawning Herring stock recruitment curve, plotting estimated spawning-stock biomass against the resulting recruitment. Year classes spawned after 2001 are plotted with open red circles, to highlight the years of recent low recruitment. The most recent year class is plotted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

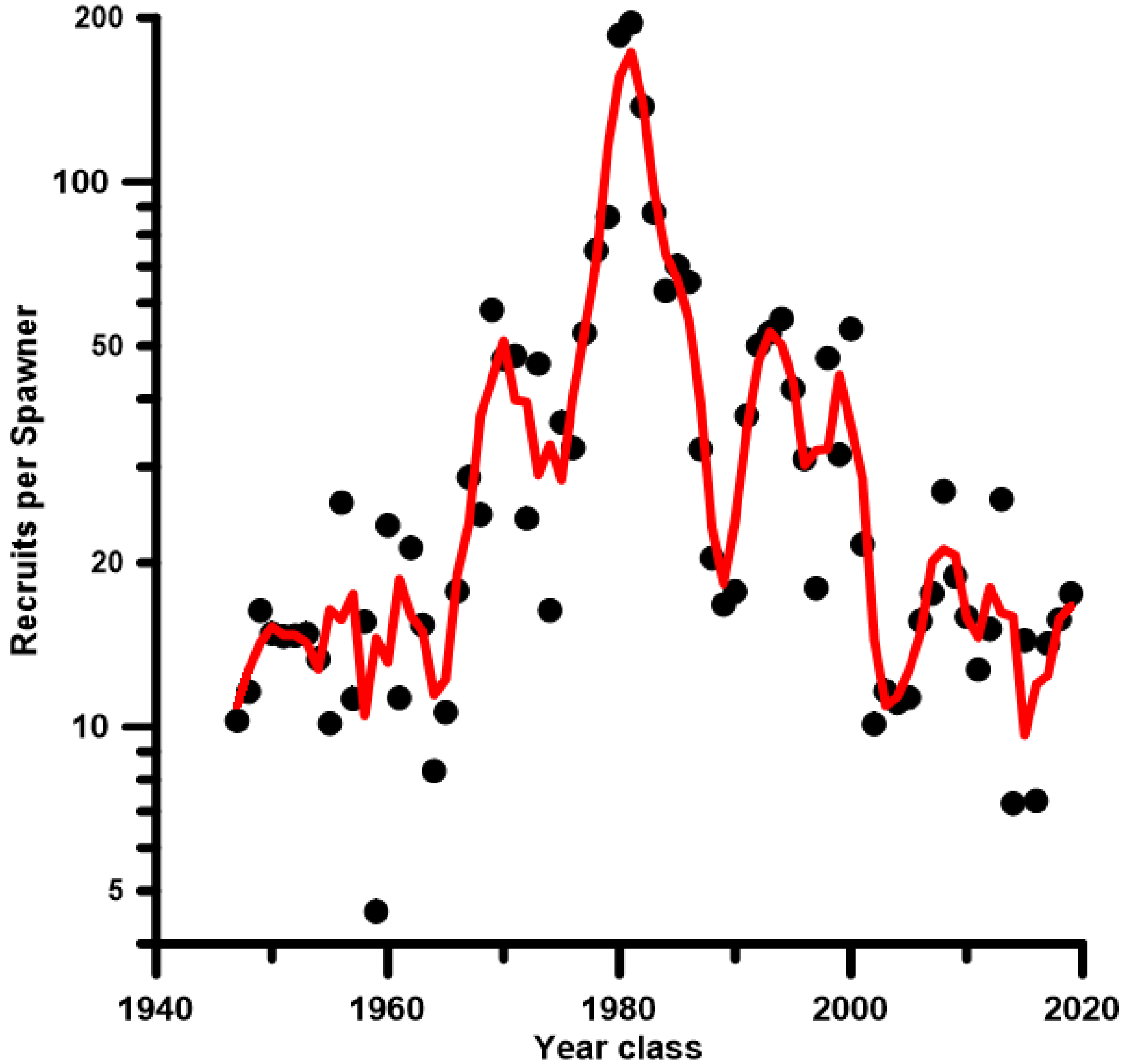


Figure 2.13.2. North Sea Autumn Spawning Herring time-series of recruits per spawner (RPS). RPS is calculated as the estimated number of recruits from the assessment divided by the estimated number of mature fish at the time of spawning and is plotted against the year in which spawning occurred. Black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

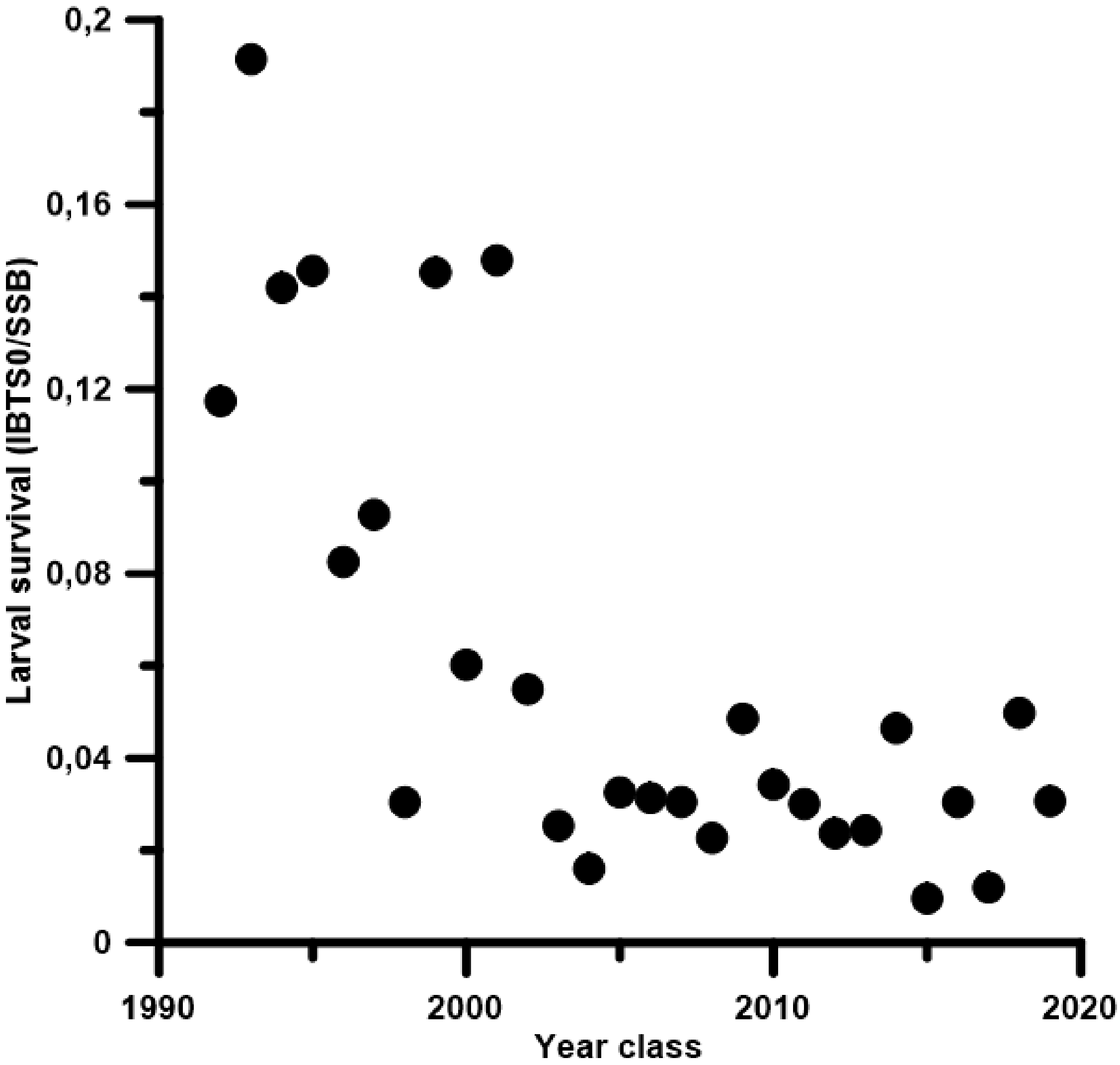


Figure 2.13.3. North Sea Autumn Spawning Herring time-series of larval survival ratio (Dickey-Collas & Nash, 2005; Payne *et al.,* 2009), defined as the ratio of the SSB larval index (representing larvae less than 10–11 mm) and the IBTS0 index (representing the late larvae, > 18 mm). Survival ratio is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

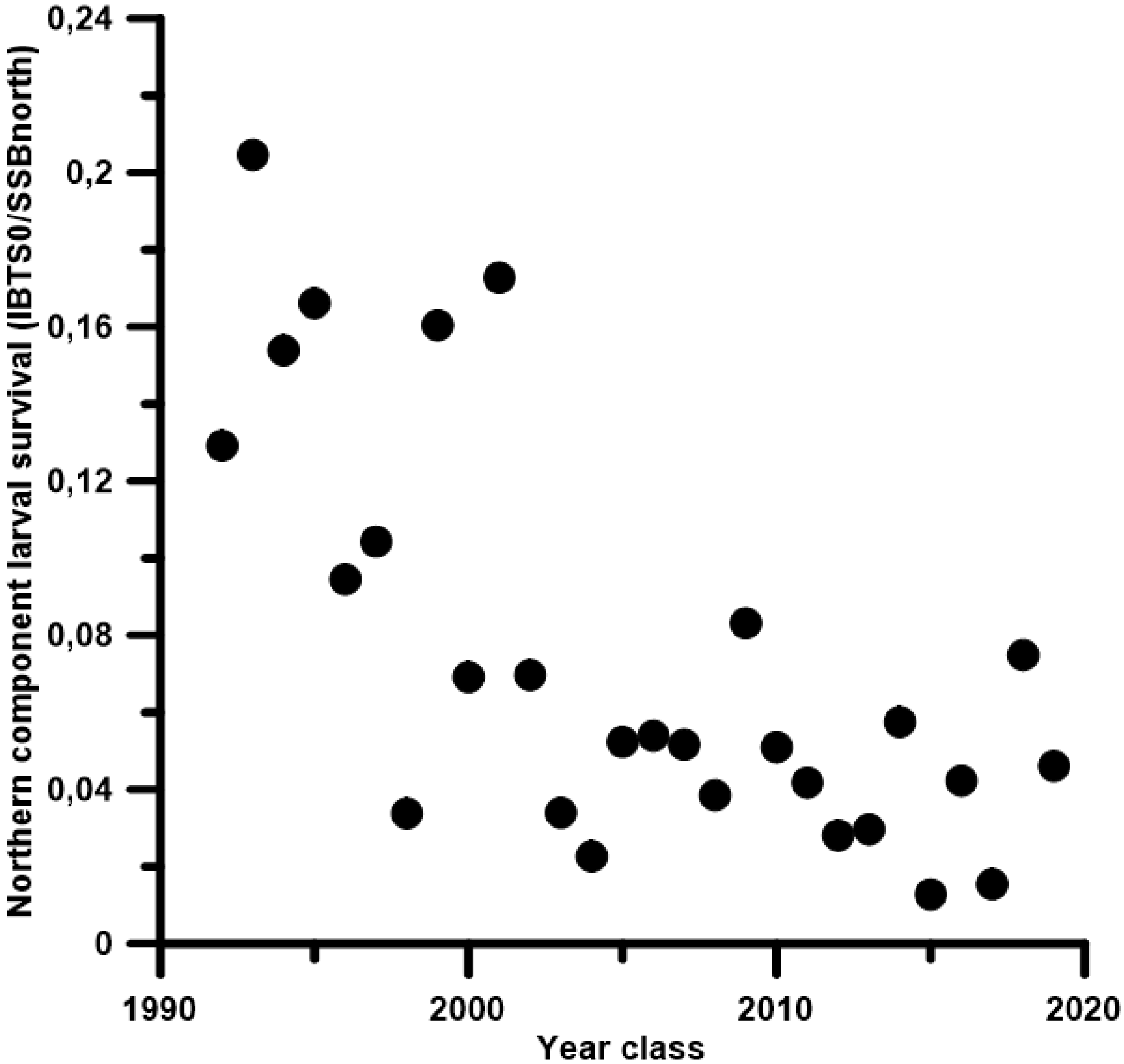


Figure 2.13.4. North Sea Autumn Spawning Herring time-series of larval survival ratio (Dickey-Collas & Nash, 2005; Payne *et al.,* 2009) for the northern-most spawning components (Banks, Buchan, Orkney-Shetland), defined as the ratio of the sum of the larvae indices for these components (representing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

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

3.1 The Fishery

3.1.1 Advice and management applicable to 2020 and 2021

ICES advised in 2019 on the basis of the MSY approach. This corresponds to zero catch in 2020 (ICES 2019).

The EU and Norway agreement on a herring TAC for 2019 was 29 326 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 2020, the EU and Norway agreement on herring TACs in Division 3.a was 24 528 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 2019, a TAC of 9001 t was set on the Western Baltic stock component. The TAC for 2020 was set at 3150 t.

3.1.2 Landings in 2019

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

Landings from 1989 to 2019 are given in Table 3.1.1 and Figure 3.1.1. In 2019, the total landings in Division 3.a and subdivisions 22–24 have decreased to 24 750 t. Landings in 2019 decreased by 27% in the Skagerrak, by 56% in the Kattegat and by 49% in subdivisions 22–24. As in previous years the 2019 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 2019 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
2019								
Div. 3.a fleet-C	29 326	12 325	197	0		12 893	25 415	3911
Div. 3.a fleet-D	6659	5692	51			916	6659	
SD 22–24 fleet-F	9001	1262	4966	1	1171	1601	9001	
% 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
2020								
Div. 3.a fleet-C	24 528	10 309	165	0		10 783	21 257	3271
Div. 3.a fleet-D	6659	5692	51			916	6659	
SD 22–24 fleet-F	3150	442	1738	0	410	560	3150	
% of 3.a fleet-C can be taken in 4 EU waters							-50%	
% of 3.a fleet-C can be taken in 4 Norwegian waters								-50%

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 occurs. Thus no catches were moved out of Division 3.a to the North Sea for catches taken in 2019.

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 realized distribution of the catches. For the fishery in 2019, the fishing industry informed HAWG that about 50% of the predicted catches in the C-fleet will be taken in Division 3.a and 50% will be transferred to the Division 4.

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 43 t in 2019. The decrease is linked to the low catches of sprat in 27.3.a. The low sprat catches is a result of merging the sprat stocks in the Skagerrak-Kattegak and in the North Sea into one stock unit (ICES, 2018), which had the consequence that most of the 3a fishery moved into the North Sea.

3.1.5 Winter rings vs. ages

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

3.2 Biological composition of the landings

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

The 24 750 t of landed herring were submitted stratified by area, fleet and quarter, resulting in 56 strata with landings. 27 of these strata were sampled – accounting for 87% of the landings.

Some strata with large amount of landings were un-sampled and 14 of the sampled strata, accounting for 13% of the landings, had less than three samples (Table 3.2.4). Un-sampled strata accounted in total for 3089 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 2019 was estimated to be 15 589 t, which represents a decrease of 29% compared to 2018 (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 2019 (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 1993–2019, are presented in tables 3.2.15 and 3.2.16.

The total catch of NSAS in Division 3.a amounted to 6087 t in 2019, which represents the third lowest value in the 27 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 2019 were reallocated to the appropriate stocks as shown in the text table below:

Stock	Catch reallocation	Tonnes
WBSS	4.aE (A-fleet)	6757
NSAS	3.a (C+D-fleet)	6087

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 2019 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 (OM) of hatch type. Different components of NSAS herring spawn at different times of the year, the three northern components spawn in autumn and are assigned to OM hatch month 9, whereas the Downs components spawning during winter in the Eastern Channel assigned to OM hatch month 12. Herring are predominantly spawning during spring in the western Baltic, the Kattegat and the Skagerrak and are assigned to the OM hatch month 4, however smaller stock components also spawn during winter, which would lead to an assignment to OM hatch month 12. This leads to potential overlapping distributions in Division 3.a of herring from both stocks with the same OM hatch month 12 signal. These winter-hatched individuals have traditionally been assigned differently in Danish and Swedish samples, where OM hatch month 12 has been assigned to WBSS in Sweden and to NSAS in Denmark. The samples from the IBTS have been split according to the Danish perception of stock affiliation.

A subsample of herring from different years 2002-2019 were individually assigned to both one of nine genetic stocks as well as to OM hatch month by Danish readers. OM type 12 and OM type 9 were pooled into OM type 9. Assignment error of OM type into genetic stock shows no specific trend and indicates around 5% incorrect assignment of OM type 4 into NSAS, and 12% incorrect assignment of OM type 9 or 12 into WBSS. There has been no correction for any bias indicated by these results.

	genetic stock	incorrectly assigned	WBSS	NSAS
All years	OM type 4	12%	478	65
	OM type 9 or 12	5%	23	448

For Danish data, OM based classification was extended using discriminant analysis (DA) based on otolith shape (OS) as well as fish and sample parameters. These data were calibrated with stock hatch type (4 or 9) and applied on production samples using non biased k = 1 nearest neighbour DA, with classification parameters: herring OS and otolith metrics as well as quarter, age, length and ICES Subdivision (see Stock Annex). The total sample size for hatch type was 2563 with 23% of the samples in Subdivision 20 (Skagerrak) and 77% in Subdivision 21 (Kattegat). Danish and Swedish sampling intensity was about equal and together covered all quarters and both subdi- vision. Proportion WBSS in sampled age classes were weighted by the national catches in the respective quarters and subdivisions. Not all age classes were covered by the sampling and thus proportions were estimated by relevant adjacent age classes or subdivisions. No samples from Kattegat 3rd quarter were available for split of ages 2-8+ wr, in this case the Swedish IBTS samples were used as a basis for the split, since it was expected to best reflect the proportions in the local distribution.

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

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

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

A total of 18 308 tonnes of herring was caught in the transfer area in 2019, with catches in quarter 2 constituting 64%, and with 5 samples (245 fish) taken in four ICES stat. rect. from this quarter being available for calculating stock proportions. No samples from the commercial fishery in other quarters in the transfer area were available.

For quarter 3, the same split as in quarter 2 was applied based on the assumption that the fishery is restricted to June and early July would catch similar proportions of the two stocks in this period.

Due to lack of sampling data in 2019 the split for quarters 1 and 4 had to be based on data from the time-series of samples from the commercial fishery with respectively 48 (from 2016 Q1) and 246 herring (from 2012 Q4 and 2014 Q4) available for the analysis.

Based on vs mean counts 6757 tonnes of WBSS herring were caught in the transfer area in 2019, with 90% from quarter 2 and 3 (fishery in June and July).

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

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

3.3 Fishery-independent Information

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

As a part of Baltic International Acoustic Survey (BIAS); the German autumn acoustic survey (GERAS) was carried out with RV “SOLEA” on 1–21 October 2019 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, 2020). In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring-spawning herring (WBSSH) and the Central Baltic herring (CBH) overlap. Survey results indicated in the recent years that in SD 24, which is part of the WBSSH management area, a considerable fraction of CBH is present and correspondingly erroneously allocated to WBSSH stock indices (ICES 2013/ACOM:46). Accordingly, a stock separation function (SF) based on growth parameters in 2005 to 2010 has been developed to quantify the proportion of CBH and WBSSH in the area (Gröhsler et al., 2013; Gröhsler et al., 2016). The estimates of the growth parameters from baseline samples of WBSSH and CBH in 2011-2018 support the applicability of the SF (Oeberst et al., 2013; WD Oeberst et al., 2014, 2015, 2016, 2017; WD Gröhsler and Schaber, 2018, 2019). The age-length distribution of herring in SDs 21, 22 and SD 23 in 2019 indicated some contribution of fish of CBH origin in 2019. This also included the SD 23 area of ICES rectangle 39G2, since biological samples of that rectangle were also used to raise the corresponding mean NASC values in the SD 24 area of the rectangle. Accordingly, the SF was applied all areas (SDs 21-24) in 2019. The applicability of the SF, which is normally checked by analysing the growth parameters based on baseline samples of WBSSH in SDs 21 and 23, could not be tested in 2019 due to some degree of mixing of CBH/WBSSH in these areas.

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 2019 was estimated to be 2.3 x 109 fish or about 51.6 x 103 tonnes in subdivisions 21–24. The biomass index in 2019 represents the lowest in the time-series.

The time-series has been revised in 2008 (ICES 2008/ACOM:02) to include the southern part of SD 21. The years 1991–1993 were excluded from the assessment due to different recording method and 2001 was also excluded from the assessment since SD 23 was not covered during that year (ICES 2008/ACOM:02).

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

3.3.2 Herring Summer Acoustic Survey (HERAS) in Division 3.a

The Herring acoustic survey (HERAS) was conducted from 25 June to 9 July 2019 and covered the Skagerrak and the Kattegat. The 2019 estimate of Western Baltic spring-spawning herring was 138 tonnes and 1,568 million herring. Compared to the value in 2018, the 2019 estimates represent an increase of 48% in numbers and of 6% in biomass. The stock biomass is dominated by 1–4 winter ring (80%). The present numbers of older herring (3+ group) in the stock decreased to 40% of the average of the whole time-series (2019: 575 million; mean 1991–2018: 1437 million). The results from the HERAS index are summarized 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 2019 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 1317 million larvae, the 2019 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. Stock proportions for these splitting are based on otolith microstructure from the IBTS samples by assuming that only OM4 (Spring-spawning) contribution to the WBSS fraction, while OM9 and OM12 (Autumn and Winter spawning) are considered non-WBSS. The following equation describes the model considered for both the presence/absence and positive parts of the Delta-Lognormal model:

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

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

Age (wr) classes (1–3) and (2-3) 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 3.2.14).

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

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

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

3.5 Recruitment

Indices of recruitment of 0-ringer WBSS for 2019 were available from the N20 larval surveys (see Section 3.3.3).

The strong correlation of the N20 with the 1-wr group of the GERAS ($R2$ = 0.74, Figure 3.5.1), which also shows a good internal consistency with the GERAS 2-wr group, indicates that the N20 is a good proxy for the strength of the new incoming year class. Since 2010, the N20 recruitment index lies below the long-term average (1992–2019: 5 667 million). The 2019 N20 recruitment index represents the fifth record low in the 28-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 multifleet 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 2019 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 multifleet assessment model SAM. The assessment model presents one fishing mortality matrix for each of the four fleets fishing WBSS herring (A, C, D, and F). The model is designed to handle fleet disaggregated catches, which are available only from year 2000 while the model is run over the time period 1991–2019. The current implementation is an R-package based on Template Model Builder (TMB) and can be found at https://github.com/fishfollower/SAM (branch "multi").

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

The disaggregation of the fishing catches in the multifleet SAM can bring problems of convergence due to the increase of zeros in the fleet observed catches, which are ignored by the model since zeros cannot be fitted with a lognormal distribution. It is therefore important to compare the outputs of both the single and the multifleet models every year and check that the results are consistent between the models. For this year update assessment, the corresponding single fleet version is available with a configuration as close as possible to the multifleet model. The single fleet model output is represented as an overlay in the SSB, F, recruitment and total catch plots in the multifleet output. Both the multifleet (WBSS_HAWG_2020) and the single fleet (WBSS_HAWG_2020_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.

This year, problems of convergence occurred when adding the 2019 data. This was due to difficulties estimating the variance parameter of the F process for the C-fleet (logSdLogFsta). To solve the problem without changing the configuration of the model, which would require a benchmark, the model was first run with coupling the variance parameters for all fleets so only one logSdLogFsta parameter was estimated. The converged run was used to provide initial values to the run with the original configuration. This allowed the logSdLogFsta parameter for the C-fleet to be well estimated in the second run and removed the problem of convergence.

3.6.4 Final run

The results of the assessment are given in Tables 3.6.11–3.6.14. The estimated SSB for 2019 is 56 621 [40 271, 79 611 (95% CI)] t. The mean fishing mortality (ages 3–6) is estimated as

0.382 [0.249, 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 was above 100 000 t in the early 2000s (Figure 3.6.4.1). After a small peak in 2006 coinciding with the maturing of the last major year-class, the SSB has declined up to 2011 with a SSB of 67.7 kt. SSB has only slightly increased in the following period up to 83 kt in 2014 and then has declined to 56.6 kt in 2019, which is the lowest SSB of the time-series.

Fishing mortality on this stock was high in the mid-1990s, reaching a maximum of over 0.6 yr-1. In 1999–2009, F3–6 stabilized between 0.50 and 0.57. In 2010 and 2011, F3–6 decreased significantly to a value of approx. 0.37 yr-1, where it stabilized for few years until it increased again above 0.4 yr-1 from 2015 to 2018. F3–6 then decreased below 0.4 in 2019 (Table 3.6.11, Figure 3.6.4.2).

Recruitment was the highest (~4 billion) at the beginning of the time-series (1991-1999) and has been decreasing overall since 2000. The 2019 estimate of 778 899 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 1991–1999 and no signs of density-dependence. This is followed by a distinct decline in recruitment to values below 3 billion at a relatively constant spawning-stock biomass between 120 and 160 kt over the period from 2000–2006. In the most recent period, from 2007 to 2019 recruitment has varied from about 1.5 billion to less than 1 billion at SSB between 57 kt and 104 kt, with a worrying trend of declining recruitment in the latest years since 2017.

The total catch is well fitted (Figure 3.6.4.5) but also the catch per fleet (Figure 3.6.4.6) except for the fleet A where some observations are outside the confidence interval of the estimated catch.

The estimated partial fishing mortalities show remarkable differences between the four fleets reflecting the targeted ages of the individual fisheries, increasing with age for the A-fleet and the F-fleet, whereas distinct peaks are found for the C-fleet and the D-fleet at ages 2 and 1 wr respectively (Figure 3.6.4.7). The fishing mortality increases in the recent years for the A-fleet. The C-fleet shows an increasing trend in F for the last three decades, while there is a decreasing trend in F for the D- and F-fleet. The selectivity pattern for the D-fleet has a tendency of shifting its highest selectivity from age 1 to age 2 (wr) in later years. Total fishing mortality on the WBSS stock increased with herring age (Figure 3.6.4.8). It decreased overall over time but showed an increase in 2015-2018 and a decrease again in 2019.

The model was constrained to have the same selectivity for the two oldest ages (wr) 7+ in all fleets. The fishing mortality was assumed to be independent across ages for the A-fleet (see

$corFlag in Table 3.6.10). The estimated correlation parameter in the F random walk for the C-fleet was estimated to a very high value, which caused convergence problems in initial runs during the benchmark, it was therefore assigned a fixed high value in the subsequent assessment runs resulting in parallel selection patterns.

The estimated survey catchability is rather different among the surveys. The HERAS and the GerAs surveys are relatively constant over the applied ages (wr) 3–6 and 1–4 respectively. Whereas both IBTS Q1 and Q3.4 surveys show, sharp declines with increasing ages 1–3 and 2–3, respectively (Figure 3.6.4.9). Interpretation of the different catchability patterns is complex, and likely, a number of reasons including ontogenetic differences in the spatial distribution and behaviour of the different age classes at the time of the surveys may affect their relative availability to the different samplings.

The surveys present some strong correlations notably between the older ages (Figure 3.6.4.10). The same is observed for fleets C and F. The tracking of each cohort can be observed in Figure 3.6.4.11.

The F-fleet (ages 1-8+) has a lower observation variance than the GerAs and the HERAS, the IBTS Q3.4 surveys variance is lower than the C-fleet (ages 2-8+), the IBTS Q1 and the N20. Both the D-fleet and the A-fleet have very high observation variances, as well as the age 0 for all fishing fleets (Figure 3.6.4.12).

Residuals for catch in different fleets generally show poorer fit to the youngest year-classes 0–1 wr (Figure 3.6.4.13). The A-fleet shows large positive residuals in 2019 showing that the model underestimates the catches-at-age in 2019. The inverse is observed for the C-fleet with large negative residuals in 2019 for ages 4-8+, showing an overestimation of the catches for these ages. The F-fleet presents large negative residuals for ages 0-1 over the entire time-series. Further, the fit by fleet to some degree follows the amount of catches in the fleets with increasingly better fit from A-fleet, D-fleet, C-fleet to the F-fleet (Figures 3.6.4.13–3.6.4.17). The fit to the combined fleets at the beginning of the time-series follows the observations to some degree except for the two youngest age classes 0–1 wr, which exhibit a rather poor fit. (Figure 3.6.4.18).

Inspection of model diagnostics shows the occurrence of high residuals in some years (i.e. 2009 and 2018-2019 in the GerAs and 2013–2014 in HERAS; Figure 3.6.4.13). Overall, the agreement between the data and the fitted model appears acceptable throughout the data sources, which are most influential in the model. The individual survey diagnostics show some differences in how the model fit the different survey data, and the level of fitting is widely in agreement with the estimated observation variance for each data component (Figures 3.6.4.19–24). In general, a similar fit is found for all included ages (wr) 3–6 of the HERAS index (Figure 3.6.4.19). In recent years, GerAs shows a clear drop in observed indices for ages (wr) 1–4 that are poorly fitted and show therefore large negative residuals (Figures 3.6.13 and 3.6.4.20). The N20 picks up the negative trend in the observations of the recruitment index (Figure 3.6.4.21) however still with negative residuals by the end of the time-series (Figure 3.6.4.13). Poorer fit is observed for the IBTS+BITS-Q1 for all ages (wr) 1–3, over the entire time-series (Figure 3.6.4.22) and likewise to the IBTS+BITS-Q3.4 for the two ages (wr) 2–3 (Figure 3.6.4.23) with large positive residuals for age (wr) 2 in recent years (Figure 3.6.4.13).

Retrospective patterns have increased compared to last year assessment (Figure 3.6.4.24). While in the 2019 assessment, the SSB had a Mohn's rho of 13% and the retrospective estimates were within the confidence interval of the 2019 SSB estimate; the Mohn's rho in this year assessment has increased to 25% and the retrospective estimates for the 2- to 4-year peels are outside the confidence interval of the 2020 SSB estimates. Moreover, retrospective in the number-at-age shows that the oldest age groups (age 7-8+) contribute most to the deterioration of the retrospective pattern in SSB. Average fishing mortality retrospective estimates are also outside the confidence bounds for F for the 2 to 4-year peels (Mohn's rho = -18% compared to -7% in the 2019 assessment, Figure 3.6.4.25). The retrospective for recruitment is acceptable having a Mohn's rho = 2% (Figure 3.6.4.26). Retrospective is very small for total catch (Figure 3.6.4.27).

This year, different exploratory runs were conducted to investigate why the retrospective patterns have increased. Two runs were made without the HERAS survey and without the GerAs survey. Both of them showed large retrospective patterns similar to the original fit suggesting that none of the two surveys is the main only responsible for the retrospective pattern in the model. The retrospective patterns seem to be due to the catch-at-age data which is poorly fitted in the recent years (see large residuals for A-, C- and F-fleet Figure 3.6.4.13). In addition, the 2019 catch data were marked by an increase in the A-fleet catches and a decrease in the C- and F-fleets catches. This was notably clear in the small proportion of old fish in the C-fleet, the large proportion of old fish in the A-fleet and a decrease in the catches of all ages, except age 2, for the F-fleet.

These contrasting signals in the catch data are the likely reason for the large retrospective patterns in the 2020 assessment.

Similarly with what happened in the 2019 assessment, the decrease in stock perception between the 2019 assessment estimates and the 2020 ones seems to follow the GerAs survey that pushes the stock down due to very low indices for ages 1–4 in 2019. Indeed, leaving out the GerAs survey from the dataset induces an increase in the perception of the stock with increasing SSB in recent year (Figures 3.6.4.32–35). This pattern is also observed in the single-fleet model (Figures 3.6.4.28–31).

3.7 State of the stock

The stock was benchmarked in 2018 with a substantial increase in the chosen value of B_{lim} and a slight downwards revision of the SSB levels. The stock has decreased consistently from mid

2000s to a historical low in 2019 (Tables 3.6.11, Figure 3.6.4.1). With the new B_{lim} (120 kt) the stock has been in a state of impaired recruitment since 2007.

The 2018 benchmark calculated a new F_{MSY} of 0.31. Fishing mortality ($F_{3–6}$) was reduced between 2007 and 2011 from above 0.50 to 0.37 (Tables 3.6.11, Figure 3.6.4.2). $F_{3–6}$ has then remained stable slightly above F_{MSY} until 2014 (~0.38), but showed an increase in 2015-2018 with an estimated $F_{3–6}$ between 0.42 and 0.50. $F_{3–6}$ then decreased in 2019 but was still well above F_{MSY} (0.382).

Recruitment has be declining in the last five years with a historical low value in 2019 of 778 899 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 68 kt in 2011 to 83 kt in 2014) despite the general low recruitment level, but since the strong 2013 year-class, recruitment has declined to historic low values that will not support a rebuilding of the stock with present levels of fishing mortalities.

3.8 Comparison with previous years perceptions of the stock

The table below summarizes the differences between the current and the previous year assessment. The addition of the 2019 data resulted in a change in the perception of the stock compared to last year assessment. The recent estimates of recruitment have decreased in the current assessment (-5.78%) and F appears to be larger than previously estimated (+16.63% to +12.05%) and SSB smaller (-16.67% to -21.64%).

In this year assessment, recruitment for the 2013 year class (most recent large year class) was estimated to be 1 581 113 thousands compared to 1 743 986 thousands in the 2019 assessment. This decrease in recruitment induced a decrease in the SSB estimates in the following years compared to the 2019 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. This change in stock perception with decrease in SSB and recruitment and increase in $F_{3–6}$ was already observed in the 2019 assessment compared to the 2018 assessment and seemed to worsen every year.

Parameter	Assessment in 2019	Assessment in 2020	Difference (2020-2019)/2020
SSB (t) 2017	83 895	71 908	-16.67%
$F_{(3–6)}$ 2017	0.416	0.499	16.63%
Recr. (‘000) 2017	1 057 849	1 000 047	-5.78%
SSB (t) 2018	74 132	60 944	-21.64%
$F_{(3–6)}$ 2018	0.416	0.473	12.05%

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 multifleet 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 multifleet 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 2020 assessment, recruitment for the forecasts was calculated on the period 2014–2018). 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 (2015–2019). Based on earlier considerations in HAWG, the different periods were chosen to reflect recent levels in recruitment and weights.

3.9.2 Intermediate year 2020

A catch constraint was assumed for the intermediate year (2020). Predicted 2020 catch by fleet is summarized in the table below and depends on two main assumptions:

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

Fleets	TAC 2020 NSAS+WBSS (t)	TAC WBSS (t)	TAC WBSS given utilization (t)
A	385 008	3184	100% = 3184
C	24 528	72.84% = 17 866	50% = 8933
D	6659	33.81% = 2251	5.47% = 123
F	3150	3150	100% = 3150
Total	419 345	26 452	15 390

The amount of WBSS taken in Division 4.aE by the A-fleet in 2020 is assumed equal to the average over the last 3 years (2017–2019) corresponding to 3184 t.

The expected catch of WBSS in Division 3.a was calculated assuming the same WBSS proportions in the catch of each fleet (stock split) in 2020 as the average of 2017–2019 in Division 3.a. This resulted in 72.84% 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 fishing industry, ICES assumes that the totality of the transfer will be use this year. Therefore, a 50% TAC transfer in 2020 results in a TAC utilization for the C-fleet in Division 3.a of 50%.

Around thirty-four percent of the D-fleet 2019 catch is assumed to be WBSS herring (average NSAS/WBSS split 2017–2019). In addition, the proportion of the TAC taken in the small-meshed fishery (D-fleet) has varied largely during the last 6 years from a maximum of 94% in 2015 to the minimum of 5.4-5.5% recorded since 2017 due to choke species effects of restricting whiting quotas. The problems with bycatches under the landings obligation may persist and 5.74% utilization of the TAC in 2020 for the D-fleet is assumed as the average utilization over the last 3 years (2017-2019).

The catch by the F-fleet fishing for human consumption in subdivisions 22–24 is usually very close to the TAC (3150 t) and an utilization 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 15 390 t of WBSS herring in 2020.

3.9.3 Catch scenarios for 2021-2023

The outputs of the short-term prediction, based on a catch constraint in the intermediate year 2020 of 15 390 t are given in Tables 3.9.1–3.9.15.

Different catch options for the years after the intermediate year were explored with fleet-wise selection patterns and deterministic forecasts. To most closely resemble current WBSS management, a constraint is added to the forecasts so that, after the intermediate year, for all scenarios (except for the constant 2020 TAC, the F = 0 and the catch for bycatch fleets only scenarios) the F-fleet is assumed to get 50% of the total catch of WBSS herring.

3.9.4 Exploring a range of total WBSS catches for 2021 (advice year) to 2023

ICES gives advice according to the FMSY approach for the WBSS stock. Because the forecasted SSB in 2022 is below Blim, ICES advises a zero catch for 2021.

None of the catch scenarios for 2021, including zero catch, is expected to bring SSB above Blim in 2022. Similarly to last year, besides requested standard scenarios HAWG also calculated the po- tential development of the stock projections until 2023 with different low F scenarios, where F2022 = F2021. None of these scenarios, even when F = 0, can bring the SSB above Blim in 2023.

The TAC for 2020 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.

This year two new scenarios were requested by ACOM for zero catch advice stocks: (1) the "Catch for bycatch fleets only" scenario (see Table below), and (2) a scenario where the biomass is constant between 2021 and 2022. For a stock with SSB calculated in the 1st of January (and the final year of assessment being 2019), this can be easily done because SSB in 2021 only depends on F in 2020 and F is estimated given a TAC constraint so is the same for all forecast scenarios. As a result, all scenarios tested in the short-term forecast would have the same SSB in 2021 and the F in 2021 can be estimated to obtain a SSB in 2022 equal to 2021. For WBSS, there are complications to this calculation because the advice is annual (Jan-Dec) but the SSB is calculated and reported at spawning time (Spring). This means that SSB in 2021 is in fact the result of catches assumed (agreed TACs) for the intermediate year (2020) and some catches in the first months of 2021. In other words, the SSB in 2021 depends on F in 2020 but also on a fraction of the F in 2021 which is the advice year. What to assume for the first months of 2021 is the real issue here. For instance, if a zero catch is assumed in 2021 according to the advice, it will be uninformative because the table of advice would still only show the average F in 2021 (so F = 0). If a F that makes SSB 2021 = SSB 2020 is assumed for 2021, it will be an unrealistic high F needed to compensate for the low catches assumed in 2020. Given the reasons described above, the constant SSB between 2021 and 2022 scenario could not be meaningfully run for WBSS herring and is not included among the catch scenarios presented by the EG.

Table	Basis	Total catch (2021)	F_{3-6}	SSB* (2021)	SSB* (2022)	% SSB change **	% advice change ***
ICES advice basis							
3.9.2	MSY approach: zero catch	0	0	66 824	87 890	32	0
Other scenarios							
3.9.3	MAP^: F = F_{MSY} × SSB_{y-1}/MSY $B_{trigger}$	10 273	0.118	65 973	77 674	18	
3.9.4	MAP^: F = $F_{MSY\ lower}$ × SSB_{y-1}/MSY $B_{trigger}$	7291	0.082	66 230	80 610	22	
3.9.5	MAP^: F = $F_{MSY\ upper}$ × SSB_{y-1}/MSY $B_{trigger}$	12 393	0.144	65 786	75 602	15	
3.9.6	F= F_{MSY}	24 535	0.31	64 618	64 275	-1	
3.9.7	F = F_{pa}	27 179	0.35	64 340	61 819	-4	
3.9.8	F = F_{lim}	33 356	0.45	63 650	56 155	-12	
SSB (2022) = B_{lim} ^^							
SSB (2022) = B_{pa} ^^							
SSB (2022) = MSY $B_{trigger}$ ^^							
3.9.9	F = F_{2020}	14 410	0.170	65 603	73 849	13	
3.9.15	Catch for bycatch fleets only ^^^	3308	0.026	66 574	85 251	28	

*** 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 (2022) relative to SSB (2021).**

***** The advised catch in 2020 was 0 tonnes.**

^ Revised Baltic MAP (2018/973) which refers to using the most recent reference points. As SSB2020 is below MSY Btrigger, the FMSY, FMSY lower and FMSY upper values in the MAP are adjusted by the SSBy-1/MSY Btrigger ratio.

^^ The Blim and Bpa cannot be achieved in 2022 even with zero catch advice.

^^^ Only the A fleet that targets NSAS herring and the D fleet that targets sprat are allowed to fish assuming the same catch as in the intermediate year 2020 (C and F fleets have 0 catch).

Table	Basis	Total catch (2021)	Total catch (2022)	F3–6 (2021)	SSB* (2021)	SSB* (2022)	SSB* (2023)	% SSB change (2021–2022)	% SSB change (2022–2023)
Medium-term catch scenarios									
3.9.10	F = 0	0	0	0	66 824	87 890	111 745	32	27
3.9.11	F = 0.05	4506	5726	0.05	66 462	83 450	102 017	26	22
3.9.12	F = 0.1	8783	10 659	0.1	66 103	79 277	93 335	20	18
3.9.13	F = 0.15	12 843	14 905	0.15	65 746	75 353	85 569	15	14
3.9.14	Constant catch 2020–2022 #	15 391	15 391	0.150	65 726	74 580	85 273	13	14

*** For spring-spawning stocks, the SSB is determined at spawning time and is influenced by fisheries and natural mortality between 1 January and spawning time (April).**

Assumptions for 2020 catches kept constant for 2021–2022.

3.10 Reference points

The WBSS stock was benchmarked in 2018 (ICES WKPELA, 2018) with subsequent changes of reference points. Blim 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. Bpa and MSY Btrigger were subsequently set to 150 000 t. Using the EqSim software FMSY was estimated to 0.31, Flim 0.45 (5% risk to Blim) and Fpa 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. Similarly to what was observed in last year assessment, the 2020 assessment shows a downward revision in the SSB estimates in recent years compared to the 2019 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 currently unknown but are likely to affect the precision of the assessment. Moreover, mixing between WBSS and central Baltic herring in subdivisions 22–24 may contribute to uncertainty in the assessment.

Interannual variability of the herring migration patterns and 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 Considerations on the 2020 advice

This year assessment shows both a decrease in SSB and its further downward revision (-18% for 2018 SSB). Recruitment continues decreasing and it is estimated at its historical minimum in 2019. Under these conditions the stock is not expected to increase above Blim in the short-term (2021) nor in the medium-term (2022, contrary to what expected in the last year advice) for any level of fishing mortality (SSB2023 = 111 745 t assuming F = 0).

To explore the potential development of the stock, projections until 2023 with different low F scenarios (F = 0.05, 0.1, 0.15) are provided in the Table in section 3.9.4. The development of a rebuilding plan for this stock remains a high priority for this stock and it is recommended by HAWG.

The EU–Norway TAC-setting procedure used for herring in Division 3.a (EU–Norway, 2013) calculates the TAC for the combined WBSS and NSAS stocks in the C-fleet as 41% of the ICES MSY advice for WBSS plus 5.7% of the TAC for the A-fleet (see section 3.13 for more details). However, according to a safety clause in the procedure, the method should not apply if serious concerns exist about the status of one of the two stocks, which is the case given the severe over-exploitation of the WBSS stock.

WBSS herring is also caught in the herring fisheries operating in the eastern part of Division 4.a (so called "transfer area"). Herring catches in the transfer area were 5043 t in 2018 of which 2164 t were estimated to be WBSS, and increased to 18 308 t in 2019 with 6757 t of WBSS. Estimation of the stock composition in the transfer area is highly uncertain which has implication for the qual- ity of the input data for the assessment, but most importantly the amount and stock composition of herring catches in the transfer area remain unpredictable and represent an inevitable source of fishing mortality on the WBSS stock without additional area and/or time restriction on the herring fishery in the North Sea.

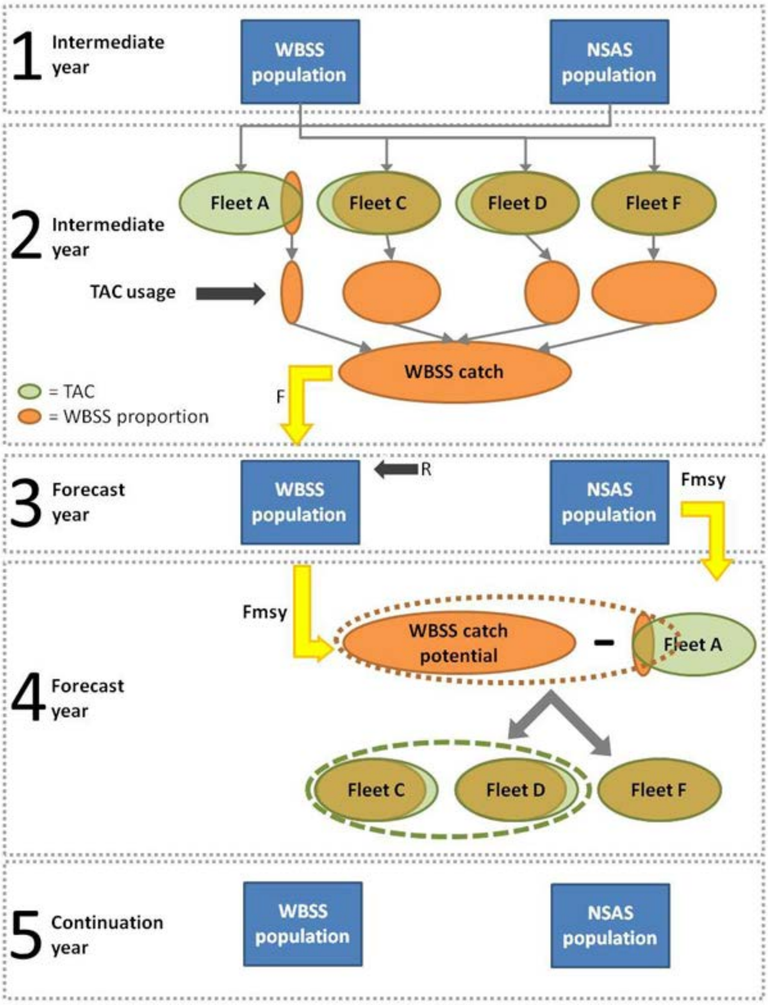
3.13 Management Considerations

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 2019. ICES assumes that a transfer of 50% will be applied in 2020 (cf. part 3.9).

ICES catch predictions vs. management TAC

ICES gives advice on catch scenarios for the entire distribution of the NSAS and WBSS herring stocks separately whereas herring is managed by areas (see the following text diagram). The procedure of setting TACs in ICES Division 3.a and SD 22–24 takes into account the occurrence of different 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 FMSY 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 realized WBSS catches may deviate from the predictions based on FMSY.

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

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 Blim, 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.

3.14 Ecosystem considerations

Migration

Herring in Division 3.a and subdivisions 22–24 is a migratory stock. There are feeding migrations from the Western Baltic into more saline waters of Division 3.a and the eastern parts of Division 4.a. There are indications from parasite infections that yet unknown proportions of stock components spawning at the southern coast in the Baltic Sea may perform similar migrations (Podolska et al., 2006). Herring in Division 3.a and subdivisions 22–24 migrate back to Rügen area (SD 24) and other spawning areas at the beginning of winter. Moreover, there are recent indications that Central Baltic herring perform migrations into Subdivision 24 (Gröhsler et al., 2013).

Overwintering is considered to take place in the Öresund (Nielsen et al., 2001). However, recent observations on the acoustic surveys (Gröhsler and Schaber, 2018) indicate changes in distribution and it is currently unclear whether fish still aggregate in the shallow parts of the Sound or whether the density of herring accumulating in the area has changed overall. Whatever the temporal limitation of this survey are and whatever the cause for this observation might be, it may underline the need to validate the multiple-decade-old information on WBSS herring migration patterns.

Similar to the NSAS, the WBSS has produced a series of poor year classes in the last one and a half decade and the 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.

Predation

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

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

The non-indigenous goby (*Neogobius melanostomus*) which reached extremely high abundances in the coastal Baltic Sea during recent years (Kornis *et al.*, 2012). It has been suspected to significantly increase predation pressure on herring eggs. However, a recent study revealed a minor effect by juvenile gobies that would ingest eggs when encountered but *N. melanostomus* in general is rather specialized on mollusc-prey and additionally there is a temporal mis-match among the juvenile gobies and herring spawning period (Wiegleb *et al.*, 2018).

Eutrophication

Estuarine WBSS herring spawning grounds in the Western Baltic Sea are still subject of increased nutrient levels and steady input of agricultural discharge. The resulting increased turbidity lead to a strict vertical limitation of perennial macrophytes in Greifswald Bay to the very littoral zone with a growth limit of about 3.5 m (Kanstinger *et al.*, 2018). The major spawning zone in the system is considered to be located in a range of 1-2 m water depth (Moll, 2018). Besides a potential reduction in spawning beds the depth limitation evidently results in increased exposure against storm-induced turbulence and consequently increased herring egg mortality (Moll *et al.*, 2018).

Although spring-spawning herring facultative selects other spawning substrates for egg deposition (e.g. stones), the complexity of spawning substrate as provided by macrophytes promotes egg survival by unknown mechanisms (von Nordheim *et al.*, 2018). Additionally, increased blooms of filamentous algae (*Pilayella littoralis*) promoted by elevated nutrient levels in synergy with warming spring temperatures cause significant herring egg mortality (von Nordheim *et al.*, *in press*).

3.15 Changes in the Environment

Climate drivers

There is ample indication that prevailing winter temperature- as expressed by the Baltic Sea Index (BSI) significantly affect recruitment strength of WBSS herring (Cardinale et al., 2009; Gröger et al., 2014). The exact ecological mechanisms causing this link remain widely unknown. However, for larval herring production in Greifswald Bay it could be shown that the optimal temperature window for embryonic development (Peck et al., 2012) is very important for reproduction-success and tends to have contracted in recent years (Dodson et al., 2019). There are strong indications that according to recent mild winter regimes the seasonal timing of spawning migration and reproduction has shifted and those phenology changes are responsible for limited reproduction success as expressed by larval productivity in Greifswald Bay reflected by the abundance of 1-year juveniles in the outer Western Baltic Sea as expressed by the GERAS 1-wr abundance index (Polte et al., unpublished). As currently the initial hatching cohorts are not resulting in significant numbers of larval survivors beyond the critical period after yolk-sac consumption, later cohorts are contributing most to recent recruitment patterns (Polte et al., 2014). However, this might overall result low recruitment compared to earlier years when the larvae of initial cohorts drove the numbers of survivors. Additionally, those later cohorts (hatching mid-April-early May) are exposed to a suit of different stressors: If the seasonal SST curve is steep and the shallow water heats fast during spring, those larvae are increasingly encountering physiological limits. Moyano et al. (in press) could recently show that WBSS larvae develop cardiac arrhythmia beyond a SST threshold of 16°C and that the number of days above this threshold increased in Greifswald bay during past decades. Besides those direct temperature effects, synergistic effects of eutrophication and warming (see Eutrophication above) lead to multiple cascades affecting egg survival of those later cohorts in particular.

Table 3.1.1. Western Baltic herring. Total catch (both WBSS and NSAS) in 1989–2019 (1000 tonnes). (Data provided by Working Group members 2020).

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	2019*
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	0.6
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	0.1
Lithuania							0.4									
Netherlands												0.03				
Norway				3.5	4.0	3.3	3.3	0.1	0.4	3.0	2.0	2.5	3.9	3.3	3.4	2.5
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	8.5
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	11.7
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	1.5
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	1.7
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	3.2
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	2.0
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	5.6
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	1.1
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	0.7
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	9.5
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	0.01
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	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	0.4
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	24.7

***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 2004-2019 by fleet and quarter (1000 t). (both WBSS and NSAS)

Year	Quarter	Div. IIIa		SD 22-24	Div. IIIa + SD 22-24	Year	Quarter	Div. IIIa		SD 22-24	Div. IIIa + SD 22-24
		Fleet C	Fleet D	Fleet F	Total			Fleet C	Fleet D	Fleet F	Total
2004	1	13.5	2.8	20.4	36.7	2012	1	4.5	1.8	14.0	20.3
	2	2.8	3.3	10.4	16.5		2	0.3	0.7	2.5	3.5
	3	8.2	10.8	2.4	21.4		3	12.3	1.7	1.1	15.0
	4	5.9	5.0	8.6	19.4		4	5.2	1.1	3.5	9.9
	Total	30.3	22.0	41.7	93.9		Total	22.3	5.4	21.1	48.8
2005	1	16.6	6.1	20.4	43.1	2013	1	8.5	0.8	11.7	20.9
	2	3.4	1.9	15.6	20.9		2	1.7	0.6	8.5	10.8
	3	23.4	3.4	1.9	28.7		3	8.4	1.0	1.1	10.4
	4	12.0	2.6	5.8	20.5		4	9.8	0.5	4.3	14.7
	Total	55.4	14.1	43.7	113.3		Total	28.4	2.9	25.5	56.7
2006	1	15.3	5.9	15.1	36.2	2014	1	6.2	0.2	10.8	17.3
	2	2.6	0.1	17.2	19.9		2	2.3	0.5	2.3	5.1
	3	15.7	0.8	3.0	19.5		3	10.7	2.4	0.8	14.0
	4	8.3	2.4	6.5	17.3		4	5.7	0.8	4.4	10.9
	Total	41.9	9.3	41.9	93.0		Total	24.9	4.0	18.3	47.2
2007	1	7.7	3.0	18.8	29.5	2015	1	9.0	1.9	14.2	25.1
	2	3.8	0.1	10.5	14.4		2	1.0	0.1	2.8	3.9
	3	22.4	0.8	1.7	24.9		3	7.5	1.5	0.9	9.9
	4	7.7	1.8	9.5	18.9		4	4.1	2.8	4.3	11.1
	Total	41.6	5.7	40.5	87.7		Total	21.6	6.3	22.1	50.0
2008	1	8.2	3.9	18.4	30.5	2016	1	7.9	0.7	15.5	24.0
	2	2.7	0.3	11.3	14.3		2	0.4	0.3	3.5	4.1
	3	14.9	0.6	6.0	21.5		3	15.7	1.3	1.4	18.5
	4	6.5	1.0	8.4	16.0		4	3.4	0.3	4.7	8.3
	Total	32.3	5.9	44.1	82.3		Total	27.4	2.5	25.1	55.0
2009	1	11.1	2.7	19.5	33.2	2017	1	7.5	0.0	16.8	24.3
	2	3.1	0.1	6.8	10.1		2	0.2	0.1	3.4	3.6
	3	14.3	0.9	1.4	16.6		3	12.1	0.1	1.0	13.2
	4	6.0	0.7	3.3	10.0		4	6.6	0.3	5.3	12.2
	Total	34.5	4.3	31.0	69.9		Total	26.4	0.4	26.5	53.3
2010	1	8.4	1.1	10.2	19.8	2018	1	10.0	0.0	12.0	21.9
	2	3.9	0.7	5.4	10.1		2	0.2	0.1	3.4	3.8
	3	13.4	0.4	0.4	14.3		3	10.2	0.1	0.2	10.6
	4	9.2	0.1	1.8	11.1		4	2.5	0.1	3.4	6.0
	Total	35.0	2.3	17.9	55.2		Total	22.9	0.4	19.0	42.2
2011	1	7.0	0.5	7.8	15.3	2019	1	4.4	0.1	6.0	10.5
	2	0.5	0.2	4.1	4.8		2	0.5	0.0	0.4	1.0
	3	6.5	1.0	0.8	8.3		3	6.5	0.2	0.3	7.0
	4	3.4	0.9	3.2	7.4		4	3.1	0.0	3.1	6.3
	Total	17.4	2.6	15.8	35.9		Total	14.6	0.4	9.8	24.7

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: 2019 Country: ALL

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	34.88	27			34.88	27
	2	25.71	65			25.71	65
	3	3.31	85			3.31	85
	4	1.02	122			1.02	122
	5	0.43	87			0.43	87
	6	0.20	137			0.20	137
	7						
	8+						
	Total	65.56		0.00		65.56	
	SOP		3,087		0		3,087
2	1	4.98	33	0.17	23	5.16	33
	2	0.44	63			0.44	63
	3	0.35	76			0.35	76
	4	0.05	90			0.05	90
	5	0.02	49			0.02	49
	6						
	7						
	8+						
	Total	5.84		0.17		6.02	
	SOP		226		4		230
3	0	1.38	22	1.71	7	3.09	14
	1	38.56	57	0.42	29	38.98	56
	2	21.80	98			21.80	98
	3	8.36	135			8.36	135
	4	2.87	143			2.87	143
	5	1.23	157			1.23	157
	6	0.95	180			0.95	180
	7	0.19	202			0.19	202
	8+						
	Total	75.33		2.13		77.46	
	SOP		6,298		24		6,322
4	0	8.74	20			8.74	20
	1	27.73	49			27.73	49
	2	4.73	87			4.73	87
	3	0.47	99			0.47	99
	4	0.39	130			0.39	130
	5	0.13	162			0.13	162
	6						
	7						
	8+						
	Total	42.19		0.00		42.19	
	SOP		2,056		0		2,056
Total	0	10.12	20	1.71	7	11.83	18
	1	106.15	44	0.60	27	106.75	44
	2	52.69	81			52.69	81
	3	12.49	119			12.49	119
	4	4.33	136			4.33	136
	5	1.81	139			1.81	139
	6	1.14	173			1.14	173
	7	0.19	202			0.19	202
	8+						
	Total	188.92		2.30		191.22	
	SOP		11,666		28		11,695

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: 2019 Country: ALL

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	3.46	30	2.35	26	5.81	28
	2	13.60	53	0.57	39	14.18	53
	3	5.75	71	0.13	65	5.87	70
	4	0.48	91			0.48	91
	5	0.13	128			0.13	128
	6	0.11	39			0.11	39
	7						
	8+						
	Total	23.53		3.05		26.58	
	SOP		1,297		91		1,388
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	4.4554	33	0.70	23	5.1539	32
	2	0.6500	59			0.6500	59
	3	0.2351	81			0.2351	81
	4	0.2643	103			0.2643	103
	5	0.2370	125			0.2370	125
	6	0.1737	138			0.1737	138
	7	0.1446	149			0.1446	149
	8+	0.0212	166			0.0212	166
	Total	6.1812		0.70		6.8797	
	SOP		310.072		16.066		326.138
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.28	26	12.69	7	12.96	8
	1	1.94	48	3.12	29	5.06	36
	2	0.78	73			0.78	73
	3	0.30	87			0.30	87
	4	0.03	97			0.03	97
	5	0.06	89			0.06	89
	6	0.00	93			0.00	93
	7						
	8+	0.00	159			0.00	159
	Total	3.39		15.80		19.19	
	SOP		193		181		375
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	1.05	26	3.19	12	4.24	15
	1	9.02	50	0.15	24	9.18	49
	2	4.53	78	0.02	60	4.55	78
	3	1.85	95			1.85	95
	4	0.46	97			0.46	97
	5	0.38	78			0.38	78
	6	0.06	93			0.06	93
	7						
	8+	0.03	159			0.03	159
	Total	17.39		3.37		20.76	
	SOP		1,092		43		1,135
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	1.32	26	15.88	8	17.20	10
	1	18.88	42	6.32	27	25.20	38
	2	19.56	60	0.59	39	20.15	59
	3	8.13	77	0.13	65	8.26	77
	4	1.25	96			1.25	96
	5	0.81	101			0.81	101
	6	0.34	99			0.34	99
	7	0.14	149			0.14	149
	8+	0.06	161			0.06	161
	Total	50.49		22.92		73.41	
	SOP		2,892		332		3,224

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: 2019 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	0.00	17			5.03	25	5.03	25
	2	0.01	53			13.62	49	13.63	49
	3	0.03	84	0.03	171	8.77	75	8.84	75
	4	0.07	125	0.02	178	7.67	120	7.76	120
1	5	0.03	138	0.08	198	4.90	147	5.01	148
	6	0.09	166	0.05	207	11.17	171	11.31	171
	7	0.03	174	0.01	207	2.90	178	2.94	178
	8+	0.02	185	0.00	186	2.40	189	2.43	189
	Total	0.28		0.19		56.47		56.95	
	SOP		40		37		5,969		6,046
		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					0.002	42	0.002	42
	2	0.001	59			0.25	50	0.25	50
	3	0.003	73	0.0001	171	0.28	68	0.29	68
	4	0.002	107	0.0001	178	0.22	96	0.22	96
2	5	0.01	159	0.0003	198	0.77	145	0.78	146
	6	0.01	161	0.0002	207	1.10	157	1.11	158
	7	0.01	165	0.0000	207	0.37	163	0.38	163
	8+	0.00	176	0.0000	186	0.16	159	0.17	160
	Total	0.04		0.0008		3.15		3.19	
	SOP		6		0.2		424		430
		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	0.0002	19					0.00	19
	1	0.0010	55					0.00	55
	2	0.0025	66			0.32	54	0.32	54
	3	0.0019	72	0.15	171	0.23	61	0.38	105
	4	0.0006	77	0.08	178	0.21	79	0.29	108
3	5	0.0007	160	0.37	198	0.24	57	0.61	143
	6	0.0006	162	0.23	207	0.15	61	0.37	150
	7	0.0007	165	0.04	207	0.42	71	0.46	84
	8+	0.0002	176	0.02	186	0.13	84	0.15	96
	Total	0.0084		0.89		1.68		2.58	
	SOP		0.8		172		110		283
		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	0.00	19			0.27	17	0.27	17
	1	0.00	54			1.84	46	1.84	46
	2	0.01	66			6.45	75	6.46	74
	3	0.01	73	0.13	171	5.93	94	6.07	96
	4	0.00	100	0.07	178	4.96	131	5.04	132
4	5	0.02	161	0.32	198	3.59	121	3.93	127
	6	0.02	162	0.20	207	2.86	145	3.08	149
	7	0.02	165	0.04	207	2.20	91	2.26	94
	8+	0.00	176	0.02	186	0.76	110	0.78	112
	Total	0.08		0.78		28.85		29.72	
	SOP		11		151		2,909		3,072
		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	0.00	19			0.27	17	0.27	17
	1	0.01	43			6.87	31	6.88	31
	2	0.02	61			20.65	57	20.67	57
	3	0.04	81	0.31	171	15.21	82	15.56	84
	4	0.07	123	0.17	178	13.05	123	13.30	124
Total	5	0.06	149	0.77	198	9.50	135	10.33	140
	6	0.12	165	0.47	207	15.27	164	15.87	166
	7	0.06	169	0.09	207	5.89	137	6.03	138
	8+	0.03	183	0.04	186	3.45	166	3.52	167
	Total	0.42		1.86		90.16		92.44	
	SOP		59		360		9,412		9,831

Table 3.2.4 Western Baltic spring spawning herring. Samples of commercial catch by quarter and area for 2019 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	0.00003	No data available		
		C	2	0.00005	No data available		
		C	3	0.56413	No data available		
		C	4	0.00001	No data available		
	Total	Total		0.56422	0	0	0
	Denmark	D	1	0.000	-		
		D	2	0.004	No data available		
		D	3	0.024	No data available		
		D	4	0.000	-		
	Total	Total		0.028	0	0	0
	Germany	C	1	0.000	-		
		C	2	0.000	-		
		C	3	0.121	No data available		
		C	4	0.000	-		
	Total	Total		0.121			
	Norway	C	1	0.647	No data available		
		C	2	0.101	No data available		
		C	3	1.691	1	50	50
		C	4	0.033	No data available		
	Total	Total		2.472	1	50	50
	Faroe Islands	C	1	0.000	-		
		C	2	0.000	-		
		C	3	0.000	-		
		C	4	0.000	-		
	Total	Total		0.000	0	0	0
	Sweden	C	1	2.440	3	579	579
		C	2	0.125	1	250	250
		C	3	3.921	5	512	511
		C	4	2.023	3	434	434
	Total	Total		8.509	12	1,775	1,774
Kattegat	Denmark	C	1	0.584	No data available		
		C	2	0.0001	No data available		
		C	3	0.146	No data available		
		C	4	0.437	2	469	199
	Total	Total		1.167	2	469	199
	Denmark	D	1	0.091	2	48	48
		D	2	0.016	2	7	7
		D	3	0.181	8	476	275
		D	4	0.043	5	170	160
	Total	Total		0.332	17	701	490
	Sweden	C	1	0.712	2	440	440
		C	2	0.310	3	574	571
		C	3	0.047	No data available		
		C	4	0.655	4	512	512
	Total	Total		1.725	9	1,526	1,523

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Table 3.2.4 (continued) Western Baltic spring spawning herring. Samples of commercial catch by quarter and area for 2019 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	0.001		No data available	
		F	2	0.0025		No data available	
		F	3	0.000		No data available	
		F	4	0.002	1	104	52
	Total	Total		0.005	1	104	52
	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	0.0398	2	859	137
		F	2	0.0037	2	866	139
		F	3	0.0004		No data available	
		F	4	0.0099		No data available	
	Total	Total		0.0537	4	1,725	276
Subdivision 23	Denmark	F	1	0.001		No data available	
		F	2	0.0002		No data available	
		F	3	0.006	No data available		
		F	4	0.002	1	189	49
	Total	Total		0.009	1	189	49
	Sweden	F	1	0.036		No data available	
		F	2	0.000		-	
		F	3	0.166		No data available	
		F	4	0.149		No data available	
	Total	Total		0.351	0	0	0
Subdivision 24	Denmark	F	1	1.374	4	1,083	175
		F	2	0.001	1	141	47
		F	3	0.001		No data available	
		F	4	0.660	7	1,253	231
	Total	Total		2.036	12	2,477	453
	Finland	F	1	0.000		-	
		F	2	0.000		-	
		F	3	0.000		-	
		F	4	0.000		-	
	Total	Total		0.000	0	0	0
	Germany	F	1	4.3410	16	6,059	1,212
		F	2	0.1081	1	591	105
		F	3	0.0009		No data available	
		F	4	1.0668	3	1,430	369
	Total	Total		5.5168	20	8,080	1,686
	Poland	F	1	0.253	4	715	196
		F	2	0.314	8	1,420	421
		F	3	0.108	1	190	65
		F	4	0.454		No data available	
	Total	Total		1.130	13	2,325	682
	Sweden	F	1	0.000		-	
		F	2	0.000		-	
		F	3	0.001		No data available	
		F	4	0.728	9	1,089	1,087
	Total	Total		0.729	9	1,089	1,087
Total	Skagerrak	C	1-4	11.666	13	1,825	1,824
		D	1-4	0.028	0	0	0
	Kattegat	C	1-4	2.892	11	1,995	1,722
		D	1-4	0.332	17	701	490
	Subdivision 22	F	1-4	0.059	5	1,829	328
	Subdivision 23	F	1-4	0.360	1	189	49
	Subdivision 24	F	1-4	9.412	54	13,971	3,908
	Total	Total	1-4	24.750	101	20,510	8,321

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 2019.

	Country	Quarter	Fleet	Sampling
Skagerrak	**Denmark**	**1**	**C**	Sweden Q1 27.3.a.20 fleet-C
		2	**C**	Sweden Q2 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
	Germany	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	Sweden Q3 27.3.a.20 fleet-C
		4	**C**	No landings
	Sweden	**1**	**C**	Sweden Q1 27.3.a.20 fleet-C
		2	**C**	Sweden Q2 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 Q2 27.3.a.21 fleet-D
		3	**D**	Denmark Q3 27.3.a.21 fleet-D
		4	**D**	No landings
	Netherlands	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	No landings
		4	**C**	No landings
	Faroe Islands	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	No landings
		4	**C**	No landings
	Norway	**1**	**C**	Sweden Q1 27.3.a.20 fleet-C
		2	**C**	Sweden Q2 27.3.a.20 fleet-C
		3	**C**	Norway Q3 27.3.a.20 fleet-C
		4	**C**	Sweden Q4 27.3.a.20 fleet-C
Kattegat	**Denmark**	**1**	**C**	Sweden Q1 27.3.a.21 fleet-C
		2	**C**	Sweden Q2 27.3.a.21 fleet-C
		3	**C**	Denmark Q4 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 Q2 27.3.a.21 fleet-C
		3	**C**	Sweden Q4 27.3.a.21 fleet-C
		4	**C**	Sweden Q4 27.3.a.21 fleet-C
	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 Q2 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**	Germany Q1 27.3.c.22 fleet-F
		2	**F**	Germany Q2 27.3.c.22 fleet-F
		3	**F**	Denmark Q4 27.3.c.22 fleet-F
		4	**F**	Denmark 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
		2	**F**	Germany Q2 27.3.c.22 fleet-F
		3	**F**	National imputation as in WD Gröhsler
		4	**F**	National imputation as in WD Gröhsler

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

Continued on next page

Table 3.2.5. (continued) Western Baltic spring spawning herring. Samples of catch by quarter and area used to estimate catch in numbers and mean weight at age as W-ringers for 2019.

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

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

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

Year: 2019

		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
1	1	94.00%	6.00%	50	96.79%	3.21%	122
	2	40.00%	60.00%	50	53.60%	46.40%	67
	3	10.00%	90.00%	30	51.63%	48.37%	54
	4	7.69%	92.31%	9	0.00%	100.00%	7
	5	7.69%	92.31%	3	0.00%	100.00%	2
	6	7.69%	92.31%	1	0.00%	100.00%	1
	7	7.69%	92.31%	0	0.00%	100.00%	0
	8+	7.69%	92.31%	0	0.00%	100.00%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
2	1	91.84%	8.16%	49	94.60%	5.40%	64
	2	10.53%	89.47%	19	19.61%	80.39%	51
	3	6.67%	93.33%	15	14.29%	85.71%	21
	4	5.56%	94.44%	2	0.00%	100.00%	13
	5	5.56%	94.44%	1	0.00%	100.00%	17
	6	5.56%	94.44%	0	0.00%	100.00%	11
	7	5.56%	94.44%	0	0.00%	100.00%	7
	8+	5.56%	94.44%	0	0.00%	100.00%	1
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
3	0	100.00%	0.00%	0	100.00%	0.00%	496
	1	82.76%	17.24%	29	76.19%	23.81%	42
	2	2.38%	97.62%	42	7.84%	92.16%	0
	3	9.09%	90.91%	44	3.85%	96.15%	0
	4	0.00%	100.00%	29	2.13%	97.87%	0
	5	5.00%	95.00%	10	2.13%	97.87%	0
	6	5.00%	95.00%	9	2.13%	97.87%	0
	7	5.00%	95.00%	1	2.13%	97.87%	0
	8	5.00%	95.00%	0	2.13%	97.87%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
4	0	40.43%	59.57%	47	97.64%	2.36%	350
	1	38.00%	62.00%	50	72.35%	27.65%	314
	2	0.00%	100.00%	49	26.49%	73.51%	180
	3	0.00%	100.00%	5	20.12%	79.88%	99
	4	0.00%	100.00%	4	3.85%	96.15%	26
	5	0.00%	100.00%	1	8.00%	92.00%	21
	6	0.00%	100.00%	0	8.00%	92.00%	3
	7	0.00%	100.00%	0	8.00%	92.00%	0
	8	0.00%	100.00%	0	8.00%	92.00%	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	4-8+	mean(4-8+)	5-8+	mean(5-8+)
2	4-8+	mean(3-5+)	7-8+	mean(6-8+)
3	5-8+	mean(5-8+)	2-8+	Q3 IBTS Kat
4	5-8+	mean(3-5+)	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: 2019 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	3.35	30	2.28	26	5.62	28
	2	7.29	53	0.31	39	7.60	53
	3	2.97	71	0.07	65	3.03	70
	4					0.00	
	5					0.00	
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	13.61		2.65		16.25	
	SOP		697.5		75.1		772.6
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	4.21	33	0.66	23	4.88	32
	2	0.13	59			0.13	59
	3	0.03	81			0.03	81
	4					0.00	
	5					0.00	
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	4.376		0.66		5.04	
	SOP		149.3		15.2		164.5
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.28	26	12.69	7	12.96	8
	1	1.48	48	2.38	29	3.86	36
	2	0.06	73			0.06	73
	3	0.01	87			0.01	87
	4	0.001	97			0.001	97
	5	0.001	89			0.001	89
	6	0.0001	93			0.0001	93
	7					0.00	
	8+	0.0001	159			0.0001	159
	Total	1.83		15.06		16.89	
	SOP		84.4		160.1		244.4
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	1.02	26	3.12	12	4.14	15
	1	6.53	50	0.11	24	6.64	49
	2	1.20	78	0.01	60	1.20	78
	3	0.37	95			0.37	95
	4	0.02	97			0.02	97
	5	0.03	78			0.03	78
	6	0.005	93			0.005	93
	7					0.00	
	8+	0.003	159			0.003	159
	Total	9.18		3.24		12.42	
	SOP		486.2		40.3		526.5
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	1.30	26	15.80	8	17.10	10
	1	15.57	41	5.43	27	21.00	37
	2	8.68	57	0.31	39	8.99	56
	3	3.38	73	0.07	65	3.45	73
	4	0.02	97	0.00		0.02	97
	5	0.03	79	0.00		0.03	79
	6	0.005	93	0.00		0.005	93
	7	0.00		0.00		0.00	
	8+	0.003	159	0.00		0.003	159
	Total	28.99		21.61		50.60	
	SOP		1,417.4		291		1,708

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: 2019 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	32.79	27			32.79	27
	2	10.28	65			10.28	65
	3	0.33	85			0.33	85
	4	0.08	122			0.08	122
	5	0.03	87			0.03	87
	6	0.02	137			0.02	137
	7					0.00	
	8+					0.00	
	Total	43.53		0.00		43.53	
	SOP		1,596.2		0.0		1,596.2

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
2	1	4.58	33	0.16	23	4.74	33
	2	0.05	63			0.05	63
	3	0.02	76			0.02	76
	4	0.003	90			0.003	90
	5	0.001	49			0.001	49
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	4.65		0.16		4.81	
	SOP		157.8		3.7		161.5

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
3	0	1.38	22	1.71	7	3.09	14
	1	31.91	57	0.35	29	32.26	56
	2	0.52	98			0.52	98
	3	0.76	135			0.76	135
	4					0.00	
	5	0.06	157			0.06	157
	6	0.05	180			0.05	180
	7	0.01	202			0.01	202
	8+					0.00	
	Total	34.68		2.06		36.74	
	SOP		2,014.1		22.4		2,036.5

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
4	0	3.53	20			3.53	20
	1	10.54	49			10.54	49
	2					0.00	
	3					0.00	
	4					0.00	
	5					0.00	
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	14.07		0.00		14.07	
	SOP		584.2		0.0		584.2

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
Total	0	4.91	21	1.71	7	6.62	17
	1	79.81	42	0.51	27	80.32	42
	2	10.85	67	0.00		10.85	67
	3	1.11	119	0.00		1.11	119
	4	0.08	121	0.00		0.08	121
	5	0.10	131	0.00		0.10	131
	6	0.06	170	0.00		0.06	170
	7	0.01	202	0.00		0.01	202
	8+	0.00		0.00		0.00	
	Total	96.94		2.22		99.16	
	SOP		4,352		26		4,378

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: 2019 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.11	30	0.08	26	0.19	28
	2	6.31	53	0.27	39	6.58	53
	3	2.78	71	0.06	65	2.84	70
	4	0.48	91			0.48	91
	5	0.13	128			0.13	128
	6	0.11	39			0.11	39
	7					0.00	
	8+					0.00	
	Total	9.92		0.40		10.33	
	SOP		599.4		16.2		615.6
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.24	33	0.04	23	0.28	32
	2	0.52	59			0.52	59
	3	0.20	81			0.20	81
	4	0.26	103			0.26	103
	5	0.24	125			0.24	125
	6	0.17	138			0.17	138
	7	0.14	149			0.14	149
	8+	0.02	166			0.02	166
	Total	1.81		0.04		1.84	
	SOP		160.7		0.9		161.6
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0					0.00	
	1	0.46	48	0.74	29	1.20	36
	2	0.72	73			0.72	73
	3	0.29	87			0.29	87
	4	0.03	97			0.03	97
	5	0.06	89			0.06	89
	6	0.004	93			0.00	93
	7					0.00	
	8+	0.00	159			0.00	159
	Total	1.56		0.74		2.30	
	SOP		108.8		21.3		130.1
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.02	26	0.08	12	0.10	15
	1	2.50	50	0.04	24	2.54	49
	2	3.33	78	0.01	60	3.34	78
	3	1.48	95			1.48	95
	4	0.45	97			0.45	97
	5	0.35	78			0.35	78
	6	0.05	93			0.05	93
	7					0.00	
	8+	0.03	159			0.03	159
	Total	8.21		0.13		8.34	
	SOP		606.0		2.8		608.8
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.02	26	0.08	12	0.10	15
	1	3.31	48	0.90	28	4.21	44
	2	10.88	62	0.28	40	11.16	62
	3	4.75	80	0.06	65	4.81	79
	4	1.23	96	0.00		1.23	96
	5	0.78	102	0.00		0.78	102
	6	0.33	100	0.00		0.33	100
	7	0.14	149	0.00		0.14	149
	8+	0.05	162	0.00		0.05	162
	Total	21.49745		1.32		22.81	
	SOP		1,475		41		1,516

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: 2019 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	2.09	27			2.09	27
	2	15.43	65			15.43	65
	3	2.98	85			2.98	85
	4	0.95	122			0.95	122
	5	0.39	87			0.39	87
	6	0.18	137			0.18	137
	7					0.00	
	8+					0.00	
	Total	22.02		0.00		22.02	
	SOP		1,490.3		0		1,490.3
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.41	33	0.01	23	0.42	33
	2	0.40	63			0.40	63
	3	0.32	76			0.32	76
	4	0.04	90			0.04	90
	5	0.02	49			0.02	49
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	1.19		0.01		1.21	
	SOP		68.1		0.3		68.5
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0					0.00	
	1	6.65	57	0.07	29	6.72	56
	2	21.28	98			21.28	98
	3	7.60	135			7.60	135
	4	2.87	143			2.87	143
	5	1.16	157			1.16	157
	6	0.90	180			0.90	180
	7	0.18	202			0.18	202
	8+					0.00	
	Total	40.64		0.07		40.72	
	SOP		4,283.4		2.1		4,285.5
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	5.21	20			5.21	20
	1	17.19	49			17.19	49
	2	4.73	87			4.73	87
	3	0.47	99			0.47	99
	4	0.39	130			0.39	130
	5	0.13	162			0.13	162
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	28.12		0.00		28.12	
	SOP		1,471.8		0.0		1,471.8
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	5.21	20	0.00		5.21	20
	1	26.34	49	0.09	28	26.43	49
	2	41.84	84	0.00		41.84	84
	3	11.38	119	0.00		11.38	119
	4	4.25	137	0.00		4.25	137
	5	1.71	140	0.00		1.71	140
	6	1.08	173	0.00		1.08	173
	7	0.18	202	0.00		0.18	202
	8+	0.00		0.00		0.00	
	Total	91.98		0.09		92.07	
	SOP		7,314		2		7,316

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: 2019 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	36.14	27	2.28	26	38.41	27
	2	17.58	60	0.31	39	17.88	60
	3	3.30	72	0.07	65	3.36	72
	4	0.08	122			0.08	122
	5	0.03	87			0.03	87
	6	0.02	137			0.02	137
	7					0.00	
	8+					0.00	
	Total	57.14		2.65		59.79	
	SOP		2,293.7		75.1		2,368.8
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	8.79	33	0.82	23	9.61	32
	2	0.17	60			0.17	60
	3	0.06	79			0.06	79
	4	0.003	90			0.00	90
	5	0.001	49			0.001	49
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	9.03		0.82		9.85	
	SOP		307.2		18.9		326.1
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	1.65	23	14.39	7	16.05	9
	1	33.39	56	2.72	29	36.11	54
	2	0.58	95			0.58	95
	3	0.77	135			0.77	135
	4	0.001	97			0.00	97
	5	0.06	155			0.06	155
	6	0.05	180			0.05	180
	7	0.01	202			0.01	202
	8+	0.0001	159			0.00	159
	Total	36.51		17.12		53.63	
	SOP		2,098.5		182.4		2,280.9
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	4.56	21	3.12	12	7.68	18
	1	17.07	49	0.11	24	17.18	49
	2	1.20	78	0.01	60	1.20	78
	3	0.37	95			0.37	95
	4	0.02	97			0.02	97
	5	0.03	78			0.03	78
	6	0.005	93			0.00	93
	7					0.00	
	8+	0.003	159			0.003	159
	Total	23.25		3.24		26.49	
	SOP		1,070.4		40.3		1,110.7
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	6.21	22	17.51	8	23.72	12
	1	95.38	42	5.93	27	101.32	41
	2	19.53	62	0.31	39	19.84	62
	3	4.50	85	0.07	65	4.56	84
	4	0.10	116	0.00		0.10	116
	5	0.13	118	0.00		0.13	118
	6	0.07	165	0.00		0.07	165
	7	0.01	202	0.00		0.01	202
	8+	0.003	159	0.00		0.003	159
	Total	125.93		23.83		149.75	
	SOP		5,770		317		6,087

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: 2019 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	2.20	27	0.08	26	2.28	27
	2	21.74	62	0.27	39	22.00	61
	3	5.76	78	0.06	65	5.82	78
	4	1.43	111			1.43	111
	5	0.52	97			0.52	97
	6	0.29	101			0.29	101
	7					0.00	
	8+					0.00	
	Total	31.95		0.40		32.35	
	SOP		2,089.8		16.2		2,105.9
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.65	33	0.05	23	0.70	32
	2	0.92	61			0.92	61
	3	0.52	78			0.52	78
	4	0.31	101			0.31	101
	5	0.26	118			0.26	118
	6	0.17	138			0.17	138
	7	0.14	149			0.14	149
	8+	0.02	166			0.02	166
	Total	3.00		0.05		3.05	
	SOP		228.9		1.2		230.1
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0					0.00	
	1	7.11	56	0.82	29	7.92	53
	2	22.00	97			22.00	97
	3	7.89	134			7.89	134
	4	2.90	143			2.90	143
	5	1.22	153			1.22	153
	6	0.90	180			0.90	180
	7	0.18	202			0.18	202
	8+	0.002	159			0.002	159
	Total	42.20		0.82		43.02	
	SOP		4,392		23.3		4,415.5
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	5.23	20	0.08	12	5.31	20
	1	19.69	49	0.04	24	19.73	49
	2	8.06	83	0.01	60	8.08	83
	3	1.95	96			1.95	96
	4	0.83	112			0.83	112
	5	0.48	101			0.48	101
	6	0.05	93			0.05	93
	7					0.00	
	8+	0.03	159			0.03	159
	Total	36.33		0.13		36.46	
	SOP		2,077.8		2.8		2,080.6
		Fleet C		Fleet D		Total	
Quarter	W-rings	**Numbers**	**Mean W.**	**Numbers**	**Mean W.**	Numbers	Mean W.
Total	0	**5.23**	**20**	**0.08**	**12**	5.31	20
	1	**29.65**	**49**	**0.99**	**28**	30.63	48
	2	**52.72**	**80**	**0.28**	**40**	53.00	80
	3	**16.13**	**107**	**0.06**	**65**	16.19	107
	4	**5.47**	**128**	**0.00**		5.47	128
	5	**2.49**	**128**	**0.00**		2.49	128
	6	**1.41**	**156**	**0.00**		1.41	156
	7	**0.33**	**178**	**0.00**		0.33	178
	8+	**0.05**	**162**	**0.00**		0.05	162
	Total	113.48		1.40		114.88	
	SOP		**8,789**		**43**		8,832

multifleet assessment input

Table 3.2.13 Western Baltic spring spawning herring. Total catch in numbers (mill) and mean weight (g), SOP (tonnes) of *Western Baltic Spring spawners* in Division 3.a and the North Sea in the years 1993–2019.

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
2019	Numbers	5.3	38.2	59.2	21.0	8.2	9.7	11.1	3.0	2.6	158.51
	Mean W.	20.0	52.8	85.0	118.9	138.4	166.1	183.3	193.9	211.4	98.35
	SOP	106	2,019	5,036	2,502	1,138	1,619	2,035	577	557	15,589

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: 2019 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	0.0012	71.00	2.28	27.03	5.03	24.96	7.32	25.61
	2	0.065	134.00	22.00	61.48	13.63	48.81	35.70	56.77
	3	0.185	149.00	5.82	77.71	8.84	75.21	14.84	77.11
	4	0.092	164.00	1.43	111.23	7.76	119.84	9.28	118.96
	5	0.897	180.00	0.52	97.05	5.01	147.73	6.43	148.10
	6	0.499	188.00	0.29	101.22	11.31	171.44	12.10	170.46
	7					2.94	177.84	2.94	177.84
	8+	0.278	209.60			2.43	188.82	2.70	190.96
	Total	2.018		32.35		56.95		91.31	
	SOP		365.1		2,105.9		6,045.7		8,516.8
		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	5.085	72.25	0.70	32.49	0.00	41.57	5.79	67.43
	2	4.618	130.87	0.92	60.67	0.25	50.17	5.79	116.21
	3	3.495	158.56	0.52	77.97	0.29	67.70	4.31	142.71
	4	1.982	159.62	0.31	100.75	0.22	96.14	2.51	146.87
	5	4.757	179.14	0.26	117.93	0.78	145.60	5.80	171.87
	6	6.541	185.58	0.17	137.90	1.11	157.53	7.82	180.54
	7	1.982	195.86	0.14	148.50	0.38	162.95	2.50	188.17
	8+	0.991	194.03	0.02	166.30	0.17	159.62	1.18	188.65
	Total	29.452		3.05		3.19		35.70	
	SOP		4,488.9		230.1		430.0		5,148.9
		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					0.00	19.25	0.00	19.25
	1	2.51	72.25	7.92	53.35	0.00	54.51	10.44	57.90
	2	1.56	130.87	22.00	97.20	0.32	54.07	23.88	98.81
	3	1.18	158.56	7.89	133.55	0.38	104.64	9.44	135.51
	4	0.67	159.62	2.90	142.78	0.29	107.69	3.86	143.07
	5	1.60	179.14	1.22	153.49	0.61	143.45	3.43	163.71
	6	2.20	185.58	0.90	179.92	0.37	149.69	3.48	180.26
	7	0.67	195.86	0.18	202.20	0.46	83.57	1.31	157.22
	8+	0.33	194.03	0.00	158.50	0.15	96.24	0.48	164.26
	Total	10.72		43.02		2.58		56.32	
	SOP		1,570.4		4,415.5		283.4		6,269.4
		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			5.31	20.01	0.27	16.69	5.58	19.85
	1			19.73	48.80	1.84	46.35	21.57	48.59
	2			8.08	83.24	6.46	74.50	14.54	79.35
	3			1.95	95.86	6.07	95.57	8.02	95.64
	4	0.008	210.80	0.83	112.46	5.04	131.54	5.88	128.94
	5			0.48	101.15	3.93	127.38	4.41	124.51
	6	0.443	221.20	0.05	93.40	3.08	149.08	3.57	157.21
	7					2.26	93.86	2.26	93.86
	8+	0.980	238.11	0.03	158.50	0.78	112.25	1.79	182.02
	Total	1.430		36.46		29.72		67.61	
	SOP		332.8		2,080.6		3,071.8		5,485.3
		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**		5.31	20.01	**0.27**	**16.69**	5.577	19.85
	1	**7.60**	**72.25**	30.63	47.98	**6.88**	**30.70**	45.114	49.44
	2	**6.24**	**130.90**	53.00	79.61	**20.67**	**56.94**	79.906	77.75
	3	**4.86**	**158.19**	16.19	107.12	**15.56**	**83.72**	36.610	103.95
	4	**2.75**	**159.91**	5.47	127.54	**13.30**	**123.62**	21.524	129.26
	5	**7.26**	**179.25**	2.49	127.74	**10.33**	**139.58**	20.077	152.45
	6	**9.69**	**187.33**	1.41	155.64	**15.87**	**165.62**	26.969	172.89
	7	**2.65**	**195.86**	0.33	178.39	**6.03**	**138.32**	9.010	156.69
	8+	**2.58**	**212.43**	0.05	161.55	**3.52**	**166.67**	6.154	185.83
	Total	43.62		114.88		92.44		250.94	
	SOP		**6,757**		8,832		**9,831**		25,420

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 1993–2019.

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
2019	Div. IV+Div. IIIa	5.3	38.2	59.2	21.0	8.2	9.7	11.1	3.0	2.6	158.5
	Subdiv. 22-24	0.3	6.9	20.7	15.6	13.3	10.3	15.9	6.0	3.5	92.4

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 IV/North Sea + 3.a and Subdivisions 22–24 in the years 1993–2019.

	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
2019	Div. IV+Div. IIIa	20.0	52.8	85.0	118.9	138.4	166.1	183.3	193.9	211.4	15,589
	Subdiv. 22-24	16.7	30.7	56.9	83.7	123.6	139.6	165.6	138.3	166.7	9,831

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 1993–2019.

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
2019	Number	23.72	101.32	19.84	4.56	0.10	0.13	0.07	0.01	0.003	149.8
	Mean W.	11.66	41.00	62.01	84.37	116.20	118.10	164.56	202.20	158.50	
	SOP	277	4,154	1,230	385	12	15	11	2	0.4	6,087

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 1993–2019 (September/October).

								*	**			***	***
Year	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
W-rings/Numbers in millions														
0	893.140	5,474.540	5,107.780	1,833.130	2,859.220	2,490.090	5,993.820	1,008.910	2,477.972	4,102.595	3,776.780	2,554.680	3,055.595	4,159.311
1	491.880	415.730	1,675.340	1,439.460	1,955.400	801.350	1,338.710	1,429.880	1,125.716	837.557	1,238.480	968.860	750.199	940.892
2	436.550	883.810	328.610	590.010	738.180	678.530	287.240	453.980	1,226.932	421.396	222.530	592.360	590.756	226.959
3	529.670	559.720	357.960	434.090	394.530	394.070	232.510	328.960	844.088	575.358	217.270	346.230	295.659	279.618
4	403.400	443.730	353.850	295.170	162.430	236.830	155.950	201.590	366.841	341.120	260.350	163.150	142.778	212.201
5	125.140	189.420	253.510	305.550	118.910	100.190	51.940	78.930	131.430	63.678	96.960	143.320	78.541	139.813
6	55.290	60.400	126.760	119.260	99.290	50.980	8.130	38.610	85.690	24.520	38.040	79.030	79.018	97.261
7	28.030	23.510	46.430	46.980	33.280	23.640	1.470	5.920	19.471	9.690	8.580	22.600	25.564	66.937
8+	12.940	2.330	27.240	18.910	47.850	9.330	2.100	4.190	9.683	13.380	9.890	11.770	15.013	27.789
Total	2,976.040	8,053.190	8,277.480	5,082.560	6,409.090	4,785.010	8,071.870	3,550.970	6,287.823	6,389.293	5,868.880	4,882.000	5,033.123	6,150.781
3+ group	1,154.470	1,279.110	1,165.750	1,219.960	856.290	815.040	452.100	658.200	1,457.203	1,027.746	631.090	766.100	636.573	823.619
W-rings/Biomass ('000 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	42.958
1	19.520	14.466	58.620	46.643	76.396	39.899	51.117	57.530	48.177	34.165	44.791	35.885	29.790	38.230
2	21.696	40.972	20.939	29.127	43.461	50.085	22.016	28.431	75.879	29.957	16.089	34.542	46.478	18.013
3	33.838	40.749	30.091	31.035	35.942	35.280	27.484	27.740	77.137	56.769	22.008	27.726	31.876	31.946
4	25.674	43.038	40.104	21.174	22.291	28.049	16.664	24.065	37.936	40.360	34.167	18.364	20.414	31.253
5	12.695	24.198	27.268	37.141	16.743	11.430	6.768	9.259	18.458	9.029	14.561	17.348	12.772	24.876
6	7.058	12.313	14.915	16.056	13.998	6.157	0.867	5.620	13.267	3.497	5.715	12.225	13.820	17.959
7	2.269	5.294	9.269	6.101	5.333	3.716	0.350	1.210	3.866	1.075	1.343	3.413	5.111	13.431
8+	1.781	0.627	6.570	2.930	10.636	2.170	0.458	0.757	2.101	1.908	1.615	1.991	3.447	6.344
Total	137.296	248.545	266.316	206.771	253.297	200.547	197.537	168.395	307.984	214.967	174.218	174.568	196.503	225.010
3+ group	83.315	126.218	128.217	114.438	104.943	86.802	52.590	68.651	152.765	112.637	79.410	81.067	87.441	125.809
W-rings/Mean weight (g)														
0	14.3	12.2	11.5	9.0	10.0	9.5	12.0	13.7	12.6	9.3	9.0	9.0	10.7	10.3
1	39.7	34.8	35.0	32.4	39.1	49.8	38.2	40.2	42.8	40.8	36.2	37.0	39.7	40.6
2	49.7	46.4	63.7	49.4	58.9	73.8	76.6	62.6	61.8	71.1	72.3	58.3	78.7	79.4
3	63.9	72.8	84.1	71.5	91.1	89.5	118.2	84.3	91.4	98.7	101.3	80.1	107.8	114.2
4	63.6	97.0	113.3	71.7	137.2	118.4	106.9	119.4	103.4	118.3	131.2	112.6	143.0	147.3
5	101.4	127.7	107.6	121.6	140.8	114.1	130.3	117.3	140.4	141.8	150.2	121.0	162.6	177.9
6	127.7	203.9	117.7	134.6	141.0	120.8	106.6	145.5	154.8	142.6	150.2	154.7	174.9	184.6
7	81.0	225.2	199.6	129.9	160.2	157.2	237.9	204.5	198.6	110.9	156.6	151.0	199.9	200.6
8+	137.7	269.1	241.2	154.9	222.3	232.6	217.9	180.7	217.0	142.6	163.3	169.2	229.6	228.3
Total	46.1	30.9	32.2	40.7	39.5	41.9	24.5	47.4	49.0	33.6	29.7	35.8	39.0	36.6

	***	***	***	***	***	***	***	***	****	*****	***	***	5*
Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
W-rings/Numbers in millions													
0	2,588.922	2,150.306	2,821.022	4,561.405	2,929.434	4,103.180	8,996.225	5,473.400	888.081	2,638.277	1,290.650	2,635.830	1,816.647
1	558.851	392.737	270.959	534.633	1,206.762	755.034	893.837	769.320	440.738	493.366	463.940	428.530	247.870
2	260.402	165.347	95.866	305.540	360.354	294.242	456.204	242.590	509.769	155.417	145.360	89.280	122.948
3	117.412	166.301	43.553	214.539	210.455	193.974	307.567	279.650	221.344	196.061	123.230	41.160	47.727
4	76.782	102.018	17.761	107.364	115.984	124.548	262.908	332.660	129.795	60.953	137.500	20.240	24.244
5	43.919	82.174	9.016	85.635	57.840	70.135	87.114	317.240	95.579	30.490	46.550	17.570	17.488
6	12.144	29.727	3.227	47.140	50.844	45.017	32.684	211.600	86.150	14.980	21.230	4.940	16.802
7	9.262	11.443	1.947	25.021	29.234	22.520	22.565	85.630	47.093	3.300	2.130	1.060	1.540
8+	8.839	9.262	1.704	15.309	14.774	21.404	11.300	56.590	37.886	0.000	1.790	1.100	0.600
Total	3,676.532	3,109.314	3,265.055	5,896.586	4,975.682	5,630.054	11,070.405	7,768.680	2,456.435	3,592.844	2,232.380	3,239.710	2,295.867
3+ group	268.357	400.924	77.208	495.007	479.131	477.597	724.139	1,283.370	617.846	305.784	332.430	86.070	108.402
W-rings/Biomass ('000 tonnes)													
0	25.202	23.699	29.449	36.791	35.064	46.955	85.185	61.640	8.179	24.072	13.623	32.010	23.081
1	22.782	17.602	10.473	21.336	46.384	29.825	38.404	30.369	16.822	18.553	18.296	18.825	9.767
2	20.202	10.446	7.069	24.593	29.560	20.380	30.587	21.490	38.573	10.579	10.159	5.797	6.761
3	11.366	15.297	4.433	23.540	24.382	22.068	27.349	32.448	22.841	18.068	11.511	3.323	3.630
4	9.679	11.077	1.961	15.193	16.361	18.653	27.350	58.819	15.196	5.859	17.427	1.785	2.700
5	6.724	11.584	1.385	15.433	9.867	11.450	10.934	63.755	14.581	3.417	6.711	2.239	2.625
6	2.001	4.823	0.616	9.018	8.391	7.985	4.849	45.705	14.304	1.723	3.175	0.719	2.673
7	1.703	1.756	0.384	4.728	5.295	4.448	3.751	18.709	8.433	0.450	0.257	0.182	0.260
8+	1.798	1.303	0.284	3.013	3.015	3.876	1.821	13.498	7.108	0.000	0.190	0.203	0.060
Total	101.456	97.588	56.055	153.646	178.320	165.640	230.231	346.433	146.035	82.722	81.349	65.083	51.557
3+ group	33.270	45.840	9.064	70.926	67.312	68.480	76.055	232.933	82.462	29.518	39.271	8.451	11.948
W-rings/Mean weight (g)													
0	9.7	11.0	10.4	8.1	12.0	11.4	9.5	11.3	9.2	9.1	10.6	12.1	12.7
1	40.8	44.8	38.7	39.9	38.4	39.5	43.0	39.5	38.2	37.6	39.4	43.9	39.4
2	77.6	63.2	73.7	80.5	82.0	69.3	67.0	88.6	75.7	68.1	69.9	64.9	55.0
3	96.8	92.0	101.8	109.7	115.9	113.8	88.9	116.0	103.2	92.2	93.4	80.7	76.1
4	126.1	108.6	110.4	141.5	141.1	149.8	104.0	176.8	117.1	96.1	126.7	88.2	111.4
5	153.1	141.0	153.6	180.2	170.6	163.3	125.5	201.0	152.5	112.1	144.2	127.4	150.1
6	164.8	162.2	190.9	191.3	165.0	177.4	148.4	216.0	166.0	115.0	149.5	145.6	159.1
7	183.8	153.5	197.4	189.0	181.1	197.5	166.2	218.5	179.1	136.4	120.5	172.0	168.7
8+	203.4	140.7	166.9	196.8	204.1	181.1	161.1	238.5	187.6	-	106.4	184.2	100.3
Total	27.6	31.4	17.2	26.1	35.8	29.4	20.8	44.6	59.5	23.0	36.4	20.1	22.5

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**

5* excl. Central Baltic Herring in SDs 21-24 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 1991–2019 (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 tonnnes)														
0		34.3	1	8.7										
1		26.8	7	0.4	77.4	52.9	4.7	7.1	74.8	61.4	3.5	137.2	79.0	63.9
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**	**2019**
W-rings/Numbers in millions															
0				112				1		314	2	203	1		2
1	2,687	2,081	3,918	5,852	565	999	2,980	1,018	49	513	1,949	425	696	106	418
2	1,342	2,217	3,621	1,160	398	511	473	1,081	627	415	1,244	255	424	224	591
3	464	1,780	933	843	205	254	259	236	525	176	446	381	661	271	315
4	201	490	499	333	161	115	163	87	53	248	224	99	401	175	109
5	103	180	154	274	82	65	70	76	30	28	171	40	94	169	67
6	84	27	34	176	86	24	53	33	12	37	82	40	53	50	52
7	37	10	26	45	39	28	22	14	8	26	89	12	52	35	19
8+	21	0.1	14	44	65	34	46	60	15	42	115	28	92	44	13
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**	**1,586**
3+ group	**910**	**2,487**	**1,660**	**1,715**	**638**	**520**	**613**	**506**	**643**	**557**	**1,127**	**600**	**1,353**	**744**	**575**
W-rings/Biomass ('000 tonnnes)															
0								0.0		1.0	0.03	1.00	0.00		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	15.0
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	49.0
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	32.0
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	15.0
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	12.0
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	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	3.0
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	3.0
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	138.0
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	74.0
W-rings/Mean weight (g)															
0				6.3				3.0		4.3	14.2	4.0	23.0		4.0
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	35.8
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	82.7
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	102.1
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	139.6
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	170.8
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	178.6
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	187.5
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	221.8
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	87.2

* revised in 1997

**the survey only covered the Skagerrak area by Norway. Additional estimates for the Kattegat area were added (see ICES 2000/ACFM:10, Table 3.5.8)

Table 3.3.3. Western Baltic spring-spawning herring. N_{20} Larval Abundance Index. Estimation of 0-Group herring reaching 20 mm in length in Greifswalder Bodden and adjacent waters (March/April to June).

Year	N_{20} (millions)
1992	1,060
1993	3,044
1994	12,515
1995	7,930
1996	21,012
1997	4,872
1998	16,743
1999	20,364
2000	3,026
2001	4,845
2002	11,324
2003	5,507
2004	5,640
2005	3,887
2006	3,774
2007*	1,829
2008*	1,622
2009	6,464
2010	7,037
2011	4,444
2012	1,140
2013	3,021
2014	539
2015	2,478
2016	442
2017	1,247

2018	1,563
2019	1,317

* small revision during HAWG 2010

Table 3.6.1.a. Western Baltic Spring-spawning Herring. *Multi fleet - Fleet A.* Catch in number (CANUM, thousands)

	0	1	2	3	4	5	6	7	8
2000	0	0	8161	9752	10223	5660	2466	605	778
2001	0	454	11344	10224	6123	7151	2664	1556	410
2002	0	0	7589	14825	10583	3349	2877	969	620
2003	0	0	30	3130	5992	3502	1167	1305	605
2004	0	0	15140	27898	3520	4110	1002	456	146
2005	0	0	6569	17434	12680	2573	3787	1084	714
2006	0	129	3514	8783	13962	22370	5102	5258	3055
2007	0	0	74	2627	1253	596	806	377	613
2008	0	0	70	87	167	77	81	182	35
2009	0	0	1017	2075	3375	1423	1733	4471	3144
2010	0	26	32	518	985	389	518	270	1018
2011	0	0	63	442	400	235	69	109	298
2012	0	0	16	214	359	0	1432	0	7395
2013	0	0	53	409	172	494	312	67	645
2014	0	34	2451	3369	5406	802	2116	1045	1573
2015	0	20	95	868	1404	3872	1837	1446	2170
2016	0	20	1209	4109	1033	1137	1182	689	1210
2017	0	2.858	46.79	2368	1013	245.2	90.16	108.3	136.3
2018	0	28.6	329.8	900.6	2277	4270	1744	860.9	623.1
2019	0	7599	6239	4857	2750	7257	9687	2650	2583

Table 3.6.1.b. Western Baltic Spring-spawning Herring. *Multi fleet - Fleet C.* Catch in number (CANUM, thousands)

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

Table 3.6.1.c. Western Baltic Spring-spawning Herring. *Multi fleet - Fleet D.* Catch in number (CANUM, thousands)

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

Table 3.6.1.d. Western Baltic Spring-spawning Herring. *Multi fleet - Fleet F.* Catch in number (CANUM, thousands)

	0	1	2	3	4	5	6	7	8
2000	37749	616321	194300	86731	77777	52964	30056	12428	9291
2001	634631	498179	283245	147601	75897	47807	28743	13928	4188
2002	80637	81436	113576	186714	119192	45110	31053	11414	6310
2003	1374	63857	82330	95798	125060	82178	22858	13098	7006
2004	217885	248412	101789	70788	74972	74400	44450	13363	10422
2005	11586	207562	115890	102482	83461	51304	54195	27767	11214
2006	650	44762	72070	118995	101731	43005	31364	22110	12157
2007	9095	68189	93857	106993	96054	52215	20752	15017	12082
2008	4707	73668	68438	98131	75655	70738	37572	13260	18475
2009	5934	31481	110715	55478	45495	37211	31948	13230	7244
2010	3285	26490	31314	39307	28455	22420	13894	7958	7505
2011	5643	15458	16413	17831	35934	21639	19649	11212	8214
2012	479	46311	36497	43760	37810	28353	13964	9008	8440
2013	1029	60576	37098	43312	55919	28716	25322	11498	10987
2014	5840	35272	37735	42119	37499	19023	11196	6541	6186
2015	26670	46242	72781	38506	48439	29846	14860	7857	9120
2016	20012	22342	37247	93863	45681	30535	17423	10455	8256
2017	51.79	9435	32839	38541	78328	38496	26936	13463	10170
2018	367.8	48383	18459	34635	23065	51273	16259	8843	4507
2019	270.3	6881	20667	15565	13301	10333	15868	6034	3517

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
2019	0.0000	0.0722	0.1309	0.1582	0.1599	0.1792	0.1873	0.1959	0.2124

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
2019	0.0201	0.0487	0.0798	0.1073	0.1275	0.1277	0.1556	0.1784	0.1616

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
2019	0.0120	0.0279	0.0397	0.0645	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
2019	0.0167	0.0307	0.0569	0.0837	0.1236	0.1396	0.1656	0.1383	0.1667

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
2019	0.0001	0.0256	0.0568	0.0771	0.1190	0.1481	0.1705	0.1778	0.1910

Table 3.6.4- Western Baltic Spring-spawning Herring. *Multi fleet.* Natural mortality (NATMOR)

	0	1	2	3	4	5	6	7	8
1991	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1997	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1998	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2001	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2003	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2004	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2006	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2007	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2008	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2009	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2010	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2011	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2012	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2013	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2014	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2

2015	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2016	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2017	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2018	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2019	0.3	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 3.6.5. Western Baltic Spring-spawning Herring. *Multi fleet.* Proportion mature (MATPROP)

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1991	0	0	0.2	0.75	0.9	1	1	1	1
1992	0	0	0.2	0.75	0.9	1	1	1	1
1993	0	0	0.2	0.75	0.9	1	1	1	1
1994	0	0	0.2	0.75	0.9	1	1	1	1
1995	0	0	0.2	0.75	0.9	1	1	1	1
1996	0	0	0.2	0.75	0.9	1	1	1	1
1997	0	0	0.2	0.75	0.9	1	1	1	1
1998	0	0	0.2	0.75	0.9	1	1	1	1
1999	0	0	0.2	0.75	0.9	1	1	1	1
2000	0	0	0.2	0.75	0.9	1	1	1	1
2001	0	0	0.2	0.75	0.9	1	1	1	1
2002	0	0	0.2	0.75	0.9	1	1	1	1
2003	0	0	0.2	0.75	0.9	1	1	1	1
2004	0	0	0.2	0.75	0.9	1	1	1	1
2005	0	0	0.2	0.75	0.9	1	1	1	1
2006	0	0	0.2	0.75	0.9	1	1	1	1
2007	0	0	0.2	0.75	0.9	1	1	1	1
2008	0	0	0.2	0.75	0.9	1	1	1	1
2009	0	0	0.2	0.75	0.9	1	1	1	1
2010	0	0	0.2	0.75	0.9	1	1	1	1
2011	0	0	0.2	0.75	0.9	1	1	1	1

2012	0	0	0.2	0.75	0.9	1	1	1	1
2013	0	0	0.2	0.75	0.9	1	1	1	1
2014	0	0	0.2	0.75	0.9	1	1	1	1
2015	0	0	0.2	0.75	0.9	1	1	1	1
2016	0	0	0.2	0.75	0.9	1	1	1	1
2017	0	0	0.2	0.75	0.9	1	1	1	1
2018	0	0	0.2	0.75	0.9	1	1	1	1
2019	0	0	0.2	0.75	0.9	1	1	1	1

Table 3.6.6. Western Baltic Spring-spawning Herring. *Multi fleet.* Fraction of harvest before spawning (FPROP)

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1991	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1992	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1993	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1994	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1995	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1996	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1997	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1998	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1999	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2001	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2002	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2003	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2004	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2005	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2006	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2007	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2008	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

2009	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2010	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2011	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2012	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2013	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2014	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2015	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2016	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2017	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2018	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2019	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table 3.6.7. Western Baltic Spring-spawning Herring. *Multi fleet.* Fraction of natural mortality before spawning (MPROP)

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1991	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1992	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1993	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1994	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1995	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1996	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1997	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1998	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1999	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2000	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2001	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2002	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2003	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2004	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2005	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

2006	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2007	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2008	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2009	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2010	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2011	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2012	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2013	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2014	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2015	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2016	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2017	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2018	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2019	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

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
2019	315000	109000	67000	52000

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
2019	247870	122948	47727	24244

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

2019		1317	

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	1253526	52049	11578
2003	597562	106389	3185
2004	308141	62014	12337
2005	217604	107178	6352
2006	137387	26839	5972
2007	206041	31787	2974
2008	174691	30464	3747
2009	618446	34226	1103
2010	266187	67641	8802
2011	161067	61937	11777
2012	345880	71190	3522
2013	165769	66426	12310
2014	135127	16529	3075
2015	279696	58286	1850
2016	199430	90532	5677
2017	441987	64496	10594
2018	103137	56666	2753
2019	431838	34486	4548

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	3024	1278
2003	6140	1381
2004	3289	1205
2005	3319	587.8
2006	2600	1156
2007	3531	633.3
2008	2215	1138
2009	2976	541.4
2010	3691	1104
2011	2629	630.2
2012	5397	782.5
2013	4876	1371
2014	1187	1178
2015	9256	1384
2016	7714	2110
2017	5056	1521
2018	5091	1002
2019	8107	2798

Table 3.6.9 - Western Baltic Spring-spawning Herring. *Multi fleet.* SAM software version

Model version: [0.5.4 , 0.5.4 , 0.5.4]

Model SHA: [e2a30d42316c , e2a30d42316c , e2a30d42316c]

Table 3.6.10. Western Baltic Spring-spawning Herring. *Multi fleet.* SAM configuration settings

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

Where a matrix is specified rows corresponds to fleets and columns to ages.

Same number indicates same parameter used

Numbers (integers) starts from zero and must be consecutive

$minAge

The minimium age class in the assessment 0

$maxAge

The maximum age class in the assessment 8

$maxAgePlusGroup

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

$keyLogFsta

Coupling of the fishing mortality states (nomally only first row is used).

-1 0 1 2 3 4 5 6 6

7 8 9 10 11 12 13 14 14

15 16 17 18 19 20 21 22 22

23 24 25 26 27 28 29 30 30

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

$corFlag

Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)

0 2 2 2

$keyLogFpar

Coupling of the survey catchability parameters (nomally first row is not used, as that is covered by fishing mortality).

-1 -1 -1 -1 -1 -1 -1 -1 -1

```
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1  0  1  2  3 -1 -1
-1  4  5  6  7 -1 -1 -1 -1
 8 -1 -1 -1 -1 -1 -1 -1 -1
-1 9 10 11 -1 -1 -1 -1 -1
-1 -1 12 13 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1
$keyQpow
# Density-dependent catchability power parameters (if any).
 -1  -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1  -1
```

continued

Table 3.6.10. Western Baltic Spring-spawning Herring continued

$keyVarF

Coupling of process variance parameters for log(F)-process (nomally only first row is used)

-1 0 0 0 0 0 0 0 0

1 1 1 1 1 1 1 1 1

2 2 2 2 2 2 2 2 2

3 3 3 3 3 3 3 3 3

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

$keyVarLogN

Coupling of process variance parameters for log(N)-process

0 1 1 1 1 1 1 1 1

$keyVarObs

Coupling of the variance parameters for the observations.

-1 0 1 1 1 1 1 1 1

2 3 4 4 4 4 4 4 4

5 6 6 6 6 6 6 6 6

7 8 8 8 8 8 8 8 8

-1 -1 -1 9 9 9 9 -1 -1

-1 10 10 10 10 -1 -1 -1 -1

11 -1 -1 -1 -1 -1 -1 -1 -1

-1 12 12 12 -1 -1 -1 -1 -1

-1 -1 13 13 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1

$obsCorStruct

Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"

"ID" "AR" "ID" "AR" "AR" "AR" "ID" "AR" "US" "NA"

$keyCorObs

Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.

NA's indicate where correlation parameters can be specified (-1 where they cannot).

#0-1 1-2 2-3 3-4 4-5 5-6 6-7 7-8

NA NA NA NA NA NA NA NA

3 3 3 3 4 4 4 4

NA NA NA NA NA NA NA NA

3 3 3 3 4 4 4 4

-1 -1 -1 0 0 1 -1 -1

-1 2 1 0 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1

-1 2 1 -1 -1 -1 -1 -1

-1 -1 NA -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1

$stockRecruitmentModelCode

Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt). 0

$noScaledYears

Number of years where catch scaling is applied. 0

$keyScaledYears

A vector of the years where catch scaling is applied.

$keyParScaledYA

A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).

$fbarRange

lowest and higest age included in Fbar 3 6

$keyBiomassTreat

To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

$obsLikelihoodFlag

Option for observational likelihood | Possible values are: "LN" "ALN"

"LN" "LN" "LN" "LN" "LN" "LN" "LN" "LN" "LN" "LN"

$fixVarToWeight

If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight). 0

Table 3.6.11. Western Baltic Spring-spawning Herring. *Multi fleet.* Stock summary - Estimated recruitment (1000), spawning-stock biomass (SSB) (tonnes), average fishing mortality and total-stock biomass (TSB) (tonnes).

Year	R(age 0)	Low	High	SSB	Low	High	$F_{bar(3-6)}$	Low	High	TSB	Low	High
1991	4799683	3606013	6388484	296049	237411	369171	0.481	0.368	0.629	593617	492727	715166
1992	3569967	2789432	4568909	291869	238821	356702	0.517	0.422	0.634	504745	424702	599873
1993	3044671	2325112	3986913	276270	227054	336154	0.559	0.463	0.675	439318	369089	522911
1994	4380591	3378901	5679237	222218	183770	268708	0.590	0.491	0.709	366505	310022	433278
1995	4168930	3256947	5336279	192232	158708	232838	0.612	0.509	0.735	311642	264354	367389
1996	4186855	3277449	5348598	131342	109638	157342	0.631	0.524	0.761	274104	234705	320116
1997	3534281	2721940	4589058	147484	123158	176615	0.621	0.518	0.745	279504	238601	327419
1998	4460258	3480288	5716166	120118	100572	143464	0.605	0.506	0.724	265591	227461	310112
1999	4735476	3689806	6077482	120658	100978	144174	0.569	0.474	0.683	268044	230224	312076
2000	2955711	2315206	3773413	121179	101793	144256	0.574	0.481	0.684	251113	215841	292150
2001	2733279	2175782	3433623	133819	113004	158469	0.565	0.472	0.677	271699	233649	315945
2002	2658828	2115568	3341592	161101	136016	190813	0.517	0.429	0.622	286795	246580	333569
2003	2851159	2245718	3619824	126813	106940	150380	0.490	0.402	0.598	217762	187622	252745
2004	2043286	1613439	2587651	127885	107828	151672	0.498	0.412	0.601	218223	187891	253452
2005	1737092	1376675	2191867	116818	98547	138476	0.510	0.427	0.608	205948	176527	240271
2006	1361046	1071176	1729357	130128	109556	154564	0.512	0.429	0.610	221643	189500	259239
2007	1409637	1113736	1784154	104089	87222	124219	0.534	0.447	0.637	170611	145228	200430
2008	1171340	926411	1481026	85831	72462	101668	0.543	0.445	0.662	150842	129365	175885
2009	1156949	913876	1464675	78832	66726	93135	0.510	0.415	0.625	138189	119287	160086
2010	1470035	1162734	1858553	74002	62667	87386	0.433	0.354	0.529	123627	106548	143445
2011	1367582	1085691	1722663	67657	57224	79994	0.369	0.289	0.471	111973	96212	130317
2012	1169338	922063	1482927	68569	57939	81150	0.376	0.305	0.463	119651	102840	139211
2013	1581113	1180798	2117143	78598	66338	93123	0.383	0.311	0.471	133931	114786	156268
2014	1161332	903540	1492675	82818	69291	98985	0.378	0.305	0.468	138927	118887	162345
2015	937438	716843	1225917	81485	67778	97964	0.423	0.347	0.514	139013	117843	163986
2016	939669	705783	1251061	77854	64693	93691	0.475	0.374	0.604	121671	102202	144848
2017	1000047	715616	1397529	71908	58822	87907	0.499	0.366	0.681	114324	94944	137661

2018	783319	509261	1204860	60944	46696	79539	0.473	0.338	0.661	97762	77151	123881
2019	778899	423940	1431060	56621	40271	79611	0.382	0.249	0.584	101574	75349	136927

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	0.217	0.340	0.391	0.453	0.507	0.574	0.637	0.637
1992	0.027	0.222	0.355	0.413	0.483	0.545	0.628	0.703	0.703
1993	0.034	0.251	0.381	0.443	0.521	0.589	0.684	0.767	0.767
1994	0.041	0.282	0.407	0.466	0.550	0.620	0.724	0.812	0.812
1995	0.064	0.361	0.444	0.490	0.569	0.640	0.749	0.838	0.838
1996	0.047	0.307	0.430	0.493	0.585	0.665	0.783	0.883	0.883
1997	0.049	0.302	0.421	0.482	0.572	0.653	0.777	0.896	0.896
1998	0.052	0.308	0.423	0.474	0.558	0.636	0.752	0.885	0.885
1999	0.037	0.255	0.399	0.449	0.525	0.598	0.704	0.835	0.835
2000	0.029	0.232	0.393	0.448	0.529	0.603	0.714	0.851	0.851
2001	0.030	0.229	0.379	0.433	0.519	0.594	0.714	0.844	0.844
2002	0.028	0.213	0.355	0.399	0.475	0.543	0.651	0.773	0.773
2003	0.025	0.201	0.334	0.375	0.450	0.515	0.621	0.738	0.738
2004	0.025	0.204	0.331	0.377	0.458	0.522	0.632	0.751	0.751
2005	0.017	0.179	0.331	0.385	0.473	0.533	0.646	0.767	0.767
2006	0.016	0.185	0.360	0.402	0.479	0.532	0.634	0.746	0.746
2007	0.013	0.174	0.369	0.418	0.502	0.556	0.658	0.762	0.762
2008	0.012	0.175	0.380	0.424	0.510	0.567	0.669	0.766	0.766
2009	0.013	0.187	0.386	0.405	0.477	0.529	0.627	0.716	0.716
2010	0.008	0.133	0.311	0.339	0.406	0.449	0.537	0.616	0.616
2011	0.006	0.104	0.247	0.279	0.345	0.385	0.467	0.539	0.539
2012	0.006	0.100	0.232	0.273	0.350	0.396	0.485	0.557	0.557
2013	0.006	0.101	0.231	0.271	0.355	0.406	0.499	0.578	0.578
2014	0.005	0.097	0.230	0.269	0.349	0.402	0.492	0.579	0.579

2015	0.007	0.120	0.270	0.299	0.387	0.451	0.553	0.666	0.666
2016	0.006	0.122	0.306	0.342	0.431	0.507	0.621	0.766	0.766
2017	0.005	0.113	0.314	0.361	0.447	0.532	0.657	0.827	0.827
2018	0.004	0.104	0.290	0.336	0.420	0.506	0.629	0.815	0.815
2019	0.003	0.081	0.227	0.266	0.336	0.408	0.516	0.689	0.689

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	0.003	0.015	0.016	0.018	0.019	0.021	0.021
1992	0.000	0.000	0.003	0.015	0.016	0.018	0.020	0.022	0.022
1993	0.000	0.000	0.003	0.015	0.016	0.018	0.020	0.023	0.023
1994	0.000	0.000	0.003	0.015	0.016	0.018	0.021	0.024	0.024
1995	0.000	0.000	0.003	0.015	0.016	0.018	0.022	0.025	0.025
1996	0.000	0.000	0.003	0.015	0.017	0.019	0.023	0.028	0.028
1997	0.000	0.000	0.003	0.015	0.017	0.019	0.023	0.031	0.031
1998	0.000	0.000	0.003	0.015	0.017	0.020	0.023	0.035	0.035
1999	0.000	0.000	0.003	0.015	0.018	0.021	0.024	0.038	0.038
2000	0.000	0.000	0.003	0.015	0.018	0.022	0.026	0.041	0.041
2001	0.000	0.000	0.003	0.014	0.019	0.022	0.027	0.042	0.042
2002	0.000	0.000	0.002	0.014	0.018	0.021	0.026	0.042	0.042
2003	0.000	0.000	0.002	0.013	0.017	0.019	0.025	0.041	0.041
2004	0.000	0.000	0.002	0.013	0.016	0.017	0.023	0.037	0.037
2005	0.000	0.000	0.002	0.011	0.015	0.015	0.023	0.038	0.038
2006	0.000	0.000	0.001	0.009	0.014	0.014	0.021	0.038	0.038
2007	0.000	0.000	0.001	0.007	0.011	0.010	0.019	0.031	0.031
2008	0.000	0.000	0.001	0.006	0.010	0.008	0.017	0.027	0.027
2009	0.000	0.000	0.001	0.005	0.009	0.007	0.017	0.030	0.030
2010	0.000	0.000	0.001	0.005	0.008	0.006	0.016	0.027	0.027
2011	0.000	0.000	0.001	0.005	0.008	0.006	0.016	0.024	0.024

2012	0.000	0.000	0.000	0.004	0.008	0.005	0.018	0.023	0.023
2013	0.000	0.000	0.001	0.005	0.008	0.006	0.019	0.026	0.026
2014	0.000	0.000	0.001	0.005	0.009	0.008	0.022	0.034	0.034
2015	0.000	0.000	0.001	0.006	0.009	0.010	0.023	0.041	0.041
2016	0.000	0.000	0.001	0.007	0.009	0.011	0.024	0.046	0.046
2017	0.000	0.000	0.001	0.007	0.010	0.012	0.023	0.052	0.052
2018	0.000	0.000	0.001	0.008	0.011	0.014	0.026	0.067	0.067
2019	0.000	0.000	0.001	0.008	0.012	0.016	0.029	0.077	0.077

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	0.039	0.135	0.110	0.087	0.077	0.072	0.073	0.073
1992	0.000	0.040	0.139	0.113	0.090	0.079	0.074	0.075	0.075
1993	0.000	0.041	0.144	0.117	0.093	0.082	0.077	0.078	0.078
1994	0.000	0.043	0.152	0.123	0.098	0.087	0.081	0.082	0.082
1995	0.000	0.046	0.160	0.130	0.103	0.091	0.086	0.086	0.086
1996	0.000	0.046	0.160	0.130	0.103	0.091	0.086	0.086	0.086
1997	0.000	0.046	0.159	0.129	0.103	0.091	0.085	0.086	0.086
1998	0.000	0.048	0.168	0.136	0.108	0.096	0.090	0.090	0.090
1999	0.000	0.050	0.174	0.141	0.112	0.099	0.093	0.094	0.094
2000	0.000	0.051	0.179	0.145	0.116	0.102	0.096	0.097	0.097
2001	0.000	0.048	0.167	0.136	0.108	0.095	0.089	0.090	0.090
2002	0.000	0.048	0.170	0.138	0.110	0.097	0.091	0.091	0.091
2003	0.000	0.044	0.152	0.123	0.098	0.087	0.081	0.082	0.082
2004	0.000	0.038	0.134	0.109	0.087	0.076	0.072	0.072	0.072
2005	0.000	0.043	0.149	0.121	0.096	0.085	0.080	0.080	0.080
2006	0.000	0.049	0.172	0.139	0.111	0.098	0.092	0.092	0.092
2007	0.000	0.054	0.188	0.152	0.121	0.107	0.100	0.101	0.101
2008	0.000	0.057	0.199	0.162	0.129	0.114	0.107	0.107	0.107

2009	0.000	0.060	0.210	0.170	0.136	0.120	0.112	0.113	0.113
2010	0.000	0.055	0.193	0.156	0.125	0.110	0.103	0.104	0.104
2011	0.000	0.044	0.153	0.124	0.099	0.087	0.082	0.082	0.082
2012	0.000	0.037	0.130	0.106	0.084	0.074	0.070	0.070	0.070
2013	0.000	0.034	0.118	0.096	0.077	0.068	0.063	0.064	0.064
2014	0.000	0.036	0.126	0.102	0.082	0.072	0.068	0.068	0.068
2015	0.000	0.041	0.142	0.115	0.092	0.081	0.076	0.076	0.076
2016	0.000	0.053	0.185	0.150	0.120	0.106	0.099	0.100	0.100
2017	0.000	0.061	0.212	0.172	0.137	0.121	0.114	0.114	0.114
2018	0.000	0.056	0.195	0.158	0.126	0.111	0.105	0.105	0.105
2019	0.000	0.043	0.151	0.123	0.098	0.086	0.081	0.082	0.082

Table 3.6.12.d. Western Baltic Spring-spawning Herring. *Multi fleet.* Estimated fishing mortality - Fleet D

Year Age	0	1	2	3	4	5	6	7	8
1991	0.014	0.042	0.017	0.008	0.004	0.003	0.004	0.004	0.004
1992	0.014	0.037	0.015	0.008	0.004	0.003	0.004	0.003	0.003
1993	0.020	0.054	0.021	0.010	0.005	0.004	0.005	0.004	0.004
1994	0.026	0.076	0.029	0.013	0.006	0.004	0.006	0.005	0.005
1995	0.049	0.149	0.052	0.021	0.009	0.006	0.008	0.006	0.006
1996	0.032	0.090	0.031	0.013	0.006	0.004	0.006	0.005	0.005
1997	0.034	0.090	0.030	0.012	0.005	0.004	0.006	0.005	0.005
1998	0.037	0.101	0.033	0.013	0.006	0.004	0.005	0.005	0.005
1999	0.023	0.060	0.021	0.008	0.004	0.003	0.004	0.003	0.003
2000	0.016	0.040	0.014	0.006	0.003	0.002	0.003	0.003	0.003
2001	0.018	0.048	0.020	0.008	0.005	0.005	0.009	0.009	0.009
2002	0.018	0.055	0.022	0.007	0.004	0.003	0.004	0.003	0.003
2003	0.016	0.059	0.032	0.015	0.009	0.008	0.010	0.008	0.008
2004	0.016	0.067	0.044	0.023	0.014	0.012	0.012	0.009	0.009
2005	0.008	0.038	0.026	0.012	0.007	0.005	0.004	0.003	0.003

2006	0.008	0.048	0.043	0.023	0.013	0.013	0.011	0.009	0.009
2007	0.005	0.032	0.030	0.015	0.008	0.009	0.008	0.007	0.007
2008	0.005	0.033	0.033	0.014	0.005	0.006	0.005	0.006	0.006
2009	0.007	0.055	0.048	0.015	0.004	0.004	0.003	0.003	0.003
2010	0.003	0.021	0.015	0.003	0.000	0.000	0.000	0.000	0.000
2011	0.001	0.013	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	0.015	0.017	0.002	0.000	0.000	0.000	0.000	0.000
2014	0.001	0.014	0.014	0.002	0.000	0.000	0.000	0.000	0.000
2015	0.002	0.029	0.030	0.003	0.000	0.000	0.000	0.000	0.000
2016	0.001	0.019	0.021	0.002	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	0.004	0.000	0.000	0.000	0.000	0.000	0.000
2019	0.000	0.002	0.003	0.000	0.000	0.000	0.000	0.000	0.000

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	0.013	0.137	0.185	0.258	0.346	0.408	0.479	0.540	0.540
1992	0.013	0.145	0.198	0.277	0.374	0.445	0.530	0.603	0.603
1993	0.014	0.156	0.213	0.301	0.407	0.485	0.581	0.663	0.663
1994	0.015	0.163	0.223	0.315	0.429	0.511	0.615	0.701	0.701
1995	0.015	0.167	0.229	0.324	0.440	0.524	0.633	0.720	0.720
1996	0.015	0.172	0.236	0.335	0.459	0.551	0.668	0.764	0.764
1997	0.015	0.166	0.229	0.325	0.446	0.539	0.663	0.774	0.774
1998	0.014	0.159	0.219	0.311	0.427	0.516	0.634	0.755	0.755
1999	0.013	0.145	0.201	0.285	0.392	0.475	0.583	0.699	0.699
2000	0.013	0.141	0.197	0.282	0.392	0.477	0.590	0.711	0.711
2001	0.012	0.133	0.189	0.275	0.388	0.472	0.588	0.703	0.703
2002	0.010	0.109	0.161	0.240	0.344	0.423	0.531	0.636	0.636

2003	0.009	0.098	0.148	0.224	0.326	0.401	0.505	0.608	0.608
2004	0.009	0.098	0.151	0.233	0.341	0.416	0.525	0.632	0.632
2005	0.009	0.098	0.154	0.241	0.355	0.428	0.539	0.646	0.646
2006	0.008	0.088	0.144	0.230	0.341	0.408	0.510	0.607	0.607
2007	0.008	0.089	0.150	0.243	0.362	0.430	0.531	0.622	0.622
2008	0.007	0.085	0.147	0.243	0.366	0.439	0.541	0.626	0.626
2009	0.006	0.071	0.128	0.214	0.328	0.398	0.496	0.569	0.569
2010	0.005	0.056	0.102	0.174	0.272	0.333	0.418	0.485	0.485
2011	0.004	0.047	0.086	0.149	0.238	0.293	0.370	0.433	0.433
2012	0.004	0.050	0.092	0.161	0.259	0.317	0.397	0.464	0.464
2013	0.004	0.051	0.095	0.168	0.271	0.332	0.416	0.488	0.488
2014	0.004	0.048	0.090	0.160	0.259	0.322	0.402	0.477	0.477
2015	0.004	0.050	0.097	0.176	0.286	0.361	0.454	0.548	0.548
2016	0.004	0.050	0.099	0.183	0.302	0.390	0.498	0.619	0.619
2017	0.004	0.048	0.096	0.181	0.300	0.399	0.520	0.660	0.660
2018	0.004	0.045	0.090	0.170	0.282	0.381	0.498	0.643	0.643
2019	0.003	0.036	0.072	0.135	0.226	0.306	0.406	0.530	0.530

Table 3.6.13. Western Baltic Spring-spawning Herring. *Multi fleet.* Estimated stock numbers (1000) at age

Year Age	0	1	2	3	4	5	6	7	8
1991	4799683	4174759	2186131	1870774	928444	562652	166842	49793	17549
1992	3569967	3521375	2021391	1279546	1036927	478681	275550	77865	29738
1993	3044671	2581178	1755580	1144063	703619	522153	225230	120472	43874
1994	4380591	2120126	1216349	1010532	589265	349455	235315	92720	62361
1995	4168930	3177171	975586	648126	544227	266447	157370	92360	56092
1996	4186855	2883667	1352501	515604	321277	250212	114769	60911	52631
1997	3534281	2968223	1278394	736759	257897	144496	102581	42800	39119
1998	4460258	2436104	1325852	687712	377186	119424	62473	37353	27400
1999	4735476	3150323	1067716	702067	352129	179507	51248	24619	21245

2000	2955711	3462052	1486267	580043	362202	173091	80939	20906	16269
2001	2733279	2084759	1674773	838734	297189	174754	76734	32948	12958
2002	2658828	1951842	974695	945021	462062	141364	79900	29809	16362
2003	2851159	1888386	959614	548903	519624	238700	66485	34255	17416
2004	2043286	2108998	941827	568359	309115	268970	117214	29425	20108
2005	1737092	1453665	1061415	567051	316643	160420	130562	51330	19107
2006	1361046	1268081	713708	628723	328604	159499	79122	55274	26895
2007	1409637	975647	647680	403456	339228	171108	73451	36249	31342
2008	1171340	1048473	485007	367541	215377	167503	82439	31006	26129
2009	1156949	850770	544397	270334	192009	107590	76392	35035	21849
2010	1470035	826687	427510	299061	149794	99298	52355	31975	23134
2011	1367582	1093372	431500	252757	172770	81697	52878	25333	24006
2012	1169338	1006185	614223	274568	154090	100165	45690	27262	23664
2013	1581113	846261	541988	411077	170838	89215	54446	23321	24047
2014	1161332	1218578	446035	345162	262371	95598	49091	27103	22381
2015	937438	856495	711048	290662	212931	144359	53392	24394	23478
2016	939669	678053	459083	461559	177708	117195	71846	25228	20623
2017	1000047	694091	359716	265469	279192	96516	57956	30457	17522
2018	783319	757396	382503	210383	142002	153186	47911	24196	16606
2019	778899	572243	416601	235197	120698	76241	75469	21652	14073

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	111420.97	681425.48	625862.72	603490.90	334413.09	220688.56	72051.70	23250.56	8194.35
1992	82764.60	584671.41	600903.63	432048.44	393902.99	198968.39	127380.53	39126.08	14943.11
1993	88882.06	484060.11	558115.29	411167.81	284562.18	230744.05	111136.58	64562.08	23512.51
1994	154899.94	445379.35	411332.43	380780.73	249659.88	161087.95	121395.19	51856.74	34877.63
1995	226695.01	846411.39	359974.86	256063.24	238014.86	126369.86	83579.40	53053.39	32220.29
1996	169243.09	658138.55	481486.92	203948.42	143169.64	121932.21	62753.33	36206.09	31284.88
1997	148209.15	667143.63	446558.41	285619.83	112882.45	69469.39	55782.45	25735.78	23522.35

1998	196528.90	557829.09	466264.98	263848.10	162523.80	56489.72	33332.50	22411.71	16439.87
1999	148739.86	601753.08	354531.60	257202.71	144756.44	81199.09	26129.79	14268.14	12312.79
2000	73054.62	603133.18	486343.29	211832.22	149949.63	78980.01	41802.68	12318.36	9586.08
2001	69611.00	359211.27	530569.39	297334.89	121055.60	78697.07	39651.24	19341.26	7606.62
2002	63086.37	315415.86	290961.09	311699.68	175012.77	59328.02	38504.84	16413.81	9009.29
2003	61229.72	288049.51	272136.72	171879.13	188003.10	95743.65	30848.63	18199.45	9253.04
2004	43039.92	326643.41	265813.88	178874.43	113239.03	108621.84	54872.18	15706.92	10733.44
2005	25714.35	197924.96	297600.23	181137.39	118974.06	65815.39	61997.26	27834.16	10361.03
2006	19030.61	179509.07	217361.93	210046.78	125822.70	66098.46	37502.78	29737.34	14469.28
2007	15687.14	129435.36	200620.62	139183.95	134923.73	73338.38	35817.46	19799.92	17119.45
2008	12504.06	139963.48	154594.24	128561.40	86789.81	72833.00	40670.42	16991.53	14318.76
2009	13325.93	121496.67	176464.62	90780.22	73379.93	44368.06	35989.09	18359.95	11450.11
2010	9953.40	84373.90	112000.25	84944.71	49650.60	35596.48	21753.96	14868.61	10757.60
2011	6875.93	87573.25	91185.97	59901.46	49259.62	25481.70	19428.00	10480.80	9932.00
2012	5742.84	77452.82	122643.66	63573.13	44304.47	31752.48	17189.48	11480.15	9965.01
2013	7822.79	65818.58	108031.76	94516.29	49487.13	28766.00	20890.22	10078.56	10392.42
2014	5405.46	91664.60	88560.65	79080.03	75141.29	30673.74	18701.69	11824.47	9764.20
2015	5291.97	79286.09	164715.54	73556.73	66965.69	51313.65	22421.66	11936.18	11487.61
2016	4762.54	63867.71	118936.69	132244.21	61924.09	46378.69	33438.20	13881.65	11347.44
2017	4064.12	60049.84	94357.99	79900.81	100932.78	39999.67	28332.78	17875.12	10283.42
2018	2970.04	60752.72	93343.60	59409.34	48524.91	60825.49	22613.36	14128.69	9697.01
2019	2344.22	35929.14	80659.03	53461.17	33705.22	25107.51	30274.27	11141.45	7241.25

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	13.26	5556.77	25424.73	12946.89	9185.91	2861.90	923.57	325.50
1992	0.00	11.19	5142.37	17333.29	14488.46	7705.56	4848.31	1517.49	579.56
1993	0.00	8.20	4452.68	15616.04	9981.02	8376.90	4087.12	2462.69	896.87
1994	0.00	6.73	3085.10	13667.96	8613.09	5622.00	4428.46	1991.71	1339.57

1995	0.00	10.09	2470.78	8813.26	8042.61	4374.32	3077.18	2094.63	1272.11
1996	0.00	9.16	3412.29	6999.14	4808.91	4235.95	2316.11	1499.87	1296.01
1997	0.00	9.43	3218.26	9972.75	3902.68	2492.68	2108.75	1189.52	1087.22
1998	0.00	7.74	3343.48	9217.53	5835.66	2156.24	1287.34	1168.26	856.96
1999	0.00	10.01	2690.95	9483.90	5539.57	3417.48	1094.70	841.21	725.92
2000	0.00	11.00	3733.99	7756.14	6000.62	3424.79	1850.31	764.26	594.75
2001	0.00	6.96	3971.04	10758.13	4939.33	3448.99	1829.06	1236.06	486.12
2002	0.00	6.24	2033.60	11707.90	7390.06	2647.03	1865.46	1121.06	615.33
2003	0.00	6.00	1613.89	6418.11	7895.16	4067.89	1468.70	1235.88	628.35
2004	0.00	6.92	1592.10	6457.39	4477.12	4175.08	2437.46	978.04	668.35
2005	0.00	5.12	1571.60	5701.35	4382.08	2232.68	2658.34	1721.87	640.95
2006	0.00	4.96	845.43	5260.27	4006.21	1966.44	1510.52	1851.18	900.73
2007	0.00	3.94	559.22	2693.45	3411.42	1581.36	1243.55	1006.86	870.55
2008	0.00	4.49	339.79	1932.35	1855.95	1221.99	1227.08	761.03	641.32
2009	0.00	3.99	335.37	1321.19	1608.26	713.12	1164.30	942.40	587.73
2010	0.00	4.37	214.98	1312.46	1148.60	568.49	770.94	771.55	558.23
2011	0.00	6.25	196.02	1038.69	1213.26	409.96	763.25	534.22	506.25
2012	0.00	6.47	267.28	1097.95	1044.50	450.44	738.58	552.25	479.37
2013	0.00	6.37	264.25	1744.01	1175.69	505.27	942.90	544.81	561.78
2014	0.00	11.15	265.57	1682.07	2022.38	676.70	952.27	811.75	670.31
2015	0.00	9.29	451.63	1546.84	1720.97	1247.93	1097.07	888.89	855.48
2016	0.00	8.57	338.32	2758.26	1500.01	1126.28	1513.48	1037.18	847.83
2017	0.00	10.03	283.19	1743.81	2495.72	1014.48	1206.75	1397.40	803.91
2018	0.00	12.83	353.70	1456.39	1422.14	1906.24	1117.05	1422.30	976.18
2019	0.00	11.16	450.91	1738.54	1282.46	1069.72	1955.23	1461.07	949.61

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	830.11	124807.26	251197.44	176429.51	70542.62	37888.80	10562.36	3174.88	1118.94

1992	634.36	108108.33	238221.00	123804.85	80853.78	33085.10	17906.07	5096.22	1946.36
1993	560.27	82012.09	213762.08	114419.84	56731.44	37324.52	15138.24	8155.24	2970.01
1994	850.74	71020.23	155722.37	106336.68	50019.85	26305.92	16657.91	6610.59	4446.13
1995	853.01	112013.56	131088.87	71631.42	48549.86	21084.90	11712.50	6923.06	4204.50
1996	856.36	101628.18	181670.84	56964.42	28650.15	19792.77	8538.62	4563.99	3943.64
1997	720.64	104290.37	171223.92	81159.68	22929.82	11395.90	7608.92	3197.33	2922.34
1998	956.81	89956.00	186105.02	79449.27	35192.11	9886.56	4864.79	2929.42	2148.84
1999	1052.35	120415.53	154820.33	83828.81	33971.41	15368.91	4127.52	1996.95	1723.28
2000	677.85	136466.05	221829.42	71323.25	35999.96	15270.60	6717.85	1747.54	1359.92
2001	584.35	76727.05	234354.06	96589.25	27638.62	14419.67	5955.65	2575.60	1012.94
2002	576.68	72854.20	138210.97	110302.35	43560.83	11825.38	6287.10	2362.53	1296.76
2003	555.26	63431.35	123176.43	57907.64	44218.70	18013.03	4718.03	2448.66	1244.96
2004	350.51	62547.24	107398.71	53181.67	23298.36	17966.14	7360.35	1861.36	1271.97
2005	331.17	47821.65	133575.14	58631.83	26402.54	11860.99	9077.25	3595.13	1338.26
2006	298.63	47872.52	102287.10	74178.38	31318.44	13491.02	6295.27	4430.48	2155.74
2007	338.62	40241.76	100858.52	51793.35	35222.34	15776.73	6372.40	3168.26	2739.34
2008	298.50	45811.19	79700.49	49839.20	23642.47	16335.29	7566.22	2866.92	2415.95
2009	310.64	39112.76	93793.10	38469.07	22137.15	11024.30	7368.05	3404.17	2123.00
2010	362.57	34989.35	68203.75	39350.36	15948.58	9390.63	4659.37	2866.87	2074.21
2011	267.11	36836.60	55550.28	26744.63	14747.90	6185.79	3765.23	1817.45	1722.28
2012	194.85	29004.79	68180.16	25001.53	11300.24	6510.77	2791.95	1678.62	1457.08
2013	239.40	22201.52	54978.85	34171.72	11427.25	5287.19	3032.80	1309.00	1349.76
2014	187.45	34044.96	48055.78	30495.84	18664.87	6027.41	2909.76	1618.80	1336.74
2015	169.83	26804.98	85365.55	28654.91	16922.62	10174.57	3538.89	1629.26	1568.03
2016	222.64	27596.91	70624.90	58526.98	18226.20	10676.51	6159.96	2179.44	1781.57
2017	271.10	32211.32	62533.43	38125.93	32496.69	9987.81	5647.10	2990.01	1720.13
2018	195.64	32453.02	61740.63	28013.56	15304.94	14670.07	4318.84	2197.59	1508.28
2019	150.50	19077.75	53109.61	24639.37	10200.16	5715.86	5321.59	1538.44	999.89

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	59028.81	134119.75	33140.08	13946.54	3430.16	1528.37	653.61	159.69	56.28
1992	41575.25	99966.32	27754.56	8708.89	3547.37	1223.53	1039.15	244.09	93.22
1993	51248.35	106343.69	33002.68	10282.32	3080.03	1661.30	1040.20	454.53	165.53
1994	98700.44	122141.92	31175.08	11703.19	3230.07	1350.89	1296.93	410.03	275.78
1995	172002.60	347550.23	44777.90	12366.80	4561.34	1488.24	1197.09	541.93	329.12
1996	112903.86	195620.66	37428.24	6088.92	1745.51	955.93	625.72	269.01	232.44
1997	102201.86	202337.33	34047.01	8027.75	1274.79	503.68	514.76	178.47	163.12
1998	141037.20	184222.31	39158.37	7754.87	1875.39	413.08	306.42	154.44	113.29
1999	94912.90	145053.63	20213.02	5157.35	1168.18	430.46	179.95	76.17	65.73
2000	40505.18	107362.81	19224.02	2922.82	851.40	304.24	215.51	50.98	39.67
2001	41268.69	77742.55	29520.89	6286.90	1358.12	769.80	627.15	279.81	110.05
2002	40194.44	83098.75	18905.74	6247.05	1601.41	369.14	268.05	77.58	42.58
2003	39306.60	85878.96	27686.65	7192.59	4233.27	1686.14	575.09	234.64	119.29
2004	27344.64	107931.90	36581.09	11765.90	3990.22	2954.65	1298.59	242.98	166.04
2005	12515.45	43159.87	24617.85	6284.55	1920.38	747.84	519.27	141.38	52.63
2006	9648.71	47093.85	27008.15	12891.02	3920.39	1929.49	808.97	440.50	214.33
2007	5945.89	23847.51	17358.54	5477.97	2448.27	1401.49	543.02	243.28	210.35
2008	4771.80	27031.26	14220.39	4592.13	1060.62	925.92	375.34	158.56	133.62
2009	6788.27	36068.28	23069.13	3569.21	669.22	379.54	179.45	105.41	65.74
2010	3306.40	13599.63	5951.54	792.03	54.75	27.74	6.84	5.63	4.07
2011	1716.14	11094.77	3205.63	247.50	11.24	4.03	1.44	1.25	1.18
2012	1125.68	9601.40	5181.70	262.12	7.10	3.56	0.90	1.09	0.95
2013	1485.79	10148.32	8088.25	827.60	15.45	5.96	1.59	1.32	1.36
2014	1072.24	13003.78	5456.45	477.35	12.88	5.23	1.07	1.20	0.99
2015	1600.53	19362.97	19328.77	824.20	25.03	27.98	2.93	2.32	2.23
2016	1016.70	10010.19	8645.25	690.58	9.87	16.32	3.22	2.25	1.84
2017	217.13	2098.98	1541.18	82.13	3.13	3.02	0.98	1.46	0.84

2018	148.70	1932.57	1380.22	60.98	1.43	4.10	0.86	1.43	0.98
2019	103.03	981.47	959.35	50.25	0.97	1.70	1.25	1.29	0.84

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	51562.05	422485.21	335968.43	387690.12	247493.42	172085.48	57973.83	18992.42	6693.63
1992	40554.99	376585.57	329785.70	282201.41	295013.38	156954.20	103587.00	32268.28	12323.97
1993	37073.44	295696.13	306897.85	270849.61	214769.69	183381.33	90871.02	53489.62	19480.10
1994	55348.76	252210.47	221349.88	249072.90	187796.87	127809.14	99011.89	42844.41	28816.15
1995	53839.40	386837.51	181637.31	163251.76	176861.05	99422.40	67592.63	43493.77	26414.56
1996	55482.87	360880.55	258975.55	133895.94	107965.07	96947.56	51272.88	29873.22	25812.79
1997	45286.65	360506.50	238069.22	186459.65	84775.16	55077.13	45550.02	21170.46	19349.67
1998	54534.89	283643.04	237658.11	167426.43	119620.64	44033.84	26873.95	18159.59	13320.78
1999	52774.61	336273.91	176807.30	158732.65	104077.28	61982.24	20727.62	11353.81	9797.86
2000	31871.59	359293.32	241555.86	129830.01	107097.65	59980.38	33019.01	9755.58	7591.74
2001	27757.96	204734.71	262723.40	183700.61	87119.53	60058.61	31239.38	15249.79	5997.51
2002	22315.25	159456.67	131810.78	183442.38	122460.47	44486.47	30084.23	12852.64	7054.62
2003	21367.86	138733.20	119659.75	100360.79	131655.97	71976.59	24086.81	14280.27	7260.44
2004	15344.77	156157.35	120241.98	107469.47	81473.33	83525.97	43775.78	12624.54	8627.08
2005	12867.73	106938.32	137835.64	110519.66	86269.06	50973.88	49742.40	22375.78	8329.19
2006	9083.27	84537.74	87221.25	117717.11	86577.66	48711.51	28888.02	23015.18	11198.48
2007	9402.63	65342.15	81844.34	79219.18	93841.70	54578.80	27658.49	15381.52	13299.21
2008	7433.76	67116.54	60333.57	72197.72	60230.77	54349.80	31501.78	13205.02	11127.87
2009	6227.02	46311.64	59267.02	47420.75	48965.30	32251.10	27277.29	13907.97	8673.64
2010	6284.43	35780.55	37629.98	43489.86	32498.67	25609.62	16316.81	11224.56	8121.09
2011	4892.68	39635.63	32234.04	31870.64	33287.22	18881.92	14898.08	8127.88	7702.29
2012	4422.31	38840.16	49014.52	37211.53	31952.63	24787.71	13658.05	9248.19	8027.61
2013	6097.60	33462.37	44700.41	57772.96	36868.74	22967.58	16912.93	8223.43	8479.52
2014	4145.77	44604.71	34782.85	46424.77	54441.16	23964.40	14838.59	9392.72	7756.16

2015	3521.61	33108.85	59569.59	42530.78	48297.07	39863.17	17782.77	9415.71	9061.87
2016	3523.20	26252.04	39328.22	70268.39	42188.01	34559.58	25761.54	10662.78	8716.20
2017	3575.89	25729.51	30000.19	39948.94	65937.24	28994.36	21477.95	13486.25	7758.54
2018	2625.70	26354.30	29869.05	29878.41	31796.40	44245.08	17176.61	10507.37	7211.57
2019	2090.69	15858.76	26139.16	27033.01	22221.63	18320.23	22996.20	8140.65	5290.91

Table 3.9.1. Western Baltic Spring-spawning Herring. *Multi fleet.* Input table for short-term predictions.

2019

wr	N	M	Mat	PM	PF	SWt
0	778899	0.3	0.00	0.25	0.1	0.0001
1	572243	0.5	0.00	0.25	0.1	0.0256
2	416602	0.2	0.20	0.25	0.1	0.0568
3	235197	0.2	0.75	0.25	0.1	0.0771
4	120698	0.2	0.90	0.25	0.1	0.1190
5	76241	0.2	1.00	0.25	0.1	0.1481
6	75469	0.2	1.00	0.25	0.1	0.1705
7	21652	0.2	1.00	0.25	0.1	0.1778
8+	14073	0.2	1.00	0.25	0.1	0.1910

2020

wr	N	M	Mat	PM	PF	SWt
0	964361	0.3	0.00	0.25	0.1	0.0001
1		0.5	0.00	0.25	0.1	0.0169
2		0.2	0.20	0.25	0.1	0.0488
3		0.2	0.75	0.25	0.1	0.0821
4		0.2	0.90	0.25	0.1	0.1136
5		0.2	1.00	0.25	0.1	0.1435
6		0.2	1.00	0.25	0.1	0.1668
7		0.2	1.00	0.25	0.1	0.1744
8+		0.2	1.00	0.25	0.1	0.1871

2021

wr	N	M	Mat	PM	PF	SWt
0	964361	0.3	0.00	0.25	0.1	0.0001
1		0.5	0.00	0.25	0.1	0.0169
2		0.2	0.20	0.25	0.1	0.0488
3		0.2	0.75	0.25	0.1	0.0821
4		0.2	0.90	0.25	0.1	0.1136
5		0.2	1.00	0.25	0.1	0.1435
6		0.2	1.00	0.25	0.1	0.1668
7		0.2	1.00	0.25	0.1	0.1744
8+		0.2	1.00	0.25	0.1	0.1871

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_{2019} wr 0-8+: Populations numbers from the assessment
$N_{2020/2021}$ wr 0: Average of wr 0 for the years 2014-2018
Natural Mortality (M): Constant
Weight in the Stock 2020-2021 (SWt): Average for 2015-2019

Table 3.9.2. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. MSY approach (zero catch).

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.000	0.000	0.000
fbar:low	0.382	0.170	0.000	0.000	0.000
fbar:high	0.382	0.170	0.000	0.000	0.000
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	66824	87890	111745
ssb:low	56621	57124	66824	87890	111745
ssb:high	56621	57124	66824	87890	111745
catch:Estimate	26223	15391	0	0	0
catch:low	26223	15391	0	0	0
catch:high	26223	15391	0	0	0

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	0	0	0
Fleet C : Estimate	10283	8933	0	0	0
Fleet D : Estimate	65	123	0	0	0
Fleet F : Estimate	14579	3150	0	0	0

Table 3.9.3. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. MAP 2018: $F=F_{MSY}(0.31)*SSB_{y-1}/MSYB_{trigger}$

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.118	0.136	0.161
fbar:low	0.382	0.170	0.118	0.136	0.161
fbar:high	0.382	0.170	0.118	0.136	0.161
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	65973	77674	88478
ssb:low	56621	57124	65973	77674	88478
ssb:high	56621	57124	65973	77674	88478
catch:Estimate	26223	15391	10273	14032	18667
catch:low	26223	15391	10273	14032	18667
catch:high	26223	15391	10273	14032	18667

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	1396	1975	2812
Fleet C : Estimate	10283	8933	3688	4972	6439
Fleet D : Estimate	65	123	52	68	82
Fleet F : Estimate	14579	3150	5137	7016	9333

Table 3.9.4. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. MAP 2018: F=FMSYlower(0.216)*SSBy-1/MSYBtrigger

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.082	0.095	0.116
fbar:low	0.382	0.170	0.082	0.095	0.116
fbar:high	0.382	0.170	0.082	0.095	0.116
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	66230	80610	94749
ssb:low	56621	57124	66230	80610	94749
ssb:high	56621	57124	66230	80610	94749
catch:Estimate	26223	15391	7291	10353	14727
catch:low	26223	15391	7291	10353	14727
catch:high	26223	15391	7291	10353	14727

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	998	1491	2307
Fleet C : Estimate	10283	8933	2611	3636	4996
Fleet D : Estimate	65	123	37	49	61
Fleet F : Estimate	14579	3150	3645	5176	7364

Table 3.9.5. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. MAP 2018: F=FMSYupper(0.379)*SSBy-1/MSYBtrigger

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.144	0.166	0.191
fbar:low	0.382	0.170	0.144	0.166	0.191
fbar:high	0.382	0.170	0.144	0.166	0.191
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	65786	75602	84241
ssb:low	56621	57124	65786	75602	84241
ssb:high	56621	57124	65786	75602	84241
catch:Estimate	26223	15391	12393	16460	20896
catch:low	26223	15391	12393	16460	20896
catch:high	26223	15391	12393	16460	20896

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	1676	2279	3061
Fleet C : Estimate	10283	8933	4457	5869	7292
Fleet D : Estimate	65	123	63	82	95
Fleet F : Estimate	14579	3150	6197	8230	10448

Table 3.9.6. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. F=F_{MSY}=0.31

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.310	0.310	0.310
fbar:low	0.382	0.170	0.310	0.310	0.310
fbar:high	0.382	0.170	0.310	0.310	0.310
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	64618	64275	65660
ssb:low	56621	57124	64618	64275	65660
ssb:high	56621	57124	64618	64275	65660
catch:Estimate	26223	15391	24535	24855	25434
catch:low	26223	15391	24535	24855	25434
catch:high	26223	15391	24535	24855	25434

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	3218	3123	3217
Fleet C : Estimate	10283	8933	8919	9164	9359
Fleet D : Estimate	65	123	131	141	141
Fleet F : Estimate	14579	3150	12267	12428	12717

Table 3.9.7. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. $F=F_{pa}=0.35$

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.350	0.350	0.350
fbar:low	0.382	0.170	0.350	0.350	0.350
fbar:high	0.382	0.170	0.350	0.350	0.350
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	64340	61819	61637
ssb:low	56621	57124	64340	61819	61637
ssb:high	56621	57124	64340	61819	61637
catch:Estimate	26223	15391	27179	26657	26651
catch:low	26223	15391	27179	26657	26651
catch:high	26223	15391	27179	26657	26651

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	3540	3269	3240
Fleet C : Estimate	10283	8933	9904	9903	9931
Fleet D : Estimate	65	123	146	156	155
Fleet F : Estimate	14579	3150	13589	13328	13326

Table 3.9.8. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. F=F_{lim}=0.45

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.450	0.450	0.450
fbar:low	0.382	0.170	0.450	0.450	0.450
fbar:high	0.382	0.170	0.450	0.450	0.450
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	63650	56155	52884
ssb:low	56621	57124	63650	56155	52884
ssb:high	56621	57124	63650	56155	52884
catch:Estimate	26223	15391	33356	30253	28688
catch:low	26223	15391	33356	30253	28688
catch:high	26223	15391	33356	30253	28688

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	4270	3493	3160
Fleet C : Estimate	10283	8933	12225	11443	10998
Fleet D : Estimate	65	123	183	191	185
Fleet F : Estimate	14579	3150	16678	15127	14344

Table 3.9.9. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. $F=F_{2020}=0.17$

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.170	0.170	0.170
fbar:low	0.382	0.170	0.170	0.170	0.170
fbar:high	0.382	0.170	0.170	0.170	0.170
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	65603	73849	82693
ssb:low	56621	57124	65603	73849	82693
ssb:high	56621	57124	65603	73849	82693
catch:Estimate	26223	15391	14410	16432	18421
catch:low	26223	15391	14410	16432	18421
catch:high	26223	15391	14410	16432	18421

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	1939	2249	2678
Fleet C : Estimate	10283	8933	5191	5884	6448
Fleet D : Estimate	65	123	74	83	85
Fleet F : Estimate	14579	3150	7205	8216	9210

Table 3.9.10. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. F=0

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.000	0.000	0.000
fbar:low	0.382	0.170	0.000	0.000	0.000
fbar:high	0.382	0.170	0.000	0.000	0.000
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	66824	87890	111745
ssb:low	56621	57124	66824	87890	111745
ssb:high	56621	57124	66824	87890	111745
catch:Estimate	26223	15391	0	0	0
catch:low	26223	15391	0	0	0
catch:high	26223	15391	0	0	0

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	0	0	0
Fleet C : Estimate	10283	8933	0	0	0
Fleet D : Estimate	65	123	0	0	0
Fleet F : Estimate	14579	3150	0	0	0

Table 3.9.11. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. F=0.05

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.050	0.050	0.050
fbar:low	0.382	0.170	0.050	0.050	0.050
fbar:high	0.382	0.170	0.050	0.050	0.050
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	66462	83450	102017
ssb:low	56621	57124	66462	83450	102017
ssb:high	56621	57124	66462	83450	102017
catch:Estimate	26223	15391	4506	5726	7037
catch:low	26223	15391	4506	5726	7037
catch:high	26223	15391	4506	5726	7037

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	621	844	1151
Fleet C : Estimate	10283	8933	1610	1993	2340
Fleet D : Estimate	65	123	22	26	27
Fleet F : Estimate	14579	3150	2253	2863	3518

Table 3.9.12. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. F=0.1

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.100	0.100	0.100
fbar:low	0.382	0.170	0.100	0.100	0.100
fbar:high	0.382	0.170	0.100	0.100	0.100
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	66103	79277	93335
ssb:low	56621	57124	66103	79277	93335
ssb:high	56621	57124	66103	79277	93335
catch:Estimate	26223	15391	8783	10659	12586
catch:low	26223	15391	8783	10659	12586
catch:high	26223	15391	8783	10659	12586

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	1198	1523	1960
Fleet C : Estimate	10283	8933	3149	3756	4280
Fleet D : Estimate	65	123	44	51	52
Fleet F : Estimate	14579	3150	4391	5329	6293

Table 3.9.13. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. F=0.15

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.150	0.150	0.150
fbar:low	0.382	0.170	0.150	0.150	0.150
fbar:high	0.382	0.170	0.150	0.150	0.150
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	65746	75353	85569
ssb:low	56621	57124	65746	75353	85569
ssb:high	56621	57124	65746	75353	85569
catch:Estimate	26223	15391	12843	14905	16951
catch:low	26223	15391	12843	14905	16951
catch:high	26223	15391	12843	14905	16951

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	1735	2065	2513
Fleet C : Estimate	10283	8933	4621	5313	5886
Fleet D : Estimate	65	123	66	74	76
Fleet F : Estimate	14579	3150	6422	7452	8476

Table 3.9.14. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. Constant 2020 TAC

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.150	0.130	0.113
fbar:low	0.382	0.170	0.150	0.130	0.113
fbar:high	0.382	0.170	0.150	0.130	0.113
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	65726	74580	85273
ssb:low	56621	57124	65726	74580	85273
ssb:high	56621	57124	65726	74580	85273
catch:Estimate	26223	15391	15391	15391	15391
catch:low	26223	15391	15391	15391	15391
catch:high	26223	15391	15391	15391	15391

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	3184	3184	3184
Fleet C : Estimate	10283	8933	8933	8933	8933
Fleet D : Estimate	65	123	123	123	123
Fleet F : Estimate	14579	3150	3150	3150	3150

Table 3.9.15. Western Baltic Spring-spawning Herring. *Multi fleet.* Forecast table. Catch for bycatch fleets only

Year	2019	2020	2021	2022	2023
fbar:Estimate	0.382	0.170	0.026	0.019	0.014
fbar:low	0.382	0.170	0.026	0.019	0.014
fbar:high	0.382	0.170	0.026	0.019	0.014
rec:Estimate	778899	964361	964361	964361	964361
rec:low	778899	964361	964361	964361	964361
rec:high	778899	964361	964361	964361	964361
ssb:Estimate	56621	57124	66574	85251	106832
ssb:low	56621	57124	66574	85251	106832
ssb:high	56621	57124	66574	85251	106832
catch:Estimate	26223	15391	3308	3308	3308
catch:low	26223	15391	3308	3308	3308
catch:high	26223	15391	3308	3308	3308

Per fleet

Year	2019	2020	2021	2022	2023
Fleet A : Estimate	1296	3184	3184	3184	3184
Fleet C : Estimate	10283	8933	0	0	0
Fleet D : Estimate	65	123	123	123	123
Fleet F : Estimate	14579	3150	0	0	0

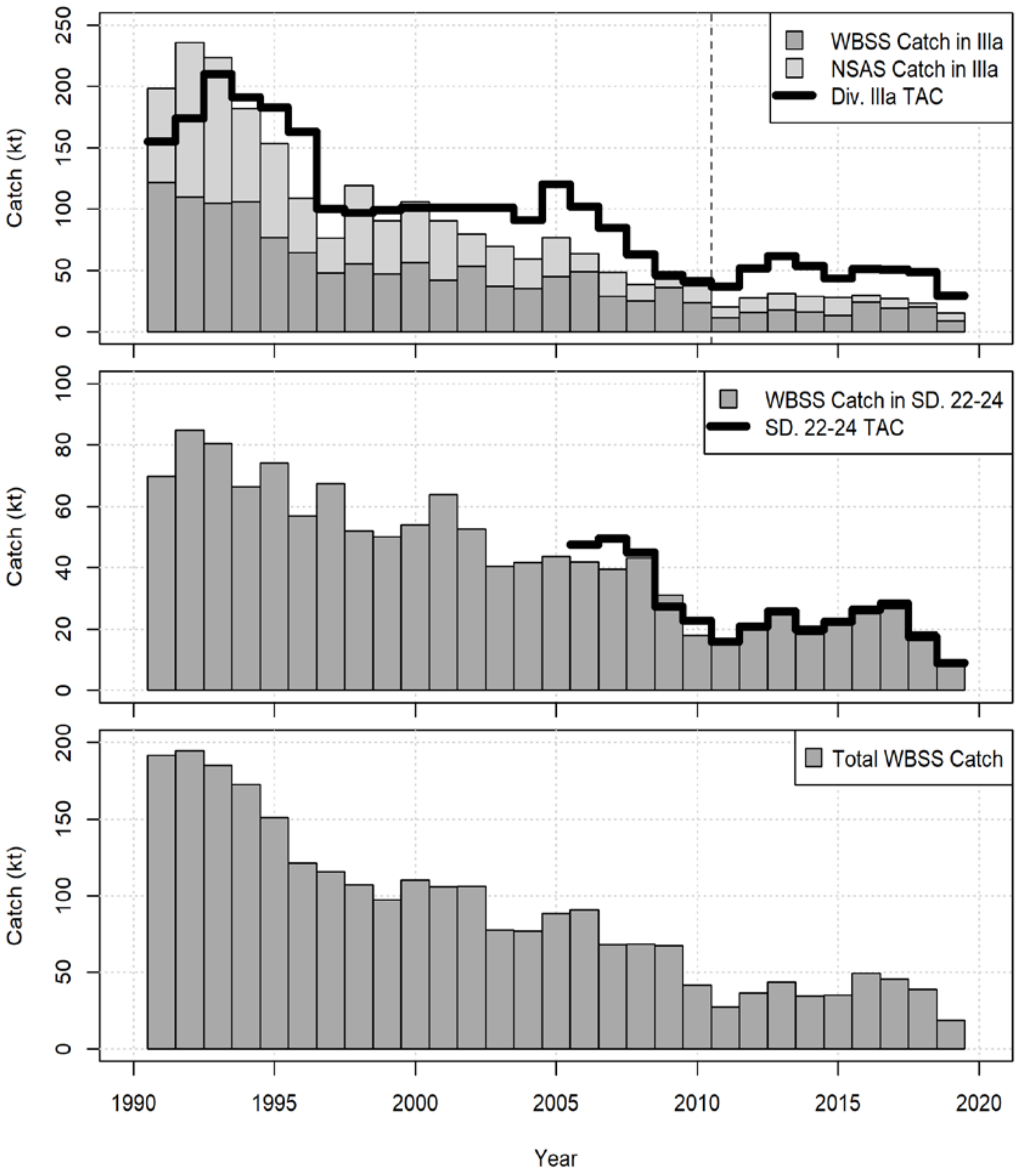

Figure 3.1.1. Western Baltic Spring-spawning Herring. CATCH and TACs (1000 t) by area. Note, the TAC for 3.a excludes the bycatch TAC, while the CATCH includes the bycatch.

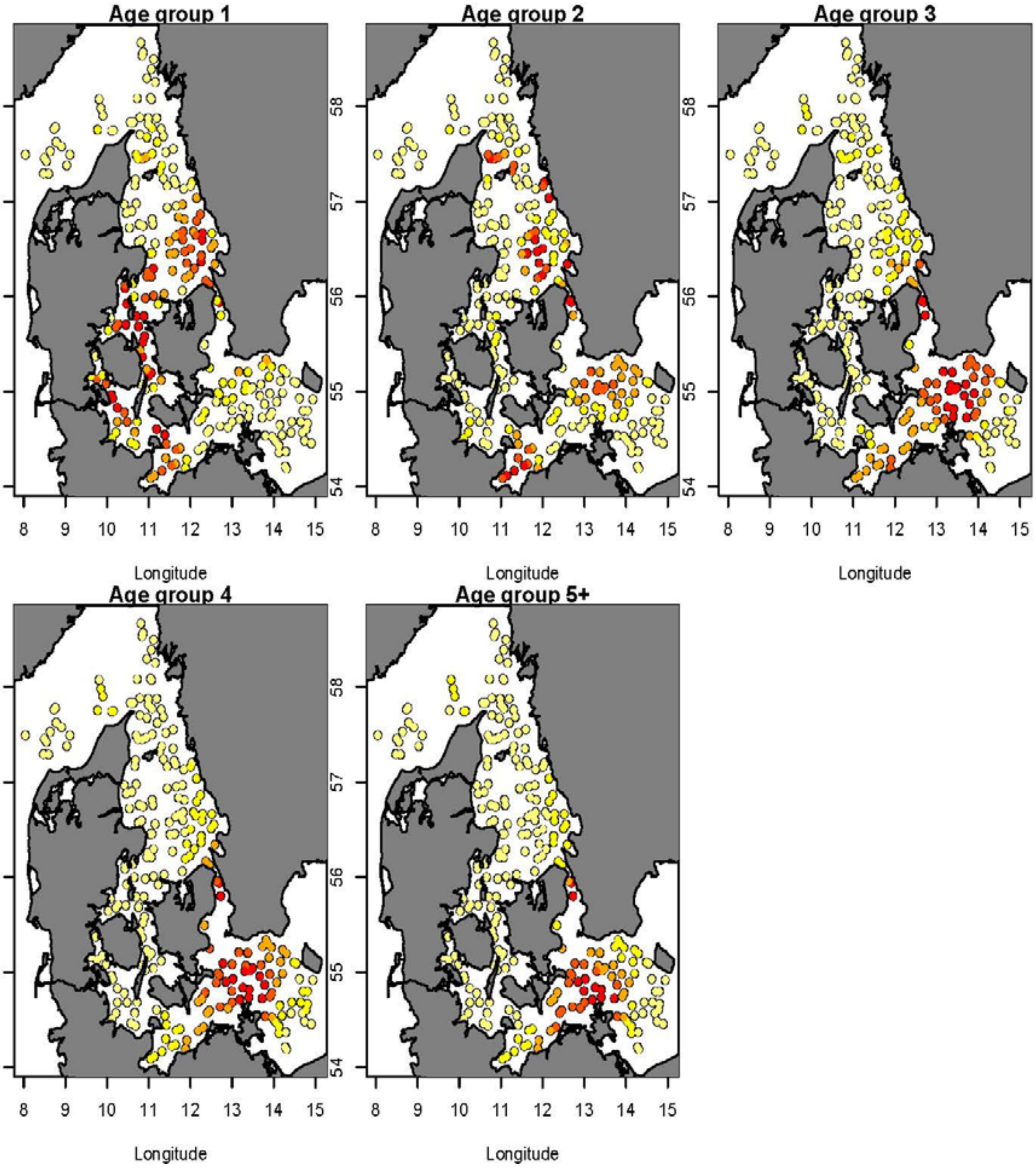

Figure 3.3.1.Western Baltic Spring-spawning Herring. Map showing distribution of hauls and the density of fish per age in the IBTS+BITS-Q1 survey.

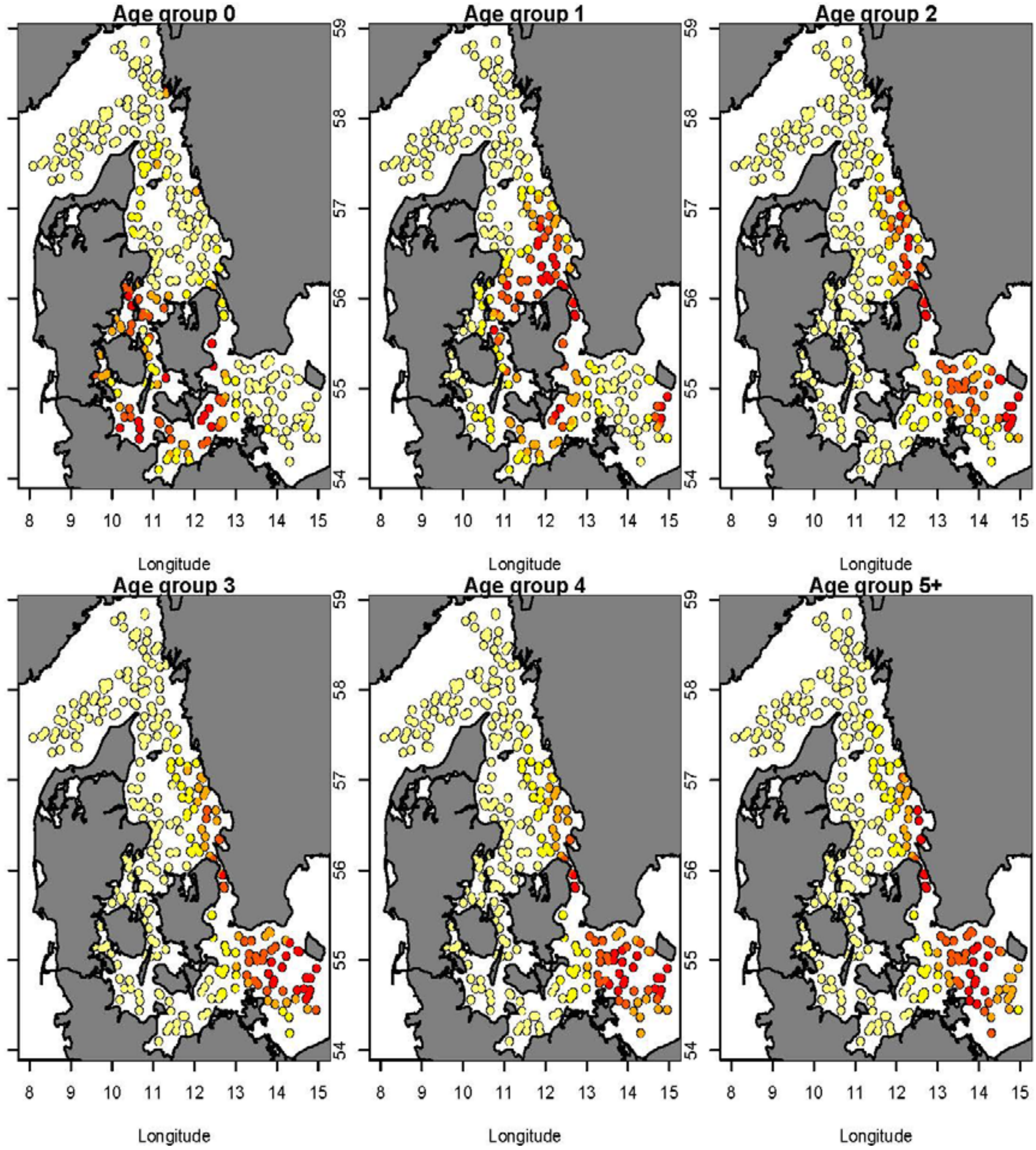

Figure 3.3.2. Western Baltic Spring-spawning Herring. Map showing distribution of hauls and the density of fish per age in the IBTS+BITS-Q3.4 survey.

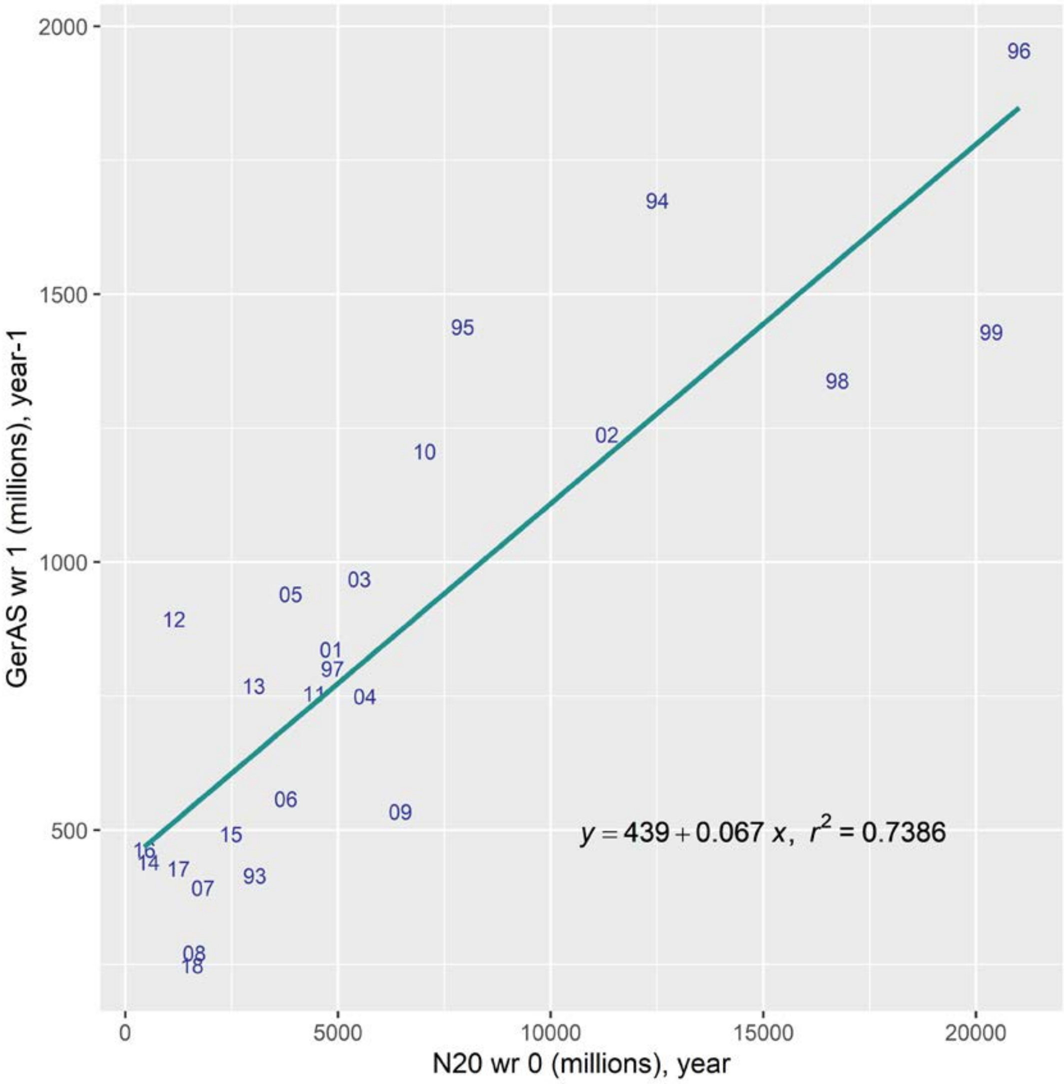

Figure 3.5.1. Western Baltic Spring-spawning Herring. Correlation of 1 wr herring from GERAS with the N20 larvae index. Note the year lag between surveys. Labels show the year of the N_{20}.

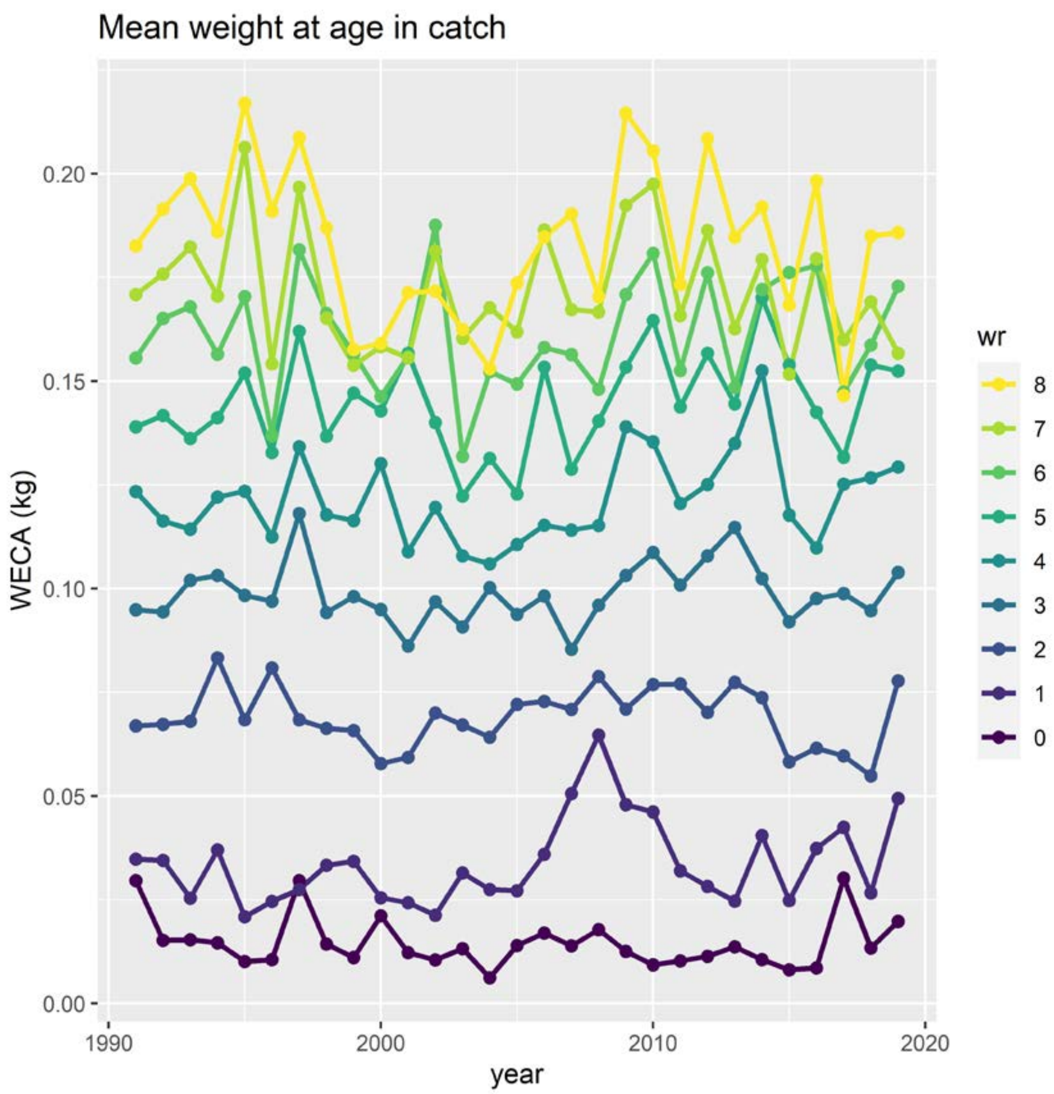

Figure 3.6.1.1. Western Baltic Spring-spawning Herring. Weight (kg) at age as W-ringers (wr) in the catch (WECA).

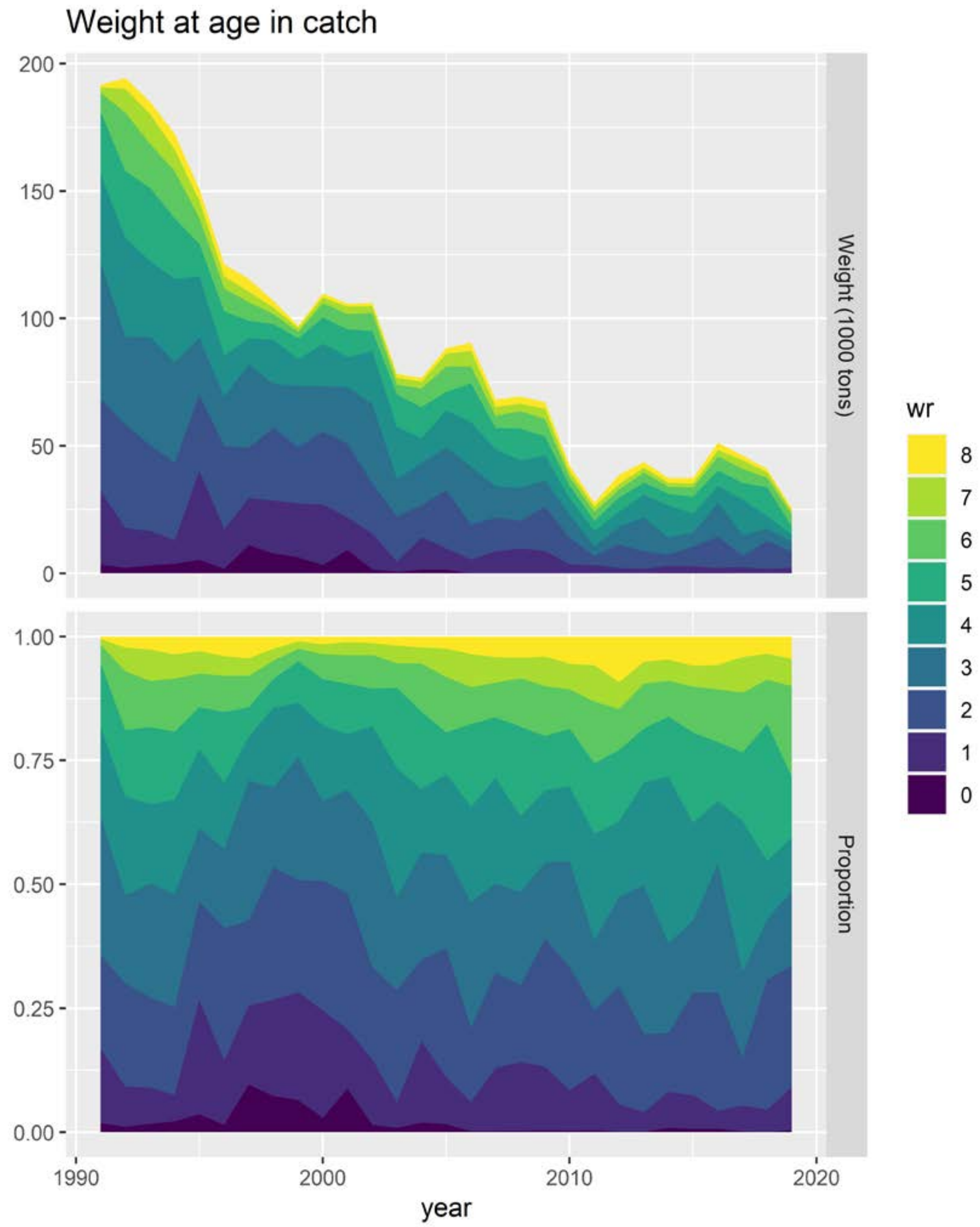

Figure 3.6.1.2. Western Baltic Spring-spawning Herring. Catch in weight. Upper panel: Catch in weight (1000 tonnes) at age as W-ringers (wr). Lower panel: Proportion (by weight) of a given age as W-ringers (wr) in the catch.

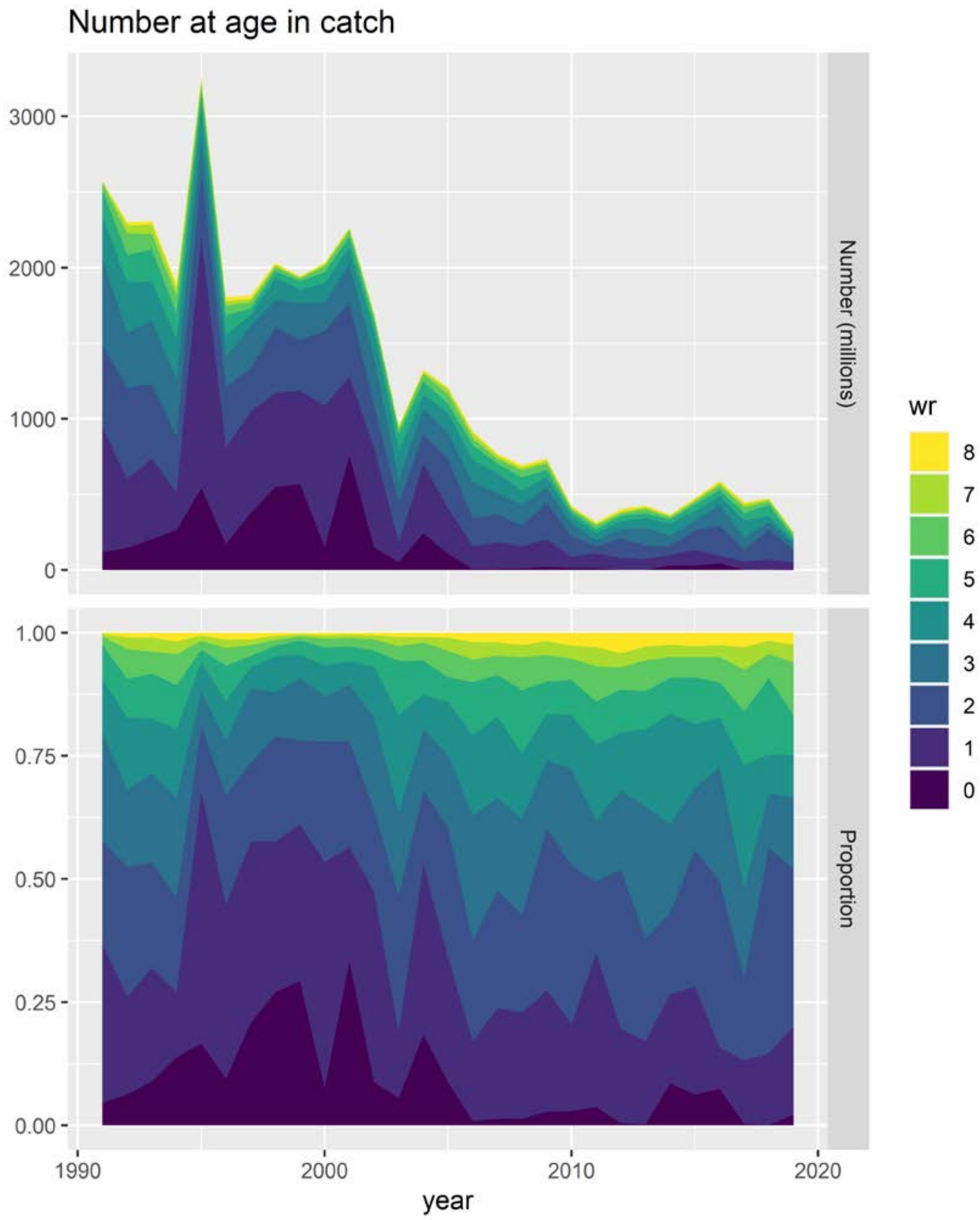

Figure 3.6.1.3. Western Baltic Spring-spawning Herring. Catch in Numbers. Upper panel: Catch in numbers (millions) at age as W-ringers (wr). Lower panel: Proportion (by number) of a given age as W-ringers (wr) in the catch.

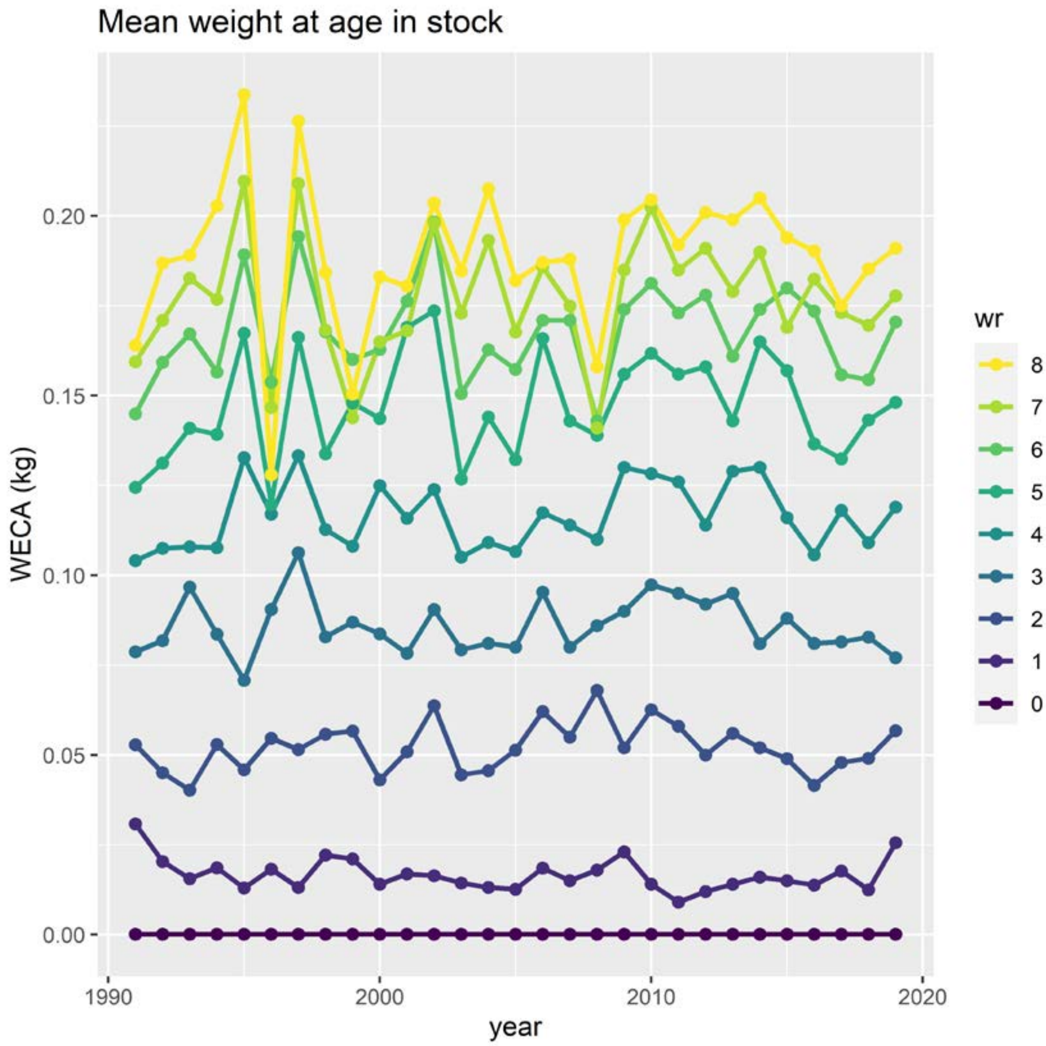

Figure 3.6.1.4. Western Baltic Spring-spawning Herring. Weight (kg) at age as W-ringers (wr) in the catch (WEST).

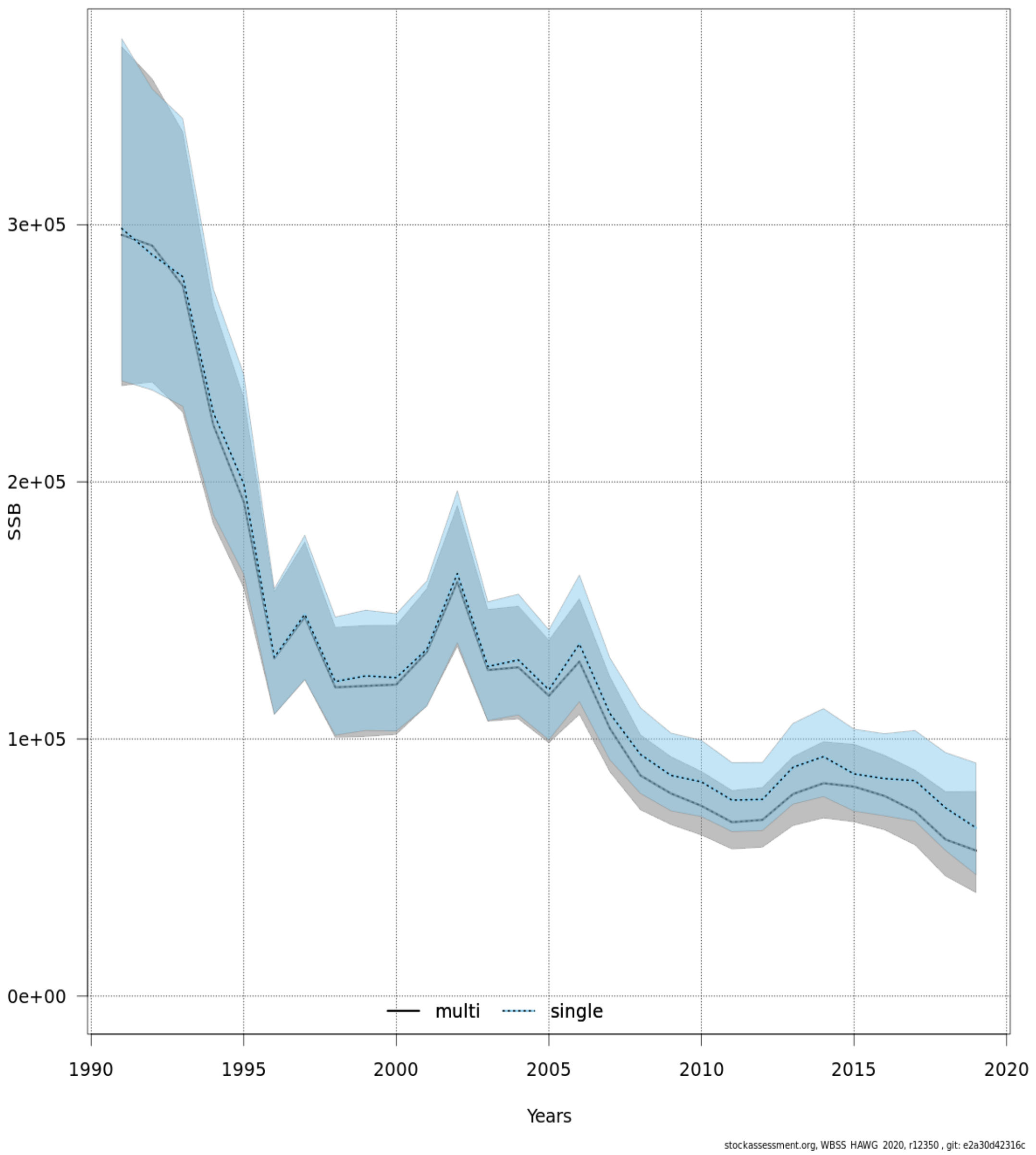

Figure 3.6.4.1. Western Baltic Spring-spawning Herring. Stock summary plot. Spawning-stock biomass (SSB). Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

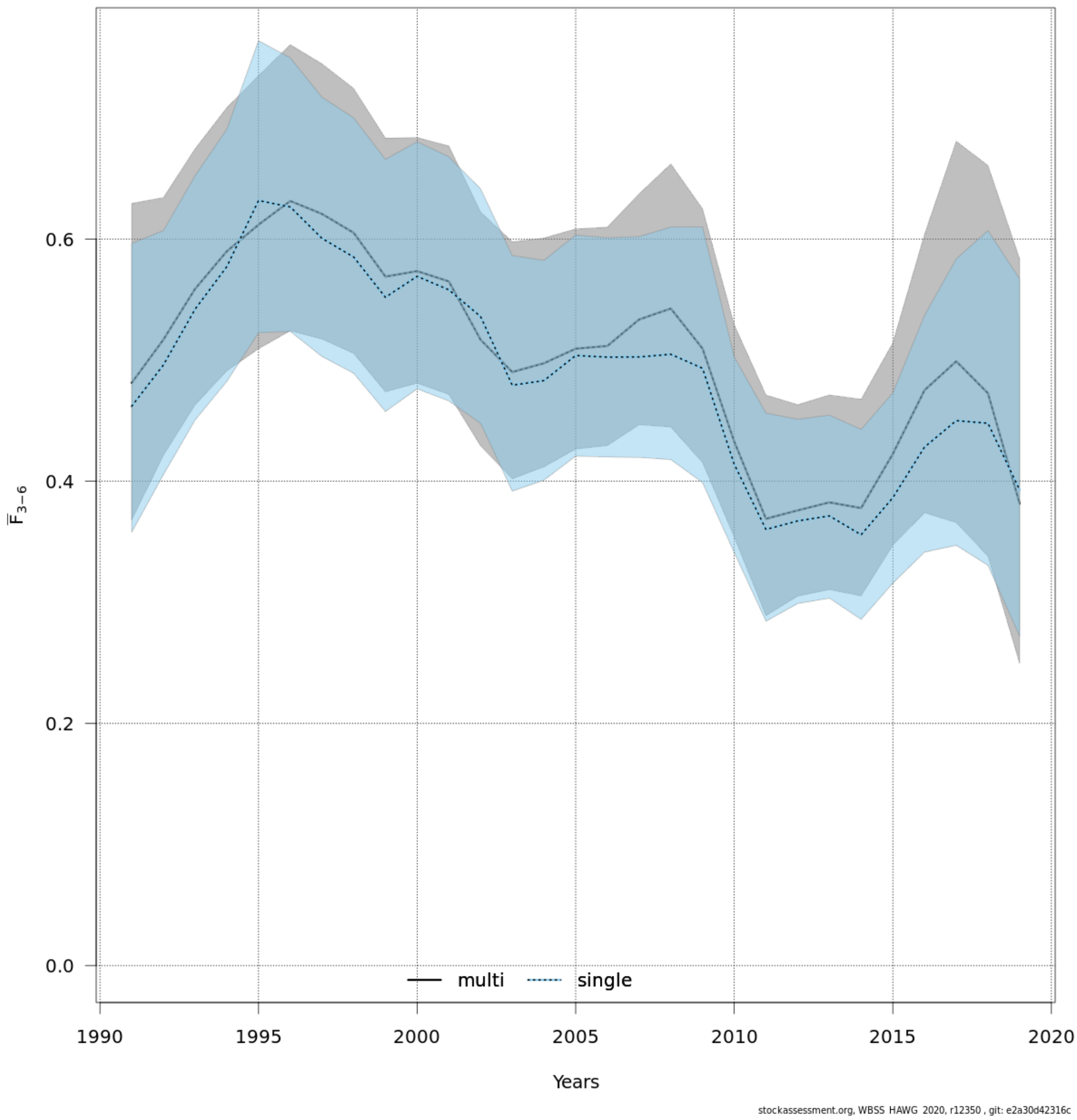

Figure 3.6.4.2. Western Baltic Spring-spawning Herring. Stock summary plot. Average fishing mortality (F) for the shown age range. Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

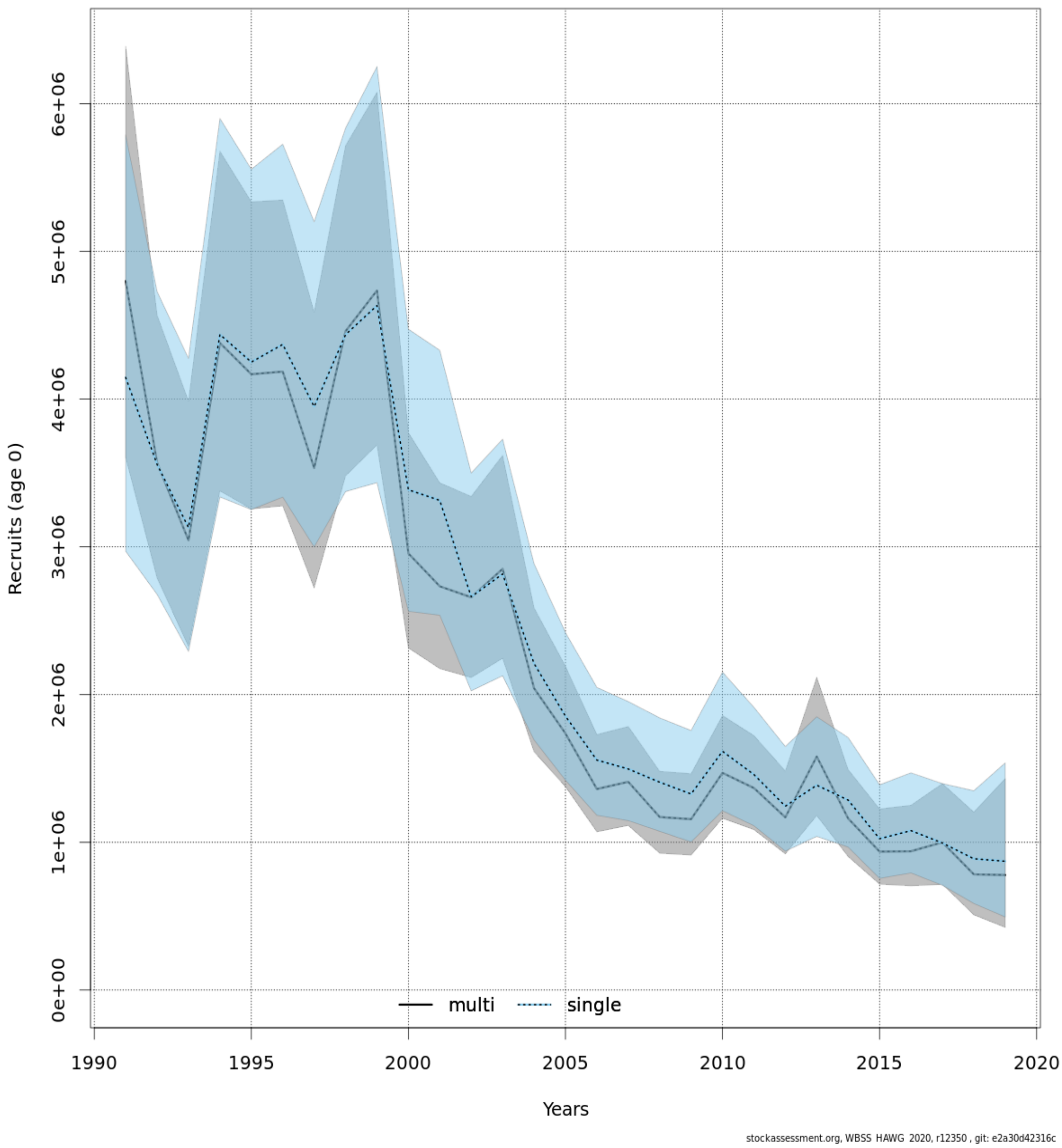

Figure 3.6.4.3. Western Baltic Spring-spawning Herring. Stock summary plot. Yearly recruitment (age 0 equal 0 W-ringers). Estimates from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area.

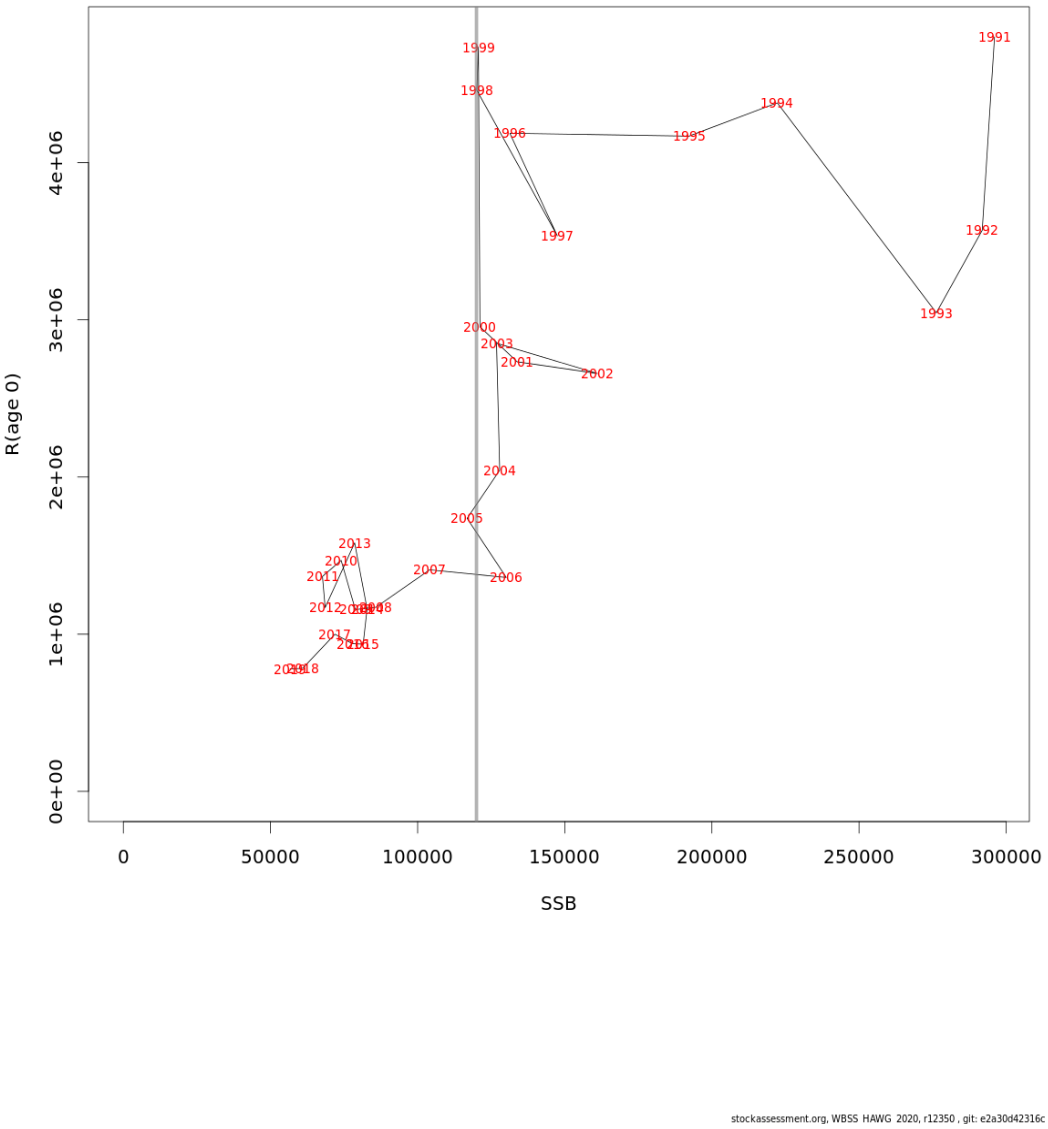

Figure 3.6.4.4. Western Baltic Spring-spawning Herring. Recruitment-at-age 0-wr (in thousands) is plotted against spawning-stock biomass (tonnes) as estimated by the assessment.

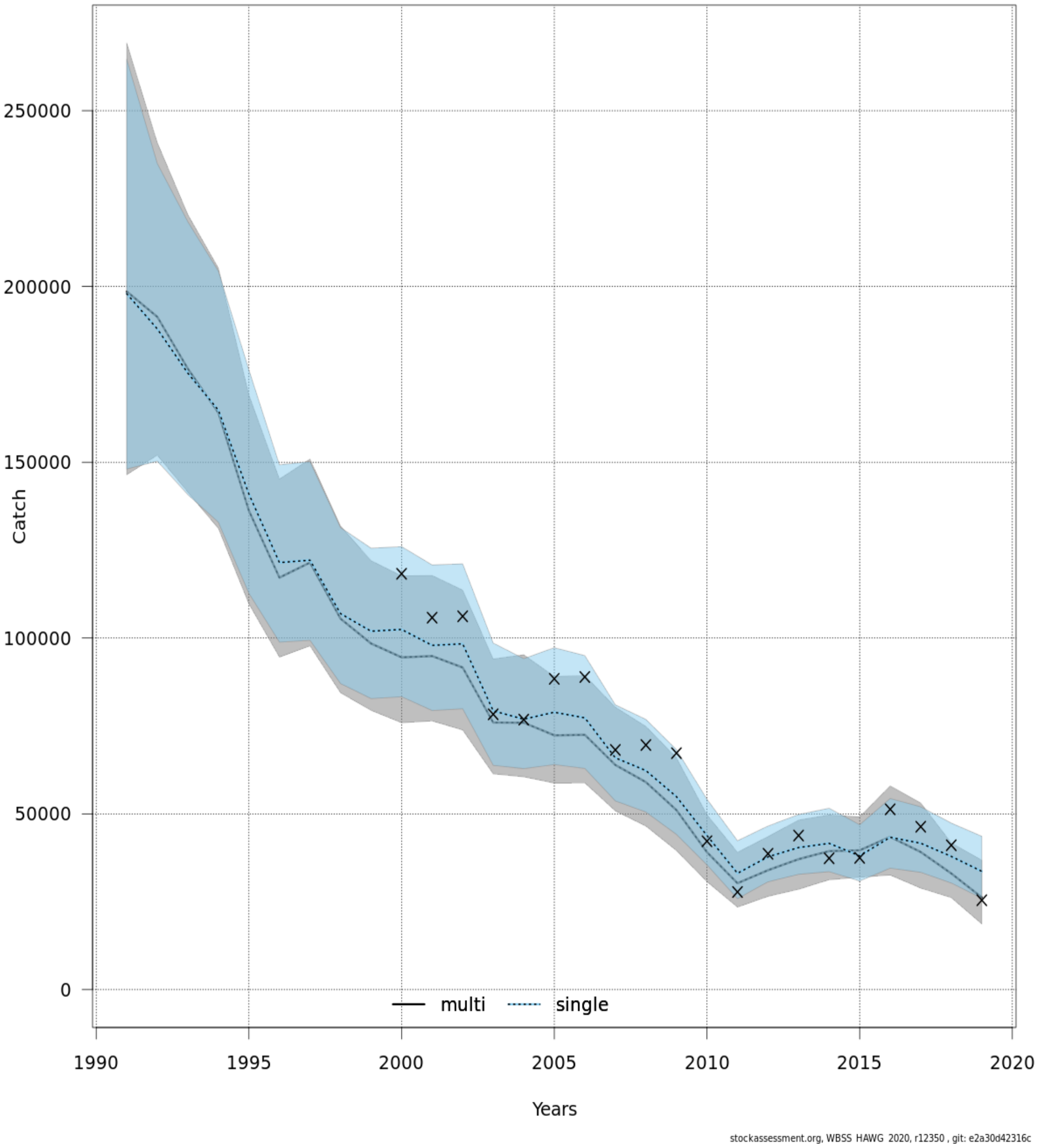

Figure 3.6.4.5. WESTERN BALTIC SPRING-SPAWNING HERRING. Total catch in weight (tonnes). Prediction from the WBSS multi fleet (multi) and the WBSS single fleet (single) assessment runs and point wise 95% confidence intervals are shown by line and shaded area. The yearly observed total catch weight (crosses)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

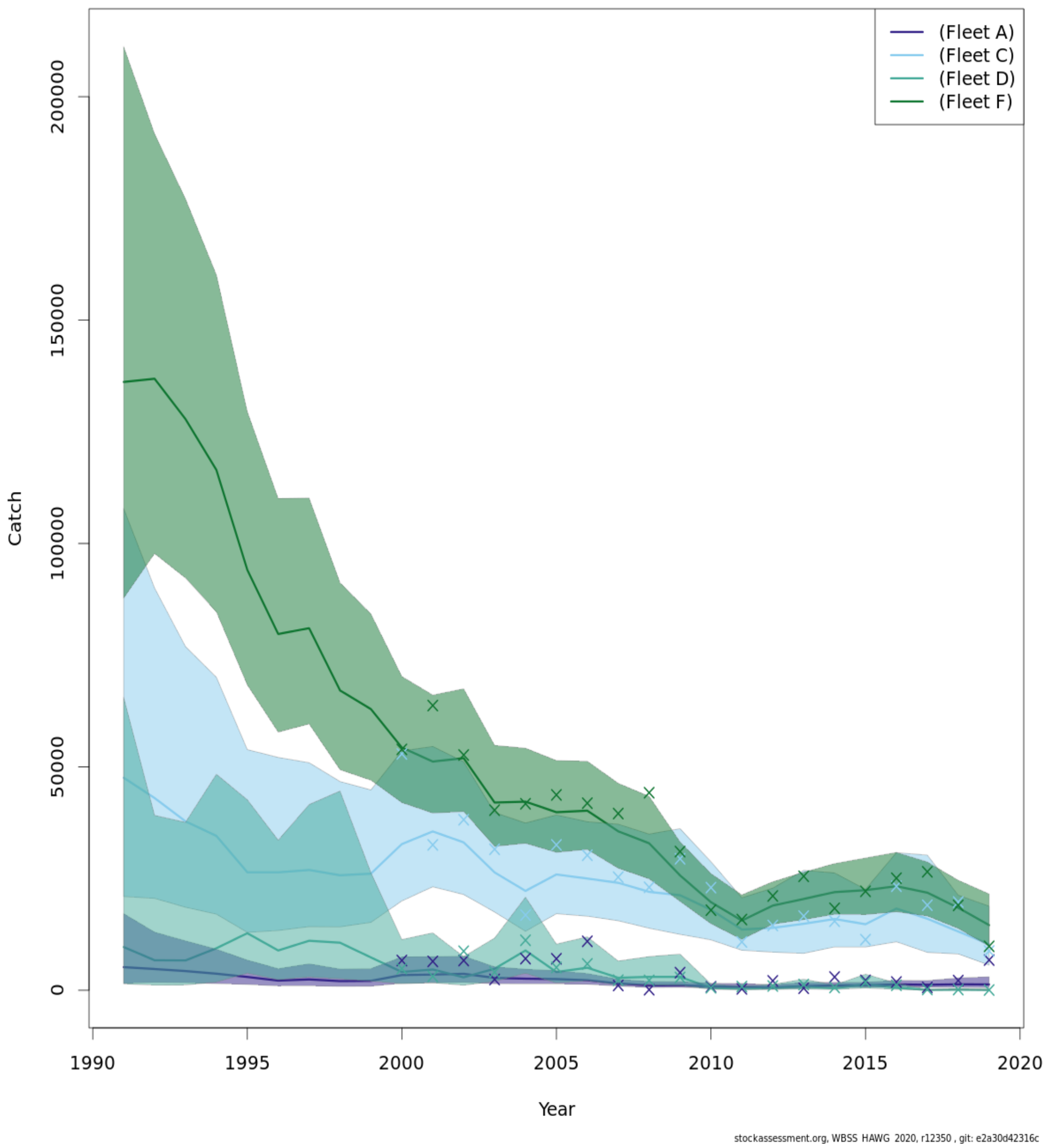

Figure 3.6.4.6. Western Baltic Spring-spawning Herring. Total catch in weight (tonnes) by fleet. Prediction from the WBSS multi fleet assessment run and point wise 95% confidence intervals are shown by line and shaded area. The plot also show the observed total catch weight per fleet (crosses).

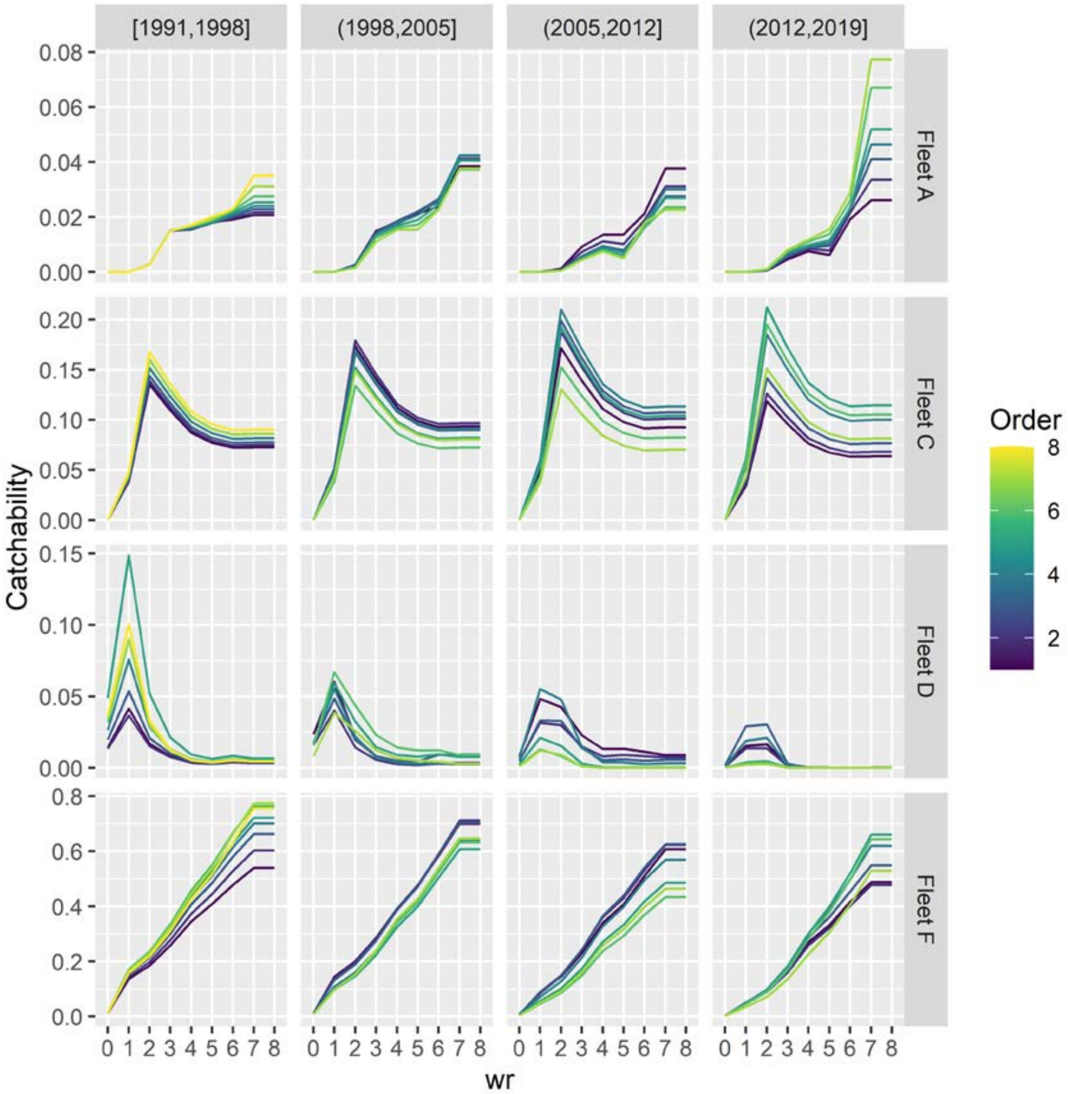

Figure 3.6.4.7. Western Baltic Spring-spawning Herring. Estimated selection pattern at age as W-ringers (wr) per fleet and year. Order: 1 equal 1st year in the respective time span.

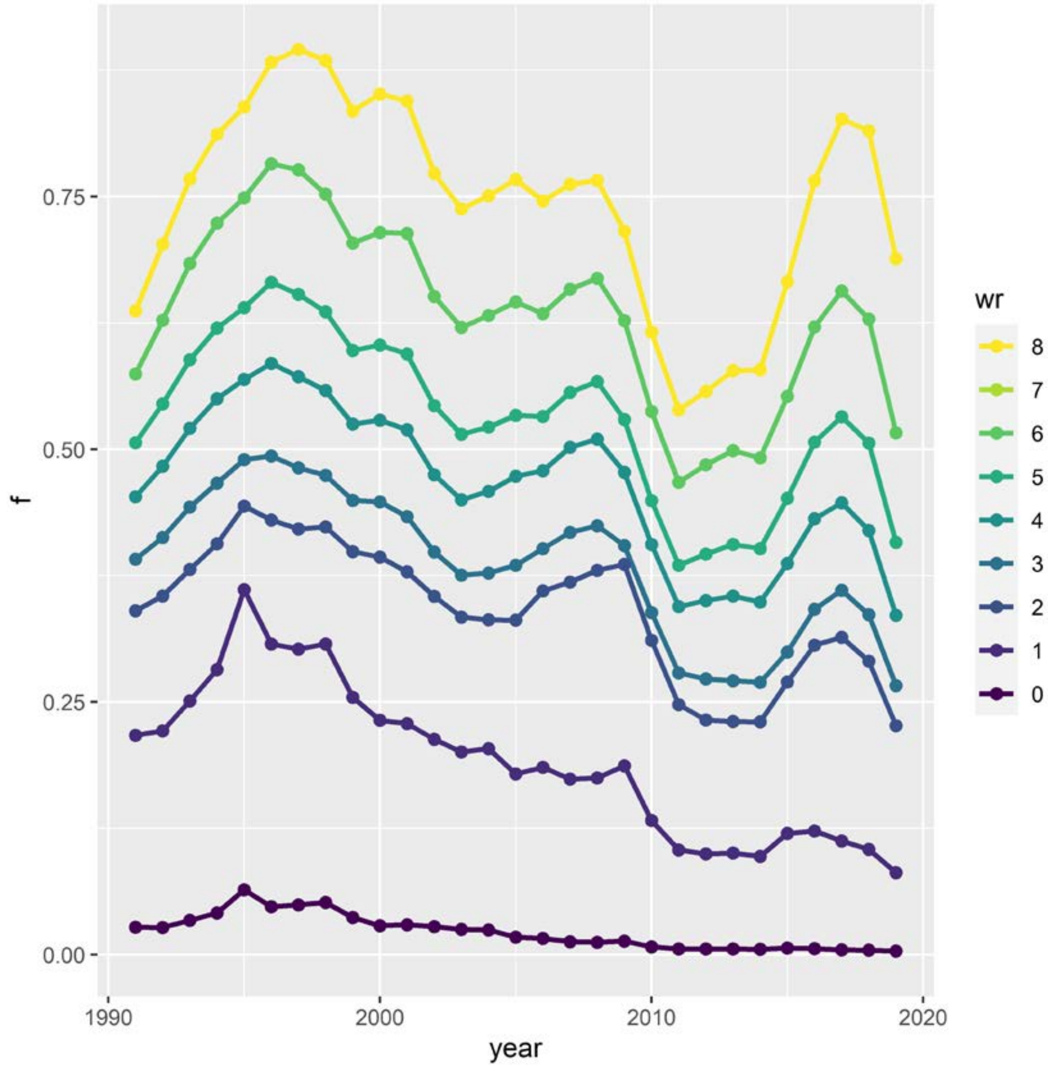

Figure 3.6.4.8. Western Baltic Spring-spawning Herring. Time-series of estimated fishing mortality-at-age as W-ringers (wr).

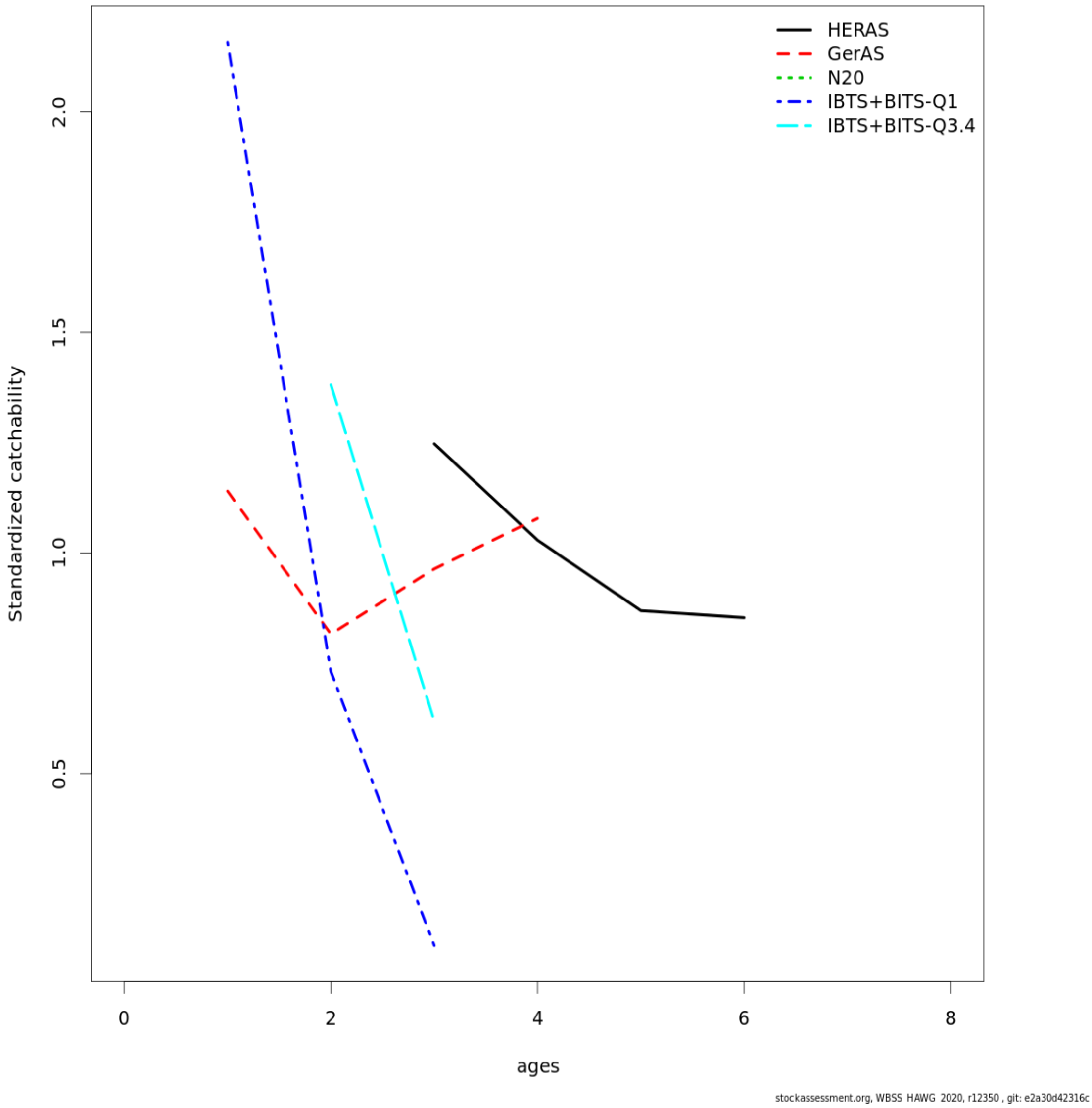

Figure 3.6.4.9. Western Baltic Spring-spawning Herring. Estimated survey catchabilities. N20 only covers a age 0 and therefore no line.

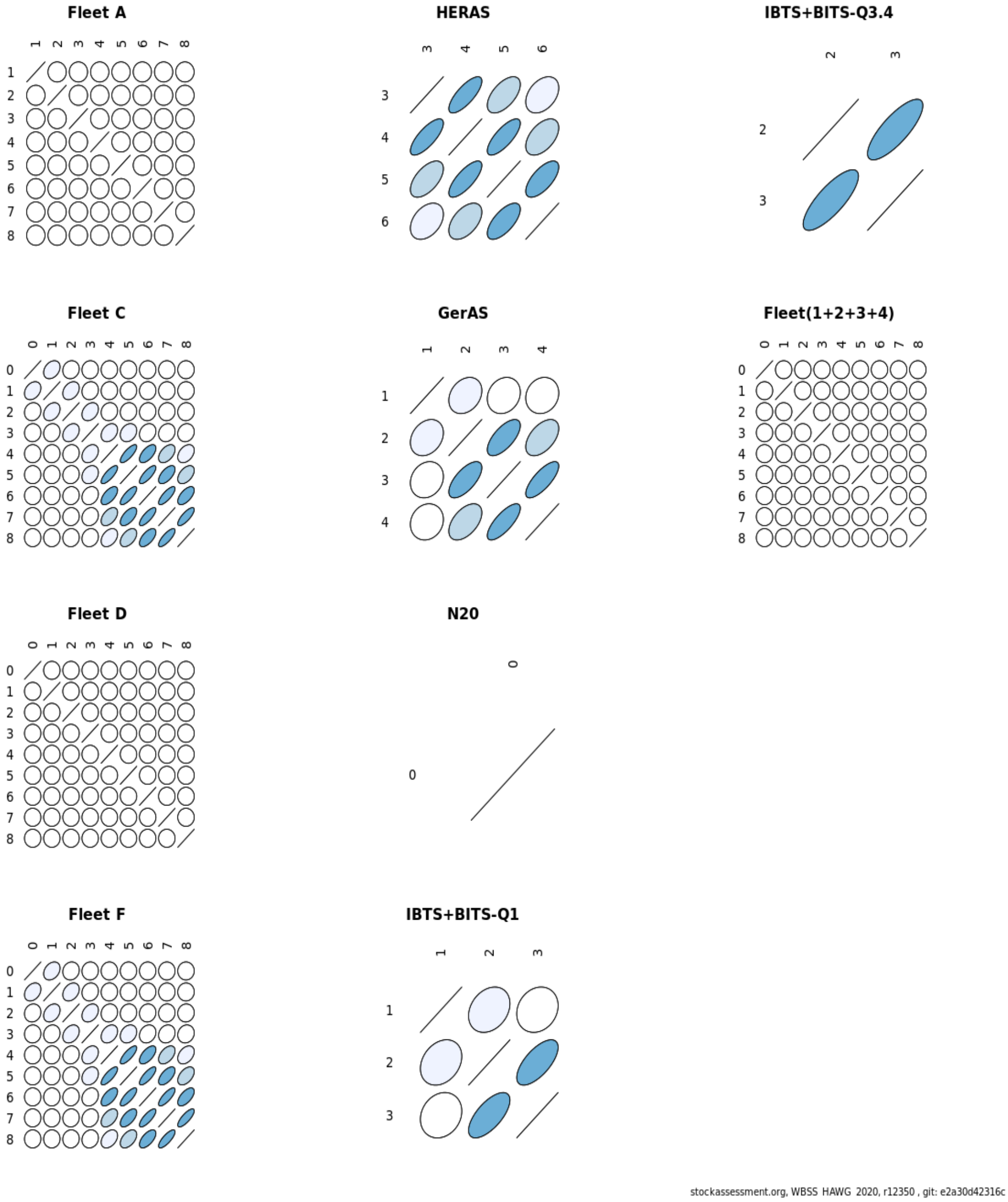

Figure 3.6.4.10. Western Baltic Spring-spawning Herring. Estimates correlations between age groups for each fleet.

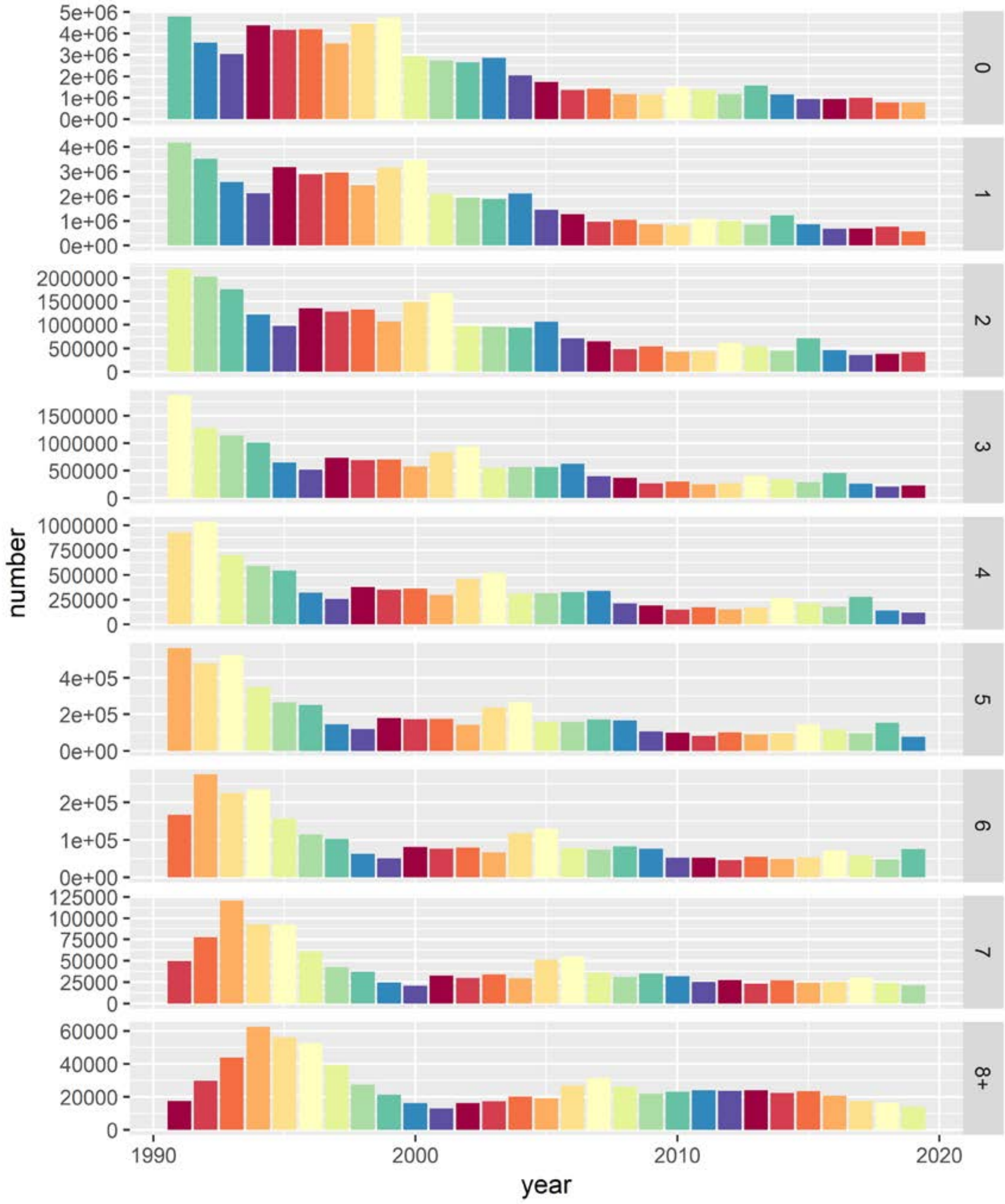

Figure 3.6.4.11. Western Baltic Spring-spawning Herring. Estimated age distribution in the stock. Colours represent a cohort

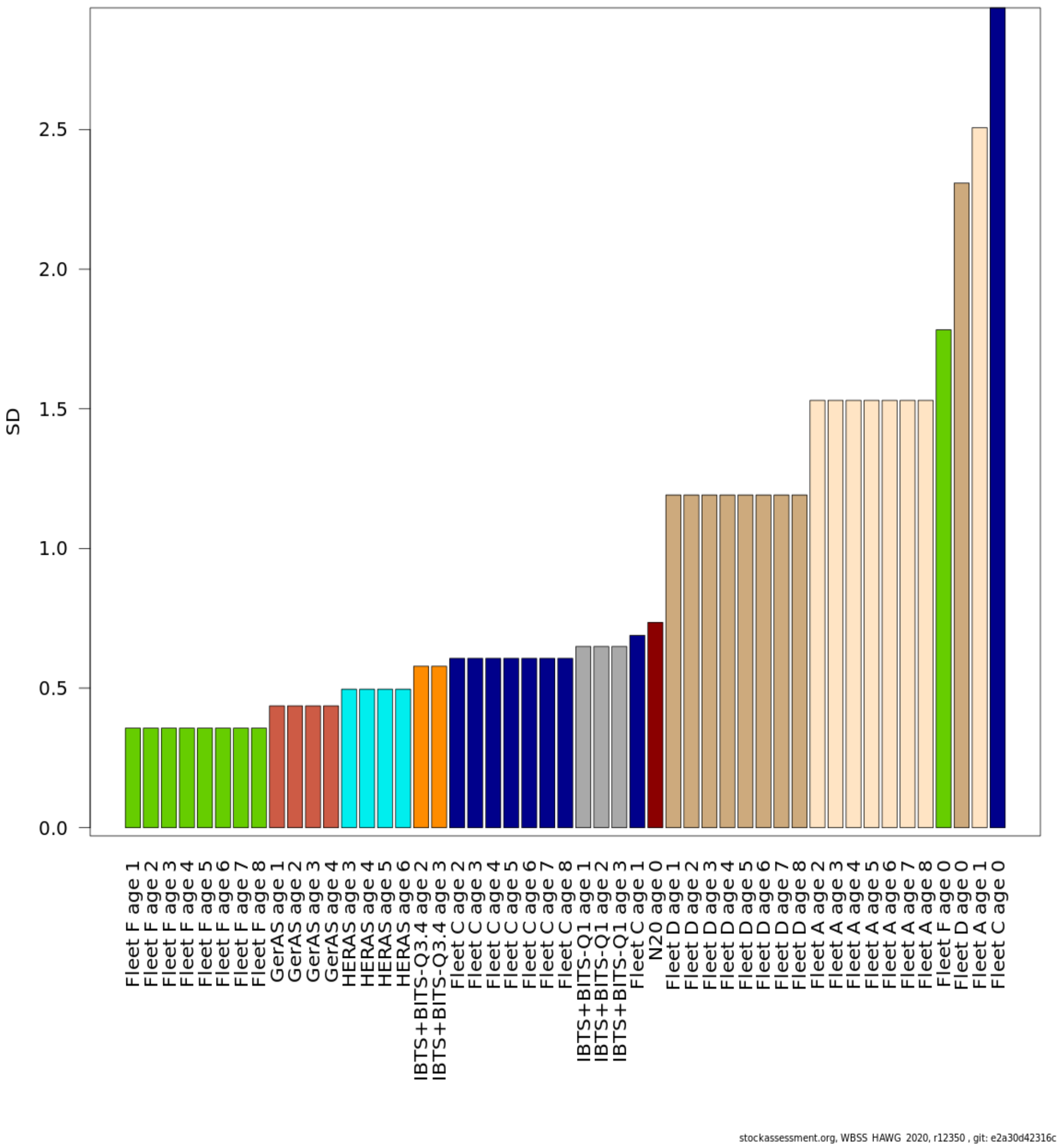

Figure 3.6.4.12. Western Baltic Spring-spawning Herring. Estimated observation variance in the WBSS multi fleet assessment run.

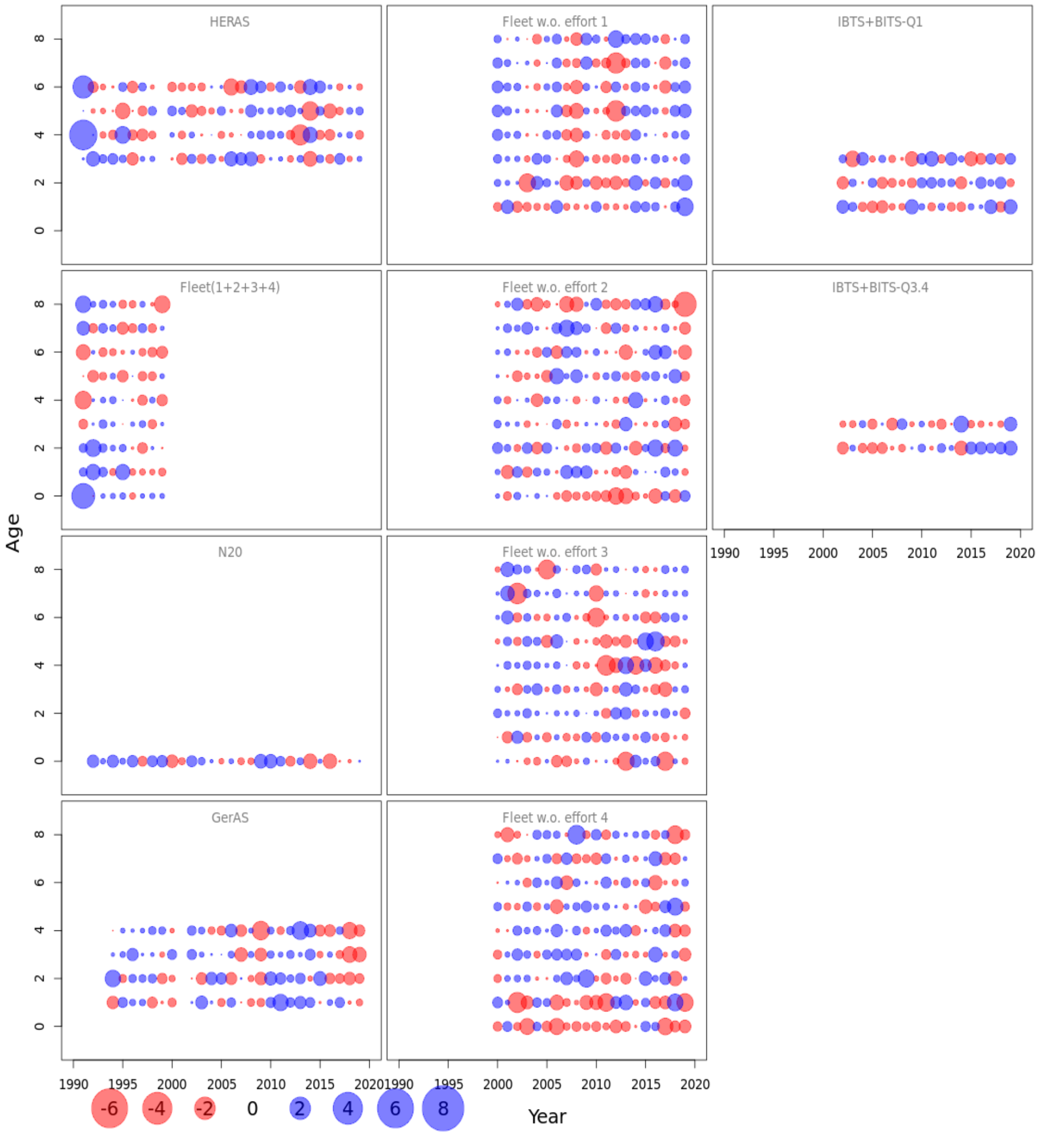

Figure 3.6.4.13. Western Baltic Spring-spawning Herring. BUBBLE PLOT. Standardized one-observation-ahead residuals from multi fleet run.

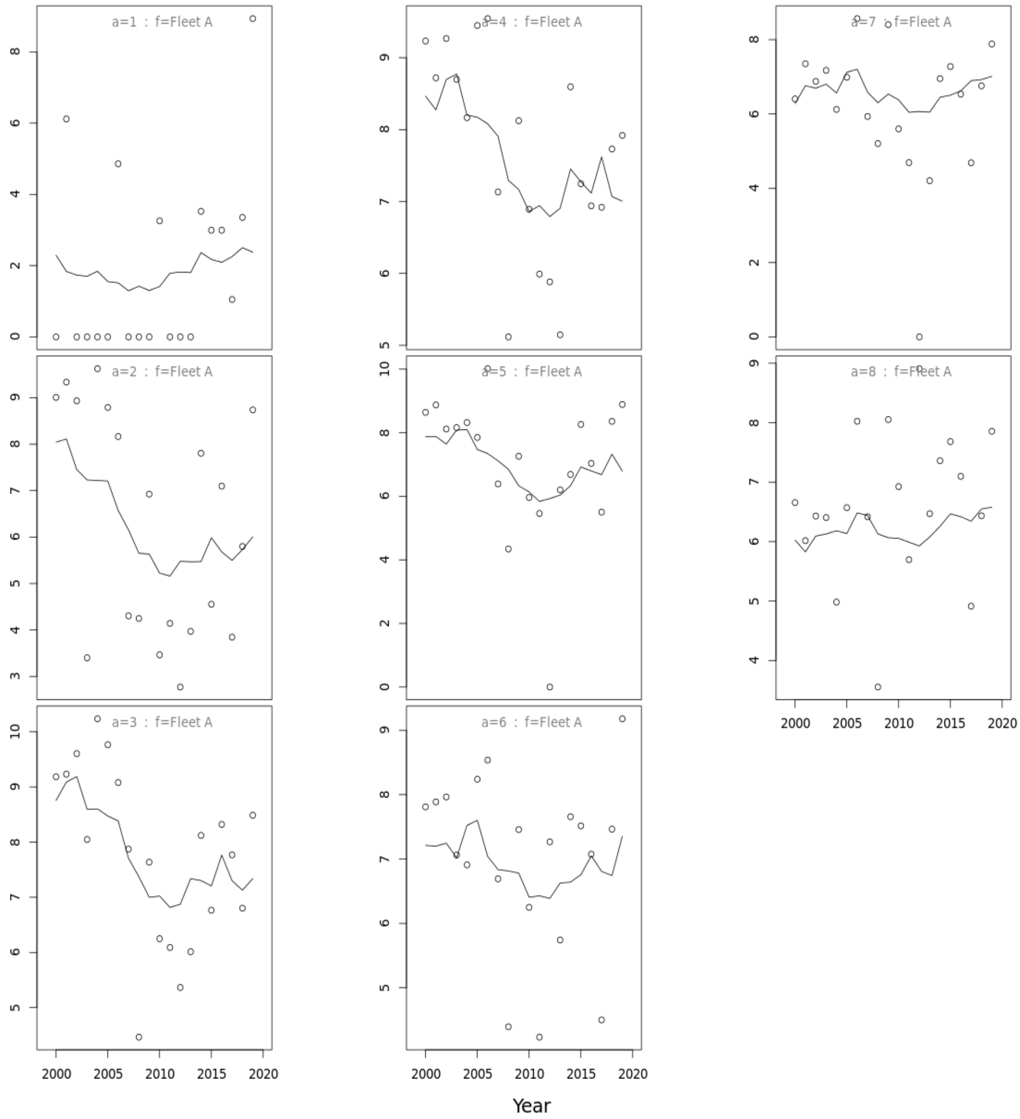

Figure 3.6.4.14. Western Baltic Spring-spawning Herring. Diagnostics of commercial catches fit per fleet. Fleet A. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

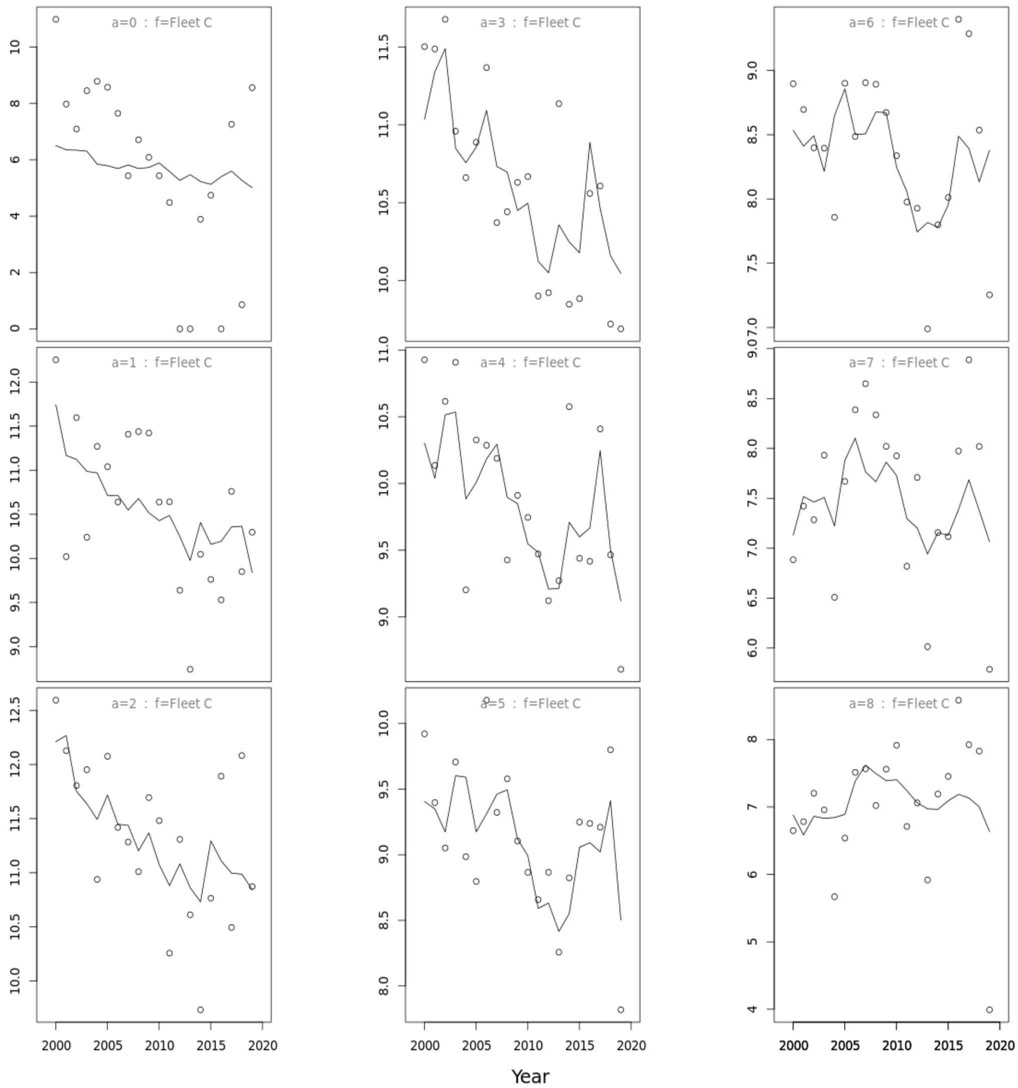

Figure 3.6.4.15. Western Baltic Spring-spawning Herring. Diagnostics of commercial catches fit per fleet. Fleet C. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

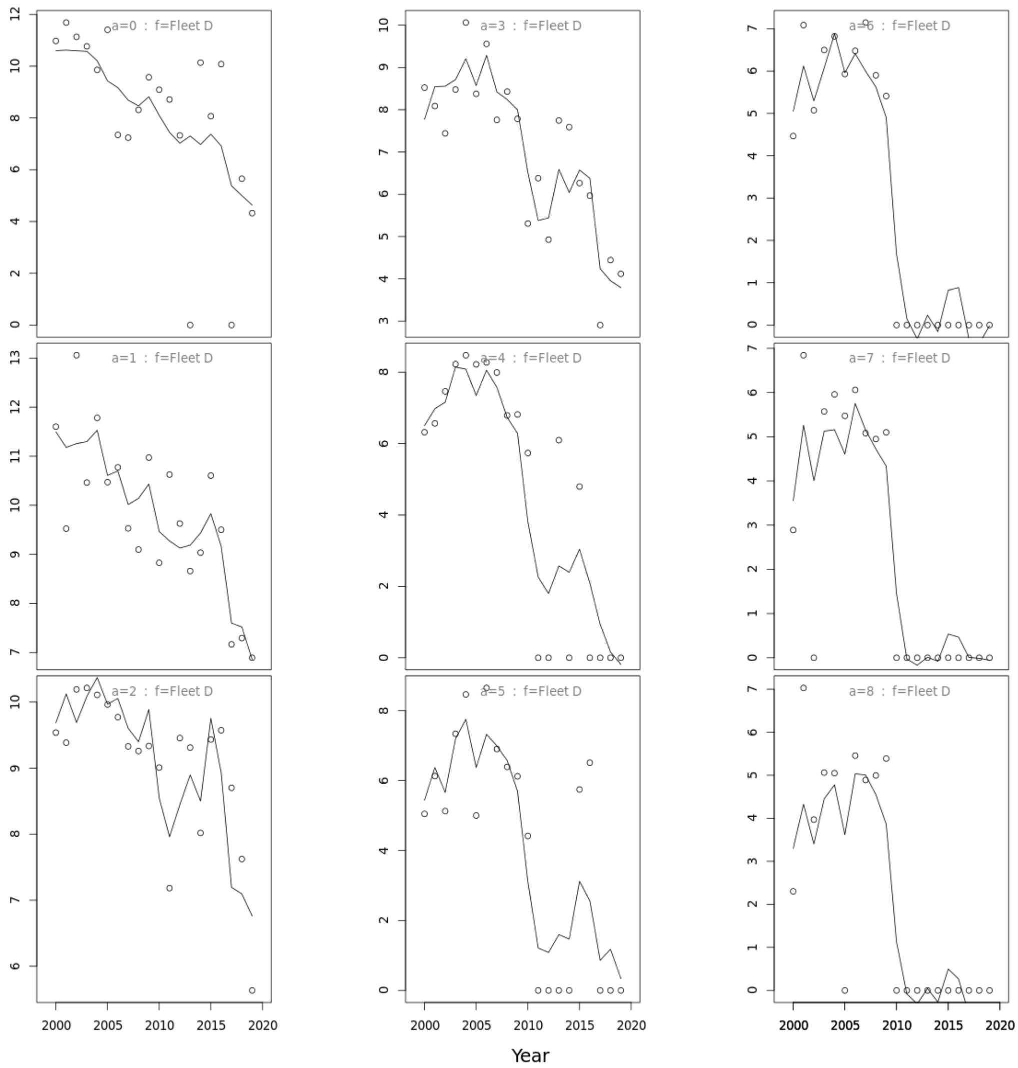

Figure 3.6.4.16. Western Baltic Spring-spawning Herring. Diagnostics of commercial catches fit per fleet. Fleet D. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

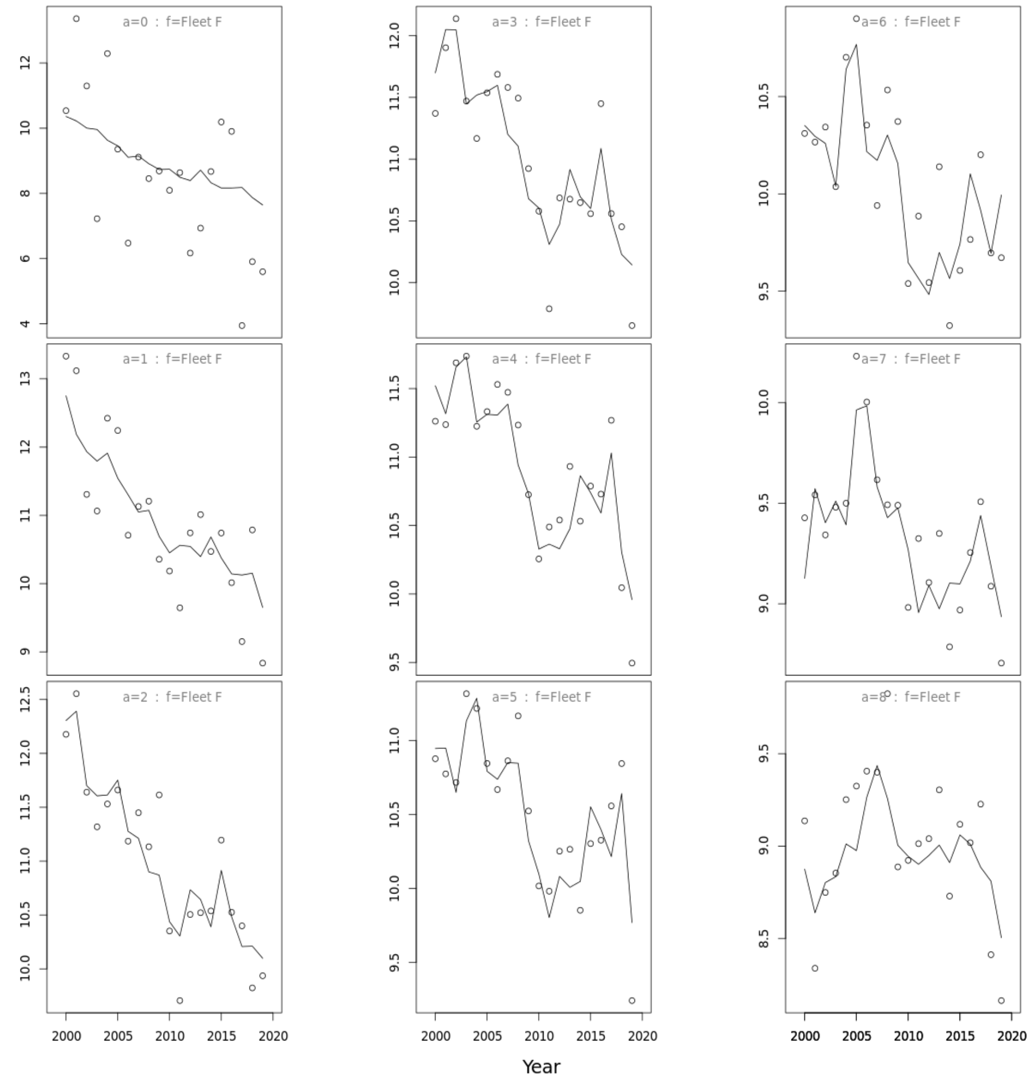

Figure 3.6.4.17. Western Baltic Spring-spawning Herring. Diagnostics of commercial catches fit per fleet. Fleet F. Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

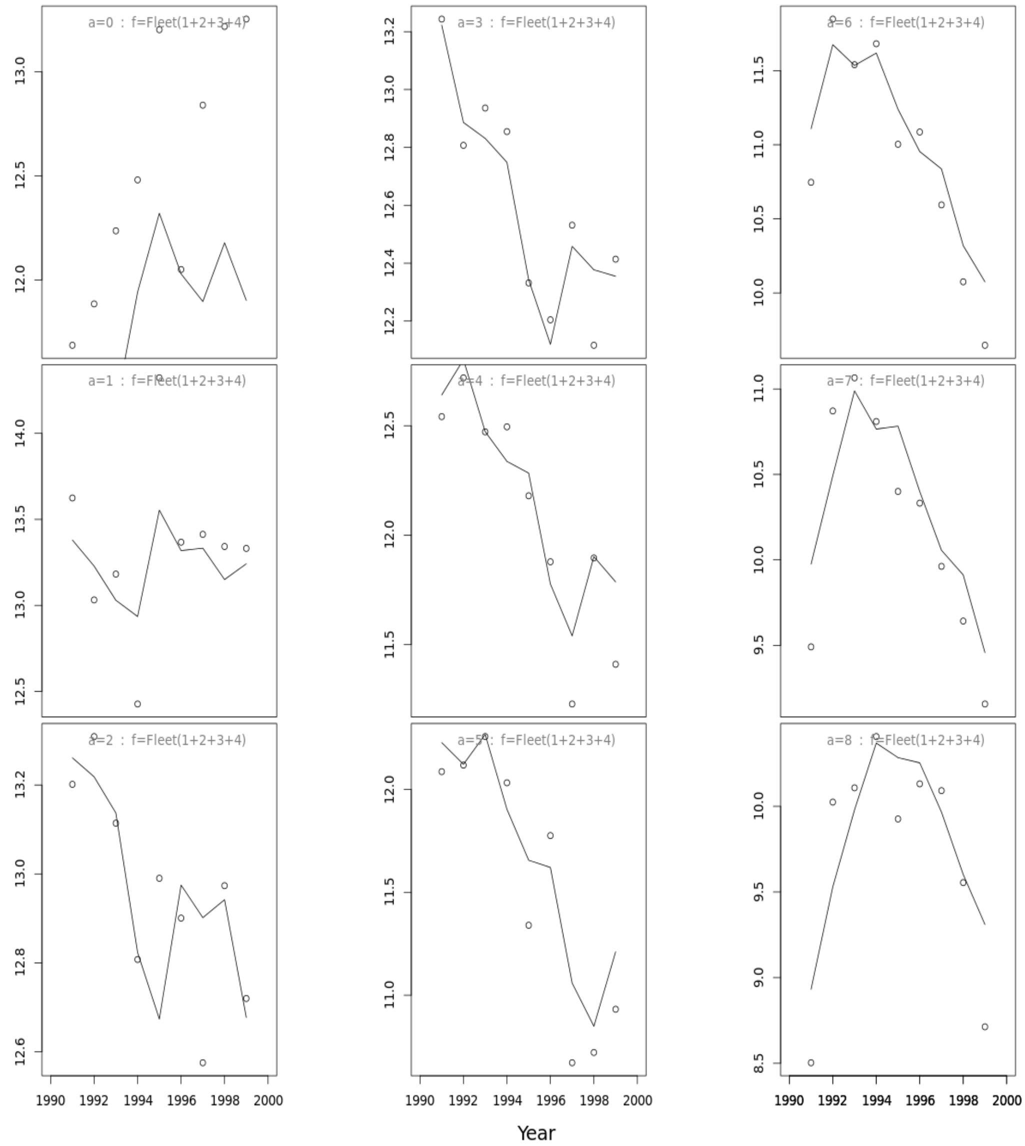

Figure 3.6.4.18, Western Baltic Spring-spawning Herring. Diagnostics of commercial catches fit per fleet. Sum of fleets Plot of predicted (line) and observed (points) catches (log scale) per W-ringers (a) and year.

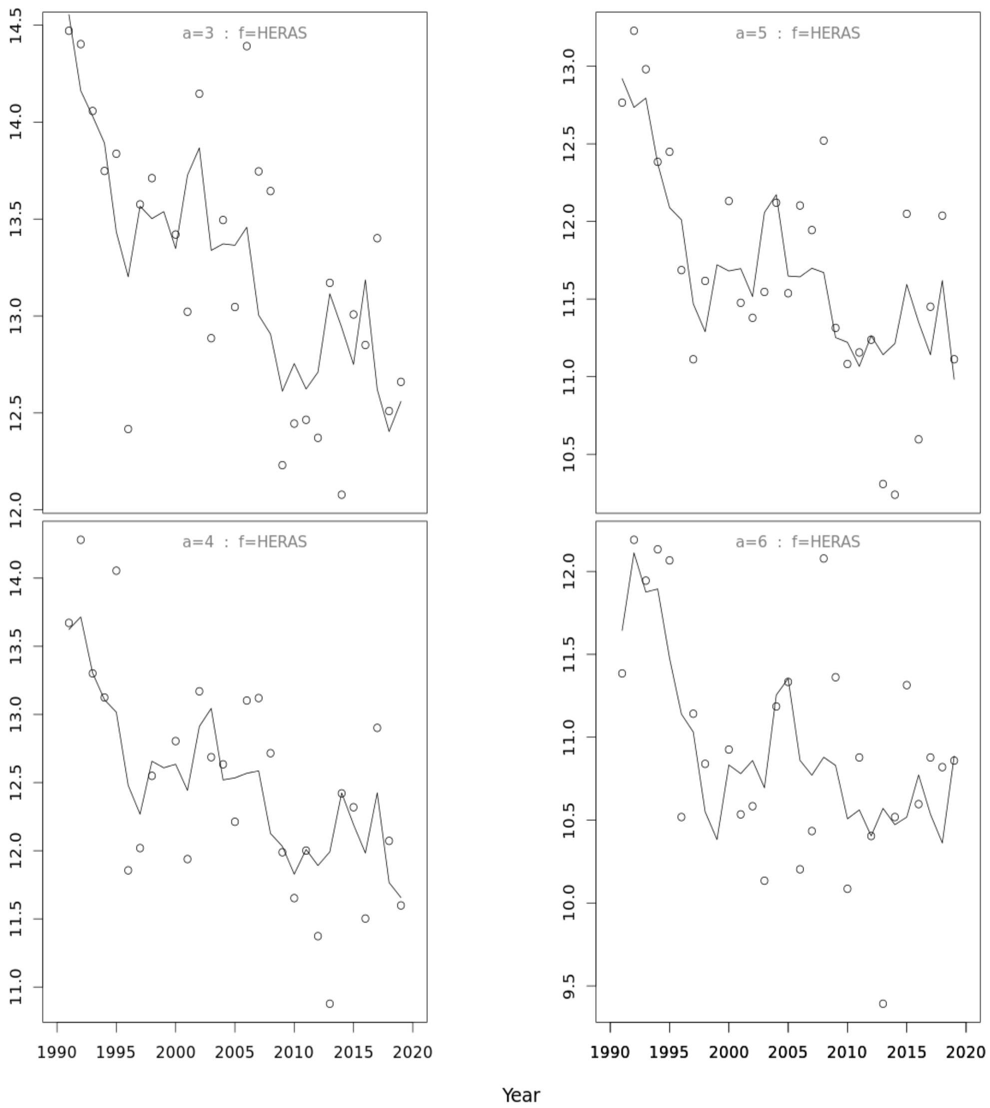

Figure 3.6.4.19. Western Baltic Spring-spawning Herring. Diagnostics of the HERAS index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

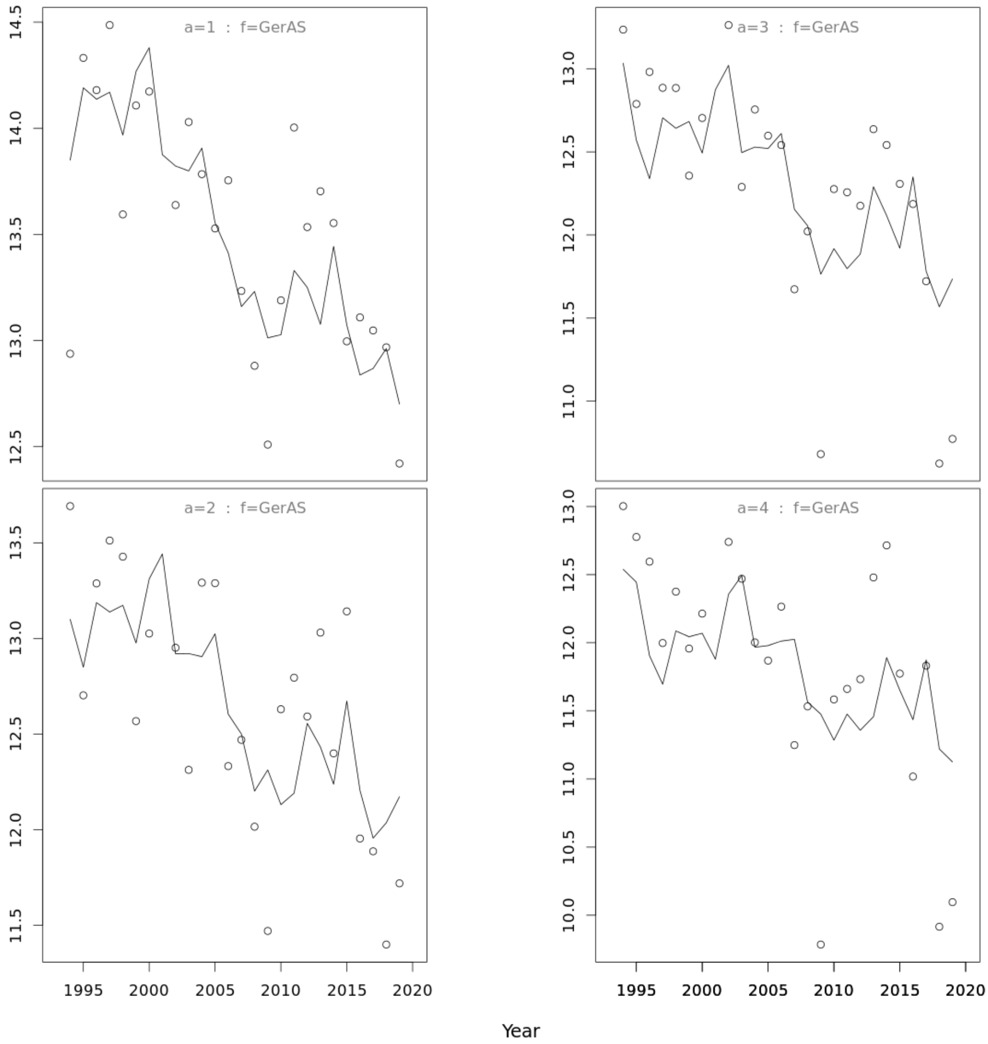

Figure 3.6.4.20. Western Baltic Spring-spawning Herring. Diagnostics of the GerAs index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

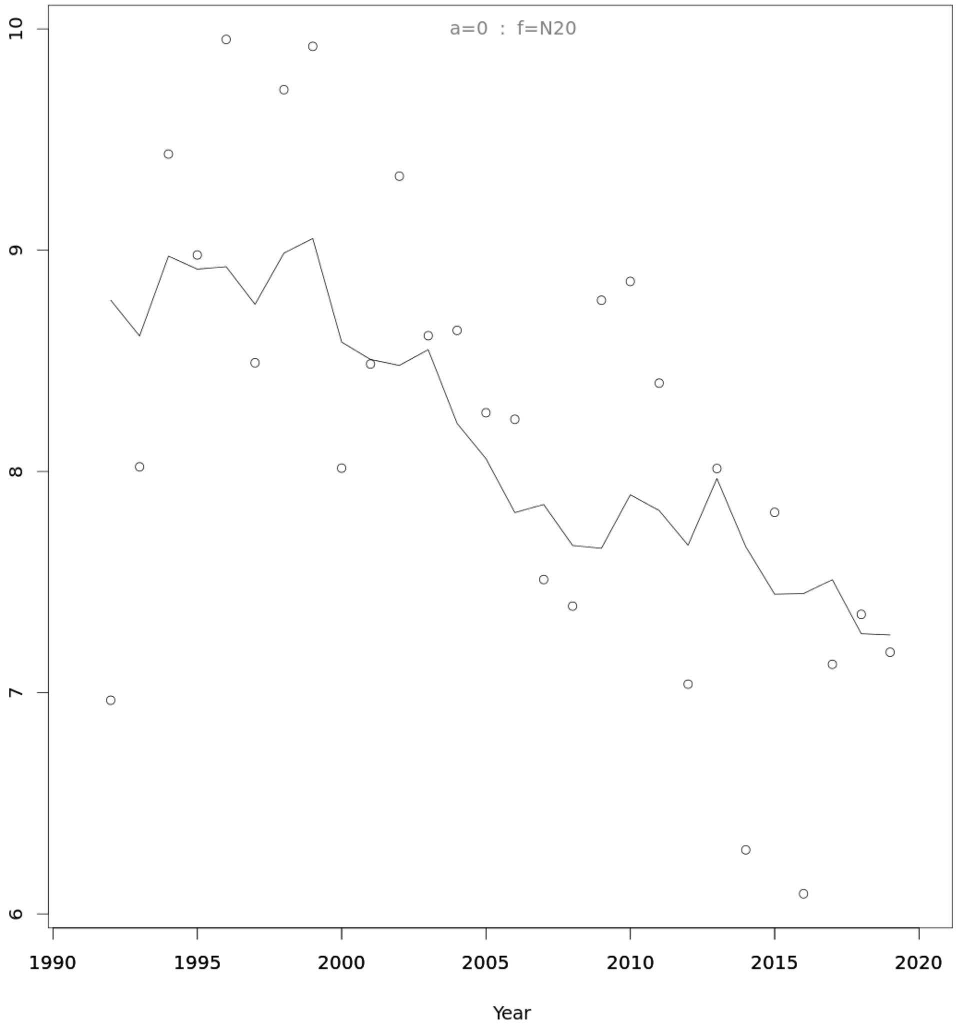

Figure 3.6.4.21. Western Baltic Spring-spawning Herring. Diagnostics of the N20 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

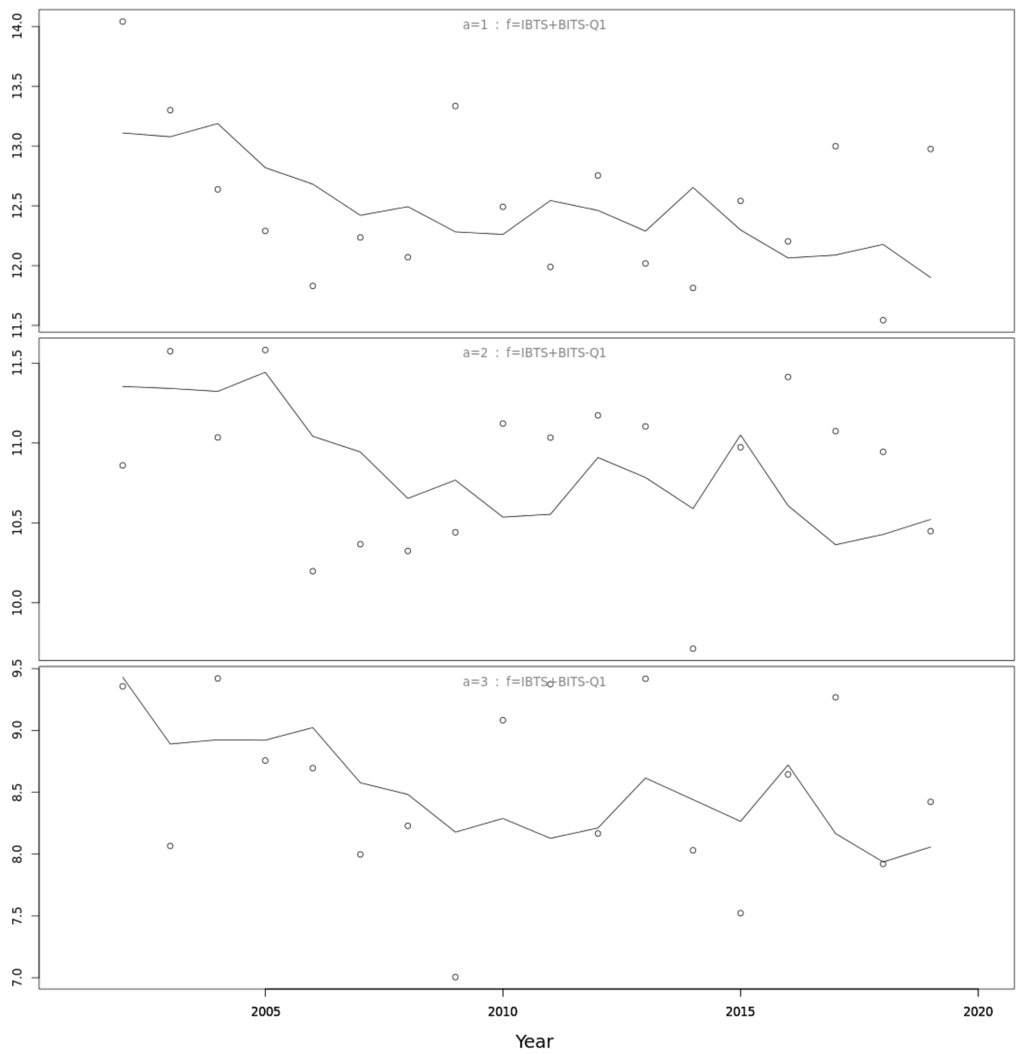

Figure 3.6.4.22. Western Baltic Spring-spawning Herring. Diagnostics of the IBTS+BITS-Q1 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

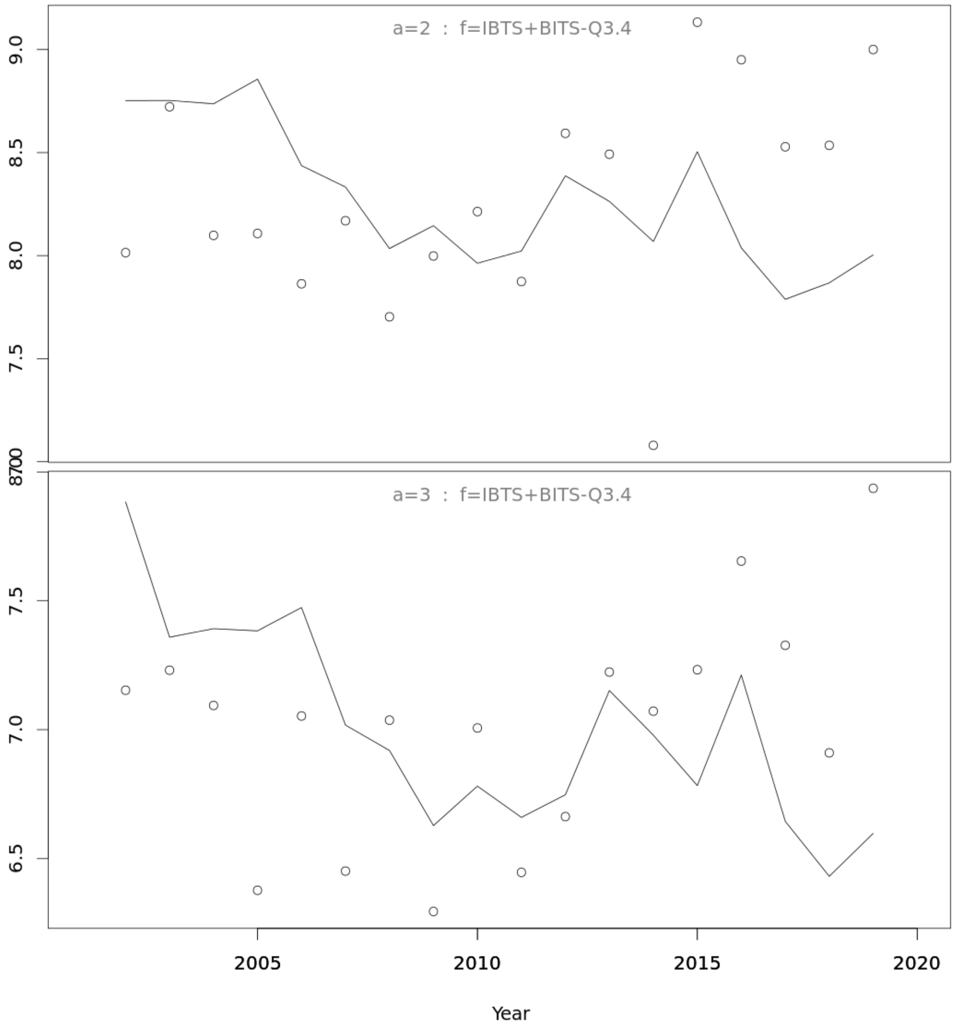

Figure 3.6.4.23. Western Baltic Spring-spawning Herring. Diagnostics of the IBTS+BITS-Q3.4 index. Plot of predicted (line) and observed (points) index (log scale) per W-ringers (a) and year.

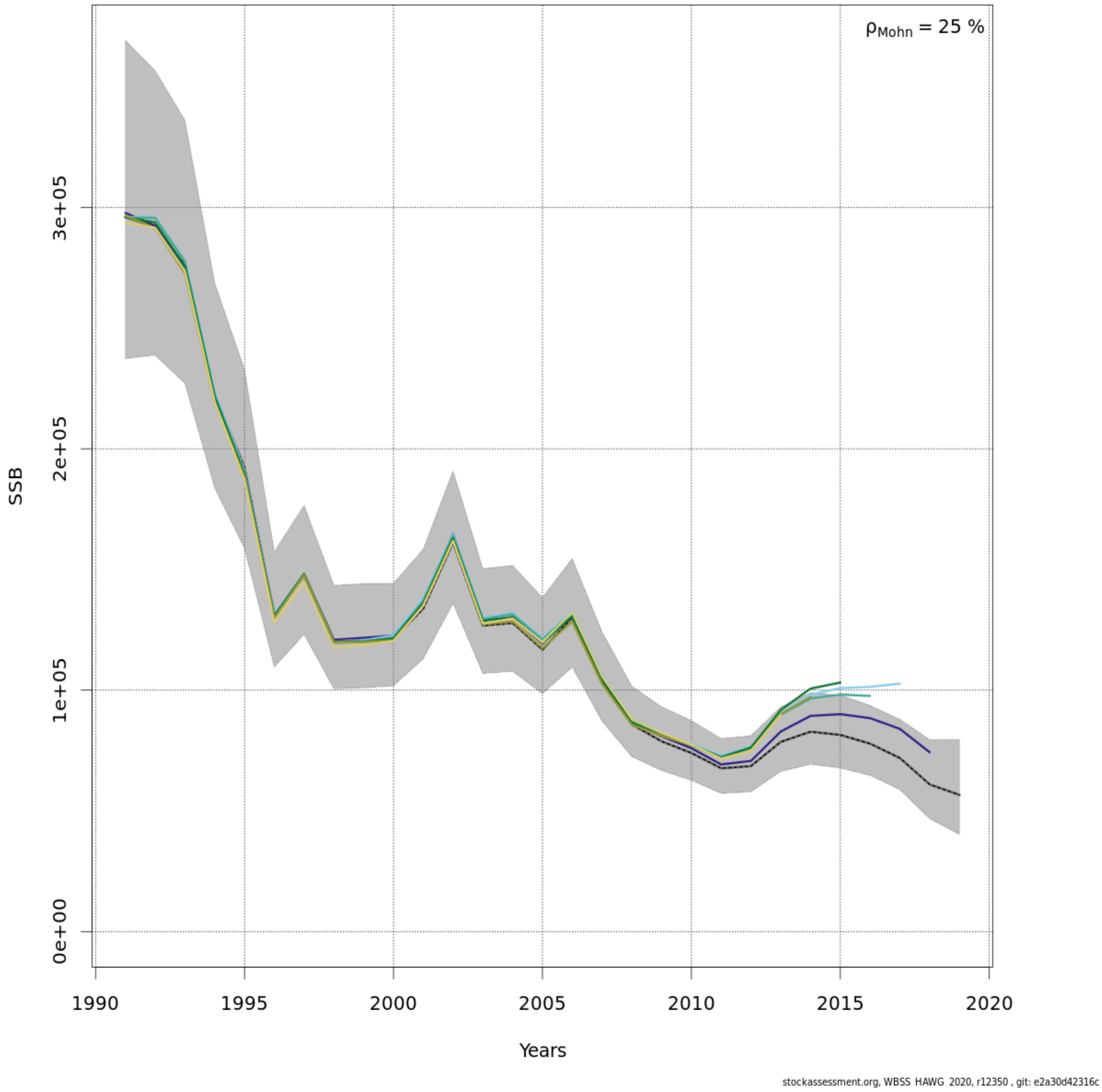

Figure 3.6.4.24. Western Baltic Spring-spawning Herring. Analytical retrospective pattern over 5 years from multi fleet run. Spawning-stock biomass.

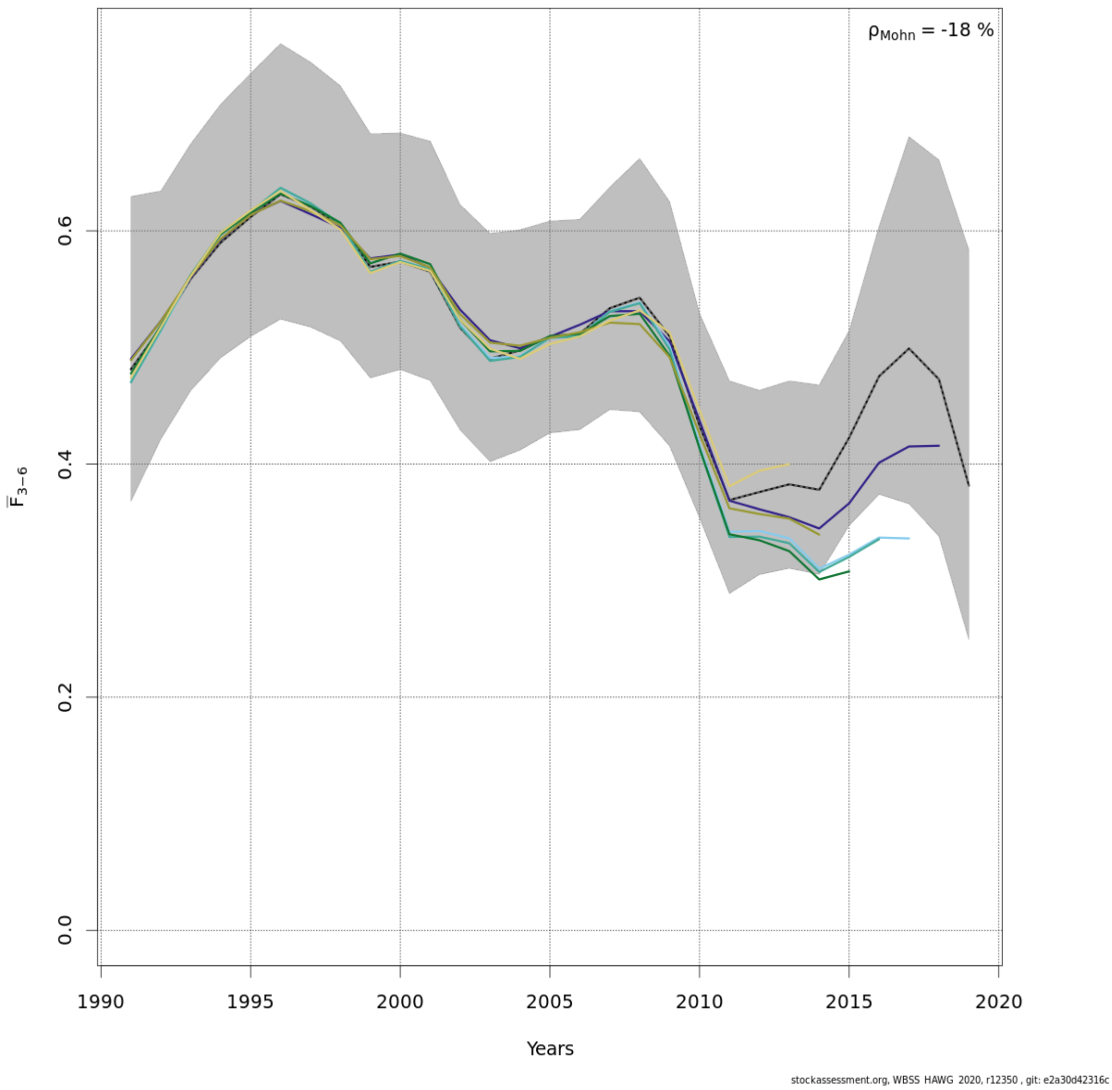

Figure 3.6.4.25. Western Baltic Spring-spawning Herring. Analytical retrospective pattern over 5 years from multi fleet run. Average fishing mortality for the shown age range.

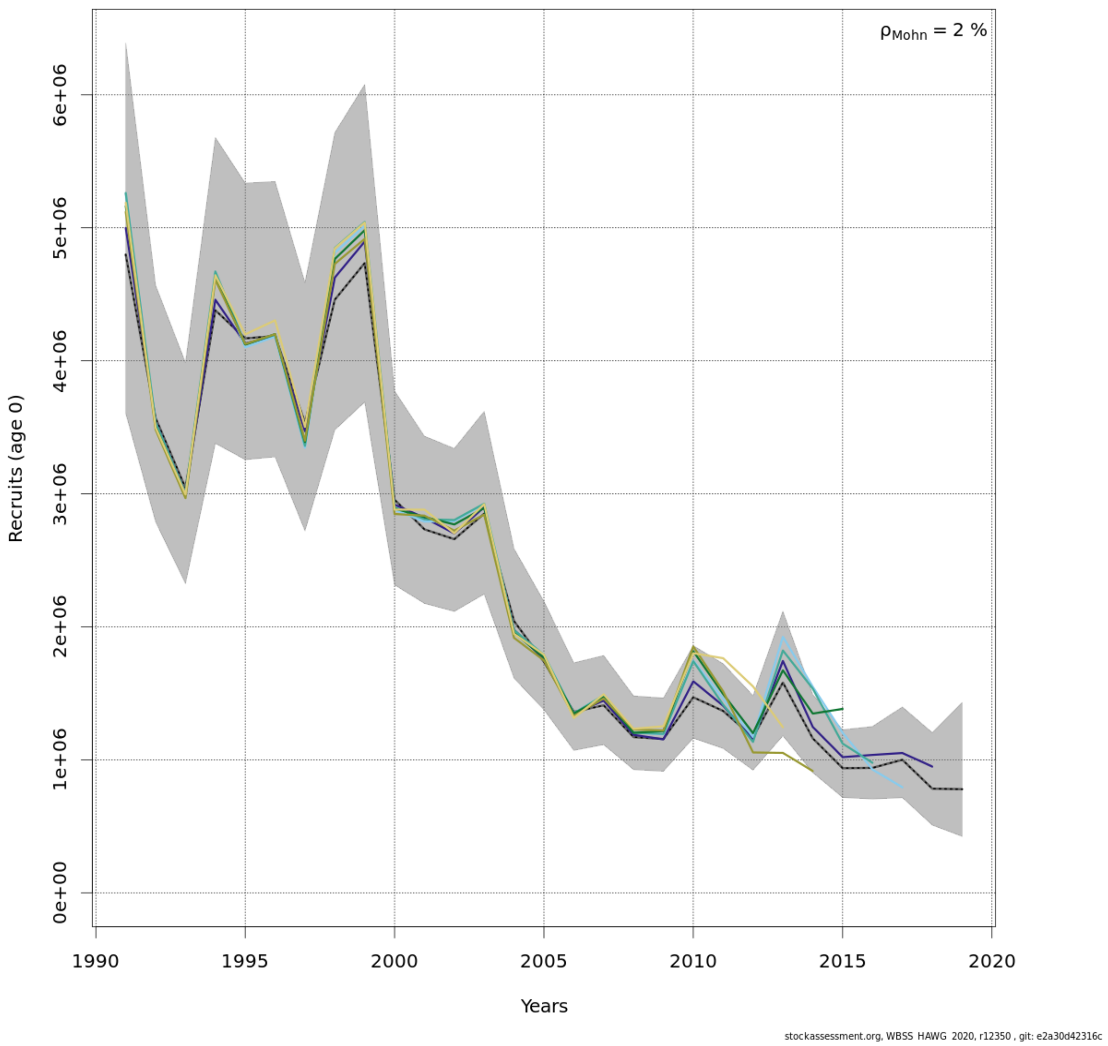

Figure 3.6.4.26. Western Baltic Spring-spawning Herring. Analytical retrospective pattern over 5 years from multi fleet run. Recruitment.

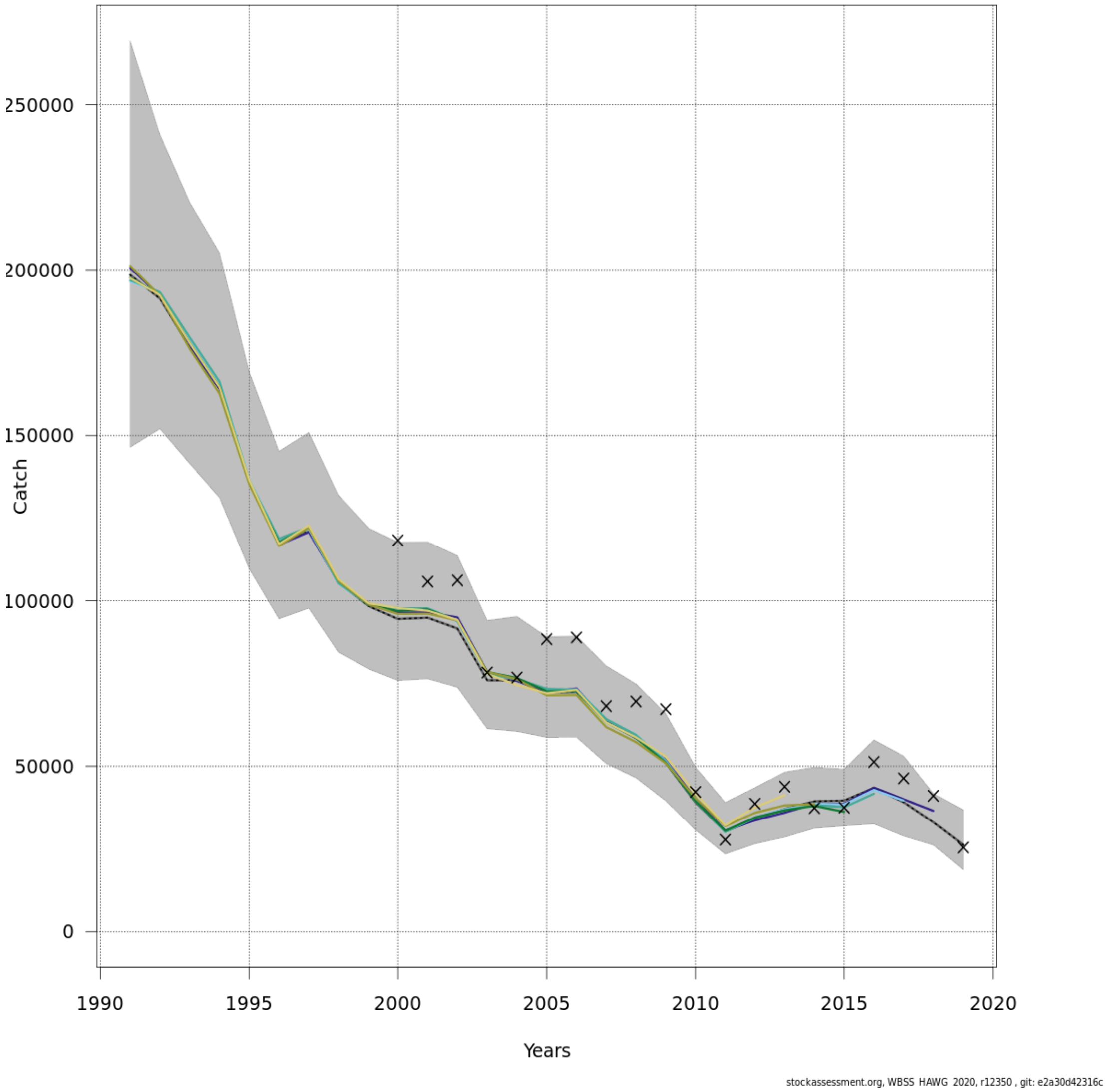

Figure 3.6.4.27.Western Baltic Spring-spawning Herring. Analytical retrospective pattern over 5 years from multi fleet run. Catch.

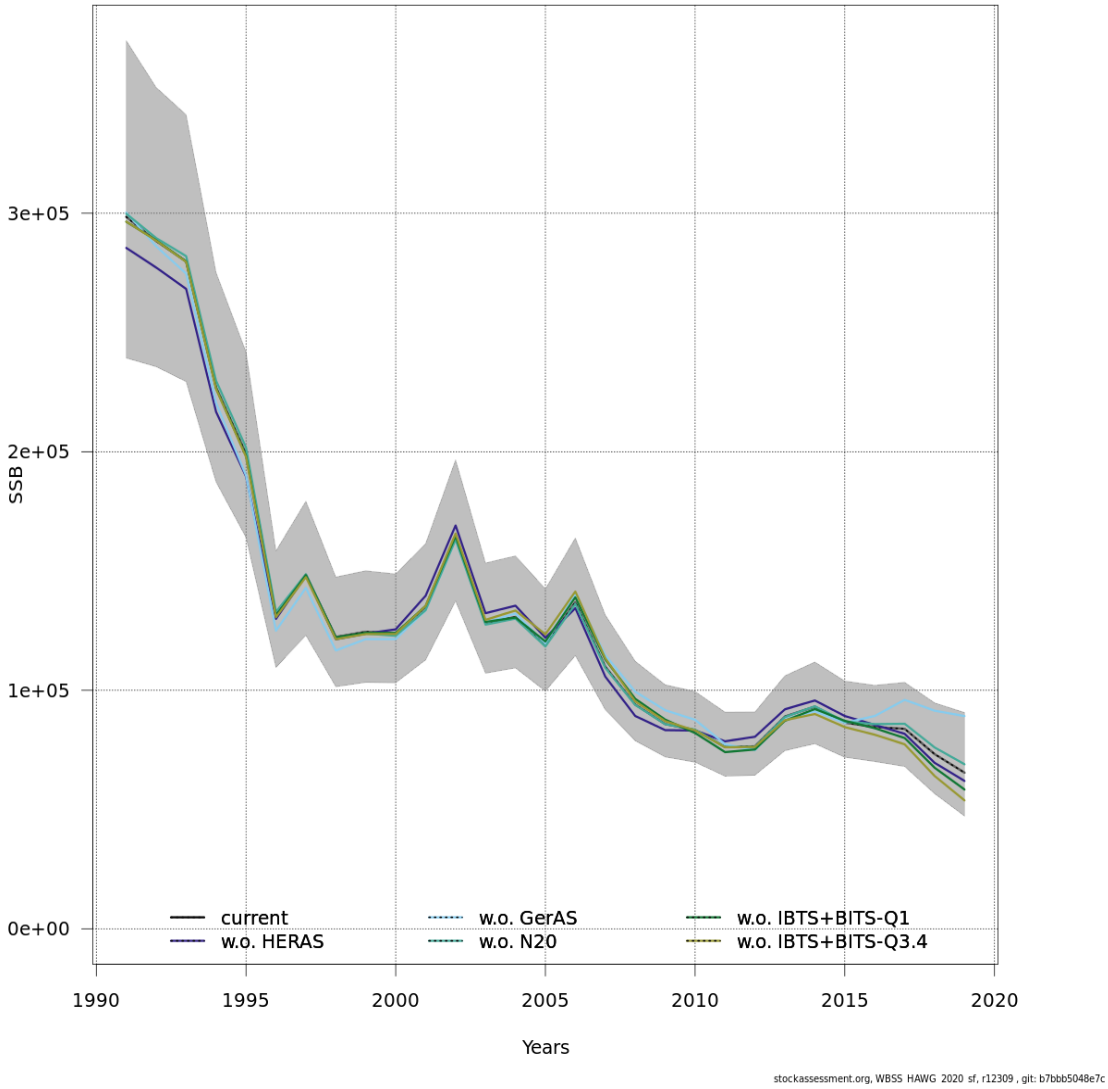

Figure 3.6.4.28. Western Baltic Spring-spawning Herring. Leave-one out from single fleet run. Spawning-stock biomass.

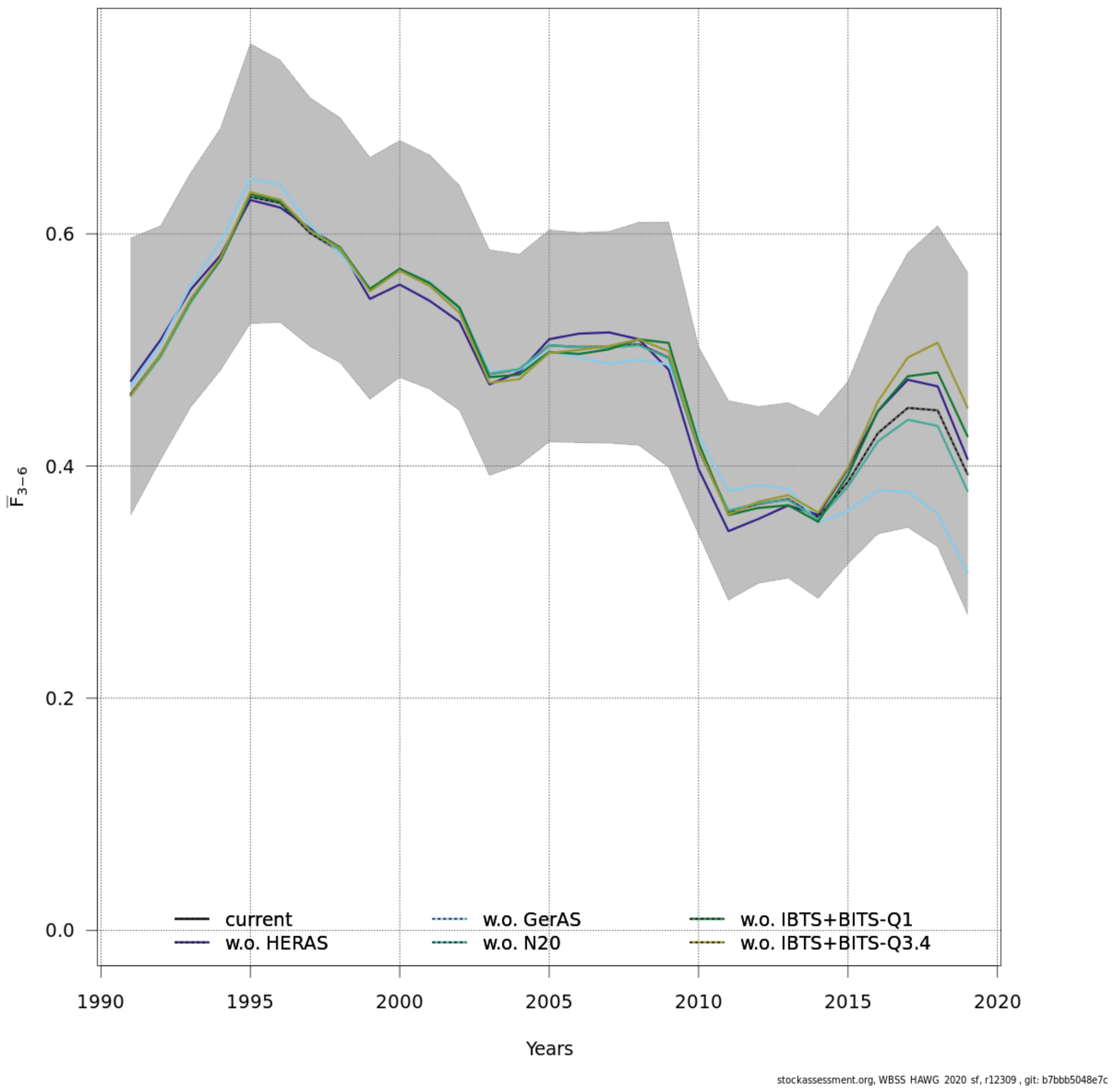

Figure 3.6.4.29. Western Baltic Spring-spawning Herring. Leave-one out from single fleet run. Average fishing mortality for the shown age range.

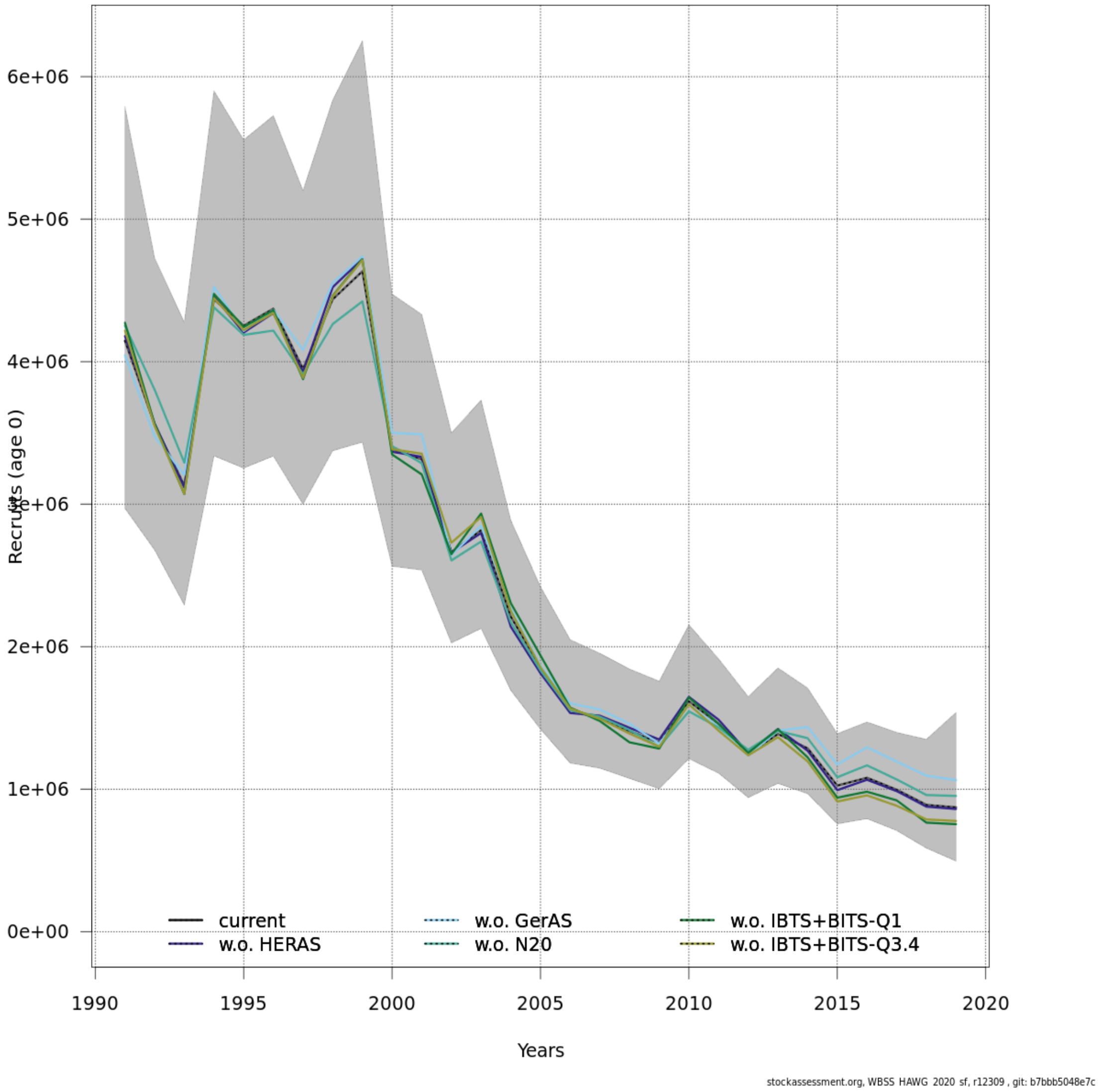

Figure 3.6.4.30. Western Baltic Spring-spawning Herring. Leave-one out from single fleet run. Recruitment.

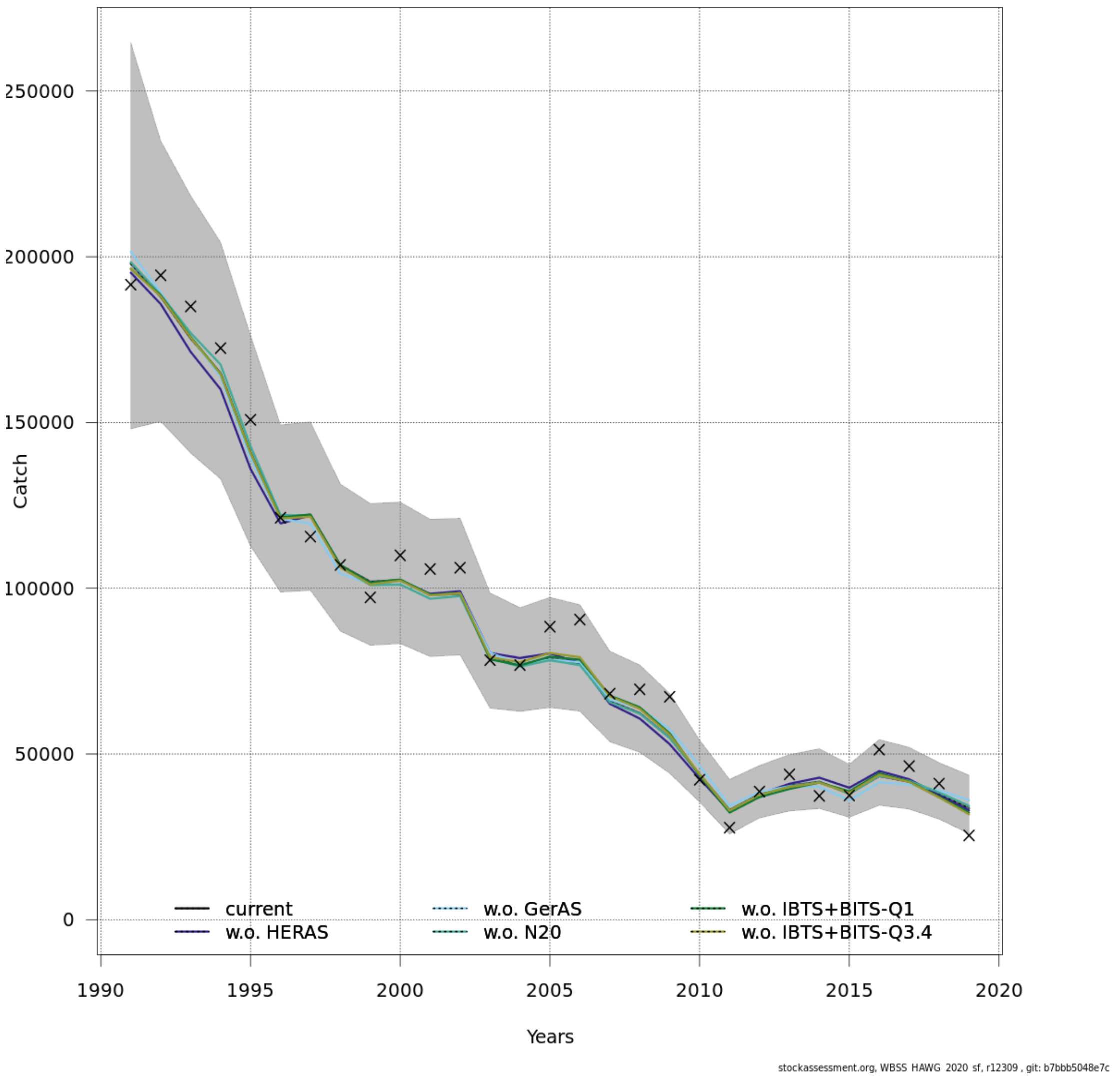

Figure 3.6.4.31. Western Baltic Spring-spawning Herring. Leave-one out from single fleet run. Catch.

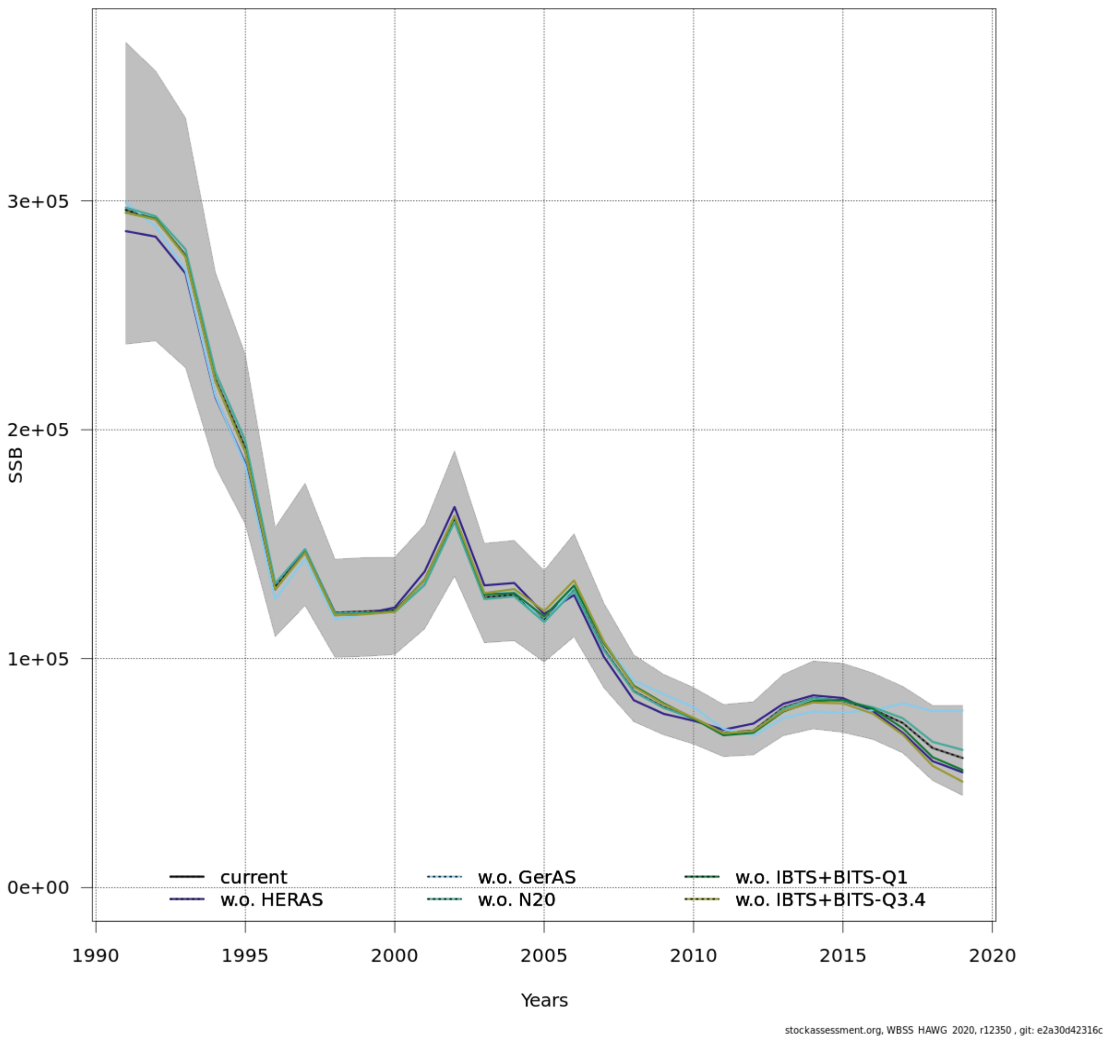

Figure 3.6.4.32. Western Baltic Spring-spawning Herring. Leave-one out from multi fleet run. Spawning-stock biomass.

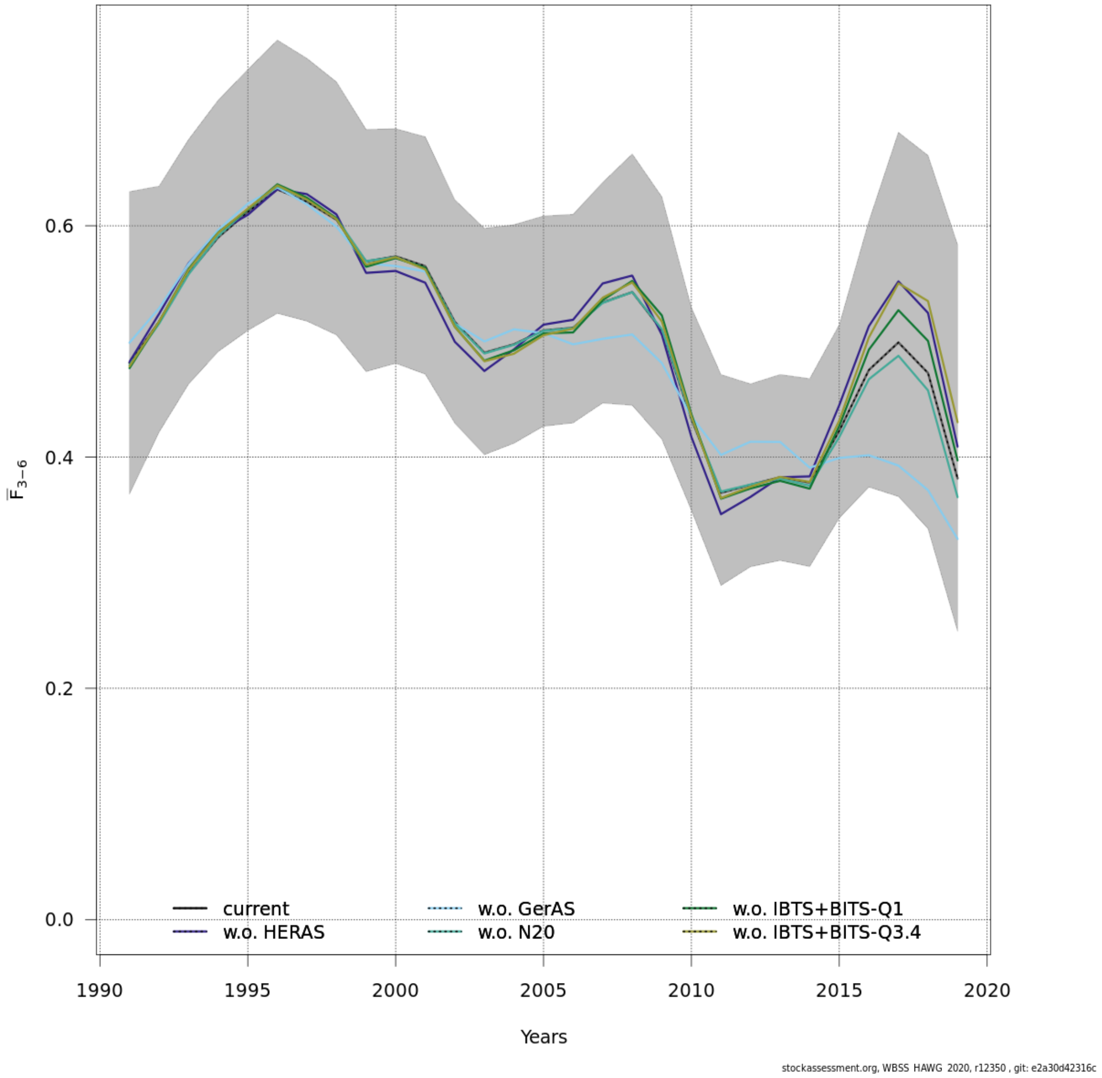

Figure 3.6.4.33. Western Baltic Spring-spawning Herring. Leave-one out from multi fleet run. Average fishing mortality for the shown age range.

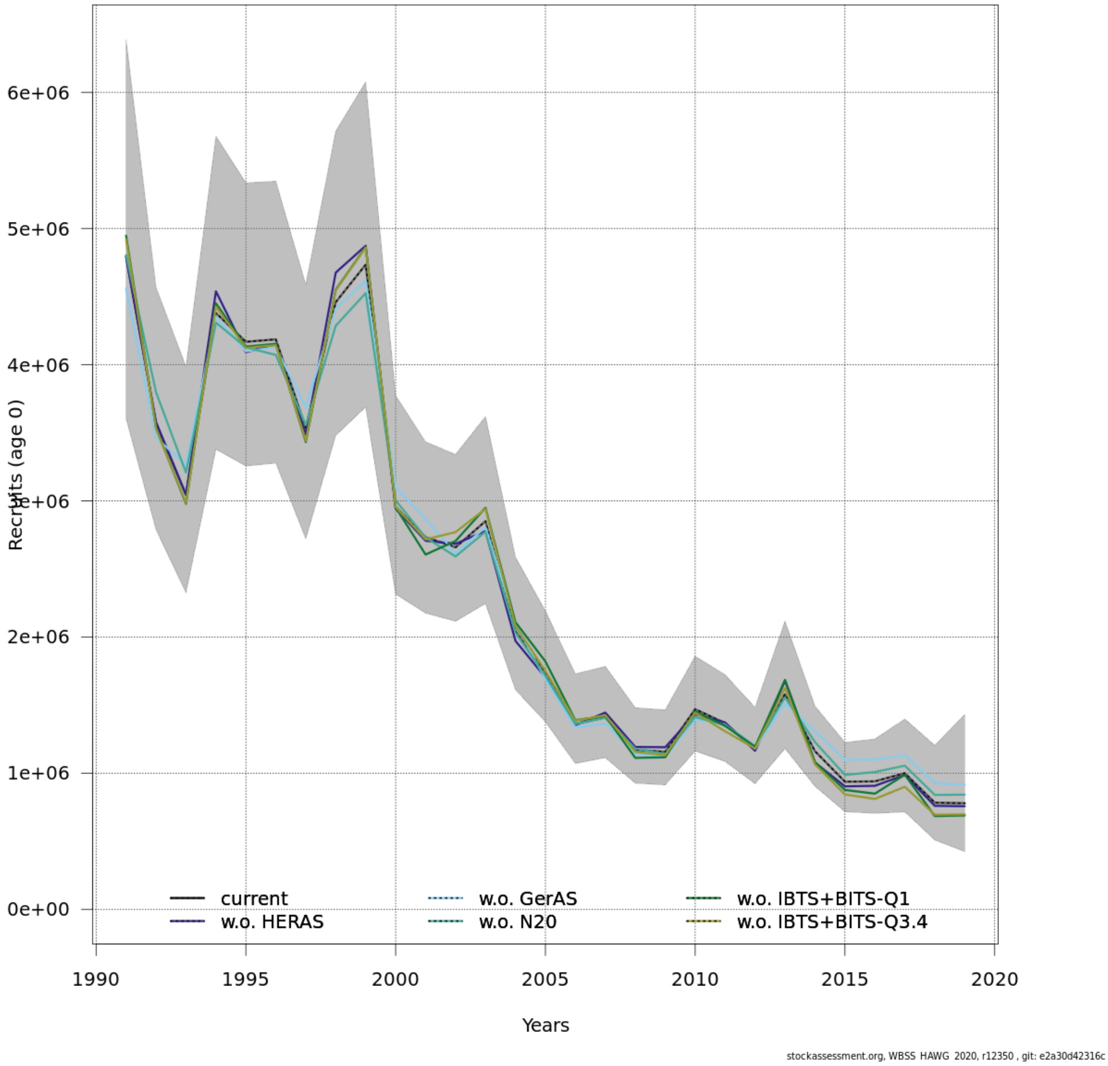

Figure 3.6.4.34. Western Baltic Spring-spawning Herring. Leave-one out from multi fleet run. Recruitment.

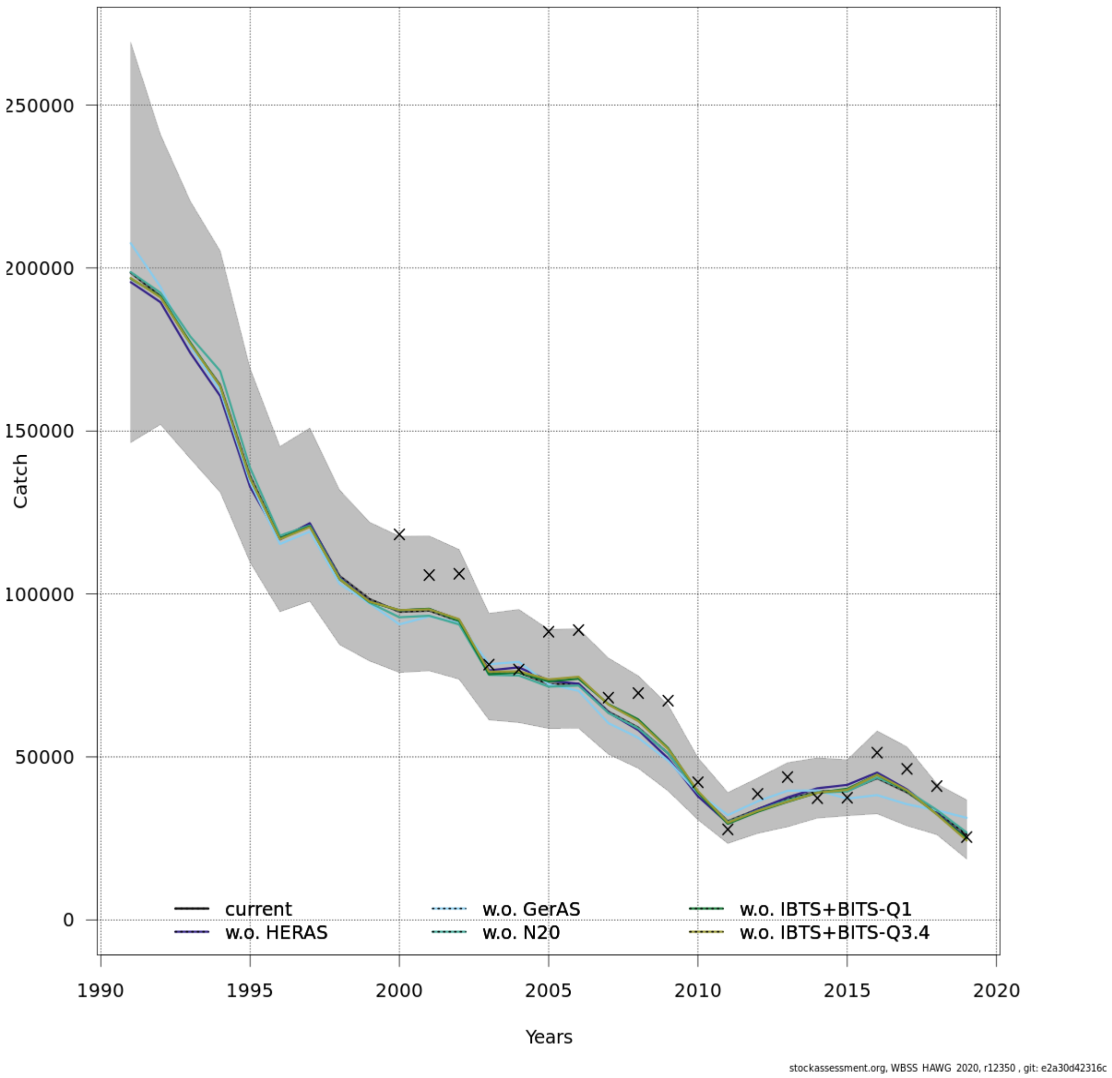

Figure 3.6.4.35. Western Baltic Spring-spawning Herring. Leave-one out from multi fleet run. Catch.

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

Fw

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 2016–2019

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

After the benchmarking process in early 2015 (WKWEST, 2015), the stocks were assessed together. The management plans in place for either stock were no longer applicable for the combined stocks. Considering the low SSB and low recruitment estimated for the combined stocks in recent years, ICES advised in 2016 that it was not possible to identify any non-zero catch that would be compatible with the MSY and precautionary approach. There were no catch options consistent with the combined stocks recovering to above B_{lim}, and consequently, ICES advised that the TAC be set at 0 t. In February 2016, the European Commission asked ICES to provide advice on a TAC of sufficiently small size to enable ongoing collection of fisheries-dependent data and continue the long-term catch-at-age dataset. ICES advised on a scientific monitoring TAC of 4840 t (with a TAC split of 3480 t to be taken in 6.aN and 1360 t in 6.aS and 7.b–c (ICES, 2016a)). Furthermore, the data should be collected in a way that (i) satisfied standard length, age, and reproductive monitoring purposes by EU Member States for ICES, and (ii) ensured that sufficient spawning-specific samples were available for morphometric and genetic analyses as agreed by the Pelagic Advisory Council monitoring scheme 2016 (Pelagic Advisory Council, 2016).

The EC set a monitoring TAC slightly higher than this advice, at 5800 t (TAC split of 4170 t in 6.aN and 1630 t in 6.aS and 7.b–c; EU 2016/0203, and the same for 2017 (EU 2017/127), 2018 (EU2018/120), and 2019 (EU 2019/124).

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, 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 (56° parallel) is not appropriate as a boundary, because it traverses the spawning and feeding grounds of 6.aS herring. Transboundary catches have occurred along this line in the past, although this has been less of an issue recently.

4.1.4 Catches in 2019

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 5-wr) dominates both the catches and the survey indices in 2019. This year class was already strongly represented at-age 3 wr in the 2017 catches. 2019 is the first time since 2012 that there was a reasonable proportion of 1 wr fish in the catch-at-age data. Previously strong 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 2019 as well as maintaining coverage of the original survey area in 6.aN.

The Malin Shelf herring estimate of SSB for 2019 is 128 000 tonnes and 740million individuals (Table 4.3.1.2), a decrease compared to the 159 000 tonnes and 925 million herring estimate in 2018. The estimate is still very low in the time-series (Table 4.3.1.3). In 2019, 55% of the biomass was observed north of 56°N (the geographic area included in the West of Scotland (6.aN index). This is not typical for the time-series; generally, the vast majority of herring are found north of 56°N. For instance, in 2018, 86% of the biomass was observed north of 56°N. The West of Scotland (6.aN) estimate of SSB is 76 000 tonnes and 406 million individuals (Table 5.2.4), a large decrease compared to the 152 000 tonnes and 875 million herring estimate in 2018. Long-term indices of abundance per age class for West of Scotland herring are provided in Table 5.2.5. In 2019, the total biomass of herring located in 6.aS and 7.b–c during the MSHAS was 66 500 tonnes compared to 34 900t in 2018.

There was a decrease in the 2019 estimates for the Malin Shelf and West of Scotland (6.a.N) compared to 2018, and the estimates since 2016 are the lowest in the time-series. The distribution of herring schools was similar to 2017 with more herring distributed south of 56°N line of latitude (Figure 5.3a). There were some strong herring marks found to the west and northwest of the Outer Hebrides and around St Kilda in 2019 again. In 2018, large aggregations of juvenile herring were observed around the Northern end of the Hebrides, around the Butt of Lewis and the North Minch. In 2019, juvenile herring were mainly found south of 56°N and to the west of the Hebrides, but in much smaller numbers compared to 2018 (Figures 5.3 and 5.17). Herring has in the past been found in high densities to the east of the 4°W line in association with a specific bathymetric feature and the occurrence of these herring west of the line in some years has the ability to strongly influence the annual estimate of abundance of the Malin Shelf/West of Scotland estimates. There is some evidence that this was the case in 2019 again. It appears that the increase in the 2017 and 2018 estimates compared to 2016 were a result of a greater spread in the distribution of herring rather than distributions occurring around the 4°W line. The 2012- and 2013-year classes (age 5 and 6 winter rings in 2019) are still strong in the stock and comprised 29% of total abundance and 35% of the biomass. The stock is otherwise dominated by 2- and 3 winter ringers (2015 and 2016 year classes), making up 50% of the abundance and 41% of the biomass. Age disaggregated survey abundance indices for the West of Scotland and Malin Shelf (WoS_MSHAS) herring since 2008 are given in Table 4.3.1.3 and Figure 4.3.1.3.

The stock is highly contagious in its spatial distribution, which explains some of the high variability in the time-series. The survey covers the area at the time of year when aggregations of herring from both the 6.aN and 6.aS, 7.b–c stocks are offshore feeding (i.e. not at spawning time). These distributions of offshore herring aggregations are considered to be more available to the survey compared to surveying spawning aggregations, which aggregate close to the seabed and are generally found inshore in areas unsuitable for the large vessels carrying out summer acoustic surveys.

4.3.1.1 Industry–Science Acoustic survey

In 2016–2019 industry acoustic surveys of herring during the spawning and prespawning 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, 2020) 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 in 6aN recorded juvenile herring in several hauls, but noticeably less than observed in 2018. (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 Groundfish survey in quarter 1 has been carried out in a consistent manner since 1987 and in quarter 4 since 1996. For quarter 1 in the years 1990–1993 age-data were not available on haul resolution and therefore the survey index for quarter 1 starts in 1994. For quarter 4 there were no survey in 2010, and in 2013 only parts of the area were covered and the data were not included in the survey calculations. The two indices were recalculated in 2019 following an Interbenchmark procedure (IBPher6a7bc, ICES 2019).

The internal consistencies in the trawl surveys indicate ability to follow cohorts in both the Q1 and Q4 indices (figures 4.3.2.1 and 4.3.2.2). Historic retrospectives for the index calculations for Q1 and Q4 are given in Figures 4.3.2.5 and 4.3.2.6, For both Q1 and Q4 the indices calculated for 2019 and 2020 assessments are nearly identical with the only difference the extra added year in 2020.

The abundance of 2 winter ring fish was at higher levels earlier in the time-series particularly in quarter 1, but since 2003 older fish have been numerically more abundant in the index in both quarters (figures 4.3.2.3 and 4.3.2.4). The stronger 2013 year-class which was age 5 wr in 2019 is still prominent especially in Q1, but its effect on overall stock size is waning and overall abundance has decreased in both quarters. Full details for the survey can be found in the Stock Annex.

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

4.4.1 Mean weight-at-age

Weights-at-age in the stock are obtained from the acoustic surveys and are given in Table 4.3.1.2 (for the current year) and Table 4.6.3 (for the time-series). The weights-at-age in the stock have been declining since 2010 particularly for younger ages. Weights-at-age in the catches for 6.aN and 6.aS, 7.bc are presented separately in Table 4.6.2a and 4.6.2b and are used separately in the multi fleet assessment. Both areas show fluctuations in catch weights over time. In several years no 1 winter ring fish have been taken in the 6.aN fishery. In 2019 the catch weights have continued to decreased 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 2019 (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 2019 were lower than in 2016 and 2017 (Figure 4.4.2.1). A greater proportion of immature fish were encountered in the survey in 2019 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 multifleet implementation of the State–space Assessment Model (www.stockassessment.org), embedded inside the FLR library (Kell *et al.*, 2007).

Data Exploration

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

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

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

Assessment

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

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

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

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

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

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

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

Figure 4.6.11 shows the trajectories for SSB, recruitment and mean F over the complete time-series from 1957–2019. 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 - 2020 and the resulting monitoring fishery has decreased F.

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

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

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

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

4.6.2 State of the combined stocks

Fishing mortality has been reduced since the introduction of zero catch advice and in line with the monitoring TAC in 2016. However, there is no information on the F on each of the constituent stocks. Unless the two stocks are of equal size, F on the smaller stock will be higher than indicated in the overall F. SSB has decreased steadily since 2003. SSB in 2019 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 among the lowest in the time-series.

4.7 Short-term Projections

4.7.1 Short-term projections

Given the current zero catch advice for herring, in divisions 6.a and 7.b–c and that a monitoring TAC has been agreed for 2020, exploratory forecasts were carried out with different catches assumed in the intermediate year (2020).

The two scenarios considered were

1. Full Uptake of the monitoring TAC (4840 t) in the intermediate year (2020).
2. Partial uptake of the monitoring TAC (3100 t) in the intermediate year (2020). This assumes full uptake in 6aS, 7b-c (1360 t) and uptake based on the 2019 catches in 6aN (1740 t).

The results of these forecasts are presented in Tables 4.7.1.1-Table 4.7.1.4. All catch options show an increase in SSB in 2021. Under the zero TAC option a further 6% increase in SSB in 2022 is forecast Full uptake of the monitoring TAC will see SSB remain unchanged, while a partial uptake of the monitoring TAC will result in an SSB increase of 2% in 2022.

4.7.2 Yield-per-recruit

No yield-per-recruit analysis was conducted at HAWG 2020.

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 interbenchmark in 2019. Improvements were made to the input data. The IBTS dataseries was recalculated using the delta GAM method and the acoustic surveys were combined into a single tuning index. The model was changed to a multi fleet SAM assessment with data from 6.aN and 6.aS 7.bc treated separately. The updated assessment provides the best statistical fit to the input data, but the assessment still has a strong retrospective bias. There is also a pattern of increasing catchability with age for the acoustic survey data which cannot be explained, given what would reasonably be expected for an acoustic survey.

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

SSB remains at a very low level. Recruitment in 2019 was stronger than any year since 2010, however there is considerable uncertainty about this estimate. Since 2012, there have been very few 1-wr herring observed in the 6.a (combined) and 7.b–c fishery. An increase in the proportion of 1 winter ring fish in the catch data were seen in 2019.

The assessment shows a similar perception of the stock to the 2019 assessment, with an improving retrospective pattern.

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

4.10 Management Considerations

There is anecdotal evidence that the stocks 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 overexploited. 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 overexploitation.

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

A research project is currently underway to assess the identity of herring stocks in this area through genetic, morphometric and otolith shape analysis. The project also aims to develop methods, which can be used in 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 2016–2019 and agreed for 2020 (4 840 t) is associated with decreased F and a continuation of the catch sampling programme.

4.11 Ecosystem Considerations

Herring constitute some of the highest biomass of forage fish to the west of Scotland and Ireland, and are thus an integral part of the ecosystem. As a dominant planktivore, herring link zooplankton production with higher trophic level predators that eat them, including fish, sea mammals and birds. Ecosystem models of the West of Scotland (Bailey *et al.*, 2011; Alexander *et al.*, 2015) show herring to be an important mid-trophic level species along with sprat, sandeel, and horse mackerel. They can also act as predators on other fish species by their predation on fish eggs at certain times of year (ICES, WGSAM 2012). Recent work, using length-based ecosystem modelling, suggests a link between herring biomass and North Sea cod (Speirs *et al.*, 2010), via the predation of cod eggs by herring.

There is no ecosystem model that covers the whole of the 6.a and 7.b–c area, so it is difficult to predict the impact of increasing or reducing the herring biomass on the ecosystem functioning as a whole. However, as herring constitute an important part of the overall biomass of plankton feeding and forage fish in the west of Scotland and Ireland ecosystem, impacts from changes in productivity from environmental drivers are likely to be widely felt.

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 Irish observer programme has not recorded any discards from this area in recent years. 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 2019. Mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	0	0.0	0.00	0.0	0.0
1	24	1.7	0.00	69.4	20.0
2	231	27.0	0.43	116.7	23.2
3	225	33.9	0.90	151.0	25.2
4	123	20.9	1.00	170.4	26.4
5	169	32.8	1.00	194.0	27.6
6	95	19.3	1.00	202.3	28.0
7	14	3.1	1.00	216.9	29.0
8	17	3.8	1.00	223.0	29.3
9+	21	4.6	1.00	216.7	29.0

Immature	180	19		105.0	22.5
Mature	740	128		173.3	26.5
Total	920	147	0.80	159.9	25.7

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 2019.

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
2019	24	231	225	123	169	95	14	17	21	128

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

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	2019
1	0.00	0.00	1504.48
2	1122.16	1508.98	1333.57
3	11929.71	3215.53	1035.12
4	4082.50	6873.26	2007.72
5	2075.35	5253.61	3100.51
6	1443.79	3068.25	1003.19
7	1416.35	844.50	214.54
8	767.37	852.31	79.03
9	273.34	680.89	42.01

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

age \ year	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
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

age \ year	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

age \ year	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

age \ year	2019
1	1995
2	2627
3	3259
4	1509
5	1895
6	1166

7	381
8	464
9	171

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

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

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	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	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  2019
  1 0.0000 0.0769 0.100 0.000 0.000 0.089
  2 0.1451 0.1425 0.144 0.137 0.126 0.129
  3 0.1877 0.1795 0.178 0.167 0.151 0.148
  4 0.2030 0.2059 0.204 0.187 0.174 0.182
  5 0.2279 0.2136 0.219 0.204 0.190 0.199
  6 0.2449 0.2307 0.229 0.213 0.208 0.210
  7 0.2608 0.2386 0.237 0.221 0.218 0.220
  8 0.2614 0.2454 0.251 0.233 0.238 0.257
  9 0.2835 0.2685 0.257 0.249 0.246 0.244
```

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
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

	year		
age	2017	2018	2019
1	0.072	0.085	0.063
2	0.106	0.101	0.099
3	0.132	0.127	0.127
4	0.145	0.144	0.147
5	0.159	0.155	0.159
6	0.168	0.166	0.164
7	0.172	0.172	0.180
8	0.179	0.170	0.174
9	0.183	0.174	0.172

Table 4.6.3. Herring in 6.a (combined) and 7.b–c. WEIGHTS-AT-AGE IN THE STOCK.

Units : kg

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

	year											
age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

	year											
age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.068
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.152
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.186
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.206
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.233

```
  6 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.252 0.253
  7 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.273
  8 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.269 0.299
  9 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.292 0.302
   year
age  1993  1994  1995  1996  1997  1998  1999  2000  2001  2002  2003  2004
  1 0.073 0.052 0.042 0.045 0.054 0.066 0.054 0.062 0.062 0.062 0.064 0.059
  2 0.164 0.150 0.144 0.140 0.142 0.138 0.137 0.141 0.132 0.153 0.138 0.138
  3 0.196 0.192 0.191 0.180 0.180 0.176 0.166 0.173 0.170 0.177 0.176 0.159
  4 0.206 0.220 0.202 0.209 0.199 0.194 0.188 0.183 0.190 0.198 0.190 0.180
  5 0.225 0.221 0.225 0.219 0.213 0.214 0.203 0.194 0.198 0.212 0.204 0.189
  6 0.234 0.233 0.227 0.222 0.222 0.226 0.219 0.204 0.212 0.215 0.213 0.202
  7 0.253 0.241 0.247 0.229 0.231 0.234 0.225 0.211 0.220 0.225 0.217 0.213
  8 0.259 0.270 0.260 0.242 0.242 0.225 0.235 0.222 0.236 0.243 0.223 0.214
  9 0.276 0.296 0.293 0.263 0.263 0.249 0.245 0.230 0.254 0.259 0.228 0.206
   year
age   2005  2006  2007  2008  2009  2010  2011  2012       2013  2014
  1 0.0751 0.075 0.075 0.055 0.059 0.068 0.057 0.066 0.06366667 0.064
  2 0.1296 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  2019
  1 0.06373333 0.0638 0.0638 0.0478 0.0638
  2 0.15500000 0.1370 0.1350 0.1100 0.1170
  3 0.18300000 0.1400 0.1700 0.1550 0.1500
  4 0.19500000 0.1750 0.1810 0.1761 0.1790
  5 0.20400000 0.2020 0.1980 0.1901 0.1960
  6 0.21100000 0.2080 0.1990 0.2097 0.2050
  7 0.21700000 0.2090 0.2140 0.2094 0.2170
  8 0.21500000 0.2100 0.2230 0.2180 0.2240
  9 0.22000000 0.2420 0.2360 0.2222 0.2180
```

Table 4.6.4. Herring in 6.a (combined) and 7.b–c. NATURAL MORTALITY.

```
Units  :  NA
   year
   year
age     1957     1958     1959     1960     1961     1962     1963     1964
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
```

```
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
   year
age     1965     1966     1967     1968     1969     1970     1971     1972
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
   year
age     1973     1974     1975     1976     1977     1978     1979     1980
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
   year
age     1981     1982     1983     1984     1985     1986     1987     1988
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
   year
age     1989     1990     1991     1992     1993     1994     1995     1996
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
  2 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728 0.384728
  3 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633 0.355633
  4 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791 0.338791
  5 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385 0.319385
  6 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574 0.313574
  7 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  8 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
  9 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805 0.306805
   year
age     1997     1998     1999     2000     2001     2002     2003     2004
  1 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005 0.767005
```

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

  9 0.306805 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
   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
  1 0.00 0.00 0.00 0.00 0.00    0 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  2 0.92 0.76 0.83 0.84 0.81    1 0.91 0.67 0.88 0.50 0.62 0.35 0.18 0.48 0.97
  3 1.00 1.00 0.97 1.00 0.97    1 0.99 0.99 0.99 0.93 0.99 0.72 0.73 0.85 0.99
  4 1.00 1.00 1.00 1.00 1.00    1 1.00 1.00 1.00 1.00 1.00 0.98 0.99 0.99 1.00
  5 1.00 1.00 1.00 1.00 1.00    1 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  6 1.00 1.00 1.00 1.00 1.00    1 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  7 1.00 1.00 1.00 1.00 1.00    1 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  8 1.00 1.00 1.00 1.00 1.00    1 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  9 1.00 1.00 1.00 1.00 1.00    1 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
   year
age 2017 2018 2019
  1 0.00 0.00 0.00
  2 0.95 0.40 0.43
  3 1.00 0.85 0.90
  4 1.00 0.98 1.00
  5 1.00 0.98 1.00
  6 1.00 1.00 1.00
  7 1.00 1.00 1.00
  8 1.00 1.00 1.00
  9 1.00 1.00 1.00
```

Table 4.6.6. Herring in 6.a (combined) and 7.b–c. FRACTION OF HARVEST BEFORE SPAWNING.

```
Units  :  NA
   year
age 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971
  1 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  2 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  3 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  4 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
```

```
  5 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  6 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  7 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  8 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  9 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
   year
age 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986
  1 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  2 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  3 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  4 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  5 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  6 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  7 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  8 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  9 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
   year
age 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001
  1 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  2 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  3 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  4 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  5 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  6 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  7 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  8 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  9 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
  1 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  2 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  3 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  4 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  5 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  6 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  7 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  8 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
  9 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67
   year
age 2017 2018 2019
  1 0.67 0.67 0.67
  2 0.67 0.67 0.67
  3 0.67 0.67 0.67
  4 0.67 0.67 0.67
  5 0.67 0.67 0.67
  6 0.67 0.67 0.67
  7 0.67 0.67 0.67
  8 0.67 0.67 0.67
  9 0.67 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 2019
  1 0.67 0.67 0.67
```

2	0.67	0.67	0.67
3	0.67	0.67	0.67
4	0.67	0.67	0.67
5	0.67	0.67	0.67
6	0.67	0.67	0.67
7	0.67	0.67	0.67
8	0.67	0.67	0.67
9	0.67	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	2019.00	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	2019
1	62834	796012	-1	1012160	-1	-1	-1	1287728	24011
2	257258	548481	209403	277504	212467	29593	25426	447304	231310
3	899637	832257	434425	241674	396545	108126	338563	106491	224691
4	484732	517267	671507	502471	747121	87773	155357	342609	122704
5	212913	249024	194706	534431	423139	111676	105728	153194	169202
6	227515	114507	70507	148259	476249	79130	110226	51928	95226
7	205093	111385	61392	32565	90102	62045	47158	72276	14485
8	113298	56526	28597	18677	23931	5530	13069	26636	16839
9	263837	104571	37398	13003	2086	957	4721	12887	21113

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	2019.00	0.00	0.25

Index type : number

IBTS_Q1 - Index Values

Units : NA

year

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
2	48916	361539	103941	106164	8303	79971	83144	88012	39795	111751	103573
3	84580	130176	165901	181522	49449	332296	132467	78484	152044	124480	338773
4	27477	98612	51093	86306	34470	207818	174263	57418	39363	126704	199851
5	25776	12012	55200	28614	16584	88314	68885	102377	14797	20421	193740
6	37978	28659	29673	20481	5902	39971	61817	55319	42601	16411	53898
7	24660	12440	12958	11595	6823	26566	33225	40904	13511	29962	48427
8	9351	21396	19755	27427	2580	18838	9441	17852	13914	13026	54985
9	4248	12641	44457	26393	7220	30831	17792	19066	15377	17169	48066

year

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015

```
  2 126936 269691 26361 27579  42619 14892  91514   8800  53738  9345  5384
  3 142233 326840 80689 33711  85158 41494 101279 122882  54054 35886  9159
  4 277516 142145 50894 34804  81747 20980  80783  47115 112942 25946 22710
  5 213430 377803 44262 26715  78610 19777  38776  25393  45629 41795 10193
  6 207622 375914 79950 24147  59040 21267  47698  14100  38312  8242 12583
  7  29038 218536 59987 29606  54827 22751  34237  13146  25973  5288  3627
  8  60557  36598 32683 33947  96454 18507  25997  10734  22398  4999  3095
  9  53780 105408 29206 20641 114446 38999  70578  28747  32892  4699   916
   year
age  2016  2017   2018   2019
  2 12747  6228   6934   8623
  3 19427 59281  29901  19883
  4  6647 23366 199126  30037
  5 14227 10905  44740 109572
  6 18106 11950  35069  13117
  7  5914 10555  17171   9048
  8  1335  5619  13907   5997
  9   563  3014   5172   5557

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   2019.00      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 16899 13478 12467  6660 5476 32780 9993 14583 16007 5204 6830 6841 3022
  3 15930  8696 10015 15398 4105  6623 7709  9939 18289 3718 2388 4088 3722
  4  6494  6633  7986 10441 9837  6995 1125 15310 13046 6991 3038 2657 3526
  5  5023  4094 10757  9474 4237 14248 1666  2227  8795 8534 6130 4789 2048
```

6	2164	2928	6098	8826	5473	10018	3257	3170	2096	5863	7628	3557	2796
7	1994	757	1891	4285	3203	6267	2220	3323	2729	878	4302	4233	5457
8	3978	1680	837	1386	2191	3049	1714	2032	1422	2094	1023	1208	3412
9	5458	1652	3568	3157	1601	1585	797	2178	1103	2359	1805	451	3725

	year										
age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
2	7121	-1	10248	2148	-1	3379	6210	13260	5609	3832	2437
3	3659	-1	4473	5865	-1	8058	6054	11055	32224	4559	1990
4	3440	-1	3676	3437	-1	6488	9756	11245	16854	13044	2428
5	4514	-1	2171	3686	-1	11270	11307	13730	22646	6196	4391
6	1667	-1	2089	2600	-1	2845	5069	14251	11412	3580	2463
7	1903	-1	792	2462	-1	890	618	6170	8330	2312	1757
8	2141	-1	519	806	-1	902	566	1358	3115	1607	696
9	**3095**	**-1**	**2235**	**5281**	**-1**	**234**	**442**	**567**	**598**	**213**	**696**

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	2019	3	6

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

```
name   : Herring in 6aN and 6aS,7bc multifleet
desc   : Imported from a VPA file. ( ./data/index.txt ).  Sun Mar 22 15:38:44 2020
range  :  min       max plusgroup   minyear   maxyear   minfbar   maxfbar
range  :  1          9          9      1957      2019         3         6
fleets :   catch N   catch S WOS_MSHAS   IBTS_Q1   IBTS_Q4
fleets :         0         0         2         2         2
plus.group      : TRUE
states          :             age
states          : fleet        1  2  3  4  5  6  7  8  9
states          :   catch N    0  1  2  3  4  5  6  7  7
states          :   catch S    8  9 10 11 12 13 14 15 15
```

```
states          :   WOS_MSHAS -1 -1 -1 -1 -1 -1 -1 -1 -1
states          :   IBTS_Q1   -1 -1 -1 -1 -1 -1 -1 -1 -1
states          :   IBTS_Q4   -1 -1 -1 -1 -1 -1 -1 -1 -1
logN.vars       : 0 1 1 1 1 1 1 1 1
logP.vars       :
catchabilities  :             age
catchabilities  : fleet        1  2  3  4  5  6  7  8  9
catchabilities  :   catch N   -1 -1 -1 -1 -1 -1 -1 -1 -1
catchabilities  :   catch S   -1 -1 -1 -1 -1 -1 -1 -1 -1
catchabilities  :   WOS_MSHAS  0  1  2  3  4  5  6  7  7
catchabilities  :   IBTS_Q1   -1  8  9 10 11 12 13 14 14
catchabilities  :   IBTS_Q4   -1 15 16 17 18 19 20 21 21
power.law.exps  :             age
power.law.exps  : fleet        1  2  3  4  5  6  7  8  9
power.law.exps  :   catch N   -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps  :   catch S   -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps  :   WOS_MSHAS -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps  :   IBTS_Q1   -1 -1 -1 -1 -1 -1 -1 -1 -1
power.law.exps  :   IBTS_Q4   -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars          :             age
f.vars          : fleet        1  2  3  4  5  6  7  8  9
f.vars          :   catch N    4  5  5  5  5  5  5  5  5
f.vars          :   catch S    0  1  2  2  2  2  2  3  3
f.vars          :   WOS_MSHAS -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars          :   IBTS_Q1   -1 -1 -1 -1 -1 -1 -1 -1 -1
f.vars          :   IBTS_Q4   -1 -1 -1 -1 -1 -1 -1 -1 -1
obs.vars        :             age
obs.vars        : fleet        1  2  3  4  5  6  7  8  9
obs.vars        :   catch N    4  5  6  6  6  6  6  7  7
obs.vars        :   catch S    0  1  2  2  2  2  3  3  3
obs.vars        :   WOS_MSHAS  8  9 10 10 10 10 11 11 11
obs.vars        :   IBTS_Q1   -1 12 13 13 13 14 14 15 15
obs.vars        :   IBTS_Q4   -1 16 17 17 17 17 18 18 18
srr             : 0
scaleNoYears    : 0
```

```
scaleYears     : NA
scalePars      :
cor.F          : 2
cor.obs         : NA NA 0 -1 -1 NA NA 0 2 3 NA NA 1 2 4 NA NA 1 2 5 NA NA 1 2 6 NA
NA 1 2 6 NA NA 1 2 6 NA NA 1 2 6
cor.obs.Flag   : ID ID AR AR AR
biomassTreat   : -1 -1 -1 -1 -1
timeout        : 3600
likFlag        : LN LN LN LN LN
fixVarToWeight : FALSE
simulate       : FALSE
residuals      : TRUE
sumFleets      :
```

Table 4.6.11. Herring in 6.a (combined) and 7.b–c. FLR, R SOFTWARE VERSIONS.

FLSAM.version	2.1.0
FLCore.version	2.6.10
R.version	R version 3.6.0 (2019-04-26)
platform	x86_64-w64-mingw32
run.date	2020-03-22 15:44:40

Table 4.6.12. Herring in 6.a (combined) and 7.b–c. STOCK SUMMARY.

Year	Recruits Mean Age 0 (Thousands)	Total biomass (tonnes) Mean	Spawing biomass (tonnes) Mean	Landings (tonnes) Mean	Mean F ages 3-6 Mean	SoP (%)
1957	1621421	760610	352222	35835	0.1531	0.7531
1958	2859152	826033	359341	48886	0.1963	0.7733
1959	3984464	963532	361490	48181	0.1801	0.7446
1960	1625674	885284	439611	39546	0.1272	0.6012
1961	2663844	905583	454996	30935	0.0912	0.6332
1962	3583033	998662	428768	47183	0.1332	0.7990
1963	3601652	1060802	456247	38677	0.1023	0.7245
1964	2445571	1036438	512094	39542	0.0963	0.6145
1965	10273513	1701640	516010	47009	0.1000	0.8730
1966	1824773	1607430	774544	73816	0.1247	1.0130
1967	3826869	1626802	882810	74657	0.1236	0.8399
1968	5117656	1708100	837018	63398	0.0958	0.8364
1969	3766356	1637206	811465	94305	0.1480	0.7945
1970	4127747	1562292	733236	126673	0.2143	0.7750
1971	8430310	1821978	558383	223160	0.4247	1.0255
1972	3295333	1521519	631085	139114	0.2572	1.0349
1973	1999872	1262774	590989	222624	0.3925	1.0331
1974	2161105	936662	376422	203325	0.5638	1.1069
1975	2325273	710539	246896	129876	0.5238	0.9806
1976	1487959	552103	195485	104787	0.5183	0.9888
1977	1807505	478341	172173	55486	0.3373	0.9200
1978	2519527	547111	179849	38419	0.2278	0.9961
1979	2803895	653099	234322	20194	0.1169	0.9380
1980	1797651	680336	311155	26523	0.1209	1.0375
1981	2396988	732711	307641	70932	0.2545	0.9699
1982	1914809	675944	264623	111193	0.3786	1.0235
1983	4855259	864178	229168	95471	0.3819	1.0182
1984	2516884	862919	318228	82232	0.2660	0.9756
1985	2913606	905088	384576	59651	0.2257	1.0078
1986	2610120	901706	387424	94108	0.2615	1.0389
1987	4570075	1034508	361865	95119	0.2819	1.0148
1988	1996258	939249	420356	70014	0.2204	1.0126
1989	1651209	844616	440688	65515	0.1928	1.0086
1990	1286884	722176	376711	79613	0.2384	0.9933
1991	1015941	577248	303714	65733	0.2252	1.0315
1992	1530360	472797	224182	61868	0.2457	1.0024
1993	1272803	438747	226691	55372	0.2549	0.9932
1994	2075166	408728	171365	52472	0.2737	0.9999
1995	1624282	391207	137344	55320	0.2901	0.9748
1996	1784161	384553	183131	53691	0.2936	1.0233
1997	2046565	416007	156501	68273	0.4268	1.0033
1998	1040343	384053	184506	69324	0.4691	0.9994
1999	917831	307230	148918	50331	0.3445	0.9998
2000	2665809	378029	118332	40867	0.3035	0.9990
2001	1809202	414044	200432	42511	0.2836	1.0028
2002	1954526	474657	232267	53640	0.3295	0.9998
2003	1109916	414119	216047	45756	0.2725	1.0021

2004	939122	338316	186184	45275	0.2540	1.0119
2005	955248	306398	161690	31010	0.1800	1.0021
2006	857048	295001	146763	45440	0.2794	0.9990
2007	548152	254537	143380	42235	0.2945	0.9990
2008	666243	210174	116958	29883	0.2354	1.0008
2009	734076	202112	96095	30513	0.2754	1.0312
2010	1182492	232555	96444	28612	0.3306	0.9960
2011	528627	188423	80767	25297	0.2790	0.9992
2012	535945	183904	92739	23194	0.2617	1.0017
2013	268023	151904	65160	26719	0.3807	0.9978
2014	342446	110736	43384	25897	0.4329	1.0091
2015	552207	113071	37414	21243	0.5237	0.9982
2016	227371	89132	53783	6876	0.1758	1.0011
2017	254278	90994	54601	6382	0.1489	0.9986
2018	337515	86700	40274	6114	0.1499	0.9978
2019	708296	111872	41978	3611	0.0814	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	0.01300610	0.01588731	0.01586657	0.01372754	0.01213297	0.01748142
2	0.05737177	0.07255302	0.07135615	0.05903161	0.04944641	0.07447207
3	0.10359862	0.12791864	0.11544142	0.08544025	0.06436973	0.09511861
4	0.12441160	0.15871846	0.14946084	0.10356466	0.07270284	0.10834575
5	0.15131402	0.19724642	0.18779583	0.13342121	0.08871037	0.13188354
6	0.16681494	0.22098351	0.20211114	0.13604915	0.08366047	0.13281665
7	0.20225122	0.28557149	0.26223326	0.17291678	0.10173090	0.16061399
8	0.20413008	0.30307148	0.28331832	0.18476536	0.10863075	0.17492860
9	0.20413008	0.30307148	0.28331832	0.18476536	0.10863075	0.17492860

year						
age	1963	1964	1965	1966	1967	1968
1	0.01455650	0.01397382	0.01343381	0.01746162	0.01624413	0.01306106
2	0.05783939	0.05275309	0.04831915	0.06434454	0.05858288	0.04538743
3	0.07553008	0.06971697	0.06606280	0.08176783	0.07697802	0.06054233
4	0.08320456	0.07861748	0.08162304	0.10106339	0.09546516	0.07105890
5	0.09744350	0.08730364	0.09094144	0.11173731	0.10606581	0.07703909
6	0.10050977	0.09349011	0.09700370	0.12212768	0.12161926	0.08992343
7	0.12125072	0.11958698	0.12737859	0.15173849	0.15462566	0.11855647
8	0.13919759	0.14653027	0.16349671	0.19457739	0.19522155	0.14722677
9	0.13919759	0.14653027	0.16349671	0.19457739	0.19522155	0.14722677

year						
age	1969	1970	1971	1972	1973	1974
1	0.01752461	0.02739944	0.05672079	0.03493807	0.04731501	0.05504408
2	0.06638373	0.11669639	0.29165881	0.16613201	0.25077400	0.31482913
3	0.09772110	0.17925860	0.44353484	0.23804359	0.35227515	0.43203729
4	0.11587680	0.19106299	0.42284404	0.22507759	0.34566819	0.46686611

```
  5 0.13046727 0.18891383 0.37655379 0.21000402 0.32700000 0.47934104
  6 0.15374550 0.19548643 0.35021220 0.20239253 0.31751404 0.52218673
  7 0.21488684 0.24791949 0.38519108 0.21214338 0.29487434 0.48221353
  8 0.26913668 0.29649661 0.42656720 0.22242162 0.28436494 0.44004821
  9 0.26913668 0.29649661 0.42656720 0.22242162 0.28436494 0.44004821
   year
age       1975       1976       1977       1978          1979          1980
  1 0.04832045 0.04583597 0.02646915 0.01513312 0.00007673234 0.00008442354
  2 0.28488090 0.28514151 0.15740593 0.08591427 0.00015281035 0.00018494133
  3 0.36448367 0.34946194 0.19860714 0.10463885 0.00016758152 0.00019240411
  4 0.37835898 0.34234415 0.19759860 0.10926232 0.00015553947 0.00017745472
  5 0.40146544 0.34546975 0.19048702 0.09635807 0.00013248412 0.00014858605
  6 0.47565192 0.45295585 0.25830187 0.12393257 0.00016531901 0.00017461969
  7 0.46145545 0.47279786 0.28446449 0.14158955 0.00019818255 0.00021477146
  8 0.41188435 0.42147870 0.24524194 0.12395656 0.00016520615 0.00017219710
  9 0.41188435 0.42147870 0.24524194 0.12395656 0.00016520615 0.00017219710
   year
age       1981       1982       1983      1984        1985       1986
  1 0.01809899 0.02500109 0.01824766 0.0113440 0.008980115 0.01060749
  2 0.13735475 0.22643722 0.17103472 0.1064722 0.086956171 0.11625626
  3 0.15533683 0.26677545 0.21598618 0.1375689 0.110403475 0.14388071
  4 0.15208625 0.27122274 0.22640128 0.1410874 0.109408469 0.14132478
  5 0.14038462 0.27784581 0.25931468 0.1612174 0.126232581 0.15938541
  6 0.16207498 0.32194373 0.31225975 0.1828648 0.143092598 0.16910995
  7 0.19157830 0.39073054 0.39615859 0.2167419 0.156306559 0.16269403
  8 0.15040596 0.35076981 0.39616786 0.2214356 0.161218173 0.16727503
  9 0.15040596 0.35076981 0.39616786 0.2214356 0.161218173 0.16727503
   year
age       1987       1988        1989        1990       1991        1992
  1 0.00714191 0.00546276 0.004621874 0.005677982 0.00449154 0.004953834
  2 0.07913010 0.06273204 0.055383231 0.076944089 0.06335851 0.079706238
  3 0.10016069 0.08008579 0.070792492 0.097403125 0.07842238 0.094826904
  4 0.10602795 0.08291400 0.070474209 0.101176918 0.08003071 0.089787993
  5 0.13291393 0.10404407 0.088009355 0.128762653 0.09940707 0.105911465
  6 0.15540284 0.11724983 0.097383784 0.147628743 0.11613173 0.123518661
  7 0.17429180 0.13421216 0.120276848 0.188829839 0.14506501 0.152999751
  8 0.20697089 0.16784458 0.161796151 0.270599963 0.19750341 0.200297800
  9 0.20697089 0.16784458 0.161796151 0.270599963 0.19750341 0.200297800
   year
age       1993        1994        1995        1996       1997        1998
  1 0.00508641 0.004122491 0.003962916 0.002577273 0.00394952 0.003713296
  2 0.09192440 0.080690283 0.086023165 0.055547004 0.10082123 0.099691444
  3 0.10337596 0.096000768 0.107154474 0.073195961 0.14364500 0.146806650
  4 0.08750930 0.080464500 0.097542374 0.076337310 0.17747810 0.182710502
  5 0.10064640 0.091199131 0.109191256 0.099676701 0.26758915 0.272739483
  6 0.11573346 0.105019836 0.119872838 0.119095539 0.34741371 0.347433823
  7 0.16137906 0.161285506 0.196155061 0.206457239 0.56263296 0.524265611
  8 0.20719217 0.219277405 0.256343530 0.264746998 0.56900705 0.471019282
  9 0.20719217 0.219277405 0.256343530 0.264746998 0.56900705 0.471019282
   year
```

age	1999	2000	2001	2002	2003	2004
1	0.003139443	0.002527381	0.001901076	0.00196423	0.001431607	0.001118418
2	0.087740066	0.073757907	0.057072745	0.06311133	0.045276881	0.034306754
3	0.133134213	0.120657512	0.101864824	0.12600570	0.098426023	0.078835549
4	0.145879953	0.135497137	0.117204579	0.15220133	0.126692014	0.112508036
5	0.190493497	0.180479148	0.173818688	0.23615979	0.195915057	0.192987046
6	0.212992906	0.194579836	0.196979920	0.25767364	0.209797927	0.224129189
7	0.281922409	0.246970054	0.265427040	0.33596979	0.302996749	0.324786688
8	0.243655167	0.211051736	0.237000711	0.29717971	0.302589797	0.362240839
9	0.243655167	0.211051736	0.237000711	0.29717971	0.302589797	0.362240839

year

age	2005	2006	2007	2008	2009	2010
1	0.0007849355	0.001076413	0.00149224	0.001059136	0.001679001	0.00217531
2	0.0228294934	0.033848314	0.05006011	0.032425480	0.055600876	0.07526371
3	0.0495012338	0.071630806	0.09175573	0.057072107	0.097828927	0.12888810
4	0.0601355920	0.096047235	0.10841709	0.064498892	0.119436455	0.15956140
5	0.0894361025	0.168920036	0.18260669	0.098339437	0.168359759	0.22690593
6	0.1026390570	0.229681833	0.26485167	0.144253151	0.219730105	0.26980539
7	0.1354931805	0.335071252	0.39380731	0.224645192	0.312778704	0.34598762
8	0.1493566920	0.397418369	0.49973936	0.306600236	0.430766960	0.48450289
9	0.1493566920	0.397418369	0.49973936	0.306600236	0.430766960	0.48450289

year

age	2011	2012	2013	2014	2015	2016
1	0.001983087	0.002002146	0.002332183	0.002246735	0.00256438	0.0008203486
2	0.067685194	0.069452474	0.084973023	0.082604573	0.09861846	0.0248490880
3	0.115278868	0.123730933	0.162834537	0.165541983	0.21140435	0.0545626210
4	0.142993000	0.157574514	0.240358201	0.260489404	0.33563326	0.0865862346
5	0.202831526	0.227194104	0.361075350	0.413013490	0.53408880	0.1308226469
6	0.239764229	0.280307757	0.477842489	0.568025644	0.83863423	0.2023116761
7	0.295347159	0.331008011	0.585516148	0.714353720	1.09636879	0.2709740410
8	0.428101628	0.502750283	1.000338491	1.243470361	1.65507517	0.4104019567
9	0.428101628	0.502750283	1.000338491	1.243470361	1.65507517	0.4104019567

year

age	2017	2018	2019
1	0.0006882971	0.0007750034	0.0003591785
2	0.0196694562	0.0222356081	0.0085751533
3	0.0461833346	0.0524898345	0.0190345915
4	0.0713228315	0.0859695370	0.0311034954
5	0.0989837791	0.1233108464	0.0389919079
6	0.1320752467	0.1523263451	0.0400577606
7	0.1447800666	0.1290489839	0.0270912436
8	0.2044354331	0.1597818284	0.0273919927
9	0.2044354331	0.1597818284	0.0273919927

, , **area = 6aS7bc**

Year

Age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0.007	0.008	0.007	0.006	0.007	0.007	0.005	0.005	0.005	0.006	0.007	0.007	0.008	0.009

3	0.013	0.015	0.013	0.011	0.012	0.013	0.01	0.01	0.011	0.014	0.016	0.015	0.016	0.018
4	0.014	0.018	0.015	0.012	0.013	0.015	0.012	0.013	0.015	0.019	0.022	0.02	0.022	0.023
5	0.018	0.022	0.017	0.013	0.014	0.016	0.013	0.014	0.017	0.021	0.025	0.023	0.025	0.027
6	0.021	0.026	0.02	0.015	0.016	0.02	0.017	0.019	0.022	0.028	0.032	0.028	0.031	0.035
7	0.031	0.038	0.03	0.021	0.023	0.029	0.026	0.029	0.033	0.041	0.046	0.037	0.04	0.044
8	0.031	0.045	0.03	0.017	0.02	0.03	0.024	0.028	0.034	0.046	0.053	0.034	0.036	0.039
9	0.031	0.045	0.03	0.017	0.02	0.03	0.024	0.028	0.034	0.046	0.053	0.034	0.036	0.039

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0	0	0.001	0.002	0.003	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.002	0.001
2	0.009	0.014	0.023	0.038	0.052	0.064	0.054	0.05	0.045	0.045	0.036	0.031	0.042	0.034
3	0.017	0.025	0.039	0.062	0.083	0.102	0.086	0.082	0.078	0.08	0.067	0.062	0.084	0.071
4	0.023	0.033	0.049	0.078	0.107	0.133	0.114	0.107	0.103	0.107	0.09	0.083	0.113	0.096
5	0.028	0.041	0.06	0.094	0.127	0.158	0.138	0.13	0.127	0.132	0.111	0.102	0.14	0.119
6	0.038	0.055	0.08	0.121	0.158	0.19	0.167	0.159	0.159	0.165	0.14	0.129	0.177	0.155
7	0.049	0.073	0.103	0.152	0.194	0.225	0.192	0.185	0.188	0.194	0.163	0.148	0.198	0.177
8	0.046	0.087	0.152	0.273	0.386	0.463	0.332	0.301	0.311	0.324	0.235	0.19	0.286	0.232
9	0.046	0.087	0.152	0.273	0.386	0.463	0.332	0.301	0.311	0.324	0.235	0.19	0.286	0.232

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.004
2	0.030	0.030	0.043	0.032	0.029	0.033	0.038	0.044	0.049	0.061	0.06	0.07	0.072	0.093
3	0.063	0.065	0.094	0.074	0.066	0.073	0.083	0.095	0.107	0.129	0.129	0.147	0.147	0.185
4	0.088	0.092	0.135	0.106	0.095	0.104	0.114	0.128	0.144	0.174	0.176	0.199	0.195	0.239
5	0.112	0.118	0.174	0.137	0.122	0.131	0.143	0.151	0.163	0.194	0.196	0.216	0.206	0.246
6	0.15	0.156	0.23	0.18	0.162	0.171	0.187	0.194	0.198	0.226	0.225	0.244	0.224	0.257
7	0.173	0.179	0.256	0.2	0.181	0.187	0.205	0.209	0.211	0.23	0.221	0.235	0.216	0.244
8	0.218	0.218	0.375	0.241	0.206	0.212	0.252	0.261	0.263	0.307	0.277	0.299	0.252	0.306
9	0.218	0.218	0.375	0.241	0.206	0.212	0.252	0.261	0.263	0.307	0.277	0.299	0.252	0.306

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0
2	0.074	0.063	0.055	0.053	0.045	0.041	0.045	0.06	0.057	0.058	0.047	0.048	0.035	0.022
3	0.147	0.128	0.116	0.114	0.098	0.091	0.1	0.136	0.132	0.136	0.112	0.115	0.085	0.054
4	0.183	0.155	0.144	0.145	0.121	0.109	0.116	0.158	0.155	0.166	0.138	0.143	0.107	0.066
5	0.181	0.151	0.142	0.144	0.121	0.105	0.105	0.138	0.134	0.15	0.132	0.144	0.111	0.068
6	0.185	0.15	0.142	0.143	0.119	0.103	0.097	0.118	0.109	0.125	0.114	0.135	0.112	0.07
7	0.173	0.137	0.124	0.12	0.096	0.081	0.074	0.084	0.071	0.079	0.072	0.091	0.081	0.055
8	0.175	0.119	0.096	0.086	0.056	0.039	0.031	0.034	0.022	0.023	0.019	0.029	0.027	0.015
9	0.175	0.119	0.096	0.086	0.056	0.039	0.031	0.034	0.022	0.023	0.019	0.029	0.027	0.015

	2013	2014	2015	2016	2017	2018	2019
1	0	0	0	0	0	0	0
2	0.020	0.019	0.011	0.014	0.015	0.012	0.014
3	0.051	0.054	0.030	0.038	0.041	0.033	0.037
4	0.067	0.074	0.040	0.050	0.053	0.04	0.043
5	0.076	0.090	0.048	0.063	0.066	0.049	0.051
6	0.086	0.107	0.058	0.078	0.087	0.063	0.066
7	0.073	0.096	0.054	0.074	0.086	0.065	0.069
8	0.029	0.050	0.02	0.034	0.049	0.032	0.037

9	0.029	0.050	0.020	0.034	0.049	0.032	0.037

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
1	1621420.73	2859151.85	3984463.95	1625673.66	2663844.39	3583033.16
2	1787827.76	729724.44	1346307.82	1901326.98	701152.24	1215003.13
3	609895.19	1164652.80	471679.91	885776.41	1209233.08	391997.82
4	262815.37	352747.36	713202.03	321242.88	593230.95	773075.06
5	291883.17	175375.29	195960.74	403792.94	230292.61	412313.20
6	133364.47	173433.37	108533.36	109020.06	243897.87	160546.60
7	58515.32	79174.73	92998.82	66881.60	67846.79	170069.38
8	10834.30	34780.97	40467.62	48873.19	41659.72	45330.53
9	34113.83	27280.01	32241.55	37178.89	48903.10	59271.90

year						
age	1963	1964	1965	1966	1967	1968
1	3601652.43	2445571.21	10273513.15	1824772.69	3826869.38	5117655.98
2	1661261.68	1703147.45	1042857.42	5411402.27	737183.48	1761662.03
3	736214.47	1079559.40	1112094.75	678959.31	3806679.72	452798.38
4	221922.73	441010.11	714877.76	724799.24	445571.12	2709152.88
5	474400.01	136994.67	273194.38	448303.89	459611.38	273301.76
6	274008.95	309114.72	88694.61	172923.76	276499.49	294361.62
7	101263.48	183736.12	204280.95	59344.81	103839.12	166007.35
8	106284.92	66498.65	119354.15	126157.66	37388.11	60728.54
9	64712.82	112421.60	115567.29	145622.35	158522.29	111667.29

year							
age	1969	1970	1971	1972	1973	1974	1975
1	3766355.8	4127746.7	8430309.65	3295333.37	1999872.33	2161104.6	2325272.56
2	2381024.4	1674979.4	1833231.58	4003373.83	1430626.29	850644.7	937017.17
3	1101687.3	1579248.7	972307.04	951722.79	2458945.04	707193.1	403172.18
4	290894.7	698820.4	906340.39	404254.45	517135.48	1223715.6	299293.77
5	1853492.5	186130.6	397691.60	411383.68	229995.27	250015.9	512684.77
6	180917.5	1145904.3	111892.88	190753.11	233589.33	116383.1	100922.63
7	195138.4	110563.3	672535.25	56799.04	107478.91	115293.1	43644.39
8	103617.3	109006.3	60941.63	329705.34	30974.25	55270.9	45651.87
9	106326.9	110907.8	113857.09	80892.66	221590.35	119825.6	64743.46

year						
age	1976	1977	1978	1979	1980	1981
1	1487959.34	1807505.24	2519526.92	2803894.98	1797651.11	2396987.77

2	1037500.05	628258.06	808263.32	1152167.82	1320957.48	787820.36
3	443459.75	493819.09	336971.80	478168.34	745639.71	851512.19
4	182350.09	191258.61	262737.37	198046.12	310221.81	487758.75
5	131783.10	81319.11	100654.88	139492.35	133934.29	194091.42
6	220771.84	57600.03	42419.40	59541.95	88373.12	90127.28
7	38562.41	86746.86	25618.65	23334.93	37333.55	60131.95
8	16408.90	14093.41	39793.11	13262.03	13716.80	21475.95
9	37306.49	15966.53	12760.38	24935.33	20533.08	18041.30

year

age	1982	1983	1984	1985	1986	1987
1	1914809.42	4855259.06	2516884.01	2913606.23	2610119.59	4570075.48
2	1119048.06	836906.14	2393660.83	1131375.41	1325994.40	1168895.30
3	428583.99	595880.44	448803.23	1522431.64	698597.98	756290.67
4	469685.11	213975.69	305820.36	242312.87	947632.81	403404.45
5	272337.59	230004.90	108085.72	171061.25	143033.77	546956.01
6	108863.88	134117.26	106571.84	59025.31	101662.78	76862.41
7	48487.02	51596.65	59617.62	55196.98	31299.44	53560.47
8	32638.60	21323.38	20946.40	29581.07	28294.06	17056.02
9	19817.58	23035.31	16338.51	17257.55	23059.43	26964.80

year

age	1988	1989	1990	1991	1992	1993
1	1996257.95	1651209.32	1286884.22	1015940.78	1530360.33	1272803.34
2	2215851.31	906074.30	757999.08	589529.93	448282.41	727589.93
3	689946.73	1480494.86	593609.55	459697.09	361300.37	253358.23
4	430944.63	403751.33	917823.12	394387.60	283659.61	212391.48
5	230094.10	246580.25	249426.59	501394.69	278131.74	168195.59
6	294516.00	132046.73	139811.17	140648.74	261730.18	180055.49
7	36858.67	155587.92	79595.76	72818.99	76183.84	129752.17
8	24796.19	19027.08	80753.49	43294.63	37250.63	40164.36
9	18034.37	21232.16	20106.43	42467.42	39731.15	35832.53

year

age	1994	1995	1996	1997	1998	1999
1	2075165.69	1624282.11	1784160.64	2046565.12	1040343.039	917830.932
2	593239.66	982801.97	771013.37	832542.35	977542.179	454477.441
3	417157.70	334781.03	550958.83	459040.34	476260.366	651963.512
4	130939.79	223964.79	181797.22	266101.14	245093.955	237739.046
5	122867.68	70090.46	104026.06	101994.57	126279.938	114587.224
6	99290.82	71119.02	40718.23	55878.14	48255.265	50157.352
7	103210.22	53659.26	37474.19	21268.33	22605.731	19578.068
8	63131.92	54528.40	28782.67	21255.36	7315.885	7136.538

9	36232.19	44143.08	44818.08	28529.03	17084.472	8797.788

age \ year	2000	2001	2002	2003	2004	2005
1	2665808.796	1809201.594	1954526.08	1109916.12	939121.78	955248.10
2	394698.303	1311957.432	837613.18	927897.46	511921.32	424926.10
3	256577.829	212098.004	838516.61	503685.32	582403.71	315666.82
4	375524.698	136776.474	107700.00	462189.80	306595.22	372539.30
5	118852.113	206281.002	78397.09	56137.15	236516.77	198696.33
6	58147.831	64221.376	114199.94	41792.54	28222.18	119868.35
7	25185.335	31882.167	34906.69	52932.51	27545.86	13369.76
8	8821.889	12659.914	15288.72	16892.39	23349.90	15569.23
9	7805.991	8625.599	10955.10	12993.48	15565.91	17205.72

age \ year	2006	2007	2008	2009	2010	2011	2012
1	857047.698	548152.21	666242.74	734076.46	1182492.30	528627.111	535945.174
2	457430.274	411740.87	254910.51	313108.52	332840.02	571840.264	237246.761
3	241275.944	276144.16	235981.11	156716.64	189342.56	195458.395	372060.843
4	177547.622	125033.35	147925.25	126017.26	85689.07	100536.931	108353.557
5	241025.205	100931.25	66909.13	82487.74	68080.71	44101.053	51466.620
6	137353.721	127940.44	53115.30	39024.21	39855.24	33785.132	24067.923
7	72383.587	75699.51	67598.39	30235.90	20961.67	17348.157	16939.841
8	8375.511	34676.38	34935.18	36970.04	15366.91	9765.047	7574.562
9	20023.870	13441.10	22668.28	30717.56	33041.36	22297.694	15243.376

age \ year	2013	2014	2015	2016	2017	2018
1	268022.814	342445.895	552206.764	227371.2386	254278.029	337514.820
2	244457.111	119459.563	156743.836	277013.1899	102209.239	117668.819
3	157270.960	147378.757	73764.617	93841.9096	206224.192	72299.939
4	223739.445	100122.708	83409.177	43973.1995	64214.826	137570.990
5	57171.739	117600.510	54105.219	38348.6113	29137.574	43741.427
6	25131.530	25858.218	45586.277	23675.2651	21308.322	17840.587
7	13748.991	10051.983	8997.215	12200.1982	13008.928	11627.187
8	8156.232	5617.871	3835.775	2140.5257	5249.835	7287.326
9	9951.675	4383.980	1747.460	769.4412	1458.965	3380.045

age \ year	2019
1	708296.430
2	155160.975
3	78498.895
4	53078.670

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5  85670.432
6  26951.191
7  10284.000
8   6459.892
9   5988.174
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Table 4.6.18. Herring in 6.a (combined) and 7.b-c. PREDICTED INDEX-AT-AGE catch N 6.aN and 6.aS/7.bc.

Units : NA

age	1957	1958	1959	1960	1961	1962	1963
1	14641.620	31497.830	43838.357	15489.523	22448.437	43403.553	36376.560
2	82650.504	42338.394	76894.587	90393.246	28038.213	72325.385	77463.933
3	50370.960	117324.829	43165.252	60889.014	63205.058	29833.240	44960.547
4	25996.437	43753.929	83761.776	26737.474	35140.275	67065.116	14979.172
5	34938.477	26750.088	28638.727	43072.995	16666.811	43433.610	37568.900
6	17492.384	29334.415	16979.176	11864.230	16713.047	17041.503	22372.851
7	9146.243	16772.992	18350.894	9096.193	5605.480	21527.133	9869.904
8	1707.060	7732.898	8544.823	7077.290	3669.751	6207.912	11803.815
9	5374.996	6065.199	6807.871	5383.848	4307.811	8117.151	7186.891

age	1964	1965	1966	1967	1968	1969	1970
1	23717.560	95805.995	22079.995	43099.304	46406.897	45735.20	78030.37
2	72611.156	40800.400	279689.630	34768.640	64773.734	126742.68	153079.98
3	61019.981	59633.971	44678.487	236147.395	22272.332	85913.74	217507.49
4	28178.421	47316.240	58755.223	34160.068	156495.710	26817.84	102568.07
5	9760.971	20221.014	40289.408	39247.513	17201.049	192494.92	27223.56
6	23533.808	6984.516	16899.651	26865.102	21501.577	21903.51	172791.68
7	17652.538	20786.181	7086.905	12593.626	15755.806	32076.58	20622.21
8	7733.208	15323.803	18901.524	5601.638	7073.749	20858.74	23848.78
9	13073.644	14837.610	21817.813	23750.449	13007.167	21404.19	24264.79

age	1971	1972	1973	1974	1975	1976	1977
1	325744.17	79167.104	64703.653	81038.27	76733.20	46610.039	32983.703
2	387019.89	508179.554	262827.140	189452.80	190148.32	209644.388	74508.748
3	294753.85	168934.497	610323.883	205862.62	100992.83	106367.178	72433.372
4	265605.58	68533.451	126662.812	379308.54	77135.42	42707.901	27789.472
5	106552.81	65847.734	53930.658	79260.57	138807.13	31026.278	11402.210
6	28163.31	29413.402	53086.347	39123.26	31023.90	64370.473	10519.361
7	182952.99	9095.882	22743.019	36025.89	12935.63	11502.268	17109.660
8	18054.29	54734.545	6215.821	15244.56	11379.76	4041.154	2294.340
9	33730.79	13429.031	44468.107	33049.75	16138.77	9187.771	2599.276

age	1978	1979	1980	1981	1982	1983	1984
1	26419.900	150.087093	105.875766	30036.551	33049.324	61329.953	19827.347
2	54140.374	143.079682	198.607366	82941.628	186944.174	107747.162	198220.895
3	27221.630	65.021900	116.287145	100451.012	82804.136	94414.444	47192.572
4	22034.954	24.894498	44.416664	56267.438	91889.179	35170.272	32806.293
5	7475.834	14.907383	16.016958	20764.478	54429.820	42544.077	13103.232
6	3959.143	7.843519	12.265434	10907.014	24498.246	28797.208	14317.732
7	2687.493	3.647714	6.306812	8429.307	12786.041	13472.634	9290.869
8	3498.368	1.634647	1.751462	2330.929	7721.602	5363.533	3248.220
9	1121.815	3.073470	2.621816	1958.142	4688.420	5794.141	2533.661

age	1985	1986	1987	1988	1989	1990	1991
1	18190.323	19235.226	22703.756	7593.004	5316.215	5087.318	3178.379
2	77365.995	119610.818	72563.349	110407.667	40062.850	46017.876	29581.420
3	130496.492	76792.758	58258.673	43291.127	82775.650	44965.840	28149.274
4	20522.313	101986.738	32461.127	27760.469	22348.841	71622.690	24465.907
5	16549.530	17165.198	54020.629	18331.165	16850.835	24383.380	38137.903
6	6332.612	12703.590	8595.924	25836.268	9787.876	15297.528	12192.104

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  7   6383.004   3746.845  6603.495   3651.596 14018.142 10892.517  7744.946
  8   3450.956   3415.015  2338.691   2973.083  2238.728 15113.240  5999.531
  9   2013.283   2783.209  3697.366   2162.336  2498.179  3762.974  5884.901
   year
age      1992      1993      1994      1995      1996      1997      1998
  1  5278.944  4507.427  5957.286  4482.879  3203.664  5627.858  2688.773
  2 28010.644 52024.048 37223.898 65596.850 33548.049 64349.506 74044.971
  3 26401.492 20004.488 30385.555 27070.533 30654.719 48570.224 50564.942
  4 19528.220 14162.607  7948.343 16337.241 10370.788 33796.368 31364.030
  5 22392.210 12824.857  8410.272  5691.423  7675.067 18846.225 23321.442
  6 23971.561 15478.137  7685.250  6244.938  3523.594 12884.323 10968.077
  7  8499.709 15201.421 11979.390  7490.778  5445.922  7300.812  7261.224
  8  5207.825  5786.570  9391.637  9455.733  5087.136  7250.928  2103.827
  9  5554.615  5162.474  5389.976  7654.821  7921.284  9732.224  4912.976
   year
age      1999      2000      2001      2002      2003       2004       2005
  1  2006.948  4695.147  2397.925  2676.645  1108.261   732.7391   523.1486
  2 30718.627 22685.083 59023.145 41580.670 33442.038 14075.4383  7802.8883
  3 64226.857 23236.924 16444.474 79622.739 38103.821 35716.2972 12266.4489
  4 25305.749 37768.697 12052.776 12128.945 44297.315 26409.6953 17510.3819
  5 15761.795 15768.668 26536.107 13315.148  8136.199 34058.2755 13895.8424
  6  7644.673  8290.208  9291.399 21031.859  6468.708  4670.6192  9623.8122
  7  3863.690  4491.570  6095.574  8203.919 11502.282  6398.6086  1415.1386
  8  1236.409  1376.898  2215.983  3281.579  3733.627  6061.4063  1840.9705
  9  1524.221  1218.339  1509.819  2351.408  2871.875  4040.7586  2034.4752
   year
age       2006      2007       2008       2009      2010       2011       2012
  1   643.4501   570.454   492.1991   859.6033  1793.578   731.1442   748.5002
  2 12304.8679 16281.879  6579.3723 13779.7841 19641.028 30634.5184 13109.6692
  3 13211.2459 19228.569 10365.1536 11709.3727 18357.237 17284.6197 35685.0582
  4 12863.5067 10181.468  7274.7161 11335.2192 10090.818 10863.4293 13061.0824
  5 30255.7850 13637.883  5019.6449 10353.0092 11158.507  6626.1211  8734.5964
  6 23077.2987 24509.050  5807.1425  6312.4219  7670.053  5916.8814  4929.4301
  7 17245.2184 20773.945 11366.3875  6826.9742  5117.205  3711.8843  4045.7550
  8  2353.8509 11781.899  7922.3850 11173.7383  5080.880  2926.2698  2593.0755
  9  5627.5020  4566.845  5140.5728  9284.0029 10924.717  6681.9001  5218.4169
   year
age       2013       2014       2015      2016      2017      2018      2019
  1   435.9744   536.6468   987.6602  130.1891  122.1645  182.5792  177.6021
  2 16427.2201  7812.7080 12198.7541 5612.1823 1642.1072 2137.2649 1092.7287
  3 19523.3659 18553.8513 11744.0097 4126.3357 7695.9691 3069.1775 1225.0921
  4 39608.2664 18978.7999 20008.2151 3029.7054 3665.2371 9457.5207 1352.4408
  5 14481.7872 33111.9090 19040.7015 3924.8700 2285.6511 4260.8148 2741.5104
  6  7994.3006  9330.1759 22174.1800 3611.9574 2182.3412 2110.0752  881.7531
  7  5162.9206  4325.1936  5193.8723 2429.4314 1456.8138 1180.3933  229.3586
  8  4500.4833  3484.0517  2761.9493  617.5747  821.7244  917.0071  147.8521
  9  5491.1810  2718.8261  1258.2584  221.9957  228.3627  425.3310  137.0556
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Table 4.6.19. Herring in 6.a (combined) and 7.b–c. INDEX-AT-AGE RESIDUALS catch N 6.aN and 6.aS/7.bc.

Units : NA

age \ year	1957	1958	1959	1960	1961
1	3.8568573860562307	0.0453761341075674	1.86167133	-2.08950943	-0.01844039
2	4.0616251067254199	0.0000116176110546	0.46430180	0.89574449	-1.17084310
3	0.0064368284001618	5.3119217944512105	-0.07711011	-0.03546531	-0.04815150
4	0.0199692719062901	0.0000000006717216	1.42715700	0.03887262	0.13472593
5	0.0241085032815805	-5.5358432232915984	-0.71332877	-0.06419766	2.44061538
6	2.9101418533669925	-0.0000001557575647	0.19958087	-1.49559780	-0.95948607
7	2.3781625396949164	-0.0636613679482962	-0.80011851	0.24128848	0.01388837
8	6.2451529345019674	-5.0621584256128180	-0.39389634	-0.40656936	1.04689001
9	-0.0000000001014859	-0.0000009296279224	-0.07712294	-1.50207846	-1.63976676

age \ year	1962	1963	1964	1965	1966	1967
1	1.545099480	-0.516475139	0.76287531	2.3935189	1.85544152	0.6213707536
2	0.009476424	0.075756984	0.03402867	-1.2709774	1.77029621	-1.8970657780
3	-2.464396761	-0.153084489	0.05978380	1.4537493	-2.26615669	2.5502759655
4	0.717015467	-2.220218473	-1.51972666	0.8657217	-0.16731562	0.8237496532
5	1.051325364	-0.004498869	-0.95252072	-0.3144383	-0.30901196	0.0008340735
6	1.984823319	1.119859549	0.30361898	-1.4091777	-0.04414642	0.1734715744
7	0.484870684	-0.294753434	0.66079352	0.2242580	-1.00886349	-0.4837526964
8	0.499331126	0.786040741	0.77749143	0.6309373	-0.31431420	0.0734702780
9	0.459005155	0.445137820	0.84048164	0.8568612	0.52314377	0.1947302892

age \ year	1968	1969	1970	1971	1972	1973
1	1.3683782	-0.31222483	0.82749726	0.8671359	0.88141094	-1.27795207
2	-0.0952595	0.08660013	-0.48766717	0.3773392	0.66169086	-0.01712888
3	-1.2199634	0.35707818	2.02204047	0.4779510	-0.63232540	2.12674099
4	0.4090388	0.22472129	-0.09276519	-0.1388656	-1.61671568	0.02845389
5	-1.1265921	1.27403725	-0.42893253	-0.7593279	0.08471802	0.45334101
6	0.2745077	0.12027720	-1.23197229	-0.2969515	-0.28022913	-0.01685711
7	-0.2424793	1.19476052	-0.42889321	-0.9299338	0.18519077	-1.26845868
8	-0.5309662	0.24940725	-0.25523339	-0.2174633	-0.15296005	-0.47191804
9	-0.2437463	0.26944822	-0.42245281	-0.4211988	1.39398015	-0.86348571

age \ year	1974	1975	1976	1977	1978	1979
1	0.22543951	0.05873452	-0.46026097	-0.8702947	-0.46990926	-2.5366587
2	-0.94845570	-0.14247940	0.53082321	-0.7392238	-0.08593096	-3.1469993
3	-0.32902405	-1.10248271	-1.25034038	0.8892728	-1.15649344	-2.2884123
4	2.44654846	-0.71258675	-0.66417264	-0.7067195	1.71626448	-2.3735802
5	0.58369702	0.95188517	-0.73153330	-0.2249700	-1.15147174	-1.6288268
6	1.42065622	0.01227114	0.96994773	0.6280251	-0.72759619	-0.2747566
7	-0.08395961	-0.16420139	0.03363985	0.8550266	-1.09089452	0.2375054
8	0.63185309	0.10003919	-0.37075466	-0.1616905	1.02025455	-1.5913961
9	-1.08071137	-0.25430355	0.29597530	-1.9173316	-0.04820941	0.0000000

age \ year	1980	1981	1982	1983	1984	1985
1	1.1382326	2.113197	-0.82177068	0.1119016	-1.6310932	0.03709153
2	-0.1414857	3.379273	1.82742603	-0.7827524	1.9017430	-0.21245440
3	-1.0945453	2.786957	-0.95129125	0.1487972	-0.7588799	0.81455393
4	0.3278985	1.755068	0.01930639	-0.8001218	-0.7966717	-1.76422780
5	-0.2483017	1.212084	0.70399820	0.2534354	-0.2252956	-0.13867320
6	-1.0788572	1.282808	-0.21870205	-0.2097654	-1.6754379	0.08553977

```
  7  1.0309544  1.438358 -0.32021922  0.2741895 -0.7836584 -0.55614107
  8 -1.2810676 -1.142957  2.36034876  1.3388076  0.4194853 -0.18624208
  9  0.0000000 -1.418447 -0.35196246  0.4090843 -1.3639428 -0.59691768
   year
age       1986       1987       1988        1989         1990        1991
  1 -0.1097627 -0.3595781 -1.5065555 -0.52735359  0.076674668  0.30882663
  2  0.5925513 -0.1025166  1.3757884  0.06045297  0.002778193 -0.76104137
  3  0.1378614 -0.6356554 -0.5740236  1.29357195  0.445442859 -0.06256543
  4  0.4242240  0.6849545 -0.3310720 -1.40248879  0.391831906  1.33566215
  5 -0.2541080  0.5191536  0.1807160 -0.25376628  0.281924360 -0.82715860
  6  0.3051730  0.1414218 -0.1924166 -0.85872294 -0.569644593  0.35778717
  7 -2.7209967  0.9460878 -0.7817801  0.40943929  0.483444306 -0.38281648
  8 -1.4327516  1.7251967 -0.3627803 -0.08094913  0.863865617  0.52876124
  9 -1.3935545  0.8789557 -0.3132126  0.38557779 -0.074660436 -1.69866395
   year
age        1992         1993        1994       1995        1996       1997
  1 -0.38463924  0.578093669 -0.77011290 -1.9053599 -0.58037882 -0.7599113
  2  0.03909353  1.443151791  1.09328482  2.0539545  0.54030945  1.1327188
  3  0.26661709 -1.429141510 -0.10254355 -0.2443528 -0.91030967 -0.2593485
  4  0.76976324 -0.661101072 -1.78403645  0.5067692 -0.11494366  0.4851624
  5  0.69611779  0.455236802 -0.08941103 -0.6445548 -0.02044922  1.8612794
  6  0.24406932  0.685245364  0.52016313 -1.0472959  0.32373435  1.6890381
  7 -0.90412208  1.128429120  0.72841429  1.2730232  0.68957744  1.0827754
  8 -0.36194108 -0.007505752  0.89274380  0.1612683  1.81380931 -0.7432733
  9  0.09428022 -0.055622223  1.61035585  1.0807988  3.12110370 -0.4547529
   year
age        1998        1999        2000       2001       2002       2003
  1  0.01612008 -0.13448681 -0.15792767 -1.7937331 -0.6716607 -2.1647547
  2  0.07688598 -0.56501841 -0.43119599  2.0119793  0.5063049  1.1959030
  3 -0.76486570  2.18616560  0.39332770 -1.2988624  0.8527155  0.5441333
  4  0.55499823 -1.40318257  1.38081479 -0.6570912 -1.2713718  0.4286503
  5 -0.03842348 -1.25006253 -0.25000065  0.7472909  1.4060218 -0.5960918
  6  1.03470072 -1.15391859  0.03527172  0.6585792  0.5290751 -0.9532226
  7  0.06879730 -1.04039006 -0.54263089  0.9630438 -0.1306426  0.6117949
  8  0.23353415 -0.23042055  0.40514825  1.6372313 -1.7871608  2.4688726
  9 -0.43458117 -0.06354671 -1.38531183 -0.9792775 -0.8709374 -1.3478524
   year
age        2004        2005         2006        2007        2008         2009
  1  0.00000000 -0.90982267 -0.568201996 -0.55041324  0.00000000  0.976734437
  2 -0.75618621  0.27646458  0.545152938  2.12291916  0.08599671 -0.042461927
  3  0.33237571  0.75795997 -0.899861119 -1.43664071 -0.58065718 -0.306459185
  4  1.68871919 -0.93172677  1.138202581 -2.10502160 -1.26078571  1.205471226
  5  1.20803368 -1.72974399  2.238575404  0.24460131 -1.56566376 -1.046577702
  6 -0.04731515 -0.52988716  2.058961009  0.89876810  0.21679251 -0.663872144
  7  1.88669966 -2.00625762  1.136531308  0.43398285  1.21764795 -0.285456038
  8  0.72427675 -0.03913166  1.082558276  0.57693454  0.35908927  0.018002923
  9  0.16975671 -0.71713201  0.001524909  0.08917023  1.67270348  0.001275926
   year
age       2010        2011       2012       2013       2014       2015
  1  1.3092960  0.01554273 -0.1430627  0.0000000  0.0000000 -0.4151762
  2 -0.5969578  0.32215449 -0.2395992 -0.4524899 -0.3138966  0.4164945
  3 -0.3388688 -0.78207215  1.2385907  1.3286381  0.2013840  0.6248313
  4  0.1054613 -0.14209151 -1.1105250  1.6330545  1.5437756 -0.7095938
  5  0.8646664  0.22417776 -0.2152577 -0.8793781  0.8217508  0.4152537
  6 -1.5426722 -0.38659918  1.3169795 -0.3563523 -0.9955322 -0.1282641
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  7 -0.9176793 -1.19693575 -0.5284426  0.7996665 -1.1353218  0.3544624
  8  0.2190244 -0.19346345 -2.0580577  0.2316324  0.1587301 -0.7280533
  9  0.4997740  0.42304579 -0.1722264 -0.2967277 -0.4048166 -1.4260896
   year
age        2016         2017        2018       2019
  1 -1.88404846  0.000000000  0.00000000  1.4072985
  2  1.10041924 -0.751567916  0.02531965 -1.2270259
  3 -1.73558106  2.312874400  0.49250309 -1.3919800
  4  0.25544760 -0.252463684 -0.40158801  1.3728579
  5 -1.55631727 -0.697096641  1.52575911 -0.8485570
  6 -0.06665280 -2.050051138  0.84763368 -0.9359209
  7  0.01265813 -1.242124075 -2.78018900 -1.9734107
  8 -0.02617118 -1.684404692 -1.17487547 -2.9611571
  9  0.72243864  0.002070352 -0.20139867 -3.1631557
```

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

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Units  :  NA
   year
age      1957       1958      1959      1960       1961      1962      1963
  1  184.2950   410.0886  506.2807  170.4285   314.1660  432.1417  277.8675
  2 9376.2644  4539.9760 7522.7505 9154.6550  3725.0069 6661.8858 6649.7179
  3 6109.5469 13618.2471 4844.7753 7743.9368 11800.3463 4126.0460 5986.8193
  4 3016.8939  4866.2701 8371.6752 3087.6144  6398.8945 9417.5724 2181.0410
  5 4130.4698  2933.7434 2621.4056 4115.0045  2597.0494 5383.8562 5147.9734
  6 2249.7244  3493.7370 1720.3841 1295.2239  3221.6868 2565.7623 3784.7962
  7 1381.6009  2223.8985 2064.5650 1126.1791  1274.7327 3939.0126 2096.8100
  8  262.6796  1157.7795  898.2497  662.7010   659.6197 1049.0919 2039.9215
  9  827.0957   908.0895  715.6576  504.1310   774.3079 1371.7394 1242.0301
   year
age      1964       1965       1966       1967       1968       1969       1970
  1  175.8823   813.7241   193.4867   486.0397   633.8954   574.9209   733.1722
  2 6542.9598  4330.2827 27561.7183  4267.1038  9939.4847 15420.3315 11908.7376
  3 8761.8994 10059.6696  7617.9125 48334.7312  5388.2584 14260.8805 21318.1282
  4 4545.8368  8438.1260 10841.5966  7745.4219 43470.2865  4981.9839 12336.4415
  5 1614.7932  3710.8454  7743.4059  9260.6853  5025.4443 37128.3522  3942.4760
  6 4725.9428  1582.9791  3863.1436  7069.7915  6634.8957  4448.5284 30686.5804
  7 4229.5934  5421.2430  1927.4786  3727.6836  4965.6025  6038.2238  3678.0769
  8 1489.4030  3217.1098  4495.6014  1518.4363  1647.2347  2786.5616  3125.0418
  9 2517.9621  3115.0376  5189.2211  6438.0357  3028.9254  2859.4301  3179.5545
   year
age      1971      1972      1973      1974      1975      1976      1977
  1  1499.017  1076.958  1301.944  2751.959  4555.581  3800.845  3653.620
  2 11920.263 42248.203 23916.731 22750.921 34726.294 46707.429 25355.185
  3 11406.697 17774.826 66930.599 29451.712 23134.832 30904.210 31345.984
  4 14237.969  9898.192 18026.962 63527.650 21822.687 16593.227 15975.913
  5  7996.859 12770.963  9924.324 15569.011 43742.751 14210.578  8246.357
  6  3028.610  8008.090 13317.917  9050.256 10309.044 27030.138  6790.521
  7 23366.280  3109.820  7960.990 11354.078  5430.063  5476.607 11548.619
  8  1951.204 21509.673  3316.725  9473.663 10677.483  4441.964  3107.818
  9  3645.429  5277.363 23727.912 20538.614 15142.803 10099.034  3520.872
   year
age      1978      1979      1980      1981      1982      1983      1984
  1  4534.748  4364.727  2627.318  2494.290  1625.710  5919.649  2367.545
  2 31301.943 42515.252 47858.921 21535.172 25920.551 26457.074 64083.613
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  3 21237.036 30165.227 48366.525 43440.317 19172.821 36563.811 24239.018
  4 21489.278 16536.938 26739.844 33279.803 28188.301 17627.543 22241.552
  5 10059.520 14264.906 14188.064 16375.300 20032.848 22941.831  9707.733
  6  5085.736  7547.834 11558.534  9427.336  9832.863 16283.402 12173.434
  7  3505.195  3459.140  5697.417  7155.743  4846.910  6731.246  7583.720
  8  8488.880  3072.666  3297.766  3642.984  4173.149  3878.584  3405.980
  9  2722.112  5777.241  4936.524  3060.360  2533.862  4189.974  2656.716
   year
age      1985      1986      1987      1988      1989       1990       1991
  1  2262.725  1979.913  5493.778  1617.443  1106.996   989.4307   923.9451
  2 26524.274 30739.971 39321.423 56929.695 20649.081 19495.3379 17757.5298
  3 75036.995 34904.845 54956.453 39945.433 76830.127 33606.0691 29782.4463
  4 16465.979 66348.463 41265.537 35591.862 30096.309 73657.1327 34917.0624
  5 14726.444 12750.388 70801.052 24053.320 23328.768 24740.5383 54754.9896
  6  6632.929 11746.929 12694.739 39757.497 16299.685 17729.4086 19606.7371
  7  7072.103  4123.128  9714.400  5450.486 21151.924 10786.9462 10925.9248
  8  4666.784  4459.464  4238.577  4260.802  2854.324 11820.5128  7649.0237
  9  2722.594  3634.427  6701.001  3098.899  3185.117  2943.1334  7502.8773
   year
age      1992      1993      1994      1995      1996      1997      1998
  1  1630.227  1499.672  3228.989  2440.676  3276.843  3901.900  2747.270
  2 15433.635 27611.054 27959.645 45879.466 42131.316 45803.891 68808.024
  3 26586.471 20609.064 40682.533 32703.209 61676.859 49644.906 63689.730
  4 27932.590 23369.773 17150.404 29470.915 27006.946 37120.768 40971.782
  5 31869.784 20829.055 17856.873 10226.127 16641.973 14489.365 21020.501
  6 37683.317 26498.425 16554.900 11725.921  7221.479  8294.526  8128.192
  7 11606.299 19831.652 17113.255  8430.464  6211.661  2802.984  3381.644
  8  6784.195  7336.425 13168.692 10220.144  5753.484  3216.235  1366.720
  9  7235.955  6545.173  7557.675  8273.644  8958.868  4316.844  3191.641
   year
age       1999       2000       2001       2002       2003       2004
  1  1770.2588  4039.2047  2204.9158  2239.0026   986.2229   709.6275
  2 25970.0058 19382.8594 56382.8169 35028.5745 33285.5607 16920.8005
  3 70992.8910 24614.2913 18679.3638 71792.9844 37789.0645 41137.8150
  4 31682.9917 43105.8883 14848.4667 11555.9154 42388.2555 25567.3986
  5 14972.6243 13167.9786 21727.7169  8141.0734  5030.9752 18514.1815
  6  6630.5928  6382.0370  6697.6998 11652.2763  3674.6327  2145.4023
  7  2366.5573  2491.0641  2851.2653  2934.2268  3662.3174  1593.9159
  8   889.3917   778.7635   900.7033   953.1003   685.1154   651.9796
  9  1096.4251   689.0838   613.6775   682.9421   526.9850   434.6338
   year
age       2005       2006       2007       2008       2009       2010
  1   763.1957   964.2935   558.8803   694.8931   584.8458   989.4075
  2 15350.7635 21811.9802 18520.3761 11757.7011 11649.4671 12536.2020
  3 24836.2624 25162.7579 27733.8751 24709.0062 13424.3710 16345.7177
  4 33748.7191 21193.9273 14598.4218 18727.2278 13136.6162  9068.5398
  5 16321.8385 24726.6914 10002.5002  7676.6258  8089.7815  7070.6361
  6  9087.0360 11895.5784 10052.6993  5022.3622  3278.4256  3844.0811
  7   769.8549  4317.7432  3752.3943  3990.9277  1568.9298  1338.6236
  8   378.7280   201.2017   518.4225   606.3055   481.2873   299.9599
  9   418.5362   481.0258   200.9485   393.4115   399.8906   644.9625
   year
age       2011        2012       2013       2014       2015       2016
  1   297.5865   168.52934    71.0223   88.42882   63.32991   37.47301
  2 15857.9873  4143.62089  3782.4004 1839.27811 1298.88145 3097.42672
```

age						
3	12750.2914	15461.83143	6135.8224	6041.67382	1647.20272	2885.82674
4	8158.3488	5446.07622	11070.6655	5400.95264	2363.45560	1765.50255
5	3635.4709	2622.01624	3048.1096	7206.11439	1715.92294	1878.20870
6	2753.9539	1236.76180	1442.1495	1752.89585	1526.36655	1390.39874
7	1021.8895	669.50934	645.1744	578.70420	253.47214	659.66408
8	181.5010	79.53506	132.4734	140.39475	33.16150	51.81054
9	414.4427	160.05979	161.6350	109.55891	15.10735	18.62400

age \ year	2017	2018	2019
1	47.02509	48.47454	130.2557
2	1247.42726	1175.76814	1825.0202
3	6788.94562	1905.75674	2352.1785
4	2742.11052	4441.23117	1876.7499
5	1531.57336	1692.64623	3568.0359
6	1429.74791	878.79643	1450.3490
7	866.78735	593.32179	580.8844
8	196.66721	182.07359	197.2603
9	54.65514	84.45031	182.8558

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

Units : NA

age \ year	1957	1958	1959	1960	1961	1962
1	0.0000000000	-0.08515360890	1.205695220	0.10940606	0.3523910	-0.8009565
2	0.0176355987	5.16229674448	1.876701505	2.05274646	-0.2923889	-0.4814406
3	-0.3653573283	-0.00002616155	-0.009514356	-0.02009563	0.5298422	0.1610676
4	0.0110348638	0.76974964907	0.160261436	0.90398081	0.7618430	0.4970246
5	0.0052478881	0.44299368151	-1.557566897	-2.93854818	0.3900659	0.5355414
6	1.1878666958	0.61468478909	-0.023483747	-1.23891963	0.2165232	1.5062561
7	2.7642791979	1.92222827905	-0.144776093	0.08974163	-0.4550517	0.8688716
8	0.0000151865	0.01054187585	-0.630216939	-0.06221864	0.5491187	1.2380725
9	-5.3520041042	0.24299380431	-0.542299244	-1.36910939	-0.4224173	0.6356603

age \ year	1963	1964	1965	1966	1967	1968
1	-1.0360411	-0.93420483	0.04731996	0.00000000	0.0000000	0.22972079
2	-0.5835777	0.21666249	0.30175335	0.05711769	-2.0783943	0.11818792
3	-0.8797072	-0.46607666	0.58551162	2.11301955	1.5717207	-0.61145341
4	-0.4796221	0.13628813	0.44338718	0.33704646	1.5969751	1.49443053
5	-1.0680630	1.15093425	-0.91672320	0.10063371	0.1608330	-0.17672032
6	0.5503309	0.02292908	1.10512426	-0.35158963	-0.4159321	-1.24729469
7	0.6389502	0.33734391	0.43615555	2.07816197	-0.4369440	-1.91885294
8	-0.2277244	0.50199577	-0.30060762	-0.89438209	1.3964391	-1.63712311
9	1.5575025	0.67870327	0.52914684	0.18609493	-0.1785971	-0.07519291

age \ year	1969	1970	1971	1972	1973	1974
1	1.04019513	-0.93520070	0.30980208	0.022773483	1.6323240	0.7542648
2	0.52799267	1.84298766	-2.23346755	0.964206741	0.7031316	0.4327145
3	-0.47281031	-0.32334248	-2.56589931	0.355429263	-0.4691261	0.6569663
4	-0.40664219	-0.42494961	-0.12228670	-0.919337011	0.1093625	-0.8004945
5	1.16388687	0.02916102	0.93238409	0.001149381	-0.4714843	0.3759125
6	0.47750381	0.93727054	1.34028630	0.855052653	-0.1462350	-0.4044232
7	-1.02089563	-0.21791730	1.15996572	0.671278298	0.3557636	-0.2365391
8	-0.82335774	-1.02115135	0.24967940	1.622009501	-0.3134155	0.3954253
9	0.02187337	-0.55972277	-0.09848908	-0.129992332	1.5789814	0.8956188

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    year
age       1975       1976        1977        1978       1979        1980
  1  0.7015174  0.8764790  0.12287259  0.84467430  0.1207658 -0.69262358
  2 -0.3129001 -1.6047644 -0.09741132 -0.09228866 -0.2447029 -0.67863361
  3 -0.2668195 -0.1044923 -3.19562082  0.01046039 -1.2276329  1.12575464
  4  0.5325000  0.9435838 -0.31029757 -2.14536382  0.7664517 -0.16797863
  5 -1.7154499  1.0859277  0.54729991 -0.08800496 -1.2309013  1.23925628
  6 -0.3042665 -2.1993770  0.09695843 -0.11968974  0.3951990 -0.90987601
  7 -0.3665658 -0.7502357 -1.81848578 -0.12566307  0.4312896 -0.05181516
  8 -0.1722669 -0.6333160 -1.73562001 -1.30363297  0.7630806  0.63356851
  9  1.1806868  0.2720190  0.01340043  0.21197807 -0.8736560 -0.40935855
    year
age       1981        1982       1983       1984       1985        1986
  1 -0.4135949 -0.64802281  0.1679160  0.2101728  0.9047697 -0.37753750
  2 -0.8351560 -0.49329432  1.6148608  0.6131774 -1.2668815 -0.22850023
  3 -0.4950135 -0.18965216  0.8909815 -0.4372249  0.1700262  0.09849959
  4 -0.3803710 -0.07768042  0.6684658 -1.2474034 -0.5140175  0.60475421
  5 -0.9820765 -0.46358946  0.1424927 -1.2462621 -0.3983343  0.47655323
  6  0.5846104 -0.53275795 -0.2022382 -0.1997021  0.3042568 -1.10439554
  7 -1.2575699 -0.25699987 -0.3700954 -0.5403286  0.3358458  0.42602655
  8 -0.2314272 -0.43921094 -0.3907094 -0.8844804  0.5185528  0.18277097
  9  0.3592862 -0.10685687 -0.3470458  0.3281008 -0.8887103 -1.60361517
    year
age         1987        1988        1989        1990        1991        1992
  1  1.411388897  0.00000000  0.23571226 -0.10443262 -0.36736308  0.51646569
  2  0.688890908 -0.99792360 -1.59716276  1.01808849  1.33993292 -0.01065358
  3  1.458281202  0.11193335  0.47829381 -0.38019213 -0.08938402  1.24286242
  4  0.428616841  0.01257401 -0.13294301  1.80579747 -1.78230480  0.19756199
  5  1.025321686 -0.46579946 -0.34263323 -0.19886761  1.33824090 -1.26635880
  6  0.305220312 -0.11103551  0.02418483 -0.01305428 -0.29615332  1.36537255
  7  0.079446790 -0.20526538 -0.09031681  0.35756341  0.21340778 -0.33708988
  8  0.374984482 -1.29168122  0.52061033 -0.94412954  1.04026719  0.29705888
  9 -0.003025288 -1.38901680 -0.75978945 -1.91128532 -0.38925200 -0.21918095
    year
age        1993        1994        1995        1996        1997        1998
  1 -1.84016777  1.82444984 -1.25111027  0.94091592  1.11989755  0.53764173
  2 -0.09481056  1.46000890  0.26719658  0.01825497  0.88871567  0.64758550
  3  0.50867868 -1.11875813  0.24928751  0.55365915 -1.29214529  1.02999964
  4  2.12218570 -0.07798071 -1.04155175  0.47583737 -0.33998873 -0.14417067
  5  0.62884531  0.74554650  1.52294544 -1.71408624 -0.25158008  0.64785235
  6 -0.80728955 -0.11860586  1.08561357  2.00338272 -1.25382301 -0.02074245
  7  1.76125643 -0.82535173 -0.68174456  0.37395769  1.57106371  0.53009709
  8  0.16894881  1.31173008 -0.01777539  1.26903334  0.71226429  1.33223742
  9  0.08427876  0.31076642  0.95406525 -0.51911606  0.08056047  0.24430741
    year
age        1999       2000        2001       2002       2003        2004
  1 -0.45299697  0.3724039 -0.01836632  0.5982263  0.1899438  0.27394774
  2  0.30037566  0.4040205 -0.99919495  0.2945073  0.3116245  0.37792536
  3 -0.34060260  0.6037636  0.16547829 -1.2539910 -0.7628464 -0.04604046
  4 -0.26788455 -1.1061176  0.59127044  1.1088524 -1.4646344 -0.62112370
  5 -1.29207352 -0.3047355 -0.14557271  0.7067992  1.4735540 -2.08717930
  6 -0.78561410 -2.0338747  1.15170485 -0.3222620  1.0333394  1.85797920
  7 -0.33929187 -0.6854198 -0.88782487 -0.1977563 -1.0089110  0.15623767
  8  0.05568918 -0.3370283 -0.38963739  0.1912542 -0.5646110 -0.38738570
  9  0.08520665  1.2916629 -0.57610332 -0.6549397 -1.3835393 -0.96780074
```

age \ year	2005	2006	2007	2008	2009	2010
1	-1.13212461	0.10017627	-1.96430019	-0.23100049	-0.8699317	0.306439254
2	0.81834622	1.15550261	0.00790073	-0.24478168	0.1730668	-0.342865256
3	0.40813878	1.23055284	0.96938963	-0.97013803	-0.5541320	0.289150285
4	-0.05711068	1.01551309	0.95430756	1.05501158	-0.9684546	-1.095849971
5	-0.31188732	0.06891095	0.67231877	1.25256463	0.9630540	0.009542082
6	-1.38712899	-0.29847337	-1.67935864	0.76701935	1.3083624	1.404574405
7	0.77722329	-0.92927537	-1.03848014	-0.33883602	0.4928059	1.445228460
8	0.87719224	1.28978077	-1.91459455	-0.04926314	0.1655225	1.573214060
9	-1.63959285	-1.27483314	-0.85262051	-0.64025774	-4.6032952	-1.403103645

age \ year	2011	2012	2013	2014	2015	2016
1	-1.4578144	1.9485437	-0.95793743	-0.7597163	-0.7490450	0.6309935
2	-0.5598460	0.0587202	-0.55051836	-2.0210903	-0.2609784	0.1520280
3	-1.0702930	-1.1428407	-0.07031460	1.8010348	-1.9709028	1.3870802
4	-0.1506917	-1.8601337	0.38949639	1.1185456	-0.6557979	-0.3745685
5	-0.5748640	-1.8856349	-0.94262200	1.3918420	-0.2609456	1.2030116
6	0.5648173	-2.3063704	0.97968897	0.5896923	-2.8437588	1.2429940
7	1.3654229	-0.3283035	0.07502605	0.7266797	-1.5183747	-0.0866015
8	2.3455981	0.4949629	2.56258306	1.6439995	-0.1137952	-0.1943473
9	-2.2362705	-2.5139494	0.56781266	-0.3427825	-0.9813287	-0.9846470

age \ year	2017	2018	2019
1	0.03126845	-1.00491952	2.49301826
2	0.30734744	1.13276381	0.17920577
3	-0.13166589	-0.09862757	0.71922264
4	1.01596591	-1.05222646	-0.80097257
5	-0.90450021	0.15354717	-1.77880737
6	1.04262273	-1.66084055	-0.46421582
7	0.38972737	0.07373696	-0.47477384
8	1.19600244	0.26922207	1.43431518
9	0.59574716	-1.94309973	-0.08297567

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

Units : NA

age	1991	1992	1993	1994	1995	1996	1997	1998
1	189299.7	285044.5	237033.9	386546.5	302598.2	332547.4	381150.25	193665.93
2	480484.6	360963.5	580435.1	473105.9	781693.7	620262.3	652723.29	758201.25
3	741881.7	573965.0	398219.8	650457.1	518587.7	860995.0	690499.33	700475.96
4	885599.0	628692.0	467236.8	284592.0	481654.3	390622.4	542238.67	486277.31
5	1264019.7	695644.1	418973.0	302623.8	170710.9	251928.2	226689.08	273827.47
6	420181.2	775624.1	534697.9	292077.7	207649.1	117711.8	144233.90	122281.34
7	250767.1	260614.7	441453.9	347385.9	178140.8	122723.4	57974.22	61963.97
8	167383.6	143084.3	153550.5	233991.5	201370.4	104525.6	67093.06	23658.21
9	164185.5	152612.3	136989.7	134290.6	163017.9	162759.0	90052.57	55248.01

age	1999	2000	2001	2002	2003	2004	2005
1	171008.52	497015.27	337502.36	364620.62	207158.78	175329.26	178366.35
2	358393.65	315546.32	1063356.86	677163.89	760832.53	423149.40	352737.46
3	986152.25	394887.01	331972.78	1296758.98	797668.10	935698.56	512688.12
4	496172.73	800304.60	296063.52	228643.61	1007928.41	678337.95	844882.12
5	269216.03	285430.30	499476.27	183277.99	135859.17	578410.48	514090.99
6	142294.12	169830.40	188122.05	323503.52	123090.60	83208.06	378847.01
7	63674.94	85127.79	107432.63	113434.54	177406.95	92009.34	49705.71
8	28051.62	36389.82	52138.71	61267.19	68636.42	92672.23	69705.85
9	34581.51	32199.30	35523.75	43900.88	52794.56	61778.75	77032.64

age	2006	2007	2008	2009	2010	2011	2012
1	159963.90	102295.26	124360.21	137002.1	220624.12	98660.33	100044.53
2	374355.25	334556.61	209011.31	255024.1	268054.62	465729.18	194418.62
3	379604.35	430682.90	374308.95	246307.1	292173.86	308819.61	595254.04
4	385848.04	270309.57	325661.79	273331.1	181346.33	218954.43	239489.19
5	586527.83	244336.09	168072.32	201504.9	160018.25	106901.50	126035.16
6	400355.75	367789.62	161636.25	114632.3	112618.89	98300.05	70054.87
7	240034.84	244818.95	238723.19	102159.0	68851.04	58870.98	57200.10
8	32698.78	128875.83	144133.76	142930.8	57380.60	37643.31	28205.73
9	78175.08	49954.25	93523.61	118757.9	123377.62	85955.46	56762.43

age	2013	2014	2015	2016	2017	2018	2019
1	50024.57	63918.43	103064.574	42475.553	47504.723	63054.24	132349.18
2	198898.55	97328.15	127214.084	233638.803	86391.324	99466.15	131988.22
3	246636.77	230439.70	113987.177	157222.221	346600.440	121636.30	134205.88
4	472325.65	208267.76	169699.005	101868.980	149766.538	320563.32	127242.68
5	129602.49	257194.36	113322.568	99277.456	76596.526	114550.00	234678.74
6	65118.86	63079.04	98552.016	71609.100	66649.913	55889.59	89638.20
7	40009.73	26936.88	20032.856	42132.167	47795.098	43588.89	40673.25
8	22981.34	13709.45	7603.876	8295.811	22584.099	32423.98	30811.85
9	28040.26	10698.35	3464.090	2982.042	6276.273	15039.06	28561.88

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

```
Units  :  NA
   year
age        1991        1992       1993        1994        1995        1996
  1 -0.31789629 -0.51856379 -2.3887969  0.35621968  0.72072306 -0.97148663
  2 -1.35507211  0.59213294  1.0989824 -0.04352356  0.58966986  0.66401906
  3 -1.06396056 -1.65163721  0.9812206 -0.48031493 -0.62626734 -0.38324502
  4  0.09138311  0.44163117  0.5872829  0.23894442 -0.06203747 -0.44996976
  5 -1.68913388  1.98051221  0.4975203  0.46066207 -0.08792389 -2.77256254
  6 -0.11539009 -3.04862443  1.9002732  0.19891634  0.84871240  0.82246659
  7 -0.23645749  1.14234980 -3.0191905  0.71377396  0.15994484  0.67513480
  8  0.53217142 -0.01372692  1.5245734 -1.41582757  1.13322911  0.71971113
  9 -1.51942514  0.09255816  0.5830900  0.65978510  0.22977149 -0.08579458
   year
age         1997        1998       1999        2000        2001       2002
  1  0.584453075  0.57977455  0.4618739  0.52598799  0.42341233  0.3662734
  2 -0.112704071 -0.25639401 -0.6638800 -0.16716148  0.89621025 -0.2345921
  3 -1.436989863 -0.19849407  1.3456264 -0.04425266 -1.01743339  0.5106388
  4 -2.317070455 -0.12339231 -1.1368138  1.30100691 -0.29477675 -1.3174552
  5 -0.527065137 -1.29159376  1.0638225  0.67606338  0.96181390 -0.0946855
  6  0.008734436  0.01716245 -0.3544561  0.80170734 -0.72539070  1.2695030
  7 -0.062356632 -0.51976284  1.2751385  1.09325274  0.84181223  0.2430176
  8  2.091120622  1.14393265 -0.3829840  0.43446294 -0.08427963 -0.4176122
  9 -1.616550569  1.16216337  1.0533572  0.16596796  0.19440726  0.4695344
   year
age        2003        2004       2005        2006       2007       2008
  1  0.59290235  0.76570753 -0.6783187  0.09327829  0.0000000 -0.4657875
  2  0.73310713 -0.27412963 -0.8541867  1.55046429 -1.9061779  0.2258437
  3  0.14573277  0.02733675 -1.4737669 -0.75352027 -0.4732398  1.2225766
  4  0.75775751 -0.91770074  0.9764640 -0.91238712  0.1449243  0.1359520
  5 -0.17511830  0.56583764  0.3576153  1.21475830 -0.4673486  0.4917576
  6 -0.04913032 -1.18923556 -1.3050080  0.71364857  1.2570493  0.1834716
  7  0.88146605  0.85491754 -1.1304443 -0.42308324  0.6622199  1.1688701
  8 -0.05667747 -0.35778717  1.9800728 -0.75520713  0.5432993  0.3037819
  9  0.15131628  1.07261109 -1.6712548  0.32030525 -1.3131906  0.8930639
   year
age        2009         2010        2011         2012       2013         2014
  1  1.09153113 -0.443652324 -0.61130576  0.594501387  0.0000000  2.034343467
  2 -0.17467621  0.076296959 -0.62482794  0.357102908  0.4937117  1.230406967
  3  0.04560381 -0.004202706  1.97335587  0.230279322  1.2593532 -0.507232668
  4  0.42010532  0.006436707 -0.54586512  1.305651696 -1.1829367  2.164257518
  5  0.94044056 -0.928405239 -0.28565158 -0.217131062 -0.1449073 -0.884666451
  6  0.62174749  0.109648743  0.34767835 -0.374675546 -1.6626767 -0.007792834
  7  0.13790905  0.862679835  0.44450031 -0.001276356  0.9450319 -2.024333546
  8  1.80330447  0.418931283 -0.04871148 -0.475558094 -1.6565902 -0.840817760
  9  1.29363104  1.152590980  0.83052928  0.221695792 -0.4024217 -1.820432760
   year
age        2015        2016        2017       2018       2019
  1  0.00000000  0.00000000  0.00000000  2.1893343 -1.2415658
  2  1.50064412 -2.14573082 -1.05893253  1.6048300  0.7364493
  3  2.21754478  0.12799053  0.78940476 -0.7001441  0.8388555
```

4	1.46367745	0.61178503	-0.02610948	0.4890236	-1.0214429
5	0.33482523	0.25240384	0.93652088	0.2652293	-1.0326681
6	0.55312675	-0.04642609	-0.02223953	-1.2890020	0.7473329
7	-0.69255525	-0.27719242	-1.34736735	1.2423347	-2.4698329
8	0.03018824	-1.47207141	-2.15743499	-1.6501774	0.1641111
9	-4.37472586	-1.90547860	0.91426877	-0.4849192	0.6475178

TABLE 4.6.24 Herring in 6a and 7bc. PREDICTED INDEX AT AGE IBTS_Q1

Units : NA

age \ year	1994	1995	1996	1997	1998	1999	2000
2	57966.99	95973.44	75488.47	81032.34	94910.792	44293.864	38588.79
3	133070.79	106632.11	175841.95	145229.21	149902.263	206527.912	81602.29
4	54500.29	92993.58	75469.59	109131.53	99902.718	98036.258	155599.54
5	59852.50	34055.57	50478.38	48527.69	59743.448	55217.766	57561.88
6	71198.16	50909.78	29081.38	38885.02	33438.593	35668.503	41627.51
7	88387.31	45808.12	31891.23	17353.78	18468.609	16634.958	21589.15
8	78596.70	67829.11	35666.00	25505.16	8827.464	9005.254	11255.75
9	45107.62	54910.57	55536.26	34233.12	20614.397	11101.505	9959.58

age \ year	2001	2002	2003	2004	2005	2006	2007
2	128671.67	82101.74	91246.62	50433.96	41904.15	44962.59	40405.11
3	67716.88	266977.79	161245.90	187062.50	101641.81	77124.20	88093.13
4	56876.24	44586.33	192522.73	128134.31	156579.97	73897.66	51978.29
5	100093.15	37735.36	27236.15	115026.41	97890.20	117086.12	48972.17
6	46006.56	81183.83	29976.54	20247.73	87380.25	98284.81	91258.74
7	27310.49	29653.61	45286.36	23548.52	11713.80	61776.99	64236.78
8	16146.77	19377.73	21478.33	29529.45	20241.45	10552.20	43197.76
9	11001.31	13885.07	16520.95	19685.43	22369.03	25227.82	16744.12

age \ year	2008	2009	2010	2011	2012	2013	2014
2	25067.03	30742.98	32595.91	56146.08	23327.028	23996.550	11730.109
3	75572.69	50082.65	60254.96	62539.08	119387.361	50234.526	47042.837
4	61751.54	52426.71	35448.63	41865.28	45273.365	92505.573	41256.070
5	32740.85	40106.56	32810.15	21404.45	25037.850	27325.082	55746.287
6	38384.66	27973.86	28316.51	24165.36	17216.530	17504.135	17762.776
7	58531.54	25916.23	17850.93	14884.58	14517.679	11387.905	8169.847
8	44575.40	46473.80	19163.82	12267.13	9440.134	9535.344	6354.744
9	28923.50	38614.02	41205.34	28011.00	18997.733	11634.372	4959.009

age \ year	2015	2016	2017	2018	2019
2	15377.578	27417.5183	10121.209	11652.294	15387.238
3	23481.923	30432.3132	66925.636	23468.794	25575.135
4	34194.934	18572.4468	27163.603	58182.034	22594.830
5	25394.503	18895.4206	14407.433	21609.609	42762.858
6	30458.981	17085.4371	15496.151	12978.896	19877.801
7	7008.353	10509.7682	11366.750	10206.538	9138.975
8	4136.910	2692.2935	6763.038	9460.681	8521.279
9	1884.648	967.7816	1879.494	4388.102	7899.032

TABLE 4.6.25 Herring in 6a and 7bc. INDEX AT AGE RESIDUALS IBTS_Q1

Units : NA

age	1994	1995	1996	1997	1998	1999
2	-0.1829313	1.3670993	0.5467289	0.3674468	-2.3751155	0.3135545
3	-1.0438316	-1.6765102	-1.0975534	0.3211505	0.4061874	1.1296883
4	-0.7779780	-0.4326752	-1.0438023	-1.4980082	-0.5249343	1.2316291
5	-0.4313325	-2.7157826	1.2779566	-0.6979957	-0.9439962	-0.3333163
6	0.6150367	1.2313403	0.0447305	-0.4508570	-1.4344771	-0.6743566
7	-1.6924980	-1.8362119	-2.1551100	0.4637272	1.2426839	1.1333942
8	-2.4829406	0.2041542	0.5089139	1.6533422	-0.4975443	0.9012445
9	-1.3441432	-1.0892881	0.7547257	-0.6105879	0.6186270	1.5225571

age	2000	2001	2002	2003	2004	2005
2	0.6749014	0.22562768	-0.3611687	0.40406463	1.0776721	0.8032212
3	0.5123974	0.16806507	-0.6737929	-1.00667258	0.4307706	-0.4634357
4	-0.5164044	0.02949048	0.5313389	-0.68840913	-0.0708595	1.3769058
5	0.1157768	-0.13099129	-2.0825981	0.08081449	-0.2217524	1.3413230
6	0.8392316	0.52026343	0.2653108	-0.35161134	1.4933175	0.2042288
7	0.2272111	0.56312443	-0.4411188	-0.40027806	0.3388006	0.5961194
8	-1.4964488	-0.74767479	0.8675265	-0.21299195	-0.7306063	0.8473689
9	1.8897196	1.20376143	0.7525260	1.29600105	0.9252764	-0.1191697

age	2006	2007	2008	2009	2010	2011
2	1.8128233	-0.6269243	-0.12977642	0.35355775	-1.084362179	0.450995801
3	0.5365593	0.2665350	-2.59264946	0.61939801	-0.004533023	-0.124583116
4	-1.1118603	0.1421153	0.30955849	-0.65121471	-0.762989366	0.533799271
5	1.7399315	0.1965468	0.80196116	0.82374150	-0.372603839	-0.067326052
6	1.1161439	-0.1904948	-0.63334321	0.46045600	0.092492451	0.078169546
7	0.2469107	0.4686867	-0.69287692	0.51657058	1.369756022	-0.029756290
8	0.4903037	-0.6582938	0.88778410	-0.02726446	-0.618236981	0.004149665
9	0.9529176	2.1242689	-0.07908953	1.38749151	-0.086350828	0.862863388

age	2012	2013	2014	2015	2016	2017
2	-1.59217500	0.93745890	-0.1017717	-0.75258235	-0.04605137	0.01303056
3	1.97748569	-0.84371521	-0.2542730	-1.02406150	-0.65829849	0.24104341
4	-0.20833977	-0.09066976	-1.3075953	0.83674613	-1.63855469	-0.22375449
5	-0.27632934	0.53398105	-0.2478679	-1.35393143	1.01127225	-0.47855960
6	-0.49806297	0.57560751	-1.6874104	-0.77016861	0.81056570	-0.67898569
7	-0.31457694	0.22928912	0.3350899	0.08094631	-2.36392855	0.29626558
8	-0.03305704	-0.32898698	-0.1719776	1.04008457	-0.01994092	-0.72922680
9	0.81859880	0.24352928	-0.7386997	-0.86443969	0.47950128	1.68034417

age	2018	2019
2	-0.5606058	-0.9414582
3	1.7283664	0.3932879
4	2.5945174	1.6886344
5	-1.1136356	1.8961459

6	0.8592042	-3.4218439
7	-1.1937230	1.1396233
8	-0.1702131	-1.1743939
9	-0.7796666	-0.1261550

TABLE 4.6.26 Herring in 6a and 7bc. PREDICTED INDEX AT AGE IBTS_Q4

Units : NA

age \ year	1996	1997	1998	1999	2000	2001	2002
2	14691.411	15220.930	17565.7451	8386.899	7445.724	25300.698	16087.025
3	14353.724	11248.499	11256.7399	16118.829	6522.644	5539.631	21482.159
4	7260.513	9760.188	8612.5646	9061.309	14801.783	5527.577	4218.951
5	6918.381	5909.958	7033.0764	7258.622	7798.711	13714.965	4926.734
6	3733.136	4270.975	3580.7159	4461.580	5419.565	6013.989	10134.299
7	3854.718	1629.467	1747.4895	1991.680	2725.521	3433.253	3546.314
8	3637.419	2144.784	767.4484	1024.106	1367.890	1958.007	2263.044
9	5663.899	2878.737	1792.1892	1262.499	1210.368	1334.052	1621.580

age \ year	2003	2004	2005	2006	2007	2008	2009
2	18230.060	10188.562	8515.095	8959.429	7972.249	5008.003	6085.868
3	13405.619	15862.964	8748.933	6354.373	7171.352	6296.695	4120.431
4	18903.357	12833.725	16225.864	7221.252	5042.961	6142.820	5109.463
5	3729.387	15978.313	14694.508	16154.099	6708.273	4718.859	5562.767
6	3948.030	2670.500	12681.423	12760.405	11624.555	5287.962	3670.828
7	5650.972	2924.777	1685.883	7596.842	7631.582	7848.710	3270.032
8	2556.565	3403.112	2753.508	1188.864	4548.047	5418.610	5166.024
9	1966.488	2268.641	3042.930	2842.294	1762.893	3515.957	4292.331

age \ year	2010	2011	2012	2013	2014	2015	2016
2	6353.288	11113.686	4656.7678	4743.4690	2323.0540	3029.30593	5694.6196
3	4833.727	5182.705	10065.7613	4120.4711	3842.9714	1887.42187	2733.9193
4	3339.879	4103.090	4528.2178	8685.7413	3795.8270	3051.66101	1981.7205
5	4315.510	2937.337	3484.5350	3419.4907	6640.1199	2850.11611	2838.6875
6	3522.634	3129.690	2230.9500	1932.7389	1805.0383	2621.22926	2334.0798
7	2166.490	1889.398	1830.2515	1169.9529	749.3307	498.13807	1366.5867
8	2030.740	1358.170	996.5538	685.8290	375.0199	183.40556	300.2845
9	4366.420	3101.272	2005.5078	836.8015	292.6518	83.55388	107.9414

age \ year	2017	2018	2019
2	2108.4160	2427.6273	3233.704
3	6038.5389	2120.4587	2362.470
4	2925.4097	6258.1801	2527.146
5	2210.5761	3298.3006	6943.858
6	2217.0398	1860.8503	3094.658
7	1609.5028	1485.8945	1432.176
8	870.7981	1275.9869	1264.680
9	242.0007	591.8348	1172.329

TABLE 4.6.27 Herring in 6a and 7bc. INDEX AT AGE RESIDUALS IBTS_Q4

Units : NA

year

age	1996	1997	1998	1999	2000	2001
2	0.53703931	-0.01871330	-0.28957285	-0.7871583	-0.62744758	1.5189712
3	-0.56443768	-0.38875024	0.04879698	1.2315611	0.03362382	-1.6188243
4	-0.79719997	-0.94092738	0.02411076	1.0567989	0.66018766	0.7055256
5	-0.57733096	0.25810781	1.70266908	0.5368667	-0.82832846	-0.7079804
6	-0.41771990	-0.03010505	0.75075965	1.2449427	1.23746698	1.0858928
7	-0.06555809	-0.57542090	-0.55847817	0.5562037	0.27546492	0.2405192
8	1.54135920	1.66364717	0.75500444	-0.5000621	0.74996827	-0.1053495
9	-0.16515903	-0.42513140	1.82884711	1.6971225	-0.25764801	-0.4294703

year

age	2002	2003	2004	2005	2006	2007
2	-0.1663632	-0.1277635	1.34955578	-1.47109069	-0.5183951	-0.5511455
3	-1.6291962	-0.1859696	-1.29769647	0.05468044	-2.1328263	-0.8045835
4	-2.2714538	0.1394682	-0.40615558	0.70462882	1.2302088	-0.4039749
5	0.6564804	-1.0263687	-2.39308054	1.14602822	-0.4723353	1.2230023
6	-0.6821673	0.8769626	0.49625332	-0.84813296	0.7816596	-1.9419365
7	1.2285021	-1.1785554	0.83414318	0.07542936	-0.3323446	1.1460417
8	0.1091658	0.5015769	-2.20876759	0.58747244	0.7436146	-1.6751811
9	-1.1841263	0.6460912	-0.08308126	-0.05790931	-0.7454526	-0.5311810

year

age	2008	2009	2010	2011	2012	2013	2014
2	-1.4845186	0.3275879	0	-0.2369361	-2.06981582	0	0.8133270
3	0.5488510	-1.0550507	0	-0.6329160	1.28139689	0	0.6589181
4	-0.0919621	-2.0114113	0	-0.1165497	0.60964570	0	-1.5821433
5	-1.0201665	0.2948684	0	-0.7882604	0.68687644	0	-0.6598157
6	0.1591594	-1.3435981	0	-0.7775760	0.20111043	0	-0.4521064
7	0.5476805	0.4294156	0	-1.7210506	-0.09573438	0	-0.8119929
8	-0.2788177	-1.0276160	0	-0.7229742	-1.64395208	0	0.3901004
9	1.0625184	0.8691068	0	0.8980930	2.20161716	0	-2.8947472

year

age	2015	2016	2017	2018	2019
2	1.7102126	2.6331228	2.5321666	0.9732747	-0.99978904
3	0.6290165	-0.1972227	0.6070622	0.6205781	0.82512142
4	-0.3955789	2.0477797	0.4149535	-0.7310537	0.92280931
5	1.2993983	-0.6306314	2.0505484	-0.3311534	-1.50422282
6	-1.6120910	0.9773852	-1.0340517	0.1483890	0.31727254
7	-0.7425485	-0.4794324	0.4152114	-0.4476619	0.93178627
8	2.4624083	0.9832754	-0.4470517	-0.2421891	-1.75539933
9	1.6437110	1.0738173	-0.3249602	-2.7401721	-0.08946237

TABLE 4.6.29 Herring in 6a and 7bc. FIT PARAMETERS

name	value	std.dev

```
1          logFpar -1.25906190 0.34770416
2          logFpar  0.06040514 0.14261439
3          logFpar  0.76040213 0.11692583
4          logFpar  1.09943650 0.11658790
5          logFpar  1.23068250 0.11757306
6          logFpar  1.43039282 0.12086034
7          logFpar  1.59434871 0.15330833
8          logFpar  1.76434140 0.16326693
9          logFpar -2.25997151 0.20613453
10         logFpar -1.07006221 0.14107729
11         logFpar -0.80242201 0.14029490
12         logFpar -0.64369728 0.14042129
13         logFpar -0.25198384 0.14870181
14         logFpar -0.06772748 0.15294688
15         logFpar  0.32329662 0.16833187
16         logFpar -3.51416319 0.12413633
17         logFpar -3.14356475 0.17239707
18         logFpar -2.68326045 0.17245981
19         logFpar -2.15466639 0.17384398
20         logFpar -1.79726945 0.17731853
21         logFpar -1.61919896 0.18972168
22         logFpar -1.30639400 0.20073339
23    logSdLogFsta -0.87593122 0.24264385
24    logSdLogFsta -1.21163168 0.17713719
25    logSdLogFsta -1.30393983 0.14464550
26    logSdLogFsta -0.77646159 0.18655921
27    logSdLogFsta  0.06214891 0.17076928
28    logSdLogFsta  0.24661454 0.08984386
29       logSdLogN -0.52272168 0.12728535
30       logSdLogN -2.10054077 0.12948604
31     logSdLogObs  0.17920610 0.10593187
32     logSdLogObs -0.58903127 0.11433054
33     logSdLogObs -0.90854682 0.06118920
34     logSdLogObs -0.41646711 0.06747122
35     logSdLogObs  0.35761583 0.11085405
36     logSdLogObs -0.96301619 0.14516596
37     logSdLogObs -1.33198579 0.07722850
38     logSdLogObs -0.80441949 0.09840191
39     logSdLogObs  0.50966789 0.14630509
40     logSdLogObs -0.34341182 0.13553671
41     logSdLogObs -0.56674495 0.10425378
42     logSdLogObs -0.31459947 0.11004938
43     logSdLogObs  0.01112219 0.13881439
44     logSdLogObs -0.40075367 0.12043951
45     logSdLogObs -0.34656904 0.11823900
46     logSdLogObs -0.29067441 0.11707574
47     logSdLogObs -0.70042105 0.16241588
48     logSdLogObs -0.27725125 0.13343657
49     logSdLogObs -0.24075096 0.13314416
50 transfIRARdist  0.52715193 0.39938159
```

```
51 transfIRARdist -1.37668651 0.24006773
52 transfIRARdist -1.36077587 0.24386848
53 transfIRARdist -1.83143472 0.54554807
54 transfIRARdist -3.05772748 0.50954683
55 transfIRARdist -2.01959224 0.44579574
56 transfIRARdist -1.19537427 0.31799135
57     itrans_rho  2.79857126 0.18724958
58     itrans_rho  1.71304289 0.20841593
```

TABLE 4.6.30 Herring in 6a and 7bc. NEGATIVE LOG-LIKELIHOOD

```
1598.27716333424
```

Table 4.7.1.1: Herring in divisions 6.a and 7bc. Assumptions made for the intermediate year and in the forecast for scenario 1.

Variable	Notes
$F_{ages\ (wr)\ 3–6}$ (2020)	F corresponding to the assumed total catch for 2020
$R_{age\ (wr)\ 1}$ (2020-2022)	Geometric mean 2015 - 2019
SSB (2020)	Tonnes; Calculated in the short-term forecast based on the assumptions for the intermediate year
Total catch (2020)	Tonnes; Monitoring TAC 4840 t

Table 4.7.1.2: Herring in divisions 6.a and 7.bc. Catch Scenarios based on full uptake of the TAC.

Basis	Total catch (2021)	% SSB change 2021 relative to 2020	% SSB change 2022 relative to 2021	% TAC change 2021 relative to 2020
Precautionary approach: zero catch	0	+15%	+6%	-100%
Other scenarios				
TAC=Monitoring TAC	4840	+9%	0%	-

Table 4.7.1.3: Herring in divisions 6.a and 7.bc. Assumptions made for the intermediate year and in the forecast for scenario 2.

Variable	Notes
$F_{ages\ (wr)\ 3–6}$ (2020)	F corresponding to the assumed total catch for 2020
$R_{age\ (wr)\ 1}$ (2020-2022)	Geometric mean 2015 - 2019

SSB (2020)	Tonnes; Calculated in the short-term forecast based on the assumptions for the intermediate year
Total catch (2020)	Tonnes; Monitoring TAC 3100 t

Table 4.7.1.4: Herring in divisions 6.a and 7.bc. Catch Scenarios based on partial uptake of the monitoring TAC.

Basis	Total catch (2021)	% SSB change 2021 relative to 2020	% SSB change 2022 relative to 2021	% TAC change 2021 relative to 2020
Precautionary approach: zero catch	0	+15%	+5%	-100%
Other scenarios				
TAC=Partial uptake of the Monitoring TAC	3100	+12%	+2%	-26%

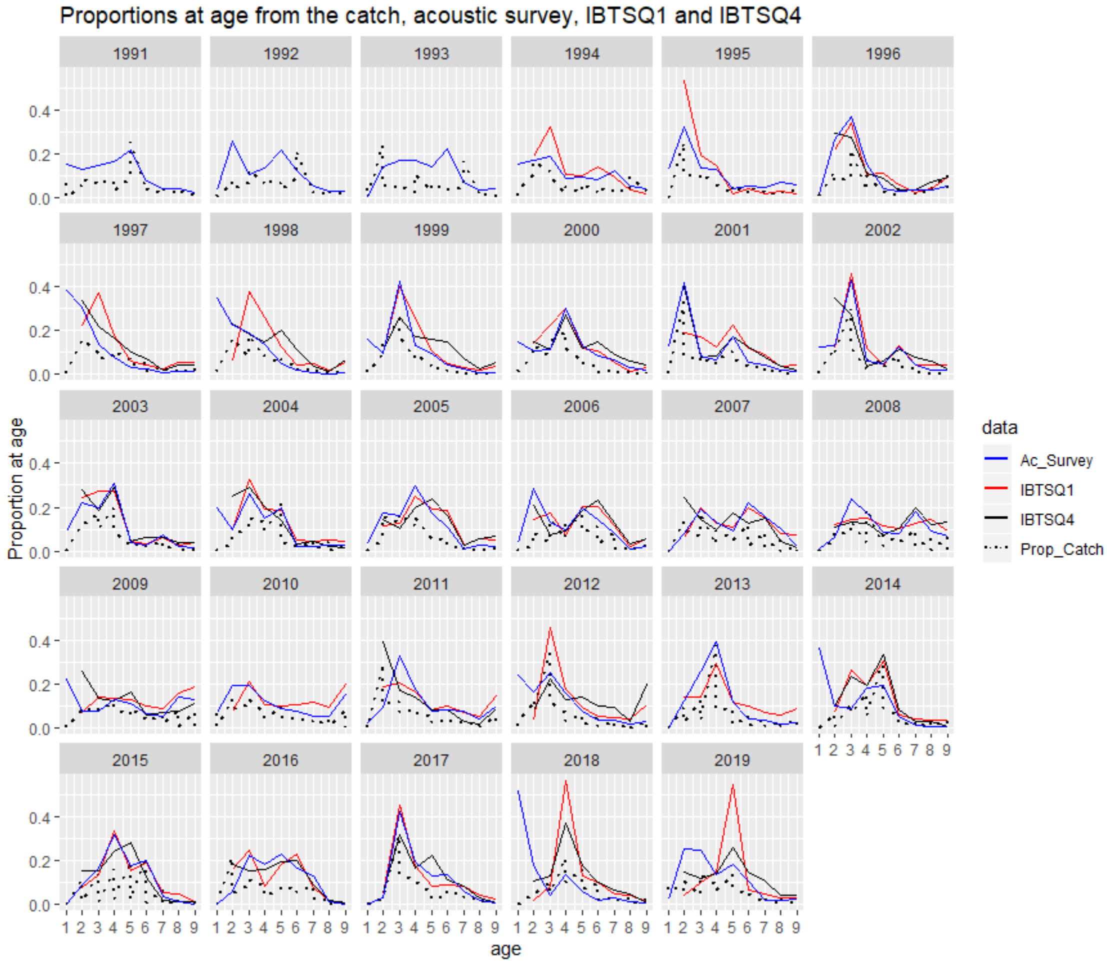


Figure 4.3.1.1. Herring in 6.a (combined) and 7.b–c. Comparison of the proportions-at-age, by age (-wr), of the catch, acoustic survey (WOS MSHAS), IBTS Q1 and IBTSQ4.

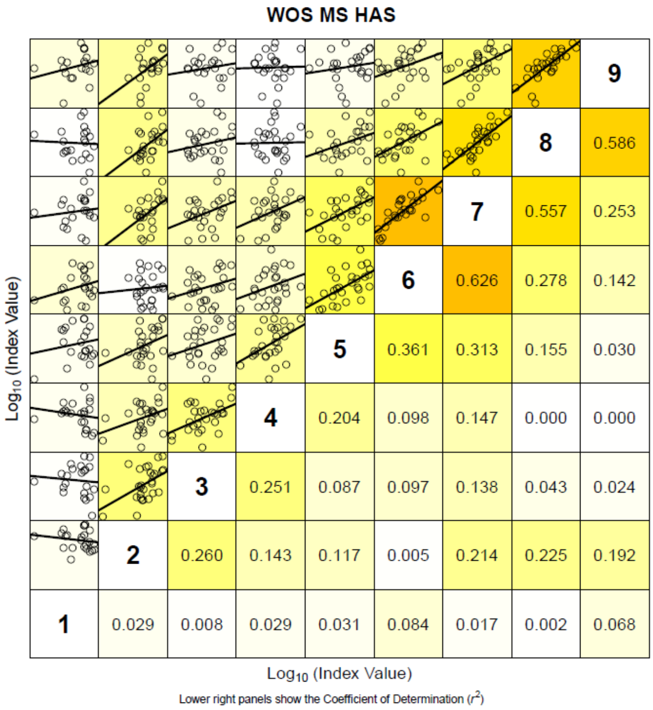


Figure 4.3.1.2. Herring in 6.a (combined) and 7.b–c. Internal consistency between ages (rings) in the WoS_MSHAS herring acoustic survey time-series (1991–2019).

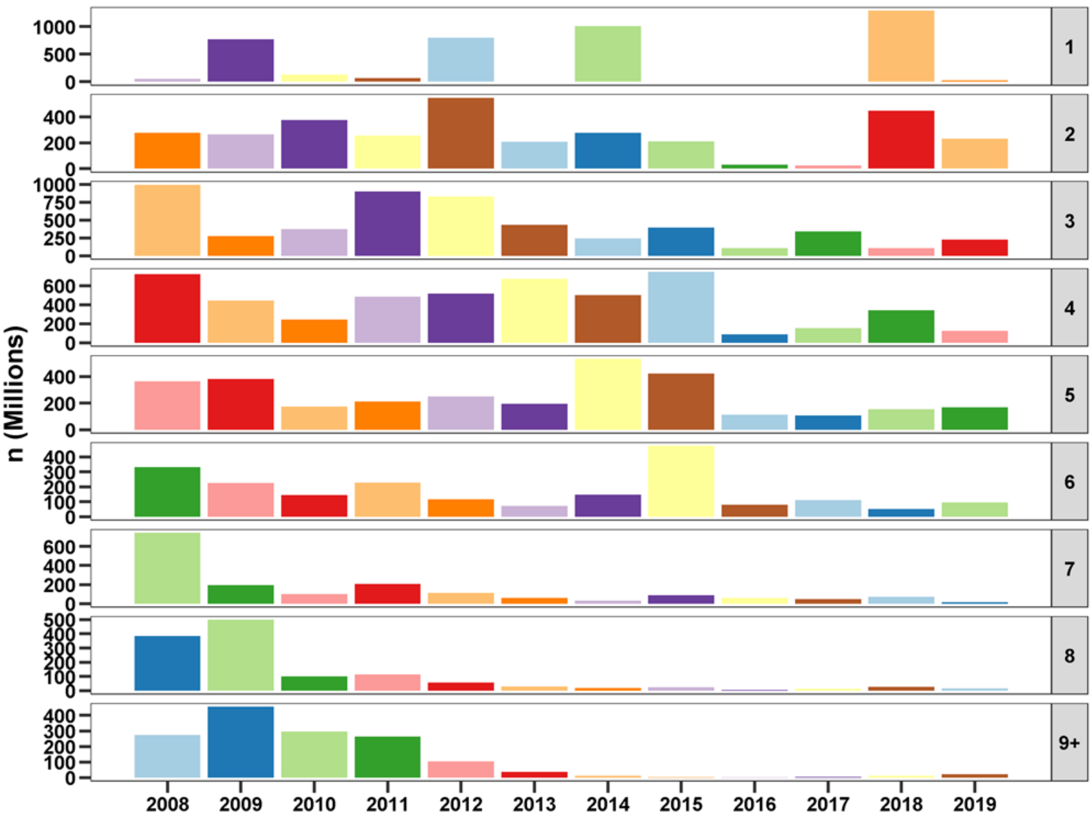


Figure 4.3.1.3 Herring in Divisions 6.a (combined) and 7.b–c. Catch numbers-at-age from Malin Shelf herring acoustic survey combined with West of Scotland acoustic survey (WoS_MSHAS) (6.a.N-S, 7.b and 7.c) time-series. Age (rings) from acoustic surveys 1991 to 2019.

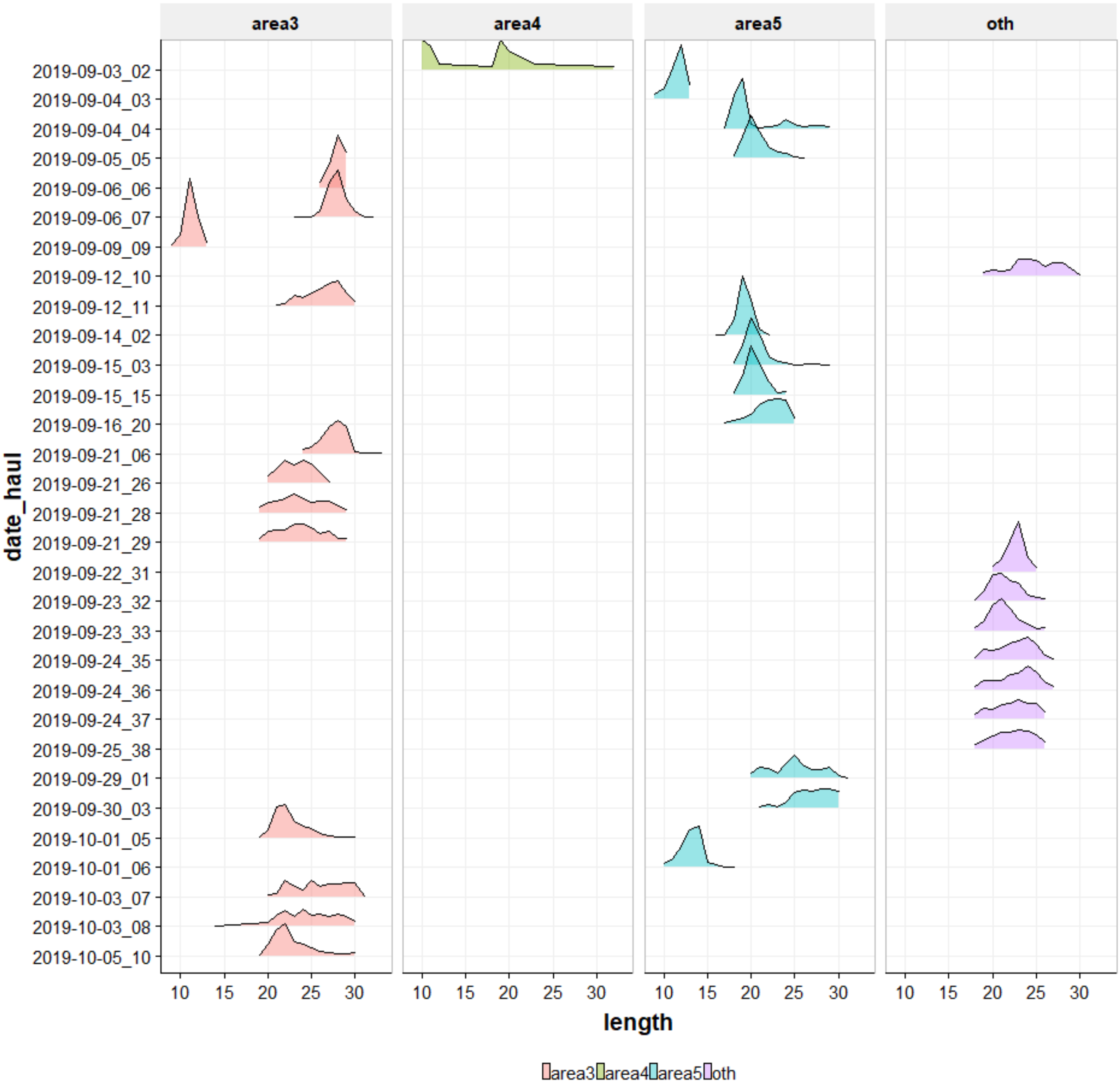


Figure 4.3.1.1.1 Relative Length-frequency distributions recorded from industry survey samples in 6aN.

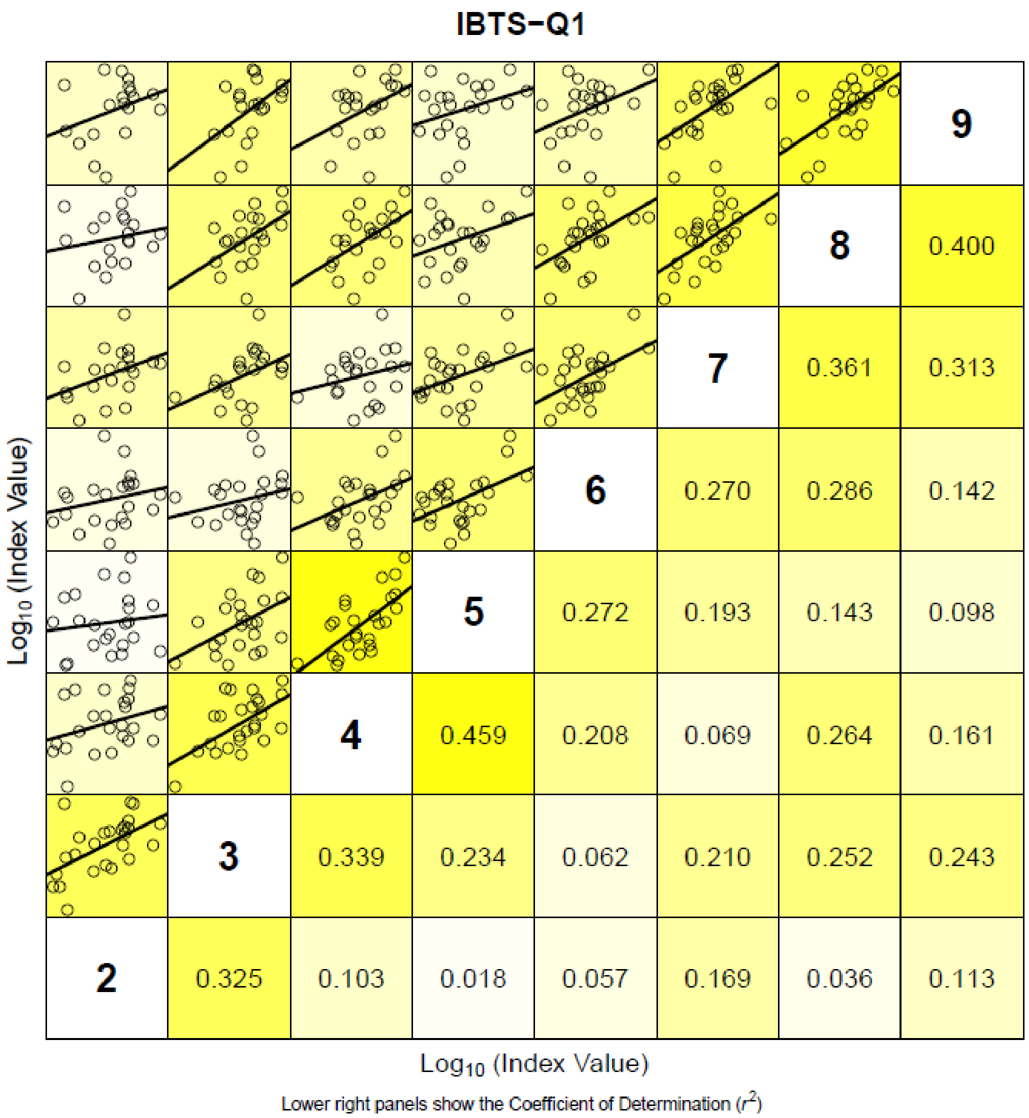


Figure 4.3.2.1. Herring in divisions 6.a (combined) and 7.b–c. Internal consistency plot of the quarter 1 Scottish bottom-trawl survey (1994–2019). Above the numbered diagonal the linear regression is shown including the observations (in points) while under the numbered diagonal the r² value that is associated with the linear regression is given.

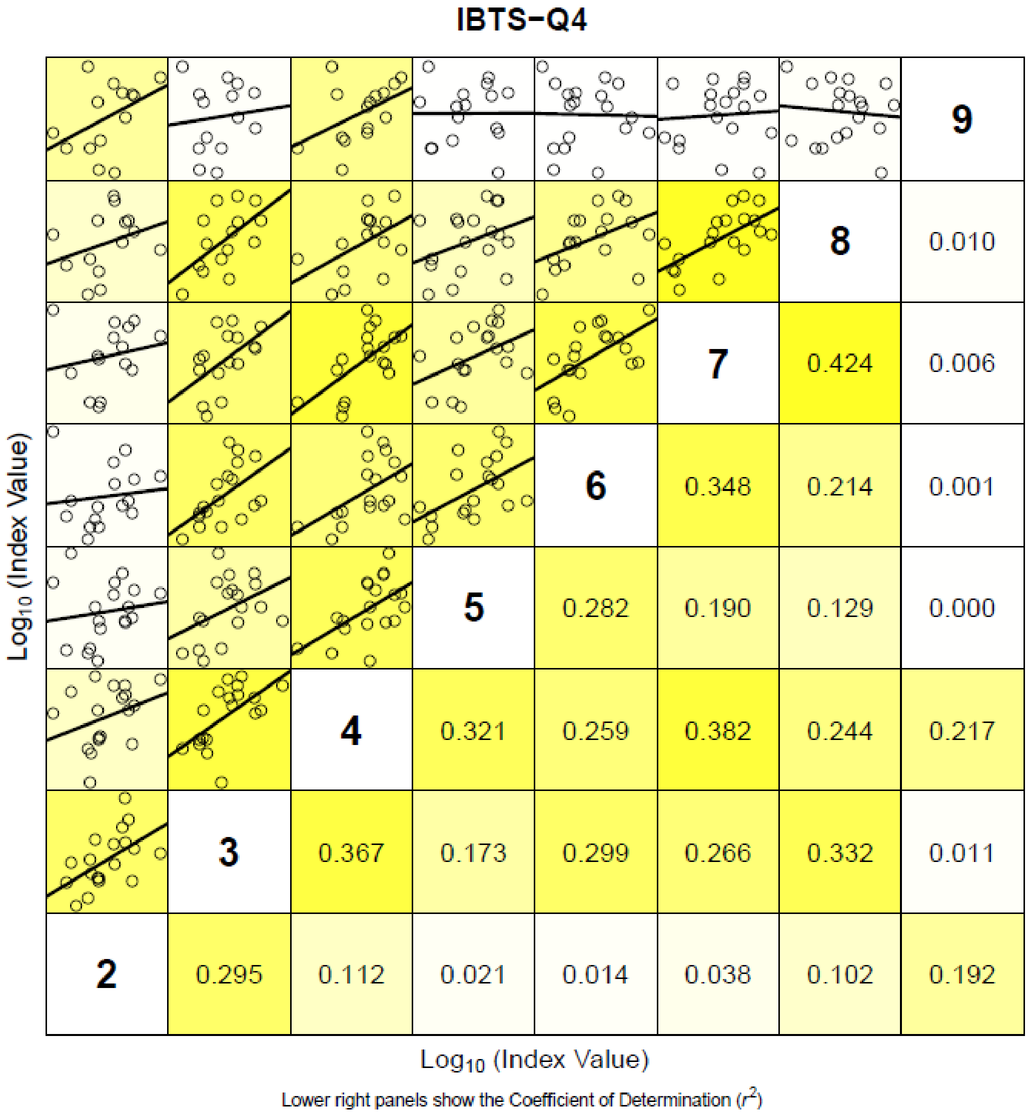


Figure 4.3.2.2. Herring in divisions 6.a (combined) and 7.b–c. Internal consistency plot of the quarter 4 Scottish bottom-trawl survey in (1996–2019). Above the numbered diagonal the linear regression is shown including the observations (in points) while under the numbered diagonal the r² value that is associated with the linear regression is given.

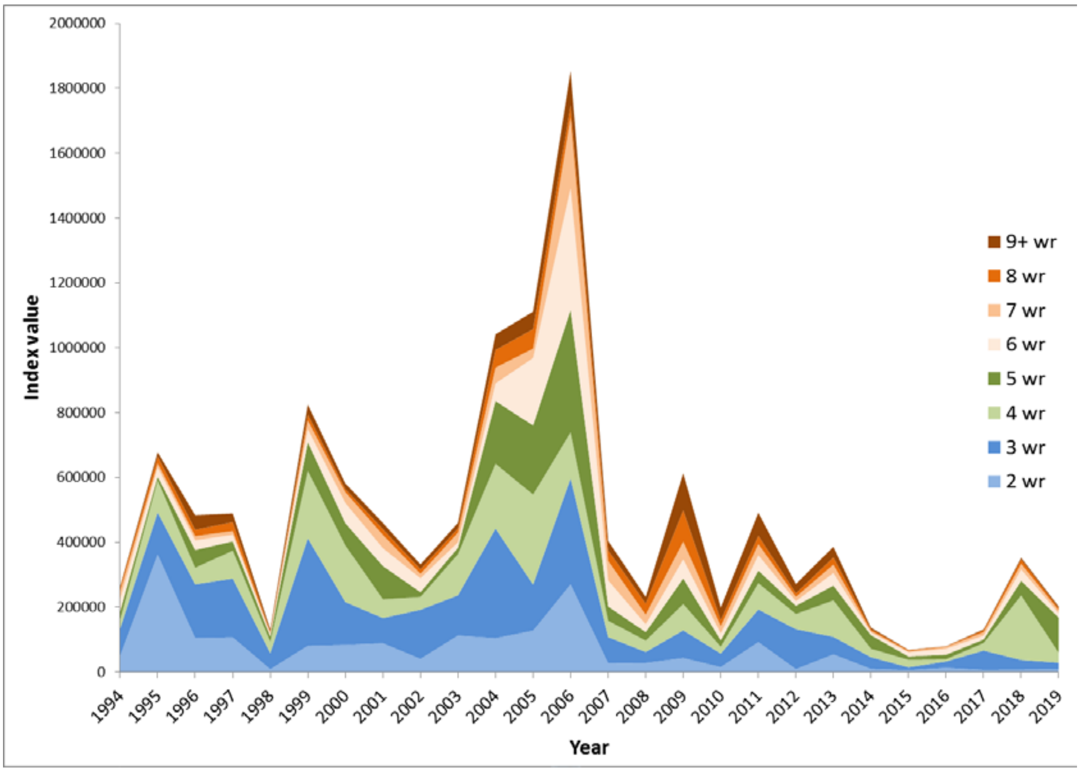


Figure 4.3.2.3. Herring in 6.a (combined) and 7.b-c. Trends in stock composition from abundance-at-age index from Scottish groundfish survey in Quarter 1.

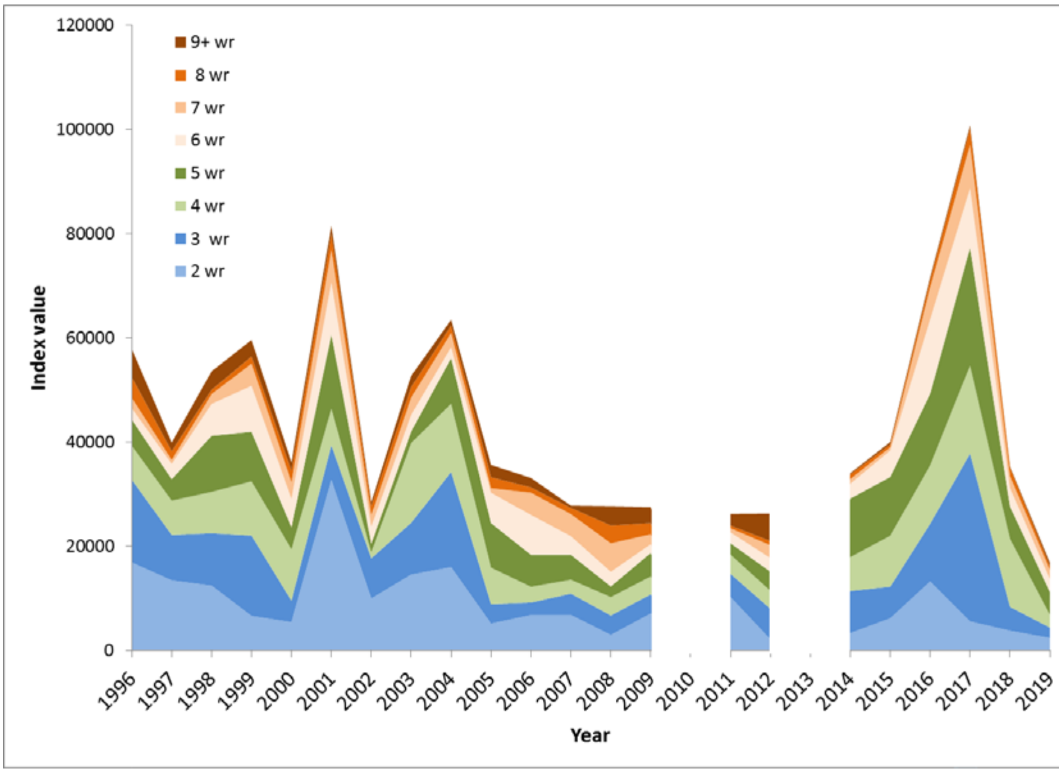


Figure 4.3.2.4. Herring in 6.a (combined) and 7.b-c. Trends in stock composition from abundance-at-age index from Scottish groundfish survey in Quarter 4. There was no survey in 2010 and in 2013 only half of the survey was completed and the data were not used for the index.

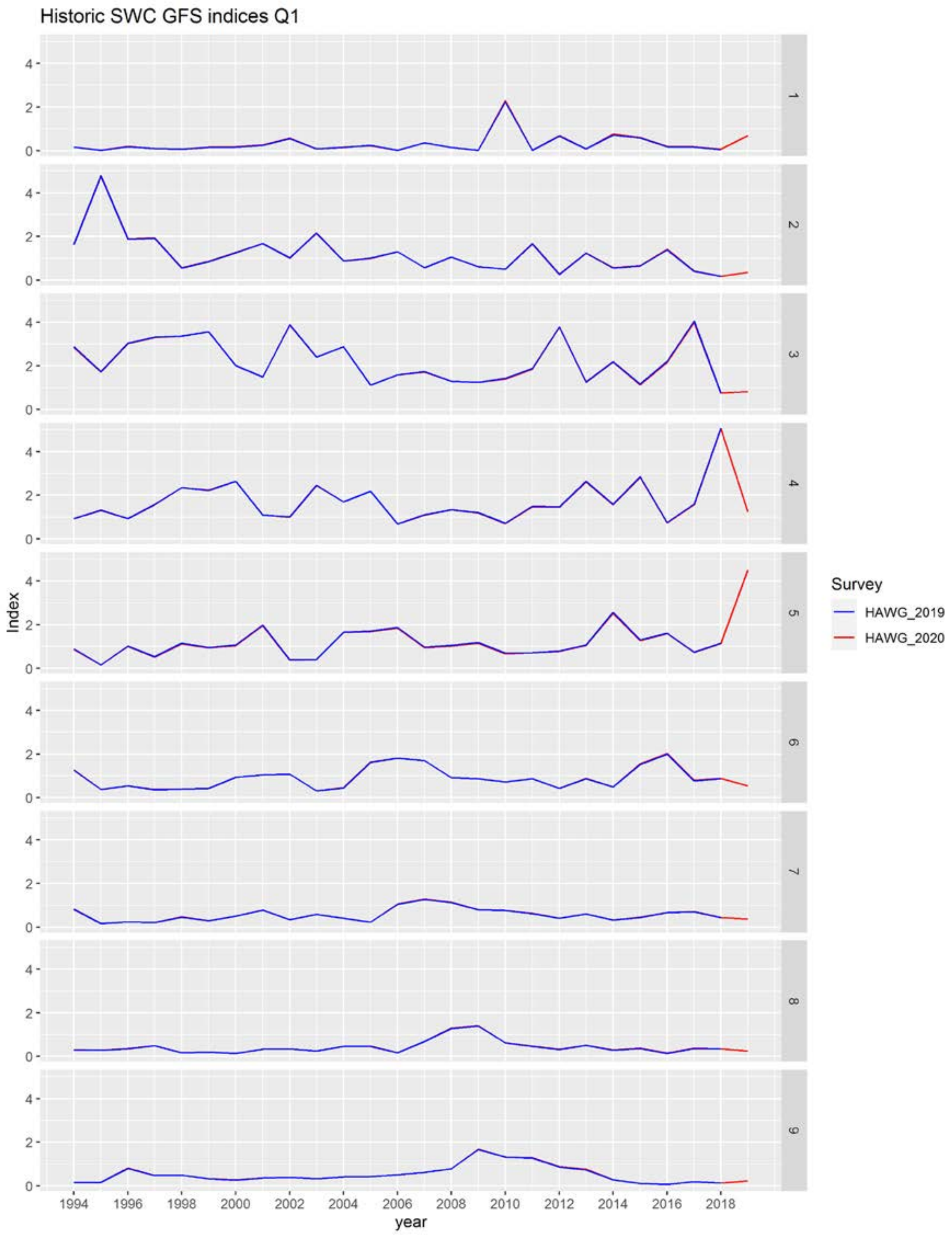


Figure 4.3.2.5 Herring in 6.a (combined) and 7.b–c. Abundance-at-age index from Scottish groundfish survey in Quarter 1 from HAWG 2019 and HAWG 2020. Each index was mean standardized by year.

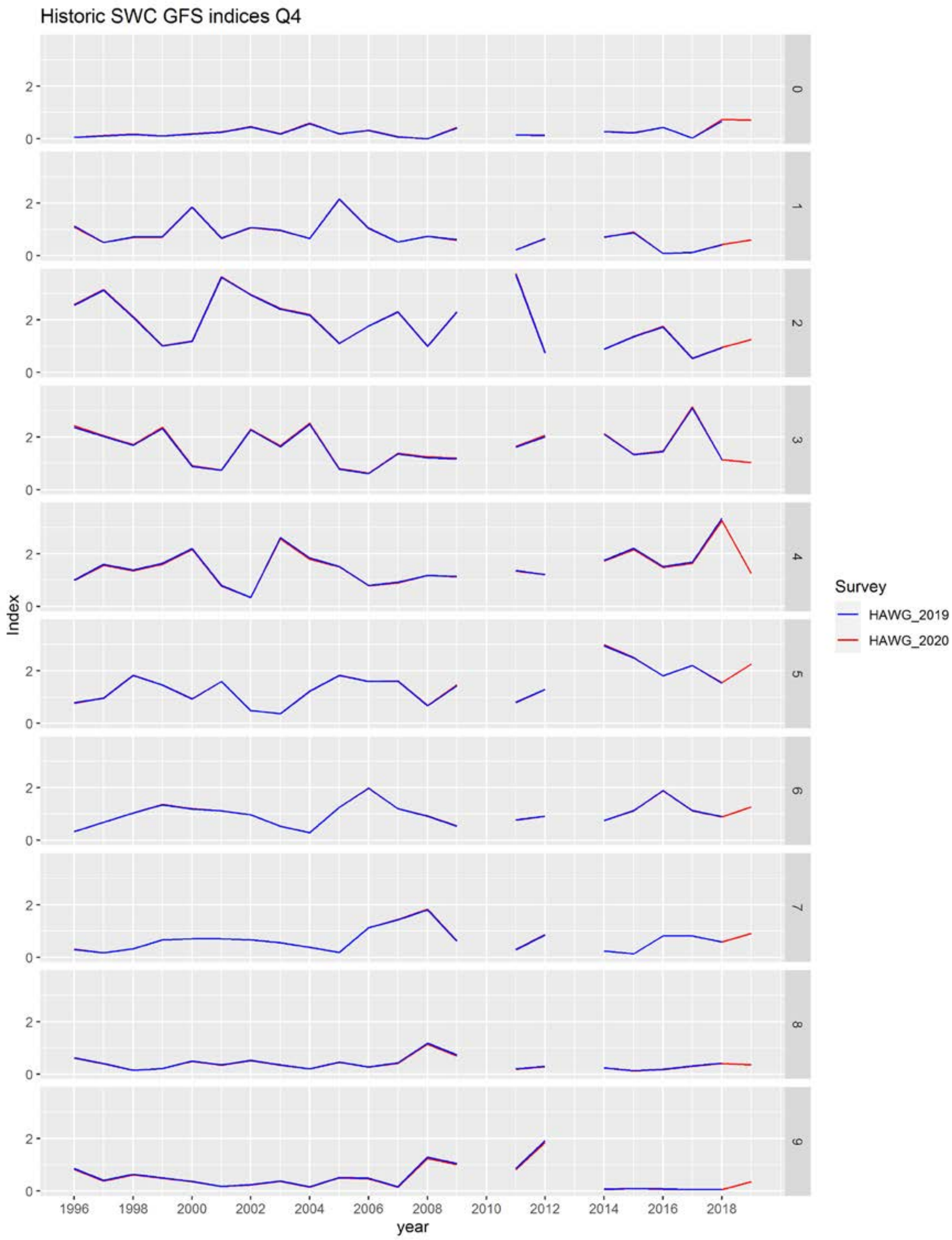


Figure 4.3.2.6 Herring in 6.a (combined) and 7.b–c. Abundance-at-age index from Scottish groundfish survey in Quarter 4 from HAWG 2019 and from HAWG 2020. Each index was mean standardized by years.

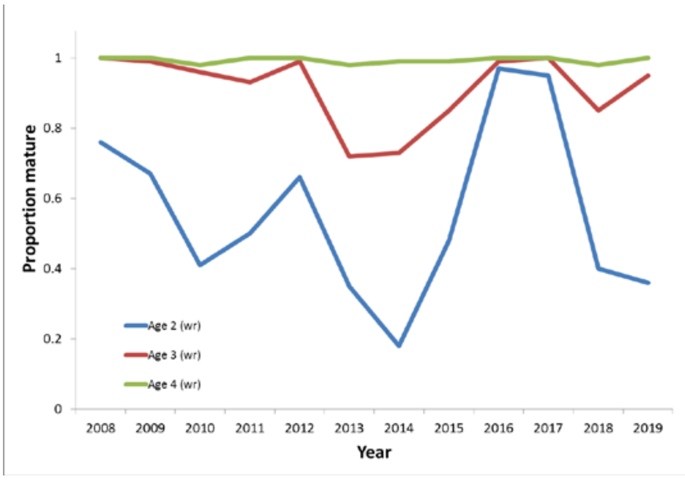


Figure 4.4.2.1. Herring in 6.a (combined) and 7.b–c. Maturity-at-ages 2–4 wr for the years 2008 to 2019.

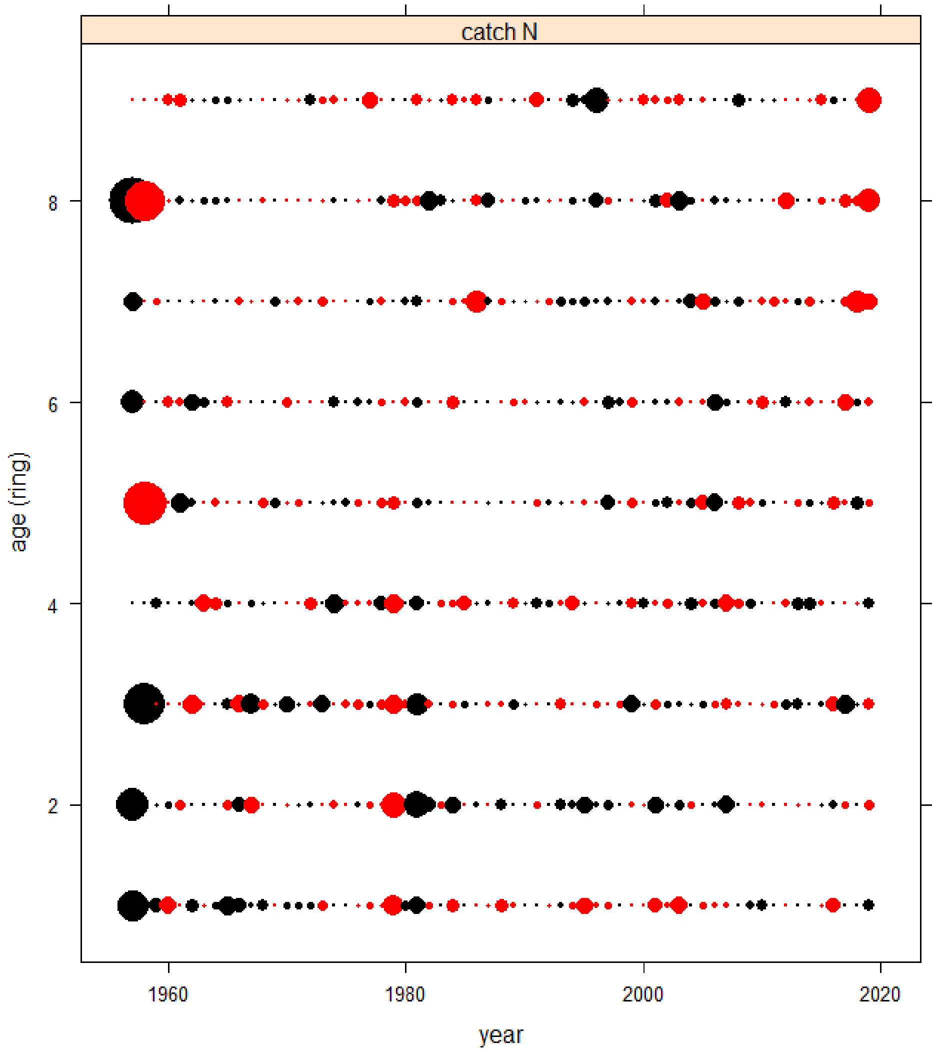


Figure 4.6.1. Herring in 6.a (combined) and 7.b–c. Bubble plot of catch N residuals (1957–2019).

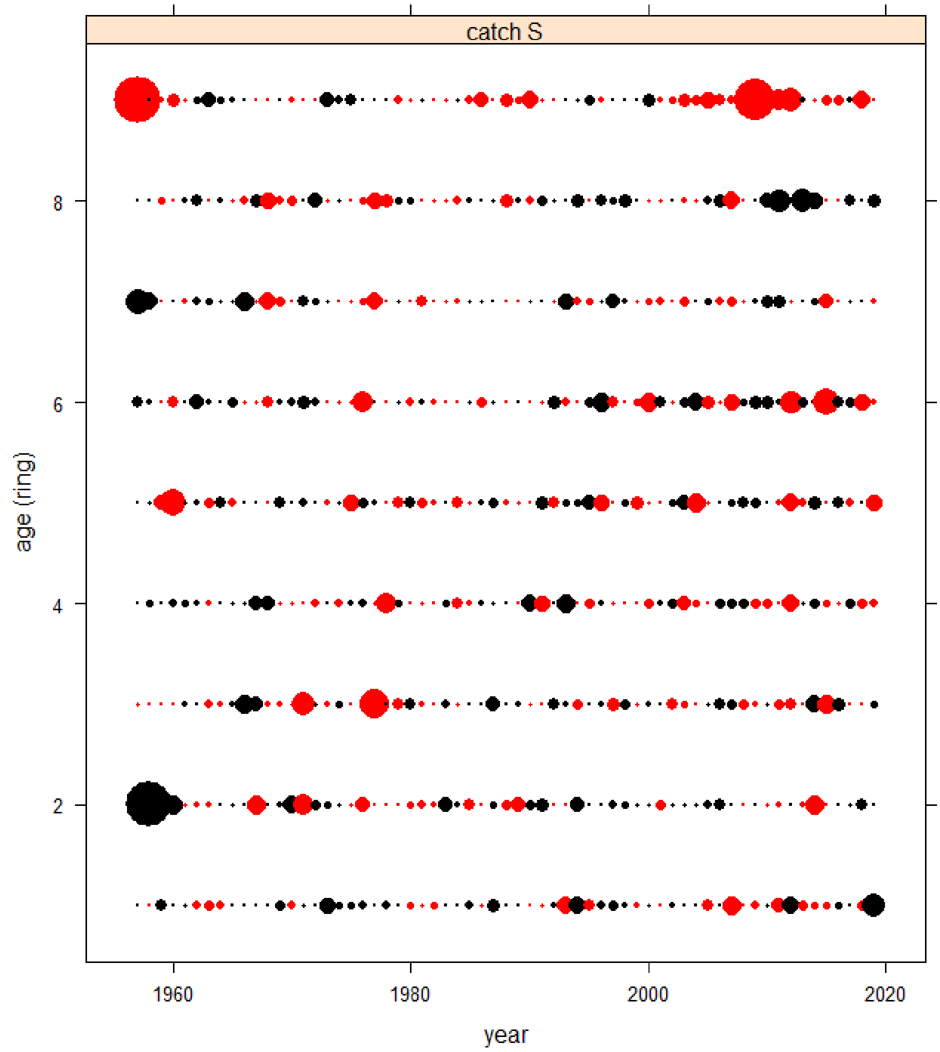


Figure 4.6.2. Herring in 6.a (combined) and 7.b–c. Bubble plot of catch S residuals (1957–2019).

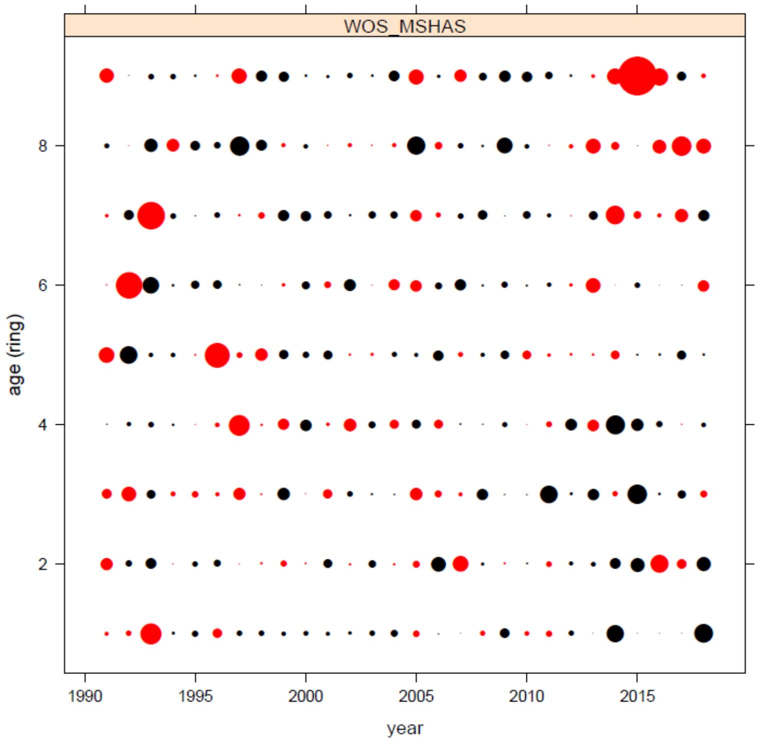


Figure 4.6.3. Herring in 6.a (combined) and 7.b–c. Bubble plot of standardized survey residuals from the WoS_MSHAS acoustic survey (1991–2019).

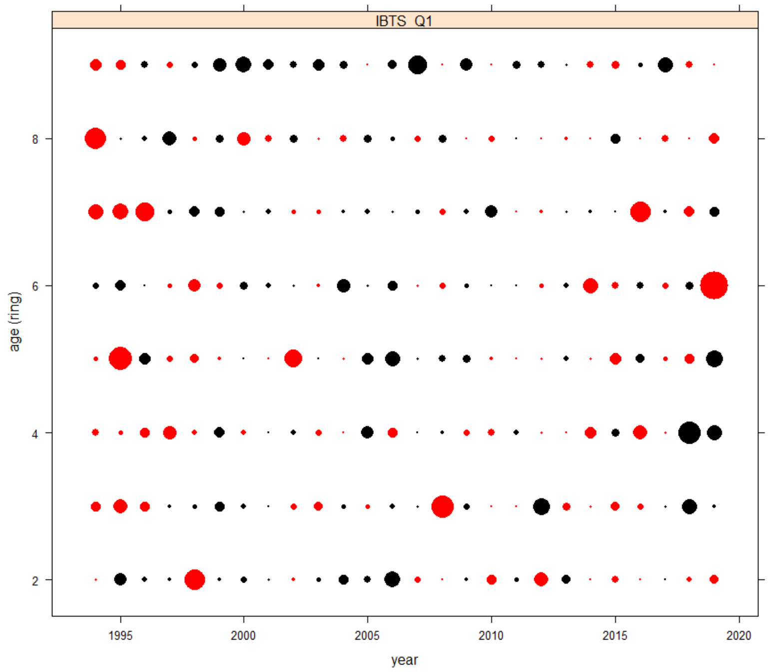


Figure 4.6.4. Herring in 6.a (combined) and 7.b–c. Bubble plot of standardized survey residuals from the Scottish bottom-trawl survey in quarter 1 (1994–2019).

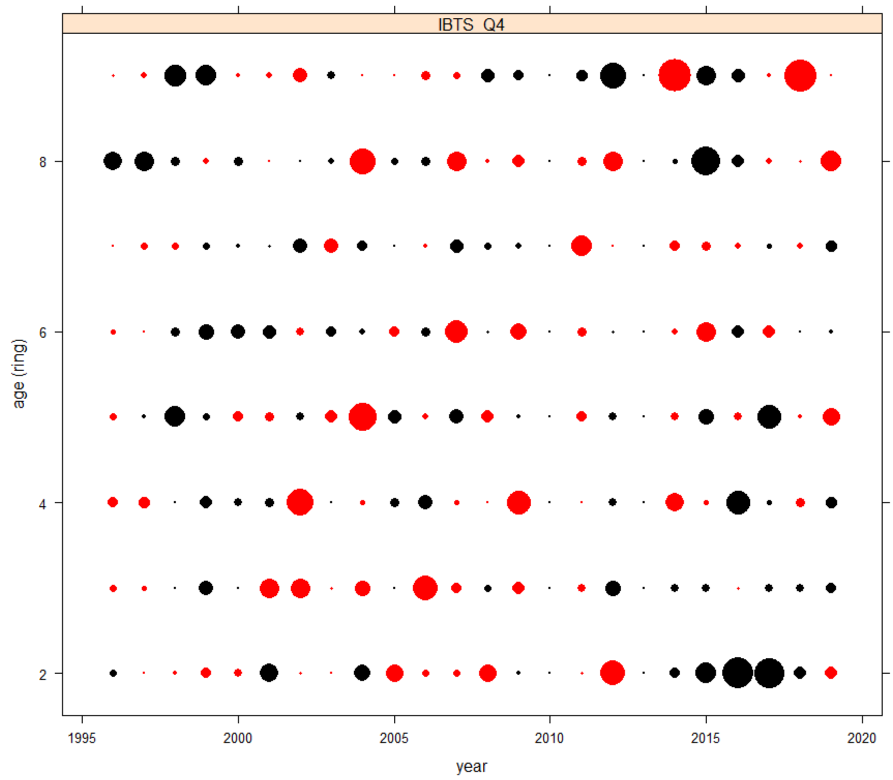


Figure 4.6.5. Herring in 6.a (combined) and 7.b–c. Bubble plot of standardized survey residuals from the Scottish bottom-trawl survey in quarter 4 (1996–2019).

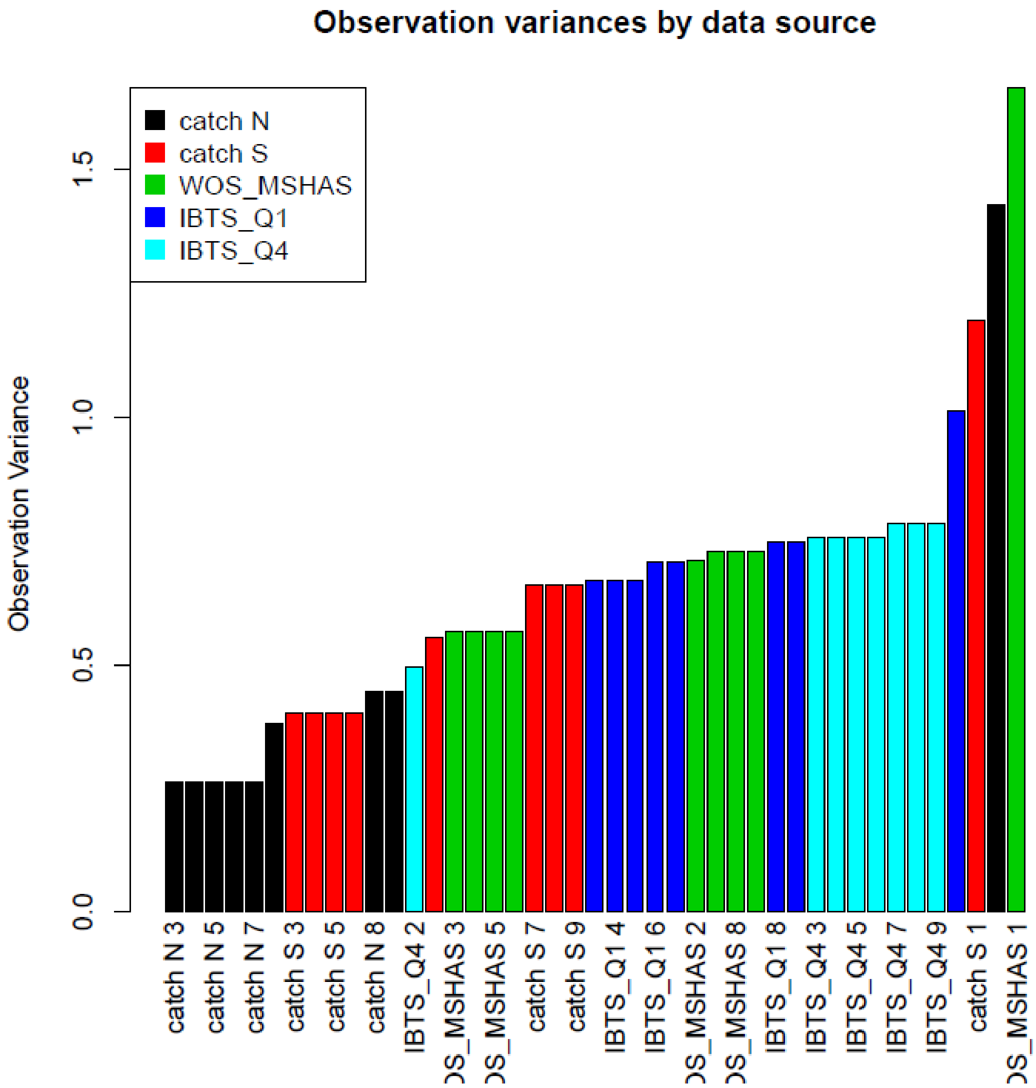


Figure 4.6.6. Herring in 6.a (combined) and 7.b–c. Observation variance by data source, ordered from least (left) to most (right). Colours indicate the different data sources. In cases where parameters are bound, observation variances have equal values.

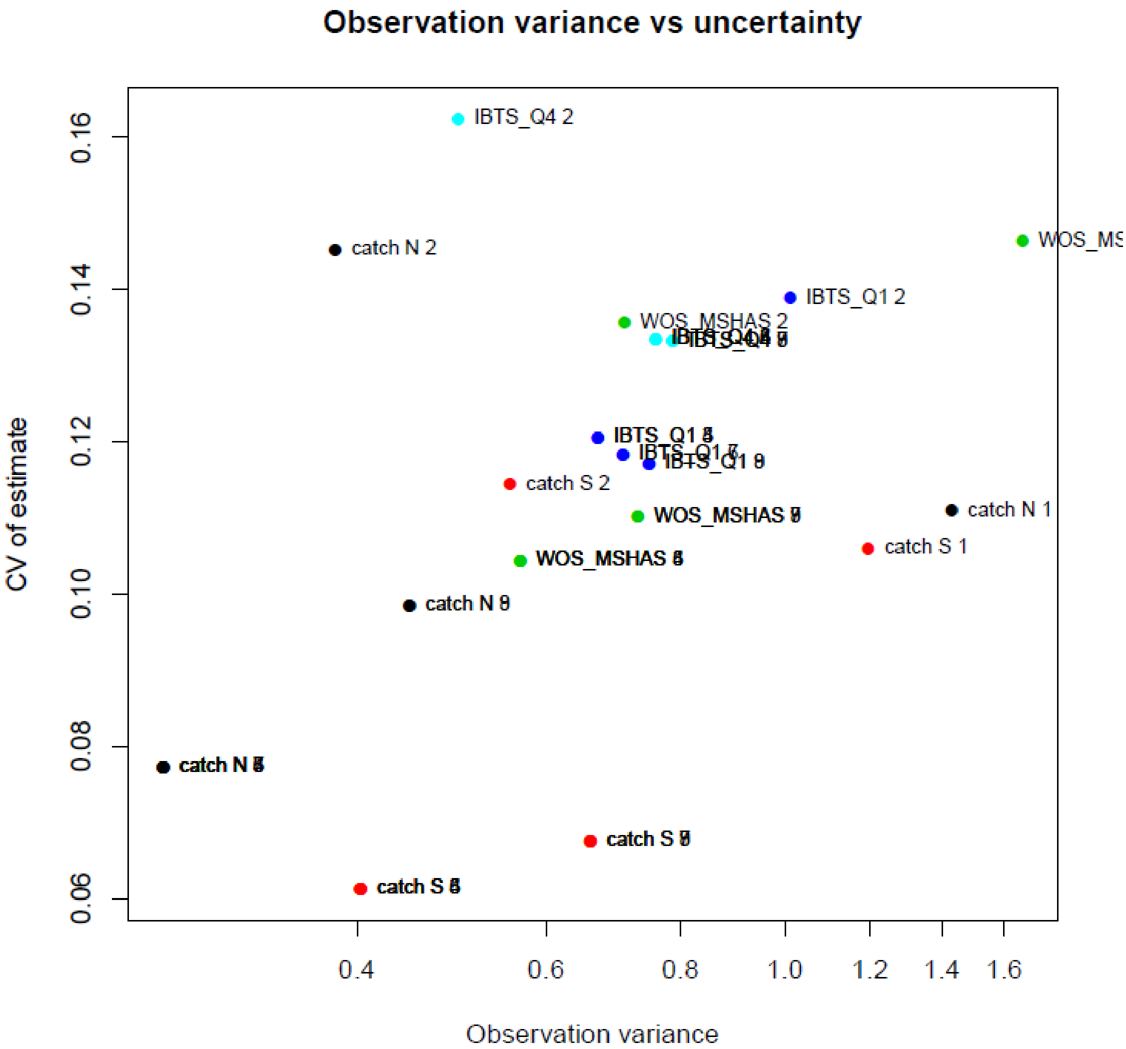


Figure 4.6.7. Herring in 6.a (combined) and 7.b–c. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

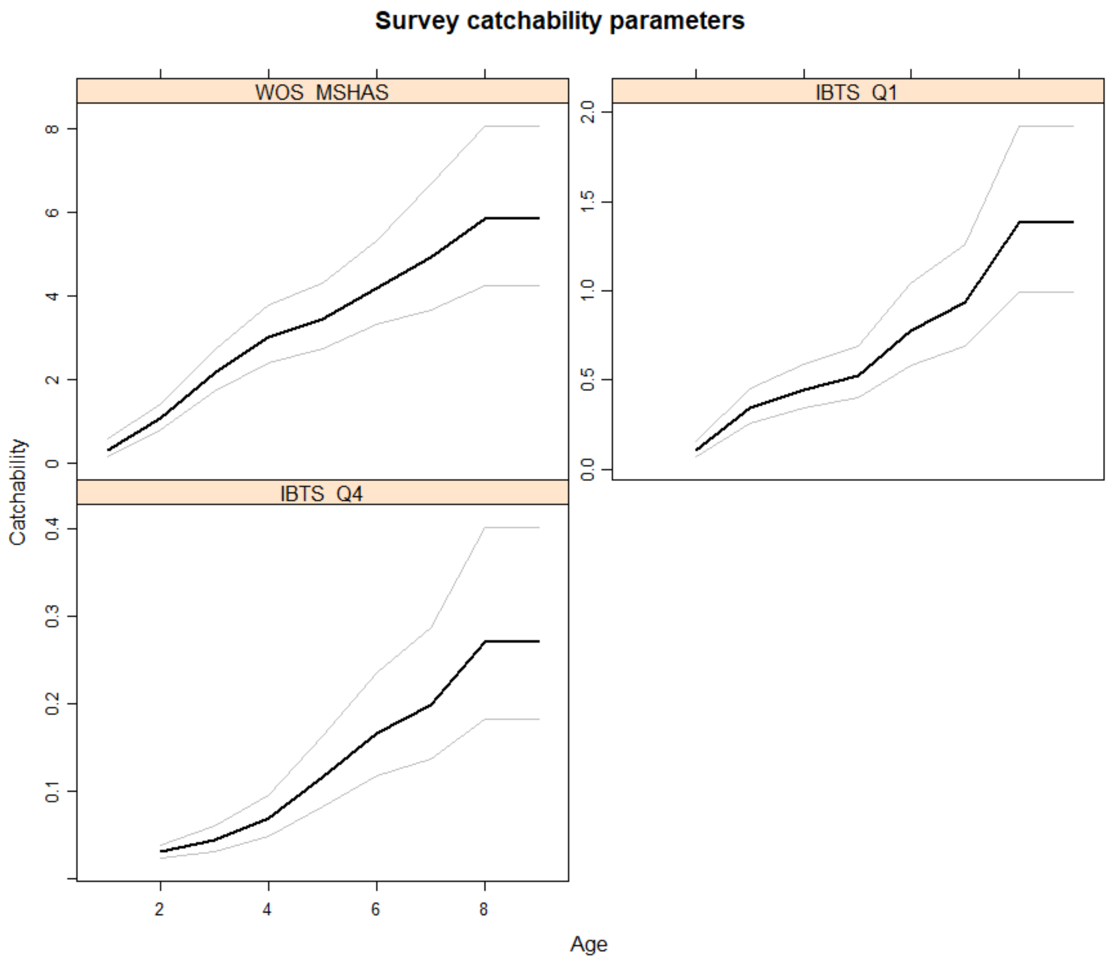


Figure 4.6.8. Herring in 6.a (combined) and 7.b–c. Survey catchability parameters from the WOS_MSHAS acoustic survey (topleft), Scottish groundfish survey index quarter 1 (IBTS_Q1, topright) and Scottish groundfish survey index quarter 4 (IBTS_Q4, bottomleft).

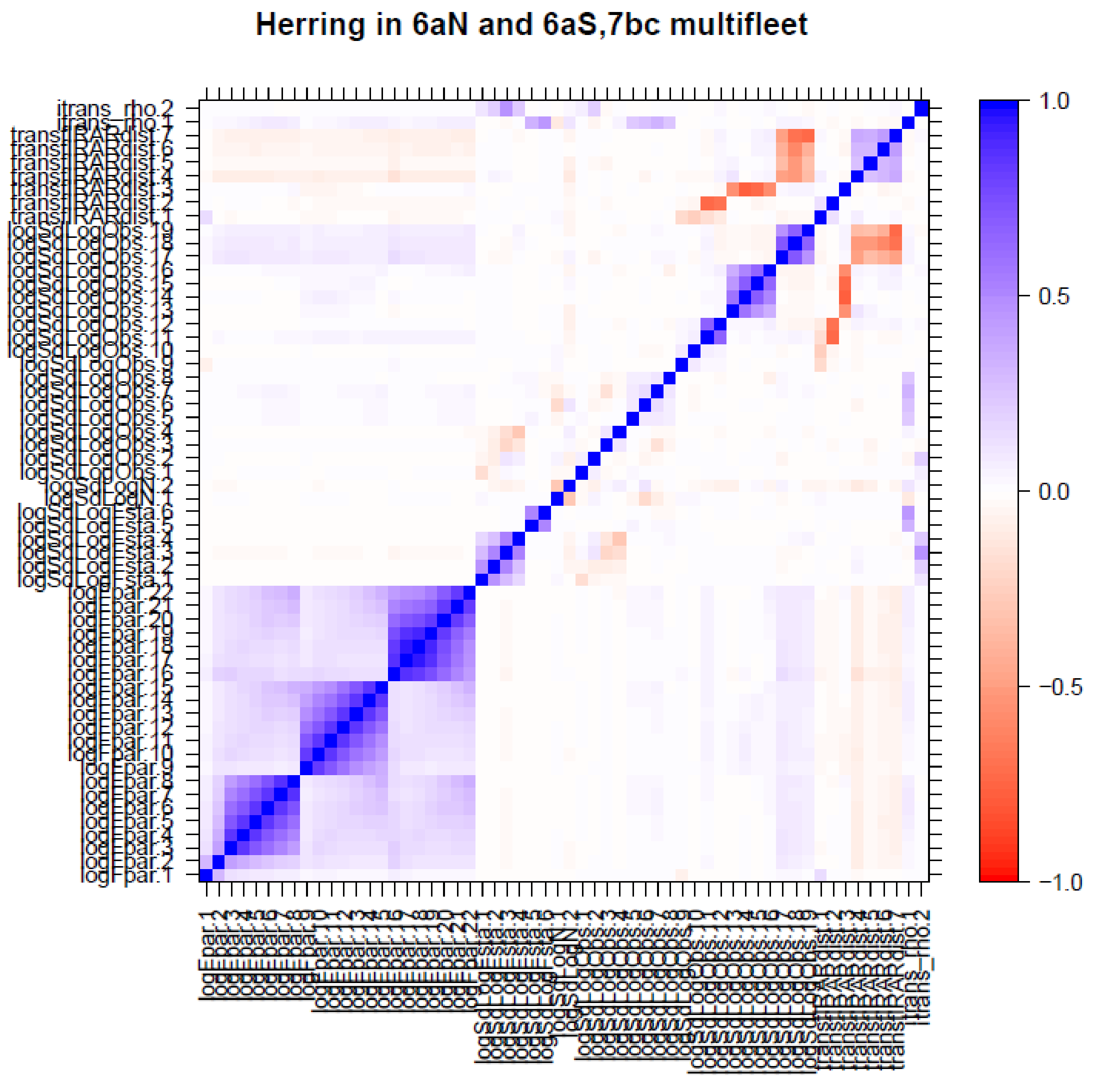


Figure 4.6.9. Herring in 6.a (combined) and 7.b–c. Correlation plot of the parameters estimated in the model. The horizontal and vertical axes show the parameters fitted by the model (labelled with names stored and fitted by FLSAM). The colouring of each pixel indicates the Pearson correlation between the two parameters. The diagonal represents the correlation with the data source itself.

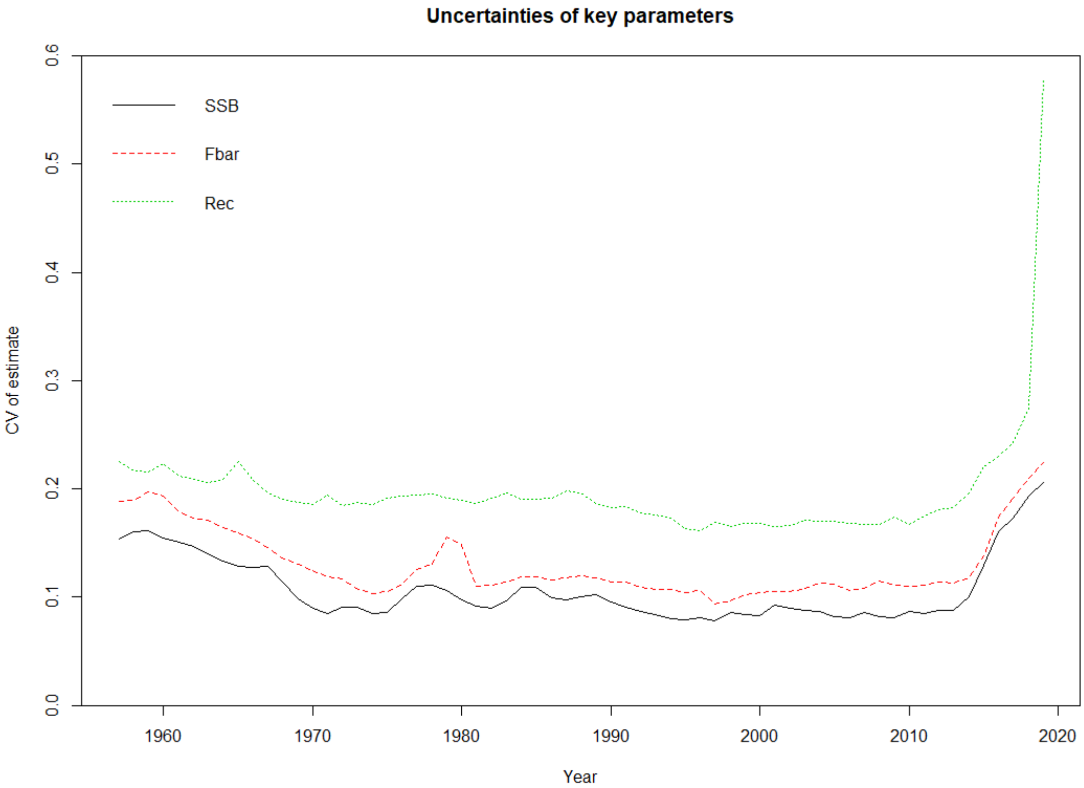


Figure 4.6.10. Herring in 6.a (combined) and 7.b–c. Uncertainty estimates in SSB, F_{bar} and recruitment parameters (1957–2019).

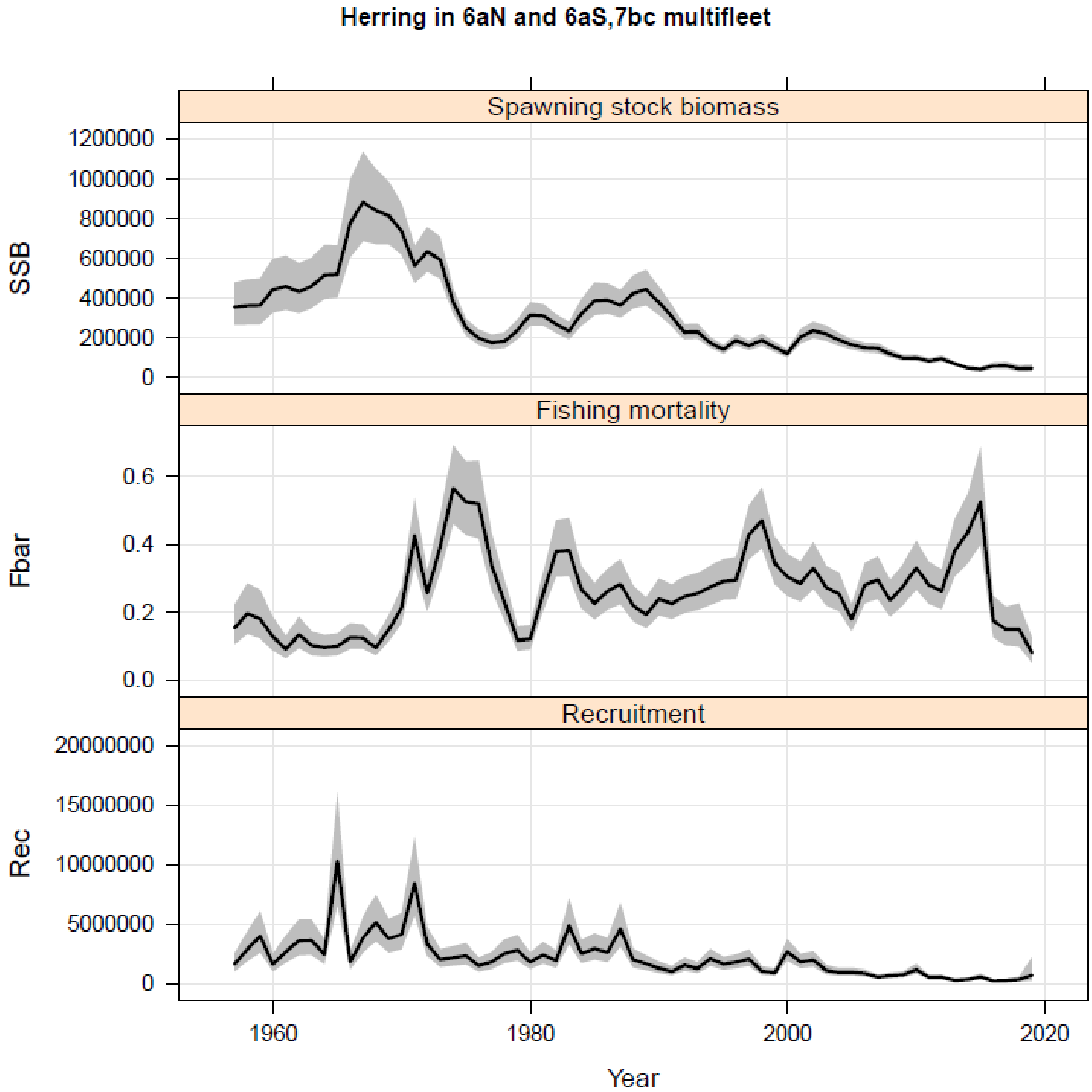


Figure 4.6.11. Herring in 6.a (combined) and 7.b–c. Stock summary plot with associated uncertainty for SSB (top panel), F ages 3–6 (middle panel) and recruitment (bottom panel).

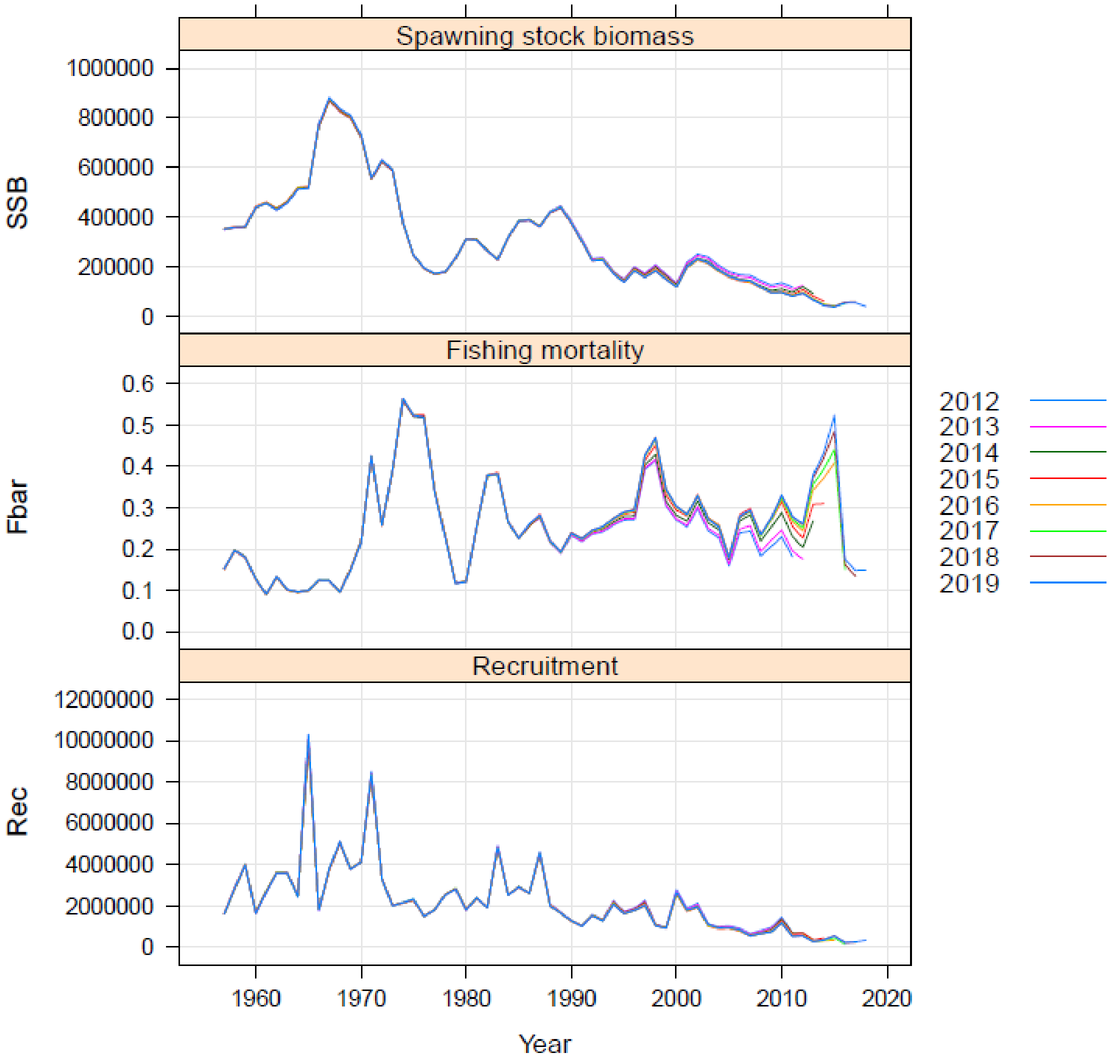


Figure 4.6.12. Herring in 6.a (combined) and 7.b–c. Analytical retrospective of the estimated spawning–stock biomass (top panel), fishing mortality (middle panel) and recruitment (bottom panel) as estimated over the years 2011–2019.

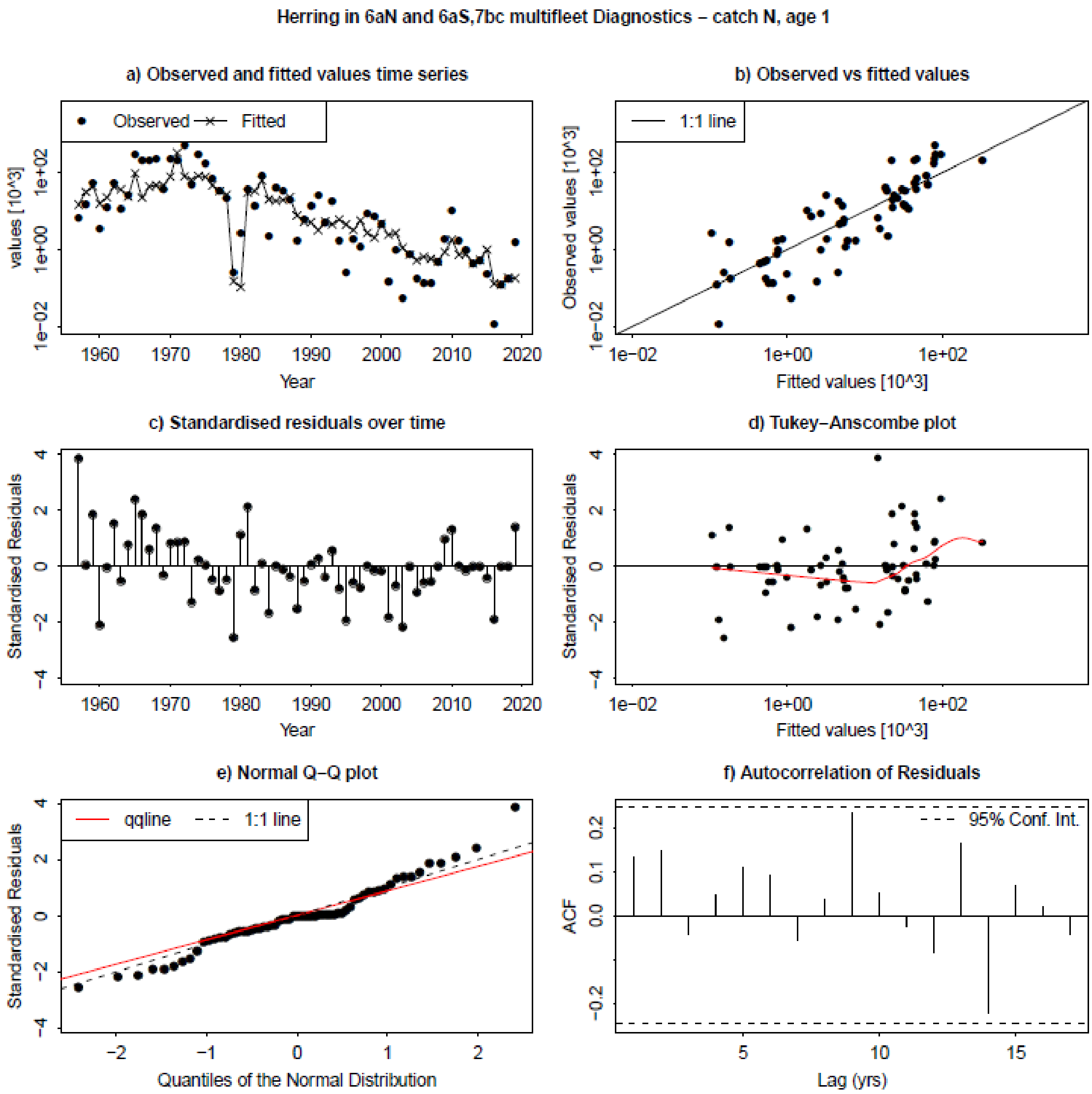


Figure 4.6.13. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 1-winter ring time-series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from catch abundance at 1-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 1-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 1-winter ring. Middle right: catch observation vs. standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

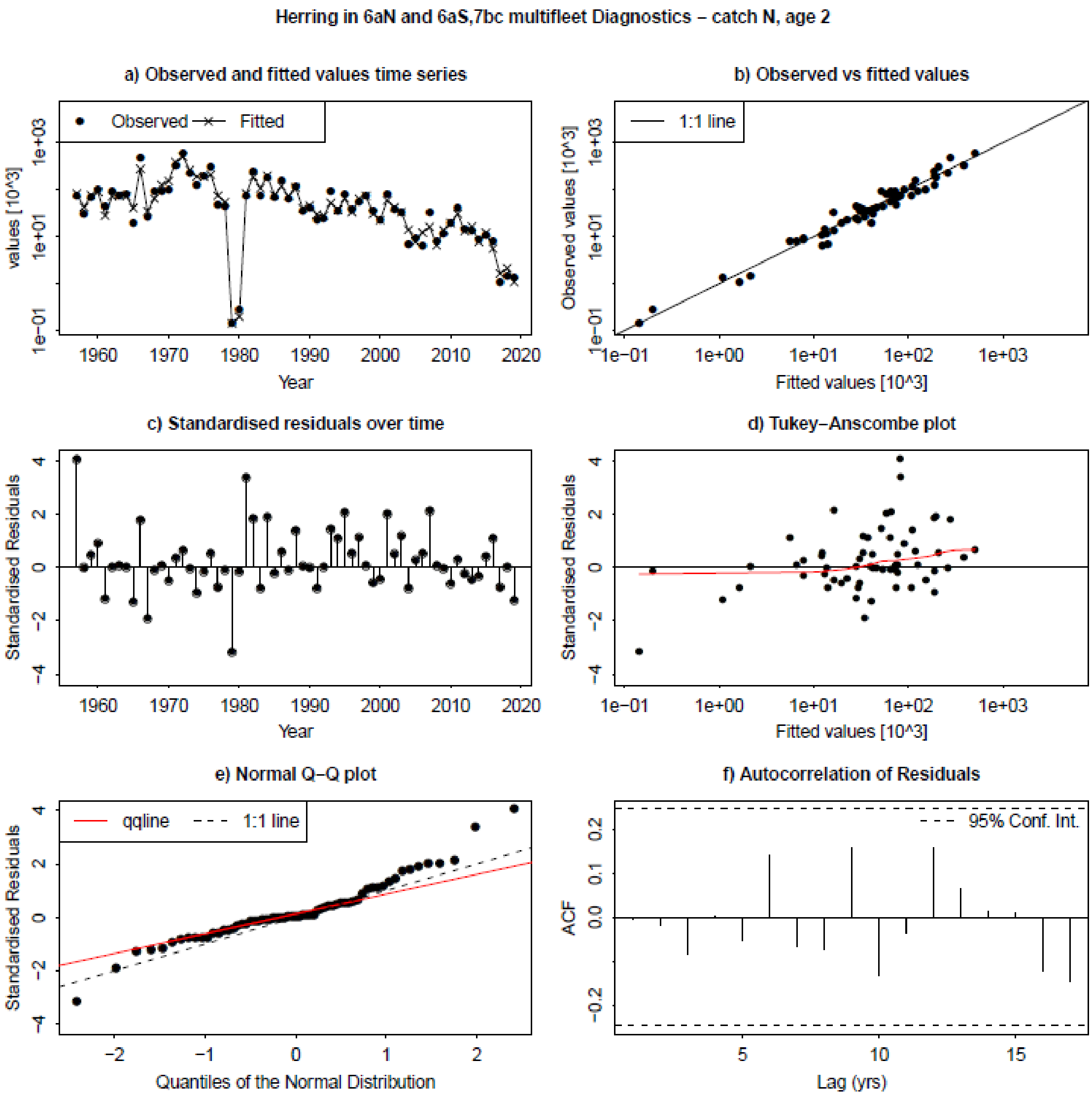


Figure 4.6.16. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from catch abundance at 2-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 2-winter ring. Middle right: catch observation vs. standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

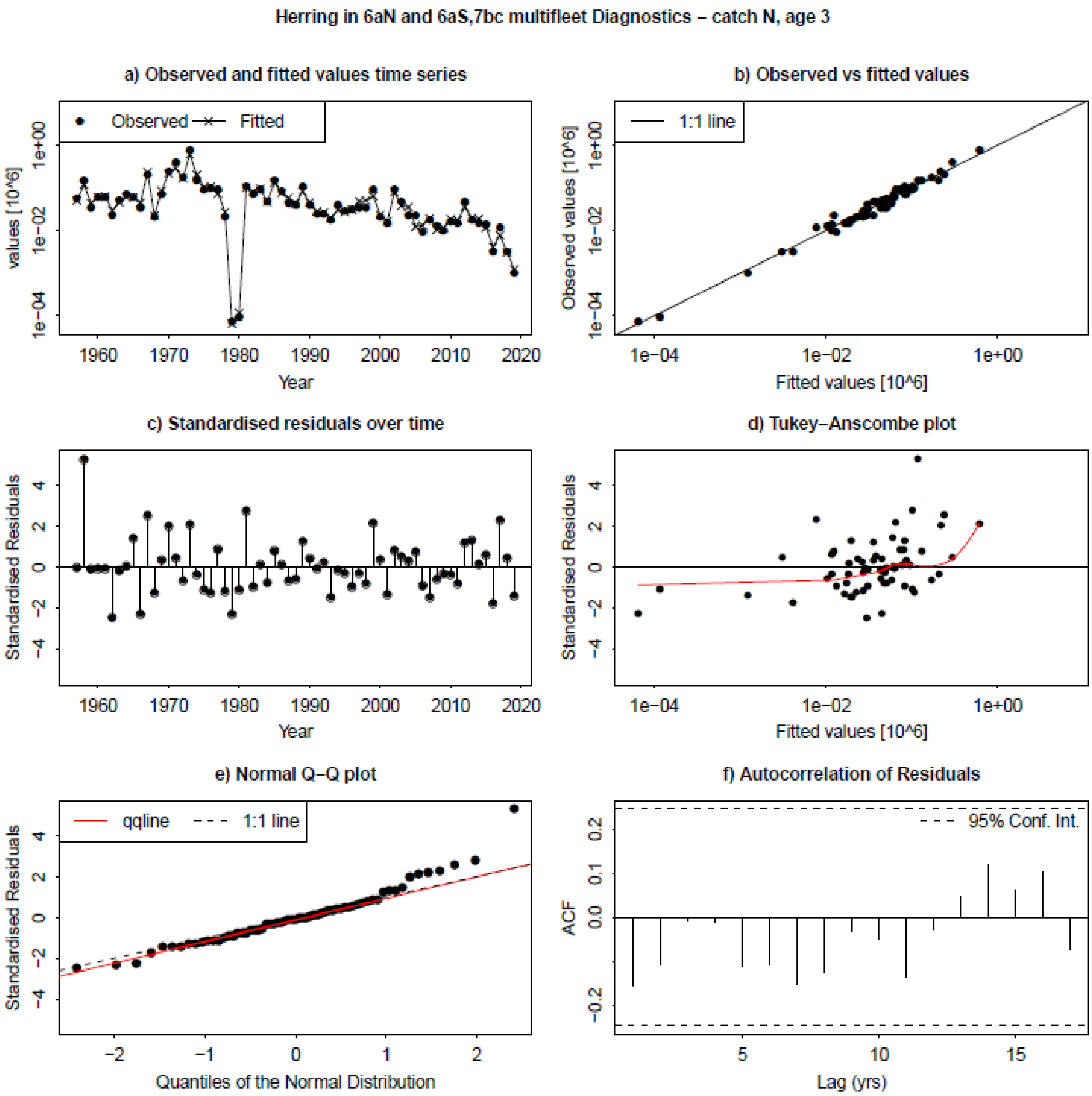


Figure 4.6.17. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from catch abundance at 3-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 3-winter ring. Middle right: catch observation vs. standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

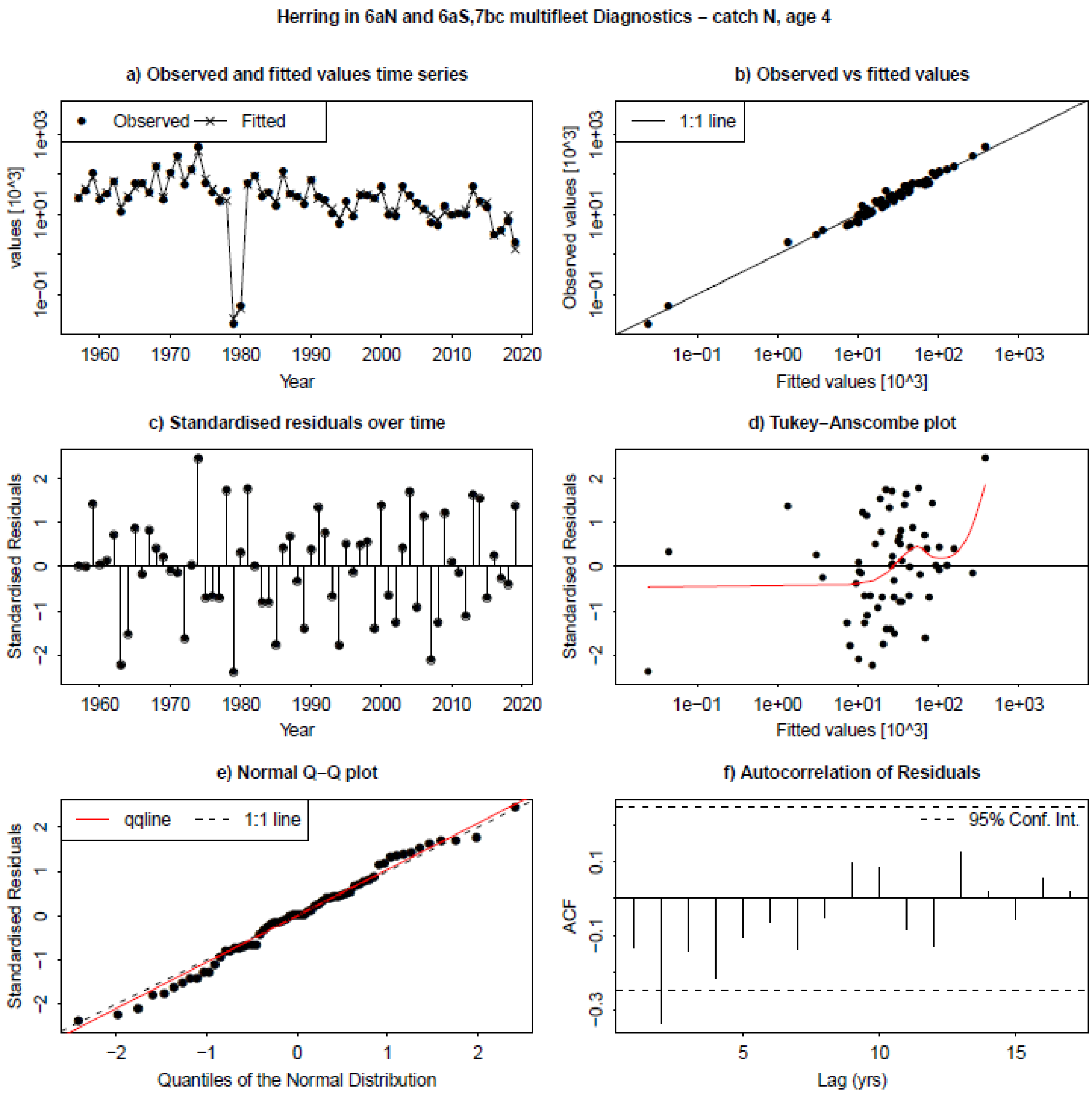


Figure 4.6.18. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from catch abundance at 4-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 4-winter ring. Middle right: catch observation vs. standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

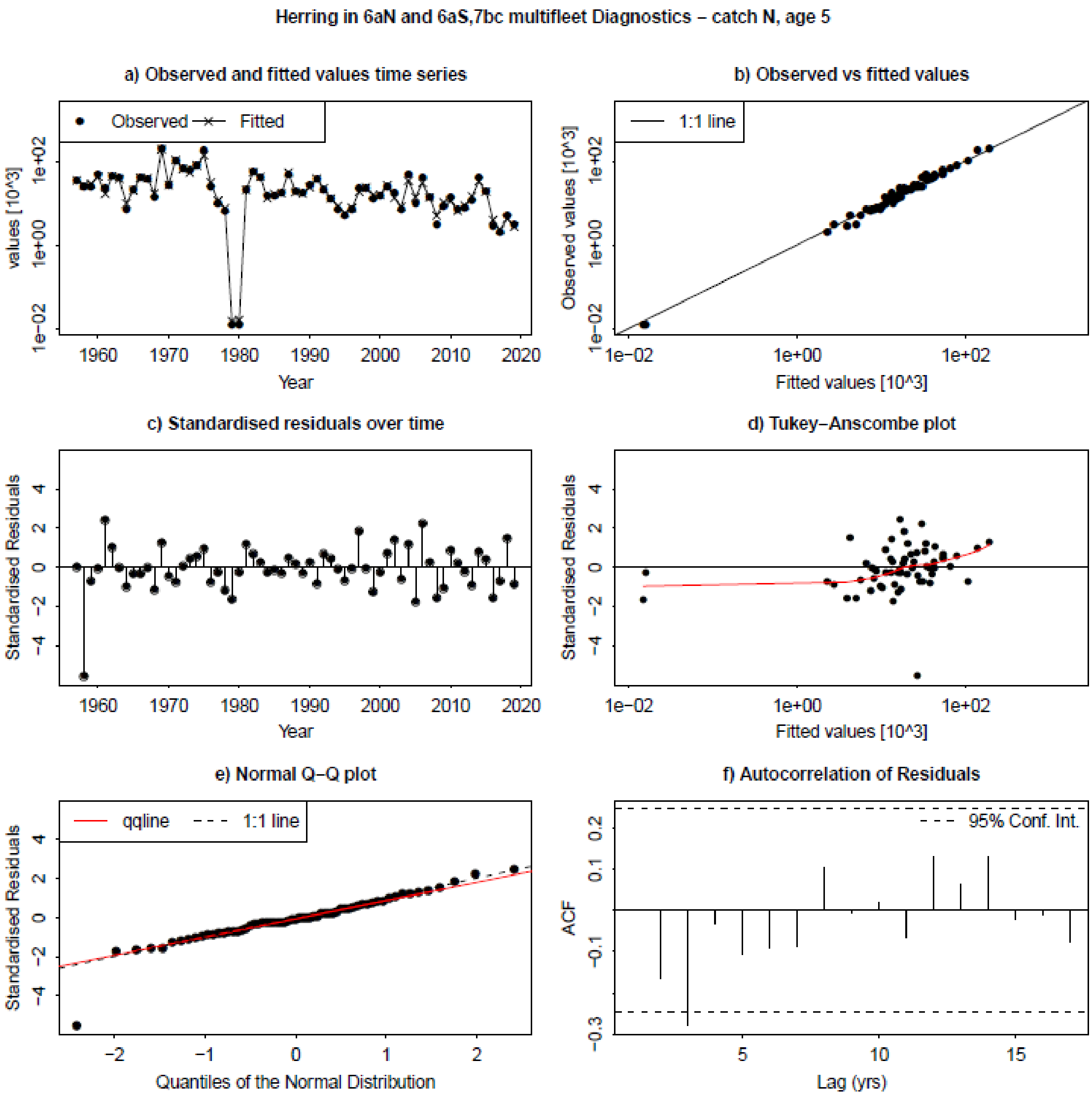


Figure 4.6.19. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from catch abundance at 5-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 5-winter ring. Middle right: catch observation vs. standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

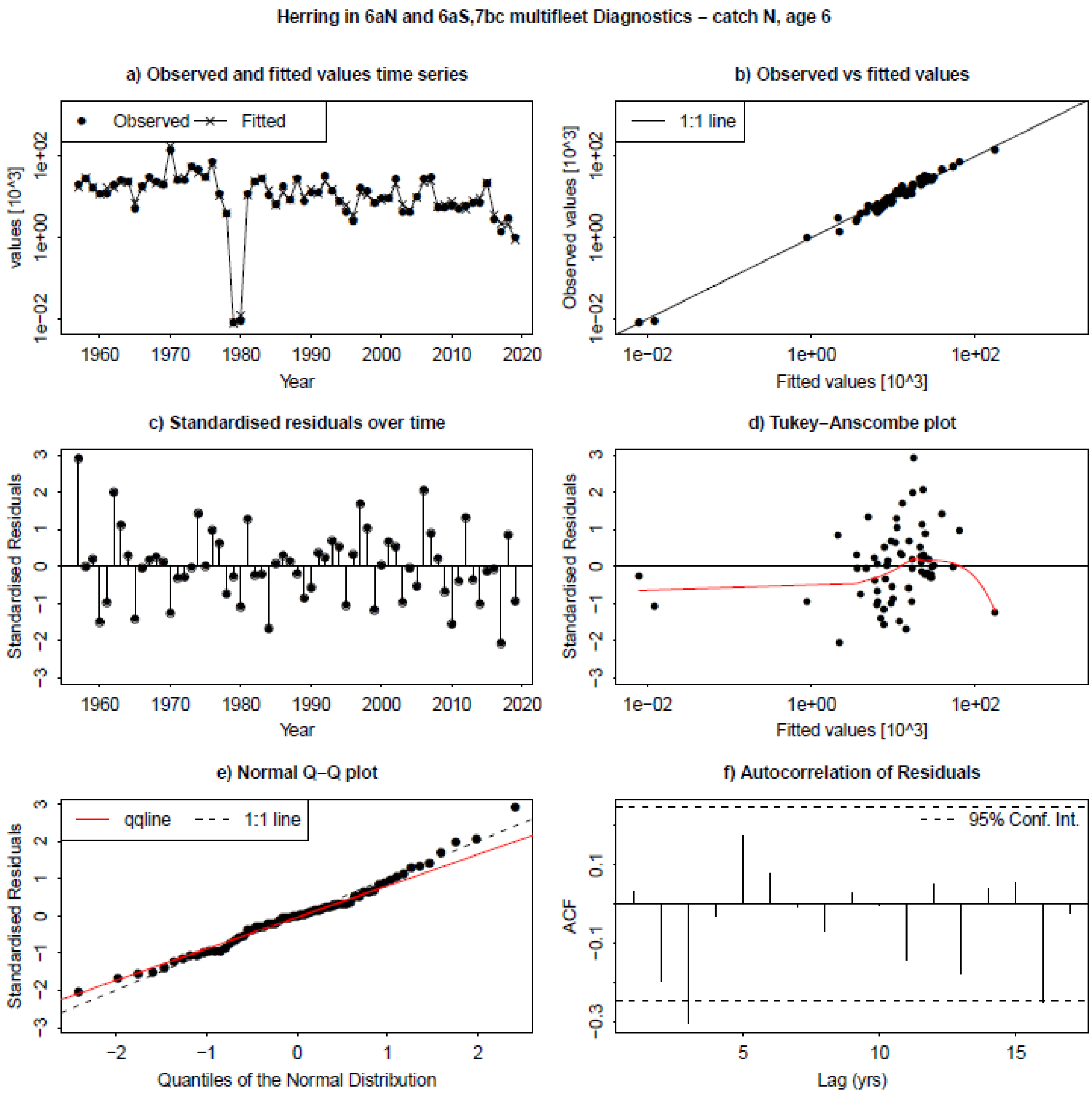


Figure 4.6.20. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from catch abundance at 6-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 6-winter ring. Middle right: catch observation vs. standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

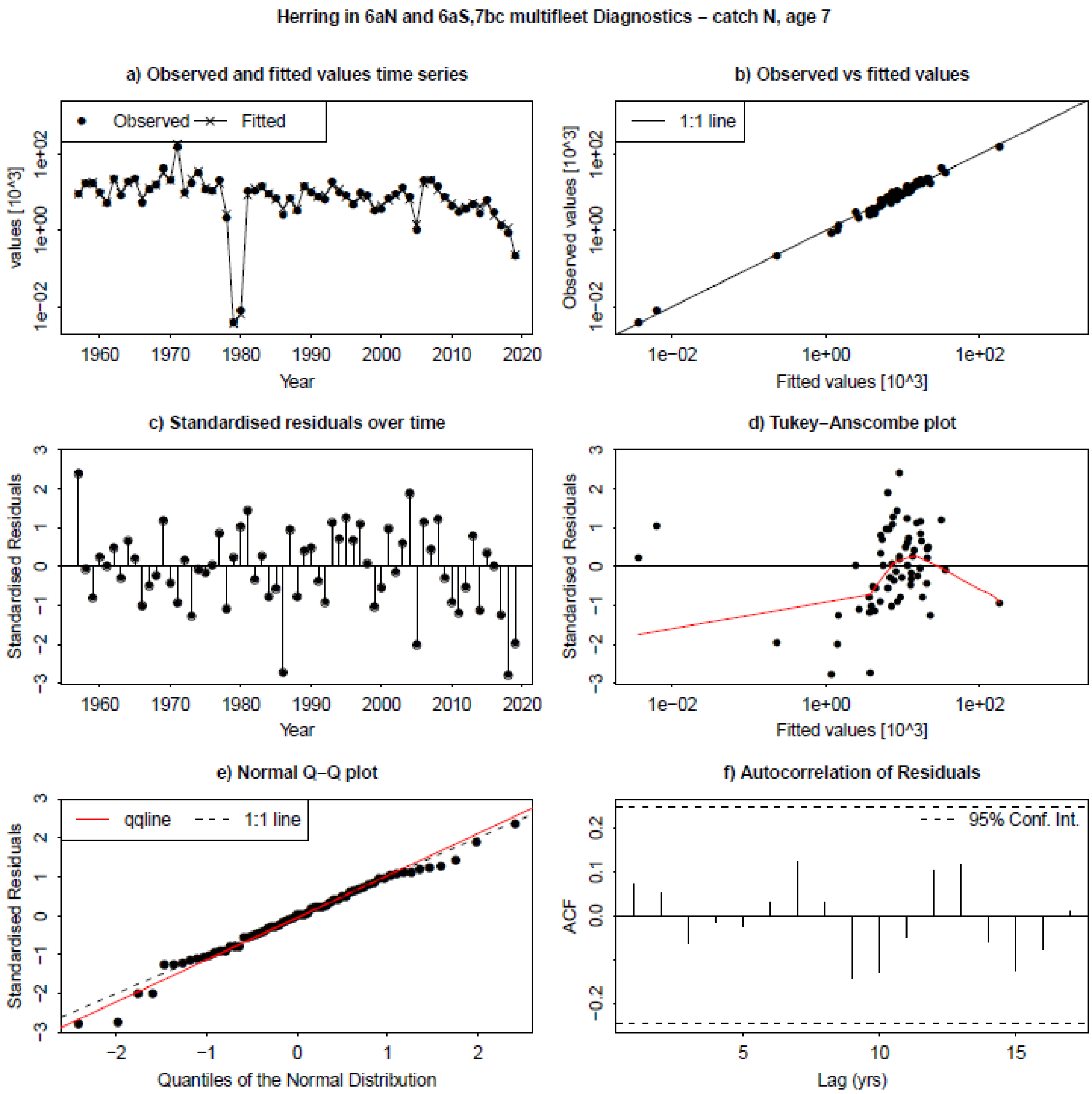


Figure 4.6.21. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from catch abundance at 7-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 7-winter ring. Middle right: catch observation vs. standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

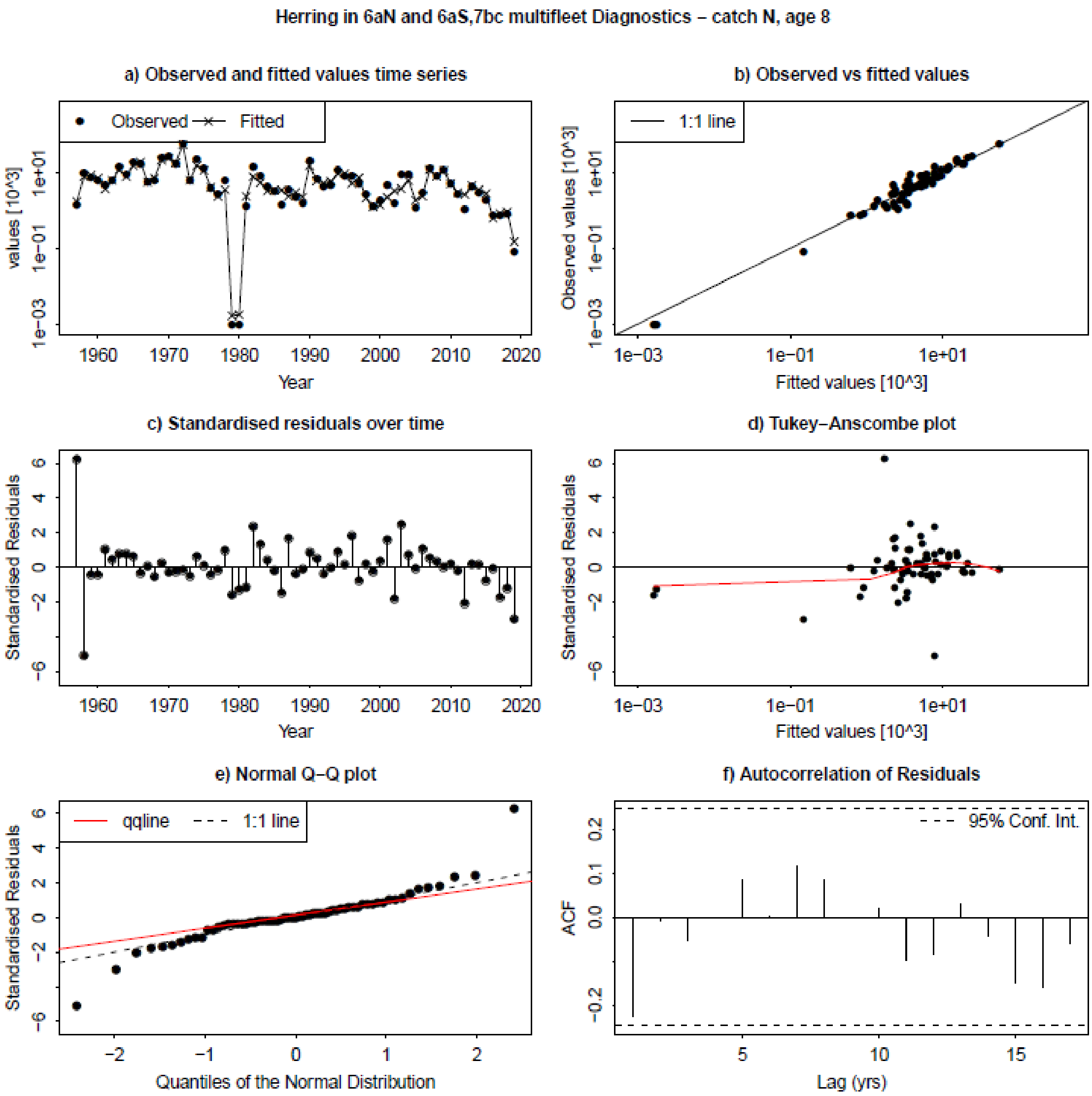


Figure 4.6.22. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from catch abundance at 8-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 8-winter ring. Middle right: catch observation vs. standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

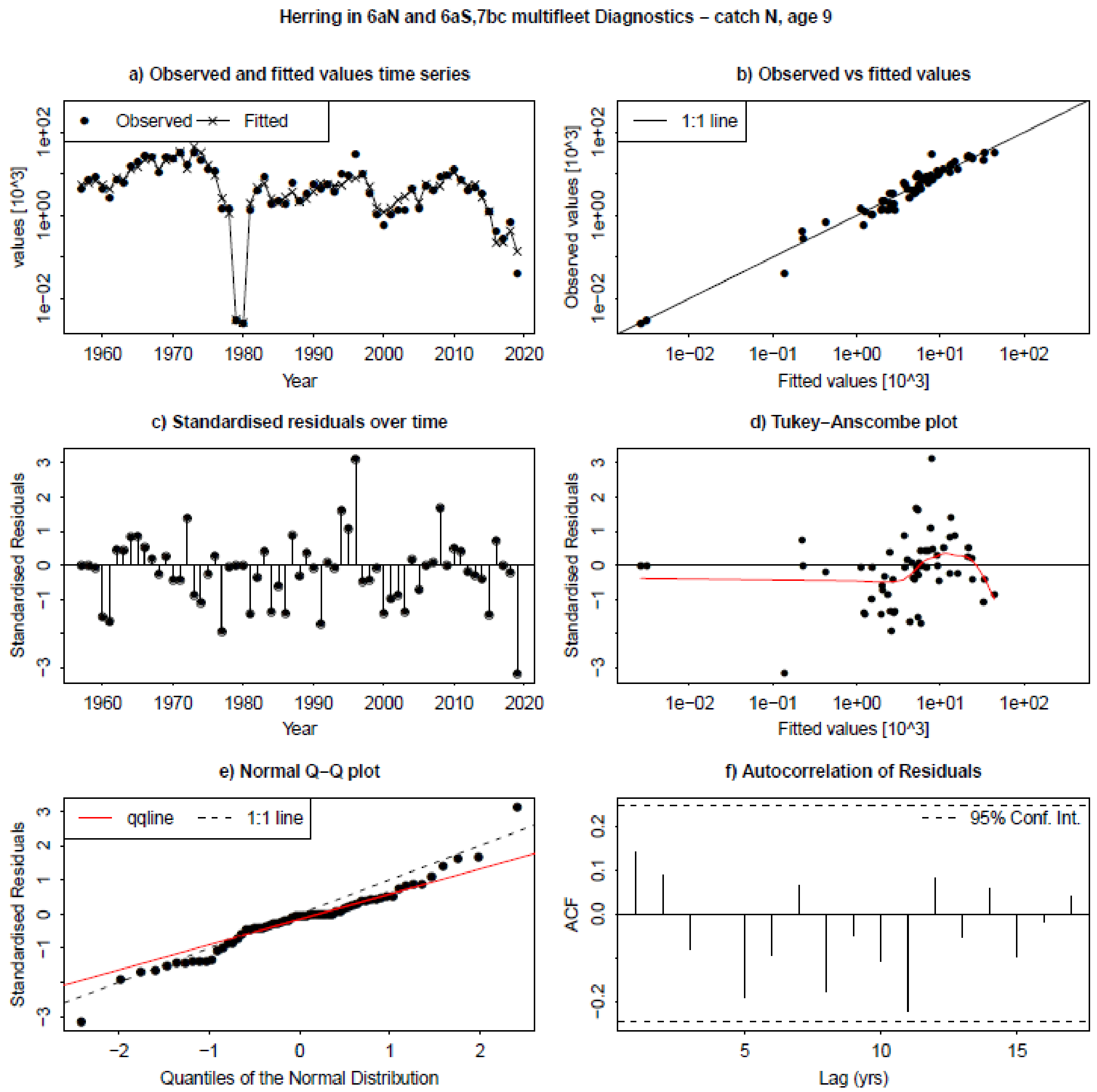


Figure 4.6.23. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from catch abundance at 9-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 9-winter ring. Middle right: catch observation vs. standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

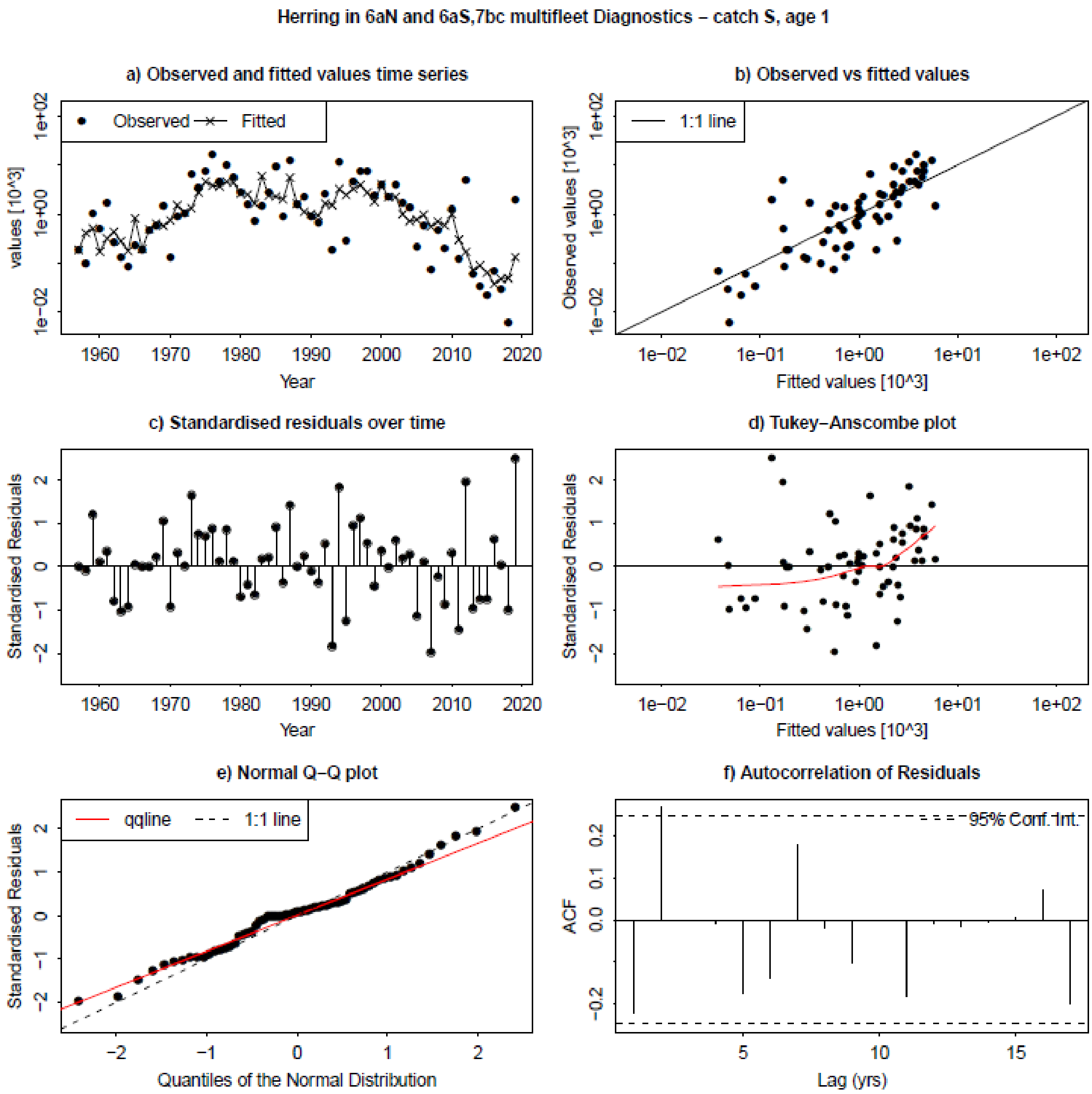


Figure 4.6.24. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 1-winter ring time-series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from catch abundance at 1-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 1-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 1-winter ring. Middle right: catch observation vs. standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

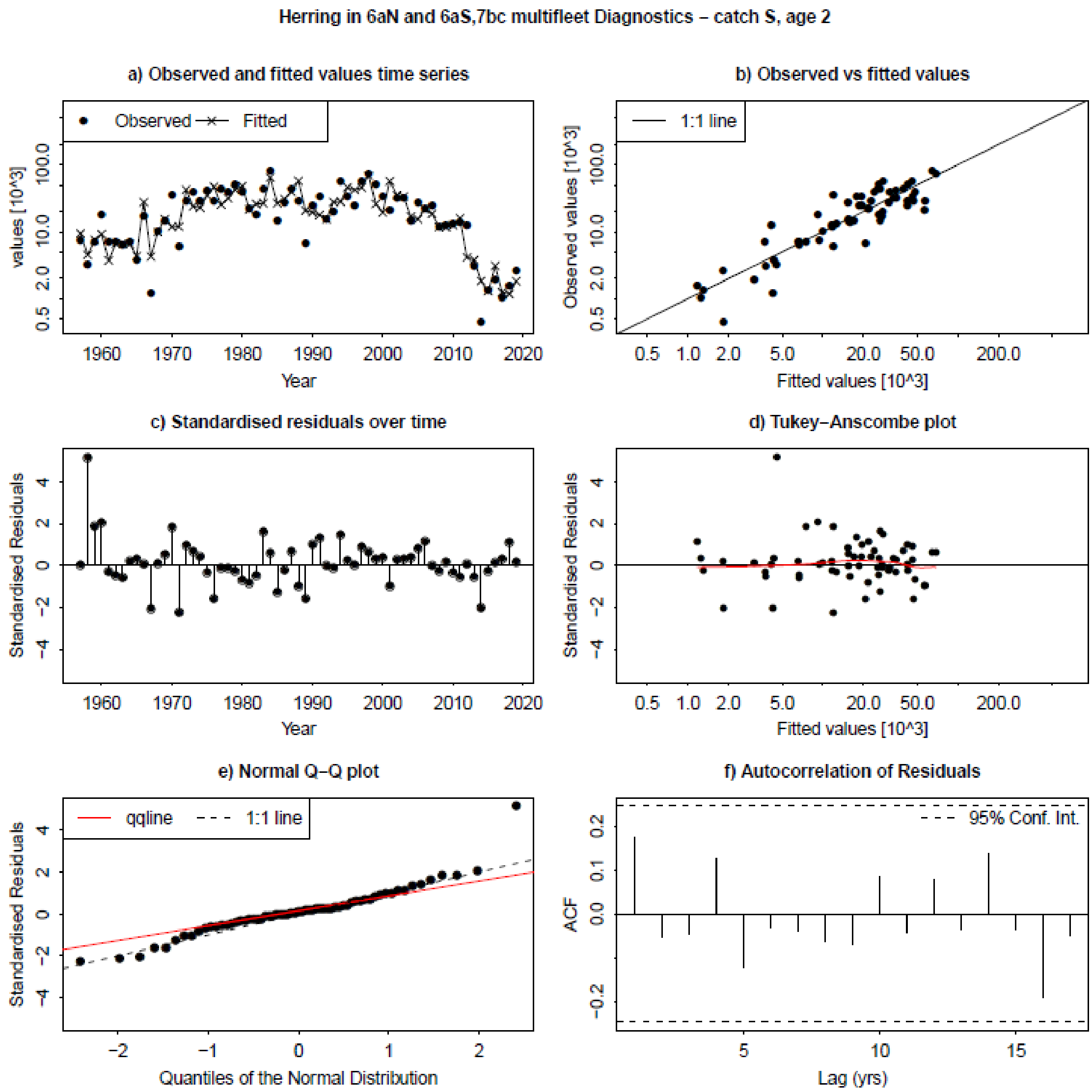


Figure 4.6.25. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from catch abundance at 2-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 2-winter ring. Middle right: catch observation vs. standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

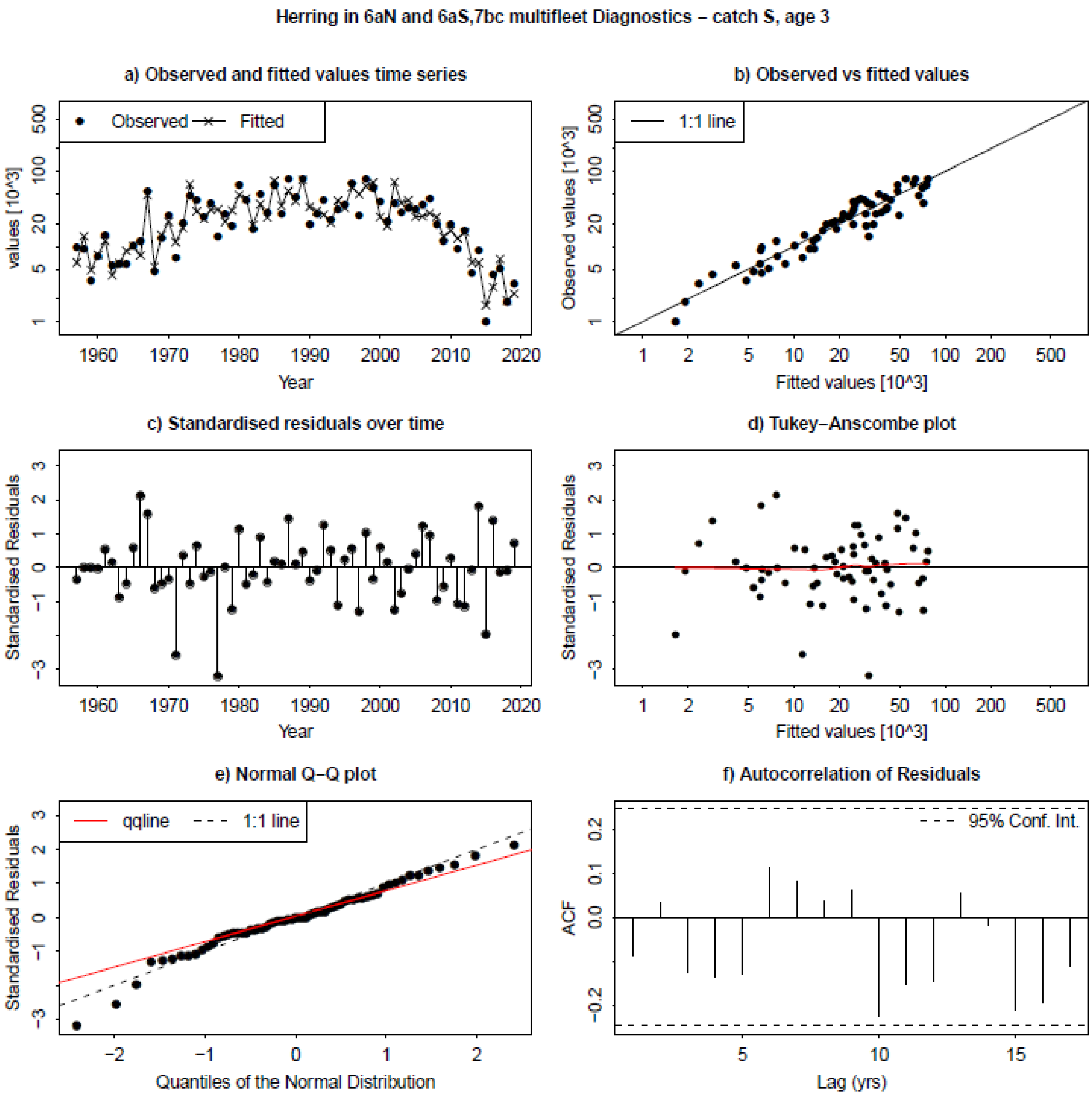


Figure 4.6.26. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from catch abundance at 3-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 3-winter ring. Middle right: catch observation vs. standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

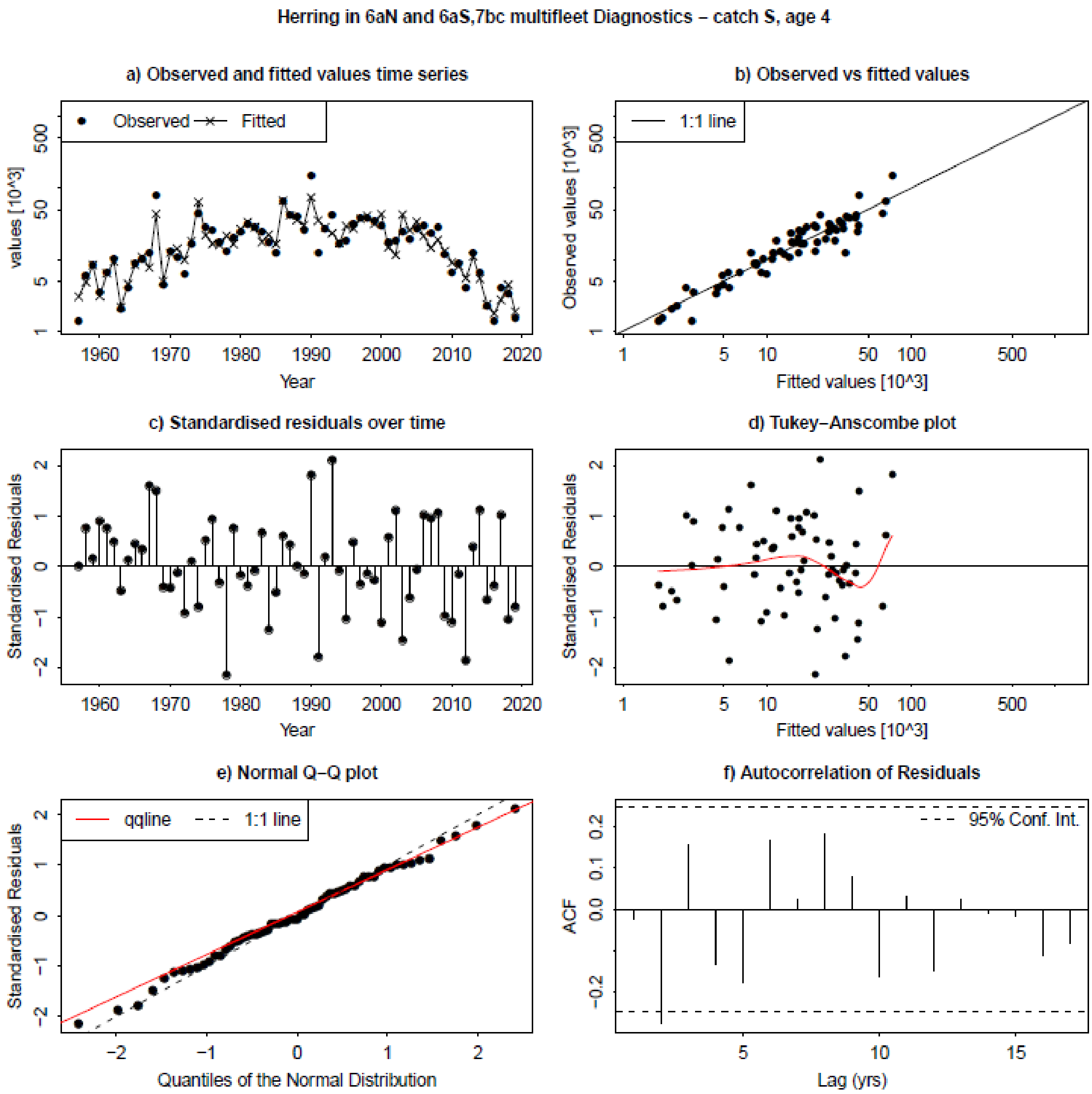


Figure 4.6.27. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from catch abundance at 4-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 4-winter ring. Middle right: catch observation vs. standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

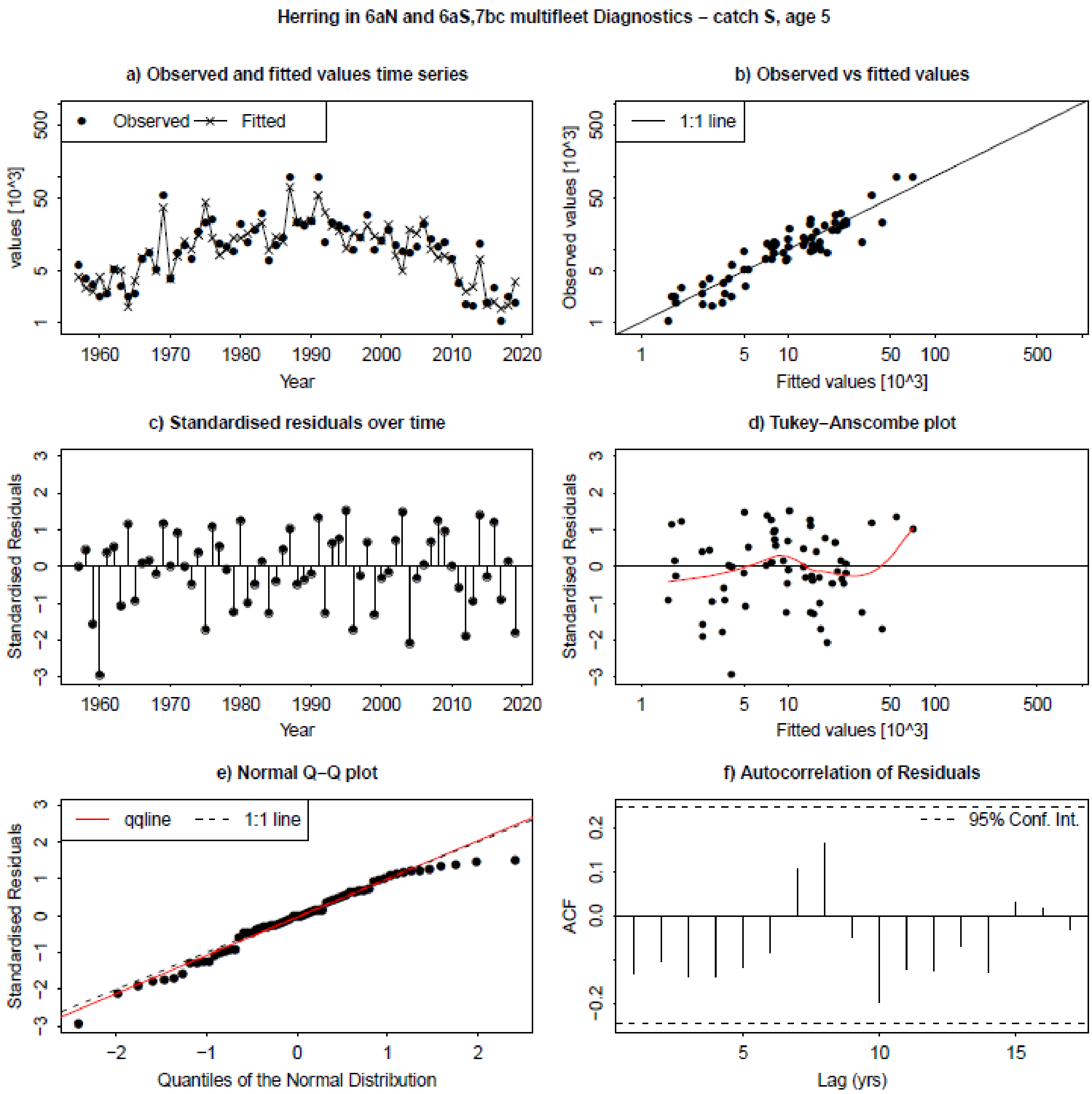


Figure 4.6.28. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from catch abundance at 5-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 5-winter ring. Middle right: catch observation vs. standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

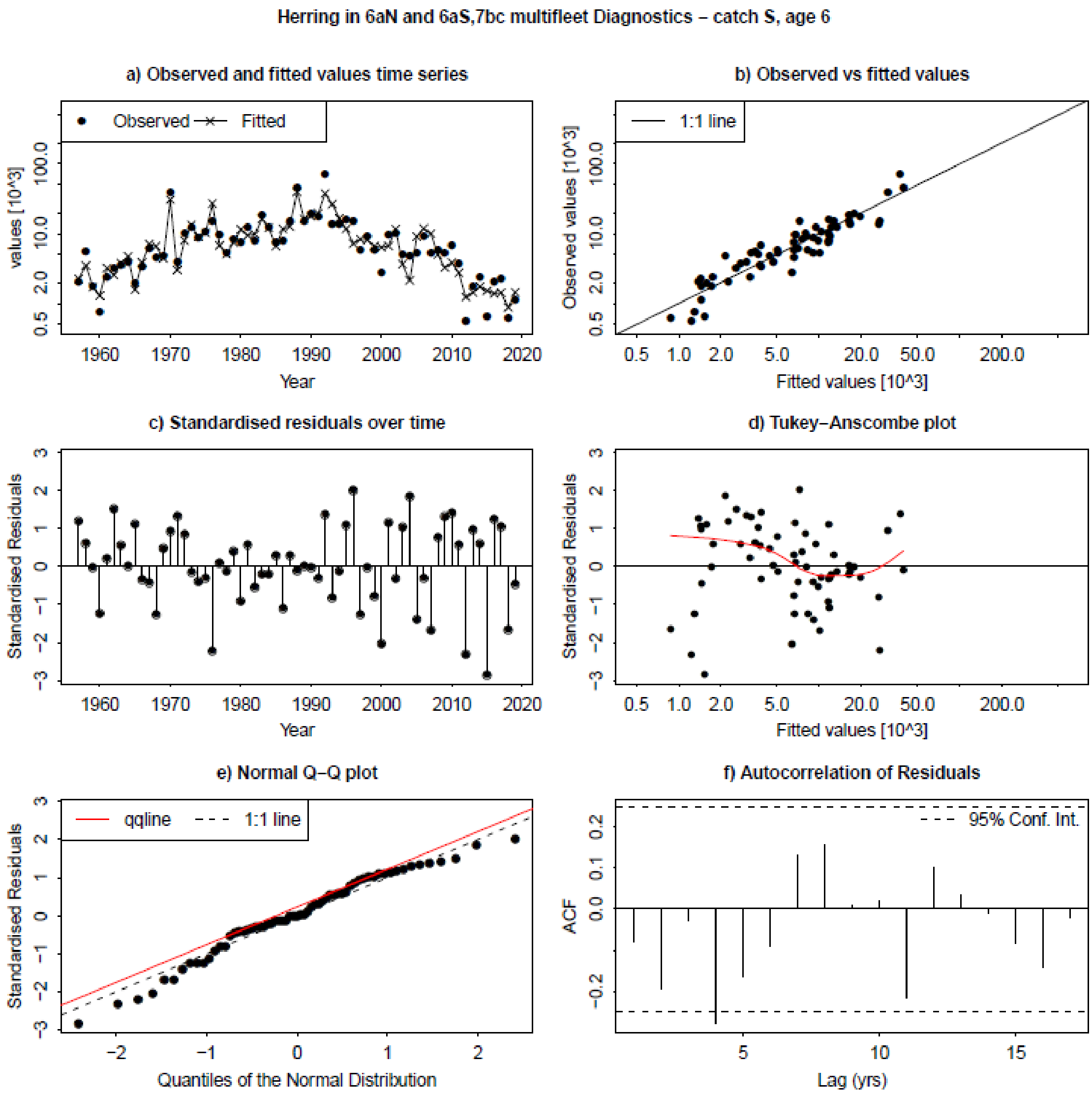


Figure 4.6.29. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from catch abundance at 6-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 6-winter ring. Middle right: catch observation vs. standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

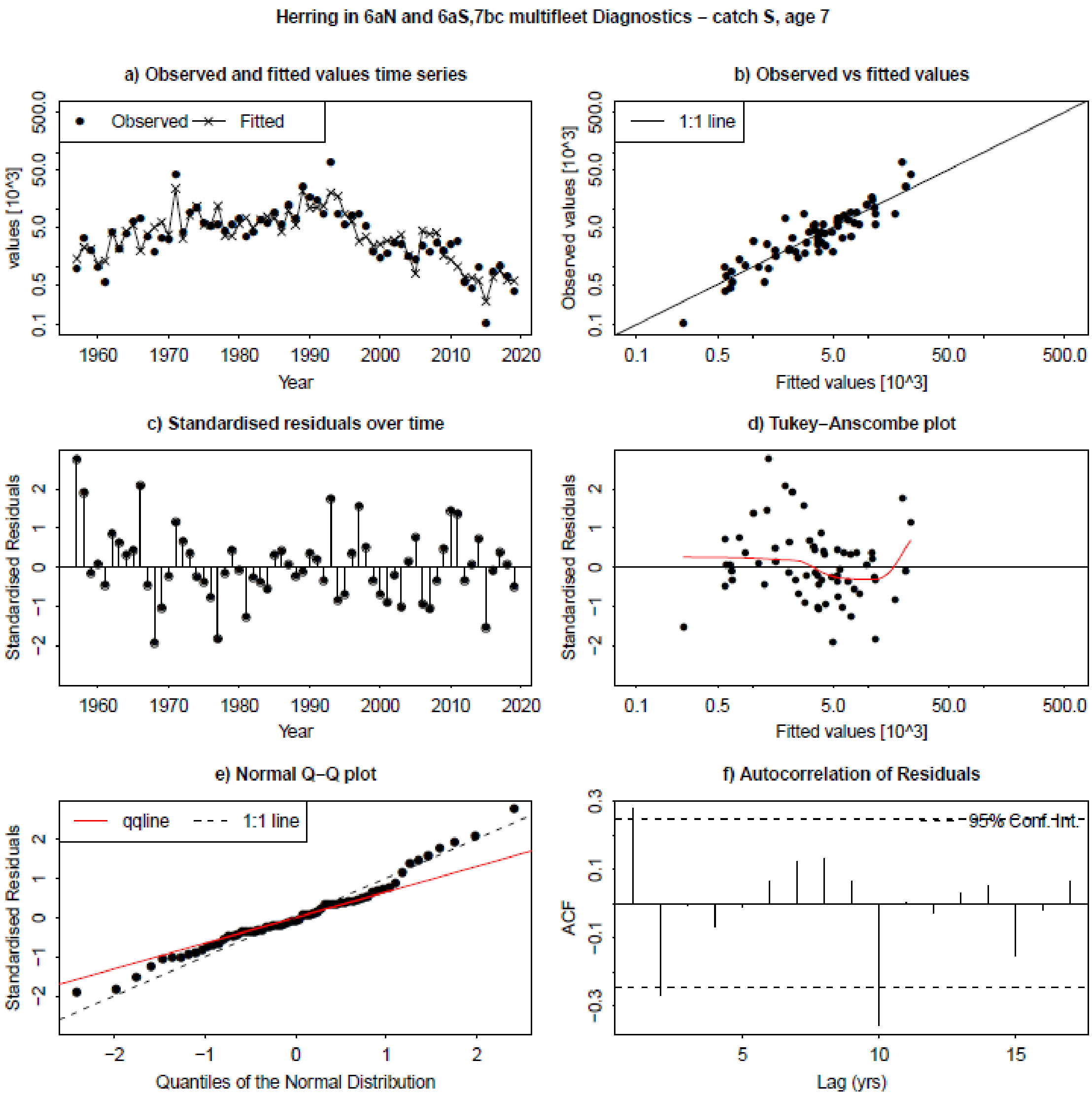


Figure 4.6.30. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from catch abundance at 7-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 7-winter ring. Middle right: catch observation vs. standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

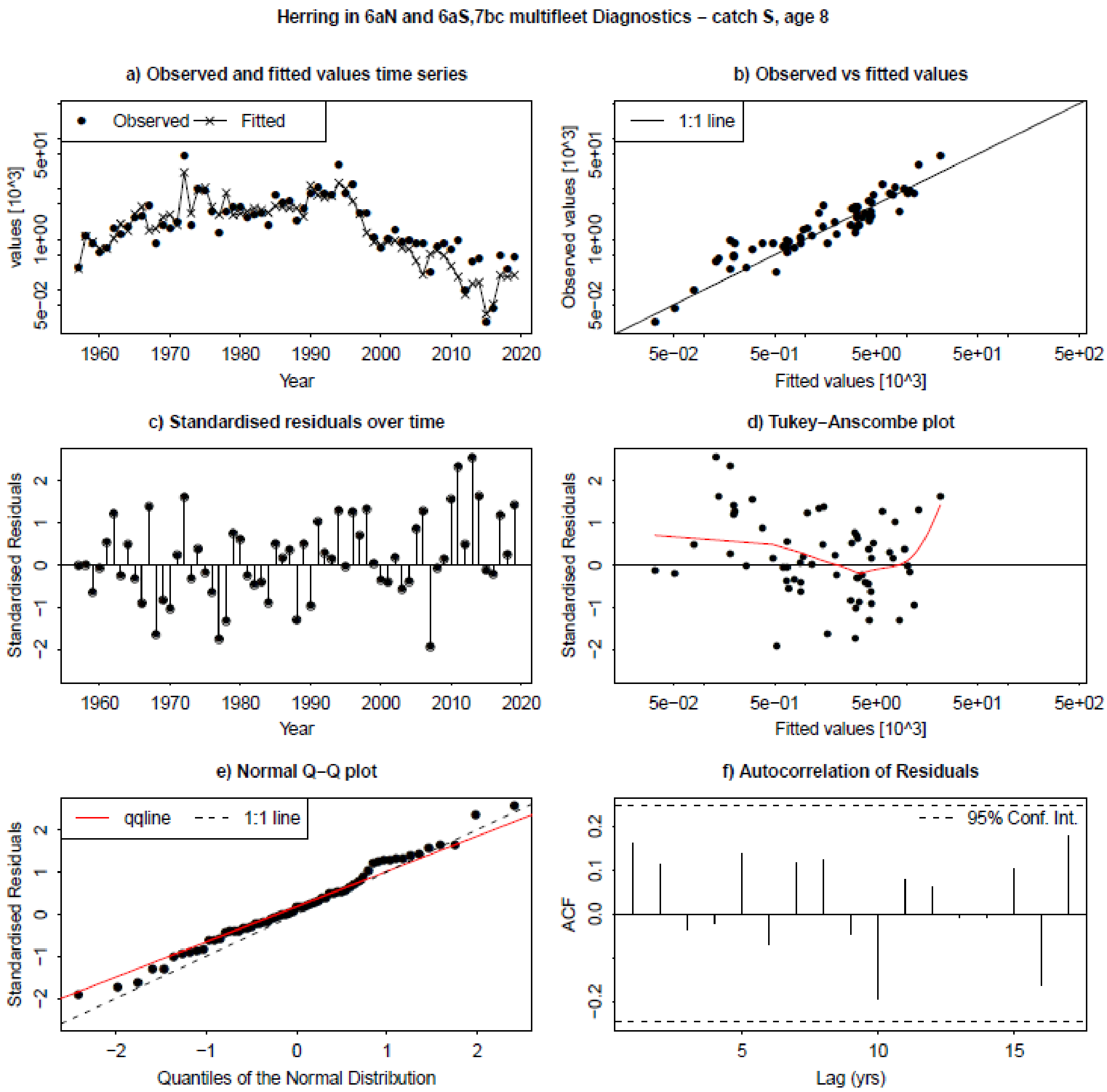


Figure 4.6.31. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from catch abundance at 8-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 8-winter ring. Middle right: catch observation vs. standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

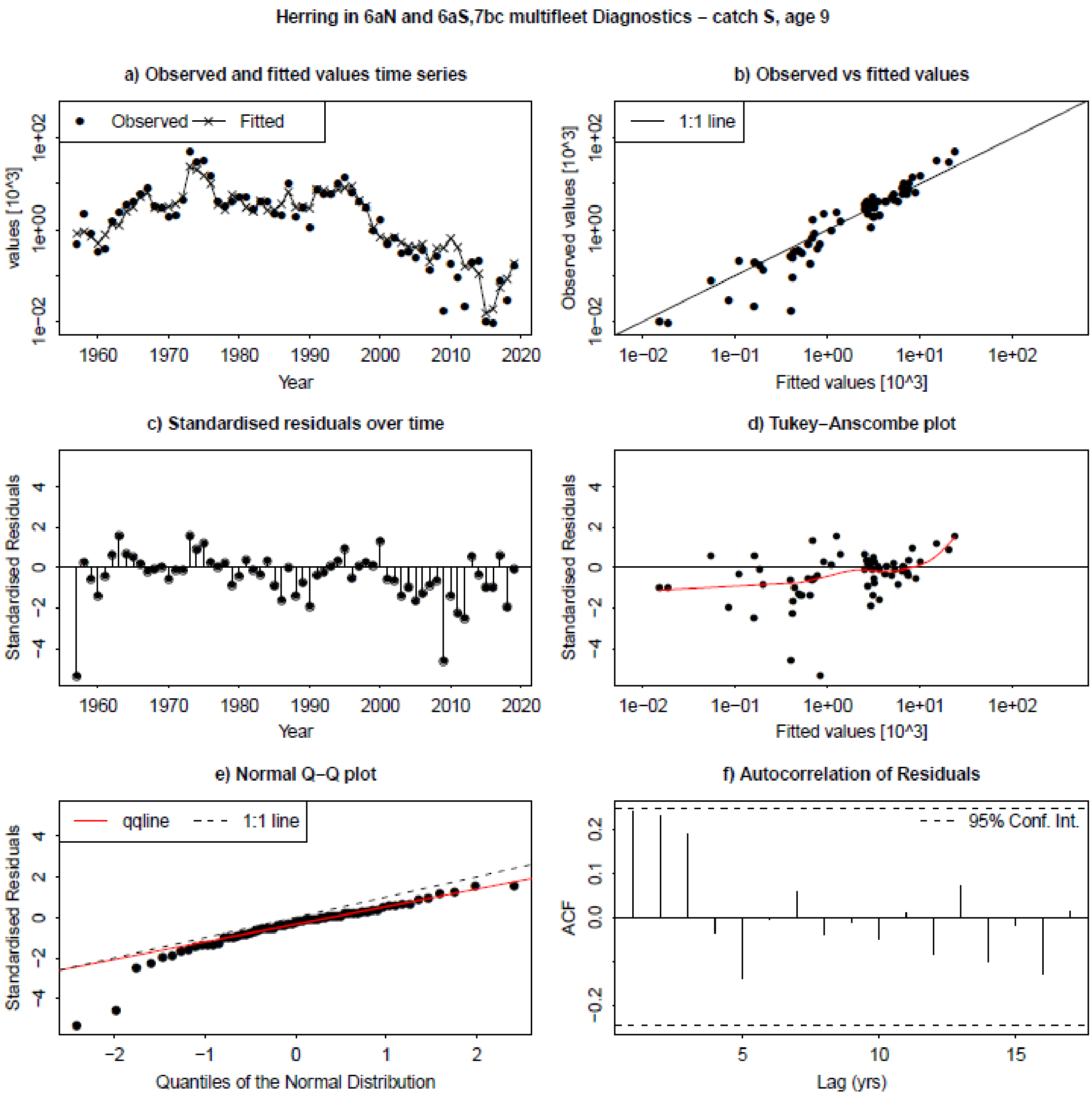


Figure 4.6.32. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the catch at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from catch abundance at 9-winter ring. Top right: scatterplot of catch observations vs. assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the catch at 9-winter ring. Middle right: catch observation vs. standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

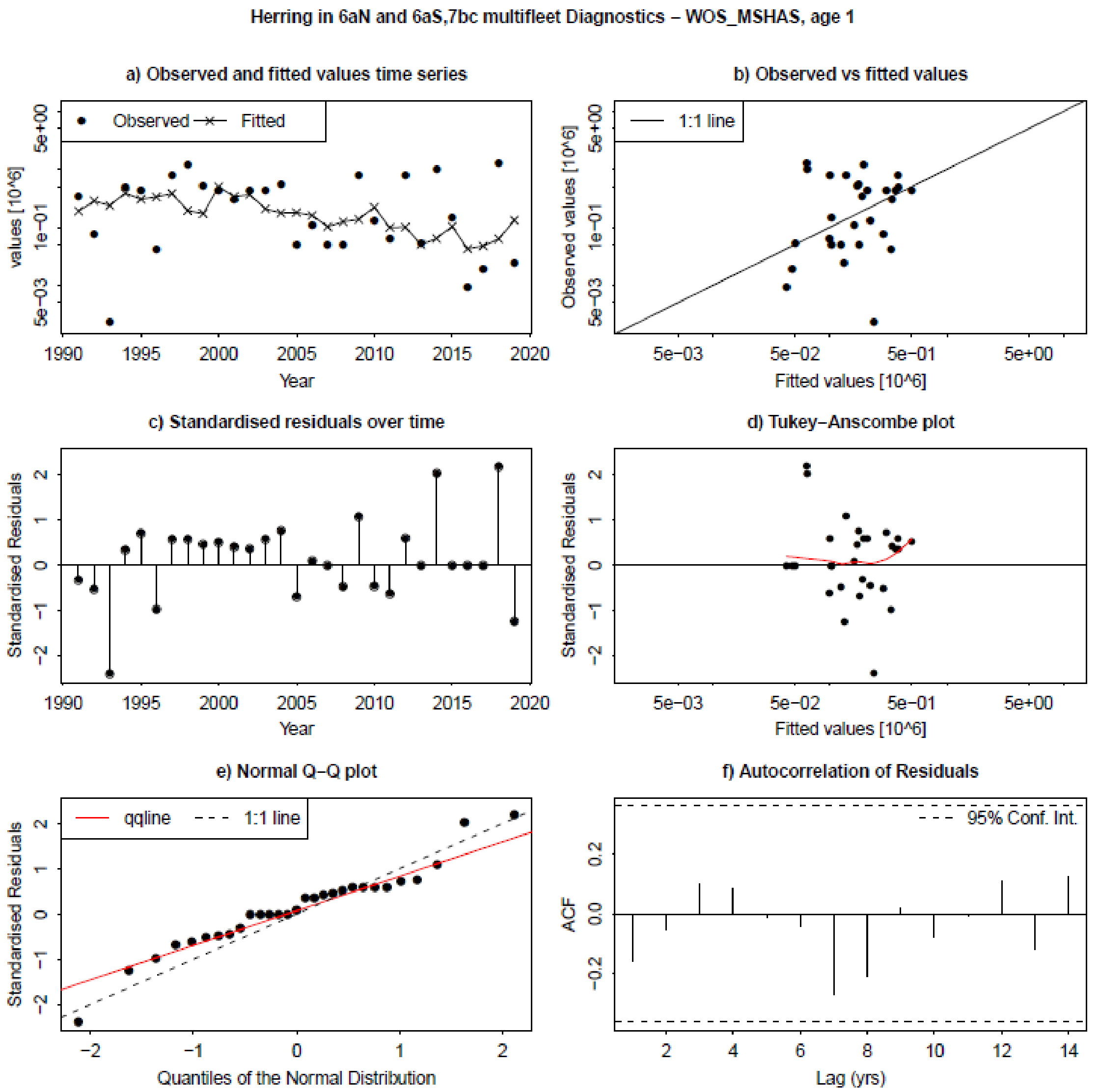


Figure 4.6.33. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 1-winter ring time-series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from index abundance at 1-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 1-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 1-winter ring. Middle right: index observation vs. standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot. There were no observations of 1 winter ring fish in this survey in 2015 and 2016, therefore the figure stops at 2014.

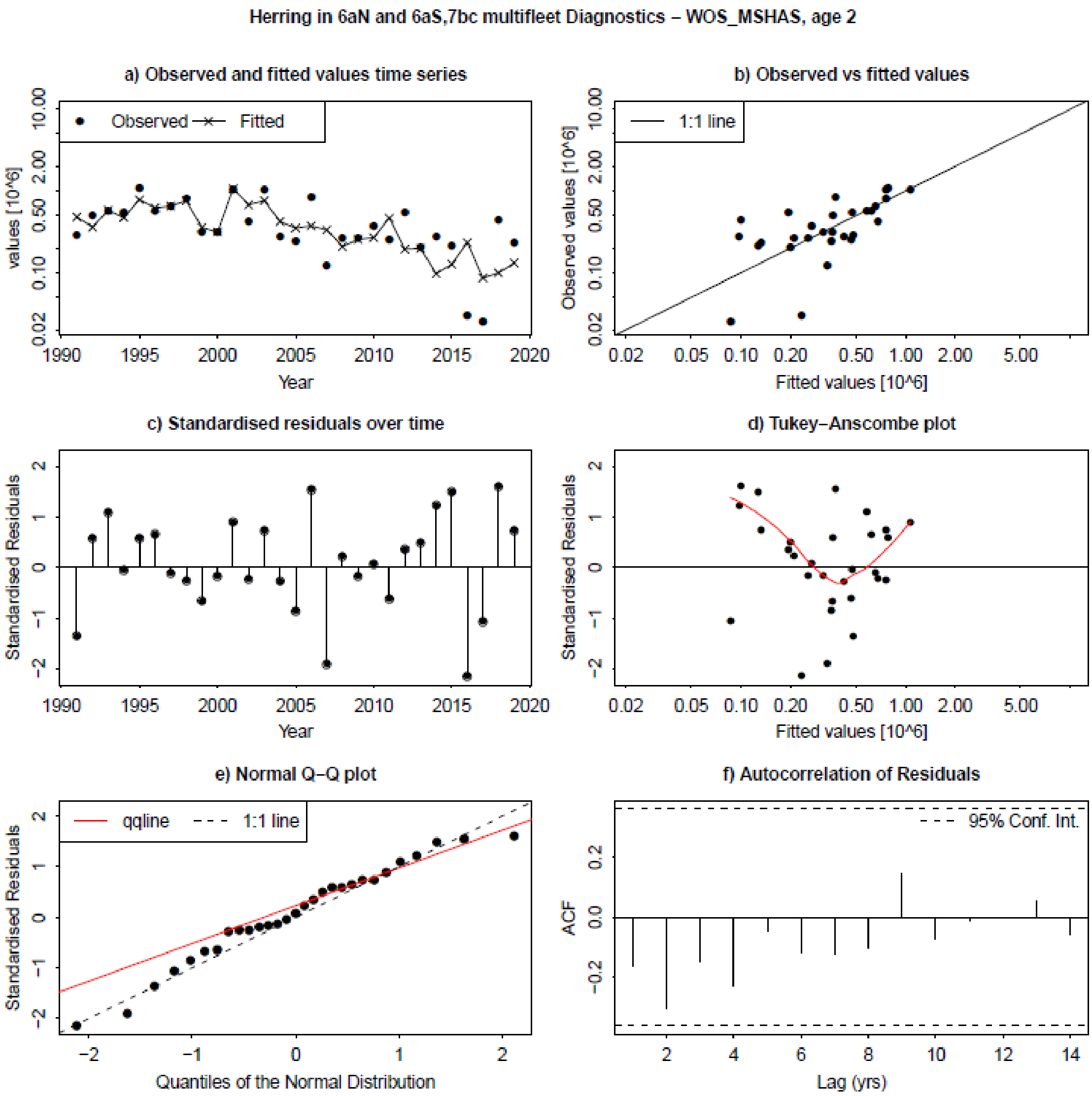
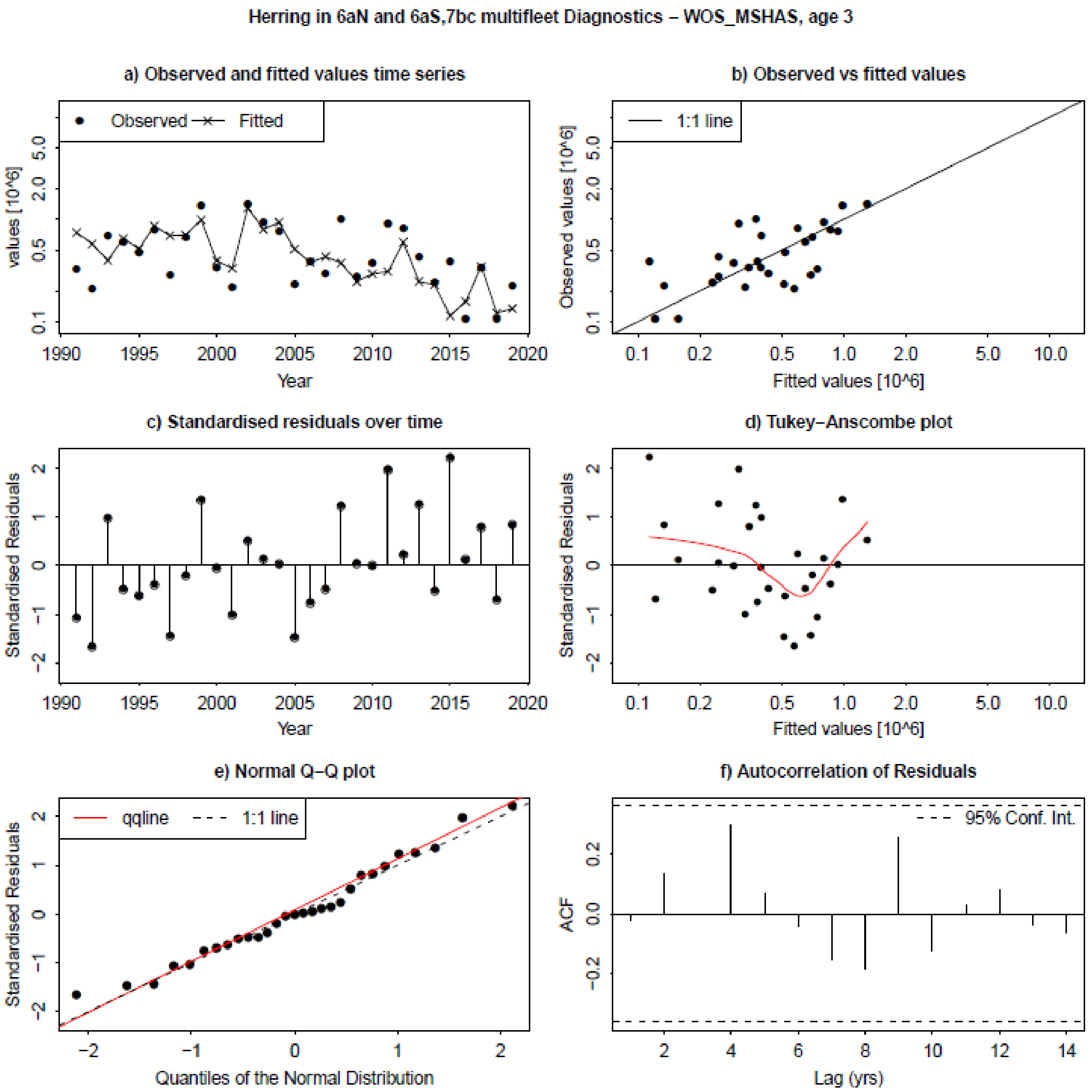


Figure 4.6.34. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 2-winter ring. Middle right: index observation vs. standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.



Herring in 6aN and 6aS,7bc multifleet Diagnostics – WOS_MSHAS, age 3
a) Observed and fitted values time series
Observed
Fitted
values [10^6]
Year
b) Observed vs fitted values
1:1 line
Observed values [10^6]
Fitted values [10^6]
c) Standardised residuals over time
Standardised Residuals
Year
d) Tukey–Anscombe plot
Standardised Residuals
Fitted values [10^6]
e) Normal Q–Q plot
qqline
1:1 line
Standardised Residuals
Quantiles of the Normal Distribution
f) Autocorrelation of Residuals
95% Conf. Int.
ACF
Lag (yrs)

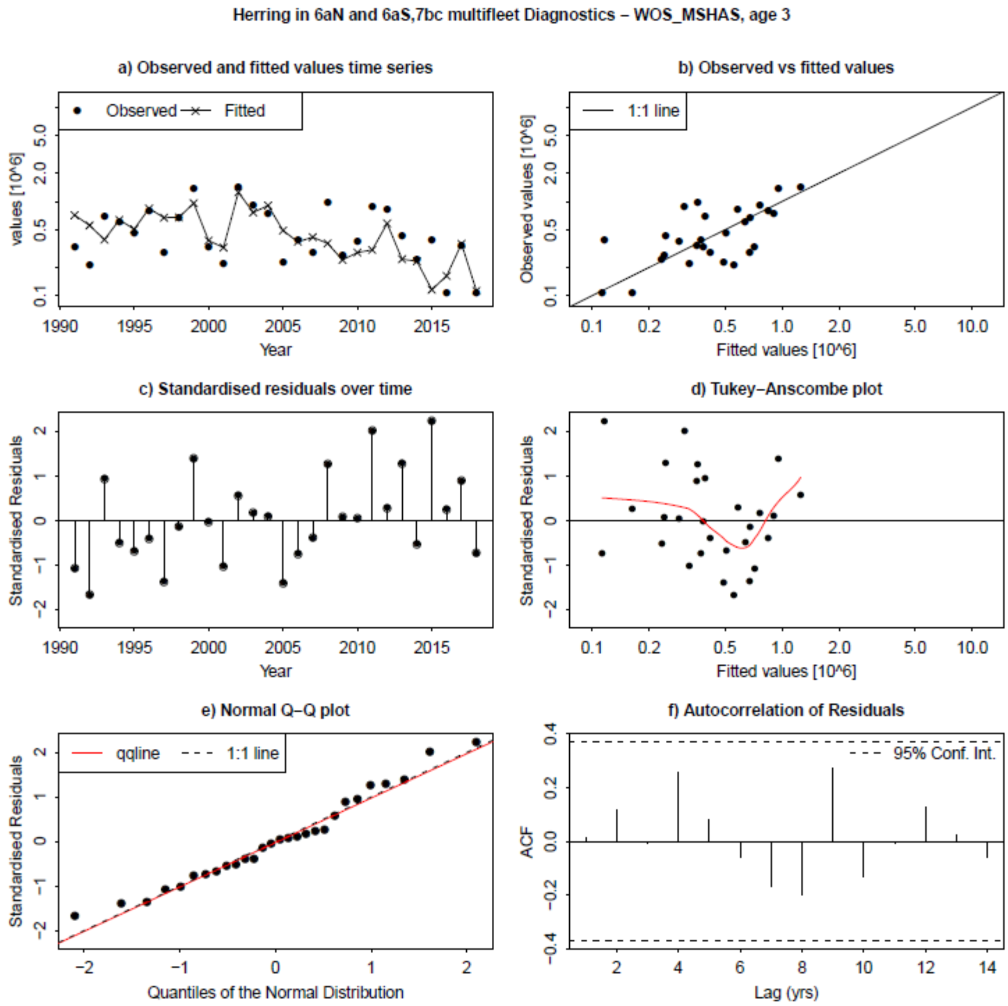


Figure 4.6.35. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 3-winter ring. Middle right: index observation vs. standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

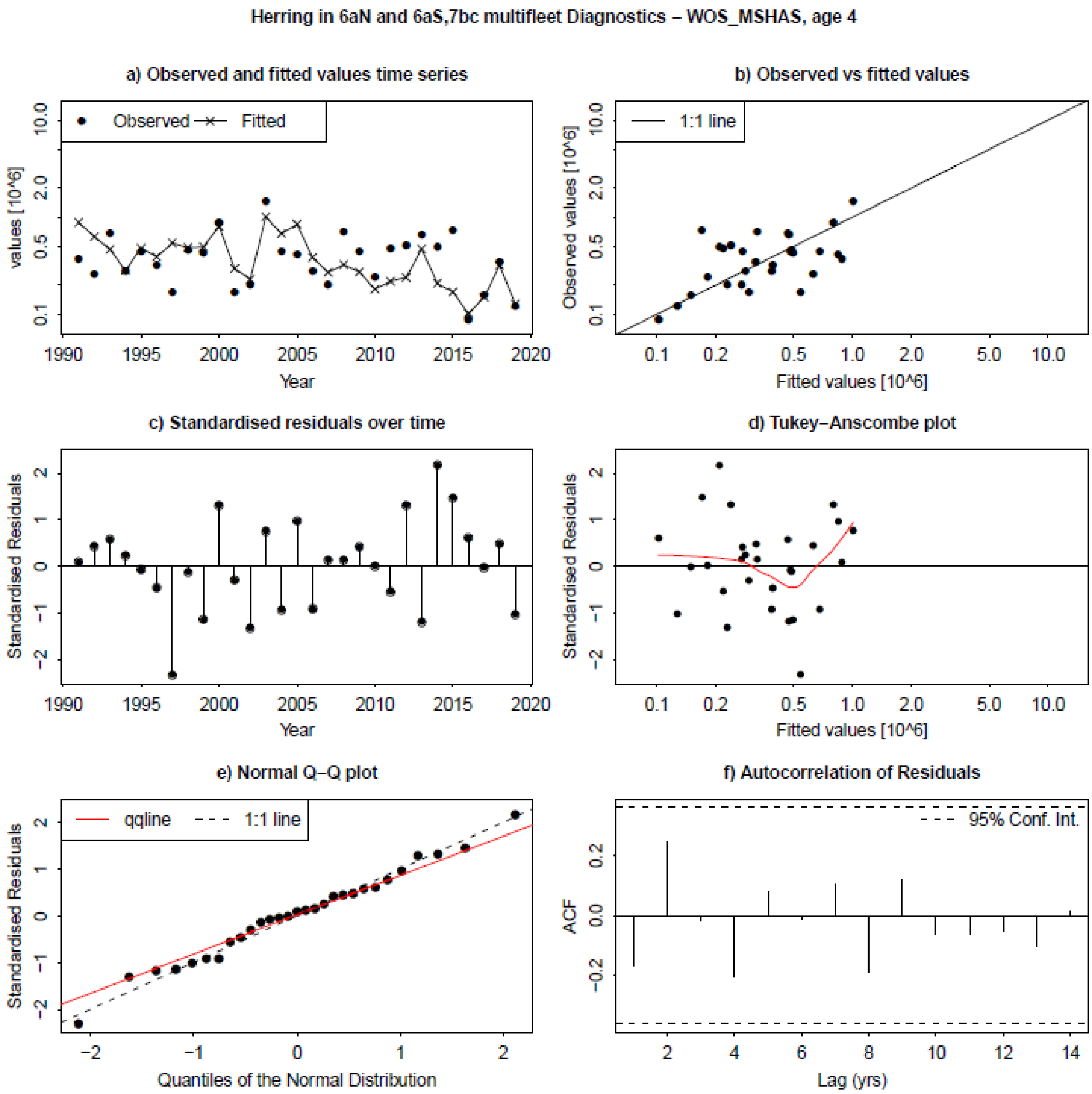


Figure 4.6.36. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 4-winter ring. Middle right: index observation vs. standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

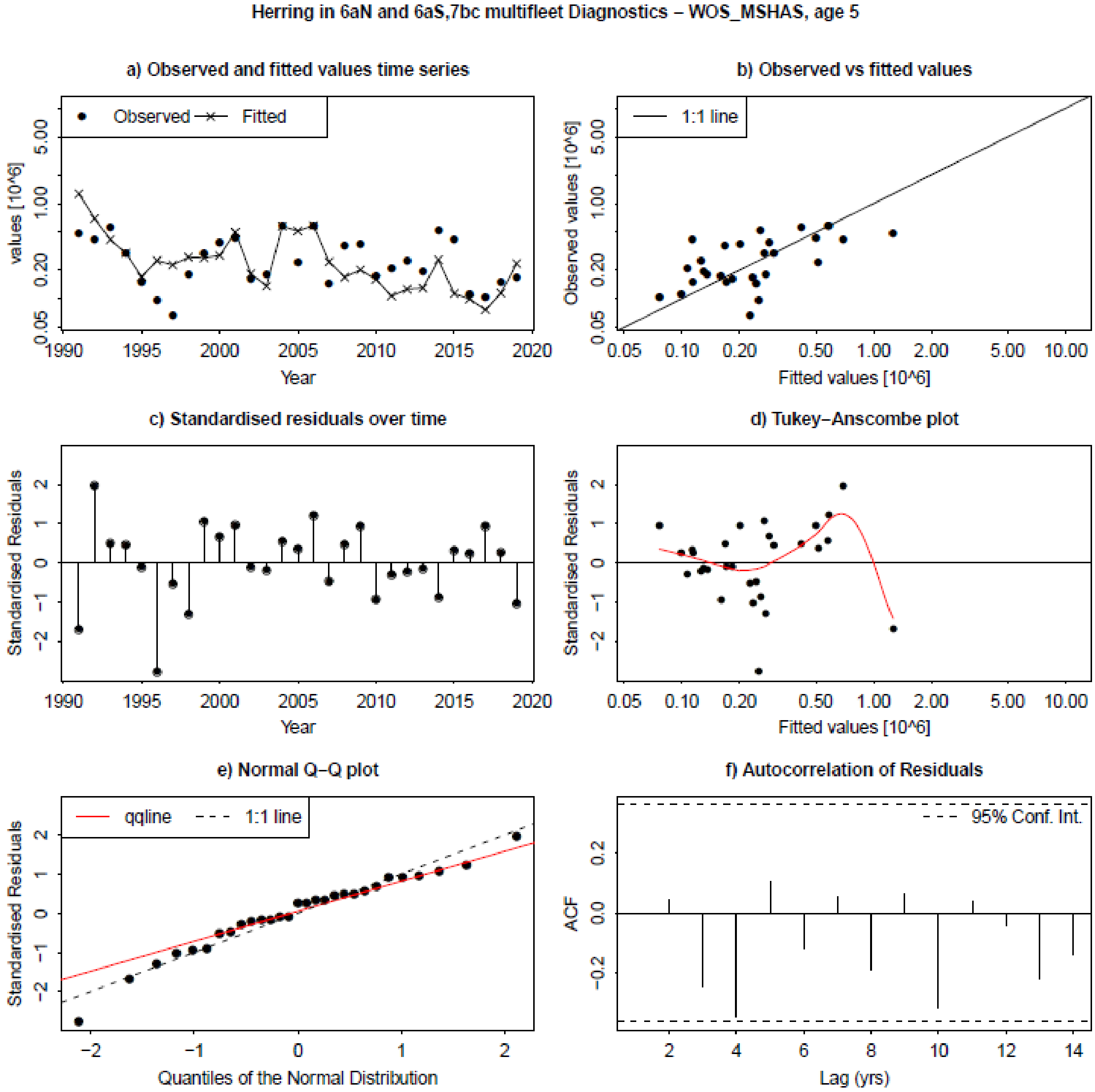


Figure 4.6.37. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 5-winter ring. Middle right: index observation vs. standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

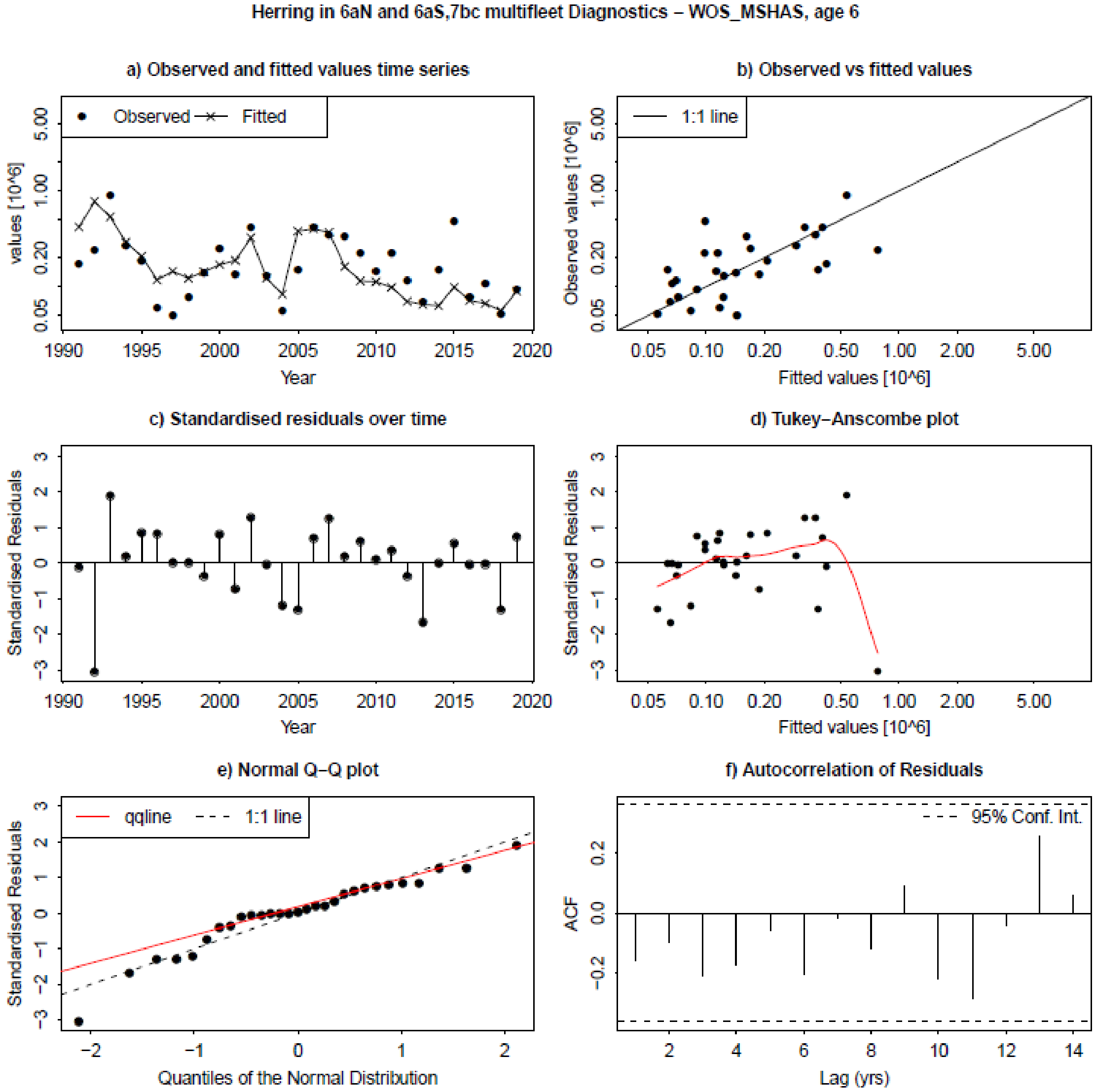


Figure 4.6.38. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 6-winter ring. Middle right: index observation vs. standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

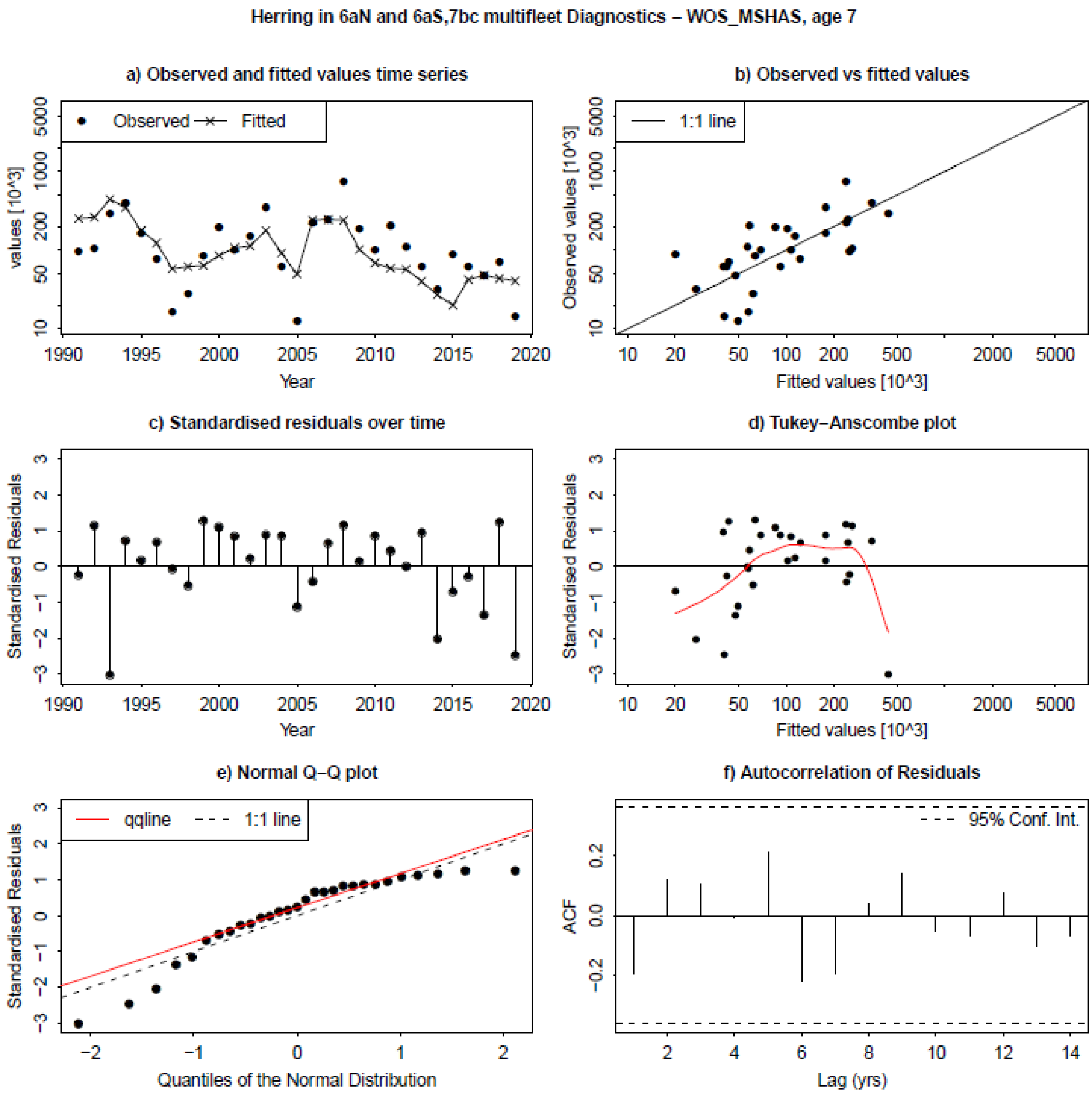


Figure 4.6.39. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 7-winter ring. Middle right: index observation vs. standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

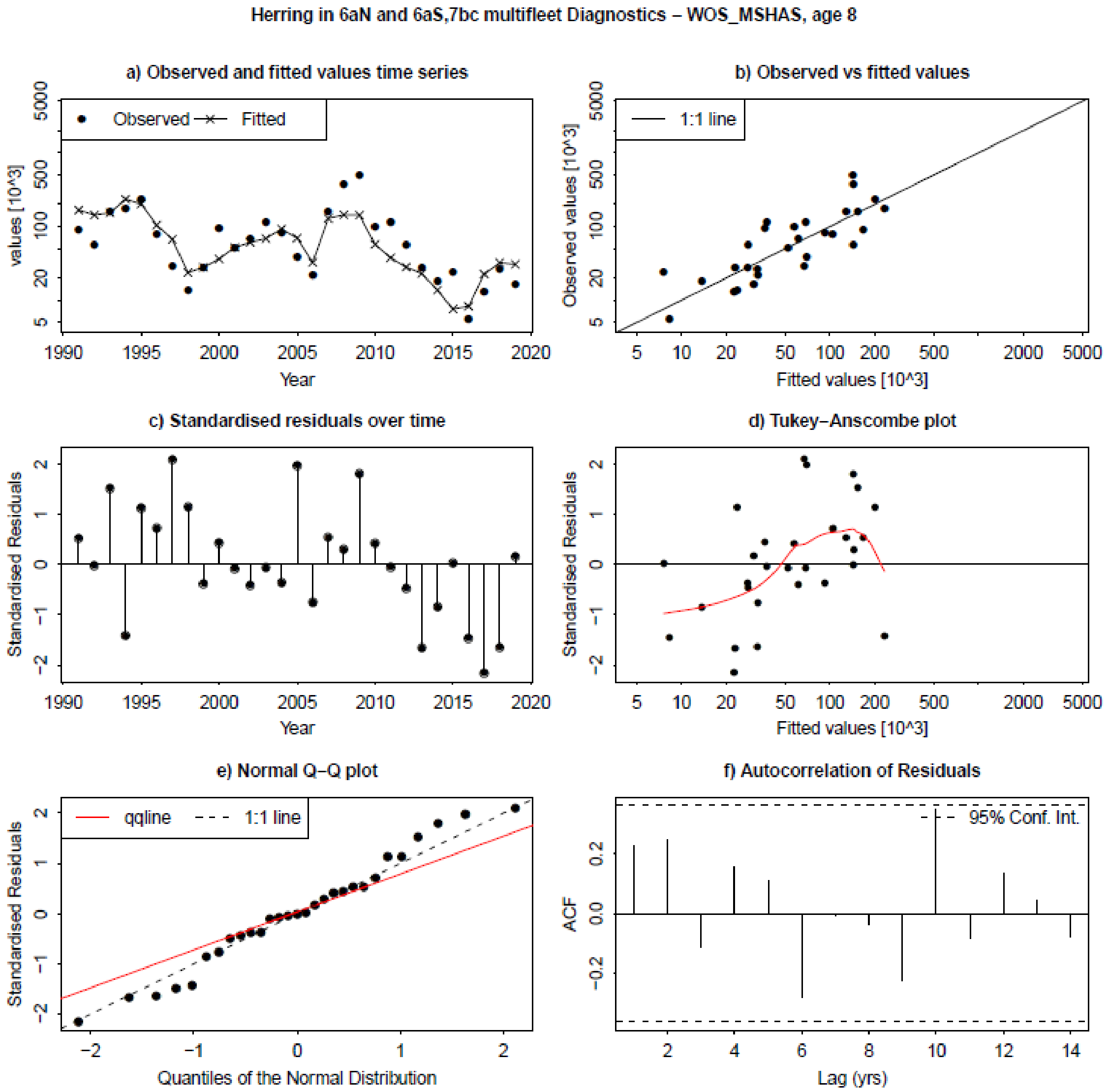


Figure 4.6.40. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 8-winter ring. Middle right: index observation vs. standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

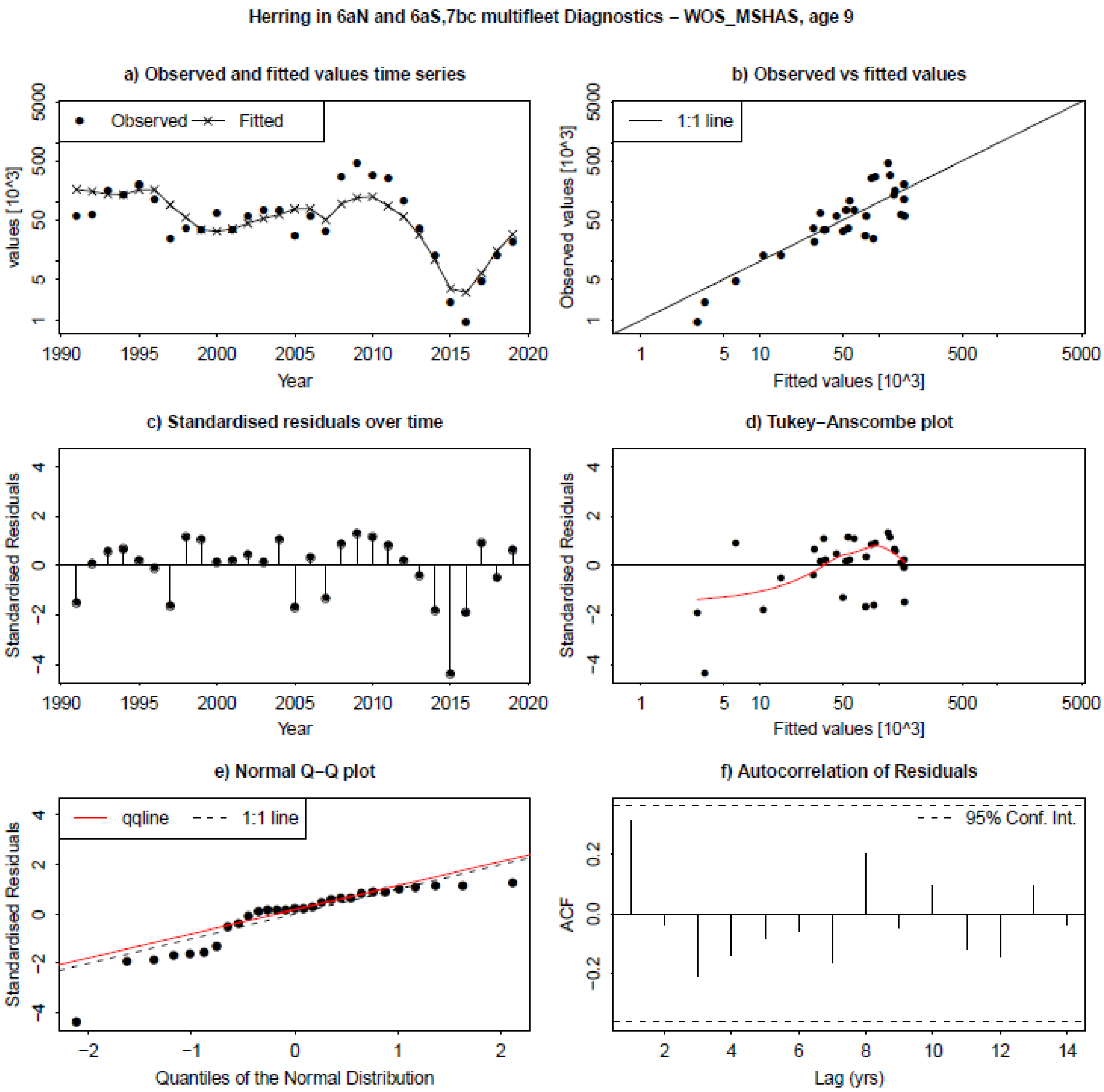


Figure 4.6.41. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the WoS_MSHAS acoustic survey index at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 9-winter ring. Middle right: index observation vs. standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

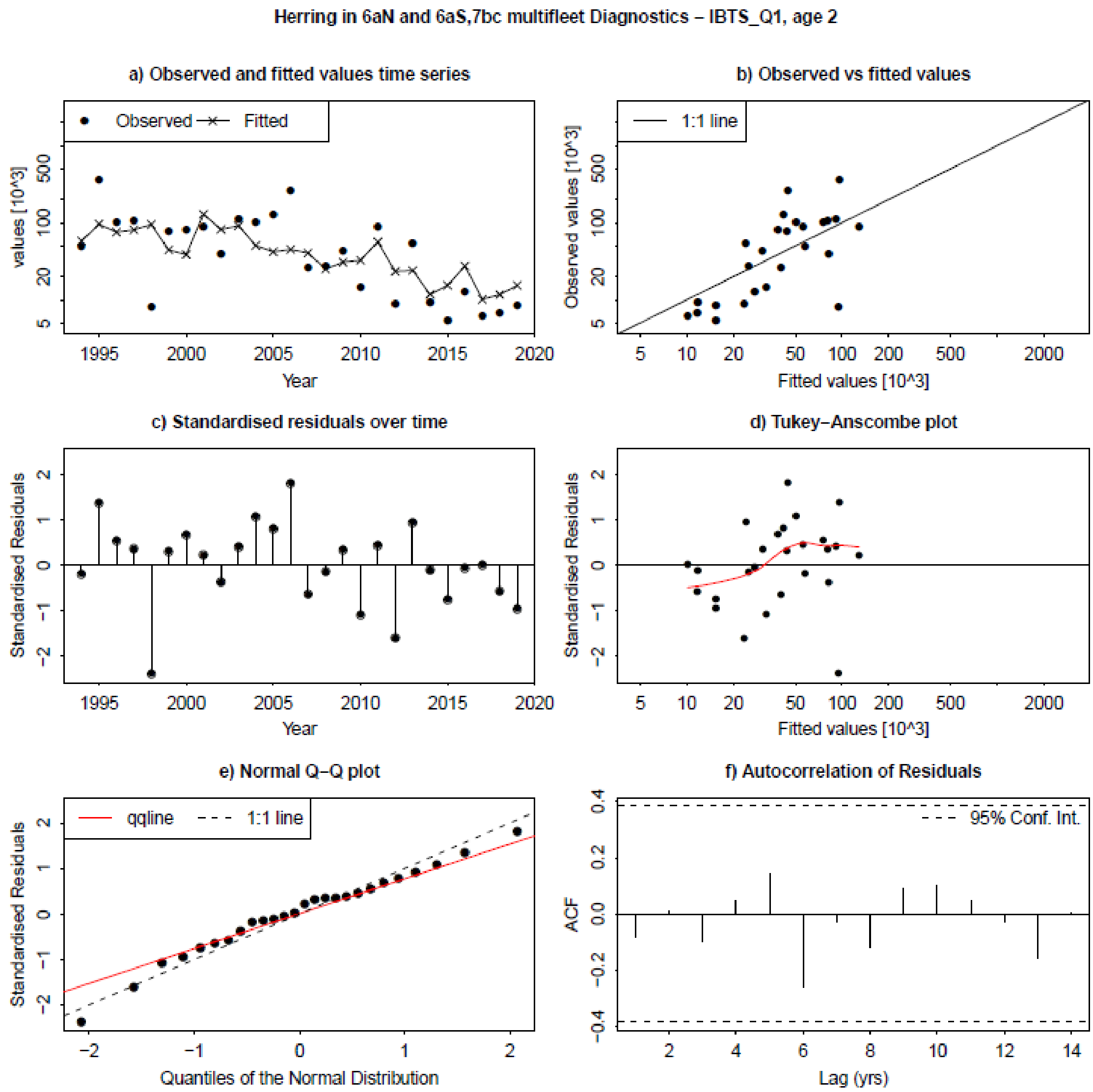


Figure 4.6.42. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 2-winter ring. Middle right: index observation vs. standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

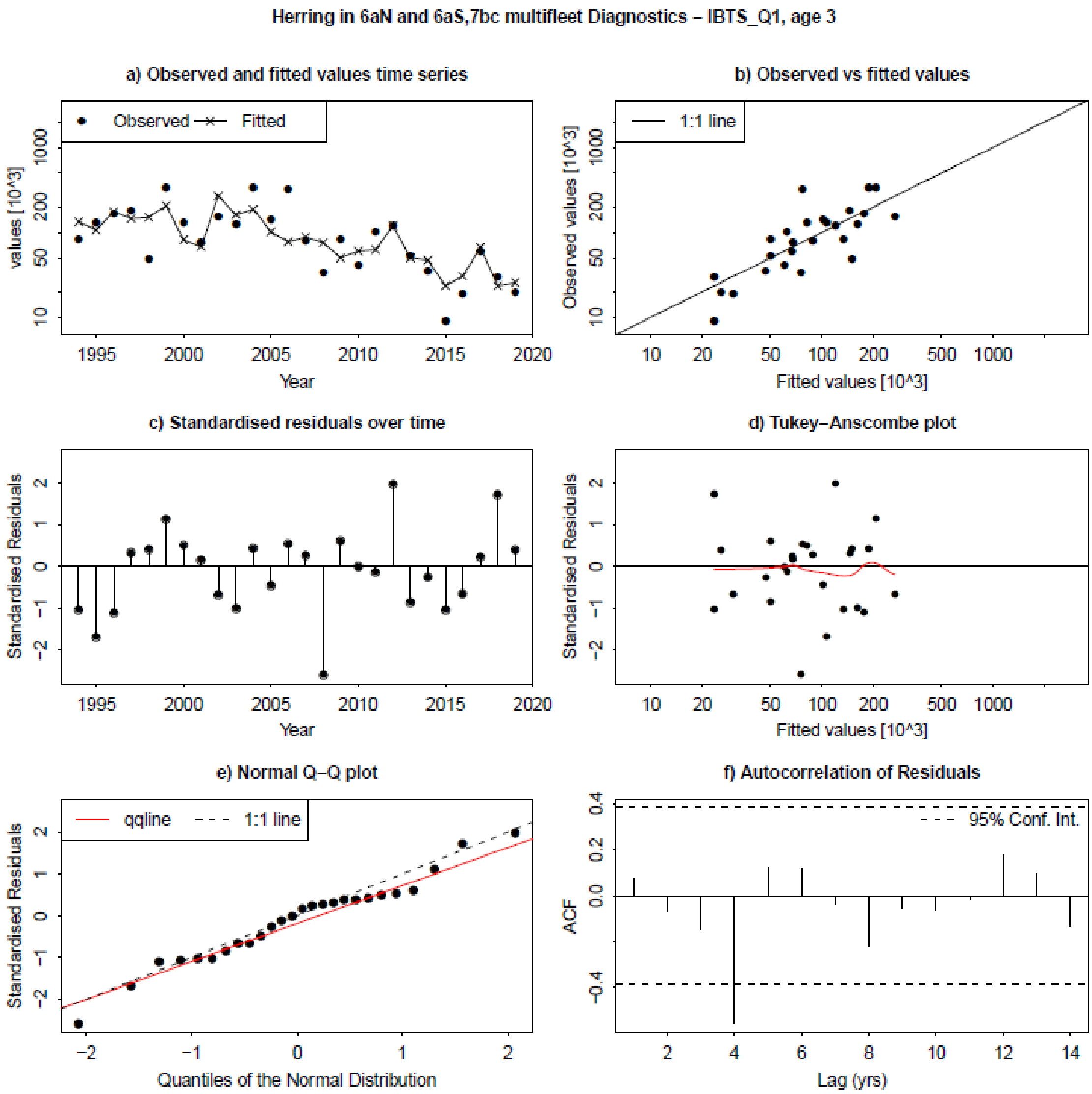


Figure 4.6.43. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 3-winter ring. Middle right: index observation vs. standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

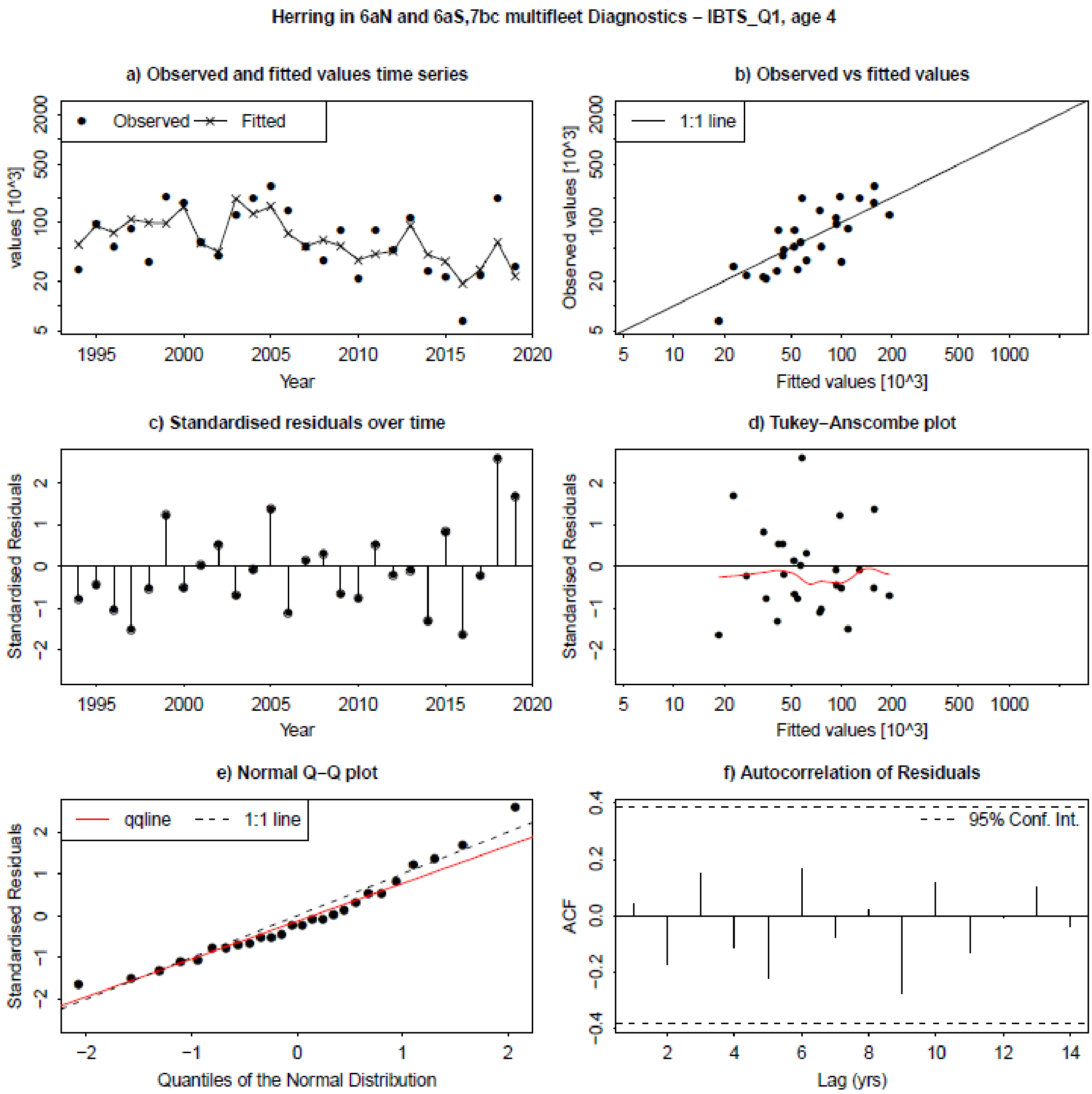


Figure 4.6.44. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 4-winter ring. Middle right: index observation vs. standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

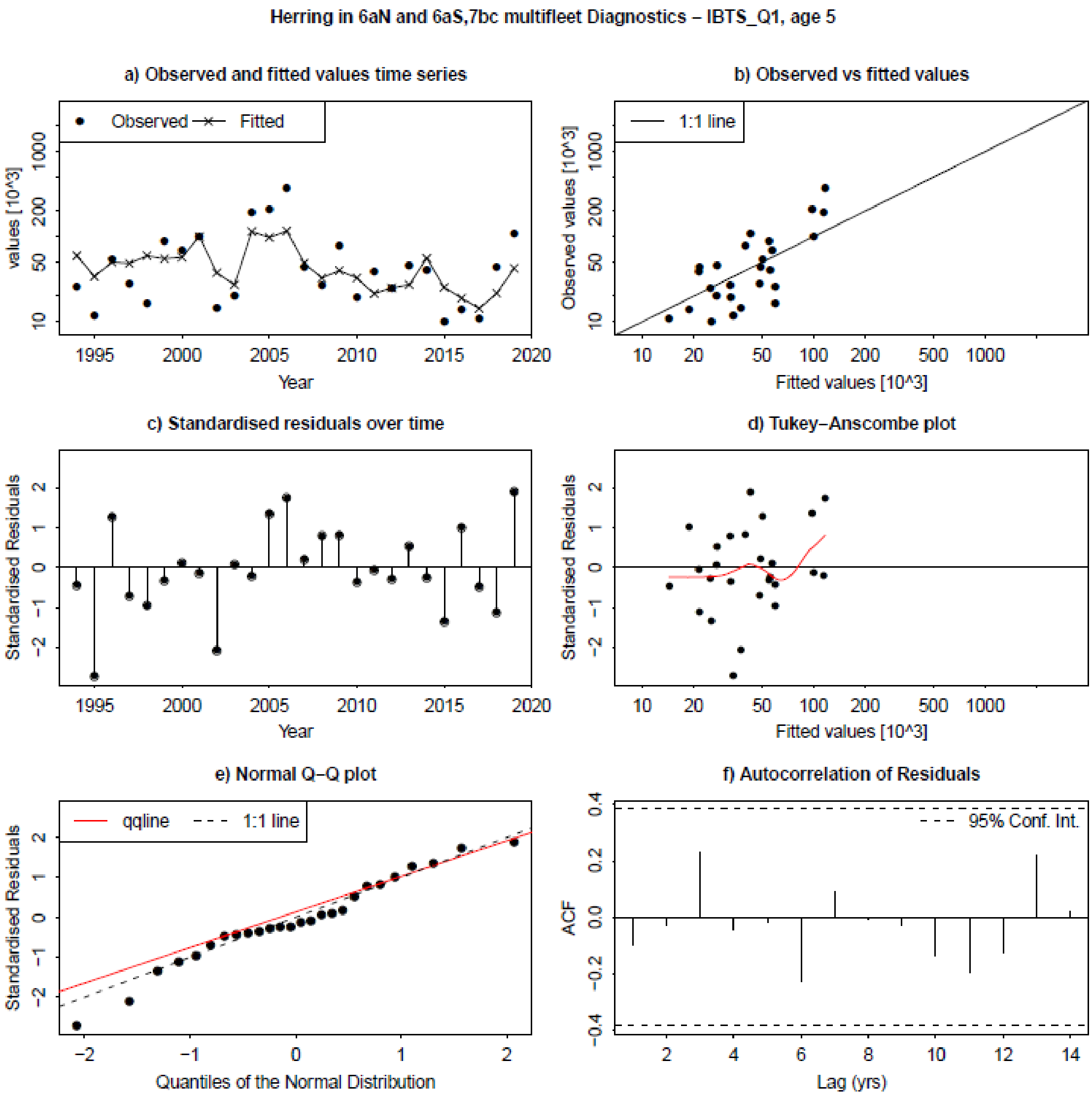


Figure 4.6.45. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 5-winter ring. Middle right: index observation vs. standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

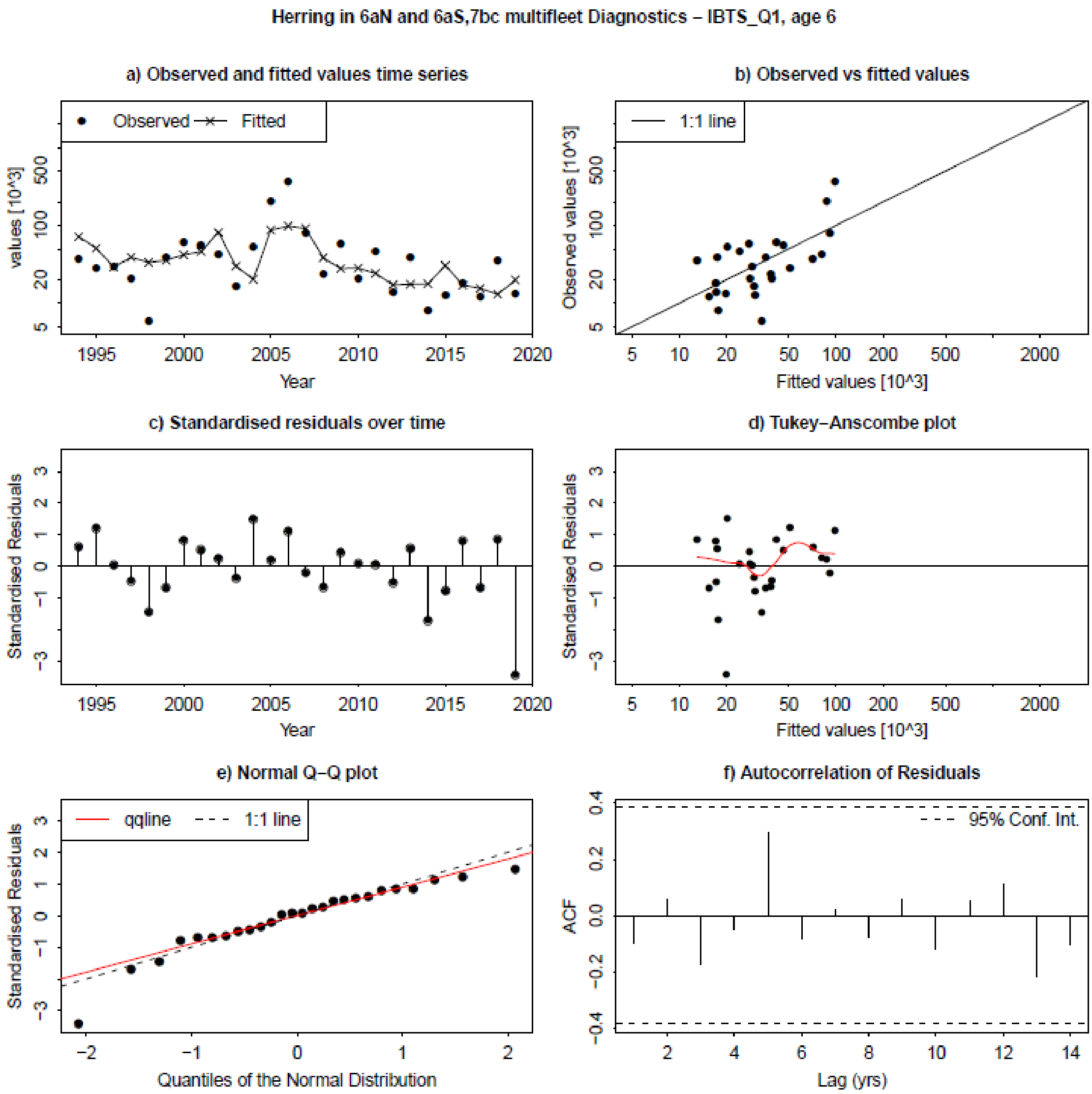


Figure 4.6.46. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 6-winter ring. Middle right: index observation vs. standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

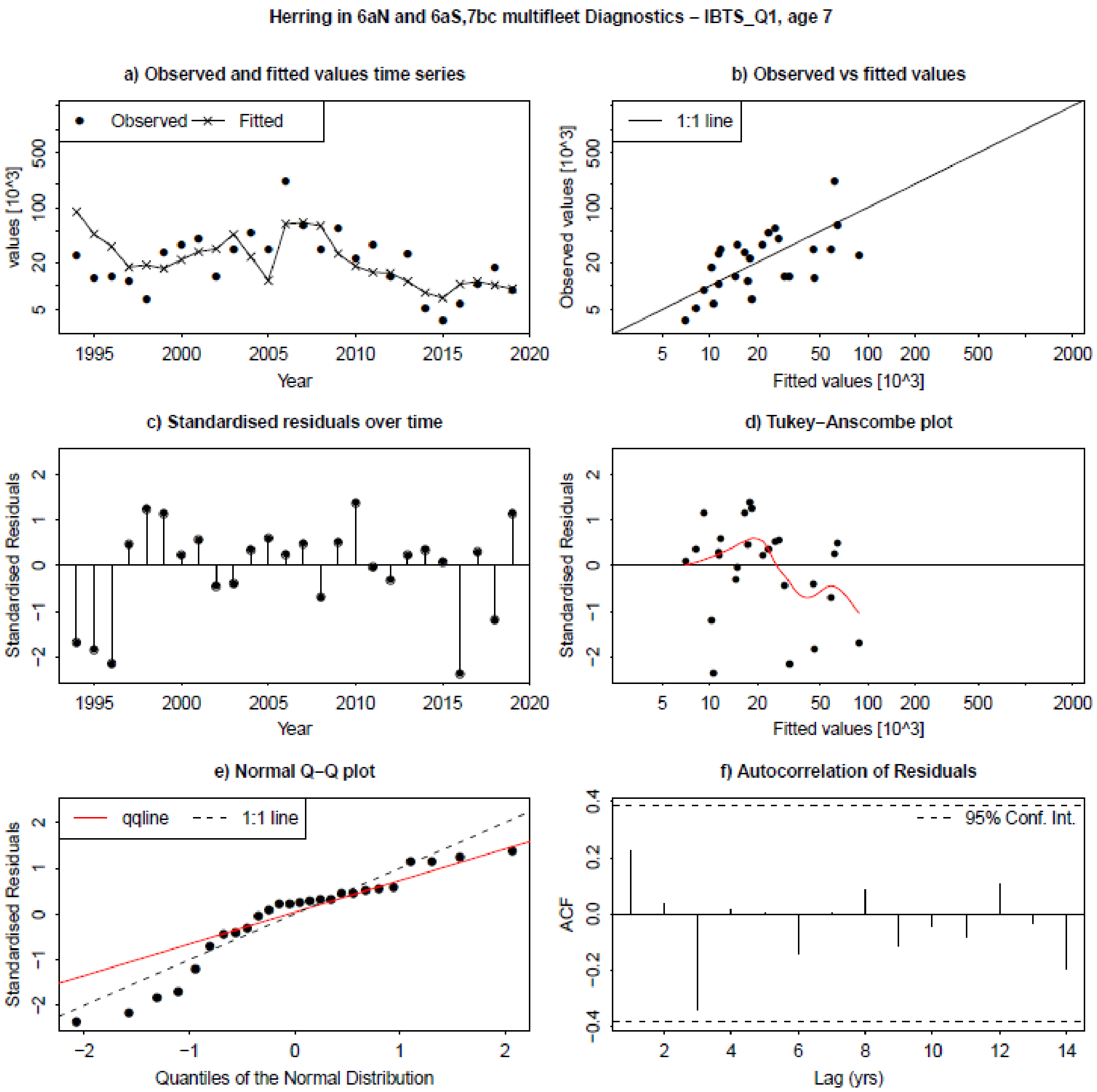


Figure 4.6.47. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 7-winter ring. Middle right: index observation vs. standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

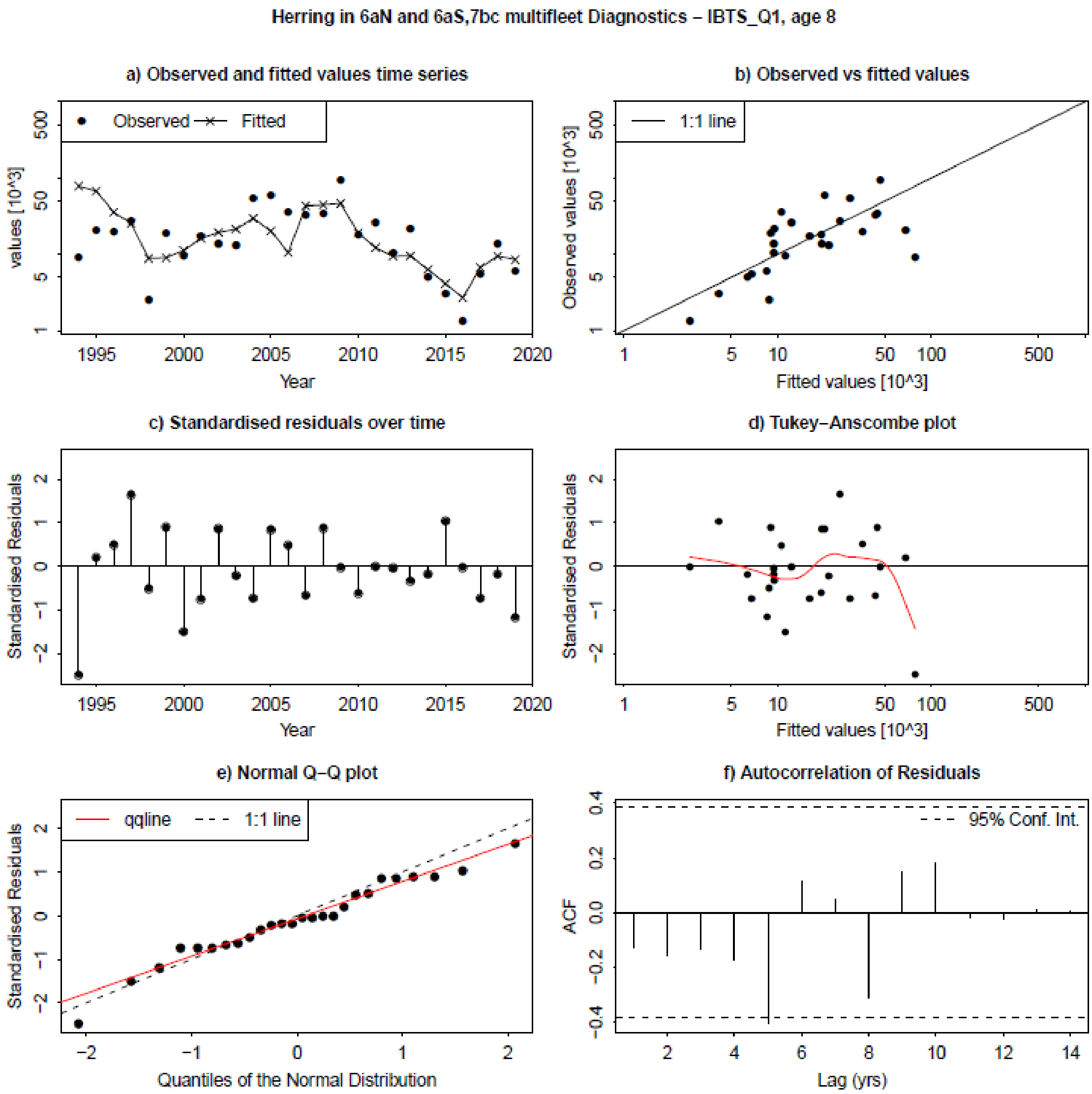


Figure 4.6.48. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 8-winter ring. Middle right: index observation vs. standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

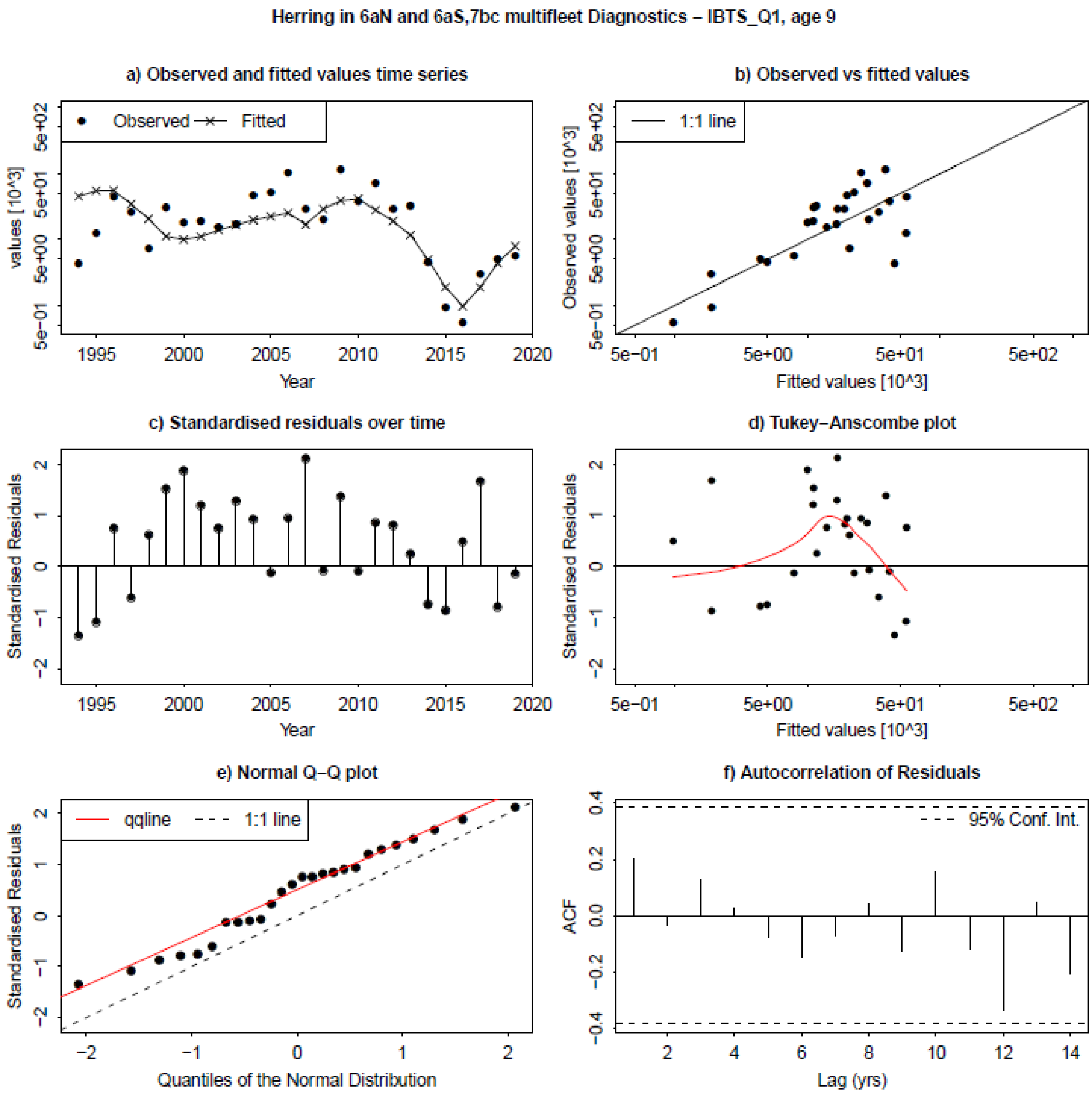


Figure 4.6.49. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 1 at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 9-winter ring. Middle right: index observation vs. standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

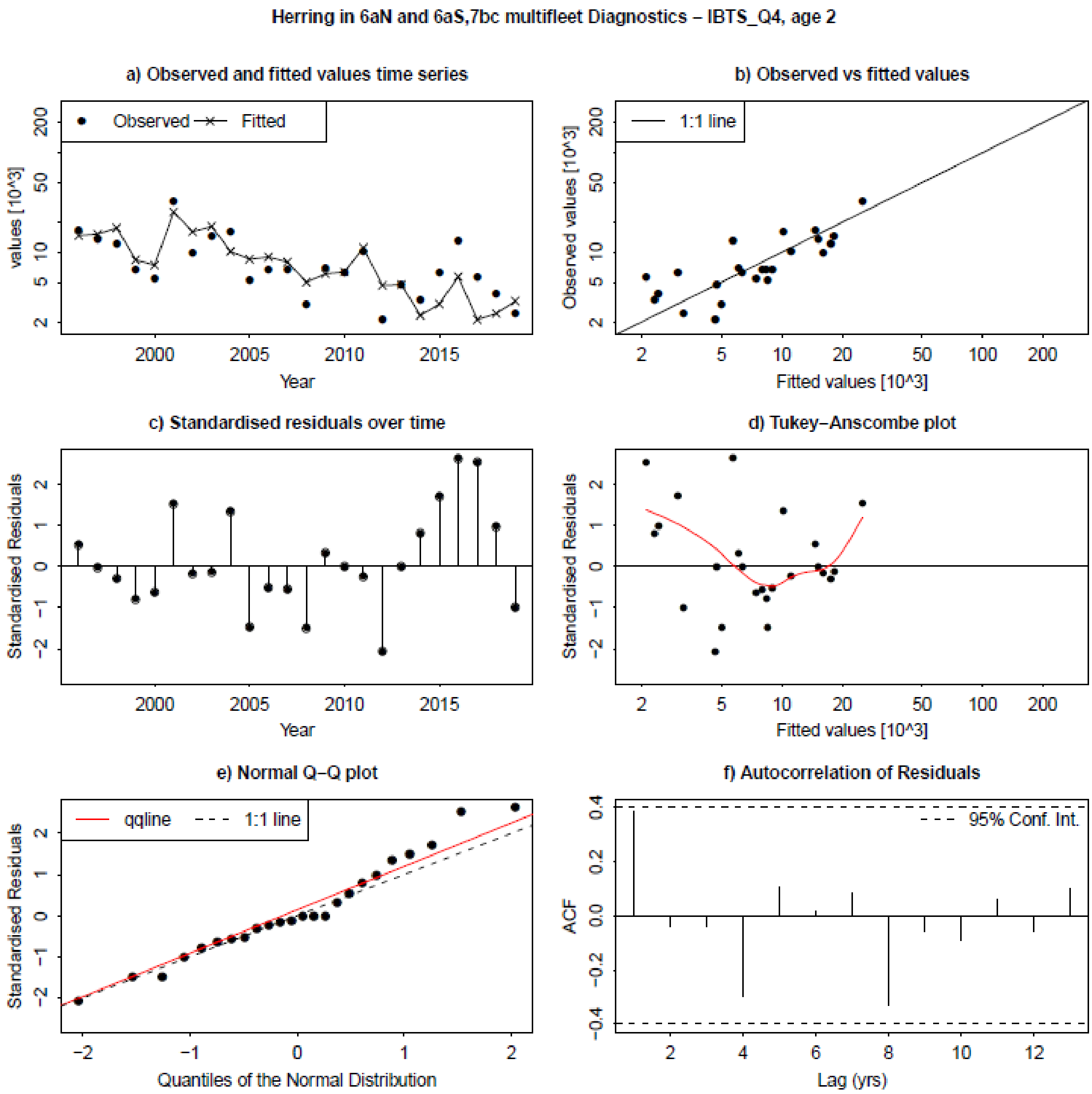


Figure 4.6.50. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 2-winter ring time-series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 2-winter ring. Middle right: index observation vs. standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

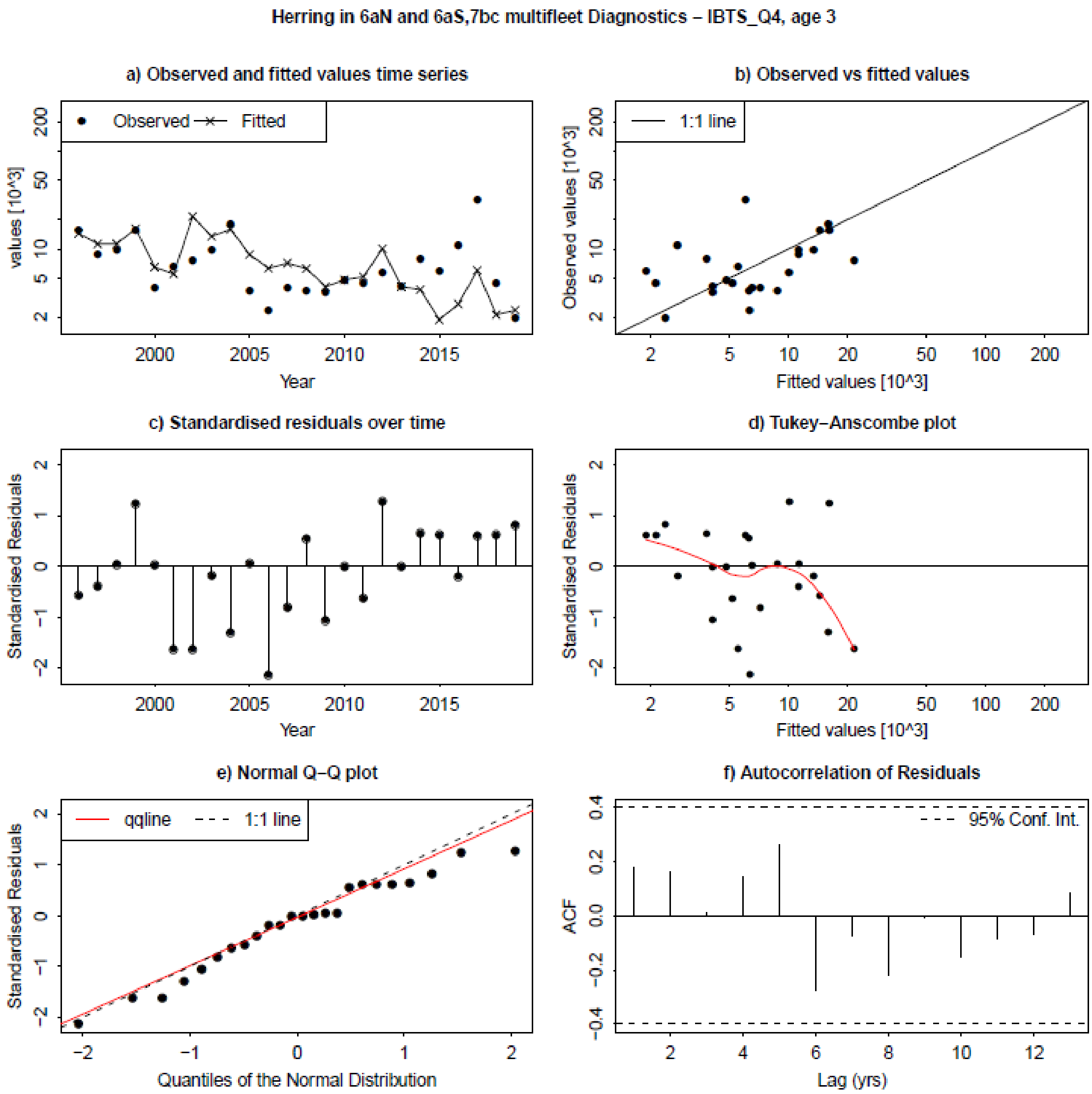


Figure 4.6.51. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 3-winter ring time-series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 3-winter ring. Middle right: index observation vs. standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

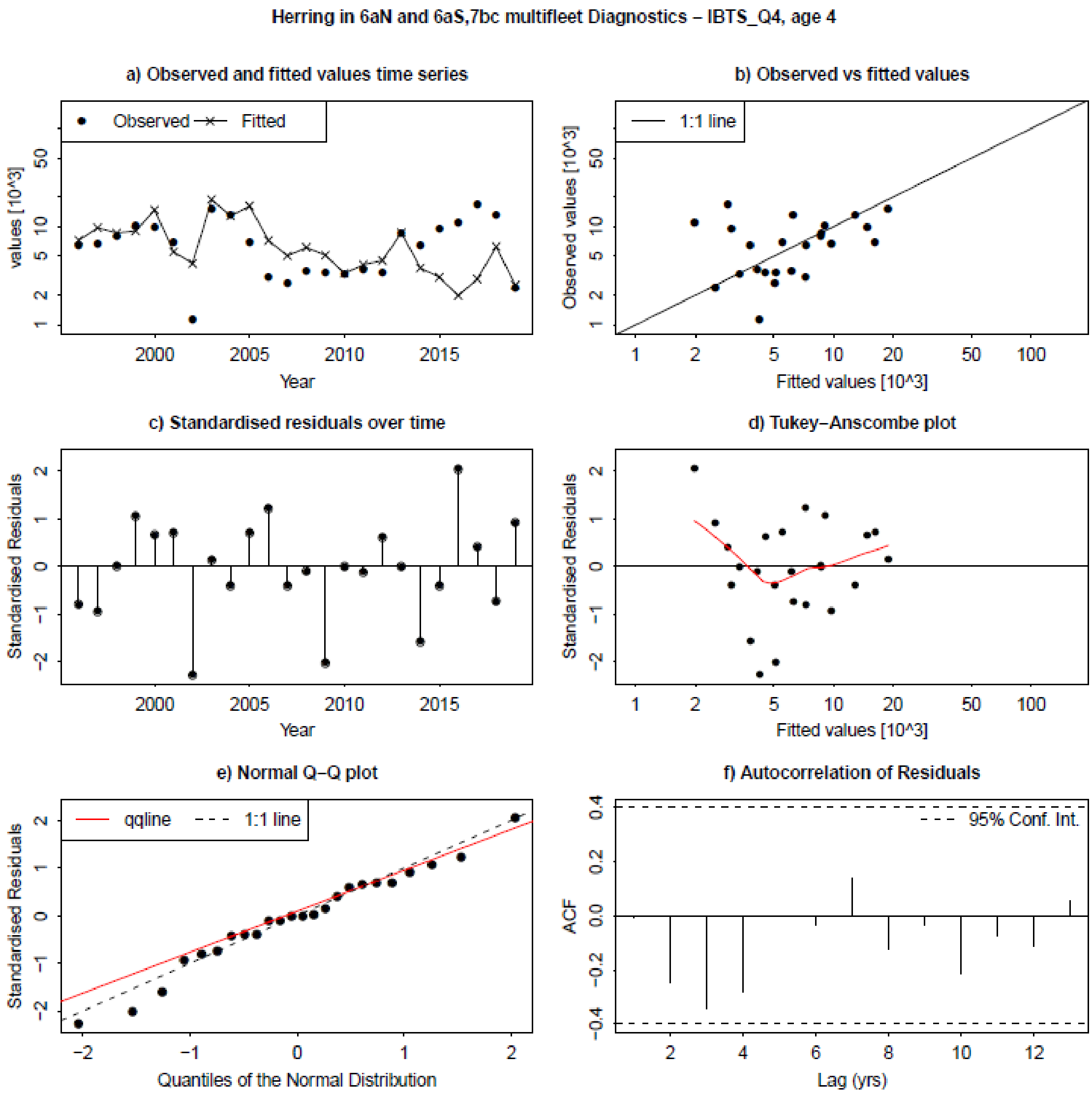


Figure 4.6.52. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 4-winter ring time-series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 4-winter ring. Middle right: index observation vs. standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

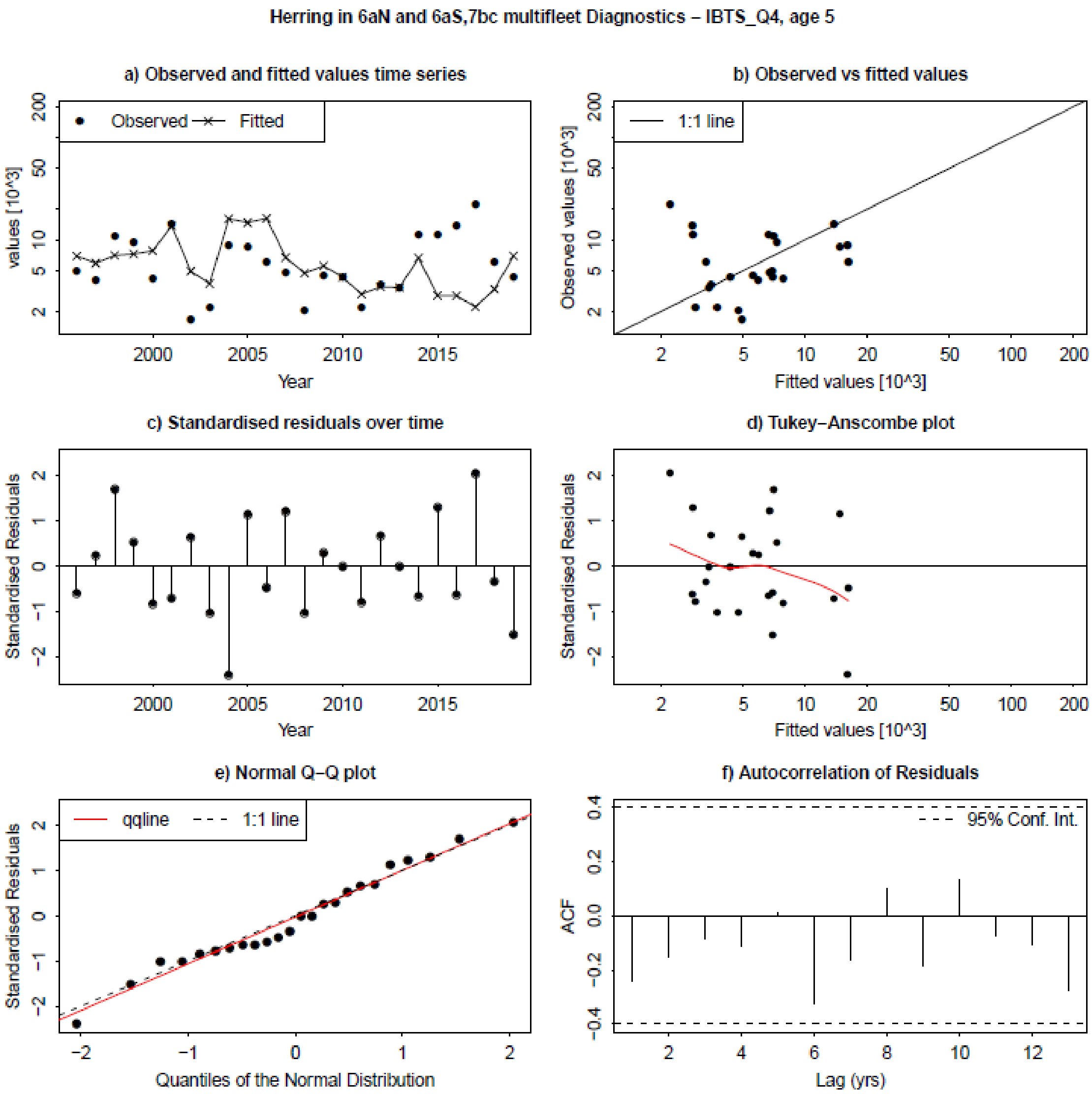


Figure 4.6.53. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 5-winter ring time-series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 5-winter ring. Middle right: index observation vs. standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

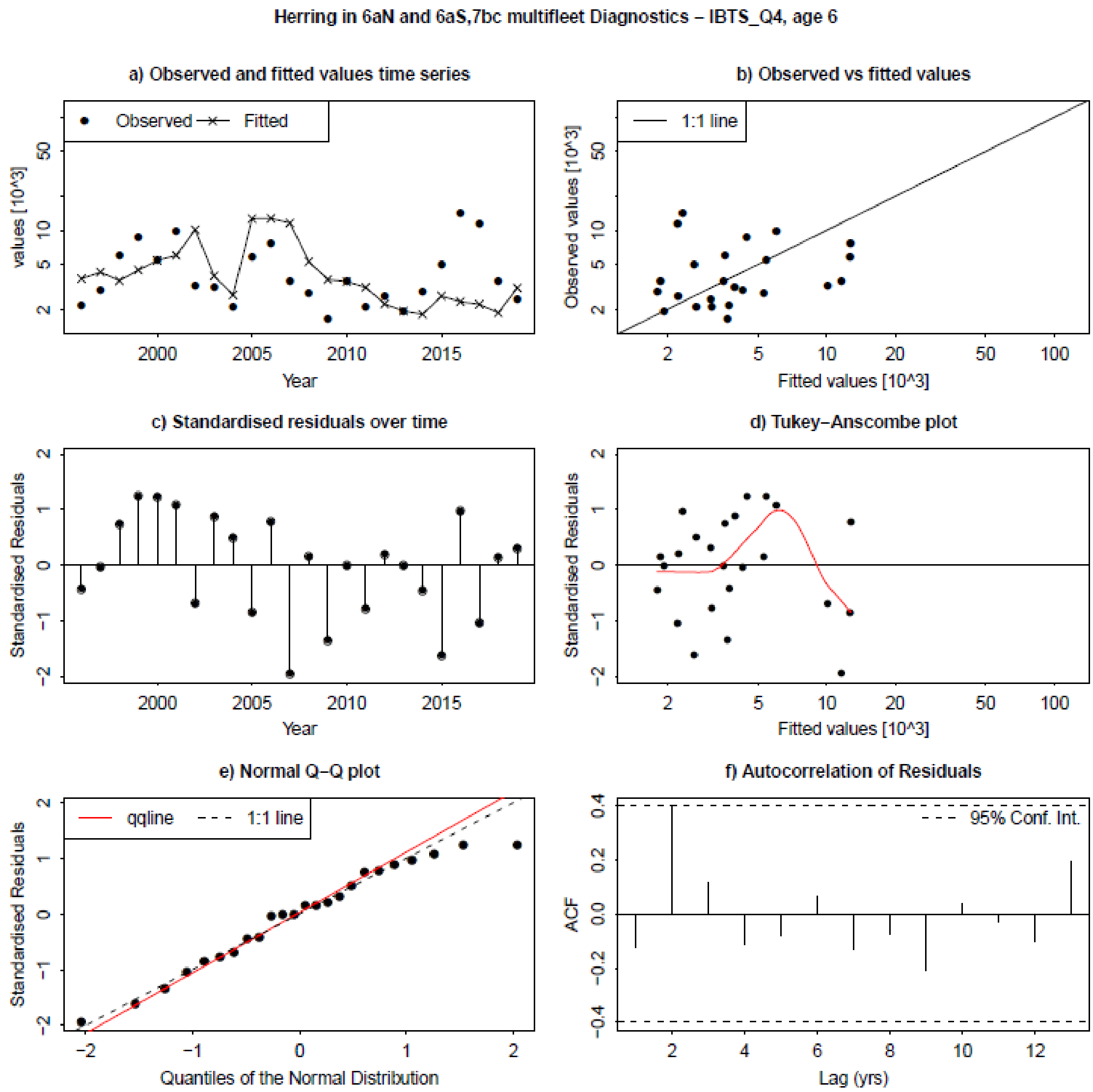


Figure 4.6.54. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 6-winter ring time-series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 6-winter ring. Middle right: index observation vs. standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

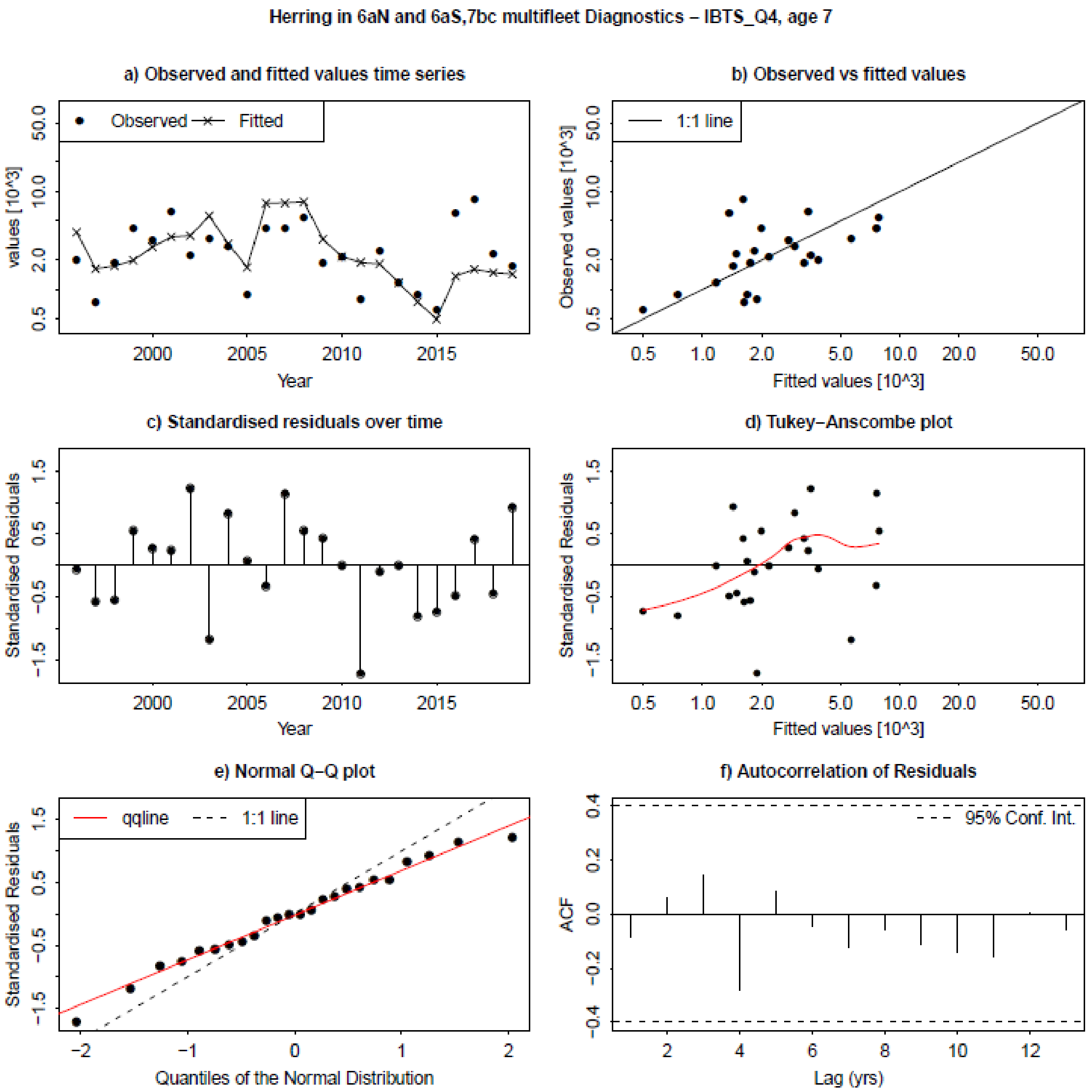


Figure 4.6.55. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 7-winter ring time-series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 7-winter ring. Middle right: index observation vs. standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

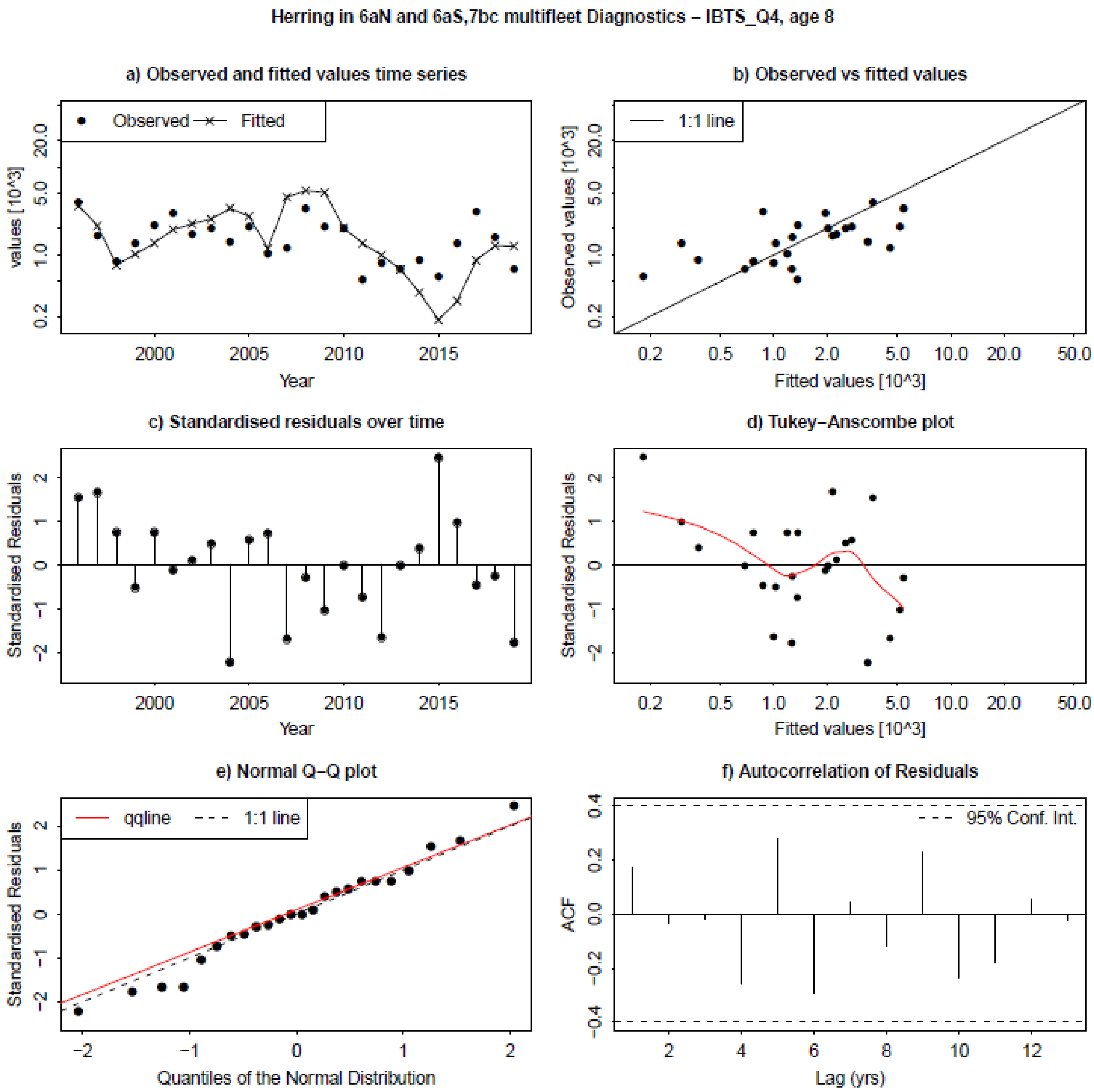


Figure 4.6.56. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 8-winter ring time-series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 8-winter ring. Middle right: index observation vs. standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

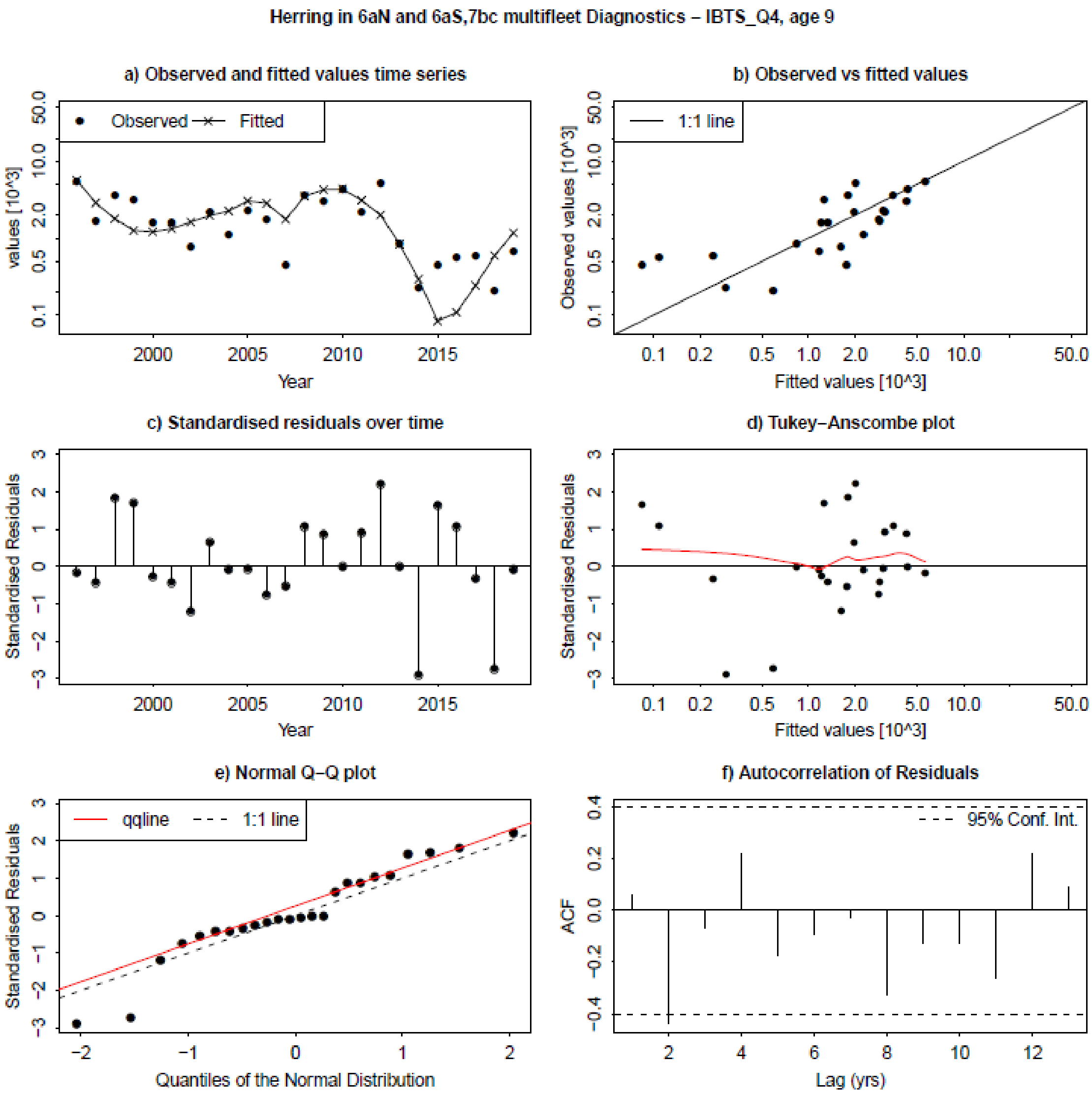


Figure 4.6.57. Herring in 6.a (combined) and 7.b–c. Diagnostics of the assessment model fit to the Scottish bottom-trawl survey index in quarter 4 at 9-winter ring time-series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations vs. assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time-series of standardized residuals of the index at 9-winter ring. Middle right: index observation vs. standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

5 Herring (*Clupea harengus*) in divisions 6.a (South), 7.b–c, and 6.a (North), separate

5.1 Herring in divisions 6.a (South) and 7.b-c

Since 2015, this stock has been combined with herring in 6.a.N (Section 5.2) for assessment and advisory purposes. This management unit existed since 1982, when it was separated from 6.a.N. Until that time, 7.b–c was also a separate management unit. The stock comprises autumn, winter, and spring-spawning components.

The WG noted that the use of "age", "winter rings", "rings" and "ringers" still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using "rings", "ringers", "winter ringers" or "wr" instead of "age" throughout this section. However, if the word "age" is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks, there is a difference of one year between "age" and "rings", which is not the case for spring spawners. Further elaboration on the rationale behind this, specific to Area 6.a.S, 7.b–c autumn, winter and spring spawners, can be found in the Stock Annex. It is the responsibility of any user of age-based data for any of these herring stocks to consult the stock annex and if in doubt consult a relevant member of the Working Group.

5.1.1 The Fishery

5.1.1.1 Advice and management applicable to 2019 and 2020

In 2016 ICES advised TAC of 0 t and that a stock recovery plan be developed for herring stocks in 6.a and 7.b–c stocks (ICES, 2016a). However, in February 2016, the European Commission asked ICES to advise on a TAC of sufficiently small size to allow ongoing collection of fisheries-dependent data. In June 2016, ICES advised on a scientific monitoring TAC of 1360 t for this stock (ICES, 2016b). The EC set a TAC slightly higher than this advice, at 1630 t was established by the EC (EU 2016/0203) for 2016-2019. The TAC for 2020 was reduced in line with the advised value given in 2016 to 1360 t.

Rebuilding plan

A revised proposed rebuilding plan for both 6.a.N and 6.a.S, 7.b–c stocks combined was reviewed by HAWG 2018 (ICES 2018, Annex 9). While the plan was considered to provide a framework for recovery of these combined stocks, it was considered unlikely that the revised proposed plan can aid the recovery of the combined stocks by 2020 as recent poor recruitments hamper a speedy recovery. Furthermore, ICES ACOM considered that further quantitative evaluation would be required to be used as the basis for advice.

5.1.1.2 Catches in 2019

The Working Group estimates of landings from 1991–2019 are given in Table 5.1.2. The catch has declined from 19 000 t in 2006 to 1495 t in 2018. Catches increased in 2019 to 1690 t. There is a monitoring TAC in place for the combined stocks in 6.a and 7.b–c. In 2019 the majority of the quota taken close inshore. Catches over time are shown in Figure 5.1.1.

In 2019 the majority of the catch was taken in the fourth quarter with subdivision 6.aS accounting for the vast majority of catch (Figure 5.1.9).

5.1.1.3 Regulations and their effects

Within the Irish fishery, the monitoring TAC in 2019 was allocated on a similar basis to 2016-2018. The quota was allocated, to a wide spectrum of small and large vessels. This resulted in more fishing opportunities across the fleet.

5.1.1.4 Changes in fishing pattern and information from the industry

The monitoring TAC, introduced in 2016 and continued in 2019, has led to a change in the pattern of the fishery. In previous years, larger vessels dominated in the fishery and took their quotas often in one haul, in a somewhat opportunistic basis. The monitoring TAC is now allocated to vessels in six different categories from over 24 m down to under 12 m. The Herring fishery in 2019 opened up earlier than in 2018 to facilitate the large RSW vessels to catch the fish off-shore but the herring were already inshore at this stage. In 2019 there was also a fishery in January for the first time in recent years.

For 2020 it was agreed that there would be additional data collection in January, February, March and April to determine the extent of spawning during these months. Information provided by the Irish industry reported for January, February and March 2020, very good marks of herring in all the bays around the Donegal coast. Similar reports are available for Lough Foyle, Lough Swilly and all areas of Donegal Bay such as Inver Bay and the approaches to Killybegs. The unanimous view of all the fishers involved in the monitoring fishery in 6.a south ,7 b.c is that they have encountered large quantities of herring along the Donegal coast particularly in period mid-October to mid-March (main period November, December and January) over the last three years. The view is that herring shoals have increased from the 2018/2019 season compared to 2019/2020.

5.1.2 Biological composition of the catch

5.1.2.1 Catch-at-age

Catch-at-age data for this fishery are shown in Table 5.1.3 and Figure 5.1.2 and in percentage terms since 1992 in Table 5.1.4. In 2019, the fishery was dominated by 1- 5-ringers accounting for 84% of the catch (Table 5.1.4). Smaller proportions of 6-9 ringers are evident in the catch data and account for 16% of the total. 3 ringers are the dominant age class 24% followed 2 ringers (20%), 1 (15%), 5 (14%), 4 (11%). 2019 is the first year since 2012 1 ringers are well represented in the catch-at-age data. Strong cohorts that were present in 2018 as 4 and 5 ringers were not as strong in 2019.

Proportion-at-age in the catches from the fishery are similar to the catches from the MSHAS for most years. In 2019 the proportions of 1 ringers was higher in the catch than the acoustic survey for the first time. Peak can be seen at 3 and 5 winter rings in both data sources (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.

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 2019

An acoustic survey of Atlantic herring *Clupea harengus* was conducted in ICES areas 6aS/7b in Dec 2019 using the research vessel RV *Celtic Voyager* and the fishing vessel MFV *Ros Ard SO745* http://hdl.handle.net/10793/1498. This survey is the fourth in a time-series that is hoped will be developed into a long-term index of spawning/prespawning herring in 6aS/7b. The survey design is based on the predicted distribution of this winter spawning herring in this area. Poor weather negatively impacted the survey in 2019, resulting in fewer transect miles completed and fewer strata areas covered than planned. In total, approximately 600nmi of cruise track was completed using 96 transects. This resulted in a total area coverage of approximately 606 nmi^2, a significant reduction compared to recent years. Parallel transect spacing was set at 3.5nmi for the Donegal Bay strata. Tightly spaced zig-zag transects were used in a relatively small area in Lough Swilly. A Simrad ES-120 7CD (120 kHz) split-beam echosounder was used to collect acoustic raw data. The transducer was mounted on a towed body from the *Celtic Voyager* in Donegal Bay and was pole mounted from the *Ros Ard* in Lough Swilly. Very strong herring marks were evident in Lough Swilly in deepest part of the channel. The herring marks continued for many miles in the upper Swilly, an area where boats in the monitoring fishery had also concentrated effort. There were some herring marks in discrete areas around Drumanoo Head, Bruckless Bay and Inver Bay in the Donegal Bay Strata. 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 Inver Bay as close spatially and temporally as possible to the survey in these areas. Herring were dominated overall by 1- and 2-wr fish, (52% of the overall numbers) followed by relatively strong 3- and 5-wr cohorts. The total-stock biomass (TSB) estimate of herring for the combined 6aS/7b area was 25,289 tonnes (Lough Swilly = 19,697 tonnes, Donegal Bay = 5,591 tonnes). This is considered to be a minimum estimate of herring in the 6aS/7b survey area at the time of the survey, and a significant decrease on the previous 3 years surveys. The reduction in the survey area completed as a consequence of the poor weather resulted in the survey not containing the stock in 2019. However, the overall CV estimate on biomass and abundance for the survey area completed is low (~0.17) in 2019. This is driven by the improved survey design in Lough Swilly, with reduced transect spacing and increased transect miles in this strata. The CV for the Donegal Bay strata is relatively high (0.63), this is mostly caused by the over-reliance on a few acoustic marks of herring in Bruckless and Inver Bays in particular and many transects with little or no herring marks. The survey in 2019 had to be altered due to weather, requiring a change in design and approach. However, the template of focusing on discrete areas was generally successful and may provide a template for future designs, particularly when reduced effort is necessary during poor weather or resource limits.

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 2019 are presented in Figure 5.1.7. In recent years there was a decrease in mean weights relative to the late 1990s. Over the longer time-series there is little trend over time, but they have dropped for most age classes in 2019 relative to 2018.

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 2019 relative to 2018 for younger ages and increased slightly for some older ages.

5.1.4.2 Maturity Ogive

One ringers are considered to be immature. All older ages are assumed to be 100% mature.

5.1.5 Recruitment

There is little information on terminal year recruitment in the catch-at-age data and there are as yet no recruitment indices from the surveys. Numbers of 1-ringers in the catches vary widely but, with the exception of 2012 (2010 cohort), have been consistently low. In 2019, however 1 ringers represented a significant proportion (15%) of the catch-at-age. 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 2020.

5.1.5.2 State of the stock

Not analytically determined.

5.1.6 Short-term projections

Not undertaken.

5.1.7 Medium-term simulations

Not undertaken.

5.1.8 Long-term simulations

Not undertaken.

5.1.9 Precautionary and yield based reference points

Not determined.

5.1.10 Quality of the assessment

Not ascertained.

5.1.11 Management considerations

There is no new information to alter the previous perception that this stock.

Fishing mortality has been kept low to allow rebuilding. The monitoring TAC should be maintained allowing sampling to continue.

The combined assessment (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.

The population structure of herring stocks in 6a/7bc is currently being examined using genetics and morphometric techniques. This project will be completed in late 2020. The results of this project will provide information on stock identity and will be used to inform the assessment of herring in this area. It is anticipated that when these results are available it will be possible to carry out a full benchmark on these stocks

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, 1991–2019. These data do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999
France	-	-	-	-	-	-	-	-	-
Germany, Fed. Rep.	-	250	-	-	11	-	-	-	-
Ireland	22500	26000	27600	24400	25450	23800	24400	25200	16325
Netherlands	600	900	2500	2500	1207	1800	3400	2500	1868
UK (N. Ireland)	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	50	24	-	-	-	-
UK (Scotland)	+	-	200	-	-	-	-	-	-
Total landings	23100	27150	30300	26950	26692	25600	27800	27700	18193
Unallocated/ area misreported	11200	4600	6250	6250	1100	6900	-700	11200	7916
Discards	3400	100	250	700	-	-	50		-
WG catch	37700	31850	36800	33900	27792	32500	27150	38900	26109

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008
France	-	-	515	-	-	-	-	-	-
Germany, Fed. Rep.	-	-	-	-	-	-	-	-	-
Ireland	10164	11278	13072	12921	10950	13351	14840	12662	10237
Netherlands	1234	2088	366	-	64	-	353	13	-
UK (N. Ireland)	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	6	-	-
Total landings	11398	13366	13953	12921	11014	13351	15199	12675	10237
Unallocated/ area misreported	8448	1390	3873	3581	2813	2880	4000	5116	3103
Discards	-	-	-	-	-	-	-	-	-
WG catch	19846	14756	17826	16502	13827	16231	19199	17791	13340

Table 5.1.2. Herring in divisions 6.a.S and 7.b–c. Estimated Herring catches in tonnes, 1991–2019 continued

Country	2019	2010	2011	2012	2013	2014	2015	2016	2017
France	-	-	-	-	-	-	-	-	-
Germany, Fed. Rep.	-	-	-	-	-	-	-	-	-
Ireland	8533	7513	4247	3791	1460	2933	73	1171	1707
Netherlands	-	-	-	-	40	-	+	72	-
UK (N. Ireland)	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	5	-	-
Total landings	8533	7513	4247	3791	1500	2933	78	1243	1707
Unallocated/ area misreported	1935	2728	2672	2780	2468	2163	1000	971	520
Discards	-	-	-	-	-	-	-	-	-
WG catch	10 468	10 241	6919	6571	3968	5096	1078	2214	2227

Country	2018	2019
France		
Germany Fed. Rep.		
Ireland	970	1625
Netherlands		65
UK (N. Ireland)		
UK (England + Wales)		
UK (Scotland)		
Total landings	970	1690
Unallocated/ area misreported	525	
Discards		
WG catch	1495	1690

Table 5.1.3. Herring in divisions 6.a.S and 7.b–c. Catch in numbers-at-age (winter rings) from 1970–2019.

	1	2	3	4	5	6	7	8	9
1970	135	35114	26007	13243	3895	40181	2982	1667	1911
1971	883	6177	7038	10856	8826	3938	40553	2286	2160
1972	1001	28786	20534	6191	11145	10057	4243	47182	4305
1973	6423	40390	47389	16863	7432	12383	9191	1969	50980
1974	3374	29406	41116	44579	17857	8882	10901	10272	30549
1975	7360	41308	25117	29192	23718	10703	5909	9378	32029
1976	16613	29011	37512	26544	25317	15000	5208	3596	15703
1977	4485	44512	13396	17176	12209	9924	5534	1360	4150
1978	10170	40320	27079	13308	10685	5356	4270	3638	3324
1979	5919	50071	19161	19969	9349	8422	5443	4423	4090
1980	2856	40058	64946	25140	22126	7748	6946	4344	5334
1981	1620	22265	41794	31460	12812	12746	3461	2735	5220
1982	748	18136	17004	28220	18280	8121	4089	3249	2875
1983	1517	43688	49534	25316	31782	18320	6695	3329	4251
1984	2794	81481	28660	17854	7190	12836	5974	2008	4020
1985	9606	15143	67355	12756	11241	7638	9185	7587	2168
1986	918	27110	27818	66383	14644	7988	5696	5422	2127
1987	12149	44160	80213	41504	99222	15226	12639	6082	10187
1988	0	29135	46300	41008	23381	45692	6946	2482	1964
1989	2241	6919	78842	26149	21481	15008	24917	4213	3036
1990	878	24977	19500	151978	24362	20164	16314	8184	1130
1991	675	34437	27810	12420	100444	17921	14865	11311	7660
1992	2592	15519	42532	26839	12565	73307	8535	8203	6286
1993	191	20562	22666	41967	23379	13547	67265	7671	6013
1994	11709	56156	31225	16877	21772	13644	8597	31729	10093
1995	284	34471	35414	18617	19133	16081	5749	8585	14215
1996	4776	24424	69307	31128	9842	15314	8158	12463	6472

	1	2	3	4	5	6	7	8	9
1997	7458	56329	25946	38742	14583	5977	8351	3418	4264
1998	7437	72777	80612	38326	30165	9138	5282	3434	2942
1999	2392	51254	61329	34901	10092	5887	1880	1086	949
2000	4101	34564	38925	30706	13345	2735	1464	690	1602
2001	2316	21717	21780	17533	18450	9953	1741	1027	508
2002	4058	32640	37749	18882	11623	10215	2747	1605	644
2003	1731	32819	28714	24189	9432	5176	2525	923	303
2004	1401	15122	32992	19720	9006	4924	1547	975	323
2005	209	28123	30896	26887	10774	5452	1348	858	243
2006	598	22036	36700	30581	21956	9080	2418	832	369
2007	76	24577	43958	23399	13738	5474	1825	231	131
2008	483	12265	19661	28483	11110	5989	2738	745	267
2009	202	12574	12077	12096	12574	5239	2040	853	17
2010	1271	13507	20127	6541	7588	6780	2563	661	189
2011	121	14207	9315	9114	3386	3780	2871	980	95
2012	5142	12844	16387	4042	1776	553	541	103	21
2013	61	3118	4532	12238	1665	1792	425	382	202
2014	34	465	8825	6735	12146	2406	1045	437	204
2015	27	1842	598	2553	1699	685	96	9	0
2016	69	1983	4252	1369	3025	2085	824	43	9
2017	30	1051	5241	4078	1025	2250	1061	480	76
2018	6	1567	1838	3280	2288	613	700	260	29
2019	1995	2627	3259	1509	1895	1166	381	464	171

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+
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%
2019	15%	20%	24%	11%	14%	9%	3%	3%	1%

Table 5.1.5. Herring in divisions 6.a.S and 7.b–c. Mean weights-at-age in the catches 1970–2019.

	1	2	3	4	5	6	7	8	9+
1970	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1971	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1972	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1973	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1974	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1975	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1976	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1977	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1978	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1979	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1980	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1981	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1982	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1983	0.090	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1984	0.106	0.141	0.181	0.210	0.226	0.237	0.243	0.247	0.248
1985	0.077	0.122	0.161	0.184	0.196	0.206	0.212	0.225	0.230
1986	0.095	0.138	0.164	0.194	0.212	0.225	0.239	0.208	0.288
1987	0.085	0.102	0.150	0.169	0.177	0.193	0.205	0.215	0.220
1988		0.098	0.133	0.153	0.166	0.171	0.183	0.191	0.201
1989	0.080	0.130	0.141	0.164	0.174	0.183	0.192	0.193	0.203
1990	0.094	0.138	0.148	0.160	0.176	0.189	0.194	0.208	0.216
1991	0.089	0.134	0.145	0.157	0.167	0.185	0.199	0.207	0.230
1992	0.095	0.141	0.147	0.157	0.165	0.171	0.180	0.194	0.219
1993	0.112	0.138	0.153	0.170	0.181	0.184	0.196	0.229	0.236
1994	0.081	0.141	0.164	0.177	0.189	0.187	0.191	0.204	0.220
1995	0.080	0.140	0.161	0.173	0.182	0.198	0.194	0.206	0.217

	1	2	3	4	5	6	7	8	9+
1996	0.085	0.135	0.172	0.182	0.199	0.209	0.220	0.233	0.237
1997	0.093	0.135	0.155	0.181	0.201	0.217	0.217	0.231	0.239
1998	0.095	0.136	0.145	0.173	0.191	0.196	0.202	0.222	0.217
1999	0.106	0.144	0.145	0.163	0.186	0.195	0.200	0.216	0.222
2000	0.102	0.129	0.154	0.172	0.180	0.184	0.204	0.203	0.204
2001	0.086	0.122	0.139	0.167	0.183	0.188	0.222	0.222	0.213
2002	0.097	0.127	0.140	0.155	0.175	0.196	0.204	0.218	0.226
2003	0.102	0.134	0.150	0.167	0.183	0.196	0.216	0.210	0.228
2004	0.085	0.140	0.150	0.167	0.182	0.193	0.222	0.221	0.285
2005	0.105	0.135	0.150	0.162	0.174	0.188	0.200	0.237	0.296
2006	0.106	0.137	0.141	0.158	0.169	0.178	0.199	0.221	0.243
2007	0.118	0.144	0.145	0.168	0.179	0.189	0.197	0.233	0.237
2008	0.1108	0.1478	0.1503	0.1663	0.1745	0.1845	0.1938	0.1990	0.2407
2009	0.077	0.146	0.171	0.194	0.200	0.207	0.211	0.218	0.275
2010	0.104	0.131	0.168	0.189	0.201	0.212	0.218	0.226	0.229
2011	0.094	0.122	0.141	0.174	0.193	0.202	0.217	0.218	0.246
2012	0.09	0.134	0.179	0.196	0.214	0.237	0.228	0.243	0.236
2013	0.083	0.121	0.141	0.170	0.181	0.196	0.202	0.226	0.226
2014	0.105	0.139	0.136	0.155	0.168	0.175	0.184	0.183	0.187
2015	0.090	0.113	0.145	0.152	0.161	0.168	0.176	0.185	0.188
2016	0.09	0.125	0.149	0.163	0.182	0.188	0.19	0.21	0.201
2017	0.072	0.106	0.132	0.145	0.159	0.168	0.172	0.179	0.183
2018	0.085	0.101	0.127	0.144	0.155	0.166	0.172	0.170	0.174
2019	0.063	0.099	0.127	0.147	0.159	0.164	0.180	0.174	0.172

Table 5.1.6. Herring in divisions 6.a.S and 7.b–c. Mean weights-at-age in the stock at spawning time 1970–2019.

	1	2	3	4	5	6	7	8	9+
1970	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1971	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1972	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1973	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1974	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1975	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1976	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1977	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1978	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1979	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1980	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1981	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1982	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1983	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1984	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1985	0.100	0.150	0.196	0.227	0.238	0.251	0.252	0.269	0.284
1986	0.098	0.169	0.209	0.238	0.256	0.276	0.280	0.287	0.312
1987	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1988	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1989	0.138	0.157	0.168	0.182	0.200	0.217	0.227	0.238	0.245
1990	0.113	0.152	0.170	0.180	0.200	0.217	0.225	0.233	0.255
1991	0.102	0.149	0.174	0.190	0.195	0.206	0.226	0.236	0.248
1992	0.102	0.144	0.167	0.182	0.194	0.197	0.214	0.218	0.242
1993	0.118	0.166	0.196	0.205	0.214	0.220	0.223	0.242	0.258
1994	0.098	0.156	0.192	0.209	0.216	0.223	0.226	0.230	0.247
1995	0.090	0.144	0.181	0.203	0.217	0.226	0.227	0.239	0.246
1996	0.086	0.137	0.186	0.206	0.219	0.234	0.233	0.249	0.253

	1	2	3	4	5	6	7	8	9+
1997	0.094	0.135	0.169	0.194	0.210	0.224	0.231	0.230	0.239
1998	0.095	0.136	0.145	0.173	0.191	0.196	0.202	0.222	0.217
1999	0.104	0.145	0.154	0.174	0.200	0.222	0.230	0.240	0.246
2000	0.100	0.134	0.157	0.177	0.197	0.207	0.217	0.230	0.245
2001	0.091	0.125	0.150	0.172	0.191	0.200	0.203	0.203	0.216
2002	0.092	0.127	0.146	0.170	0.190	0.201	0.210	0.227	0.229
2003	0.094	0.131	0.155	0.175	0.192	0.203	0.232	0.222	0.243
2004	0.081	0.133	0.151	0.175	0.194	0.207	0.238	0.233	0.276
2005	0.095	0.127	0.15	0.172	0.185	0.196	0.223	0.234	0.274
2006	0.092	0.130	0.133	0.162	0.177	0.186	0.209	0.238	0.247
2007	0.114	0.133	0.133	0.171	0.186	0.196	0.208	0.228	0.229
2008	0.098	0.136	0.140	0.174	0.185	0.196	0.192	0.205	0.234
2009	0.072	0.141	0.162	0.197	0.215	0.223	0.225	0.221	0.286
2010	0.092	0.128	0.157	0.189	0.208	0.227	0.234	0.239	0.247
2011	0.082	0.118	0.136	0.177	0.199	0.207	0.225	0.239	0.240
2012	0.084	0.135	0.182	0.203	0.214	0.226	0.225	0.21	0.226
2013	0.074	0.114	0.140	0.170	0.188	0.198	0.204	0.223	0.222
2014	0.093	0.128	0.135	0.154	0.169	0.170	0.188	0.169	0.206
2015	0.077	0.112	0.146	0.155	0.165	0.173	0.179	0.183	0.217
2016	0.078	0.119	0.147	0.164	0.185	0.191	0.197	0.21	0.175
2017	0.064	0.099	0.130	0.145	0.163	0.173	0.176	0.185	0.180
2018	0.072	0.097	0.126	0.146	0.156	0.168	0.172	0.169	0.170
2019	0.063	0.098	0.124	0.149	0.164	0.166	0.180	0.180	0.175

Table 5.1.7. Herring in divisions 6.a.S and 7.b–c. Sampling intensity of catches in 2019.

Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
6.a.S	1	235	5	358	869	1527
6.a.S	4	1391	26	1992	6382	1433

Total	1625	31	2350	7275	1446

Table 5.1.8. Herring in divisions 6.a.S and 7.b–c. Details of acoustic surveys dedicated to the 6a.S/7.b–c stock alone.

Year	Type	Biomass	SSB
1994	Feeding phase	-	353772
1995	Feeding phase	137670	125800
1996	Feeding phase	34290	12550
1997	-	-	-
1998	-	-	-
1999	Autumn	23762	22788
2000	Autumn	21000	20500
2001	Autumn	11100	9800
2002	Winter	8900	7200
2003	Winter	10300	9500
2004	Winter	41700	41399
2005	Winter	71253	66138
2006	Winter	27770	27200
2007	Winter	14222	13974
2016	Winter	35475	35475
2017	Winter	40646	40646
2018	Winter	50145	49523
2019*	Winter	25289	22,386
*reduced survey area			

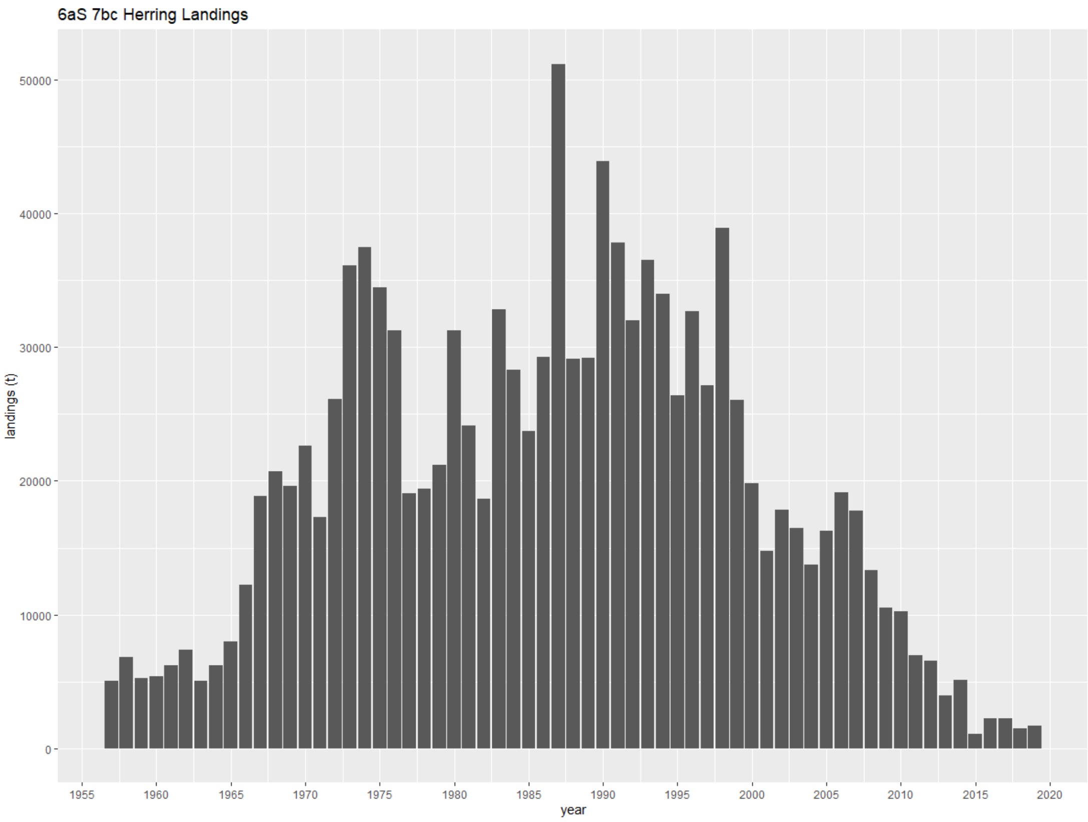


Figure 5.1.1. Herring in divisions 6.a.S and 7.b–c. Working group estimate of catches from 1957–2019.

Figure 5.1.2. Herring in divisions 6.a.S and 7.b–c. catch numbers-at-age standardized by year for the fishery 1957–2019.

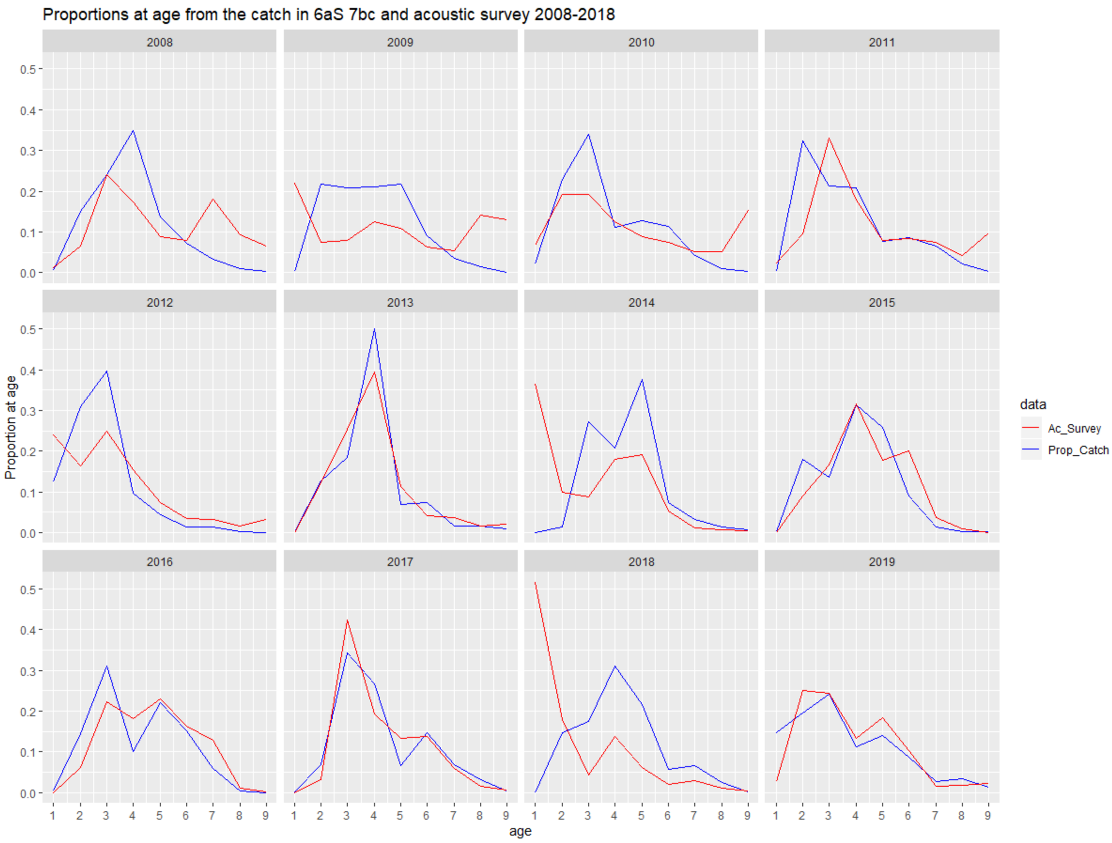


Figure 5.1.4. Herring in divisions 6.a.S and 7.b–c. Percentages-at-age in the 6aS/7.b–c catch and 6aS/7.b–c Malin Shelf acoustic survey (MSHAS) 2008-2019.

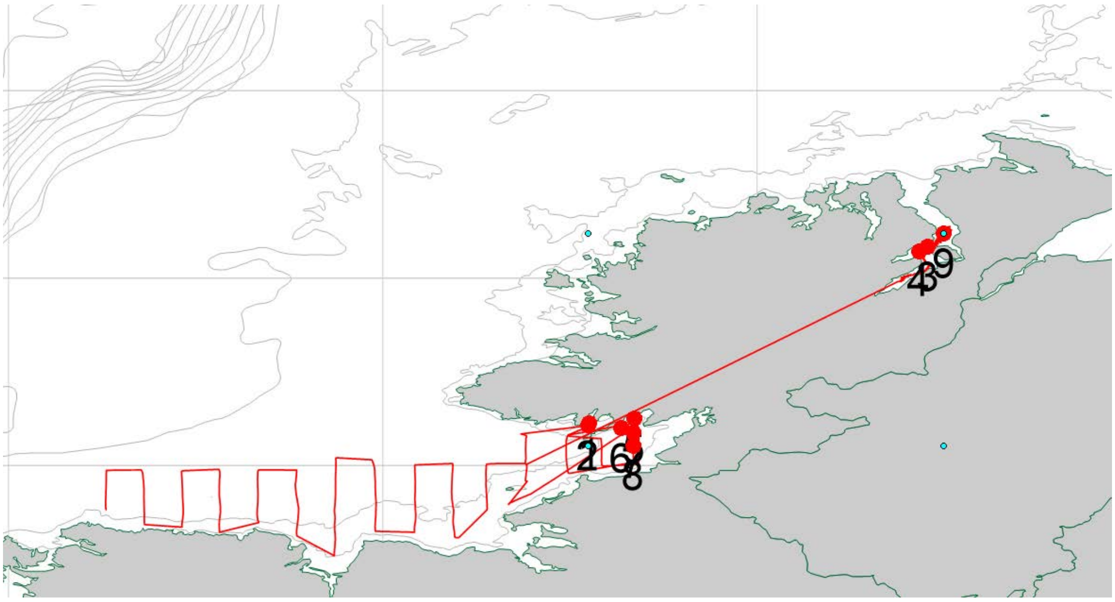


Figure 5.1.5. Herring in divisions 6.a.S and 7.b–c. Acoustic survey in 2019: distribution of biological samples obtained in 6aS.

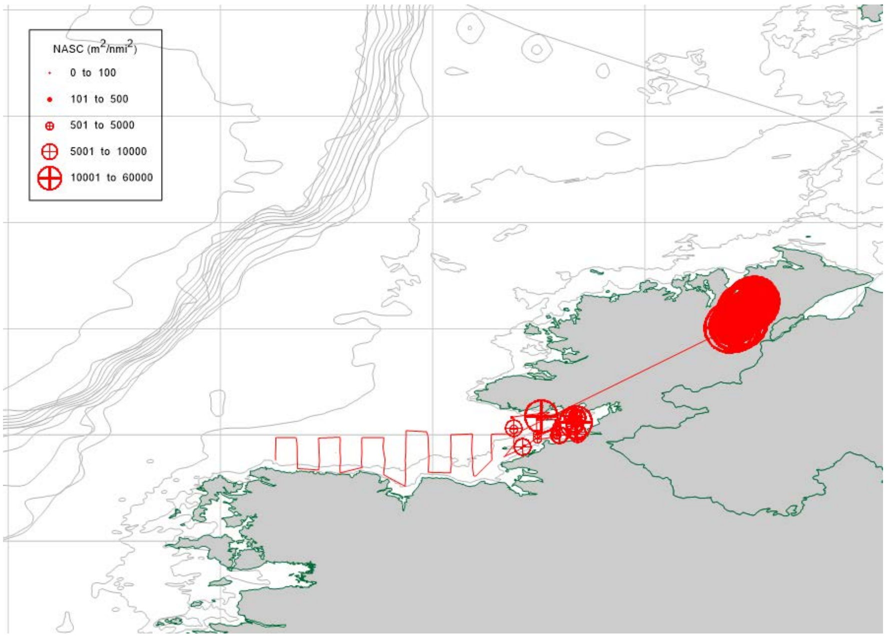


Figure 5.1.6. Herring in division 6.a.S and 7.b–c. Acoustic survey in 2019: NASC of herring.

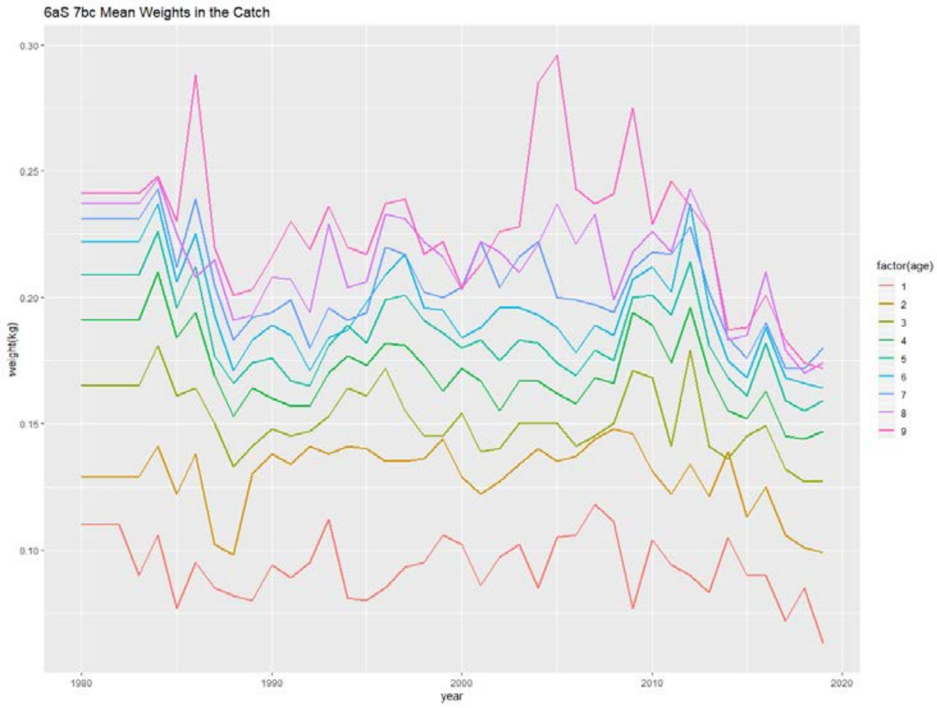


Figure 5.1.7. Herring in divisions 6.a.S and 7.b–c. Mean weights in the catch (kg) by age in winter rings (1980–2019). Prior to 1981 weights were fixed.

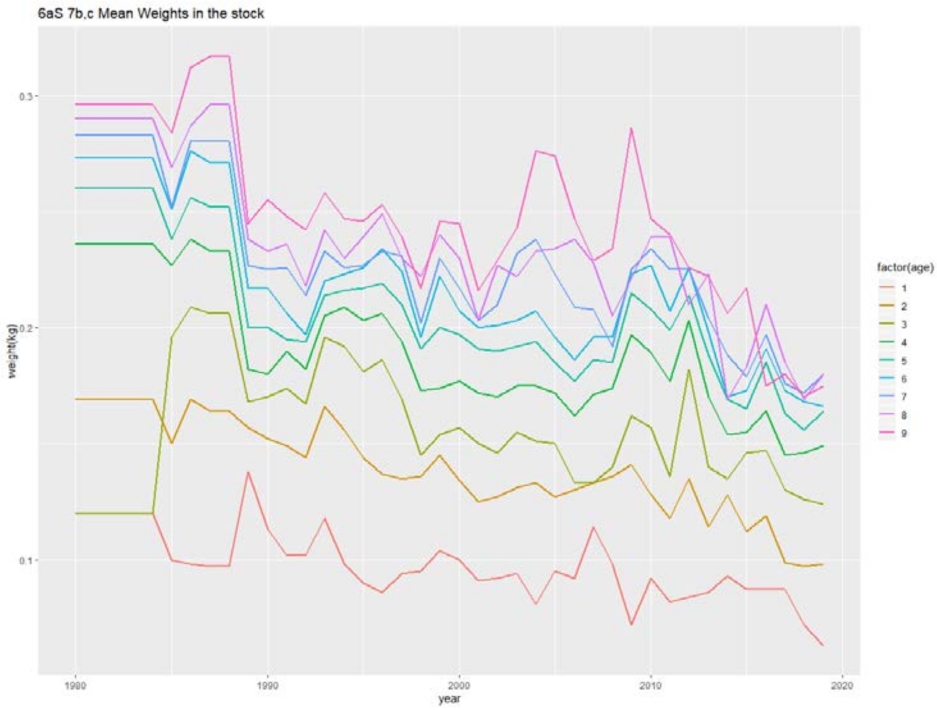


Figure 5.1.8. Herring in divisions 6.a.S and 7.b–c. Mean weights in the stock (kg) at spawning time by age in winter rings (1980–2019). Prior to 1981 weights were fixed.

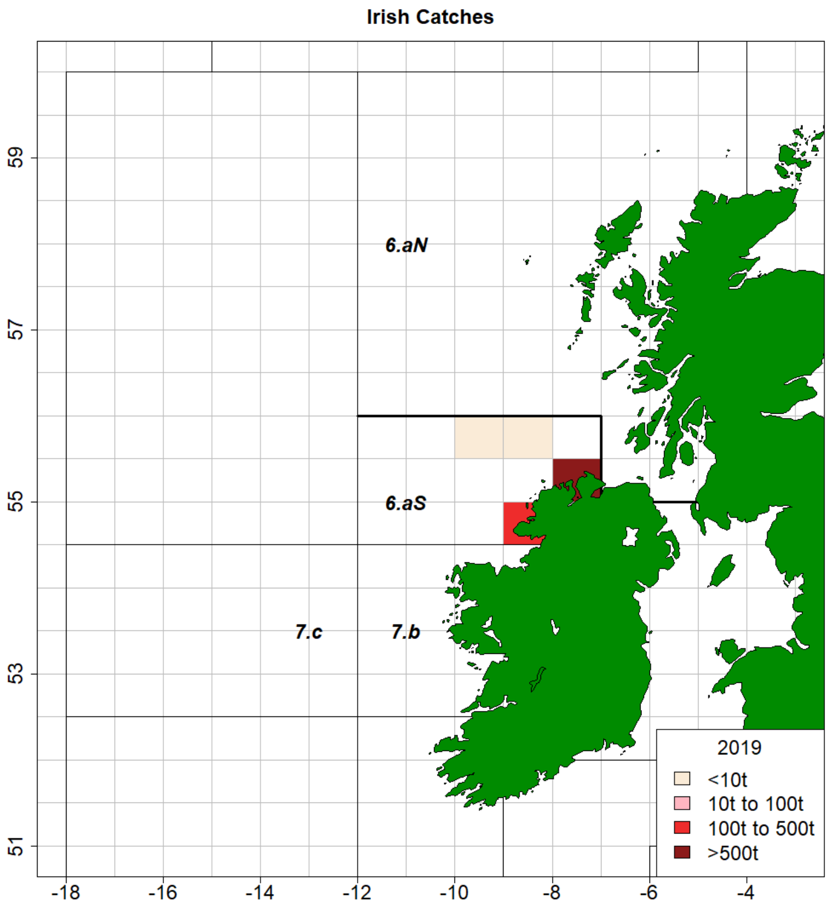


Figure 5.1.9. Herring in divisions 6.a.S and 7.b–c. Irish catches in 2019.

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 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 2019

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), 2018 (EU 2018/120) and 2019 ((EU) 2019/124).

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 the years prior to 2016 (ICES 2016). Area 5 was a new addition for 2018 based on evidence from 2017 from local creel fishers catches of herring on the east side of the North Minch.

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. Systematic acoustic surveys were conducted in areas 2-5 in 6.aN. Samples for genetic data were taken from any samples containing fish where the maturity stage indicated they were close to spawning.

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 Scottish vessels completed their scientific survey duties prior to undertaking any commercial activity. In 2019, evidence of lack of herring on the ground resulted in the Scottish fleet not taking their allocated quota. Alternative arrangements were agreed for vessels to get paid for their work with allocation of scientific quota of other species.

Details of the survey are reported in WGIPS ICES (2020) and Mackinson *et al*. (2020).

5.2.1.3 Stock recovery plan

The Pelagic Advisory Council submitted a revised proposed rebuilding plan for both 6.aN and 6.a.S 7.b–c stocks combined which was reviewed by HAWG 2018 (ICES 2018 Annex 9)). However, ICES ACOM considered that further quantitative evaluation would be required to be used as the basis for advice. ICES advice in 2019 states *'ICES still considers it important to develop a stock recovery plan for herring in divisions 6.a and 7.b–c, but given the large changes in perception of the stock, fishing pressure and recruitment together with the continued uncertainty in the quality of the assessment, the requirement for a rebuilding plan (or plans) are considered to be better addressed during a full benchmark, anticipated for 2021'.*

5.2.1.4 Catches in 2019

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 2019 resulted in the 6.aN TAC being split between the six participating pelagic vessels.

The 2019 official catches of herring in 6.aN total 1739 t compared with the 4170 t monitoring TAC. This included 181 t caught outwith the monitoring fishery primarily as bycatch during the mackerel fishery. There were 3.83 t of non-retained herring catch during the monitoring survey in 2019 under the discard derogation and 2.52 t of other species (Mackinson *et al.*, 2020).

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 2016–2019 resulted in the 6.aN TAC being split between the six 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 = 9) were used to allocate the age distribution for the 6.aN catches used in the assessment. This number of samples falls short of the requirements for the monitoring fishery as advised by ICES (ICES 2016). The requirement is 1 sample per 120t catch (assuming 1 sample per haul and a haul being on average 120t) meaning a total catch of 1522t in the monitoring fishery should have generated 13 samples. 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 2019.

The 2013 year class (5-ringers in 2019) continue to be prominent both in the catch in 6.aN and in the MSHAS_N acoustic survey index (30% of the catch, 31% of MSHAS_N index figures 5.2.3 and 5.2.4 Table 5.2.5). This year class are also coming through clearly in the neighbouring North Sea autumn spawning stock. This year 1-wr herring was observed in the largest number since 2011 in the catches (15%). Prior to 2011 these were a steady component of the catches (although very small in some years), recently they have only appeared sporadically in the catches. 1-wr herring are observed in the acoustic 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 2019 survey values are shown in tables 5.2.4 and 5.2.5.

Full details of the 2019 survey are available in the Report of the Working Group for International Pelagic Surveys (WGIPS ICES 2020 Annex 5b).

Vessel	Period	Strata
Celtic Explorer (IRL) EIGB	04 July–24 July	2 3 4 5 6
Scotia (SCO) MXHR6	27 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 at a historic low at76 kt in 2019 a significant decrease from the estimate of 152 kt in 2018 (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 5-ringers (2013 year class) 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 2018, a large proportion of the stock was made up of 1 and 2 winter ring fish (2015 and 2016 year class). These year classes were prominent again this year in the 2019 survey as 2 and 3 winter ringers (29% of total abundance).

WGIPS noted that the results for the 2019 acoustic survey in 6aN was compromised by very little biological sampling. Although the overall biomass are though to be accurate, the stock composition might not be as samples from the adjacent North Sea survey was used to inform this for the Northern most strata.

5.2.3.2 Acoustic survey- 6.a Herring industry–science survey 2019

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.

Similar to 2018, a notable feature of the 2019 was a predominance in Area 5 (East side of Lewis) of young herring mixed with sprat. Horse mackerel were also recorded again, often in close proximity with herring marks and mixed diffuse aggregations of sprat. Mackerel were found in abundance distributed throughout the area, being caught in every survey haul. Total herring biomass was estimated to be 76 000 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 (2020) who conclude that while the survey provided a reliable estimate of the minimum biomass of mature herring at age observed in survey areas, it did not provide a reliable estimate of the minimum spawning biomass, because many fish sampled in 2019 were still in the maturing stage, and because in area 2 in particular the lack of any biological samples meant that biological data had to be inferred from another survey area. The survey provides a fourth datapoint in a new survey series, the details of and utility of which will be explored during the next benchmark.

5.2.4 Mean Weights-at-age and Maturity-at-age

5.2.4.1 Mean weight-at-age

Weights-at-age in the stock are obtained from the West of Scotland part of the Malin Shelf herring acoustic survey (WGIPS ICES 2020a) and are given in Table 5.2.4 (for the current year). The weights-at-age in the stock in 2019 were similar for all age groups compared to last year (Table 5.2.7). Overall there is a trend of decreasing weights-at-age in the stock for all ages over the last ten years.

Weights in the catch (Table 5.2.8) in 2019 were also similar for all age groups compared to recent years. .

5.2.4.2 Maturity ogive

The maturity ogive is obtained from the West of Scotland part of the Malin Shelf herring acoustic survey (Table 5.2.4, WGIPS ICES 2020a). The survey provides estimated values for the period 1992–2019 (Table 5.2.9). In 2019 the level of maturity for 2 winter ring fish continued the decreasing trend observed since 2017 to only 36% mature. 3 winter ring fish were 95% which is in line with the time-series. At age 4 and above maturity levels were 100%.

5.2.5 Recruitment

There are no specific recruitment indices for this stock. This year both catches and the acoustic survey recorded catches of 1-ringers. Typically the encounter of this age group occurs only incidentally in the survey but has in the past been a small but stable component of the catches. The first reliable appearance of a cohort appears at 3-ring in both the catch and the survey for this stock. In 2019 the proportion of 3-ringers was low 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). Further changes to the assessment input data sources and the assessment were carried out in early 2019 during an interbenchmark procedure ((IBPher6a7bc, ICES 2019). Details of the 2020 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 (5-wr in 2019) was strong in the 2016 catches and again in the 2017,2018 and 2019 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 7, 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. 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 and the 2020 value was the lowest on record for this stock.

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 1991–2019. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999
Faroes	482			274					
France	1168	119	818	5087	3672	2297	3093	1903	463
Germany	6450	5640	4693	7938	3733	7836	8873	8253	6752
Ireland	8000	7985	8236	6093	3548	9721	1875	11199	7915
Netherlands	7979	8000	6132	8183	7808	9396	9873	8483	7244
Norway	3318	2389	7447	30676	4840	6223	4962	5317	2695
UK	32628	32730	32602	-4287	42661	46639	44273	42302	36446
Unallocated	-10597	-5485	-3753	700	-4541	-17753	-8015	-11748	-8155
Discards*	1180	200					62	90	
Total	50608	51578	56175	54664	61271	64359	64995	65799	61514
Area-Misreported	-22079	-22593	-24397	-30234	-32146	-38254	-29766	-32446	-23623
WG Estimate	28529	28985	31778	24430	29575	26105	35233	33353	29736
Source (WG)	1993	1994	1995	1996	1997	1997	1998	1999	2000

*** Unraised discards.**

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008
Faroes			800	400	228	1810	570	484	927
France	870	760	1340	1370	625	613	701	703	564
Germany	4615	3944	3810	2935	1046	2691	3152	1749	2526
Ireland	4841	4311	4239	3581	1894	2880	4352	5129	3103
Netherlands	4647	4534	4612	3609	8232	5132	7008	8052	4133
Norway									
UK	22816	21862	20604	16947	17706	17494	18284	17618	13963
Unallocated		277**	6244**	2820**	3490**				
Discards*					123	772	163		
Total	37789	35688**	41649**	31662**	33344**	31392	34230	33735	25216
Area-Misreported	-14627**	-10437**	-8735	-3581	-6885**	-17263	-6884	-4119	-9162
WG Estimate	23162**	25251**	32914	28081**	26459**	14129	27346	29616	16054
Source (WG)	2001	2002	2003	2004	2005	2006	2007	2008	2009

*** Unraised discards.**

**** Revised at WKWEST 2015.**

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017
Denmark								23	
Faroes	1544	70				360			
France	1049	511	504	244	586	589			
Germany	27	3583	3518	1829	4025	3354	3292	1028	
Ireland	1935	2728	3956	3451	3124	2632	1799	569	10
Lithuania						770			
Norway							0.98		
Netherlands	5675	3600	1684	3523	1775	1641	956	300	829
UK	11076	12018	11696	12249	15906	16769	15260	3254	3356
Unallocated									
Discards*		95			30				
Total	21306	22510	21358	21296	25446	26115	21307	5174	4201
Area-Misreported	-2798	-2728	-3599	-2780	-2468	-4088	-2506	-450	
WG Estimate	18508	19877	17759	18516	22978	22027	18801	4724	4201
Source (WG)	2010	2011	2012	2013	2014	2015	2016	2017	2018

*** Unraised discards.**

Country	2018	2019
Denmark	39	71
Faroes		
France	7	46**
Germany	17	2
Ireland	84	37
Lithuania		
Norway	4	3
Netherlands	1000	653
UK	2911	928
Unallocated		
Discards*		
Total	4063	1739
Area-Misreported		
WG Estimate	4063	1739
Source (WG)	2019	2020

*** Unraised discards. **From ICES preliminary catch statistics database.**

Table 5.2.2. Herring in 6.a (North). Catch and sampling effort by nation in the fishery in 2019.

Country	Quarter	Sampled Catch (t)	Official Catch (t)	No. Hauls	No. of samples	No. meas-ured	No. aged	SOP
UK (Sco)	Q1	0	11	-	-	-	-	0%
	Q3	170	170	3	3	521	184	100%
	Q4	0	5	-	-	-	-	0%
UK (NI)	Q4	0	19	-	-	-	-	0%
UK(E&W)	Q4	723	723	8	4	922	295	100%
Ireland	Q1	0	27	-	-	-	-	0%
	Q4	0	10	-	-	-	-	0%
Netherlands	Q1	0	19	-	-	-	-	0%
	Q3	629	629	9	2*	200	90*	100%
	Q4	0	5	-	-	-	-	0%
Denmark	Q1	0	45	-	-	-	-	0%
	Q4	0	26	-	-	-	-	0%
Others	All	0	5	-	-	-	-	0%
Total		1522	1739	20	9	1643	569	88%

*4 hauls were fully sampled, however due to uncertainty surrounding the quality of the data from 2 of these only 2 hauls were used in the raising of commercial catches.

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    2019
  1     0.00    0.00 1504.48
  2  1122.16 1508.98 1333.57
  3 11929.71 3215.53 1035.12
  4  4082.50 6873.26 2007.72
  5  2075.35 5253.61 3100.51
  6  1443.79 3068.25 1003.19
  7  1416.35  844.50  214.54
  8   767.37  852.31   79.03
  9   273.34  680.89   42.01
```

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 2019.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	0	0.0	0.00	0.0	0.0
1	3	0.3	0.00	98.1	22.2
2	50	5.8	0.36	117.0	23.4
3	77	11.6	0.95	149.8	25.4
4	41	7.4	1.00	179.0	27.0
5	137	26.8	1.00	195.8	27.8
6	86	17.6	1.00	205.4	28.2
7	14	3.1	1.00	216.9	29.0
8	16	3.6	1.00	223.5	29.3
9+	20	4.3	1.00	218.1	28.9
Immature	39	4		114.3	23.1
Mature	406	76		187.7	27.4
Total	445	81	0.91	181.3	27.0

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

2019	3423	49913	77088	41128	137031	85553	14485	16319	19903	76 146

Table 5.2.6. Total Abundance and overall biological composition of herring in 6.a North from the industry acoustic survey on FV Pathway in 2019. (Figures in bold are weighted averages based on the numbers in each age group.)

Age (wr)	Numbers (mill)	Biomass (kt)	Maturity	Mean Weight (g)	Mean Length (cm)
0	263	2.7	0.00	10.4	11.3
1	131	1.5	0.00	11.3	11.7
2	449	31.5	0.01	70.2	19.9
3	156	16.9	0.60	108.2	22.5
4	22	3.8	1.00	177.9	26.5
5	74	15.9	1.00	215.0	28.1
6	15	3.4	1.00	230.6	29.1
7	0	0.1	1.00	256.0	32.0
8	1	0.3	1.00	262.3	30.7
9+	0	0.0			
Immature	902	41		45.7	16.3
Mature	209	35		167.0	25.6
Total	1112	76	0.19	68.5	18.1

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	2019
1	0.06373333	0.0638	0.0638	0.0478	0.098
2	0.15500000	0.1370	0.1350	0.1100	0.117
3	0.18300000	0.1400	0.1700	0.1550	0.149
4	0.19500000	0.1750	0.1810	0.1761	0.179
5	0.20400000	0.2020	0.1980	0.1901	0.196
6	0.21100000	0.2080	0.1990	0.2097	0.205
7	0.21700000	0.2090	0.2140	0.2094	0.217
8	0.21500000	0.2100	0.2230	0.2180	0.224
9	0.22000000	0.2420	0.2360	0.2222	0.218

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  2019
 1 0.0000 0.0769 0.100 0.000 0.000 0.089
 2 0.1451 0.1425 0.144 0.137 0.126 0.129
 3 0.1877 0.1795 0.178 0.167 0.151 0.148
 4 0.2030 0.2059 0.204 0.187 0.174 0.182
 5 0.2279 0.2136 0.219 0.204 0.190 0.199
 6 0.2449 0.2307 0.229 0.213 0.208 0.210
 7 0.2608 0.2386 0.237 0.221 0.218 0.220
 8 0.2614 0.2454 0.251 0.233 0.238 0.257
 9 0.2835 0.2685 0.257 0.249 0.246 0.244
```

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	2019
1	0.00	0.00
2	0.48	0.36
3	0.91	0.95
4	0.98	1.00
5	0.98	1.00
6	1.00	1.00
7	1.00	1.00
8	1.00	1.00
9	1.00	1.00

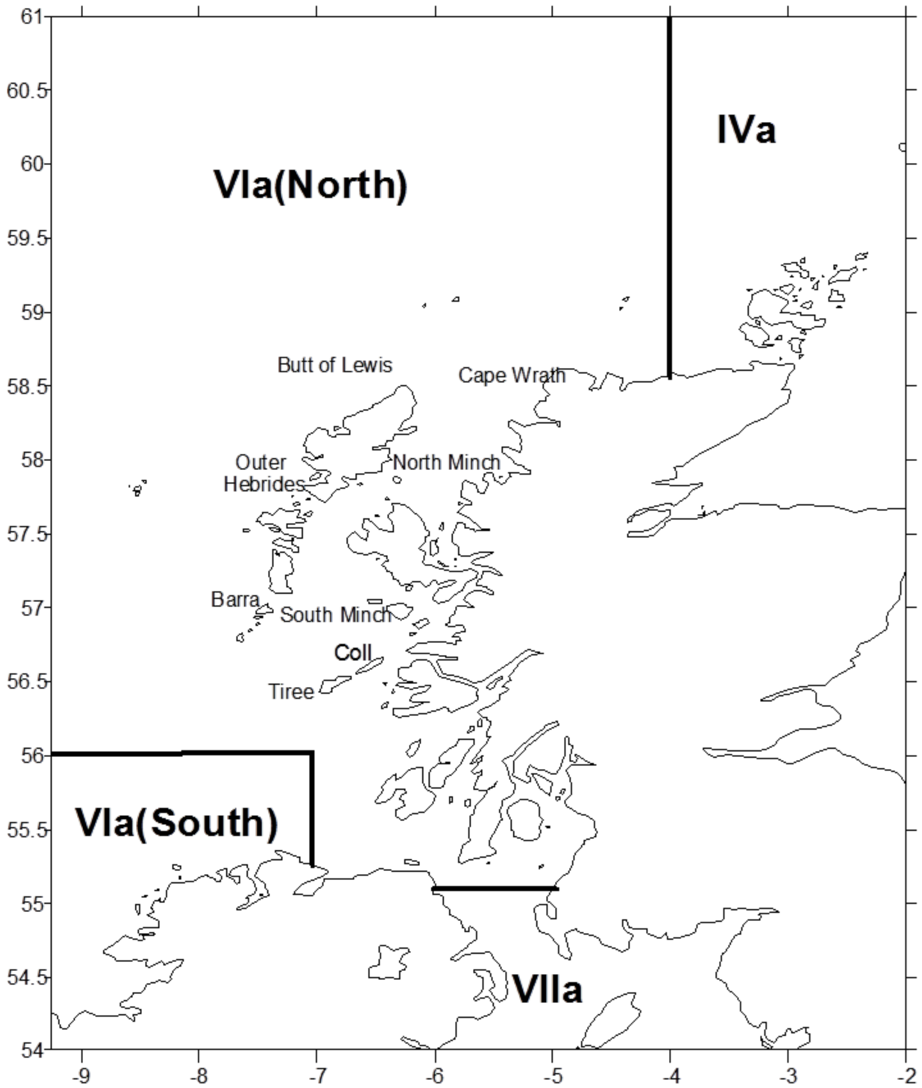


Figure 5.2.1. Location of ICES area 6.a (North) and adjacent areas with place names.

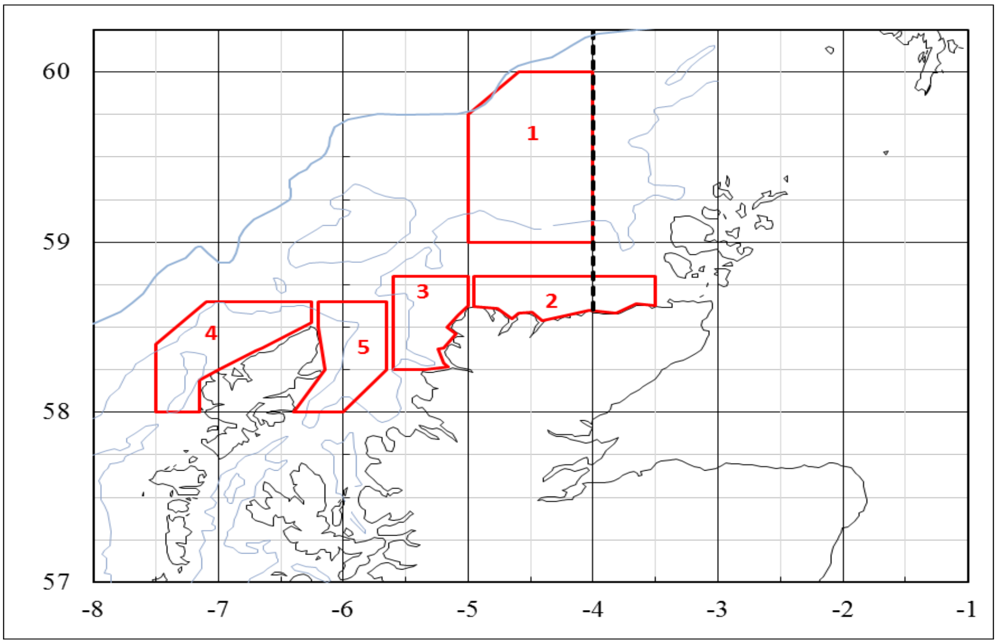


Figure 5.2.2. Planned survey areas used in the 6.a North surveys. Area 1- North prespawning mixing area Area 2 -East of cape Wrath Area 3 – The Minch Area 4 – Outer Hebrides Area 5 – east Minch.

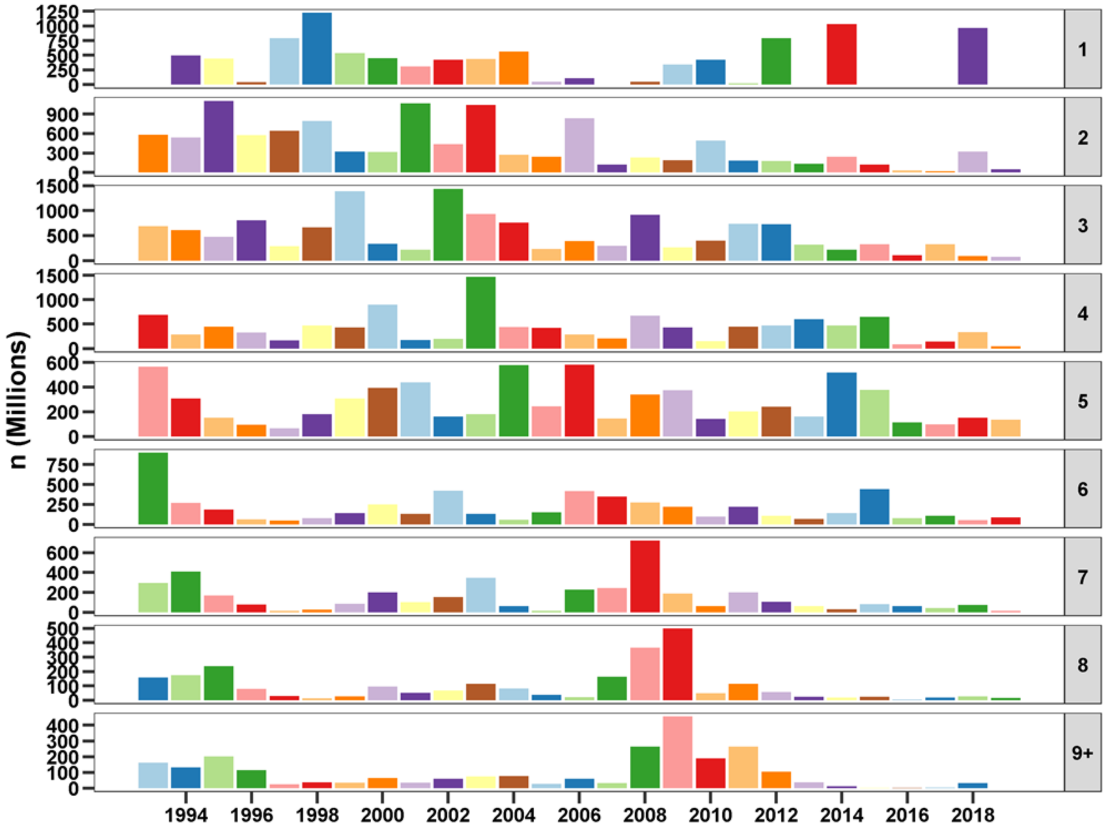


Figure 5.2.3. Herring in 6.a (North). West of Scotland (6.aN) autumn spawning herring subset from MSHAS indices (millions) by age (winter rings) and year from the acoustic surveys 1993–2019. Age 9+ includes ages 9 and older.

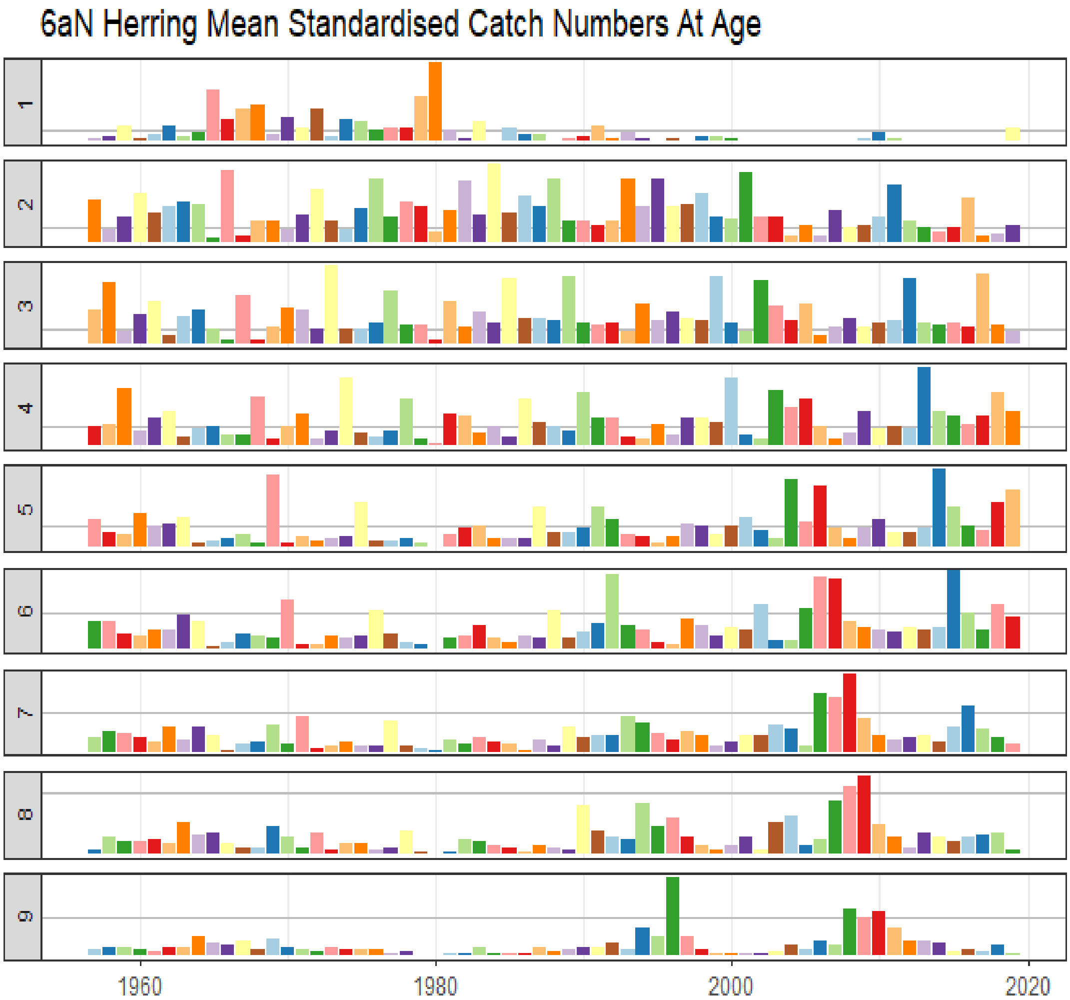


Figure 5.2.4. Herring in 6.a (North). Mean standardized catch numbers-at-age standardized by age 1957 to 2019

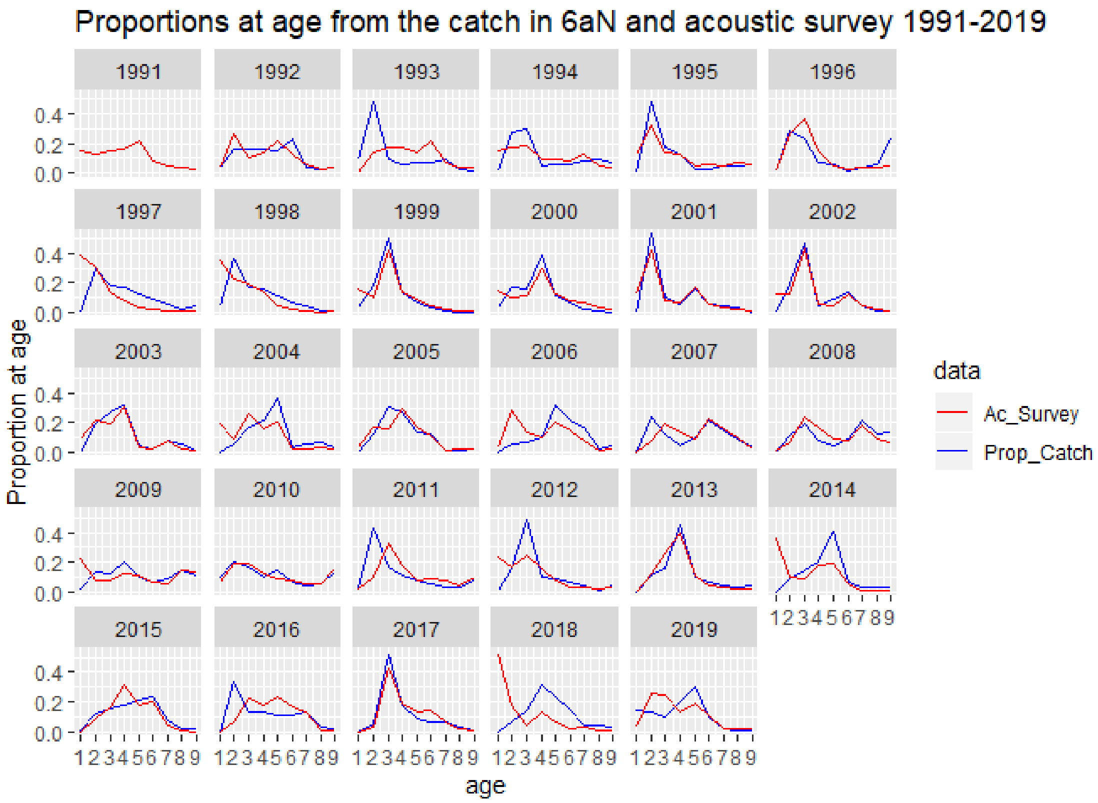


Figure 5.2.5. Herring in 6.a (North). Comparison of the proportions-at-age by year class in the acoustic survey and the catch 1991-2019

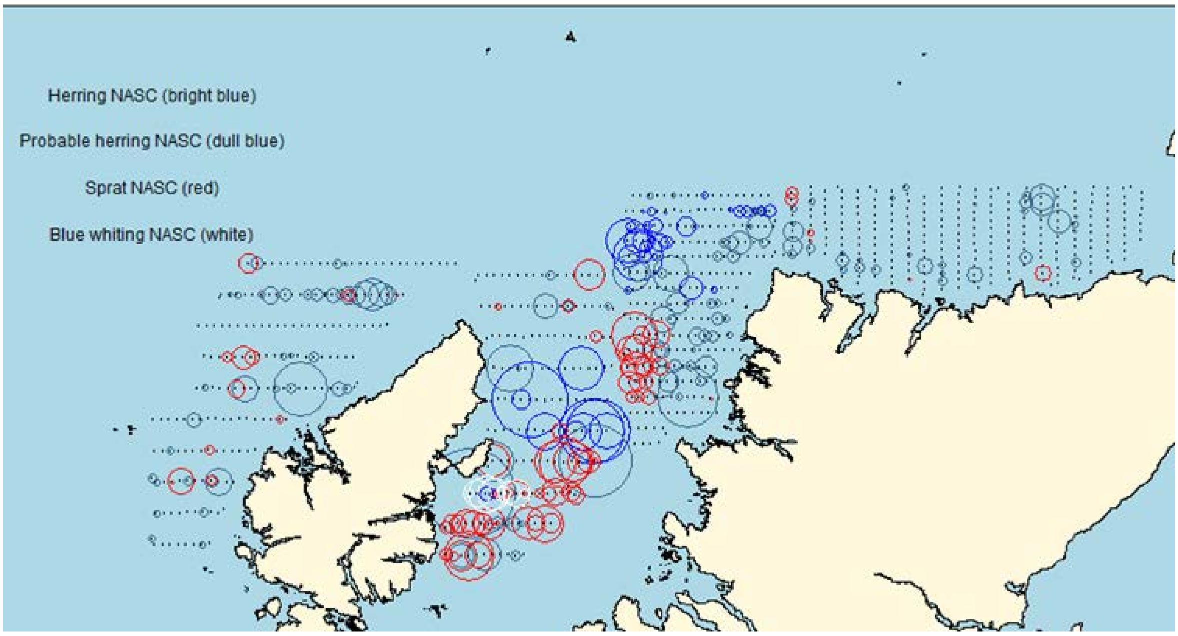
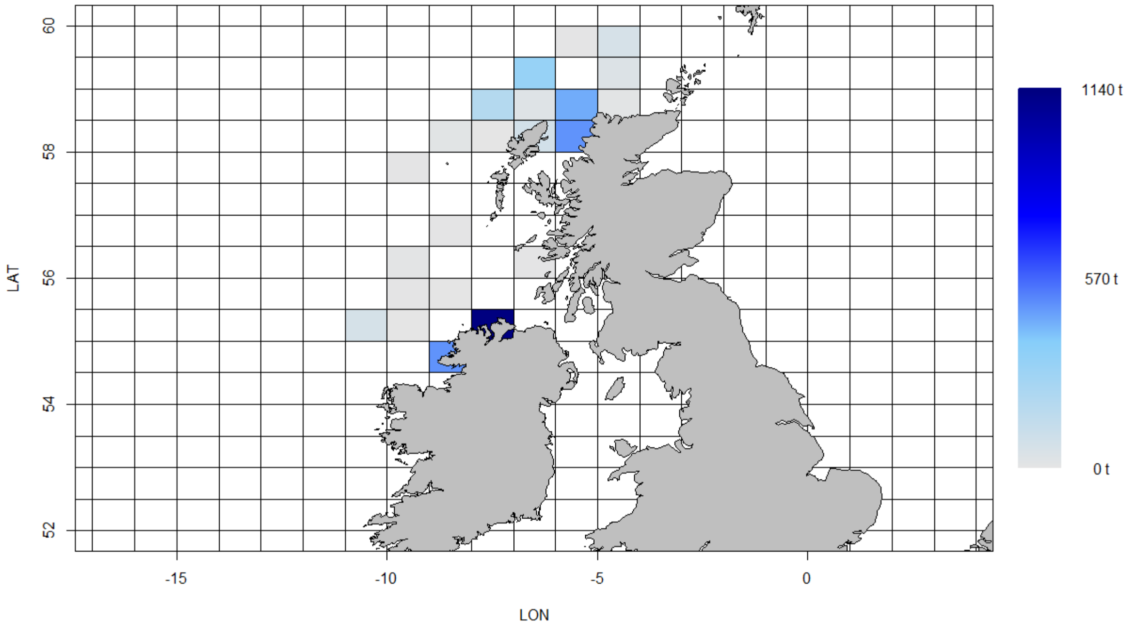


Figure 5.2.6. Relative acoustic densities (NASC m2/mn2) of all fish marks for Pathway recorded during the 2019 6.aN herring industry–science survey. (details in WGIPS 2020).



Herring in 6.a (North). Herring catches in tonnes in all quarters in 2019 by statistical rectangle. WG estimates.

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. 2019 refers to the 2019–2020 season.

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

6.1 The Fishery

6.1.1 Advice and management applicable to 2019–2020

The TAC is set by calendar year and in 2019 was 4 742 t (agreed by the Council of the European Union, based on the long-term management plan). In 2019, the EC requested ICES to advise on the minimum level of catches (tonnages) required in a sentinel TAC, which would provide sufficient data for ICES in order to continue providing scientific advice on the state of the stock (ICES, 2019). ICES advised that at least 17 samples from the main and the sentinel fleet would be required to provide advice on similar bases as with a commercial fishery. Those samples could be obtained through a monitoring catch of 869 t. As a result, the TAC agreed by the Council of the European Union was 869 t.

Long-Term Management Plan

A long-term management plan has been proposed by the Pelagic RAC in 2011. The most recent evaluation of this plan took place in 2018 (ICES, 2018).

ICES advises that the harvest control rule in the long-term management plan for Celtic Sea herring is no longer consistent with the precautionary approach. The management plan results in a greater than 5% probability of the stock falling below B_{lim} in several years throughout the 20 year simulated period. The simulations indicate the management plan cannot ensure that the stock is fished and maintained at levels which can produce maximum sustainable yield as soon as or by 2020.

6.1.2 The fishery in 2019–2020

In 2019, the Irish fishery took place in 7.g in Q3 and in 7.g and 7.a.S in Q4 as in previous years.

The Irish fishery is divided in two fleets, the main fleet and the sentinel fleet. The Celtic Sea Herring Management Advisory Committee (CSHMAC) provide inputs in the management of the Celtic Sea Herring. According to 2019 herring fishery arrangements, the main fleet was scheduled to fish from 15th September to 04th October 2019 and from 13th October 22nd November. The Sentinel fleet was scheduled to fish from the 16th November to 20th December.

The main fleet started to fish as planned on 15th September. The first catches of this fleet were reported with a majority of fish < 20cm (MCRS). As a result, the CSHMAC advised the Irish Department of Agriculture Food and the Marine (DAFM) to close the fishery which was enacted on 19th September. Over that week of fishing, 976 t of fish were landed. Two pairs of vessels were allowed to fish from 06th to 11th October and tested various fishing grounds (the smalls, off Cork harbour and off Ballycotton). Although, some hauls exhibited a higher prevalence of fish >MCRS, there was no evidence that the size composition of the Celtic Sea Herring stock was meeting the regulation criteria. The catch taken by those vessels was 314 t. Following that trial, the main fleet was not allowed to fish until the end the year 2019.

The sentinel fleet fished from 16th November to 20th December as planned in the fishery arrangements. An enhanced sampling programme was arranged by the Marine Institute. The primary fishing grounds were the estuary off Dunmore East and off Power Head. The fleet fished on aggregations of fish meeting the management criteria in regards to the size composition. The total landings of this fleet was 512 t.

The Netherlands reported a total catch of 38 t from 7.g in Q4. Germany, France and the UK did not utilize their quota. The area 7.h is part of the management area, but it is unclear if it is part of the stock area.

The spatial distribution of the 2019 landings is presented in Figure 6.1.2.1. There was not full quota uptake in 2019.

The estimated catches from 1988–2019 for the combined areas (7.aS, 7.g, 7.h, 7.j) by quota year and by assessment year (1st April–31st March) are given in tables 6.1.2.1 and 6.1.2.2 respectively. The catch taken during the 2019–2020 season decreased to 1841 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 and 2019. 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 patterns and Information from the Industry

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. 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 in 2018. In 2019, the high prevalence of fish <MCRS prevented the main fleet to fish more than 5 days and catch their quota.

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).

Information provided by the Irish industry reported that in late 2019 fish were considered to be good quality inshore but offshore they were plentiful but small. A decision was made not to open the fishery at the time. A monitoring TAC of 869 t has been agreed for 2020 and the Celtic Sea Advisory Committee is actively engaged with the Marine Institute on how to implement this in autumn 2020. Irish fishers are very concerned about the future of this fishery given the lack of marketable herring on the traditional fishing grounds. Fishers are also of the view that there is considerable mixing with Irish Sea herring which needs to be addressed from scientific viewpoint. It is known that mixing occurs but the level of mixing is unquantified

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 seven herring directed discard trips in 2019 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 2019 and no discard estimates were available for those two years.

Since 2015, this stock is covered by the landings obligation.

6.2 Biological composition of the catch

6.2.1 Catches in numbers-at-age

Catch numbers-at-age are available for the period 1958 to 2019. One winter ringers were the dominant age class in 2019, followed by 2–, 4– and 3–wr, respectively (Table 6.2.1.1.). The 1 ringers were mainly taken by the main fleet in quarter 3. The yearly mean standardized catch numbers-at-age are shown in Figure 6.2.1.1. Year classes 6, 7, 8 and 9 wr were barely observed in the catch. Truncation of ages is again evident in this stock.

The overall proportions-at-age in the catch and the survey are presented in Figure 6.2.1.2. There is generally good agreement between the data sources. The Q4 acoustic survey picks up 1-wr fish in larger proportions than the catch data in some years including 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. In 2019, a larger proportion of 4–wr was observed in the commercial fishery that might be related to the 3 wr observed in 2018. These fish were caught by the sentinel fleet in Dunmore East's estuary where a significant part of the catch was taken. An enhanced sampling programme was arranged in 2019 to monitor this fleet's catch.

Length–frequency data by division and quarter are presented in Table 6.2.1.2. The 3 length frequencies show 3 different patterns. In Q3 7.g, the catches show the largest size range with a significant amount of fish <20 cm (MCRS). The size composition of this catch led to the closure of the fishery. The trial fishery from 06th–11th October still had a proportion of the catch <20 cm meaning, the main fleet was not allowed to fish again in 2019. The sentinel fleet, which fished in 7.aS in Q4 primarily inshore (estuary at Dunmore East and off power head) and also caught a proportion of fish >MCRS.

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 2019. Under the Data Collection Framework, the sampling of this stock is well above that required by the Minimum Programme (Section 1.5). In the context of high prevalence of fish <MCRS in the catch, an enhanced port sampling programme was arranged by the MI. As a result, 35 samples were collected, 10 from the main fleet and 25 for the sentinel fleet.

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 2019, excluding 2004 (no survey) and 2017 (insufficient biological data). The full survey time-series is presented in Table 6.3.1.1. The internal consistency between ages 1–9 from the acoustic survey is good and presented in Figure 6.3.1.4.

The acoustic survey of the 2019–2020 season was carried out from 09th to 29th October 2019, on the Celtic Explorer https://oar.marine.ie/handle/10793/1494 (O'Donnell *et al*., 2019). Survey effort (acoustic sampling) for the core area consisted of 3 011 nautical miles (nm), an increase of 25% from 2018. The geographical coverage was 16 360 square nautical miles. Five adaptive surveys were carried out, accounting for 700 nm of transects covering an area of 1 508 nm^2. The acoustic survey track is shown in Figure 6.3.1.1.

The 2019 survey consisted of laddered replicate surveys (two broad-scale Pass 1 and Pass 2, and five adaptive mini-surveys) covering the same area. Pass 1 and adaptive survey "Smalls 2" were used in combination to estimate the biomass and numbers–at–age that were used as input data to tune ASAP. 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 2019 survey were 3 070 t and 129 327·10^3 individuals respectively.

A total of 21 trawl hauls were carried out during the survey in 2019, with one haul containing >50% herring by weight of catch. Of the 21 hauls, 9 contained herring of less than 50% contribution by weight. A total of 263 herring were aged from survey samples in addition to 338 length measurements and 356 length–weights recorded. Herring age samples ranged from 0–5 winter-rings.

A large proportion of 0 group herring was observed during the 2019 survey. Small herring are often found to mix with sprat. A number of tows were carried out on these echotraces to estimate the prevalence of fish from each species.

Herring were found in two areas. The first area was located inshore from Cork Harbour to Helvick, within 6 nm of the coast. The second area was located offshore and to the east of the first one, on the "Smalls grounds". Those two areas were also identified by the main fleet that operated in September and early October.

During the 2018 CSHAS, an increased number of 0 group herring were observed above baseline levels. This year class was also observed during the WESPAS survey in June 2019. Although the survey effort increased in the CSHAS 2019, this year class was not observed in the numbers expected.

The SSB estimate in 2019 is the lowest SSB point 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 making the estimation of the biomass in the survey area difficult. However, this was not the case in 2019, and was supported by observations from the commercial fleet.

In 2019 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 2019 (https://oar.marine.ie/handle/10793/1462) but is not used for stock assessment purposes. This survey is scheduled in 2020 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. However, given the current low standing stock biomass, the ability of this, or any acoustic survey to report reliable year–on–year estimates of abundance are limited.

6.4 Mean weights-at-age and maturity-at-age and Natural Mortality

The mean weights in the catch and mean weights in the stock at spawning time are presented in Figure 6.4.1.1 and Figure 6.4.1.2 respectively. There has been an overall downward trend in mean weights-at-age in the catch since the early 1980s. After a slight increase around 2008, they have declined again. In 2018 slight increases in mean weights at some ages were observed but 2019 exhibited again a decrease for most of the year classes. None of the increasing 2019 year classes exhibited a high increase in body weight. Mean weights in the stock at spawning time were calculated from biological samples from Q4 (Figure 6.4.1.2). The overall trends in stock weights are the same as the catch weights.

In the assessment, 50% of 1-wr fish are considered mature. Sampling data from the Celtic Sea catches suggest that greater than 50% of 1-wr fish are mature (Lynch, 2011). However, the 2014 benchmark (ICES, 2014) concluded that there was insufficient information to change the maturity ogive.

Following the final procedure of 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 rings and excluding the 2004 and 2017 surveys. The input data are presented in tables 6.6.1.1 and 6.6.1.2. The ASAP settings are as per the 2018 inter-benchmark (Table 6.6.1.3). The stock summary is presented in Table 6.6.1.4.

Figure 6.6.1.1 shows the catch proportions-at-age residuals. The residuals are large for the young ages, which is to be expected because these are estimated with low precision. Larger residuals can be seen in recent years. Overall there is no pattern in the residuals. Figure 6.6.1.2 shows the observed and predicted catches. The model followed closely the observed catches. The observed and predicted catch proportions-at-age are shown in Figure 6.6.1.3. There is some divergence in the most recent years, most notable at 2 and 9 wr with a larger proportion predicted than observed catches. Overall the fits are good throughout the full time-series.

The selection pattern in the fishery for the final assessment run is shown in Figure 6.6.1.4. Selection is fixed at 1 for 3-wr which is the age that Celtic Sea herring are considered to be fully selected. Selection at all other ages is estimated by the model. This gives a dome-shaped selection pattern which is considered appropriate to this fishery. The model predicts a drop in selection at-age 9-wr. This may be the case given the lesser abundance of 9-wr in the catch data.

Figure 6.6.1.5 shows the residuals of the index proportions-at-age. The largest residuals can be seen at the younger ages. The index fit shows generally good agreement with the exception of the very large survey index in 2012 (Figure 6.6.1.6). The selectivity parameters were adjusted at the inter-benchmark. Selection is now fixed for ages 3–5. This gives a more dome-shaped selection pattern with selection declining at older ages (Figure 6.6.1.7).

The analytical retrospective for SSB, Fishing pressure and recruitment is shown in Figure 6.6.1.8. The Mohn's Rho on SSB calculated by ASAP is 1.1 over a five–year peel. This is a significant increase compared to the previous update assessment (–0.17) and it is significantly higher than the 0.2 threshold. Following WKFORBIAS suggestion (ICES, 2020), the 95% confidence interval of the update assessment was added to figures. Regarding SSB (top panel of Figure 6.6.1.8), 3 out of 5 peels were out of the 95% CI bounds. This is most likely due to the current low level of the stock, the low level of the survey index (associated with high CV) and the absence of index for the year 2017. Following the decision tree provided by WKFORBIAS, advice was given because $SSB<B_{lim}$.

Figure 6.6.1.9 shows uncertainties over time in the assessment estimates. Overall, the uncertainty is higher at the start and at the end of the time-series. Recruitment exhibits the highest uncertainty from 2013 to 2019. 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 2019 and the update assessment in 2020 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 11 751 t in 2019,well below B_{lim} (34 000 t). There is a strong historical retrospective with a downward revision in SSB. HAWG 2019 estimated that SSB was below B_{lim} in 2017–2018. The update assessment indicates that the stock was below B_{lim} in 2016–2019.

The update assessment estimated mean F (2–5 ring) in 2019 to be 0.49, decreasing from 1.16 and 1.11 for 2017 and 2018 respectively. F was estimated to be above F_{pa} (0.27) and F_{MSY} (0.26) since 2014 and above F_{lim} (0.45) since 2015. There is again a strong historical retrospective with F being revised upwards.

Recruitment was good for several years with strong cohorts in 2005, 2007, 2009, 2010, 2011, and 2012 having entered the stock. However, since 2013, recruitment has been below average and no strong cohort has entered the fishery. The 2019 recruitment predicted by the model is higher than the 2018 recruitment and if confirmed in the years ahead might help to rebuild the stock.

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 2020 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 (2018). As this SSB value (6 493 t) is below the change-point (54 453 t), the following adjustment is applied.

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

$$Recruitment_{2020} = 441545.4 \times \frac{6462.79}{54452.73} = 52405$$

Interim year catch was taken to be the monitoring TAC. No carryover on the national quotas was used as it is a monitoring TAC. Non-Irish intermediate year catches were not adjusted based on recent quota uptake as done in recent years. The intermediate year catch was 869 t.

The deterministic short-term forecast was performed in FLR. The input data are presented in Table 6.7.1.1.

The results of the short-term projection are presented in Table 6.7.1.2. Fishing in accordance with the MSY approach implies a zero catch in 2021.

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 advised that the harvest control rule was no longer consistent with the precautionary approach. The management plan resulted in >5% probability of the stock falling below B_{lim} in several years throughout the 20 year simulated period. The simulations indicated the management plan could not ensure that the stock is fished and maintained at levels which can produce maximum sustainable yield as soon as or by 2020. The long-term management plan is no longer used to give advice for this stock.

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

6.9 Precautionary and yield-based reference points

Reference points were re-estimated by WKPELA 2018.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	54 000 t	B_{pa}	ICES (2018a)
	F_{MSY}	0.26	Stochastic simulations using segmented regression stock–recruitment relationship from 1970–2014	ICES (2018a)

Precautionary approach	B_{lim}	34 000 t	B_{loss} = the lowest observed SSB (1980)	ICES (2018a)
	B_{pa}	54 000 t	$B_{pa} = B_{lim} \times \exp(1.645 \times \sigma B)$, with $\sigma B = 0.29$.	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 $\sigma F = 0.30$ 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 for the three key parameters (SSB, recruitment and F). The CVs for each of the parameters are between 0.1 and 0.3 for the majority of the time-series; uncertainties have increased in the final years. Recruitment estimates in the final year show the highest uncertainty.

The SSB and F values based on the assessment and forecast in 2019 are compared with the assessment outputs in 2020 and are shown in the table below. The assessment in 2020 shows a significantly 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

2019 Assessment				2020 Assessment				% change in the estimates	
Year	**SSB**	**Catch**	**F 2-5**	**Year**	**SSB**	**Catch**	**F 2-5**	**SSB**	**F 2-5**
2017	21999	10767	0.64	2017	12034	10767	1.16	–45%	81%
2018	22977	4418	0.33	2018	6463	4418	1.11	–72%	236%
2019*	22787	5320	0.34	2019	11751	1841	0.49	–48%	44%

*** from intermediate year in STF.**

The 2019 acoustic survey estimate is by far the lowest in the time-series. The survey time-series used in the assessment includes data from 2002 to 2019 (no survey in 2004 and the 2017 survey excluded). Since 2014, herring have been observed close to the bottom in the acoustic dead–zone of the echosounder. The stock is therefore less reliably estimated by the 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 2021. Fishing is currently above F_{MSY} (0.26) and F_{lim} (0.45).

The advice provided for this stock for 2021 is based on the ICES MSY approach. The basis for the advice is the same as previous years. The Council of the European Union set the 2020 TAC based on the response to a special request where ICES advised that monitoring catches of 869 t would be required to collect sufficient information to provide advice on similar bases as with a commercial fishery. The management plan that was used to set the TAC from 2011 to 2018 was evaluated in 2018. ICES advised that the long-term management plan was no longer precautionary (ICES, 2018).

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), 1988–2019. (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	-	-	16 800	-	-	-	2400	19 200
1989	+	-	16 000	1900	-	1300	3500	22 700
1990	+	-	15 800	1000	200	700	2500	20 200
1991	+	100	19 400	1600	-	600	1900	23 600
1992	500	-	18 000	100	+	2300	2100	23 000
1993	-	-	19 000	1300	+	-1100	1900	21 100
1994	+	200	17 400	1300	+	-1500	1700	19 100
1995	200	200	18 000	100	+	-200	700	19 000
1996	1000	0	18 600	1000	-	-1800	3000	21 800
1997	1300	0	18 000	1400	-	-2600	700	18 800
1998	+	-	19 300	1200	-	-200	-	20 300
1999		200	17 900	1300	+	-1300	-	18 100
2000	573	228	18 038	44	1	-617	-	18 267
2001	1359	219	17 729	-	-	-1578	-	17 729
2002	734	-	10 550	257	-	-991	-	10 550
2003	800	-	10 875	692	14	-1506	-	10 875
2004	801	41	11 024	-	-	-801	-	11 065
2005	821	150	8452	799	-	-1770	-	8452
2006	-	-	8530	518	5	-523	-	8530
2007	581	248	8268	463	63	-1355	-	8268
2008	503	191	6853	291	-	-985	-	6853
2009	364	135	5760	-	-	-499	-	5760
2010	636	278	8406	325	-	-1239	na	8406
2011	241	-	11 503	7	-	-248	na	11 503
2012	3	230	16 132	3135	-	2104	161*	21 765
2013	-	450	14 785	832	-	-	118	16 185
2014	244	578	17 287	821	-		644	19 574
2015	-	477	15 798	1304	+	-	247	17 825
2016	-	419	15 107	1025	559	-451	182	16 847
2017	-	298	10 184	648	64		130	11 324
2018			4398	436		-245		4589
2019	-	-	1803	38	-	-	-	1841

* 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) 1988/1989–2019/2020. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	France	Germany	Ireland	Netherlands	UK	Unallocated	Discards	Total
1988/1989	-	-	17 000	-	-	-	3400	20 400
1989/1990	+	-	15 000	1900	-	2600	3600	23 100
1990/1991	+	-	15 000	1000	200	700	1700	18 600
1991/1992	500	100	21 400	1600	-	-100	2100	25 600
1992/1993	-	-	18 000	1300	-	-100	2000	21 200
1993/1994	-	-	16 600	1300	+	-1100	1800	18 600
1994/1995	+	200	17 400	1300	+	-1500	1900	19 300
1995/1996	200	200	20 000	100	+	-200	3000	23 300
1996/1997	1000	-	17 900	1000	-	-1800	750	18 800
1997/1998	1300	-	19 900	1400	-	-2100	-	20 500
1998/1999	+	-	17 700	1200	-	-700	-	18 200
1999/2000		200	18 300	1300	+	-1300	-	18 500
2000/2001	573	228	16 962	44	1	-617	-	17 191
2001/2002	-	-	15 236	-	-	-	-	15 236
2002/2003	734	-	7465	257	-	-991	-	7465
2003/2004	800	-	11 536	610	14	-1424	-	11 536
2004/2005	801	41	12 702	-	-	-801	-	12 743
2005/2006	821	150	9494	799	-	-1770	-	9494
2006/2007	-	-	6944	518	5	-523	-	6944
2007/2008	379	248	7636	327	-	-954	-	7636
2008/2009	503	191	5872	150	-	-844	-	5872
2009/2010	364	135	5745	-	-	-499	-	5745
2010/2011	636	278	8370	325	-	-1239	na	8370
2011/2012	241	-	11 470	7	-	-248	na	11 470
2012/2013	3	230	16 132	3135	-	2104	161*	21 765
2013/2014	-	450	14 785	832	-	-	118	16 185
2014/2015	244	578	17 287	821	-	-	644	19 574
2015/2016	-	477	16 320	1304	+	-	254	18 355
2016/2017	-	419	14 585	1025	559	-451	182	16 319
2017/2018	-	298	9627	648	64	-	130	10 767
2018/2019	-	-	4227	436	-	-245	-	4418

2019/2020	-	-	1803	38	-	-	-	1841

*** 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 1970–2019/2020. Age is in winter rings.

Year	1	2	3	4	5	6	7	8	9
1970	1%	24%	33%	17%	12%	5%	4%	1%	2%
1971	8%	15%	24%	27%	12%	7%	3%	3%	1%
1972	4%	67%	9%	8%	7%	2%	1%	1%	0%
1973	16%	26%	38%	5%	7%	4%	2%	2%	1%
1974	5%	43%	17%	22%	4%	4%	3%	1%	1%
1975	18%	22%	25%	11%	13%	5%	2%	2%	2%
1976	26%	22%	14%	14%	6%	9%	4%	2%	3%
1977	20%	31%	22%	13%	4%	5%	3%	1%	1%
1978	7%	35%	31%	14%	4%	4%	1%	2%	1%
1979	21%	26%	23%	16%	5%	2%	2%	1%	1%
1980	11%	47%	18%	10%	4%	3%	2%	2%	1%
1981	40%	22%	22%	6%	5%	4%	1%	0%	1%
1982	20%	55%	11%	6%	2%	2%	2%	0%	1%
1983	9%	68%	18%	2%	1%	0%	0%	1%	0%
1984	11%	53%	24%	9%	1%	1%	0%	0%	0%
1985	14%	44%	28%	12%	2%	0%	0%	0%	0%
1986	3%	39%	29%	22%	6%	1%	0%	0%	0%
1987	4%	42%	27%	15%	9%	2%	1%	0%	0%
1988	2%	61%	23%	7%	4%	2%	1%	0%	0%
1989	5%	27%	44%	13%	5%	2%	2%	0%	0%
1990	2%	35%	21%	30%	7%	3%	1%	1%	0%
1991	1%	40%	24%	11%	18%	3%	2%	1%	0%
1992	8%	19%	25%	20%	7%	13%	2%	5%	0%
1993	1%	72%	7%	8%	3%	2%	5%	1%	0%

Year	1	2	3	4	5	6	7	8	9
1994	10%	29%	50%	3%	2%	4%	1%	1%	0%
1995	6%	49%	14%	23%	2%	2%	2%	1%	1%
1996	3%	46%	29%	6%	12%	2%	1%	1%	1%
1997	3%	26%	37%	22%	6%	4%	1%	1%	0%
1998	5%	34%	22%	23%	11%	3%	2%	0%	0%
1999	11%	27%	28%	11%	12%	7%	1%	2%	0%
2000	7%	58%	14%	9%	4%	5%	2%	0%	0%
2001	12%	49%	28%	5%	3%	1%	1%	0%	0%
2002	6%	46%	32%	9%	2%	2%	1%	0%	0%
2003	3%	41%	27%	16%	6%	4%	3%	0%	1%
2004	5%	10%	50%	24%	9%	2%	1%	0%	0%
2005	12%	38%	30%	10%	4%	3%	2%	1%	1%
2006	3%	58%	19%	4%	11%	4%	1%	0%	0%
2007	12%	17%	56%	9%	2%	3%	1%	0%	0%
2008	3%	31%	20%	38%	6%	1%	1%	0%	0%
2009	24%	11%	30%	12%	20%	2%	1%	1%	0%
2010	4%	33%	13%	25%	8%	16%	1%	0%	1%
2011	7%	19%	38%	8%	15%	6%	6%	1%	0%
2012	6%	34%	24%	20%	3%	6%	3%	2%	0%
2013	5%	24%	33%	18%	13%	3%	4%	1%	0%
2014	11%	16%	25%	22%	15%	7%	2%	2%	1%
2015	0%	9%	18%	24%	21%	15%	7%	3%	2%
2016	2%	8%	20%	18%	20%	18%	8%	4%	1%
2017	1%	15%	34%	17%	12%	10%	7%	3%	2%
2018	4%	19%	51%	15%	6%	3%	1%	1%	0%
2019	60%	18%	8%	10%	3%	1%	0%	0%	0%

Table 6.2.1.2. Herring in the Celtic Sea. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2019/2020 season.

Length cm	7G Q3	7G Q4	7aS Q4
6.5	15		
13.5	15		
16	45		
16.5	76		3
17	121		10
17.5	423	10	35
18	1 149	30	84
18.5	1 663	18	125
19	2 541	25	200
19.5	2 571	35	168
20	2 465	45	246
20.5	1 558	75	183
21	741	70	320
21.5	423	80	281
22	242	178	448
22.5	151	178	419
23	151	258	488
23.5	60	223	383
24	106	334	434
24.5	136	386	435
25	91	366	504
25.5	45	308	385
26		203	211
26.5	15	53	88
27	30	23	56
27.5	15	5	30

28	5	25
28.5	5	8

Table 6.2.2.1. Herring in the Celtic Sea. Sampling intensity of commercial catches (2019–2020). Only Ireland provides samples of this stock.

Division	Year	Quarter	Catch (t)	No. Samples	No. Measured	No. aged	Aged/1000 t
7.g	2019	3	976	4	982	150	154
7.g	2019	4	314	6	1162	300	955
7.aS	2019	4	512	25	4452	830	1621
Total	2019		1803	35	6596	1280	710

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	2019 2020
0	0	0	0	0	109	98
1	41	0	125	0	55	22
2	117	40	21	6	16	8
3	112	48	43	3	27	0.5
4	69	41	40	7	6	0.3
5	20	38	36	5	0	0.1
6	24	7	25	4	0	0
7	7	6	5	1	-	0
8	17	5	6	1	-	0
9	1	0	0	0		0
Nos.	408	184	301	27	213	129
SSB	48	25	30	4	8	362.6
CV	0.59	0.18	0.33	-	49.6	55

Table 6.6.1.1. Herring in the Celtic Sea: Natural mortality inputs to the ASAP model. Age is in winter rings.

Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Maturity inputs to the ASAP model. Age is in winter rings.

Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
0.5	1	1	1	1	1	1	1	1

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Weight-at-age in the catch inputs to the ASAP model. Age is in winter rings.

	1	2	3	4	5	6	7	8	9
1958	0.096	0.115	0.162	0.185	0.205	0.217	0.227	0.232	0.23
1959	0.087	0.119	0.166	0.185	0.2	0.21	0.217	0.23	0.231
1960	0.093	0.122	0.156	0.191	0.205	0.207	0.22	0.225	0.239
1961	0.098	0.127	0.156	0.185	0.207	0.212	0.22	0.235	0.235
1962	0.109	0.146	0.17	0.187	0.21	0.227	0.232	0.237	0.24
1963	0.103	0.139	0.194	0.205	0.217	0.23	0.237	0.245	0.251
1964	0.105	0.139	0.182	0.215	0.225	0.23	0.237	0.245	0.253
1965	0.103	0.143	0.18	0.212	0.232	0.243	0.243	0.256	0.26
1966	0.122	0.154	0.191	0.212	0.237	0.248	0.24	0.253	0.257
1967	0.119	0.158	0.185	0.217	0.243	0.251	0.256	0.259	0.264
1968	0.119	0.166	0.196	0.215	0.235	0.248	0.256	0.262	0.266
1969	0.122	0.164	0.2	0.217	0.237	0.245	0.264	0.264	0.262
1970	0.128	0.162	0.2	0.225	0.24	0.253	0.264	0.276	0.272
1971	0.117	0.166	0.2	0.225	0.245	0.253	0.262	0.267	0.283
1972	0.132	0.17	0.194	0.22	0.245	0.259	0.264	0.27	0.285
1973	0.125	0.174	0.205	0.215	0.245	0.262	0.262	0.285	0.285
1974	0.141	0.18	0.21	0.225	0.237	0.259	0.262	0.288	0.27
1975	0.137	0.187	0.215	0.24	0.251	0.26	0.27	0.279	0.284
1976	0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293
1977	0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298
1978	0.127	0.189	0.217	0.24	0.279	0.276	0.291	0.297	0.302
1979	0.127	0.174	0.212	0.23	0.253	0.273	0.291	0.279	0.284
1980	0.117	0.174	0.207	0.237	0.259	0.276	0.27	0.27	0.275
1981	0.115	0.172	0.21	0.245	0.267	0.276	0.297	0.309	0.315
1982	0.115	0.154	0.194	0.237	0.262	0.273	0.279	0.288	0.293
1983	0.109	0.148	0.198	0.22	0.276	0.282	0.276	0.319	0.325

	1	2	3	4	5	6	7	8	9
1984	0.093	0.142	0.185	0.213	0.213	0.245	0.246	0.263	0.262
1985	0.104	0.14	0.17	0.201	0.234	0.248	0.256	0.26	0.263
1986	0.112	0.155	0.172	0.187	0.215	0.248	0.276	0.284	0.332
1987	0.096	0.138	0.186	0.192	0.204	0.231	0.255	0.267	0.284
1988	0.097	0.132	0.168	0.203	0.209	0.215	0.237	0.257	0.283
1989	0.106	0.129	0.151	0.169	0.194	0.199	0.21	0.221	0.24
1990	0.099	0.137	0.153	0.167	0.188	0.208	0.209	0.229	0.251
1991	0.092	0.128	0.168	0.182	0.19	0.206	0.229	0.236	0.251
1992	0.096	0.123	0.15	0.177	0.191	0.194	0.212	0.228	0.248
1993	0.092	0.129	0.155	0.18	0.201	0.204	0.21	0.225	0.24
1994	0.097	0.135	0.168	0.179	0.19	0.21	0.218	0.217	0.227
1995	0.088	0.126	0.151	0.178	0.188	0.198	0.207	0.227	0.227
1996	0.088	0.118	0.147	0.159	0.185	0.196	0.207	0.219	0.231
1997	0.093	0.124	0.141	0.157	0.172	0.192	0.206	0.216	0.22
1998	0.099	0.121	0.153	0.163	0.173	0.185	0.199	0.204	0.225
1999	0.09	0.12	0.149	0.167	0.18	0.183	0.202	0.209	0.208
2000	0.092	0.111	0.148	0.168	0.185	0.187	0.197	0.21	0.224
2001	0.082	0.107	0.139	0.162	0.177	0.19	0.185	0.204	0.229
2002	0.096	0.115	0.139	0.156	0.185	0.196	0.203	0.211	0.226
2003	0.089	0.102	0.128	0.146	0.165	0.184	0.195	0.202	0.214
2004	0.08	0.13	0.134	0.151	0.159	0.174	0.203	0.215	0.225
2005	0.077	0.102	0.142	0.147	0.158	0.168	0.181	0.208	0.252
2006	0.093	0.105	0.127	0.151	0.155	0.165	0.174	0.186	0.198
2007	0.074	0.106	0.123	0.141	0.166	0.162	0.17	0.171	0.229
2008	0.091	0.12	0.144	0.156	0.172	0.191	0.194	0.199	0.224
2009	0.078	0.122	0.146	0.16	0.169	0.185	0.187	0.197	0.211
2010	0.076	0.111	0.131	0.145	0.158	0.159	0.163	0.178	0.19
2011	0.07	0.104	0.127	0.141	0.154	0.161	0.167	0.18	0.179

	1	2	3	4	5	6	7	8	9
2012	0.072	0.094	0.124	0.138	0.152	0.157	0.164	0.164	0.171
2013	0.062	0.101	0.122	0.142	0.153	0.164	0.17	0.166	0.18
2014	0.067	0.1	0.127	0.14	0.153	0.161	0.163	0.179	0.176
2015	0.071	0.102	0.122	0.137	0.143	0.151	0.158	0.167	0.182
2016	0.061	0.095	0.119	0.131	0.140	0.144	0.151	0.157	0.162
2017	0.06	0.080	0.090	0.123	0.143	0.160	0.163	0.171	0.178
2018	0.067	0.092	0.11	0.124	0.136	0.146	0.162	0.143	0.15
2019	0.06	0.085	0.109	0.123	0.131	0.155	0.153	0.156	0.163

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Weight-at-age in the stock inputs to the ASAP model. Age is in winter rings.

	1	2	3	4	5	6	7	8	9
1958	0.096	0.115	0.162	0.185	0.205	0.217	0.227	0.232	0.23
1959	0.087	0.119	0.166	0.185	0.2	0.21	0.217	0.23	0.231
1960	0.093	0.122	0.156	0.191	0.205	0.207	0.22	0.225	0.239
1961	0.098	0.127	0.156	0.185	0.207	0.212	0.22	0.235	0.235
1962	0.109	0.146	0.17	0.187	0.21	0.227	0.232	0.237	0.24
1963	0.103	0.139	0.194	0.205	0.217	0.23	0.237	0.245	0.251
1964	0.105	0.139	0.182	0.215	0.225	0.23	0.237	0.245	0.253
1965	0.103	0.143	0.18	0.212	0.232	0.243	0.243	0.256	0.26
1966	0.122	0.154	0.191	0.212	0.237	0.248	0.24	0.253	0.257
1967	0.119	0.158	0.185	0.217	0.243	0.251	0.256	0.259	0.264
1968	0.119	0.166	0.196	0.215	0.235	0.248	0.256	0.262	0.266
1969	0.122	0.164	0.2	0.217	0.237	0.245	0.264	0.264	0.262
1970	0.128	0.162	0.2	0.225	0.24	0.253	0.264	0.276	0.272
1971	0.117	0.166	0.2	0.225	0.245	0.253	0.262	0.267	0.283
1972	0.132	0.17	0.194	0.22	0.245	0.259	0.264	0.27	0.285
1973	0.125	0.174	0.205	0.215	0.245	0.262	0.262	0.285	0.285
1974	0.141	0.18	0.21	0.225	0.237	0.259	0.262	0.288	0.27

	1	2	3	4	5	6	7	8	9
1975	0.137	0.187	0.215	0.24	0.251	0.26	0.27	0.279	0.284
1976	0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293
1977	0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298
1978	0.127	0.189	0.217	0.24	0.279	0.276	0.291	0.297	0.302
1979	0.127	0.174	0.212	0.23	0.253	0.273	0.291	0.279	0.284
1980	0.117	0.174	0.207	0.237	0.259	0.276	0.27	0.27	0.275
1981	0.115	0.172	0.21	0.245	0.267	0.276	0.297	0.309	0.315
1982	0.115	0.154	0.194	0.237	0.262	0.273	0.279	0.288	0.293
1983	0.109	0.148	0.198	0.22	0.276	0.282	0.276	0.319	0.325
1984	0.093	0.142	0.185	0.213	0.213	0.245	0.246	0.263	0.262
1985	0.104	0.14	0.17	0.201	0.234	0.248	0.256	0.26	0.263
1986	0.112	0.155	0.172	0.187	0.215	0.248	0.276	0.284	0.332
1987	0.096	0.138	0.186	0.192	0.204	0.231	0.255	0.267	0.284
1988	0.097	0.132	0.168	0.203	0.209	0.215	0.237	0.257	0.283
1989	0.106	0.129	0.151	0.169	0.194	0.199	0.21	0.221	0.24
1990	0.099	0.137	0.153	0.167	0.188	0.208	0.209	0.229	0.251
1991	0.092	0.128	0.168	0.182	0.19	0.206	0.229	0.236	0.251
1992	0.096	0.123	0.15	0.177	0.191	0.194	0.212	0.228	0.248
1993	0.092	0.129	0.155	0.18	0.201	0.204	0.21	0.225	0.24
1994	0.097	0.135	0.168	0.179	0.19	0.21	0.218	0.217	0.227
1995	0.088	0.126	0.151	0.178	0.188	0.198	0.207	0.227	0.227
1996	0.088	0.118	0.147	0.159	0.185	0.196	0.207	0.219	0.231
1997	0.093	0.124	0.141	0.157	0.172	0.192	0.206	0.216	0.22
1998	0.099	0.121	0.153	0.163	0.173	0.185	0.199	0.204	0.225
1999	0.09	0.12	0.149	0.167	0.18	0.183	0.202	0.209	0.208
2000	0.092	0.111	0.148	0.168	0.185	0.187	0.197	0.21	0.224
2001	0.082	0.107	0.139	0.162	0.177	0.19	0.185	0.204	0.229
2002	0.096	0.115	0.139	0.156	0.184	0.196	0.203	0.211	0.223

	1	2	3	4	5	6	7	8	9
2003	0.078	0.1	0.13	0.141	0.156	0.158	0.168	0.2	0.213
2004	0.077	0.127	0.133	0.151	0.156	0.168	0.216	0.228	0.257
2005	0.074	0.103	0.145	0.143	0.155	0.161	0.175	0.221	0.233
2006	0.085	0.104	0.123	0.153	0.15	0.157	0.164	0.177	0.188
2007	0.068	0.101	0.122	0.138	0.156	0.159	0.163	0.167	0.251
2008	0.083	0.117	0.14	0.156	0.17	0.18	0.177	0.189	0.232
2009	0.076	0.117	0.142	0.158	0.168	0.176	0.17	0.186	0.226
2010	0.076	0.106	0.127	0.139	0.152	0.157	0.164	0.188	0.18
2011	0.067	0.108	0.127	0.138	0.148	0.16	0.17	0.194	0.197
2012	0.061	0.094	0.125	0.138	0.149	0.159	0.161	0.165	0.167
2013	0.06	0.101	0.126	0.144	0.153	0.159	0.168	0.17	0.186
2014	0.065	0.1	0.128	0.142	0.153	0.158	0.163	0.177	0.169
2015	0.065	0.098	0.119	0.133	0.14	0.146	0.153	0.16	0.162
2016	0.059	0.096	0.117	0.131	0.139	0.143	0.150	0.160	0.165
2017	0.055	0.079	0.088	0.116	0.139	0.158	0.164	0.170	0.177
2018	0.065	0.095	0.121	0.142	0.154	0.166	0.171	0.166	0.170
2019	0.055	0.087	0.106	0.122	0.127	0.141	0.15	0.161	0.16

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

Year	1	2	3	4	5	6	7	8	9	Total catch
1984	19517	92892	41121	16043	2450	1085	376	231	180	26779
1985	17916	57054	36258	16032	2306	228	85	173	132	20426
1986	4159	56747	42881	32930	8790	1127	98	29	12	25024
1987	5976	67000	43075	23014	14323	2716	1175	296	464	26200
1988	2307	82027	30962	9398	5963	3047	869	297	86	20447
1989	8260	42413	68399	19601	8205	3837	2589	767	682	23254
1990	2702	41756	24634	35258	8116	3808	1671	695	462	18404
1991	1912	63854	38342	16916	28405	4869	2588	954	593	25562
1992	10410	26752	35019	27591	10139	18061	3021	6285	689	21127
1993	1608	94061	9372	10221	4491	2790	5932	855	508	18618
1994	12130	35768	61737	3289	3025	4773	1713	1705	474	19300
1995	9450	79159	22591	36541	3686	3420	2651	1859	842	23305
1996	3476	61923	38244	7943	16114	2077	1586	1507	1025	18816
1997	3849	37440	53040	31442	8318	6142	1148	827	603	20496
1998	5818	41510	27102	28274	13178	3746	2675	597	387	18041
1999	14274	34072	36086	14642	15515	8877	1865	2012	551	18485
2000	9953	77378	18952	12060	5230	6227	2320	662	578	17191
2001	15724	62153	35816	5953	4249	1774	1145	466	386	15269
2002	3495	26472	18532	5309	1416	1269	437	154	201	7465
2003	2711	37006	24444	14763	5719	3363	2335	388	542	11536
2004	4276	9470	46243	21863	8638	1412	473	191	75	12743
2005	15419	30710	5766	18666	7349	1923	435	77	60	9494
2006	1460	33894	10914	2469	6261	2331	561	57	48	6944
2007	8043	11028	36223	5509	1365	2040	410	56	4	7636
2008	1288	12468	8144	15565	2328	518	321	58	11	5872
2009	10171	4465	12859	4887	8458	971	279	247	80	5745
2010	2468	20929	8183	15917	4846	10080	919	273	321	8370
2011	6384	17151	33453	7301	13087	5347	5165	1089	141	11470

Year	1	2	3	4	5	6	7	8	9	Total catch
2012	11712	62528	44819	37500	6303	11811	5549	3540	347	21820
2013	6191	30471	42133	22649	16687	3305	5463	1778	535	16247
2014	16664	24120	39102	33320	22450	11165	3047	2774	1022	19574
2015	286	12247	23835	32140	27382	19861	9820	4207	3279	18355
2016	2023	9822	25030	22800	25310	22447	10484	4684	1464	16318
2017	707	14144	31912	16004	10718	8963	6722	2401	1473	10767
2018	1654	7646	20545	5974	2296	1011	264	380	188	4418
2019	14146	4371	1857	2265	612	212	88	73	33	1841

Table 6.6.1.1. Continued. Herring in the Celtic Sea: Index selectivity inputs (2–7) to the ASAP model. Age is in winter rings.

Age (wr)	Index-1	Selectivity
2	0.8	4
3	1	-1
4	1	-1
5	1	-1
6	1	4
7	1	4

Table 6.6.1.2. Herring in the Celtic Sea. Survey data input to ASAP. Age is in winter rings.

year	value	CV	2	3	4	5	6	7	Sample Size
2002	381900	0.5	185200	150600	29700	6600	7100	2700	15
2003	146400	0.5	61700	60400	17200	5400	1400	300	15
2004	-1	-1	-1	-1	-1	-1	-1	-1	0
2005	246700	0.5	137100	28200	54200	21600	4900	700	18
2006	284999	0.5	211000	48000	14000	11000	1000	-1	17
2007	346120	0.5	69800	220000	30600	8970	13100	3650	21
2008	606000	0.5	295000	111000	162000	27000	6000	5000	21
2009	519370	0.5	112040	209850	57490	124630	11710	3650	23
2010	1060760	0.5	548940	155860	193030	65240	91040	6650	18
2011	953000	0.5	479000	299000	47000	71000	24000	33000	16
2012	1995300	0.5	856000	615000	330000	48500	121000	24800	13

2013	584900	0.5	291400	197400	43700	37900	9800	4700	9
2014	349000	0.5	117300	112100	69400	19800	23600	6800	5
2015	179400	0.5	40100	48100	41200	37700	6800	5500	6
2016	169376	0.5	20629	42736	39835	36124	24590	5462	10
2017	-1	-1	-1	-1	-1	-1	-1	-1	0
2018	49130	0.5	16104	26831	5984	110	101	0	9
2019	8873	0.5	98229	7934	524	284	131	0	3

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	2002–2019 (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, 2018 and 2019
Lambda for F-Mult in 1st year	0 (freely estimated)
CV for F mult in the first year	0.5
Lambda for F-Mult deviations	0 (freely estimated)
CV for f mult deviations by fleet	0.5
Lambda for N in 1st year deviations	0 (freely estimated)
CV for N in the 1st year deviations	1
Lambda for recruitment deviations	1
Lambda for catchability in 1st year index	0
CV for catchability in 1st year by index	1
Lambda for catchability deviations	0
CV for catchability deviations	1
Lambda for deviation from initial 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	212881	288401	0.127	416389
1959	15086	203797	331840	0.11	1594650
1960	18283	194358	262201	0.123	368441
1961	15372	164157	226821	0.118	399134

Year	Catch	SSB	TSB	Fbar 2-5	Recruitment
1962	21552	160451	258184	0.19	853511
1963	17349	148618	211785	0.151	407405
1964	10599	168268	292743	0.095	1392530
1965	19126	172804	243341	0.138	419978
1966	27030	167733	269110	0.197	739764
1967	27658	161269	263025	0.223	772745
1968	30236	164268	277325	0.241	903981
1969	44389	143568	231462	0.36	464186
1970	31727	108429	167458	0.329	250351
1971	31396	99043	194233	0.451	823299
1972	38203	86732	149747	0.557	280943
1973	26936	65242	119014	0.516	326911
1974	19940	50604	86801	0.492	161218
1975	15588	40093	74381	0.514	203101
1976	9771	37219	69100	0.385	227445
1977	7833	37807	64937	0.288	185840
1978	7559	36540	59521	0.266	146362
1979	10321	36355	71083	0.423	279745
1980	13130	33306	60395	0.541	167492
1981	17103	36829	87249	0.832	467127
1982	13000	57842	127196	0.454	728109
1983	24981	76920	159816	0.552	788475
1984	26779	79578	149508	0.468	669958
1985	20426	85739	154963	0.317	646179
1986	25024	93825	171769	0.363	658128
1987	26200	106334	212706	0.386	1207080
1988	20447	109884	171881	0.23	478279
1989	23254	96523	165556	0.284	579069

Year	Catch	SSB	TSB	Fbar 2-5	Recruitment
1990	18404	90006	148262	0.246	506130
1991	25562	71730	112583	0.379	208702
1992	21127	71592	153847	0.482	967209
1993	18618	74274	120320	0.323	361611
1994	19300	81042	152741	0.32	772174
1995	23305	82505	150819	0.385	725049
1996	18816	72951	117277	0.307	353773
1997	20496	60327	105456	0.406	374420
1998	18041	48357	83668	0.444	249788
1999	18485	42320	88372	0.622	488919
2000	17191	42348	87825	0.63	478526
2001	15269	41902	83659	0.531	493225
2002	7465	53935	99872	0.209	539997
2003	11536	42922	65223	0.306	142293
2004	12743	39128	70945	0.392	360298
2005	9494	54395	116761	0.308	1054640
2006	6944	66923	102403	0.133	354347
2007	7636	69590	116543	0.132	720272
2008	5872	82391	116310	0.08	292507
2009	5745	93745	160167	0.077	1006110
2010	8370	101575	159799	0.101	746881
2011	11470	109720	175603	0.13	952159
2012	21820	99597	154951	0.253	628844
2013	16247	87806	127867	0.214	365501
2014	19574	67969	104862	0.322	303675
2015	18355	43886	70248	0.46	172583
2016	16318	26045	49388	0.765	209482
2017	10767	12034	24404	1.156	61806

Year	Catch	SSB	TSB	Fbar 2-5	Recruitment
2018	4418	6463	13587	1.107	56038.5
2019	1841	11751	29809	0.492	451705

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

2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	52405	0.77	0.5	0.5	0.5	0.058	0.06	0.062
2	202760	0.38	1	0.5	0.5	0.087	0.72	0.086
3	11158	0.36	1	0.5	0.5	0.105	0.98	0.103
4	3136	0.34	1	0.5	0.5	0.127	0.98	0.123
5	2284	0.32	1	0.5	0.5	0.14	0.98	0.137
6	549	0.31	1	0.5	0.5	0.155	0.98	0.154
7	398	0.31	1	0.5	0.5	0.162	0.92	0.159
8	250	0.31	1	0.5	0.5	0.166	0.92	0.157
9	3993	0.31	1	0.5	0.5	0.169	0.26	0.164

2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	52405	0.77	0.5	0.5	0.5	0.058	0.06	0.062
2	-	0.38	1	0.5	0.5	0.087	0.72	0.086
3	-	0.36	1	0.5	0.5	0.105	0.98	0.103
4	-	0.34	1	0.5	0.5	0.127	0.98	0.123
5	-	0.32	1	0.5	0.5	0.14	0.98	0.137
6	-	0.31	1	0.5	0.5	0.155	0.98	0.154
7	-	0.31	1	0.5	0.5	0.162	0.92	0.159
8	-	0.31	1	0.5	0.5	0.166	0.92	0.157
9	-	0.31	1	0.5	0.5	0.169	0.26	0.164

2022								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	52405	0.77	0.5	0.5	0.5	0.058	0.06	0.062
2	-	0.38	1	0.5	0.5	0.087	0.72	0.086
3	-	0.36	1	0.5	0.5	0.105	0.98	0.103
4	-	0.34	1	0.5	0.5	0.127	0.98	0.123
5	-	0.32	1	0.5	0.5	0.14	0.98	0.137
6	-	0.31	1	0.5	0.5	0.155	0.98	0.154
7	-	0.31	1	0.5	0.5	0.162	0.92	0.159
8	-	0.31	1	0.5	0.5	0.166	0.92	0.157
9	-	0.31	1	0.5	0.5	0.169	0.26	0.164

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

Rationale	**Fbar (2020)**	**Catch (2020)**	**SSB (2020)**	**F_{bar} (2021)**	**Catch (2021)**	**SSB (2021)**	**SSB (2022)**
Catch(2021) = Zero	**0.066**	**869**	**17485**	**0**	**0**	**16063**	**15426**
$F_{bar(2020)} = F_{MSY}$	0.066	869	17485	0.26	3504	14199	11055
$F_{bar(2020)} = F_{pa}$	0.066	869	17485	0.27	3622	14132	10919
$F_{bar(2020)} = F_{lim}$	0.066	869	17485	0.45	5566	12987	8786
$F_{bar(2020)} = F_{2020}$	0.066	869	17485	0.34	978	15564	14144
Catch(2021) = 2020 TAC	0.066	869	17485	0.294	869	15620	14240

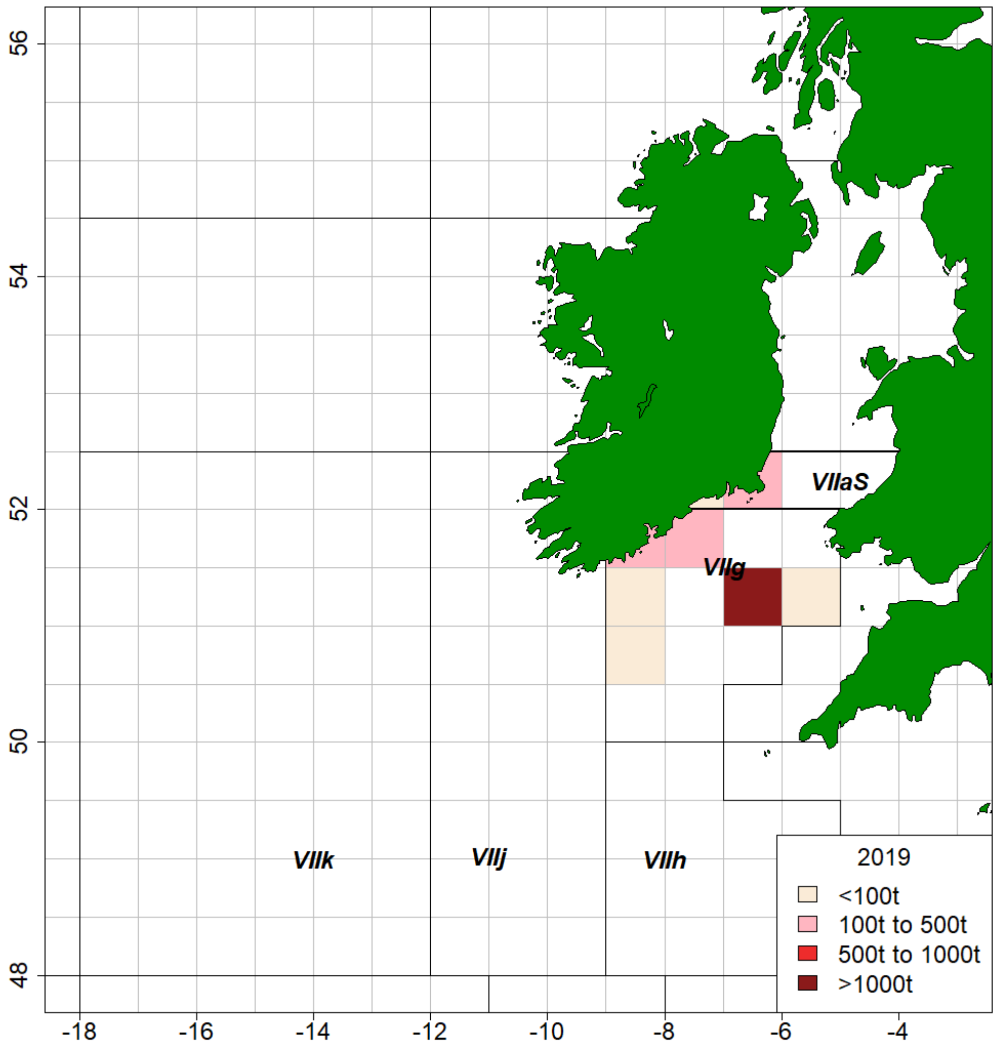


Figure 6.1.2.1. Herring in the Celtic Sea. Total official herring catches by statistical rectangle in 2019/2020.

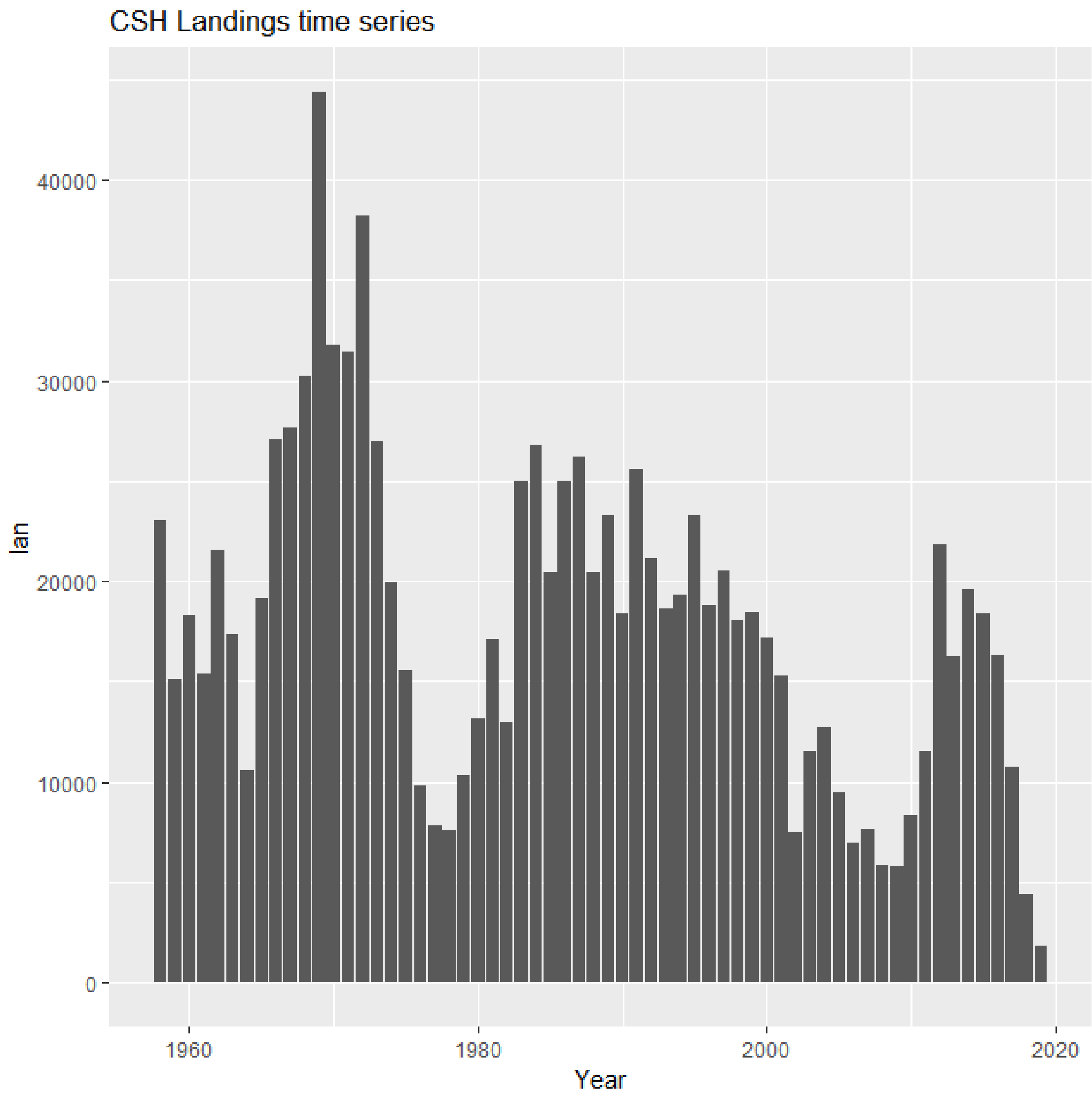


Figure 6.1.2.2. Herring in the Celtic Sea. Working Group estimates of herring catches per season.

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.

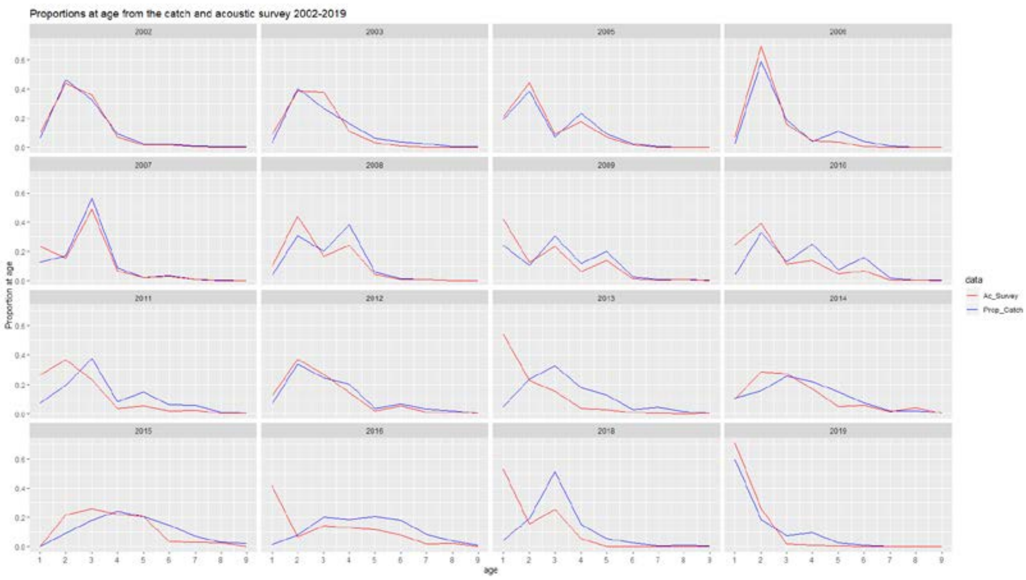


Figure 6.2.1.2. Herring in the Celtic Sea. Proportions at age in the survey (1–9 wr) and the commercial fishery (1–9 wr) by year. Age in winter rings.

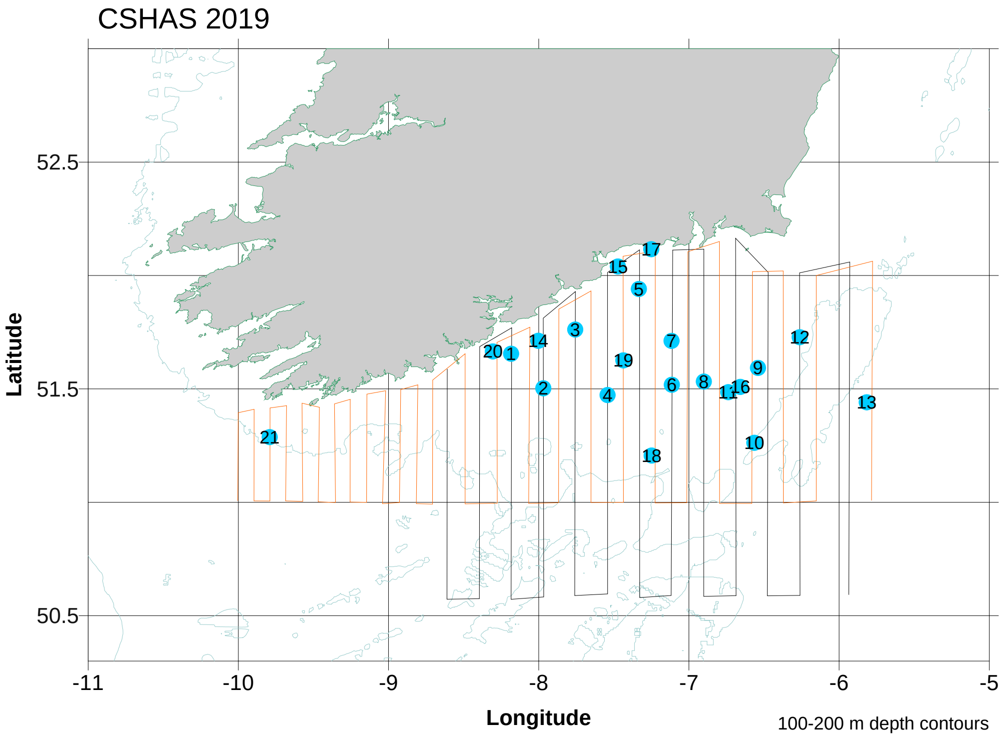


Figure 6.3.1.1. Herring in the Celtic Sea. Acoustic survey tracks for the core and adaptive surveys in 2019, haul positions are numbered.

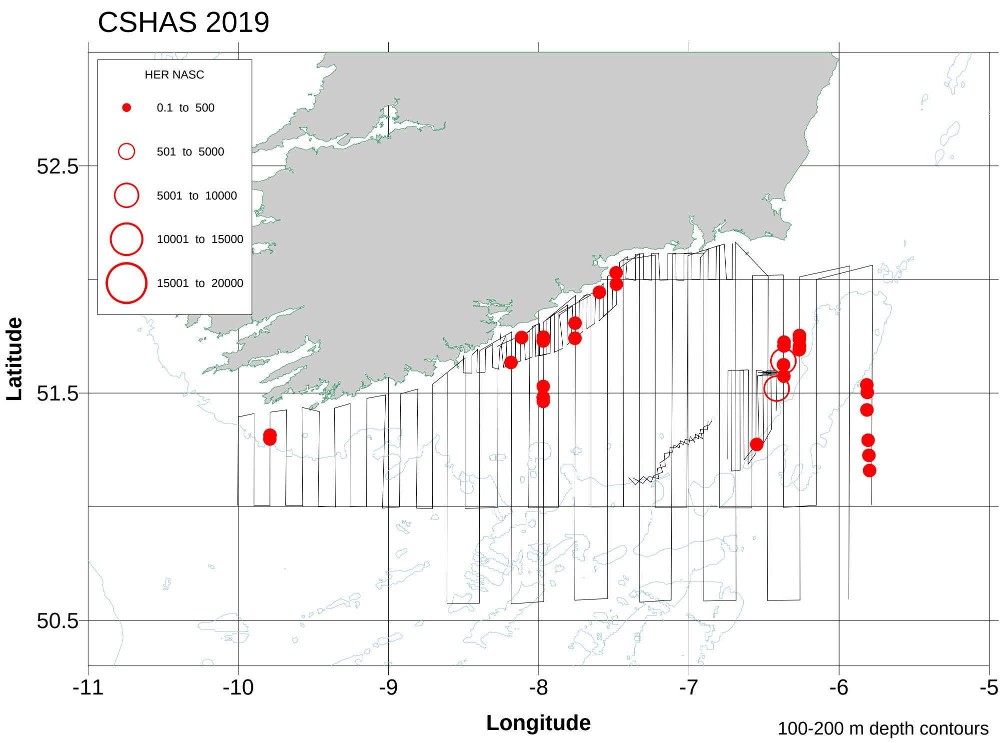


Figure 6.3.1.2. Herring in the Celtic Sea. NASC (Nautical area scattering coefficient) distribution plot of the distribution of herring in 2019 in the broad-scale surveys (1st pass = black lines; 2nd pass = orange lines).

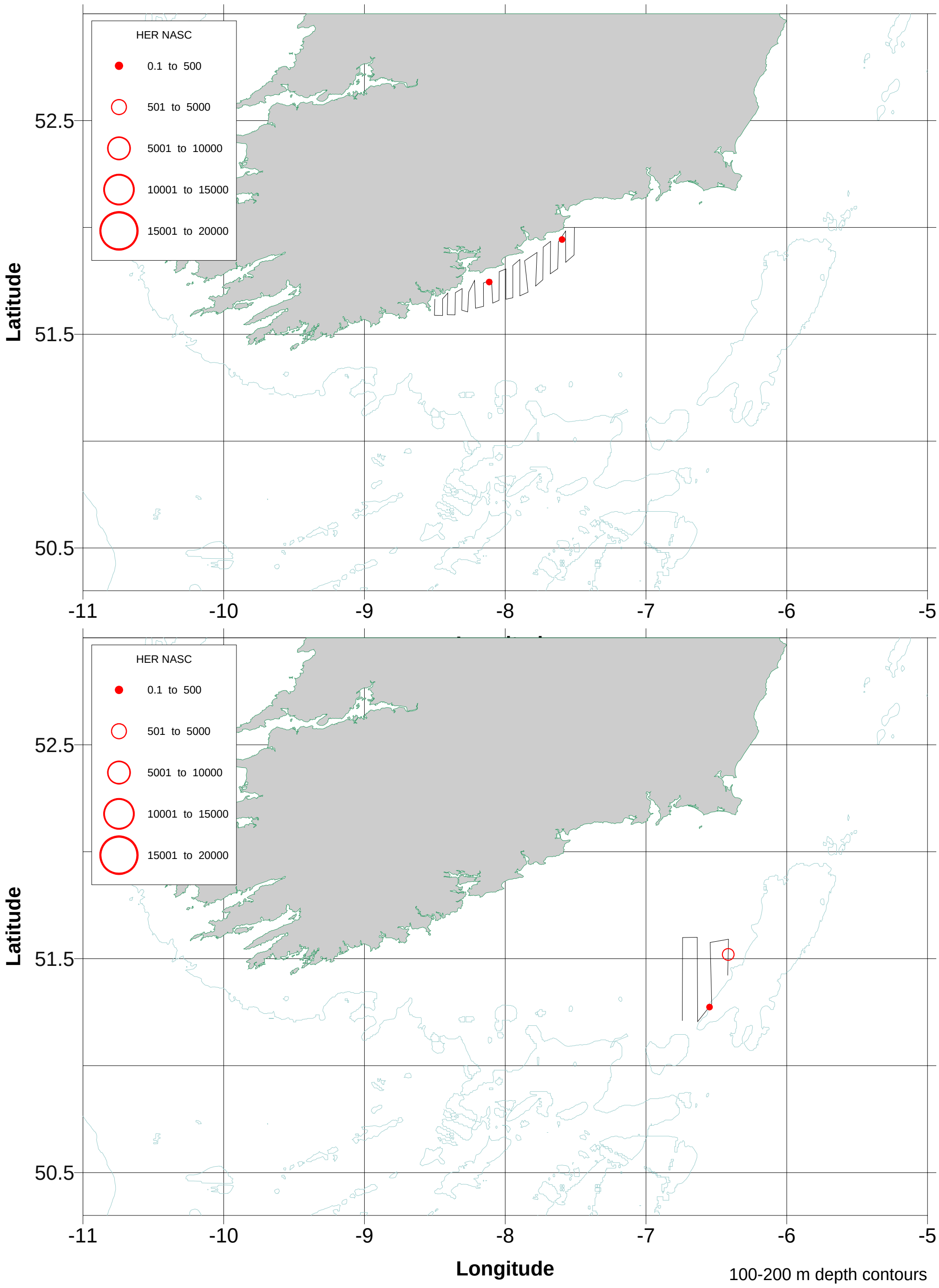


Figure 6.3.1.3. Herring in the Celtic Sea. NASC (nautical area scattering coefficient) plot of the distribution of herring in 2019 in the adaptive mini-survey 2 strata. Top Panel: coastal area; bottom panel: offshore area.

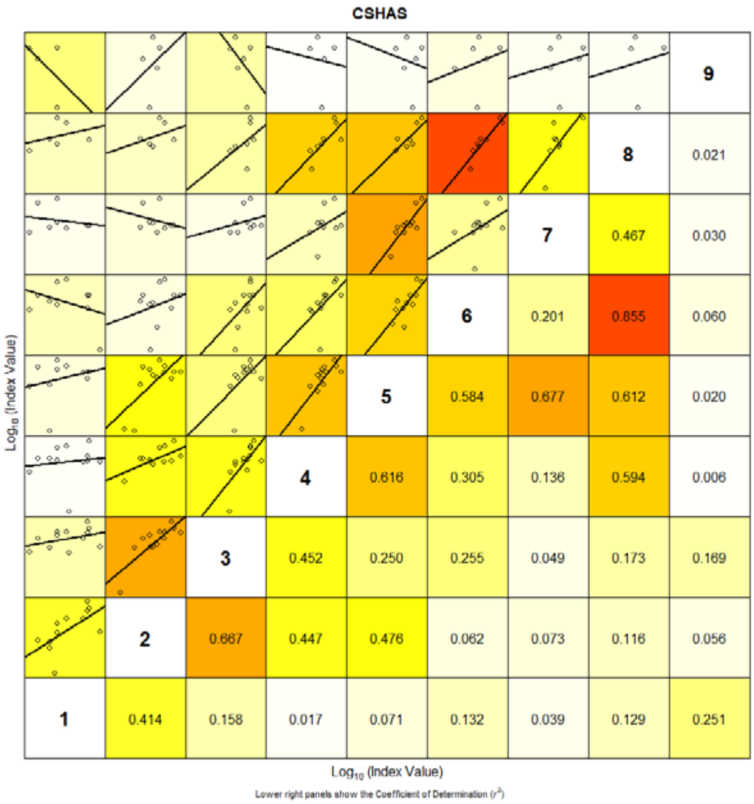


Figure 6.3.1.4. Herring in the Celtic Sea. Internal consistency between ages in the Celtic Sea Herring acoustic survey time-series. Age in winter rings.

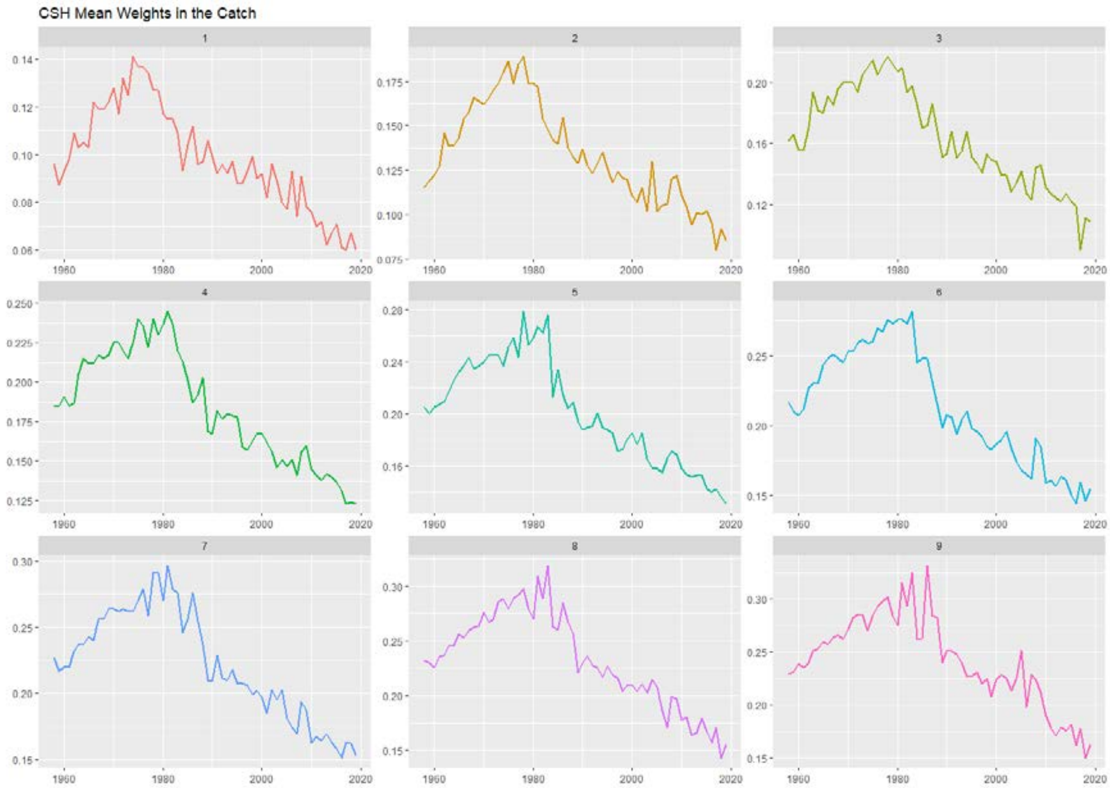


Figure 6.4.1.1. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the catch from 1958–2019 for 1–9+.

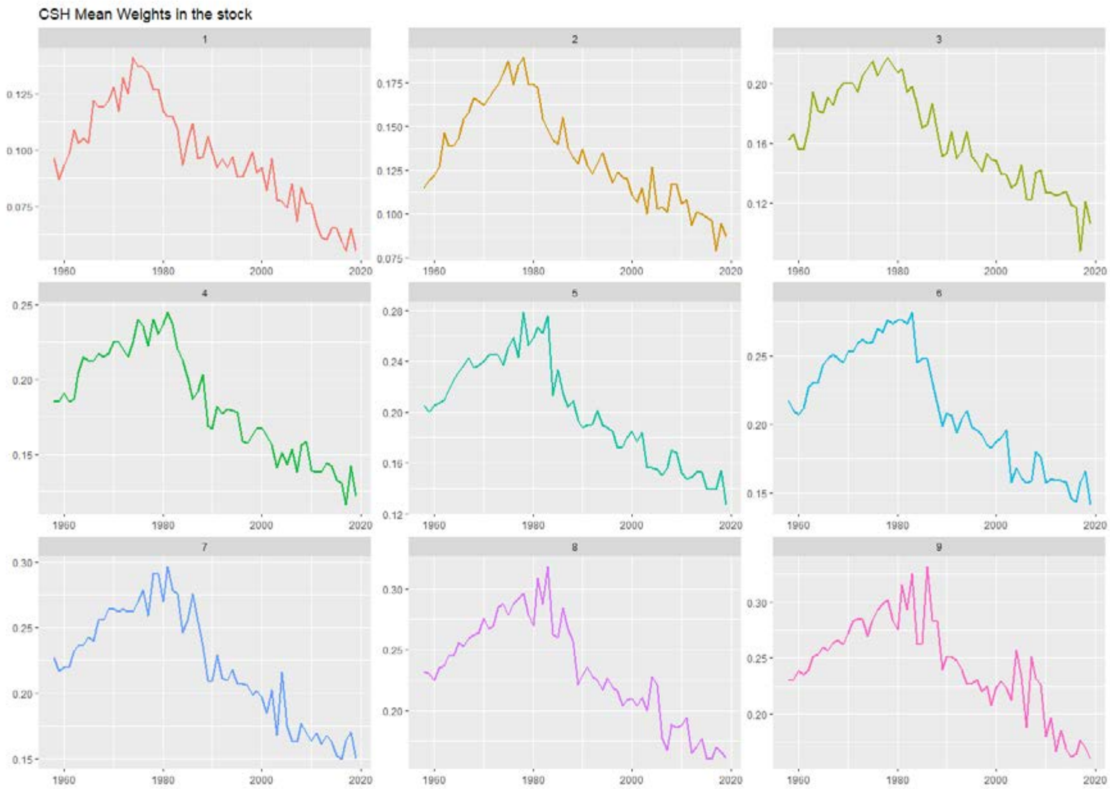


Figure 6.4.1.2. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the stock at spawning time from 1958–2019 for 1–9+. Age in winter rings.

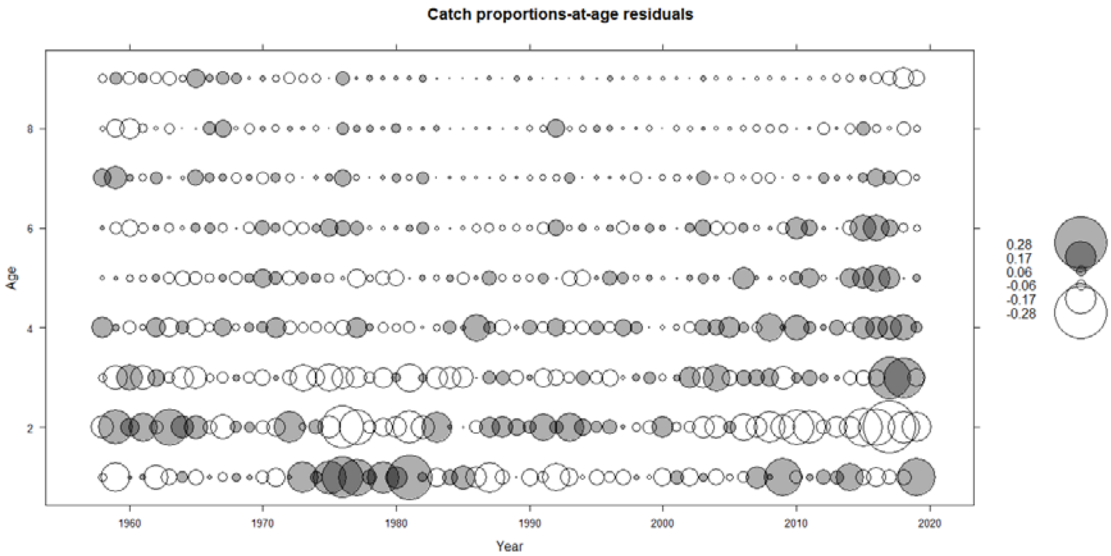


Figure 6.6.1.1. Herring in the Celtic Sea. Catch proportion-at-age residuals. Age in winter rings.

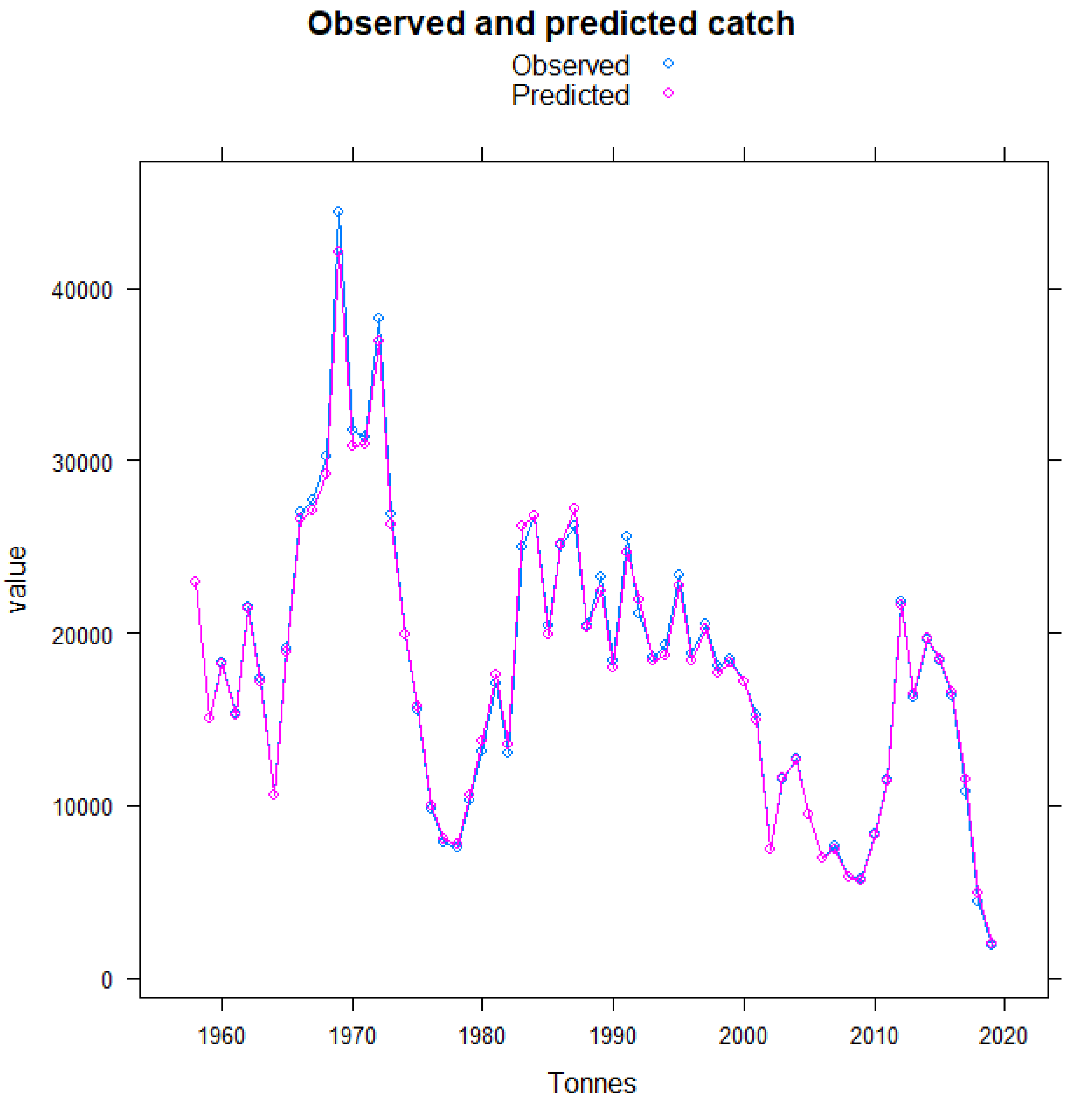


Figure 6.6.1.2. Herring in the Celtic Sea. Observed catch and predicted catch for the final ASAP assessment.

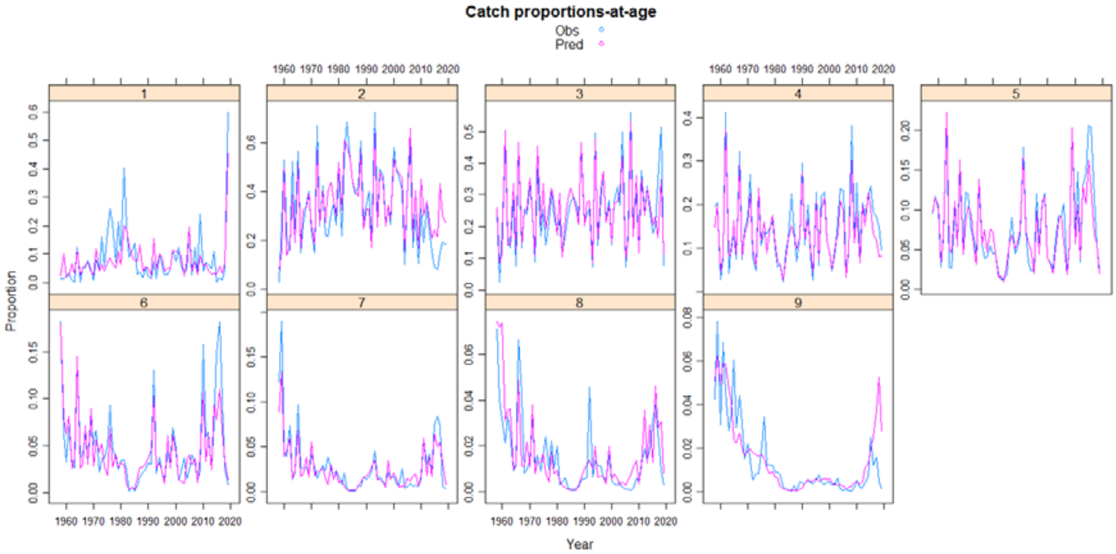


Figure 6.6.1.3. Herring in the Celtic Sea. Observed and predicted catch proportions-at-age for the final ASAP assessment.

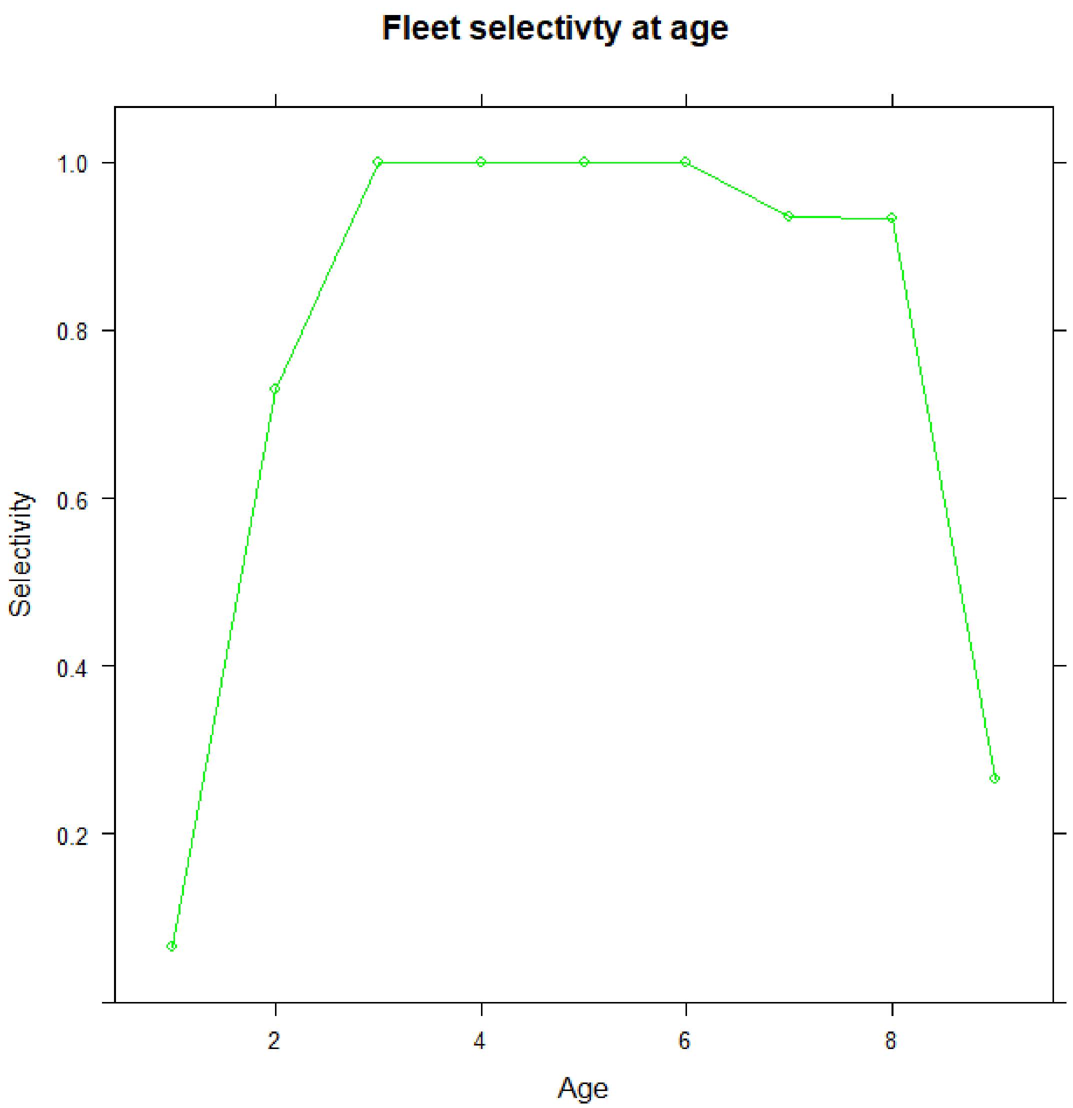


Figure 6.6.1.4. Herring in the Celtic Sea. Selection pattern in the fishery from the final ASAP assessment.

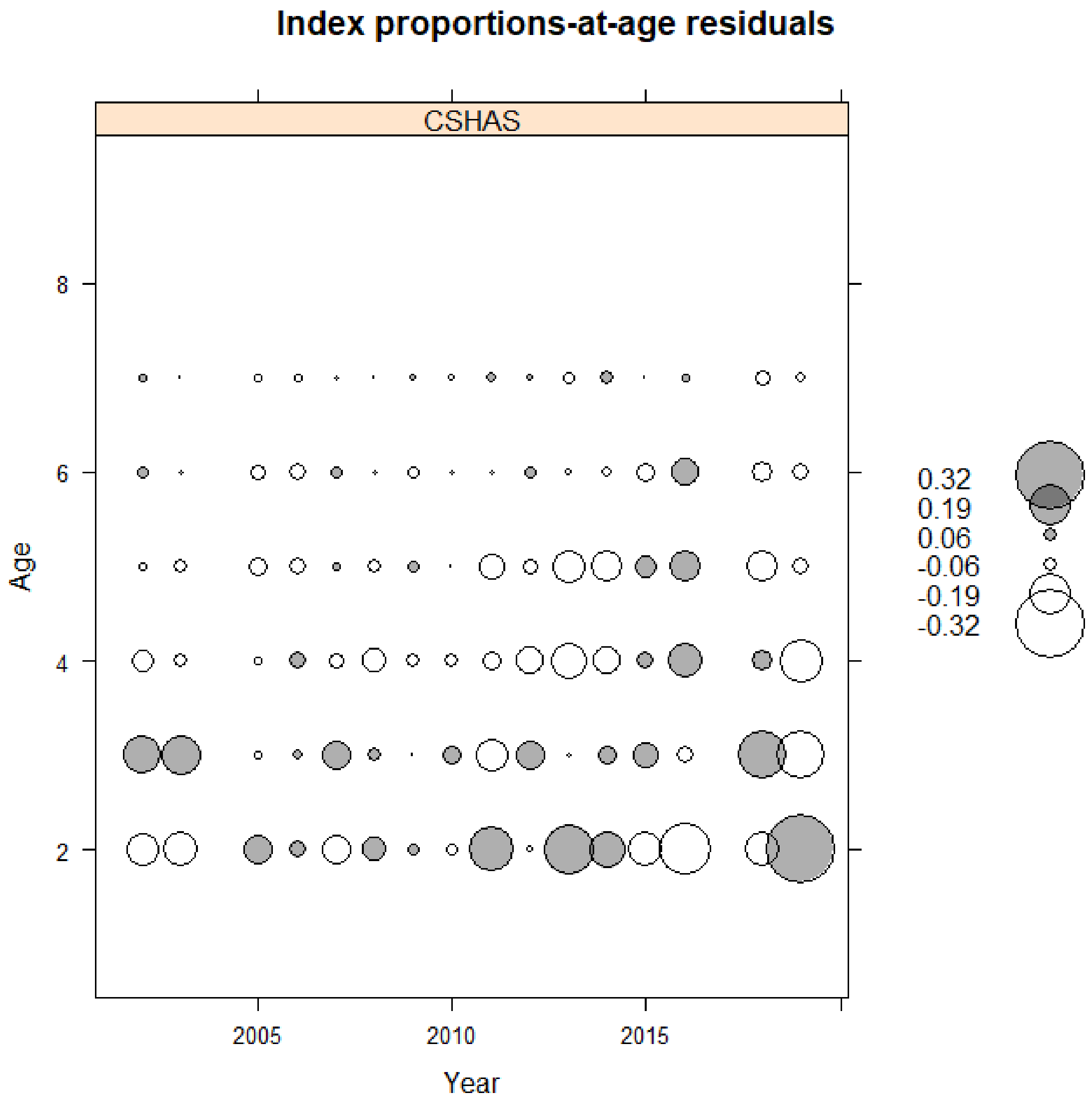


Figure 6.6.1.5. Herring in the Celtic Sea. Index proportions-at-age residuals (observed–predicted). Age in winter rings.

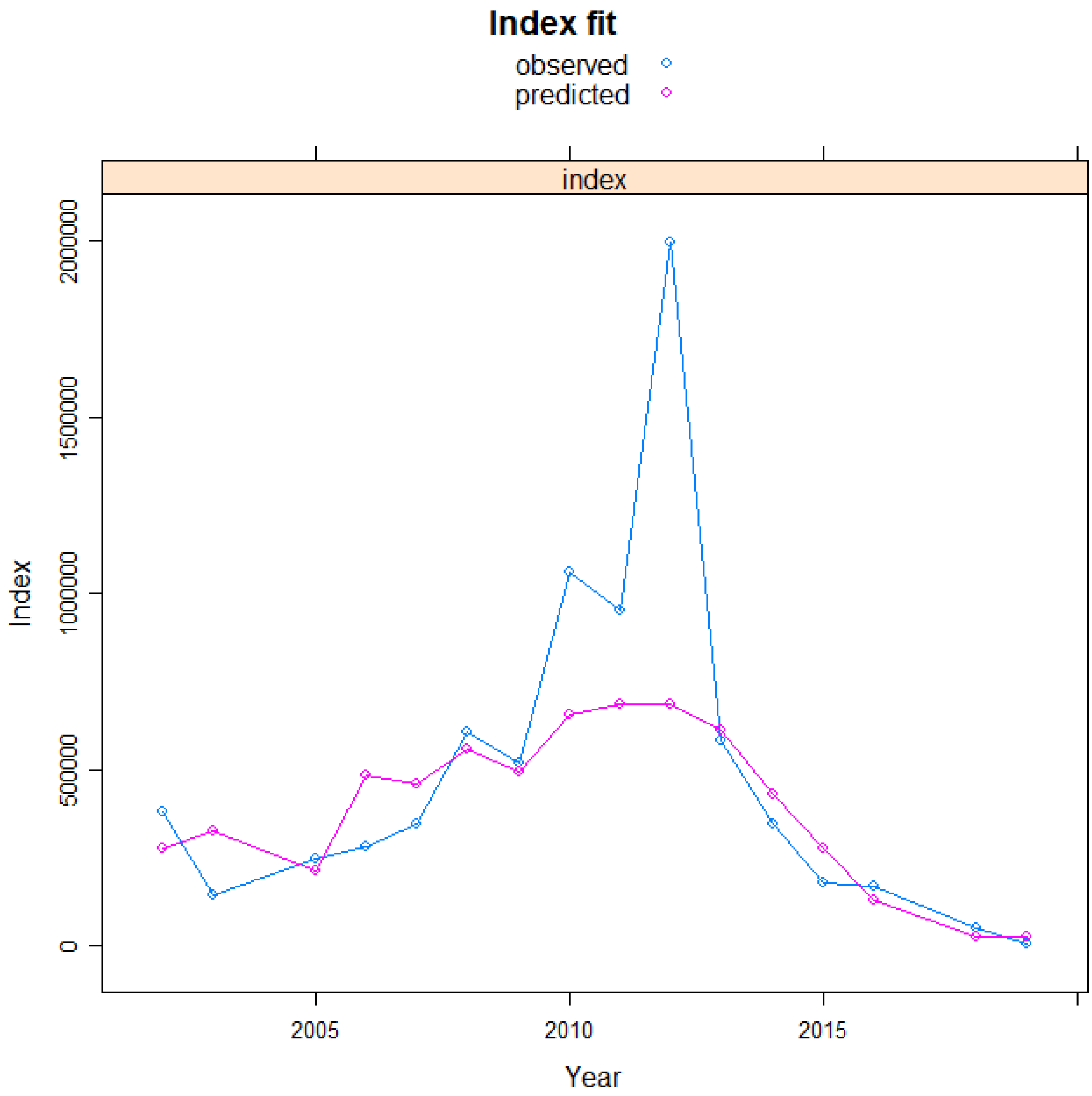


Figure 6.6.1.6. Herring in the Celtic Sea. Index fits.

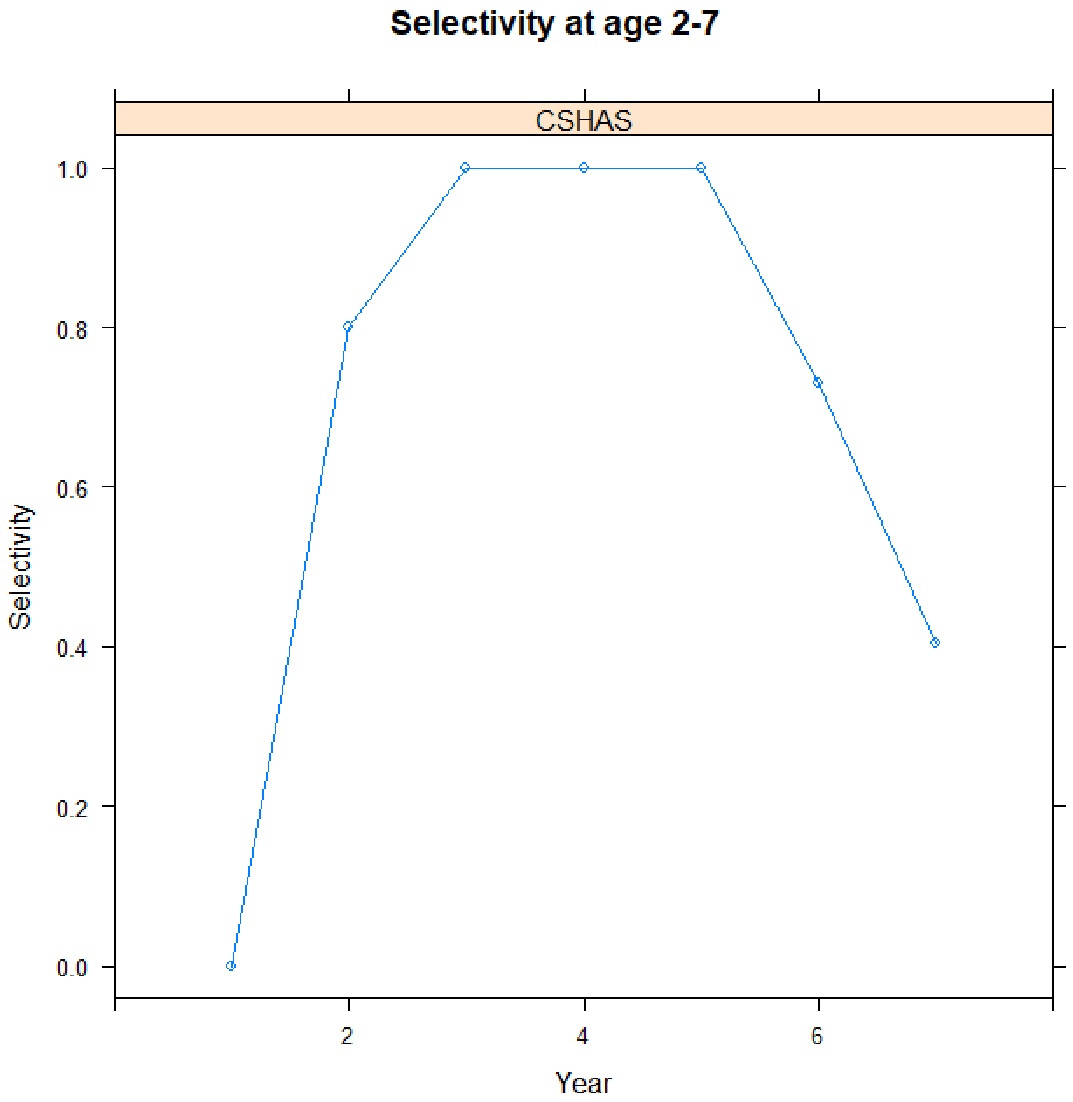


Figure 6.6.1.7. Herring in the Celtic Sea. Survey Selectivity pattern from the final assessment run.

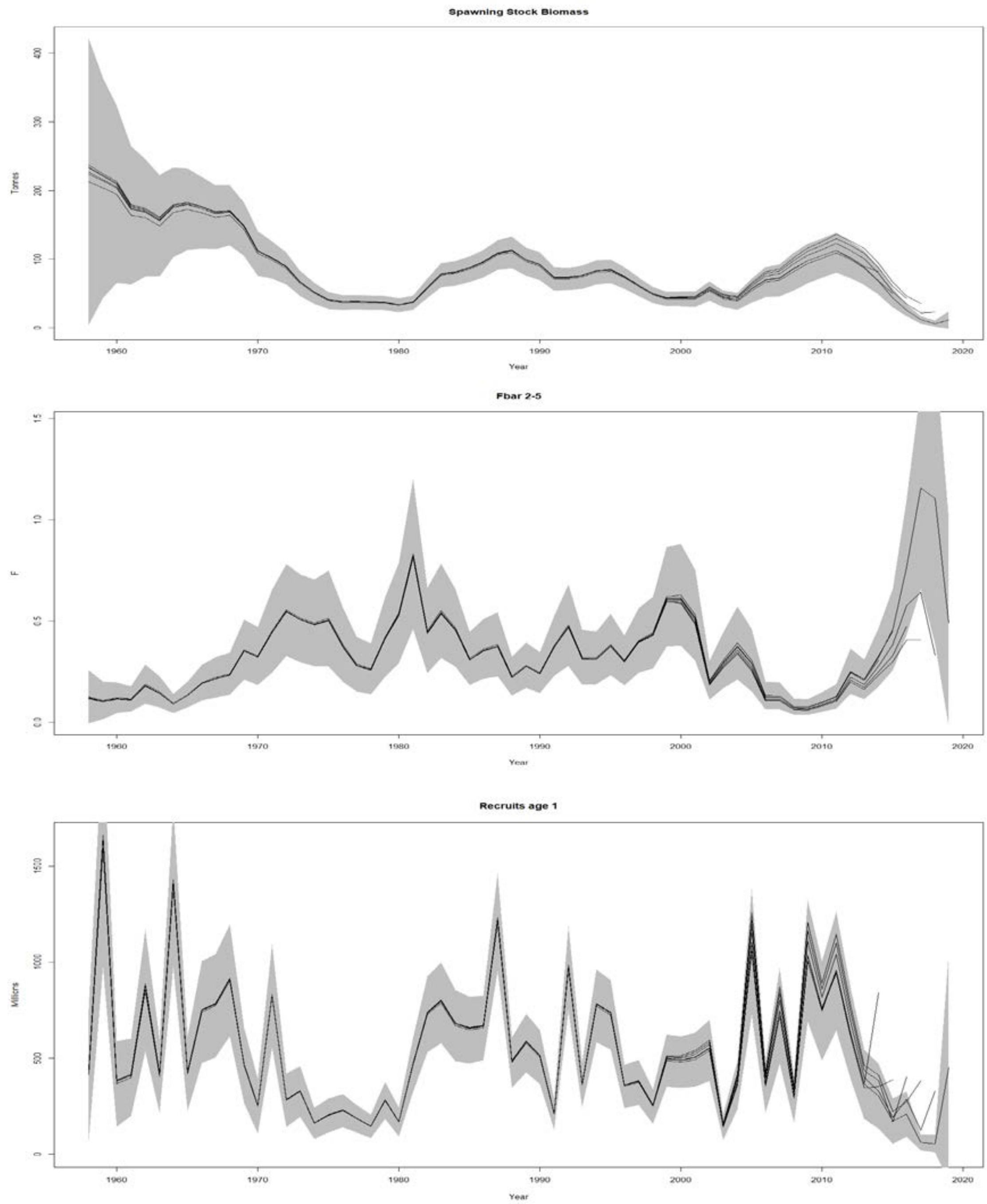


Figure 6.6.1.8. Herring in the Celtic Sea. Retrospective plots for SSB (top), Mean F (bottom left), Recruitment (bottom). The shaded area is the 95% confidence interval.

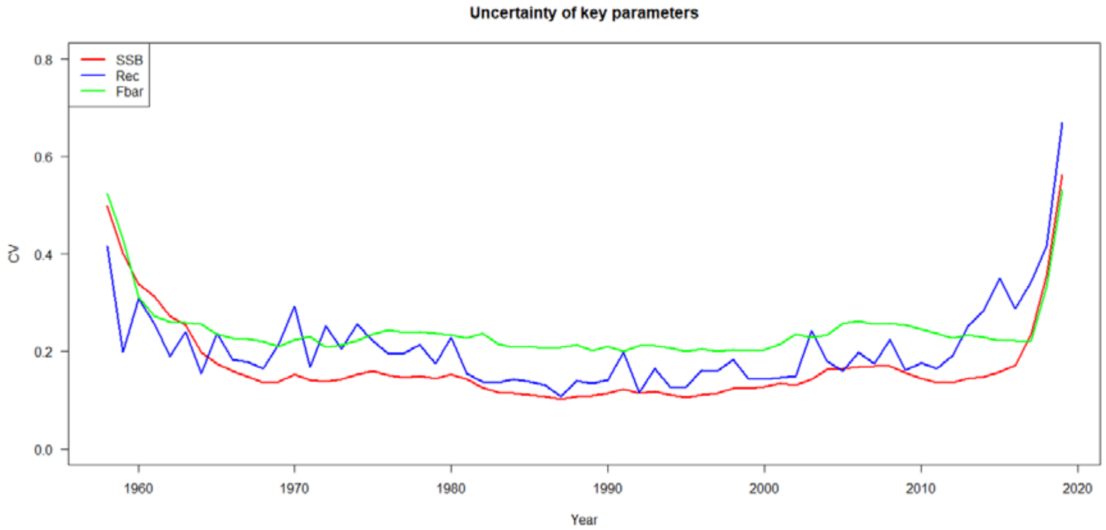


Figure 6.6.1.9. Herring in the Celtic Sea. Uncertainty of key parameters in the final assessment.

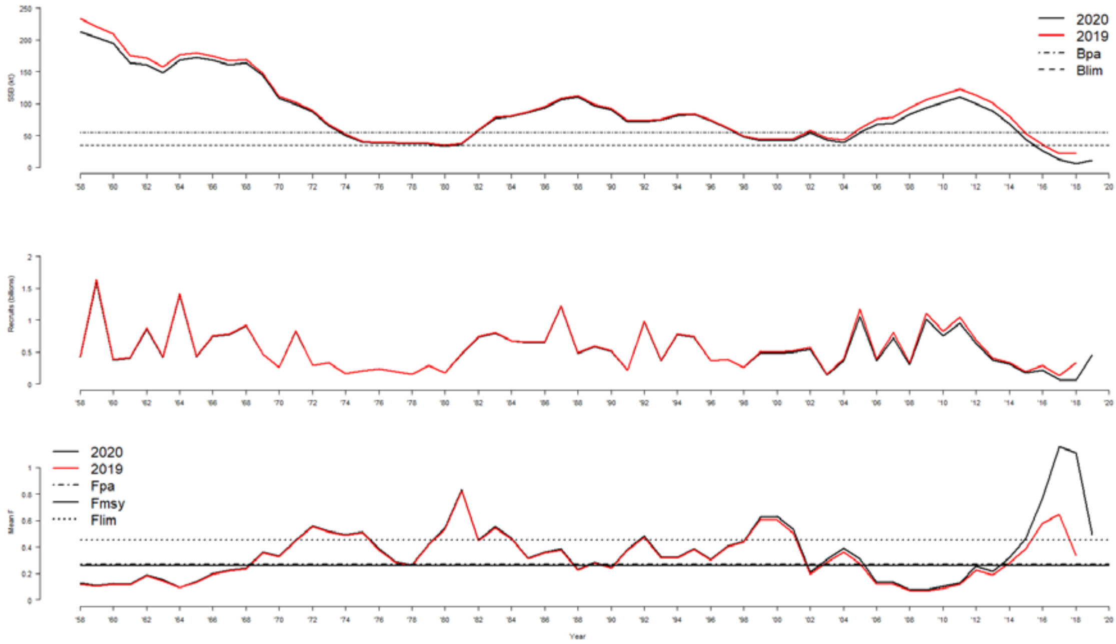


Figure 6.6.1.10. Herring in the Celtic Sea. Stock Summary from the final assessment run showing SSB (top), Recruitment (middle) and Mean F_{2-5} (bottom)

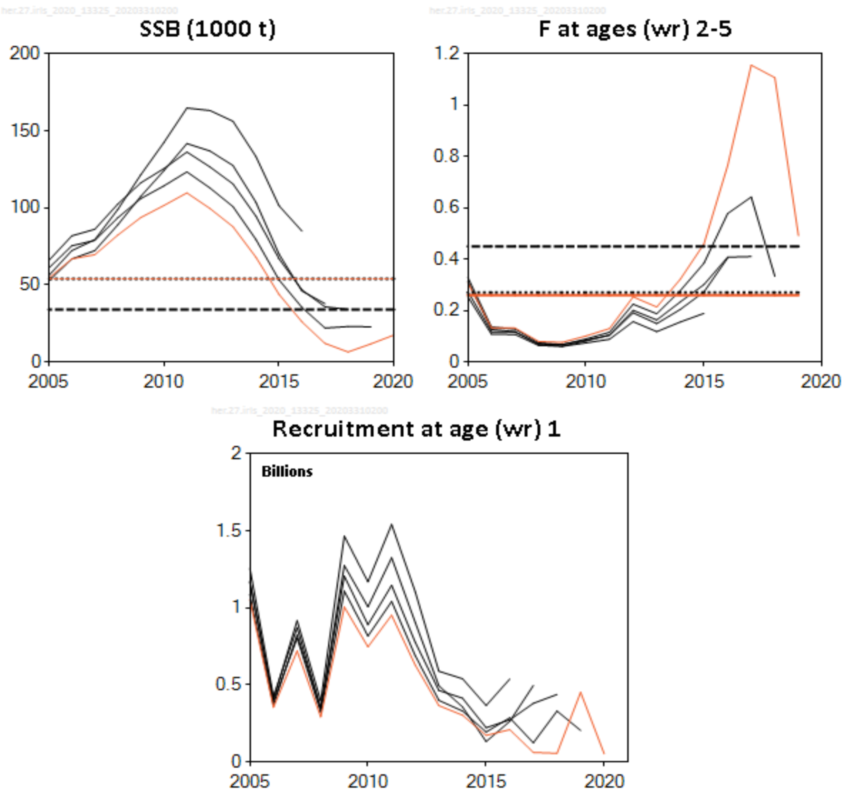


Figure 6.10.1. Herring in the Celtic Sea. Historical retrospective from the final assessments 2015–2020

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 2019

The catches reported from each country for the period 1987 to 2019 are given in Table 7.1.1, and total catches from 1961 to 2019 in Figure 7.1.1. Reported international landings in 2019 for the Irish Sea amounted to 6377 t with UK vessels acquiring the majority of the quota through swaps with the Republic of Ireland. The majority of catches in 2019 were taken during the 3rd quarter, with landings also made in quarter 1 and more typically in quarter 4.

The traditional 2019 7.a(N) herring fishery began in late August, with catches taken to the north-west of the Isle of Man, before moving to the Douglas Bank. The majority of catches were taken by a UK pairtrawlers and by midwater pelagic fishing vessels from Ireland. In previous years a ‘Mourne’ fishery, limited to boats under 40ft usually in October and November, this fishery did not land any herring in 2019.

7.1.3 Regulations and their effects

Closed areas for herring fishing in the Irish Sea along the east coast of Ireland and within 12 nautical miles of the west coast of Britain were maintained throughout the year. The traditional gillnet fishery on the Mourne herring has a derogation to fish within the Irish closed box. The area to the east of the Isle of Man, encompassing the Douglas Bank spawning ground (described in ICES 2001, ACFM:10), was closed from 21 September to 15 November. Boats from the Republic of Ireland are not permitted to fish east of the Isle of Man.

The arrangement of closed areas in Division 7.a(N) prior to 1999 is discussed in detail in ICES (1996/ACFM:10) with a change to the closed area to the east of the Isle of Man being altered in 1999 (ICES 2001/ACFM:10). The closed areas consist of: all year juvenile closures along part of the east coast of Ireland, and the west coast of Scotland, England and Wales; spawning closures along the east coast of the Isle of Man from 21 September to 15 November, and along the east coast of Ireland all year-round. In 2019 theses restrictions were no longer in place due to the changes within the EU Technical Regulations (EU) 2019/1241, however, national licensing measures still restrict vessels from fishing in some areas and seasons.

7.1.4 Changes in fishing technology and fishing patterns

UK Northern Irish and Irish pelagic pair and single trawlers take the majority of catches during the 3rd and 4th quarters. In 2019 landings were also made in quarter 1. . 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 and no catches in 2019. Recently there has been a marked increase in the landings made by Irish vessels comprising 19% of the landings in 2018 and 21% in 2019 compared to an average of 2% during 2015 - 2017.

7.2 Biological Composition of the Catch

7.2.2 Catch in numbers

Routine sampling of the main catch component was conducted in 2019Sampling was carried out on landings at fish processing factories for both Irish, Northern Irish vessels and UK English vessels. There was no biological sampling of the main catch component (pairtrawlers) 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 2019 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 2019, excluding 2009.

7.2.2 Quality of catch and biological data

The number of samples acquired from the main catch component was 28 in 2019, which are similar sampling levels than has been achieved in the past. The number of measurements also remained similar to past sampling levels. At sea observer data have been collected since 2010 (~15% of fishing trips sampled annually) with no discards observed. 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 dataseries 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.

7.4 Fishery Independent Information

7.4.1 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 2019 was carried out over the period 28th August–13th September. The survey conditions were good. A survey design of stratified, systematic transects was employed, as in previous years (Figure 7.3.1). Sprat and 0-group herring were distributed around the periphery of the Irish Sea (Figure 7.3.1). Highest abundance of 1+ herring targets in 2019 were observed on both the western sides of the Isle of Man and on the Scottish coast of the North Channel (Figure 7.3.1). Local high areas of high abundance of herring were also observed on the known spawning banks toward the county Down coast. The survey followed the methods described in the ICES WGIPS International Pelagic Survey Manual (ICES xxxx). Sampling intensity was high during the 2019 survey with 30 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 In 2018 the estimate was 39 319 t, similar to that observed in 2018 (Table 7.3.1, Figure 7.3.4). The biomass estimate of 68 078 t for 1+ ringers is a further 25% increase on last year's biomass estimate. A large proportion of the 1+biomass estimate was seen to the west of the Isle of Man and in North Channel close to the Scottish coast. 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 prespawning aggregations sampled in the Irish Sea during the acoustic survey. The presence of these winter hatched fish has implications for the estimates of 1-ringer+ biomass and SSB, as well as confounding traditional cohort type assessment methods. However, removal of winter hatched fish, leaving only fish of autumn spawning origin, does not change the perception of a significant increase in biomass estimates (Figures 7.3.6–7). The benchmark working group (ICES WKPELA 2012) investigated the mixing issue and its impact on the assessment. The benchmark group concluded that the data should be treated as for a mixed stock. Both the fishery and survey operate on this mixture and by using the data without adjustment for winter hatched fish, the assessment is conducted on the mixed stock. The recruitment data (1 winter rings) have the largest proportion of "alien" stock. The benchmark suggested that this is considered in the assessment model configuration and dealt with objectively within the model.

7.4.2 Spawning-stock biomass survey (7.aNSpawn)

A series of additional acoustic surveys has been conducted since 2007 by Northern Ireland, following the annual pelagic acoustic survey (conducted during the beginning of September). The enhanced survey programme was initiated to investigate the temporal and spatial variability of the population estimates from the routine acoustic survey. The purpose was to track the spawning migration entering into the Irish Sea via the North Channel on route to the main spawning grounds of the Douglas Bank. The survey only concentrates on the spawning grounds surrounding the Isle of Man and the Scottish coastal waters (Figure 7.3.4). Herring found in this area represents >75% of the SSB index generated from the routine survey. In 2019 the survey estimates the spawning biomass to be 44.2t, this is a small increase from 2018 (39t) and within the previously observed range (28.4 – 114.0t).

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, timing of the survey is directed by input from the commercial fishery reporting movements of fish onto the spawning grounds.

7.5 Mean weight, maturity and natural mortality-at-age

Biological sampling in 2019 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). This has also been observed in other stocks. It is recommended that potential drivers for this decline is investigate to explore potential large-scale ecosystem change. No biological sampling information was available for 2009 and the weights at age for 2009 were replaced by averaging the weight at age observed in 2008 and 2010. The final agreed model from the 2012 benchmark used the natural mortality estimates from the North Sea (Table 7.6.3.4). These were again reviewed at the 2017 benchmark and although not considered ideal it is still the best available in the absence of specific Irish Sea derived natural mortality estimates. A variable maturity ogive is used based on the corresponding annual quarter 3 biological sampling from the catch (Table 7.6.3.5).

7.6 Recruitment

An estimate of total abundance of 0-ringers and 1-ringers is provided by the 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.

7.7 Assessment

7.7.1 Data exploration and preliminary modelling

The stock was benchmarked in 2017. The assessment model did not change and was applied without change in 2020. At the benchmark the following changes were made to the input data and model setting:

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

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

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

The primary issue with the current perception of stock status of Irish Sea herring is trying to reconcile the SAM model estimates of stock size (primarily driven by catch data) and the much higher estimate of stock size estimates from 9 years of repeat surveys that specifically focused on the spawning population within the Irish Sea. By design, acoustic surveys are aimed to produce an absolute estimate of stock biomass (with some uncertainty). This would result in a catchability of ~1. The previous assessment estimates catchability to be around ~ 2.5 for the acoustic survey. The benchmark also revealed very significant issues with the catch data, on which the previous assessment and advice is based on.

The concerns from the benchmark were satisfactorily addressed and did not highlight any major issues that could not be explained. In general the assessment model fit improved in the proposed model where the SSB survey is included at the catchability set to 1. Given that the primary aim is to provide credible scientific advice, the best proposal on this trade-off scenario (neither of which are ideal), is to base the assessment and advice on a more balanced assessment model. HAWG did recognize that this is not an ideal scenario and further work needs to be done in the short term to improve the assessment (see Section 1.9, HAWG 2017)

Acoustic (AC(7.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 realized catchability for the survey deviated from one.

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

A feature of the assessment model is the estimation of an observation variance parameter for each dataset (Figure 7.6.20). Overall, the catch data (2+ winter ring) are associated with low observation variances, where 1 ringers (from catch and survey) are perceived to be the noisiest dataseries. 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.

7.7.2 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.

7.7.3 State of the stock

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

7.8 Short-term projections

7.8.1 Deterministic short-term projections

A deterministic short-term forecast was conducted for Irish Sea herring with code in R software. Population abundances, F at age and input data were taken from the final SAM assessment, 1980–2019 (Table 7.7.1). Geometric mean recruitment of 1-ringers (2008–2017) replaced recruitment for 1-ringers in 2019 and is used as the intermediate year assumption. The forecast was based on a TAC (2020 quota = 8064 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 2020–2022, but is predicted to decrease if fishing at F_{MSY}. SSB with zero catch is forecast to increase (+10.2%). This is largely in response to maturation of the 2019 year class, which will contribute more than 30% of the SSB in 2021.

7.8.2 Yield per recruit

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

7.9 Medium term projections

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

7.10 Reference points

MSY evaluations

New reference points were derived using the stock-recruit pairs generated by the 2017 assessment (WKIRISH3 and HAWG 2017). B_{lim} was set to the lowest SSB that generate above average recruitment, 8500 t. B_{pa}, 11 800 t calculated from B_{lim} with assessment error (σ = 0.201, based on the average CV from the terminal assessment year) MSY $B_{trigger}$ is set to B_{pa} as the stock has not been fished at or below F_{MSY} for more than five years. F_{MSY} median point estimates is 0.27 (0.266). The upper bound of the F_{MSY} range giving at least 95% of the maximum yield was estimated to 0.35(0.345) and the lower bound at 0.20(0.198). F_{lim} is estimated to be 0.40 (0.397) as F with 50% probability of SSB <B_{lim} with F_{pa} as 0.29 (0.286) calculated as F_{lim} combined with the assessment error; F_{lim} x exp(-1.645 x σ); σ = 0.231.

7.11 Quality of the assessment

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

The stock is very well sampled and catch information is representative of the fishery (with the exception of 2009 when no samples were provided). The current assessment, being a time-series model, can estimate the missing catch numbers in 2009.

The main issues with the stock are stock mixing (at younger ages from fish of different spawning season origin) and the different trends in mortality observed in the survey and the commercial catches. The majority of this variation may arise from the inter-annual variation in herring migration patterns and their effect on the selectivity of both the fishery and acoustic survey, but is also affected by the effect the annual closure of the Douglas Bank spawning grounds has on the fishery patterns. There are some inconsistencies between observed and modelled landings. The magnitude of these differs between years, but is on average +/-12% over the assessment period and mostly falls within the confidence limits of the estimate. The reason behind these needs further investigation, but might be due to conflicting mortality signals from the surveys and catches and the use of a constant M throughout the time-series.

The data are treated as for a mixed stock. Both the fishery and survey operate on this mixture and by using the data without adjustment for winter hatched fish, the assessment is conducted on the mixed stock. The mixing issue was considered in detail during the 2012 benchmark, but no further analysis was performed at the 2017 benchmark given that there was no new information presented. The noise in the data due to juvenile stock mixing resulted in increased estimates of F, catchability estimates >1 across the younger ages in the survey, or most likely a combination of these. Most of the mixing occurs at younger ages, and this is objectively, but only partially, corrected for in the model through a high catchability (3) estimated for the acoustic survey. Currently, the model doesn't have the structure to specifically deal with the emigration of small herring from other stocks.

The F_{bar} range 4–6 is considered representative of the mortality on the autumn spawning stock in the Irish Sea, excluding most the ages with significant mixed components.

The survey data quality is good, but the survey index is variable linked to the migration and biological characteristics of the stock and the need to assess similar stock components which the fishery exploits to ensure the sustainable exploitation of the Irish Sea spawning stock.

No major validations of the assumption underpinning the assessment model were found. The final assessment model is dominated by information from the catch, but with the noise being added to the survey information as age and year effects. The model does fit the catch data significantly better despite the significant quality issues with the catch data reported at the 2017 benchmark. This is not desirable. The new survey information adds more weight to the previously observed increase abundance trend observed from the main age-disaggregated acoustic survey. The 2017 assessment model attempted to provide a more balanced model, giving more weight to the SSB survey.

SAM down weights the 1 ring data and survey information in general. The uncertainty estimates of the model parameters, suggest the model is both appropriate for the available data and that the model describes these data reasonably well. Very little retrospective bias was also present.

7.12 Management considerations

Given the historical landings from this stock and the knowledge that fishing pressure is light and mostly confined to one pair of UK vessels it can be assumed that fishing pressure and activity has not varied considerably in recent years. The catches have been close to TAC levels and the main fishing activity has not varied considerably as shown from landing data (Figure 7.1.1).

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.

7.13 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	2019
Ireland	119	0	82	200	1299	1317
UK	5089	4868	4245	3696	5504	5061
Unallocated	-	22	-			
Total	5208	4891	4327	3896	6804	6378

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	2019
14															-					-				16	
14.5															-					-				0	11
15															-					15				31	50
15.5					10								16		-	93				14				54	74
16	21	21	17		19	12	9					2			-	107	30		8	0		109		47	233
16.5	55	51	94		53	49	27			13	1	44	33	1	-	487	165		84	14		174		176	401
17	139	127	281	26	97	67	53			25	39	140	69	3	-	764	356	89	202	213	16	261	86	431	883
17.5	148	200	525	30	82	97	105			84	117	211	286	11	-	1155	851	143	470	808	32	413	62	749	1170
18	300	173	1022	123	145	115	229			102	291	586	852	34	-	1574	1406	301	533	1644	72	326	148	594	1532
18.5	280	415	1066	206	135	134	240	36		114	521	726	2088	64	-	1405	841	533	555	3246	64	457	148	1097	1346
19	310	554	1720	317	234	164	385	18		203	758	895	2979	85	-	866	1029	479	588	5357	136	522	234	841	1051
19.5	305	652	1263	277	82	97	439	0	29	269	933	1246	3527	108	-	673	1026	493	680	5371	199	718	382	928	1331
20	326	749	1366	427	218	109	523	0	73	368	943	984	3516	100	-	787	1062	298	1041	4025	271	826	1121	1608	1585
20.5	404	867	1029	297	242	85	608	18	215	444	923	1443	2852	133	-	888	1502	511	1419	2905	279	1087	1343	1881	2263
21	468	886	1510	522	449	115	1086	307	272	862	1256	1521	3451	192	-	1470	1874	643	2364	2608	439	1783	3154	3352	2716
21.5	782	1258	1192	549	362	138	1201	433	290	1007	1380	1621	2929	217	-	1758	1396	1104	2963	2381	854	1762	3007	3838	3340

Length (cm)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009*	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
22	1509	1530	2607	1354	1261	289	1748	1750	463	1495	1361	2748	3821	271	-	2363	2372	1586	3052	2906	1896	2588	4374	5232	4676
22.5	2541	2190	2482	1099	2305	418	1763	1949	600	2140	1448	3629	3503	229	-	3362	2778	2404	3599	2766	2028	2675	2711	6046	4289
23	4198	2362	3508	2493	4784	607	2670	2490	1158	2089	1035	4358	4196	322	-	4530	4100	3920	3432	2596	2470	2893	3475	7485	4476
23.5	4547	2917	3902	2041	4183	951	2254	1552	1380	2214	1256	2920	3697	264	-	5232	3394	6024	3039	1775	1977	3110	2625	6404	3745
24	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054	1276	3679	3178	259	-	4559	4759	8849	3882	2161	2124	2849	2649	6912	4841
24.5	3391	4077	4138	2769	3397	1783	4098	758	1249	2269	1083	2431	2136	204	-	3616	3729	7777	3985	1879	1911	2523	2144	4992	5033
25	3100	4015	5031	2625	2620	2144	5566	776	1163	1749	1086	3438	1503	148	-	3083	3430	7020	3364	2282	2367	2414	2378	4462	3713
25.5	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206	584	2198	952	114	-	2582	2662	5759	2693	2264	2319	2458	1824	2632	2079
26	2334	2480	3871	3115	1694	1349	3814	1570	1140	823	438	1714	643	78	-	1777	2343	4835	1934	1612	1962	1936	1331	1455	1401
26.5	1807	2177	2455	2641	1547	840	2243	1552	1573	587	203	605	330	42	-	950	1595	2664	1026	900	1016	1631	739	798	421
27	1622	1949	1711	2992	1475	616	1489	776	1607	510	165	445	147	23	-	460	1083	1716	412	498	827	826	370	458	210
27.5	990	1267	1131	1747	867	479	644	433	1189	383	60	155	72	10	-	216	472	629	179	326	252	283	123	198	41
28	834	906	638	1235	276	212	496	162	726	198	45	104	33	12	-	9	248	231	85	256	141	65	37	104	52
28.5	123	564	440	170	169	58	179	108	569	51	18	9	26	1	-		53	159	28	156	48	65	12	0	11
29	248	210	280	111	61	42	10	36	163		12	46			-	9		108		57	16	22	25	16	
29.5	56	79	59	92		12	0	36	129				7		-			54		14	8		12	0	
30	40	32	8	84		6	9		43						-			17		0	8				

Length (cm)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009*	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
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)	978	-	-	-
	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	889	6	1576	340
	UK (N. Ireland)	2970	15	1908	842
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	1025	0	0	0
4	Ireland	428	5	605	247
	UK (N. Ireland)	88	1	152	50
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-

*** no information, but catch is likely to be negligible**

Table 7.3.1 Herring in Division 7.a North (Irish Sea). Summary of acoustic survey AC(7.aN) information for the period 1989–2018. 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 0001	0.20
1992	W. Irish Sea + IOM E. coast	20/07–31/07	17 490	0.19			43 200	0.25
1994	Area 7.a(N)	28/08–8/09	31 400	0.36	25 133	-	68 600	0.10
	Douglas Bank	22/09–26/09			28 200	-	-	-
1995	Area 7.a(N)	11/09–22/09	38 400	0.29	20 167	-	348 600	0.13
	Douglas Bank	10/10–11/10		-	9 840	-	-	-
	Douglas Bank	23/10–24/10			1 750	0.51	-	-
1996	Area 7.a(N)	2/09–12/09	24 500	0.25	21 426	0.25	-2	-
1997	Area 7.a(N)-reduced	8/09–12/09	20 100	0.28	10 702	0.35	46 600	0.20
1998	Area 7.a(N)	8/09–14/09	14 500	0.20	9 157	0.18	228 000	0.11
1999	Area 7.a(N)	6/09–17/09	31 600	0.59	21 040	0.75	272 200	0.10
2000	Area 7.a(N)	11/09–21/09	40 200	0.26	33 144	0.32	234 700	0.11
2001	Area 7.a(N)	10/09–18/09	35 400	0.40	13 647	0.42	299 700	0.08
2002	Area 7.a(N)	9/09–20/09	41 400	0.56	25 102	0.83	413 900	0.09
2003	Area 7.a(N)	7/09–20/09	49 500	0.22	24 390	0.24	265 900	0.10
2004	Area 7.a(N)	6/09–10/09 15/09–16/09 28/09–29/09	34 437	0.41	21 593	0.41	281 000	0.07
2005	Area 7.a(N)	29/08–14/09	36 866	0.37	31 445	0.42	141 900	0.10
2006	Area 7.a(N)	30/08–9/09	33 136	0.24	16 332	0.22	143 200	0.09
2007	Area 7.a(N)	29/08–13/09	120 878	0.53	51 819	0.42	204 700	0.09
2008	Area 7.a(N)	27/08–14/09	106 921	0.22	77 172	0.23	252 300	0.12
2009	Area 7.a(N)	1/09–13/09	95 989	0.39	71 180	0.47	175 000	0.08
2010	Area 7.a(N)	28/08–11/09	131 849	0.22	99 877	0.22	107 400	0.10

Year	Area	Dates	herring biomass (1+rings)	CV	herring biomass (SSB)	CV	small clupeoids (biomass)	CV
2011	Area 7.a(N)	27/08–10/09 11–12/10	131 527	0.36	49 128	0.22	280 000	0.11
2012	Area 7.a(N)	29/08–12/09	79 051	0.18	56 759	0.22	171 190	0.11
2013	Area 7.a(N)	29/08–12/09	65 649	0.24	55 350	0.25	255 268	0.09
2014	Area 7.a(N)	27/08–14/09	79 826	0.30	56 629	0.33	393 024	0.10
2015	Area 7.a(N)	29/08–17/09	55 773	0.24	29 056	0.23	237 063	0.09
2016	Area 7.a(N)	31/08–15/09	102840	0.25	91332	0.28	240 926	0.10
2017	Area 7.a(N)	28/08–09/09	40974	0.21	36499	0.23	219 186	0.09
2018	Area 7.a(N)	29/08–13/09	54661	0.29	39997	0.31	196 600	0.13
2019	Area 7.a(N)	28/08–13/09	7437768078	0.09	39318	0.08	146 140	0.08

[1] sprat only

[2]Data can be made available for the IoM waters only

Table 7.3.2 Herring in Division 7.a North (Irish Sea). Age-disaggregated acoustic estimates (thousands) of herring abundance from the Northern Ireland surveys in September AC(7.aN). Ages in winter rings.

AGE (RINGS)	1	2	3	4	5	6	7	8+
1994	66.8	68.3	73.5	11.9	9.3	7.6	3.9	10.1
1995	319.1	82.3	11.9	29.2	4.6	3.5	4.9	6.9
1996	11.3	42.4	67.5	9	26.5	4.2	5.9	5.8
1997	134.1	50	14.8	11	7.8	4.6	0.6	1.9
1998	110.4	27.3	8.1	9.3	6.5	1.8	2.3	0.8
1999	157.8	77.7	34	5.1	10.3	13.5	1.6	6.3
2000	78.5	103.4	105.3	27.5	8.1	5.4	4.9	2.4
2001	387.6	93.4	10.1	17.5	7.7	1.4	0.6	2.2
2002	391	71.9	31.7	24.8	31.3	14.8	2.8	4.5
2003	349.2	220	32	4.7	3.9	4.1	1	0.9
2004	241	115.5	29.6	15.4	2.1	2.3	0.2	0.2
2005	94.3	109.9	97.1	17	8	0.8	0.6	5.8
2006	374.7	96.6	15.6	10.0	0.5	0.4	0.5	0.5
2007	1316.7	251.3	46.6	21.1	20.8	1.2	0.7	0.6

AGE (RINGS)	1	2	3	4	5	6	7	8+
2008	475.7	452.4	114.2	39.1	26.4	17.1	4.3	0.6
2009	371.2	182.6	177.8	92.7	32.5	15.1	13.9	6.9
2010	580.6	561.2	117.7	120.8	34.3	16.8	4.3	6.5
2011	1927.0	330.2	43.9	15.0	21.9	6.3	2.7	2.0
2012	369.1	191.9	161.0	51.4	21.6	19.3	12.1	3.1
2013	100.0	285.2	81.6	54.3	41.2	13.4	11.1	6.8
2014	299.7	193.3	127.3	29.7	43.1	17.3	7.8	12.5
2015	491.9	141.9	25.2	17.0	10.3	9.0	1.9	4.3
2016	131.5	449.3	257.2	110.2	32.2	18.3	8.2	7.0
2017	42.2	89.7	104.1	56.5	9.0	20.3	4.4	11.8
2018	237.9	120.7	63.3	110.9	29.6	7.6	7.9	5.1
2019	148.9	247.5	44.7	21.2	14.6	9.0	1.8	0.9

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
Year / Age	**2019**												
1	12176												
2	23112												
3	11083												
4	6776												
5	6661												
6	1360												
7	182												
8	194												

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	2019
1	0.054	0.072	0.060	0.057
2	0.102	0.093	0.096	0.096
3	0.126	0.121	0.120	0.119
4	0.143	0.14	0.132	0.137
5	0.159	0.147	0.147	0.143
6	0.161	0.154	0.159	0.156
7	0.167	0.154	0.164	0.159
8	0.177	0.162	0.204	0.181

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**	**2019**								
1	0.054	0.072	0.060	0.057								
2	0.102	0.093	0.096	0.096								
3	0.126	0.121	0.120	0.119								
4	0.143	0.14	0.132	0.137								

5	0.159	0.147	0.147	0.143
6	0.161	0.154	0.159	0.156
7	0.167	0.154	0.164	0.159
8	0.177	0.162	0.204	0.181

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**	**2019**								
1	0.787	0.787	0.787	0.787								
2	0.38	0.38	0.38	0.38								

3	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304
8	0.304	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**	**2019**					
1	0.11	0.08	0.1	0.06	0.16	0.11	0.07	0.1	0.08	0.16					
2	0.92	0.9	0.84	0.82	0.94	0.87	0.81	0.85	0.67	0.9					
3	1	1	1	0.99	1	1	0.99	1	0.97	1					
4	0.98	1	1	1	1	1	1	1	1	1					
5	0.97	1	1	1	1	1	1	1	1	1					
6	1	1	1	1	1	1	1	1	1	1					
7	1	1	1	1	1	1	1	1	1	1					
8	1	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**	**2019**					
1	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					
3	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					
5	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					
7	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					

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**	**2019**					
1	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					
3	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					
5	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					
7	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					

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**	**2015**
1	94330	374731	1316673	475675	371230	580602	1927032	369094	100023	299689	491894
2	109938	96623	251276	452364	182643	561245	330180	191900	285238	193267	141854
3	97111	15625	46570	114210	177813	117699	43855	160980	81601	127352	25153
4	17023	9982	21101	39076	92741	120777	14978	51363	54347	29691	17018
5	8029	530	20818	26370	32490	34325	21896	21643	41153	43057	10340
6	810	369	1200	17063	15071	16759	6308	19285	13441	17342	8954
7	607	478	718	4254	13940	4336	2715	12105	11132	7848	1890
8	5804	469	556	599	6871	6453	1959	3128	6776	12481	4342
Year / Age	**2016**	**2017**	**2018**	**2019**							
1	131512	42175	237857	148867							
2	449316	89653	120683	247509							
3	257152	104059	63334	44690							
4	110196	56474	110874	21226							
5	32232	9007	29555	14595							
6	18312	20297	7645	8952							

7	8157	4395	7926	1849
8	7042	11779	5053	882

Table 7.6.3.8 Irish Sea Herring. Survey Indices

```
AC(VIIaN) - Configuration

Irish Sea herring (Division VIIa) (run name: ICAMDC20) . Imported from VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
      1.0       8.0       8.0    1994.0    2019.0       0.7       0.8
Index type : number

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    2019
 all 60328.27 74275.73 41683.6 38973.8 44184.9
```

Table 7.6.3.9 Irish Sea Herring. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        1         8         8      1980      2019         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      2019         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	1.02
FLCore.version	2.6.6
R.version	R version 3.2.0 (2015-04-16)
platform	i386-w64-mingw32
run.date	2020-03-18 19:45:23

Table 7.6.3.12 Irish Sea Herring. STOCK SUMMARY

Year	Recruit-ment	Low	High	TSB	Low	High	SSB	Low	High	Fbar	Low	High	Landings	SOP
1980	174556	86487	352304	37384	26121	53504	14634	9882	21671	0.293	0.202	0.425	10613	1.031
1981	196811	97606	396848	37086	25815	53278	13790	9617	19774	0.285	0.200	0.407	4377	1.100
1982	212140	105016	428536	41110	28321	59674	14012	9624	20401	0.277	0.197	0.389	4855	1.017
1983	168552	81028	350618	42108	29152	60823	15096	10302	22122	0.273	0.197	0.379	3933	1.016
1984	125367	62123	252996	41440	30202	56859	16108	11396	22769	0.277	0.204	0.374	4066	1.039
1985	169397	84494	339614	45297	33288	61639	15829	11821	21195	0.289	0.219	0.380	9187	0.980
1986	208772	104293	417916	46723	34636	63029	18312	13713	24453	0.295	0.227	0.382	7440	1.024
1987	258590	127675	523743	45388	33184	62079	16548	12111	22610	0.300	0.233	0.387	5823	0.963
1988	112984	56333	226603	42531	31921	56669	19339	13861	26983	0.310	0.241	0.399	10172	0.950
1989	145219	72069	292618	38832	28606	52713	14577	10653	19947	0.309	0.241	0.397	4949	0.997
1990	127899	64334	254271	36827	27659	49034	13997	10384	18867	0.311	0.243	0.398	6312	0.987
1991	80098	40272	159307	28510	21949	37032	9682	7224	12976	0.310	0.243	0.395	4398	0.999
1992	249946	125367	498320	32598	22715	46780	10333	7771	13739	0.314	0.247	0.400	5270	0.989
1993	64151	33227	123858	30001	22513	39981	10366	7746	13872	0.315	0.247	0.402	4409	0.987
1994	160813	85801	301408	30946	22905	41810	11707	8744	15673	0.318	0.249	0.408	4828	0.976
1995	141068	73675	270110	30424	22373	41373	11451	8425	15564	0.321	0.249	0.413	5076	1.001
1996	91126	46547	178401	25514	19006	34252	9434	6803	13084	0.326	0.250	0.424	5301	1.000

Year	Recruit-ment	Low	High	TSB	Low	High	SSB	Low	High	Fbar	Low	High	Landings	SOP
1997	131663	68703	252318	24785	17882	34354	8938	6318	12646	0.334	0.252	0.442	6651	1.000
1998	168721	90327	315152	27502	19597	38594	9993	7274	13728	0.338	0.251	0.455	4905	0.995
1999	80580	42455	152940	23365	17326	31509	9515	6737	13438	0.330	0.244	0.446	4127	1.000
2000	83617	43514	160680	20715	15373	27912	9151	6579	12728	0.321	0.237	0.436	2002	0.999
2001	117125	59742	229625	21365	14756	30933	7301	4995	10671	0.326	0.235	0.451	5461	1.000
2002	82951	42909	160359	19954	14300	27844	7455	5156	10777	0.319	0.228	0.447	2393	0.998
2003	145947	77060	276417	23017	15716	33711	6582	4685	9248	0.314	0.222	0.445	2399	1.001
2004	164062	85246	315748	25463	17596	36849	9467	6584	13613	0.298	0.210	0.421	2531	0.998
2005	183506	95101	354090	29086	19898	42516	11525	7917	16777	0.285	0.201	0.405	4387	1.006
2006	312700	164768	593448	37798	25418	56207	12582	8910	17766	0.267	0.188	0.380	4402	1.000
2007	558494	280535	1111864	67778	42989	106864	20064	14117	28518	0.243	0.169	0.349	4629	1.001
2008	282377	135431	588766	60962	42234	87993	25591	17712	36975	0.230	0.157	0.336	4895	1.001
2009	354336	174503	719495	63577	43621	92662	25719	17576	37636	0.219	0.148	0.325	4594	NA
2010	404335	209188	781532	64991	45339	93160	26876	18596	38844	0.209	0.139	0.315	4894	0.999
2011	265402	130101	541409	56954	40430	80231	26769	18727	38264	0.203	0.134	0.308	5202	1.001
2012	288659	150431	553900	54014	38519	75743	24029	16594	34794	0.199	0.132	0.303	5693	1.000
2013	161135	83855	309635	43958	31722	60915	21597	14919	31263	0.193	0.126	0.297	4828	0.998
2014	343176	174063	676594	55492	38040	80952	22788	16028	32399	0.187	0.120	0.292	5083	1.001

Year	Recruit-ment	Low	High	TSB	Low	High	SSB	Low	High	Fbar	Low	High	Landings	SOP
2015	360051	188595	687380	56840	39811	81155	20975	14750	29828	0.189	0.122	0.291	4891	1.000
2016	200386	104946	382621	48339	35395	66018	22720	15922	32420	0.186	0.120	0.289	4327	1.000
2017	199187	100651	394191	46444	33539	64314	20933	14799	29610	0.182	0.115	0.287	3896	1.000
2018	366224	172912	775656	54885	37008	81399	20236	13854	29557	0.183	0.115	0.289	6804	1.003
2019	343863	86414	1368320	56444	32031	99463	24785	16357	37556	0.184	0.115	0.293	6377	1.002

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**	**2019**		
1	0.025253	0.024783	0.024699	0.024967	0.027582		
2	0.1652	0.167579	0.176453	0.188266	0.182319		
3	0.160703	0.15812	0.164458	0.174697	0.191781		
4	0.191283	0.192396	0.186169	0.188266	0.213846		
5	0.136395	0.12986	0.125531	0.127314	0.166443		
6	0.18452	0.172131	0.158089	0.153217	0.171615		
7	0.197247	0.131941	0.087004	0.028607	0.049987		
8	0.197247	0.131941	0.087004	0.028607	0.049987		

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	2019		
1	378889.5	208772.4	192528.6	333700.8	343863.5		
2	137447.9	182955.8	99111.43	96857.88	165049.4		
3	39026.65	77419.97	111190.5	66237.36	60961.63		
4	40134.84	23647.2	44134.63	73570.54	36424.61		
5	14033.46	22925.38	10511.24	27173.57	37123.3		
6	16079.49	9018.2	14298.36	6197.492	12200.11		
7	6723.741	8580.093	5092.886	9824.161	3354.641		
8	8058.639	7752.728	8568.946	6461.392	5697.598		

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**	**2019**			
1	3543.11	3257.32	5703.641	23017.27			
2	23618.84	13407.51	13914.68	9010.357			
3	9580.068	14269.22	8991.905	5996.493			
4	3537.304	6402.732	10779.48	4904.655			
5	2403.569	1067.346	2796.265	1660.859			
6	1231.121	1804.358	759.7124	141.2399			
7	917.6261	366.7755	239.1043	239.8131			
8	829.033	617.0685	157.2458	23017.27			

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**	**2019**		
1	-1.64218	-0.55981	-0.51682	0.402246	0.757835		
2	-0.31374	-0.53057	-0.10635	1.23417	0.010254		
3	-0.03394	-1.1622	-0.34395	1.37354	0.521348		
4	0.523569	0.691716	-0.9251	0.339657	0.307742		
5	0.106348	-0.36706	-1.29443	0.339783	0.70198		
6	1.39139	0.330904	-1.21627	-0.79608	-0.45833		
7	1.09693	-0.05502	0.654036	1.13455	0.581494		
8	-0.27035	-0.20361	0.022073	-2.64322	-0.4862		

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**	**2019**		
1	435652.4	240073.4	221460.6	383540.3	278284.7		
2	242292.3	322223.3	173268.9	167946.4	72947.84		
3	49632.44	98567.81	140899.2	83333.01	38642.19		
4	45152.46	26587.59	49826.39	82900.8	41410.92		
5	16695.76	27413.75	12608.42	32552.19	13595.44		
6	18503.03	10476.4	16785.15	7302.85	4116.012		
7	7702.344	10324.14	6338.516	12774.55	6988.701		
8	9232.914	9327.385	10664.01	8401.033	278284.7		

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	2019
1	0.128627	-0.63743	-1.75663	-0.50611	-0.95982
2	-0.87602	0.544119	-1.07818	-0.54077	-0.18874
3	-1.1122	1.56915	-0.4959	-0.44909	-0.78908
4	-1.59669	2.32655	0.204908	0.475725	-0.96475
5	-0.78404	0.264898	-0.55042	-0.15811	-1.67935
6	-0.98263	0.756009	0.257192	0.061986	-0.54142
7	-1.90202	-0.31897	-0.49574	-0.64618	-1.03689
8	-1.02136	-0.38051	0.134627	-0.68824	-2.68195

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**	**2019**	
8	23668.49	22086.02	24374.68	22941.44	22018.1	24772.76	

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**	**2019**	
8	0.288037	1.58879	1.76184	0.944197	0.902875	0.914946	

Table 7.6.3.25 Irish Sea Herring. FIT PARAMETERS

	name	value	std.dev
1	logFpar	0.74855	0.22157
2	logFpar	0.97627	0.1719
3	logFpar	0.62531	0.17791
4	logFpar	0.51233	0.18162
5	logSdLogFsta	-1.8965	0.65801
6	logSdLogFsta	-1.9814	0.4029
7	logSdLogFsta	-2.0027	0.50896
8	logSdLogFsta	-0.55843	0.23198
9	logSdLogN	-1.4842	0.206
10	logSdLogObs	-0.17635	0.14415
11	logSdLogObs	-0.90691	0.12824
12	logSdLogObs	-0.83591	0.10837
13	logSdLogObs	-0.05752	0.16106
14	logSdLogObs	-0.49248	0.08001
15	logSdLogObs	-0.30198	0.09612

Table 7.6.3.26 Irish Sea Herring. NEGATIVE LOG-LIKELIHOOD

552.321

Table 7.7.1. Herring in Division 7.a North (Irish Sea). Input data for short-term forecast.

2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	274882.8	0.787	0.113333	0.9	0.75	0.063	0.027155	0.063
2	152271.2	0.38	0.806667	0.9	0.75	0.095	0.179913	0.095
3	94059.37	0.353	0.99	0.9	0.75	0.12	0.186649	0.12
4	35355.84	0.335	1	0.9	0.75	0.136333	0.211119	0.136333
5	21039.44	0.315	1	0.9	0.75	0.145667	0.16249	0.145667
6	22938.15	0.311	1	0.9	0.75	0.156333	0.174767	0.156333
7	7529.506	0.304	1	0.9	0.75	0.159	0.06767	0.159
8	6353.625	0.304	1	0.9	0.75	0.182333	0.06767	0.182333
2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	274882.8	0.787	0.113333	0.9	0.75	0.063	0.027155	0.063
2	-	0.38	0.806667	0.9	0.75	0.095	0.179913	0.095
3	-	0.353	0.99	0.9	0.75	0.12	0.186649	0.12
4	-	0.335	1	0.9	0.75	0.136333	0.211119	0.136333
5	-	0.315	1	0.9	0.75	0.145667	0.16249	0.145667
6	-	0.311	1	0.9	0.75	0.156333	0.174767	0.156333
7	-	0.304	1	0.9	0.75	0.159	0.06767	0.159
8	-	0.304	1	0.9	0.75	0.182333	0.06767	0.182333
2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	274882.8	0.787	0.113333	0.9	0.75	0.063	0.027155	0.063
2	-	0.38	0.806667	0.9	0.75	0.095	0.179913	0.095
3	-	0.353	0.99	0.9	0.75	0.12	0.186649	0.12
4	-	0.335	1	0.9	0.75	0.136333	0.211119	0.136333
5	-	0.315	1	0.9	0.75	0.145667	0.16249	0.145667
6	-	0.311	1	0.9	0.75	0.156333	0.174767	0.156333
7	-	0.304	1	0.9	0.75	0.159	0.06767	0.159
8	-	0.304	1	0.9	0.75	0.182333	0.06767	0.182333

Table 7.7.2. Herring in Division 7.a North (Irish Sea). Management options table.

Fbar (2020)	Catch (2020)	SSB (2020)	Fbar (2021)	Catch (2021)	SSB (2021)	SSB (2022)
0.265478	8064	23483.29	0	0	27314.73	26801.94
0.265478	8064	23483.29	0.1	2964.404	25156.52	24946.46
0.265478	8064	23483.29	0.2	5677.159	23182.85	23259.35
0.265478	8064	23483.29	0.3	8161.782	21377.47	21724.42
0.265478	8064	23483.29	0.4	10439.53	19725.61	20327.04
0.265478	8064	23483.29	0.5	12529.6	18213.79	19054.03
0.265478	8064	23483.29	0.6	14449.37	16829.74	17893.5
0.265478	8064	23483.29	0.7	16214.53	15562.27	16834.71
0.265478	8064	23483.29	0.8	17839.28	14401.21	15867.97
0.265478	8064	23483.29	0.9	19336.45	13337.26	14984.56
0.265478	8064	23483.29	1	20717.66	12361.98	14176.56
0.265478	8064	23483.29	1.1	21993.42	11467.64	13436.87
0.265478	8064	23483.29	1.2	23173.25	10647.23	12759.05
0.265478	8064	23483.29	1.3	24265.75	9894.343	12137.3
0.265478	8064	23483.29	1.4	25278.71	9203.133	11566.36
0.265478	8064	23483.29	1.5	26219.2	8568.28	11041.5
0.265478	8064	23483.29	1.6	27093.62	7984.929	10558.45
0.265478	8064	23483.29	1.7	27907.76	7448.654	10113.34
0.265478	8064	23483.29	1.8	28666.87	6955.417	9702.668
0.265478	8064	23483.29	1.9	29375.72	6501.536	9323.281
0.265478	8064	23483.29	2	30038.62	6083.652	8972.325

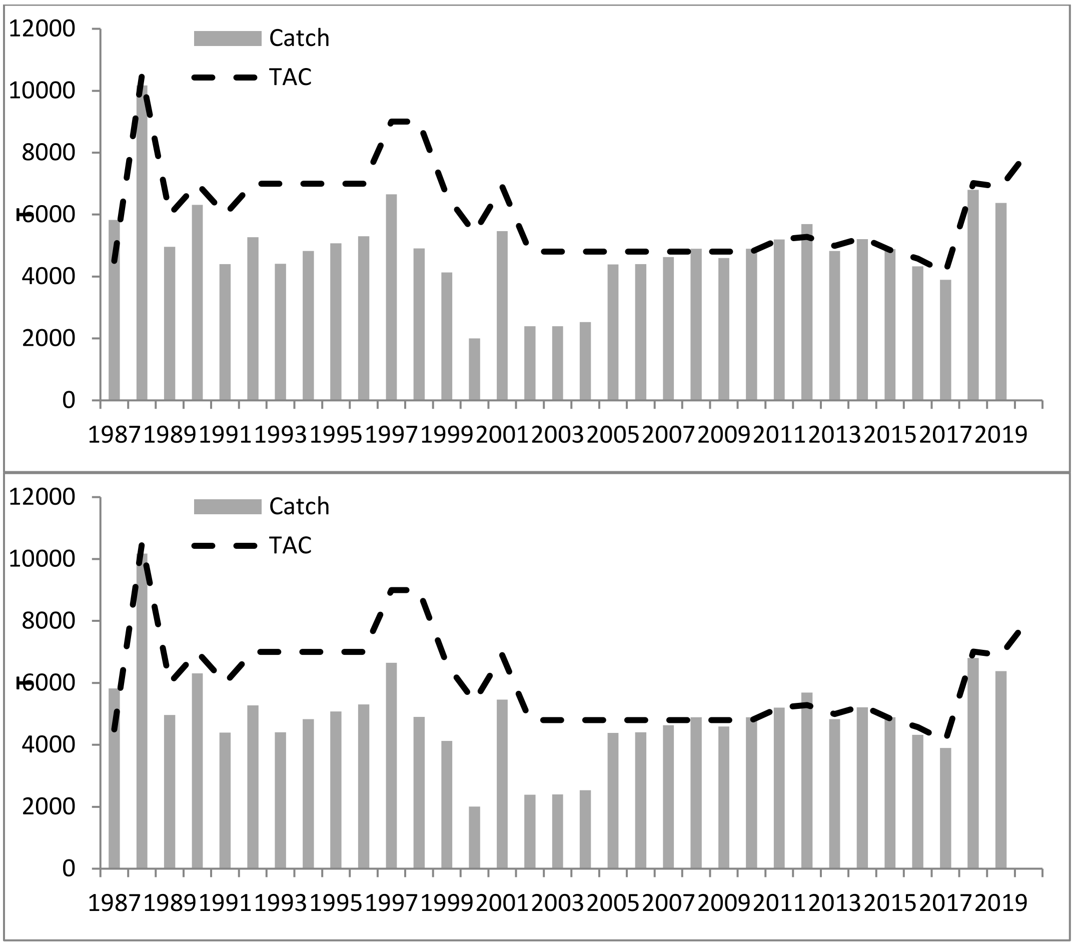


Figure 7.1.1 Herring in Division 7.a North (Irish Sea). Landings of herring from 7.a(N) from 1961 to 2019.

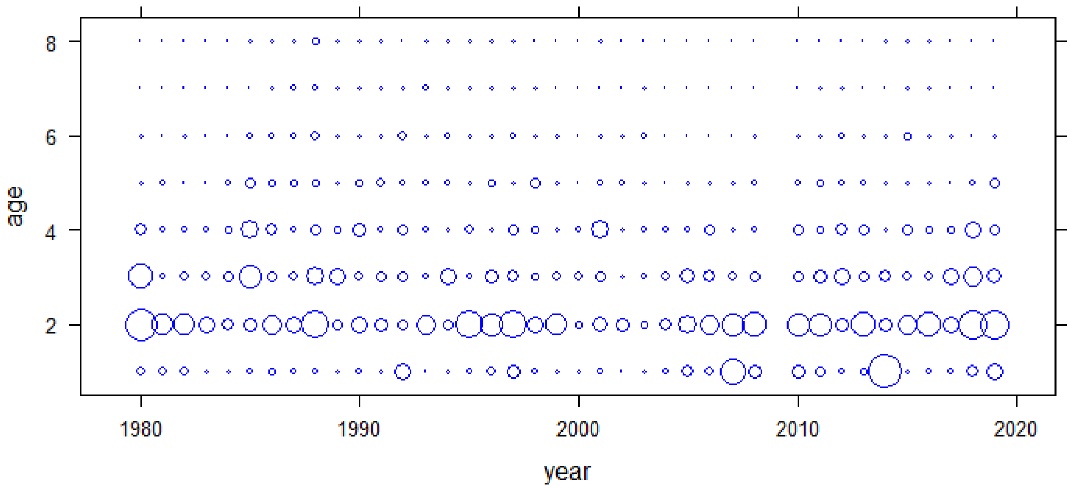


Figure 7.2.1 Herring in Division 7.a North (Irish Sea). Landings (catch-at-age) of herring from 7.a(N) from 1980 to 2019. No 2009 commercial samples.

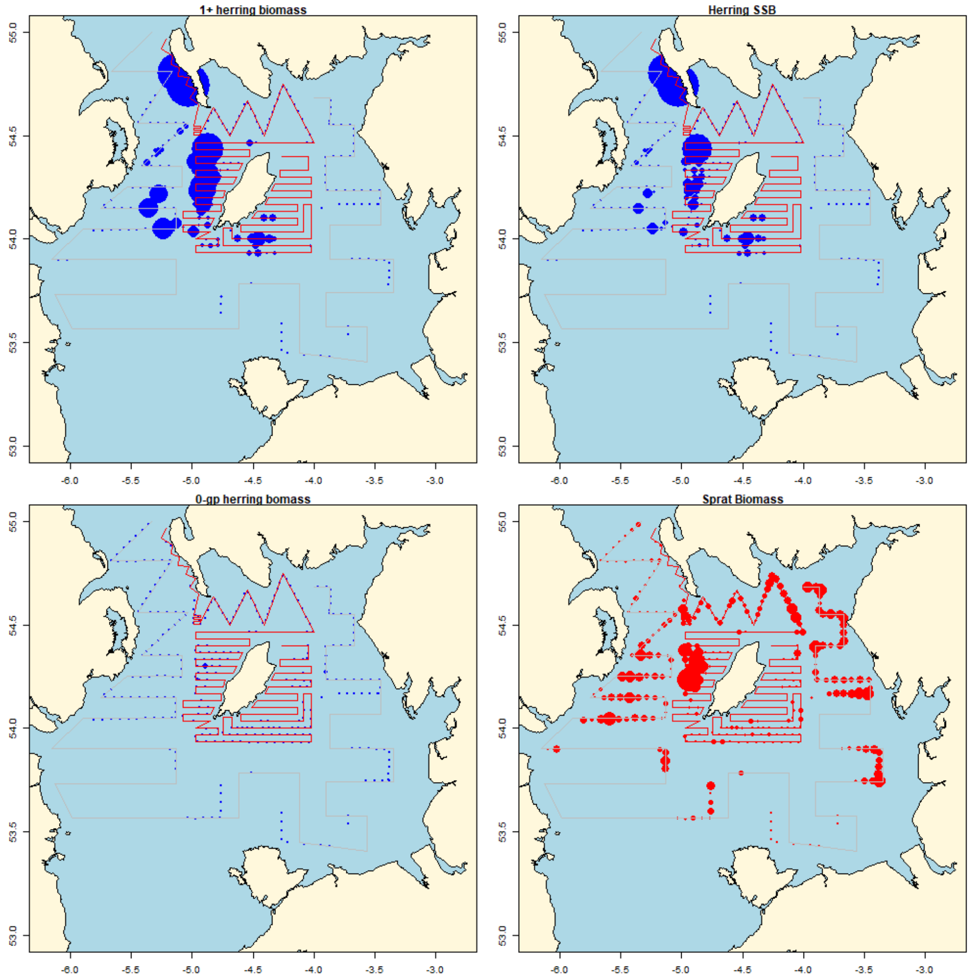


Figure 7.3.1 Herring in Division 7.a North (Irish Sea). Density distribution of 1-ring and older herring (top left panel) for the 2018 acoustic survey; SSB (top right panel); 0-ring herring (bottom left panel) and sprat biomass (bottom right panel). Note: size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval and the same scaling is used for all figures.

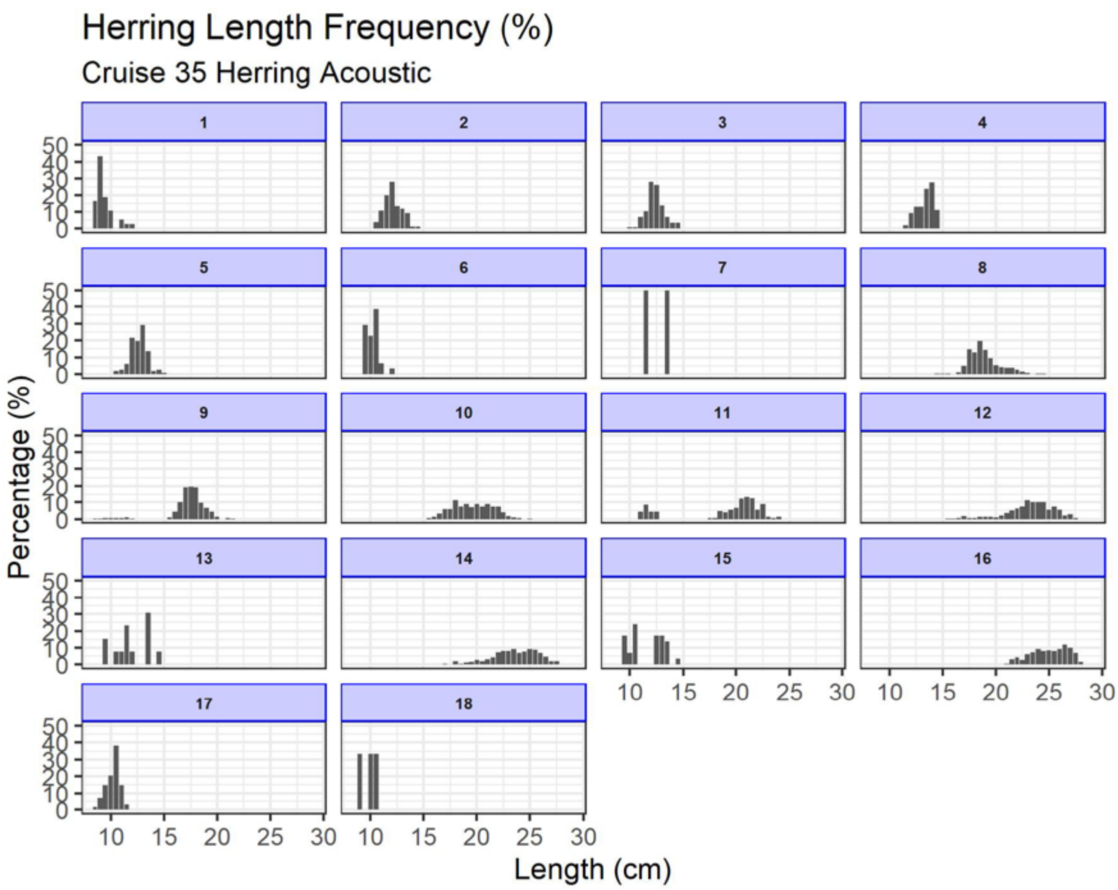


Figure 7.3.2 Herring in Division 7.a North (Irish Sea). Percentage length compositions of herring in each trawl sample in the September 2019 acoustic survey.

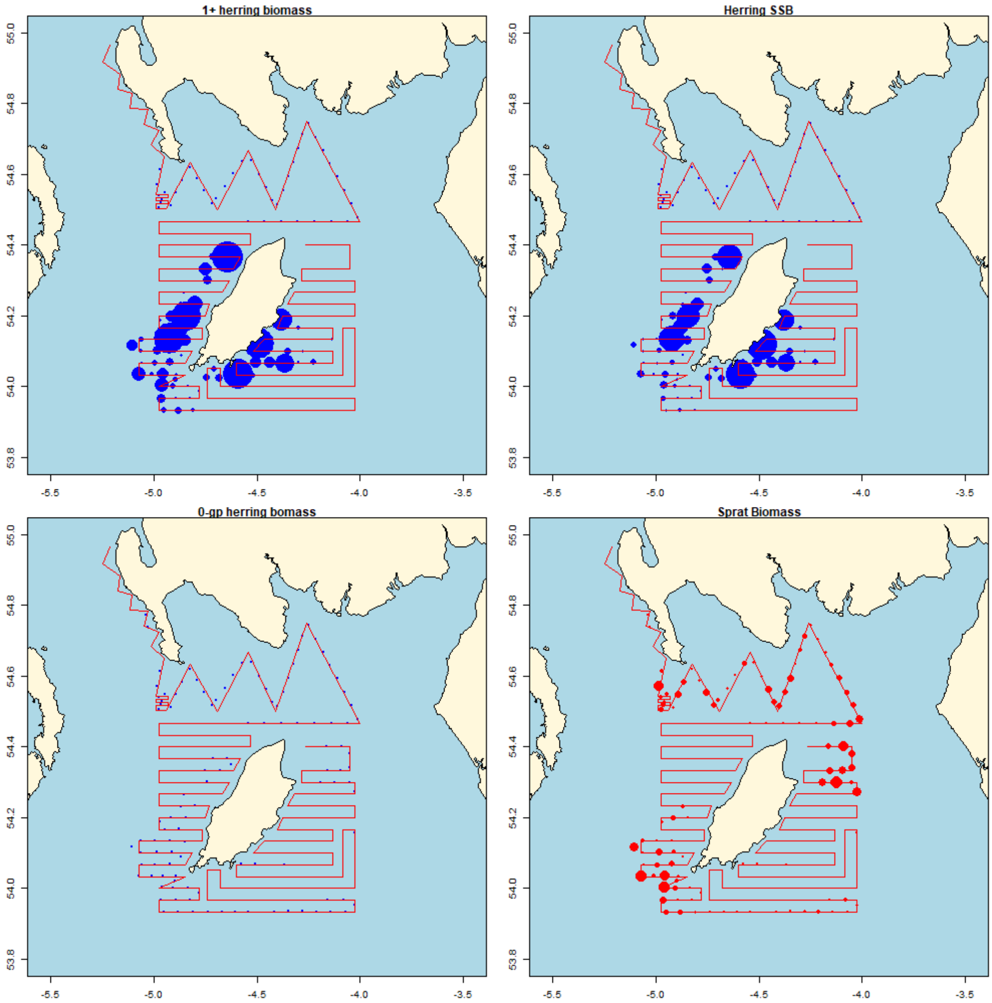


Figure 7.3.3 Herring in Division 7.a North (Irish Sea). Distribution plots for the 7.aNSpawn survey (2008–2019) (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval).

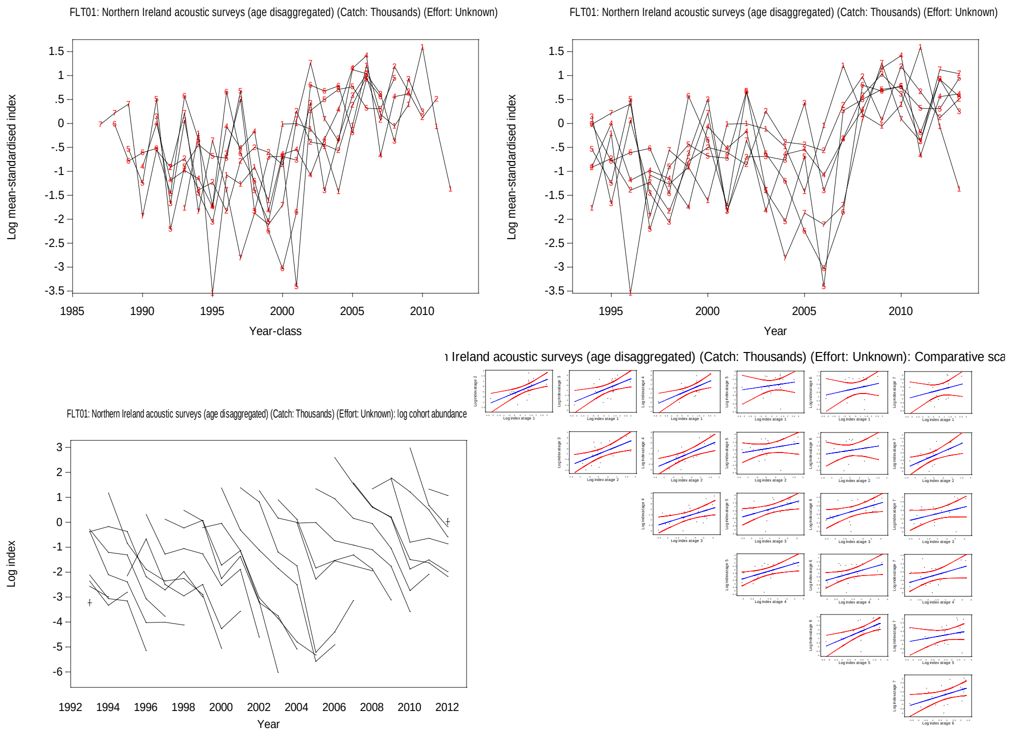


Figure 7.3.4 Herring in Division 7.a North (Irish Sea). Acoustic survey (AC(7.aN)) log mean-standardized indices by year and age class, scatterplots and catch curves.

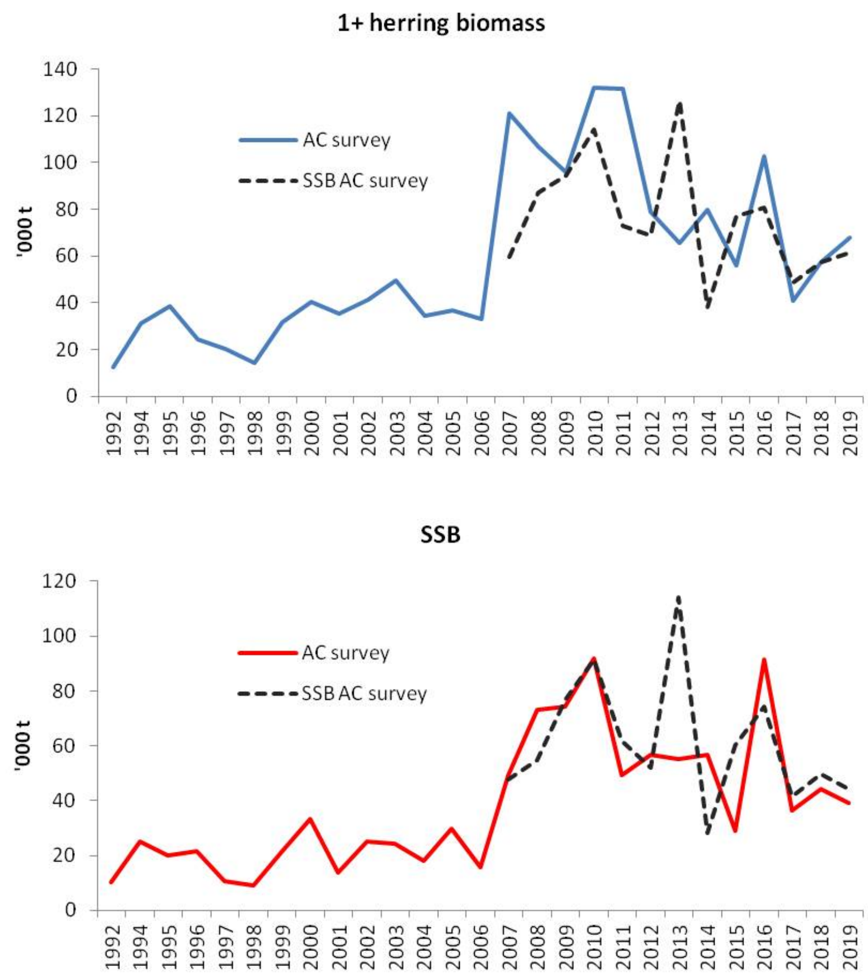


Figure 7.3.5 Herring in Division 7.a North (Irish Sea). Comparison of SSB indices from the acoustic survey estimates of SSB (red line) and the later survey 7.aNSpawn (dotted line).

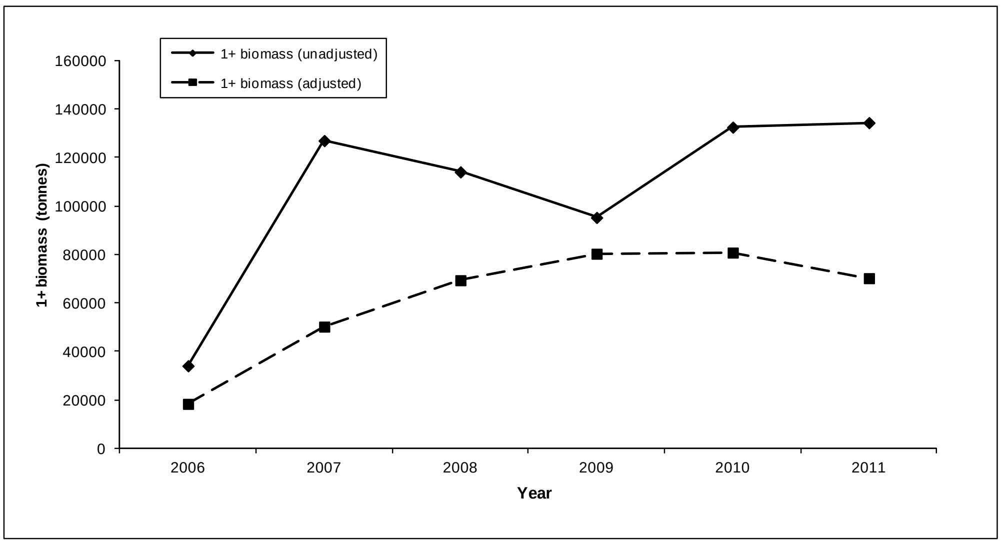


Figure 7.3.6 Herring in Division 7.a North (Irish Sea). Comparison of 1-ringer+ biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted datasets.

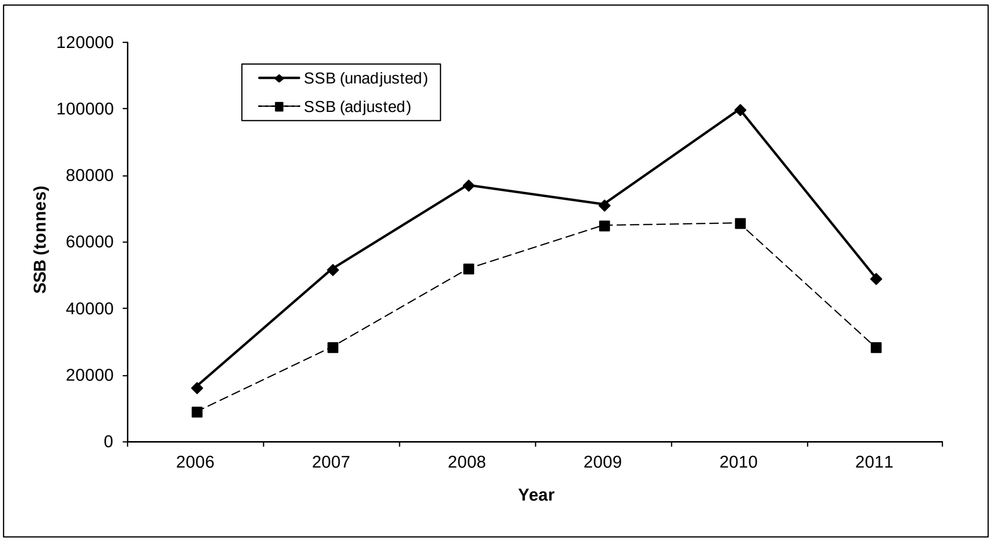


Figure 7.3.7 Herring in Division 7.a North (Irish Sea). Comparison of SSB biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted datasets.

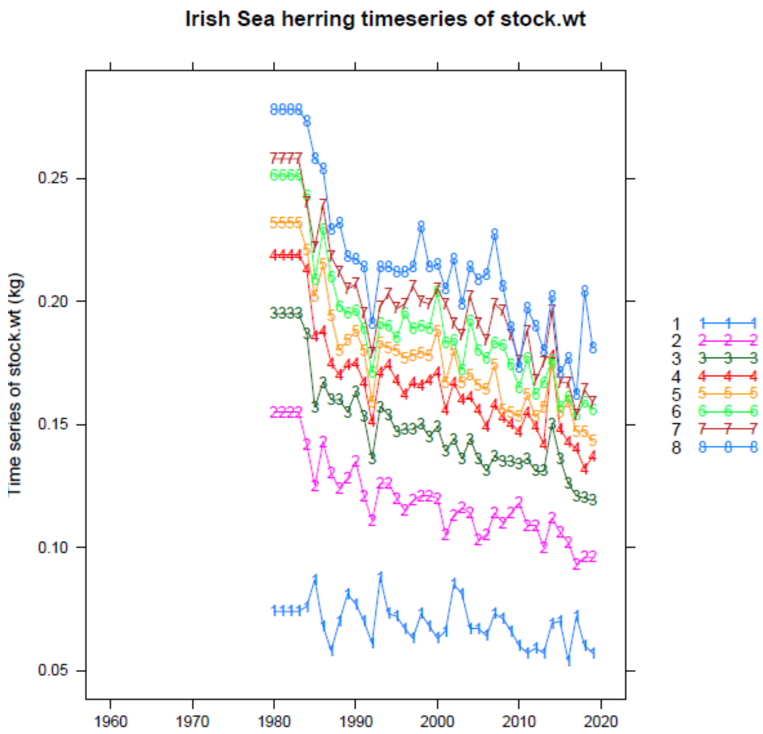


Figure 7.4.1 Herring in Division 7.a North (Irish Sea). Time-series of catch weights at age.

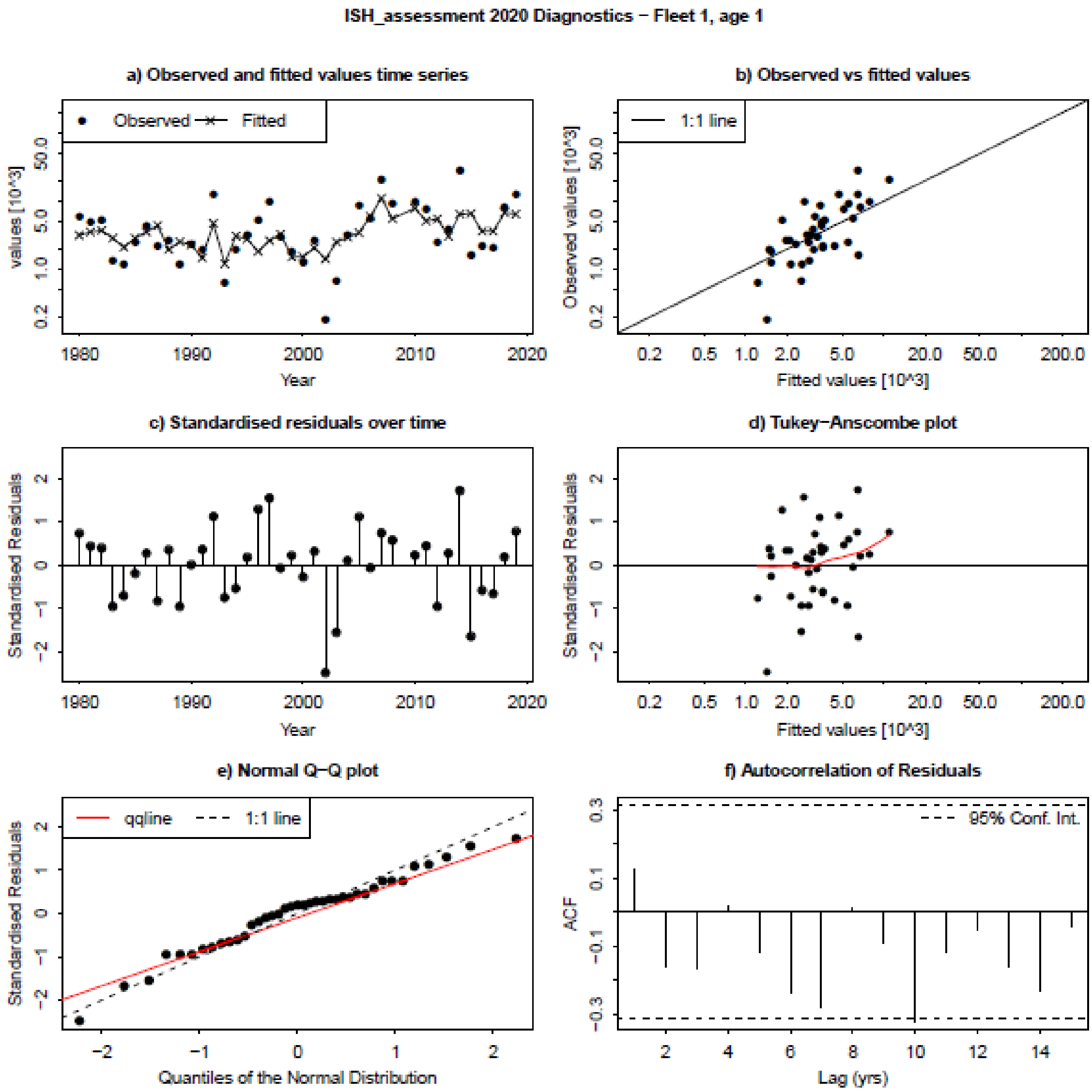


Figure 7.6.1 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age1.

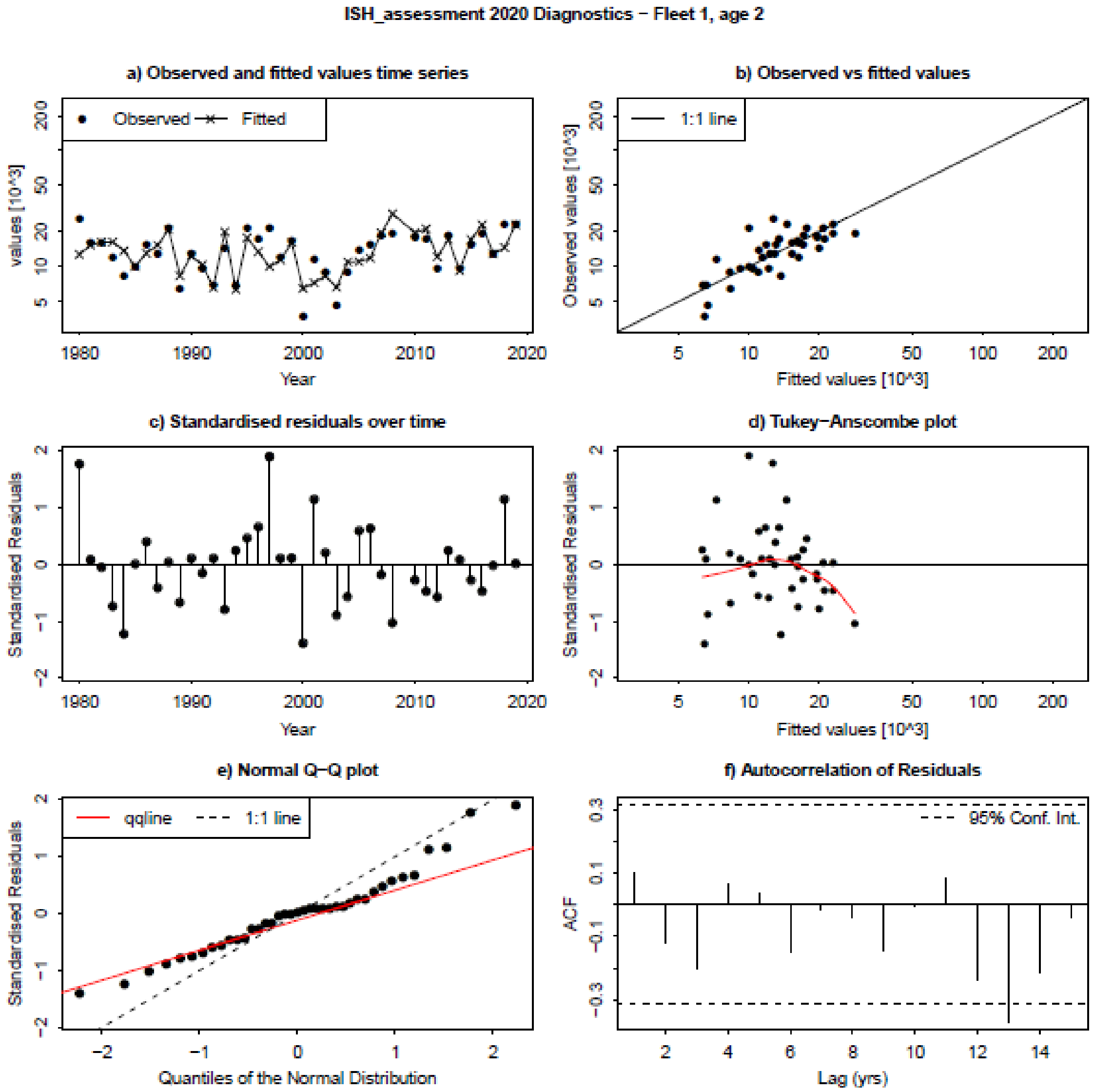


Figure 7.6.2 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age2.

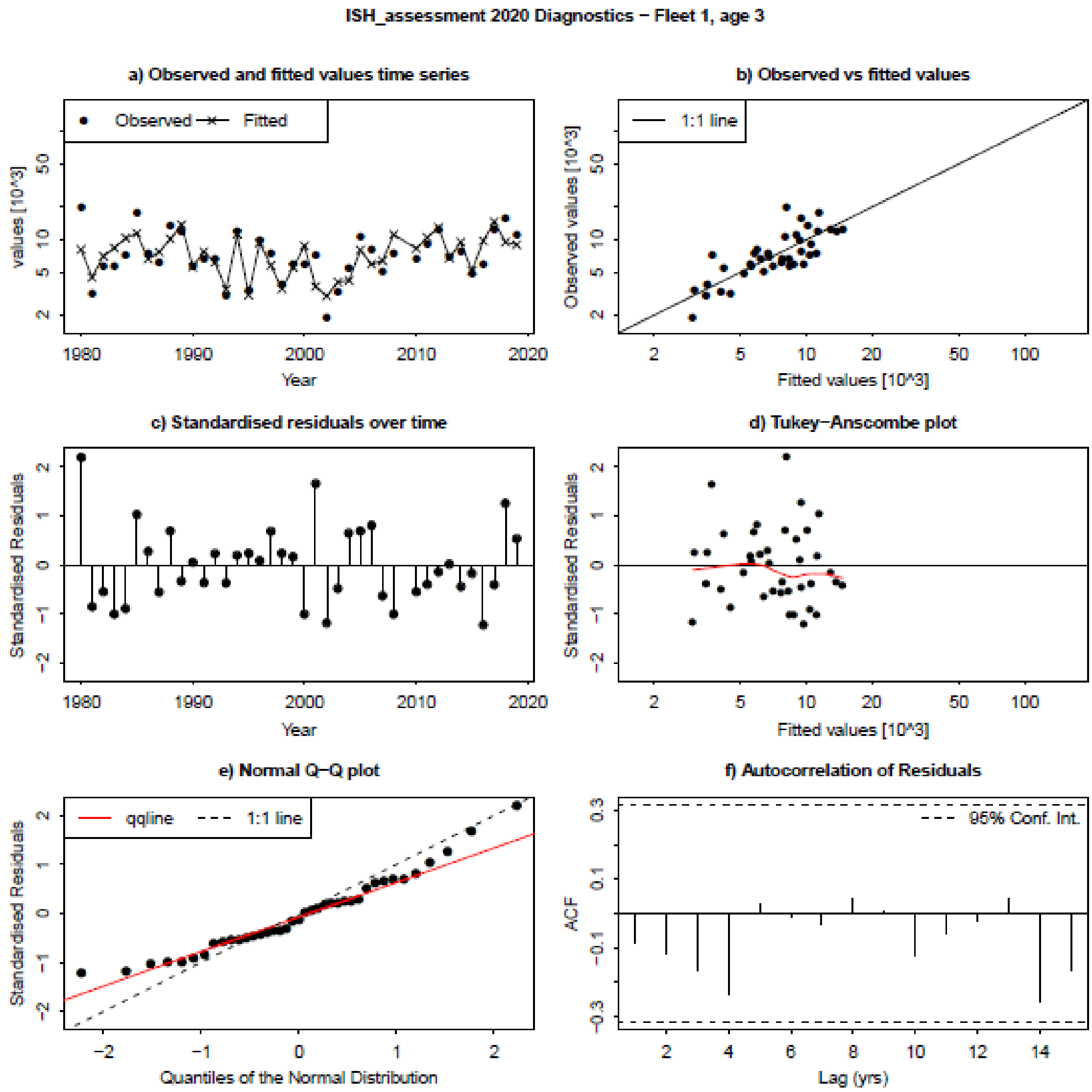


Figure 7.6.3 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age3.

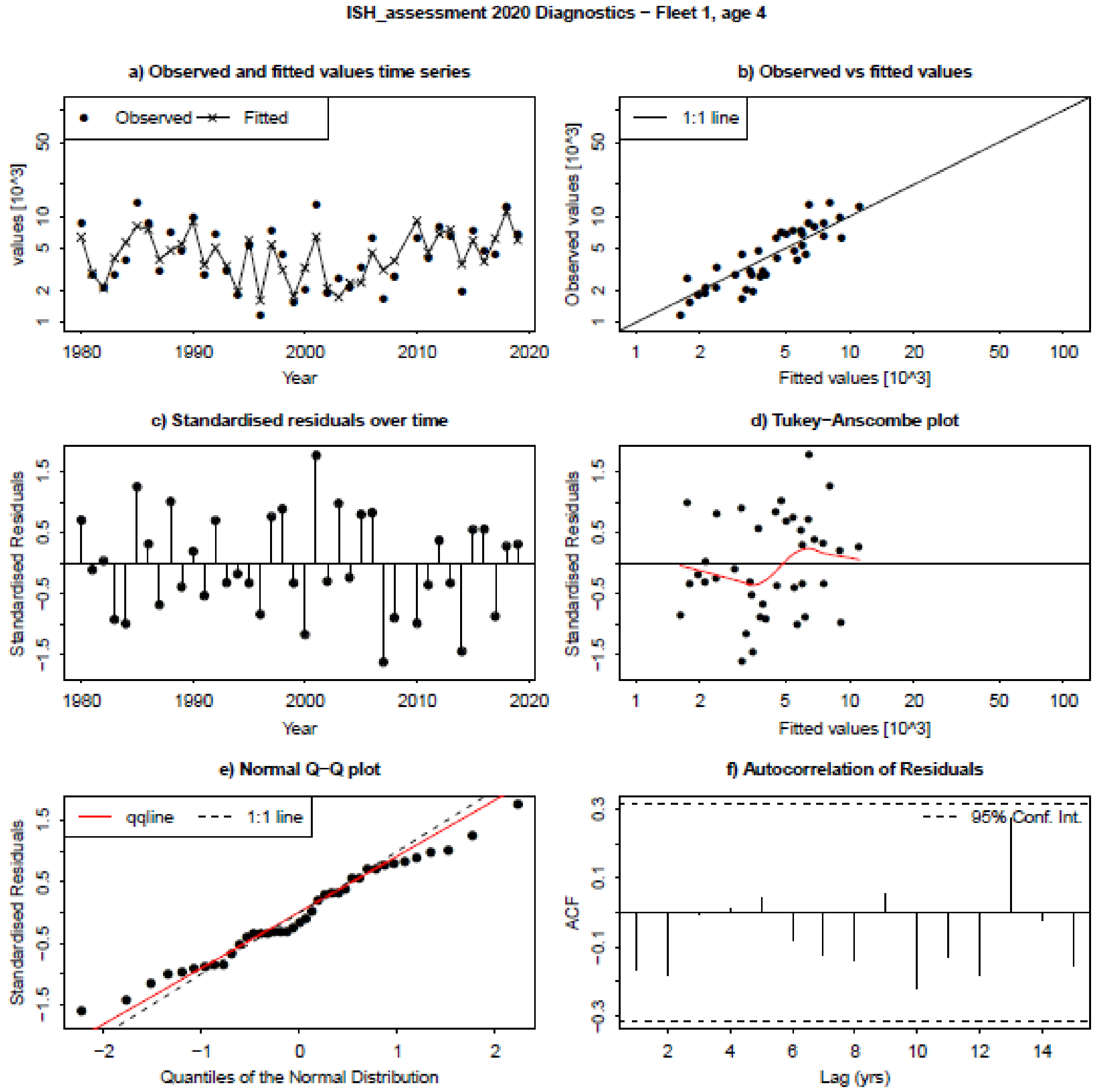


Figure 7.6.4 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age4.

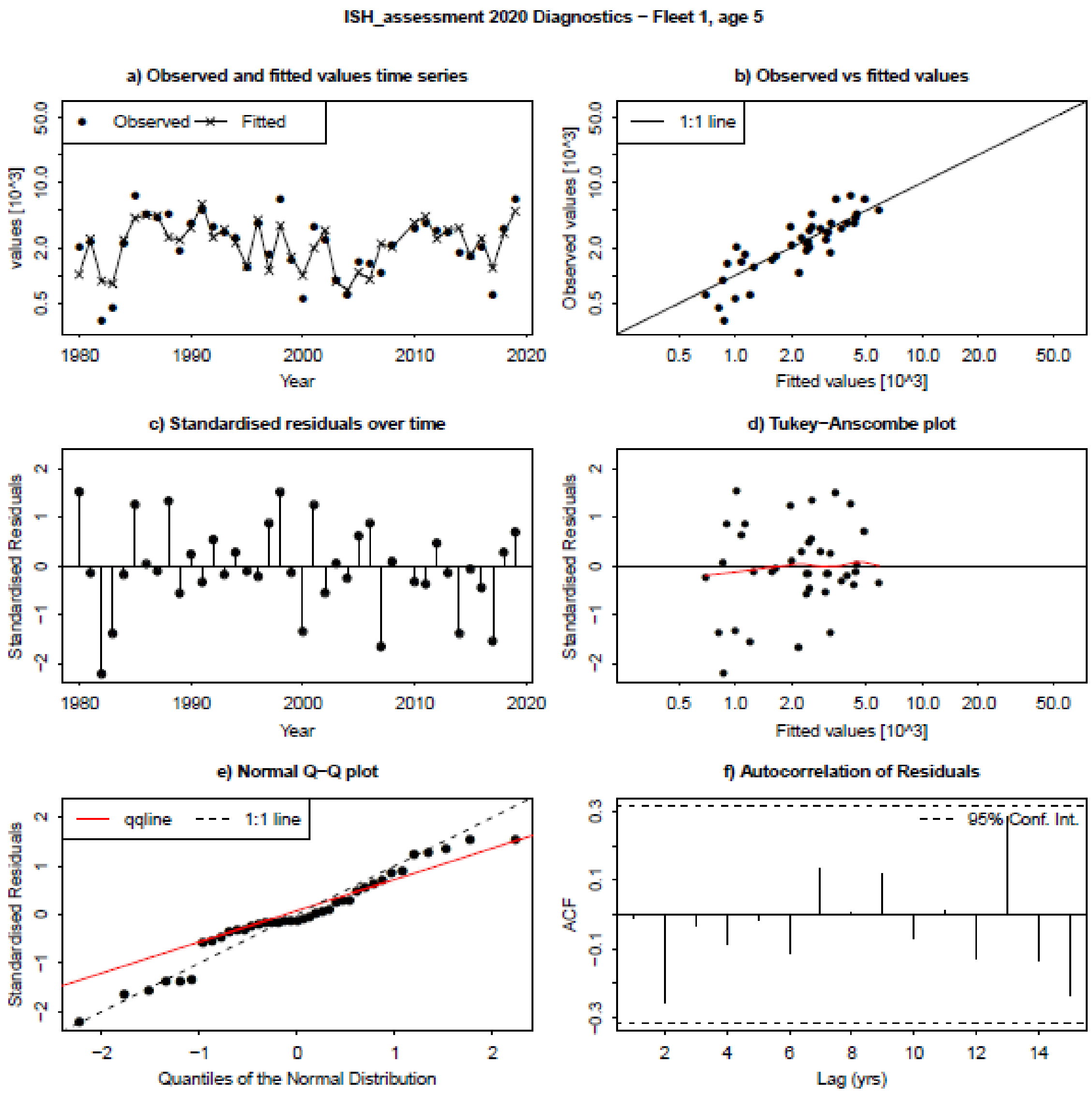


Figure 7.6.5 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age5.

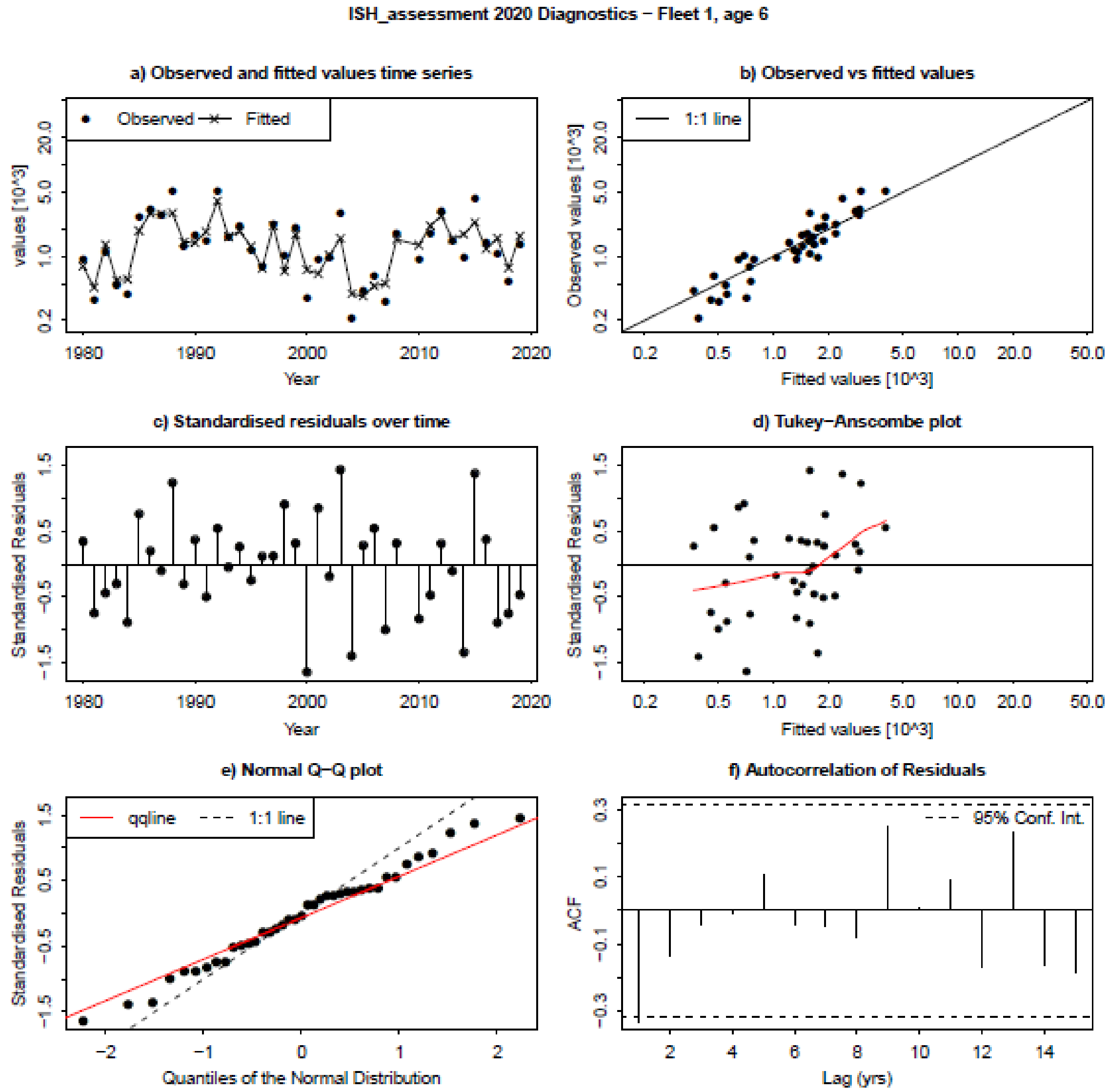


Figure 7.6.6 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age6.

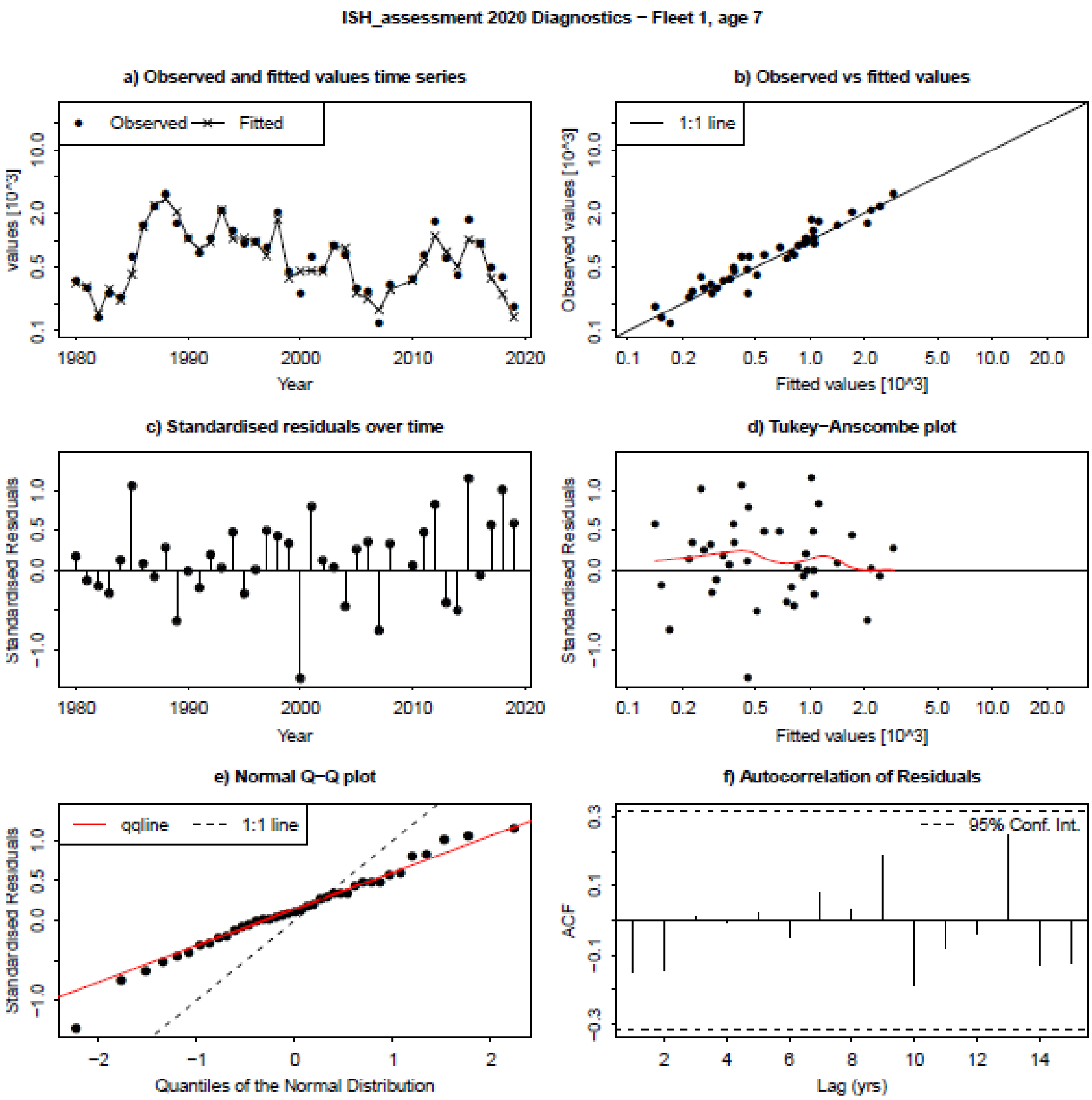


Figure 7.6.7 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age7.

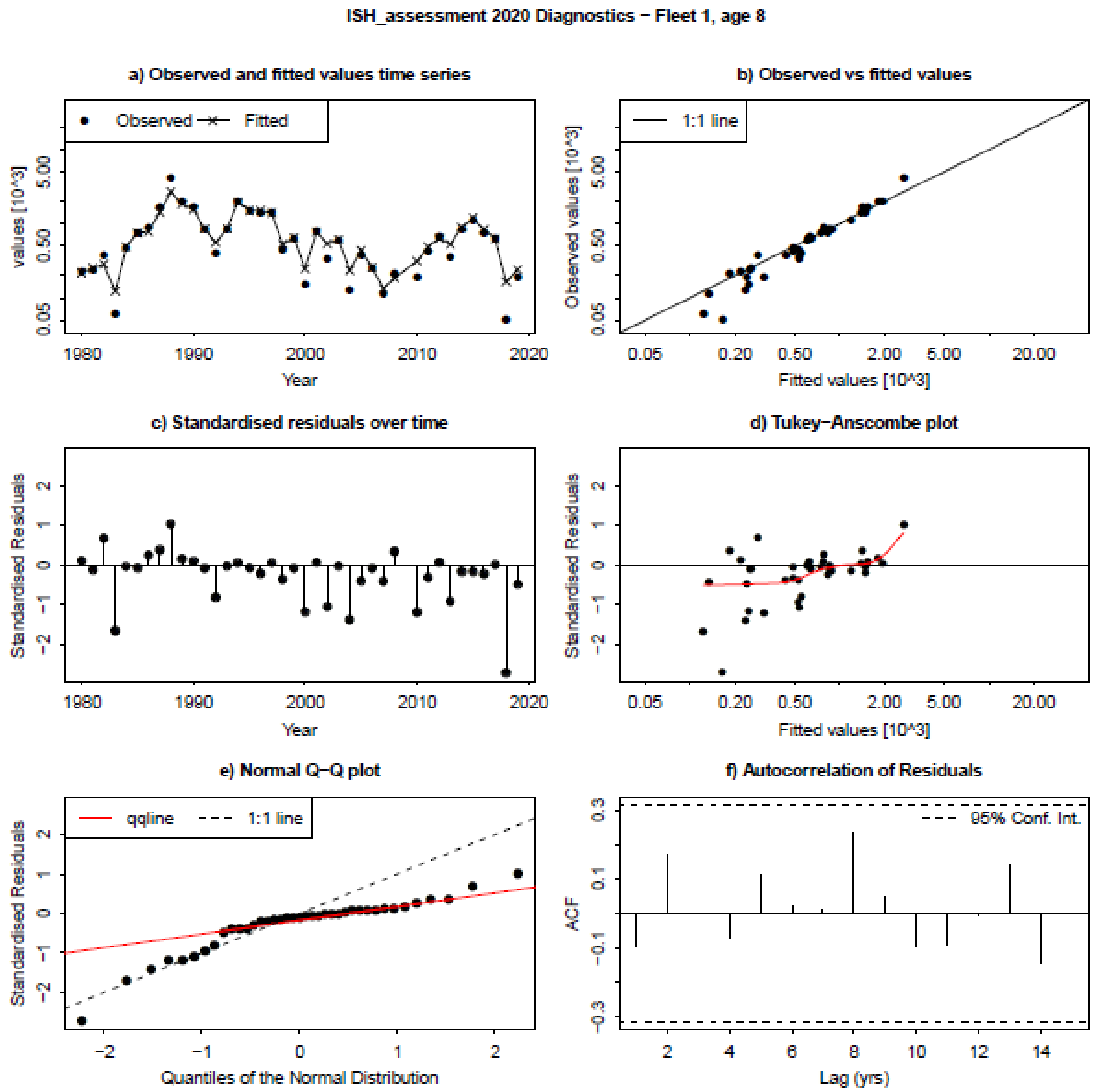


Figure 7.6.8 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age8.

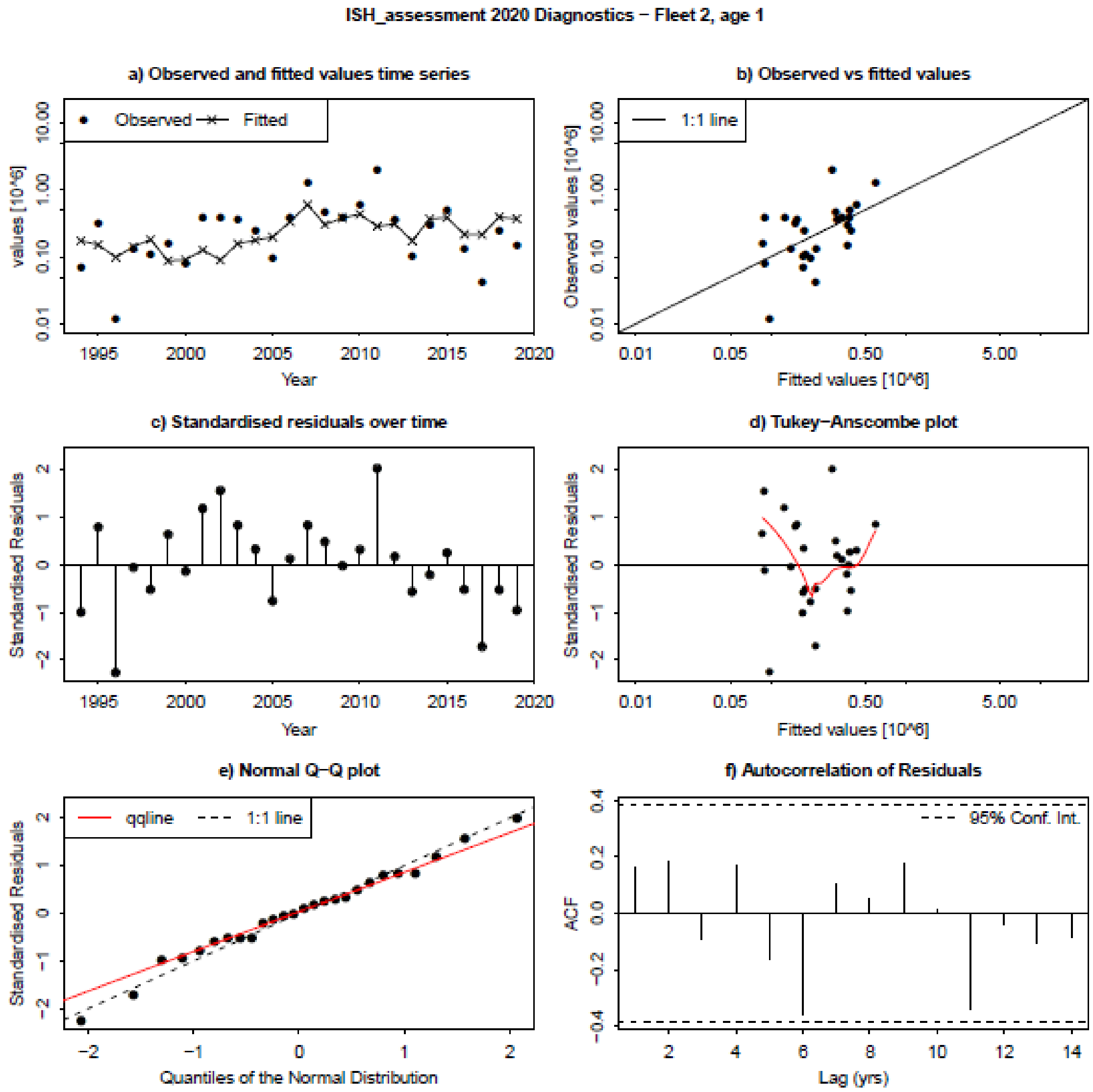


Figure 7.6.9 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age1.

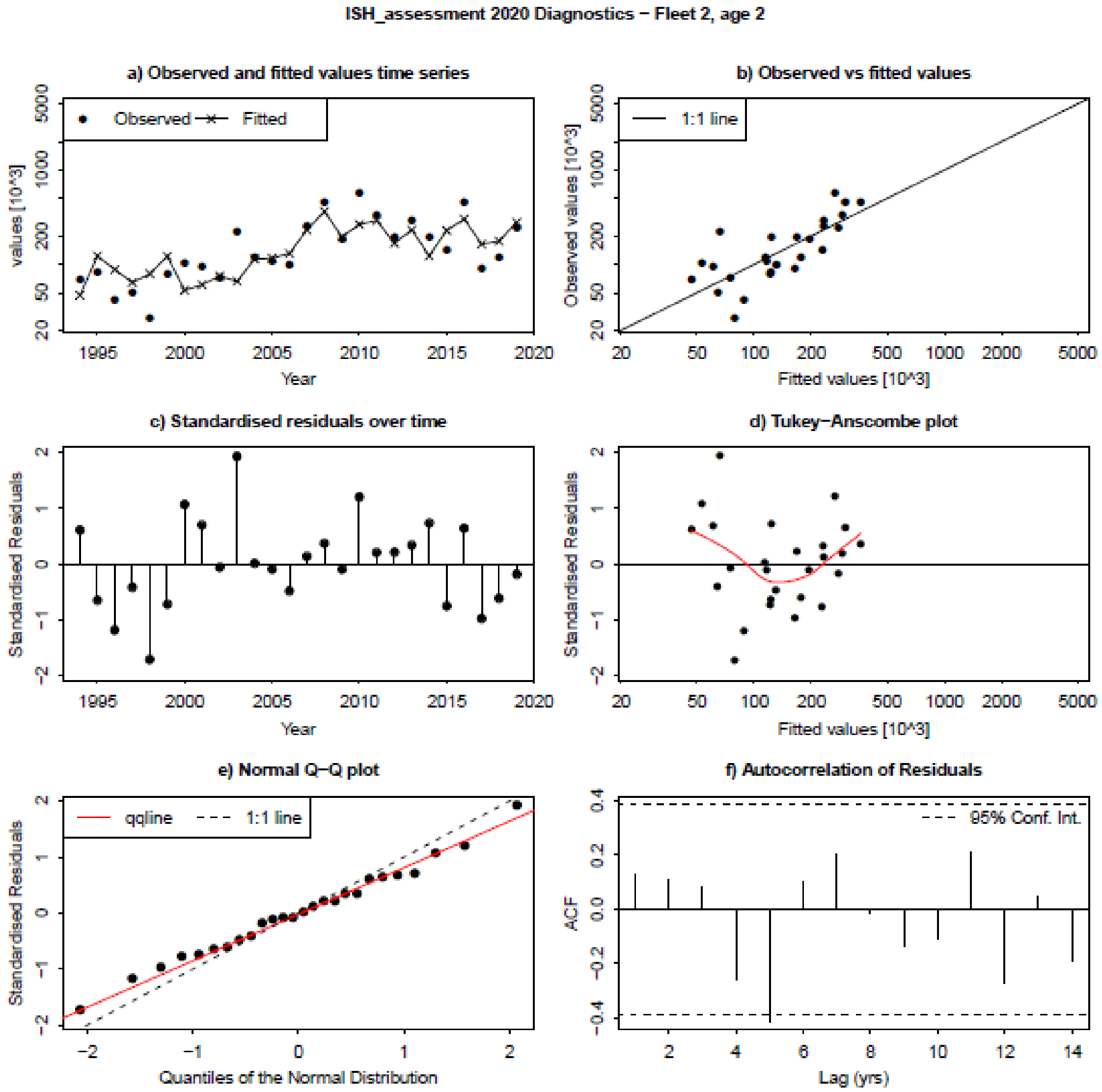


Figure 7.6.10 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age2.

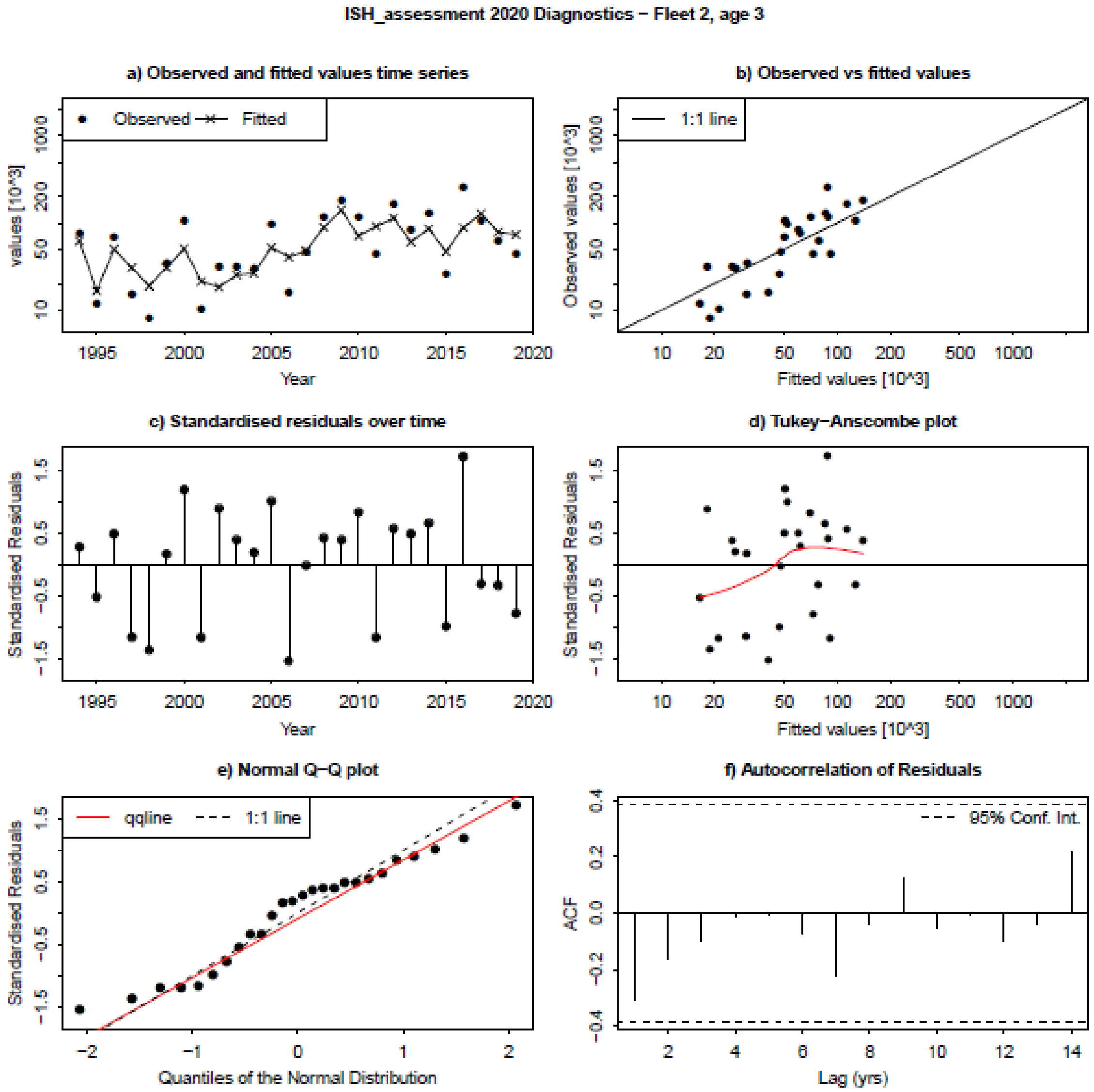


Figure 7.6.11 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age3.

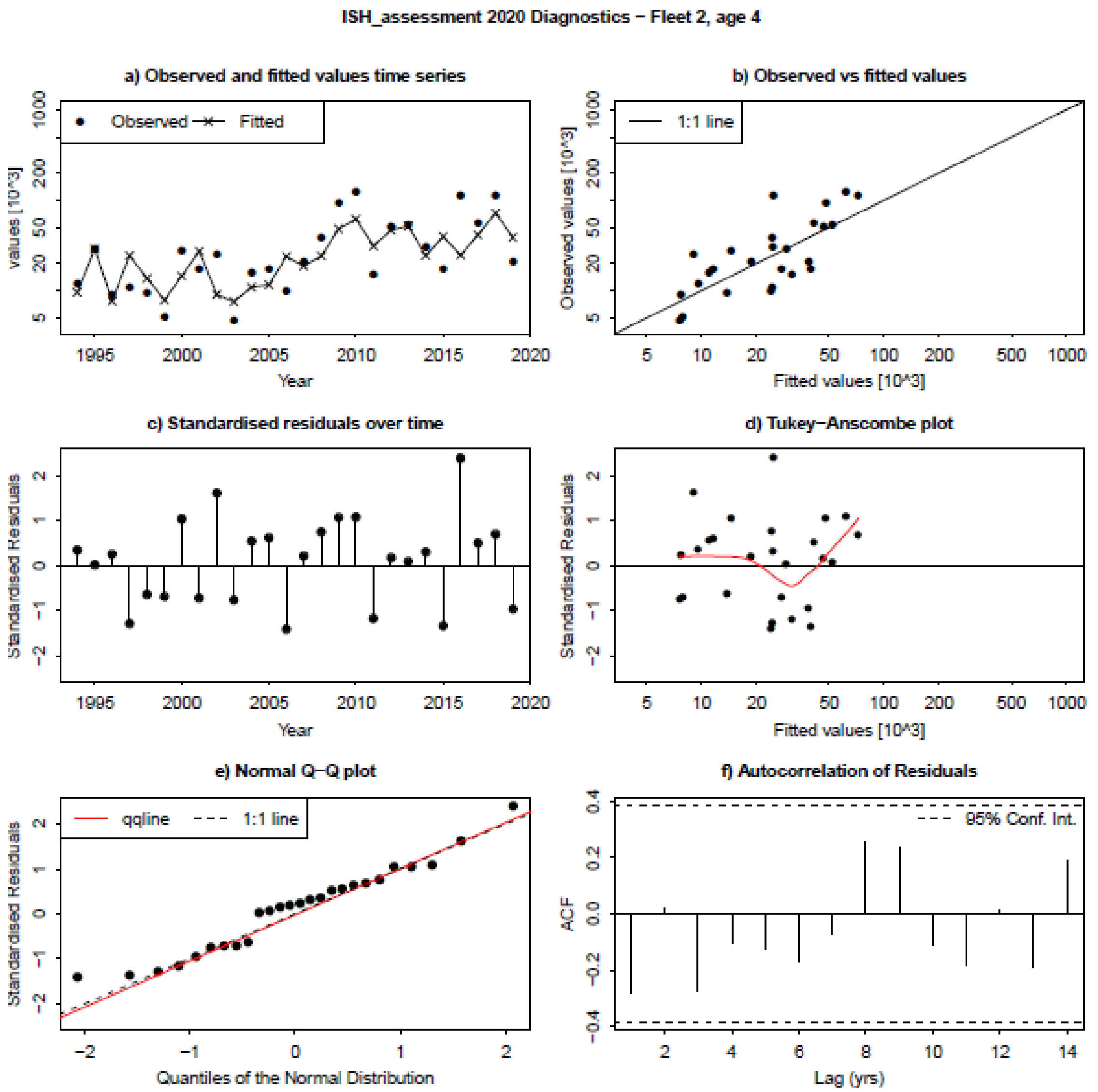


Figure 7.6.12 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age4.

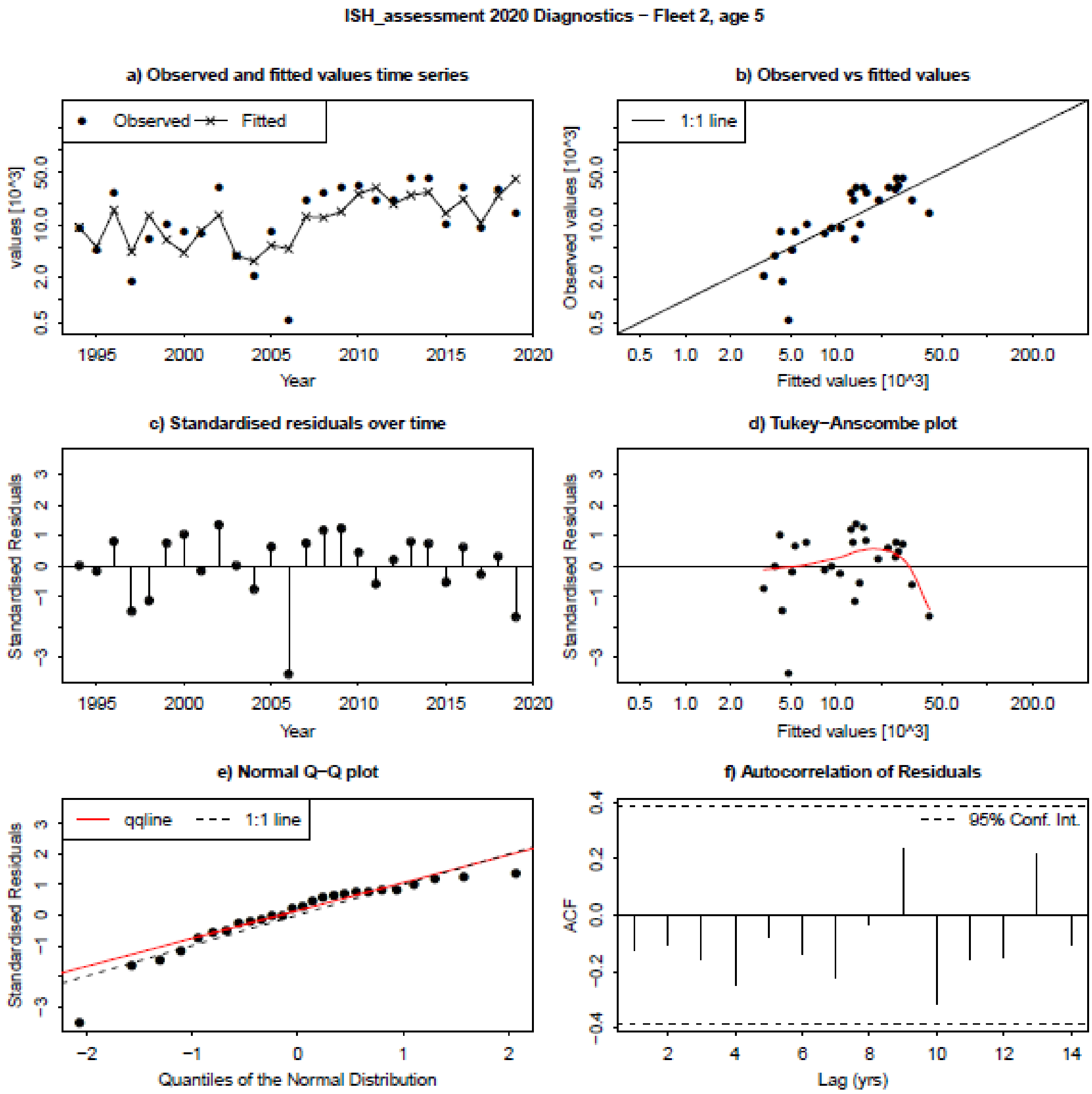


Figure 7.6.13 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age5.

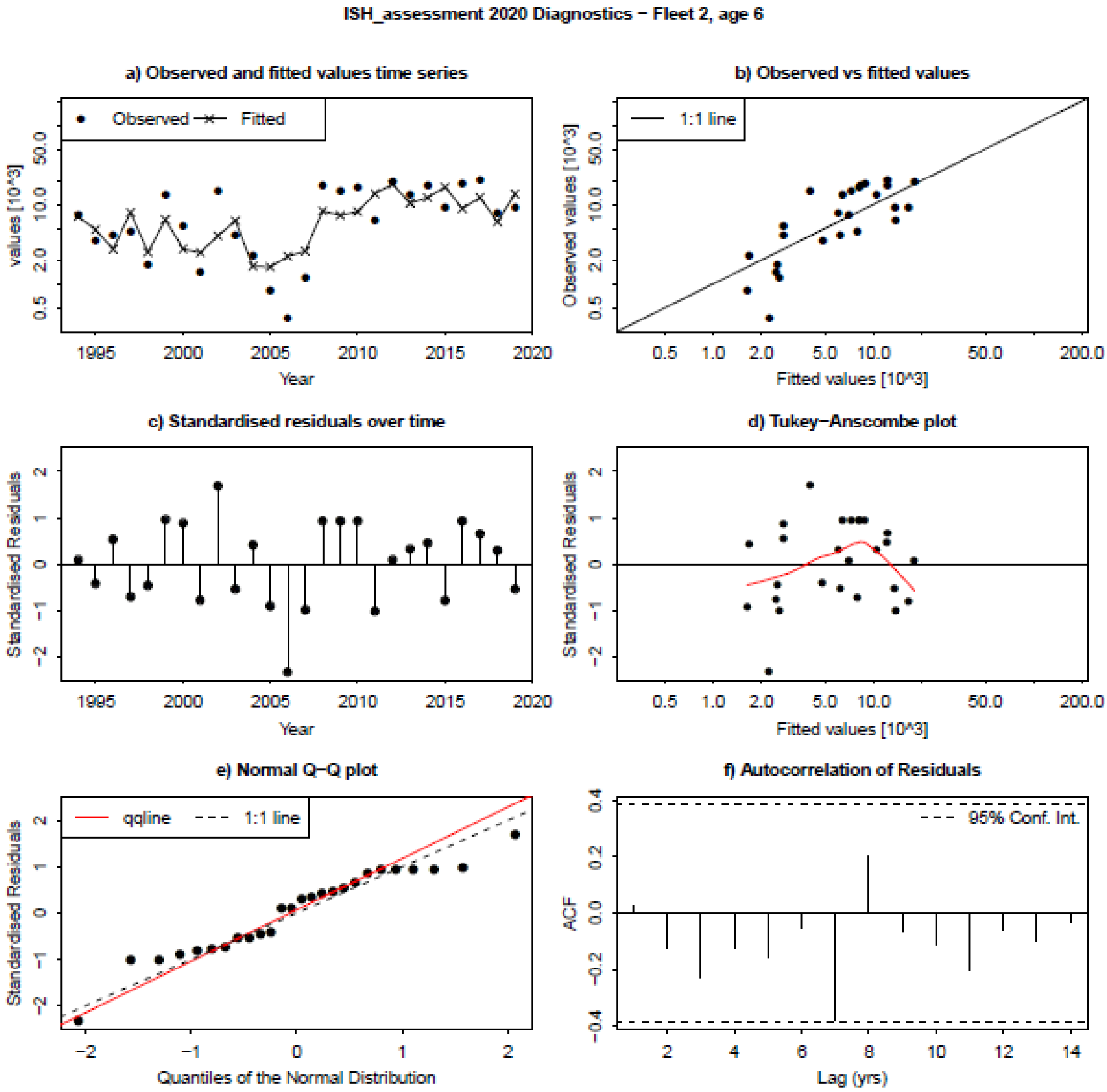


Figure 7.6.14 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age6.

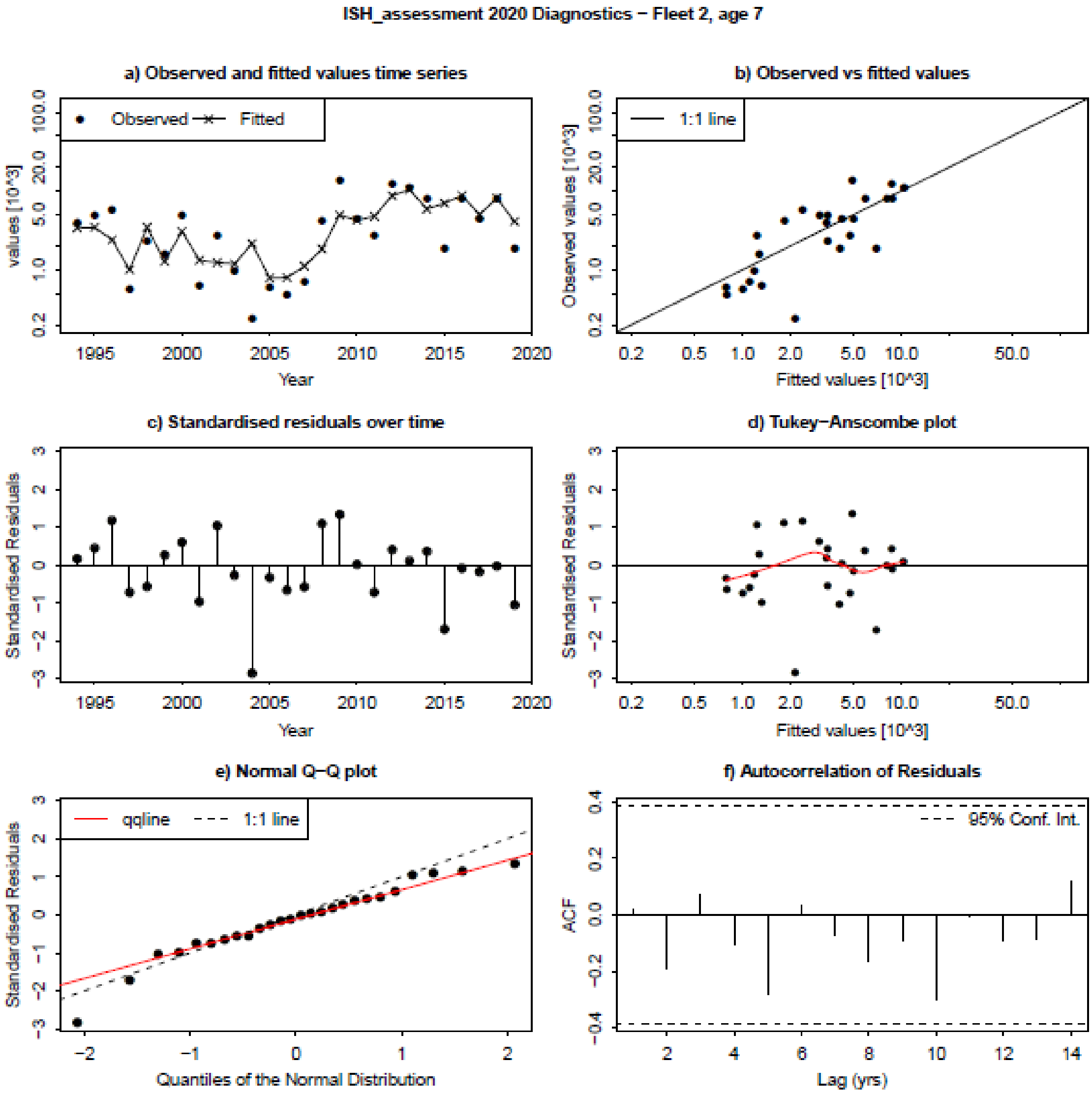


Figure 7.6.15 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age7.

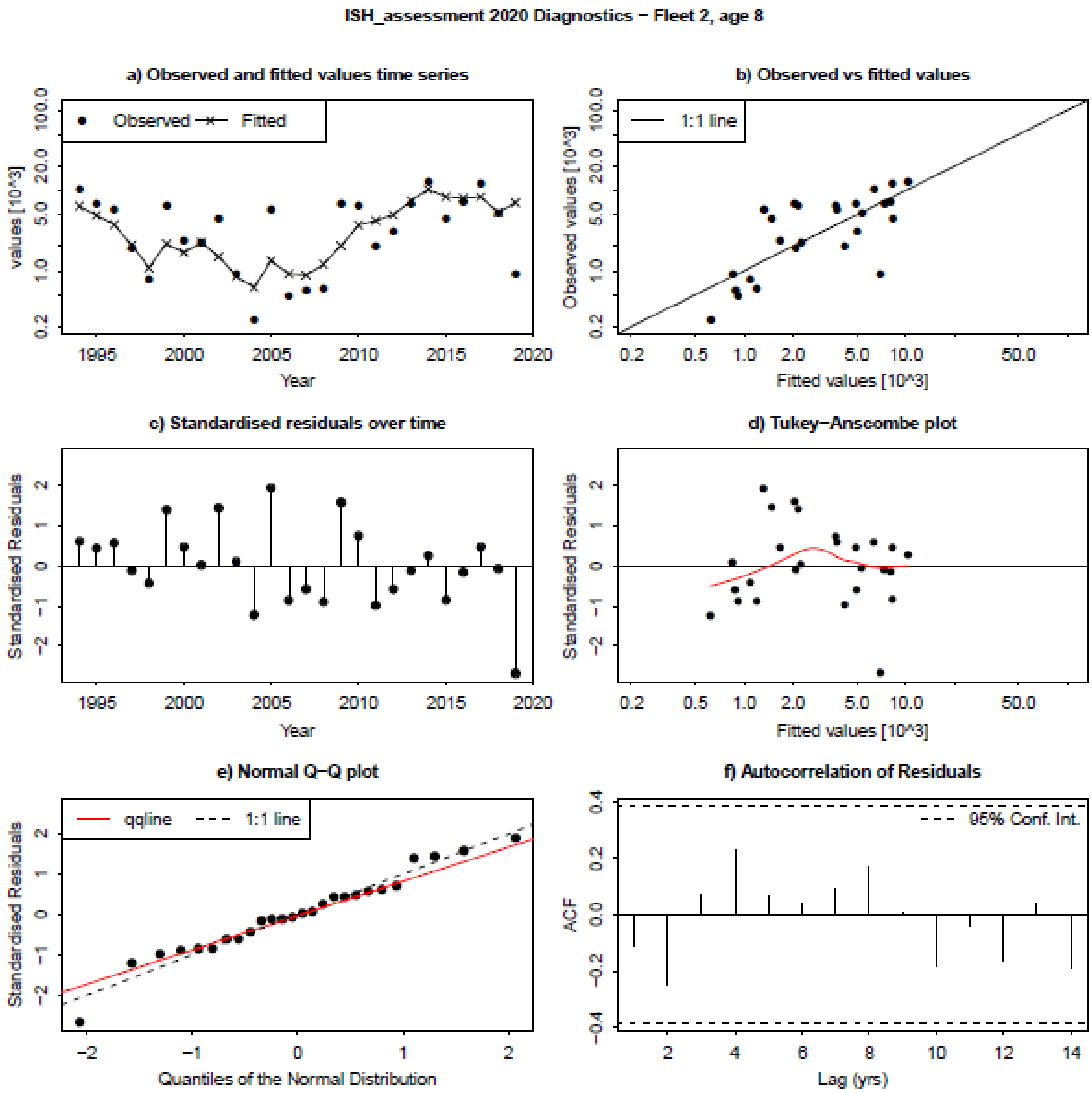


Figure 7.6.16 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age8.

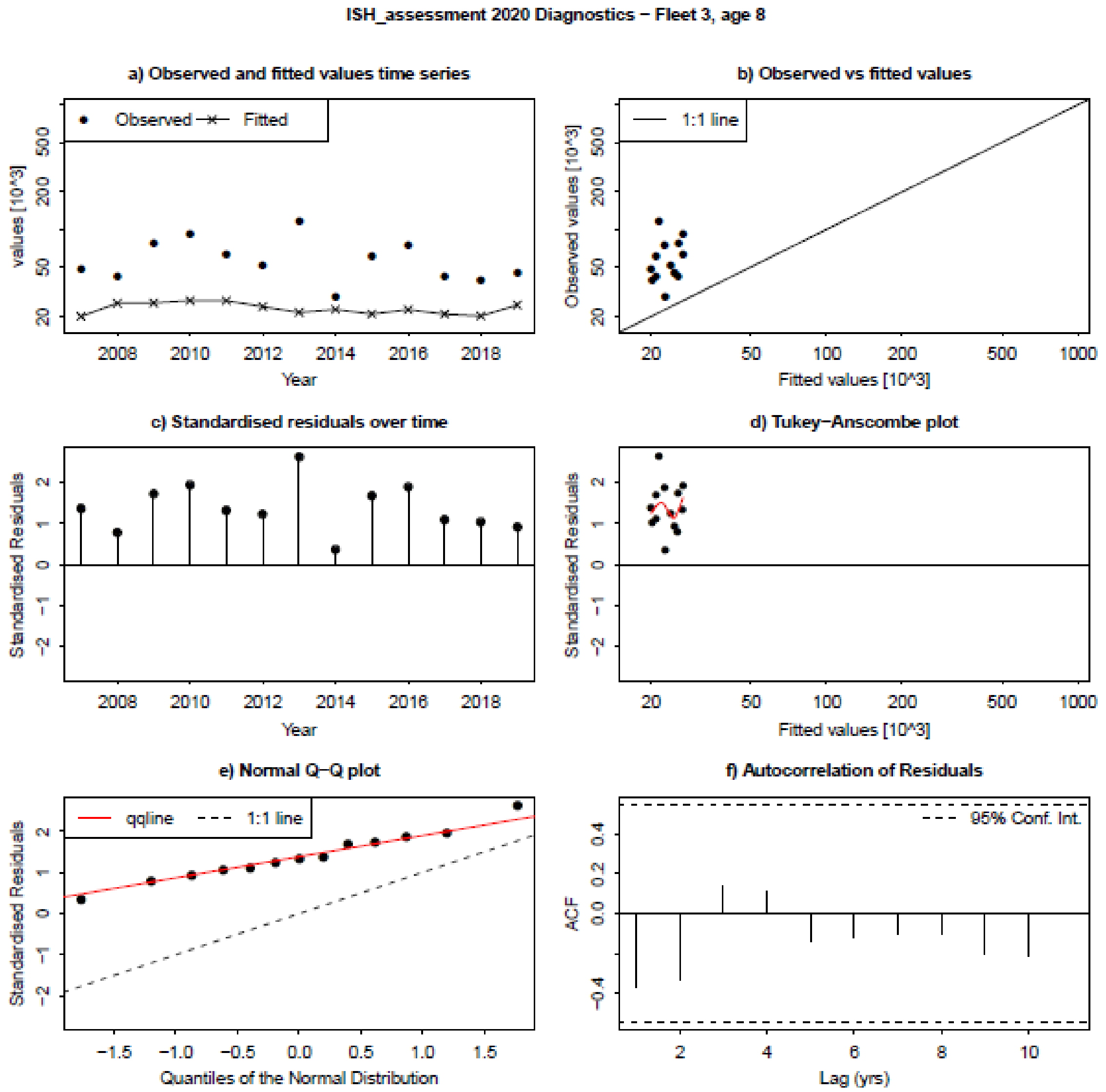


Figure 7.6.17 Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the SSB acoustic survey (SSB 7.aN)).

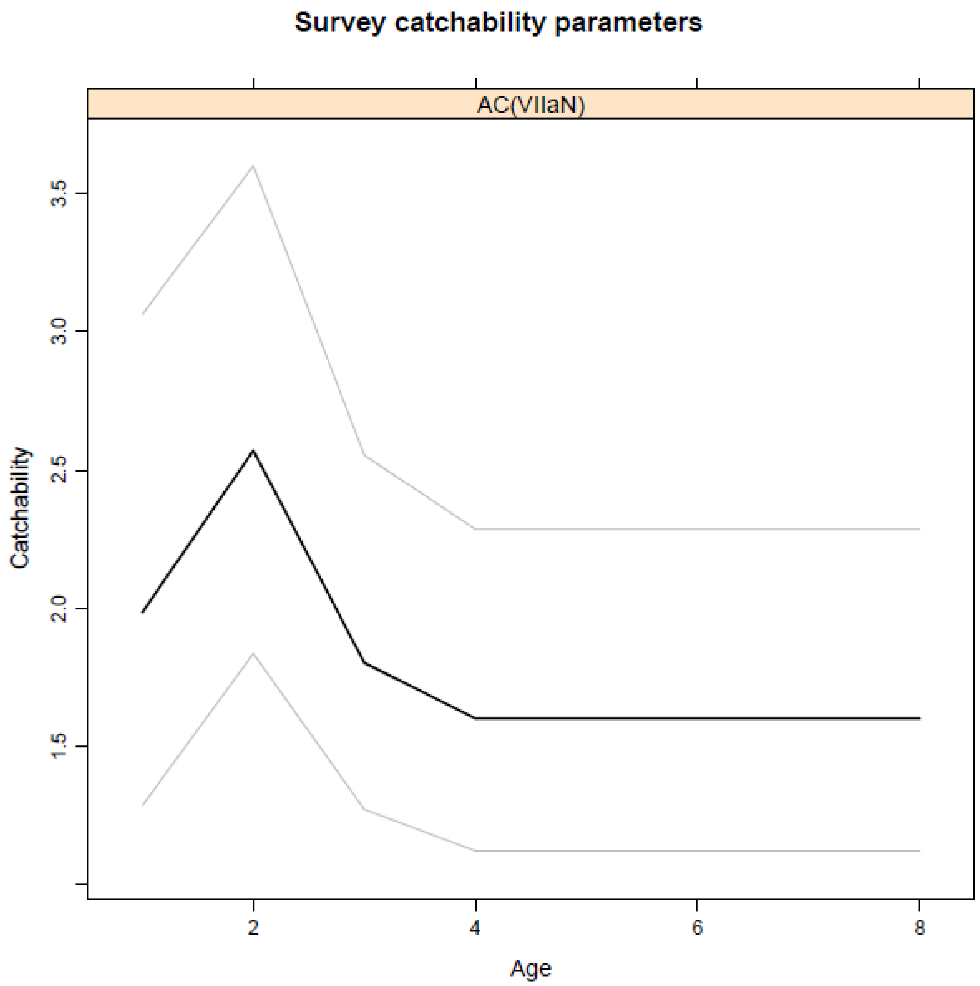


Figure 7.6.18 Herring in Division 7.a North (Irish Sea). FLSAM run output. Survey catchability parameter from the acoustic survey AC(7.aN).

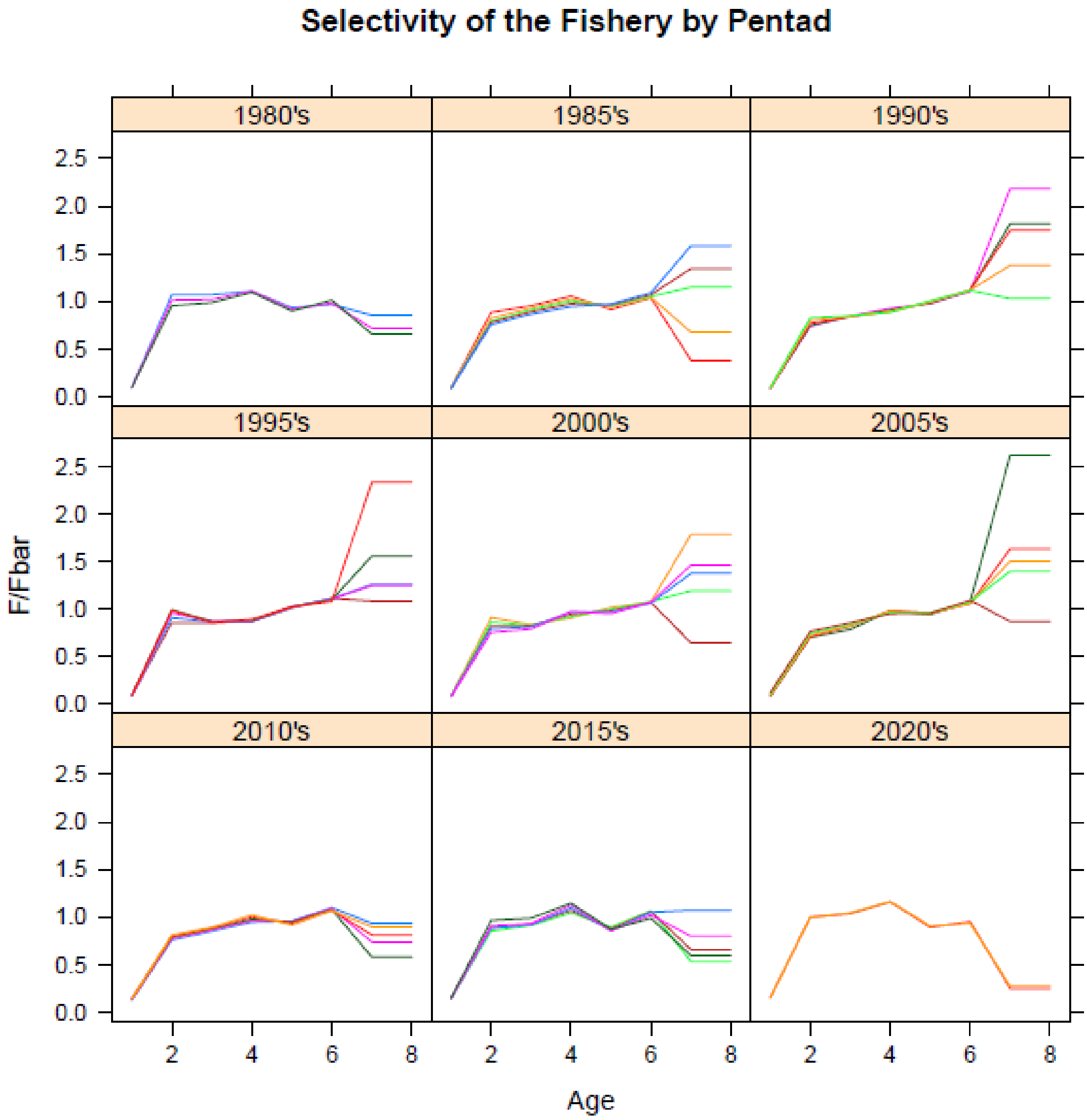


Figure 7.6.19 Herring in Division 7.a North (Irish Sea). FLSAM run output. Selectivity of the fishery by pentad.

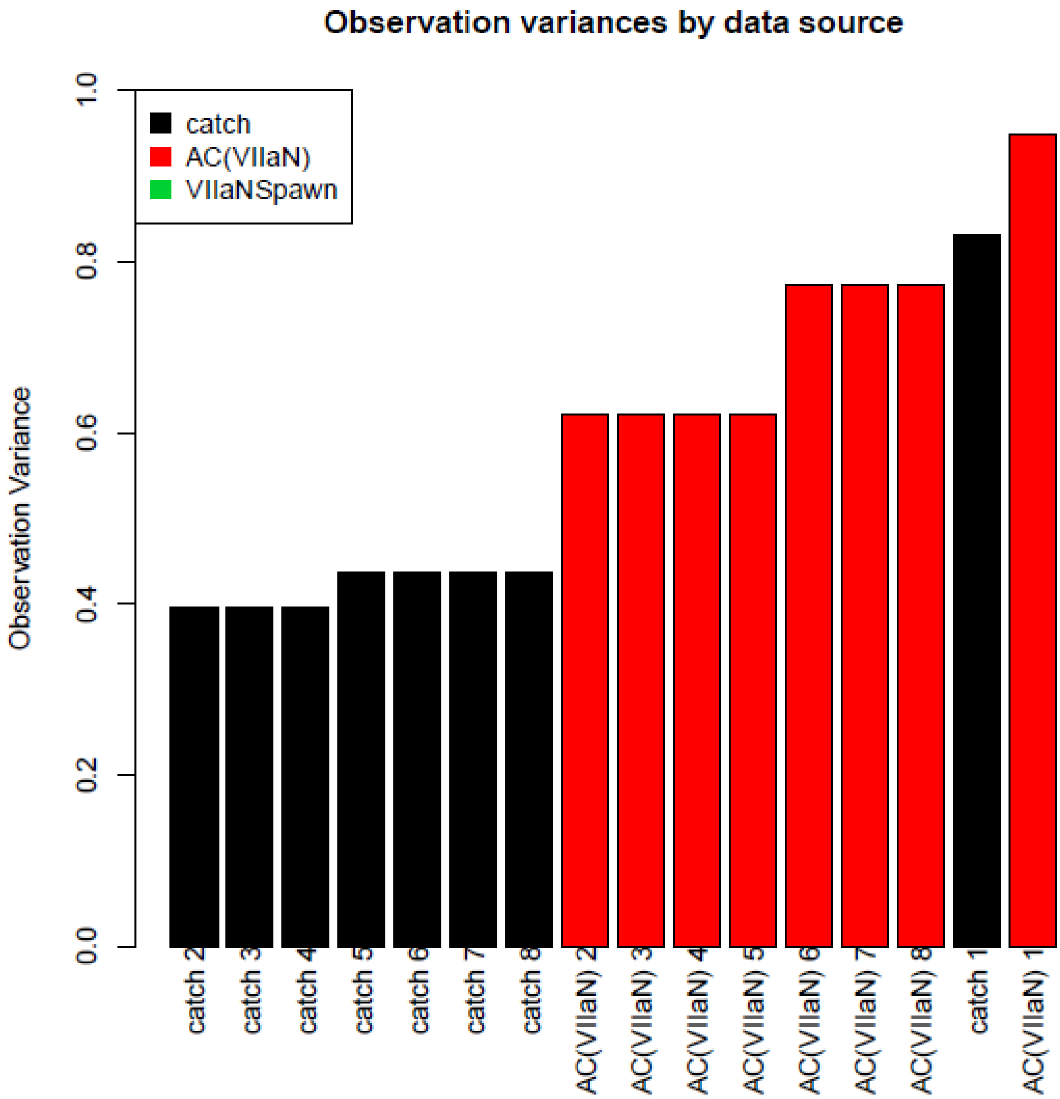


Figure 7.6.20 Herring in Division 7.a North (Irish Sea). Observation variances of all the data sources fitted in the FLSAM assessment model. The observation variance of 7.aNSpawn is fixed at 0.4

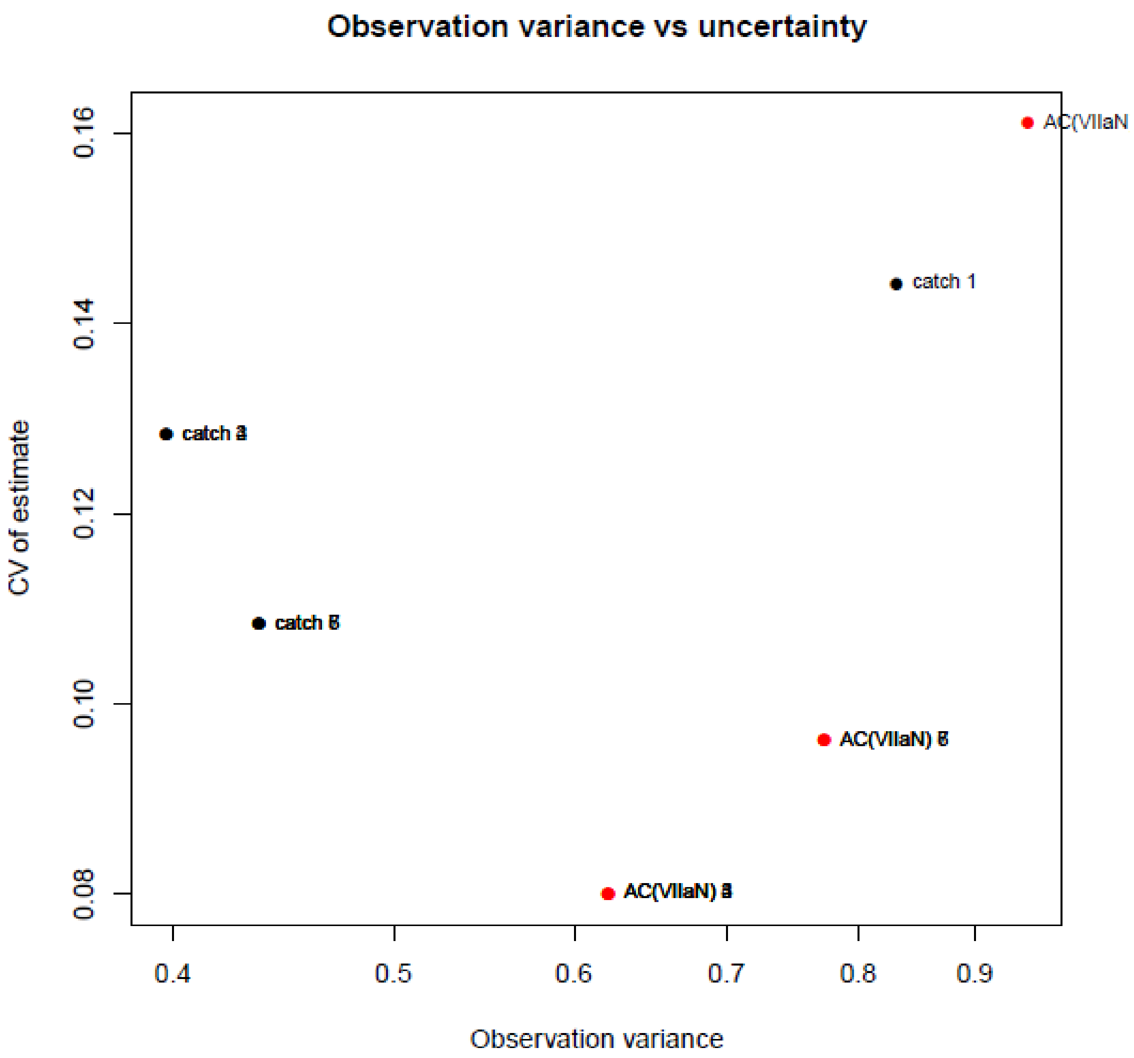


Figure 7.6.21 Herring in Division 7.a North (Irish Sea). Observation variances vs uncertainty of the data sources fitted in the FLSAM assessment model.

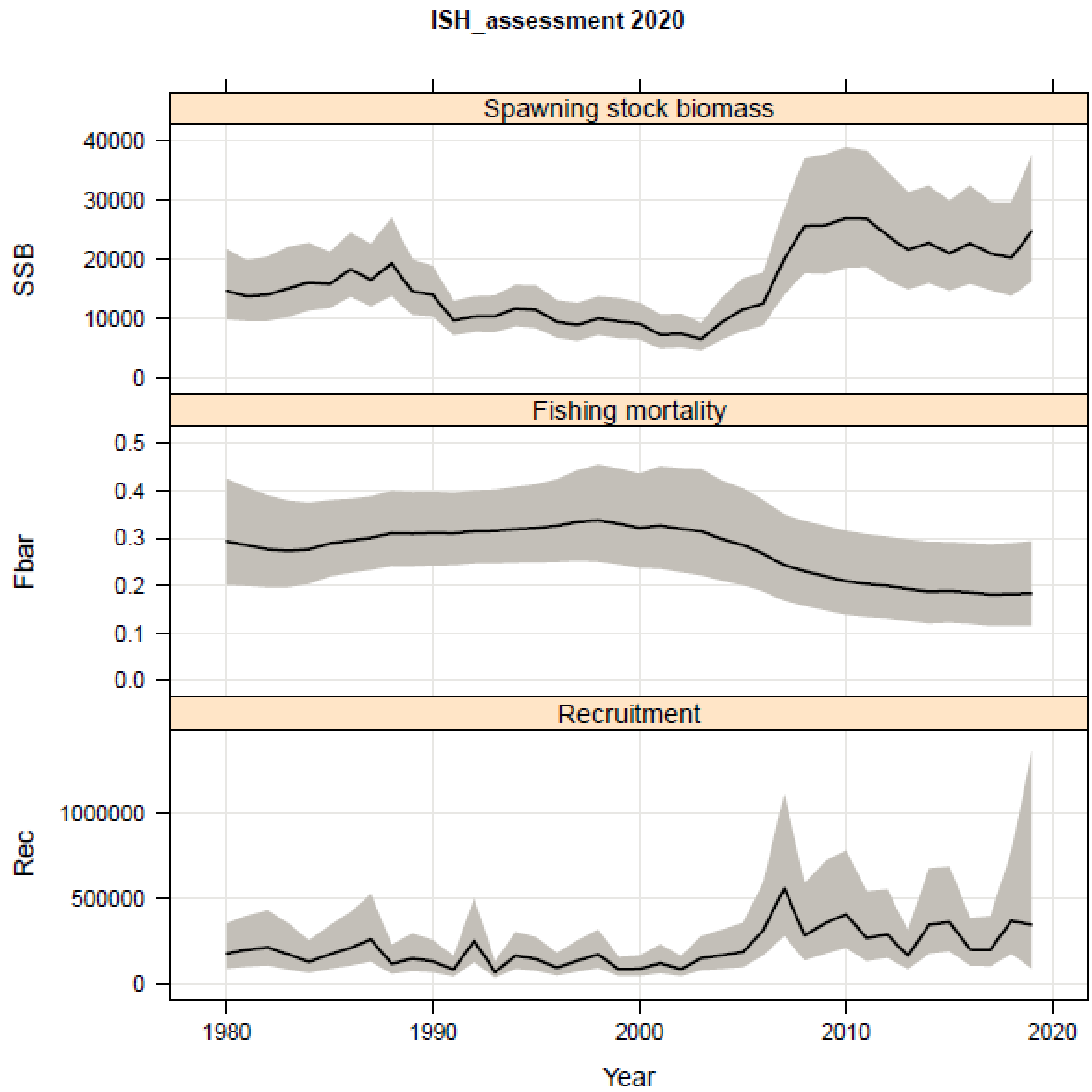


Figure 7.6.22 Herring in Division 7.a North (Irish Sea). Stock trends from the final FLSAM run, with 95% confidence intervals. Summary of estimates of spawning stock at spawning time, recruitment at 1-winter ring, mean $F_{4\text{-}6}$.

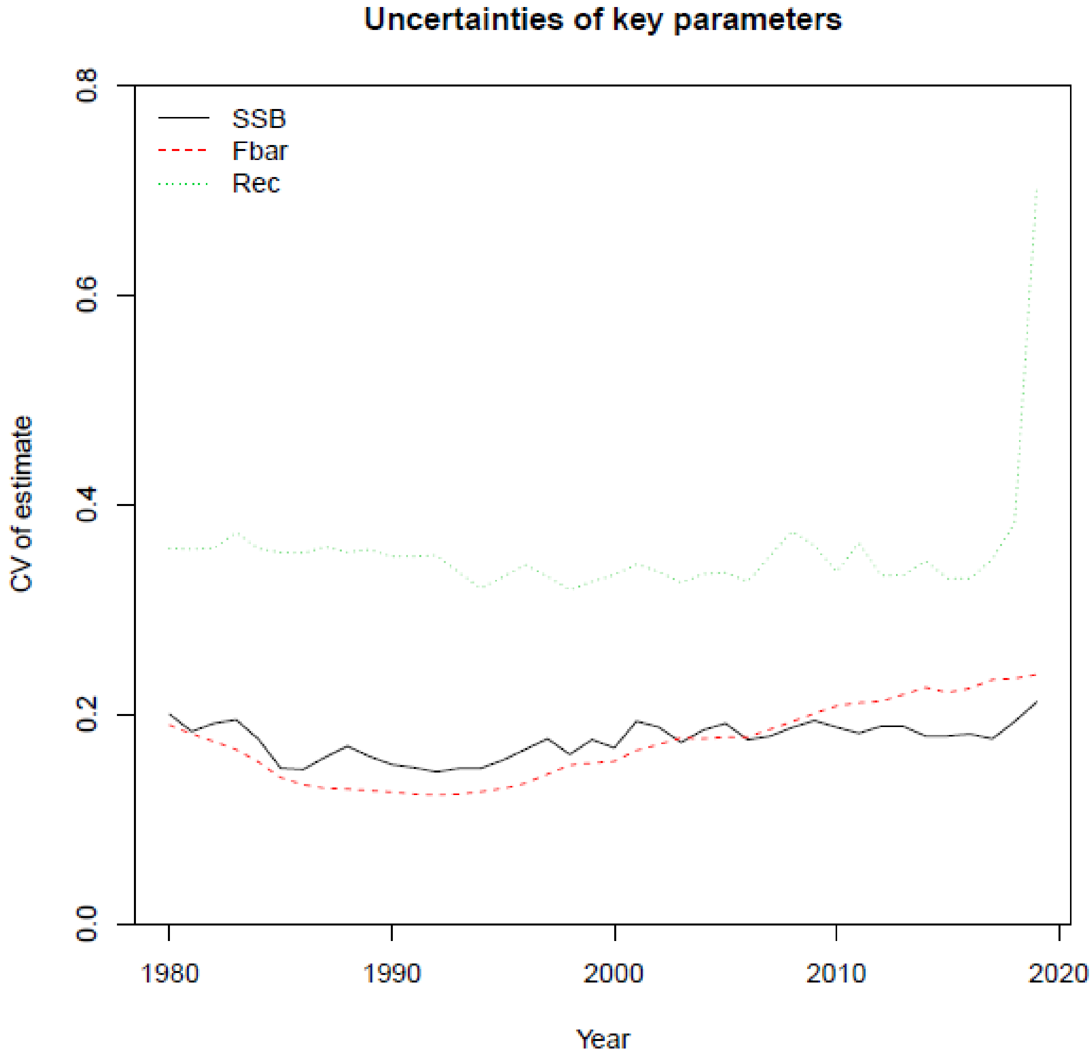


Figure 7.6.23 Herring in Division 7.a North (Irish Sea). Uncertainty of stock parameter estimates from the final FLSAM assessment. Rec = recruitment 1 winter ring.

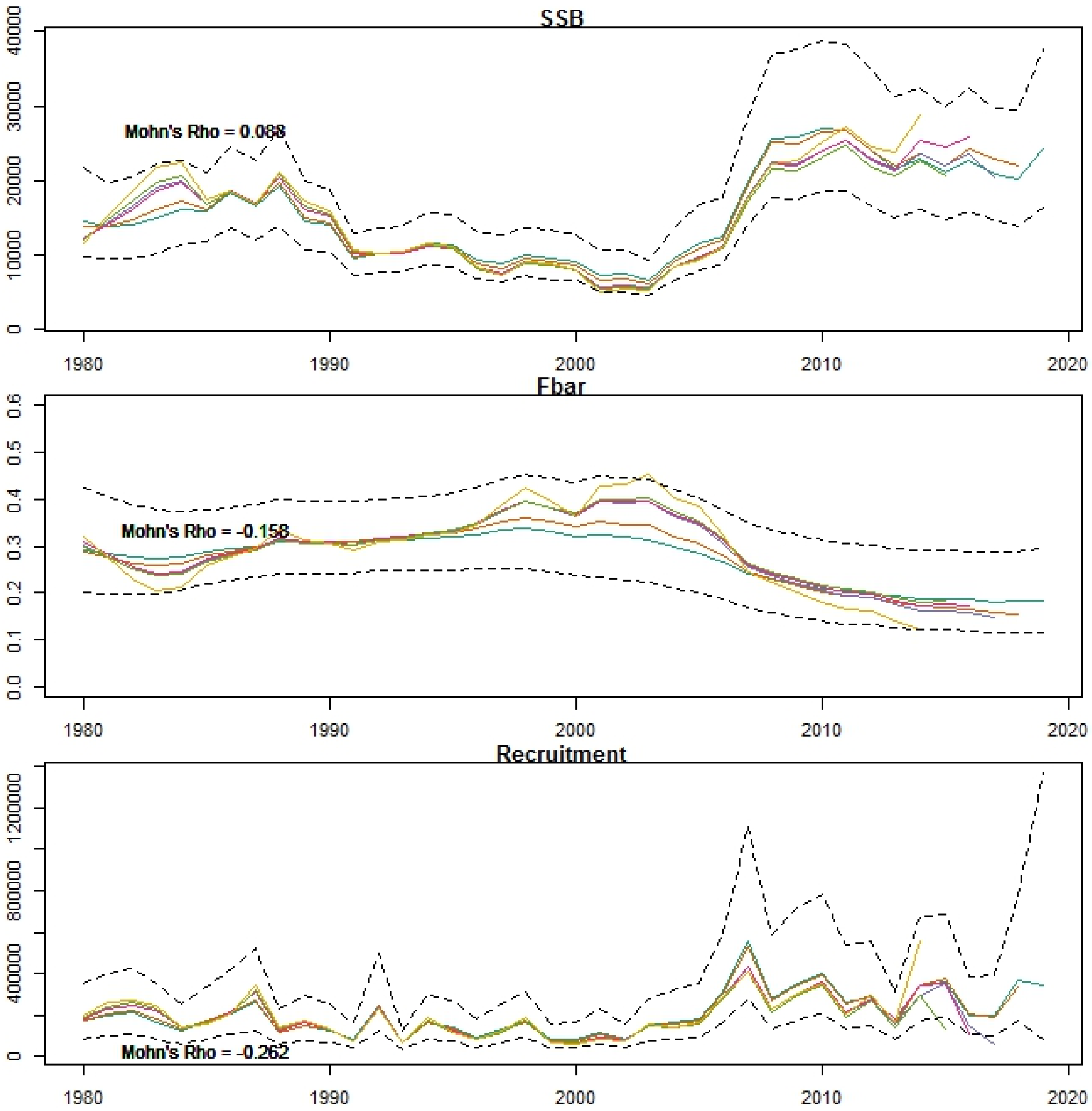


Figure 7.6.24 Herring in Division 7.a North (Irish Sea). Analytical retrospective patterns (2018 to 2013) of SSB, recruitment and mean F_{4-6} from the final FLSAM assessment. Confidence limits for the current year assessment are shown with dashed lines.

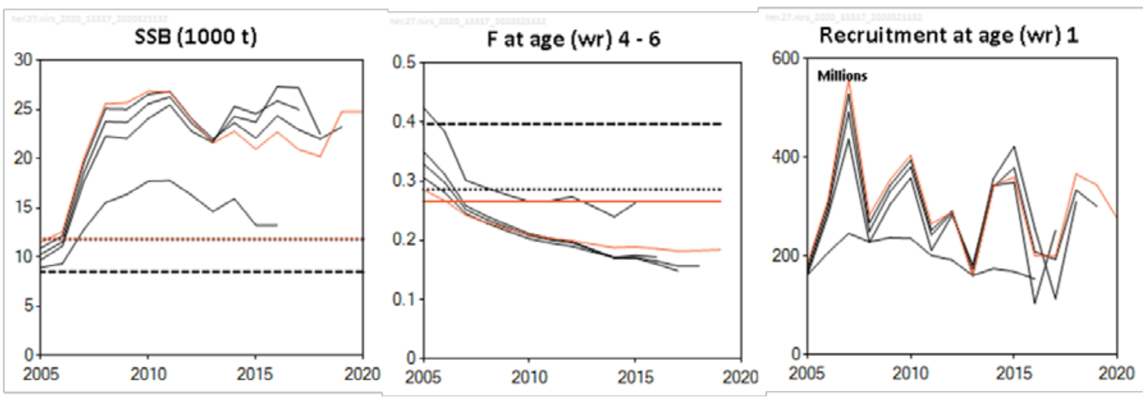


Figure 7.6.25 Herring in Division 7.a North (Irish Sea). Comparison of stock parameters between the 2019 (red line) and previous assessments.

8 Stocks with limited data

Three herring stocks have very little data associated with them and have been poorly described in recent reports. These are Clyde herring, part of Division 6aN (Section 5.11 in ICES 2005a), herring in 7.e,f and herring in the Bay of Biscay (Subarea 8). In this section only the time-series of landings are maintained.

8.1 Clyde herring

In 2011 under the provisions of the TAC and Quota Regulations (57/2011), the European Commission delegated the function of setting the TAC for certain stocks which are only fished by one Member State, to that Member State. This provision currently applies to herring in the Firth of Clyde with TAC setting responsibility delegated to Scotland. The stock is as such not an ICES stock with limited data, but it has been decided to continue to display the updated historical landings table for reasons of continuity. Since 1998 the agreed TAC for Clyde herring has never been reached. The TAC has been 583 t in 2019. No landings are reported in 2019 (Table 12.1).

8.2 Division 7.e.f

Figure 12.1 shows the time-series of landings over the period 1974–2019 in Division 7.e and 7.f. Data are taken from the ICES historical and official nominal databases and adjusted, where possible, with data supplied by working group members.

Since 1999, landings in Division 7.e are stable and have fluctuated between 5 and 800 t except in 2008 where they reached more than 1000 t (Figure 12.1).

In Division 7.f, it can be seen that there was a pulse of landings in the late 1970s. Since then landings have fluctuated between 200 t and a very few tonnes in recent years, without any obvious trend. Landings in 2019 amount to 10 tonnes (Figure 12.1).

8.3 Subarea 8 (Bay of Biscay)

In the Bay of Biscay, French landings peaked at 1700 t in 1976, declining gradually to very low levels by the late 1980s. More recently there was a sudden peak pulse of Dutch landings of 8000 t in 2002, declining to low levels since (Figure 12.2, Table 12.3). Data before 2005 were taken from the FISHSTAT database, and data from Spain updated. Data for later years were adjusted, where possible, with data supplied by working group members and from ICES official and preliminary catch statistics.

Table 12.1 Herring from the Firth of Clyde. Catch in tonnes by country, 1959–2019. Spring and autumn-spawners combined.

Year	**1959**	**1960**	**1961**	**1962**	**1963**	**1964**	**1965**	**1966**	**1967**	**1968**	**1969**	**1970**	**1971**	**1972**	**1973**	**1974**
All Catches																
Total	10 530	15 680	10 848	3 989	7 073	14 509	15 096	9 807	7 929	9 433	10 594	7 763	4 088	4 226	4 715	4 061
Year	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
All Catches																
Total	3 664	4 139	4 847	3 862	1 951	2 081	2 135	4 021	4 361	5 770	4 800	4 650	3 612	1 923	2 343	2 259
Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Scotland	713	929	852	608	392	598	371	779	16	1	78	46	88	-	-	+
Other UK	-	-	1	-	194	127	475	310	240	0	392	335	240	-	318	512
Unallocated*	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Discards	**	**	**	**	**	-	-	-	-	-	-	-	-	-	-	-
Agreed TAC	2 900	2 300	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Total	731	929	853	608	586	725	846	1089	256	1	480	381	328	0	318	512
Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019			

Scotland	163	54	266	-	90	119	21	0	0	0	0	0	0
Other UK	458	622	488	301	111	184	-	-	-	-	-	-	-
Unallocated*	-	-	-	-	-	-	-	-	-	-	-	-	-
Discards	-	-	-	-	-	-	-	-	-	-	-	-	-
Agreed TAC	800	800	800	720	720	720	648	648	583	583	583	583	583
Total	621	676	754	301	201	303	21	0	0	0	0	0	0

***Calculated from estimates of weight per box and in some years estimated bycatch in the sprat fishery**

****Reported to be at a low level, assumed to be zero, for 1989–1995.**

Table 12.2. Stocks with limited data. Landings of herring in Divisions 7.e and 7.f. Source: ICES official landings database 2006 – 2017, national databases and ICES preliminary catch statistics 2018 and 2019.

Division	Country	2012	2013	2014	2015	2016	2017	2018*	2019*
7e	UK (Eng,Wal,NI,Scot,Guernsey)	162	274	435	268	204	22	11	8
7e	Denmark	-	-	-	-	-	-	-	-
7e	France	278	7	314	3	1	1	380	193
7e	Germany, Fed. Rep. Of	-	-	-	-	-	-	-	-
7e	Netherlands	-	-	4	0	-	-	-	-
	Total	440	275	753	271	205	23	391	201

Division	Country	2012	2013	2014	2015	2016	2017	2018*	2019*
7f	UK (Eng, Wal, Scot, NI)	113	136	20	111	227	29	3	5
7f	Belgium	-	-	-	-	-	-	-	-
7f	France	-	-	-	-	-	-	-	-
7f	Netherlands	-	-	-	-	-	-	-	5
7f	Poland	-	-	-	-	-	-	-	-
	Total	113	136	20	111	227	29	3	10

*Preliminary data

Table 12.3. Stocks with limited data. Landings of herring in Subarea 8.

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018*	2019*
France	12	34	50	82	22	7	5	5	4	12	3	1
Netherlands	24	68	502	222	-	-	-	-	-	-	-	-
Portugal	.	-	-	-	-	-	-	-	-	-	-	-
Spain	131	55	38	54	2	-	-	-	-	-	-	-
UK	0	-	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	-	-	1	1	-
	167	157	590	358	24	7	5	5	4	13	13	1

*Preliminary data

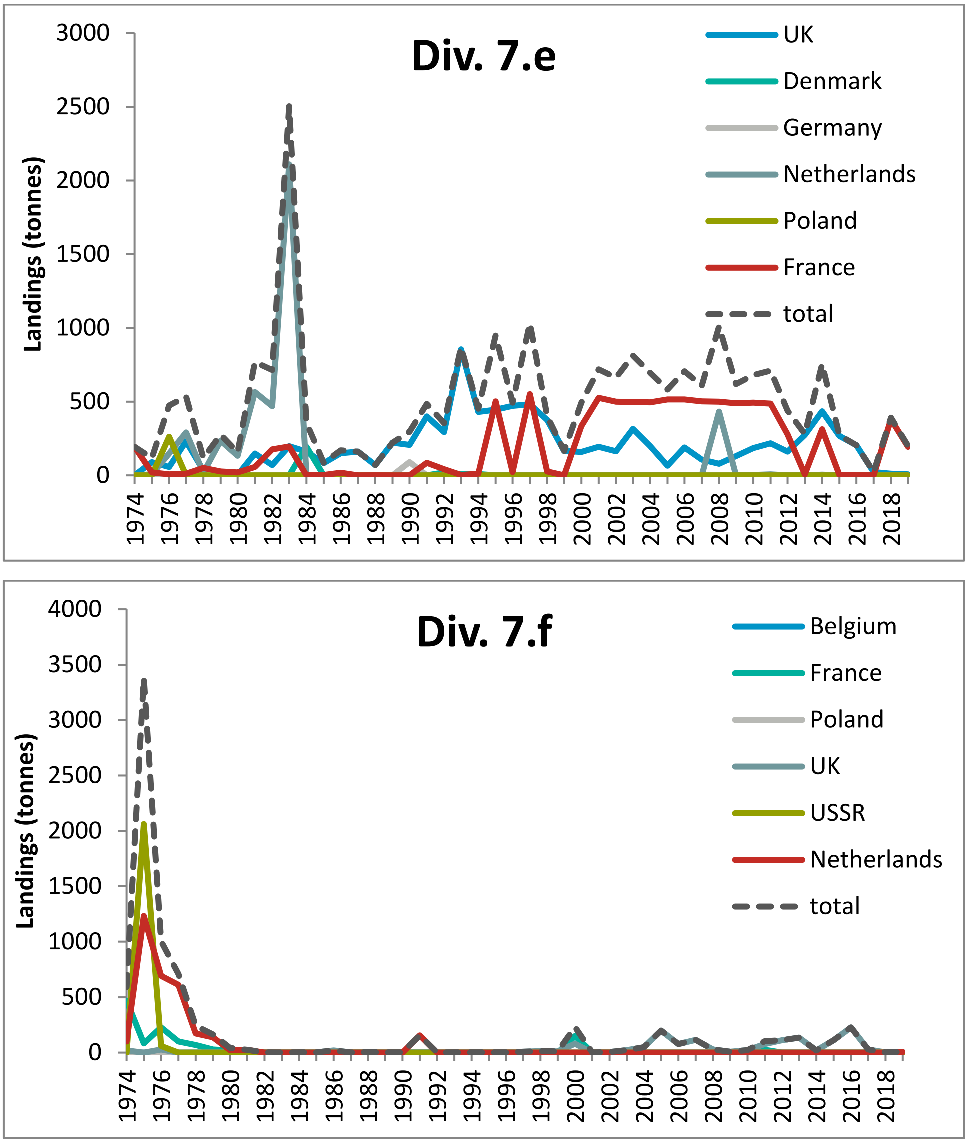


Figure 12.1. Stocks with limited data. Landings over time of herring in divisions 7.e (upper panel) and 7.f (lower panel).

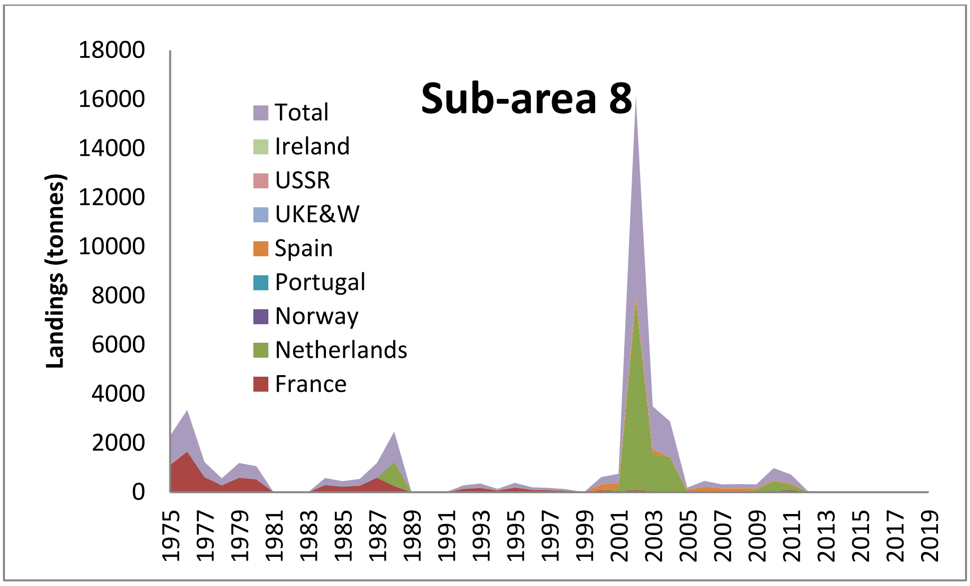


Figure 12.2. Stocks with limited data. Landings over time of herring in Subarea 8.

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 subpopulations (ICES, 2016, Figure 9.1.1), each of which is assessed by area specific assessments. Currently fishing takes place in five out of these seven areas (sandeel area (SA) 1r, 2r, 3r, 4, and 6). Analytical stock assessments are currently carried out in SA 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 subpopulations (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 2019, 25 vessels participated in the fishery. From 2011 to 2018, the average GRT per vessel in the Norwegian fleet increased from 1100 to 1325 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 2019 was opened 1 April and continued until the end of July. In NEEZ the fishery opened 15 April and ended 23 June.

9.1.3 ICES Advice

ICES advised that the fishery in 2019 should be allowed only if the analytical stock assessment indicated that the stock would be above B_{pa} by 2020 (Escapement strategy). This approach resulted in an advised TAC for 2019 in SA 1r, SA 2r, SA 3r, and 4 of 91 916 t, 5000 t (monitoring catch), 133 610 t and 5000 t (monitoring catch), 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 55 000 tonnes for 2019 was given. As the acoustic survey abundance estimate of age 1 showed a relatively good year class the final TAC increased to 125 000 tonnes. Fishery was allowed in the subareas 1b, 1c, 2b, 2c, 3b, 3c, 4a (see Stock Annex for area definitions).

9.1.5 Management

Norwegian sandeel management plan

An Area Based Sandeel Management Plan for the Norwegian EEZ was fully implemented in 2011, but was also partly used in 2010 (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 UK coast since 2000. Note that a limited fishery for stock monitoring purposes occurs in May–June in this area.

9.1.6 Catch

Adjustment of official catches

Previously, there has been substantial misreporting of catches between areas (ICES, 2015, 2016b (HAWG)). Since 2015, the Danish regulation has not allowed fishing in several stock areas on a single fishing trip. This eliminated the misreporting issue for Danish catches. However, German and Swedish catches were still high in the four rectangles, and an analysis of Swedish VMS for the years 2012 to 2015 indicated that misreporting had also occurred of Swedish catches in 2014 and 2015 (see HAWG 2017). Because of this, the working in accordance with previous year's reallocated reported catches (14781 t) from rectangles 41F2, 41F3 and 41F4 to SA 1 in 2015. From 2016 onwards, no correction was made.

Catch and trends in catches

Catch statistics for Division 4 are given by country in Table 9.1.1. Catch statistics and effort by assessment area are given in Tables 9.1.2–9.1.7. Figure 9.1.1 shows the areas for which catches are tabulated.

The sandeel fishery developed during the 1970s, and catches peaked in 1997 and 1998 with more than 1 million t. Since 1983 the total catches have fluctuated between 1.2 million t (1997) and 73420 t (2016) (Figure 9.1.3).

Spatial distribution of catches

Yearly catches for the period 2000–2019 distributed by ICES rectangle are shown in Figure 9.1.2 (with no spatial adjustment of official catches distribution in 2014 and 2015). The spatial distribution is variable from one year to the next, however with common characteristics. The Dogger Bank area includes the most important fishing banks for SA 1r sandeel. The fishery in SA 3r has varied over time, primarily as a result of changes in regulations and very low abundance of sandeel on the northern fishing grounds.

Table 9.1.2 shows catch weight by area. There are large differences in the regional patterns of the catches. SAs 1r and 3r have consistently been the most important with regard to sandeel catches. On average, these areas together have contributed ~76% of the total sandeel catches in the period since 1983.

The third most important area for the sandeel fishery is SA 2r. In the period since 2003 catches from this area contributed ~16% of the total catches on average.

SA 4 has contributed about 6% of the total catches since 1994, but there have been a few outstanding years with particular high catches (1994, 1996 and 2003 contributing 19, 17 and 20% of the total catches, respectively). In 2017 and 2018, the first non-monitoring fishery was advised in the area since 2011 with a total TAC of 54043 t and 59345 t, respectively. In 2019, only a monitoring TAC was advised.

Several banks in the northern areas of Norwegian EEZ have not provided catches between 2001 and 2008. In this period, almost all catches from the Norwegian EEZ came from the Vestbank area (Norwegian management area 3 in Figure 9.1.5).From 2010, catches have been taken mainly from the Norwegian management areas 1, 2 and 3, and from area 4 in from 2016.

Effect of vessel size on CPUE

In order to avoid bias in effort introduced by changes in the average size of fishing vessels over time, the CPUEs are used to estimate a vessel standardization coefficient, *b*. The parameter *b* was estimated using a mixed model for separate periods. Because the model estimates the parameter from several years of data, the time-series for the most recent period is updated for all years as the parameter *b* is updated with the most recent data. More information can be found in the Stock Annex.

9.1.7 Sampling the catch

Sampling activity for commercial catches is shown in Table 9.1.8.

9.1.8 Survey indices

Abundance of sandeel is monitored by a Danish/Norwegian dredge survey (covering SA 1r–3r) and a Scottish dredge survey (SA 4) in November/December. See the Stock Annex for more details. An acoustic survey was carried out in Norwegian EEZ in April/May following the standard procedures described in the benchmark report (ICES, 2010a).

The dredge survey in 2019 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, 3r, and 4. 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 2019, the proportion 3-group was 26% by weight, corresponding to the large 2016 cohort (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 decreased since 2016 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 multispecies 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 2013-2014 below long-term average. CPUE peaked again in 2016-2018, but have decreased to levels below average in 2018 and 2019.

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 small number of samples in this period.

CPUE data from the dredge survey (Table 9.2.4 and Figure 9.2.5) in 2019 show indices of age 0 and 1 just above and below the average, respectively.

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 2019. In the SMS model, it is assumed that fishing mortality is proportional to fishing effort. For details about the SMS model and model settings, see the Stock Annex.

The diagnostics output from SMS are shown in Table 9.2.5. The seasonal effect on the relation between effort and F (“F, Season effect” in the table) is rather constant over the 5-year ranges used. The “age selection” (“F, age effect” in the table) shows a change in the fishery pattern where the fishery was mainly targeting the age 2+ sandeel at 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 (0.71) for age 1. The survey residual plot (Figure 9.2.6) shows no clear patterns.

The CV of the RTM time-series is moderate (0.52) for age 1 and age 3 and low (0.45) 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 (0.33) for age 1 and age 2 in the first half of the year and moderate to high (> 0.60) for the remaining ages and season combinations. The catch-at-age residuals (Figure 9.2.7) show no alarming patterns.

The CV of the fitted Stock recruitment relationship (Table 9.2.5) is high (0.86), which is also indicated by the stock recruitment plot (Figure 9.2.8). The high CV of recruitment is probably due to biological characteristic of the stock (i.e. weak stock-recruitment relationship) and not so much due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set low (0.05 in "objective function weight" in Table 9.2.5) such that SSB-R estimates do not contribute much to the overall likelihood and model fit.

The retrospective analysis (Figure 9.2.9) shows consistent assessment results from one year to the next 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, F and SSB estimates show virtually no retrospective pattern in the last three years.

Uncertainties of the estimated SSB, F and recruitment (Figure 9.2.10) are in general small. The overall pattern with a lower F:effort ratio for older data indicates that the model assumption of no efficiency creeping is violated across periods but not within catchability periods.

9.2.7 Final assessment

The output from the assessment is presented in Tables 9.2.6 (fishing mortality-at-age by year), 9.2.7 (fishing mortality-at-age by half year), 9.2.9 (stock numbers-at-age) and 9.2.10 (stock summary).

9.2.8 Historic Stock Trends

The stock summary (Figure 9.2.13 and Table 9.2.10) shows that SSB have been at or below B_{lim} from 2004 to 2007 and again in 2013-2015. $F_{(1\text{–}2)}$ is estimated to have been just below the long-time average since 2010. Recruitment in 2017 was estimated to be the lowest observed in the time-series, whereas 2019 shows 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 1983–2018 (108 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2019. 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 2014–2019. 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 113 987 t should be set for 2020. This will leave SSB at 169 415 t in 2019 and predicted F at F_{cap} (0.49). The TAC according to the escapement strategy is therefore 113 987 t in 2020.

9.2.10 Biological reference points

B_{lim} is set at 110 000 t and B_{pa} at 145 000 t. MSY $B_{trigger}$ is set at B_{pa}.

Further information about biological reference points for sandeel in 1 can be found in the Stock Annex.

9.2.11 Quality of the assessment

The quality of the present assessment has improved compared to the combined assessment for the whole of the North Sea previously presented by ICES before 2010. This is mainly due to the fact that the present division of stock assessment areas better reflects the spatial stock structure and dynamics of sandeel. Addition of fishery independent data from the dredge survey has also improved the quality of the assessment. Together with the application of the statistical assessment model SMS-effort, this has removed the retrospective bias in F and SSB for the most recent years. The model provides rather narrow confidence limits for the model estimates of F, SSB and recruitment, but a poorer fit for the oldest data.

The model uses effort as basis for the calculation of F. The total international effort is derived from Danish CPUE and total international catches. Danish catches are by far the largest in the area, but effort data from the other countries could improve the quality of the assessment.

Abundance of the 1-group, which in most years dominates the catches, is estimated on the basis of the 0-group index from the dredge survey in December of the preceding year. The model estimates a low variance on the survey index for age 0. There are indications of a retrospective pattern in recent years as older fish do not seem to appear in the catches at the expected level. This pattern can be caused by uncertainty in the selection pattern when using a relatively short period to estimate this or unallocated mortality caused by e.g. overwintering mortality increasing when fish condition is low (van Deurs *et al.,* 2011).

9.2.11.1 Status of the stock

The SSB was below B_{lim} in 2019 and 2020. As noted in last year's report (ICES, 2019), the introduction of a very low recruitment in 2018 combined with a continued decrease in mean weight-at-age led to a stock below MSY B_{lim} and $B_{trigger}$ at the beginning of 2020.

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 utilizing 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 2019 catch with largest proportion of 3-group in the time-series (52%)(Figure 9.3.1).

9.3.2 Weight-at-age

The methods applied to compile age-length-weight keys and mean weights-at-age in the catches and in the stock are described in the Stock Annex.

The mean weights-at-age observed in the catch are given in Table 9.3.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time-series of mean weight in the catch and in the stock is shown in Figure 9.3.2. Mean weight-at-age for all age groups in 2019 was above the historic average, reaching 108% of the long-term average on average.

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 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 in 2019 was the lowest in the time-series and CPUE was well below levels observed in 2015–2018.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

The dredge survey in SA 2r (Table 9.3.4 and Figure 9.3.5) increased coverage in 2010 and this is therefore used as the start year of the dredge time-series for the assessment. The coverage has however varied somewhat in this period and the time-series is still short. Details about the dredge survey are given in the Stock Annex and the benchmark report (ICES, 2016).

Adjustment to standard settings to accommodate retrospective pattern in recruitment

In previous years, there has been a large overestimation of recruitment in the terminal year in cases where the dredge survey showed large abundance of age 0. The working group examined the relationship between dredge survey catches-at-age 0 and the number of recruits as estimated in the SPALY run and considered that the retrospective pattern could be caused by ignoring density-dependence in catchability (increased catchability at high abundance). The relationship seemed to be well fitted using a power relationship between dredge index and abundance, with no indication of this given errors in estimated abundance in high or low abundance years. The use of a power model for survey catchability of the youngest age groups is routinely used for North Sea sprat (ICES 2018). It is an adjustment of the model where one additional parameter is estimated. HAWG evaluated the retrospective bias in recruitment without density-dependent catchability (Mohn's ro = 0.63) and with density-dependent catchability (Mohn's ro = 0.52). The AIC of the model including density-dependent was unchanged. Based on these considerations, HAWG decided to include density-dependent catchability in the final run.

9.3.6 Data analysis

The diagnostics output from SMS-effort are shown in Table 9.3.5.

The CV of the dredge survey (Table 9.3.5) is low (0.30) after the introduction of the density-dependent catchability for age 0 indicating a high consistency between the results from the dredge survey and the overall model results. The residual plot (Figure 9.3.6) shows no bias for this time-series.

The model CV of catch-at-age 1 and 2 is low (0.37) in the first half of the year and medium or high (> 0.70) for the remaining ages and season combinations. The residual plots for catch-at-age (Figure 9.3.7) confirm that the fit is generally poor except for age 1 and 2 in the first half year. The residual plot (Figure 9.3.7) shows no long-term bias for this time-series for ages 1 and 2 in the first half year.

The CV of the fitted stock recruitment relationship (Table 9.3.5) is high (1.03 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 2010–2019, 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 is improved by the introduction of density-dependent catchability in the model. Reasons for the previous pattern can be connected to either overestimation of recruitment in the dredge survey lower than expected survival of the two cohorts, or lower than expected catchability of these cohorts in the fishery. Both the selectivity pattern and the dredge survey are based on a relatively short time-series, and hence variation between years is to be expected.

9.3.7 Final assessment

The output from the assessment is presented in tables 9.3.6 (fishing mortality-at-age by year), 9.3.7 (fishing mortality-at-age by half year), 9.3.9 (stock numbers-at-age) and 9.3.10 (stock summary).

9.3.8 Historic Stock Trends

The stock summary (Figure 9.3.13 and Table 9.3.10) show that recruitment has been highly variable and with a weak decreasing trend over the full time-series until the 2016 year class, which is estimated to be the 4th strongest on record, followed by a 2017 year class which is estimated to be the lowest observed and a 2018 year class which was the fifth lowest on record and continued to be low in 2019. In 2020 the year class was above average. 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 and 2019. F_{1-2} 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 2019.

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 2020 is the geometric mean of the recruitment in 2009–2018 (21 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2019. 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 2015–2019. 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 TAC of 62 658 corresponding to $F_{cap} = 0.45$ results in an SSB of 91 553 will be above the MSY $B_{escapement}$ of 84 000 t and B_{lim} of 55 000 t in 2021 The TAC according to the escapement strategy is therefore 62 658 t in 2020. 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.

9.3.10 Quality of the assessment

This stock was benchmarked between the 2016 and 2017 assessments where the ICES statistical rectangles included in sandeel area 2 changed. The assessment now includes fisheries independent information from a dredge survey representative for the area. The assessment is considered to be of good quality but with indications of a retrospective pattern in recent years as older fish do not seem to appear in the catches at the expected level. This pattern can be caused by uncertainty in the selection pattern when using a relatively short period to estimate this or unallocated mortality caused by e.g. overwintering mortality increasing when fish condition is low (van Deurs *et al.*, 2011.). HAWG also highlighted that the pattern might also have a link to the possible multispecies fishery within this area (i.e. suspected to catch *Ammodytes tobianus*). The dredge survey time-series in SA2 is still short (2010–2019) and the quality of the assessment will likely improve once a longer time-series becomes available.

9.3.11 Status of the Stock

A moderate F in most of the years from 2010 in combination with a low recruitment have given a slow increase in SSB since the historical low values in 2004 to 2010. F in 2019 was the lowest on record. SSB in 2019 are estimated below B_{pa} and in 2020 below B_{lim}, which is consistent with prediction (HAWG, 2019). Recruitment in 2016 is estimated to be the fourth highest on record and 2019 is the third highest since 1997, while the 2017 and 2018 year classes are extremely low.

9.3.12 Management considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such as sandeel is the escapement strategy, i.e. to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Management strategy evaluations (ICES, 2016) established that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (F_{cap}) on the fishing mortality and estimated this F_{cap} for 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 47% 1-group, but in 2019, the 3-group provided the second largest contribution to the catches (44%) a bit below the 65% reported in 2012 when the large 2009 year class were 3 years old (Figure 9.4.1). The proportion of group-2 was only 6% 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. 2019 mean weight was just below long-term average.

9.4.3 Maturity

Maturity estimates are obtained from the average observed in the dredge survey in December as described in the Stock Annex. The values used are given in Table 9.4.3.

9.4.4 Natural mortality

In 2017, WGSAM provided updated estimates of natural mortality-at-age from multispecies 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 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 1998, and declined thereafter and has been less than 2000 days per year since 2003.

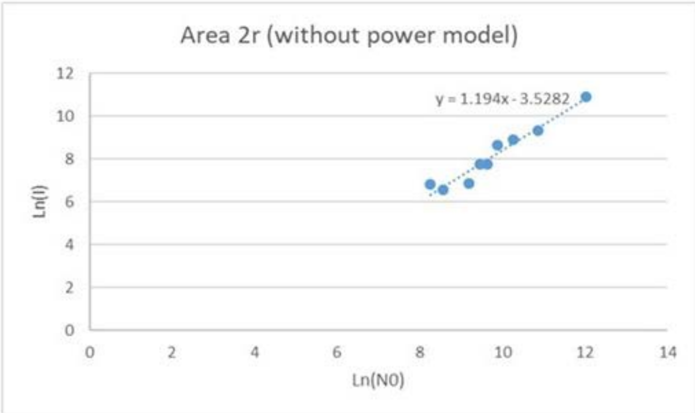
Tuning series used in the assessments

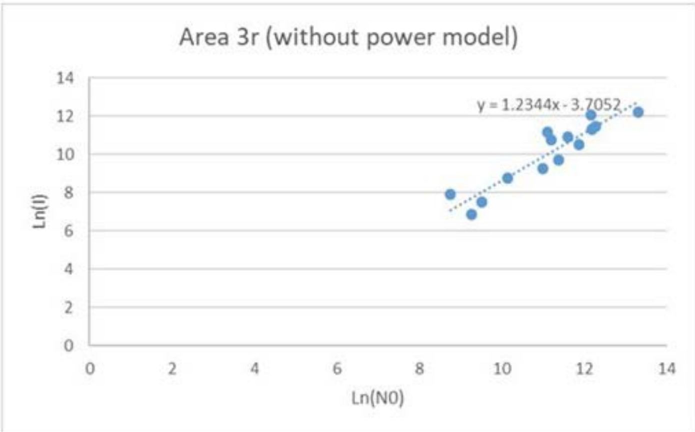
CPUE data from the dredge survey (Table 9.4.4 and Figure 9.4.5) in 2019 show above average indices for both age 0 and age 1 in 2019 (Table 9.4.4). The internal consistency plot (Figure 9.4.4) shows medium consistency for age 0 vs. age 1 (i.e. $r^2 = 0.33$ on log scales). In 2014, 13 new positions were 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 (2009–2019) carried out in Norwegian EEZ is used as tuning series in the assessment in SA 3r (Table 9.4.13 and figures 9.4.14-9.4.16). The survey covers the main sandeel grounds in SA 3r. The acoustic estimate in number of individuals by age and survey is presented in Table 9.4.13.

Adjustment to standard settings to accommodate retrospective pattern in recruitment

In previous years, there has been a large overestimation of recruitment in the terminal year in cases where the dredge survey showed large abundance of age 0. The working group examined the relationship between dredge survey catches-at-age 0 and the number of recruits as estimated in the SPALY run (see figure below, where I is the survey index of age-0 and N0 the number of recruits) and considered that the retrospective pattern could be caused by ignoring density-dependence in catchability (increased catchability at high abundance). The relationship seemed to be well fitted using a power relationship between dredge index and abundance, with no indication of this given errors in estimated abundance in high or low abundance years. The use of a power model for survey catchability of the youngest age groups is routinely used for North Sea sprat (ICES 2018). It is an adjustment of the model where one additional parameter is estimated. HAWG evaluated the retrospective bias in recruitment without density-dependent catchability (Mohn's ro = 0.57) and with density-dependent catchability (Mohn's ro = 0.13). The AIC of the model including density-dependent was unchanged. Based on these considerations, HAWG decided to include density-dependent catchability in the final run.





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 (0.65) and age 1 (0.83), 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 1 and age 2 (0.55) and high for age 3 (0.92), showing an overall medium consistency between the results from the dredge survey and the overall model results.

The model CV of catch-at-age is medium (0.66) for age 1 and age 2 in the first half of the year (Table 9.4.5). For the older ages and for all ages in the second half year, the CVs are high (> 1.00).

The catch residual plots for catch-at-age (Figure 9.4.7) confirm that the fits are generally very poor except for age 1 and 2 in the first half year. There is a tendency for clusters of negative or positive residuals for ages 1 and 2.

The CV of the fitted stock recruitment relationship (Table 9.4.5) is high (1.05), which is also indicated by the stock recruitment plot (Figure 9.4.8). The high CV of recruitment is probably due to the biological characteristics of the stock and less due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set low (0.01 in "objective function weight" in Table 9.4.5) such that SSB-R estimates do not contribute much to the overall model likelihood and fit.

There used to be a large retrospective pattern in the recruitment that consistently overestimated large recruiting year-classes. However, after implementing density-dependence on the relationship between recruitment and the dredge survey (i.e. increasing catchability with increasing densities), the retrospective bias was reduced from a Mohn´s Rho > 0.5 to 0.13 in the present year´s assessment (see working document about this change).

Uncertainties of the estimated SSB, F and recruitment (Figure 9.4.10) are in general medium, which gives wide confidence limits (Figure 9.4.11) on output variables.

The plot of standardized fishing effort and estimated F (Figure 9.4.12) shows a moderate relation between effort and F as assumed by the model specification. As the model assumes a different catchability-at-age for the three periods 1986–1998, 1999–present, the relation between effort and F varies between these periods. There is a shift in the ratio between effort and F over the full time-series. In the year range 1986–1998, F is in generally lower than effort on the plot, while the opposite is the case for the remaining periods, corresponding to a technical creep over time (ICES, 2016).

9.4.7 Final assessment

The output from the final assessment is presented in Tables 9.4.6 (fishing mortality-at-age), 9.4.7 (fishing mortality-at-age by half year), 9.4.9 (stock numbers-at-age) and 9.4.10 (Stock summary).

9.4.8 Historic Stock Trends

SSB has been at or below B_{lim} from 1999 to 2006 after which SSB increased to above B_{pa} in 2008. This was followed by SSB below B_{lim} in 2013 (Figure 9.4.16 and Table 9.4.17). Above average recruitments in 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 1 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 155 072 t in 2020 will result in a fishing mortality of 0.29, identical to F_{cap}, and leave SSB at 298 955 t, well above MSY $B_{trigger}$ of 129 000 t, in 2020. The TAC according to the escapement strategy is therefore 155 072 t in 2020.

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. Although 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 2019 is third largest since 2008 when the stock started recovering.

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 2019, age group 1 contributed more to the catches than ages 2 and 3 which were almost equal (Figure 9.5.1).

9.5.2 Weight-at-age

The methods applied to compile age-length-weight keys and mean weights-at-age in the catches and in the stock are described in the Stock Annex. The mean weights-at-age observed in the catch are given in Table 9.5.2 and Figure 9.5.2 by half year. Mean weight-at-age in the first half year seems to have recovered to above average for all ages after the very low levels in 2001 to 2005. The second half year mean weights 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 followed by a much lower effort in 2019. Effort since 2004 has been extremely low. CPUE in later years has been around the average prior to 2004 from 2013-2018 but low in 2019.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

CPUE data from the dredge survey (Table 9.5.4 and Figure 9.5.5) show that the 2019 year class is the 6th highest 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 2019. 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 (0.71) 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 at the beginning of the time-series.

The CV of the fitted Stock recruitment relationship (Table 9.5.5) is high (1.24), 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 and between B_{lim} and B_{pa} in 2020. $F_{(1–2)}$ is estimated to have been very low since 2005 increasing in 2018 to the highest since 2004 and decreased in 2019. Recruitment in 2014, 2016, 2017 and 2019.

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 2020 is the geometric mean of the recruitment 1993–2018 (60 billion-at-age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2019. 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 2015–2019. Natural mortality and maturity are as applied in the assessment in final year. The Stock Annex gives more details about the forecast methodology.

Output

The short-term forecast (Table 9.3.12) shows that a SSB will be above the MSY $B_{trigger}$ of 84 000 t and B_{lim} of 55 000 t in 2020 with a TAC of 39 611 t. The TAC according to the escapement strategy is therefore 39 611 t in 2020.

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 2020 is high (0.37).

9.5.10.2 Status of the Stock

Recruitment in 2014, 2016, 2017 and 2019 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 and between B_{lim} and B_{pa} in 2020.

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.

ICES. 2018. Benchmark Workshop on Sprat (WKSPRAT 2018). ICES WKSPRAT Report 2018, 5–9 November 2018. ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:35.60 pp.

ICES. 2019. Herring Assessment Working Group for the Area South of 62° N (HAWG). ICES Scientific Reports. 1:2. 971 pp. http://doi.org/10.17895/ices.pub.5460 - WD01 Marine Scotland Science sandeel dredge survey indices for SA4.

van Deurs, M., Hartvig, M., & Steffensen, J. F. (2011). Critical threshold size for overwintering sandeels (*Ammodytes marinus*). Marine biology, 158(12), 2755-2764.

Table 9.1.1 Sandeel. Catches ('000 t), 1952-2019. (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

Year	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	Total
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
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

Year	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	Total
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
2019	93.6	3.9	-	-	-	124.8	11.4	1.119	-	234.9

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2000	374724	101952	196525	37792	303	0	4371	715667
2001	540248	97210	196209	47918	1678	26	971	884260
2002	610161	120520	115207	12762	8	493	453	859604
2003	178642	56248	35365	64049	44	111	260	334718
2004	215352	116837	33658	6882	0	573	0	373302
2005	126261	34569	13994	1557	0	259	0	176640
2006	247510	37952	7094	86	0	161	0	292802
2007	110395	44069	75376	11	4	0	0	229855
2008	236069	35655	74943	1168	0	0	0	347836
2009	309712	37049	6161	0	0	0	0	352922
2010	300896	52470	60542	275	0	0	0	414183
2011	320241	24310	92450	270	0	489	0	437761
2012	45954	12672	40141	2618	0	214	0	101599
2013	214787	48172	9838	5119	0	72	0	277989
2014	99059	64707	95426	4505	0	65	0	263762
2015	162861	39492	104607	4736	0	198	0	311894
2016	15407	9569	44074	6232	0	123	0	75405
2017	242069	141314	115642	18474	0	0	0	517499
2018	131898	20240	75143	42298	0	0	0	269579
2019	86066	5274	136732	6603	0	103	0	234778
arith. mean	296923	102769	149196	30287	5834	1174	991	587174

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2012	45946	11520	40141	2618	0	213	0	100438
2013	207886	43818	9838	5119	0	72	0	266733
2014	94278	62110	95426	4505	0	65	0	256383
2015	162860	38723	104607	4736	0	197	0	311123
2016	15407	9519	44074	6232	0	123	0	75354
2017	239742	130640	115642	18474	0	0	0	504498
2018	125303	19957	74567	42298	0	0	0	262126
2019	71072	5271	136727	6603	0	103	0	219777
arith. mean	268019	73545	124222	25545	5352	1070	784	498537

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2001	171466	47891	136258	426	0	0	236	356277
2002	5577	15123	561	0	0	0	352	21613
2003	23636	31137	12562	1469	0	0	73	68877
2004	15869	25432	12026	22	0	2	0	53351
2005	4466	9728	11	0	0	0	0	14206
2006	6165	14455	136	30	0	0	0	20787
2007	6	0	0	0	0	0	0	6
2008	3821	3053	0	0	0	0	0	6873
2009	16183	11650	137	0	0	0	0	27970
2010	7537	7560	291	0	0	0	0	15387
2011	3891	265	0	0	0	0	0	4156
2012	8	1153	0	0	0	0	0	1161
2013	6902	4354	0	0	0	0	0	11256
2014	4781	2598	0	0	0	0	0	7379
2015	1	769	0	0	0	0	0	771
2016	0	50	0	0	0	0	0	51
2017	2327	10673	0	0	0	0	0	13000
2018	6595	283	576	0	0	0	0	7453
2019	14993	3	5	0	0	0	0	15001
arith. mean	28905	29224	24974	4741	482	103	207	88637

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
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	2936	584	1344	491	0	0	0	5356

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
2019	2639	142	1828	187	0	3	0	4799
arith. mean	5440	2667	3042	352	85	45	9	11640

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
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	2645	579	1332	491	0	0	0	5047
2019	2320	142	1828	187	0	3	0	4480
arith. mean	4763	1863	2432	295	80	42	7	9483

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

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
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	291	6	12	0	0	0	0	309
2019	319	0	0	0	0	0	0	319
arith. mean	678	804	609	56	5	4	2	2158

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

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
2012	220	112	31	21	0	12	0	396
2013	292	220	41	5	0	3	0	561
2014	143	133	29	18	0	5	0	328
2015	308	117	48	38	0	4	0	515
2016	154	159	42	35	0	0	0	390
2017	279	204	50	40	0	0	0	573
2018	350	136	162	71	0	0	0	719
2019	284	83	177	32	0	0	0	576
Sum	6490	2862	1949	882	39	71	0	12293

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2001	47080	56780	3127	8549	474	1098	49	972	98
2002	16	84878	605	10772	108	1212	15	225	6
2003	2474	3843	386	13302	4390	1117	141	302	31
2004	566	30654	2479	786	110	2364	230	480	47
2005	44	11106	383	4435	211	263	14	435	27
2006	37	33600	800	2590	94	817	43	163	19
2007	0	10581	0	4674	0	315	0	172	0
2008	6	26735	281	4009	75	1205	33	214	6
2009	979	18898	2254	14265	278	1556	12	392	3
2010	10	39951	1184	2130	35	942	16	108	2
2011	5	1894	39	32692	325	1305	14	266	1
2012	0	383	0	419	0	3354	0	129	0
2013	3	18090	598	7916	131	2182	100	4301	49
2014	925	8930	131	3354	98	401	23	360	25
2015	0	25326	0	1918	0	579	0	172	0
2016	0	208	0	1193	0	97	0	17	0
2017	3	33038	253	3015	40	4604	38	103	7
2018	91	1699	158	14468	792	971	44	331	10
2019	6193	5435	328	832	16	1916	16	95	0
arith. mean	2761	23258	1701	9060	609	2350	194	686	38

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

	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
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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2018	2.6	4.7	4.3	7.0	6.6	9.5	8.4	11.5	10.0
2019	2.2	4.1	3.1	7.2	7.4	8.0	9.2	10.0	10.8
arith. mean	3.6	5.8	6.2	9.3	10.2	12.9	13.9	14.9	15.8

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. Dregde survey indices.

Year	Age 0	Age 1
2004	140061.87	7077.655
2005	277241.20	3288.987
2006	117233.03	12244.596
2007	402355.16	5326.731
2008	35633.70	13619.791
2009	474590.87	9040.642
2010	49722.00	125308.581
2011	77113.07	27178.527
2012	136586.42	3922.222
2013	80356.85	13156.382
2014	235943.73	3413.488
2015	23030.02	13597.662
2016	304655.46	7277.881
2017	32663.00	38561.000
2018	165064.00	11168.000
2019	199148.10	18720.400

Table 9.2.5 Sandeel Area-1r. SMS settings and statistics.

```
Date: 01/24/20  Start time:10:11:30 run time:13 seconds

objective function (negative log likelihood):  18.7273
Number of parameters: 78
Maximum gradient: 7.47598e-005
Akaike information criterion (AIC):   193.455
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             333      65      37       0     435

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
               28.2   -10.1    13.0     0.0     0.0      0.00      31


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.08   -0.16    0.35    0.00


contribution by fleet:
----------------------
RTM 2007-2019               total:  -6.774   mean:  -0.205
Dredge survey 2004-2019     total:  -3.307   mean:  -0.103

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
    2010-2019:   0.000 1.000
age: 1 - 4
    1983-1988:   0.461 0.500
    1989-1998:   0.466 0.500
    1999-2004:   0.377 0.500
    2005-2009:   0.257 0.500
    2010-2019:   0.538 0.500

F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.025  0.252  0.936  1.379  1.379
1989-1998:  0.012  0.539  0.723  0.722  0.722
1999-2004:  0.070  1.058  1.161  1.131  1.131
2005-2009:  0.007  1.487  2.184  2.282  2.282
```

```
2010-2019:  0.016  0.297  0.774  1.411  1.411


Exploitation pattern (scaled to mean F=1)
----------------------------------------
                        0      1      2      3      4
1983-1988 season 1:      0  0.321  1.190  1.755  1.755
          season 2:  0.021  0.104  0.385  0.567  0.567

1989-1998 season 1:      0  0.821  1.101  1.098  1.098
          season 2:  0.001  0.033  0.045  0.045  0.045

1999-2004 season 1:      0  0.813  0.892  0.869  0.869
          season 2:  0.019  0.140  0.154  0.150  0.150

2005-2009 season 1:      0  0.755  1.109  1.159  1.159
          season 2:  0.001  0.055  0.081  0.085  0.085

2010-2019 season 1:      0  0.531  1.382  2.520  2.520
          season 2:  0.003  0.024  0.063  0.115  0.115


sqrt(catch variance) ~ CV:
--------------------------

               season
----------------------
age        1       2

 0               1.675
 1       0.332   0.595
 2       0.332   0.595
 3       0.690   1.054
 4       0.690   1.054


Survey catchability:
--------------------
                           age 0    age 1    age 2    age 3
 RTM 2007-2019                      0.856    1.895    2.678
 Dredge survey 2004-2019       2.667    1.147

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1    age 2    age 3
 RTM 2007-2019                       0.52     0.45     0.52
 Dredge survey 2004-2019        0.39     0.77

Recruit-SSB              alfa       beta        recruit s2      recruit s
Area-1r              1016.962   1.100e+005   0.741           0.861
```

Table 9.2.6 Sandeel Area-1r. Annual fishing mortality (F) at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.012	0.283	1.014	1.482	1.485	0.649
1984	0.013	0.319	1.145	1.669	1.678	0.732
1985	0.014	0.341	1.224	1.792	1.787	0.782
1986	0.005	0.241	0.862	1.252	1.246	0.551
1987	0.008	0.178	0.648	0.948	0.946	0.413
1988	0.005	0.260	0.934	1.350	1.348	0.597
1989	0.001	0.816	1.068	1.057	1.055	0.942
1990	0.002	0.818	1.065	1.052	1.053	0.942
1991	0.005	0.547	0.723	0.720	0.721	0.635
1992	0.003	0.821	1.079	1.068	1.071	0.950
1993	0.001	0.362	0.474	0.474	0.474	0.418
1994	0.001	0.299	0.389	0.386	0.386	0.344
1995	0.002	0.562	0.729	0.722	0.721	0.645
1996	0.003	0.526	0.681	0.673	0.673	0.603
1997	0.005	0.497	0.645	0.640	0.642	0.571
1998	0.002	0.649	0.824	0.815	0.815	0.737
1999	0.018	1.053	1.102	1.064	1.065	1.078
2000	0.016	0.842	0.878	0.852	0.851	0.860
2001	0.051	1.277	1.350	1.316	1.320	1.314
2002	0.004	0.978	1.033	0.977	0.972	1.006
2003	0.015	0.813	0.862	0.819	0.822	0.837
2004	0.008	0.856	0.896	0.848	0.849	0.876
2005	0.001	0.932	1.297	1.346	1.344	1.115
2006	0.001	1.139	1.585	1.638	1.633	1.362
2007	0.000	0.430	0.600	0.621	0.617	0.515
2008	0.000	0.802	1.117	1.145	1.143	0.960
2009	0.001	0.989	1.384	1.428	1.421	1.187
2010	0.002	0.422	1.019	1.801	1.787	0.720
2011	0.001	0.477	1.127	2.002	1.981	0.802

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2012	0.000	0.090	0.215	0.387	0.383	0.152
2013	0.000	0.543	1.291	2.288	2.279	0.917
2014	0.001	0.315	0.759	1.363	1.361	0.537
2015	0.000	0.299	0.718	1.293	1.285	0.509
2016	0.000	0.021	0.051	0.093	0.092	0.036
2017	0.001	0.402	0.965	1.733	1.724	0.684
2018	0.003	0.406	0.983	1.776	1.768	0.694
2019	0.004	0.362	0.879	1.593	1.586	0.620
arith. mean	0.006	0.567	0.909	1.148	1.145	0.738

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	0.189	0.061	0.702	0.227	1.035	0.335	1.035	0.335
1984	0.013	0.216	0.067	0.802	0.248	1.182	0.366	1.182	0.366
1985	0.014	0.231	0.072	0.856	0.266	1.262	0.392	1.262	0.392
1986	0.005	0.180	0.024	0.666	0.088	0.982	0.130	0.982	0.130
1987	0.008	0.117	0.041	0.435	0.153	0.641	0.226	0.641	0.226
1988	0.005	0.196	0.024	0.727	0.089	1.072	0.131	1.072	0.131
1989	0.001	0.665	0.027	0.892	0.036	0.890	0.036	0.890	0.036
1990	0.002	0.646	0.045	0.867	0.060	0.864	0.060	0.864	0.060
1991	0.005	0.370	0.121	0.497	0.163	0.495	0.162	0.495	0.162
1992	0.003	0.640	0.076	0.858	0.102	0.856	0.102	0.856	0.102
1993	0.001	0.282	0.034	0.378	0.046	0.377	0.046	0.377	0.046
1994	0.001	0.230	0.026	0.309	0.034	0.308	0.034	0.308	0.034
1995	0.002	0.427	0.052	0.573	0.070	0.572	0.070	0.572	0.070
1996	0.003	0.388	0.060	0.520	0.080	0.519	0.080	0.519	0.080
1997	0.005	0.322	0.118	0.433	0.159	0.431	0.158	0.431	0.158
1998	0.002	0.492	0.049	0.660	0.066	0.658	0.066	0.658	0.066
1999	0.018	0.768	0.133	0.843	0.145	0.821	0.142	0.821	0.142
2000	0.016	0.603	0.124	0.662	0.136	0.645	0.133	0.645	0.133

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2001	0.051	0.784	0.386	0.860	0.423	0.838	0.412	0.838	0.412
2002	0.004	0.775	0.028	0.850	0.031	0.828	0.030	0.828	0.030
2003	0.015	0.576	0.116	0.632	0.127	0.616	0.124	0.616	0.124
2004	0.008	0.643	0.059	0.706	0.065	0.688	0.063	0.688	0.063
2005	0.001	0.729	0.053	1.070	0.078	1.118	0.082	1.118	0.082
2006	0.001	0.881	0.077	1.295	0.112	1.353	0.118	1.353	0.118
2007	0.000	0.345	0.000	0.507	0.000	0.530	0.000	0.530	0.000
2008	0.000	0.618	0.037	0.908	0.054	0.949	0.056	0.949	0.056
2009	0.001	0.747	0.075	1.098	0.110	1.147	0.115	1.147	0.115
2010	0.002	0.318	0.015	0.827	0.038	1.508	0.069	1.508	0.069
2011	0.001	0.358	0.010	0.933	0.027	1.701	0.048	1.701	0.048
2012	0.000	0.068	0.000	0.178	0.000	0.325	0.000	0.325	0.000
2013	0.000	0.431	0.000	1.122	0.000	2.046	0.000	2.046	0.000
2014	0.001	0.247	0.009	0.644	0.023	1.175	0.042	1.175	0.042
2015	0.000	0.241	0.000	0.629	0.000	1.146	0.000	1.146	0.000
2016	0.000	0.017	0.000	0.044	0.000	0.080	0.000	0.080	0.000
2017	0.001	0.322	0.006	0.838	0.014	1.529	0.026	1.529	0.026
2018	0.003	0.308	0.032	0.803	0.082	1.464	0.150	1.464	0.150
2019	0.004	0.270	0.035	0.704	0.090	1.284	0.164	1.284	0.164
arith. mean	0.006	0.423	0.057	0.712	0.093	0.917	0.113	0.917	0.113

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

	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
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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2018	0.606	0.514	0.516	0.390	0.331	0.271	0.323	0.251	0.304
2019	0.606	0.514	0.516	0.390	0.331	0.271	0.323	0.251	0.304
arith. mean	0.598	0.448	0.516	0.371	0.389	0.294	0.354	0.263	0.342

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	315012	13309	53330	2987	243
1984	76638	186509	4311	10033	429
1985	514496	45793	59051	715	1209
1986	78625	302763	14417	9256	197
1987	46010	46005	105237	3188	1605
1988	208826	26656	16546	27126	1043
1989	93442	120394	8969	3357	4327
1990	128891	55321	25387	1633	1568
1991	163784	74709	11528	4758	658
1992	35715	94019	19613	2915	1546
1993	149079	20888	20333	3812	974
1994	215905	89212	6895	6839	1785
1995	54367	129296	30626	2482	3449
1996	385539	32585	34775	7970	1763
1997	60715	224447	9201	9625	2966
1998	116741	34763	61064	2538	3822
1999	152587	64509	7959	14385	1685
2000	245619	82763	9774	1397	3233
2001	399337	135076	14930	2106	1192
2002	24856	210490	16792	2022	526
2003	147740	12989	34894	2942	546
2004	64700	74966	2318	6707	795
2005	155315	32565	12043	430	1652

	Age 0	Age 1	Age 2	Age 3	Age 4
2006	73255	80034	5240	1739	322
2007	190172	36539	10283	567	242
2008	67170	91564	8950	2788	246
2009	476968	33554	15743	1486	575
2010	29244	244053	5365	2192	306
2011	37244	14874	59739	1017	260
2012	87465	18048	3250	10513	110
2013	49402	42727	5171	1165	3663
2014	173022	25710	9042	725	323
2015	27463	91618	7342	2112	168
2016	214650	14986	25698	1904	401
2017	17201	117129	5261	11954	1183
2018	67277	9380	30144	1090	1537
2019	145971	36589	2384	6047	296
2020		79361	9630	524	824

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	314973794	640289	473071	378795	0.590
1984	76668386	1208990	201390	498626	0.667
1985	514651227	806470	471182	437114	0.712
1986	78609255	1882390	278452	382844	0.479
1987	45993011	1529080	983625	373021	0.373
1988	208823509	786450	587129	413646	0.518
1989	93455879	759875	156686	446028	0.810
1990	128829451	660083	252963	306240	0.809
1991	163774330	938693	333701	332204	0.575
1992	35712096	1046130	282377	558599	0.838
1993	149080949	461159	264078	132024	0.370
1994	215829651	672629	179512	193241	0.299

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1995	54352436	1430820	398316	400588	0.561
1996	385480051	601826	364762	265869	0.524
1997	60733136	1841750	232118	426089	0.516
1998	116686336	843316	520216	377073	0.633
1999	152549547	574742	223910	422718	0.944
2000	245547262	669085	142486	299167	0.762
2001	399210738	784460	160653	531265	1.226
2002	24865702	1406250	153277	606466	0.842
2003	147745240	333863	237044	148039	0.726
2004	64682420	466877	90944	203646	0.737
2005	155320301	341463	113210	123422	0.965
2006	73221526	546287	74682	240646	1.183
2007	190088441	311131	93060	109624	0.426
2008	67187649	712496	130353	234447	0.808
2009	476987098	380721	148301	290995	1.015
2010	29238591	1639520	120813	300508	0.598
2011	37243947	617085	435827	318840	0.664
2012	87486933	266390	145801	46117	0.123
2013	49377233	286848	84204	214359	0.777
2014	173034231	196107	64216	78830	0.462
2015	27453384	588221	83952	163381	0.435
2016	214753196	367446	239187	14613	0.030
2017	17192779	779268	164555	241916	0.590
2018	67254871	284464	198988	129525	0.612
2019	145982893	218684	67711	59584	0.550
2020			84881		
arith. mean	148390381	753550	243096	289192	0.642
geo. mean	104114311				

arith. mean for the period 1983-2019

geo. mean for the period 1983-2018

Table 9.2.11 Sandeel Area-1r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2020)	104153.964	79361.2	9629.89	523.733	824.273
Exploitation pattern 1st half		0.270	0.704	1.284	1.284
Exploitation pattern 2nd half	0.004	0.035	0.090	0.164	0.164
Weight in the stock 1st half		4.952	7.964	9.961	12.162
Weight in the catch 1st half		4.952	7.964	9.961	12.162
weight in the catch 2nd half	2.984	5.119	8.389	10.898	12.703
Proportion mature(2020)	0.000	0.021	0.801	0.988	1.000
Proportion mature(2021)	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(2019)=0.5497; Yield(2019)=59.584; Recruitment(2019)=145.982893; Recruitment(2020)=geometric mean (GM 1983-2018)=104.153964 billions;SSB(2020)=84.881

F multiplier	Basis	F(2020)	Catch(2020)	SSB(2021)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	242.708	186 %	-100
0.890	Fsq*0.89	0.490	113.987	169.415	100 %	24
1.000	Fsq*1	0.550	124.970	162.636	92 %	36
2.000	Fsq*2	1.100	206.343	114.297	35 %	124
1.000	Fsq*1	0.550	124.970	162.636	92 %	36
1.400	Fsq*1.4	0.770	161.272	140.640	66 %	75
1.800	Fsq*1.8	0.989	192.317	122.372	44 %	109
2.200	Fsq*2.2	1.209	219.157	107.024	26 %	138
2.400	Fsq*2.4	1.319	231.251	100.255	18 %	152
1.314	MSY	0.723	153.990	144.999	71 %	68

***SSB in 2021 relative to SSB in 2020**

**** Catch scenario for 2020 relative to TAC in 2019 (91 916 t).**

Table 9.3.1 Sandeel Area-2r. Catch-at-age numbers (million) by half year.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	12882	4162	476	6190	877	203	104	67	0
1984	0	10284	3846	912	186	1154	193	38	10
1985	1827	1411	392	5501	768	473	387	109	50
1986	1443	24479	3495	3144	208	436	95	6	7
1987	45	831	512	2621	591	131	17	20	4
1988	5602	1030	545	3379	226	3163	775	478	31
1989	2819	23364	3809	1666	273	938	10	909	34
1990	5046	7332	854	3967	196	587	29	177	9
1991	10053	14203	3628	2099	110	451	35	156	1
1992	6830	12016	886	4066	85	475	34	298	7
1993	14083	4814	873	1294	660	642	226	475	56
1994	0	25596	4477	3619	919	341	275	199	118
1995	1798	4897	1316	1598	1777	209	211	88	159
1996	26463	2472	7161	1573	475	905	278	260	186
1997	284	29071	8330	1640	193	628	83	207	47
1998	1070	645	106	4749	1424	437	136	348	144
1999	4130	841	1113	177	102	855	501	186	149
2000	519	8160	1066	566	164	217	98	518	134
2001	5767	2625	2414	1010	563	129	73	367	228
2002	4	15855	1379	891	185	393	35	85	28
2003	3711	267	79	1723	453	136	43	67	17
2004	755	10761	2034	711	212	537	297	174	55
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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2011	0	404	19	1474	91	236	17	59	3
2012	0	168	6	194	51	293	6	60	10
2013	0	4824	431	1158	47	296	16	99	5
2014	301	2987	141	2371	28	340	3	119	5
2015	0	2275	42	772	9	561	2	197	2
2016	4	272	1	136	3	108	0	66	0
2017	0	23040	1325	243	5	51	25	20	2
2018	0	50	0	1949	22	63	2	11	0
2019	0	246	0	54	0	181	0	3	0
arith. mean	2853	7145	1504	1724	314	439	113	165	44

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1999	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	3.5	4.6	7.4	9.6	11.4	12.4	13.8	14.0	16.1
2019	4.0	7.3	8.3	12.0	12.7	15.0	15.4	18.3	18.0
arith. mean	4.0	6.3	8.2	10.8	13.5	15.0	18.0	17.5	20.2

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. Dregde survey indices.

Year	Age 0	Age 1
2010	938.752	1482.382
2011	2290.448	259.021
2012	11342.580	94.156
2013	7546.966	2103.482
2014	5760.235	810.806
2015	706.350	106.920
2016	53839.804	113.297
2017	899.000	2976.000
2018	2326.000	372.000
2019	26129.000	522.000

Table 9.3.5 Sandeel Area-2r. SMS settings and statistics.

```
Date: 01/20/20  Start time:15:43:07 run time:0 seconds

objective function (negative log likelihood):  65.6094
Number of parameters: 73
Maximum gradient: 5.39924e-005
Akaike information criterion (AIC):   277.219
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             333      20      37       0     390

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
               68.4    -4.7    19.6     0.0     0.0      0.00      83


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.21   -0.24    0.53    0.00


contribution by fleet:
----------------------
Dredge survey 2010-2019     total:  -4.701   mean:  -0.235

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
    2010-2019:   0.000 1.000
age: 1 - 4
    1983-1988:   0.480 0.500
    1989-1998:   0.674 0.500
    1999-2004:   0.421 0.500
    2005-2009:   0.193 0.500
    2010-2019:   0.503 0.500
```

```
F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.040  0.277  0.889  1.488  1.488
1989-1998:  0.100  0.344  0.410  0.480  0.480
1999-2004:  0.041  0.600  0.725  0.735  0.735
2005-2009:  0.001  1.982  1.687  1.806  1.806
2010-2019:  0.001  0.256  0.491  0.709  0.709
```

```
Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1983-1988 season 1:      0  0.301  0.966  1.616  1.616
          season 2:  0.051  0.174  0.559  0.936  0.936

1989-1998 season 1:      0  0.724  0.863  1.012  1.012
          season 2:  0.109  0.188  0.224  0.263  0.263

1999-2004 season 1:      0  0.308  0.373  0.378  0.378
          season 2:  0.081  0.597  0.722  0.732  0.732

2005-2009 season 1:      0  0.540  0.459  0.492  0.492
          season 2:  0.001  0.541  0.460  0.493  0.493

2010-2019 season 1:      0  0.562  1.077  1.556  1.556
          season 2:  0.001  0.124  0.237  0.342  0.342
```

```
sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age         1       2

 0              1.662
 1      0.374   0.739
 2      0.374   0.739
 3      0.805   1.090
```

```
 4       0.805   1.090

Survey catchability:
---------------------
                            age 0    age 1
 Dredge survey 2010-2019       1.992   20.938

Stock size dependent catchability (power model)
----------------------------------------------    age 0    age 1
Dredge survey 2010-2019        1.19     1.00

sqrt(Survey variance) ~ CV:
---------------------------
                            age 0    age 1
 Dredge survey 2010-2019        0.30     0.79

Recruit-SSB            alfa      beta       recruit s2     recruit s
Area-2r             1110.019   5.600e+004   1.060          1.029
```

Table 9.3.6 Sandeel Area-2r. Annual fishing mortality (F) at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.037	0.368	1.169	1.949	1.947	0.769
1984	0.033	0.309	0.985	1.648	1.647	0.647
1985	0.022	0.289	0.912	1.510	1.508	0.601
1986	0.025	0.416	1.297	2.130	2.127	0.856
1987	0.008	0.091	0.291	0.485	0.485	0.191
1988	0.026	0.308	0.976	1.620	1.618	0.642
1989	0.076	0.733	0.857	0.992	0.990	0.795
1990	0.037	0.493	0.573	0.661	0.660	0.533
1991	0.071	0.556	0.652	0.758	0.756	0.604
1992	0.051	0.565	0.659	0.762	0.760	0.612
1993	0.080	0.446	0.527	0.616	0.616	0.486
1994	0.051	0.473	0.553	0.641	0.639	0.513
1995	0.043	0.257	0.304	0.355	0.354	0.281
1996	0.133	0.383	0.464	0.555	0.555	0.424
1997	0.083	0.560	0.659	0.767	0.766	0.609
1998	0.046	0.288	0.340	0.397	0.396	0.314
1999	0.036	0.371	0.461	0.481	0.481	0.416

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2000	0.017	0.552	0.656	0.661	0.660	0.604
2001	0.036	0.481	0.588	0.606	0.606	0.534
2002	0.020	0.667	0.793	0.797	0.796	0.730
2003	0.037	0.442	0.544	0.563	0.563	0.493
2004	0.030	0.900	1.072	1.081	1.079	0.986
2005	0.001	1.196	1.026	1.111	1.111	1.111
2006	0.001	1.249	1.077	1.173	1.173	1.163
2007	0.000	0.767	0.635	0.663	0.661	0.701
2008	0.000	0.823	0.692	0.735	0.734	0.757
2009	0.000	0.786	0.673	0.728	0.728	0.729
2010	0.000	0.327	0.610	0.866	0.864	0.468
2011	0.000	0.210	0.389	0.550	0.549	0.299
2012	0.000	0.120	0.221	0.313	0.312	0.171
2013	0.000	0.521	0.963	1.358	1.355	0.742
2014	0.000	0.393	0.724	1.019	1.015	0.559
2015	0.000	0.345	0.634	0.889	0.886	0.489
2016	0.000	0.149	0.275	0.387	0.386	0.212
2017	0.001	0.677	1.248	1.759	1.755	0.962
2018	0.000	0.201	0.370	0.519	0.517	0.285
2019	0.000	0.049	0.091	0.128	0.127	0.070
arith. mean	0.027	0.480	0.674	0.871	0.870	0.577

Table 9.3.7 Sandeel Area-2r. Fishing mortality (F) at age.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.037	0.216	0.125	0.695	0.402	1.162	0.673	1.162	0.673
1984	0.033	0.176	0.114	0.566	0.367	0.947	0.613	0.947	0.613
1985	0.022	0.183	0.075	0.589	0.241	0.986	0.404	0.986	0.404
1986	0.025	0.277	0.086	0.890	0.275	1.489	0.460	1.489	0.460
1987	0.008	0.056	0.028	0.178	0.089	0.298	0.149	0.298	0.149
1988	0.026	0.190	0.090	0.609	0.290	1.020	0.485	1.020	0.485

	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
1989	0.076	0.504	0.131	0.601	0.156	0.704	0.183	0.704	0.183
1990	0.037	0.351	0.064	0.418	0.076	0.491	0.089	0.491	0.089
1991	0.071	0.367	0.122	0.438	0.145	0.513	0.170	0.513	0.170
1992	0.051	0.394	0.089	0.470	0.106	0.550	0.124	0.550	0.124
1993	0.080	0.270	0.139	0.322	0.165	0.377	0.194	0.377	0.194
1994	0.051	0.321	0.087	0.383	0.104	0.449	0.122	0.449	0.122
1995	0.043	0.159	0.075	0.189	0.089	0.222	0.104	0.222	0.104
1996	0.133	0.169	0.229	0.201	0.274	0.236	0.321	0.236	0.321
1997	0.083	0.357	0.144	0.426	0.171	0.499	0.201	0.499	0.201
1998	0.046	0.180	0.080	0.215	0.095	0.252	0.111	0.252	0.111
1999	0.036	0.138	0.268	0.167	0.324	0.169	0.328	0.169	0.328
2000	0.017	0.360	0.128	0.435	0.154	0.441	0.156	0.441	0.156
2001	0.036	0.223	0.268	0.269	0.324	0.273	0.329	0.273	0.329
2002	0.020	0.442	0.144	0.535	0.174	0.542	0.176	0.542	0.176
2003	0.037	0.192	0.269	0.233	0.326	0.236	0.330	0.236	0.330
2004	0.030	0.582	0.223	0.704	0.270	0.713	0.273	0.713	0.273
2005	0.001	0.595	0.596	0.506	0.508	0.542	0.543	0.542	0.543
2006	0.001	0.569	0.712	0.485	0.606	0.519	0.649	0.519	0.649
2007	0.000	0.612	0.000	0.521	0.000	0.558	0.000	0.558	0.000
2008	0.000	0.539	0.191	0.459	0.162	0.492	0.174	0.492	0.174
2009	0.000	0.398	0.379	0.339	0.323	0.362	0.346	0.362	0.346
2010	0.000	0.227	0.050	0.435	0.096	0.629	0.138	0.629	0.138
2011	0.000	0.153	0.018	0.294	0.035	0.425	0.051	0.425	0.051
2012	0.000	0.089	0.007	0.171	0.013	0.247	0.019	0.247	0.019
2013	0.000	0.381	0.052	0.729	0.099	1.053	0.143	1.053	0.143
2014	0.000	0.298	0.019	0.571	0.037	0.825	0.053	0.825	0.053
2015	0.000	0.268	0.005	0.514	0.010	0.742	0.014	0.742	0.014
2016	0.000	0.114	0.004	0.218	0.008	0.315	0.011	0.315	0.011
2017	0.001	0.496	0.068	0.950	0.131	1.372	0.189	1.372	0.189

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2018	0.000	0.156	0.002	0.299	0.003	0.432	0.004	0.432	0.004
2019	0.000	0.038	0.000	0.073	0.000	0.106	0.000	0.106	0.000
arith. mean	0.027	0.298	0.137	0.435	0.180	0.573	0.225	0.573	0.225

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2006	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2007	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2008	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2009	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2010	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2011	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2012	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2013	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2014	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2015	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2016	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2017	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2018	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2019	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
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	159523	16053	14304	705	32
1984	47353	61293	3577	1885	56
1985	282607	18254	14375	555	195
1986	61498	110185	4419	2472	90
1987	36103	23904	24038	544	174
1988	177505	14272	6894	7257	220
1989	87111	68902	3382	1107	793
1990	156075	32177	11450	626	376
1991	110958	59939	6662	2755	270
1992	116562	41208	11525	1468	730
1993	235244	44124	7974	2558	538

	Age 0	Age 1	Age 2	Age 3	Age 4
1994	107622	86510	9196	1934	838
1995	77669	40772	18021	2229	752
1996	421155	29641	10123	5384	1032
1997	15752	146917	6239	2484	1760
1998	26856	5775	27911	1355	1014
1999	75388	10219	1396	8080	793
2000	44074	28968	2134	337	2578
2001	130967	17262	5576	467	779
2002	10300	50323	3313	1216	330
2003	47353	4025	8776	643	361
2004	19000	18192	795	1981	274
2005	19124	7345	2550	119	402
2006	26769	7615	700	365	85
2007	39196	10658	663	93	67
2008	24925	15620	1811	155	44
2009	79247	9931	2359	384	49
2010	9770	31566	1431	480	102
2011	12833	3892	7498	332	129
2012	52422	5114	1028	2129	138
2013	28683	20890	1456	337	830
2014	19509	11426	4250	251	171
2015	5290	7774	2608	913	84
2016	168519	2108	1854	610	224
2017	3868	67156	587	584	288
2018	15268	1541	11971	79	88
2019	95720	6084	413	3492	52
2020		38146	1836	151	1522

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	159571076	246986	139525	155664	0.719
1984	47346336	411151	70404	133343	0.611
1985	282729170	278633	134996	110546	0.544
1986	61527821	724264	83700	225470	0.764
1987	36107097	418134	235861	49070	0.176
1988	177592117	277453	187213	149466	0.590
1989	87137684	447017	54176	223507	0.696
1990	156098847	354515	112308	133874	0.455
1991	110995476	644819	180593	215508	0.536
1992	116569708	433509	133786	184033	0.529
1993	235212519	514895	161943	139826	0.447
1994	107607403	607841	135266	244939	0.448
1995	77671581	584929	241591	113899	0.256
1996	421360787	453183	228662	182562	0.437
1997	15744474	886091	117360	242094	0.549
1998	26856005	391280	302247	99814	0.285
1999	75376039	239211	155127	69427	0.448
2000	44057229	270455	73204	92908	0.539
2001	130907300	198555	85477	90200	0.542
2002	10303560	329938	46074	117388	0.648
2003	47346336	139427	99012	53710	0.510
2004	19000959	153147	36717	110546	0.889
2005	19115307	92589	33759	34396	1.102
2006	26775558	71882	14167	37860	1.186
2007	39192658	76365	10735	43090	0.567
2008	24915484	112565	23766	35604	0.676
2009	79240651	87530	25084	35687	0.719
2010	9771690	201884	22743	51670	0.404

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2011	12839026	116911	76191	24896	0.250
2012	52430550	89235	45982	10594	0.140
2013	28688302	151078	28538	47814	0.630
2014	19501462	108747	42447	48033	0.463
2015	5288261	100908	43391	37902	0.398
2016	168593323	41938	31351	5230	0.172
2017	3867040	388900	23133	141314	0.823
2018	15263883	124709	98125	20239	0.230
2019	95725952	102578	58454	5216	0.056
2020			47240		
arith. mean	82373452	293872	95803	100469	0.525
geo. mean	47016069				

arith. mean for the period 1983-2019
geo. mean for the period 1983-2018

Table 9.3.11 Sandeel Area-2r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2020)	20825.766	38146.4	1835.81	151.273	1521.51
Exploitation pattern 1st half		0.038	0.073	0.106	0.106
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.499	10.797	14.083	16.071
Weight in the catch 1st half		5.499	10.797	14.083	16.071
weight in the catch 2nd half	3.663	8.091	12.395	15.077	17.955
Proportion mature(2020)	0.000	0.020	0.830	1.000	1.000
Proportion mature(2021)	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(2019)=0.0557; Yield(2019)=5.216; Recruitment(2019)=95.725952; Recruitment(2020)=geometric mean (GM 2009-2018)=20.825766 billions;SSB(2020)=47.24

F multiplier	Basis	F(2020)	Catch(2020)	SSB(2021)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	131.351	178 %	-100
7.890	Fsq*7.89	0.440	62.658	91.553	94 %	1153
1.000	Fsq*1	0.056	9.447	125.298	165 %	89
3.040	Fsq*3.04	0.169	27.193	113.970	141 %	444
5.000	Fsq*5	0.279	42.578	104.204	121 %	752
7.000	Fsq*7	0.390	56.763	95.255	102 %	1035
9.000	Fsq*9	0.502	69.620	87.196	85 %	1292
11.000	Fsq*11	0.613	81.308	79.922	69 %	1526
13.000	Fsq*13	0.725	91.963	73.341	55 %	1739
9.854	MSY	0.549	74.745	84.000	78 %	1395

*SSB in 2021 relative to SSB in 2020

** **Catch scenario for 2020 relative to the monitoring TAC in 2019 (5000 t).**

Table 9.4.1 Sandeel Area-3r. Catch-at-age numbers (million) by half year.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	7965	18939	7987	2063	533	161	2	0	0
1987	5	33760	65	14020	4	453	0	200	0
1988	8769	6584	853	17321	233	893	144	19	13
1989	159	47004	190	1844	13	2806	0	4	0
1990	9793	9302	1377	2791	286	413	43	125	13
1991	14442	24009	942	1391	30	526	9	184	3
1992	525	7100	87	2862	8	342	3	215	1
1993	9663	15164	851	558	155	211	71	1336	12
1994	0	23742	615	4818	684	938	78	386	10
1995	1020	25037	484	1894	78	238	13	156	17
1996	6263	4319	3111	3394	97	465	33	399	248
1997	2975	66856	10388	2912	134	607	13	194	9

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1998	30136	3954	992	28137	740	2553	192	290	32
1999	6444	5182	1835	1554	118	1979	401	421	169
2000	0	18793	344	3286	4	541	1	533	9
2001	18263	5327	3968	992	9	163	2	160	6
2002	0	9075	21	2680	3	387	1	135	0
2003	2755	939	61	808	53	130	2	78	1
2004	1091	1976	737	256	16	74	6	92	1
2005	0	1404	1	146	0	21	0	12	0
2006	0	769	3	47	1	27	0	4	0
2007	0	8600	0	571	0	86	0	19	0
2008	0	4077	0	2012	0	460	0	73	0
2009	1	827	12	69	2	8	0	0	0
2010	0	3042	51	740	1	1006	1	173	0
2011	0	1304	0	5224	0	825	0	24	0
2012	0	32	0	186	0	1157	0	356	0
2013	0	648	0	211	0	55	0	42	0
2014	0	5384	0	2373	0	643	0	319	0
2015	0	6451	0	2340	0	956	0	99	0
2016	0	156	0	2006	0	415	0	284	0
2017	0	11734	0	671	0	434	0	409	0
2018	0	413	6	6631	48	40	1	305	1
2019	0	7901	0	747	0	4282	0	147	0
arith. mean	3537	11171	1029	3457	96	715	30	212	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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2014	4.1	8.6	8.6	12.7	13.9	13.9	18.9	18.3	20.5
2015	5.6	8.3	11.7	12.7	18.8	19.3	25.7	30.1	27.7
2016	1.5	4.0	3.1	12.4	5.0	19.8	6.8	32.1	7.4
2017	4.3	7.7	8.8	11.9	14.1	17.7	18.9	24.2	20.5
2018	3.9	5.8	7.0	9.9	10.7	13.5	13.6	20.6	15.2
2019	5.2	8.1	9.3	10.8	14.2	14.1	18.2	18.8	20.2
arith. mean	4.7	7.0	9.4	12.3	15.9	18.1	21.1	23.1	22.8

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. Dregde survey indices.

Year	Age 0	Age 1
2005	68667.988	
2006	55709.239	1225.934
2007	10611.085	3717.149
2008	16658.095	1521.160
2009	37088.951	16328.039
2010	1844.740	5076.749
2011	973.111	1961.856
2012	47713.266	767.514
2013	174467.733	790.887
2014	92703.238	5349.152
2015	2667.397	11100.794
2016	194644.941	322.967
2017	6359.000	15640.000
2018	82359.000	5980.000
2019	112538.400	10448.300

Table 9.4.5 Sandeel Area-3r. SMS settings and statistics.

```
Date: 01/23/20  Start time:11:26:37 run time:0 seconds

objective function (negative log likelihood):  111.639
Number of parameters: 59
Maximum gradient: 8.75414e-005
Akaike information criterion (AIC):   341.279
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                              306      73      34       0     413

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
               99.3    12.2    18.8     0.0     0.0      0.00     130


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.32    0.17    0.55    0.00


contribution by fleet:
----------------------
Acoustic survey             total:   6.814   mean:   0.155
Dredge survey 2004-2019     total:   5.357   mean:   0.185

F, season effect:
-----------------
age: 0
    1986-1998:   0.000 1.000
    1999-2019:   0.000 1.000
age: 1 - 4
    1986-1998:   0.893 0.500
    1999-2019:   1.059 0.500

F, age effect:
--------------
                0      1      2      3      4
1986-1998:  0.102  0.366  0.401  0.322  0.322
1999-2019:  0.057  0.179  0.291  0.285  0.285


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1986-1998 season 1:      0  0.646  0.709  0.568  0.568
          season 2:  0.172  0.308  0.338  0.271  0.271
```

```
1999-2019 season 1:      0  0.530  0.863  0.843  0.843
          season 2:  0.147  0.231  0.376  0.367  0.367


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1        2

 0                1.155
 1       0.658   1.027
 2       0.658   1.027
 3       1.053   1.205
 4       1.053   1.205


Survey catchability:
--------------------
                           age 0    age 1    age 2    age 3    age 4
 Acoustic survey                     2.868    5.602    4.527    4.527
 Dredge survey 2004-2019       0.534    0.534

Stock size dependent catchability (power model)
------------------------------------------------      age  0      age  1
age 2    age 3    age 4
Acoustic survey                               1.00      1.00      1.00
1.00
Dredge survey 2004-2019        1.03     1.00

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1    age 2    age 3    age 4
 Acoustic survey                      0.55     0.55     0.92     0.92
 Dredge survey 2004-2019        0.65     0.83

Recruit-SSB            alfa       beta        recruit s2     recruit s
Area-3r           1472.216   8.000e+004   1.111          1.054
```

Table 9.4.6 Sandeel Area-3r. Annual fishing mortality (F) at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1986	0.076	0.449	0.486	0.388	0.390	0.467
1987	0.001	0.709	0.745	0.583	0.582	0.727
1988	0.051	0.909	0.958	0.759	0.758	0.933
1989	0.003	1.027	1.079	0.864	0.861	1.053
1990	0.050	0.576	0.612	0.489	0.489	0.594

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1991	0.039	0.696	0.739	0.587	0.586	0.718
1992	0.003	0.324	0.340	0.263	0.264	0.332
1993	0.042	0.600	0.639	0.505	0.504	0.620
1994	0.016	0.642	0.680	0.527	0.523	0.661
1995	0.007	0.511	0.544	0.423	0.422	0.527
1996	0.043	0.500	0.537	0.420	0.420	0.518
1997	0.066	0.900	0.964	0.770	0.766	0.932
1998	0.140	1.139	1.231	0.987	0.981	1.185
1999	0.151	0.843	1.359	1.308	1.302	1.101
2000	0.004	0.871	1.359	1.268	1.260	1.115
2001	0.156	0.543	0.889	0.866	0.869	0.716
2002	0.000	0.573	0.886	0.860	0.856	0.730
2003	0.021	0.306	0.479	0.471	0.469	0.392
2004	0.020	0.213	0.336	0.331	0.330	0.274
2005	0.000	0.103	0.161	0.155	0.154	0.132
2006	0.000	0.044	0.068	0.065	0.065	0.056
2007	0.000	0.260	0.406	0.388	0.387	0.333
2008	0.000	0.280	0.438	0.426	0.425	0.359
2009	0.000	0.024	0.037	0.036	0.036	0.030
2010	0.001	0.304	0.479	0.460	0.457	0.391
2011	0.000	0.197	0.310	0.299	0.296	0.253
2012	0.000	0.119	0.188	0.183	0.182	0.153
2013	0.000	0.058	0.092	0.090	0.089	0.075
2014	0.000	0.231	0.364	0.356	0.353	0.298
2015	0.000	0.304	0.478	0.467	0.464	0.391
2016	0.000	0.119	0.188	0.183	0.182	0.153
2017	0.000	0.263	0.414	0.405	0.402	0.339
2018	0.000	0.281	0.442	0.432	0.429	0.362
2019	0.000	0.385	0.604	0.591	0.587	0.494

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
arith. mean	0.026	0.450	0.574	0.506	0.504	0.512

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	0.284	0.135	0.311	0.148	0.250	0.119	0.250	0.119
1987	0.001	0.572	0.002	0.628	0.002	0.504	0.002	0.504	0.002
1988	0.051	0.682	0.091	0.748	0.100	0.600	0.080	0.600	0.080
1989	0.003	0.857	0.006	0.941	0.006	0.754	0.005	0.754	0.005
1990	0.050	0.423	0.089	0.464	0.098	0.372	0.078	0.372	0.078
1991	0.039	0.537	0.070	0.589	0.077	0.472	0.062	0.472	0.062
1992	0.003	0.259	0.006	0.284	0.006	0.228	0.005	0.228	0.005
1993	0.042	0.446	0.074	0.490	0.082	0.393	0.065	0.393	0.065
1994	0.016	0.498	0.028	0.547	0.031	0.439	0.025	0.439	0.025
1995	0.007	0.406	0.013	0.445	0.014	0.357	0.011	0.357	0.011
1996	0.043	0.356	0.076	0.390	0.084	0.313	0.067	0.313	0.067
1997	0.066	0.666	0.117	0.731	0.129	0.586	0.103	0.586	0.103
1998	0.140	0.789	0.249	0.866	0.274	0.694	0.220	0.694	0.220
1999	0.151	0.545	0.238	0.887	0.387	0.867	0.378	0.867	0.378
2000	0.004	0.687	0.006	1.119	0.010	1.093	0.010	1.093	0.010
2001	0.156	0.287	0.246	0.466	0.401	0.456	0.392	0.456	0.392
2002	0.000	0.427	0.000	0.696	0.000	0.680	0.000	0.680	0.000
2003	0.021	0.212	0.033	0.345	0.053	0.337	0.052	0.337	0.052
2004	0.020	0.147	0.032	0.239	0.052	0.233	0.051	0.233	0.051
2005	0.000	0.079	0.000	0.129	0.000	0.126	0.000	0.126	0.000
2006	0.000	0.034	0.000	0.055	0.001	0.054	0.001	0.054	0.001
2007	0.000	0.206	0.000	0.336	0.000	0.328	0.000	0.328	0.000
2008	0.000	0.228	0.000	0.372	0.000	0.363	0.000	0.363	0.000
2009	0.000	0.019	0.000	0.031	0.000	0.031	0.000	0.031	0.000
2010	0.001	0.247	0.001	0.402	0.001	0.392	0.001	0.392	0.001
2011	0.000	0.157	0.000	0.255	0.000	0.250	0.000	0.250	0.000

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2012	0.000	0.095	0.000	0.155	0.000	0.152	0.000	0.152	0.000
2013	0.000	0.046	0.000	0.075	0.000	0.074	0.000	0.074	0.000
2014	0.000	0.186	0.000	0.302	0.000	0.295	0.000	0.295	0.000
2015	0.000	0.245	0.000	0.398	0.000	0.389	0.000	0.389	0.000
2016	0.000	0.095	0.000	0.155	0.000	0.152	0.000	0.152	0.000
2017	0.000	0.212	0.000	0.345	0.000	0.337	0.000	0.337	0.000
2018	0.000	0.226	0.000	0.368	0.000	0.360	0.000	0.360	0.000
2019	0.000	0.311	0.000	0.505	0.000	0.494	0.000	0.494	0.000
arith. mean	0.026	0.337	0.045	0.443	0.058	0.395	0.051	0.395	0.051

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

	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
2003	1.220	0.830	0.770	0.720	0.640	0.580	0.620	0.540	0.600
2004	1.210	0.850	0.700	0.710	0.570	0.560	0.550	0.510	0.530
2005	1.150	0.840	0.650	0.690	0.530	0.500	0.470	0.470	0.450
2006	1.120	0.820	0.610	0.660	0.490	0.480	0.420	0.440	0.410
2007	1.050	0.770	0.580	0.610	0.470	0.450	0.400	0.420	0.390
2008	0.990	0.680	0.500	0.550	0.400	0.430	0.380	0.400	0.370
2009	0.990	0.590	0.470	0.480	0.390	0.370	0.340	0.340	0.330
2010	1.110	0.590	0.500	0.450	0.420	0.360	0.370	0.330	0.350
2011	1.210	0.660	0.550	0.510	0.460	0.390	0.420	0.350	0.390
2012	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2013	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2014	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2015	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2016	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2017	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2018	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2019	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
arith. mean	1.164	0.713	0.571	0.566	0.463	0.419	0.404	0.386	0.387

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	511454	85279	5876	262	713
1987	116770	124178	14400	1273	325
1988	359650	27914	18678	2710	453
1989	107078	73263	3547	2942	770
1990	202638	28228	9591	554	852
1991	123415	53608	5578	2362	484
1992	261819	35028	9721	1237	904
1993	191801	79389	8343	3015	924

	Age 0	Age 1	Age 2	Age 3	Age 4
1994	181907	58843	14348	1896	1284
1995	148761	59016	9760	2992	1010
1996	777484	53797	11016	2246	1308
1997	63136	276825	10209	2523	1165
1998	94126	24038	39242	1671	859
1999	120659	31034	2721	5104	494
2000	126550	36680	3829	277	814
2001	118051	41127	4300	388	167
2002	28428	30719	4874	478	89
2003	63135	8393	3886	606	87
2004	40332	18258	1327	670	142
2005	70254	11783	3241	276	204
2006	111300	22245	2453	841	164
2007	59086	36306	5144	734	390
2008	87236	20676	7658	1249	351
2009	140677	32415	5056	2042	499
2010	13783	52267	11015	2052	1221
2011	10571	4540	13719	3084	1084
2012	74946	3152	1157	4028	1472
2013	195640	22800	829	365	2028
2014	218094	59518	6299	283	981
2015	6698	66339	14302	1712	414
2016	593191	2038	15029	3533	616
2017	26436	180461	536	4735	1520
2018	202344	8042	42256	140	1914
2019	334269	61557	1856	10758	635
2020		101692	13058	412	2950

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	511572565	593822	77188	282315	0.439
1987	116803080	999662	190804	395296	0.602
1988	359778816	465938	271034	330358	0.811
1989	107070708	542831	101215	350409	0.905
1990	202651842	330283	105451	163224	0.536
1991	123407198	555224	161781	274839	0.637
1992	261776070	353078	123500	86788	0.278
1993	191806959	670738	196614	175786	0.546
1994	181905886	632964	239187	267281	0.552
1995	148783085	481372	142629	173607	0.439
1996	777815572	728497	238232	159024	0.453
1997	63148522	1606030	187025	470670	0.822
1998	94112365	554639	347319	462081	1.089
1999	120601225	340687	114348	191253	1.028
2000	126531266	313028	60779	186837	0.911
2001	118095007	349849	65907	193684	0.700
2002	28431266	319131	65121	116298	0.561
2003	63148522	115899	59695	34673	0.321
2004	40345886	157299	26291	31285	0.235
2005	70280153	154987	54339	13991	0.104
2006	111328962	218642	50111	7094	0.045
2007	59115280	370279	90762	74972	0.271
2008	87224865	317369	130744	74933	0.300
2009	140680230	304604	94278	6261	0.025
2010	13783737	659317	235861	61241	0.325
2011	10574965	306092	232350	92452	0.206
2012	74925137	184366	150242	40116	0.125
2013	195681716	255792	52892	9844	0.061

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean $F_{1\text{-}2}$
2014	217998775	610801	101316	90876	0.244
2015	6695860	777262	204230	104631	0.322
2016	593174986	284316	232815	42845	0.125
2017	26429728	1512330	175255	115642	0.278
2018	202246943	504599	361855	75143	0.297
2019	334116402	684291	197402	135590	0.408
2020			221239		
arith. mean	170050526	507530	153141	155628	0.441
geo. mean	102975330				

arith. mean for the period 1986-2019
geo. mean for the period 1986-2018

Table 9.4.11 Sandeel Area-3r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2020)	102992.005	101692	13057.7	411.9	2950.35
Exploitation pattern 1st half		0.311	0.505	0.494	0.494
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		6.782	11.533	16.879	25.136
Weight in the catch 1st half		6.782	11.533	16.879	25.136
weight in the catch 2nd half	4.095	7.982	12.575	16.638	18.197
Proportion mature(2020)	0.000	0.036	0.766	1.000	1.000
Proportion mature(2021)	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(2019)=0.408; Yield(2019)=135.59; Recruitment(2019)=334.116402; Recruitment(2020)=geometric mean (GM 1986-2018)=102.992005 billions;SSB(2020)=221.239

F multiplier	Basis	F(2020)	Catch(2020)	SSB(2021)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	385.956	74 %	-100
0.710	Fsq*0.71	0.290	155.072	298.955	35 %	14
1.000	Fsq*1	0.408	208.340	269.841	22 %	54

F multiplier	Basis	F(2020)	Catch(2020)	SSB(2021)	%SSB change*	%TAC change**
0.400	Fsq*0.4	0.163	91.844	334.055	51 %	-32
0.600	Fsq*0.6	0.245	133.299	310.979	41 %	-2
0.800	Fsq*0.8	0.326	172.066	289.619	31 %	27
0.100	Fsq*0.1	0.041	24.151	372.212	68 %	-82
0.120	Fsq*0.12	0.049	28.882	369.527	67 %	-79
0.140	Fsq*0.14	0.057	33.582	366.863	66 %	-75
3.167	MSY	1.292	482.681	129.001	-42 %	256

***SSB in 2021 relative to SSB in 2020**

**** Catch scenario for 2020 relative to TAC in 2019 (135 689 t, sum of the Norwegian 125000 t and EU TAC 10689 t).**

Table 9.4.13. Sandeel Area-3r. Acoustic survey indices (millions of individuals).

Year	Age 1	Age 2	Age 3	Age 4
2009	7709.06 (CV=0.29)	4923.33 (CV=0.34)	945.29 (CV=0.3)	64.03 (CV=0.47)
2010	16852.06 (CV=0.19)	6133.6 (CV=0.18)	1123.19 (CV=0.38)	608.57 (CV=0.4)
2011	816.16 (CV=0.73)	8622.2 (CV=0.19)	855.81 (CV=0.33)	192.37 (CV=0.49)
2012	846.68 (CV=0.81)	211.31 (CV=0.67)	3226.29 (CV=0.25)	368.16 (CV=0.24)
2013	2154.47 (CV=0.2)	258.25 (CV=0.36)	72.62 (CV=0.41)	554.48 (CV=0.43)
2014	21889.62 (CV=0.23)	1711.1 (CV=0.36)	170.41 (CV=0.64)	80.34 (CV=0.85)
2015	9466.6 (CV=0.12)	2254.92 (CV=0.27)	686.55 (CV=0.29)	7.03 (CV=1.18)
2016	79.55 (CV=1)	6317.38 (CV=0.29)	679.13 (CV=0.25)	259.1 (CV=0.37)
2017	35267.58 (CV=0.16)	131.65 (CV=0.77)	3465.88 (CV=0.27)	631.09 (CV=0.27)
2018	1544.39 (CV=0.31)	16989.62 (CV=0.1)	79.82 (CV=0.34)	440.33 (CV=0.31)
2019	9564.52 (CV=0.16)	464.24 (CV=0.25)	15573.73 (CV=0.12)	214.53 (CV=0.33)

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1996	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	874	0	1259	0	355	0	1133	0
2019	0	314	0	162	0	149	0	57	0
arith. mean	129	1113	175	994	152	633	26	265	49

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	3.3	5.7	4.8	9.4	7.6	13.1	11.1	18.3	13.9
2019	3.3	5.9	4.8	10.0	7.6	13.5	11.1	19.6	13.9
arith. mean	3.8	5.6	7.7	9.5	13.3	13.2	16.1	17.3	21.2

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. Dregde survey indices.

Year	Age 0	Age 1
1999	615	494
2000	586	3170
2001	48	2656
2002	243	404
2003	580	
2004		
2005		
2006		
2007		
2008	52	24
2009	832	87
2010	147	1032
2011	89	165
2012	95	135
2013	62	85
2014	445	43
2015	136	1044
2016	300	81
2017	346	223
2018	16	461
2019	371	92

Table 9.5.5 Sandeel Area-4. SMS settings and statistics.

```
Date: 01/20/20  Start time:15:07:04 run time:0 seconds

objective function (negative log likelihood):  3.22347
Number of parameters: 46
Maximum gradient: 8.9242e-005
Akaike information criterion (AIC):   98.4469
```

```
Number of observations used in the likelihood:
                             Catch    CPUE     S/R Stomach     Sum
                               243      33      27       0     303

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
               27.6   -25.3    19.3      0.0      0.0     0.00      22


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.11   -0.77    0.71    0.00


contribution by fleet:
-----------------------
Old Dredge survey 1999-2003     total:  -9.450   mean:  -1.050
New Dredge survey 2008-2019     total: -15.848   mean:  -0.660

F, season effect:
-----------------
age: 0
    1993-2019:   0.000 1.000
age: 1 - 4
    1993-2019:   0.583 0.500

F, age effect:
--------------
                 0      1      2      3      4
1993-2019:  0.003  0.109  0.188  0.264  0.264


Exploitation pattern (scaled to mean F=1)
------------------------------------------
                         0      1      2      3      4
1993-2019 season 1:      0  0.649  1.116  1.567  1.567
          season 2:  0.004  0.086  0.149  0.209  0.209


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age         1       2

 0               2.004
 1       0.709   0.375
 2       0.709   0.375
```

```
 3       0.723   1.267
 4       0.723   1.267


Survey catchability:
--------------------
                           age 0    age 1
 Old Dredge survey 1999-2003       0.773   17.637
 New Dredge survey 2008-2019       0.570    3.164

sqrt(Survey variance) ~ CV:
---------------------------
                           age 0    age 1
 Old Dredge survey 1999-2003        0.30     0.30
 New Dredge survey 2008-2019        0.30     0.40

Recruit-SSB             alfa      beta       recruit s2     recruit s
Area-4              1419.336   4.800e+004   1.532          1.238
```

Table 9.5.6 Sandeel Area-4. Annual fishing mortality (F) at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1993	0.002	0.337	0.563	0.770	0.768	0.450
1994	0.002	0.390	0.651	0.888	0.886	0.520
1995	0.000	0.115	0.191	0.259	0.258	0.153
1996	0.009	0.245	0.435	0.631	0.636	0.340
1997	0.001	0.144	0.244	0.336	0.336	0.194
1998	0.000	0.156	0.259	0.353	0.351	0.207
1999	0.000	0.224	0.371	0.503	0.501	0.298
2000	0.000	0.111	0.185	0.251	0.249	0.148
2001	0.000	0.175	0.290	0.394	0.392	0.232
2002	0.000	0.037	0.062	0.084	0.083	0.049
2003	0.001	0.279	0.464	0.631	0.629	0.371
2004	0.000	0.054	0.089	0.121	0.120	0.071
2005	0.000	0.023	0.039	0.053	0.053	0.031
2006	0.000	0.000	0.001	0.001	0.001	0.000
2007	0.000	0.000	0.000	0.001	0.001	0.000
2008	0.000	0.002	0.003	0.004	0.004	0.003
2009	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.001	0.002	0.002	0.002	0.001

	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
2011	0.000	0.002	0.003	0.004	0.004	0.002
2012	0.000	0.018	0.030	0.040	0.040	0.024
2013	0.000	0.010	0.017	0.022	0.022	0.013
2014	0.000	0.013	0.022	0.030	0.030	0.018
2015	0.000	0.011	0.018	0.024	0.024	0.014
2016	0.000	0.021	0.034	0.047	0.046	0.028
2017	0.000	0.045	0.076	0.102	0.102	0.061
2018	0.000	0.130	0.215	0.292	0.290	0.173
2019	0.000	0.049	0.082	0.111	0.111	0.066
arith. mean	0.001	0.096	0.161	0.221	0.220	0.128

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	0.249	0.033	0.429	0.057	0.602	0.080	0.602	0.080
1994	0.002	0.293	0.032	0.504	0.055	0.707	0.077	0.707	0.077
1995	0.000	0.090	0.000	0.156	0.000	0.219	0.001	0.219	0.001
1996	0.009	0.108	0.168	0.185	0.289	0.260	0.406	0.260	0.406
1997	0.001	0.102	0.023	0.175	0.040	0.246	0.057	0.246	0.057
1998	0.000	0.119	0.006	0.205	0.011	0.288	0.015	0.288	0.015
1999	0.000	0.177	0.000	0.305	0.000	0.428	0.000	0.428	0.000
2000	0.000	0.088	0.000	0.151	0.000	0.212	0.000	0.212	0.000
2001	0.000	0.136	0.002	0.235	0.004	0.330	0.006	0.330	0.006
2002	0.000	0.029	0.000	0.050	0.000	0.070	0.000	0.070	0.000
2003	0.001	0.214	0.013	0.368	0.022	0.517	0.031	0.517	0.031
2004	0.000	0.042	0.000	0.072	0.001	0.101	0.001	0.101	0.001
2005	0.000	0.018	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	0.002	0.000	0.003	0.000	0.004	0.000	0.004	0.000
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2010	0.000	0.001	0.000	0.001	0.000	0.002	0.000	0.002	0.000
2011	0.000	0.001	0.000	0.002	0.000	0.003	0.000	0.003	0.000
2012	0.000	0.014	0.000	0.024	0.000	0.034	0.000	0.034	0.000
2013	0.000	0.008	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	0.025	0.000	0.025	0.000
2015	0.000	0.008	0.000	0.014	0.000	0.020	0.000	0.020	0.000
2016	0.000	0.016	0.000	0.028	0.000	0.039	0.000	0.039	0.000
2017	0.000	0.036	0.000	0.061	0.000	0.086	0.000	0.086	0.000
2018	0.000	0.102	0.000	0.176	0.000	0.247	0.000	0.247	0.000
2019	0.000	0.039	0.000	0.067	0.000	0.094	0.000	0.094	0.000
arith. mean	0.001	0.070	0.010	0.121	0.018	0.170	0.025	0.170	0.025

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

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
2008	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2009	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2010	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2011	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2012	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2013	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2014	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2015	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2016	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2017	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2018	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2019	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
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	116157	21644	23310	7442	1549
1994	250967	37085	4193	4821	2012
1995	68533	80132	6888	807	1389
1996	370244	21918	18803	1981	798
1997	94522	117381	4274	3932	635
1998	42629	30193	26611	1159	1492
1999	227134	13629	6843	7209	883
2000	194316	72642	2934	1697	2329
2001	23129	62146	17098	848	1470
2002	84912	7396	13897	4527	750
2003	146616	27156	1846	4444	2174
2004	12149	46860	5563	420	1708
2005	8840	3885	11542	1739	876

	Age 0	Age 1	Age 2	Age 3	Age 4
2006	5523	2827	980	3760	1116
2007	8305	1766	726	329	2163
2008	24104	2656	454	244	1140
2009	368411	7709	681	152	629
2010	64554	117825	1981	229	356
2011	43688	20646	30248	665	264
2012	40514	13972	5297	10145	412
2013	27753	12957	3540	1739	4491
2014	277178	8876	3303	1174	2777
2015	53937	88647	2257	1091	1750
2016	112981	17250	22587	748	1259
2017	131608	36134	4361	7385	873
2018	14597	42091	8958	1379	3344
2019	175399	4668	9764	2526	1675
2020		56096	1154	3071	1712

Table 9.5.10 Sandeel Area-4. Estimated recruitment, total-stock biomass (TBS), spawning-stock biomass (SSB), catch weight (Yield) and average fishing mortality.

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
1993	116104360	577242	357897	132599	0.384
1994	251009162	561609	147414	158690	0.441
1995	68544930	819658	122027	52591	0.123
1996	370365162	413415	245733	158490	0.375
1997	94489568	872976	79618	58446	0.170
1998	42627068	496312	255250	58746	0.171
1999	227122482	290757	190232	53334	0.241
2000	194316727	367455	80822	37714	0.119
2001	23138304	342115	109316	47902	0.189
2002	84901303	166795	120813	12736	0.040
2003	146567994	196899	68734	63731	0.308
2004	12151947	256567	59814	6882	0.057

	Recruits (thousands)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F_{1-2}
2005	8841791	111459	79858	1557	0.025
2006	5520616	99216	80660	0	0.000
2007	8301942	53740	43783	0	0.000
2008	24106691	37542	24029	0	0.002
2009	368517958	66605	20137	0	0.000
2010	64553184	631281	23718	0	0.001
2011	43706177	381954	225032	0	0.002
2012	40507593	202118	134996	2585	0.019
2013	27757038	203949	128027	5225	0.011
2014	277130757	179737	107689	4314	0.014
2015	53919352	448870	57584	4392	0.011
2016	113011484	354774	221461	6188	0.022
2017	131563476	430908	148301	18474	0.049
2018	14592234	404892	145510	42296	0.139
2019	175473747	192614	143774	6598	0.053
2020			84120		
arith. mean	110692564	339313	125219	34574	0.110
geo. mean	60008693				

arith. mean for the period 1993-2019
geo. mean for the period 1993-2018

Table 9.5.11 Sandeel Area-4. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2020)	72089.623	56095.8	1153.77	3070.97	1712.31
Exploitation pattern 1st half		0.039	0.067	0.094	0.094
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.695	9.821	13.905	19.478
Weight in the catch 1st half		5.695	9.821	13.905	19.478
weight in the catch 2nd half	4.109	6.534	10.335	14.417	17.065
Proportion mature(2020)	0.000	0.000	0.790	0.980	1.000
Proportion mature(2021)	0.000	0.000	0.790	0.980	1.000

	Age 0	Age 1	Age 2	Age 3	Age 4
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(2019)=0.0528; Yield(2019)=6.598; Recruitment(2019)=175.473747; Recruitment(2020)=geometric mean (GM 2009-2018)=72.089623 billions;SSB(2020)=84.12

F multiplier	Basis	F(2020)	Catch(2020)	SSB(2021)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	158.773	89 %	-100
2.840	Fsq*2.84	0.150	39.611	136.457	62 %	692
1.000	Fsq*1	0.053	14.645	150.454	79 %	193
2.000	Fsq*2	0.106	28.509	142.651	70 %	470
3.000	Fsq*3	0.158	41.645	135.328	61 %	733
4.000	Fsq*4	0.211	54.102	128.450	53 %	982
5.000	Fsq*5	0.264	65.923	121.986	45 %	1218
6.000	Fsq*6	0.317	77.151	115.906	38 %	1443
7.000	Fsq*7	0.369	87.822	110.183	31 %	1656
8.543	MSY	0.451	103.276	102.000	21 %	1966

***SSB in 2021 relative to SSB in 2020**
**** Catch scenario for 2020 relative to TAC in 2019 (5000 t).**

Table 9.6.1. Acoustic survey index (Area-5) is estimated as biomass (tonnes) methods and acoustic target strength described in ICES (2016) (Benchmark report).

Year	Biomass (tonnes)
2009	256.5
2010	6320.9
2011	3300.2
2012	732.2
2013	3949.1
2014	1331.8
2015	10477.6
2016	733.2
2017	493.1

Year	Biomass (tonnes)
2018	945.0
2019	3844.6

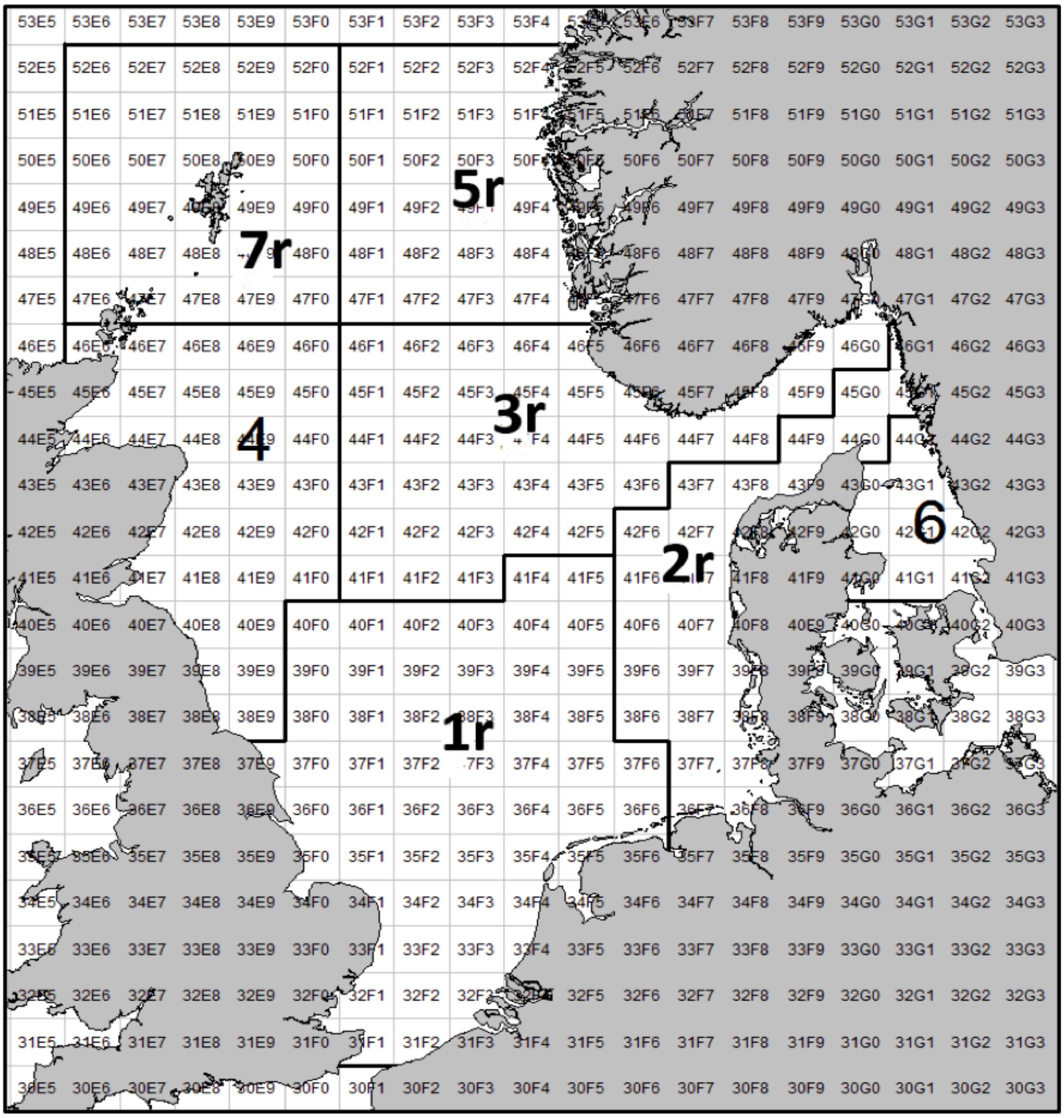


Figure 9.1.1. Sandeel in ICES divisions 4 and 3.a. Sandeel management areas.

Figure 9.1.2. Sandeel in ICES divisions 4 and 3.a. Catch by ICES rectangles 2004-2019. Area of the circles is proportional to catch by rectangle.

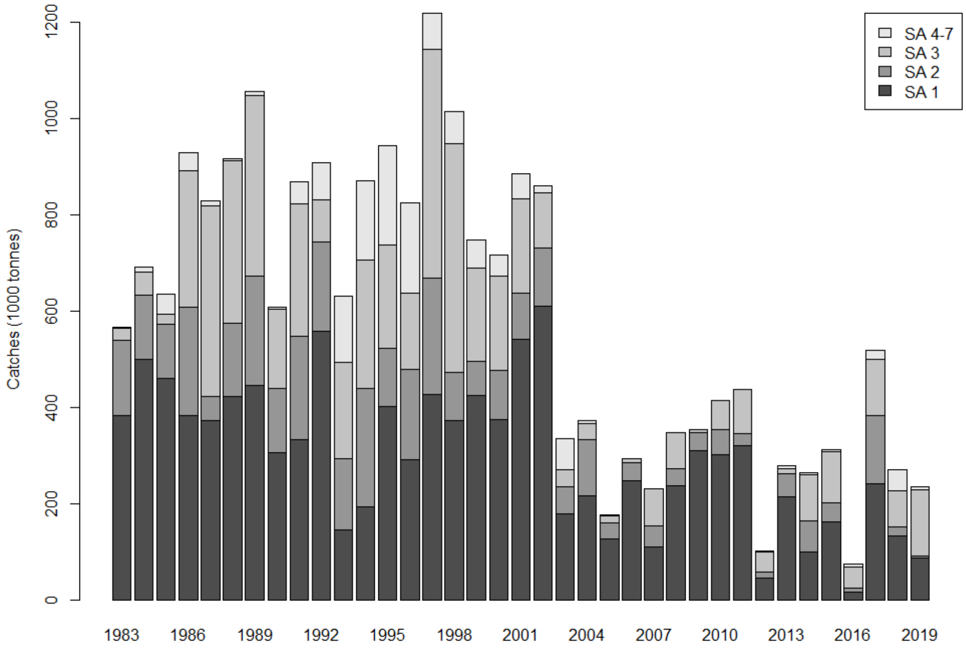


Figure 9.1.3 Sandeel in ICES divisions 4 and 3.a. Total catches by year and area.

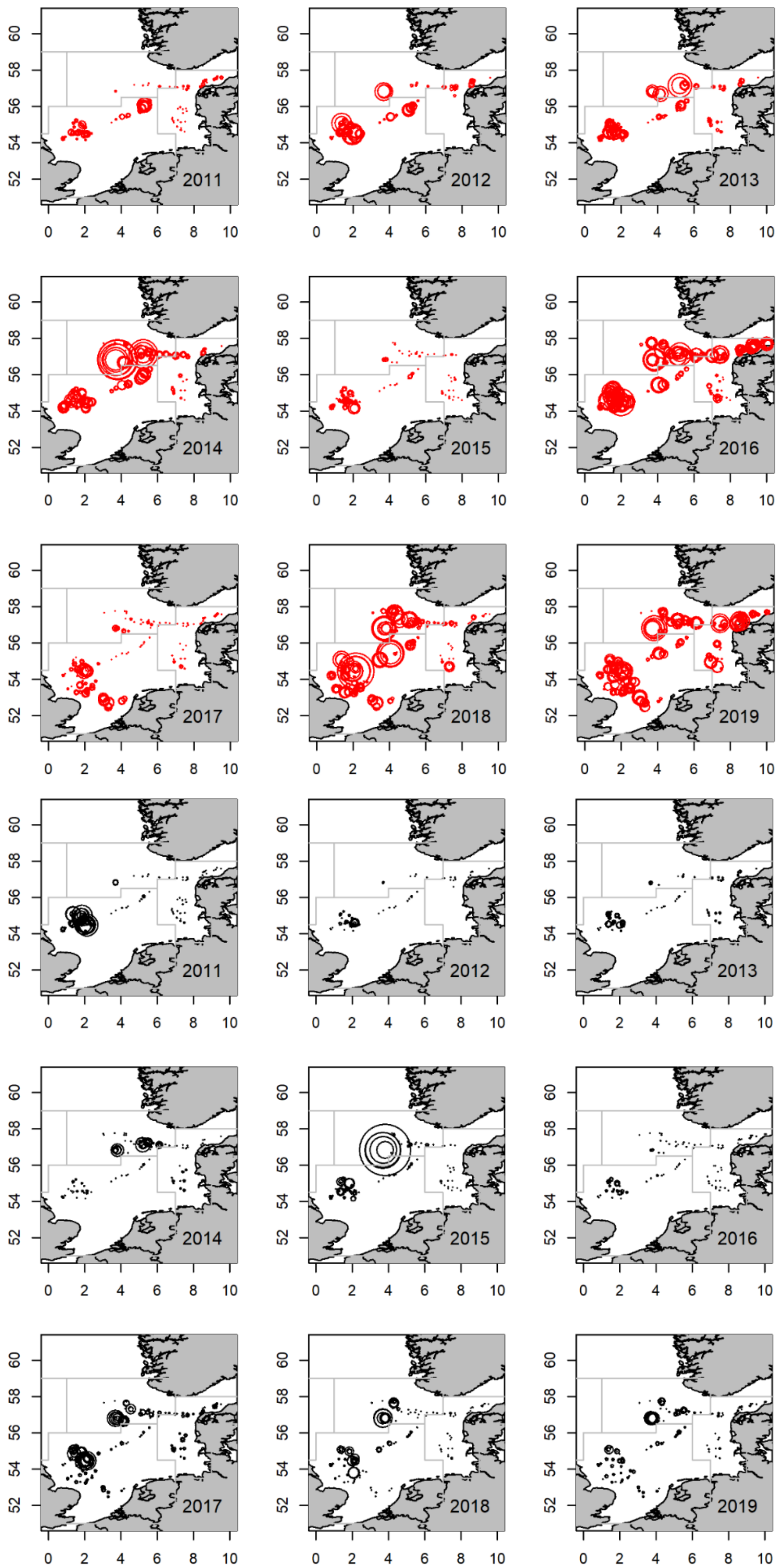


Figure 9.1.4. Sandeel in ICES divisions 4 and 3.a. Sandeel in ICES divisions 4 and 3.a. Danish survey catches by haul for 0-group (upper and red) and 1-group (lower and black). Area of the circles is proportional to catch number.

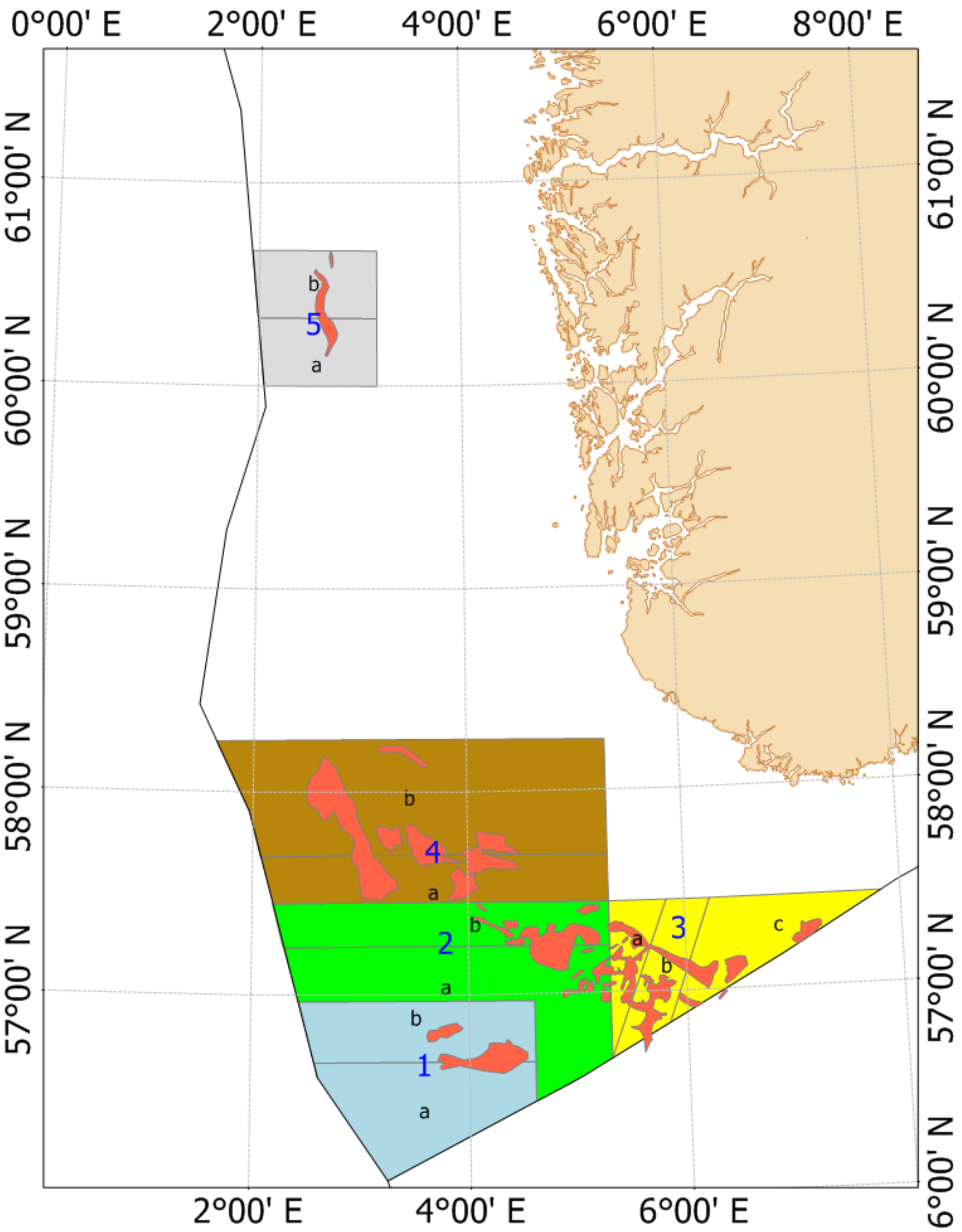


Figure 9.1.5. Sandeel in ICES divisions 4 and 3.a. Norwegian sandeel management areas. There are 6 main areas consisting of subareas a and b. Subarea3 consist of three subareas a, b, and c.

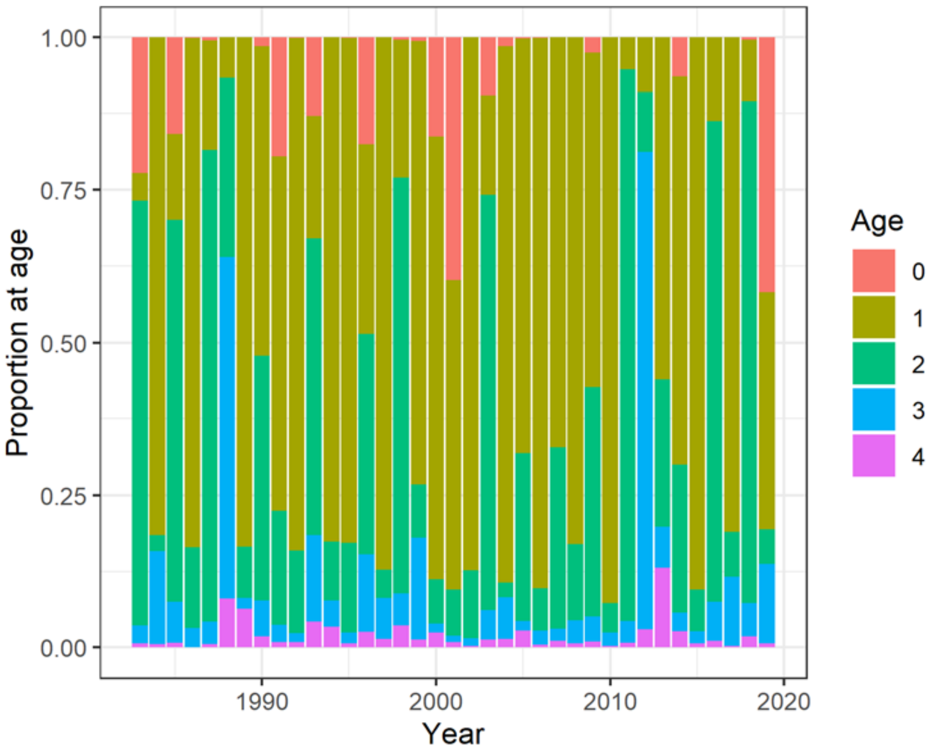


Figure 9.2.1. Sandeel Area-1r. Catch numbers, proportion-at-age.

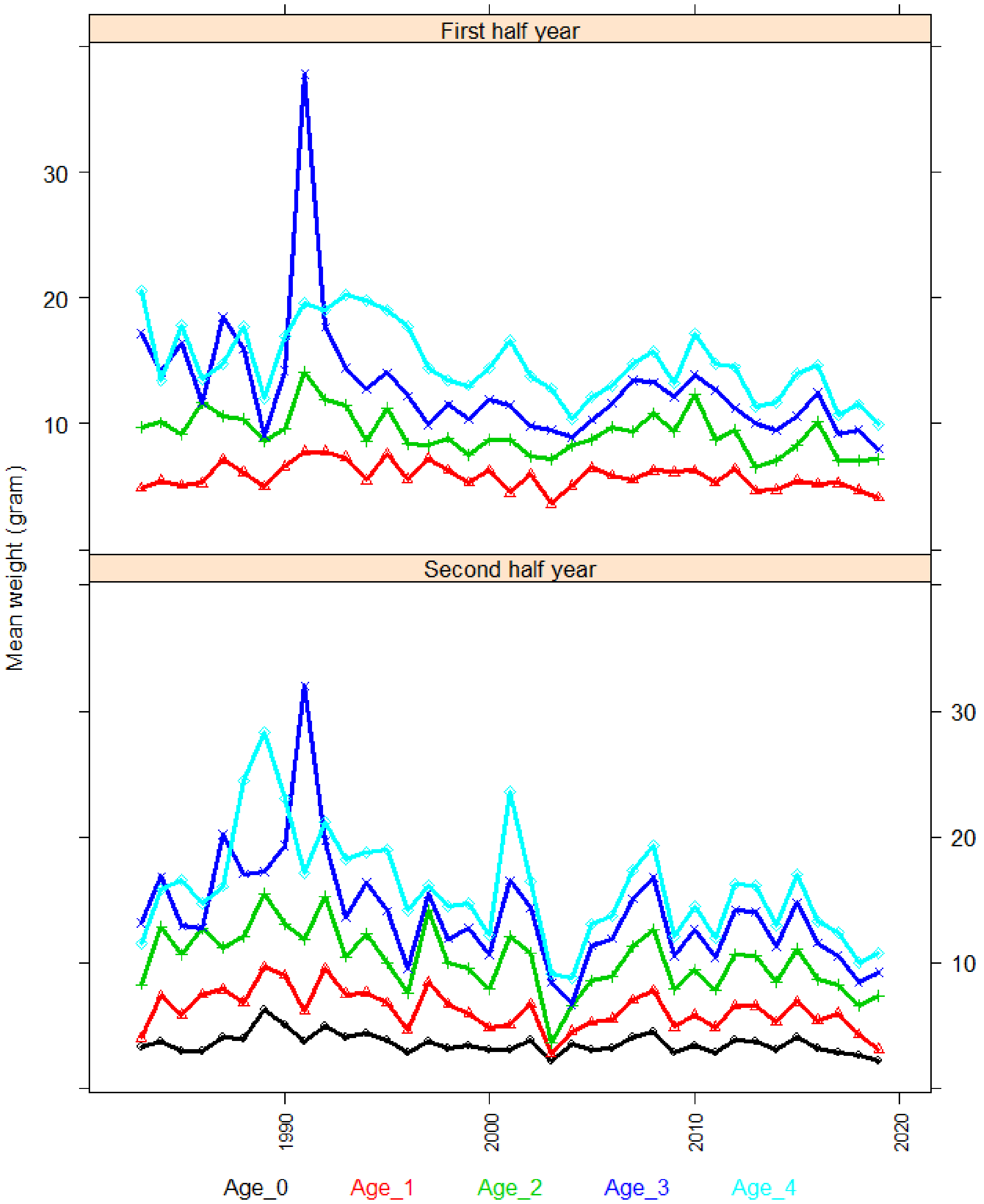


Figure 9.2.2. Sandeel Area-1r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

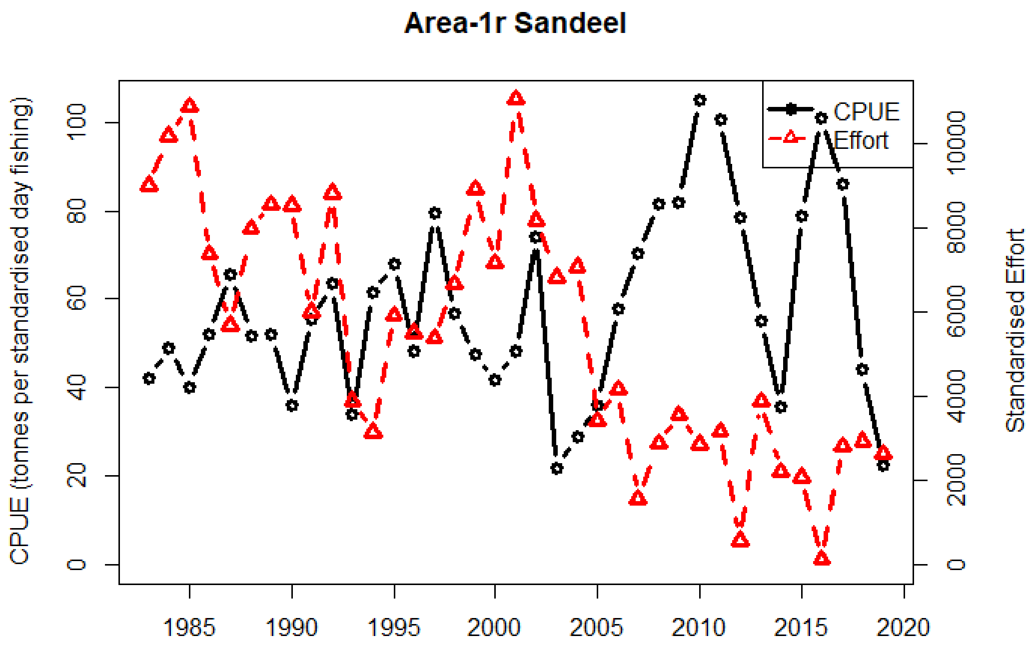


Figure 9.2.3. Sandeel Area-1r. CPUE and effort.

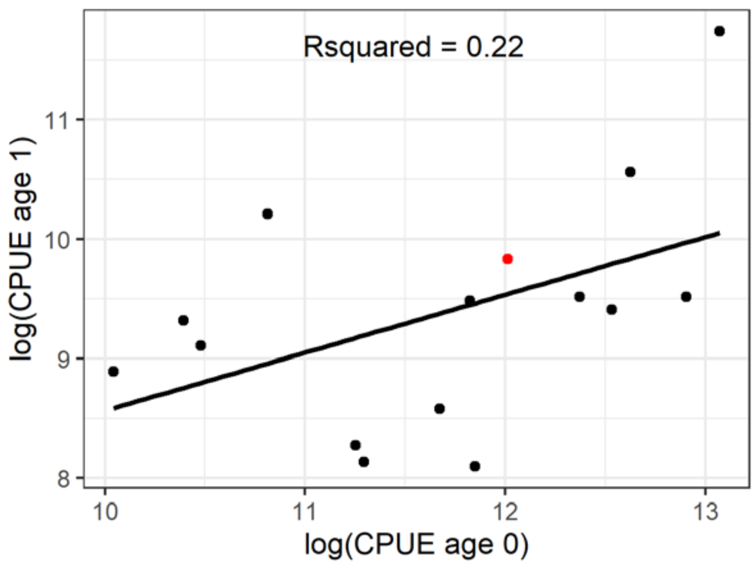


Figure 9.2.4. Sandeel Area-1r. Internal consistency by age of the dregde survey. Red dot indicates the most recent data point.

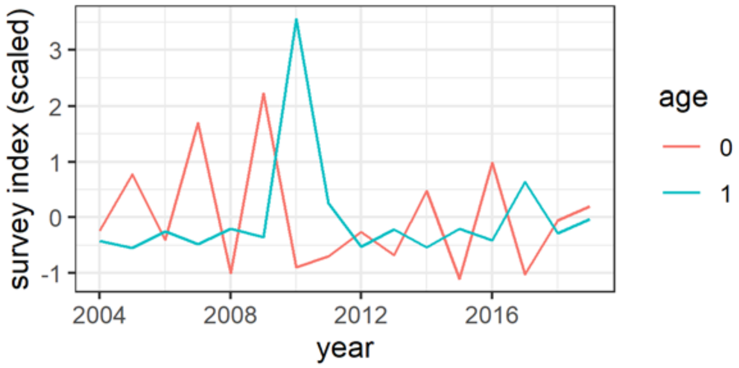


Figure 9.2.5. Sandeel Area-1r. Dredge survey index timeline.

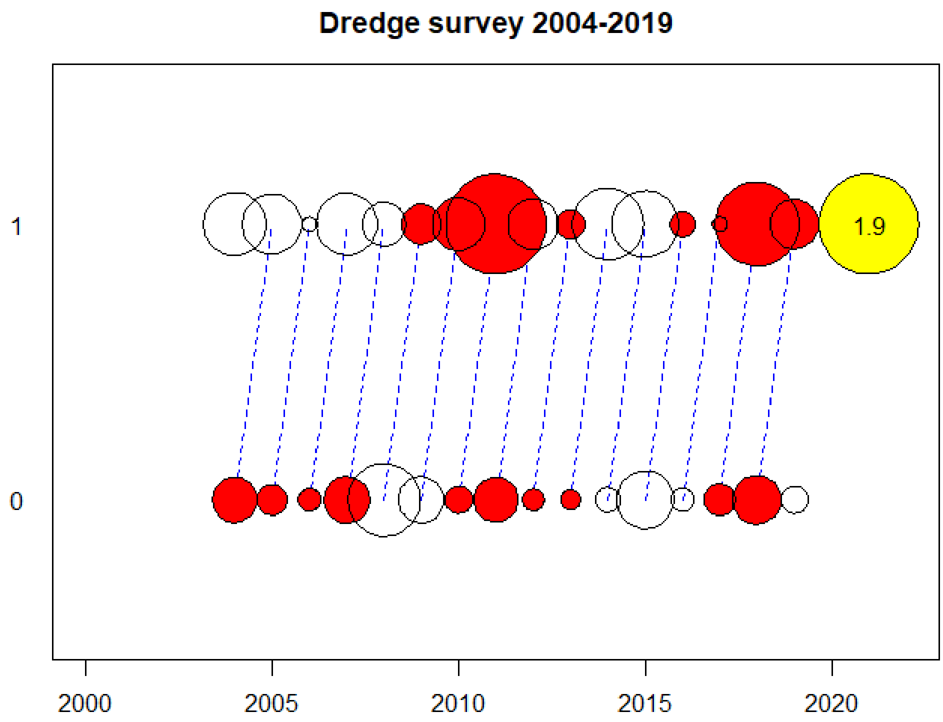


Figure 9.2.6. Sandeel Area-1r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

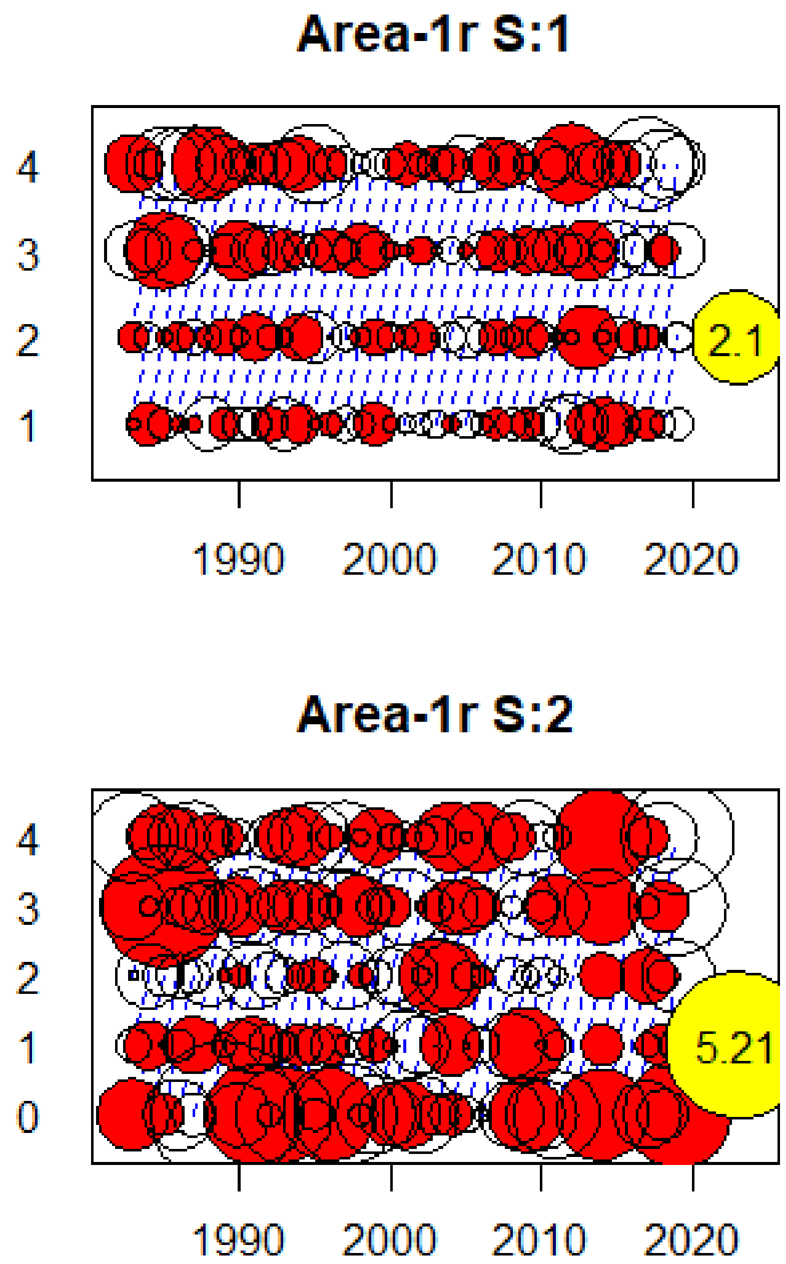


Figure 9.2.7. Sandeel Area-1r. Catch-at-age residuals (log(observed CPUE)- log(expected CPUE). “Red” dots show a positive residual.

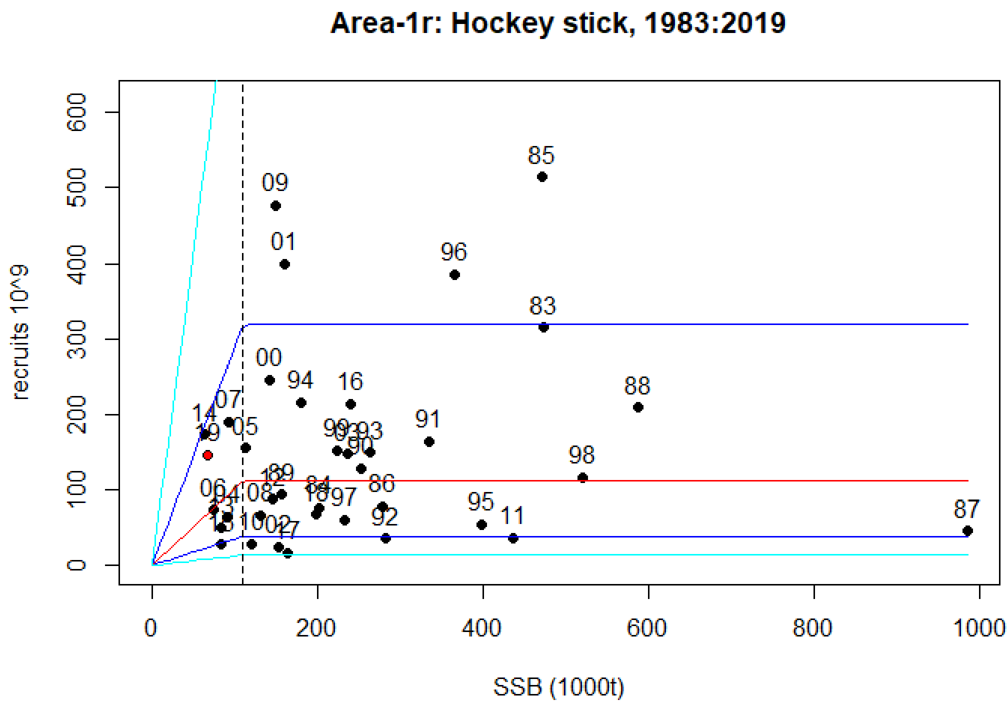


Figure 9.2.8 Sandeel Area-1r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

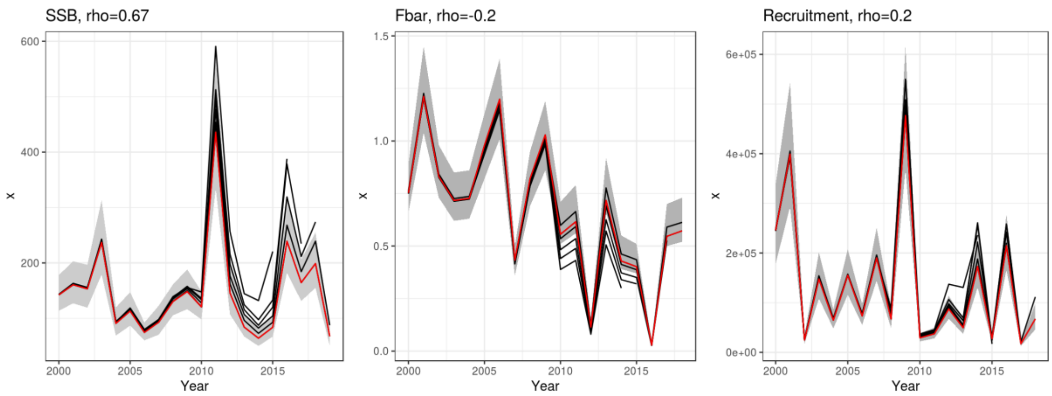


Figure 9.2.9 Sandeel Area-1r. Retrospective analysis.

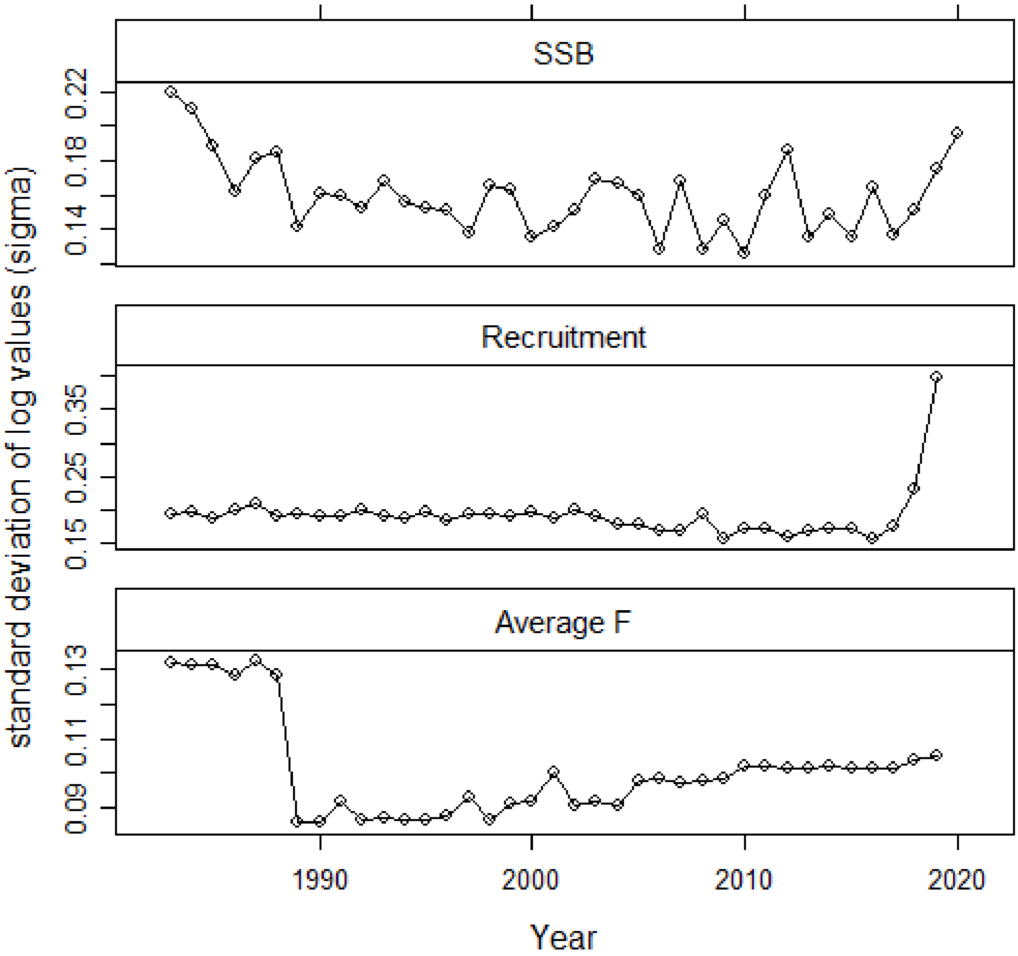


Figure 9.2.10. Sandeel Area-1r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

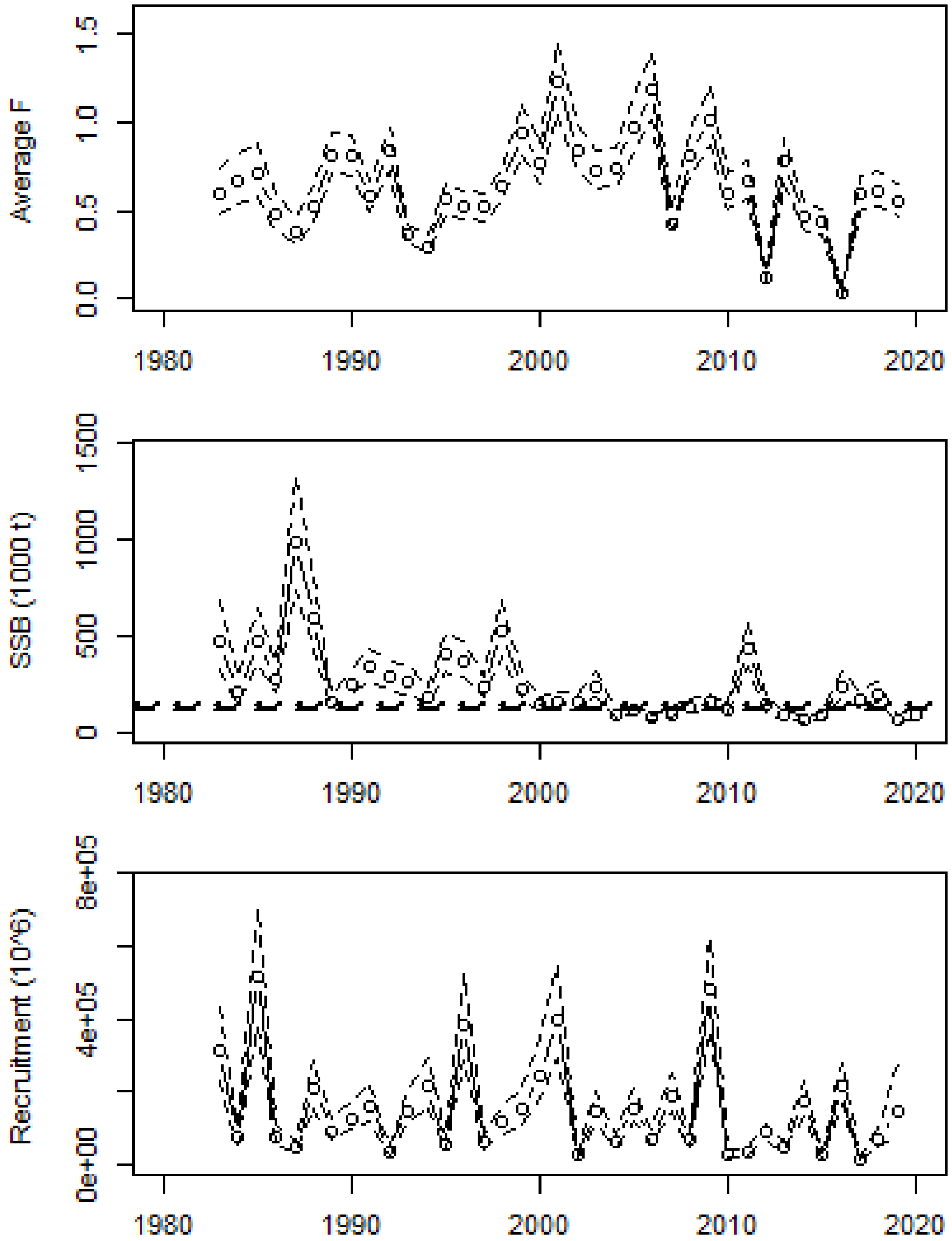


Figure 9.2.11. Sandeel Area-1r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

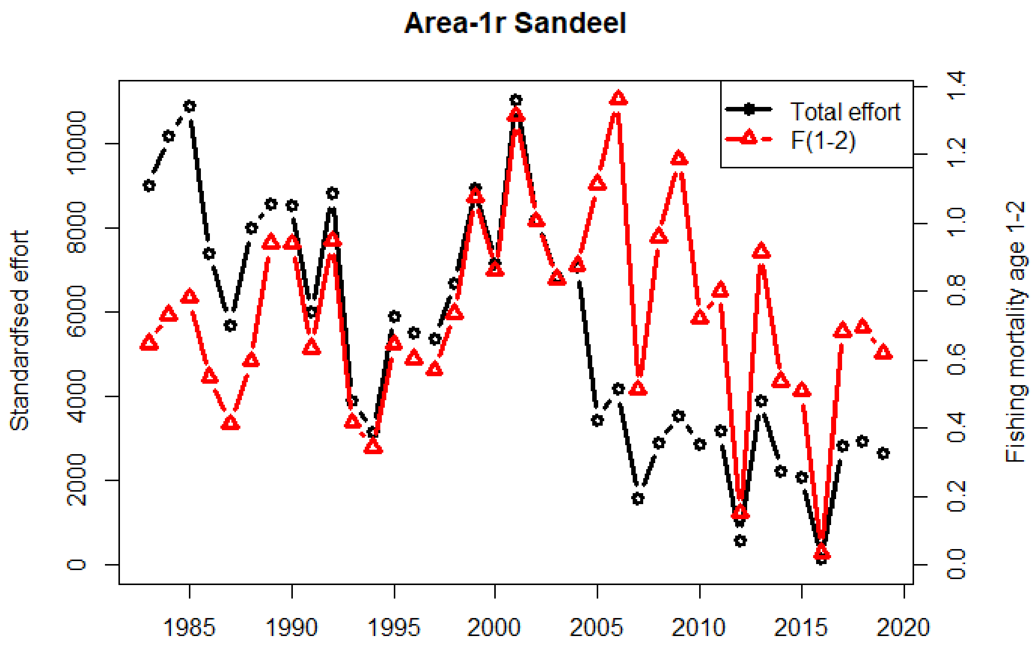


Figure 9.2.12 Sandeel Area-1r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

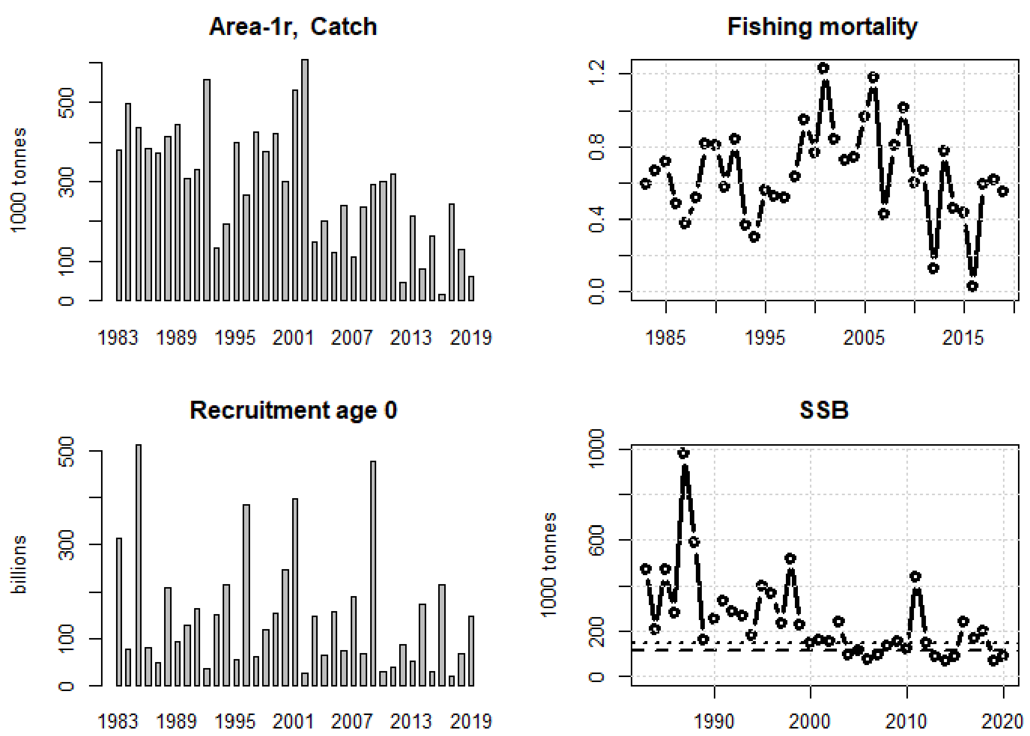


Figure 9.2.13 Sandeel Area-1r. Stock summary.

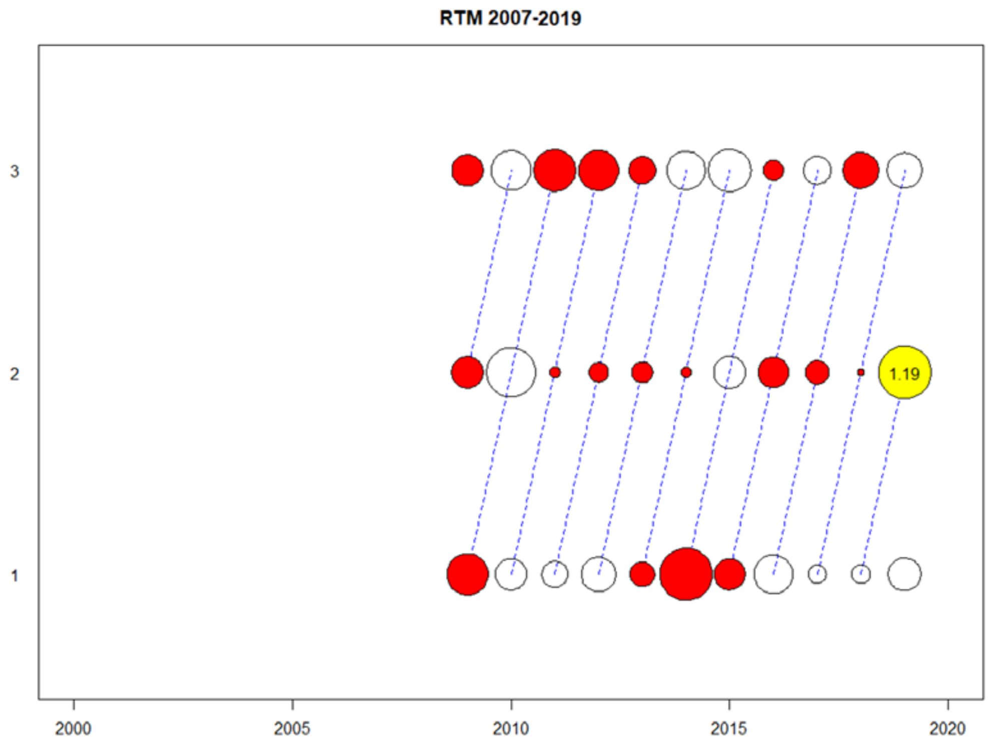


Figure 9.2.14. Sandeel Area-1r. RTM survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

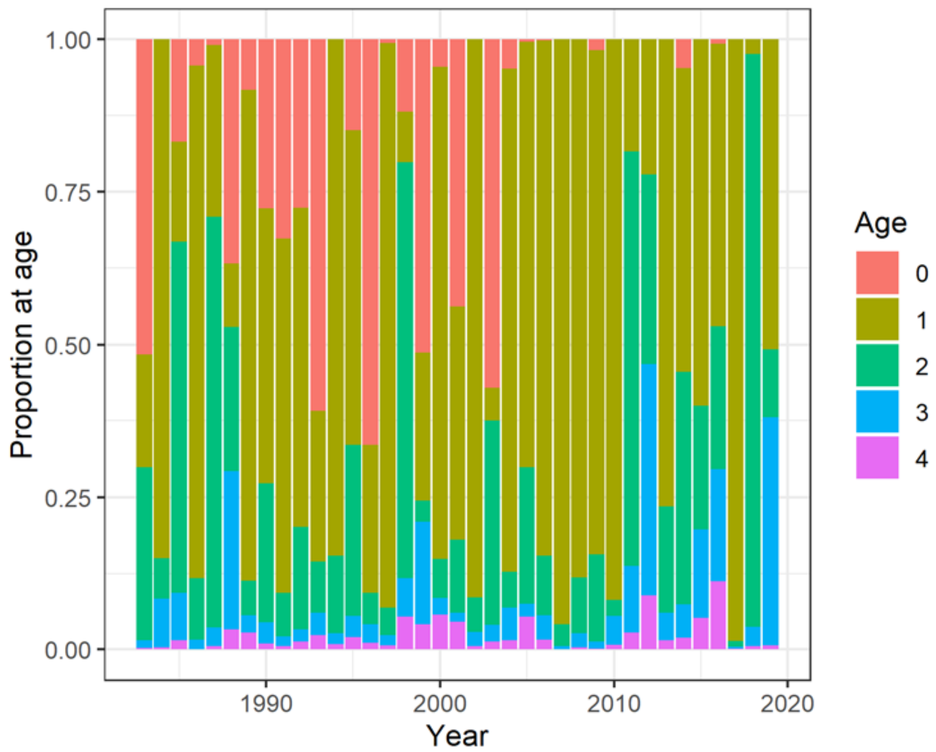


Figure 9.3.1. Sandeel Area-2r. Catch numbers, proportion-at-age.

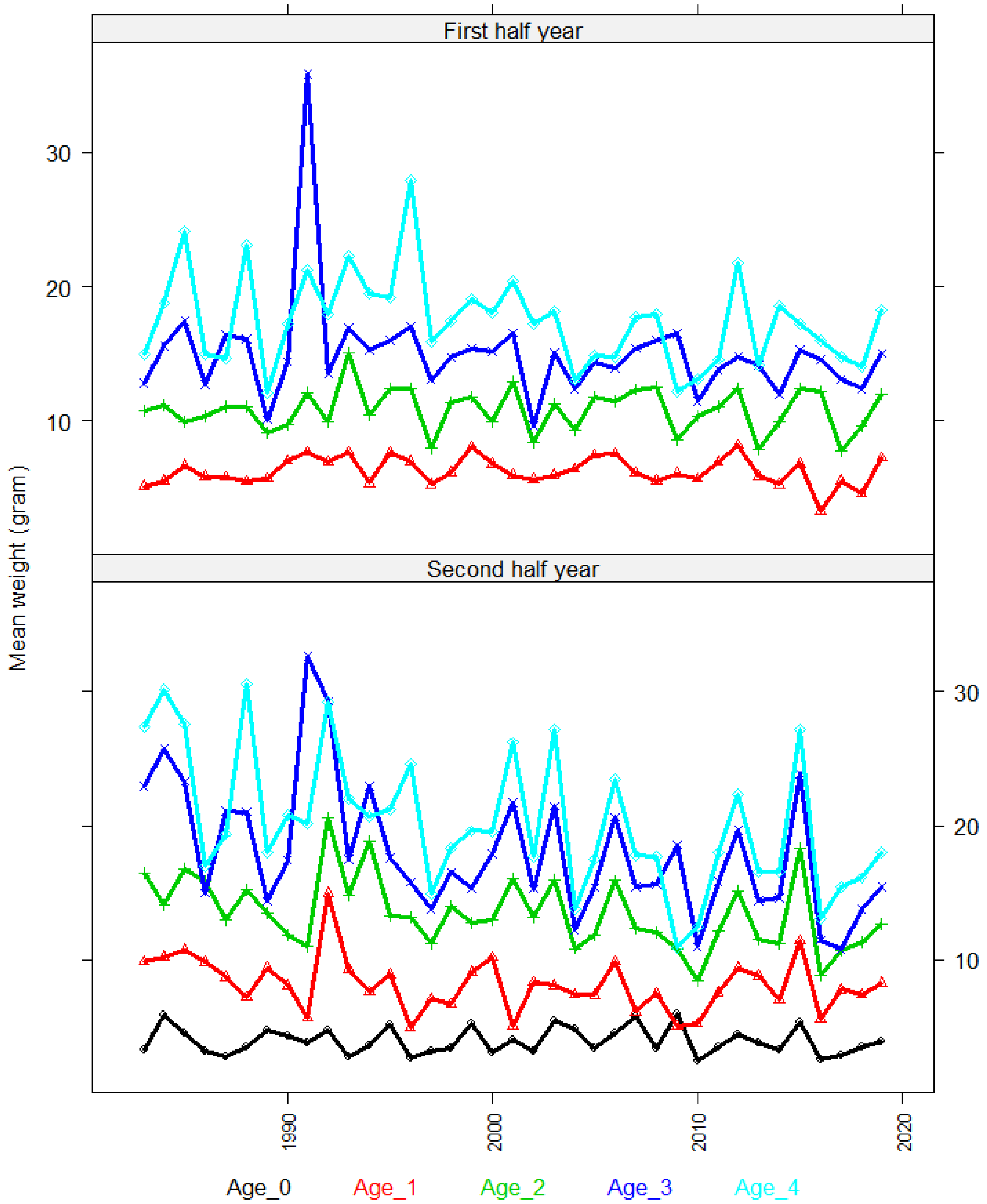


Figure 9.3.2. Sandeel Area-2r. Mean weight-at-age in the first half year (age 1-4+) and second half year (age 0-4+).

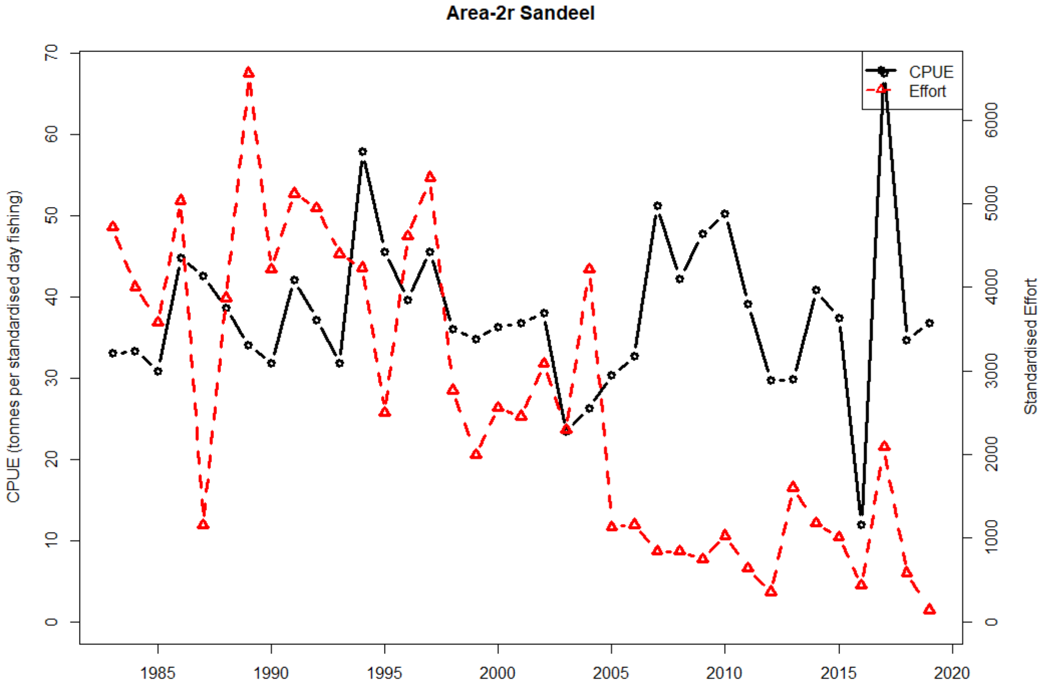


Figure 9.3.3. Sandeel Area-2r. CPUE and effort.

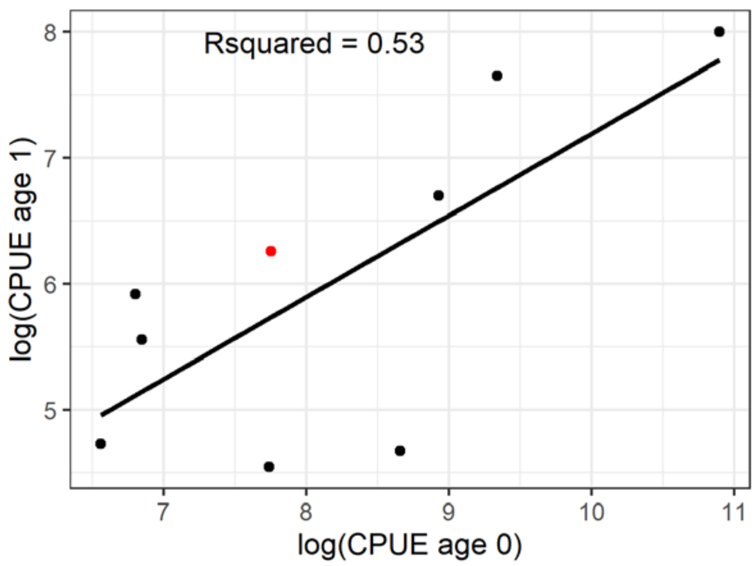


Figure 9.3.4. Sandeel Area-2r. Internal consistency by age of the dregde survey. Red dot indicates the most recent data point.

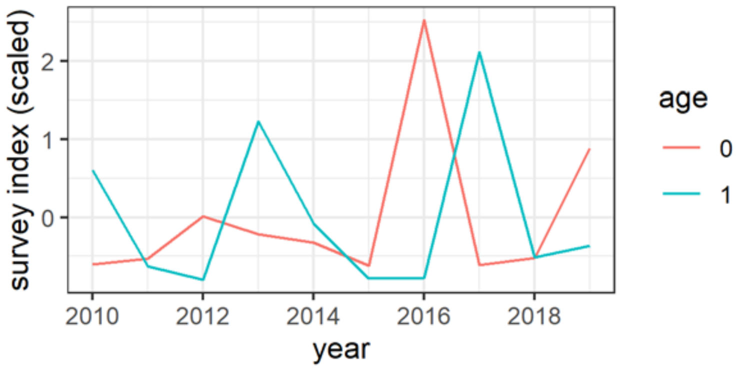


Figure 9.3.5 Sandeel Area-2r. Dredge survey index timeline.

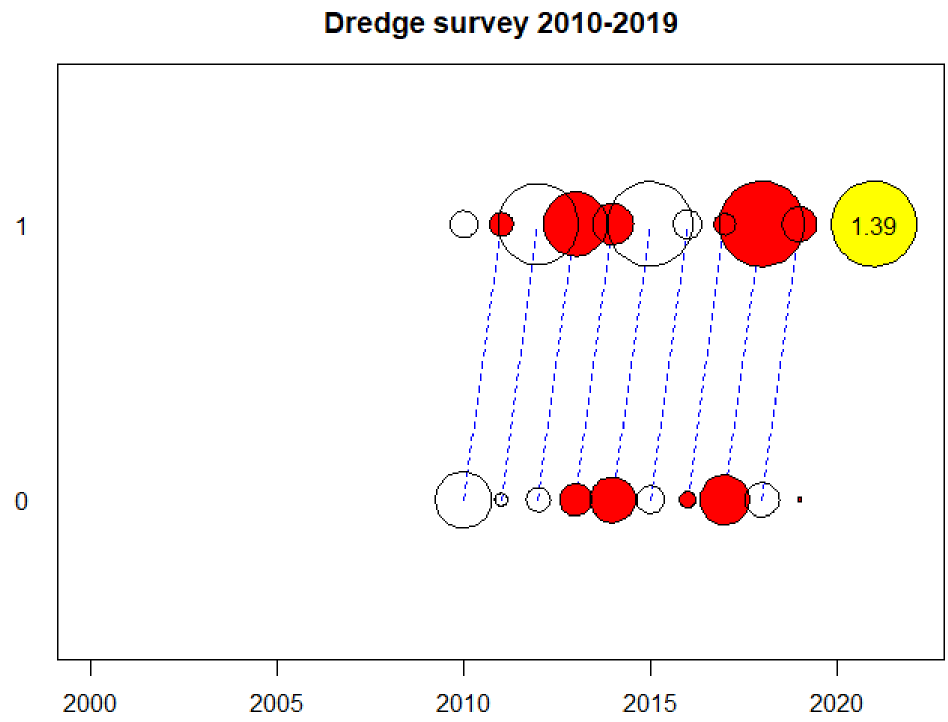


Figure 9.3.6 Sandeel Area-2r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

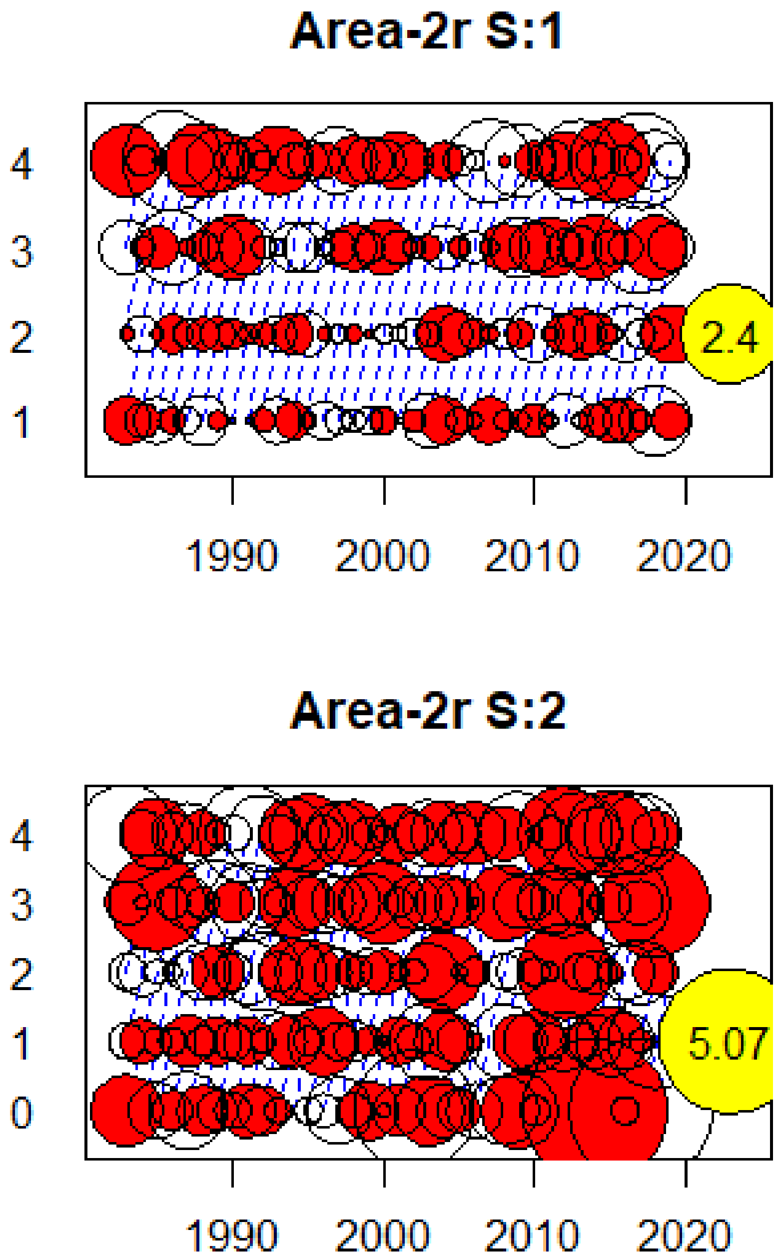


Figure 9.3.7 Sandeel Area-2r. Catch-at-age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

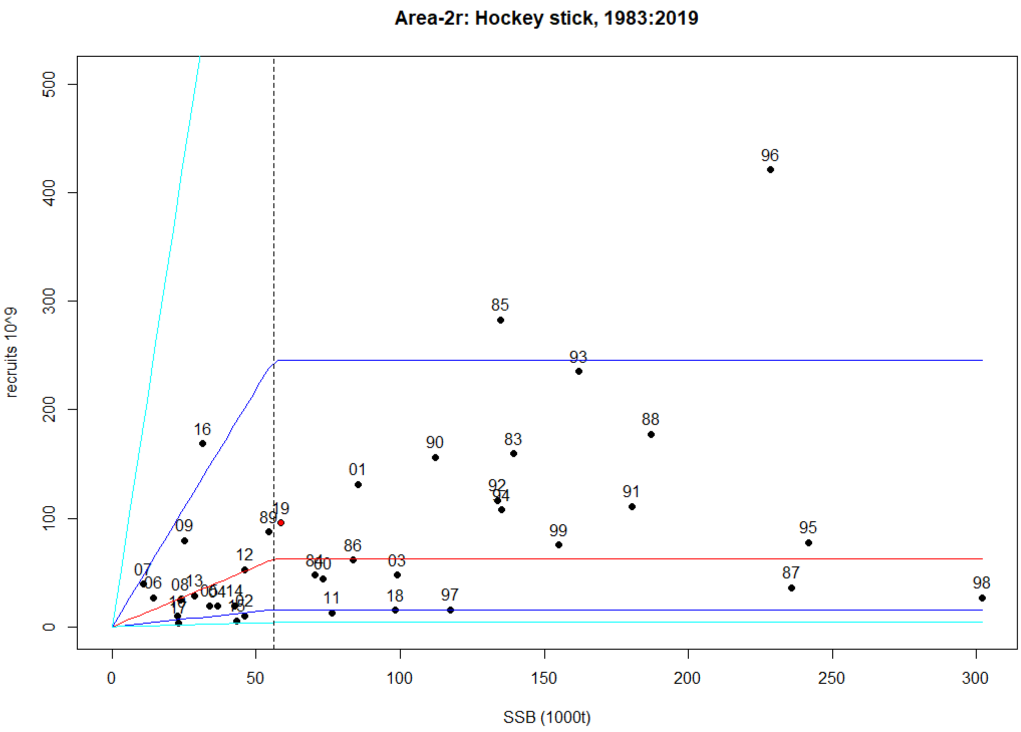


Figure 9.3.8. Sandeel Area-2r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

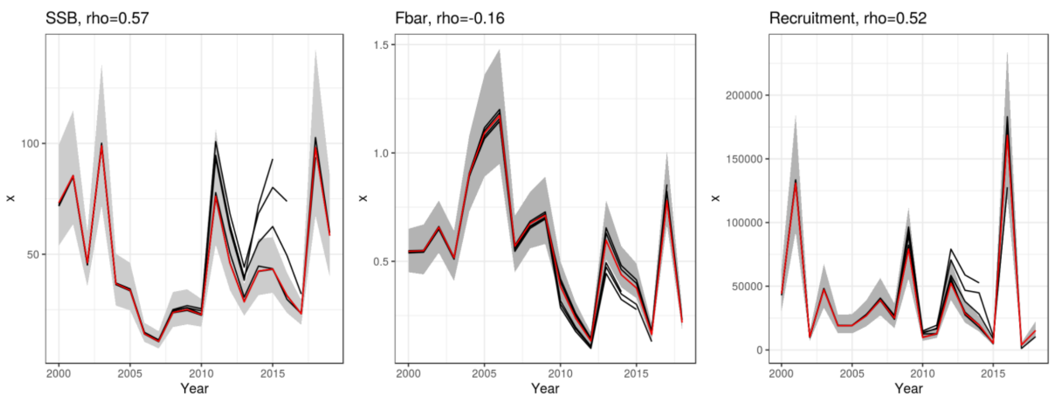


Figure 9.3.9. Sandeel Area-2r. Retrospective analysis.

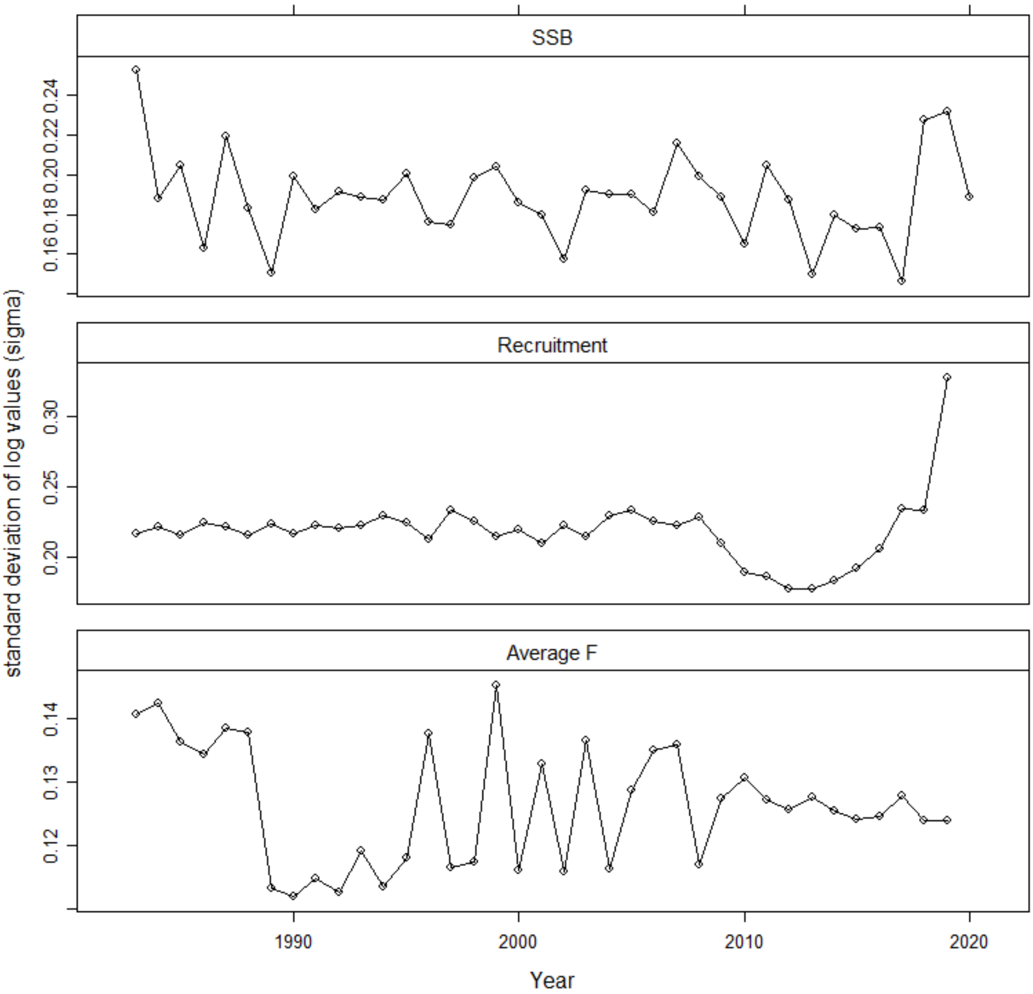


Figure 9.3.10. Sandeel Area-2r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

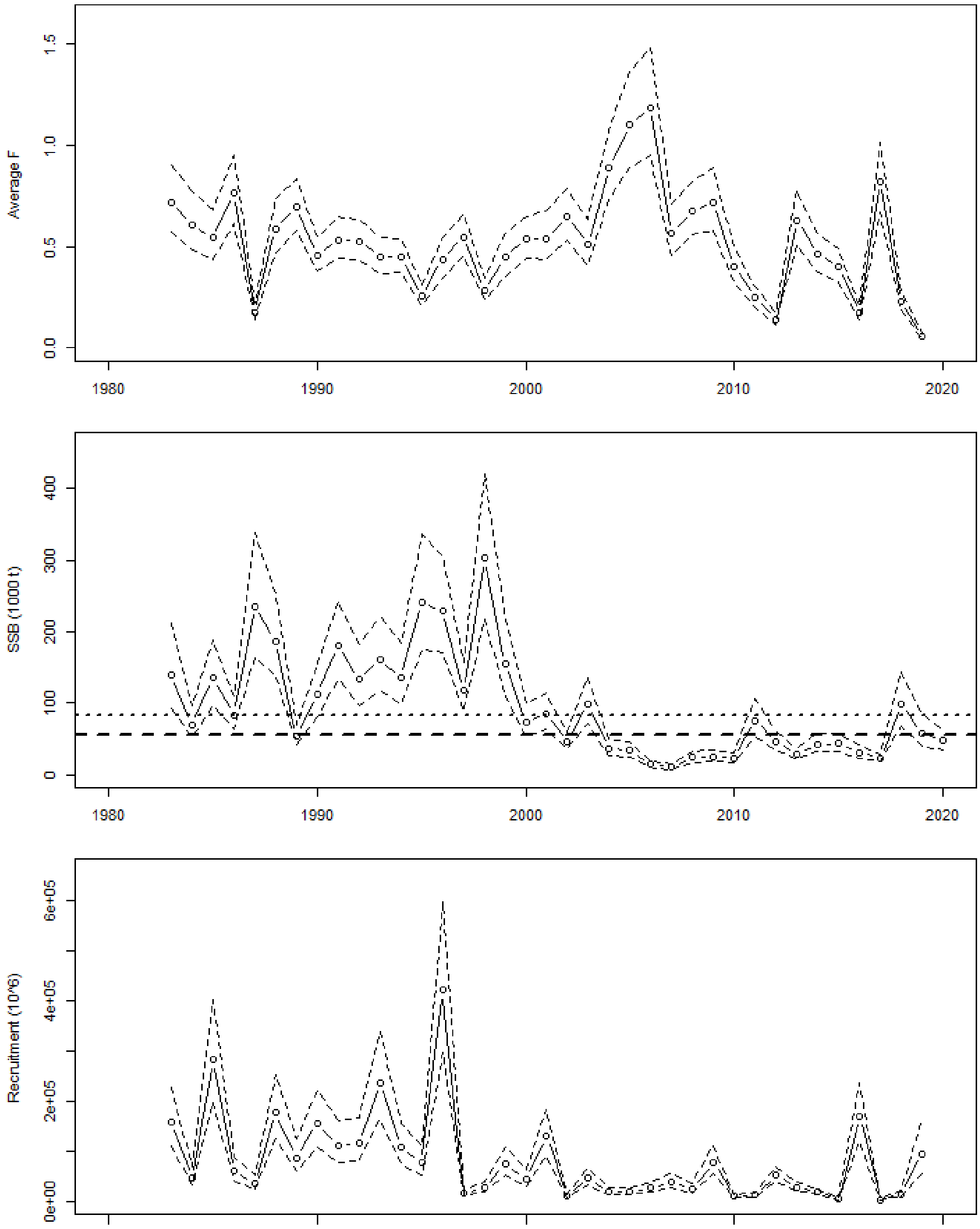


Figure 9.3.11. Sandeel Area-2r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

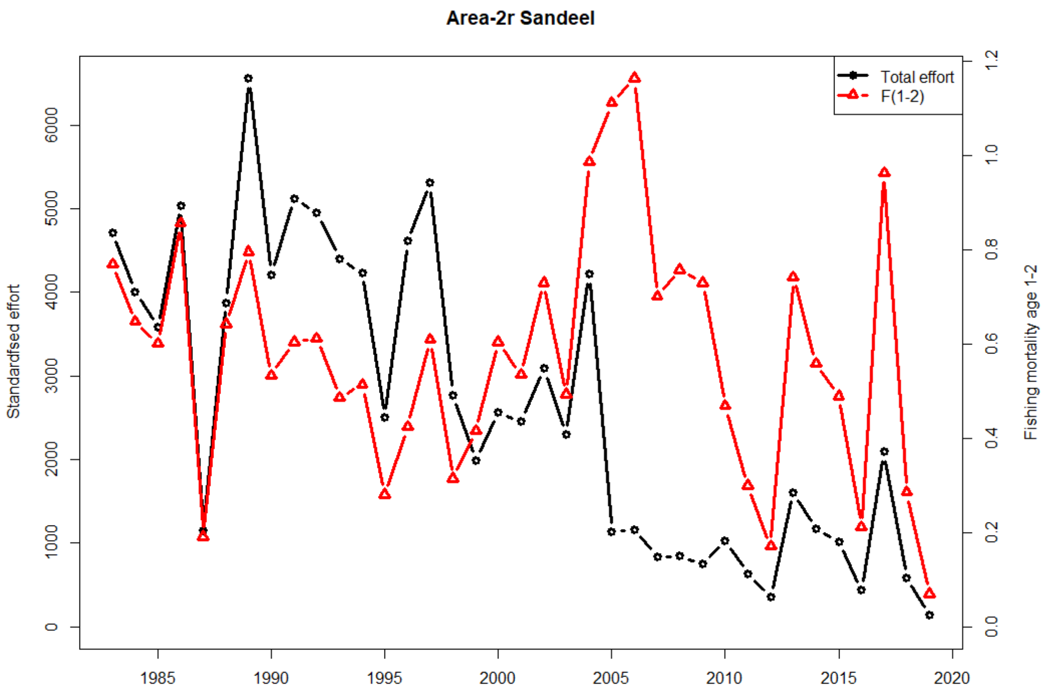


Figure 9.3.12. Sandeel Area-2r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

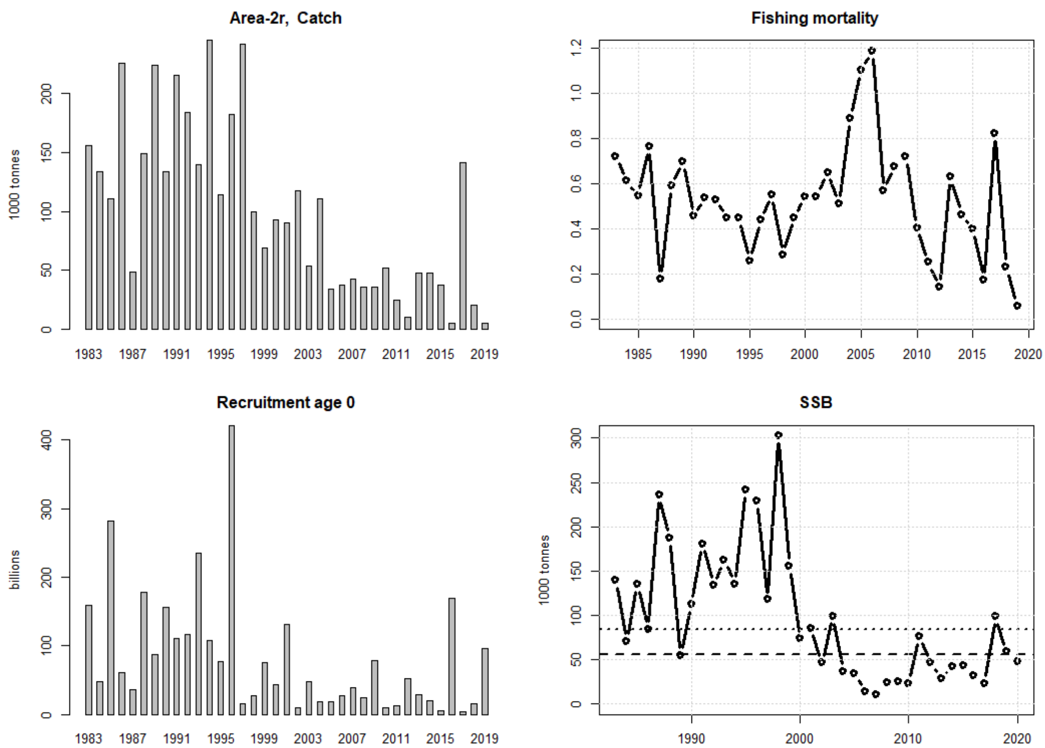


Figure 9.3.13 Sandeel Area-2r. Stock summary.

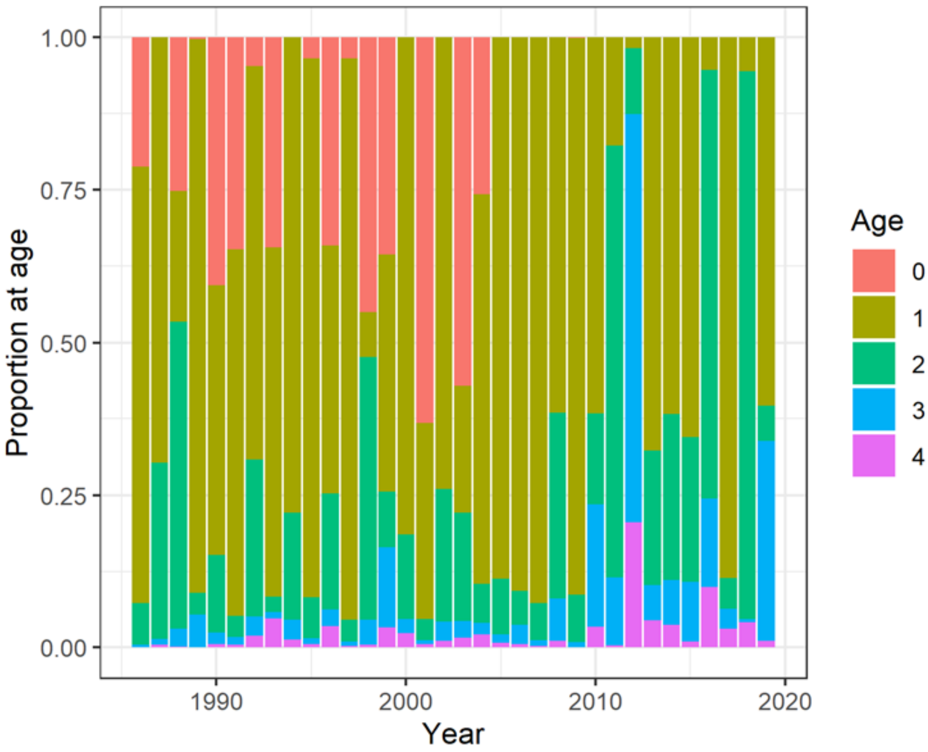


Figure 9.4.1 Sandeel Area-3r. Catch numbers, proportion-at-age.

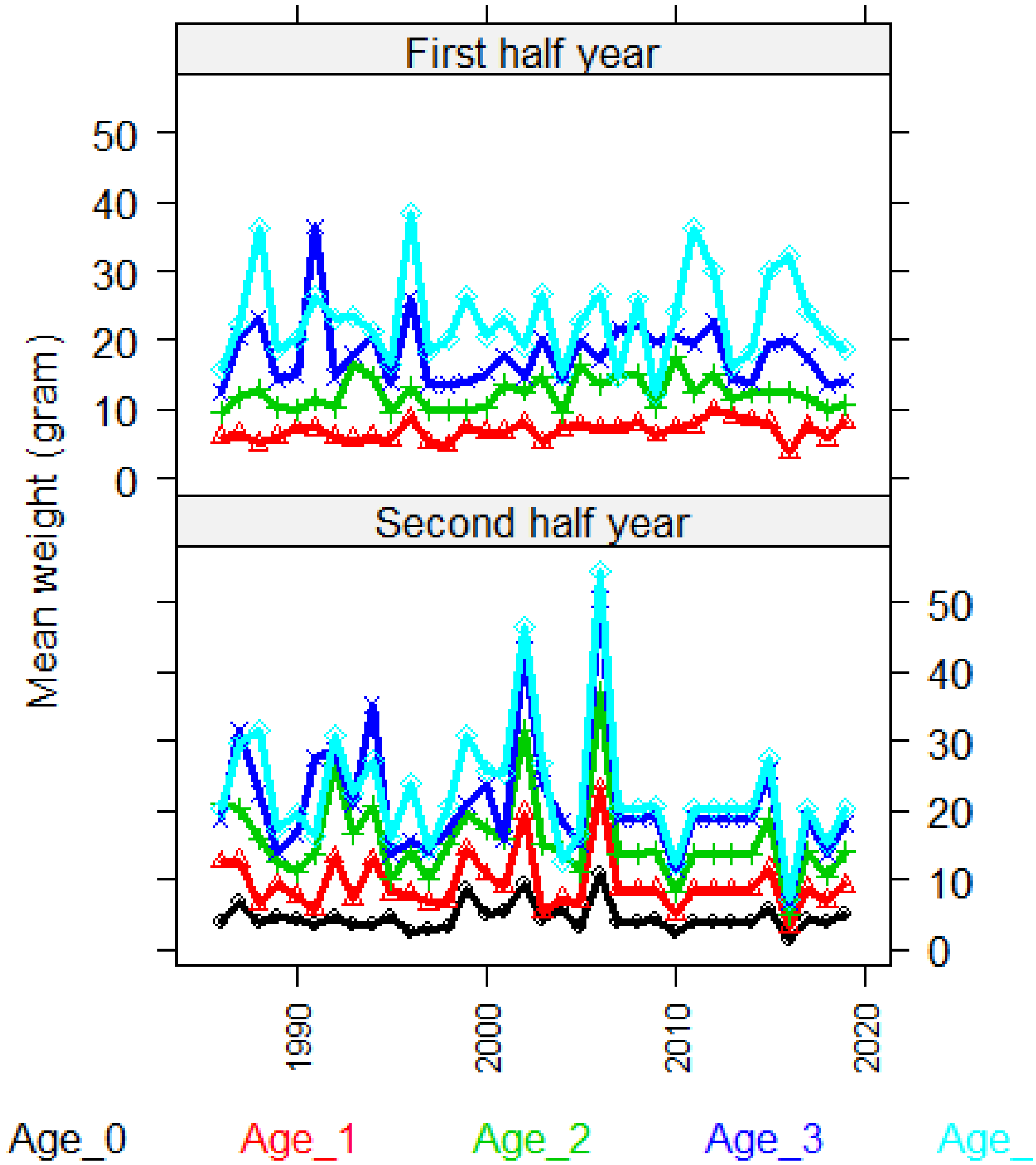


Figure 9.4.2. Sandeel Area-3r. Mean weight-at-age in the first half year (age 1-4+) and second half year (age 0-4+).

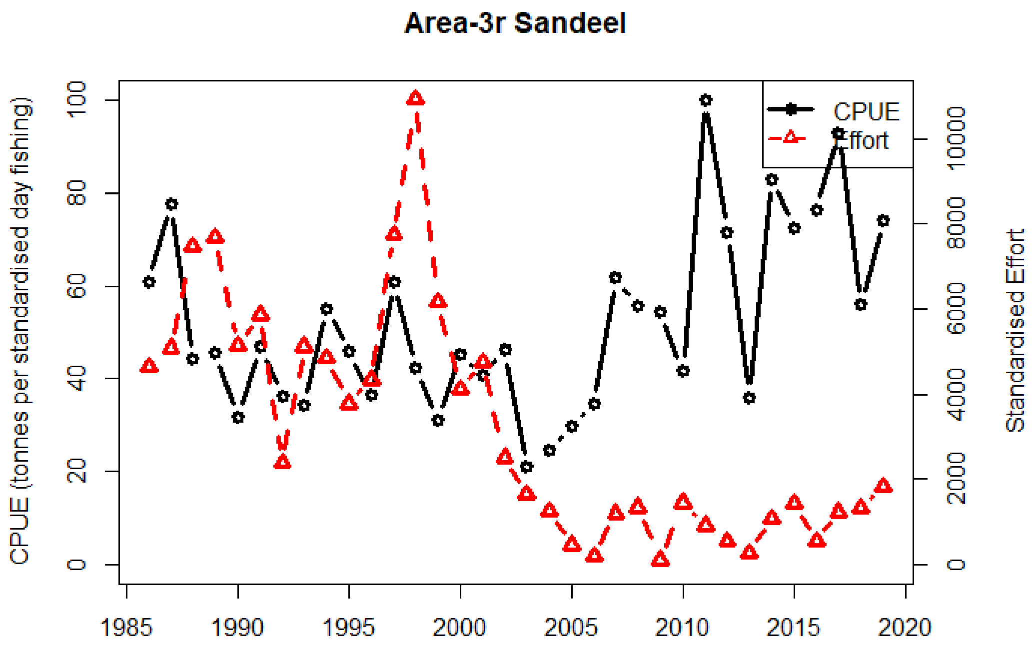


Figure 9.4.3. Sandeel Area-3r. CPUE and effort.

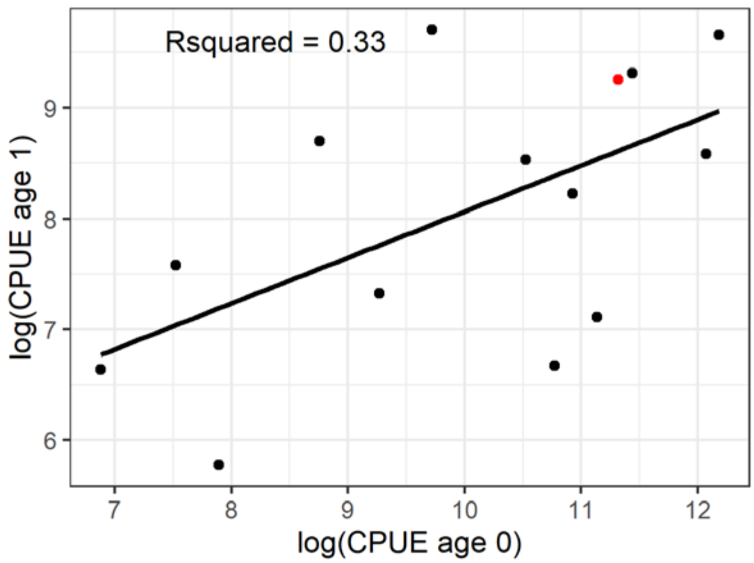


Figure 9.4.4. Sandeel Area-3r. Internal consistency by age of the dregde survey. Red dot indicates the most recent data point.

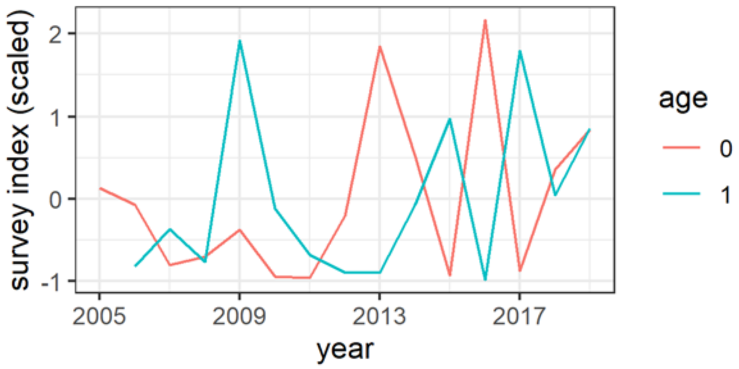


Figure 9.4.5. Sandeel Area-3r. Dredge survey index timeline.

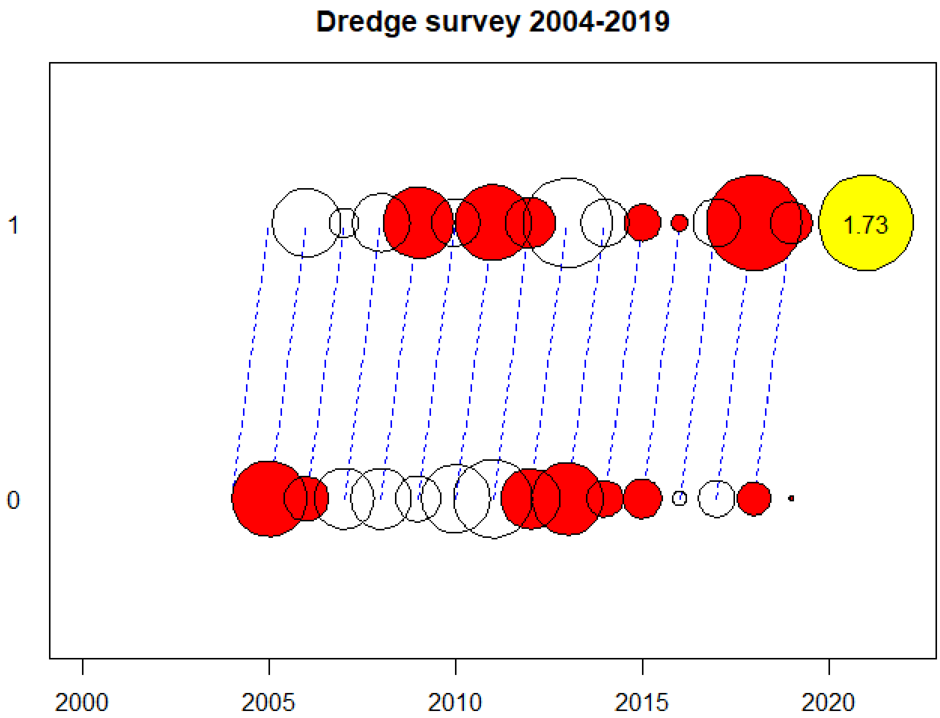


Figure 9.4.6. Sandeel Area-3r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). “Red” dots show a positive residual.

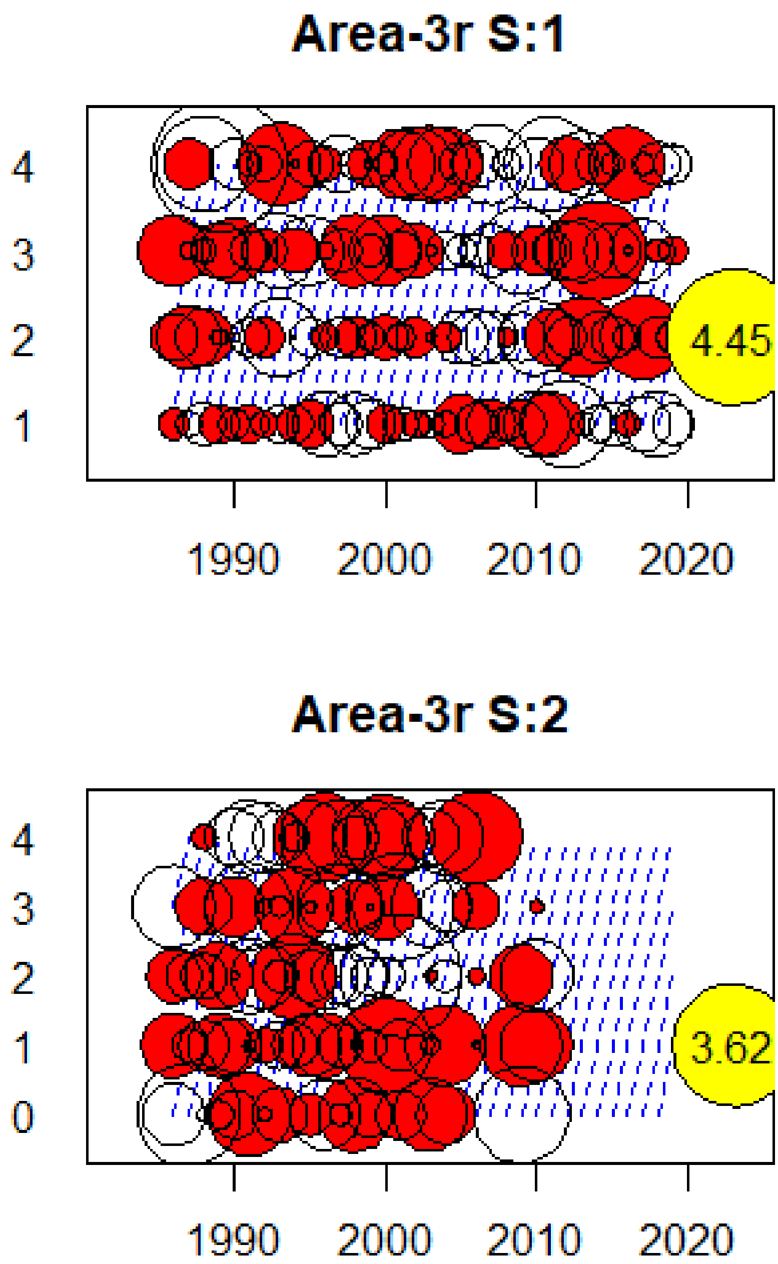


Figure 9.4.7. Sandeel Area-3r. Catch-at-age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

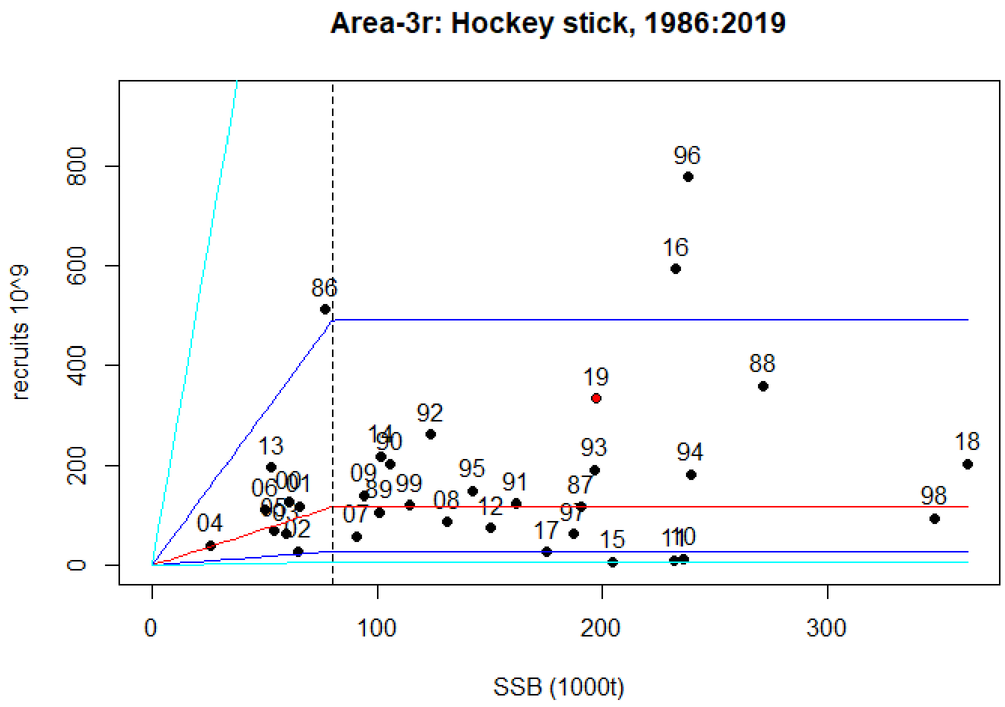


Figure 9.4.8. Sandeel Area-3r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

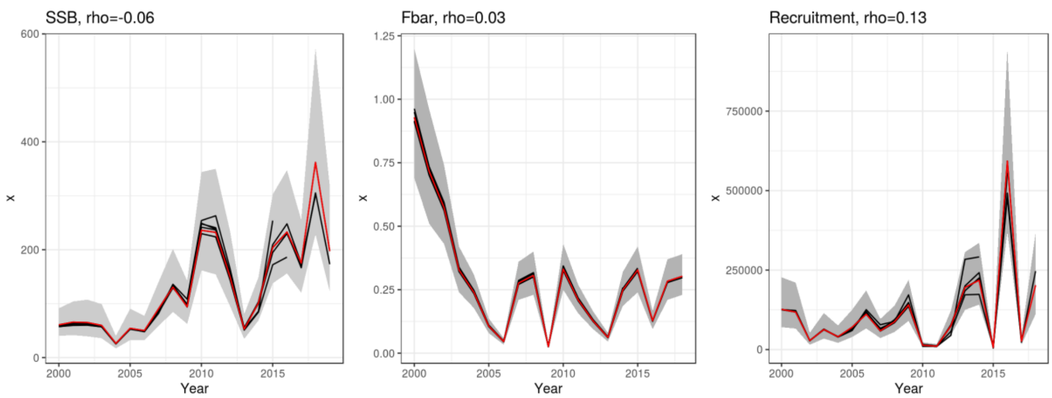


Figure 9.4.9. Sandeel Area-3r. Retrospective analysis.

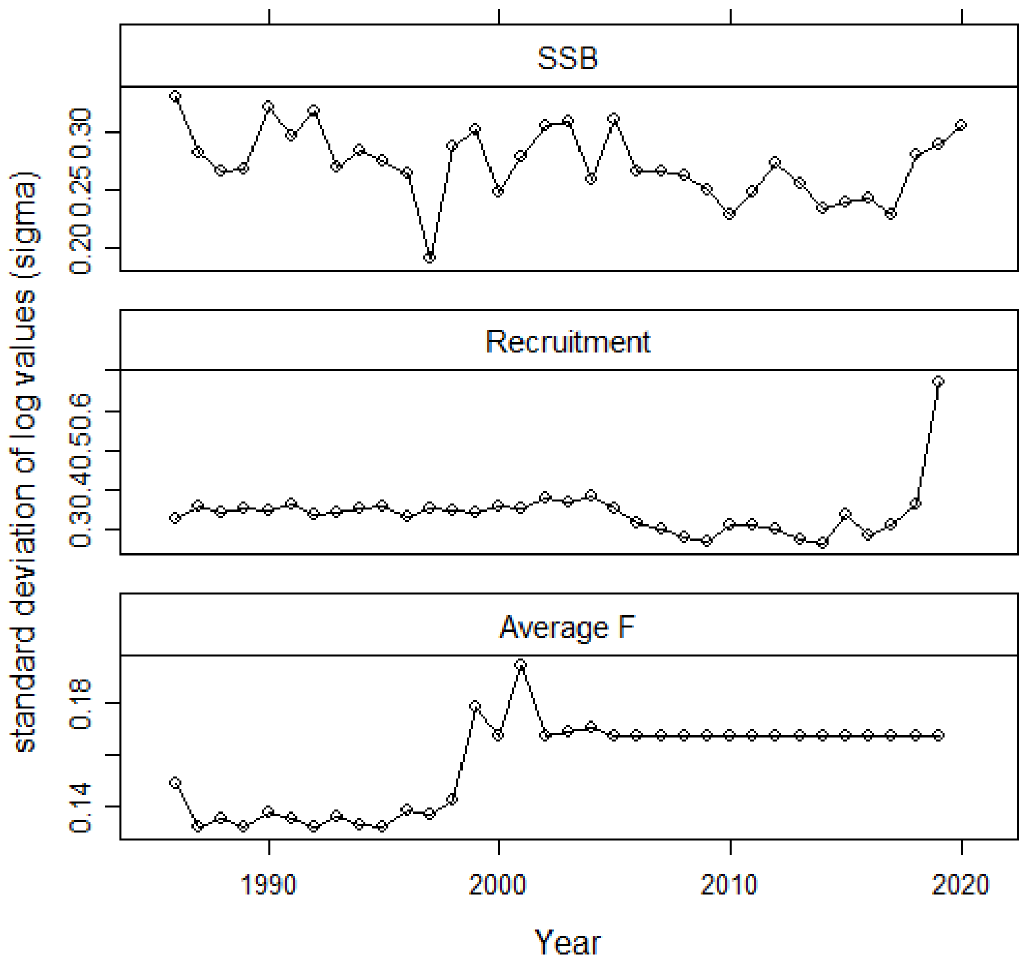


Figure 9.4.10. Sandeel Area-3r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

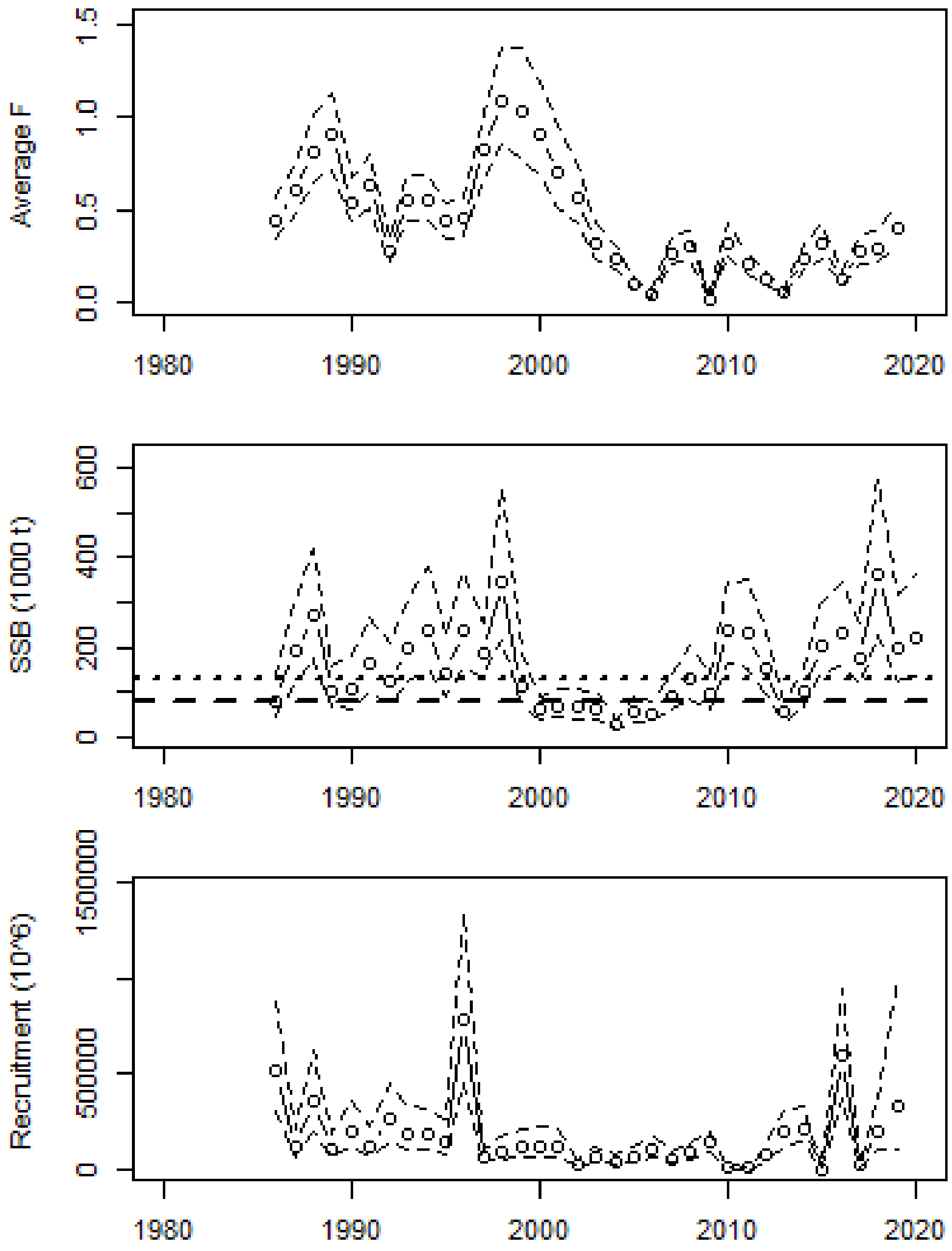


Figure 9.4.11. Sandeel Area-3r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

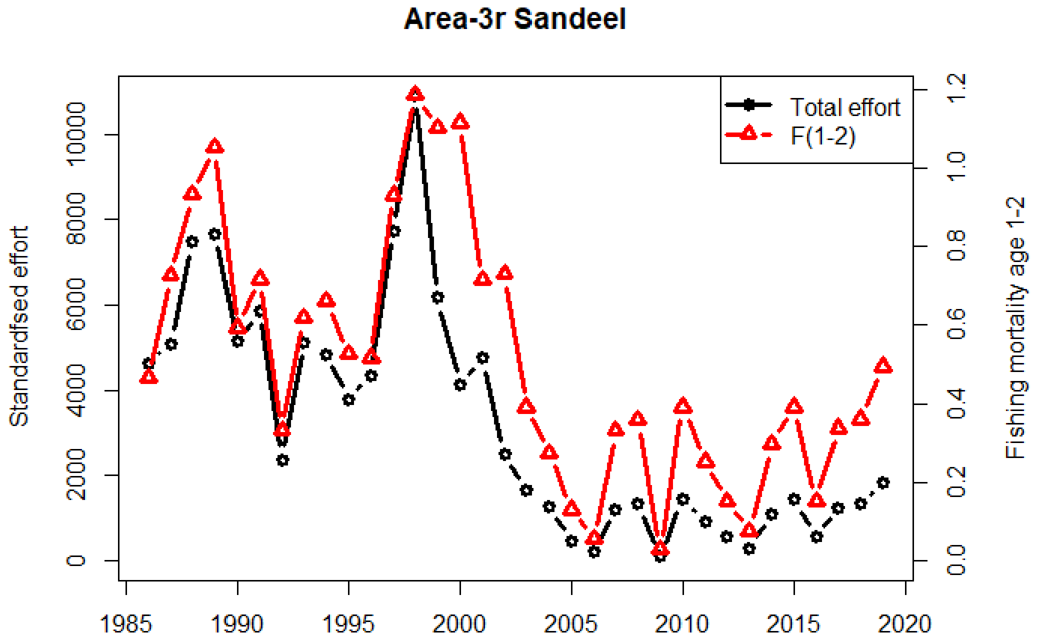


Figure 9.4.12. Sandeel Area-3r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

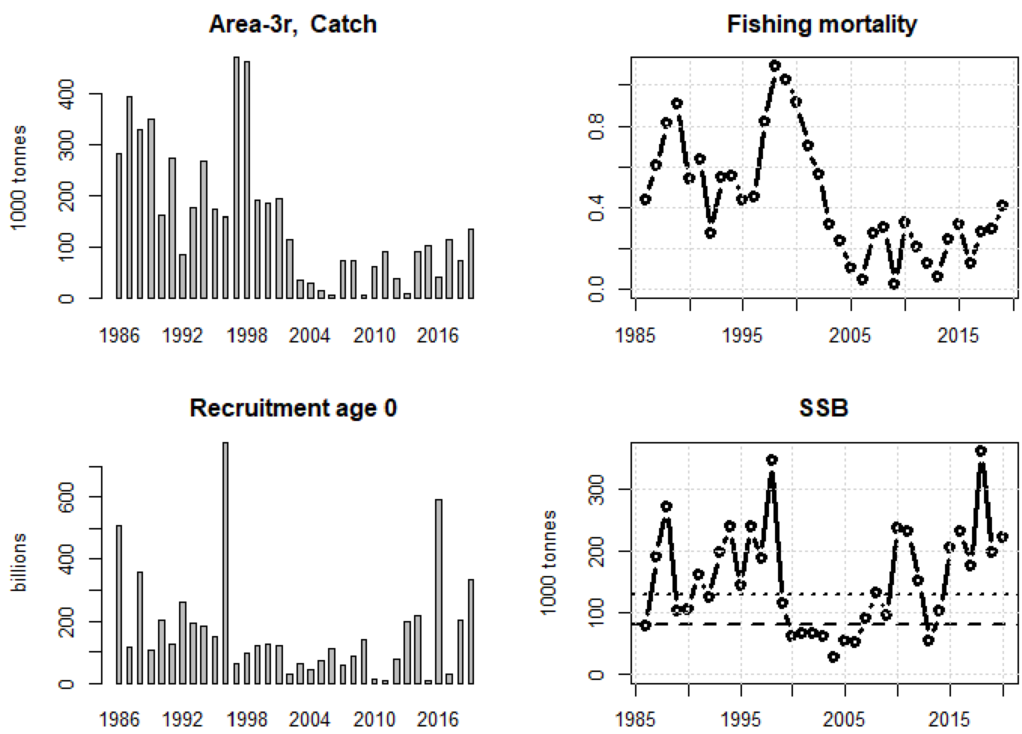


Figure 9.4.13. Sandeel Area-3r. Stock summary.

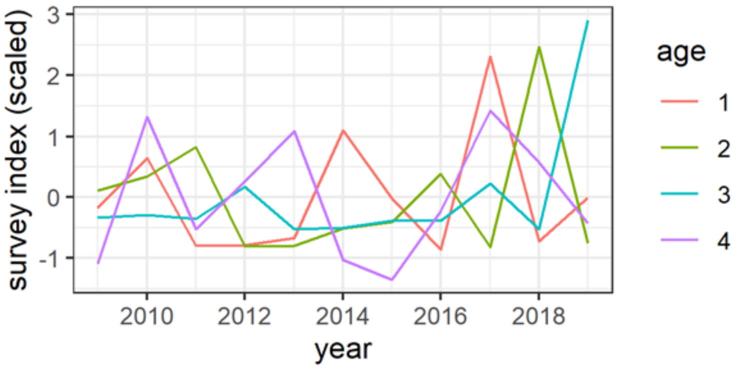


Figure 9.4.14. Sandeel Area-3r. Acoustic survey index timeline.

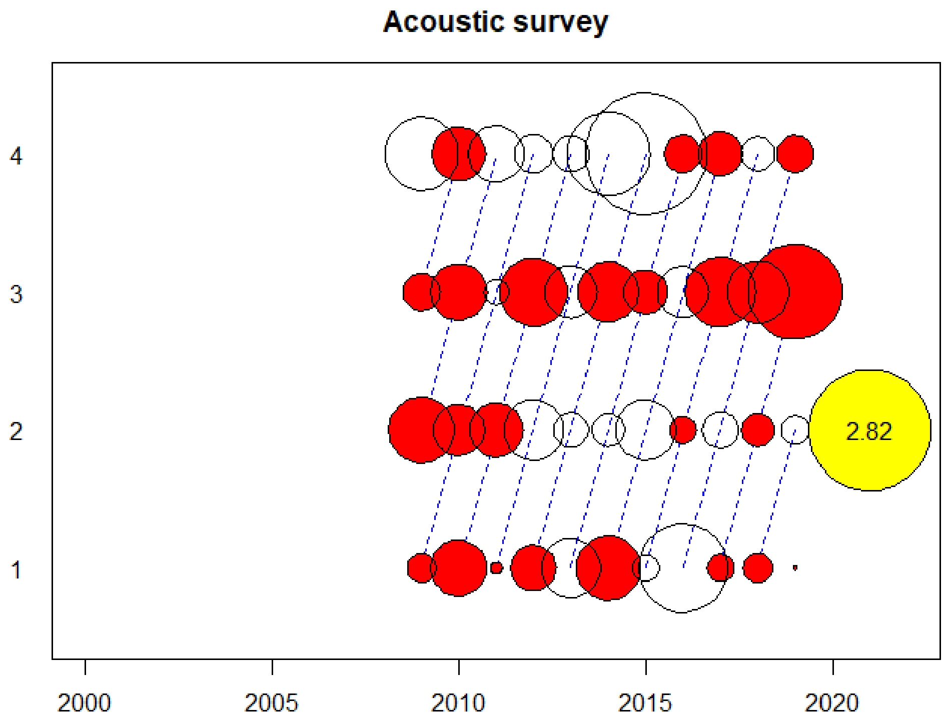


Figure 9.4.15. Sandeel Area-3r. Norwegian acoustic survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

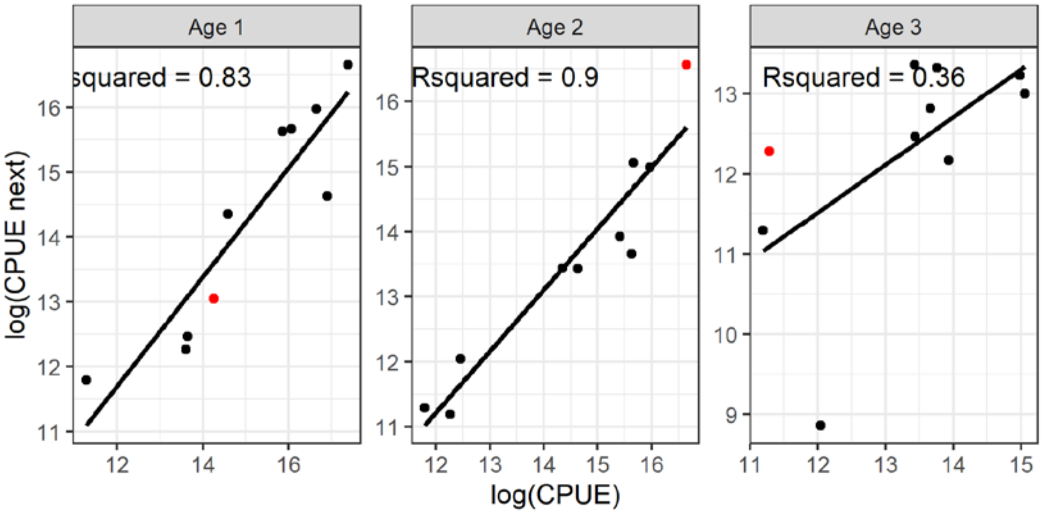


Figure 9.4.16. Sandeel Area-3r. Internal consistency by age of the acoustic survey. Red dot indicates the most recent data point.

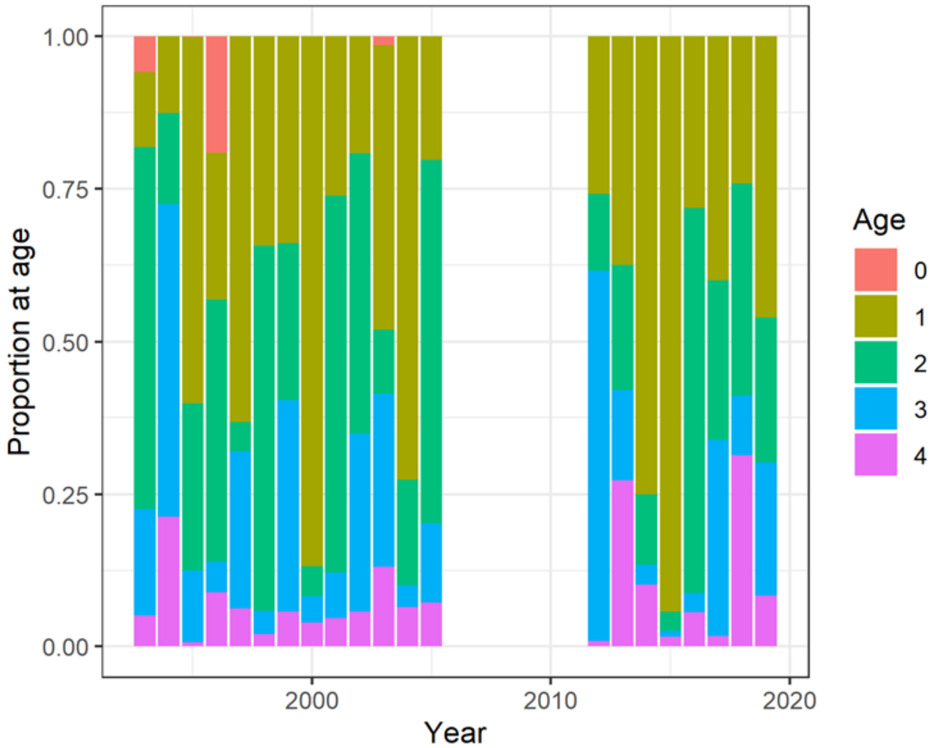


Figure 9.5.1. Sandeel Area-4. Catch numbers, proportion-at-age.

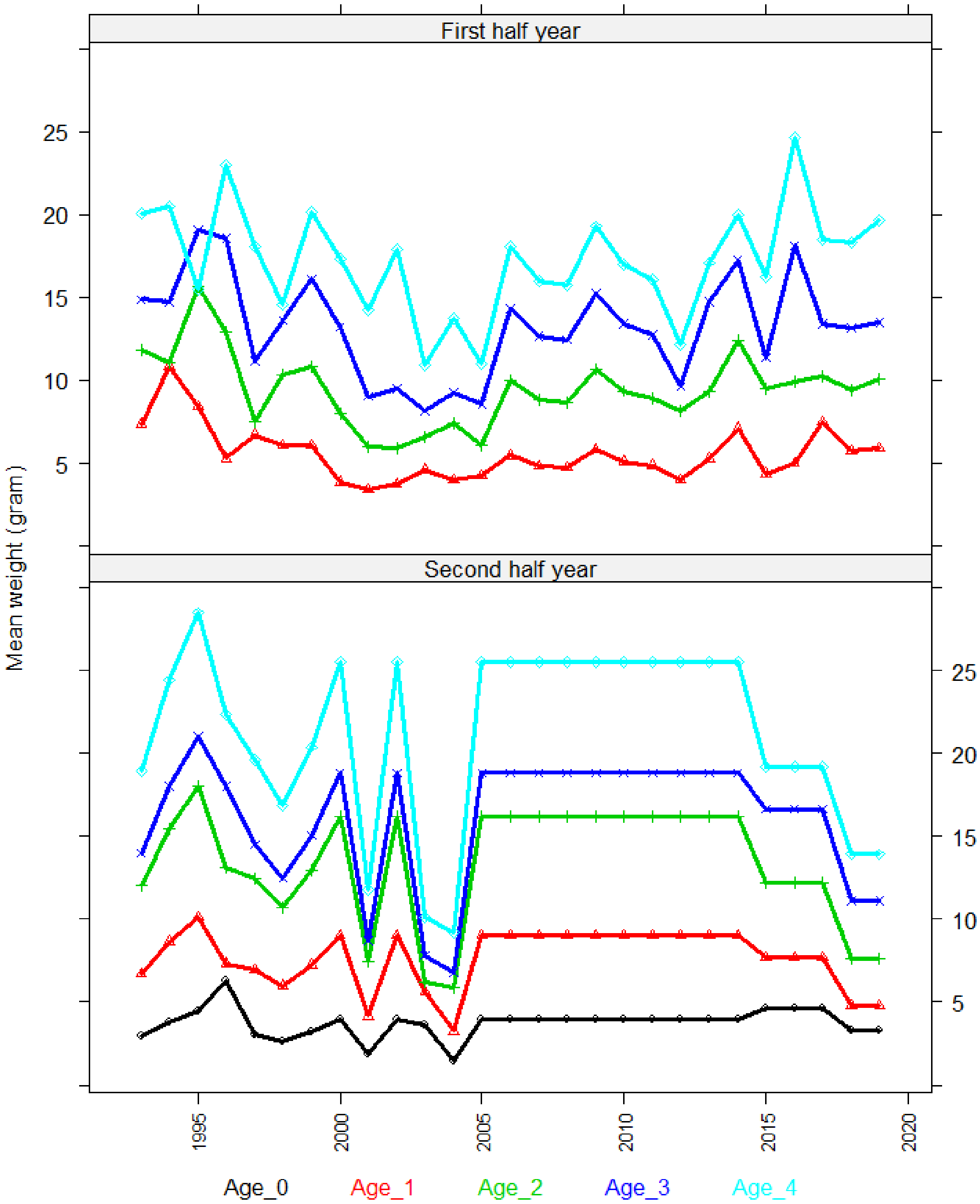


Figure 9.5.2. Sandeel Area-4. Mean weight-at-age in the first half year (age 1-4+) and second half year (age 0-4+).

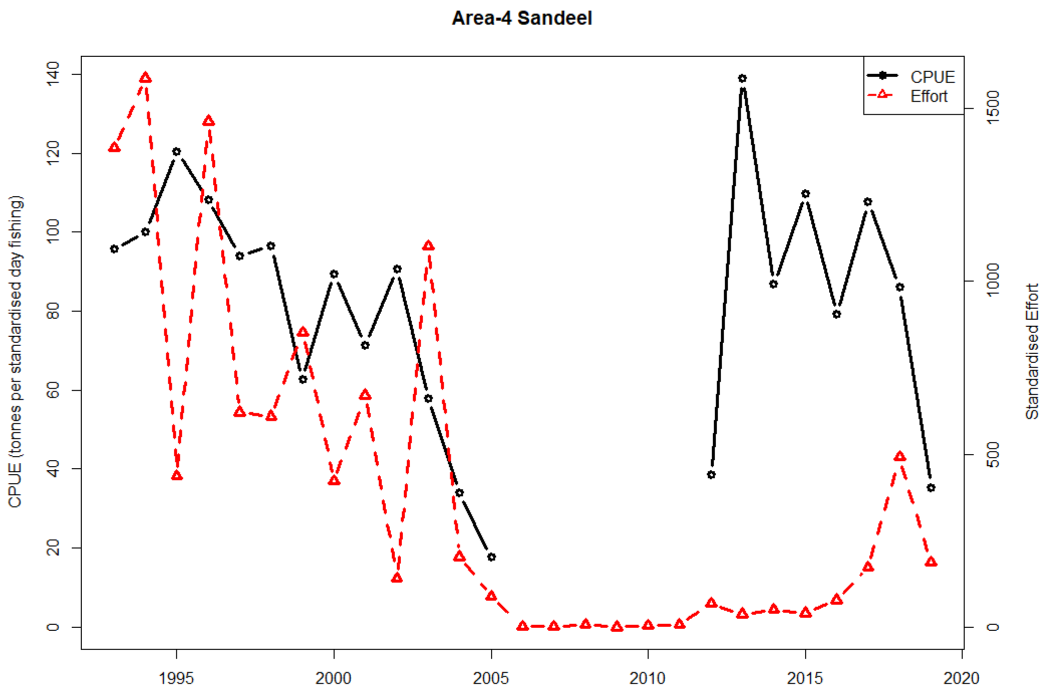


Figure 9.5.3. Sandeel Area-4. CPUE and effort.

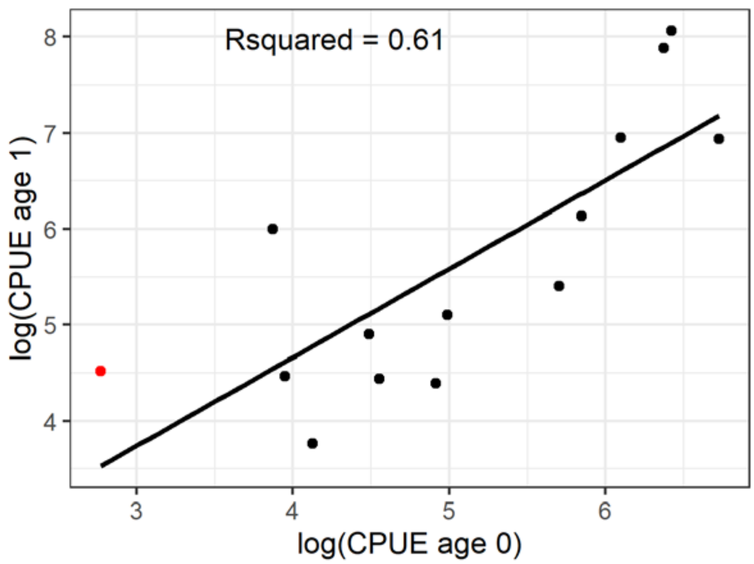


Figure 9.5.4. Sandeel Area-4. Internal consistency by age of the dregde survey. Red dot indicates the most recent data point.

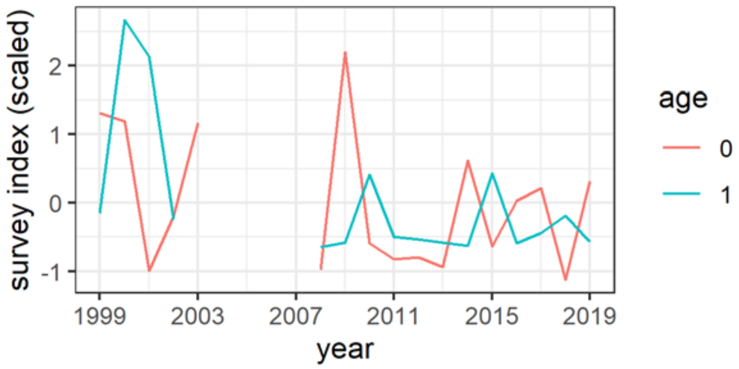


Figure 9.5.5. Sandeel Area-4. Dredge survey index timeline.

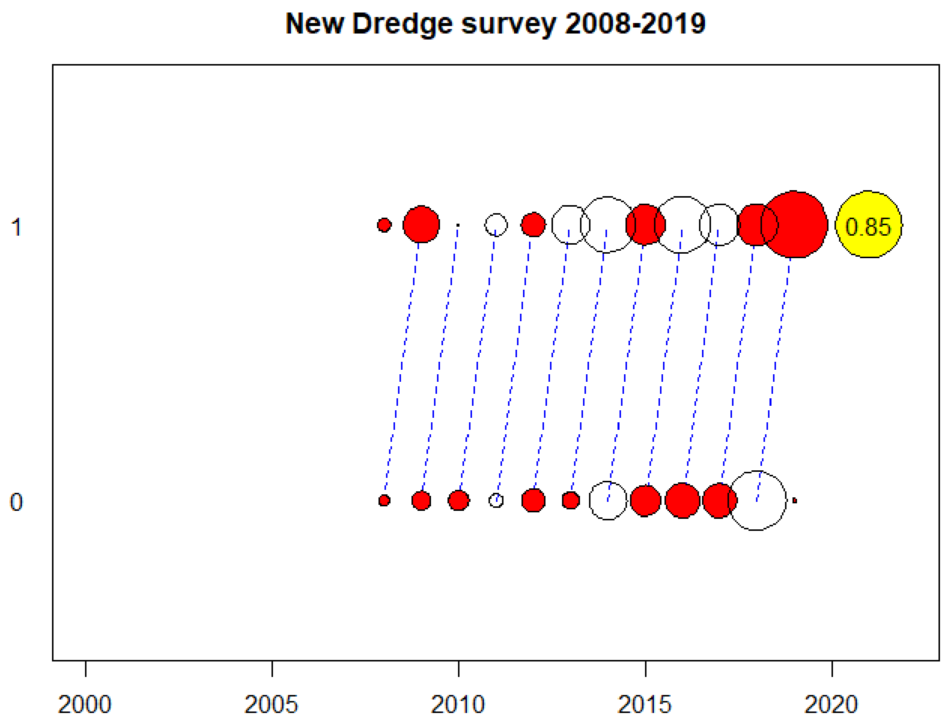


Figure 9.5.6. Sandeel Area-4. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

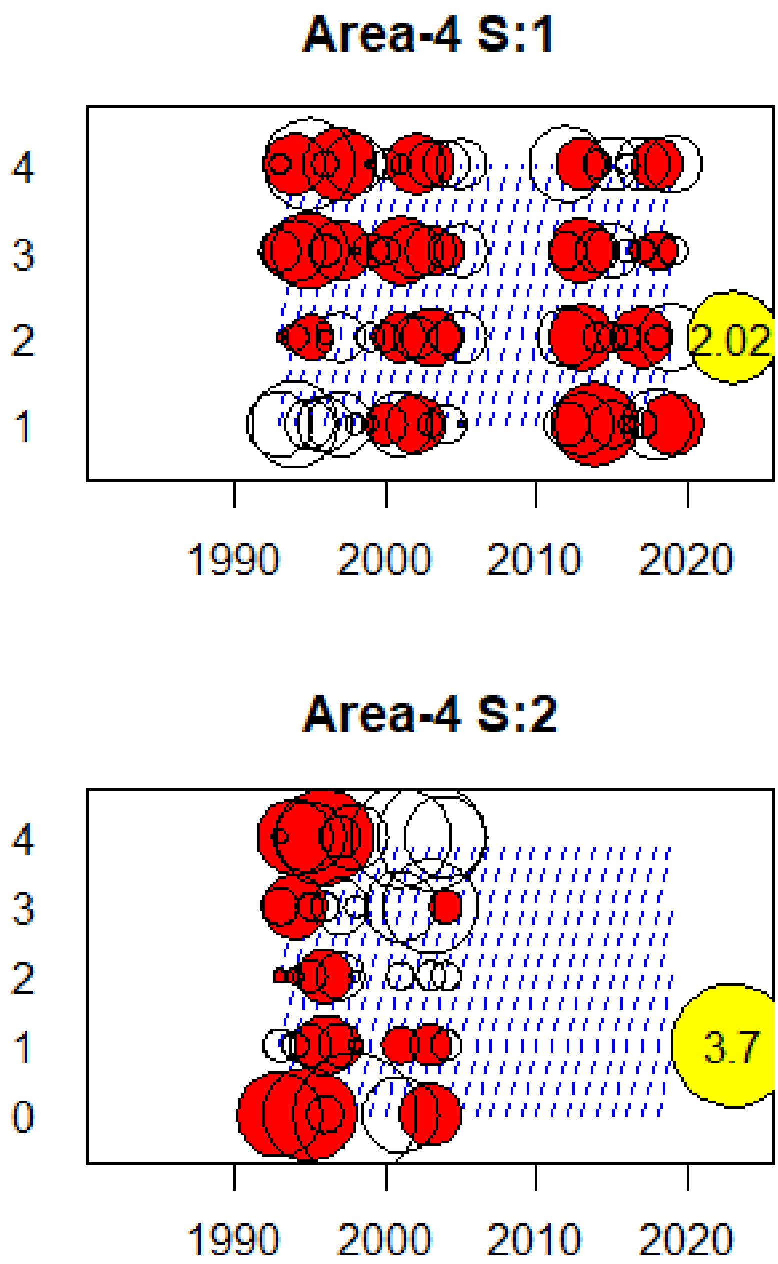


Figure 9.5.7. Sandeel Area-4. Catch-at-age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

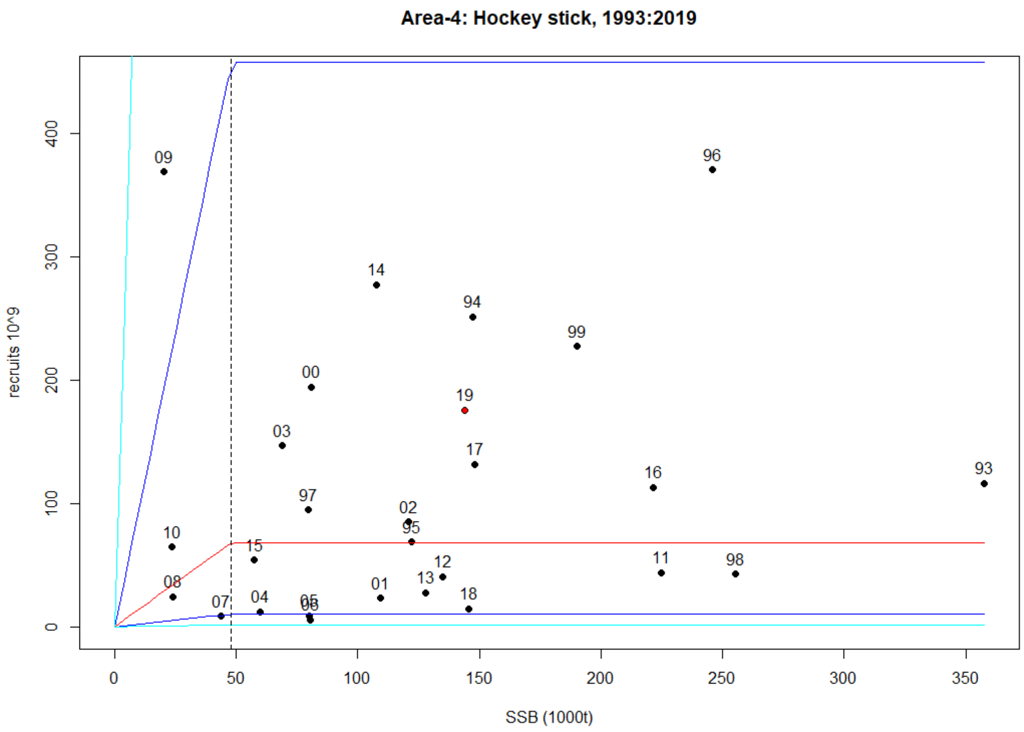


Figure 9.5.8. Sandeel Area-4. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

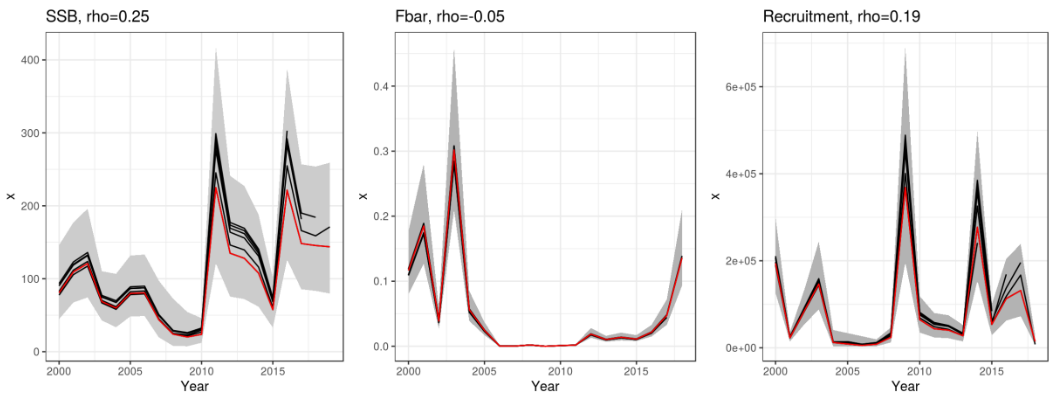


Figure 9.5.9. Sandeel Area-4. Retrospective analysis.

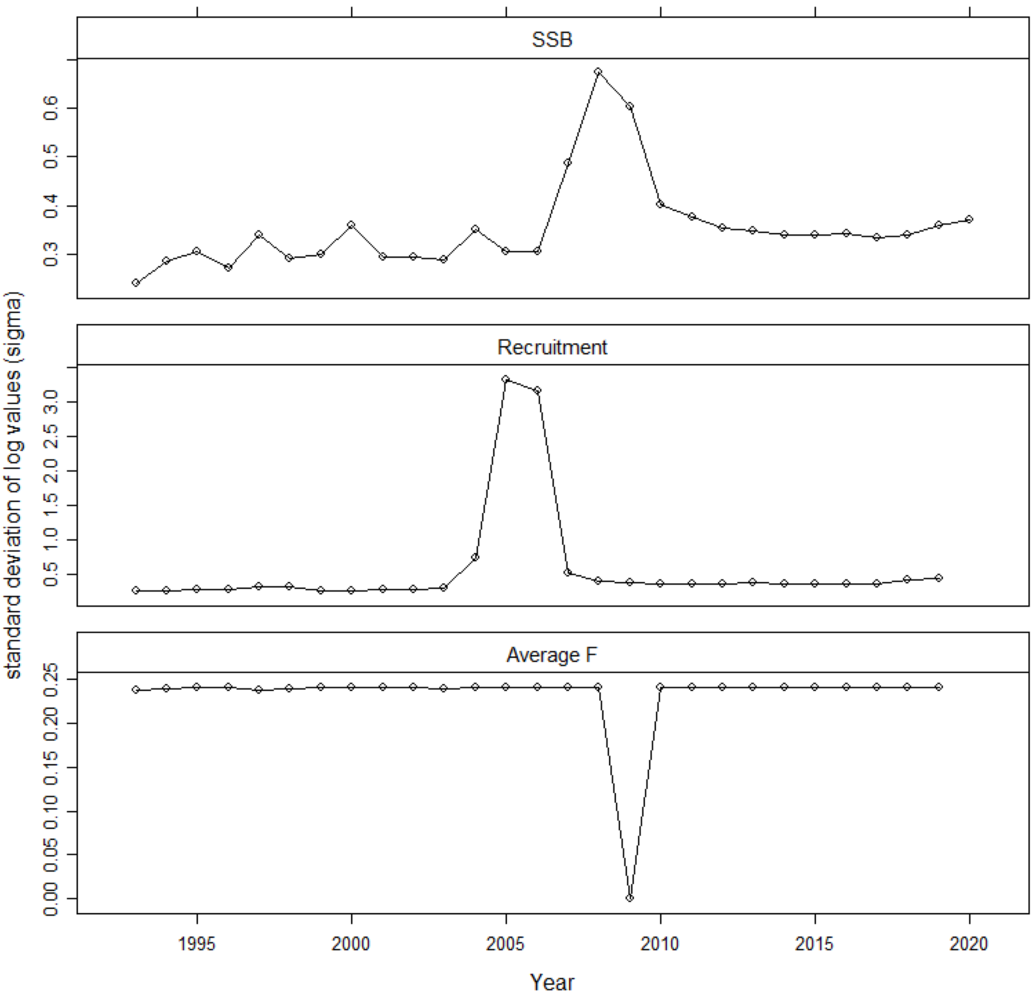


Figure 9.5.10. Sandeel Area-4. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

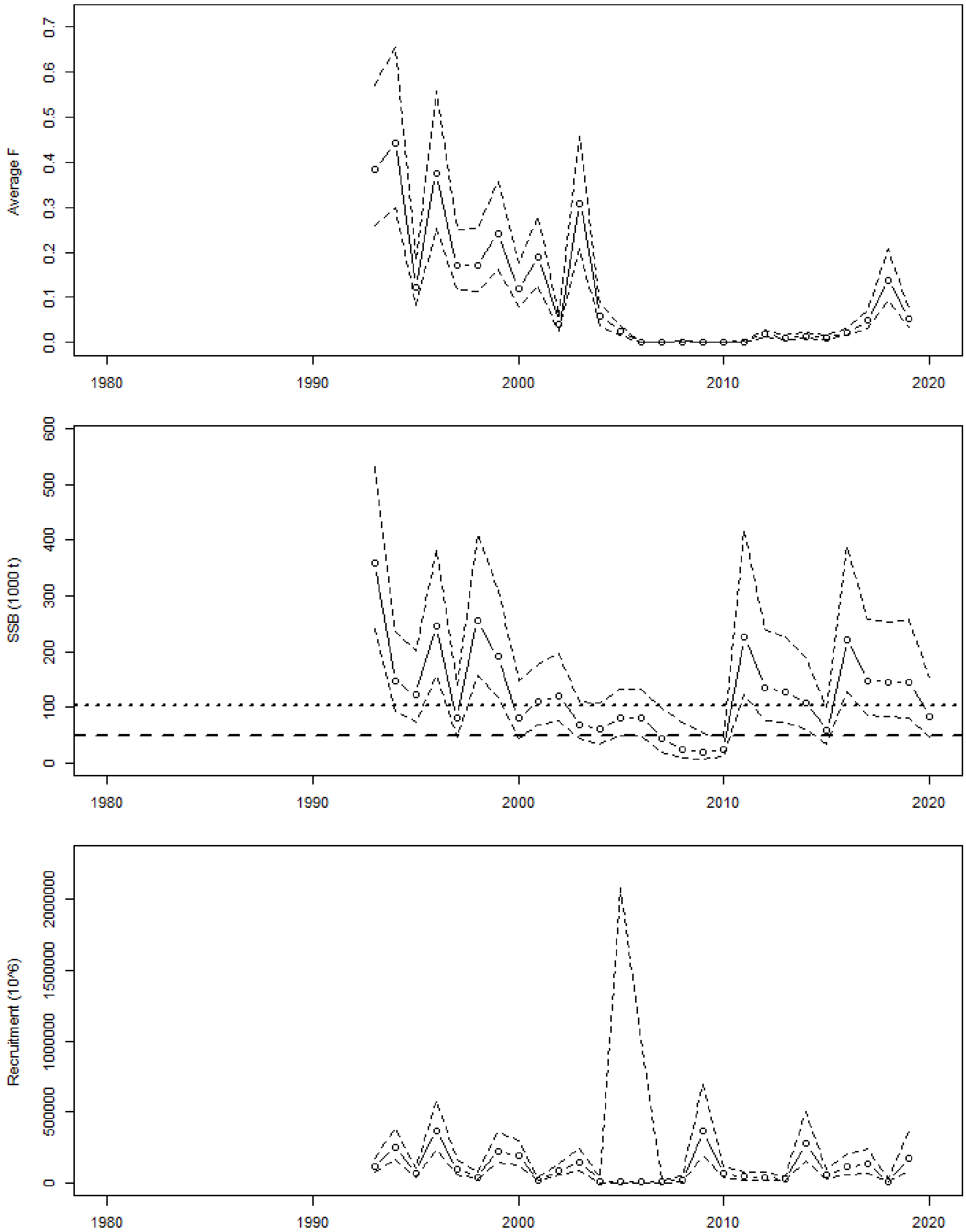


Figure 9.5.11. Sandeel Area-4. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

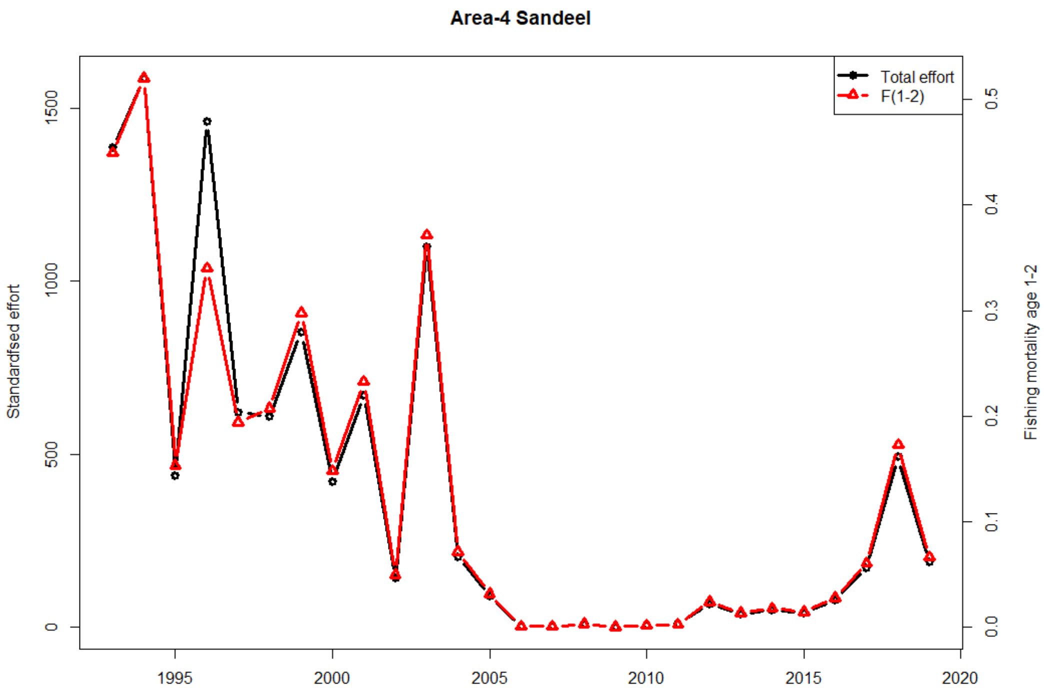


Figure 9.5.12. Sandeel Area-4. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

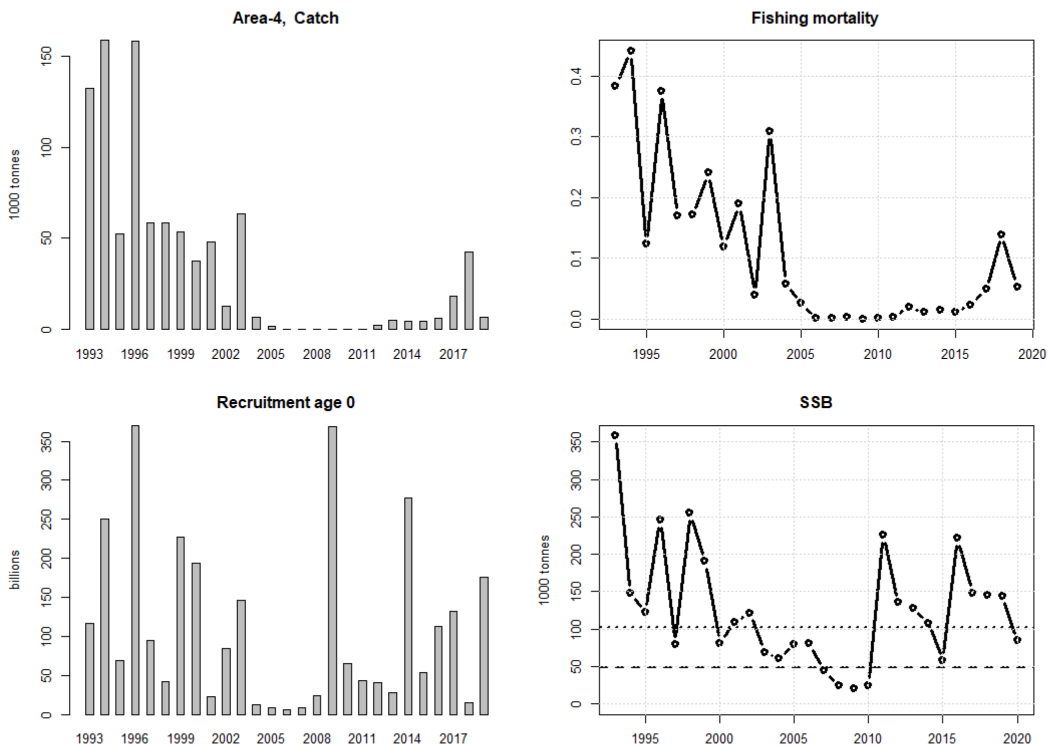


Figure 9.5.13. Sandeel Area-4. Stock summary.

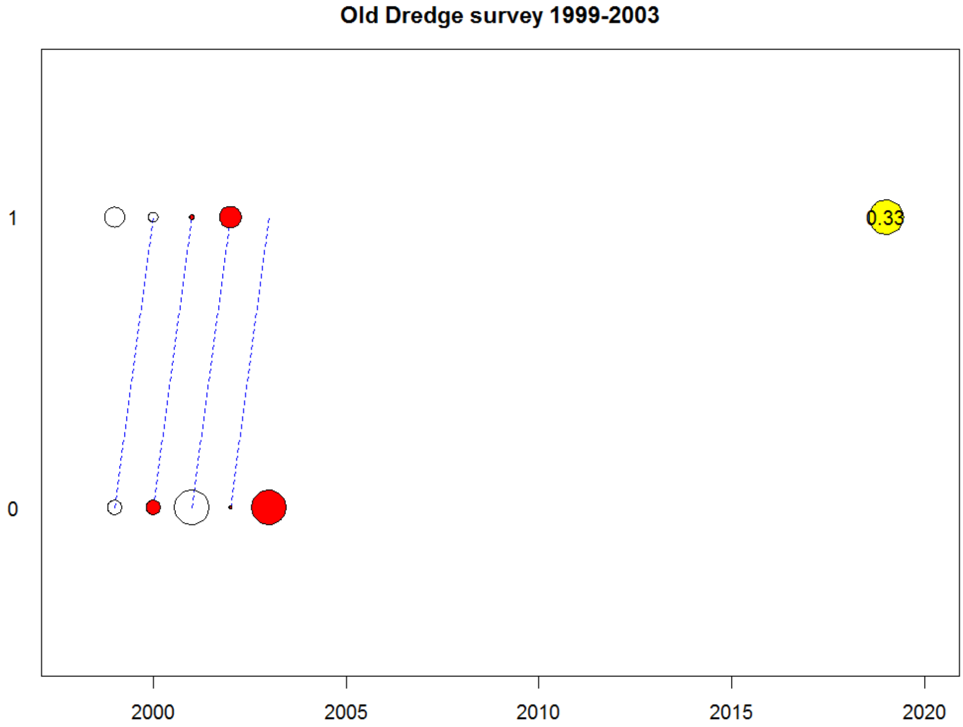


Figure 9.5.1. Sandeel Area-4. Old dredge survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

10 Sprat in Division 3.a and Subarea 4 (Skagerrak, Kattegat and North Sea)

10.1 The Fishery

10.1.1 ACOM advice applicable to 2019 and 2020

There have never been any explicit management objectives for this stock. Last year, the advised TAC (July 2019 to June 2020) was set to 138 726 t for sprat in Subarea 4 and Division 3.a. The 2019 herring bycatch quotas were 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 2019

Catch statistics for 1996–2019 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 2019 were 147 793 t (total official catches amounted to 147 919 t). This is a 23% decrease compared to 2018, but not far from the average for the time-series. The Danish catches represent 83% of the total catches.

The spatial distribution of landings was similar to 2018 (Figure 10.1.1). As in previous years, a low percentage (10% in 2019) of the catches were landed in the first and second quarter of 2019 (Table 10.1.2).

10.1.3 Regulations and their effects

The Norwegian vessels have a maximum vessel quota of 550 t when fishing in the North Sea. A herring bycatch of up to 10% in biomass is allowed in Norwegian sprat catches.

Most sprat catches are taken in an industrial fishery where catches are limited by herring bycatch quantities. Bycatches of herring are practically unavoidable except in years with high sprat abundance or low herring recruitment. Bycatch is especially considered to be a problem in area 4.c. This led to the introduction of a closed area (sprat box) to ensure that sprat catches were not taken close to the Danish west coast where large bycatches were expected.

ICES evaluated the effectiveness of the sprat box in 2017 (ICES, 2017). The evaluation showed that fishing inside the sprat box would be expected to reduce unwanted catches of herring by weight but not in number and concluded that other management measures are sufficient to control herring bycatch. The sprat box was removed in 2017.

10.1.4 Changes in fishing technology and fishing patterns

No major changes in fishing technology and fishing patterns for the sprat fisheries in the North Sea have been reported. From about 2000, Norwegian pelagic trawlers were licensed to take part in the sprat fishery in the North Sea. In the first years, the Norwegian catches were mainly taken by purse-seine, and the catches taken by trawl were low. In recent years, the share of the total Norwegian catches taken by trawl has increased (2019: 90% taken by trawl).

10.2 Biological composition of the catch

Only data on bycatch from the Danish fishery were available to the Working Group (Table 10.2.1). The Danish sprat fishery was conducted with a 2.2% and 9.1% bycatch of herring in 2019 in the North Sea and Division 3.a, respectively. The total amount of herring caught as bycatch in the sprat fishery has mostly been less than 10%.

The estimated quarterly landings at age in numbers for the period 1974–2019 are presented in Table 10.2.2. In the model year 2019 (1 July 2019–30 June 2020), one-year old sprat contributed 52% of the total landings, which is lower compared to the 1990–2018 average (63%) and the lowest since 2011 (45%). 2-year olds contributed 26% in 2019 (model year), which is above the 1990–2018 average (22%). 0-year olds contributed 18% of the total landings, which is higher than the 1990–2018 average (9%).

Denmark, Sweden, and Norway provided age data of commercial landings in 2019 (Table 10.2.4). All quarters were covered. The sample data were used to raise the landings data from the North Sea, Skagerrak, and Kattegat. The landings by UK-England (168 t), UK-Scotland (1324 t), Germany (3441 t) and Belgium (<1 t) were unsampled. The sampling level has been greatly improved since 2014 because of the implementation of a sampling programme for collecting haul-based samples from the Danish sprat fishery. The sampling level in 2019 (model year) was 1.8 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 and Sweden. 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 11.3.1 and Figure 11.3.1 and 11.3.2 give the time-series of IBTS indices by age (calculated using a delta-GAM model formulation; see WKSPRAT report (2018) for further details). The data source is the IBTS Q1 data from 1983–2020. The index for IBTS Q1 1-year old in 2020 (age-0 in the model and the table, serving as a recruitment index) was the fifth highest in the time-series, 20% higher than last year's index. There has been a tendency for an increase in the IBTS age 0 in the time-series since 1990. IBTS Q3 survey indices were also used in the assessment, and the 2019 values were 15% higher for age-1 and 71% and 60% higher for age-2 and age-3, respectively, compared to 2018. To track changes in Subarea 4 and Division 3.a, separately, IBTS indices for the North Sea and 3.a, respectively, are shown in Figure 11.3.2c and 11.3.3.

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 11.3.2 and Figure 11.3.2b). The 2019 values were 14% lower, 177% higher, and 577% higher (age-1, age-2, and age-3, respectively) compared to the 2018-values. To track changes in Subarea 4 and Division 3.a separately, WGIPS abundance indices for the North Sea and 3.a, respectively, are shown in Figure 11.3.4.

10.4 Mean weights-at-age and maturity-at-age

Mean weights-at-age in catches are given in Table 11.2.3 and Figure 11.4.1. Mean weights in model season 1 and 2 (S1 and S2; quarter 3 and 4), where most of the catches are taken, show a declining trend over the past decade. In 2019, the mean weights of age-1 and age-3 fish in S1 were the lowest observed for nearly two decades. Mean weight of age-2 in 2019 was about the same as in 2018, which was the lowest observed for two decades. Mean weight-at-age was also very low in S2 (Figure 11.4.1).

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

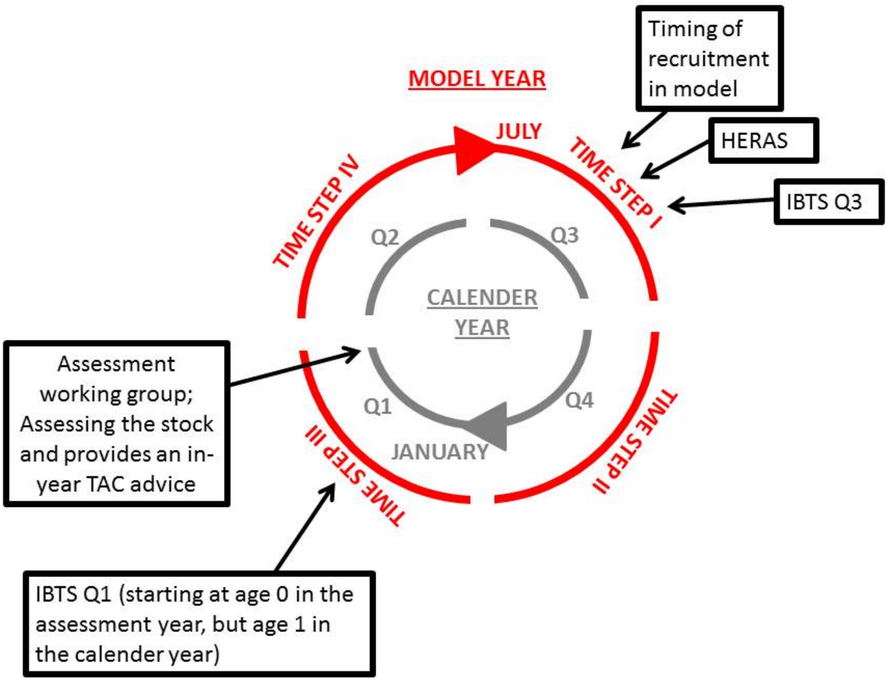
The IBTS Q1 age-1 index (age-0 in the model) (Table 10.3.1) is used as a recruitment index for this stock. The 2020 value, indicative of the 2019 recruitment, was the fifth highest in the time-series, and 20% higher than year. The recruitment estimated by the model for 2019 is 15% higher than the recruitment in 2018 and twice as high as the 1990-2018 arithmetic mean. At the most recent benchmark, it was decided to implement a power model (directly within the assessment model) to the age-0 IBTS Q1 index to dampen the effect of very high index values. This was done to reduce the retrospective bias on recruitment (see WKSPRAT 2018 for further details).

10.6 Stock Assessment

The stock assessment was benchmarked in November 2018 (WKSPRAT: ICES, 2018). During the WKSPRAT benchmark meeting in 2018, sprat in Subarea 4 and Division 3.a were merged into one stock assessment model. Also, a number of other modifications were made to the configuration of the assessment model (see WKSPRAT report (ICES, 2018) for further details).

In-year advice is the only possible type of advice for this short-lived species with a fishery dominated by 1- and 2-year-old fish. This, however, requires information about incoming 1-year-old fish. In order to meet this requirement and to come up with a model that logically matches the natural life cycle of sprat, the annual time-step in the model was shifted, relative to the calendar year, to a time-step going from July to June (see text table below). SSB and recruitment was estimated at 1 July. In figures and tables with assessment output and input, the years refer to the shifted model year (July to June) and in each figure and table it is noted whether model year or calendar year apply (when the model year is given the year refers to the year at the beginning of the model year; for example: 2000 refers to the model year 1 July 2000 to 30 June 2001). The following schematic illustrates the shifted model year relative to the calendar year and provides an overview of the timing of surveys etc.

Model year		Calendar year	
2000	Season 1	2000	Quarter 3
2000	Season 2	2000	Quarter 4
2000	Season 3	2001	Quarter 1
2000	Season 4	2001	Quarter 2



10.6.1 Input data

10.6.1.1 Catch data

Information on catch data are provided in Tables 10.1.1–2 and in Figures 10.1.13 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. In 2020, only 638 t were taken in quarter 1 and as a result, only one age sample was taken. To avoid the resulting high uncertainty in the age distribution of these catches, they were transferred to 2019 quarter 4, leading to a total catch of 34 456 t in this quarter.

10.6.1.2 Weight-at-age

The mean weights at age observed in the catch are given in Table 10.2.3 and Figure 10.4.1 by season. It is assumed that the mean weights in the stock are the same as in the catch. The mean weight at age of S1 that is used to calculated SSB.

10.6.1.3 Surveys

Three surveys were included (Tables 10.3.1–3), IBTS Q1 (1975–present), IBTS Q3 (1991–present) and HERAS (Q3) (2003–present). 0-group (young-of-the-year) sprat is unlikely to be fully recruited by the time of IBTS Q3 and HERAS, and for this reason these age indices were excluded from the model. 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 10.6.1.

10.6.1.5 Proportion mature

Proportion of mature fish was derived from IBTSQ1, following the benchmark procedure. Long-term average maturity ogives were used in the assessment model (0.0, 0.41, 0.87, and 0.95 for age-0 to age-3+). More details about the maturity staging are given in Section 4.5.3.2 in the WKSPRAT 2013 report (ICES, 2013).

10.6.2 Stock assessment model

The assessment was made using SMS (Lewy and Vinther, 2004) with quarterly time-steps (referred to as season S1–S4). Three surveys were included, IBTS Q1 ages 1–4+, IBTS Q3 ages 1–3 and HERAS (Q3) ages 1–3. 0-group sprat is unlikely to be fully recruited to the IBTSQ3 or HERAS in Q3 and these age indices were excluded from runs. External consistency between IBTS Q1, IBTS Q3 and HERAS can be found in the benchmark report (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 = 0.31) (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 = 0.35).The assessment model was improved with this respect during the last benchmark and Mohn´s rho was reduced by roughly a factor of 3 due to the improvement.

The final outputs detailing trends in mean F, SSB and recruitment are given in Figures 10.6.4–7 and Tables 10.6.3–4.

10.7 Reference points

A B_{lim} of 94 000 t (Figure 10.7.1) and B_{pa} of 125 000 t were agreed at the most recent benchmark. B_{pa} is defined as the upper 90% confidence interval of B_{lim} and calculated based on a terminal SSB CV of 0.173.

10.8 State of the stock

The sprat stock is abundant judging by all the surveys and by the assessment output. The stock has been well above B_{pa} since 2013 and above B_{lim} since 1991. The current SSB is more than twice the B_{lim}, and among the six highest since 1980. Fishing mortality has been decreasing and is now for the first time in five years below the long-term average. The advised TAC was based on the predicted catch at F equal to F_{cap} (0.69). A large overshoot of F_{cap} is seen in simulations applying the escapement strategy on very large incoming year classes, and this is the rationale for implementing an F_{cap} as otherwise, the escapement strategy is not precautionary at large stock sizes.

A stock summary from the assessment output can be found in Table 10.6.4 and Figure 10.6.7.

10.9 Short-term projections

Management strategy evaluations for this stock were made in December 2018 (WKSPRATMSE: ICES, 2018). These evaluations clearly show that the current management strategy ($B_{escapement}$) is not precautionary unless an additional constraint is imposed on the fishing mortality (referred to as F_{cap}). During the WKSPRATMSE (ICES, 2018) 0.69 was found to be the optimal F_{cap} value (from both a full MSE and a shortcut MSE, see the WKSPRATMSE report (WKSPRATMSE: ICES, 2018) for further details), which is a revision of the previous value of 0.7. This means, that the fishing mortality (F_{bar}(1–2)) derived from the $B_{escapement}$ strategy, should not exceed 0.69.

SSB in 2020 is expected to be higher than 2019, 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 2021 of 393 000 t (Table 11.9.2). 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 207 807 t (July 2020–June 2021), which is expected to result in an SSB of 263 000 t in July 2021, well above B_{pa}.

10.10 Quality of the assessment

The data used within the assessment, the assessment methods and settings were carefully scrutinized during the 2018 benchmark (ICES, 2018). A complete overview of the choices made during the benchmark can be found in the WKSPRAT report (ICES, 2018) and these are also described in the Stock Annex for sprat in Division 3.a and Subarea 4.

The assessment shows medium to high CVs for the catches but low CVs for surveys. The CVs of F, SSB and recruitment are generally low (see Table 10.6.2 and Figure 10.6.4). The model converged and fitted the catches of the main ages caught in the main seasons (the periods with most samples) reasonably well (ages 1–2, season 2, Table 10.6.2). The retrospective pattern in SSB and recruitment (5 years mohn´s rho of 0.35 and 0.31, respectively) is slightly above the advised limit of 0.3 discussed in WKFORBIAS (2019). However, the Mohn’s rho has not been consistently above 0.3 (i.e. last year it was 0.29) and 0.35 is within the 90% confidence intervals of Mohn´s rho distribution from the MSE, this was not considered to cause concern about the quality of the assessment.

There appears to be a systematic pattern in the catch residuals of model season 1 (quarter 3), which remains unexplained.

10.11 Management Considerations

A management plan needs to be developed for this stock. Sprat is an important forage fish, thus also multispecies considerations should be made.

The sprat stock in the North Sea is dominated by young fish. The stock size is mostly driven by the recruiting year class. Thus, the fishery in a given year will be dependent on that year's incoming year class.

Industrial fisheries are allocated a bycatch of 8954 t and 6659 t of juvenile herring in 2020 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.

Despite the fact that sprat in the North Sea and 3.a is assessed as a single stock, schedule of the TAC setting are different between these two management areas. In the North Sea the TAC is set from 1 July to 30 June in line with the in year-advice provided for the stock, while the TAC for Division 3.a is still based on a calendar year from 1 January to 31 December creating an inherent mismatch.

10.11.1 Stock units

After the latest benchmark, sprat in the Subarea 4 and Division 3.a is considered to be one cohesive stock. This is documented in the WKSPRAT report (ICES, 2018). In addition, there are several peripheral areas of the North Sea and Division 3.a where there may be populations of sprat that behave as separate stocks from the main stock. Local depletion of sprat in such areas can be an issue of ecological concern.

10.12 Ecosystem Considerations

Sprat is an important prey species in the North Sea ecosystem. The influence of the sprat fishery on other fish species and seabirds are at present not documented to be substantial.

In the North Sea, the key predators consuming sprats are included in the stock assessment, using SMS estimates of sprat consumption for each predatory fish stock, and estimates for seabirds. 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) 1996–2019. 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	2019
Division 27.4.a																								
Denmark	0.3			0.7		0.1	1.1		*		*	0.8	*	*					*	*	0.1	0.1		*
Norway														*		*								0.1
Sweden						0.1																		
UK (Scotland)																0.5						*	*	
Germany																				*	*			
Netherlands																				*				
Total	0.3			0.7		0.2	1.1		*		*	0.8	*	*		0.5			*	*	0.1	0.1	*	0.1
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	110.3
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	10.0
Sweden	0.5		1.7	2.1		1.4				*				0.3	0.6	1.1	1.8	0.1	3.9	5.5	11.7	8.1	7.6	7.5
UK(Scotland)				1.4								0.1		2.5	1.1	1.9	0.7						*	1.3
UK(Engl.& Wales)														*								*	*	
Germany																3.3	0.5	0.6	1.5	3.1	5.4	6.0	3.7	3.4

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Nether-lands																1.1	2.7	0.4	2.4	1.2	1.0	1.6	1.6	
Faroe Is-lands																					4.7	1.0	1.0	
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	132.6
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	8.9
Norway		0.1	16.0	5.7	1.8	3.6					9.0	2.9		1.8	3.2	9.9	3.0	1.7	0.1	8.8	0.6		0.5	0.6
Sweden														0.6	0.6	0.2	0.4	1.3		1.2	0.4			
UK(Scot-land)													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	*	*	*	*	*	0.1	0.2
Germany																*	*	1.0		0.6	0.2			
Nether-lands				0.2												4.2	1.0	0.7	*	1.2	0.8	*	0.7	
Belgium																*		*	*	*	*	*		*
France																				*		*		
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	9.6
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	3.9

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
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	1.7
Germany																			*				*	
Faroe Islands																					*			
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	5.6
Total North Sea and 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	123.1
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	10.6
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	9.2
UK(Scotland)				1.4								0.1	0.2	2.5	1.1	2.8	0.7				*	*	*	1.3
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	*	*	*	*	*	*	0.2
Germany																3.3	0.5	1.6	1.6	3.7	5.6	6.0	3.7	3.4
Netherlands				0.2												5.3	3.7	1.1	2.4	2.4	1.8	1.6	2.3	
Faroe Islands																					4.7	1.0	1.0	
Belgium																*		*	*	*	*	*		*
France																				*		*		
Total	153.6	118.8	181.7	214.9	215.1	197.9	161.3	192.2	215.2	247.3	125.9	97.9	69.3	141.6	153.3	144.1	95.5	68.9	158.7	303.3	248.5	129.9	191.2	147.8

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
* < 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	1462	29 510
	2		1722	45		1767		2		3235	3	648	3886
	3		131 306	1216		132 522		3		14 220		3405	17 625
	4		12 680	2718		15 398		4		62 006	35 973	4278	102 257
	Total		163 834	32 042		195 876		Total		90 437	53 048	9793	153 278
2001	1	115	40 903	9716		50 734	**2011**	1		3747	21 039	3216	28 002
	2		1071			1071		2		2067	3	617	2687
	3		44 174	481		44 655		3		22 309	451	2311	25 072
	4	79	65 102	8538		73 719		4	8	70 256	13 759	3887	87 910
	Total	194	151 249	18 735		170 177		Total	8	98 380	35 252	10 031	143 671
2002	1	1 136	2182	2790		6108	**2012**	1		81	1649	4668	6399
	2		435	93		528		2		2924	0	909	3832
	3		70 504	647		71 151		3		26 779	307	1631	28 717

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	
	4		52 942	12 911		65 853		4		47 765	6060	2728	56 553
	Total	1 136	126 063	16 441		143 640		Total		77 549	8016	9936	95 501
2003	1		11 458	7727	5217	24 402	**2013**	1		1281	3158	1296	5734
	2		625	26	1397	2049		2		32	0	443	474
	3		56 207	165	1720	58 092		3		25 577	720	211	26 509
	4		84 629	15 651	7349	107 629		4		18 892	16 276	943	36 110
	Total		152 919	23 570	15 683	192 172		Total		45 781	20 154	2893	68 827
2004	1		827	1831	4456	7113	**2014**	1		59	125	384	568
	2	7	260	16	1510	1793		2		11 631	3	1415	13 050
	3		54 161	496	4138	58 794		3	1	88 457	1428	9622	99 507
	4		120 685	15 937	10 775	147 397		4	7	37 851	822	6905	45 586
	Total	7	175 932	18 280	20 879	215 097		Total	8	137 999	2378	18 327	158 711
2005	1		11 538	2457	8148	22 143	**2015**	1	*	14 816	16 972	1442	33 230
	2		2515	123	4722	7360		2		16 843	107	619	17 568
	3		107 530		19 418	126 948		3		124 512	335	6528	131 375
	4		82 474	1033	7296	90 803		4	25	88 395	28 375	4389	121 184
	Total		204 057	3613	39 584	247 254		Total	25	244 566	45 789	12 978	303 358

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	
2006	1	47	13 713	33 534	8105	55 399	**2016**	1	68	18 487	5969	746	25 250
	2		190	8	324	522		2		8927	51	669	9 647
	3		40 051	8	1440	41 499		3	*	158 522	111	4664	163 297
	4	2	26 579	77	2335	28 993		4	2	34 070	14 466	1764	50 301
	Total	49	80 533	33 627	12 204	126 413		Total	70	220 007	20 596	7843	248 516
2007	1		582	247	2646	3475	**2017**	1	1	3432	1220	92	4 745
	2		241	3	1291	1535		2		1327	0	33	1 360
	3		16 603		5357	21 960		3	*	92 885	217	227	93 329
	4	769	41 850	23 531	4761	70 911		4	94	29 310	174	849	30 426
	Total	769	59 276	23 781	14 055	97 881		Total	95	126 954	1611	1200	129 860
2008	1		2872	43	2890	5805	**2018**	1	*	8994	1628	168	10 790
	2		52	*	1017	1069		2		11 898	0	224	12 122
	3		21 787		636	22 423		3		112 361	1	1328	113 690
	4		27 994	8334	3672	40 001		4		46 411	5922	2249	54 582
	Total		52 706	8377	8215	69 298		Total	*	179 664	7551	3969	191 184
2009	1		36	1268	2600	3904	**2019**	1		389	9592	627	10 609
	2		2526	1	300	2827		2	2	3606	11	379	3999

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	22	41 513		3300	44 835		3	2	95 829	7	2 249	98 087
	4		78 373	9336	2400	90 109		4	49	32 750	3	2 296	35 098
	Total	22	122 448	10 604	8600	141 675		Total	53	132 574	9614	5551	147 793

*** < 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.

	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
Tonnes	2019	118 302	2 757	1	897	1	176	0	3	503	122 639
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
Percent	2019	96.5	2.2	0.0	0.7	0.0	0.1	0.0	0.0	0.4	100.0

	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
Tonnes	2019	3 429	351	0	59	0	2	0	0	8	3 850
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
Percent	2019	89.1	9.1	0.0	1.5	0.0	0.1	0.0	0.0	0.2	100.0

Table 10.2.2. North Sea & 3.a sprat. Catch in numbers by age (1000's) by season and year. (Model year)

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	4548741	11562002	2878462	310552
2018	2	2090509	2888456	1516387	534059
2018	3	157673	1090798	254223	15776
2018	4	0	0	0	0
2019	1	4107847	8278419	3109083	196243
2019	2	945227	2315850	992645	154144
2019	3	0	0	0	0
2019	1	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	0.00664	0.0086	0.0126
2018	2	0.0053	0.0074	0.0097	0.0134
2018	3	0.0041	0.0067	0.0095	0.0136
2018	4	0.0057	0.0065	0.00762	0.0129
2019	1	0.0051	0.0063	0.0087	0.0120
2019	2	0.0053	0.0076	0.0096	0.0141
2019	3	0.0057	0.0100	0.0144	0.0165
2019	4	0.0065	0.0103	0.0134	0.0161

Table 10.2.4. North Sea and Division 3.a sprat. Sampling for biological parameters in 2019. 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	9.76	15	1 557	695
	2	3.94	4	403	190
	3	81.50	65	6 790	2 796
	4	27.87	32	3 336	1 315
	Total	123.08	116	12086	4996
Norway	1	0.57			
	2	0.00			
	3	6.78			
	4	3.23	4	298	182
	Total	9.78	4	298	182
Sweden	1	0.11	5	471	470
	2	0.05			
	3	7.07			
	4	1.95	9	576	569
	Total	9.18	14	1047	1039
All countries	1	10.61	20	2028	1165
	2	4.00	4	403	190
	3	98.09	65	6790	2796
	4	35.10	45	4210	2066
Total		147.79	134	13 431	6 217

Table 10.2.5. North Sea and Division 3.a sprat. Number of biological samples taken from 1991 and onward. The number of samples may differ from Table 8.2.4, since this table shows both length and age-length samples. These are the samples used to generate the catch-at-age matrix for the assessment model (Model year).

Year	S1	S2	S3	S4
1974	15	31	102	25
1975	67	46	40	11
1976	54	70	53	16
1977	37	51	32	18
1978	52	78	47	22
1979	86	55	90	9
1980	0	0	49	28
1981	61	32	29	14
1982	27	48	13	16
1983	11	44	27	8
1984	9	23	29	7

Year	S1	S2	S3	S4
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
2013	31	23	2	10

Year	S1	S2	S3	S4
2014	116	19	19	13
2015	165	47	21	2
2016	90	30	3	0
2017	69	21	11	6
2018	65	60	20	5
2019	65	45	0	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
2019	7316245	2219294	421523	40023

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
2018	18709889	3123833	200733

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**
2019	40210818	8468920	521293

Table 10.3.2. North Sea and Division 3.a sprat. HERAS survey index.

HERAS abundance index (sa 4 and 3.a summed), data are from WGIPS (2019)			
Years and ages apply to the model year and calendar year			
Year	**Age 1**	**Age 2**	**Age 3**
2006	21923	21368	1413
2007	42862	5837	2252
2008	17188	7868	840
2009	47690	16920	2815
2010	20328	14087	1174
2011	26581	14207	3412
2012	22036	12831	4693
2013	9347	6342	2049
2014	59020	20274	3982
2015	27082	22676	10142
2016	58604	33989	8160
2017	38135	3664	1465
2018	109180	10113	779
2019	93775	28020	5275

Table 10.6.1. North Sea and Division 3.a sprat. Natural mortality input (Model year). From multispecies SMS (WKSAM: ICES, 2017) 2017 key run.

Year	Season	age 0	age 1	age 2	age 3
1974	1	0.483	0.456	0.402	0.280
1974	2	0.327	0.235	0.217	0.188
1974	3	0.297	0.275	0.175	0.175

Year	Season	age 0	age 1	age 2	age 3
1974	4	0.445	0.409	0.318	0.318
1975	1	0.518	0.492	0.422	0.237
1975	2	0.289	0.220	0.200	0.169
1975	3	0.329	0.299	0.218	0.218
1975	4	0.474	0.442	0.423	0.423
1976	1	0.490	0.466	0.415	0.290
1976	2	0.318	0.242	0.225	0.195
1976	3	0.364	0.332	0.240	0.240
1976	4	0.485	0.443	0.421	0.421
1977	1	0.441	0.411	0.368	0.312
1977	2	0.373	0.245	0.227	0.199
1977	3	0.380	0.351	0.248	0.248
1977	4	0.490	0.440	0.432	0.432
1978	1	0.411	0.398	0.385	0.330
1978	2	0.347	0.230	0.218	0.192
1978	3	0.382	0.356	0.208	0.208
1978	4	0.445	0.396	0.374	0.374
1979	1	0.436	0.424	0.419	0.405
1979	2	0.416	0.252	0.245	0.227
1979	3	0.393	0.366	0.232	0.232
1979	4	0.444	0.389	0.377	0.377
1980	1	0.470	0.464	0.444	0.415
1980	2	0.447	0.261	0.257	0.230
1980	3	0.388	0.355	0.232	0.232
1980	4	0.419	0.372	0.336	0.336
1981	1	0.501	0.486	0.448	0.360
1981	2	0.409	0.271	0.267	0.232
1981	3	0.361	0.314	0.222	0.222
1981	4	0.376	0.330	0.267	0.267

Year	Season	age 0	age 1	age 2	age 3
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
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

Year	Season	age 0	age 1	age 2	age 3
1989	2	0.525	0.332	0.294	0.261
1989	3	0.356	0.228	0.221	0.221
1989	4	0.374	0.312	0.281	0.281
1990	1	0.518	0.489	0.402	0.244
1990	2	0.496	0.331	0.283	0.261
1990	3	0.337	0.260	0.249	0.249
1990	4	0.387	0.319	0.287	0.287
1991	1	0.462	0.423	0.320	0.263
1991	2	0.396	0.269	0.232	0.211
1991	3	0.310	0.264	0.223	0.223
1991	4	0.389	0.320	0.287	0.287
1992	1	0.410	0.360	0.281	0.255
1992	2	0.312	0.227	0.204	0.180
1992	3	0.294	0.275	0.212	0.212
1992	4	0.371	0.299	0.270	0.270
1993	1	0.456	0.414	0.340	0.303
1993	2	0.238	0.209	0.190	0.173
1993	3	0.272	0.253	0.192	0.192
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

Year	Season	age 0	age 1	age 2	age 3
1996	3	0.215	0.171	0.151	0.151
1996	4	0.238	0.195	0.156	0.156
1997	1	0.451	0.293	0.210	0.155
1997	2	0.298	0.204	0.187	0.154
1997	3	0.227	0.193	0.171	0.171
1997	4	0.269	0.214	0.171	0.171
1998	1	0.430	0.283	0.226	0.190
1998	2	0.362	0.197	0.176	0.145
1998	3	0.252	0.209	0.173	0.173
1998	4	0.318	0.245	0.197	0.197
1999	1	0.421	0.287	0.232	0.214
1999	2	0.291	0.191	0.169	0.152
1999	3	0.275	0.241	0.191	0.191
1999	4	0.335	0.267	0.242	0.242
2000	1	0.406	0.342	0.253	0.219
2000	2	0.355	0.199	0.180	0.170
2000	3	0.254	0.213	0.157	0.157
2000	4	0.279	0.236	0.192	0.192
2001	1	0.409	0.328	0.233	0.190
2001	2	0.299	0.213	0.202	0.195
2001	3	0.266	0.225	0.191	0.191
2001	4	0.306	0.258	0.213	0.213
2002	1	0.434	0.321	0.240	0.171
2002	2	0.315	0.223	0.214	0.206
2002	3	0.252	0.206	0.194	0.194
2002	4	0.323	0.262	0.218	0.218
2003	1	0.419	0.269	0.215	0.168
2003	2	0.295	0.229	0.208	0.204
2003	3	0.259	0.229	0.226	0.226

Year	Season	age 0	age 1	age 2	age 3
2003	4	0.383	0.308	0.286	0.286
2004	1	0.436	0.276	0.231	0.192
2004	2	0.278	0.216	0.193	0.185
2004	3	0.231	0.212	0.208	0.208
2004	4	0.376	0.302	0.278	0.278
2005	1	0.442	0.321	0.227	0.216
2005	2	0.309	0.219	0.181	0.174
2005	3	0.220	0.201	0.179	0.179
2005	4	0.367	0.291	0.225	0.225
2006	1	0.504	0.315	0.226	0.215
2006	2	0.265	0.212	0.172	0.166
2006	3	0.217	0.197	0.172	0.172
2006	4	0.364	0.277	0.202	0.202
2007	1	0.480	0.312	0.204	0.184
2007	2	0.287	0.222	0.170	0.166
2007	3	0.210	0.175	0.152	0.152
2007	4	0.312	0.237	0.175	0.175
2008	1	0.478	0.307	0.187	0.166
2008	2	0.269	0.203	0.157	0.151
2008	3	0.200	0.173	0.167	0.167
2008	4	0.304	0.225	0.197	0.197
2009	1	0.444	0.362	0.233	0.162
2009	2	0.327	0.200	0.158	0.150
2009	3	0.190	0.170	0.163	0.163
2009	4	0.293	0.215	0.190	0.190
2010	1	0.527	0.412	0.312	0.170
2010	2	0.395	0.217	0.179	0.164
2010	3	0.207	0.182	0.159	0.159
2010	4	0.309	0.226	0.197	0.197

Year	Season	age 0	age 1	age 2	age 3
2011	1	0.511	0.437	0.386	0.182
2011	2	0.381	0.239	0.193	0.179
2011	3	0.229	0.202	0.179	0.179
2011	4	0.338	0.254	0.224	0.224
2012	1	0.509	0.432	0.344	0.176
2012	2	0.368	0.238	0.191	0.178
2012	3	0.219	0.176	0.145	0.145
2012	4	0.292	0.225	0.180	0.180
2013	1	0.399	0.367	0.285	0.150
2013	2	0.271	0.209	0.164	0.158
2013	3	0.206	0.175	0.148	0.148
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

Year	Season	age 0	age 1	age 2	age 3
2018	2	0.255	0.200	0.165	0.153
2018	3	0.212	0.177	0.149	0.149
2018	4	0.278	0.224	0.181	0.181
2019	1	0.377	0.347	0.260	0.143
2019	2	0.255	0.200	0.165	0.153
2019	3	0.212	0.177	0.149	0.149
2019	4	0.278	0.224	0.181	0.181

Table 10.6.2. North Sea sprat. Assessment diagnostics.

Date: 03/17/20 Start time:10:24:13 run time:0 seconds

objective function (negative log likelihood): 262.46

Number of parameters: 139

Maximum gradient: 0.0235217

Akaike information criterion (AIC): 802.921

Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
736	278	46	0	1060

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
369.2	-107.9	11.8	0.0	0.0	0.00	273

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.50	-0.39	0.26	0.00

contribution by fleet:

IBTS Q1 total: -53.794 mean: -0.354

IBTS Q3 total: -43.182 mean: -0.514

Acoustic total: -10.951 mean: -0.261

F, season effect:

----

age: 0

1974-2019: 0.036 0.213 0.401 0.250

age: 1

```
   1974-2019:   0.523 0.533 0.221 0.250
age: 2
   1974-2019:   0.248 0.487 0.136 0.250
age: 3
   1974-2019:   0.217 0.492 0.320 0.250

F, age effect:
--------------
             0      1      2      3
1974-2019:  0.038  0.418  1.479  1.479



Exploitation pattern (scaled to mean F=1)
----------------------------------------
                   0      1      2      3
1974-2019 season 1:  0.001  0.190  0.320  0.280
        season 2:  0.007  0.194  0.627  0.634
        season 3:  0.013  0.080  0.176  0.413
        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   1.140   0.100
 1      0.851   0.704   1.414   0.100
 2      1.027   1.062   1.414   0.100
 3      1.027   1.062   1.414   0.100



Survey catchability:
--------------------
```

	age 0	age 1	age 2	age 3
IBTS Q1	0.000	1.477	2.808	4.390
IBTS Q3		0.788	1.011	0.941
Acoustic		1.097	2.374	6.268

Stock size dependent catchability (power model)

--	age 0	age 1	age 2	age 3
IBTS Q1	1.57	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	0.46	0.41	0.41	0.41
IBTS Q3		0.46	0.32	0.32
Acoustic		0.45	0.47	0.47

Recruit-SSB		alfa	beta	recruit s2	recruit s
Sprat	Hockey stick -break.:	1398.274	9.000e+004	0.615	0.784

Table 10.6.3. North Sea and Division 3.a Sprat. Assessment output: Stock numbers (thousands) (years, seasons, and age refer to the model year)
Table 1 Sprat : Stock numbers (thousands)

Year/Age Quarter	A00S1	A00S2	A00S3	A00S4	A01S1	A01S2	A01S3	A01S4	A02S1	A02S2	A02S3	A02S4	A03S1	A03S2	A03S3	A03S4
1974	531294000	327375000	234228000	171491000	137815000	70157300	44368400	30735600	10751800	4981450	1949210	1337180	485763	266256	106519	55662
1975	708503000	420914000	310678000	217664000	108873000	45286100	24551900	15479900	18389800	6315140	1454130	819530	700274	313832	73535	25672
1976	329513000	201433000	144462000	97671400	135557000	57280300	30084700	18259000	9953490	3384450	735216	401498	553735	231750	51185	17097
1977	629835000	404571000	275123000	183776000	60113100	28230300	15554200	9460970	11723700	4542310	1159990	658025	274826	121080	31438	11607
1978	1030770000	682344000	478123000	321279000	112636000	60230300	37920800	24110200	6095220	2827400	1071470	705327	434786	223541	86289	42765
1979	533480000	344586000	226051000	150975000	205930000	116064000	77472800	50437000	16220000	8301940	3970410	2743890	514618	275645	133608	76667
1980	328643000	204749000	128429000	84091800	96809100	36348900	16549600	9330450	34170900	9215640	1301230	640591	1934750	598072	85260	22087
1981	93374300	56509100	37182200	25481900	55308500	26511100	15676300	10308800	6430720	2702210	908526	577744	473380	228709	78994	36819
1982	48913000	29314800	20873500	15141600	17489200	9039330	5686460	4096850	7409220	3459550	1310670	884621	470590	263068	102839	52216
1983	65947200	38631000	27211700	19705600	11017300	4886550	2611870	1806060	3106050	1149420	260735	153825	762913	346574	79438	29057
1984	33146600	19317200	12888300	9320330	14420500	7563950	4777650	3429950	1393340	722731	284155	194252	154549	93221	37105	19296
1985	23122800	13325800	8136680	5770670	6758380	3023060	1683300	1154810	2607350	1079060	309245	195763	175316	92110	27226	11822
1986	78564100	43491900	27416400	19066700	4197470	1918250	1087920	756170	882128	380578	125433	82578	176004	94573	32832	15847
1987	40500500	22305300	13892500	9671750	13636800	7728740	5176620	4023160	568976	317318	178434	136557	83096	56843	34098	23509
1988	60276600	32317100	19527600	13194900	6898670	3101930	1627770	1130920	3037550	1168840	319693	194939	133079	66352	18801	7917
1989	53727800	29371100	17322600	12072600	9193330	5138900	3424420	2643000	836627	480241	281924	211339	160760	116661	70605	48365

Year/Age Quarter	A00S1	A00S2	A00S3	A00S4	A01S1	A01S2	A01S3	A01S4	A02S1	A02S2	A02S3	A02S4	A03S1	A03S2	A03S3	A03S4
1990	73002800	43403000	26100200	18185700	8304260	3581420	1797770	1194480	1934970	716285	169126	95266	196010	91488	21832	7936
1991	111661000	70263300	47023200	34086300	12350300	6863310	4434730	3178110	868593	478478	220740	151681	77471	46766	21904	12267
1992	103357000	68505900	49789400	36620300	23104000	13306100	8724870	6110600	2307520	1261940	547221	370808	123024	71924	31722	16933
1993	148792000	94136000	73159200	54304100	25277100	11504100	6383790	4233160	4531220	1721880	416051	243227	295922	126171	30594	11238
1994	127237000	76908900	57071700	43615500	38364600	20863300	14139900	10599400	3217460	1728510	830683	591070	199383	112116	54401	31616
1995	35891200	21462400	15853100	12398100	31742500	14197800	7992550	5708420	8273280	3303270	871324	530341	498270	220562	58306	23101
1996	60221400	36302300	24952700	19690000	9515340	4658520	2682320	1974960	4622780	2078870	593662	380250	457836	231220	66982	28846
1997	48601800	30909300	22758200	17840200	15520600	9162550	5886920	4396670	1625350	888886	340820	231492	349961	212458	83571	42424
1998	109096000	70824400	48613200	36783500	13631600	6927010	3806310	2614930	3548620	1458660	333258	194831	230859	106852	24849	8893
1999	77300400	50654100	37593600	28163500	26768400	16334400	10937100	7878280	2046170	1145930	489438	334085	167342	99665	42998	22694
2000	72790600	48398000	33506800	25393700	20154200	10183900	5898150	4126490	6031410	2640230	716483	447029	279994	136279	36949	15081
2001	60700900	40243800	29448500	22007900	19218800	9676880	5428860	3724340	3260110	1414580	354901	210587	381355	186182	46479	17660
2002	81359700	52565900	37814400	28636800	16201400	8048250	4383170	3039950	2876160	1198310	278230	161590	184422	89162	20607	7476
2003	105903000	69503200	51207400	38740800	20739300	11863200	7028010	4945220	2340160	1160020	362679	221549	135977	75062	23343	9946
2004	186658000	120328000	89653700	69014300	26424500	12880700	6612400	4437650	3633790	1371880	263188	142136	173924	74881	14261	4441
2005	65683000	42154200	30596700	24030300	47396500	25356100	14935400	10741100	3279790	1565930	478239	301663	110961	57095	17383	7503
2006	83504400	50329000	38076200	29835300	16652000	8248740	4496940	3135050	8026590	3338360	782339	460229	246876	112597	26204	9513
2007	60069200	37081200	27435400	21665600	20726300	10436000	5712590	4095750	2376020	1033610	254231	154622	383698	184175	44903	17150

Year/Age Quarter	A00S1	A00S2	A00S3	A00S4	A01S1	A01S2	A01S3	A01S4	A02S1	A02S2	A02S3	A02S4	A03S1	A03S2	A03S3	A03S4
2008	137938000	85372300	64500200	51653000	15853300	8520120	5048010	3717710	3230000	1579400	479137	303458	144192	76914	23221	9947
2009	113163000	72487700	51878300	42284500	38113400	21665700	14425400	11174200	2967330	1671720	731897	515439	257391	162397	71142	38928
2010	118962000	70117500	46816900	37462800	31559800	16531200	10481900	7913440	9009610	4449590	1718750	1180760	458580	274042	106631	54738
2011	90353100	54147300	36709200	28780100	27505500	14374800	9125390	6816860	6310230	3005170	1231510	846470	1014800	619512	255609	134956
2012	72394900	43421100	29686400	23322100	20524800	9651160	5472730	4005030	5289840	2179640	621048	398610	784220	408922	116718	50121
2013	168991000	113180000	85403800	68114500	17420000	9072300	5507820	4098630	3197720	1488710	493591	327047	374955	212256	70121	32579
2014	187417000	129736000	99793600	80017600	51999100	32481400	23202800	18286200	3286430	2048400	1108940	839358	300901	214345	117060	74852
2015	99598400	68996000	53786500	42534600	60965700	31410600	18610700	13594900	14571400	6592320	1924580	1229680	760797	411009	120418	51420
2016	135526000	92650300	70397800	54887800	32214800	13419500	6412440	4296180	10862800	3447360	512085	270860	1069500	426120	62880	17230
2017	185758000	127143000	97297800	76884400	41570800	21015400	12230500	8892390	3432790	1508040	423970	268125	240506	127379	35810	14927
2018	170291000	116583000	89341100	70781400	58230500	30568500	18486500	13656700	7105320	3325480	1058620	693191	236299	132285	42163	19072
2019	199213000	136390000	104546000	84549400	53608300	28337600	17258800	14456000	10912200	5166970	1682820	1449880	594615	336287	109685	94503
2020	0				64035800				11550800				1289290			

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	531386	605010	1.149	463344
1975	708740	602595	1.605	732312
1976	329471	494350	1.647	628598
1977	629855	336381	1.439	385257
1978	1031211	387317	0.951	458804
1979	533516	618468	0.623	463638
1980	328484	424641	2.152	387434
1981	93362	302247	1.041	280582
1982	48935	180773	0.954	162357
1983	65923	87029	1.602	115440
1984	33132	64861	0.917	113444
1985	23115	59755	1.263	62514
1986	78531	22834	1.04	27520
1987	40508	55105	0.35	53942
1988	60249	57125	1.241	103652
1989	53704	42235	0.302	58420
1990	73002	41274	1.468	78180
1991	111663	85221	0.685	125815
1992	103388	120331	0.8	156471
1993	148783	165215	1.557	208848
1994	127293	134054	0.678	424206
1995	35891	196418	1.439	446555
1996	60249	107152	1.33	95496
1997	48593	107581	0.976	125174
1998	109125	133252	1.645	188907
1999	77284	129056	0.862	243158
2000	72784	183506	1.422	222027
2001	60672	124742	1.494	153321

Year	**Recruits (in 1000s)**	**SSB (tonnes)**	**F (ages 1–2)**	**Yield (tonnes)**
2002	81328	110084	1.577	174713
2003	105899	138413	1.207	174988
2004	186697	171785	1.845	231352
2005	65660	226613	1.272	280275
2006	83470	170587	1.618	78028
2007	60069	133252	1.559	99902
2008	137895	100912	1.311	69892
2009	113125	184795	0.846	170934
2010	118925	185165	0.976	145415
2011	90332	164226	0.884	122472
2012	72421	132853	1.347	96030
2013	168931	107152	1.19	60207
2014	187446	216858	0.565	190268
2015	99633	346972	1.351	298227
2016	135570	222571	2.204	227169
2017	185766	175080	1.397	135824
2018	170288	213630	1.24	190779
2019	199236	226613	1.015	136523
2020		265933		

Table 10.9.1. North Sea and Division 3.a Sprat. Input to forecast (years and age refer to the model year).

Age	Age 0	Age 1	Age 2	Age 3
Stock numbers(2020) (millions)	128111	64036	11551	1289
Exploitation pattern Q1	0.002	0.292	0.49	0.429
Exploitation pattern Q2	0.011	0.297	0.962	0.972
Exploitation pattern Q3	0.02	0.121	0.264	0.619
Exploitation pattern Q4	0	0.002	0.008	0.008
Weight in the stock Q1 (gram)	5.351	7.055	9.186	12.825
Weight in the catch Q1 (gram)	5.35	7.05	9.19	12.82
Weight in the catch Q2 (gram)	4.82	7.6	9.73	14.55
Weight in the catch Q3 (gram)	4.7	7.69	11.21	14.39
Weight in the catch Q4 (gram)	6.6	10.3	13.26	16.71
Proportion mature(2019)	0	0.41	0.87	0.95
Proportion mature(2020)	0	0.41	0.87	0.95
Natural mortality Q1	0.38	0.35	0.26	0.14
Natural mortality Q2	0.26	0.2	0.16	0.15
Natural mortality Q3	0.21	0.18	0.15	0.15
Natural mortality Q4	0.28	0.22	0.18	0.18

Table 10.9.2. Sprat North Sea Division 3.a. Short-term predictions options table. Years refer to the model year.

Catch options. Landings and SSB are in thousands of tonnes.					
3-year average weight-at-age was used to calculate SSB. Recruitment(2020) = geom average 2009–2018.					
Basis	F(2020)	Landings(2020)	SSB(2021)	%SSB change	%TAC change
F_{cap}	0.69	207.8065	262.7235	-1.21	50.58
$F_{(status\ quo)}$	1.015	269.7096	226.8775	-14.69	95.44
F=0	0	0.001	393.3348	47.91	-100
F=0.1	0.1	39.33497	367.6805	38.26	-71.5
F=0.2	0.2	74.87602	344.8219	29.66	-45.74
F=0.3	0.3	107.0927	324.3962	21.98	-22.4
F=0.4	0.4	136.387	306.0933	15.1	-1.17
F=0.5	0.5	163.1051	289.6472	8.92	18.19
F=0.6	0.6	187.5449	274.8297	3.35	35.9
F=0.7	0.7	209.9641	261.4445	-1.69	52.14
F=0.8	0.8	230.5859	249.3222	-6.25	67.09
F=0.9	0.9	249.6039	238.3167	-10.38	80.87
F=1.0	1	267.1866	228.3014	-14.15	93.61
$B_{escapement}$ without F_{cap}	3.492	480.0401	124.9997	-53	247.85

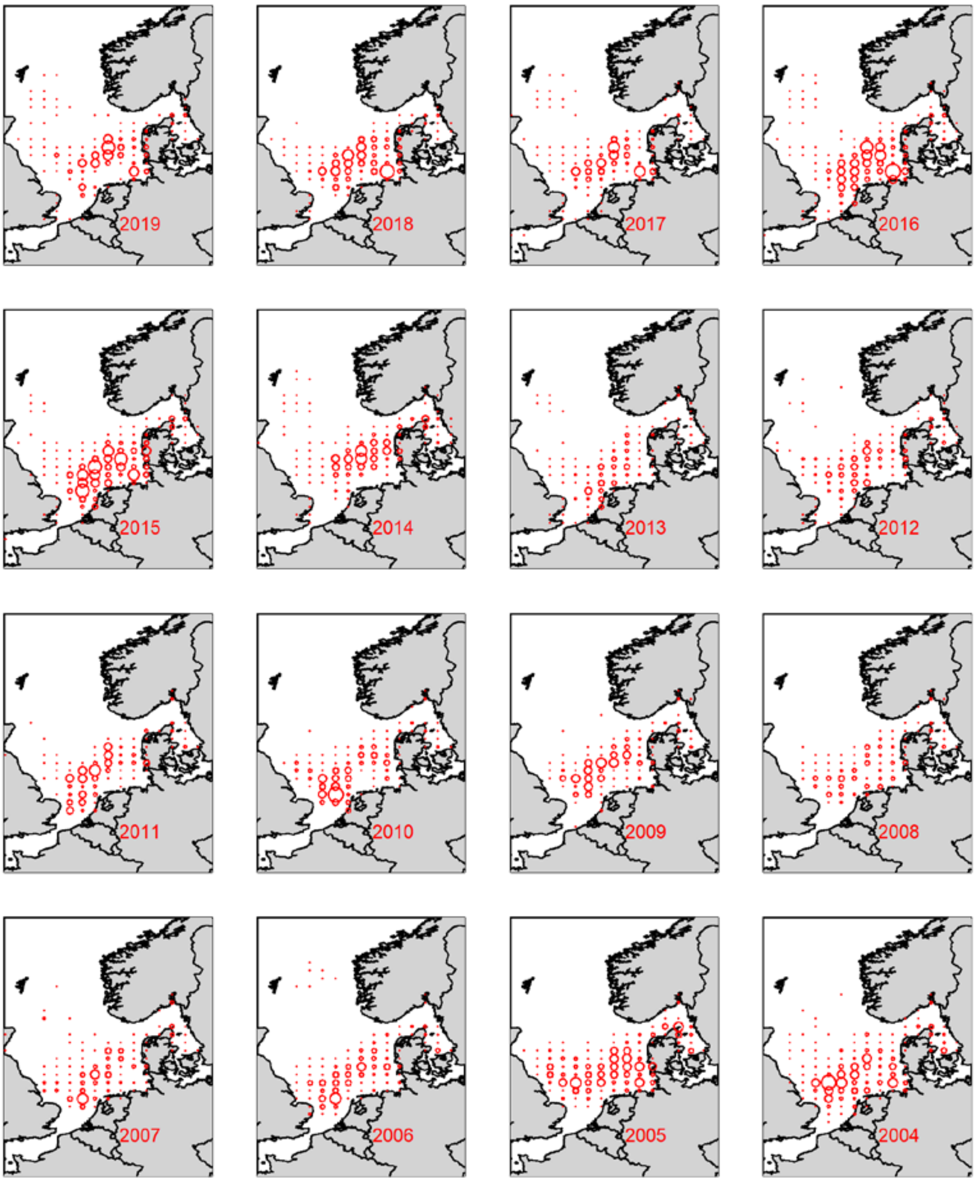


Figure 10.1.1. North Sea and Division 3.a sprat. Sprat catches in the North Sea and Division 3.a (in tonnes) for each calendar year by statistical rectangle.

Figure 10.2.1. North Sea and Division 3.a sprat. Number of samples taken in the North Sea and Division 3.a for each calendar year by statistical rectangle.

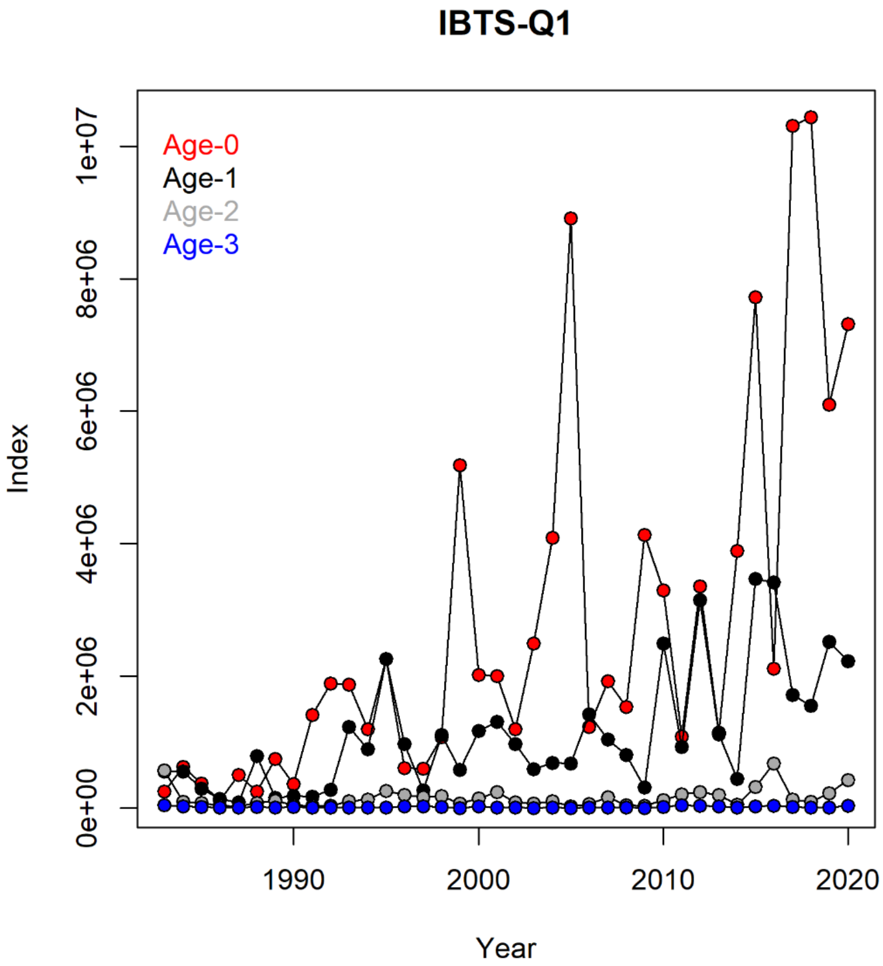


Figure 10.3.1. North Sea and Division 3.a sprat. IBTS Q1 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018) for details). Years refer to the calendar year.

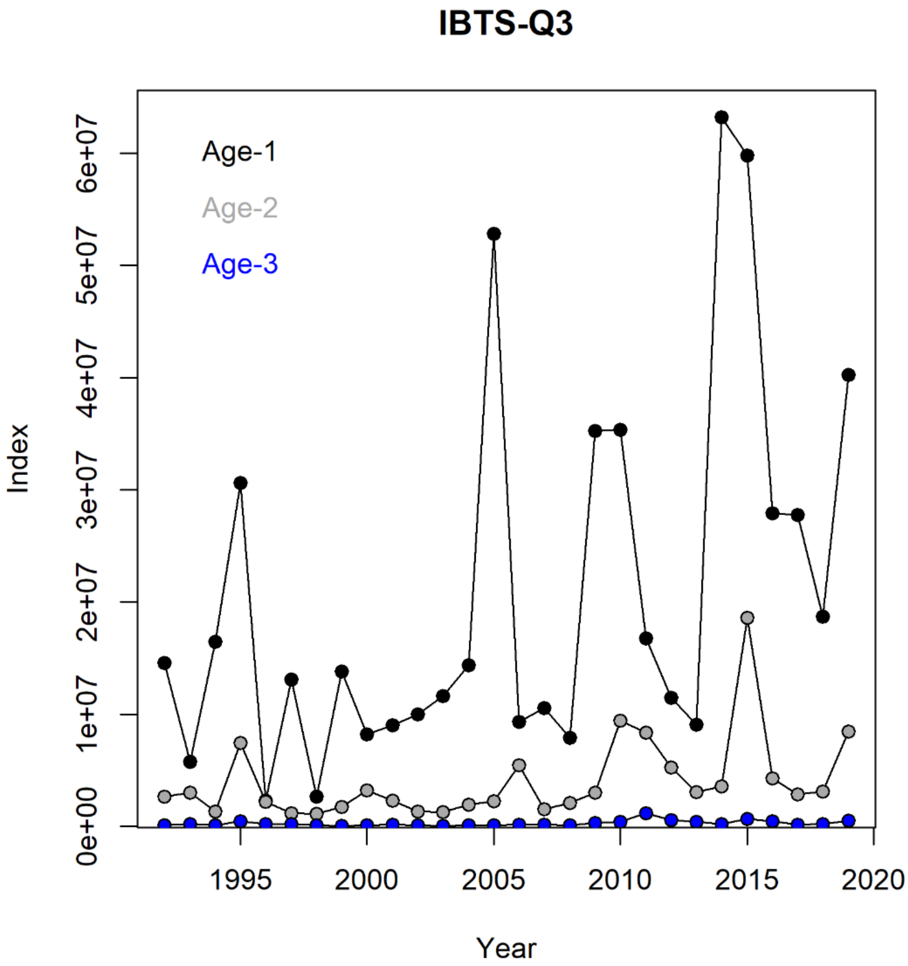


Figure 10.3.2a. North Sea and Division 3.a sprat. IBTS Q3 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018) for details). Years refer to the calendar year.

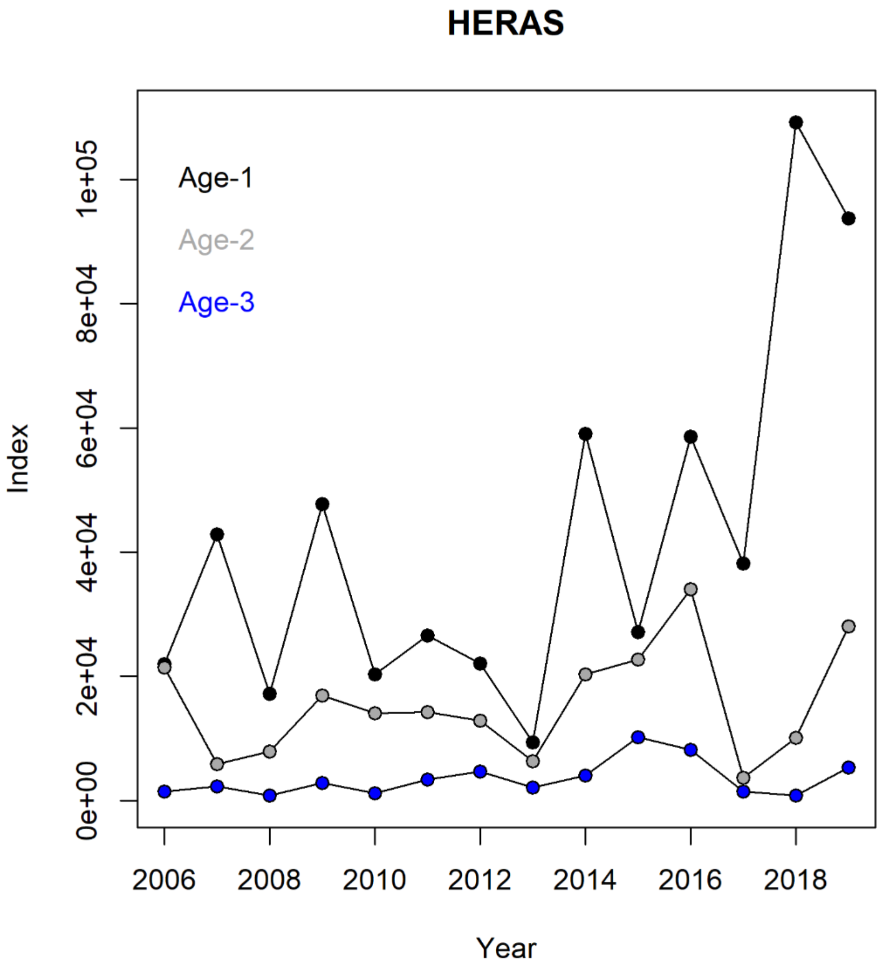
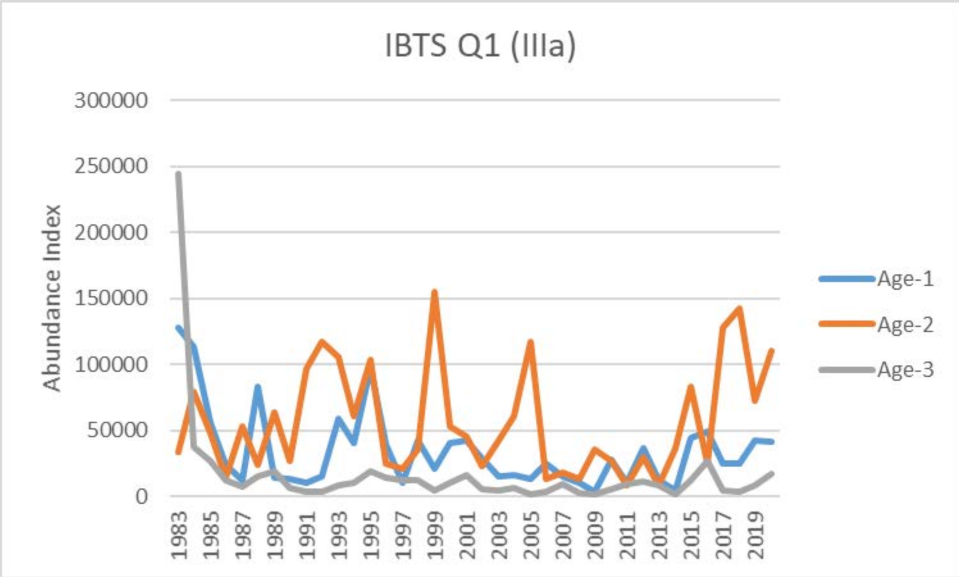


Figure 10.3.2b. North Sea and Division 3.a sprat. HERAS survey index for Subarea 4 and Division 3.a combined (sum of abundance indices published by WGIPS). Years refer to the calendar year.



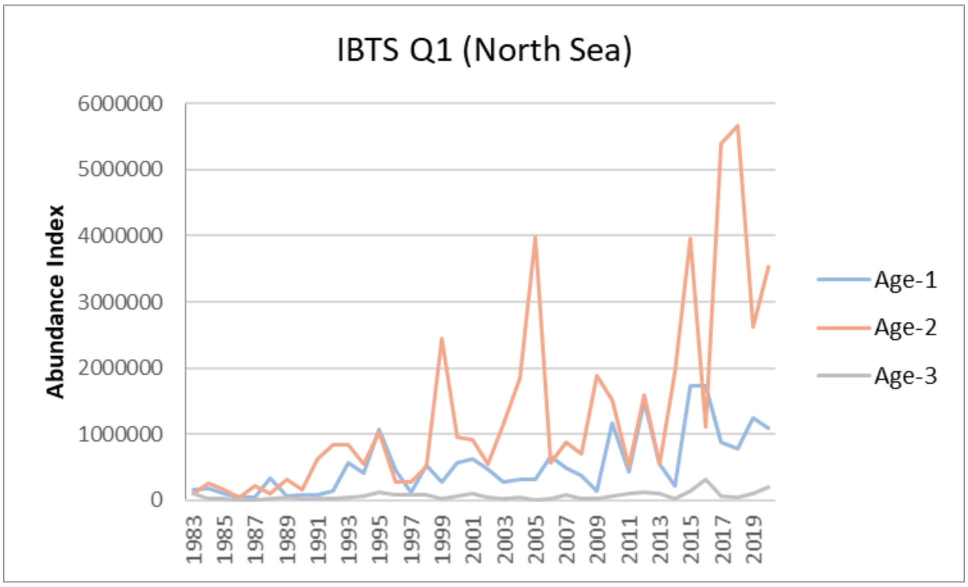
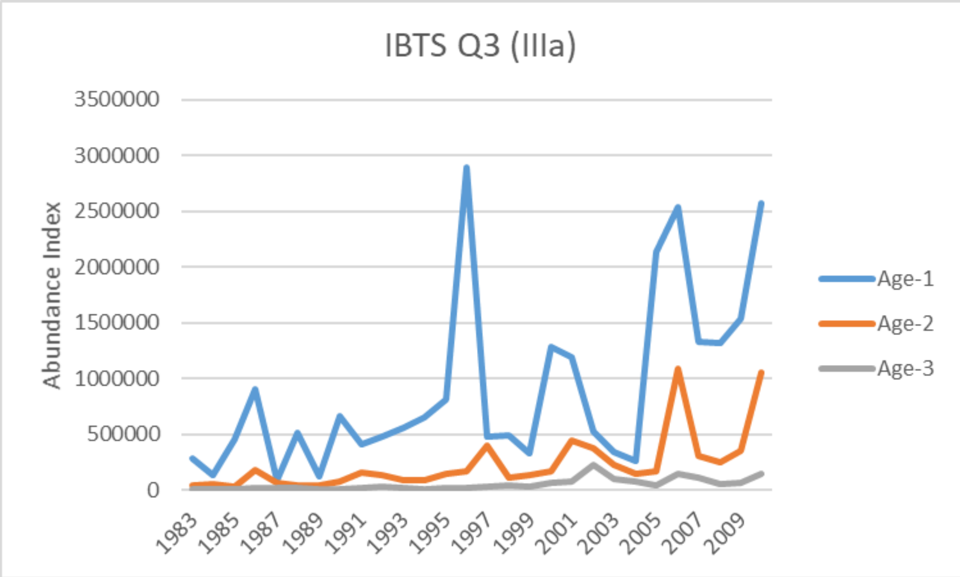


Figure 10.3.2c. North Sea (bottom figure) and Division 3.a sprat (top figure). Modelled IBTS Q1 indices for age 1, age 2, and age 3. Indices are additive, hence, adding the indices presented here results in the index time-series used as input for the model.



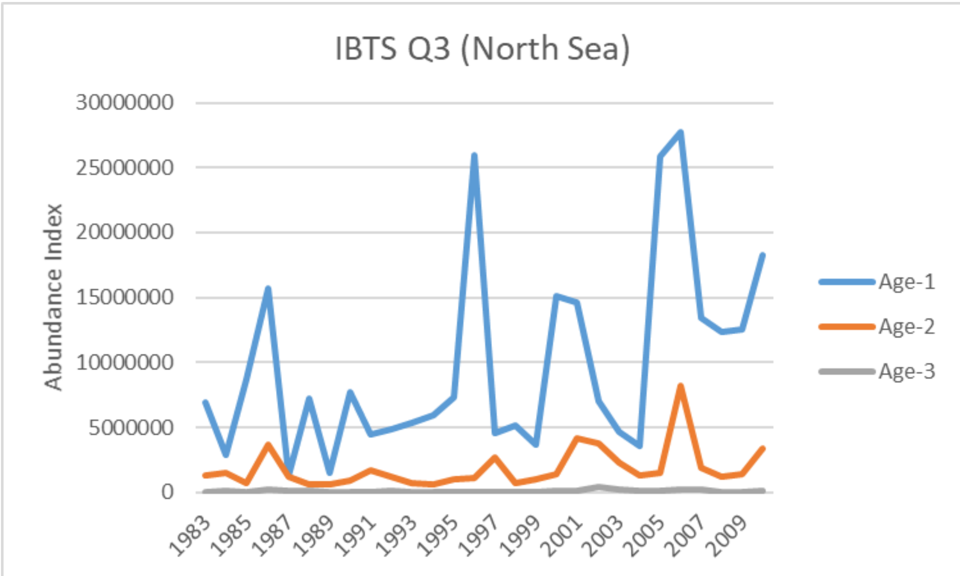
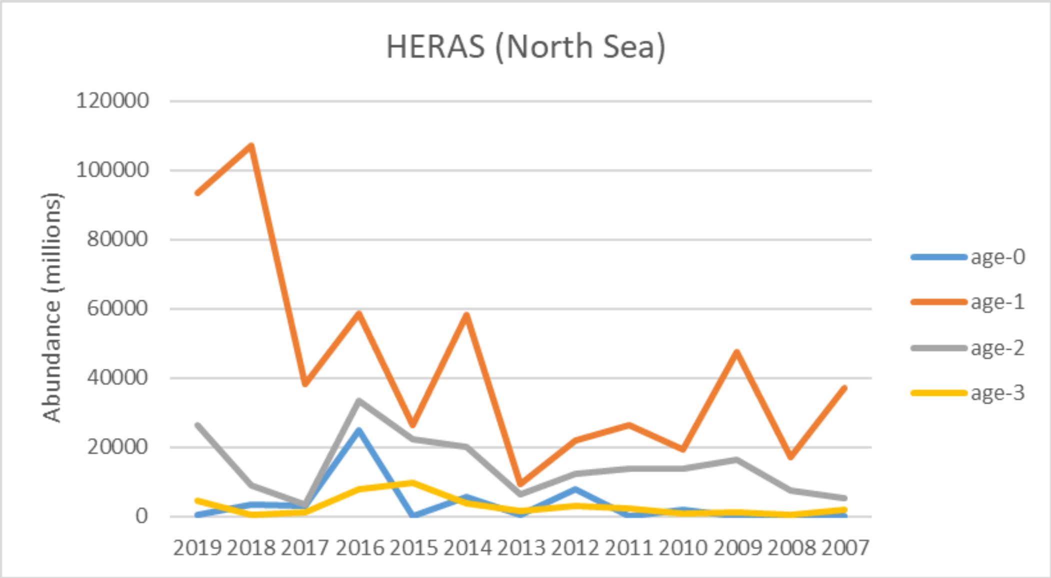


Figure 10.3.3. North Sea (bottom figure) and Division 3.a sprat (top figure). Modelled IBTS Q3 indices for age 1, age 2, and age 3. Indices are additive, hence, adding the indices presented here results in the index time-series used as input for the model.


HERAS (North Sea)
Abundance (millions)
120000
100000
80000
60000
40000
20000
0
2019 2018 2017 2016 2015 2014 2013 2012 2011 2010 2009 2008 2007
age-0
age-1
age-2
age-3

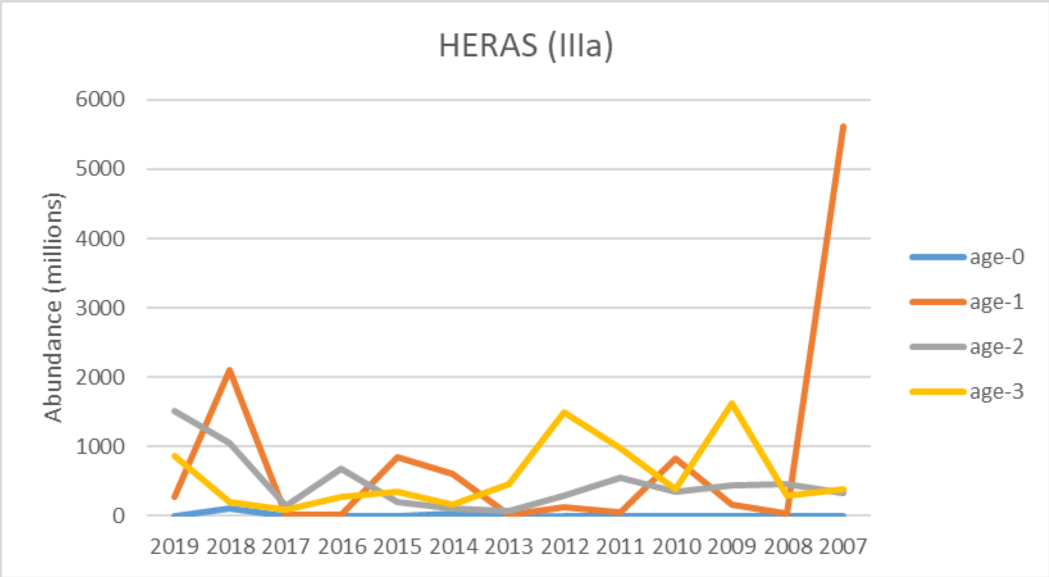
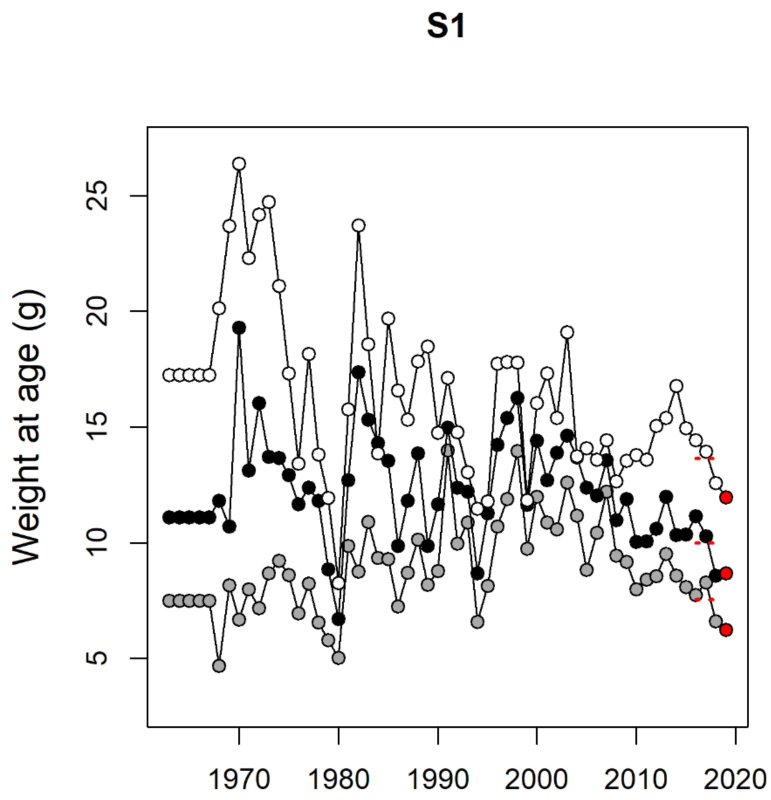


Figure 10.3.4. North Sea and Division 3.a sprat. HERAS survey index (abundance) for Subarea 4 and Division 3.a, respectively. Data were taken from the most recent WGIPS report.



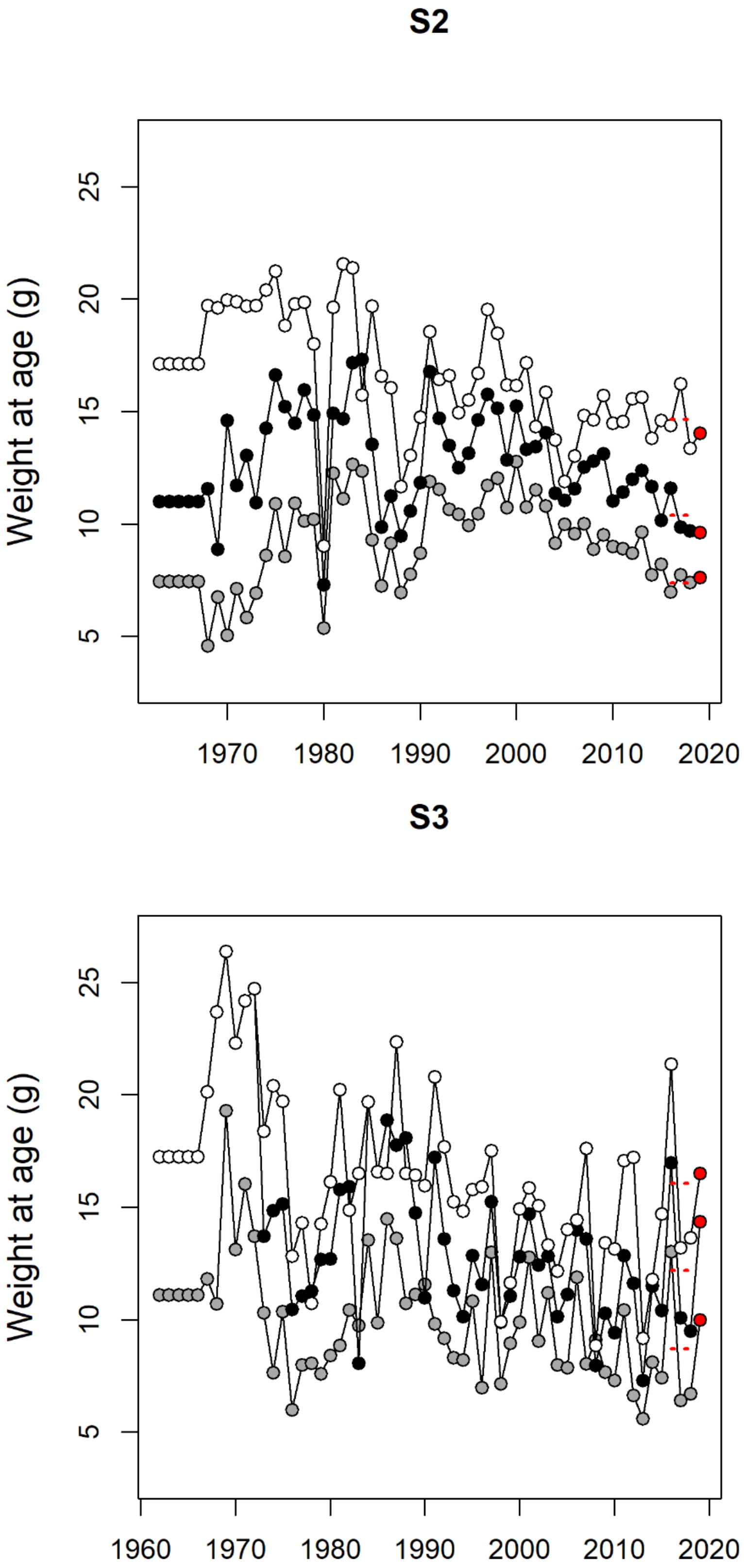


Figure 10.4.1. North Sea & 3.a sprat. Top: Mean weight at age in season 1 (years refer to the model year). Age 1 (grey), age 2 (black), age 3 (white). Red dot is the status quo weight and the red dashed line refer to the 3-year average used in the forecast last year. Middle: Mean weight at age in season 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.

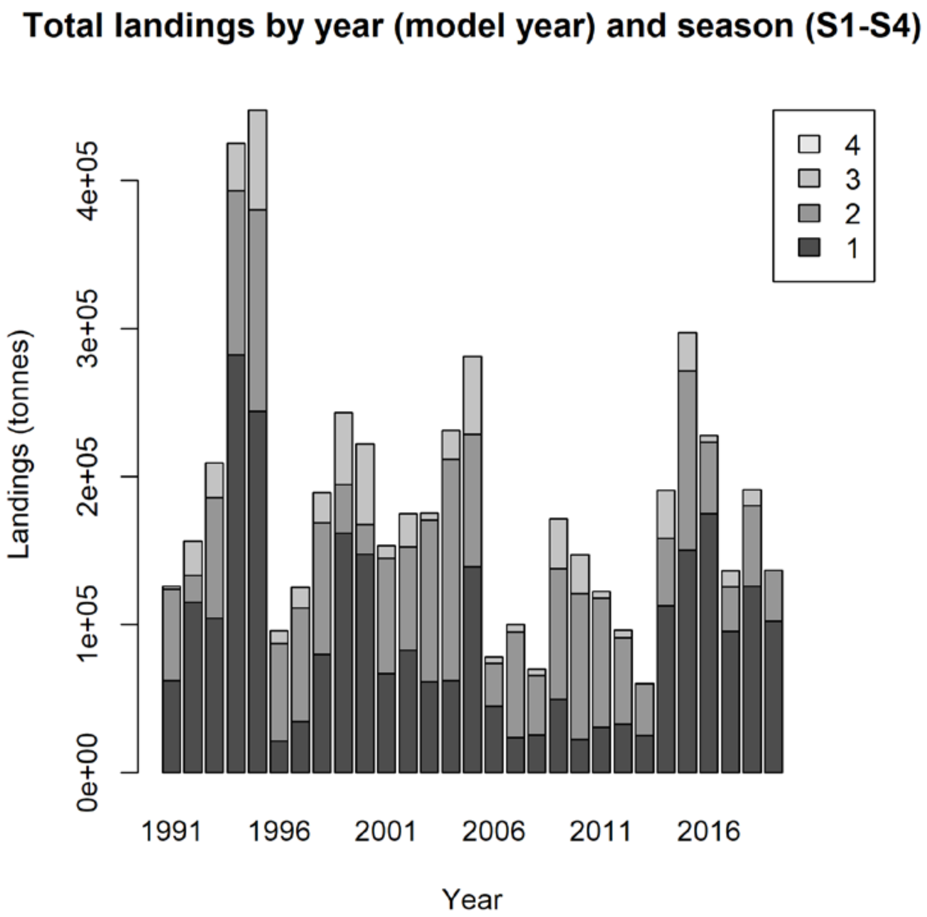


Figure 10.6.1. North Sea & 3.a sprat. Seasonal distribution of catches (Calendar year). Year and season 1-4 refer to the time-steps of the model. Note that since the model year of 2018 is not yet finished, the 2018 column will be updated

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).

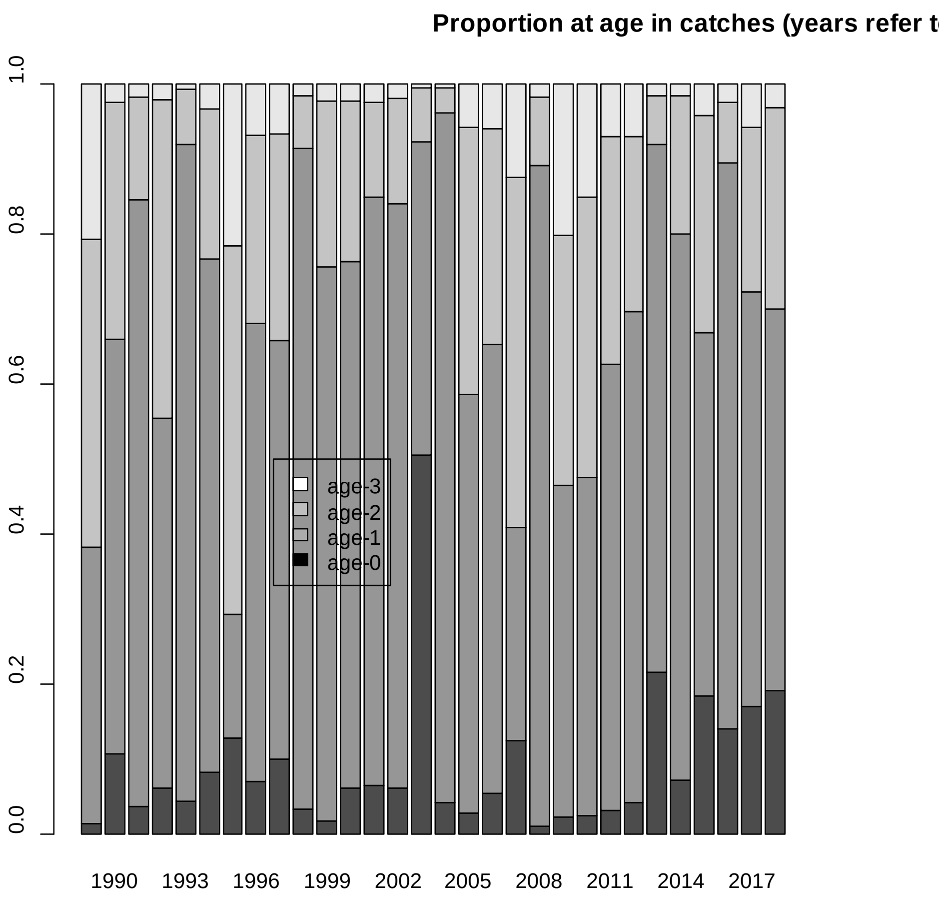


Figure 10.6.1. North Sea & 3.a sprat. Proportion of each age group in the catches. Year and age refer to the model year.

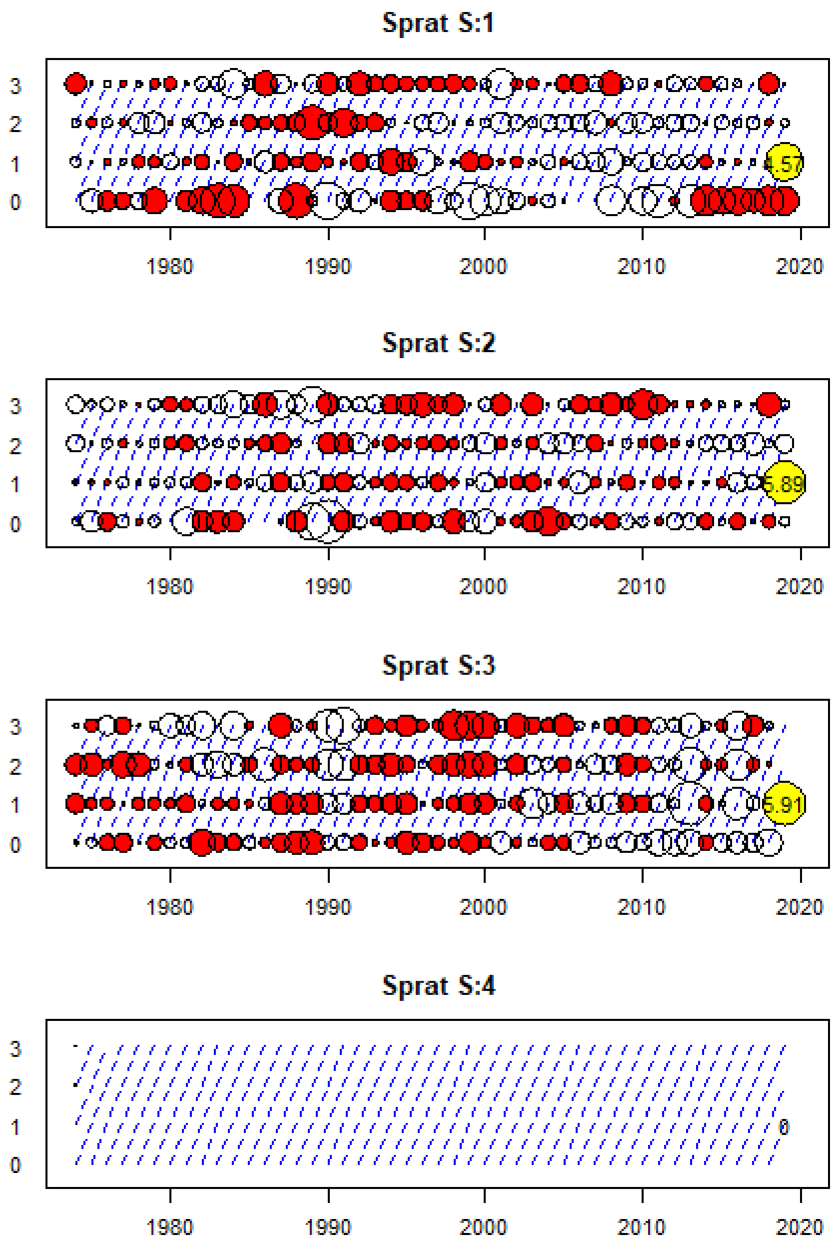


Figure 10.6.2. North Sea & 3.a sprat. Catch residuals by age. (Model year)

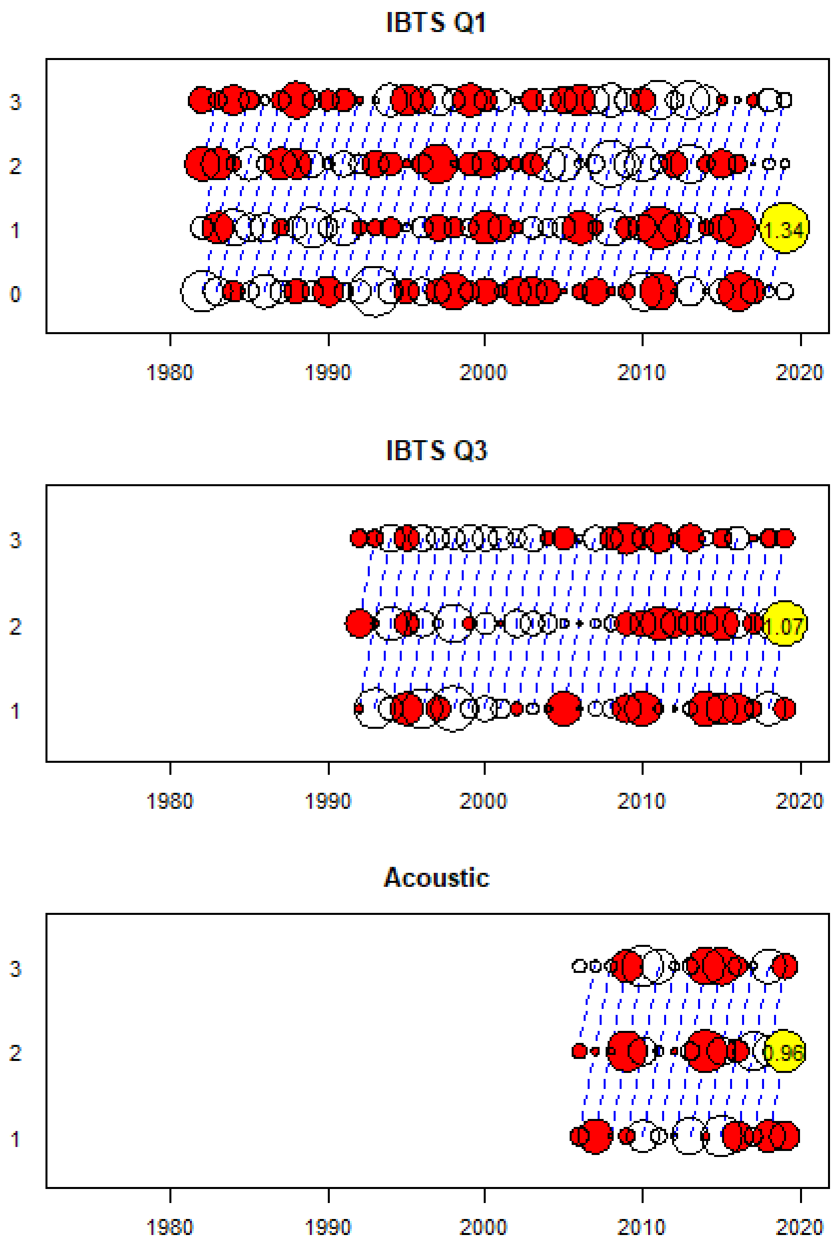


Figure 10.6.3. North Sea & 3.a sprat. Survey residuals by age. (Model year)

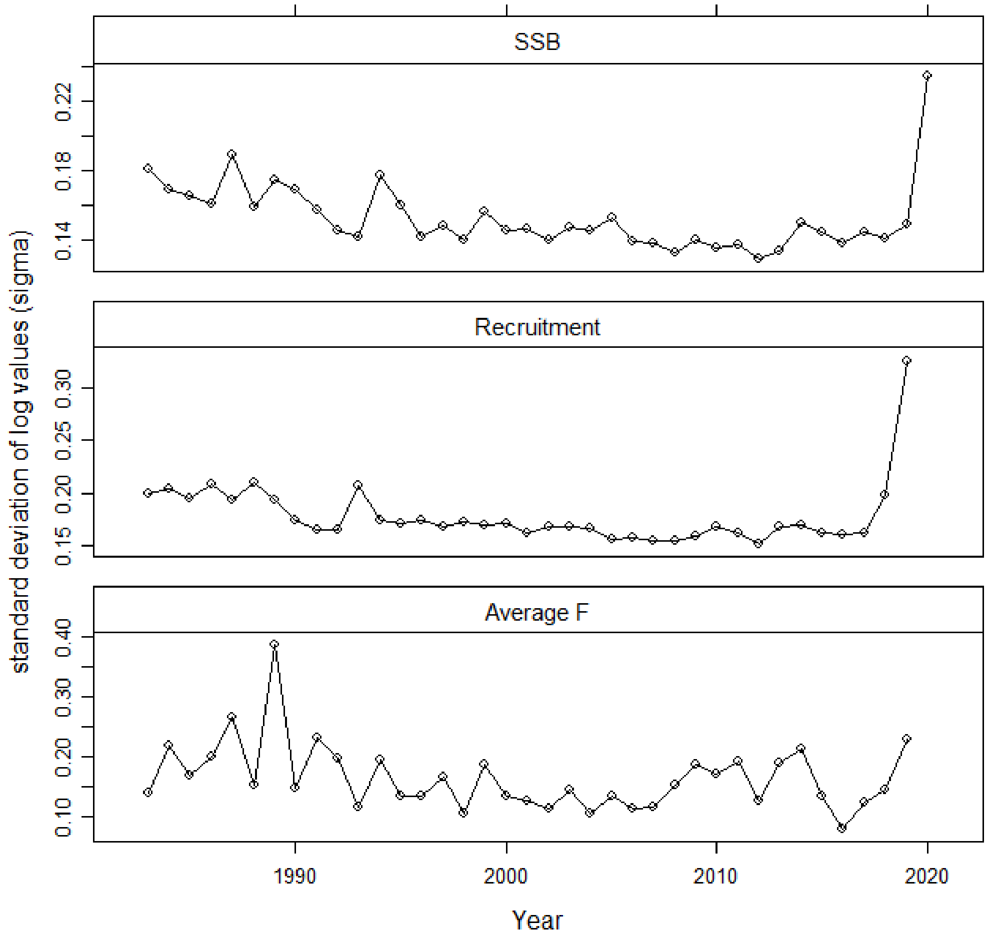


Figure 10.6.4. North Sea & 3.a sprat. Coefficients of variance (Model year).

Figure 10.6.5. North Sea & 3.a sprat. Retrospective analysis (Model year)

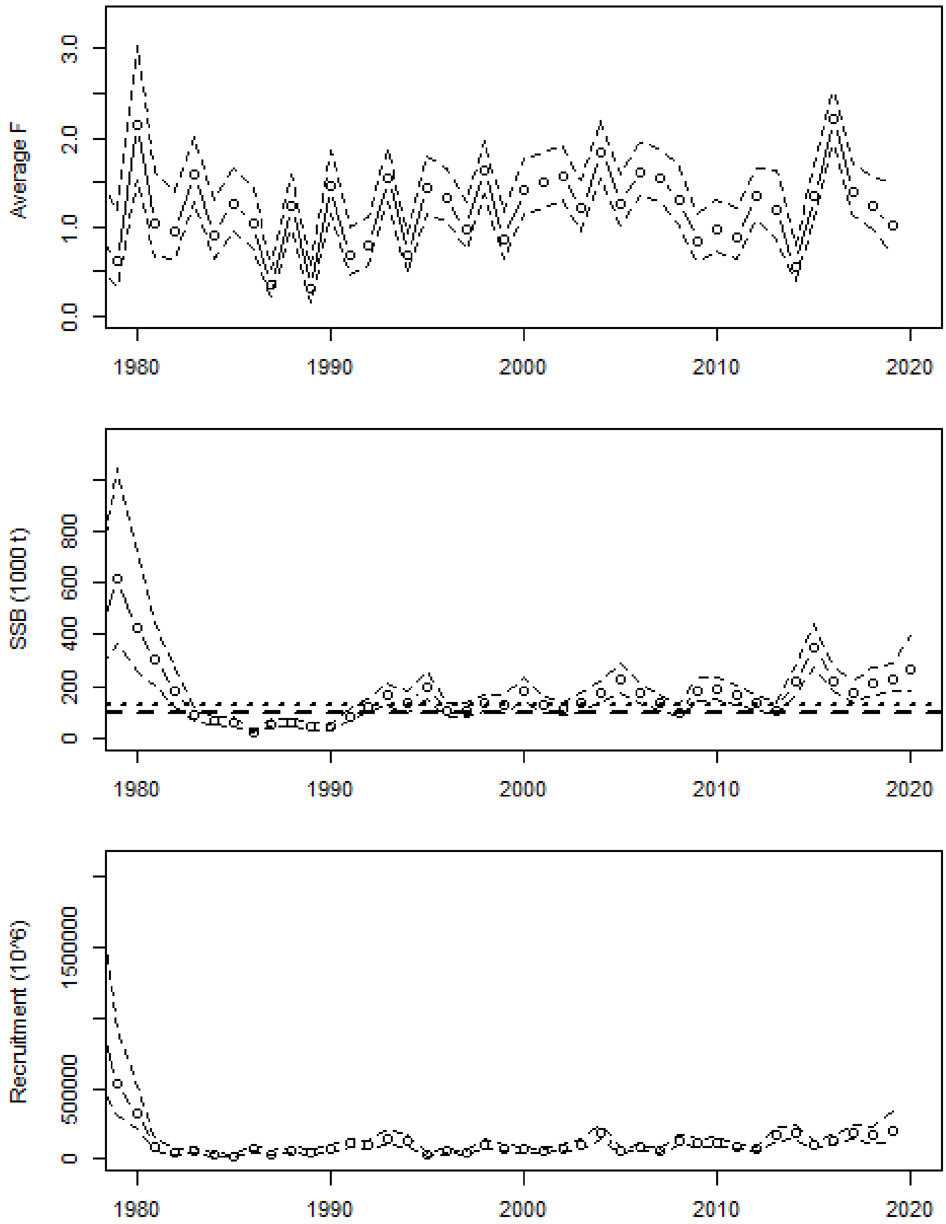


Figure 10.6.6. North Sea & 3.a sprat. Temporal development in Mean F, SSB and recruitment. Hatched lines are 95% confidence intervals (Model year).

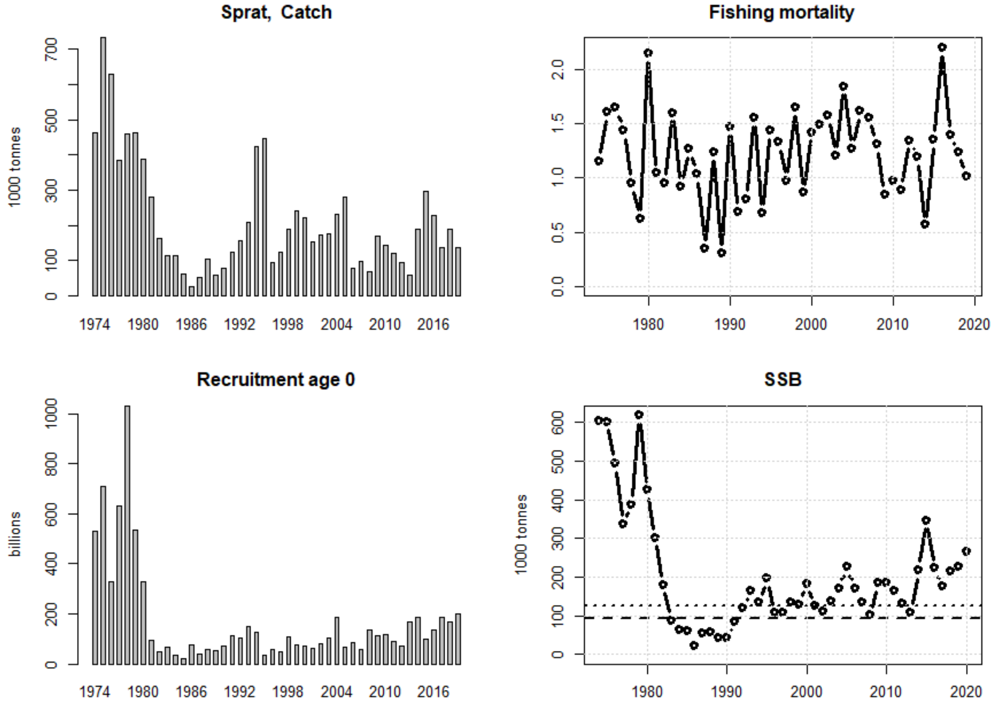


Figure 10.6.7. North Sea & 3.a sprat. Assessment summary (Model year)

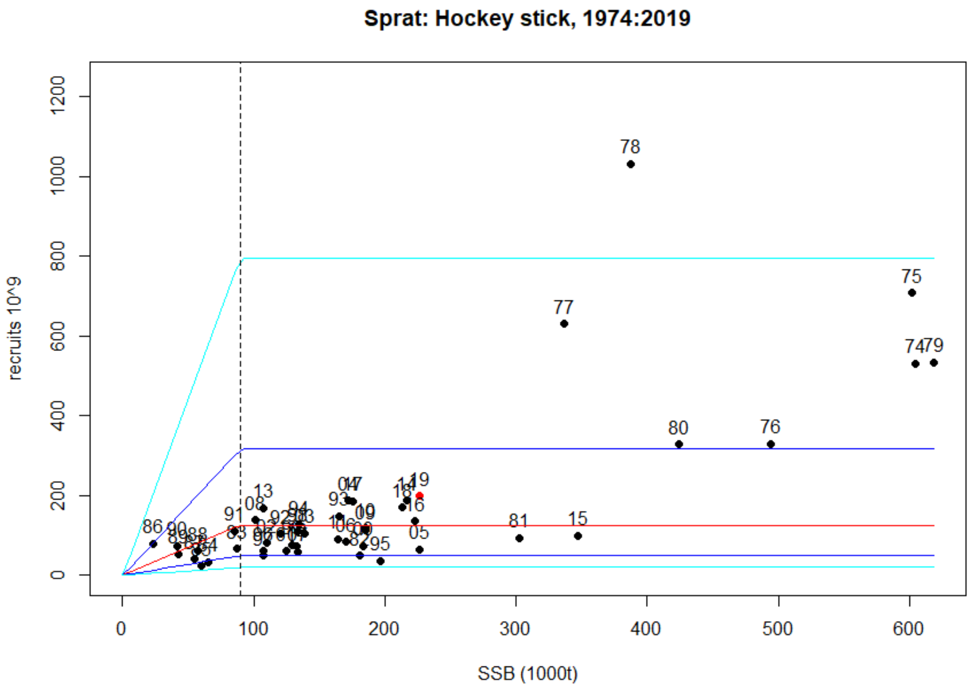


Figure 10.7.1. North Sea & 3.a sprat. Stock-recruitment relationship (Model year).

10.14 Audit of spr.27.3a4 (Sprat in the North Sea)

Working Group: HAWG **Stock Name: spr.4-3.a**

Date: 23/03/2020
Auditor: Henrik Mosegaard, Christophe Loots

General

During the the previous benchmark in 2018 the stock unit was re-defined, combining division 3.a and subarea 4.

For single-stock summary sheet advice:
Short description of the assessment: extremely useful for reference of ACOM.

1) **Assessment type:** Update abbreviated advice
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:** all identified issues resolved
6) **Consistency**: Second assessment for the re-defined stock Mohn's Rho slightly higher than 0.3 but well within MSE 95% cf interval
7) **Stock status**: B>Bescapement, F is higher than Fcap (0.69).
8) **Management Plan**: No management plan has been developed.

General comments
This was a well documented, well ordered and considered section. It was easy to follow and interpret…. etc

Technical comments

There is no technical issue with this stock

Conclusions
The assessment has been performed correctly

10.15 References

WKSPRAT 2013. Report of the Benchmark Workshop on Sprat Stocks. ICES CM 2013/ACOM:48

WGSAM 2017. Interim Report of the Working Group on Multispecies Assessment Methods (WGSAM). ICES CM 2017/SSGEPI:20

WKSPRAT 2018. Report of the Benchmark Workshop on Sprat. ICES CM 2018/ACOM:35. 60 pp

ICES. 2020. ICES Working Group of International Pelagic Surveys (WGIPS). ICES Scientific Reports. 2:xx. xxx pp. http://doi.org/10.17895/ices.pub.xxx (to be published)

ICES. 2020. Workshop on Catch Forecast from Biased Assessments (WKFORBIAS; outputs from 2019 meeting). ICES Scientific Reports. 2:28. 38 pp. http://doi.org/10.17895/ices.pub.5997

11 Sprat in the North Sea

The information formerly kept in this section is now found in Section 10: “Sprat in the North Sea and 3.a”

12 Sprat in the English Channel (divisions 7. de)

The stock structure of sprat populations in this region is not clear, despite evidence from acoustic surveys suggesting the stock is mainly confined to the UK side of 7.e. Further investigations and work are required to resolve this uncertainty.

12.1 The Fishery

12.1.1 ICES advice applicable for 2019 and 2020

The advised catch for the English Channel (7.d and e) was set equal to 2637 and 1506 tonnes for 2019 and 2020, 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 February and sometimes March the following year. Most of the catch is taken in 7.e, in particular in the Lyme Bay area. In the last decade catch from UK covered about 99% of landed sprat, however in 2015 and 2016 this percentage diminished, with Netherlands, Denmark, and for the first time in the whole time-series, Germany, contributing to about 11% of the reported landings. In 2019, 98% of the catches were by UK (England, Wales and Northern Ireland), with the remaining 2 % taken by Germany and France. 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 variability such as spatial and temporal changes in temperature and/or salinity.

12.1.3 Fleets

In the English Channel the primary gear used for the capture of sprat is midwater trawl. Within that gear type three vessels under 15 m have actively targeted sprat and have been responsible for the majority of landings (since 2003 they took on average 96% of the total landings). Sprat is also caught by driftnet, fixed nets, lines and pots and most of the landings are sold for human consumption.

12.1.4 Regulations and their effects

There is a TAC for sprat in ICES divisions 7.de, English Channel. Up until recent years the TAC did not limit the sprat landings in this area (Figure 12.1.2).

12.1.5 Changes in fishing technology and fishing patterns

There is insufficient information available.

12.2 Biological Composition of the Catch

12.2.1 Catches in number and weight-at-age

In 2017/2018 fishing season a pilot self-sampling program started in the Southwest of UK, involving sprat fisher from Lyme bay. This program has continued in 2019 and the fishery is keen to continue contributing data and are receptive to improving their sampling scheme and providing useful scientific data in the future. The data shown are raw numbers-at-length in the samples, and not raised to the total catches.

The skippers have collected length measurements from the catches and recorded information on fishing trips. The main processors for the fishery were engaged in 2019 and have provided length and weight data from landings subsamples. The sprat lengths in the fishers' samples ranged from 7.5 to 15 cm (Figure 12.2.1). The length distributions recorded by the processors was reasonably consistent again in 2019 (Figure 12.2.2).

12.3 Fishery-independent information

PELTIC Acoustic Survey

A pelagic survey was undertaken in autumn in the English Channel and off the coast of Normandy 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. In 2018 the survey was further extended into division 7.d to investigate the presence of the stock in the channel, this was not repeated during 2019.

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 swimbladder 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 survey 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 area surrounding the haul.

A software bug which effected the "SA correction" was made know to the survey during December 2019 , this software bug resulted in an underestimate of the sprat biomass in 2018. The software bug has now been removed and the 2018 biomass value revised upward.

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 2019 is shown in Figure 12.3.2.

12.4 Mean weight-at-age and maturity-at-age

No data on mean weight-at-age or maturity-at-age in the catch are available.

12.5 Recruitment

The acoustic surveys may provide an index of sprat recruitment in divisions 7.d–e. However further work is required.

12.6 Stock Assessment

This stock is considered a category 3 stock with the assessment and advice based on survey trends (ICES Advice 2018).

The ICES workshop on short lived species (WKDLSSLS 2019) tested the implementation of 1 over 2 against the current 2 over 3 advice rule using management strategy evaluations. The workshop concluded that 2 over 3 was not suitable for species such as sprat. An Interim proposal was put forward by the workshop of 1 over 2 with an 80% uncertainty cap. However, it was acknowledged that further work on the 1 over 2 guidelines is needed, and the interim proposal is likely to change at the upcoming WKDLSSLS workshop in 2020. The advice for 2021 is based on the 1 over 2 rule with the 20% uncertainty cap and the precautionary buffer applied. This is the most precautionary application of the 1 over 2 rule. HAWG have recommended an inter benchmark in late 2020 to implement the updated recommendations of the WKDLSSLS 2020. The results will be available for HAWG 2021.

12.6.1 Data exploration

Biomass Index

A 8-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 2019 showed a concentration of 0 age sprat in Lyme bay. This year the survey covered the area around the Channel Islands (Figure 12.6.1).

Sprat was in general the dominant small pelagic species in the trawl samples, with highest densities in the eastern parts of the western Channel and the Bristol Channel. As in previous years, large schools in the Bristol Channel appeared to consist mainly of juvenile sprat, whereas those in the English Channel also included larger size classes. For more details on the survey design see ICES 2015/SSGIEOM:05.

The age distribution of sprat in the survey area shows a marked distinction between the young fish (0 and 1) found in the Bristol Channel and the older age classes that occupy the Western English Channel. Whether the two clusters belong to the same stock has yet to be proved: the circulation pattern of the area would allow sprat eggs/larvae to travel northward, from division

7.e to 7.g; however, the formation of a front in late spring/early summer seems to suggest these may be two different stocks.

In 2019 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 index of the last 2 years and average biomass index of the previous 3 years). The index was also used to provide an indication of the current harvest rate. The advice guidance has changed in 2020 following testing of the 1 over 2 rule at WKDLSSL 2019. It is intended to convene an inter benchmark can be held to review the stock following any conclusion from WKDLSSLS 2020.

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, however the stock index has increased by a third in 2019.

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, although the biomass is still half of the high levels recorded in the period 2013–2015. The PELTIC biomass index has increased past its last high value in of 32751 tonnes to 36,789 tonnes. The harvest rate index (Figure 12.7.1) has decreased to its pre 2016 value of 5%, having been around 10% between 2017 and 2018. The change in index value (using the 2 over 3 rule) was less than 20%.

12.8 Catch Advice

Given that the index value has a greater than 20% change in the perception of the stock, the biomass index trend continues to be positive and the 2020 guidelines for advice (ICES 2020). A TAC of 1446 tonnes is given after applying the uncertainty cap and the precautionary bufferIn addition, there is an interbenchmark planned for the stock before spring of 2021 where a new, more responsive advice rule for short-lived pelagic species will be examined. The ICES advice for 2021 is therefore 1446 tonnes.

12.9 Short-term projections

No projections are presented for this stock.

12.10 Reference Points

No precautionary reference points are defined for sprat populations in this region due to uncertainty in stock definition.

12.11 Quality of the Assessment

The coverage of the PELTIC acoustic survey was extended in 2017 towards the southern part of Division 7.e: this extension confirmed that the bulk of the sprat distribution in 7.e is located in Lyme Bay and surrounding areas, and very little extend outside. In fact, the transects carried out off the French coast found very little sprat, mostly of ages 0 and 1. This pattern may have changed somewhat in recent years as sprat have been recorded off the coast of France and around the channel island in 2018 and 2019.

The extent to which the population migrate into Division 7.d was investigated during the 2018 survey. The survey showed that very little sprat was found on the eastern border of division 7.e suggesting no movements of sprat between the two areas and very little was found in 7.d.

Concerns have been raised about the connection between the Western English Channel stock and the Bristol Channel, where large numbers of juveniles are found

12.12 Management Considerations

Sprat is a short-lived species with large interannual fluctuations in stock biomass. The natural interannual variability of stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

Sprat annual landings from 7.d–e over the past 20 years have been 2570 tonnes on average. The average harvest rate for the 8 year time-series is 10%, however if the 2016 value of 34% is removed this drop to 6% over the entire time-series and 8% over the last 3 years. In general, however, it seems that Lyme Bay, where most of the fishery occurs, consistently hosts quite a substantial part of the sprat stock: this is confirmed by the fact that even in 2016, when the estimated biomass was overall very low, Lyme Bay still contributed 50% of the total sprat population in the Western English Channel.

The strong biomass fluctuations observed in the acoustic index and the relatively strong increase in biomass observed in 2017, suggests that the low level of catch is not impairing the stock and that the reduced sprat biomass is not due to fishing mortality, but it is most likely caused by environmental factors.

The timing of the advice relative to the PELTIC survey should also be considered, currently the survey runs 1 year prior to the generation of the advice which is implemented 1 year later. This is a 2-year time-lag from data collection to advice and has been identified as a weakness in the advice especially for sprat which only live 3-4 years. The advice is therefore being given based on fish that are no longer present in the population at the time of the fishery. In year advice has been proposed to remedy this mismatch of survey data with the fishery.

12.13 Ecosystem Considerations

Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem, for both fish and seabirds. At present, there are no analysis available on the total amount of sprat, and in general of other pelagic species, taken by seabirds, marine mammals and large predators in the Celtic Seas Ecoregion. However, a wide spectrum of data that covers the whole trophic chain have been collected during the PELTIC acoustic survey: these data will in the future provide a substantial contribution to the knowledge base for the area.

Table 12.1.1 Sprat in 7.d-e. Landings of sprat, 1986–2019.

Country	Denmark	France	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
1986	15	0	0	1 163	0	0	1 178
1987	250	23	0	2 441	0	0	2 714
1988	2 529	2	1	2 944	0	0	5 476
1989	2 092	10	0	1 520	0	0	3 622
1990	608	79	0	1 562	0	0	2 249
1991	0	0	0	2 567	0	0	2 567
1992	5 389	35	0	1 791	0	0	7 215
1993	0	3	0	1 798	0	0	1 801
1994	3 572	1	0	3 176	40	0	6 789
1995	2 084	0	0	1 516	0	0	3 600
1996	0	2	0	1 789	0	0	1 791
1997	1 245	1	0	1 621	0	0	2 867
1998	3 741	0	0	1 973	0	0	5 714
1999	3 064	0	1	3 558	0	0	6 623
2000	0	1	1	1 693	0	0	1 695
2001	0	0	0	1 349	0	0	1 349
2002	0	0	0	1 196	0	0	1 196
2003	0	2	72	1 368	0	0	1 442
2004	0	6	0	836	0	0	842
2005	0	0	0	1 635	0	0	1 635
2006	0	7	0	1 969	0	0	1 976
2007	0	0	0	2 706	0	0	2 706
2008	0	0	0	3 367	0	0	3 367
2009	0	2	0	2 773	0	0	2 775
2010	0	2	0	4 408	0	0	4 410
2011	0	1	37	3 138	0	0	3 176
2012	6	2	8	4 458	0	0	4 474

Country	Denmark	France	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
2013	0	0	0	3 793	0	0	3 793
2014	45	0	275	3 338	0	0	3 658
2015	0	1	352	2 659	0	0	3 012
2016	185	7	231	2 867	0	49	3 339
2017	0	0	235	2 498	0	0	2 733
2018	474	1	0	1 776	0	0	2 252
2019	0	0.67	0	1544	0	28	1573

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	2012	2013	2014	2015	2016	2017	2018	2019
Partial	Lyme Bay	Oct	24 246	62 040	67 538	12 212	6 181	29 996	16 036	30 406
FSP	Lyme Bay*	Oct	27 971							
PELTIC	W Eng Ch	May								
PELTIC	W Eng Ch	Oct		70 680	85 184	65 219	9 826	32 751	21 772	36 789

* 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 2016	HAWG 2017	HAWG 2018	HAWG 2019*	HAWG 2020
1989	682	395	4 432	4 432	4432
1990	429	569	3 684	3 684	3684
1991	528	481	4 147	4 147	4147
1992	422	560	3 887	3 784	3784
1993	630	850	4 779	4 737	4737
1994	747	612	7 809	7 809	7809
1995	599	899	5 831	5 831	5831
1996	803	927	6 768	6 768	6768
1997	868	601	6 845	6 808	6808
1998	736	971	6 794	6 794	6794
1999	970	844	8 919	8 919	8919

2000	683	732	8 369	8 369	8369
2001	521	944	5 976	5 976	5976
2002	644	622	5 992	5 992	5992
2003	375	841	4 215	4 190	4190
2004	588	1 108	5 938	5 841	5841
2005	1 050	1 388	8 820	8 820	8820
2006	992	1 059	8 035	8 035	8035
2007	1 050	945	8 241	8 241	8241
2008	1 029	890	8 085	8 085	8085
2009	773	1 388	7 474	7 474	7474
2010	1 527	1 288	13 260	13 260	13260
2011	1 042	1 709	9 801	9 801	9801
2012	1 904	1 870	13 475	13 475	13475
2013	1 933	2 225	11 398	11 398	11398
2014	2 405	1 683	11 977	11 977	11977
2015	2 221	1 765	8 763	8 763	8763
2016		624	9 459	9 459	9459
2017			9 515	9 457	9457
2018				8 373	8373
2019					8235

***provisional**

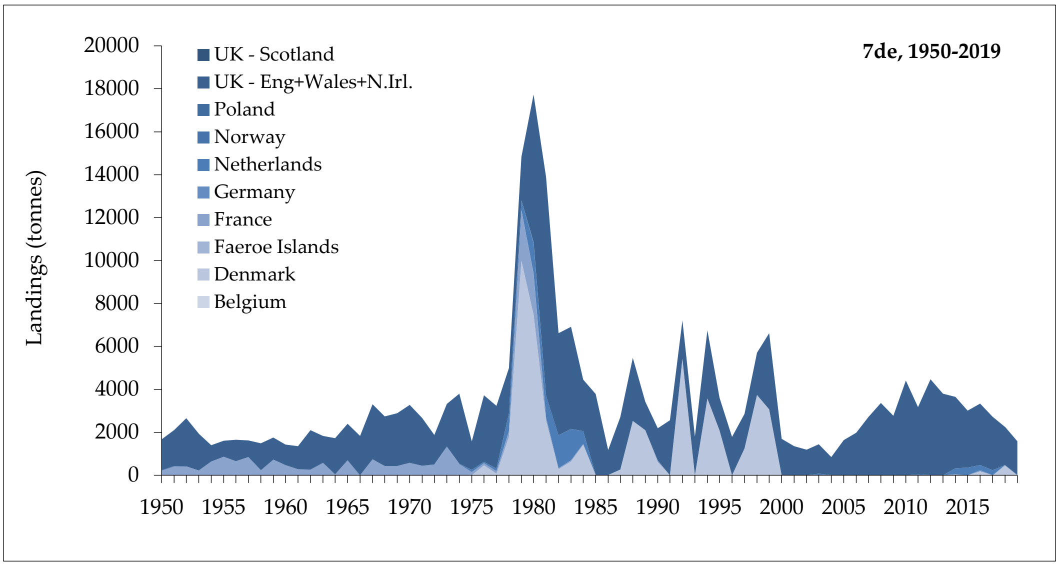


Figure 12.1.1. Sprat in 7.d-e. Landings of sprat 1950–2018.

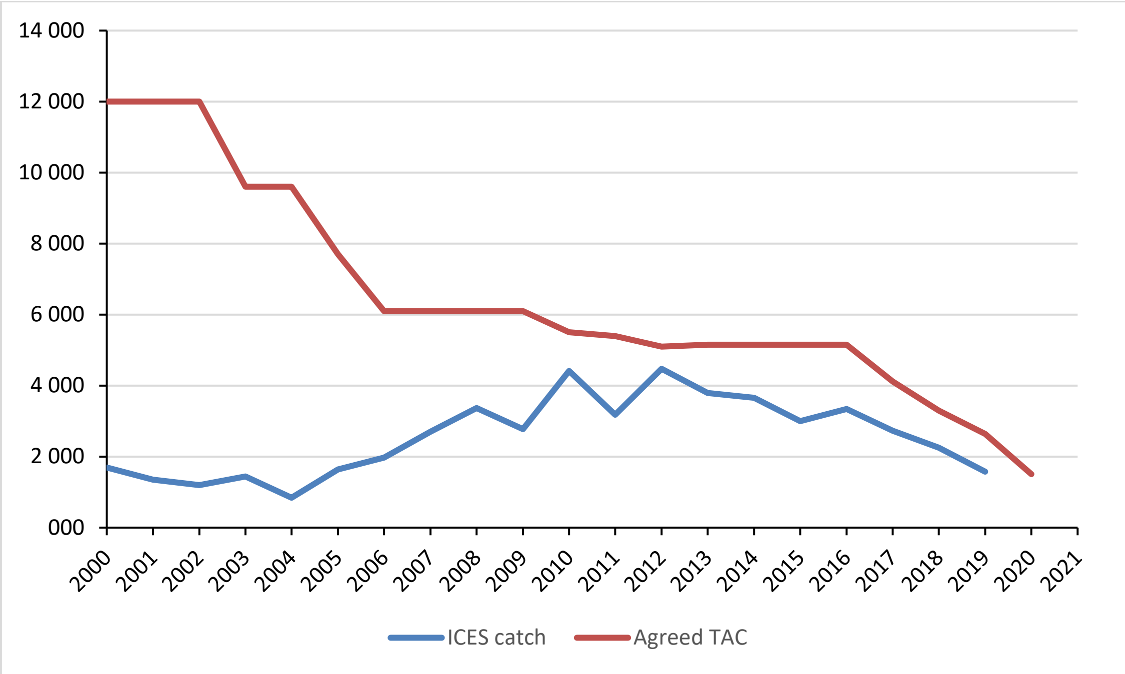


Figure 12.1.2. Sprat in 7.d-e. ICES catch (blue line) and agreed TAC (red line) from 2000 to 2020.

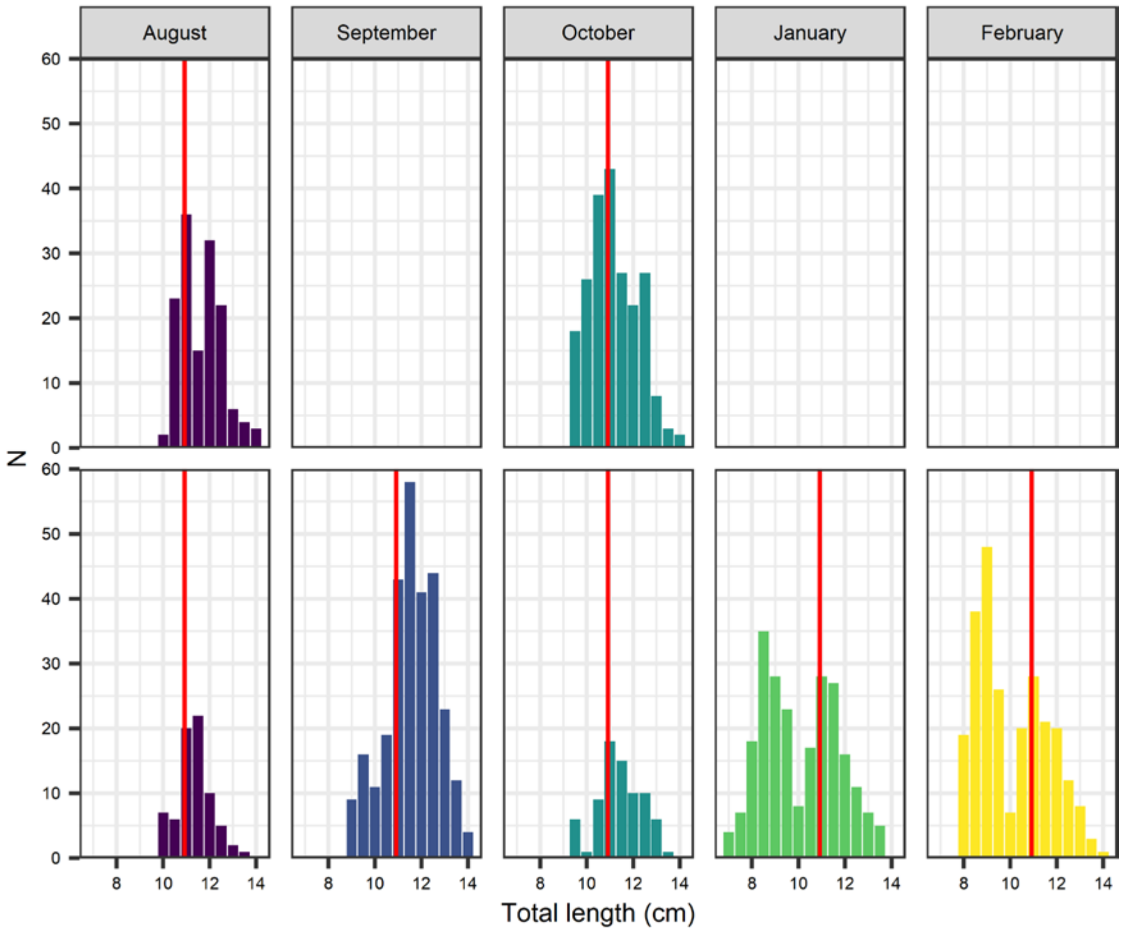


Figure 12.2.1. Length distribution collected by the fishers by month. Red line indicates weighted mean length at each month.

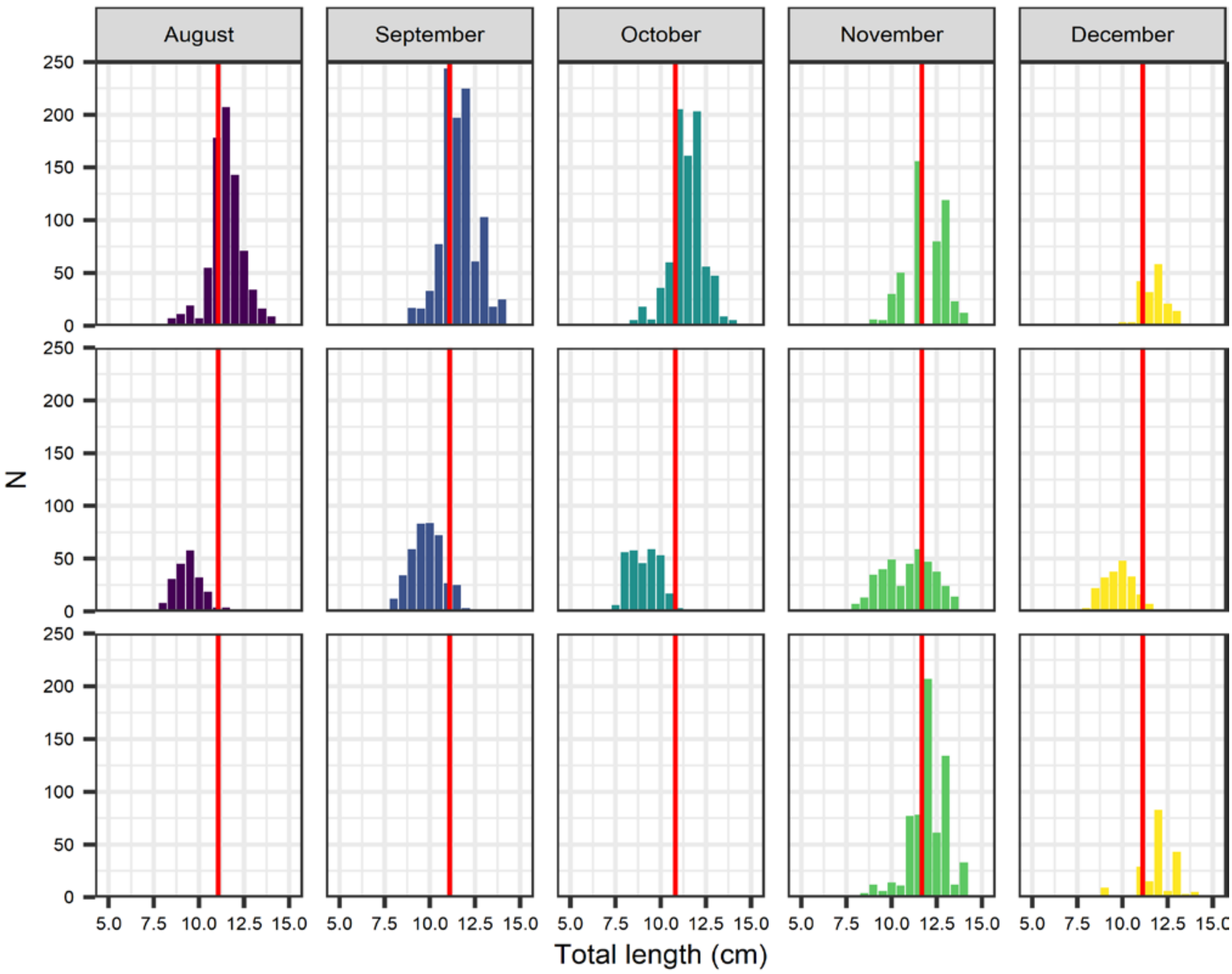


Figure 12.2.2. Monthly collected sprat total length distribution by all processors (3) in season 2019-2020. Red line indicates weighted mean length at each month.

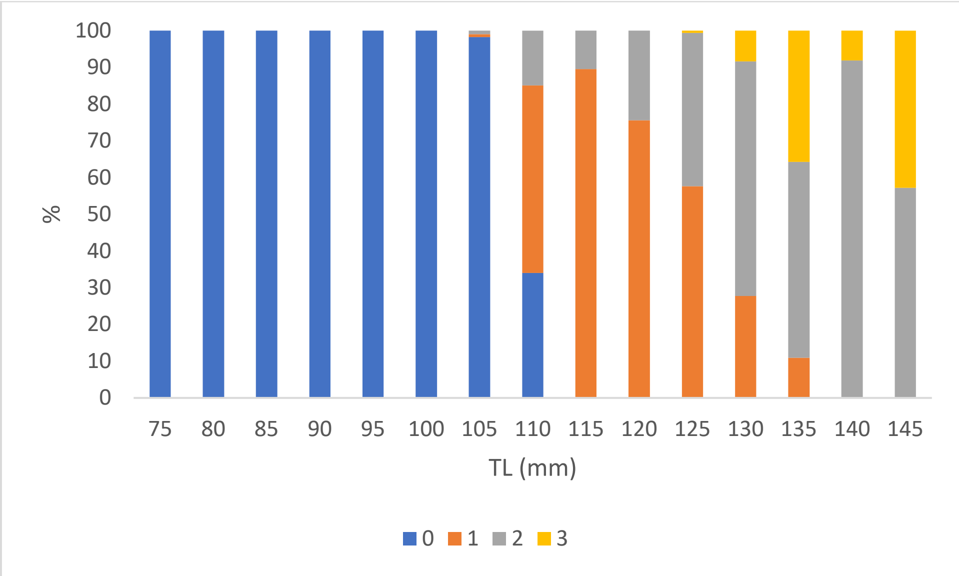


Figure 12.3.2. Sprat in 7.d-e. Proportion of numbers-at-age in the biological sample collected during the 2019 PELTIC acoustic survey

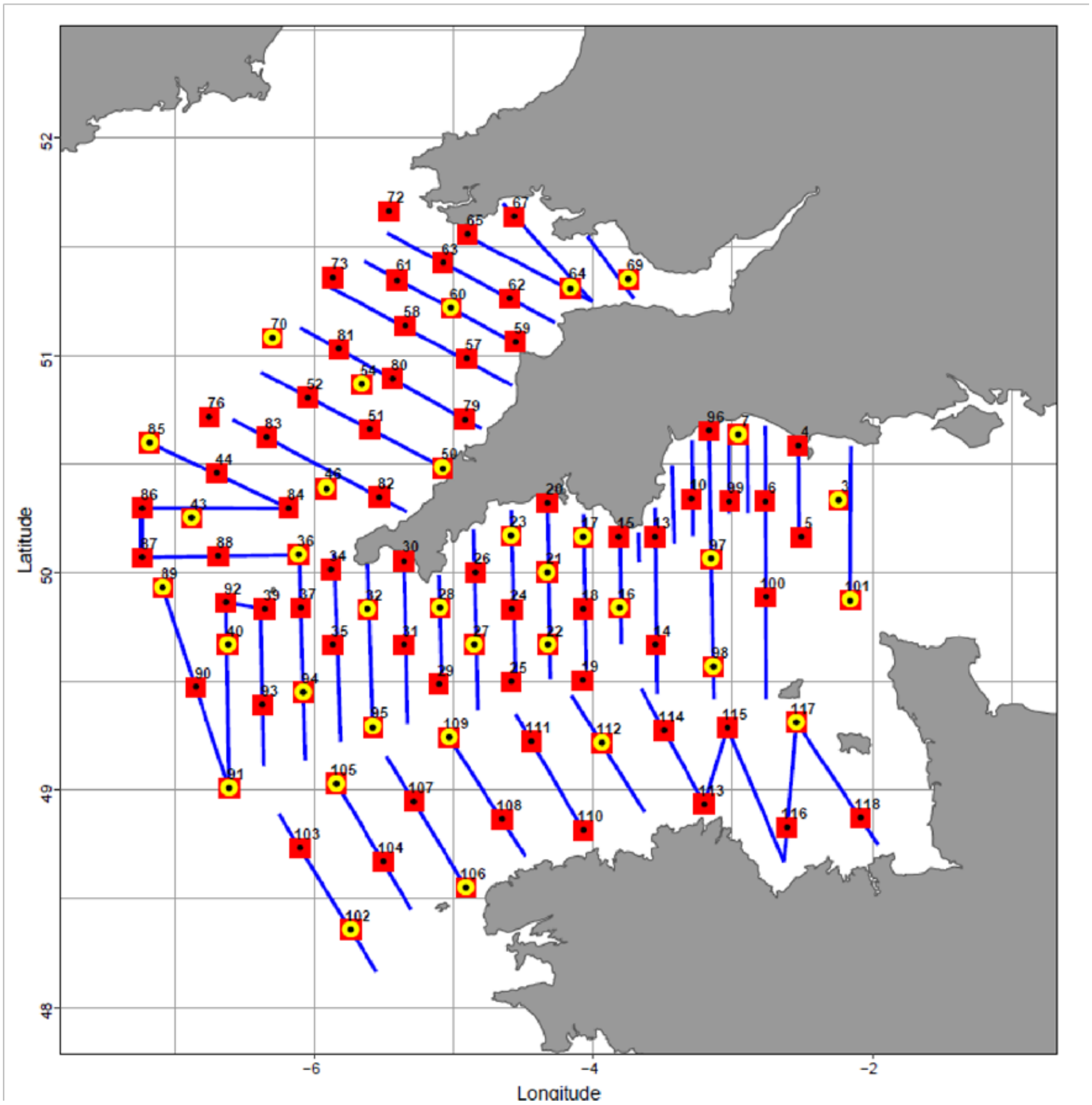


Figure 12.3.1. Sprat in 7.d–e. Survey design with acoustic transects (blue lines), zooplankton stations (red squares) and oceanographic stations (yellow circles).

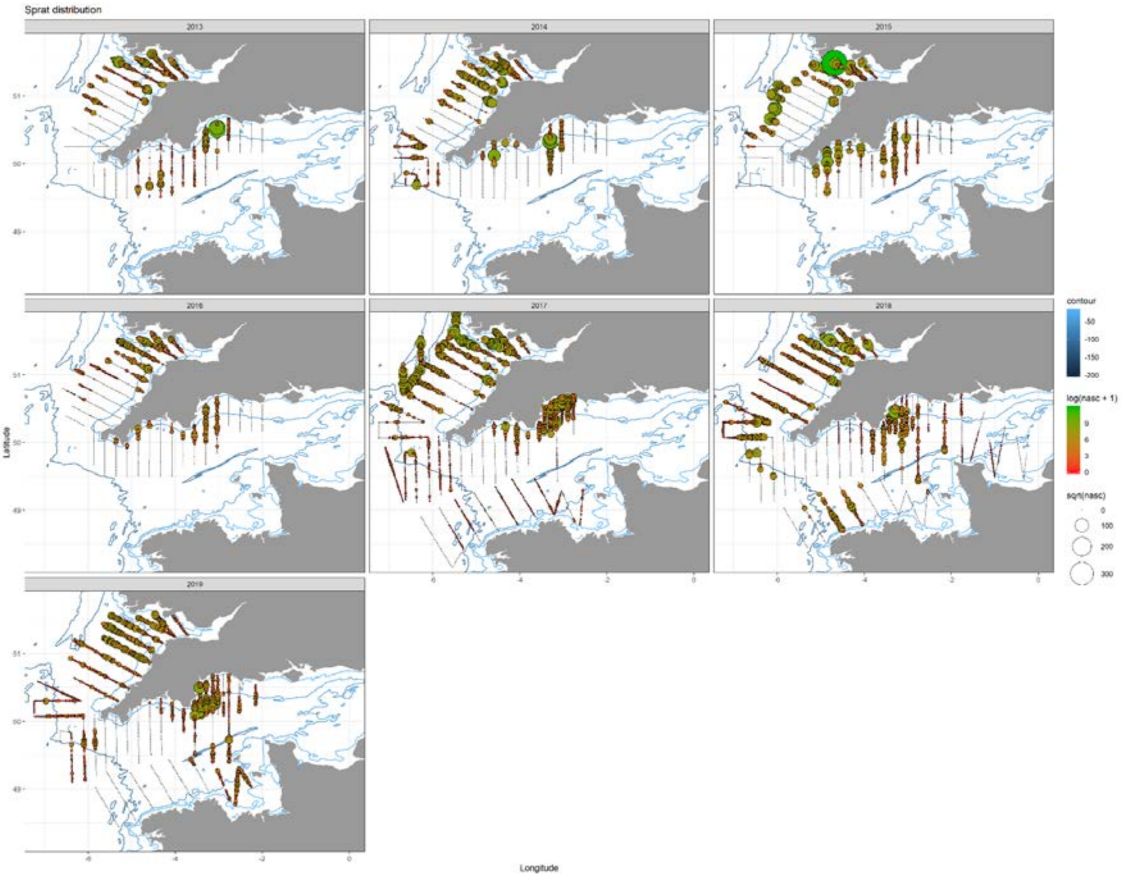


Figure 12.6.1. Sprat in 7.d–e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October.

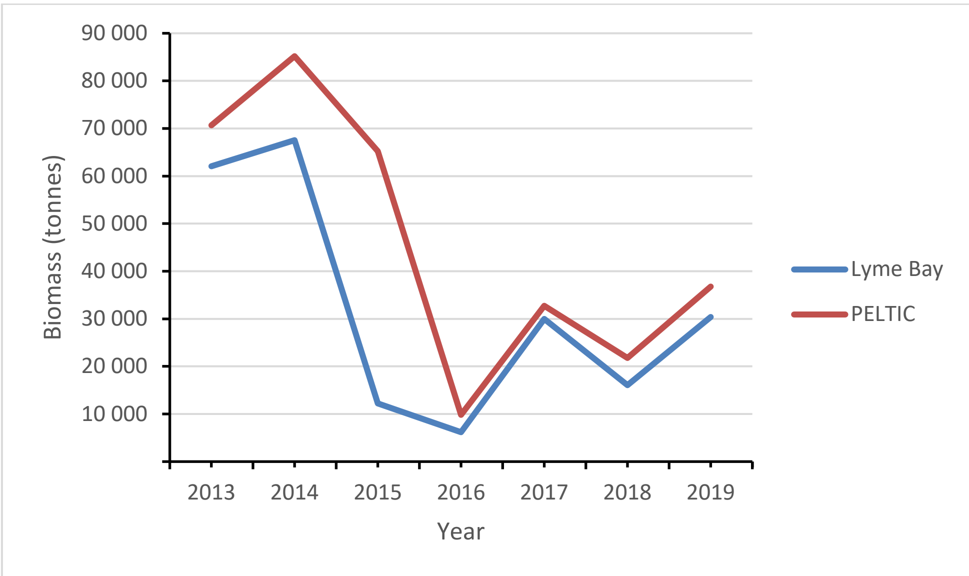


Figure 12.6.2. Sprat in 7.d-e. Biomass of sprat estimated from the PELTIC acoustic survey from 2013 to 2018 for Division 7.e (red line) and the Lyme Bay area (blue line).

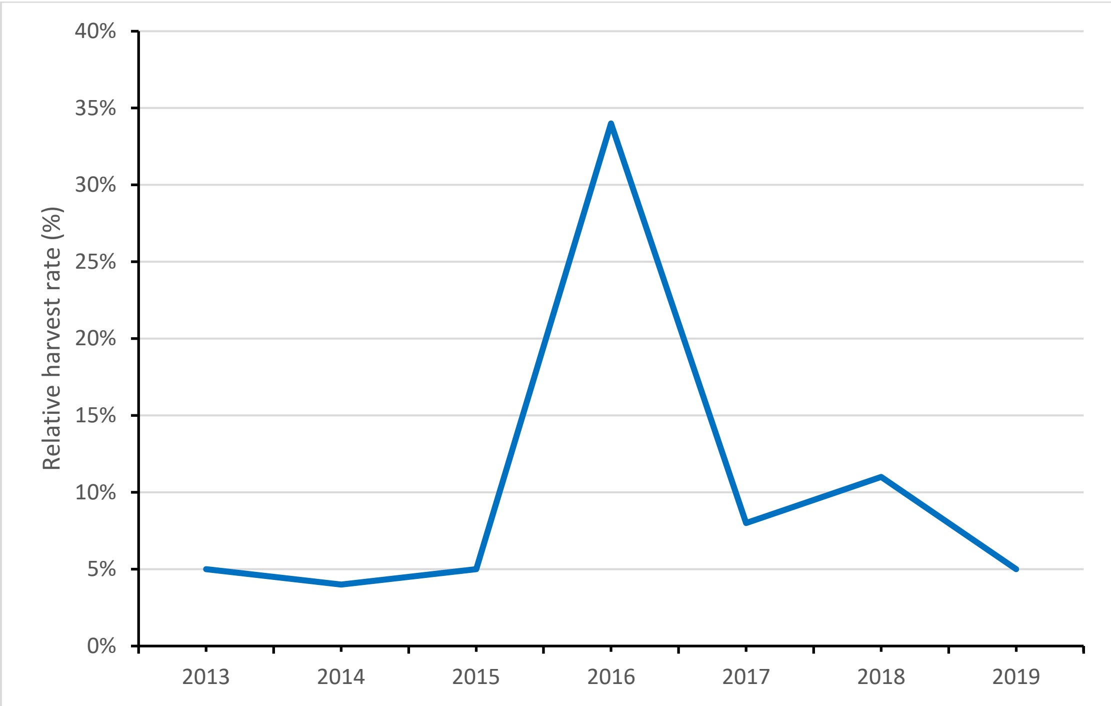


Figure 12.7.1. Sprat in 7.d-e. Harvest rate index (ratio between landings and PELTIC acoustic survey biomass estimate).

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. Irish landings in 2019 have increased substantially to 3423 tonnes. This has been attributed to a low herring quota in the Celtic sea for the Irish fishery. Limitations to the licensing of large boats is currently being introduced and the landings are expected to decrease next year.

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 fishmeal factory in the area. It is not known what proportion of the catch was made up of juvenile herring, though the fishing grounds were in the known herring nursery areas. In the late 1990s and early 2000s, UK vessels landed up to 500 t per year. In recent years a trial fishery for sprat was carried out by the vessels that fish herring in the area. This was carried out to investigate the feasibility of a clean commercially viable sprat fishery. The results of the trials were inconclusive and plans to conduct further experiments are under discussion.

Irish Landings from 1950–1994 may be from 7.aN or 7.aS. Very high catches in 7.aS were reported in 2012 (Table 13.1.3) with a decrease in 2013 and only 16 t reported in 2014. In 2015 the catches raised again to over 3500 t and dropped again to less than 1000 t in 2016. Despite the high catches registered in some years, those figures should be interpreted with caution because they may be overestimated. 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. Irish landings in 2019 were 9 t in 7aN and 2785 t from 7aS. With the exception of 2014, the last decade, Irish landings are mainly from 7.aS, predominantly from Waterford Harbour (Table 13.1.3).

Divisions 7.b–c (West of Ireland)

Sporadic fisheries have taken place, mainly in Galway Bay and the Mouth of the Shannon. The highest recorded landings were in 1980 and 1981 during winter of 1980/1981, when over 5000 t were landed by Irish boats (Table 13.1.4, Figure 13.2.4). This fishery took place in Galway Bay in winter 1980/1981 (Department of Fisheries and Forestry, 1982). Since the early 1990s landings fluctuated from very low levels to no more than 700 t per year in 2000. Zero catches were reported for 2016, increasing to above 500 tonnes in the two most recent years. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length. Irish landings in 2019 were 842 t.

Divisions 7.g–k (Celtic Sea)

Sprat landings in the Celtic Sea from 1985 onwards are WG estimates. In the Celtic Sea, Ireland has dominated landings. Patterns of Irish landings in divisions 7.g and 7.j are similar, though the 7.j landings have been higher. Landings for 7.g and 7.j were aggregated in this report. Landings have increased from low levels in the early 1990s, with catches fluctuating between 0 t in 1993 and just under 4200 t in 2005 (Table 13.1.7). The average catches in the last 10 years were equal to 2452 t. Irish landings increased significantly in 2019 to 6148 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 while smaller ones for fishmeal. 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 fishmeal 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 are not available electronically at the present time.

Sampling of sprat in 6.a came to an end in 2003 and no information on biological composition of catches exists in the period 2003–2011. Sampling was resumed in 2012 where a total of 8 landings were sampled. The sampling programme has been carried out since and it is anticipated that it will continue in the future.

13.3 Fishery-independent information

Celtic Sea Acoustic Survey

The Irish Celtic Sea Herring Acoustic Survey calculates an annual estimate of sprat biomass. Biomass estimates for Celtic Sea Sprat for the period November 1991 to October 2019 are shown in Figure 13.3.1 and Table 13.3.1. However, the survey results prior to 2002 are not comparable with the latter surveys because different survey designs were applied.

Since 2004 the survey has taken place each October in the Celtic Sea. Due to the lack of reliable 38 kHz data in 2010, no sprat abundance is available for this year.

It can be seen that there are large interannual variations in sprat abundance. Large sprat schools were notably missing in 2006, and so no biomass could be calculated. The utility of this survey as an index of sprat abundance should be considered carefully (Fallon *et al.*, 2012). Sprat is the second most abundant species observed from survey data. Sprat biomass over the time-series up to 2009 is highly variable, more so than could be accounted for by 'normal' inter survey variability (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 groundfish bottom trawl survey it does catch sprat throughout the survey area. The survey provides numbers at length per haul and aggregated age-length keys on a subarea basis. In the period 1981 to 2012 a total of 1434 hauls were completed and approximately half of these caught sprat. Although the survey is still carried out the figure has not been updated in the last five years (2013 to 2018).

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 groundfish and acoustic surveys may provide an index of sprat recruitment in this ecoregion. However further work is required.

13.6 Stock Assessment

Currently, the only assessment carried out in the Celtic ecoregion is for sprat in 7.d-e and it is based on a survey index of biomass (Please refer to Section 12 - Sprat in divisions 7.d-e).

13.7 State of the Stock

The state of the sprat stock in the Celtic Seas is currently unknown and the data available are not enough to provide any indication on its status. The only assessment available in the area for this species is for sprat in the English Channel (for that, please refer to Section 12 of this report).

13.8 Short-term projections

No projections are presented for this stock.

13.9 Reference Points

No precautionary reference points are defined for sprat populations in the region

13.10 Quality of the Assessment

The stock status is unknown and the Working Group does not have enough information to assess the status of the stock in relation to reference points.

13.11 Management Considerations

Sprat is a short-lived species with large interannual fluctuations in stock biomass. The natural interannual variability of stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

The sprat has mainly been fished together with herring. The human consumption fishery only takes a minor proportion of the total catch. Within the current management regime, where there is a bycatch ceiling limitation of herring as well as bycatch percentage limits, the sprat fishery is controlled by these factors. Most management areas in this ecoregion do not have a quota for sprat. However, there is a quota in 7.d–e, English Channel, which has not been fully utilized.

13.12 Ecosystem Considerations

In the North Sea Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem, for both fish and seabirds. At present, there are no data available on the total amount of sprat, and in general of other pelagic species, taken by seabirds in the Celtic Seas Ecoregion.

The Celtic Seas Ecoregion is a feeding ground for several species of large baleen whales (O'Donnell *et al.*, 2004–2009). These whales feed primarily on sprat and herring from September to February.

Table 13.1.1 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2019, Division 6.a. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length. (tonnes)

Country	Denmark	Faroe Islands	Ireland	Norway	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
1985	0	0	51	557	0	2946	0	3554
1986	0	0	348	0	2	520	0	870
1987	269	0	0	0	0	582	0	851
1988	364	0	150	0	0	3 864	0	4 378
1989	0	0	147	0	0	1 146	0	1 293
1990	0	0	800	0	0	813	0	1 613
1991	0	0	151	0	0	1 526	0	1 677
1992	28	0	360	0	0	1 555	0	1 943
1993	22	0	2 350	0	0	2 230	0	4 602
1994	0	0	39	0	0	1 491	0	1 530
1995	241	0	0	0	0	4 124	0	4 365
1996	0	0	269	0	0	2 350	0	2 619
1997	0	0	1 596	0	0	5 313	0	6 909
1998	40	0	94	0	0	3 467	0	3 601
1999	0	0	2 533	0	310	8 161	0	11 004
2000	0	0	3 447	0	0	4 238	0	7 685
2001	0	0	4	0	98	1 294	0	1 396
2002	0	0	1 333	0	0	2 657	0	3 990
2003	887	0	1 060	0	0	2 593	0	4 540
2004	0	0	97	0	0	1 416	0	1 513
2005	0	252	1 134	0	13	0	0	1 399
2006	0	0	601	0	0	0	0	601
2007	0	0	333	0	0	14	0	347
2008	0	0	892	0	0	0	0	892
2009	0	0	104	0	0	70	0	174
2010	0	0	332	0	0	537	0	869
2011	0	0	468	0	248	507	0	1 223
2012	0	0	113	0	0	1 688	0	1 801

Country	Denmark	Faroe Islands	Ireland	Norway	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
2013	0	0	487	0	0	968	0	1 455
2014	0	0	3	0	0	1 540	0	1 543
2015	0	0	1 305	0	0	1 060	0	2 365
2016	0	0	431	0	0	2 177	0	2 608
2017	0	0	604	0	0	1 354	0	1 958
2018	0	0	1	0	0	0	0	1
2019	0	0	3243	0	66	1265	1	14350

Table 13.1.2 Sprat in the Celtic Seas Ecoregion. Irish landings of sprat, 1985–2019 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

Country	Ireland	Isle of Man	UK Eng+Wales+N.Irl.	UK Scotland	Total
2003	0	0	592	0	592
2004	0	0	134	0	134
2005	0	0	591	0	591
2006	0	0	563	0	563
2007	0	0	0	0	0
2008	0	0	2	0	2
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	0	0	0	0	0
2014	522	0	0	0	522
2015	792	0	0	0	771
2016	150	0	0	0	150
2017	150	0	0	0	150
2018	0	0	0	0	0
2019	9	0	0	0	9

Table 13.1.3 Sprat in the Celtic Seas Ecoregion. Irish landings of sprat, 1985–2019 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
2019	2785

Table 13.1.4. Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2019, 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
2019	842

Table 13.1.5 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2019, 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

Country	Denmark	France	Netherlands	UK Eng+Wales+N.Irl.	UK Scotland	Other	Total
2004	0	6	0	0 836	0	0	842
2005	0	0	0	1 635	0	0	1 635
2006	0	7	0	1 969	0	0	1 976
2007	0	0	0	2 706	0	0	2 706
2008	0	0	0	3 367	0	0	3 367
2009	0	2	0	2 773	0	0	2 775
2010	0	2	0	4 408	0	0	4 410
2011	0	1	37	3 138	0	0	3 176
2012	6	2	8	4 458	0	0	4 474
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
2019	0	0.66	0	1544.37	0	27.58	1573

Table 13.1.6 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2019, 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

Country	Netherlands	UK Eng+Wales+N.Irl.	Total
1994	0	2	2
1995	0	0	0
1996	0	0	0
1997	0	0	0
1998	0	51	51
1999	0	0	0
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	2	2
2008	0	0	0
2009	0	1	1
2010	0	7	7
2011	0	1	1
2012	0	2	2
2013	0	2	2
2014	0	1	1
2015	0	0	0
2016	0	1	1
2017	0	0	0
2018	0	0	0
2019	0	0	0

Table 13.1.7 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2019, 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
2019	0	0	6148	0	0	0	6148

Table 13.1.8 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2019. 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	Faroe 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
2019	0	0	0	13027	0	1	0	0	66	1265		14350

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).

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	50 810
2005	29 019
2008	5 493
2009	16 229
2011	31 593
2012	35 114
2013	44 685
2014	54 826
2015	83 779
2016	42 694
2017	70 745
2018	47 806
2019	60 608

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.

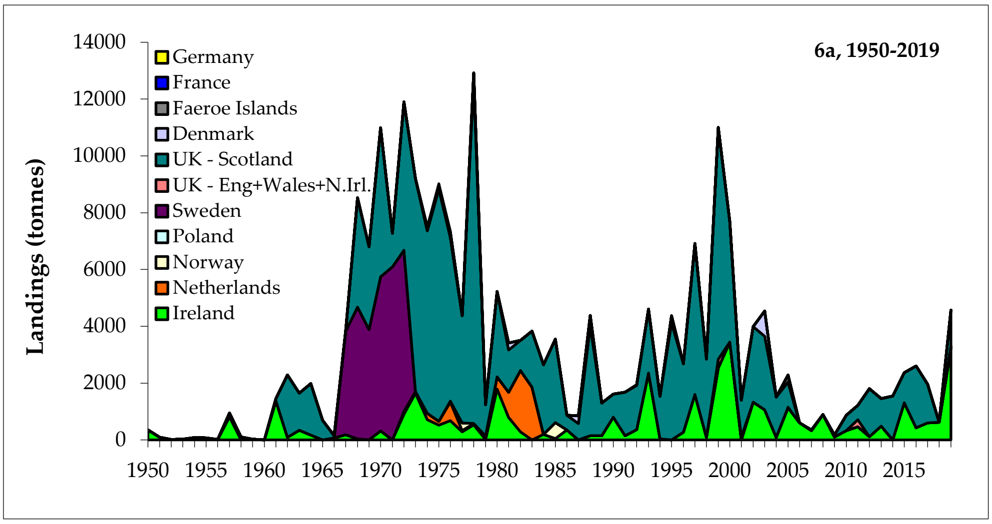


Figure 13.2.1. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2019 ICES Division 6.a.

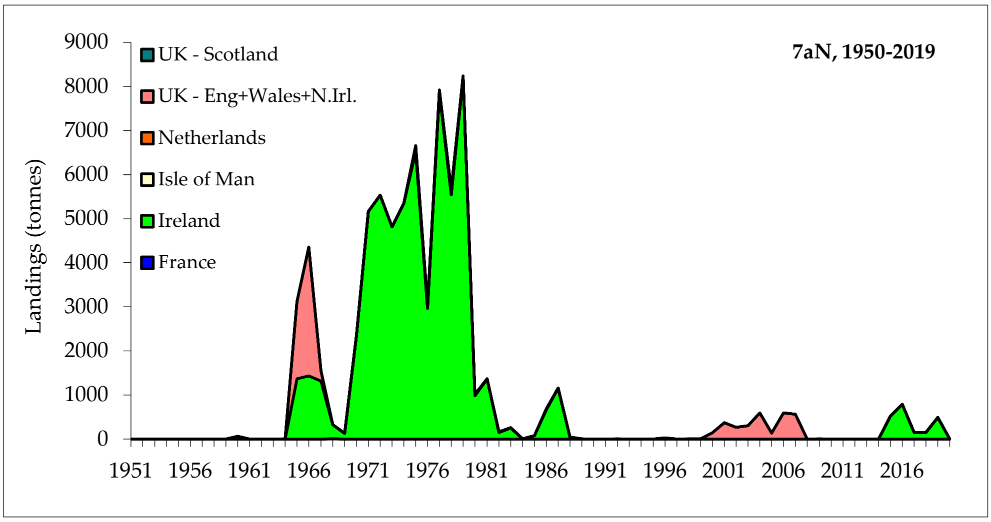


Figure 13.2.2. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2019 ICES Division 7.aN. Note: Irish landings from 1973–1995 may be from 7.aN or 7.aS.

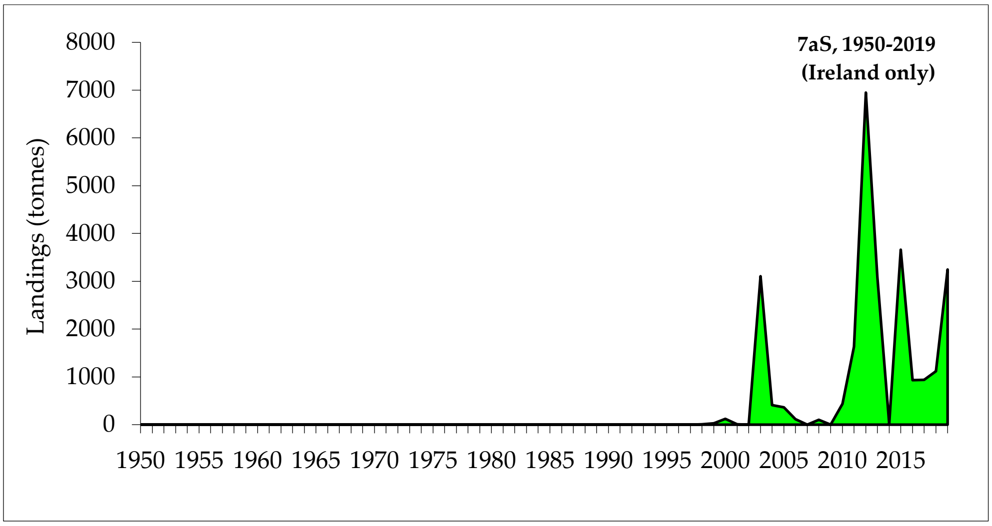


Figure 13.2.3. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2019 ICES Division 7.aS.

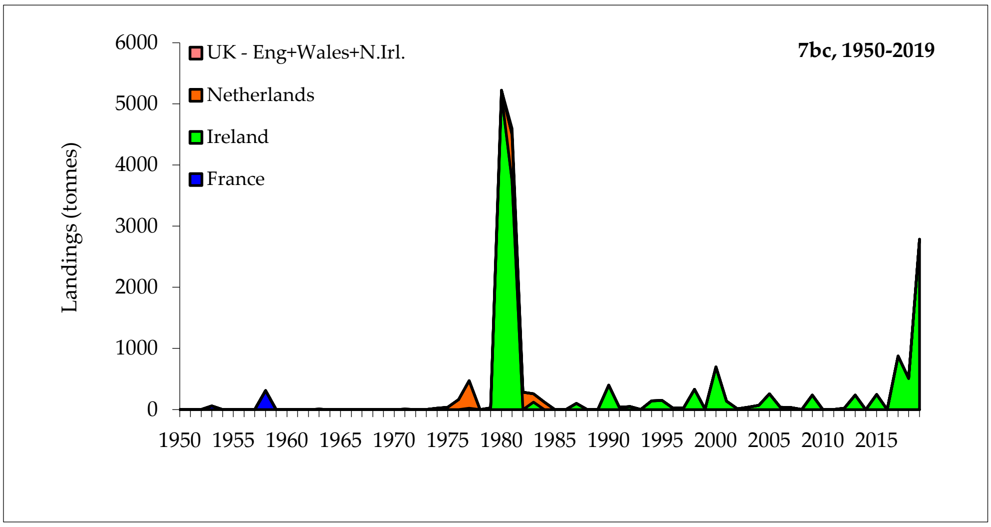


Figure 13.2.4. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2019 ICES divisions 7.b–c.

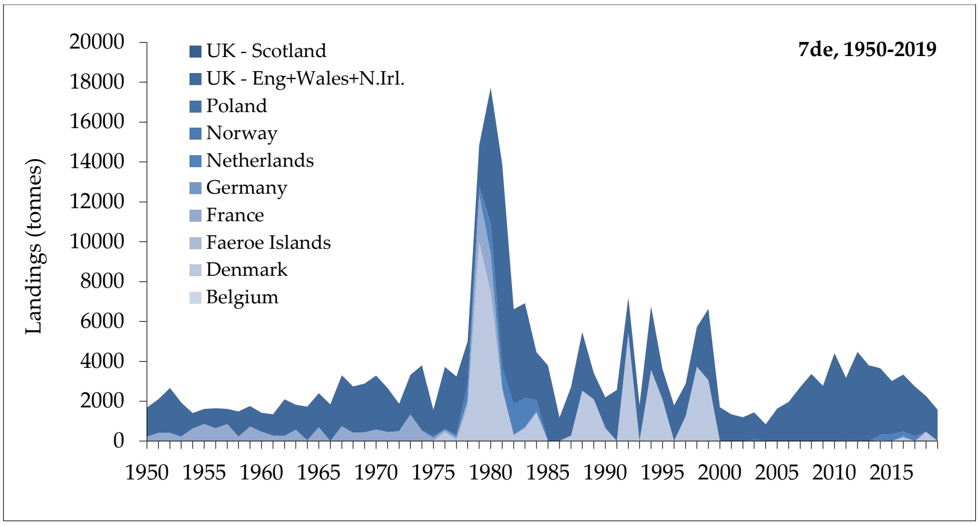


Figure 13.2.5. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2019 ICES divisions 7.d–e.

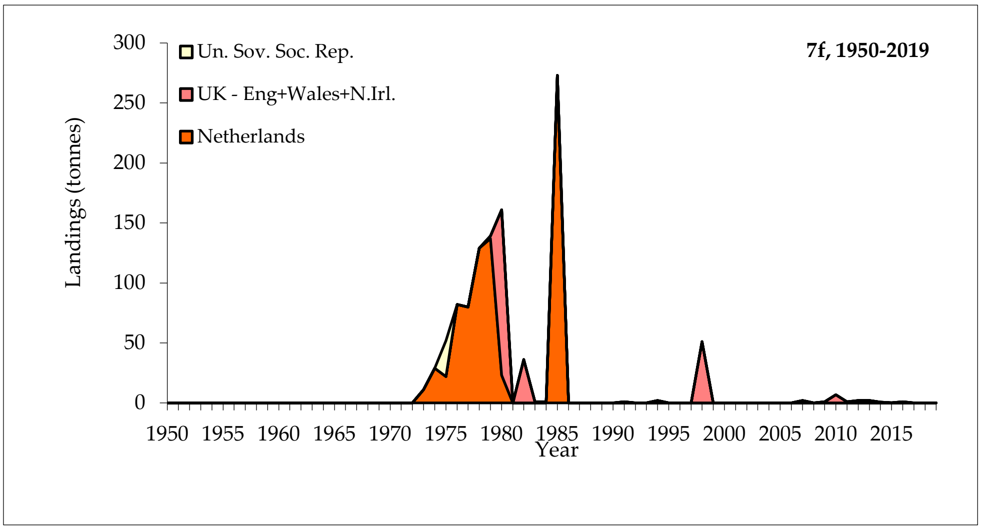


Figure 13.2.6. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2019 ICES Division 7.f.

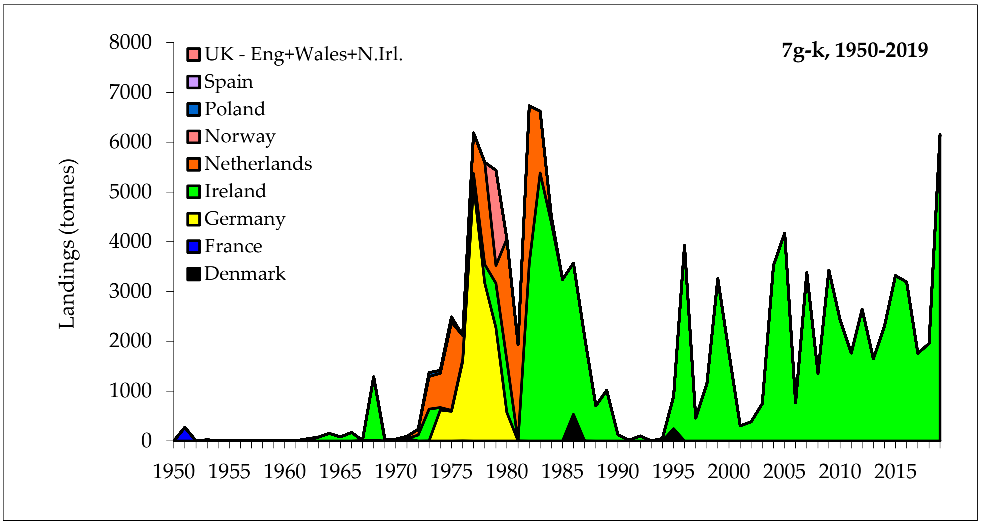


Figure 13.2.7. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2019 ICES divisions 7.g–k.

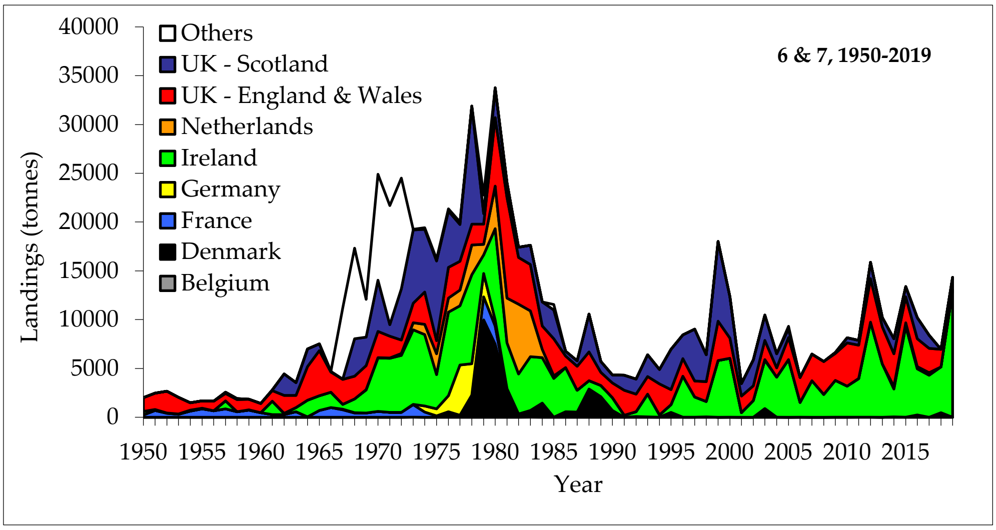


Figure 13.2.8. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2019 ICES subareas 6 and 7 (Celtic Seas Ecoregion).

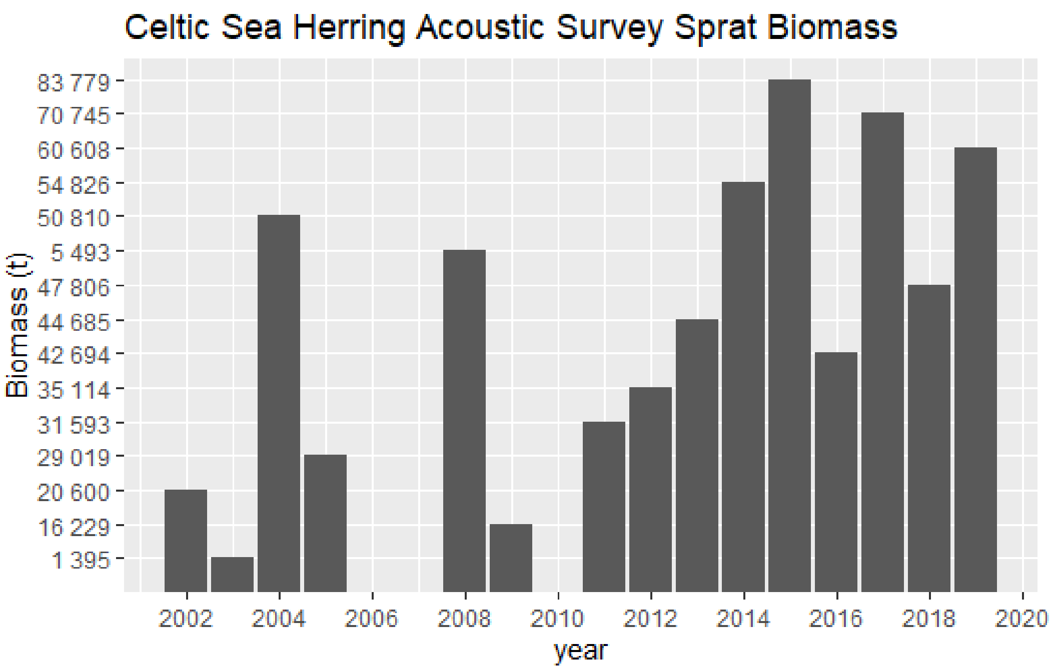


Figure 13.3.1. Sprat in the Celtic Seas Ecoregion. Estimated sprat biomass in the Celtic Sea. (Source: MI Celtic Sea Herring Acoustic Survey). 2002 – 2019 corresponds to the period where the surveys are considered consistent.

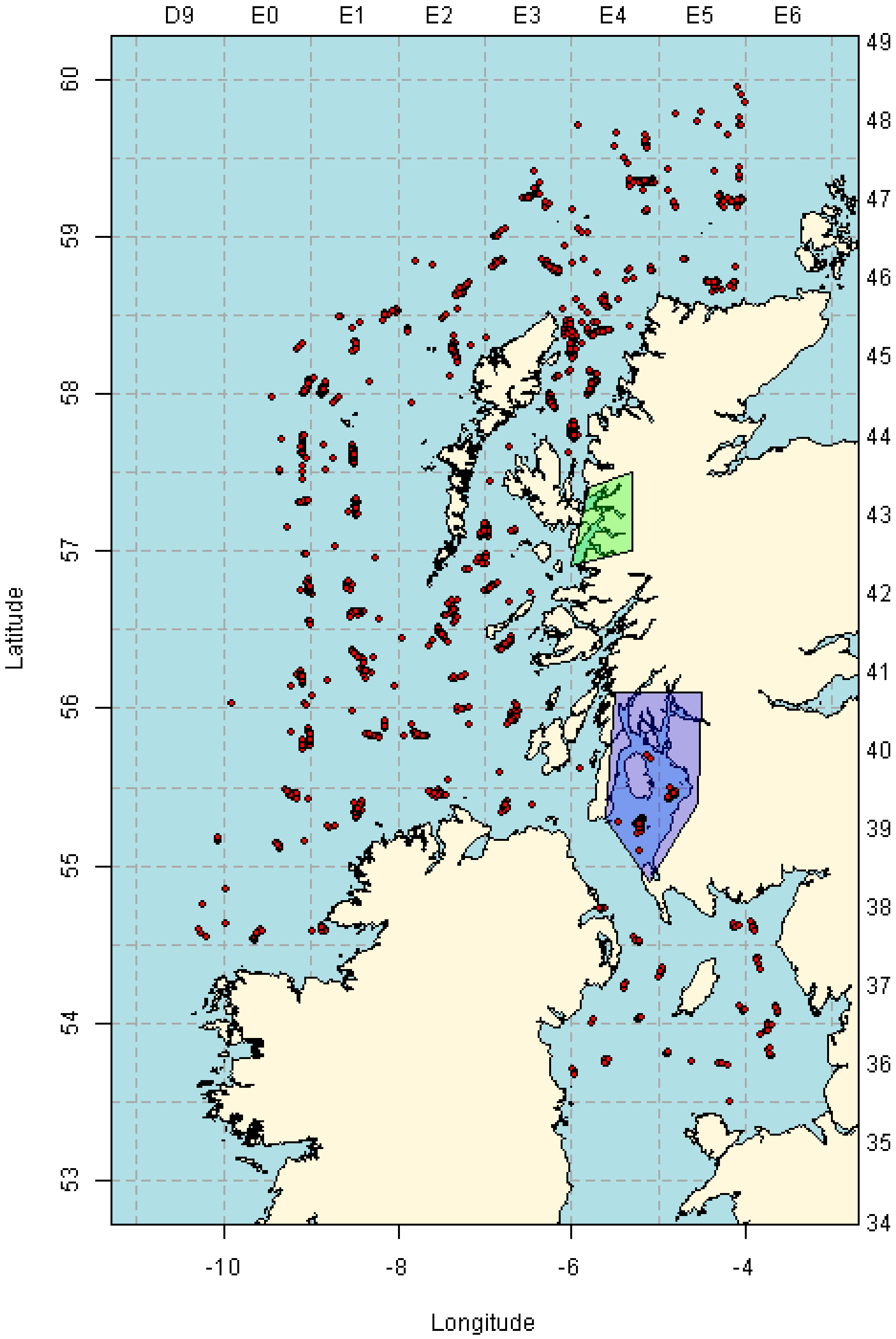


Figure 13.3.2: Extent of Scottish surveys that may provide information about sprat in 6.a. In purple is the extent of the Clyde Herring and Sprat Acoustic Surveys carried out in July between 1985 and 1989 and again in October 2012. In green is the extent of the Sea Lochs Surveys carried out annually 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.

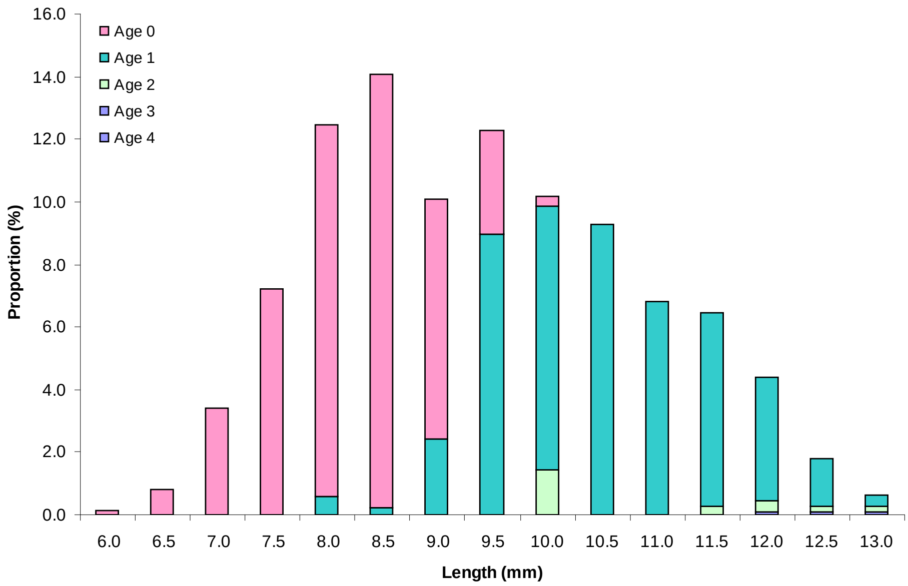


Figure 13.3.3. Length and age of sprat caught in the October 2012 Clyde Herring and Sprat Acoustic Survey. Data from six hauls were combined giving equal weight to the age and length distribution in each haul. 1442 sprat were measured and 182 were aged.

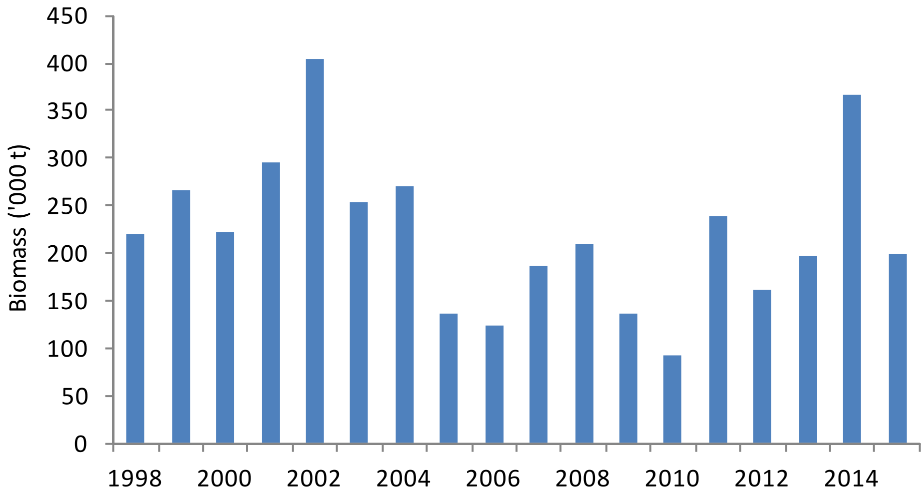


Figure 13.3.4. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Division 7.aN.

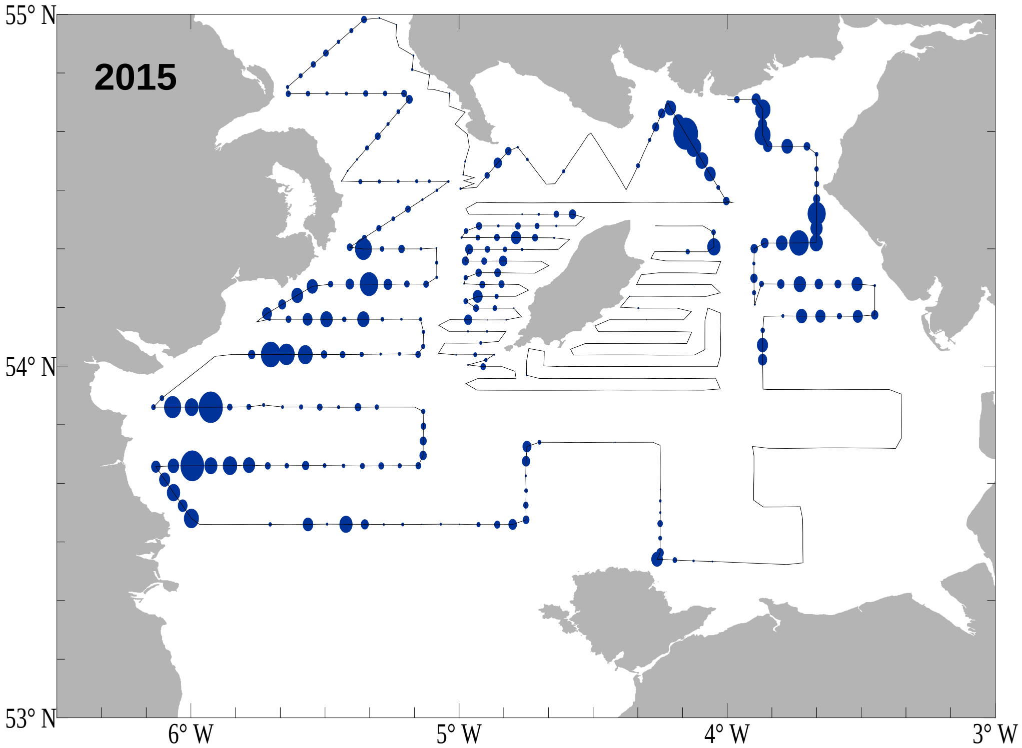


Figure 13.3.5. Sprat in the Celtic Seas Ecoregion. Sprat acoustic densities in ICES Division 7.aN. Size of ellipse is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval) for the UK (NI). September 2015 acoustic survey (AC(7.aN)) . Maximum density was 470 t n.mile^{-2}.

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Annex 2: Resolution

HAWG – Herring Assessment Working Group for the Area South of 62ºN

This resolution was approved 1 October 2019

2019/2/FRSG03 The **Herring Assessment Working Group for the Area South of 62ºN** (HAWG), chaired by Valerio Bartolino, Sweden, and Afra Egan*, Ireland, will meet at ICES Headquarters:

22–24 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;

and work by correspondence 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 to the meeting must be available to the group on the dates specified in the 2020 ICES data call.

HAWG will report by 10 February and 8 April 2020 for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

Due to the COVID-19 disruption that started early 2020, ACOM drafted a "spring 2020 approach" for recurring fishing opportunities advice. The generic Terms of Reference have been adjusted as described in the letter to ICES chairs below.

Chairs of Expert Groups

Our Ref: C.4.e/MDC/mo 13 March 2020

Subject: **Spring 2020 approach to advice production**

Dear Expert Group Chair,

I am writing this letter to keep you up to date about the approach of ACOM to the COVID-19 disruption. Many of our institutes now have travel bans and/or working from home policies. ACOM has developed a "spring 2020 approach" to this year's spring advice season. This letter covers the recurrent fishing opportunities advice. Any special request processes and non-fisheries advice will be dealt with separately. The expert groups effected are listed in Annex 1.

ACOM is encouraging all expert groups to keep working, and stick broadly to the time line, but clearly this needs to be through virtual meetings. ICES secretariat will support your efforts and make WebEx available. They will also produce a broad training document on WebEx. We know that the use of virtual meetings will result in an increased burden on the Chairs and members of the expert groups, therefore we have made changes to the generic terms of reference (see Annex 2 below) categorizing them as high, medium and low priority for this year's work. We also suggest that the expert group works virtually through smaller sub-groups, and only hold larger virtual meetings when necessary.

The requesters of advice have been informed that there will be disruption/change to the delivery of advice for the spring 2020 season.

ACOM will also change the way that ICES gives advice for the spring 2020 season. There will be three types of advice:

- **Standard advice** sheet (the advice sheet following the January 2020 guidelines)
- **Abbreviated advice** sheet (a shortened advice sheet)
- **Rollover advice** (the same advice as in 2019)

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The choice of which type of advice to apply to a stock is based on criteria determined by ACOM:

a. **Standard advice** - stocks with 2020 benchmarked methods
b. **Abbreviated advice** – most stocks, including management plan and MSY advice stocks, and some Cat 3 stocks. The abbreviated advice will contain the advice of the headline advice, catch scenario tables, plots and automated tables (last years' advice will be added as an annex to each sheet). The guidance for abbreviated advice is being written now and you should receive it in a few days.
c. **Rollover advice** – same as 2019 advice. This will be provided for stocks in the following categories:
    - zero TAC has been advised in recent years and no change likely,
    - category 3 or greater roll over advice, except if due to be reviewed in 2020
    - long lived stable stocks, with no strong trends in dynamics in recent years
    - some non-standard stocks (e.g. North Atlantic salmon)

We need to consult both you and the requesters of advice about which type of advice to apply to each stock. Today the ACOM criteria are being used by the secretariat to allocate advice types to stocks. This is the first version. We would like you to consider this list and comment if you think that the allocation needs changing. Please remember that the abbreviated advice is being developed to help your processes and also the ACOM processes during the disruption. The list of allocated advice type for each stock will hopefully be sent to you today or Monday. Please reply with your comments by 19th March so that we can start the dialogue with requesters. ACOM hopes that we could have a definitive list by 25th March. (This is too late for HAWG, so we suggest that HAWG use the list compiled in cooperation with Secretariat expecting requesters of advice to agree).

ACOM is recommending that for North Sea stocks with re-opening of advice in the autumn, the stock assessments be carried out in the spring but not the forecasts (postponed until early autumn). The advice would be delivered in the autumn of 2020.

You will shortly receive the first version of the **list of advice types allocated to stocks** and the **guidelines for abbreviated advice**. Please respond by 19th March with your comments on the first version of the list. Your professional officer has been briefed about these changes. The changes are designed to reduce both expert group and ACOM workload. Lotte, your professional officer, the ACOM leadership and the FRSG Chair are available for further explanation.

Best regards

Mark

Mark Dickey-Collas
ACOM Chair

Annex 1. Expert groups associated with 2020 spring advice season

Herring Assessment Working Group for the Area South of 62°N
Working Group on North Atlantic Salmon*
Assessment Working Group on Baltic Salmon and Trout*
Baltic Fisheries Assessment Working Group
Arctic Fisheries Working Group
Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak
North-Western Working Group
Working Group on the Biology and Assessment of Deep-sea Fisheries Resources
Working Group for the Bay of Biscay and the Iberian Waters Ecoregion
Working Group for the Celtic Seas Ecoregion
Working Group on Southern Horse Mackerel, Anchovy, and Sardine
Working Group on Elasmobranch Fishes

* These groups already have different approaches.

Annex 2. Spring 2020 adapted generic terms of reference. [Agreed by ACOM 12 March 2020]

In light of the disruptions caused by COVID-19 in 2020, the generic terms of reference for the FRSG stock assessment groups have been re-prioritised. This applies to expert groups that feed into the spring advice season process[1]. ACOM is encouraging expert groups to use virtual meetings (e.g. WebEx) and subgroups to deliver the high priority terms of reference. See letter from the ACOM Chair to expert groups.

High Priority for spring 2020 advice season

c) Conduct an assessment on the stock(s) to be addressed in 2020 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. **Check the list of the stocks to be done in detail and those to roll over.**

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 2019.

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 succinct 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.

d) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines. Check list to confirm whether the stock requires a concise advice sheet or a traditional advice sheet.

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

j) Audit all data and methods used to produce stock assessments and projections.

[1] These do not apply to Assessment Working Group on Baltic Salmon and Trout and Working Group on North Atlantic Salmon.

Medium Priority for spring 2020 advice season

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

b) For the aim of providing input for the Fisheries Overviews, consider and comment 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;

e) Review progress on benchmark processes of relevance to the Expert Group; High for application;

Low Priority for spring 2020 advice season

c iv) Estimate MSY proxy reference points for the category 3 and 4 stocks

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

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

i) Take 15 minutes, and fill a line in the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity'; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice. ACOM would encourage expert groups to carry out this term of reference later in the year through a webex.

Annex 3: List of stock annexes

The table below provides an overview of the NWWG Stock Annexes. Stock annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year*, *ecoregion*, *species*, and *acronym* of the relevant ICES expert group.

Stock ID	**Stock name**	**Last up-dated**	**Link**
her.27.20-24	Herring (*Clupea harengus*) in subdivisions 20-24, spring spawners (Skagerrak, Kattegat, and western Baltic)	March 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)	March 2018	her.27.irls SA
her.27.nirs	Herring (*Clupea harengus*) in Division 7.a North of 52°30'N (Irish Sea)	June 2017	her.27.nirs SA
san.sa.1r	Sandeel (*Ammodytes* spp.) in Divisions 4.b and 4.c, Sandeel Area 1r (central and southern North Sea, Dogger Bank)	Jan 2018	san.sa.1r SA
san.sa.2r	Sandeel (*Ammodytes* spp.) in Divisions 4.b and 4.c, and Subdivision 20, Sandeel Area 2r (Skagerrak, central and southern North Sea)	Jan 2020	san.sa.2r SA
san.sa.3r	Sandeel (*Ammodytes* spp.) in Divisions 4.a and 4.b, and Subdivision 20, Sandeel Area 3r (Skagerrak, northern and central North Sea)	Jan 2020	san.sa.3r SA
san.sa.4	Sandeel (*Ammodytes* spp.) in divisions 4.a and 4.b, Sandeel Area 4 (northern and central North Sea)	Nov 2016	san.sa.4 SA
san.sa.5r	Sandeel (*Ammodytes* spp.) in Division 4.a, Sandeel Area 5r (northern North Sea, Viking and Bergen banks)	Nov 2016	san.sa.5r SA
san.sa.6	Sandeel (*Ammodytes* spp.) in subdivisions 20-22, Sandeel Area 6 (Kattegat)	Nov 2016	san.sa.6r SA
san.sa.7r	Sandeel (*Ammodytes* spp.) in Division 4.a, Sandeel Area 7r (northern North Sea, Shetland)	Nov 2016	san.sa.7r SA
spr.27.3a4	Sprat (*Sprattus sprattus*) in Division 3.a and Subarea 4 (Skagerrak, Kattegat and North Sea)	March 2019	spr.27.3a4 SA
spr.27.67a–cf–k	Sprat (*Sprattus sprattus*) in Subarea 6 and Divisions 7.a-c and 7.f-k (West of Scotland, southern Celtic Seas)	2013	spr.27.67a–cf–k SA

spr.27.7de	Sprat (*Sprattus sprattus*) in divisions 7.d and 7.e (English Channel)	Feb 2019	spr.27.7de_SA

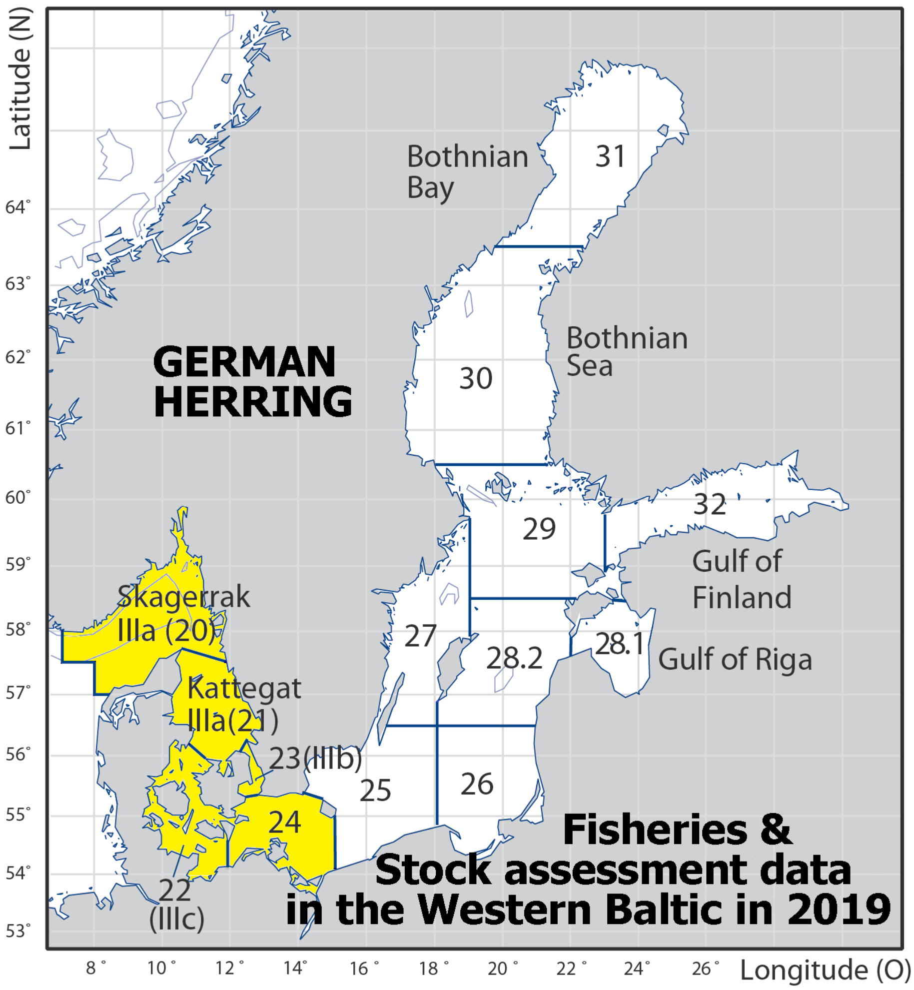
Annex 5: Working documents

Working documents HAWG 2020	
WD 01	German herring fisheries and stock assessment input data in 2019
WD 02	2019 Western Baltic spring spawning herring recruitment monitored by the Rügen Herring Larvae Survey
WD 03	PFA self-sampling report for North Sea herring fisheries 2015–2020
WD 04	Sprat (*Sprattus sprattus*) in Divisions 7.d and 7.e (English Channel): latest biomass estimates and results of revision of advice methods
WD 05	Updated Survey Index Calculations for North Sea Sprat (inclusive area IIIa) from IBTS data
WD06	Explorative SMS runs to compare currently applied IBTS indices to those from an improved model

HAWG 2020 WD01: German herring fisheries and stock assessment input data in 2019

Working Document XX

Herring Assessment WG for the area South of 62° North (HAWG)/WBSSH
17 - 25 March 2020



compiled by Tomas Gröhsler
Thünen Institut of Baltic Sea Fisheries (TI-OF)
Germany

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1 German herring fisheries in 2019

1.1 Fisheries

In 2019 the total German herring landings from the Western Baltic Sea in Subdivisions (SD) 22 and 24 amounted to 5,571 t, which represents a decrease of 51 % compared to the landings in 2018 (11,304 t). This decrease was caused by a decrease of the TAC/quota (German quota for SDs 22 and 24 in 2019: 4,966 t + quota-transfer of 808 t). The German quota in 2019 was used by 97 % (2018: 94 %, 2017: 88 %). The fishing activities in one of the main fishing areas, the Greifswald Bay (SD 24), started already in mid-Januray. The main German fishery stopped their activities at the beginning 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*
2019	121 (=61 % of GER quota (>32 mm) of 358 t*

*Including a quota transfer of +1 t in 2017/2019 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		39.780	4,340.962	**4,380.742**	**77.0**
			-3.174	**-3.174**	**-0.056**
II		3.670	108.134	**111.804**	**2.0**
			-0.215	**-0.215**	**-0.004**
III	120.952	0.377	0.911	**122.240**	**2.1**
	-120.952			**-120.952**	**-2.125**
IV		9.862	1,066.835	**1,076.697**	**18.9**
TOTAL	**120.952**	**53.689**	**5,516.842**	**5,691.483**	**100.0**
	-120.952	**0.000**	**-3.389**	**-124.341**	**-2.185**

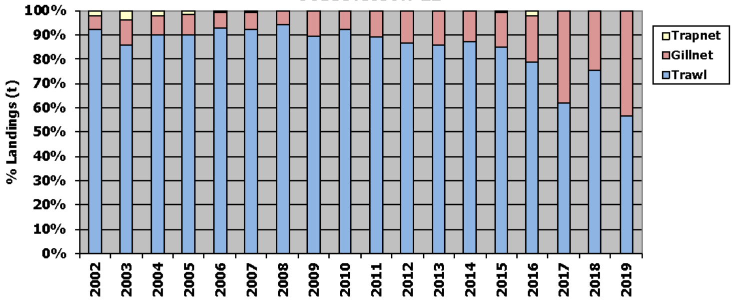
Source: Federal Centre for Agriculture and Food (BLE). Since 2008 the obligation to report via logbooks changed to vessels >8 m (until 2007 for vessels >10 m)

Landings = **Total landings**
-Landings = **Fraction landed abroad**

Just as in former years the main fishing season was during the first and second quarter. About 79 % of the herring in 2019 in SDs 20-24 was caught between January and April (2018: 88 %, 2017: 86 %, 2016 : 84 %, 2015: 84 %). As in last years, the main fishing area was located in Subdivision 24 (2016-2019: 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 in 2019 of 70 % (2018: 72 %, 2017: 67 %). The trawl fishery was mostly carried out in Subdivision 24 (2018-2019: 99 %, 2016-2017: 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 2002-2019 in Subdivisions 22 and 24.

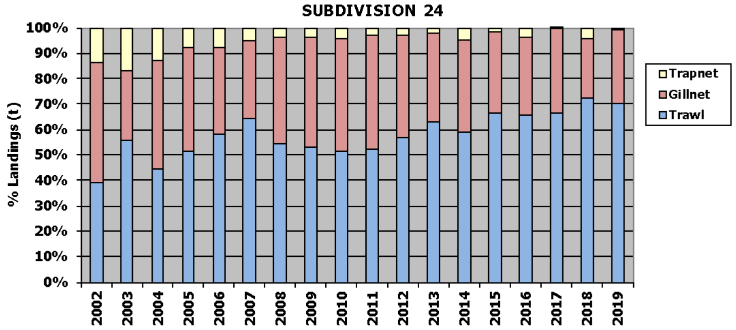
SD 22 (t)	Trawl	Gillnet	Trapnet	Total	SD 22 (%)	Trawl	Gillnet	Trapnet
2002	3,871.716	253.710	78.838	4,204.264	2002	92.1%	6.0%	1.9%
2003	3,147.054	382.678	150.007	3,679.739	2003	85.5%	10.4%	4.1%
2004	2,282.844	196.963	55.674	2,535.481	2004	90.0%	7.8%	2.2%
2005	1,700.627	162.795	29.312	1,892.734	2005	89.9%	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%
2019	30.506	23.052	0.131	53.689	2019	56.8%	42.9%	0.2%

SUBDIVISION 22



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%
2019	3,882.004	1,592.857	41.981	5,516.842	2019	70.4%	28.9%	0.8%

SUBDIVISION 24



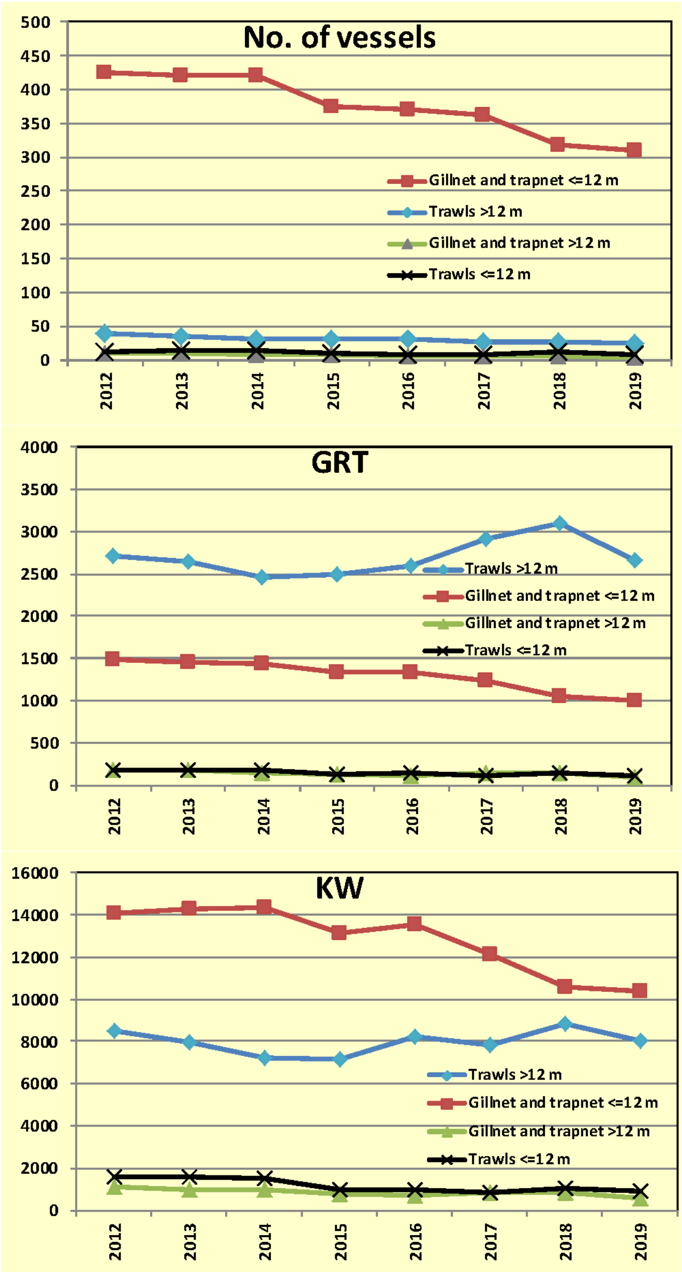
1.2 Fishing fleet

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 2012 until 2019 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 %):

	Type of gear	Vessel length (m)	No. of vessels	GRT	kW
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**
2019	**Fixed gears**	**<=12**	309	1,008	10,374
	(gillnet and trapnet)	**>12**	4	100	598
	Trawls	**<=12**	8	114	897
		>12	25	2,655	8,025
	TOTAL		**346**	**3,877**	**19,894**


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
2012
2013
2014
2015
2016
2017
2018
2019
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
2012
2013
2014
2015
2016
2017
2018
2019
KW
16000
14000
12000
10000
8000
6000
4000
2000
0
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m
2012
2013
2014
2015
2016
2017
2018
2019

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, 2 and 4 in 2019, are given below:

SD 24/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
January	1	55.9	0.0	0.0	0.0	55.9	100.0	0.0	0.0	0.0
	2									
	3									
	Mean	55.9	0.0	0.0	0.0	55.9	100.0	0.0	0.0	0.0
February	1	47.2	0.0	0.0	0.0	47.2	99.9	0.1	0.0	0.0
	2	69.4	0.0	0.0	0.0	69.4	100.0	0.0	0.0	0.0
	3									
	Mean	58.3	0.0	0.0	0.0	58.3	99.9	0.1	0.0	0.0
March	1	75.7	0.0	0.0	0.0	75.7	100.0	0.0	0.0	0.0
	2									
	3									
	Mean	75.7	0.0	0.0	0.0	75.7	100.0	0.0	0.0	0.0
Q I	Mean	63.3	0.0	0.0	0.0	63.3	100.0	0.0	0.0	0.0

SD 24/Quarter II		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
April	1	49.4	0.1	0.0	0.0	49.6	99.7	0.3	0.0	0.0
	2									
	3									
	Mean	49.4	0.1	0.0	0.0	49.6	99.7	0.3	0.0	0.0
May	1									
	2									
	Mean									
June	1									
	2									
	Mean									
Q II	Mean	49.4	0.1	0.0	0.0	49.6	99.7	0.3	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	42.0	0.2	0.0	0.0	42.2	99.6	0.4	0.0	0.0
	2									
	3									
	Mean	42.0	0.2	0.0	0.0	42.2	99.6	0.4	0.0	0.0
Decemb.	1	73.5	0.0	0.0	0.0	73.5	100.0	0.0	0.0	0.0
	2	67.3	0.0	0.0	0.0	67.3	100.0	0.0	0.0	0.0
	3									
	Mean	70.4	0.0	0.0	0.0	70.4	100.0	0.0	0.0	0.0
Q IV	Mean	56.2	0.1	0.0	0.0	56.3	99.8	0.2	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:

Quarter	Trawl landings (t)	Mean Contribution of Herring (%)	Total Herring corrected (t)	Difference (t)
I	**2,842.608**	100.0	2,842.608	0.000
II	**12.646**	99.7	12.613	-0.033
IV	**1,026.750**	99.8	1,024.925	-1.825

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 3,913 t – 2 t: <0.1 % difference).

1.4 Logbook registered discards/BMS landings

No BMS landings (new catch categories since 2015) of herring have been reported in the German herring fisheries in 2019 (no BMS landing have been reported since 2015). A total amount logbook registered discards (new catch categories since 2015) of 21.882 t were recorded by the German fisherman (as predation by seals?) in the gillnet/trapnet fisheries in SDs 22/24 in 2019 (2018/SD 24/gillnet fisheries: 14.510 t). Neither discards nor logbook registered discards have been reported before 2018.

		Trapnet			Gillnet			Total		
		27.3.c.22	27.3.d.24	Total	27.3.c.22	27.3.d.24	Total	27.3.c.22	27.3.d.24	Total
Month	1	0.000	0.000	0.000	0.000	0.050	0.050	0.000	0.050	0.050
	2	0.000	0.000	0.000	0.000	3.945	3.945	0.000	3.945	3.945
	3	0.000	0.000	0.000	0.000	11.667	11.667	0.000	11.667	11.667
	4	0.000	0.000	0.000	0.100	2.845	2.945	0.100	2.845	2.945
	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9	0.010	0.000	0.010	0.000	0.000	0.000	0.010	0.000	0.010
	10	0.005	0.090	0.095	0.000	0.050	0.050	0.005	0.140	0.145
	11	0.000	0.415	0.415	0.000	0.870	0.870	0.000	1.285	1.285
	12	0.000	0.285	0.285	0.000	1.550	1.550	0.000	1.835	1.835
Quarter	1	0.000	0.000	0.000	0.000	15.662	15.662	0.000	15.662	15.662
	2	0.000	0.000	0.000	0.100	2.845	2.945	0.100	2.845	2.945
	3	0.010	0.000	0.010	0.000	0.000	0.000	0.010	0.000	0.010
	4	0.005	0.790	0.795	0.000	2.470	2.470	0.005	3.260	3.265
Total		0.015	0.790	0.805	0.100	20.977	21.077	0.115	21.767	21.882

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 (no update for 2019, due CBH occurring in baseline samples in SD 21 and SD 23, 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 2019

2.1 Landings (tons) and sampling effort

Gear	Quarter	SKAGERRAK (DIVISION IIIaN/SD 20) Landings (tons)	No. samples	No. measured	No. aged	KATTEGAT (DIVISION IIIaS/SD21) Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	no landings	-	-	-	no landings	-	-	-
	Q 2	no landings	-	-	-	no landings	-	-	-
	Q 3	120.952	0	0	0	no landings	-	-	-
	Q 4	no landings	-	-	-	no landings	-	-	-
	Total	120.952	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	**120.952**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
	Q 4	**0.000**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
	Total	**120.952**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**

Gear	Quarter	SUBDIVISION 22 Landings (tons)	No. samples	No. measured	No. aged	SUBDIVISION 24 Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	30.218	0	0	0	2,842.608	4	1,809	455
	Q 2	0.203	0	0	0	12.646	1	591	105
	Q 3	0.000	-	-	-	0.000	-	-	-
	Q 4	0.085	0	0	0	1,026.750	3	1,430	369
	Total	30.506	0	0	0	3,882.004	8	3,830	929
GILLNET	Q 1	9.562	2	859	137	1,459.079	10	3,519	554
	Q 2	3.381	1	465	62	92.818	0	0	0
	Q 3	0.357	0	0	0	0.909	0	0	0
	Q 4	9.752	0	0	0	40.051	0	0	0
	Total	23.052	3	1,324	199	1,592.857	10	3,519	554
TRAPNET	Q 1	0.000	-	-	-	39.275	2	731	203
	Q 2	0.086	1	401	77	2.670	0	0	0
	Q 3	0.020	0	0	0	0.002	0	0	0
	Q 4	0.025	0	0	0	0.034	0	0	0
	Total	0.131	1	401	77	41.981	2	731	203
TOTAL	Q 1	**39.780**	**2**	**859**	**137**	**4,340.962**	**16**	**6,059**	**1,212**
	Q 2	**3.670**	**2**	**866**	**139**	**108.134**	**1**	**591**	**105**
	Q 3	**0.377**	**0**	**0**	**0**	**0.911**	**0**	**0**	**0**
	Q 4	**9.862**	**0**	**0**	**0**	**1,066.835**	**3**	**1,430**	**369**
	Total	**53.689**	**4**	**1,725**	**276**	**5,516.842**	**20**	**8,080**	**1,686**

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Gear	Quarter	TOTAL (DIV. IIIa & SUBDIV. 22+24) Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	2,872.826	4	1,809	455
	Q 2	12.849	1	591	105
	Q 3	120.952	0	0	0
	Q 4	1,026.835	3	1,430	369
	Total	4,033.462	8	3,830	929
GILLNET	Q 1	1,468.641	12	4,378	691
	Q 2	96.199	1	465	62
	Q 3	1.266	0	0	0
	Q 4	49.803	0	0	0
	Total	1,615.909	13	4,843	753
TRAPNET	Q 1	39.275	2	731	203
	Q 2	2.756	1	401	77
	Q 3	0.022	0	0	0
	Q 4	0.059	0	0	0
	Total	42.112	3	1,132	280
TOTAL	Q 1	4,380.742	18	6,918	1,349
	Q 2	111.804	3	1,457	244
	Q 3	122.240	0	0	0
	Q 4	1,076.697	3	1,430	369
	Total	5,691.483	24	9,805	1,962

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2.2 Catch in numbers (millions)

		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								0.000				0.047				0.047
	1					0.002			0.000	0.195			0.401	0.197			0.401
	2					0.008	0.001		0.000	0.798	0.032		2.099	0.806	0.032		2.100
	3					0.026	0.001		0.000	2.481	0.068		1.699	2.507	0.069		1.699
	4					0.059	0.000		0.000	5.560	0.028		1.676	5.619	0.029		1.676
	5					0.026	0.000		0.000	2.490	0.013		0.965	2.516	0.014		0.965
	6					0.066	0.000		0.000	6.254	0.006		1.256	6.320	0.006		1.256
	7					0.015	0.000		0.000	1.429	0.002		0.174	1.445	0.002		0.174
	8+					0.016	0.000		0.000	1.519	0.002		0.151	1.535	0.002		0.151
	Sum					0.220	0.002		0.001	20.725	0.151		8.468	20.945	0.154		8.469
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0																
	1																
	2																
	3					0.003	0.0000	0.000	0.000	0.023	0.001	0.000	0.001	0.026	0.001	0.000	0.001
	4					0.008	0.001	0.000	0.002	**0.615**	0.016	0.000	0.007	0.622	0.017	0.000	0.009
	5					0.004	0.006	0.001	0.018	**1.505**	0.171	0.002	0.074	1.509	0.178	0.002	0.092
	6					0.026	0.006	0.001	0.017	**3.924**	0.166	0.002	0.072	3.950	0.172	0.002	0.089
	7					0.013	0.006	0.001	0.018	**1.192**	0.170	0.002	0.073	1.205	0.176	0.002	0.091
	8+					0.006	0.002	0.000	0.005	**0.780**	0.046	0.000	0.020	0.786	0.048	0.001	0.025
	Sum					0.059	0.021	0.002	0.060	**8.039**	0.571	0.006	0.246	8.098	0.591	0.008	0.306
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0																
	1																
	2						0.0001	0.000	0.0000	0.020	0.004	0.0000	0.000	0.020	0.004	0.000	0.0001
	3						0.0008	0.000	0.0002	0.079	0.023	0.0000	0.000	0.079	0.024	0.000	0.0005
	4						0.0003	0.000	0.0001	0.157	0.008	0.0000	0.000	0.157	0.009	0.000	0.0002
	5						0.0000	0.000	0.0000	0.034	0.001	0.0000	0.000	0.034	0.001	0.000	0.0000
	6						0.0000	0.000	0.0000	0.062	0.001	0.0000	0.000	0.062	0.001	0.000	0.0000
	7						0.0000	0.000	0.0000	0.014	0.000	0.0000	0.000	0.014	0.000	0.000	0.0000
	8+						0.000	0.000	0.0000	0.013	0.000	0.0000	0.000	0.013	0.000	0.000	0.0000
	Sum						0.001	0.000	0.0003	0.378	0.037	0.0000	0.000	0.378	0.038	0.000	0.0008
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								0.000				0.047				0.047
	1					0.002			0.0000	0.195			0.401	0.197			0.401
	2					0.0085	0.001	0.000	0.0002	0.818	0.036	0.000	2.099	0.826	0.036	0.000	2.100
	3					0.029	0.002	0.000	0.0005	2.583	0.093	0.000	1.699	2.612	0.095	0.000	1.700
	4					0.067	0.001	0.000	0.0019	6.331	0.052	0.000	1.683	6.398	0.054	0.000	1.685
	5					0.031	0.006	0.001	0.0181	4.029	0.185	0.002	1.039	4.059	0.192	0.002	1.057
	6					0.092	0.006	0.001	0.0175	10.240	0.172	0.002	1.327	10.332	0.179	0.002	1.345
	7					0.028	0.006	0.001	0.0179	2.635	0.172	0.002	0.247	2.664	0.178	0.002	0.265
	8+					0.022	0.002	0.000	0.0049	2.312	0.048	0.000	0.171	2.334	0.050	0.001	0.176
	Sum					0.279	0.024	0.002	0.0610	29.142	0.759	0.006	8.715	29.421	0.783	0.008	8.776

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	24	Trawl	1	Gillnet	2, 3, 4	22	Gillnet	2
Trawl	2	24	Trawl	2	Trapn	2, 3, 4	22	Trapn	2
Trawl	4	24	Trawl	4					
Gillnet	3, 4	22	Gillnet	2					
Trapn	3, 4	22	Trapn	2					

2.3 Mean weight (grammes) 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								16.0				16.0				16.0
	1					17.0			46.7	17.0			46.7	17.0			46.7
	2					53.1	60.4		80.2	53.1	60.4		80.2	53.1	60.4		80.2
	3					79.6	76.4		98.4	79.6	76.4		98.4	79.6	76.4		98.4
	4					122.5	87.1		143.9	122.5	87.1		143.9	122.5	87.1		143.9
	5					136.3	123.1		154.8	136.3	123.1		154.8	136.3	123.1		154.8
	6					166.3	140.8		178.1	166.3	140.8		178.1	166.3	140.8		178.1
	7					178.7	147.5		176.0	178.7	147.5		176.0	178.7	147.5		176.0
	8+					186.5	155.8		177.7	186.5	155.8		177.7	186.5	155.8		177.7
	Sum					137.2	83.7		121.3	137.2	83.7		121.3	137.2	83.7		121.3
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0																
	1																
	2																
	3					125.9	88.9	88.9	88.9	140.4	88.9	88.9	88.9	138.9	88.9	88.9	88.9
	4					145.9	134.3	134.3	134.3	156.4	134.3	134.3	134.3	156.2	134.3	134.3	134.3
	5					146.9	160.9	160.9	160.9	172.9	160.9	160.9	160.9	172.9	160.9	160.9	160.9
	6					165.4	161.9	161.9	161.9	182.2	161.9	161.9	161.9	182.1	161.9	161.9	161.9
	7					169.2	164.8	164.8	164.8	190.4	164.8	164.8	164.8	190.1	164.8	164.8	164.8
	8+					181.7	176.3	176.3	176.3	201.9	176.3	176.3	176.3	201.8	176.3	176.3	176.3
	Sum					162.1	162.7	162.7	162.7	181.5	162.7	162.7	162.7	181.4	162.7	162.7	162.7
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0																
	1																
	2						54.1	54.1	54.1	58.0	54.1	54.1	54.1	58.0	54.1	54.1	54.1
	3						68.0	68.0	68.0	81.3	68.0	68.0	68.0	81.3	68.0	68.0	68.0
	4						81.0	81.0	81.0	101.0	81.0	81.0	81.0	101.0	81.0	81.0	81.0
	5						104.9	104.9	104.9	109.2	104.9	104.9	104.9	109.2	104.9	104.9	104.9
	6						126.8	126.8	126.8	136.3	126.8	126.8	126.8	136.3	126.8	126.8	126.8
	7						118.9	118.9	118.9	123.8	118.9	118.9	118.9	123.8	118.9	118.9	118.9
	8+						117.3	117.3	117.3	153.5	117.3	117.3	117.3	153.5	117.3	117.3	117.3
	Sum						71.7	71.7	71.7	103.8	71.7	71.7	71.7	103.8	71.7	71.7	71.7
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								16.0				16.0				16.0
	1					17.0			46.7	17.0			46.7	17.0			46.7
	2					53.1	59.2	54.1	75.8	53.2	59.8	54.1	80.2	53.2	59.8	54.1	80.2
	3					83.9	73.3	68.6	82.2	80.2	74.4	76.5	98.3	80.3	74.4	69.7	98.3
	4					125.3	106.9	107.5	132.8	125.3	100.5	132.2	143.8	125.3	100.6	121.6	143.8
	5					137.7	159.5	160.4	160.9	149.8	158.0	160.9	155.3	149.7	158.0	160.8	155.4
	6					166.1	161.4	161.6	162.0	172.2	161.0	161.9	177.3	172.2	161.0	161.8	177.1
	7					174.3	164.6	164.7	164.8	183.7	164.5	164.7	172.6	183.6	164.5	164.7	172.1
	8+					185.3	175.9	176.1	176.3	191.5	175.4	176.3	177.5	191.5	175.5	176.3	177.5
	Sum					142.4	150.4	152.4	161.7	149.0	142.5	162.2	122.4	148.9	142.7	159.2	122.7

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	24	Trawl	1	Gillnet	2, 3, 4	22	Gillnet	2
Trawl	2	24	Trawl	2	Trapn	2, 3, 4	22	Trapn	2
Trawl	4	24	Trawl	4					
Gillnet	3, 4	22	Gillnet	2					
Trapn	3, 4	22	Trapn	2					

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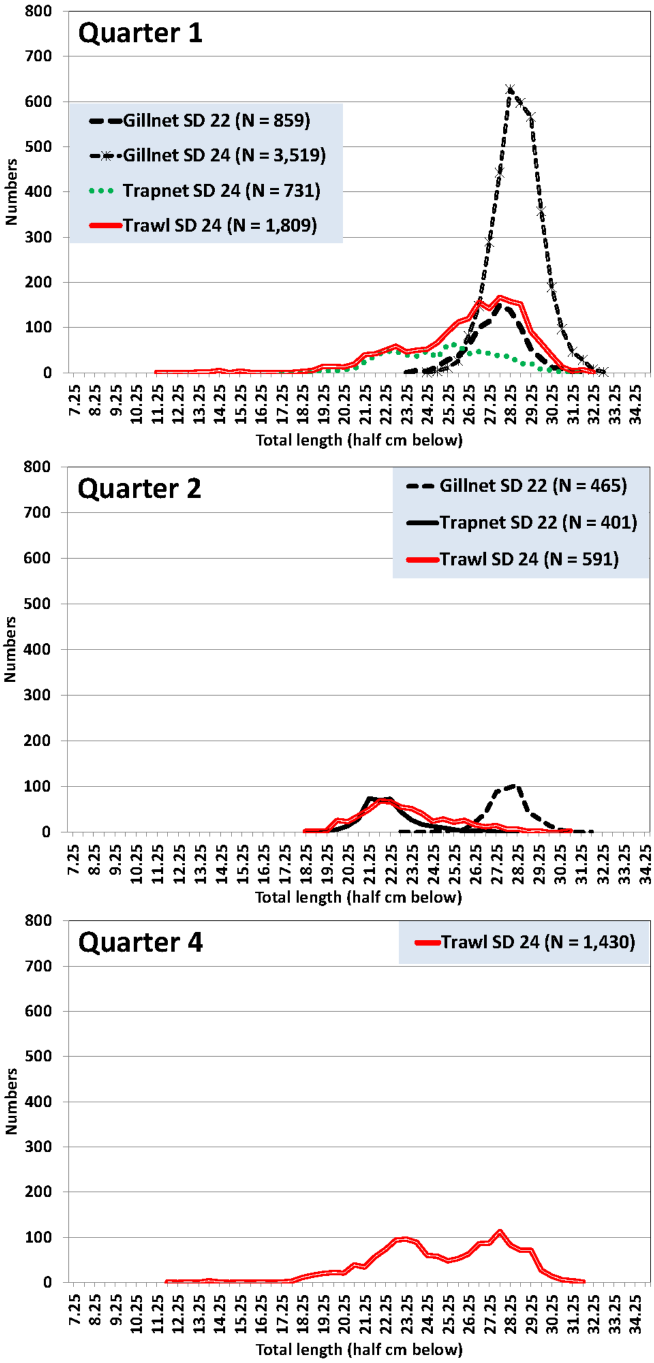
2.4 Mean length (cm) in the catch

		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								13.6				13.6				13.6
	1					14.3			19.3	14.3			19.3	14.3			19.3
	2					20.3	21.0		22.7	20.3	21.0		22.7	20.3	21.0		22.7
	3					22.7	22.6		24.0	22.7	22.6		24.0	22.7	22.6		24.0
	4					25.5	23.4		26.5	25.5	23.4		26.5	25.5	23.4		26.5
	5					26.3	26.0		27.0	26.3	26.0		27.0	26.3	26.0		27.0
	6					28.0	27.2		28.3	28.0	27.2		28.3	28.0	27.2		28.3
	7					28.7	28.2		28.2	28.7	28.2		28.2	28.7	28.2		28.2
	8+					29.1	28.7		28.1	29.1	28.7		28.1	29.1	28.7		28.1
	Sum					26.2	23.1		25.0	26.2	23.1		25.0	26.2	23.1		25.0
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0																
	1																
	2																
	3					25.3	22.8	22.8	22.8	26.0	22.8	22.8	22.8	26.0	22.8	22.8	22.8
	4					26.5	25.9	25.9	25.9	27.0	25.9	25.9	25.9	27.0	25.9	25.9	25.9
	5					26.6	27.7	27.7	27.7	28.1	27.7	27.7	27.7	28.0	27.7	27.7	27.7
	6					27.8	27.8	27.8	27.8	28.7	27.8	27.8	27.8	28.6	27.8	27.8	27.8
	7					28.1	27.9	27.9	27.9	29.2	27.9	27.9	27.9	29.2	27.9	27.9	27.9
	8+					29.1	28.9	28.9	28.9	29.9	28.9	28.9	28.9	29.9	28.9	28.9	28.9
	Sum					27.7	27.8	27.8	27.8	28.6	27.8	27.8	27.8	28.6	27.8	27.8	27.8
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0																
	1																
	2						20.3	20.3	20.3	20.9	20.3	20.3	20.3	20.9	20.3	20.3	20.3
	3						21.9	21.9	21.9	23.3	21.9	21.9	21.9	23.3	21.9	21.9	21.9
	4						23.1	23.1	23.1	24.8	23.1	23.1	23.1	24.8	23.1	23.1	23.1
	5						24.9	24.9	24.9	25.5	24.9	24.9	24.9	25.5	24.9	24.9	24.9
	6						26.4	26.4	26.4	27.5	26.4	26.4	26.4	27.5	26.4	26.4	26.4
	7						26.3	26.3	26.3	26.5	26.3	26.3	26.3	26.5	26.3	26.3	26.3
	8+						26.3	26.3	26.3	28.9	26.3	26.3	26.3	28.9	26.3	26.3	26.3
	Sum						22.2	22.2	22.2	25.0	22.2	22.2	22.2	25.0	22.2	22.2	22.2
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								13.6				13.6				13.6
	1					14.3			19.3	14.3			19.3	14.3			19.3
	2					20.3	20.9	20.3	22.3	20.3	21.0	20.3	22.7	20.3	20.9	20.3	22.7
	3					23.0	22.3	22.0	22.7	22.8	22.4	22.3	24.0	22.8	22.4	22.0	24.0
	4					25.6	24.5	24.5	25.9	25.7	24.1	25.8	26.5	25.7	24.1	25.2	26.5
	5					26.3	27.6	27.7	27.7	26.9	27.5	27.7	27.0	26.9	27.5	27.7	27.1
	6					27.9	27.8	27.8	27.8	28.2	27.8	27.8	28.3	28.2	27.8	27.8	28.2
	7					28.4	27.9	27.9	27.9	28.9	27.9	27.9	28.1	28.9	27.9	27.9	28.1
	8+					29.1	28.9	28.9	28.9	29.4	28.9	28.9	28.2	29.4	28.9	28.9	28.3
	Sum					26.5	27.1	27.2	27.8	26.8	26.6	27.8	25.1	26.8	26.6	27.6	25.1

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	24	Trawl	1	Gillnet	2, 3, 4	22	Gillnet	2
Trawl	2	24	Trawl	2	Trapn	2, 3, 4	22	Trapn	2
Trawl	4	24	Trawl	4					
Gillnet	3, 4	22	Gillnet	2					
Trapn	3, 4	22	Trapn	2					

2.5 Sampled length distributions by Subdivision, quarter and type of gear



HAWG 2020 WD02

Working Document XX **Herring Assessment WG for the area South of 62° North (HAWG)/WBSSH**
17 – 25 March 2020

2019 Western Baltic spring spawning herring recruitment monitored by the Rügen Herring Larvae Survey

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The waters of Greifswald Bay (ICES area 24) are considered a major spawning area of Western Baltic spring spawning (WBSS) herring. The German Thünen Institute of Baltic Sea Fisheries (TI-OF), Rostock, and its predecessor monitors the density of herring larvae as a vector of recruitment success since 1977 within the framework of the Rügen Herring Larvae Survey (RHLS). It delivers a unique high-resolution dataset on the herring larvae ecology in the Western Baltic, both temporally and spatially. Onboard the research vessel FFS CLUPEA a sampling grid including 35 stations is sampled weekly using ichthyoplankton gear (Bongo-net, mesh size 335 µm) during the main reproduction period from March to June. The weekly assessment of the entire sampling area is conducted within two days (detailed description of the survey design can be found in Polte 2013, ICES WD08). The collected data provide an important baseline for detailed investigations of spawning and recruitment ecology of WBSS herring spawning components. As a fishery-independent indicator of stock development, the recruitment index is incorporated into the assessment of the ICES Herring Assessment Working Group (HAWG).
The rationale for the *N20* recruitment index is based on strong correlations between the amount of larvae reaching a length of 20 mm (TL) in Greifswald Bay and abundance data of juveniles (1-wr and 2-wr fish) as determined by acoustic surveys in the Arkona and Belt Seas (GERAS).
This correlation supports the underlying hypotheses that i) major variability of natural mortality occurs at early life stages before larvae reach a total length of 20 mm and ii) larval herring production in Greifswald Bay is an adequate proxy for annual recruitment strength of the WBSS herring stock.
The *N20* recruitment index is calculated every year based on data obtained from the RHLS. This is done by estimating weekly growth of larvae for seasonal temperature change and taking the sum of larvae reaching 20 mm by every survey week until the end of the investigation period. On the spatial scale, the 35 sampling stations are assigned to 5 strata and mean values of stations for each stratum are extrapolated to the strata area (for details see Oeberst et. al 2009).
Calculation procedures have been 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.

2019 N20 index results:

The regular Rügen-herring larvae Survey started on March 11th and was conducted until June 26th, over a 17-week period.
With an estimated product of **1317 million** larvae, the 2019 *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.

2019 additional survey observations:

Additionally, on two dates in February (start Feb. 26nd) and November (start Nov 11th) control surveys were conducted testing for winter and autumn larvae respectively. Using the standard Bongo net and a 1550 µm CalCofi net the presence of advanced larvae stages in the system was investigated (Polte et al. 2017). During February limited numbers of post-flexion larvae assigned to herring spawning in November 2018 by otolith microstructure analysis were detected (Janke 2019). However, during November 2019 no larvae were found in Greifswald Bay in samples taken with both sampling gear. However, scientific gill net sampling for spawning fish during November 2019 resulted in about 10% of herring present in the system at maturity stage ≥ 5.

Table 1: *N20* larval herring index for spring spawning herring of the Western Baltic Sea (WBSS), generated by RHLS data.

Year	N20 (Millions)
1992	1,060
1993	3,044
1994	12,515
1995	7,930
1996	21,012
1997	4,872
1998	16,743
1999	20,364
2000	3,026
2001	4,845
2002	11,324
2003	5,507
2004	5,640
2005	3,887
2006	3,774
2007	1,829
2008	1,622
2009	6,464
2010	7,037
2011	4,444
2012	1,140
2013	3,021
2014	539
2015	2,478
2016	442
2017	1,247
2018	1,563
2019	1,317

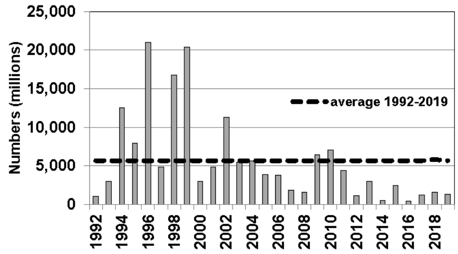

Figure 1 Time series of the N20 index

Revision of the relation between N20 and GERAS 1-wr herring after years with low larvae production

After multiple years with the record low N20 (2014,2016), the relation with the 1-group juveniles as monitored by the German hydroacoustic survey (GERAS) was re-evaluated to see if recent years with extremely low larvae production are reflected in the abundance of 1-wr juveniles on the scale of the western Baltic Sea. The results reveal an unchanged and strong 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).

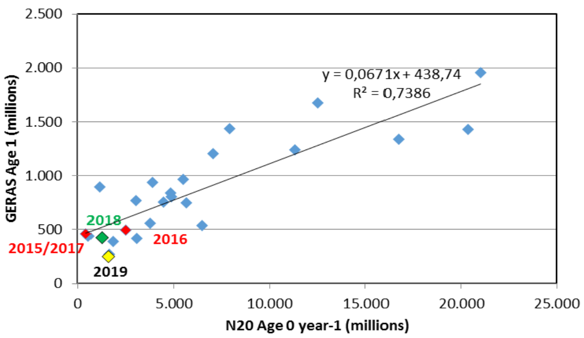

Figure 3 Correlation of N20 larvae index (1993-2018) with the 1-wr herring from GERAS (1994-2019). Note: The one-year lag phase between indices. E.g. the exceptionally low N20 year 2016 is represented by the GERAS 1-wr index 2017.

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HAWG 2020 WD03

PFA
Pelagic Freezer-Trawler Association

REPORT

PFA self-sampling report for North Sea herring fisheries, 2015-2020

Including sprat and pilchard

M.A. Pastoors, F.J. Quirijns

PFA report 2020/06
18/03/2020 12:45:45

Pelagic Freezer-trawler Association (PFA)

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Please cite as:

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1 Introduction

The Pelagic Freezer-trawler Association (PFA) is an association that has nine member companies that together operate 17 (in 2019) 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 by 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 PFA self-sampling programme has been implemented incrementally on many vessels that belong to the members of the PFA. 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 relevant information for documenting the performance of the fishery and to assist stock assessments of the stocks involved. The following main elements can be distinguished in the self-sampling protocol:

- haul information (date, time, position, weather conditions, environmental conditions, gear attributed, estimated catch, optionally: species composition)
- batch information (total catch per batch=production unit, including variables like species, average size, average weight, fat content, gonads y/n and stomach fill)
- linking batch and haul information (essentially a key of how much of a batch is caught in which of the hauls)
- length information (length frequency measurements, either by batch or by haul)

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.

A major 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 by species because not all vessels have supplied data on the species composition of the catch.

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.

For this report, the PFA self-sampling data has been filtered using the following criteria:

- hauls in divisions 27.4.a, 27.4.b, 27.4.c, 27.7.d, 27.7.e
- catch of her, spr, pil by trip and week at least 10% of the total catch of that trip and week.
- catch of her, spr, pil by trip and week at least 10 tonnes.

3 Results

3.1 General summary of self-sampling for herring, sprat and pilchards fisheries in the North Sea and adjacent waters**

An overview of all the self-sampled trips for her, spr, pil in 27.4.a, 27.4.b, 27.4.c, 27.7.d, 27.7.e

year	nvessels	ntrips	ndays	nhauls	catch	nlength	catch/trip	catch/day	catch/haul
2015	8	40	391	974	73,351	38,035	1,833	187	75
2016	10	52	539	1,417	144,712	48,645	2,782	268	102
2017	11	47	451	1,202	111,504	39,440	2,372	247	92
2018	15	84	870	2,259	201,830	98,032	2,402	231	89
2019	14	69	712	1,871	144,158	56,007	2,089	202	77
2020*	4	4	8	13	998	552	249	124	76
(all)	.	296	2,971	7,736	676,553	280,711	.	.	.

Table 3.1.1: PFA selfsampling summary of hauls for her, spr, pil in 27.4.a, 27.4.b, 27.4.c, 27.7.d, 27.7.e with the number of days, hauls, trips, vessels, catch (tonnes), number of fish measured, catch rates (ton/day) by year

Catch by species in the selected fisheries

species	english_name	scientific_name	2015	2016	2017	2018	2019	2020*	all
her	herring	Clupea harengus	56,550	109,756	93,253	172,076	132,051	199	563,886
mac	mackerel	Scomber scombrus	6,824	8,266	7,918	20,481	7,793	1	51,284
hom	horse mackerel	Trachurus trachurus	5,089	5,854	5,567	5,772	3,566	5	25,852
pil	pilchard	Sardina pilchardus	1,706	17,352	1,521	1,207	330	0	22,116
spr	sprat	Sprattus sprattus	2,749	2,338	3,002	2,037	64	794	10,983
ane	anchovy	Engraulis encrasicolus	279	870	97	10	1	0	1,257
pok	saithe	Pollachius virens	36	64	56	146	60	0	361
whb	blue whiting	Micromesistius poutassou	1	0	0	0	219	0	220
mzz	other fish	Osteichthyes	60	63	37	0	0	0	160
whg	whiting	Merlangius merlangus	12	42	25	34	46	0	159
oth	NA	NA	47	107	29	68	29	0	280
(all)	(all)	(all)	73,351	144,712	111,504	201,831	144,159	999	676,557

Table 3.1.2: PFA selfsampling summary of total catch (ton) by species and year for hauls that have been selected as part of the (extended) North Sea herring fisheries.

Haul positions

An overview of all self-sampled hauls in the selected fisheries where North Sea herring (or sprat, pilchard) was caught.

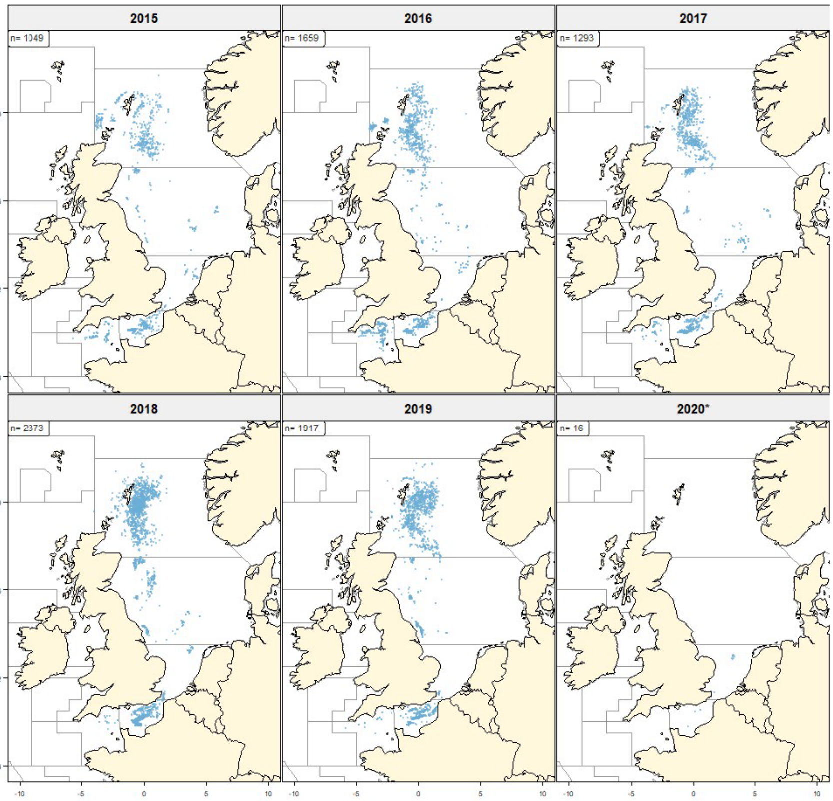

Figure 3.1.1: Haul positions in PFA self-sampled North Sea herring fisheries. N indicates the number of hauls.

3.2 North Sea herring

An overview of self-sampling for North Sea herring.

species	division	year	nvessels	ntrips	ndays	nhauls	catch	nlength	catch/day
her	27.4.a	2015	7	24	190	422	36,159	22,022	190
her	27.4.a	2016	10	27	271	652	72,503	26,221	267
her	27.4.a	2017	9	26	249	620	59,392	24,873	238
her	27.4.a	2018	14	51	454	1,156	106,252	58,621	234
her	27.4.a	2019	12	40	385	935	73,114	28,752	189
her	27.4.b	2015	5	13	32	51	5,452	1,749	170
her	27.4.b	2016	10	21	68	131	16,172	3,530	237
her	27.4.b	2017	10	17	66	154	15,352	6,003	232
her	27.4.b	2018	12	22	144	297	33,724	13,466	234
her	27.4.b	2019	10	20	116	249	26,823	11,797	231
her	27.4.c	2015	2	2	2	3	83	0	41
her	27.4.c	2016	3	3	4	6	283	0	70
her	27.4.c	2017	1	2	3	4	213	0	71
her	27.4.c	2018	5	8	15	17	1,104	0	73
her	27.4.c	2019	3	4	8	12	745	61	93
her	27.4.c	2020*	2	2	2	2	155	0	77
her	27.7.d	2015	8	13	74	240	14,854	10,354	200
her	27.7.d	2016	7	15	77	245	20,266	11,138	263
her	27.7.d	2017	9	12	78	258	18,294	8,563	234
her	27.7.d	2018	11	19	143	492	30,573	18,125	213
her	27.7.d	2019	12	21	156	508	31,187	13,767	199
her	27.7.d	2020*	2	2	2	2	42	83	21
her	other	2015	1	1	2	2	0	0	0
her	other	2016	1	2	7	12	530	0	75
her	other	2018	3	3	4	5	421	0	105
her	other	2019	2	2	2	3	179	0	89
her	(all)	2015		53	300	718	56,548	34,125	
her	(all)	2016		68	427	1,046	109,754	40,889	
her	(all)	2017		57	396	1,036	93,251	39,439	
her	(all)	2018		103	760	1,967	172,074	90,212	
her	(all)	2019		87	667	1,707	132,048	54,377	
her	(all)	2020*		4	4	4	197	83	
her	(all)	(all)		372	2,554	6,478	563,872	259,125	

Table 3.2.1: PFA selfsampling summary for herring by year and division for hauls that have been selected as part of the (extended) North Sea herring fisheries.

Total catch of herring by rectangle

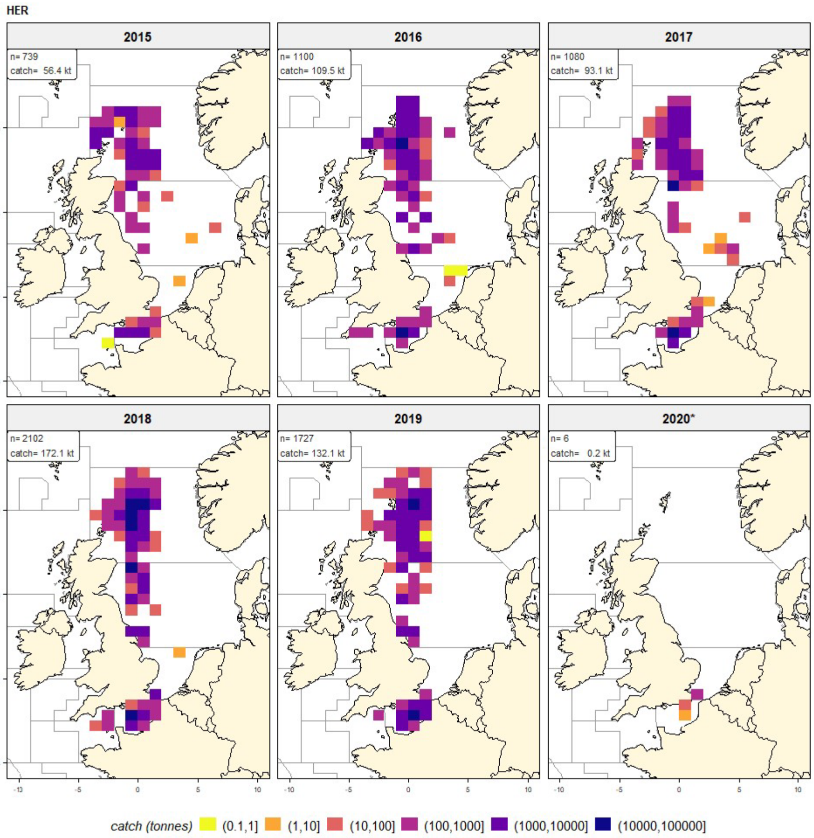

Figure 3.2.1: Herring catch by rectangle in PFA self-sampled North Sea herring fisheries. N indicates the number of hauls and total refers to the total herring catch (ton) for that year.

Catch rates (ton/day) of herring by rectangle

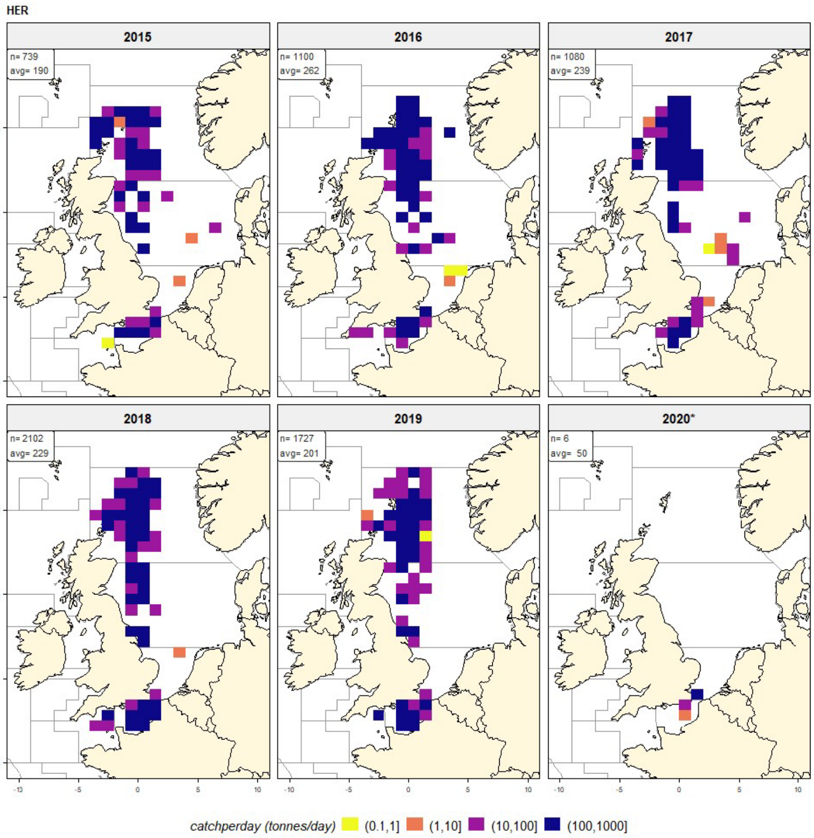

Figure 3.2.2: Herring catchrate (catch/day) by rectangle in PFA self-sampled North Sea herring fisheries. N indicates the number of hauls and avg refers to the average herring catch by day (ton/day) for that year.

Catch rates (ton/day) of the herring summer fisheries by year, month and 1/4th rectangle

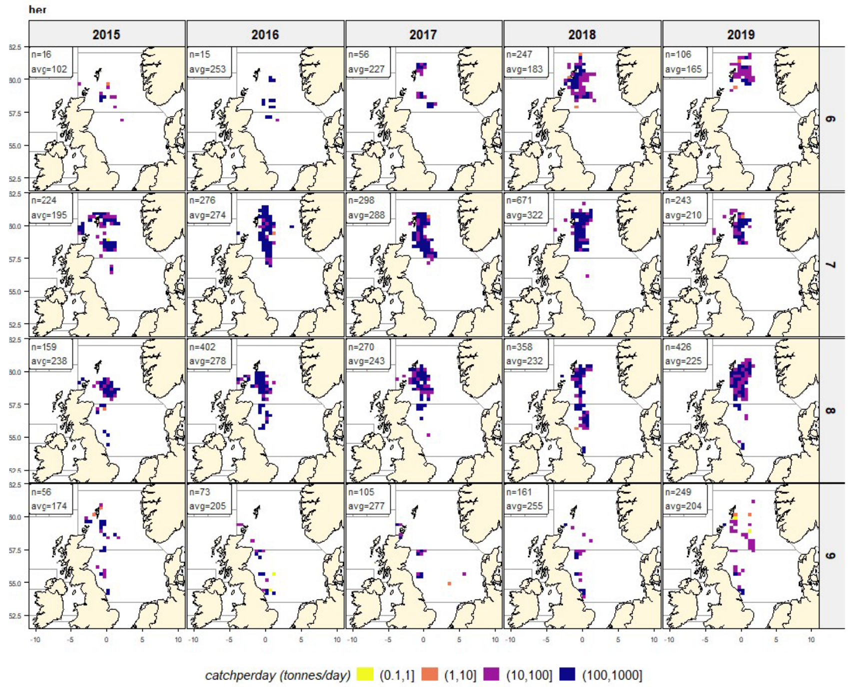

Figure 3.2.3: Herring catchrate (catch/day) in the summer fishery by year and month and by 1/4th rectangle. N indicates the number of hauls and avg refers to the average herring catch by day (ton/day) for that year/month combination.

Catch rates (ton/day) of the herring december fisheries by year and 1/4th rectangle

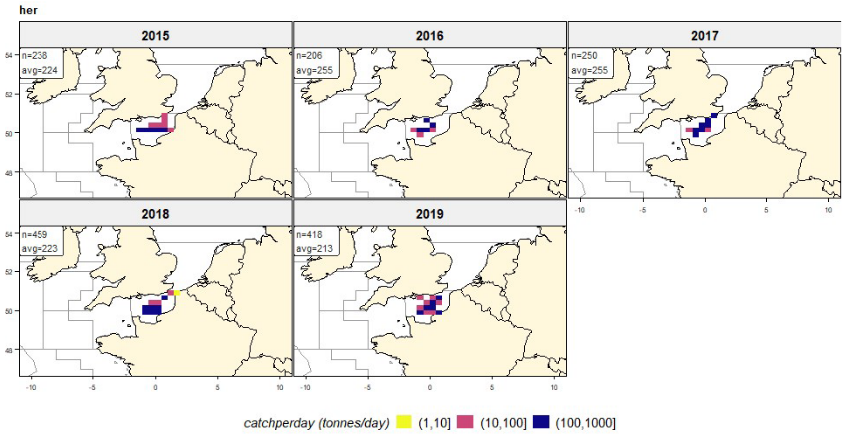

Figure 3.2.4: Herring catchrate (catch/day) in the december fishery by year and by 1/4th rectangle. N indicates the number of hauls and avg refers to the average herring catch by day (ton/day) for that year.

Relative length distributions of herring by year

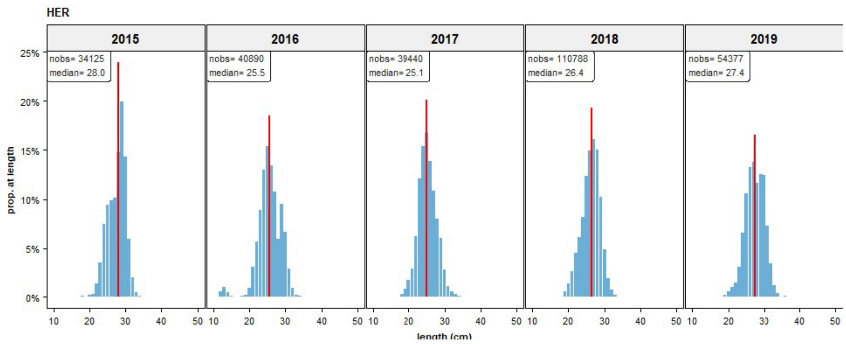

Figure 3.2.5: Herring relative length distributions in PFA self-sampled North Sea herring fisheries. Nobs indicates the number of measurements and median indicates the median size in cm

Average weight, fat and weight-fat relationship of herring by year and by year and division

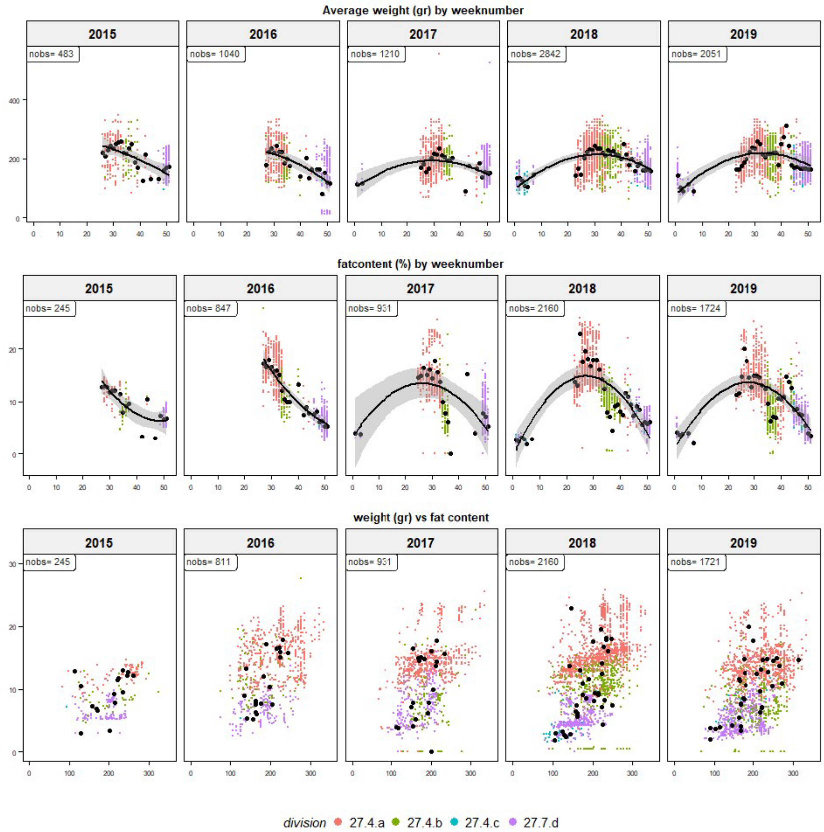

Figure 3.2.6: Average weight, fat content and weight-fat relationship in PFA self-sampled North Sea herring fisheries. Nobs indicates the number of measurements and median indicates the median size in cm

Herring Relative length distributions by year and division

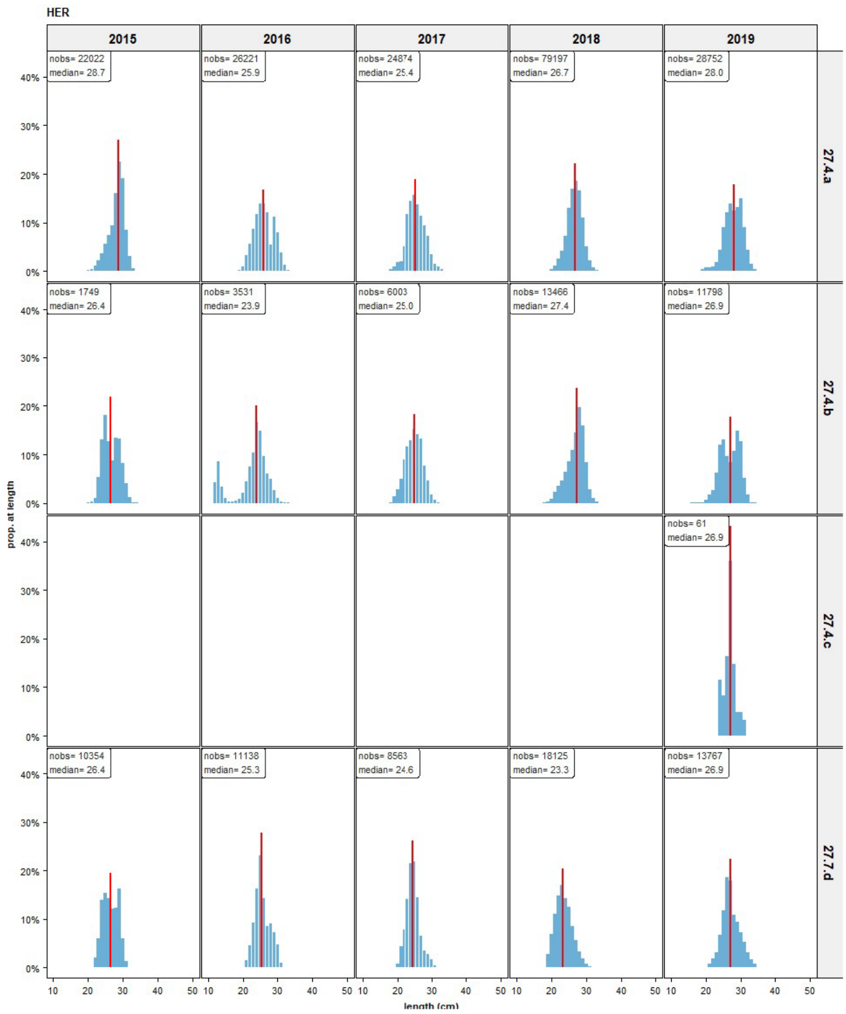

Figure 3.2.7: Herring relative length distributions by year and division in PFA self-sampled North Sea herring fisheries. Nobs indicates the number of length measurements and median refers to the median length (cm) for that year and division.

Herring Average fat content by year and division

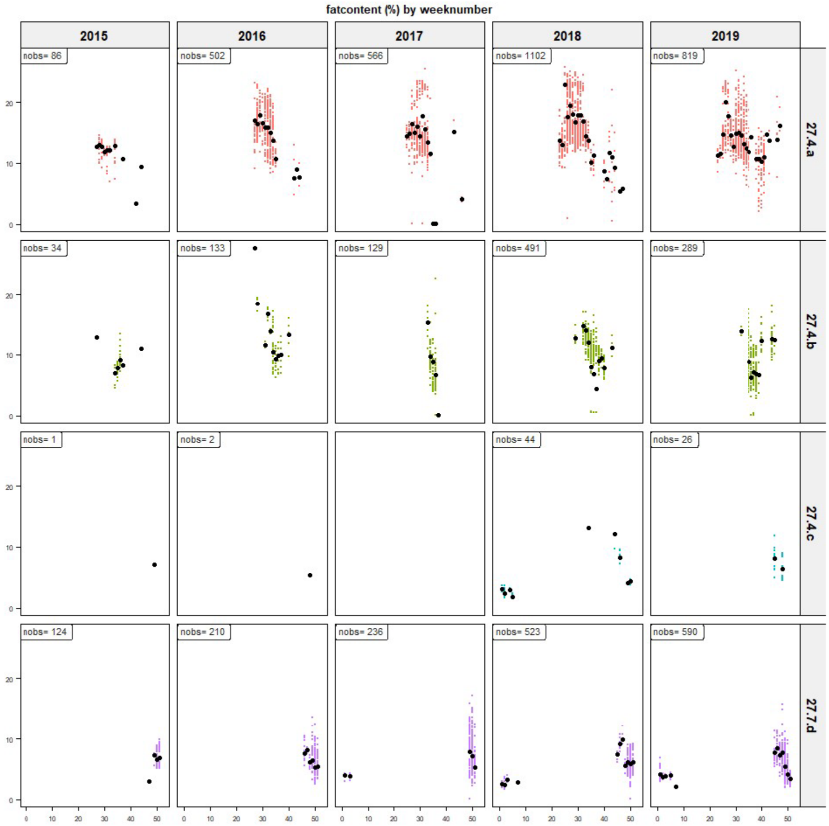

Figure 3.2.8: Herring fat content (%) by year and division in PFA self-sampled North Sea herring fisheries. Nobs indicates the number of batches for which average fat content has been measured. Grey dots indicate fat measurements of individual batches while blue dots indicate the average fat content for that week.

3.3 North Sea sprat

An overview of self-sampling for North Sea sprat.

species	division	year	nvessels	ntrips	ndays	nhauls	catch	nlength	catch/day
spr	27.4.b	2015	2	3	8	15	1,215	0	151
spr	27.4.b	2016	4	4	6	13	477	468	79
spr	27.4.b	2017	3	4	12	32	2,616	0	218
spr	27.4.b	2018	2	2	6	16	547	3,660	91
spr	27.4.b	2019	1	1	1	1	13	314	13
spr	27.4.c	2015	2	2	9	17	772	0	85
spr	27.4.c	2016	3	3	8	18	1,026	0	128
spr	27.4.c	2018	2	2	4	14	1,489	1,908	372
spr	27.4.c	2020*	3	3	4	8	793	469	198
spr	27.7.e	2015	2	2	4	7	760	0	190
spr	27.7.e	2016	3	3	8	16	833	0	104
spr	27.7.e	2017	3	3	5	10	385	0	77
spr	27.7.e	2019	1	1	2	4	50	546	25
spr	(all)	2015		7	21	39	2,747	0	
spr	(all)	2016		10	22	47	2,336	468	
spr	(all)	2017		7	17	42	3,001	0	
spr	(all)	2018		4	10	30	2,036	5,568	
spr	(all)	2019		2	3	5	63	860	
spr	(all)	2020*		3	4	8	793	469	
spr	(all)	(all)		33	77	171	10,976	7,365	

Table 3.3.1: PFA selfsampling summary for Sprat by year and division for hauls that have been selected as part of the (extended) North Sea herring fisheries.

Sprat Total catch by rectangle

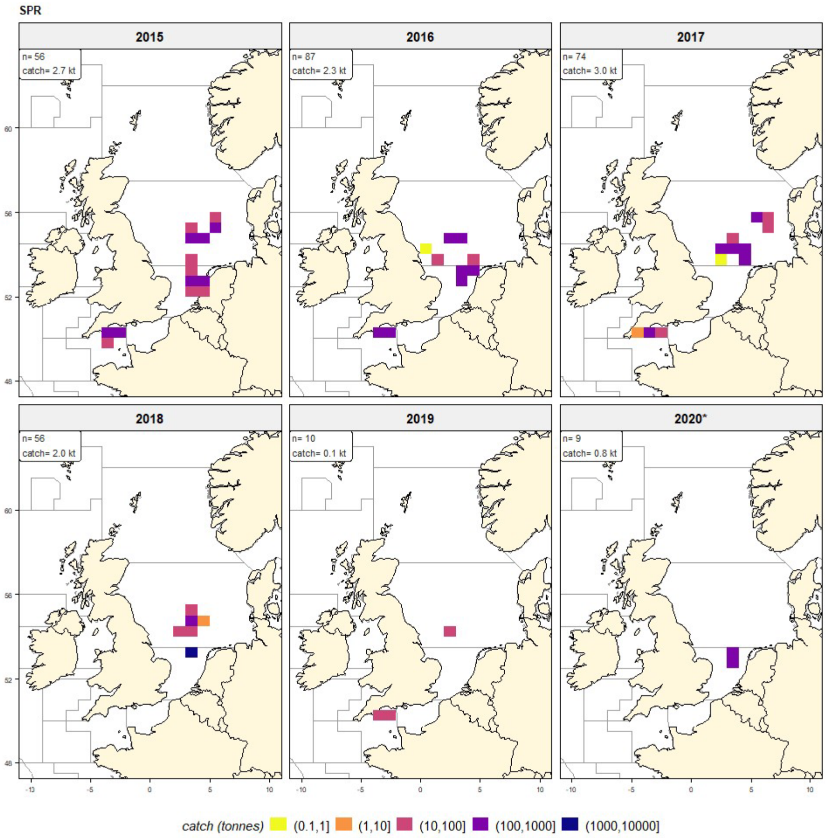

Figure 3.3.1: Sprat catch by rectangle in PFA self-sampled North Sea herring fisheries. N indicates the number of hauls and total refers to the total herring catch (ton) for that year.

Sprat Catch rates (ton/day) by rectangle

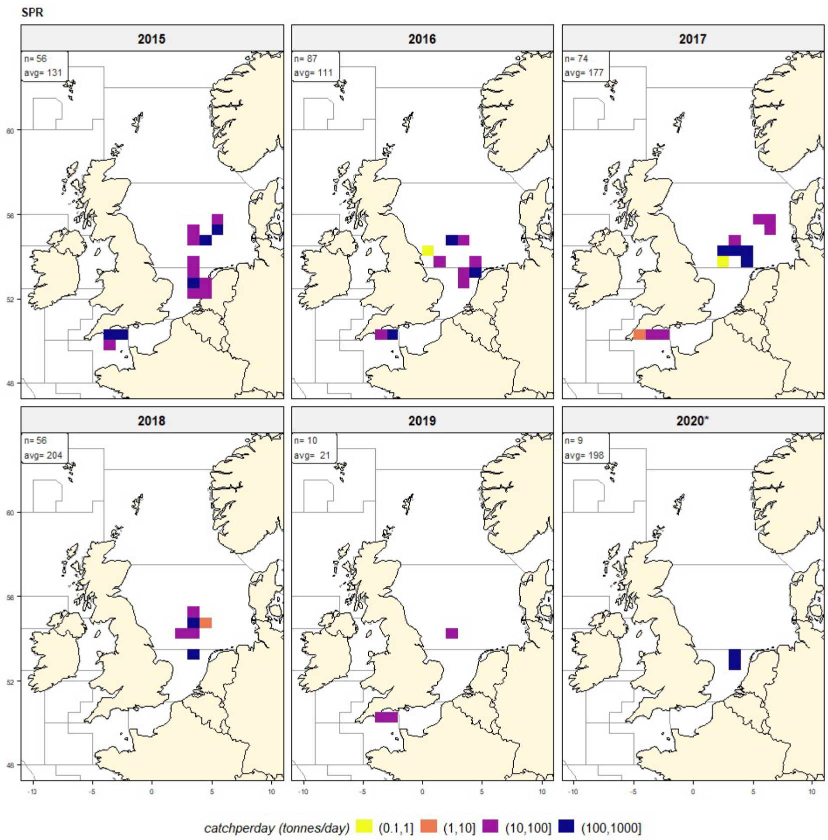

Figure 3.3.2: Sprat catchrate (catch/day) by rectangle in PFA self-sampled North Sea herring fisheries. N indicates the number of hauls and avg refers to the average herring catch by day (ton/day) for that year.

Sprat Relative length distributions by year and division

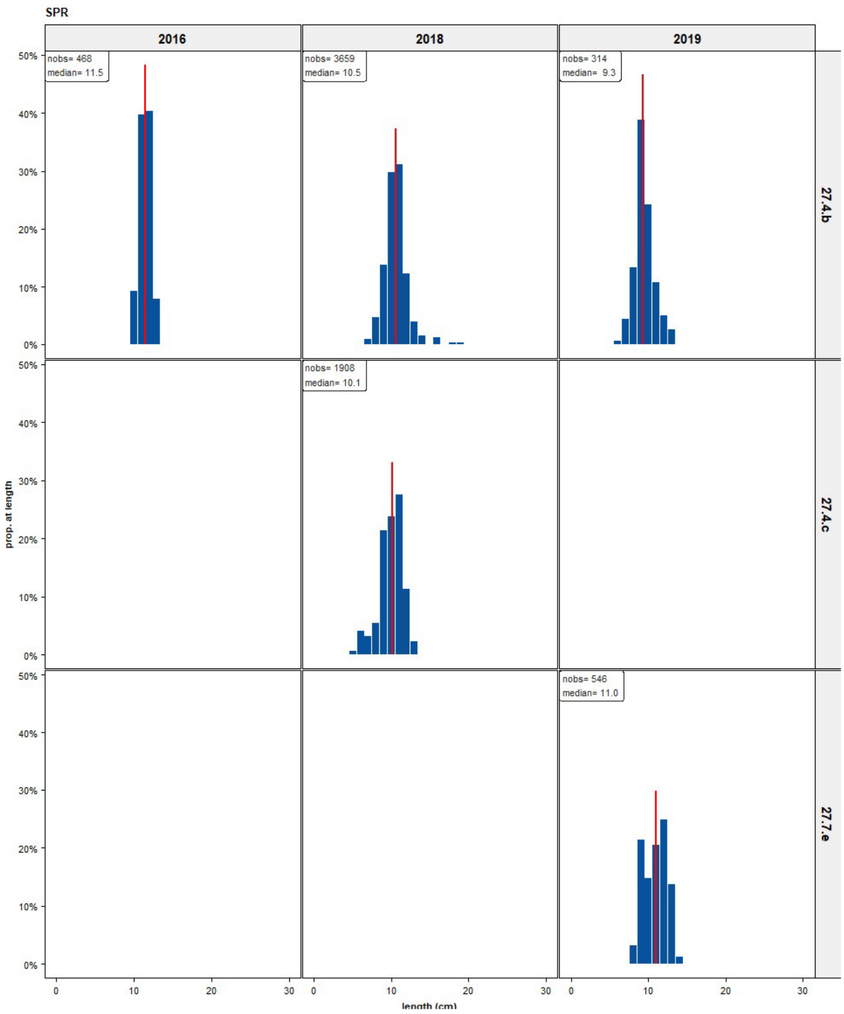

Figure 3.3.2: Sprat relative length distributions by year and division in PFA self-sampled North Sea herring fisheries. Nobs indicates the number of length measurements and median refers to the median length (cm) for that year and division.

3.4 Pilchards

An overview of self-sampling for pilchards.

species	division	year	nvessels	ntrips	ndays	nhauls	catch	nlength	catch/day
pil	27.4.b	2016	1	1	1	1	0	3	0
pil	27.4.b	2017	1	1	1	1	278	0	278
pil	27.4.c	2019	1	1	1	1	20	0	20
pil	27.7.d	2015	4	5	11	11	260	509	23
pil	27.7.d	2016	6	9	26	45	1,242	2,102	47
pil	27.7.d	2017	4	6	8	9	63	0	7
pil	27.7.d	2018	6	9	25	39	1,079	2,252	43
pil	27.7.d	2019	6	7	21	31	296	244	14
pil	27.7.d	2020*	1	1	1	1	0	0	0
pil	27.7.e	2015	6	7	18	40	1,445	3,400	80
pil	27.7.e	2016	7	12	62	167	16,108	5,182	259
pil	27.7.e	2017	3	8	16	28	1,178	0	73
pil	27.7.e	2018	2	3	6	9	127	0	21
pil	27.7.e	2019	2	2	3	3	12	526	4
pil	(all)	2015		12	29	51	1,705	3,909	
pil	(all)	2016		22	89	213	17,350	7,287	
pil	(all)	2017		15	25	38	1,519	0	
pil	(all)	2018		12	31	48	1,206	2,252	
pil	(all)	2019		10	25	35	328	770	
pil	(all)	2020*		1	1	1	0	0	
pil	(all)	(all)		72	200	386	22,108	14,218	

Table 3.4.1: PFA selfsampling summary for Pilchard by year and division for hauls that have been selected as part of the (extended) North Sea herring fisheries.

Pilchard Total catch by rectangle

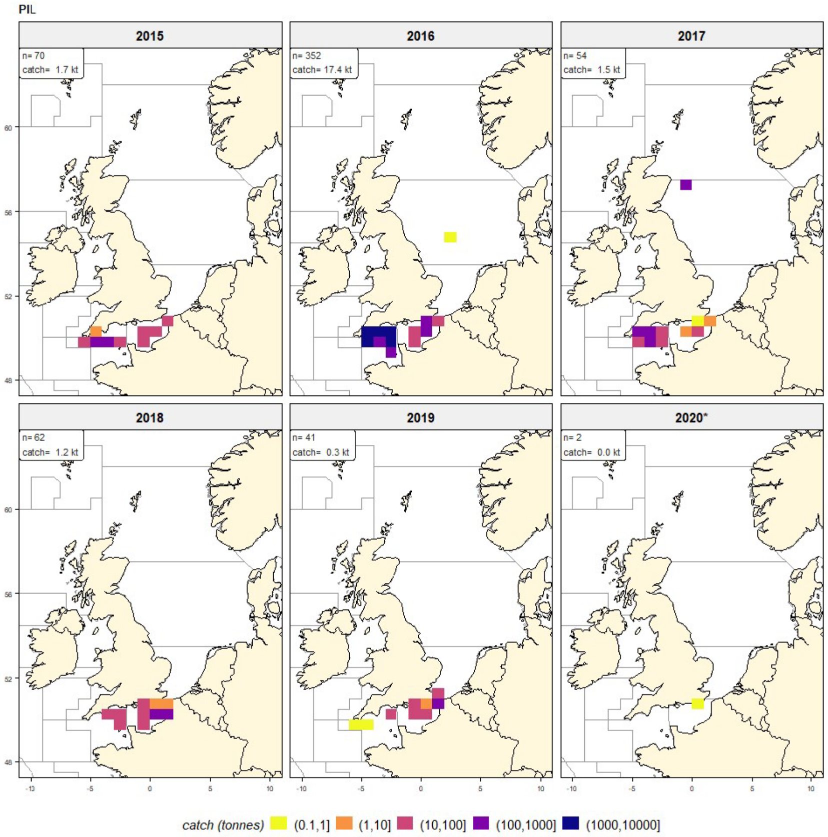

Figure 3.4.1: Pilchard catch by rectangle in PFA self-sampled North Sea herring fisheries. N indicates the number of hauls and total refers to the total herring catch (ton) for that year.

Pilchard Catch rates (ton/day) by rectangle

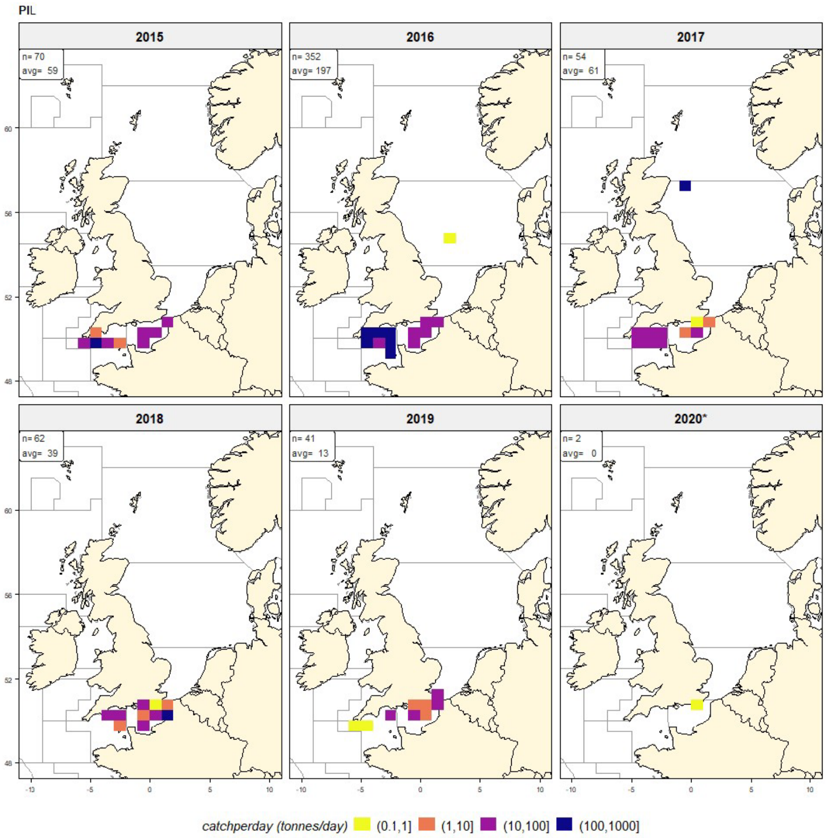

Figure 3.4.2: Pilchard catchrate (catch/day) by rectangle in PFA self-sampled North Sea herring fisheries. N indicates the number of hauls and avg refers to the average herring catch by day (ton/day) for that year.

Pilchard Relative length distributions by year and division

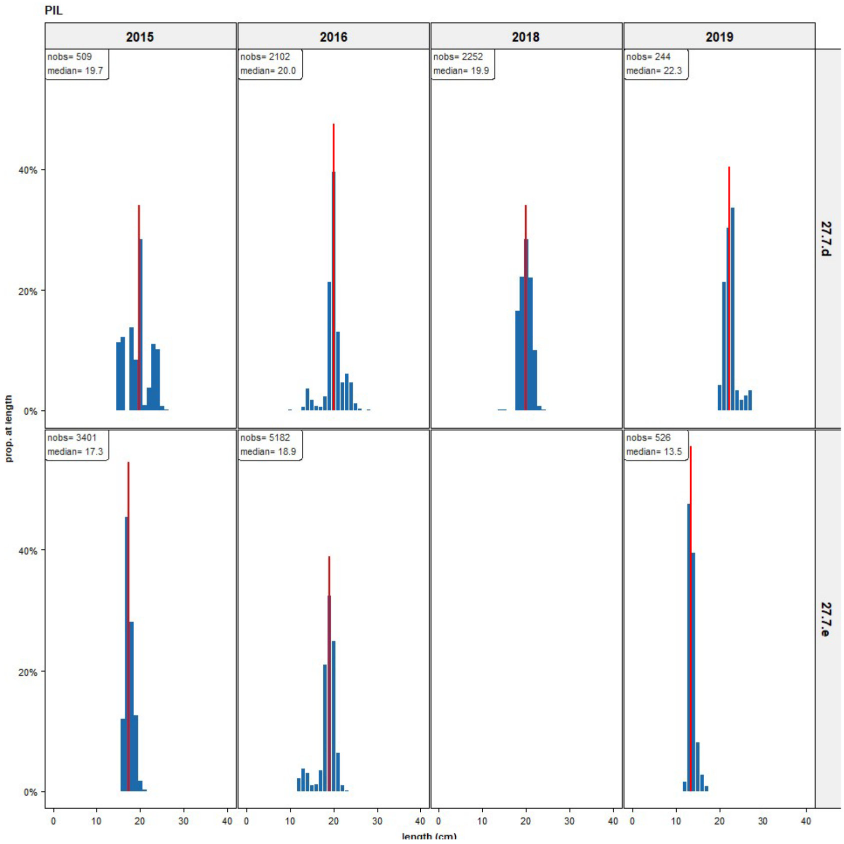

Figure 3.4.3: Pilchard relative length distributions by year and division in PFA self-sampled North Sea herring fisheries. Nobs indicates the number of length measurements and median refers to the median length (cm) for that year and division.

4 Discussion and conclusions

By the end of 2019, all vessels were participating in the PFA self-sampling programme. 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 definition of what constitutes 'a fishery' for a certain species is not well specified. In this report we selected all trips within divisions 27.4.b, 27.4.c, 27.7.d, 27.7.e and were the weekly catches had more than 10 tonnes of herring and where the proportion of species in the catch of that week was at least 10%.

New in the standard report in 2020 is the inclusion of weight and fat content data. Weights and fat content are routinely being collected for some of the target species (e.g. herring, mackerel) on the basis of production units (batches). The measurements are being carried out both when the species is the main target of the fishery or when it is a bycatch in other fisheries (e.g. for mackerel).

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 pro

HAWG 2020 WD04

Centre for Environment Fisheries & Aquaculture Science

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Sprat (*Sprattus sprattus*) in Divisions 7.d and 7.e (English Channel): latest biomass estimates and results of revision of advice methods

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V3.1	Johnathan ball	20/03/2020	Minor correction

Executive Summary

This document considers the latest guidance and information with respect to sprat in Divisions 7.d and 7.e (English Channel) presenting: i) the results of possible advice of sprat in Divisions 7.d and 7.e, considering a number of harvest control rule scenarios using both the most recent PELTIC survey estimates and the latest 1-over-2 guidance from recent workshops for shortlived species, proposed by WKDLSSLS (2019) and reviewed by WKLIFE (2019); ii) a revised biomass estimate for the 2018 sprat in ICES Divisions 7.d and 7.e, following the discovery of a manufacture's software bug and subsequent correction to the algorithms in the acoustic system - the 2018 estimate used in the ICES' assessment for assessing sprat was revised upwards from 17,091 tonnes to 21,772 tonnes - an increase of 27%; and iii) the 2019 PELTIC survey biomass estimate which was calculated to be 36,789 tonnes, an increase of 69% from the 2018 revised estimate.

The last advice published by ICES for catches in 2020 was to reduce the previously advised catch for 2019 by 20%. This reduction was advised based on the ICES' framework for Category 3 stocks and uses the PELTIC index by averaging the last 2 years and dividing this by the average of the previous 3 years and includes the uncertainty cap as the reduction was greater than 20%. Using the corrected 2018 value the advice using this method remains the same as the uncertainty cap would still be necessary as the reduction remains greater that 20%.

Given the recent developments with harvest control rules for short-lived species, an analysis was carried out using the proposed 1-over-2 rule. Several different approaches were investigated to explore the possibilities for catches in 2021 (symmetric 20% and 80% uncertainty caps and applied to the whole survey index and to 2020 only) and the resulting catch-rates amounting to harvest rates up to a maximum of 11%; below the 17% suggested sustainable rate identified by WKDLSSLS.

While WKDLSSLS in 2019 acknowledged that more work was needed, it proposed to apply a preliminary 80% uncertainty cap to the 1-over-2 approach. This would result in a significant loss of yield and reduction in the harvest rate, in some scenarios this was less than 2% (when applied to the timeseries). However, given that further study of the uncertainty cap was agreed upon, other scenarios were tested and the results presented in this report suggesting that a 1-over-2 approach applied to the last few years of survey index with a 20% uncertainty cap would provide more appropriate advice for this short-lived stock.

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1 Scope of the document

This document provides an overview of results on the assessment of sprat in the English Channel (Divisions 7.d and 7.e), making use of the recent advances in guidance for data limited stocks (WKLIFE, 2019) through adoption of the 1-over-2 approach for short-lived species like sprat. It presents i) an analysis using the revised biomass estimate for the 2018 survey following the discovery of a bug and subsequent correction of the algorithm to calculate biomass in the acoustic software, ii) assessment results using the latest biomass estimate from the 2019 survey, iii) a summary of the possible outcomes of several scenarios when applying a 1 over 2 rule, iv) the proposal of a revision of the advice provided in 2019 for 2020 and implications for catch in 2021.

2 Introduction

Sprat in the English Channel is currently managed as a single stock unit (ICES Divisions 7.d and 7.e – subsequently, abbreviated to 7.de in this document) through an annual Total Allowable Catch (TAC). Advice is provided by ICES on an annual basis and, in recent years, has been based on an acoustic survey (PELTIC, ICES 2015) that has been carried out in the area during October since 2013. While the survey covers a wide area (including north of the Cornish peninsula), coverage relevant to the management unit of sprat in 7.de from 2013 – 2016 was limited to the English waters of the western English Channel (ICES Division 7.e). Despite the coverage being expanded into French waters of Division 7.e between 2017 and 2019, only the consistently covered core area (English waters of Division 7.e) has continued to be used in the assessment to maintain the time-series. This core area includes what appears to be the main sprat population in the Channel (and the most important area for the English sprat fishery) in Lyme Bay. However, the expanded coverage in French waters confirms that a component of the population, albeit it smaller than in Lyme Bay and more variable, also resides there. In 2017, the survey expanded into the eastern English Channel and while sprat was found, biomass was low at the time of the survey. Small numbers of sprat are landed in the eastern Channel however, so given that sprat is present outside the core area used from the survey, the biomass estimate used in the assessment for 7.de sprat can therefore be considered an underestimate.

In 2015 and 2016, the advice for sprat in ICES Divisions 7.d and 7.e was based on a 2-over-3 rule applied to an abundance index from commercial landings per unit effort (LPUE): the two latest index values (index A) with the three preceding values (index B), multiplied by the recent catch advice. Upper and lower uncertainty caps of 20% were applied. From 2017 the commercial LPUE was replaced by the survey index and the basis of advice varied from 1-over2 (2017), to 1-over-3 (2018) and 2-over-3 (2019, 2020). Advice is provided on an annual basis where the latest estimates from the October PELTIC survey feed into an assessment in March to give advice starting the following January. As a consequence, using a 2-over-3 method, advice is affected by biomass values from six years previously, while very few sprat older than 4 years old are ever found in the survey. Sprat is considered a short-lived species with a high inter-annual variability in recruitment. In addition, it is prey for many larger piscivores which results in a relatively high natural mortality. At the last benchmark (ICES WKSPRAT, 2018) it was agreed that the 2-over-3 rule is not dynamic enough for short-lived and highly productive species. This was further investigated using management strategy evaluation (MSE) approaches at WKspratMSE (2018), WKDLSSLS (2019) and WKLIFE (in press). Two main conclusions were drawn (WKDLSSLS, 2019): 1) the 1-over-2 rule outperforms the 2-over-3 rule and 2) an in-year advice schedule outperforms the current calendar year advice schedule. While ICES ACOM has adapted the recommendations from WKLIFE, details on the approach, e.g. uncertainty caps, have not yet been agreed on. WKDLSSLS tested a range of symmetric and asymmetric uncertainty caps and found a 20% cap to be the least precautionary option. Asymmetric caps that allow advice to decrease more than increase were found to be more precautionary but resulted in a large loss of long-term yield. Given that a limited number of asymmetric uncertainty cap options were trialled, WKDLSSLS suggested that the 1-over-2 rule with 80% uncertainty cap should be taken as an interim proposal while work is ongoing in 2020. In this document we evaluate the implications to the advice if a 1-over-2 method was used for sprat in 7.de, and we present the latest (2019) biomass values from the survey.

3 Methods and Results

3.1 Updated sprat biomass for 2018

In December 2019, after completion of the 2019 PELTIC survey (1-29th of October 2019) and subsequent survey working group (ICES WGACEGG), Simrad Kongsberg released the latest EK80 acoustic software (v 1.12.4). In the associated release note (https://www.simrad.online/ek80/swrn/ek80_swrn_current_en_a4.pdf), details were provided of a bug discovered in the calibration software of previous versions. The bug affected the Sa correction, which affects the backscatter (Nautical Area Scattering Coefficient, NASC) and ultimately the acoustically derived biomass estimates. The PELTIC survey aboard the RV Cefas Endeavour has been using the Simrad EK60 echosounder but as the operating software (ER60) has not been supported by Simrad for several years, Cefas installed the EK80 software to operate the EK60 system in 2018. Data results prior to 2018 were not affected and only PELTIC derived biomass estimates for 2018 and 2019 were compromised.

Recommended corrections were applied to the PELTIC 2018 and 2019 “Sa correction” calibration outputs for each of the frequencies and pulse durations used (Table 3.1). Method and results were verified with Simrad technical staff.

Updated calibration settings were applied to the raw echograms. For each year, the difference between the 38kHz post-calibration values and those corrected (Table 3.1), is indicative of the change in backscatter and subsequent abundance and biomass estimates. As well as the absolute backscatter values per species, the outputs from the multifrequency algorithms were affected as these use acoustic properties such as the difference in frequency response, to distinguish between different echotypes. Therefore, a full reprocess was conducted on the data. The 2018 sprat biomass for the consistently sampled area (English waters of 7.e) was increased from 17,091 to 21,772 tonnes with a CV of 38.7%.

Table 3.1: Original (affected by bug) and corrected Sa correction values for each of the three frequencies used aboard the RV Cefas Endeavour for 2018 and 2019 for calibration at 0.512 ms.

Original Sa correction values (affected by bug)				
	2018		**2019**	
	Pre-calibration	Post-calibration	Pre-calibration	Post-calibration
38	0.16	-1.0232	-0.96	0.0903
120	-0.38	-0.0124	-0.01	-0.3416
200	-0.34	0.0413	0.04	-0.4021
Corrected Sa correction values				
38	-0.8632		-0.8697	
120	-0.3924		-0.3516	
200	-0.2987		-0.3621	

3.2 Sprat biomass estimation in 2019.

Original details of the PELTIC19 results had previously been provided in the survey report and discussed at ICES WGACEGG (November 2019, in press) and WGIPS (January 2020, in press). The biomass estimates presented at WGEACEGG were also affected by a software bug (see 3.1) and have subsequently been updated. In summary, sprat (*Sprattus sprattus*) was widespread in most of the survey area with the typical presence of two core areas: one in the Bristol Channel, including the coastal waters in the west, and the other in English waters of the Western Channel (Lyme Bay). In the Lyme Bay area, for the second year in a row, high numbers of age-0 sprat (2019 year class) in Lyme Bay suggested good recruitment.

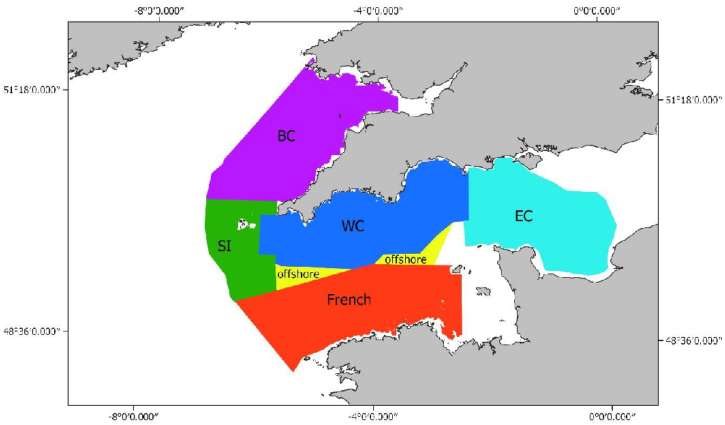

Figure 3.1: Map of the total survey area covered by PELTIC. Only stratum WC (Western Channel) is used for the stock assessment of sprat in 7.de as this is consistently sampled between 2013-2019 in 7.e.

Considering the corrected calibration details, the biomass estimate of the sprat population in English waters of western Channel (Figure 3.1), used in the sprat 7.de stock assessment, was 36,789 tonnes (CV= 32.6%), an increase of 69% from 21,772 tonnes in 2018. Sprat was also found in French waters although further east than in previous years.

3.3 Application of different 1-over-2 scenarios

It was acknowledged that the 2-over-3 approach was not capable of capturing the dynamics of short-lived species. Following ACOM endorsement to apply 1-over-2 method on existing category 3 short-lived species, its implications for sprat in 7.de were tested and compared with the existing advice approaches (Table 3.2). Table 3.2 shows a decrease in catch for both the 2-over-3 and 1-over-2 if applied only to the last year of the index. In neither option does the correction to the biomass index affect the advice for 2020. While there is a change to the advice derived from the index ratio alone, the corrected values are still limited by the 20% uncertainty cap. Compared to the existing advice, the approach with the largest difference, occurs when applying 1-over-2 from 2017 onwards, which is when the survey index was first used to underpin advice. The resulting advice index is also more consistent between years compared to the other advice options tested. It should be noted that for 2021 both 1-over-2 options (applied to last year only and when applied to time series from 2017) would have produced an increase to 1,807 and 2,675 tonnes in advice respectively, if the precautionary buffer was not applied to the last year.

Table 3.2: Existing advice by year and potential revisions to the ICES advice for sprat in 7.de using the updated biomass index from the PELTIC survey in a number of different harvest control rules. Please note that parenthesised percentage reflect the precautionary buffer applied.

HAWG year	PELTIC survey year	Biomass (tonnes) WC stratum (CV)	Management year	Method applied	Catch	Scenario			
						1-over-2 (20%) to 2020	1-over-2 (80%) to 2020	1-over-2 (20%) to 2017-'20	1-over-2 (80%) to 2017-'20
2014	2013	70,676 (0.67)							
2015	2014	85,184 (0.67)							
2016	2015	65,219 (0.35)	2017	1-over-2	3,678	3,678	3,678	3,678	3,678
2017	2016	9,826 (0.33)	2018	1-over-3	2,354	2,354	2,354	2,354	588
2018	2017	32,751 (0.22)	2019	2-over-3	1,883	1,883	1,883	2,055	515
2019	2018	21,772 (0.39)	2020	2-over-3	1,506	1,506	1,506	2,101	525
2020	2019	36,789 (0.33)	2021	2-over-3	*982	1,446	2,032	2,017	567

*Implied for 2021 if 2-over-3 was applied

ICES workshop meetings (ICES WKSpratMSE, 2018; ICES WKDLSSLS , 2019) proposed that harvest rates of less than 20% of the total biomass and a precautionary harvest rates of less than 17% were appropriate for maintaining high yield and ensuring a precautionary approach to the stock (ICES WKDLSSLS , 2019). The harvest rates for the advice options tested in this report are presented in Table 3.3, for 2017 - 2019.

Table 3.3: Harvest rates (%) for sprat in 7.de for each advice year under different harvest control rules, relative to the survey biomass value in the same year

Advice Year	2-over-3	1-over-2 (20%) to 2020	1-over-2 (80%) to 2020	1-over-2 (20%) to 2017-20	1-over-2 (80%) to 2017-20
2017	11.2	11.2	11.2	11.2	11.2
2018	10.8	10.8	10.8	10.8	2.7
2019	5.1	5.1	5.8	6.1	1.4

Harvest rates are well below the suggested guidelines at a maximum of around 11%. The recommended scenario of 1-over-2 with 80% precautionary buffer reduced the harvest rate to less than 2% when applying the rule from 2017. The harvest rate would suggest that even with an increase in advice under a revised advice timeseries the expected stock exploitation level is perceived to be well below the sustainable rate.

4 Discussion

4.1 Summary

Biomass estimates from the PELTIC survey for the Western Channel were presented for sprat and included a revised value for 2018 and the latest estimate from the 2019 survey. The latter showed an increase from 2018 and the long-term index appears to suggest a more stable period in the last few years.

Pending further confirmation on the details in the application of the 1-over-2 harvest control rule, and considering the need to provide advice in the short term, we applied the 1-over-2 method to sprat in 7.de considering different uncertainty caps (20 and 80%) and applied it to different starting points (last year of existing advice only and the whole time series for which the survey index was available) The motivation for also applying the method from 2017 was the lack of consistent advice methods applied: 1-over-2 (2017), to 1-over-3 (2018) with 2-over3 only used in the last two years (2019-2020) as detailed in Table 3.2. All approaches yielded harvest rates of 11% or less, well below the 17% threshold suggested (WKSpratMSE, 2018). The 80% uncertainty cap led to a significant reduction in catches, relative to the other scenarios including the current advice. WKDLSSLS noted the potential for an 80% uncertainty cap to lead to major reductions in catches over time and suggested that such a cap should be temporary while management is improved. We note this behaviour as a result of compounding percentage decreases and that sequentially applying the same percentages as increases does not result in the same advice. Although asymmetric caps that allow advice to decrease more than increase are more precautionary, only the converse will allow catches to return to initial levels following an increase in the biomass index (for example a 20% decrease would need to be followed by a 25% increase to result in the same advice).

The results of the 1-over-2 method applied to the survey index from 2017 (with 20% uncertainty) are the most consistent compared to the other approaches. Adopting the 2021 advice of 2,140 t would see an increase from the 2020 advice. There are however several reasons why the 2020 advice could be reconsidered:

1. It was based on the 2-over-3 rule and the decrease in biomass in 2016 is still affecting advice in 2020
2. Most sprat do not live longer than 3 years.
3. The trend in existing advice does not reflect the trend in the population: the October 2019 biomass estimate from the relevant fisheries survey (PELTIC), which was presented at the November ICES WGACEGG, showed a sharp increase (69%) from the 2018 biomass.

4.2 Recommendations

Based on the results from this study, we recommend presenting the 2021 advice using the 1over-2 rule to the survey index from 2017 onwards with a 20% uncertainty cap and/or precautionary buffer. The reasons are:

- The advice provides the most consistent index of the options considered
- The harvest rate (max of 11%) remains below the preliminary harvest rate threshold of 17% suggested suitable for short-lived species (including sprat) by WKDLSSLS (2019)
- The 80% uncertainty cap resulted in very low yields and is unlikely to sustain the fishery
- Past (existing) advice for sprat in 7.de has developed over time and uses several harvest control rules.
- The existing decrease in advice during the last two years does not reflect the perceived trends in the population from the survey.

4.3 Future Work

Following the conclusions of WKDLSSLS, one of the other options to consider was the effect of issuing seasonal advice and an in-year update. Unlike sprat in the North Sea and 3a, which moved to seasonal advice, the Western Channel sprat management unit continues to be assessed on an annual basis. However, given the delay between the timing of the survey (year x), HAWG (year x+1) and the year advice is set for (x+2), and the majority of the catches take the 1 and 2 year old fish, a sensible alternative would be to use the survey in year x+1 to provide an in-year adjustment of original advice given for year x+2.

Details of planned work under WKDLSSLS 2 are available in the Terms of Reference (ToRs). In addition, we make further suggestions:

Firstly, to consider the need for a benchmark process and provide updates to index-specific reference points when testing biomass safeguards. In addition to uncertainty caps, biomass safeguards were considered another mechanism to safeguard stocks when perceived to be at low biomass. These operate by reducing the advised catch if a new index value falls below reference points derived from the historic biomass index. Biomass safeguards showed promise in terms of reducing risk without associated large reductions in catch, but further work is needed to define appropriate reference points. An MSE framework conditioned on sprat in 7.de tested harvest rates as an alternative to the catch rules and found this to result in the highest precautionary yields (Walker, 2019). However, the view of WKDLSSLS was that use of such a method should be species specific and requires good knowledge of the catchability and error properties of the index or extensive sensitivity analyses. It was agreed that more work was required. Secondly, it was deemed necessary to test asymmetric uncertainty caps that allow advice to increase more than decrease paying attention to compound applications. Therefore, as part of a second WKDLSSLS meeting (scheduled for September 2020), further testing of symmetric and asymmetric uncertainty caps, biomass safeguards and harvest rate strategies will take place. In addition, the group will consider effectiveness of the precautionary buffer and shifting uncertainty cap levels in time.

5 References

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HAWG 2020 WD05

Updated Survey Index Calculations for North Sea Sprat (inclusive area IIIa) from IBTS data

Casper W. Berg

March 17, 2020

1 Summary

This document describes an updated procedure for calculating standardized survey indices of abundance for North Sea sprat using the methodology of [3] and [1]. The update consists of three changes to the current model:

- The spline basis is changed from isotropic thin-plate/cubic regression splines (for space/time) with 2nd derivative penalization to anisotropic Duchon splines with first derivative penalization.
- The spatial spline basis dimension is increased
- Random vessel effects are included

While the estimates from the updated model display the same trends as the current model, has slightly better internal consistencies on average, and is more stable when updated with new data (less retrospective patterns).

2 Data filtering

The data filtering is unchanged and the same between models, but the description is included for completeness. We consider only data from 1983 and onwards, since the NS-IBTS data collection in earlier years was not properly standardized between countries. The precision of survey indices calculated with a Delta-Lognormal model is likely to drop if large areas with nearly zero densities are included. The northern part (above 57° latitude for longitudes larger than -1.5° or above 59° for longitudes less than -1.5°, and all hauls taken at longtidudes larger than 7°) of the North Sea has therefore been excluded from the index calculations. This was done for both Q1 and Q3 data (see figures 1 and 2).

Only hauls taken with the “GOV” gear is included (less than 10% of the hauls are taken with other gear types).

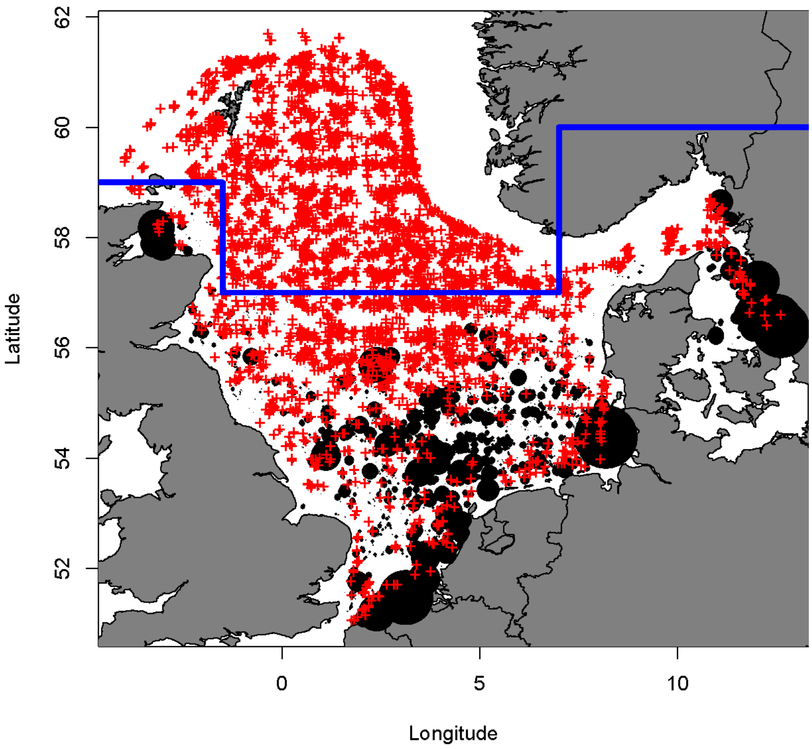


Figure 1: Quarter 1: All hauls, sizes of bubbles are proportional to total catch weight. Red crosses represent zero catch hauls. Hauls north of the blue line are excluded.

3 ALKs

The ALKs are also unchanged and the same between models. Spatially varying age-length keys are estimated using the methodology described in [2]. Numbers-at-age by haul are then calculated using the observed numbers-at-length and the estimated ALKs. This methodology was found to give internal consistency in survey indices for haddock when compared to current standard

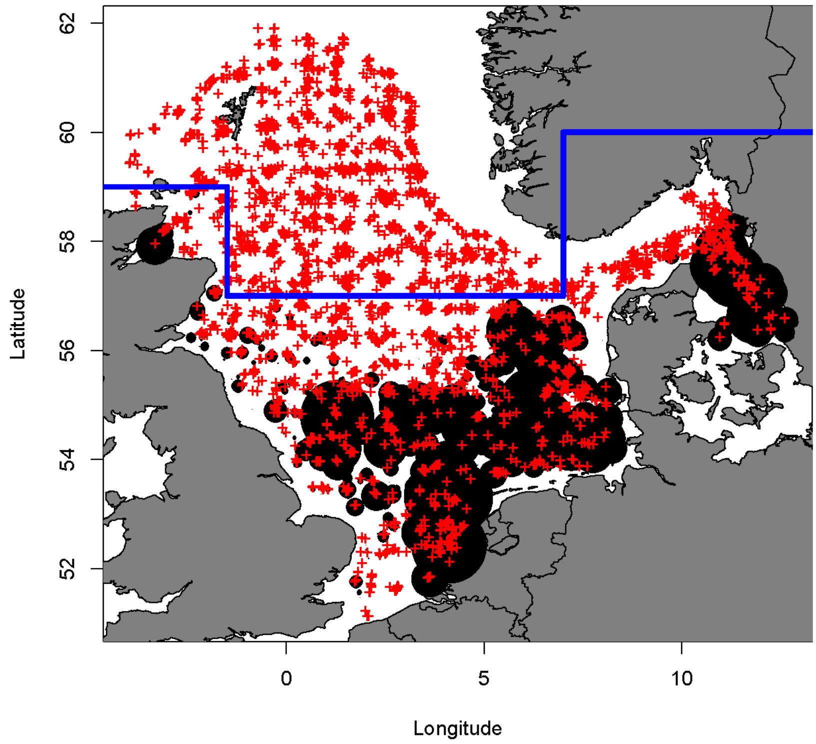


Figure 2: Quarter 3: All hauls, sizes of bubbles are proportional to total catch weight. Red crosses represent zero catch hauls. Hauls north of the blue line are excluded.

approach of estimating ALKs that are constant within "Roundfish" (RF) areas in [2]. It avoids ad-hoc borrowing of samples from neighbour RF areas, when certain age groups are missing, and it provides an objective fill-in procedure for missing length groups also. The methodology has been implemented in the DATRAS package with full source code available [4]. Tables with numbers of age samples by year and quarter are available in the appendix.

4 Survey Indices

Survey indices by age are calculated using the methodology described in [3], although we consider a broader class of equations describing the observed abundance in each haul. While [3] considered a time-invariant spatial effect and a data set consisting almost exclusively of 30 min hauls, the following model classes contains a space-time smoother, which allows for smooth changes in the spatial distribution of each age group over time, as well as haul duration effect. The standard stratified mean method (for each year and age group: average CPUE per ICES rectangle, averaged over all rectangles) is also applied for comparison.

The following equation describes the maximal model considered for both the presence-absence and the positive parts of the model:

$$g(\mu_i) = \text{Year(i)} + f_1(\text{Year}_i, \text{lon}_i, \text{lat}_i) \tag{1}$$

$$+ f_2(\text{depth}_i) + f_3(\text{timeOfDay}_i) + \log(\text{HaulDur}_i) + U_{ship}(i) \tag{2}$$

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 3-dimensional tensor product spline using Duchon basis functions (the old model is using a 2D thin-plate spline for space $\times$ a 1D cubic spline for time). The Duchon splines uses first derivative penalization rather than second derivative, which implies that the Duchon splines "go flat" outside the data range as opposed to following linear trends.

f_2 is a 1-dimensional Duchon spline for the effect of bottom depth, and f_3 is a cyclic cubic spline for the effect of time of day. The logarithm of the haul duration is used as a model offset (coefficient is assumed to be 1, which corresponds to proportionality between catch and effort), and finally U_{ship} is a normal distributed random vessel effect. The function g is the link function, which is taken to be the logit function for the binomial model. The positive part of the delta-distribution is assumed be lognormal distributed. 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 variables such as time-of-day and haul duration are corrected for in this process. For simplicity no vessel effects were considered here.

The whole procedure consists of the following steps:

1. Apply spatial ALK
2. Fit model for catch-at-age by age and quarter
3. Select grid of haul positions
4. Predict abundance on grid by year (using reference vessel, time-of-day etc).
5. Sum of grid points = index

5 Results

The average internal consistencies (correlation coefficient R, not R^2) for the new model in Q1 and Q3 are 0.569 and 0.594 respectively, while they for the old model are 0.546 and 0.584, i.e. a small improvement.

The retrospecitve analyses (figures 18 – 21) show that the new model is more stable, in particular for age 1 in Q3, where the old model has substantial retrospective patterns.

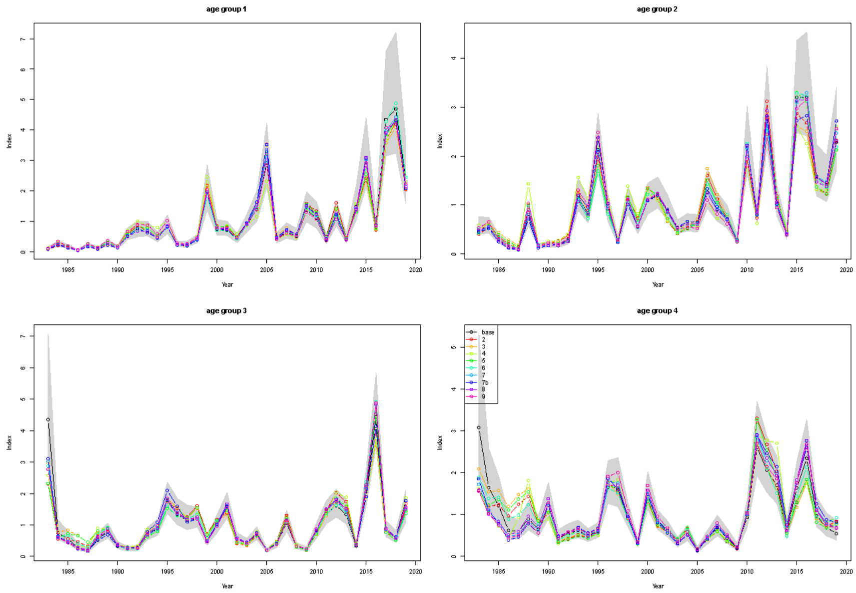


Figure 3: Several model formulations using various spatio-temporal resolutions and with/without ship effects were tried initially on the Q1 indices. These models were compared using AIC/BIC and internal consistency but will not be described in detail in this document This plot shows Q1 indices estimated using 10 different formulations of the model. The "base" model (black with grey confidence region) is the currently used model. Model "7b" is the proposed new model.

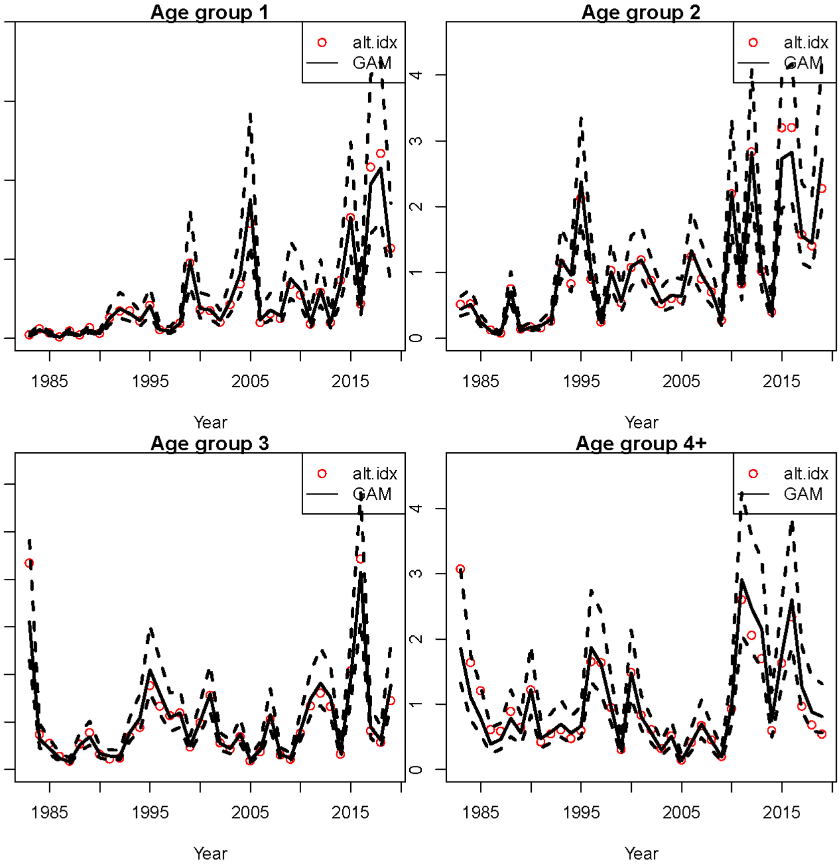


Figure 4: Estimated indices Q1 by age from new model. All indices have been divided by their mean by age group. The red dots are from the currently used model.

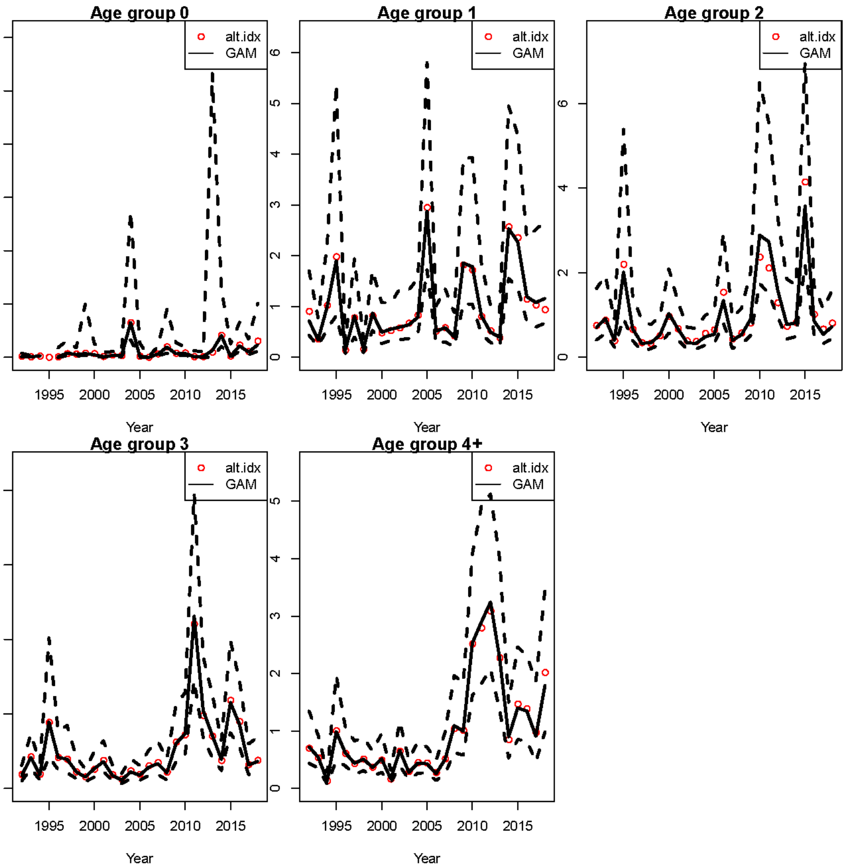


Figure 5: Estimated indices Q3 by age from new model. All indices have been divided by their mean by age group. The red dots are from the currently used model.

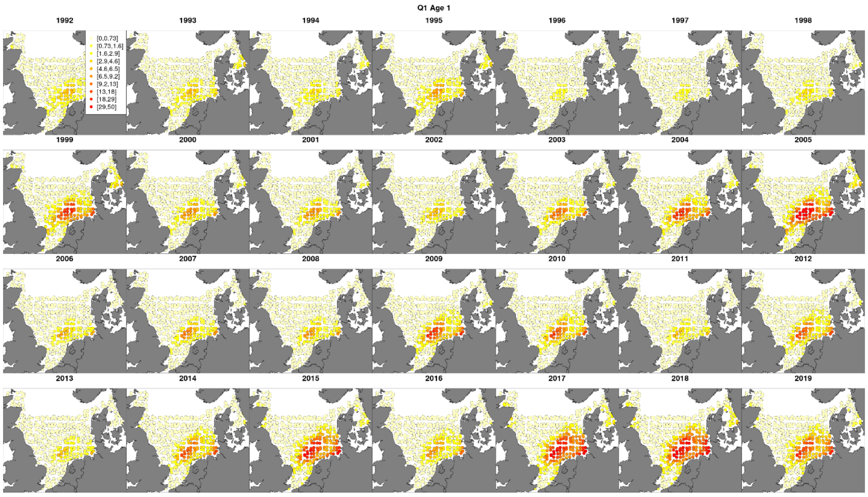


Figure 6: Absolute maps Q1 age 1 - new model

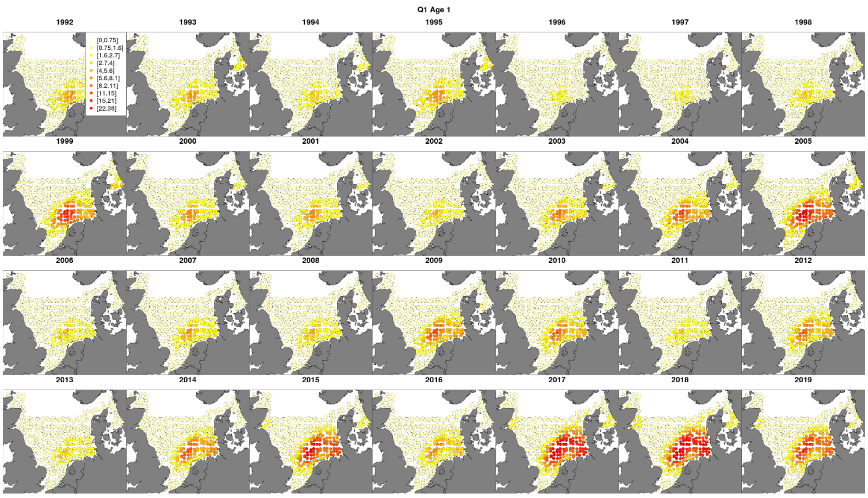


Figure 7: Absolute maps Q1 age 1 - old model

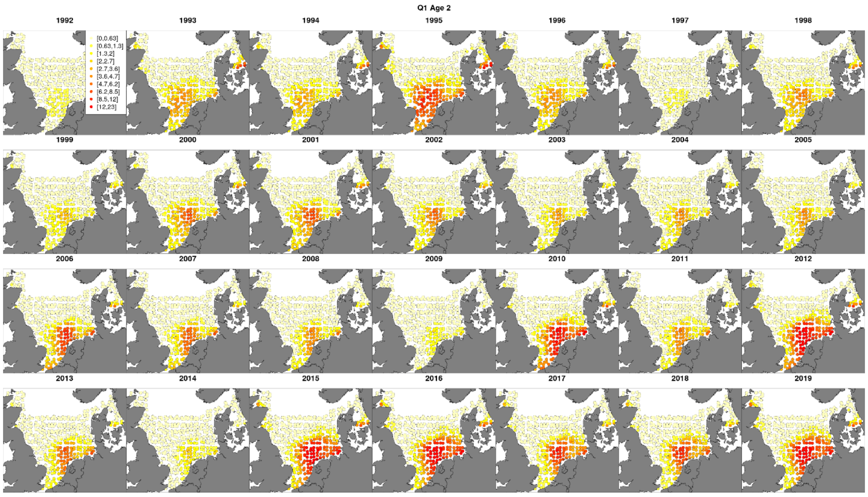


Figure 8: Absolute maps Q1 age 2- new model

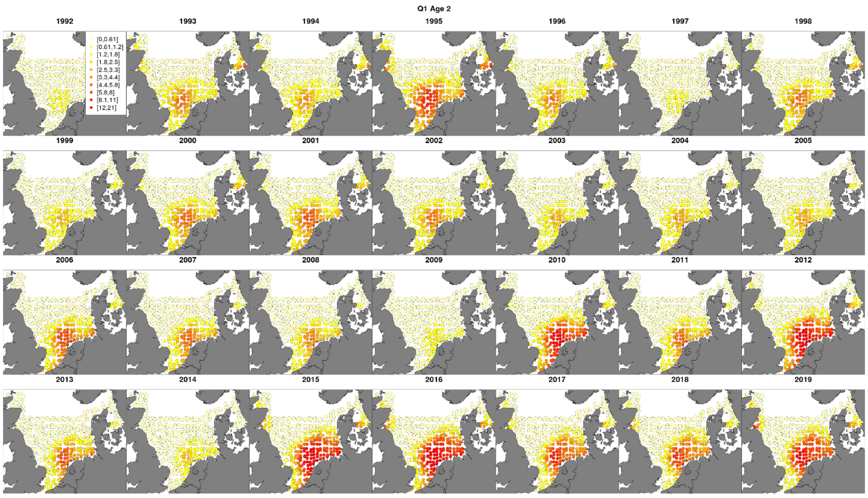


Figure 9: Absolute maps Q1 age 2- old model

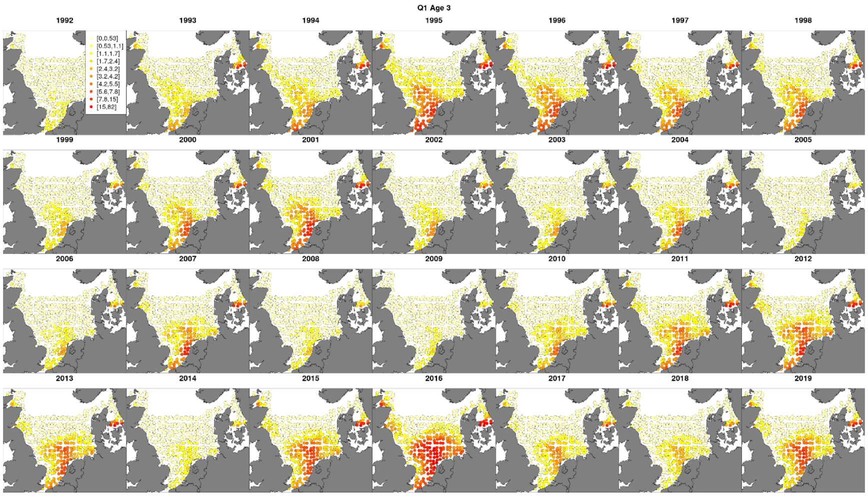


Figure 10: Absolute maps Q1 age 3- new model

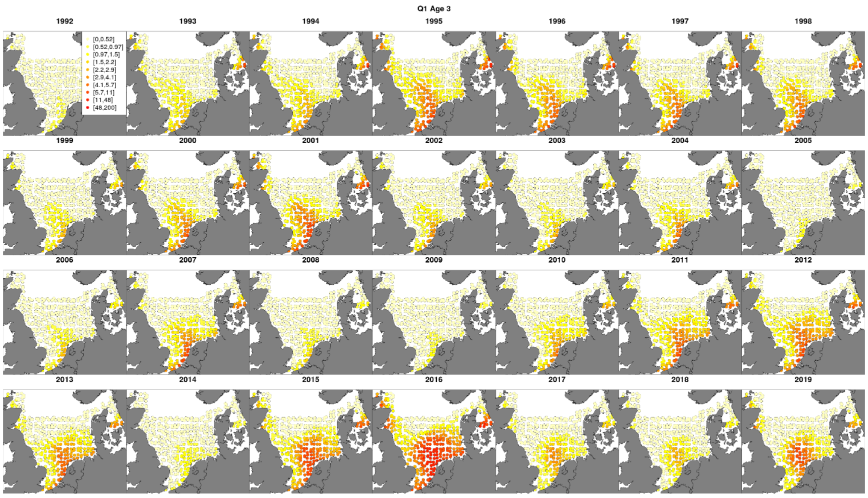


Figure 11: Absolute maps Q1 age 3- old model

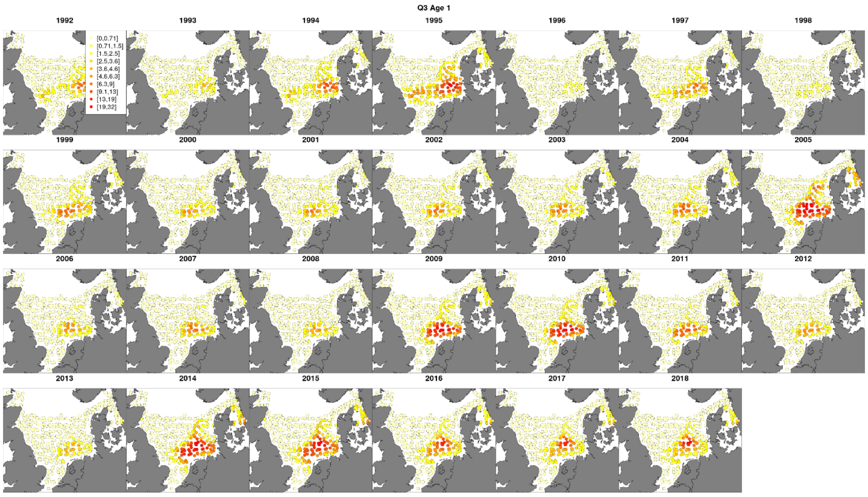


Figure 12: Absolute maps Q3 age 1- new model

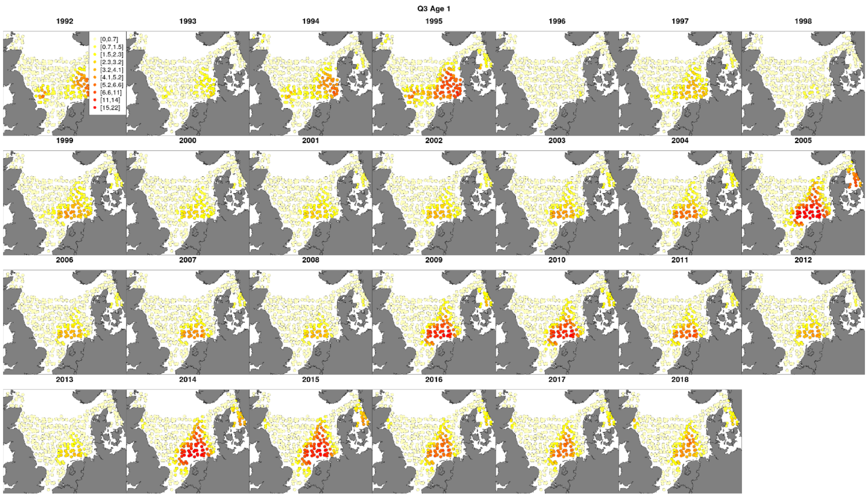


Figure 13: Absolute maps Q3 age 1- old model

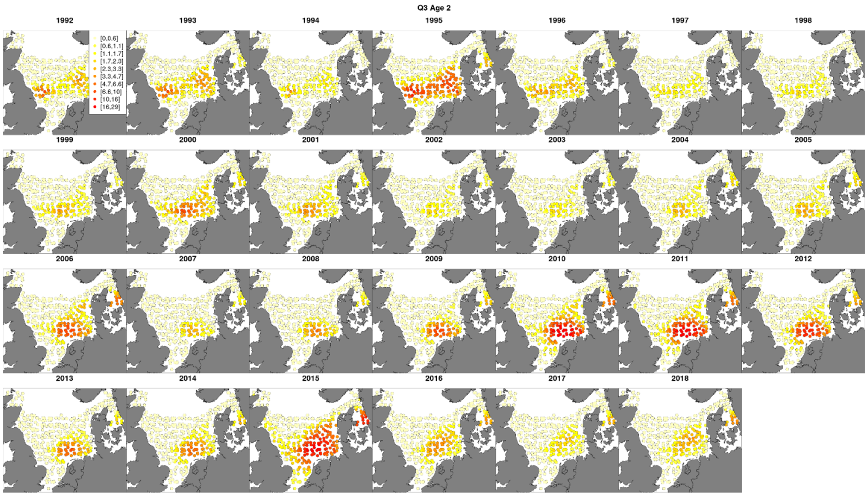


Figure 14: Absolute maps Q3 age 2- new model

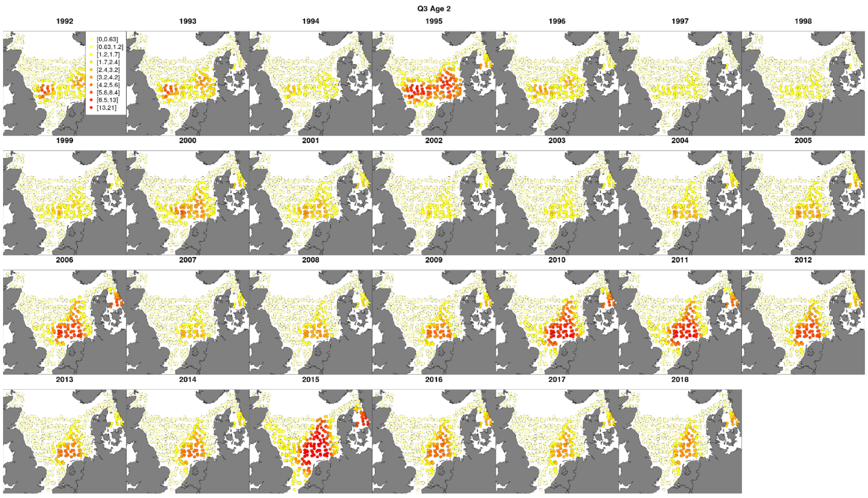


Figure 15: Absolute maps Q3 age 2- old model

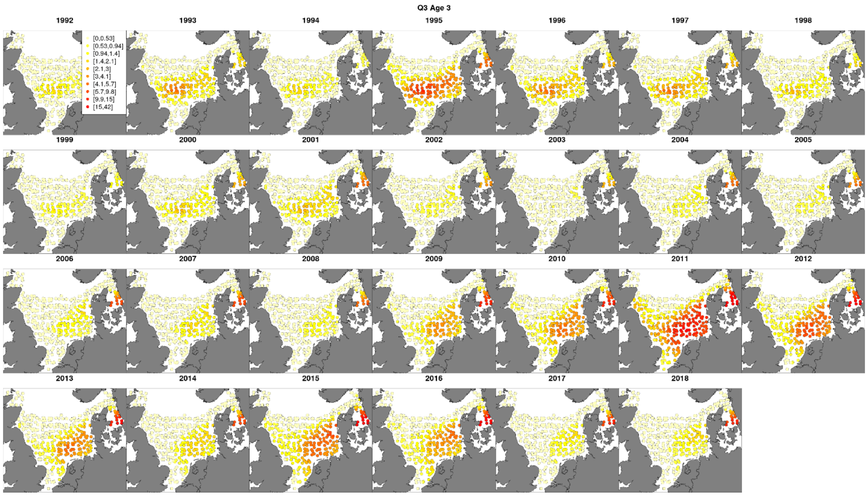


Figure 16: Absolute maps Q3 age 3- new model

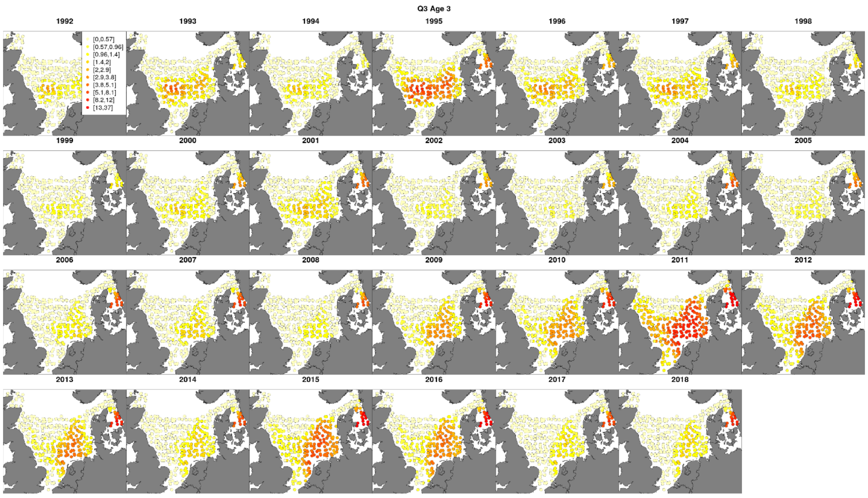


Figure 17: Absolute maps Q3 age 3- old model

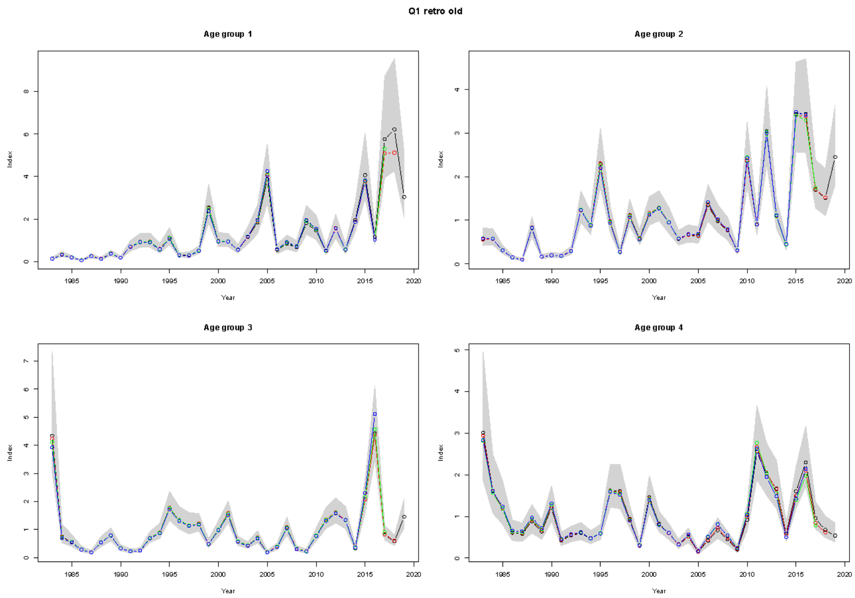


Figure 18: Retrospective analysis Q1 (old model)

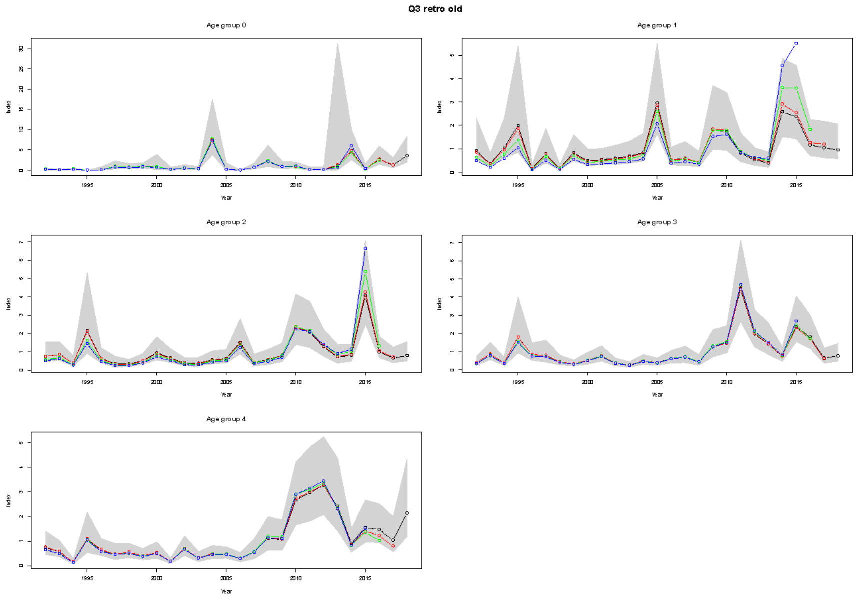


Figure 19: Retrospective analysis Q3 (old model)

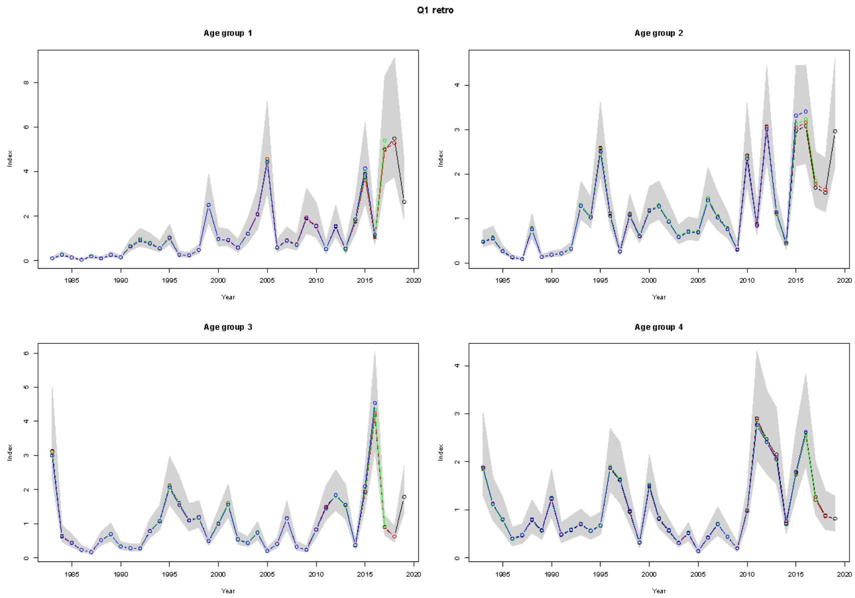


Figure 20: Retrospective analysis Q1 (new model)

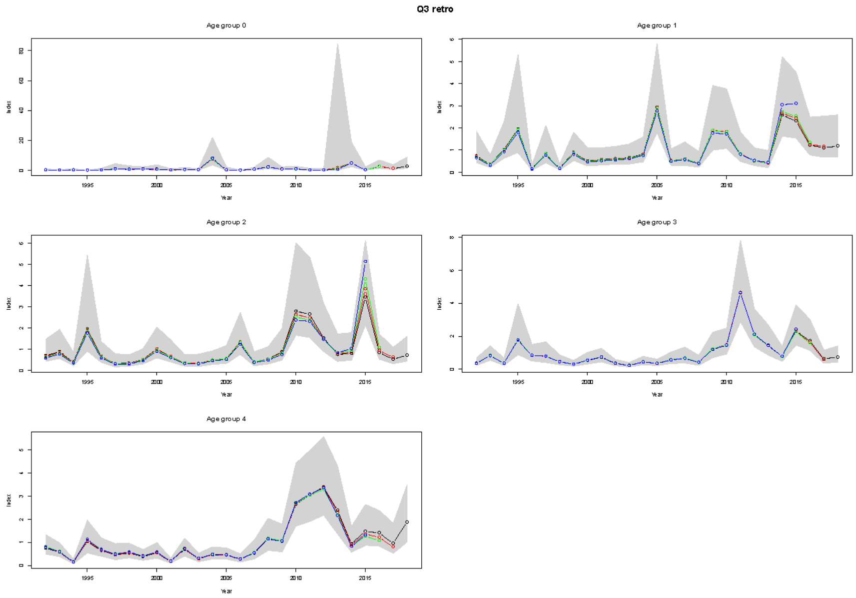


Figure 21: Retrospective analysis Q3 (new model)

6 Appendix

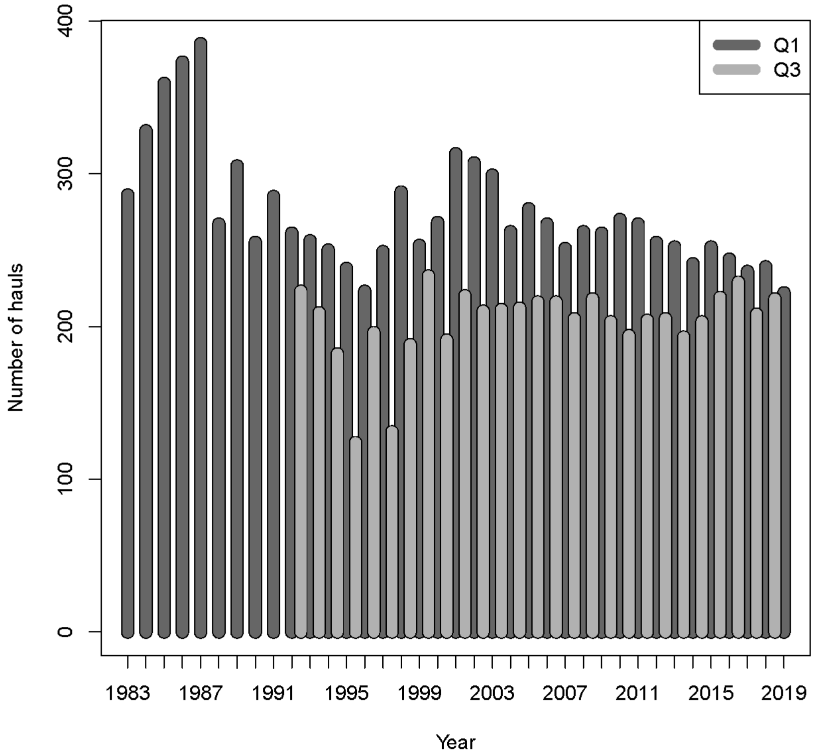


Figure 22: Number of hauls by year and quarter.

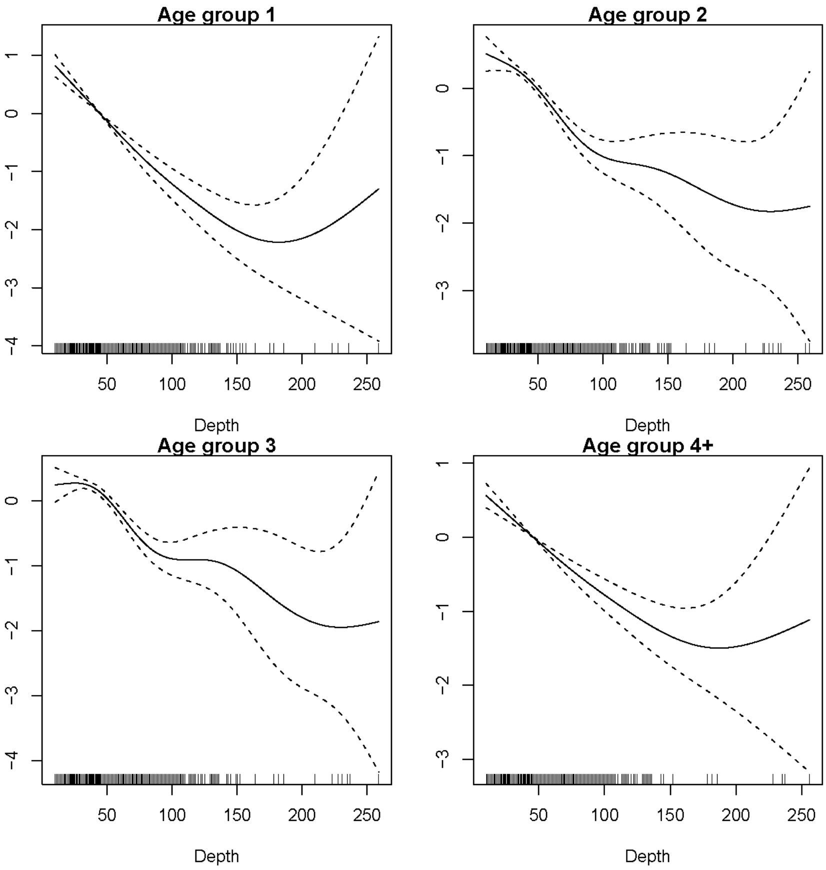


Figure 23: Estimated depth effect Q1 by age.

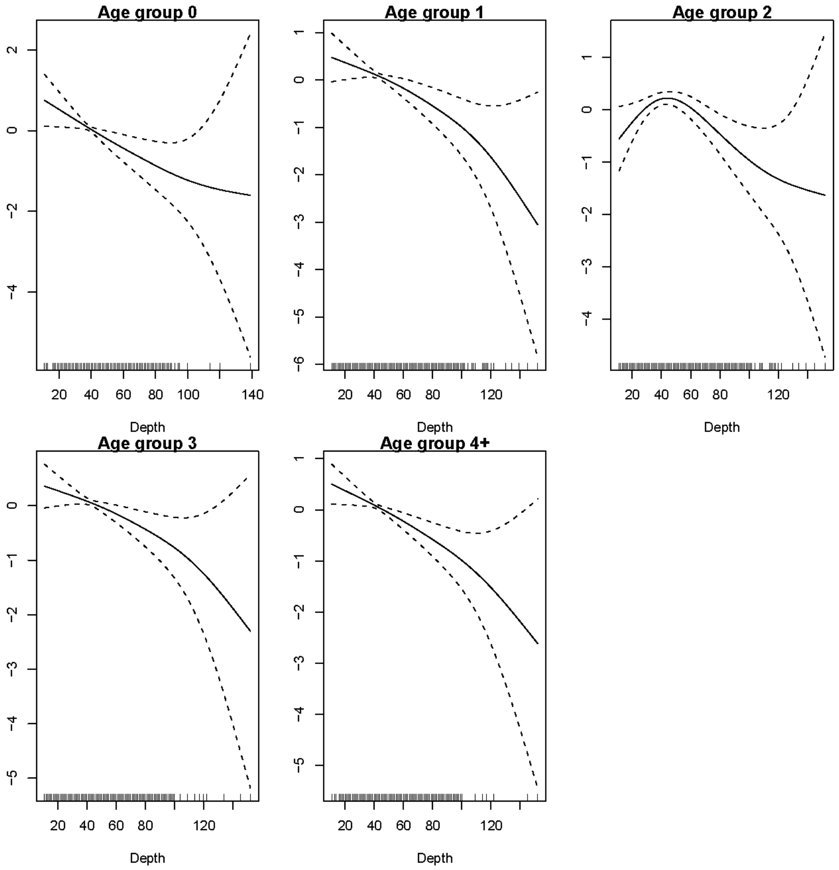


Figure 24: Estimated depth effect Q3 by age.

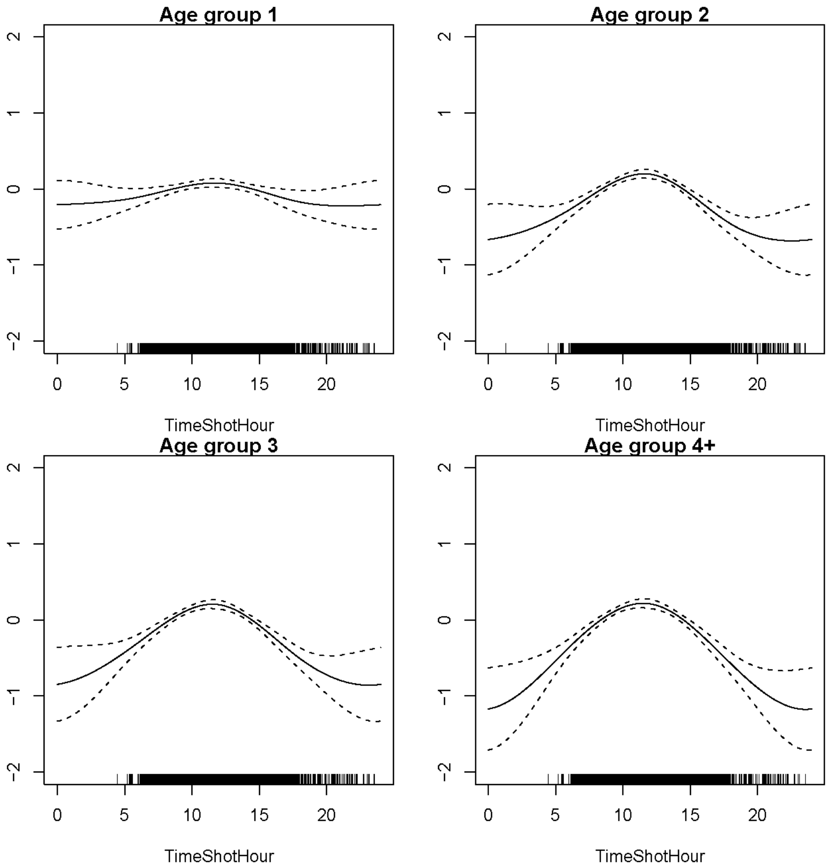


Figure 25: Estimated time of day effect Q1 by age.

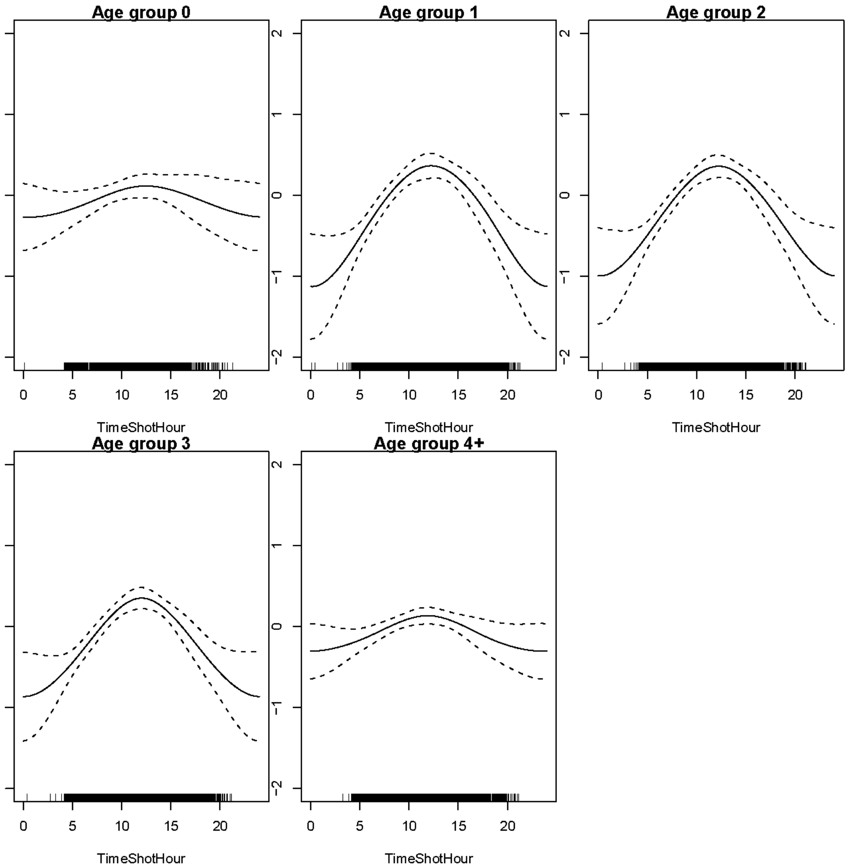


Figure 26: Estimated time of day effect Q3 by age.

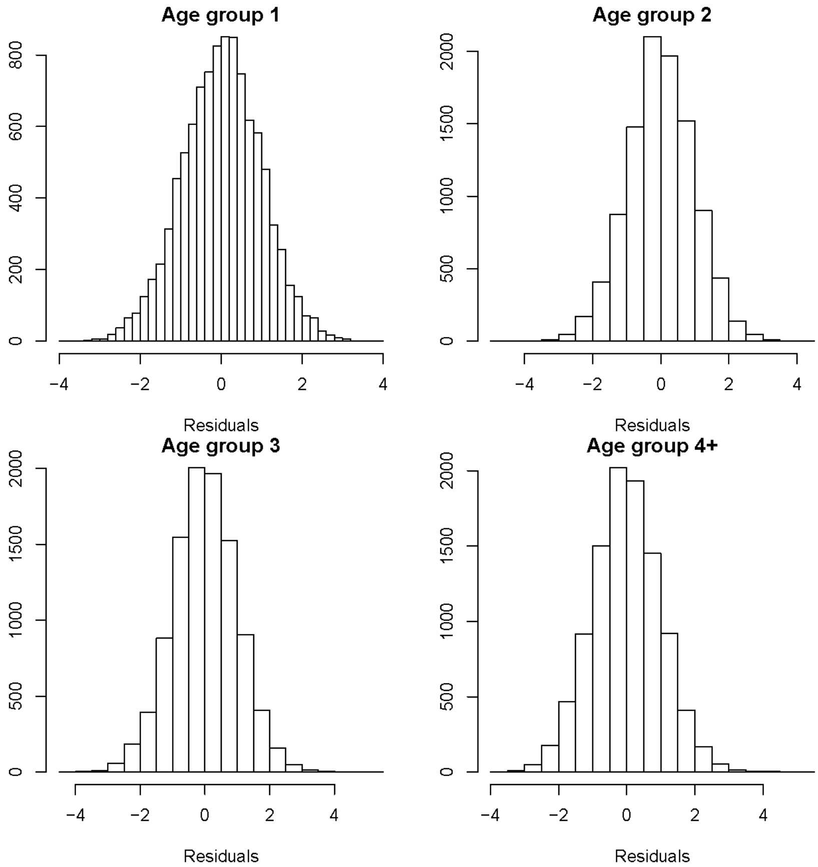


Figure 27: Q1: residuals.

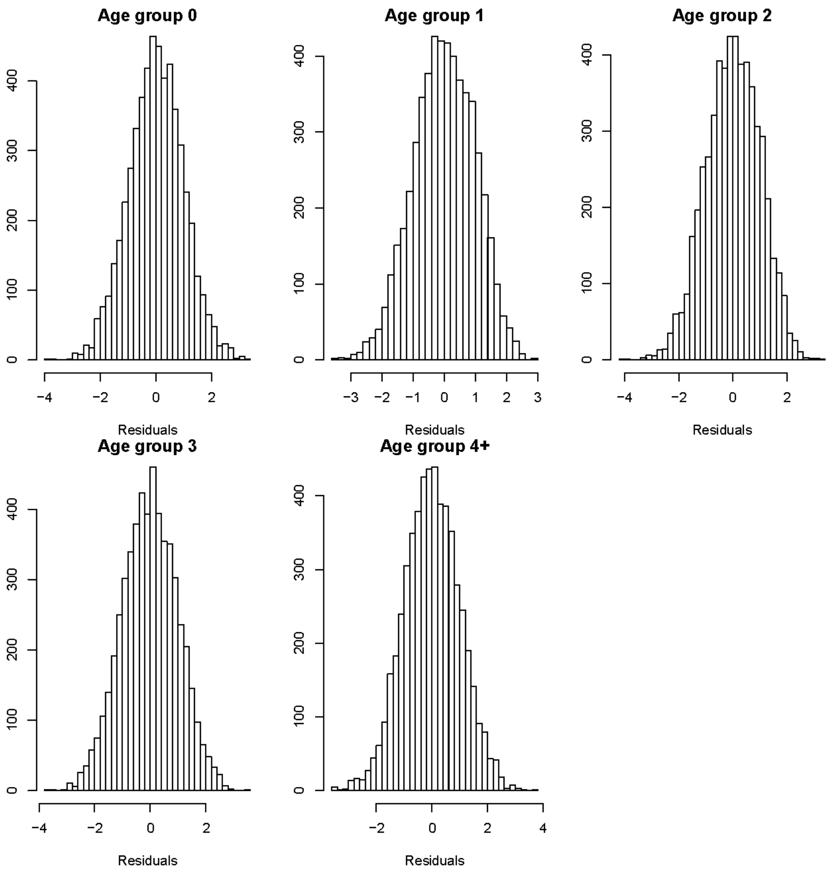


Figure 28: Q3: residuals.

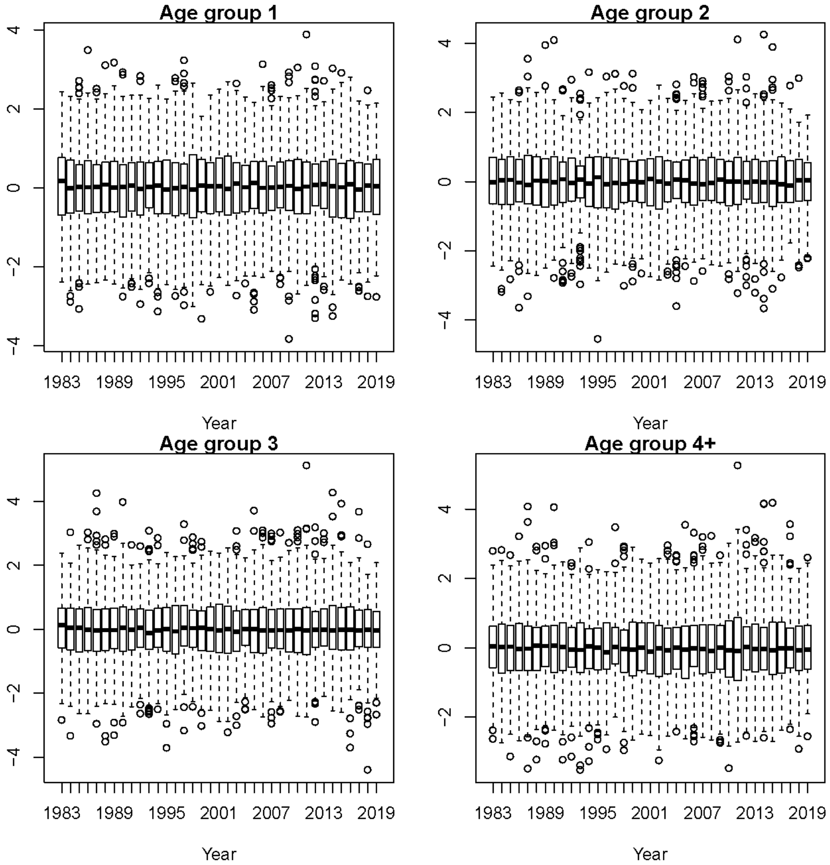


Figure 29: Q1: residuals versus year.

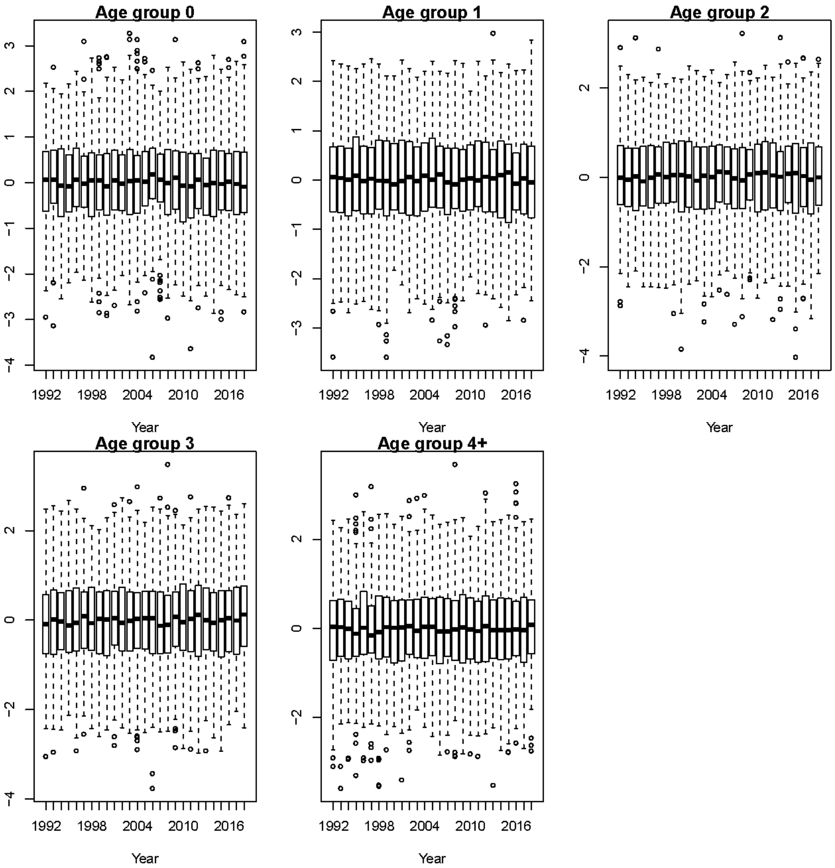


Figure 30: Q3: residuals versus year.

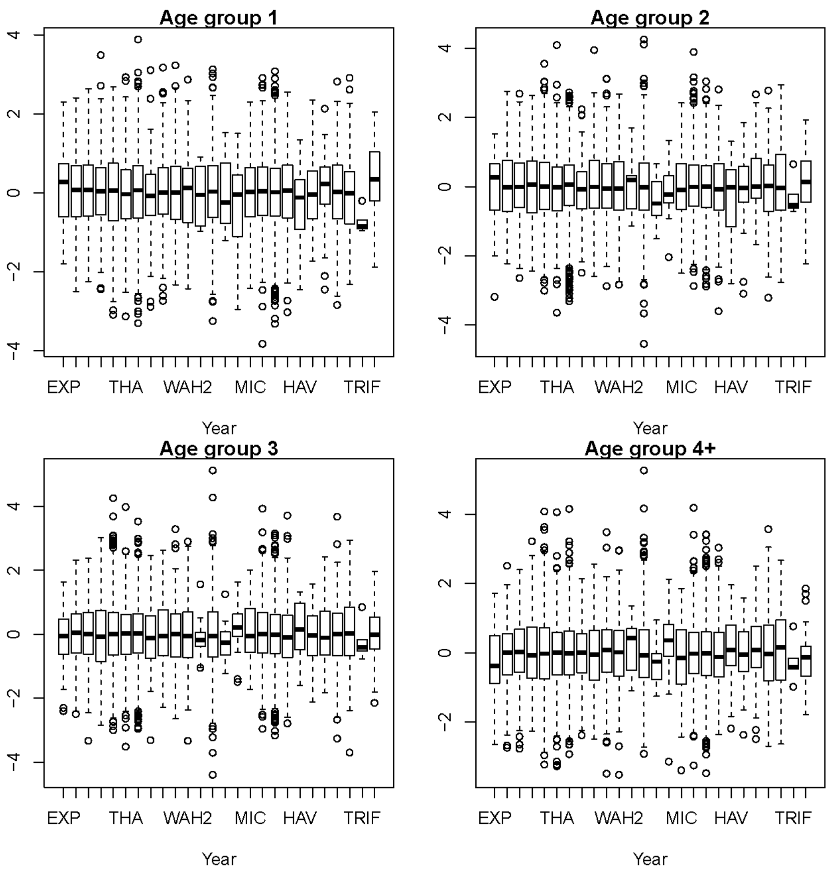


Figure 31: Q1: residuals versus ship.

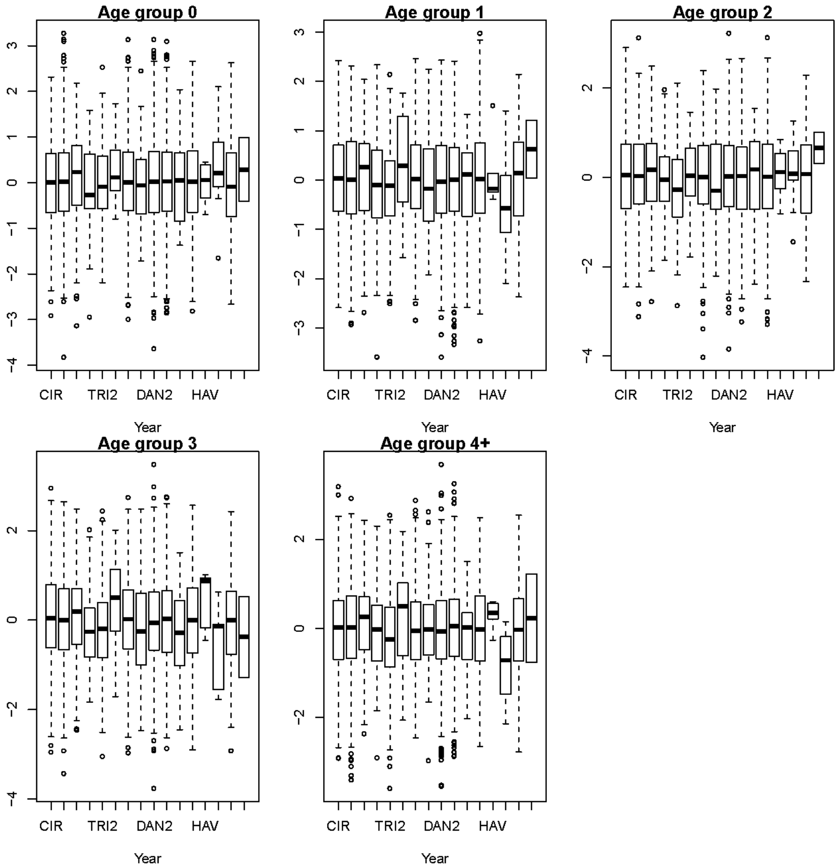


Figure 32: Q3: residuals versus ship.

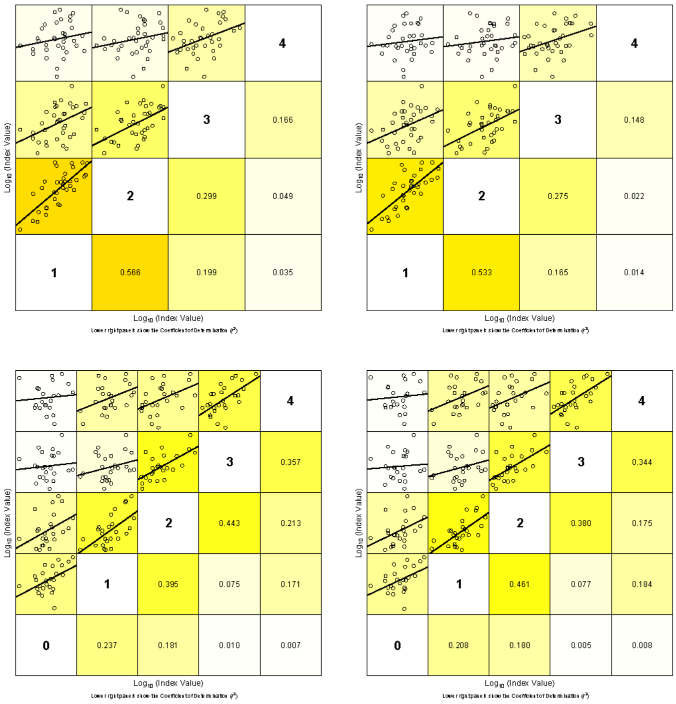


Figure 33: Internal consistency using the new model in Q1 (top left), old model in Q1 (top right), new model in Q3 (bottom left), and old model in Q3 (bottom right).

	0	1	2	3	4	5	6	7	8	9	10	12	13	23
1983	0	482	1742	658	55	3	0	0	0	0	0	0	0	0
1984	0	828	1593	457	132	27	6	1	0	0	0	0	0	0
1985	0	1687	1078	260	77	15	10	1	0	0	0	0	0	0
1986	0	537	998	341	53	11	6	0	0	0	0	0	0	0
1987	0	1291	633	298	67	6	3	1	0	0	0	0	0	0
1988	0	640	1778	204	125	25	2	2	1	0	0	0	0	0
1989	0	996	443	520	61	12	0	0	0	0	0	0	0	0
1990	0	811	834	251	171	23	2	0	0	0	0	0	0	0
1991	2	2783	359	109	17	14	3	1	0	0	0	0	0	0
1992	0	726	405	81	29	4	2	0	0	0	0	0	0	0
1993	0	756	468	119	20	9	1	1	0	0	0	0	0	0
1994	0	390	507	282	49	3	4	0	0	0	0	0	0	0
1995	0	342	534	126	27	5	0	0	0	0	0	0	0	0
1996	0	417	664	307	75	23	1	1	0	0	0	0	0	0
1997	0	448	449	394	75	12	5	0	0	0	0	0	0	0
1998	0	374	706	214	115	18	6	3	1	0	0	0	0	0
1999	0	773	601	206	25	24	3	2	2	0	0	0	0	0
2000	0	605	729	254	44	3	4	0	1	0	1	0	0	0
2001	0	1159	990	428	37	7	1	1	0	0	0	0	0	1
2002	0	666	1236	252	83	12	2	1	1	0	0	0	0	0
2003	0	756	697	317	61	23	2	2	0	0	0	0	0	0
2004	0	1071	443	175	47	6	9	1	0	0	0	0	0	0
2005	0	1503	647	103	41	18	2	2	0	0	0	0	0	0
2006	0	479	1054	177	20	22	1	0	0	0	0	0	0	0
2007	0	869	721	392	46	6	4	2	0	0	0	0	0	0
2008	0	626	709	154	86	32	2	1	0	0	0	0	0	0
2009	0	1233	388	242	46	22	13	0	0	0	0	0	0	0
2010	0	865	938	205	159	28	37	7	0	0	0	0	0	0
2011	0	467	998	541	143	105	51	27	10	0	0	0	0	0
2012	2	972	1429	434	137	37	22	6	1	1	0	0	0	0
2013	0	476	943	511	184	66	13	5	1	3	0	0	0	0
2014	0	1267	534	246	157	26	19	2	1	0	1	0	0	0
2015	0	1365	1193	304	58	49	12	3	2	0	0	0	0	0
2016	0	718	1369	732	114	15	28	1	1	0	0	0	0	0
2017	0	968	791	319	114	7	9	6	0	0	0	1	2	0
2018	0	1931	1165	210	111	22	10	0	1	0	0	0	0	0
2019	0	830	1232	315	45	50	13	3	0	0	0	0	0	0

Table 1: Q1: Number of age samples by year and age

	0	1	2	3	4	5	6	7	8	9
1991	9	17	16	3	3	2	0	1	0	0
1992	11	353	209	37	14	3	1	0	0	1
1993	13	235	354	135	21	2	1	0	0	0
1994	11	580	261	83	8	0	1	0	0	0
1995	0	485	367	137	25	7	1	0	0	0
1996	2	181	352	114	25	19	0	1	0	0
1997	47	527	188	107	18	3	2	0	0	0
1998	69	493	452	158	49	2	1	2	1	0
1999	64	947	360	100	17	9	3	2	0	0
2000	50	589	551	88	6	0	0	0	0	0
2001	71	780	662	242	10	1	1	0	1	0
2002	165	824	379	103	36	3	1	0	0	0
2003	164	773	474	113	28	10	2	0	0	0
2004	279	821	475	119	28	4	2	0	0	0
2005	26	1289	343	69	22	10	3	1	0	0
2006	6	529	932	185	24	20	5	1	0	0
2007	77	837	357	218	44	3	2	0	0	0
2008	118	454	426	117	93	22	2	1	0	0
2009	107	938	368	225	70	35	13	0	0	0
2010	49	755	687	162	69	40	9	0	1	0
2011	19	481	579	438	74	37	13	7	3	0
2012	19	616	712	406	155	28	7	0	1	0
2013	14	328	406	320	119	36	9	5	3	0
2014	119	1048	293	122	60	21	14	2	2	0
2015	12	990	797	151	29	19	5	0	1	0
2016	37	632	472	265	40	16	9	0	0	0
2017	35	495	274	160	94	22	6	6	0	0
2018	74	778	249	117	101	27	8	1	0	1

Table 2: Q3: Number of age samples by year and age

References

[1] Casper W. Berg. `surveyIndex`: R package for calculating survey indices by age from DATRAS exchange data. `https://github.com/casperwberg/surveyIndex`, 2014.

[2] Casper W Berg and Kasper Kristensen. Spatial age-length key modelling using continuation ratio logits. *Fisheries Research*, 129:119–126, 2012.

[3] 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.

[4] Kasper Kristensen and Casper W. Berg. DATRAS package for R. `https://github.com/DTUAqua/DATRAS`, 2012.

HAWG 2020 WD06

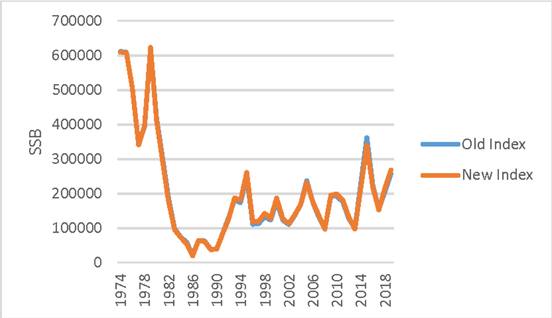
Explorative SMS runs to compare currently applied IBTS indices to those from an improved model

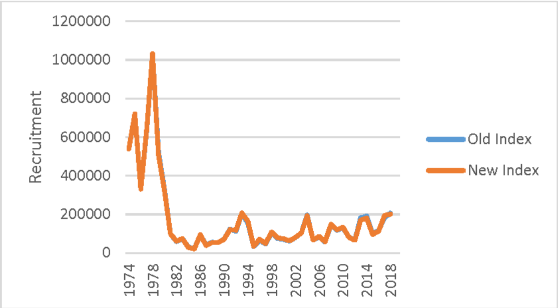
The present working document presents the results from Explorative SMS runs to compare the currently applied IBTS indices to those from an improved Index-model. A description of the model improvement can be found in the working doc “updatedNSSpratIndices_A” together with the new index time-series.

The SMS model was run with the currently applied default settings (in accordance with stock annex and benchmark in 2018). Catch data until 2018 was used (2018 included). The SMS model with the current setting could not converge when using the new index, unless density dependent catchability on IBTS Q1 age-1 was switched off. We therefore switched density dependent catchability off in the explorative runs. The table below contains a comparison of the main diagnostic and the graphs shows SSB and Recruitment time-series. The new index improve some diagnostics, while others deteriorated. For example, AIC increased, while Mohn´s Rho decreased, when moving from the old to the new index. The effect of SSB and recruitment time-series were minute, hence, reference points are not likely to be substantially affected.

Diagnostic	Old Index	New Index
Neg. Log Likelihood	0.0000753	0.000127
AIC	797.33	802.47
Catch CV (age-1 S1)	0.818	0.819
Catch CV (age-1 S2)	0.657	0.643
IBTS Q1 CV age-0	0.65	0.7
IBTS Q1 CV age-1	0.42	0.41
IBTS Q3 CV age-1	0.4	0.39
IBTS Q3 CV age-2	0.3	0.34
HERAS CV age-1	0.45	0.44
HERAS CV age-2	0.49	0.5
Mohn´s Rho Rec	0.97	0.9
Rec Peel-1	1.08	0.79
Rec Peel-2	2.4	2.11
Rec Peel-3	0.31	0.38
Rec Peel-4	1.65	1.87
Rec Peel-5	-0.59	-0.65
Mohn´s Rho SSB	0.82	0.74
SSB Peel-1	1.36	1.09
SSB Peel-2	1.78	1.6

SSB Peel-3	1.46	0.44
SSB Peel-4	1	1.15
SSB Peel-5	-0.54	-0.58





European Union
European Maritime and Fisheries Fund

HAV & FISK

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Annex 6: Audit reports

Audit of her.27.20-24

Working Group: HAWG **Stock Name: her.27.20-24**

Date: 25 March 2020
Auditor: Steven Mackinson and Claus Reedtz Sparrevohn

- *Audience to write for: ADG, ACOM, benchmark groups and EG next year.*
- *Aim is to audit (check if correct):*
  - *the stock assessment– concentrate on the input data, settings and output data from the assessment*
  - *the correct use of the assessment output in the forecast, and check if forecast settings are applied correctly*
- *Any deviations from the stock annex should be described sufficiently.*
- *By the conclusion of the working group, all update assessments should be audited successfully.*
- *Store all audits on SharePoint for future reference.*

[BITS IN YELLOW ARE FROM LAST YEAR, SO AMEND/ DELETE AS NECESSARY]

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

9) **Assessment type: update -special abbreviated advice with 2019 advice appended**

10) **Assessment**: Analytical
11) **Forecast**: Presented
12) **Assessment model**: Age-based analytical assessment SAM – tuned by 5 surveys.
13) **Data issues:** The stock annex for WBSS was updated at HAWG 2019 following a benchmark. Survey numbers going into the assessment can be found in the report tables and stockassessment.org. Similar for catch numbers and other biological information. The final assessment input data on sharepoint, matches that of the final assessment on stockassessment.org. Leave on out analysis shows that the trajectory of the assessment is most sensitive to the GERAS acoustic data, which shows very low index values in 2019 and 2018 that stand out as much lower than the downward trend in the index.

14) **Consistency**: The new assessment shows the same pattern as the 2019 assessment but the stock perception is lower over the whole time series. The recruitment series is lower throughout and more variable.

15) **Stock status**: The reference points were changed during the 2018 benchmark, and the updated assessment indicates that SSB <Blim and F>Fmsy. Future short and medium predictions show that there are no scenarios that SSB is predicted to be above Blim by 2023, and there are no scenarios to indicate what might be the earliest year at which stock size may exceed Blim.

16) **Management Plan**: No specific management plan for WBSS are present. The Baltic MAP and the 3.a TAC setting rule are reflected in the advice.

General comments

- *This was a well documented, well ordered and considered section. It was easy to follow and interpret…. Etc*

- The reference points for this WBSS assessment were changed at the 2018 benchmark. In particular Blim has increased from 90kt to 120kt. This has had important consequences for the perception of the stock abundance, fishing pressure and the catch advice since 2019.
- Notwithstanding the changes from the benchmark, the assessment of this stock is not straightforward due to mixing of WBSS with North Sea Autumn spawners both within IIIa and in the transition area of the North Sea. Further there has in recent years been suspicion of a mixing with central Baltic herring.
- The fishery on WBSS is conducted by several fleets both in a directed consumption fishery and as bycatch in small meshed industrial fisheries.
- A considerable amount of time was devoted to issue of method for estimating Blim - as the reference point indicating impaired recruitment. The impact of this on the quality of the assessment and the advice scenarios was discussed a length.
- A new multi-fleet assessments is used for the assessment and advice. The multi-fleet assessment model based on the basic state-space assessment model (SAM). The new model is extended from having one fishing mortality matrix describing the total fishing mortality by year and age to having one fishing mortality matrix for each of the four fleets (A, C, D, F). The single fleet model assessment is also made available. Comparisons show that they are generally consistent with one another. However, comparison of the 2019 and 2020 assessment shows that while the single fleet assessments are very similar, the multifleet model shows and difference between 2019 and 2020, with 2020 assessment of SSB being lower from around 2011 onward. [CLAUS]

Technical comments

(Include comments on points where the draft report contains errors, is unclear and if the assessment is done according to the stock annex)

- The complexity of the assessment and the advice make this difficult to follow and careful attention is needed to improving the language further to make the advice understood and accessible to its users.
- The stock annex was updated in 2019 and the assessment settings and data files are consistent with the stock annex. No obvious errors were detected.

- Note that in the Canum table, the last three years are to multiple decimal points, whereas others are to whole number.

- Weight at age in the stock for 2017 for fish 6 and older were considerably lower than in the previous 8 years. The same is observed in the landings.

-

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

Has the EG answered those TORs relevant to providing advice?

Is the assessment according to the stock annex description?

If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?

Have the data been used as specified in the stock annex?

Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

Is there any **major** reason to deviate from the standard procedure for this stock?
Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

It is useful to print previous year advice sheet for comparison purposes it will make it easier to find potential errors and or inconsistencies.

Along with the spelling and structure of the text ensure that any values referenced in the text match the values or percentages shown in the tables.

All the values presented in the advice sheet should not be rounded at the WG. All rounded will be done at the ADG.

The check list below is given by section and it results from a compilation of the most frequent errors but by no means is it a complete list.

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

Comments and edits have been made directly on the draft advice sheet by SM on 25/3/19 and the stock assessors notified by email the same day.

☒ The advised value of catches should be the same as presented in the catch options table.

☒ Check the years for which the advice is given.

The top line of the advice could indicated that this is abbreviated advice based on the guidelines of ICES regarding procedures during covid-19. A suggestion was made on the advice sheet

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

|

Should the title of the catches graph be 'Landings'?

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be un-shaded.

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results.

Audit of Her. 27. 3a74d

Working Group: HAWG **Stock Name: her.27.3a47d**Choose an item.

Date:
Auditor:
Florian Berg, Institute of Marine Research, Norway
Niels Hintzen, Wageningen Marine Research, The Netherlands
Johnathan Ball, Centre for Environment, Fisheries and Aquaculture Science, UK

- *Audience to write for: ADG, ACOM, benchmark groups and EG next year.*
- *Aim is to audit (check if correct):*
  - *the stock assessment– concentrate on the input data, settings and output data from the assessment*
  - *the correct use of the assessment output in the forecast, and check if forecast settings are applied correctly*
- *Any deviations from the stock annex should be described sufficiently.*
- *By the conclusion of the working group, all update assessments should be audited successfully.*
- *Store all audits on SharePoint for future reference.*

General

The assessment of the stock is complicated by the mixing of Western Baltic Spring Spawners with North Sea Autumn spawners within Div. 3a and in the northeastern North Sea. Additionally, there is some doubt as to the stock boundary with the adjacent management area stock in Div. 6a. Where there is the possibility of misallocated catches/fish in both the fisheries and the surveys. There is a complex fleet structure operating in the area consisting of a human consumption fishery (A-fleet in the North Sea and C in Div. 3.a) and a sprat fishery, that takes juvenile herring as a by-catch (B- and D-fleet, respectively, in the two areas).

For single stock summary sheet advice:

This stock was last benchmarked in February 2018. Assignment of catches to relevant stocks/areas is relatively complex but is agreed and has been utilized for many years. The assessment uses all catches from most of the North Sea area and the estimated catches of NSAS herring in the transfer area in Subdiv. 27.4.aEast and Div. 27.3.a. A variable natural mortality at age (from the SMS North Sea multispecies model) is used, and was updated in the benchmark. The most recent natural mortalities have thus been used. This SMS run provides the most up-to-date perception of the natural mortality fields for herring, by age and year, in the North Sea. An averaging process is used to estimate M for years post the SMS model key run and for years prior to the first SMS years estimated. Updated survey indices, along with updated biological parameters e.g. mean weight, catches etc. are all used.

17) **Assessment type:** Benchmarked in 2018, and previously in 2012
18) **Assessment:** Analytical assessment
19) **Forecast:** Presented
20) **Assessment model:** "state-space" modelling approach (SAM, in the FLR environment), single fleet, tuned by 5 tuning indices (IBTSQ1 1-ringer, IBTS0, LAI, HERAS 1-8 ringers, IBTSQ3 0-5 ringers) for the assessment. In addition, a multi-fleet (Fleet A-D) assessment was run for estimating fleet selectivity for use in the forecast (new in last benchmark, WKPELA 2018).

21) **Data issues:** All data were available to the working group, and there did not appear to be any issues.
22) **Consistency:** The same set up for the assessment have been used since the benchmark in February 2018 (WKPELA 2018).
23) **Stock status:** $MSYB_{trigger}$> B > B_{lim}, F < F_{lim}. The poor productivity of this stock continues with survival from larvae to recruitment continuing to be low. 2013 is a strong year class whereas later year classes were very weak (2014) or weak (2016,2018,2019).
24) **Management Plan:** There is not an approved management plan yet. An EU-Norway request for an MSE of different management plan options was tested and advice delivered by the WKSNMSE in 2019.

General comments

In general, the chapter on North Sea autumn spawning herring is well-documented, well ordered and considered, as well as easy to follow and interpret.

The assessment shows a 1-directional bias in change in perception over the years (retrospective pattern) with a mohs-rho of 13% over the last 5 years in SSB. The retrospective pattern might be caused by poor internal consistency for age 6-7 for HERAS in the last recent years (see working report).

Requesters of advice indicated that the advice provided by ICES did not completely follow the Fmsy approach in 2019 as there was a fixed F outtake by the B-fleet assumed. HAWG slightly modified its approach to be consistent with the ICES MSY approach and consistent with the estimated reference points that were derived at the benchmark. Catch proportions by fleet are still presented in the catch option table and rely on partial selection by each of the fleets catching NSAS.

Technical comments

The assessment has been completed according to the Stock Annex.
We have worked through the detailed check list given in this template, and, where needed, corrections and comments has been added directly into the advice sheet.

Conclusions

The assessment has been performed correctly.

Audit of Her.6a7bc

Working Group: HAWG **Stock Name: her.27.6a7bc**

Date: 27.03.20
Auditor: Norbert Rohlf and Mathieu Lundy

General
Herring in this Division consists of two stocks. It is not possible yet to differentiate the two stocks and although HAWG still considers them to be discrete, they will be assessed together as a meta-population until the combined survey indices can be successfully split. A monitoring TAC is in place since 2016.

For single stock summary sheet advice:

1) **Assessment type:** new procedures as agreed in Interbenchmark 2019
2) **Assessment**: Analytical assessment
3) **Forecast**: not presented
4) **Assessment model**: Multifleet FLSAM with 3 tuning indices (one acoustic survey, two trawl surveys)
5) **Data issues:** The updated assessment provides the best statistical fit to the input data, but the assessment still has a strong retrospective bias. There is also a pattern of increasing catchability with age for the acoustic survey data
6) **Consistency**: New assessment method following inter-benchmark process.
7) **Stock status**: The assessment does not provide any information on the state of either constituent stock. No reference points defined. Assessment used as indicative of trends only.
8) **Management Plan**: No management plan in place

General comments
The model and decisions of the inter-benchmark process as presented to HAWG were used in the assessment. The report of the inter-benchmark process is not yet published.

Technical comments
None

Conclusions
The assessment has been performed correctly. This stock would benefit from a benchmark which addresses the methods to split stock components.

Checklist for audit process

General aspects

Has the EG answered those TORs relevant to providing advice?

Is the assessment according to the stock annex description?

If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?

Have the data been used as specified in the stock annex?

Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

Is there any **major** reason to deviate from the standard procedure for this stock?
Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

It is useful to print previous year advice sheet for comparison purposes it will make it easier to find potential errors and or inconsistencies.

Along with the spelling and structure of the text ensure that any values referenced in the text match the values or percentages shown in the tables.

All the values presented in the advice sheet should not be rounded at the WG. All rounded will be done at the ADG.

The check list below is given by section and it results from a compilation of the most frequent errors but by no means is it a complete list.

Quality of the assessment

☒ Are the units in plots correct?

☐ Are the titles in the plots correct including F (age range) recruitment (age). –No. F(wr) is missing -

☐ The red line correspond to the year of assessment (except F which is year of assessment -1)

☒ Each plot should have five lines.

☐ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots.

Audit of Her.27.irls

Working Group: HAWG **Stock Name: her.27.irls**

Date: 22 March 2020
Auditor: Richard Nash and Cindy van Damme

General

The spawning-stock biomass (SSB) has decreased significantly in the last decade and is below Blim since 2017. The fishing mortality (F) is above Fmsy since 2014. Recruitment has been below average since 2013. The assessment has a substantial historical retrospective revision compared to last year, with the spawning-stock biomass now estimated to be lower and fishing mortality to be higher than previous year assumed. Applying ICES MSY approach advice is zero catch for 2021. However, in order to continue to monitor the stock development ICES advices also to allow a 869 tonnes monitoring TAC.

For single stock summary sheet advice:

1) **Assessment type: update**assessment
2) **Assessment**: analytical assessment
3) **Forecast**: presented
4) **Assessment model**: ASAP tuned to a single acoustic survey using age 2-7
5)
6) **Data issues:** *Data are available as described in the stock annex*
7) **Consistency**: The assessment has a substantial historical retrospective revision compared to last year, with the spawning-stock biomass now estimated to be lower and fishing mortality to be higher than previous year assumed. Recruitment is forecasted to increase in recent years, but in retrospective is estimated to be lower and decreasing.**Stock status**: *B<Blim for a while, Flim<F<Fpa, R uncertain, seem to be high recent years* B<Blim since 2016, F>Fpa, R is uncertain, seems to be high in recent years, but in retrospective is estimated lower and decreasing
8) **Management Plan**: The long-term management strategy for Celtic Sea herring that was proposed by the Pelagic AC in 2011 (Pelagic AC, 2011) was evaluated by ICES in 2018. ICES advises that the harvest control rule is no longer consistent with the precautionary approach.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret

Technical comments

No comments

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

Has the EG answered those TORs relevant to providing advice?
Yes

Is the assessment according to the stock annex description?
Yes

If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
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 Blim in several years throughout the 20 year simulated period.

Have the data been used as specified in the stock annex?
Yes

Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
Yes

Is there any **major** reason to deviate from the standard procedure for this stock? No

Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

It is useful to print previous year advice sheet for comparison purposes it will make it easier to find potential errors and or inconsistencies.

Has been done

Along with the spelling and structure of the text ensure that any values referenced in the text match the values or percentages shown in the tables. Correct

All the values presented in the advice sheet should not be rounded at the WG. All rounded will be done at the ADG. OK

The check list below is given by section and it results from a compilation of the most frequent errors but by no means is it a complete list.

Audit of Her.27.nirls

Working Group: HAWG **Stock Name: her.27.nirs**

Date: 3 April 2020
Auditor: Martin Pastoors, Cecilie Kvamme

General

- The report section on Irish Sea herring in the HAWG 2020 report was available for auditing
- The input files were cross referenced with the input files from last year ("GIT\wg_HAWG\IrishSea\QC.Rmd") and with the tables in the WG report. It was noted that:
  - The catch in numbers for 2019 in canum.txt deviate from the catch in numbers in table 7.6.3.1
  - A small deviation existed in the 2019 proportion mature at 3 WR (1.0 in matprop.txt, 0.9 in table 7.6.3.5
  - A large deviation existed in the 2019 1 WR Acoustic index (548867 in fleet.txt, 148867 in table 7.3.2 and 7.6.3.8)
  - A small deviation existed in the 2019 SSB acoustic index (41.1849 in ssbll.txt and 44184.9 in table 7.6.3.8
- No checks between the acoustic indices and WGIPS has been made so far, as the final WGIPS report was not yet available.
- The structure of data folders on github is somewhat confusing.
  - There is a folder called 'assessment' that has data up to 2018 and assessments for 2017 and 2018.
  - There is a folder called 'UpdateAssessments' that has a 'SAM' folder the data up to 2019 and assessments (RData) carried in 2019 and 2020. For the data comparison we have used the UpdateAssessments folder
- The configuration and bindings on the parameters for the catch and the acoustic survey used in the SAM assessment are as per the stock annex (2017 version).

For single stock summary sheet advice:

This stock was benchmarked in 2017 and incorporates commercial catches, two acoustic survey indices (one age disaggregated and the second an SSB index), and invariant natural mortalities from the SMS North Sea multispecies model supplied by WGSAM (2010).

25) **Assessment type: update**
26) **Assessment**: analytical
27) **Forecast**: presented
28) **Assessment model**: FLSAM version 1.02 with 2 tuning indices based on acoustic surveys in September and during spawning time respectively.
    FLSAM.version 1.02
    FLCore.version 2.6.6
    R.version R version 3.2.0 (2015-04-16)
    platform i386-w64-mingw32
    run.date 2020-03-12 10:01:42
29) **Data issues:** The data described in the stock annex were available

30) **Consistency**: Last years assessment was accepted.
31) **Stock status**: SSB > Bpa and MSYB trigger since 2007. F < Fmsy and Fpa since 2007
32) **Management Plan**: No management plan in place

General comments

This was a well documented and well ordered section. It was easy to follow and interpret.

Technical comments

There are a few minor editorial errors in the draft report, some where updating from previous years reports have not been made (e.g. section 7.1.1, 7.1.2). The assessment in terms of parameter bindings and model configuration has been completed according to the stock annex.

The treatment of landings data could benefit from a more transparent description in the stock annex. There is a large discrepancy between the official landings data and the ICES estimated landings. Probably this is due to separating between 7a North and 7a South. However, it is not explained how this is done and, more importantly, how this split turns out in terms of landings from 7a North and from 7a South.

Conclusions

The assessment has been performed correctly, although some mismatches between the assessment input data and the tables in the report needs to be cleared up.

Checklist for audit process

General aspects

Has the EG answered those TORs relevant to providing advice? **YES**

Is the assessment according to the stock annex description? **YES**

If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? **No management plan**

Have the data been used as specified in the stock annex? **YES**

Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **YES**

Is there any **major** reason to deviate from the standard procedure for this stock? **NO**

Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **YES**

ICES stock advice

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☒ The advised value of catches should be the same as presented in the catch options table.

☒ Check the years for which the advice is given.

Stock development over time

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (0, 1, 2…); relative index

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be un-shaded.

☒ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP. **(Note: checked with reference points from 2019 advice)**

☒ Check if the legend of the plots is consistent with what is shown in the plots.

☒ Check that the graphs match the data in table of stock assessment results.

Stock and exploitation status

☒ Compare with the previous year's advice sheet. The years in common should have the same status (symbol).

☒ Check if the labels for the years are correct.

☒ Compare the status table with the F and SSB plots they should show the same information.

☐ Does the stock have a management plan? If yes than the row for the management plan should be filled as well otherwise will read not applicable.

Catch options

<u>Basis of catch options table</u>:

For each of the rows in the table ensure that:

☒ The year is correct,

☐ The value is correct, **Note: the rounding of F seems inconsistent with the values in the report**

☒ The notes are correct and

☒ The sources are correct.

<u>**Catch options table:**</u>

☐ The forecast should be re-run to ensure all values are correct. **Note: the forecast is not on github**

☐ Compare the input data with previous year run (previous year should be in the share point under the data folder). **Note: unclear what should be compared**

☒ The wanted catch and SSB values should be given in tonnes (t);

☒ Confirm if the F values for the options F_{lim}; F_{pa}; are correct.

☒ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

☐ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct. **Not relevant**

☒ For all the options given in the table calculate the percentage of change in SSB and TAC.

☒ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under "Other options".

☒ Compare different catch options; higher F should result in lower SSB

☒ Check if SSB change is in line with F.

Basis of the advice

☒ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

☐ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.)

Quality of the assessment

☒ Are the units in plots correct?

☒ Are the titles in the plots correct including F (age range) recruitment (age).

☒ The red line correspond to the year of assessment (except F which is year of assessment -1)

☒ Each plot should have five lines.

☒ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots.

Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

Reference points

☐ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year. **Reference points table not shown; values used are correct**

Basis of the assessment

☐ If there is no change from the previous year the table should be the same. **[this table is not shown]**

☐ Ensure there is no typos wrong acronyms for the surveys.

☐ Assessment type- check that the standard text is used.

Information from stakeholders

☐ If no information is available the standard sentence should be "There is no available information" **[this section is not shown]**

History of advice, and management

☒ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years.

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

History of catch and landings

Catch distribution by fleet table:

☐ Ensure the legend of the table reflects the year for the data given in the table. **[table is not shown]**

☐ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☐ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown.

History of commercial landings table:

☐ Ensure that the values for the last row are correct check against the preliminary landings (link to be added)

Summary of the assessment

☒ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected.

☒ Check if the column names are correct mainly recruitment age and age range for F.

☐ If the stock is category 5 or 6 then it should read "There is no assessment for this stock"

Sources and references

☒ Ensure all references are correct.

☒ Ensure all references in the advice sheet are referenced in this section.

Audit of San.sa.1r

Working Group: HAWG **Stock Name: san.sa.1r**

Date: January 31, 2020
Auditor: Claus R. Sparrevohn

- *Audience to write for: ADG, ACOM, benchmark groups and EG next year.*
- *Aim is to audit (check if correct):*
  - *the stock assessment– concentrate on the input data, settings and output data from the assessment*
  - *the correct use of the assessment output in the forecast, and check if forecast settings are applied correctly*
- *Any deviations from the stock annex should be described sufficiently.*
- *By the conclusion of the working group, all update assessments should be audited successfully.*
- *Store all audits on SharePoint for future reference.*

General

Use bullet points and subheadings (Recommendations, General remarks, etc.) if needed

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

33) **Assessment type: update**
34) **Assessment**: analytical
35) **Forecast**: presented
36) **Assessment model**: *SMS seasonal model,*
37) **Data issues:** *No data issues*
38) **Consistency**: *There is considerable retrospective bias in SSB in the assessment.*
39) **Stock status:** *SSB is estimated to be under Blim the 1st January 2020. SSB was also below Blim 1st January 2019. The stock is expected to increase due to the incoming 2019 yearclass.*
40) **Management Plan**: *No agreed or evaluated management plan*

General comments

Well document assessment.

Technical comments

No comments

Conclusions

The assessment has been performed correctly and in accordance with the stock annex

Checklist for audit process

General aspects

Has the EG answered those TORs relevant to providing advice?
yes

Is the assessment according to the stock annex description?
Yes

If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
NA

Have the data been used as specified in the stock annex?
Yes

Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
Yes

Is there any **major** reason to deviate from the standard procedure for this stock?
No

Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

yes

It is useful to print previous year advice sheet for comparison purposes it will make it easier to find potential errors and or inconsistencies.

Along with the spelling and structure of the text ensure that any values referenced in the text match the values or percentages shown in the tables.

All the values presented in the advice sheet should not be rounded at the WG. All rounded will be done at the ADG.

The check list below is given by section and it results from a compilation of the most frequent errors but by no means is it a complete list.

Audit of San.sa.2r

Working Group: HAWG **Stock Name: san.sa.2r**

Date: 03-02-2020
Auditor: Valerio Bartolino

- *Audience to write for: ADG, ACOM, benchmark groups and EG next year.*
- *Aim is to audit (check if correct):*
  - *the stock assessment– concentrate on the input data, settings and output data from the assessment*
  - *the correct use of the assessment output in the forecast, and check if forecast settings are applied correctly*
- *Any deviations from the stock annex should be described sufficiently.*
- *By the conclusion of the working group, all update assessments should be audited successfully.*
- *Store all audits on SharePoint for future reference.*

General

The assessment was last benchmarked in 2016 and the area 2 revised into 2r in a special request in 2017. The status of the stock has raised concerns for numerous year given its poor status since the early 2000s.

Since the benchmark, the assessment is known to be affected by strong retrospective in both R and SSB. This year the WG has proposed an adjustment of the survey catchability for recruits which resulted in in a reduction of the retrospective patterns. Main justifications for such an interim (before the planned benchmark for 2021) include:

- the poor status of the stock
- the estimated high recruitment index in 2019 which will contribute considerably to the 2020 catch
- the apparent link between survey index catchability and the strength of the year class

Catches in 2019 matched approx. the monitoring TAC of 5000 t which was advised last year by ICES.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

41) **Assessment type:** Update (but an adjustment of the model has been done via an inter-benchmark following the assessment)
42) **Assessment**: Analytical assessment based on SMS
43) **Forecast**: presented
44) **Assessment model**: SMS assuming a relationship between F and fishing effort – 1 fleet and 1 dredge survey
45) **Data issues:** commercial and survey time series are only updated with 1 extra year. No particular issues with 2019 data. The dredge survey shows a high recruitment in 2019. Age composition in the commercial catches follows the good 2016 year class which still made quite a proportion of the catches in 2019 (age3)
46) **Consistency**: Consistent with last year with the exception of the introduction of a power function to account for density.-dependency in the survey catchability of age0 (reviewed in an IBP prior the ADG)
47) **Stock status**: B<Blim for a while and still at the beginning of 2020, but the estimated good incoming year class is expected to bring the stock well above Bpa and sustain some fishery.

48) **Management Plan**: No MP for SA2r

General comments

The advice text is simple and clear enough. Data in support of the assessment are described in the report. The stock annex has been updated with information on the adjustment of the model passed through the IBP.

Technical comments

The assessment is in agreement with the updated stock annex.

Conclusions

The assessment has been performed correctly. The temporal pattern in the mohn's rho value suggests that the oldest peel of the retrospective contributes to inflate this statistic. This suggests that next year mohn's rho should be improved. Together with the model adjustment included this year via the IBP the model appears suitable for advice.

Checklist for audit process

General aspects

Has the EG answered those TORs relevant to providing advice? YES

Is the assessment according to the stock annex description? YES

If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? NO MP

Have the data been used as specified in the stock annex? YES

Has the assessment, recruitment and forecast model been applied as specified in the stock annex? YES

Is there any **major** reason to deviate from the standard procedure for this stock? THE DEVIATION HAS BEEN REVIEWED IN THE IBP AND INTEGRATED IN THE UPDATED STOCK ANNEX

Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? YES, SEE REASONS ABOVE UNDER CONCLUSIONS

It is useful to print previous year advice sheet for comparison purposes it will make it easier to find potential errors and or inconsistencies. DONE

Along with the spelling and structure of the text ensure that any values referenced in the text match the values or percentages shown in the tables. DONE

All the values presented in the advice sheet should not be rounded at the WG. All rounded will be done at the ADG. SOME OF THE ROUNDING DONE BY THE WG, BUT IT SEEMS ACCORDING TO THE STANDARD RULES

The check list below is given by section and it results from a compilation of the most frequent errors but by no means is it a complete list.

Audit of San.sa.3r

Working Group: HAWG **Stock Name: san.sa.3r**

Date: 03.02.2020
Auditor: Norbert Rohlf

General
The stock is separated in seven management areas. Fishing takes place in five of these seven areas (sandeel area 1r-3r, 4 and 6). The stock was last benchmarked in 2016. Interbenchmark in 2020. Sandeel area 3r mainly consists of fishing grounds in Norwegian EEZ.

For single stock summary sheet advice:
1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: Short-term forecast presented
4) **Assessment model**: Seasonal SMS-effort model, tuned by dredge and acoustic survey index. As a result of the interbenchmark, density-dependency in the recruitment index of the dredge survey was included to account for overestimation of large incoming year classes.
5) **Data issues:** Input data as in the stock annex. In 2019, most catches consists of 1-group (47%) and 3-group fish (44%), while the proportion of 2-group in 2018 was only 6%. These proportions are similar to catches obtained in 2013-2015.
6) **Consistency:** Model was applied as per stock annex. The formerly seen large retrospective pattern in the recruitment is now reduced due to the inclusion of density-dependent catchability.
7) **Stock status**: SSB has been above B_{pa} since 2015. High recruitment in 2019 and 2018, very low in 2017. F has increased in the last three years, but is below long term average.
8) **Management Plan**: There is no agreed management plan for this stock.

General comments
The report is very concise and documents all decisions and settings made in the assessment well. The inclusion of density-dependent catchability in the dredge survey reduced the retrospective bias in the recruitment.

Technical comments
None

Conclusions
The assessment has been performed correctly and considered adequate as the basis for TAC advice. Most of the fishing grounds are in Norwegian EEZ and managed according to a Norwegian area based management plan. However, this management plan has not been evaluated by ICES.

Checklist for audit process

General aspects

Has the EG answered those TORs relevant to providing advice?
Yes

Is the assessment according to the stock annex description?
Yes

If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
NA

Have the data been used as specified in the stock annex?
Yes

Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
Yes

Is there any **major** reason to deviate from the standard procedure for this stock?
No

Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Yes

It is useful to print previous year advice sheet for comparison purposes it will make it easier to find potential errors and or inconsistencies.

Along with the spelling and structure of the text ensure that any values referenced in the text match the values or percentages shown in the tables.

All the values presented in the advice sheet should not be rounded at the WG. All rounded will be done at the ADG.

The check list below is given by section and it results from a compilation of the most frequent errors but by no means is it a complete list.

Audit of San.sa.4

Working Group: HAWG **Stock Name: san.sa 0.4**

Date: 30-01-2020
Auditor: Claus R. Sparrevohn

- *Audience to write for: ADG, ACOM, benchmark groups and EG next year.*
- *Aim is to audit (check if correct):*
  - *the stock assessment– concentrate on the input data, settings and output data from the assessment*
  - *the correct use of the assessment output in the forecast, and check if forecast settings are applied correctly*
- *Any deviations from the stock annex should be described sufficiently.*
- *By the conclusion of the working group, all update assessments should be audited successfully.*
- *Store all audits on SharePoint for future reference.*

General
Sandeel in this area was first in 2017 assessed as a category 1 advice. The change was done after latest benchmark in 2016.

Use bullet points and subheadings (Recommendations, General remarks, etc.) if needed

For single stock summary sheet advice:
Short description of the assessment: extremely useful for reference of ACOM.

49) **Assessment type:** Update
50) **Assessment**: Analytical assessment
51) **Forecast**: presented
52) **Assessment model**: *Seasonal SMS*
53) **Data issues:** *No data issues*
54) **Consistency**: *This is the fourth advice based upon an analytic assessment. Last year, a zero-catch advice with a recommended monitoring fishery, was advised.*
55) **Stock status**: *SSB is below MSYBtrigger 1 january 2020 and above Blim. The stock size is expected to increase due to the incoming yearclass.*
56) **Management Plan**: *No management plan for this stock exist.*
57)

General comments
Well documented assessment.

Technical comments

Conclusions
The assessment has been performed correctly

Checklist for audit process

General aspects

Has the EG answered those TORs relevant to providing advice?
Yes

Is the assessment according to the stock annex description?
Yes

If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
NA

Have the data been used as specified in the stock annex?
Yes

Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
Yes

Is there any **major** reason to deviate from the standard procedure for this stock?
No

Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Yes

It is useful to print previous year advice sheet for comparison purposes it will make it easier to find potential errors and or inconsistencies.

Along with the spelling and structure of the text ensure that any values referenced in the text match the values or percentages shown in the tables.

All the values presented in the advice sheet should not be rounded at the WG. All rounded will be done at the ADG.

The check list below is given by section and it results from a compilation of the most frequent errors but by no means is it a complete list.

Audit of spr.27.3a4

Working Group: HAWG **Stock Name: spr.4-3.a**Choose an item.

Date: 23/03/2020
Auditor: Henrik Mosegaard, Christophe Loots

General

During the the previous benchmark in 2018 the stock unit was re-defined, combining division 3.a and subarea 4.

For single stock summary sheet advice:
Short description of the assessment: extremely useful for reference of ACOM.

58) **Assessment type:** Update abbreviated advice
59) **Assessment**: Analytical assessment
60) **Forecast**: presented
61) **Assessment model**: SMS in quarterly steps. Tuning data IBTS Q1 (age 0-3), IBTS Q3 (age 1-3), HERAS (age 1-3)
62) **Data issues:** all identified issues resolved
63) **Consistency**: Second assessment for the re-defined stock Mohn's Rho slightly higher than 0.3 but well within MSE 95% cf interval
64) **Stock status**: B>Bescapement, F is higher than Fcap (0.69).
65) **Management Plan**: No management plan has been developed.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret…. etc

Technical comments

There is no technical issue with this stock

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?

Yes, the assessment and advice for sprat in division 3.a and subarea 4 have been carried out according to the TORs.

- Is the assessment according to the stock annex description?

Yes, according to stock annex

- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?

No management plan used.

- Have the data been used as specified in the stock annex?

Catches are supposed to be raised to ICES landings – it is not specified how this is done for 2020 Q2

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

Yes

- Is there any **major** reason to deviate from the standard procedure for this stock?

No

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Yes

Audit of Spr.27.7de

Working Group: HAWG **Stock Name: spr.27.7.de** Choose an item.

Date: 25/03/2020
Auditor: Christophe Loots, Michael Gras

General
This is a category 3 stock for which the assessment is based on the trend and absolute estimate of biomass in the PELTIC acoustic index from 2013 onward. The acoustic survey covers a much wider area than the Lyme Bay area where the stock is defined and the fishery is focused.

The stock biomass index has been revised upward in 2018 (+27%) due to a software bug detected during the PELTIC survey (see the report).

In the advice sheet, sentence before table 3 : "***[advice for 2021] x [uncertainty cap]History of the advice, catch, and management" should be amended.

For single stock summary sheet advice:
Short description of the assessment: extremely useful for reference of ACOM.

1) **Assessment type:** Update
2) **Assessment**: Trends based on the PELTIC survey result used as an absolute assessment of stock size
3) **Forecast**: N/A
4) **Assessment model**: No model used
5) **Data issues:** No data issues
6) **Consistency**: Same advice as in 2020 is given for 2021 given that there was a change of less than 20% in the stock biomass following the 2 over 3 rule calculation.
7) **Stock status**: No reference points but an increase in the stock biomass and a decrease in fishing pressure.
8) **Management Plan**: There is no management plan for this stock.

General comments
The draft report is well documented and easy to read. The ways the assessment is performed and the catch advice is provided are clear and well explained.

Technical comments
The assessment appears to be done according to the stock annex.
The decision to use the 2 over 3 rule (following the ICES framework for category 3 stocks but defined as not precautionary according to the MSE performed during WKspratMSE and WKDLSSLS) rather than the 1 over 2 rule (more adapted but still need to be approved) to evaluate change in the biomass index is clearly explained in the report. Change in the biomass according to this rule is less than 20% hence conducting to rollover for 2021 the same advice as for 2020.

Conclusions
The assessment has apparently been performed correctly according to the Stock Annex and the advice was given following the rules accepted during the last benchmark of this category 3 stock.

Checklist for audit process

General aspects

Has the EG answered those TORs relevant to providing advice?

Yes

Is the assessment according to the stock annex description?

Yes

If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?

No management plan available.

Have the data been used as specified in the stock annex?

Yes

Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

N/A

Is there any **major** reason to deviate from the standard procedure for this stock?

No

Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Yes

It is useful to print previous year advice sheet for comparison purposes it will make it easier to find potential errors and or inconsistencies.

Along with the spelling and structure of the text ensure that any values referenced in the text match the values or percentages shown in the tables.

All the values presented in the advice sheet should not be rounded at the WG. All rounded will be done at the ADG.

The check list below is given by section and it results from a compilation of the most frequent errors but by no means is it a complete list.