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Herring Assessment Working Group for the Area South of 62 deg N (HAWG)

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Executive Summary

The ICES herring assessment working group (HAWG) met for seven days in March 2017 to assess the state of five herring stocks and four sprat stocks. HAWG also provided advice for seven sandeel stocks but reported on those prior to this meeting. The working group conducted update assessments for five of the herring stocks. An analytical assessment was performed for North Sea sprat and data limited assessments were conducted for English Channel sprat, Celtic Sea sprat and 3.a sprat.

The **North Sea autumn spawning herring** SSB in 2016 was estimated at 2.20 m tonnes while $F_{2\text{–}6}$ in 2016 was estimated at 0.26, at the management plan target $F_{2\text{-}6}$ and below F_{msy}. Fishing mortality on juveniles, mean $F_{0\text{-}1}$ is 0.05, just below the agreed ceiling. Recruitment in 2017 is estimated to be very low. The estimate of 0-wr fish in 2016 (2015 year class) is estimated to be at approximately 29 billion, being low but in line with recent recruitment. Year classes since 2002 are estimated to be consistently week with year classes 2002 to 2007 to be among the weakest. ICES considers that the stock is still in a low productivity phase. The **Western Baltic spring spawning herring** assessment was updated. The SSB in 2016 was relatively stable compared to recent years and is estimated to be around 97 000 tonnes. Fishing mortality has been estimated at 0.41 and seems to have increased again after a period of reductions. It is above the estimate of F_{msy} (0.32). Recruitment in 2016 is very low and potentially the lowest in the time-series. Under an historical perspective the estimates of SSB are considered still low, and the stock seems not to be able to recover to these higher biomass levels. The **Celtic Sea autumn and winter spawning stock** is estimated to be at a low level, declining from a recent high biomass that peaked in 2011. SSB is currently estimated at 46 000 tonnes in 2016, coming down from 140 000 tonnes in 2011. Mean F (2–5 rings) was estimated at 0.4 in 2016, having increased from 0.07 in 2009. Recruitment has been good in recent years with several strong cohorts (2003, 2005, 2007, 2011, 2012) entering the fishery but has come down substantially in the most recent years with the poorest year class in 2015. The 2016 SSB estimate of **6.a/7.b, c herring** (the combined stock of 6.aN and 6.aS/7.b, c) was 151 000 tonnes, well below B_{pa}. Low recruitment has caused a decline of the stock while fishing mortality is low at 0.05-0.1 in recent years. Advice has been drafted to setup a monitoring fishery to ensure data relevant for the assessment and genetic studies are secured. **Irish Sea autumn spawning herring** was benchmarked in 2017 and the assessment shows a stable SSB in 2016 compared to previous years at around 26 000 tonnes, estimated substantially higher than pre-benchmark. The stock increased owing to large incoming year classes in most recent years. Fishing mortality is estimated at the lowest level in the time series at 0.17, below F_{msy}. Catches have been relatively stable since the 1980s, and close to TAC levels in recent years. **North Sea sprat** came down from a time-series high since the early '80, driven by high recruitment in 2014 and shows another increase owing to the 2016 year class. The stock appears to be well above Bpa (142 000 t) in 2016 at 246 170t. Fishing mortality in the last years has fluctuated between 0.4–1.6. Expected recruitment for 2017 is estimated to be in line with long-term recruitment. **Sprat in Division 3.a** was benchmarked in 2013 (WKSPRAT) but an analytical assessment is not presented. Short term projections are to be based on a combination of indices providing in year advice for 3.a based on the ICES approach for data limited stocks (Category 3 / 4). (Category 3/4). The surveys show variability over time without a clear trend. The most recent change is negative compared to the 4 years before**.** Catch advice for **sprat in the English Channel (7.d, e)** was based on criteria for data limited stocks. Data available are landings and a short time series of acoustic biomass (2013–2016). The acoustic biomass indicates a decline

in the stock. Quantitative advice was provided for **Sprat in the Celtic Sea (spr-irls)** based on criteria for data limited stocks where only data on landings are available.

The HAWG reviewed the assessments performed on seven sandeel stocks and the related advice of these stocks. Section 11 of this report contains the assessment 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 relevant for small pelagic fish were discussed.

All data and scripts used to perform the assessment and perform the forecast calculations are available on GitHub and accessible to anyone.

1 Introduction

1.1 Terms of Reference

2016/2/ACOM07 The Herring Assessment Working Group for the Area South of 62ºN (HAWG), chaired by Niels Hintzen, the Netherlands, will meet at ICES Head-quarters for two meetings: 18–19/20 January, 2017 to:

a) Compile the catch data of sandeel in assessment areas 1-7 and address generic ToRs for Regional and Species Working Groups that are specific to sandeel stocks in the North sea ecoregion;

b) Estimate MSY proxy reference points for the category 3 and 4 stocks in need of new advice in 2017 (see table below).

i. Collate necessary data and information for the stocks listed below prior to the Expert Group meeting. An official ICES data call was made for length and select life history parameters for each stock in the table below;

and 14–22 March 2017 to:

c) compile the catch data of North Sea and Western Baltic herring on 14–15 March;

d) address generic ToRs for Regional and Species Working Groups 16-22 March for all other stocks assessed by HAWG.

e) Propose appropriate MSY proxies for each of the stocks listed below by using meth-ods provided in the ICES Technical Guidelines (i.e. peer reviewed meth-ods that were developed by WKLIFE V, WKLIFE VI, and WKProxy) along with available data and expert judgement.

Stock Code	Stock name description	EG	Data Category
spr-kask	Sprat (*Sprattus sprattus*) in Division 3.a (Skagerrak and Kattegat)	HAWG	3.2
spr-ech	Sprat (*Sprattus sprattus*) in divisions 7.d and 7.e (English Channel)	HAWG	3.2

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

Material and data relevant for the meeting must be available to the group no later than 18 January for sandeel stocks and 16 March 2016 for other stocks according to the Data Call 2017.

HAWG will report by 27 January 2017 (on sandeel), and by 14 April 2017 (all stocks except sandeel) for the attention of ACOM.

Fish Stock	Stock Name	Stock Coord.	Assesss. Coord. 1	Assess. Coord. 2	Advice	Review (SA)
san-sa	Sandeel in Division 3.a and Subarea 4	Denmark	Denmark	Norway	Update	Germany / Sweden
her-27.20-24	Herring in Subdivisions 20–24 (Western Baltic Spring spawners)	Denmark	Sweden	Denmark	Update	UK

her-27.3a47d	Herring in Subarea 4 and Division 3.a and 7.d (North Sea Autumn spawners)	Germany	NL	UK (Scotland)	Update	UK (Scotland)
her-27.irls	Herring in Division 7.a South of 52° 30′ N and 7.g-h and 7.j-k (Celtic Sea and South of Ireland)	Ireland	Ireland		Update	Norway
her-27.6a7bc	Herring in Divisions 6.a and 7.b and 7.c	UK (Scotland) / Ireland	UK (Scotland)	Ireland	Update	Denmark
her-27.nirs	Herring in Division 7.a North of 52° 30′ N (Irish Sea)	UK (Northern Ireland)	UK (Northern Ireland)		Update	Ireland
spr-27.3a	Sprat in Division 3.a (Skagerrak - Kattegat)	Norway	Denmark	-	Update	UK
spr-27.4	Sprat in Subarea 4 (North Sea)	Denmark	Denmark	Norway	Update	NL
spr-27.7de	Sprat in the Western Channel	UK	UK		Update	Norway
spr-27.67a-cf-k	Sprat in the Celtic Seas	UK	UK		Update	UK (Scotland)

1.1.1 Generic ToRs for Regional and Species Working Groups

2016/2/ACOM05 The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

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 overview, and

   iv) emerging issues of relevance for the management of the fisheries;

c) Conduct an assessment to update advice on the stock(s) using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarising where the item is relevant:

   i) Input data and examination of data quality;

ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;

iii) For relevant stocks (i.e., all stocks with catches in the NEAFC area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in the last year.

iv) 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;

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

vi) Catch options for next year;

vii) Historical performance of the assessment and catch options and brief description of quality issues with these;

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

e) Review progress on benchmark processes of relevance to the expert group;

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

g) Identify research needs of relevance for the expert group.

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

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

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

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)

HAWG was informed about the WGCHAIRS meeting in January 2017. A wide array of initiatives being led by the ACOM leadership was communicated to working group chairs. The presentation focused on the following main outcome relevant for HAWG:

Benchmarks: In 2015 a new benchmark process was suggested, which however received substantial criticisms at the ASC in 2016. It was therefore decided that some herring stocks from HAWG would be used as a test case. For HAWG 2017 no test cases were defined yet but herring in VIa may be a suitable candidate.

Data call: ICES sends out one data call on all ICES assessment or related working groups. ICES members are requested to either upload the catch/landings data in Inter-Catch or send it to the ICES secretariat for registration purposes. BMS and logbook registered discard data was requested this year as well for 2016. HAWG reported very minor deviations from the data call and in general had access to all the data that was requested, although French data came in late. Even members that didn't upload data last year did so this year. A discussion with ICES secretariat on how to improve the data call was held.

Rounding: New rules to round numbers were presented. It was agreed that HAWG would not round any number in the advice and that the ADGs would take care of that.

MSY approach for cat 3 stocks: New procedures and a course were developed by ICES to estimate MSY reference points for category 3 and 4 stocks. These apply in HAWG for two sprat stocks.

Advice format: Only minor changes were proposed to the advice format, most of them referring to changes in stock names.

1.2.2 Working Group for International Pelagic Surveys [WGIPS]

The Working Group of International Pelagic Surveys (WGIPS) met in Reykjavik, Iceland on 16–20 January 2017. 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 2017 surveys.

Results of the 2016 surveys covered by WGIPS and coordination plans for the 2017 pelagic acoustic and larvae surveys are available from the WGIPS report (ICES CM 2017/SSGIEOM:15). The following text refers only to the surveys of relevance to HAWG.

Review of larvae surveys in 2016: Within the framework of the International Herring Larval Surveys in the North Sea, five of six planned survey metiers were covered in the **North Sea**. Due to severe technical breakdown of the research vessel scheduled to survey in September around Orkney-Shetland, the cruise had to be cancelled and this metier was not covered in the 2016/2017 survey. The herring larvae sampling was still in progress at the time of the WGIPS meeting, thus sample examination and larvae measurements had not yet been completed. The information necessary for the larvae abundance index calculation will be ready for, and presented at the HAWG meeting in March 2017.

The 2016 survey in the **Irish Sea** was successfully completed in fair to moderate weather conditions, resulting in a total of 63 stations sampled. The spatial distribution of herring larvae was similar to previous years, with larvae distributed to the north of the Isle of Man and Douglas bank regions. Larvae were also located to the west of the Isle of Man mainly associated with more coastal stations, suggestive of dispersal via local currents. A particularly high abundance of newly hatched larvae (yolk sacs evident) was located over the Douglas bank spawning area. The point estimate of production in the north eastern Irish Sea for 2016 (1.09 x 1012 larvae) remains below the time series mean. The index is used as an indicator of spawning-stock biomass in the assessment of Irish Sea herring by the Herring Assessment Working Group (HAWG).

North Sea, West of Scotland and Malin Shelf summer acoustic surveys in 2016: Six surveys were carried out during late June and July covering most of the continental shelf in the North Sea, West of Scotland and the Malin Shelf.

The estimate of North Sea autumn spawning herring spawning stock biomass is slightly higher than previous year at 2.6 million tonnes largely due to an increase in the number of fish in the stock (2016: 17 499mill. fish, 2015: 14 222 mill. fish). The stock is now dominated by young fish of age 2 and 3 wr.

The 2016 estimate of Western Baltic spring-spawning herring SSB is 78 000 tonnes and 537 million. This is a reduction of more than 60% compared to the 2015 estimates of 207 000 tonnes and 537 million fish and a return to the very low stock levels observed between 2009 and 2014.

The West of Scotland estimate (VIaN) of SSB is 87,713 tonnes and 483,200 individuals, a considerable decrease compared to the 387 000 tonnes and 1 935 million herring estimate in 2015.

The 2016 SSB estimate for the Malin Shelf area (VIaN-S and VIIb,c) is 87,713 tonnes and 483,200 individuals and is the same figure as for the West of Scotland estimate (VIaN) as no herring were observed south of the 56°N line of latitude. This is a significant decrease compared to 2015 (430 000 tonnes and 2 181 million herring).

Sprat in the North Sea and Division 3.a: The total abundance of North Sea sprat (Subarea IV) in 2016 was estimated at 124 588 million individuals and the biomass at 1118 000 tonnes (Table 5.10). This is the highest estimate observed in the time series, in terms of both abundance and biomass. The stock is dominated by 1- and 2-year-old sprat. The estimate also included 0-gr sprat (20% in numbers, and 2% in biomass), which only occasionally is observed in the HERAS survey.

In Division IIIa, the sprat abundance is estimated at 957 million individuals and the biomass at 13 516 tonnes. This is well below the long-term average both in terms of abundance and biomass. The stock is dominated by 2-year-old sprat.

Irish Sea Acoustic Survey: For this survey herring abundance for the Irish Sea and North Channel in August-September 2015 has been reported by Northern Ireland, UK. The estimate of herring SSB of 29 056 t and the biomass estimate of 55 733 t for 1+ ringers for 2015 is the lowest observed since 2007 and significantly lower than the 2014 estimates. The survey estimates are influenced by the timing of the spawning migration, but 2015 was an unusual year with warm conditions and the migration occurred much later than previously observed (this has also been confirmed by the industry). The distribution of herring was also unlike previous observation where the usual high densities around the Isle of Man were much reduced, and a more homogenous distribution across the survey area was observed. Results of a successive acoustic survey conducted later in September confirmed similar biomass estimates of what has been observed in the last 8 years. The evidence of very low abundance of spawning herring suggests poor reflection of the current age structure and abundance of the herring population in the Irish Sea. The survey results are still within the range of what has been observed historically and will have to be dealt with as a year effect within the assessment

Celtic Sea herring acoustic survey (CHAS): For this survey herring and sprat abundance for the Celtic Sea in October 2016 was reported by Ireland.

The stock was considered contained within the extended survey area in 2016 with two clear areas of distribution and no herring observed around the survey periphery. Overall herring distribution indicated that the bulk of the spawning stock was located offshore in a highly localised area as in 2015. Inshore aggregations contained a higher proportion if immature fish.

The dominate age classes of the stock were evident within the survey and comparable to commercial catch samples from the fishery. The presence of immature fish from coastal waters may indicate the presence of an emerging year class.

The ability to accurately measure offshore abundance was limited in 2016 due to fish behaviour. A large proportion of aggregations were spread thinly (<0.4m) over the seabed and within the acoustic deadzone (ADZ) hampering accurate acoustic measurements. This carpeting behaviour increased the geographical extent of aggregations from 20 nmi2 in 2015 to 200 nmi2 in 2016. The factors driving this behaviour are not readily explained, but further work is planned investigate correcting for the ADZ at higher frequency.

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 2016. The survey provides abundance data on pelagic species in the area such as herring, sardine, anchovy, mackerel and boarfish. Pending completion of the acoustic data processing, preliminary results on the small pelagic fish community suggested that most species were doing well apart from sprat. Few sprat schools were observed in Lyme Bay and also the offshore schools in deep waters of the Bristol Channel in 2015 were no present in the survey area.

Anchovy was found in large numbers in the western English Channel, extending further west as was the case in 2015. Good sardine numbers were found and their distribution was widespread. Sardine spawning (based on egg distribution) was similar to in 2014 and 2015 both in terms of magnitude and distribution although for the second consecutive year, eggs were observed in the Bristol Channel and in good numbers.

Mackerel were observed throughout the survey area, although particular areas contained higher densities, such as the Celtic Deep. Horse mackerel were prevalent in the survey area although they dominated the offshore areas of the western Channel and around the Isles of Scilly.

One of the most notable observations were the seven separate feeding aggregations of blue fin tuna along the coast; the only other time one this species was observed during the 5 year time series was in the other hot year (2014).

1.2.3 PGDATA, WGBIOP & WGCATCH

The Planning Group on Data Needs for Assessments and Advice (PGDATA) met in February 2017. This planning group is the umbrella for the newly formed WGBIOP, WGCATCH and WGREFS, which together embrace the responsibilities of PGCCDBS (Planning Group on Commercial Catches, Discards and Biological Sampling) and beyond in relation to data and sampling in general. This year the meeting focused on reviewing ICES's "Data call 2017: Landings, discards, biological sample and effort data from 2016 in support of the ICES fisheries advice in 2017"and planning the upcoming Workshop on Optimization of Biological Sampling at Sample Level (WKBIOPTIM), which will take place from the 20th–22nd of June 2017 in Lisbon.

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. However, the focus of such a group is not only on technical aspects of data collection and quality assurance but also on accuracy in life history parameter estimations to support stock assessment. WGBIOP review stock specific life history parameters and monitor potential changes in biological processes, such as growth rate, onset of maturity, maturity and fecundity at size/age, and related causal factors.

A main objective of WGBIOP is to support the development and quality assurance of regional and national provision of biological parameters as reliable input data to integrated ecosystem stock assessment and advice, while making the most efficient use of expert resources. 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.

The ICES Working Group on Commercial Catches (WGCATCH) will continue 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 (e.g. developing relative abundance indices based on fishery catch rates). The group will also evaluate 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 will also continue to develop and promote the use of a range of indicators of fishery data quality for different types of end users. These include indicators to allow stock assessment and other ICES scientists to decide if data are of sufficient quality to be used, or how different data sets can be weighted in an assessment model according to their relative quality.

WGCATCH 2016 focused on guidelines for best-practice in sampling of small-scale fisheries, documenting fishery-dependent LPUE/CPUE indices and sampling, data recording and estimation of commercial catches under the landing obligation. The group also reviewed the 'Fishery Dependent Information' (FDI) data call from STECF and the work plans under the EU multiannual Union Programme (EU MAUP).

1.2.4 WGSAM

In 2016, the new WGSAM multispecies key-run was used for North Sea herring. Main changes in the North Sea key run that affect the natural mortality of herring and sprat are the lower cod abundance (in numbers) and inclusion of hake into the multispecies model. Overall, this resulted in a lower overall natural mortality for herring in the order of 13% (over all ages) compared to earlier key runs. During the next benchmark of North Sea herring arrangements need to be made to define a process on how best to facilitate the availability of new key-run information, uptake and implementation into the assessment.

1.2.5 Other activities relevant for HAWG

Industry-Science survey of herring in 6.a, 7b-c. in 2016.

In 2016, industry and scientific institutions from Scotland, Netherlands, Ireland, England and Germany successfully carried out scientific surveys with the aim to improve the knowledge base for the herring spawning components in 6a.N and 6a.S, 7b-c, and submit relevant data to ICES to assist in assessing the herring stocks and contribute to establishing a rebuilding plan. (see Section 06 for additional details).

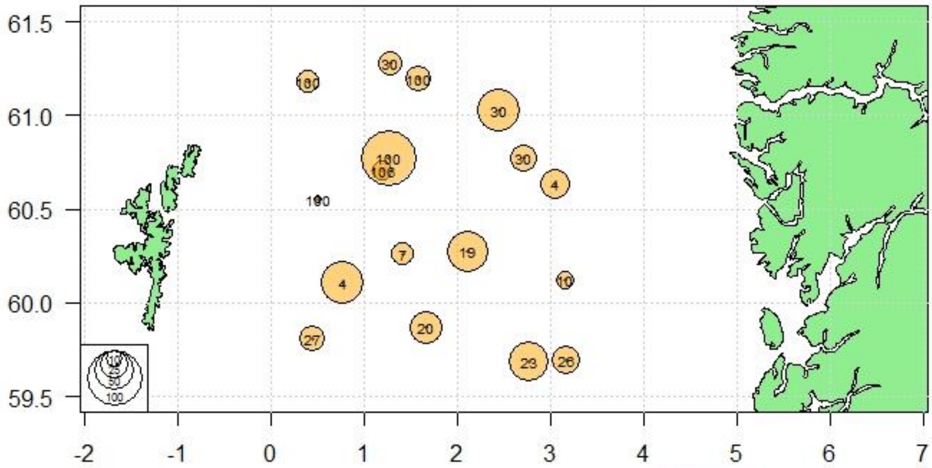
Following agreement on a monitoring fishery TAC of 5800 t (EU 2016/0203), the scientific survey was designed based on ICES advice for the timing, location and number of samples required to collect assessment-relevant data from the monitoring fishery (ICES 2016b).

Biological samples taken during the survey and subsequent commercial catches were used to construct a catch-at-age used in the 2017 stock assessment. Acoustic surveys on the biomass of the spawning components (ICES 2017a) provide first data points in possible future time series. Morphometric and genetic data from spawning fish will provide new baseline data required to assess separately the stocks in 6.aN and 6.aS, 7b-c. This information would be considered in a future benchmark assessment.

Following ICES advice on the need for a stock recovery plan for herring in 6.a, 7b-c (ICES 2016b), a draft recovery plan is under development under the auspices of the Northern Pelagic Working Group and Pelagic Advisory Council.

Ichthyophonus

Ichthyophonus hoferi is a parasite found in fish. It has a low host-specifity, 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 & 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 prepared for HAWG2017, and the occurrence is usually below 1%, except for the beginning of the 1990ies. In the Norwegian part of IBTSQ1, however, high occurrences were again observed (Figure 1.3.5.1). This led to a recommendation for all countries to screen herring for *Ichthyophonus* during the IBTS surveys (both Q1 and Q3) and HERAS, as well as for the commercial sampling.



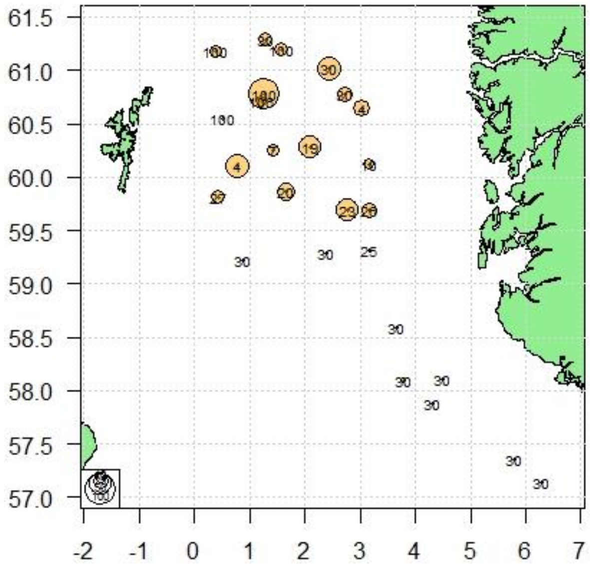


Figure 1.3.5.1 Occurrence of *Ichthyophonus hoferi* in the Norwegian part of the IBTSQ1 2017. Bubble size show the percentage of diseased herring, whereas the numbers show the number of herring.

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The review of information currently available from the two North Sea larvae surveys highlighted ways in which information currently obtained in the two surveys could be used to provide more robust indices of North Sea herring SSB and recruitment. There is a recommendation to look at the possibility of changing the timing in one survey period to generate a recruitment index for the Downs component of the stock and to adjust the method used to estimate the recruitment index so as to reduce uncertainty due to interannual variations in larval drift patterns. The particle tracking modelling can also be used to refine the recruitment indices for the North Sea stock, using interannual variations in hydrography. This will form part of a new algorithm for estimating the recruitment index.

Further investigations of the current surveys indicated that an increased usage of particle tracking models could provide a framework for estimating ingress of VIa (west of Scotland larvae) in to the northern North Sea. It may also be possible to generate a recruitment index for the VIaN portion of that stock.

An investigation of the timing of the surveys relative to hatching (SSB estimates) or when the year class strength is apparent (recruitment index) also highlight the future use of particle tracking models and the need for periodic reviews on the timing and spatial coverage of the surveys. This is important due to the various components of the stock and their spatial and temporal differences in spawning and contribution to the stock dynamics.

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 data set.

Since 2015, ICES requested relevant countries within a data call to submit the national catches into InterCatch or to accessions@ices (via the standard exchange files). National catch data submission was due by 09 March 2017, very close to the start of the HAWG meeting. However, most EU member states and Norway delivered their data in due time or the day after. One nation missed the date and provided data on the very last day of the data preparation meeting for HAWG.

"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. Comparisons between InterCatch and conventional used systems (e.g., Salloc and spreadsheets) have been carried out annually since 2007. The comparison is available for a collection of stocks. Maximum discrepancies between the systems are presented in Table 1.5.1.

For Herring caught in the North Sea, these discrepancies were small. The overall landings calculated by both procedures for North Sea autumn spawning herring were in close agreement. 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 VIa.

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 t catch). There is considerable variation between areas. Further details of the sampling quality and the required level of samples can be found by stock in the respective sections in the report and the stock annexes.

Area	Official Catch	Sampled Catch	Age Readings	Age Readings per 1000t
4.a(E)	98417	91009	1954	20
4.a(W)	330413	304276	5803	18
4.b	85255	69492	1927	23
4.c	2738	597	111	41
7.d	43096	31045	501	12
7.a(N)	4 327	3 387	991	229
6.a(N)	5 174	4 301	1 686	326
3.a	54 972	49 109	10 124	184
Celtic, 7.j	16 588	13 810	1 814	109
6.a(S), 7.b and 7.c	1 171	2 205	2 059	1 758

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

1.3.3 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 FLSAM

The FLR (Fisheries Library in R) system (www.flr-project.org) 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. FLSAM was used to assess North Sea herring.

FLSAM is a wrapper for the SAM Spate-space stock assessment model. This model has the standard exponential decay equations to carry forth the N's (with appropriate treatment of the plus-group), and the Baranov catch equation to calculate catch-at-age based on the F's. 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 F's. 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. This option of SAM was used for Western Baltic Spring Spawning herring. Western Baltic, Celtic Sea and Irish Sea herring are assessed by means of SAM.

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 originally develop by Chris Legault and Victor Restrepo while they were at the Southeast Fisheries Science Center (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 multi-species assessment model, including seasonality, used for sprat in the North Sea and for exploratory purposes for sprat in IIIa. 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 the 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

FLR

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. The Western Baltic Spring Spawner, 6.a herring, 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.

1.4.5 F_{MSY} management simulations

The eqsim software (https://github.com/ices-tools-prod/msy) was previously used to estimate MSY reference points for herring stocks of HAWG. For sprat stocks, a biomass reference point was estimated assuming that the highest observed survey index would represent B_0 from which Blim was calculated being four times smaller. Bescapement was derived from Blim by adding a 20% buffer.

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 can store their data and code to run the assessments. 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 for herring, sprat and sandeel stocks covered by the Herring Assessment Working Group for herring stocks south of 62oN (HAWG) are given for the Greater North Sea and Celtic Seas Ecoregions (ICES 2016 a,b).

A more detailed account specific to herring ise documented in ICES HAWG (2015). A number of topics are covered in this section including the use of single species assessment and management, the use of ecosystem drivers, factors affecting early life history stages, the effects of gravel extraction, variability in the biology and ecology of species and populations (including biological and environmental drivers), and disease.

It should be pointed out that whilst numerous studies have greatly improved our understanding on the effects of environmental forcing on the herring stock productivity and dynamics, further work is still required to move beyond simple correlative understanding and elucidate the underlying mechanisms. Furthermore, mechanisms to incorporate this understanding into the provision of management advice are limited. ICES could therefore benefit greatly from developments that unify these two aspects of its community.

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-47d3):

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

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

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

Western Baltic Spring Spawners (her-3a22):

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 can occurred in the trawl fishery for herring. In addition North Sea herring are also caught within the Skagerrak. The by-catch of sea mammals and birds is low enough to be below detection levels based on observer programmes. At present there is a very limited industrial fishery in Division 3.a and hence a limited by catch of juvenile herring. The pelagic fisheries on herring claim to be some of the "cleanest" fisheries in terms of by catch, disturbance of the seabed and discarding. Pelagic fish interact with other components of the ecosystem, including demersal fish, zooplankton and 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 Western Baltic herring fishery is the removal of fish that could provide other "ecosystem services." There is, however, no recent research on the multispecies interactions in the foodweb in which the WBSS interact.

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-irls):

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

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

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

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

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

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

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

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

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

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

Herring in the Irish Sea (her-nirs):

The targeted fishery for herring in the Irish Sea is considered to be clean, with limited by-catch of other species. Herring is a common prey species for many species but at present the extent of this is not quantified. Stock discrimination techniques, tagging, and otolith microstructure and shape show that juveniles originating from the Celtic Sea are present in the Irish Sea. The majority of mixing between these populations occurs at winterrings 1–2. Over the period 2006 to 2010 interannual variation in the proportion of mixing was large, with between 60% and 15% observed in the wintering 1+ biomass estimate during the study period. The main fish predators on herring in the Irish Sea include whiting (*Merlangius merlangus*) (mainly 0–1 ring), hake (*Merluccius merluccius*) and spurdog (*Squalus acanthias*) (all age classes). The small clupeids are an important source of food for piscivorous seabirds and marine mammals which occur seasonally in areas where herring aggregate. Whilst small juvenile herring occur throughout the coastal waters of the western and eastern Irish Sea, their distribution overlaps extensively with sprats (*Sprattus sprattus*). 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). There has been an increase in water temperatures in this area which has affected the distribution of some fish species.

North Sea Sprat (spr-nsea):

Sprat is a short-lived forage fish that is predated by a wide range of marine organisms, from predatory gadoids, through birds to marine mammals. Therefore, the dynamics of sprat populations are affected by the dynamics of other species through annually varying natural mortality rates. Because sprat interacts with many other components of the ecosystem (fish, zooplankton and predators) the fishery may impact on these other components via second order interactions. It is uncertain how many sprat migrate into and out of adjacent management areas i.e. 3.a and the English Channel (7.d and 7.e) or how this may vary annually. Young herring as a by-catch is acknowledged for this fishery with by-catch regulations in force. The by-catch of marine mammals and birds is considered to be very low (undetectable using observer programs).

Sprat in 3.a (spr-kask):

Whilst it is acknowledged that the dynamics of the sprat population will be affected by the dynamics of other species through annually varying natural mortality rates there is insufficient information on the predator-prey dynamics in the area for this to be quantified. Because sprat interacts with many other components of the ecosystem (fish, zooplankton and predators) the fishery may impact on these other components via second order interactions. A major source of uncertainty with this stock is whether it actually constitutes a discrete stock and the extent that individuals migrate in and out of adjacent management areas. Young herring as a by-catch is acknowledged for this fishery with by-catch regulations in force. 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.

Sprat in the English Channel (7.d and 7.e) (spr-ech):

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

Sprat in the Celtic Seas EcoRegion (6 and 7 (excluding 7.d and 7.e)) (spr-celt):

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

1.7 Stock overview

The WG was able to perform analytical assessment for 10 of the 16 stocks investigated. Results of the assessments are presented in the subsequent sections of the report and are summarized below and in Figures 1.11.1–1.11.3.

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 management plan target. The spawning stock at spawning time in 2016 is estimated at 2.2 million tonnes. Recruitment in 2017 is estimated to be very low. The estimate of 0-wr fish in 2016 (2015 year class) is estimated to be at approximately 29 billion, being low but in line with recent recruitment. Mean $F_{2\text{–}6}$ in 2016 is estimated at approximately 0.26, which is at the management agreement target F. From 2016 to 2017, SSB is expected to slightly decrease to ~2.0 million tonnes. Under all scenarios, except when the fishery is closed, SSB is predicted to decrease in 2018 (between 4–61% according to the scenario) and a further decline in 2018 to approximately 1.5 million tonnes. SSB is expected to be above B_{pa} in 2017, 2018 and 2019.

Western Baltic Spring Spawners (her-27 20-24) is the only spring spawning stock assessed within this WG. It is distributed in the eastern part of the North Sea, the Skagerrak, the Kattegat and the subdivisions 22, 23 and 24. Within the northern area, the stock mixes with North Sea autumn spawners, and recently mixing with Central Baltic herring stock has been reported in the western Baltic area. The stock has decreased consistently during the second half of the 2000s. SSB was at a minimum of about 90 000 t in 2011 and recruitment had a minimum in 2012. Under a historical perspective the estimate of SSB of 97246 tonnes in 2016 is considered low, below Bpa and closer to Blim. Fishing mortality ($F_{3\text{–}6}$) was drastically reduced in 2010 (0.36) and 2011 (0.31) followed by a minor increase. In the most recent years, F is increasing again and is estimated for 2016 at 0.41 which is above the recommended F_{MSY} (0.32). The expected overall catch of WBSS is 34 618 t in 2018, and that will result in an expected increase in SSB to around 95 000t and 102 000 t in 2018 and 2018 respectively.

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 was very low in the mid-2000s, with a historical minimum SSB of 35 000 t in 2004. The stock recovered from that low level in the years after, but in recent years a significant downward revision of the perception of SSB is visible. SSB is estimated around 46 000 t in 2016, which is below B_{pa} (at 54 000t) but above B_{lim} (at33 000t) . Several strong cohorts (2004, 2008, 2009, 2010 and 2013) have entered the fishery recently, and as they gain weight, they maintain the stock at a high level. Fishing mortality ($F_{2–5}$) declined between 2003 and 2009 but started to rise again in 2010 due to increased catches. This year assessment estimates a fishing mortality, $F_{2–5}$ of 0.41 in 2016 which is above the F_{MSY} (0.26). Short term projections under the long term management plan show a decrease in SSB to respectively 38 000 t in 2017 and an increase to 43 000t in 2018.

Herring in 6.a: The stock was larger in the 1960s when the productivity of the stock was higher. The stock experienced a heavy fishery in the mid-70s following closure of the North Sea fishery. The fishery was closed before the stock collapsed. It was opened again along with the North Sea. In the mid-1990s there was substantial area misreporting of catch into this area and sampling of catch deteriorated. Area misreporting was reduced to a very low level and information on catch has improved; in recent years misreporting has remained relatively low. The assessment is a combination of two herring stocks, one residing in 6.aS, 7.b and 7.c, and one in 6.aN. It is currently not possible to separate the two stocks for assessment purposes and therefore stock size is estimated combined. SSB is at a recent low at 151 145 t in 2016, well below B_{lim}. $F_{3–6}$ is estimated at 0.05, in line with the expected impact of the monitoring fishery. Fishing is likely not the cause of the low stock size. The lack of recruitment in recent years leads to expected SSB of 134 158t in 2018.

Herring in the Irish Sea (her-nirs) comprises two spawning groups (Manx and Mourne). This stock complex experienced a decline during the 1970s. In the mid-1980s the introduction of quotas resulted in a temporary increase, but the stock continued its decline from the late 1980s up to the early 2000s. During this time period the contribution of the Mourne spawning component declined. An increase in activity on the Mourne spawning area has been observed since 2006. In the past decade there have been problems in assessing the stock, partly as a consequence of the variability in spawning migrations and mixing with the Celtic Sea stock. A benchmark in 2017 resulted in a substantial revision of SSB perception leading to an increased SSB in the most recent period compared to pre-benchmark perceptions. In 2016, SSB and recruitment have been estimated at 25 874 t and 103 777 thousand respectively, where SSB is showing a slight increase over recent years.. $F_{4–6}$ is estimated at 0.17 in 2017. Under the MSY approach the stock is expected to show minor decline to 22 883t in 2018.

North Sea Sprat (spr-nsea) The stock is dominated by age 1–2 fish. Due to the short life cycle and early maturation, the majority 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. The sprat stock came down from a time-series high since the early ’80, driven by high recruitment in 2014 and shows another increase owing to the 2016 yearclass. The stock appears to be well above B_{pa} (142 000 t) in 2016 at 246 170t. Fishing mortality in the last years has fluctuated between 0.4–1.6. A recent management strategy evaluation (WKMSYREF2) suggested that the current manage strategy ($B_{escapement}$) is not precautionary. In the short term projections a provisional F_{cap} value of 0.7 was used. SSB is expected to increase to approximately 330 563 t with a change in catch of ~33% coming from a high catch in 2016.

Sprat in 3.a (spr-kask) Sprat cannot be fished without by-catches of herring except in years with high sprat abundance or low herring recruitment. For this reason the sprat fishery in 3.a is controlled by sprat TAC and herring by-catch quota. Various assessment methods have been explored for 3.a sprat without success, and no analytical assessment is available for this stock. Short term projections are based on the IBTSQ1 age 1 as an indicator of the incoming year class and IBTSQ1 age 2, IBTSQ3 age 1 the previous year and HERAS age 1 the previous year as indicators of age 2. These should provide in year advice for 3.a based on the ICES data limited stock approach (Category 3/4). The surveys show variability over time without a clear trend. The most recent change is negative compared to the 4 years before and therefore a decrease in TAC, applying an uncertainty cap of 20%, is advised.

Sprat in the English Channel (7.d and 7.e) (spr-ech) 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. The advice provided is based on the biomass estimates from the acoustic survey which shows a decline in biomass. Therefore the advice is set 64% lower compared to last year (applying both the uncertainty cap and the precautionary buffer).

Sprat in the Celtic Sea (spr-celt): The stock structure of sprat populations in this eco-region (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 eco-region are caught by small pelagic vessels that also target herring, mainly Irish and Scottish vessels. This is the sixth year ICES provides quantitative advice for sprat in this eco-region. The quality of information available for sprat is heterogeneous across this composite area. There is evidence from different survey sources of significant inter-annual variation in sprat abundance. Landed biomass, but not biological information on the catch, is available from 1970s in some areas (i.e., 6.a and 7.a), while Irish acoustic surveys started in 1991, with some gaps in the time series provide sprat estimates but their validity to provide a reliable sprat index is questionable because they do not always cover the core of sprat distribution in the area. Acoustic estimates in the Irish Sea are more reliable. The state of the stock of sprat in the Celtic Seas ecoregion is uncertain.

Sandeel in 4 (san-nsea): Sandeels in the North Sea can be divided into a number of more or less reproductively isolated sub-populations. A decline in the sandeel population in recent years concurrent with a marked change in distribution has increased the concern about local depletion, of which there has been some evidence. Since 2010 this has been accounted for by dividing the North Sea into 7 management areas. Denmark and Norway are responsible for most of the fishery of sandeel in the North Sea. The catches are largely represented by age 1 fish. Analytical assessments are performed in four of the management areas (A1–4) 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 well above B_{pa} (222 190 t) in 2016 and remains at a level of 233 586 t in 2018.

A2: SSB increased from 2007, with a peak in 2011and has since been stable around Blim with 46 578t in 2016. F is relatively low (around 0.16) in 2016. SSB is below $B_{escapement}$ in

2016 but is expected to increase to well above this target at 260 229t in 2018 as one of the largest yearclasses since the late 90's is expected to enter the fishery.

A3: The stock has increased from the record low SSB in 2004 at half of B_{lim} to above B_{pa} in 2016 up to 221 550 t. In 2018 SSB is expected to decline again to 133 087 t, just above $B_{escapement}$.

A4: This stock was for the first time since the mid 2000's assessed with an analytical assessment in 2017. SSB is expected to be well above $B_{escapement}$ and is at 283 840t in 2016. Over the course of 2017 and 2018 SSB is expected to decline towards $B_{escapement}$, while remaining stable at around 180 000t in these years.

1.8 Benchmark process

HAWG has made some strategic decisions regarding the future benchmarking of its stocks (Table 1.12). In 2017/2018 it is suggested to benchmark WBSS and NSAS

Stock	Ass status	Latest benchmark	Benchmark next year	Planning Year +2	Further planning	Comments
NSAS	Update	2012	Yes	No		Issuelist available
WBSS	Update	2013	Yes	No		Issuelist available
6.a	Update	2015	No	2019*	Splitting of Malin surveys	Issuelist available
Celtic Sea	Update	2015	Inter-benchmark / benchmark	Inter-benchmark/benchmark	Same timing as NSAS and WBSS	Issuelist available
7.aN	Update	2012	2017	No		
Sprat NS	Update	2013	No	2019	Consider stock components	Issuelist in prep
Sprat 3.a	Exploratory	2013	No	2019	Consider stock components	Issuelist in prep
Sprat 7.d and 7.e	Exploratory	2013	No	2019	Consider stock components	Issuelist in prep
Sprat Celtic	Exploratory	2013	No	2019	Consider stock components	Issuelist in prep
Sandeel areas 1–4	Update	2010	2016	No	Improve survey indices, explore environmental indicators, explore sandeel area 4 as category 1 assessment	Prediction of recruitment of short-lived species must be explored

***Provisional, timeline to be decided**

1.8.1 Benchmark planning

There are benchmarks on North Sea, Celtic Sea and Western Baltic herring scheduled for 2017/2018.

1.8.2 Ecosystem and long-term benchmark planning

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

General

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

North Sea Autumn Spawning (NSAS) herring

- Splitting of catches, where possible, into autumn and winter-spawning components.
- Refinement of the IBTS0 index calculation to provide component-resolved information.
- Modification of the assessment model to account for reduced precision in catch statistics prior to the 1960s.

6.a herring

- Extraction of West of Scotland herring larval abundance estimates from the North Sea IBTS0 survey.

Irish Sea herring

- Develop techniques to maximize the information content in the Irish Sea larval survey.

Celtic Sea pelagic ecosystem

- Identify stock boundaries for the main pelagic species inhabiting the Celtic Sea ecoregion, with main focus on Sprat.

1.8.3 WKIRISH3-Extension at HAWG 2017

WKIRISH3 did not reach consensus on an Irish Sea herring (Division 7aN) bench-mark assessment and requested further analyses to be performed intersessional. These were provided but did not result in a unified view of the reviewers. These reviewers decided to leave the decision on a way forward to HAWG.

In the benchmark proposed assessment an SSB survey is used with an assumed catchability of 1 which caused substantial debate in WKIRISH3 and also at HAWG. Several arguments pro and con on an assumed catchability of 1 were exchanged in discussions at HAWG. The text below summarizes the biological understanding that underlies the discussion, the pros and cons of the proposed assessment method and the agreed way forward from HAWG. Note that the term population refers to the biological entity that has its origin in the area it is named after and that the term stock refers to the fish being caught in the management area and is used as the basis for advice.

Studies from Molloy (et al. 1993) and others (Bowers 1964; Molloy and Corten 1975; Molloy 1980; Burke et al. 2008, 2009 and Beggs et al. 2007) show that the herring residing in the Irish Sea includes young fish that eventually migrate to the Celtic Sea to spawn. The appearance of Celtic Sea fish in this area is further confirmed by Beggs et al. (2008) who studied otolith microstructures. A new study (Harma et al. 2012) showed that the presumed winter spawners that are considered Celtic Sea herring may be an Irish Sea component of winter spawners and the autum spawners found in the Celtic

Sea may not necessarily be of Irish Sea population origin either, A tagging study from 1993 showed that of adult herring tagged at spawning time around the Isle of Man, about 50% were Celtic Sea fish (ICES, 1994; Molloy et al. 1993). Only a minority were captured around the Isle of Man, the remainder being taken close to Northern Ireland. It is known that the rates of mixing seem to vary over time and depend on population size of either Irish Sea herring and Celtic Sea herring (Hintzen et al. 2015). The mixing is greater for younger ages, particularly 0- to 2-ringers. Maturity of 0-1 Celtic Sea ringers in the Celtic Sea is between 10-50% whilst 2-ringers are largely mature. Maturity of fish residing in the Irish Sea is substantially lower at 6% - 16% for 1 ringers and 81-94% for 2-year old fish in the last ten years. The 2012 benchmark (WKPELA 2012) reviewed the mixed fisheries issue in the Irish Sea and concluded that the data should be treated as for a mixed stock. Both the fishery and survey operate on this mixture and the assessment will be conducted on the mixed stock. The 2012 benchmark concluded that the noise in the data due to juvenile stock mixing resulted in increased estimates of F, catchability estimates >1 across all ages in the age disaggregated survey, or most likely a combination of these. The mixing issue was presented at the 2017 benchmark, but there was no new information available to change this perception or how to accommodate for this in the assessment.

The proposed Irish Sea herring assessment treats all herring around the Isle of Man targeted in a short duration survey (one to two weeks) around spawning time as belonging to the Irish Sea herring stock. The primary purpose of the survey series was to track the spawning migration through the North Channel, southwards toward the Douglas Bank. This was to aid the establishment of optimal timing to ensure the survey abundance is primarily generated from the spawning population in an attempt to reduce the effect of mixing in the index. The acoustic survey (5 consecutive survey weeks a year from 2007- 2009 and then reduced to 3 surveys have been presented and scrutinised by ICES WGIPS) covers this area and the abundance index calculated from this survey is treated as an absolute indicator of spawning stock size (so only taking spawning adult fish), rather than a relative one. After restricting the survey area to close to the spawning grounds to minimise any contamination from pre-recruits and individuals which may not belong to the Irish Sea stock, no attempts are made to distinguish population origin or the magnitude of straying.

In the assessment model, the catch and survey data are in contradiction with each other, i.e. spawning stock biomass estimated based on catch data only is ~4-5x smaller than is estimated by the acoustic SSB index. Potential mixing (addition of Celtic Sea population) can only explain part of this difference. To what extent the catch contains a mixture of Irish Sea and Celtic Sea fish, and the SSB acoustic index contains some Celtic Sea fish is not quantifiable.

Based on the above, a few members of the HAWG expressed concerns that the assumption of an absolute biomass for the SSB index was tantamount to saying that the SSB index reflected the Irish Sea SSB size which would be an overestimate of the actual SSB due to the presence of fish from at least one other stock. It was pointed out that the resulting SSB estimate of the assessment which was presented balances the extent to which catch and survey information can be considered absolute estimators of stock size and result in an estimate ~ on the average of the two data sources. Through this approach, both data sources are treated with larger uncertainty.

In this case the assessment and TAC advice will be based on a mixture of both stocks rather than on the individual Irish Sea herring population. The mixture of Celtic and Irish Sea herring will then be exploited at the F corresponding to the Fmsy approach derived from the Irish Sea herring stock assessment, which resides at an F of 0.27. In case the assessment reflects the mixture but the reference points reflect the productivity of the Irish Sea population only, the Celtic Sea part of the catch is at risk of being overexploited. Fmsy for Celtic Sea is estimated at 0.26, while in 2017 the stock is below Bpa and therefore an F of 0.18 is advised. The Irish Sea herring advice is based on the benchmarked stock and suggests a TAC of 7000t vs 4100t a year earlier based on the prebenchmarked assessment. Celtic Sea herring stock size is in 2016 at spawning time estimated at 46.000t and Irish Sea herring at 26.000t.

Each individual HAWG member was asked to express their views on the proposed benchmark or an alternative DLS category 3 assessment. No material was presented on the DLS approach however. Some members expressed at this stage their concerns and disagreement on using an assessment with an absolute index of abundance. A minority statement by one HAWG member on the disagreement with this section presenting an alternative view is given in Annex 7. Most HAWG members felt not equipped to judge whether to include a relative or absolute index of abundance. All these members however indicated that a DLS category 3 approach should not be undertaken as they felt using the available data in an analytical assessment was a better basis for advice. Some other members expressed their preference in using the assessment with the absolute index of abundance.

HAWG agreed to move forward with the benchmark proposed assessment and to prepare a draft ICES advice for 2018 on that basis. Furthermore, HAWG agreed to schedule a benchmark for Irish Sea herring in 3 years' time and to commit to an MSE process that evaluated the consequences of herring mixing in the area for management. It was recognized by HAWG that the agreed assessment will likely be improved if a method to incorporate biological knowledge on the degree of mixing directly into the assessment is developed. Work on this should continue in the future.

Recommendations

Please see Annex 2. All recommendations have been uploaded to the ICES Recommendation database.

Table 1.5.1: Comparison of CANUM and WECA-estimates from conventional systems and InterCatch, by stock and age-group (winter-rings).

North Sea (47d3)							
2016	CANUM	CANUM	Deviation	2016	WECA	WECA	%
wr	Salloc	IC	(%)	wr	Salloc	IC	Deviation
0	1583568	1660899	0.047	0	0.007	0.007	0.018
1	109136	109110	0.000	1	0.027	0.027	0.001
2	625483	617323	-0.013	2	0.127	0.128	0.007
3	818586	815176	-0.004	3	0.155	0.155	0.002
4	293372	292238	-0.004	4	0.180	0.181	0.002
5	280451	280194	-0.001	5	0.206	0.206	0.000
6	367843	367849	0.000	6	0.215	0.215	0.000
7	307348	307137	-0.001	7	0.231	0.231	0.000
8	185926	186031	0.001	8	0.221	0.221	0.000
9+	173150	173048	-0.001	9+	0.239	0.239	0.000
Sum	4744862	4809004	0.013				

Her 6.aN	Ring	Intercatch	Sallocl	% Deviation
CATON		18791	18801	0.05
CANUM	1	254.45	231.18	-9.14
CANUM	2	11117.85	10854.96	-2.36
CANUM	3	14065.75	13937.56	-0.91
CANUM	4	15431.88	15716.6	1.84
CANUM	5	20136.53	19386.7	-3.72
CANUM	6	21351.34	21621.33	1.26
CANUM	7	6177.65	6397.35	3.56
CANUM	8	1901.85	1932.73	1.62
CANUM	9	1240.71	1250.55	0.79
WECA	1	0.07748	0.0769	-0.75
WECA	2	0.13793	0.1425	3.31
WECA	3	0.17712	0.1795	1.34
WECA	4	0.20142	0.2059	2.22
WECA	5	0.21105	0.2136	1.21
WECA	6	0.22771	0.2307	1.31
WECA	7	0.23665	0.2386	0.82
WECA	8	0.24418	0.2454	0.50
WECA	9	0.27279	0.2685	-1.57

Table 1.8.1. Studies known to HAWG of environmental drivers influencing recruitment, growth, migration, predation by and predation of herring or sprat, the timing of spawning and studies of incorporating environmentally influenced changes in productivity into management.

Stock	Recruitment	Growth	Migration	Predation on her/sprat	Predation by her/sprat	Time of spawning	Managing productivity changes
North Sea herring	X	X	X	X	X	X	X
Western Baltic SS herring	X	X		X			
6.aN herring			X				X
6.aS herring		X	X			X	X
7.aN herring					X		
Celtic Sea herring		X	X	X		X	X
North Sea sprat	X	X		X	X	X	
3.a sprat							

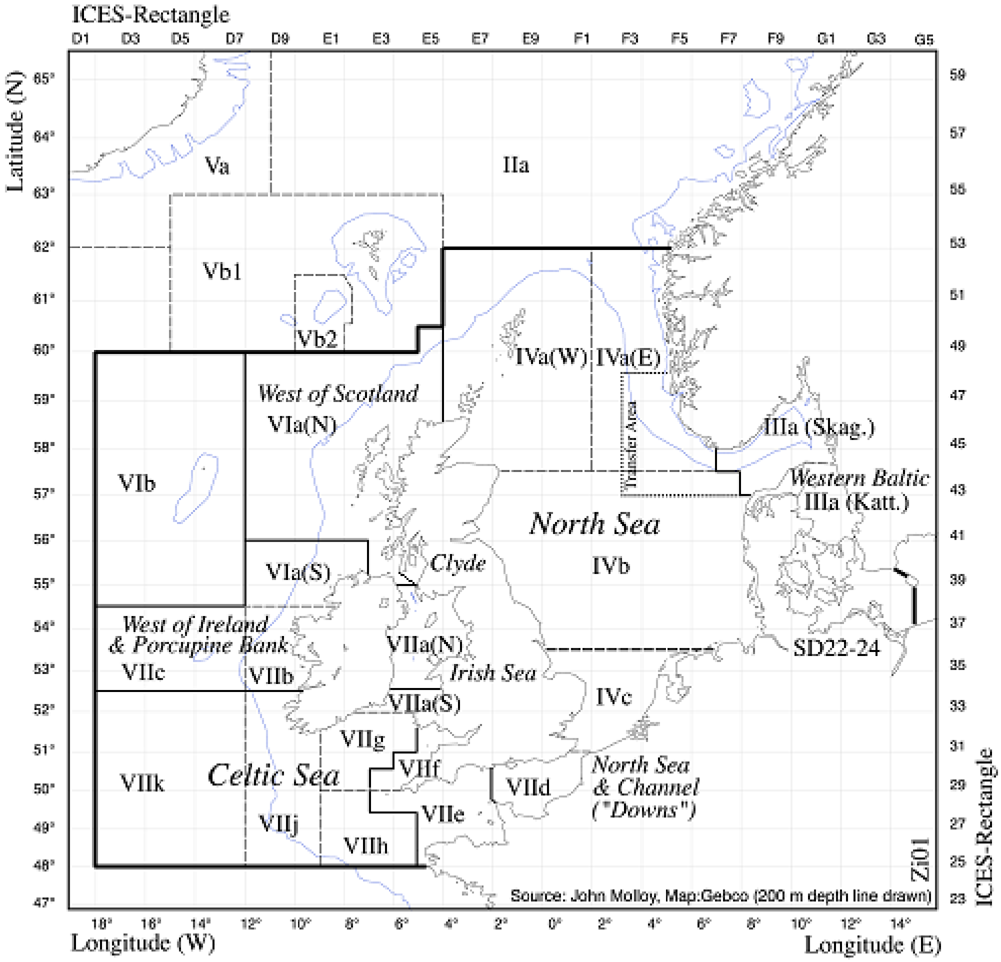


Figure 1.5.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North Sea to the Baltic Assessment.

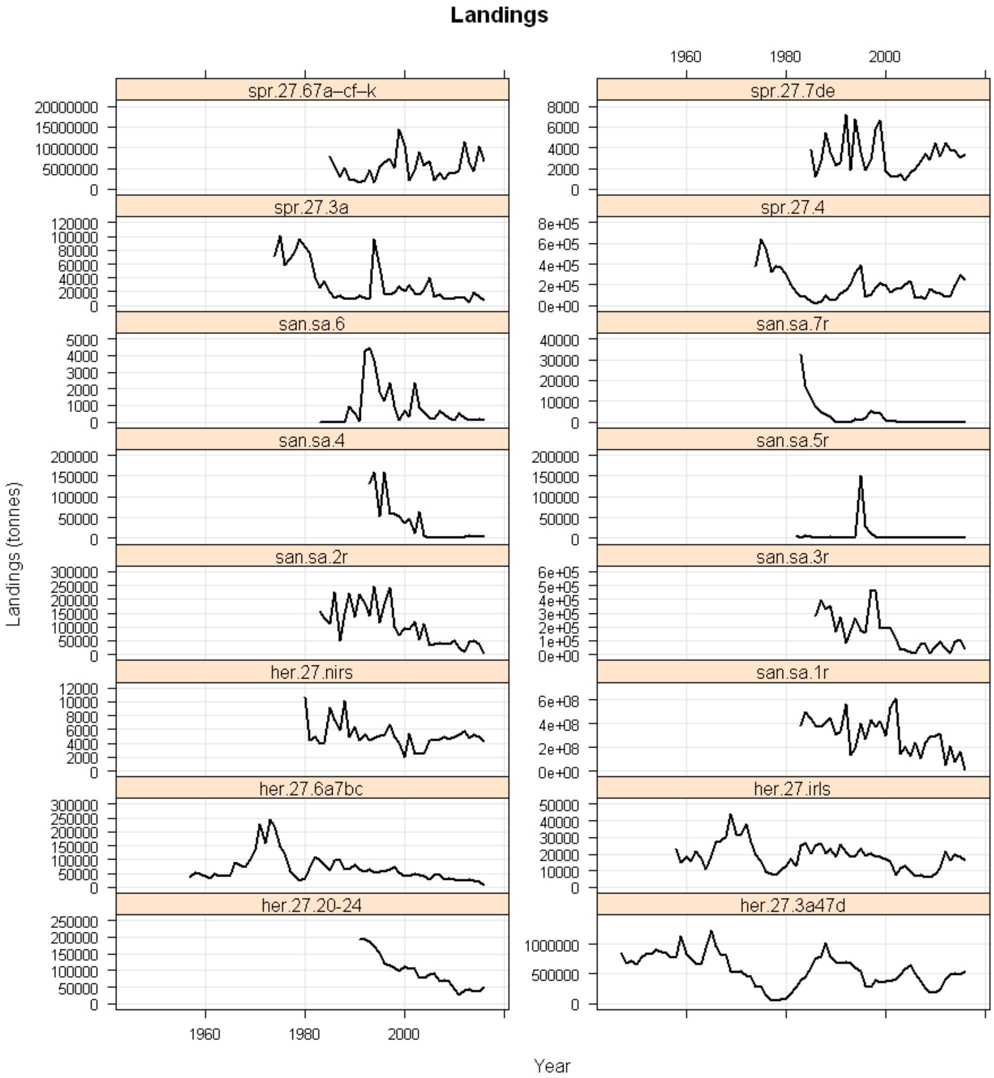


Figure 1.11.1 WG estimates of catch/landings (yield) of the herring and sprat stocks presented in HAWG 2017.

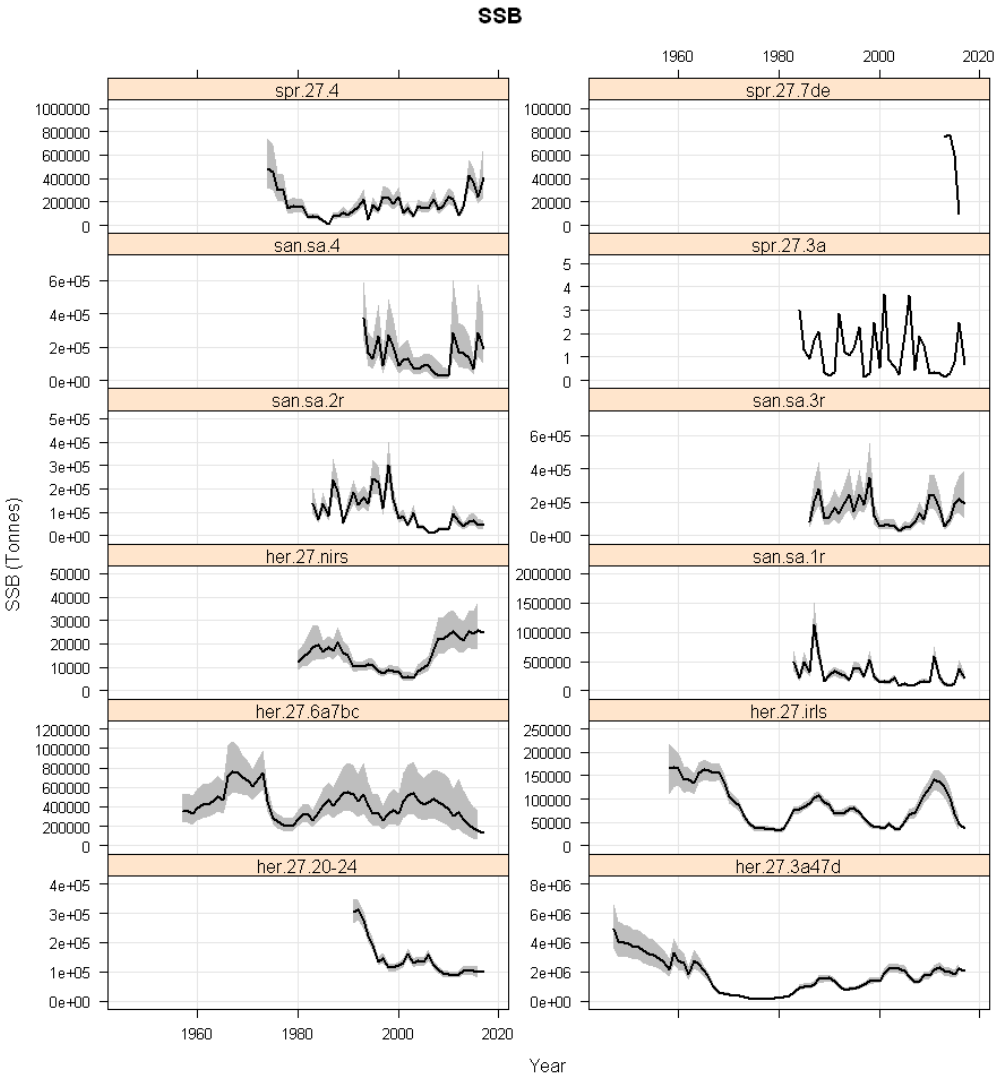


Figure 1.11.2 Spawning stock biomass estimates for the sprat and herring stocks under analytical assessment presented in HAWG 2017.

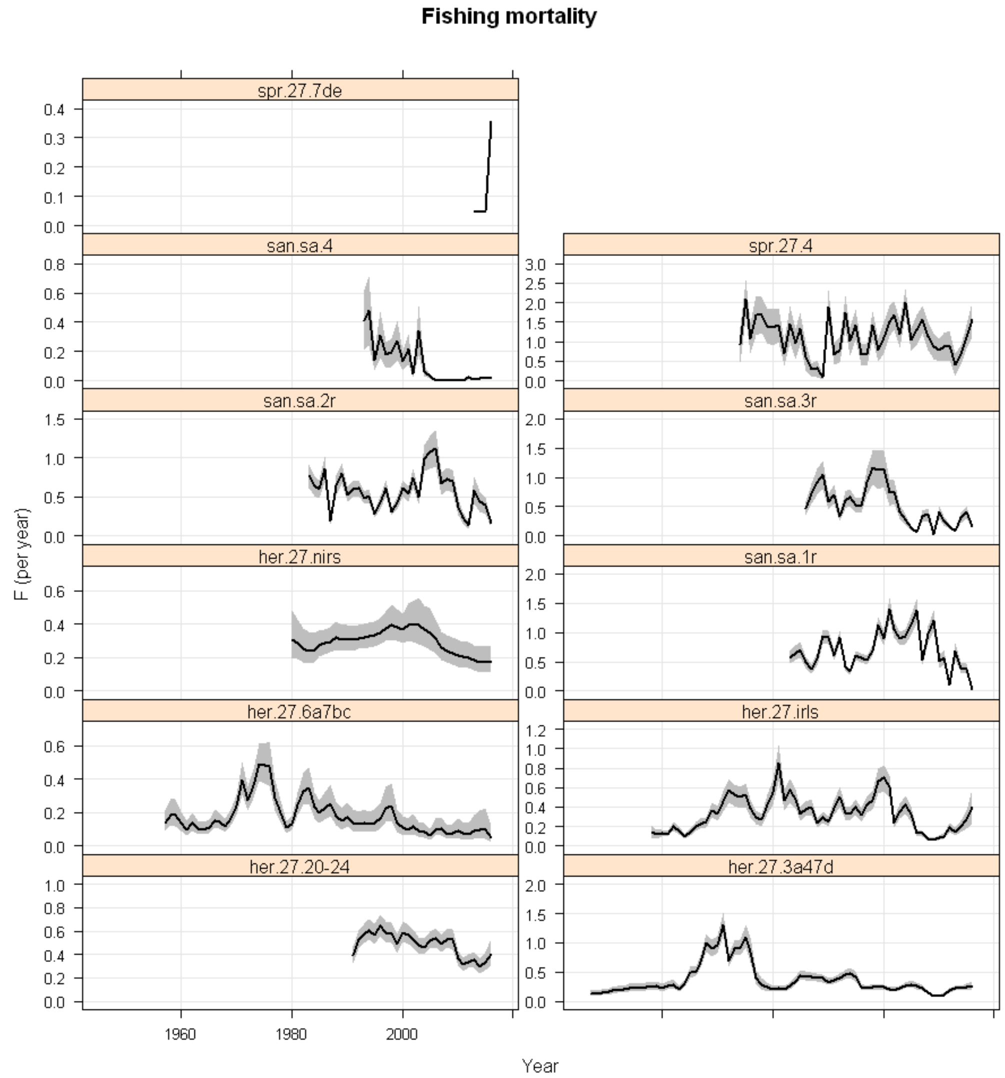


Figure 1.11.3 Estimates of mean F for the sprat stock and herring stocks under analytical assessment presented in HAWG 2017.

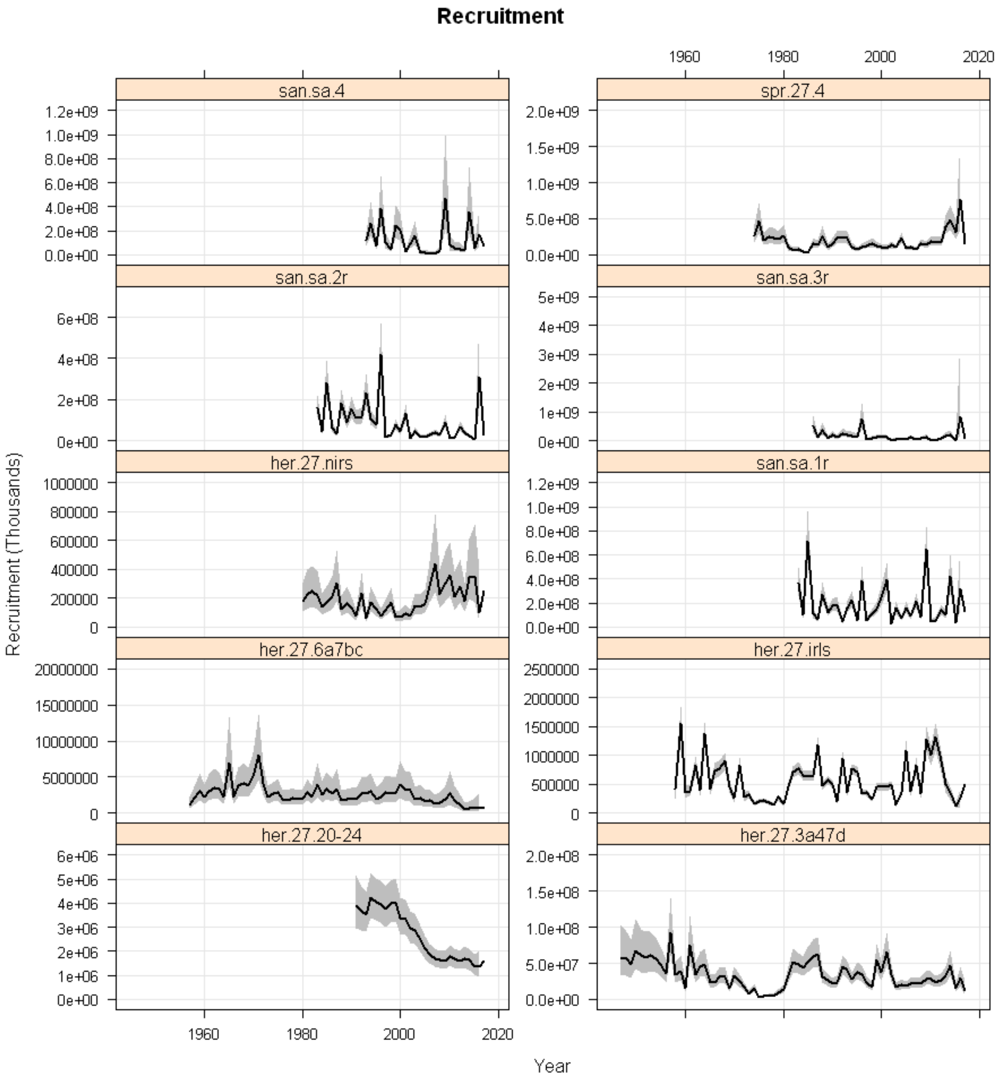


Figure 1.11.4 Estimates of recruitment for the sprat stock and herring stocks under analytical assessment presented in HAWG 2017.

2 Herring (*Clupea harengus*) in subdivisions 20–24, spring spawners

2.1 The Fishery

2.1.1 Advice and management applicable to 2016 and 2017

ICES advised in 2016 on the basis of the MSY approach. This corresponds to landings of no more than 56 802 t in 2017 as estimated by the last year assessment (ICES CM 2016/ACOM:07).

The EU and Norway agreement on a herring TAC for 2016 was 51 084 t in Division 3.a for the human consumption fleet and a by-catch ceiling of 6 659 t to be taken in the small mesh fishery. For 2017, the EU and Norway agreement on herring TACs in Division 3.a was 50 740 t for the human consumption fleet and a by-catch ceiling of 6 659 t to be taken in the small mesh fishery.

Prior to 2006 no separate TAC for Subdivisions 22—24 was set. In 2016, a TAC of 26 274 t was set on the Western Baltic stock component. The TAC for 2017 was set at 28 401 t.

2.1.2 Landings in 2016

Herring caught in Division 3.a are a mixture of North Sea Autumn Spawners (NSAS) and Western Baltic Spring Spawners (WBSS). This section gives the landings of both NSAS and WBSS but the stock assessment applies only to the spring spawners.

Landings from 1989 to 2016 are given in Table 2.1.1 and Figure 2.1.1. In 2016 the total landings in Division 3.a and Subdivisions 22—24 have overall increased to 54 972 t. Landings in 2016 increased by 6% in the Skagerrak, by 12 % in the Kattegat and by 13 % in Subdivisions 22-24. As in previous years the 2016 landing data are calculated by fleet according to the fleet definitions used when setting TACs.

Fleets are defined regardless their nationality as follows since 1998:

Fleet C: directed fishery for herring in which trawlers (with 32 mm minimum mesh size) and purse seiners participate.

Fleet D: All fisheries in which trawlers (with mesh sizes less than 32 mm) and small purse seiners, fishing for sprat along the Swedish coast and in the Swedish fjords, participate. For most of the landings taken by this fleet, herring is landed as by-catch. Danish and Swedish by-catches of herring from the sprat fishery and the Norway pout and blue whiting fisheries are listed under Fleet D.

Fleet F: Landings from Subdivisions 22—24. Most of the catches are taken in a directed fishery for herring and some as by-catch in a directed sprat fishery.

In Table 2.1.2 the landings are given for 2003 to 2016 in thousands of tonnes by fleet (as defined by HAWG) and quarter.

The Danish fleet definition follows the definition set by HAWG, where Fleet D (or the so called industrial fleet) is defined as all fisheries in which trawlers (with mesh sizes less than 32 mm) and small purse seiners, fish for sprat. For most of the landings taken by this fleet, herring is landed as by-catch from the sprat fishery and the Norway pout fishery. The Swedish fleet definition is based on mesh size of the gear, as for the Danish fleet. However, 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.

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
	2016							
Div. 3.a fleet-C	51 084	21 178	339	600		22 154	43 671	6 813
Div. 3.a fleet-D	6 659	5 692	51			916	6 659	
SD 22-24 fleet-F	26 274	3 683	14 496	2	3 419	4 674	26 274	26 274
% of 3.a fleet-C can be taken in 4 EU waters							-50%	
% of 3.a fleet-C can be taken in 4 Norwigian waters								-50 %
	2017							
Div. 3.a fleet-C	50 740	21 131	338	400		22 104*	43 573	6 767
Div. 3.a fleet-D	6 659	5 692	51			916	6 659	
SD 22-24 fleet-F	28 401	3 981	15 670	2	3 695	5 053	28 401	28 401
% of 3.a fleet-C can be taken in 4 EU waters							-50%	
% of 3.a fleet-C can be taken in 4 Norwigian waters								-50 %

2.1.3 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 not occur. Thus no catches were moved out of Division 3.a to the North Sea for catches taken in 2016.

Regulations allowing quota transfers from Division 3.a to the North Sea were introduced as an incentive to decrease misreporting of the fishery, and the percentage has gradually been reduced until 2010. Since 2011 the EU – Norway agreement allowed 50% of the Division 3.a quotas for human consumption (Fleet C) to be taken in the North Sea. The optional transfer of quotas from one management area to another introduces uncertainty for catch predictions and thus influence the quality of the stock projections. To decrease the uncertainty industry agreed in the 2013 benchmark to inform HAWG prior to the meeting of the assumed transfer in the intermediate year. In the last few years this information has proved to be highly valuable and consistent with the realised distribution of the catches. In 2017 the industry (Pelagic RAC) informed HAWG that about 54% of the catches in the C-fleet will be taken in Division 3.a.

The quota for the C fleet and the by-catch 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.

2.1.4 Changes in fishing technology and fishing patterns

There have been no significant changes in the last few years. The amount of catch taken in the first quarter varies between years in Div. 3.a, however, there is no clear trend over the time series.

2.1.5 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.

2.2 Biological composition of the landings

Table 2.2.1 and Table 2.2.2 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 2.2.3.

The level of sampling of the commercial landings was generally within the directions set by the DCMAP, however, as the landings were minor in certain areas and periods, the regulation of 1 sample per 1 000 t landed resulted in few samples being taken (Table 2.2.4). Where sampling was missing in areas and quarters on national landings, sampling from either other nations or adjacent areas and quarters were used to estimate catch in numbers and mean weight-at-age (Table 2.2.5).

Based on the proportions of spring- and autumn-spawners in the landings, catches were split between NSAS and WBSS (Table 2.2.6 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 (Table 2.2.7—2.2.12).

The total catch, expressed as SOP, of the WBSS taken in the North Sea + Division 3.a in 2016 was estimated to be 26 224 t, which represents an increase of 71 % compared to 2015 (Table 2.2.13).

Total catches of WBSS from the North Sea, Division 3.a, and Subdivisions 22-24 respectively, by quarter, were estimated for 2016 (Table 2.2.14). 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—2016, are presented in Tables 2.2.15 and 2.2.16.

The total catch of NSAS in Division 3.a amounted to 5 506 t in 2016, which represents the record low in the 24 year time series (Table 2.2.17).

The catches of WBSS from Subarea 4.aE and the catches of NSAS from Division 3.a in 2016 were reallocated to the appropriate stocks as shown in the text table below:

STOCK	CATCH REALLOCATION	TONNES
WBSS	4.aE (A-fleet)	1 839
NSAS	3.a (C+D-fleet)	5 506

2.2.1 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 2016 is assumed to be insignificant, as in previous years.

Table 2.2.4 shows the number of fish aged by country, area, fishery and quarter. The overall sampling in 2016 meets the recommended level of one sample per 1 000 t landed per quarter and the coverage of areas, times of the year and gear (mesh size). Fortunately occasional lack of national sampling of catches by quarter and area has been covered by similar fisheries in other countries.

Splitting of catches into WBSS (Spring spawners) and NSAS (Autumn spawners) in Division 3.a were based on Danish and Swedish analyses of otolith micro-structure of hatch type and extended with discriminant analysis of otolith shape calibrated with hatch type and applied on production samples with classification parameters: herring length weight and age as well as otolith metrics (see Stock annex). The total sample size for hatch type was 1666 with 52% of the samples in subdivision 20 (Skagerrak) and 48% in subdivision 21 (Kattegat).

Sampling for split of commercial catches in the transfer area in Division 4.a East in 2016 was based on 3154 Norwegian vertebral count (VC) observations from scientific cruises and commercial catches in the period 2008-2016 The applied method was based on the average VC by age group and quarters 1-4 as described in the stock annex. For 2016 quarter 1 age 2-8 the split was based on 50 Danish samples of otolith micro-structure.

There are indications of mixing with Central Baltic herring in catches from SD 24 throughout the year from most of the countries. However, the catches are dominated by the German directed fishery in the spawning areas where mixing is likely to be minimum. Catch data are not corrected for this mixing neither potential catches of Western Baltic Spring Spawning herring from SD 25-26.

2.3 Fishery Independent Information

2.3.1 German Autumn Acoustic Survey (GERAS) in Subdivisions 21–24

As a part of Baltic International Acoustic Survey (BIAS); the German autumn acoustic survey (GERAS) was carried out with R/V "SOLEA" between 30 September – 20 October 2016 in the Western Baltic, covering Subdivisions 21, 22, 23 and 24. A survey report is given in the 'Report of the Working Group for International Pelagic Surveys (ICES CM 2016/SSGEIOM:05).

In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring Spawning herring (WBSSH) and the Central Baltic herring (CBH) overlap. Survey results indicated in the recent years that in SD 24, which is part of the WBSSH management area, a considerable fraction of CBH is present and correspondingly erroneously allocated to WBSSH stock indices (ICES 2013/ACOM:46). Accordingly, a stock separation function (SF) based on growth parameters in 2005 to 2010 has been developed to quantify the proportion of CBH and WBSSH in the area (Gröhsler *et al.* 2013; Gröhsler et al. 2016). The estimates of the growth parameters based on baseline samples of WBSSH and CBH in 2011-2015 and in 2016 support the applicability of SF (Oeberst *et al.*, 2013 – WD for HAWG 2013; Oeberst *et al.*, 2014 – WD for WGIPS 2014; Oeberst *et al.*, 2015 – WD for WGIPS 2015; Oeberst et al., 2016 – WD for WGBIFS 2016, Oeberst et al., 2017 – WD for WGIPS 2017). Thus, SF was applied to correct the GERAS index for WBSS from 2005–2016.

The age-length distribution of herring in SD 22 in 2016 indicated a higher contribution of older fish of CBH origin. Thus, the SF was also applied in SD 22.

Individual mean weight, total numbers and biomass by age as estimated from the GERAS are presented in Table 2.3.1. The Western Baltic spring spawning herring stock index in 2016 was estimated to be 3.6 x 10^9 fish or about 82.7 x 10^3 tonnes in Subdivisions 21-24. Compared to previous results, the present estimates of herring show a further significant decrease in biomass. The biomass index in 2016 represents the second record low in the 24 year time series (with a difference of 26.6 x 10^3 tonnes compared to the former record low in 1999).

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). All age (wr) classes (0—8+) are included in the assessment.

2.3.2 Herring Summer Acoustic Survey (HERAS) in Division 3.a

The Herring acoustic survey (HERAS) was conducted from 22 June to 5 July 2016 and covered the Skagerrak and the Kattegat. The 2016 estimate of Western Baltic spring-spawning herring was 126 tonnes and 1 483 million herring. Compared to 2015, the 2016 estimates represent a decrease by 66 % in numbers and 64 % in biomass. The decrease was primarily driven by a 79 % decrease in numbers of both 1 and 2 winter ring fish from the year before. The stock biomass is dominated by 2 and 3 winter ring. The numbers of older herring (3+ group) in the stock has returned to the 2009 to 2014 level, but comprise a relatively large proportion of the total stock compared to this period (40% as compared to an average of 26 % for 2009 to 2014). Mean weights at age were comparable to last year's. The results from the HERAS index are summarised in Table 2.3.2.

Ages (wr) 1-8+ are used in the assessment. The 1999 survey was excluded from the assessment due to different survey area coverage.

2.3.3 Larvae Surveys (N20)

Herring larvae surveys (Greifswalder Bodden and adjacent waters; SD 24) were conducted in the western Baltic at weekly intervals during the 2016 spawning season (March to June). The larval index was defined as the total number of larvae that reach the length of 20 mm (N20; Table 2.3.3; Oeberst et al, 2009). With an estimated product of 442 million larvae, the 2016 N20 recruitment index represents the record low in the 25 year time series (with a difference of 97 million larvae compared to the former low in 2014).

2.3.4 IBTS Q1 and Q3

The International Bottom Trawl Surveys (IBTS) in Division 3.a are part of the IBTS surveys in the North Sea. The survey is conducted during January (Q1) and August (Q3) and covers the Kattegat and Skagerrak. Details of the surveys are provided in the IBTSWG report (ICES CM 2016/SSGEIOM:24). Catch per unit effort (CPUE; n/h) were retrieved from DATRAS database (http://datras.ices.dk).

Both the IBTS indices show overall highly variable behaviour and low internal consistency without a particular trend. Since the recent benchmark (ICES 2013/ACOM:46), ages (wr) 1-4 are used in the assessment of WBSS.

2.4 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 2.6.3).

The maturity ogive of WBSS applied in HAWG has been assumed constant between years and has been the same since 1991 (ICES 1992/Assess:13), although large year-to-year variations in the percentage mature have been observed (Gröhsler and Müller, 2004). Maturity ogive has been investigated in the recent benchmark assessment of WBSS (ICES 2013/ACOM:46). WKPELA in 2013 decided to carry on with the application of the constant maturity ogive vector for WBSS.

The same maturity ogive was used as in the last year assessment (ICES CM 2016/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

2.5 Recruitment

Indices of recruitment of 0-ringer WBSS for 2016 were available from both the GERAS and the N20 larval surveys (see Section 2.3.1 and 2.3.3, respectively). However, the GERAS is not considered to deliver a quantitatively adequate index for the 0-group as

- most young-of-the-year juveniles may remain to far inshore to be assessed,
- the mesh size in the codend of the pelagic gear is too large to catch the 0-group quantitatively.

The strong correlation of the N20 with the 1-wr group of the GERAS ($R^2 = 0.7$, Figure 2.5.1), 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 yearclass. Since 2010, the N20 recruitment index lies below the long-term average (1992–2016: 6,182 Million). The 2016 N20 recruitment index represents the record low in the 25 year time series (Table 2.3.3).

2.6 Assessment of Western Baltic spring spawners in Division 3.a and Subdivisions 22-24

2.6.1 Input data

2.6.1.1 Landings data

Catch in numbers at age from 1991 to 2016 were available for Subdivision 4.a (East), Division 3.a and Subdivisions 22—24 (Table 2.6.1). 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 2.6.2; Figure 2.6.1.1). Proportions at age thus reflect the combined variation in numbers at age and weight at age (Figure 2.6.1.3).

2.6.1.2 Biological data

Estimates of the mean weight of individuals in the stock (Tables 2.6.3 (Q1) and Figure 2.6.1.4) 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 2.6.4). 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 2.6.5): 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 2.6.6-7). The difference between these two values is due to differences in the seasonal patterns of fishing and natural mortality.

2.6.1.3 Surveys

According to the last benchmark of WBSS (ICES 2013/ACOM:46), 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 Q1		■	■	■	■				
IBTS Q3		■	■	■	■				

2.6.2 Assessment method

The assessment of WBSS is based on the state-space assessment model SAM (https://www.stockassessment.org). The assessment is run using FLSAM which implements an R based version of SAM embedded within the FLR library (Kell *et al.* 2007). Details of the software version employed are given in Table 2.6.11.

2.6.3 Assessment configuration

The model configuration was set as specified in Tables 2.6.9—10.

2.6.4 Final run

The results of the assessment are given in Tables 2.6.12—23. The estimated SSB for 2016 is 97 240 [79 481, 118 981 (95% CI)] t. The mean fishing mortality (ages 3—6) is estimated as 0.407 [0.308, 0.537 (95% CI)] yr^{-1} (Figure 2.6.4.1).

After a marked decline from over 300 000 t in the early 1990s to a low of less than 115 000 t in the late 1990s, the SSB of this stock recovered somewhat, reaching a secondary peak of around 160 000 tonnes in the early 2000s (Figure 2.6.4.2). After a small peak in 2006 coinciding with the maturing of the 2003 year-class, the SSB has declined up to 2011 with the lowest SSB observed in the time series. SSB stayed low in the following period recording a 4.4% decrease between 2015 and 2016.

Fishing mortality on this stock was high in the mid-1990s, reaching a maximum of over 0.6 yr^{-1}. In 1999—2009 $F_{3\text{-}6}$ stabilised slightly above 0.5. In 2010 and 2011 $F_{3\text{-}6}$ decreased significantly to the value of approx. 0.31 yr^{-1}. $F_{3\text{-}6}$ reached a minimum in 2014 with a value of 0.29 but increased in 2015 and further in 2016 which sets to the value of 0.41. (Table 2.6.12, Figure 2.6.4.1).

The observation variance estimated for each data component is largely in agreement with the last year assessment (ICES 2016/ACOM:07).

Inspection of the residuals for the catch shows a good fitting of the catch-at-age matrix with little patterns over both time and age. The catch residuals are slightly larger for age 1-2 in the assessment terminal year (2016) than in 2015. (Figure 2.6.4.5—13, 2.6.4.41).

The individual survey diagnostics show remarkable 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 2.6.4.15—39, 2.6.4.41). In this respect, a generally better fit is found for the age (wr) 3—6 of the HERAS index and age (wr) 3-4 of the GERAS index (with the exception of a major outlier in 2009) compared to the other ages, but the fitting to the surveys seems somehow worse in recent years. Poorer fit is observed for the other survey components, including the N20 larval index, all ages in the IBTS Q1, and ages (wr) 1—2 in IBTS Q3. The model shows also poor fitting of the age (wr) 1 HERAS index and the age (wr) 0 GERAS index. Inspection of model diagnostics shows the occurrence of high residuals in some years (i.e., 2009 in the GERAS and 2013 in HERAS; Figure 2.6.4.41). This generate year effects which are generally more problematic than age effects with the assessment model used, as temporally-invariant parameters have been adopted. Overall, the agreement between the data and the fitted model appears good throughout the data sources which are most influential in the model.

Estimation of the selectivity pattern shows an increase in the selectivity with age; the model was constrained to have same selectivity for age (wr) 5+. The selection pattern is relatively stable throughout the time period of the assessment, but selectivity of age (wr) 4 has progressively increased in recent years (Figure 2.6.4.4).

The estimated surveys' catchability are rather different among the surveys (Figure 2.6.4.40). In the GERAS survey, age (wr) 0 has the highest catchability, which rapidly drops for age (wr) 1 and 2. Then it progressively increases up to age (wr) 5 to level a bit lower in ages (wr) 7—8+. In the HERAS survey, age (wr) 1 has the lowest catchability, while ages (wr) 2—3 have the highest catchability which declines for the oldest age groups. Even more pronounced reduction in catchability is estimated from age (wr) 1 to age (wr) 4 in both the IBTS surveys. 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 estimated correlation parameter in the F random walk of 0.83 (it was 0.86 in the 2016 assessment) result in highly parallel estimates of fishing mortality at age (Figure 2.6.4.42).

Retrospective analysis suggests that the assessment method gives a consistent perception of the stock and its dynamics (Figure 2.6.4.43). The changes from year-to-year retrospective analysis are within the uncertainty of the estimated values and are therefore consistent with the level of confidence in our estimates. A stable uncertainty associated to the model parameters was estimated for all the retrospective runs.

Retrospective analysis of the selectivity pattern for the fishery in the model suggests a stable selection pattern (Figure 2.6.4.44). Surveys' catchabilities are rather stable in the analytical retrospective with the exception of the age0 in the GERAS and age1 in the IBTS Q3 which both show a decreasing catchability (Figure 2.6.4.45).

The stock-recruitment plot for this stock (Figure 2.6.4.46) shows indications of a relationship between stock-size and recruitment with the low recruitment levels observed during the last decade associated to SSB levels below 110 000 tonnes. In contrast, the high recruitment observed during the first half of the 1990s were all associated to SSB levels above 170 000 tonnes. No density-dependent response is visible in the range of SSB values observed.

2.7 State of the stock

The stock has decreased consistently during the second half of the 2000s. The perception of the stock has changed from last year's assessment, and it is now perceived to have a less optimistic development. The SSB is now seen to slightly decrease again after an increase following the estimated minimum in 2011. Fishing mortality (F3—6) was drastically reduced between 2008 and 2010, being low the following four years with a minimum in 2014 (0.29 yr^{-1}). F has been estimated to increase in 2015 (0.34 yr^{-1}) and again in 2016 (0.41 yr^{-1}).

Recruitment trends are estimated to be relatively smooth by the model with a decline since 1999, probably causing the subsequent continuous reduction of SSB. Recruitment in 2015 and 2016 are estimated to be historically low.

2.8 Comparison with previous years perception of the stock

Overall there is a major downward revision of SSB and upward revision of F for the 2014 and 2015 estimates, which substantially change our perception of the stock dynamics. F has been revised upward of 19% for 2014 and 31% for 2015. The text table below summarises the differences between the current and the previous year assessments.

PARAMETER	ASSESSMENT IN 2016	ASSESSMENT IN 2017	DIFF. 17–16
			(+/-) %
SSB (t) 2014	119850	103570	-13.6%
F(3-6) 2014	0.244	0.291	19.3%
Recr. ('000) 2014	1955194	1624970	-16.9%
SSB (t) 2015	125744	101722	-19.1%
F(3-6) 2015	0.256	0.335	30.9%

2.9 Short term predictions

Short term predictions were made in R using the function 'fwd', which implements a generic method for forward projections within FLR.

2.9.1 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 2017 assessment, recruitment for the forecasts was calculated on the period 2011—2015). 1-wr in the current year is calculated according to the geometric mean recruitment in the previous year. The mean weight-at-age in the catch and in the stock, as well as the maturities-at-age were calculated as the arithmetic averages over the last three years of the assessment (2014—2016). Based on earlier considerations in the herring working group, the different periods were chosen to reflect recent levels in recruitment and weights. The input data are shown in Table 2.9.1.

2.9.2 Intermediate year 2017

A catch constraint was assumed for the intermediate year (2017) by the following procedure:

The EU – Norway agreement allows an optional transfer of 50% of the human consumption TAC for herring in Division 3.a into the Area 4 in the North Sea. Based on information from the Pelagic RAC ICES assumes a 46% TAC transfer in 2017. This assumption influences the perception of the stock development in 2017 and 2018.

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.

The catch by the F-fleet fishing for human consumption in Subdivisions 22-24 in 2016 was close to the TAC and utilisation of 100% is assumed for the intermediate year. The TAC utilisation for the C-fleet in Division 3.a is assumed to be 54% (based on consultation with the industry). The proportion of the TAC taken in the small meshed fishery (D-fleet) has varied largely during the last five years from a maximum of 94% to the minimum of 38% recorded in 2016. However with the landings obligation in force from 2015 a 100% TAC utilisation for the intermediate year (2017) is assumed for the D-fleet.

The catch of herring in Division 3.a consists of both WBSS and NSAS components. The expected catch of WBSS in Division 3.a was calculated assuming the same WBSS proportions in the catch of each fleet in 2017 as the average of 2014—2016 in Division 3.a (67% and, 30% of WBSS in the C- and the D-fleet, respectively).

For the MSY based advice the fractions of the total catch of WBSS in Division 3.a and Subdivisions 22—24 taken by each of the three fleets C, D, and F are assumed to be equal to the predicted utilised TAC in the respective areas times the proportion of WBSS in the catches for the assessment year 2016.

The same amount of WBSS taken in Division 4.aE by the A-fleet in 2016, corresponding to 1839 t, is also assumed in 2017.

The mix of the two stocks in the Division 3.a catches is used to derive the out-take of NSAS and total catches in Division 3.a, whereas the Subdivision 22—24 TAC is assumed to be only WBSS herring.

Summary: predicted catches for 2017 of WBSS and NSAS by fleet in 3.a are based on 1) the expected TAC utilisation of 54% by the C-fleet (provided by the industry) a TAC utilisation of 100% in the D-fleet plus a constant catch of WBSS in 4.aE (2016 catch) and 2) the 2014—2016 average proportion of the two stocks in the catches of the different fleets. These assumptions give the expected catch by fleet summing up to a total of 50 428 t WBSS in 2017.

2.9.3 Catch options for 2018

The output of the short-term prediction, based on a catch constraint in the intermediate year 2017 of 50 428 t is given in Table 2.9.2.

The following catch options for 2017 were explored with an invariant selection pattern over all fleets for options 1—4:

1) F_{MSY} approach = $F_{MSY} \cdot SSB_{2017}$/MSY Btrigger = 0.295
2) Zero catch
3) F_{MSY} lower bound = 0.23
4) F_{MSY} upper bound = 0.41

5) F_{pa} = 0.45

6) F_{lim} = 0.52

7) B_{pa} = MSY $B_{trigger}$ = 110 000 t in 2019

8) B_{lim} = 90 000 t in 2019

9) F = F_{2016} = 0.407

10) 0.01 intervals between F_{MSY} lower and upper bounds

In addition, two fleet-wise forecasts were also calculated for the catch option 1 by following the management rule for the C-fleet:

1) with 0% transfer of the C-fleet quota to the North Sea

2) with 50% transfer of the C-fleet quota to the North Sea

For the fleet-wise forecasts the following additional assumptions were made:

i) Individual fleet wise selection patterns are applied according to the 2014-2016 fishing pattern

ii) The F fleet takes 50% of the catch calculated according to F_{MSY} approach = 0.295 and thus kept constant.

iii) The D fleet catches are kept constant taking 100% of the by-catch quota (6659 t).

iv) The WBSS catch in the A-fleet corresponds to 0.5% of the catch (based on three years average)

2.9.4 Exploring a range of total WBSS catches for 2018 (advice year)

ICES gives advice according to the F_{MSY} approach for the WBSS stock. Because SSB in 2017 is below MSY $B_{trigger}$ (but still above B_{lim}) a reduction in fishing mortality is applied proportional to the ratio between the size of the spawning stock and MSY $B_{trigger}$ which results in a value of F = 0.295.

Basis	Total catch (2018)	Ftotal (2018)	SSB* (2018)	SSB* (2019)	% SSB change **	% TAC change ***
ICES advice basis						
MSY approach: F = FMSY · SSB2017/MSY Btrigger	34618	0.295	94649	101764	+7.5	-39.1
Other options						
F = 0	0	0	97467	135428	+38.9	-100.0
Fpa	49602	0.45	93204	87793	-5.8	-12.7
Flim	55763	0.52	92558	82170	-11.2	-1.8
SSB (2019) = Blim	47206	0.424	93446	90000	-3.7	-16.9
SSB (2019) = Bpa	25973	0.214	95414	110000	+15.3	-54.3
SSB (2019) = MSY Btrigger	25973	0.214	95414	110000	+15.3	-54.3
F = F2016	45622	0.407	93604	91465	+38.9	-19.7
F = MAP^ FMSY lower	27714	0.23	95264	108332	+13.7	-51.2
F = MAP FMSY lower differing by 0.01	28800	0.24	95169	107294	+12.7	-49.3
F = MAP FMSY lower differing by 0.02	29876	0.25	95075	106267	+11.8	-47.4
F = MAP FMSY lower differing by 0.03	30943	0.26	94980	105250	+10.8	-45.5
F = MAP FMSY lower differing by 0.04	32002	0.27	94886	104244	+9.9	-43.7
F = MAP FMSY lower differing by 0.05	33051	0.28	94792	103248	+8.9	-41.8
F = MAP FMSY lower differing by 0.06	34091	0.29	94697	102263	+8.0	-40.0
F = MAP FMSY lower differing by 0.07	35123	0.30	94603	101287	+7.1	-38.2
F = MAP FMSY lower differing by 0.08	36146	0.31	94509	100321	+6.1	-36.4
F = MAP FMSY lower differing by 0.09	37161	0.32	94416	99366	+5.2	-34.6
F = MAP FMSY lower differing by 0.10	38167	0.33	94322	98420	+4.3	-32.8
F = MAP FMSY lower differing by 0.11	39164	0.34	94228	97483	+3.5	-31.1
F = MAP FMSY lower differing by 0.12	40153	0.35	94134	96556	+2.6	-29.3
F = MAP FMSY lower differing by 0.13	41134	0.36	94041	95639	+1.7	-27.6
F = MAP FMSY lower differing by 0.14	42107	0.37	93948	94731	+0.8	-25.9
F = MAP FMSY lower differing by 0.15	43071	0.38	93854	93833	0.0	-24.2
F = MAP FMSY lower differing by 0.16	44028	0.39	93761	92943	-0.9	-22.5
F = MAP FMSY lower differing by 0.17	44976	0.40	93668	92063	-1.7	-20.8
F = MAP^ FMSY upper	45917	0.41	93575	91191	-2.5	-19.2

*** 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 (2019) relative to SSB (2018).**

***** Catch 2018 relative to ICES advice 2017 (56802 t) for the western Baltic spring-spawning herring stock.**

^ MAP Baltic multiannual management plan (EU 2016).

ICES has evaluated the agreed management rule between EU and No and found it precautionary under the assumption of a minimum 10% quota transfer from Division 3.a to the North Sea, see management considerations (ICES 2015c). The TAC for 2017 was set according to the management rule and ICES assumes that TAC settings for 2018 will follow the management rule. Therefore ICES also provides fleet-wise catch options based on the implementation of the LTMP for the North Sea. Catch options 11 and 12 assume 0% and 50% quota transfer from Division 3.a into Subarea 4

The tables below gives the 2018 fleet wise catch options for the Western Baltic spring spawners and North Sea North Sea autumn spawners in Subdivisions 20—24, and in Subarea IVaE for the catch options described in section 2.9.3. The options follow the North Sea LTMP, the WBSS catch advice with F = 0.295, and the agreed EU Norway management rule with 0% and 50% TAC transfer flexibility.

The amount of WBSS catch in Division 4.a East is highly variable since it is dependent on the geographical distribution of the stock components. As for 2016 a catch of 1 839 t WBSS herring taken in the transfer area in Division 4.a East is assumed for the MSY-based advice. For the fleet-wise catch options based on the 3.a management rule a % split for herring catch in 4.a east is applied.

2.10 Reference points

Based on a Blim value of 90 000 t (equal Bloss, ICES 2013/ACOM:46), the Bpa value of 110 000 t was calculated according to the concept developed by the study group on the Precautionary Approach to Fisheries Management (ICES 2003/ACFM:15) and later REF (ICES 2007/ACFM:11).

The F_{MSY} reference point for WBSS was estimated in 2014 by WKMSYREF 2014 (ICES 2014/ACOM:64) using the function eqSim in the R package 'msy'. The estimated F_{MSY} value of 0.32 yr^{-1} with lower and upper bounds (F_{MSY} lower = 0.23 and F_{MSY} upper=0.41) and FP0.5=0.46 (5% risk to Blim) as proxy for F_{pa} were based on stochastic simulation of recruitment generated on a combination of Beverton & Holt, Ricker and segmented regression (ICES 2014/ACOM:64).

2.11 Quality of the Assessment

The 2017 assessment follows the procedures and settings specified in the Stock Annex. The current assessment gives a different perception of the stock compared to last year. This is also reflected in the variability in the retrospective pattern where the 2016 and 2017 estimates of the SSB in 2015 has a low probability (<.02) to reflect the same true SSB.

During the 2013 benchmark mixing of WBSS and Central Baltic herring (CBH) in SD24 was investigated. The mixing in catches and its variability in time is unknown, but it is expected to change as a function of variable distributions of the two stocks as well as variability in the spatial and temporal distribution of the fisheries. Indications of mixing between the two stocks exist in 2016 catch data and the working group reiterates the need for future specific investigations on the issue.

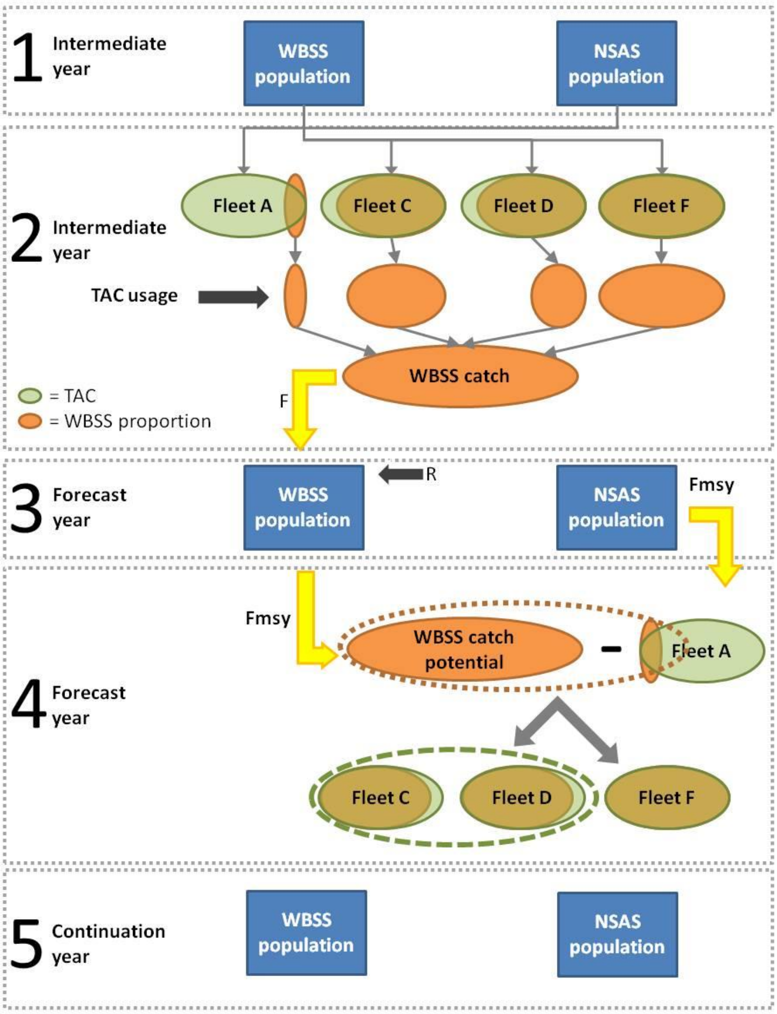
2.12 Management Considerations

Quotas in Division 3.a

The quota for the C-fleet and the by-catch 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). 50% 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 2017. ICES assumes that a transfer of 46% will be applied in 2017.

ICES catch predictions versus management TAC

ICES gives advice on catch options for the entire distribution of the NSAS and WBSS herring stocks separately whereas herring is managed by areas (see the following text diagram). The procedure of setting TACs in ICES Division 3.a and SD22-24 takes into account the occurrence of different fleets catches of both WBSS and NSAS herring utilization of TACs and the proportion of NSAS and WBSS that mix in the areas. In the flowchart below a schematic is presented:



Box 1: Each year estimations of the WBSS and NSAS stock size are made using a stock assessment model. Stock size estimation together with the estimated pattern of harvesting is used as the starting point for the short term forecast.

Box 2: To derive at a TAC proposal in the forecast year first the intermediate year (the year where the TAC has already been agreed on) catches need to be resolved. Four different fleets catch WBSS the A fleet (within the 4.a East area where they take it as a mixture of mainly NSAS and partly WBSS) the C and D fleet (within the 3.a area where they take it as a mixture of mainly WBSS and partly NSAS) and the F fleet (within area 22-24 where they only take WBSS). Each of these fleets target herring taking into account a fleet share of the total TAC. Only part of this TAC is WBSS catches and not all fleets utilize their full TAC fleet share. This results in an estimate of the intermediate year WBSS catches. Given WBSS stock size and these intermediate year catches the fishing mortality that the WBSS stock is exploited at can be estimated.

Box 3: Based on the estimated fishing mortality we can now calculate the survivors from the intermediate year to the forecast year assuming an incoming constant recruitment. The calculation of the stock size January 1st in the forecast year is needed to project catches in the forecast year.

Box 4: The management rule for the C-fleet TAC uses the potential WBSS catches calculated from the 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 realised 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

The agreed management rule was evaluated by ICES and found precautionary under the conditions of a minimum quota transfer of 10% from Division 3.a C fleet to the North Sea (ICES 2015/ACOM:47).

This management rule is the basis for setting the C-fleet TAC in Division 3.a, 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.

Data used for catch options for 2017 (advice year)

The catches at Fmsy in 2017 of WBSS were calculated according to the specifications in sec. 2.9.3 option 1. Of this total WBSS ICES MSY advice, 50% was allocated to the F fleet, a constant catch in the D fleet was calculated as the bycatch TAC x $split_{.D}$ = 1 731 t ($split_{.D}$ = 0.28) and a percentage of the A-fleet (0.38%) allocated to catches of WBSS in the A fleet in 4.aEast. The catch of WBSS in the C fleet was estimated as the WBSS proportion ($split_{.C}$=0.58) in the C fleet TAC according to the rule:

*TAC Skagerrak and Kattegat = (TAC_NSAS * 5.7%) + (WBSS ICES MSY advice * 41%)*

with an associated TAC constraint of +/- 15%.

The TAC calculation is circular and may be described by the following pseudo code and illustrated by the schematic below:

1) Rule starting conditions are calculated as 41% of $WBSS_{MSYadvice}$*(1+NSAS:WBSS) → C-fleet TAC[1]

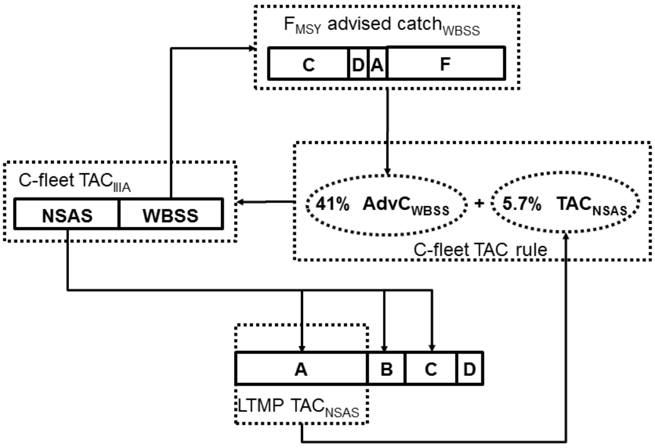
2) C-fleet TAC^i → resulting catches are split according to stock composition: WBSS in C-fleet + NSAS in C-fleet

3) NSAS in C-fleet + NSAS in D-fleet are fixed → catch options for NSAS in B-fleet and A-fleet (given F_{0-1} and F_{2-6} in LTMP)

4) 5.7 % of NSAS in A,B,C and D-fleets + 41% of $WBSS_{MSYadvice}$ → C-fleet TAC^{i+1}

5) i=i+1

6) IF C-fleet TAC^{i+1} <> C-fleet TAC^i GOTO 1)



2.13 Ecosystem considerations

Herring in Division 3.a and Subdivisions 22–24 is a migratory stock. There are feeding migrations from the Western Baltic into more saline waters of Division 3.a and the eastern parts of Division 4.a. There are indications from parasite infections that yet unknown proportions of stock components spawning at the southern coast in the Baltic Sea may perform similar migrations (Podolska *et al.* 2006). Herring in Division 3.a and Subdivisions 22—24 migrate back to Rügen area (SD 24) and other spawning areas at the beginning of the winter. Moreover, there are recent indications that Central Baltic herring perform migrations into Subdivision 24 (Gröhsler *et al.* 2013).

Similarly to the NSAS, the WBSS has produced a series of poor year classes in the last decade and the trend continues to decline. A recent 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.

2.14 Changes in the Environment

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

Table 2.1.1 WESTERN BALTIC SPRING SPAWNING HERRING.

Total catch (both WBSS and NSAS) in 1989-2016 (1000 tonnes).

(Data provided by Working Group members 2017).

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
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
Faroe Islands													
Germany													
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
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
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
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
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
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
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
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
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
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
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
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
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
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**

Year	2002	2003	2004	2005	2006**	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Skagerrak															
Denmark	26.0	15.5	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
Faroe Islands				0.4			0.0	0.6	0.4					0.5	0.3
Germany		0.7	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
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
Sweden	26.4	25.8	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
Total	52.3	42.0	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
Kattegat															
Denmark	18.6	16.0	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
Sweden	7.2	10.2	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
Germany								0.6	0.0						
Total	25.9	26.2	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
Subdivisions 22+24															
Denmark	13.1	6.1	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
Germany	22.4	18.8	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
Poland		4.4	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
Sweden	10.7	9.4	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
Total	46.2	38.7	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
Subdivision 23															
Denmark	4.6	2.3	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
Sweden		0.2	0.3	0.4	0.7		0.3	0.8	0.9	0.5	0.7	0.6	0.3	0.2	0.3
Total	4.6	2.6	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
Grand Total	**128.9**	**109.5**	**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**

* Preliminary data

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

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

Table 2.1.2 WESTERN BALTIC SPRING SPAWNING HERRING.

Catch (SOP) in 2003 - 2016 by fleet and quarter (1000 t).
(both WBSS and NSAS)

Year	Quarter	Div. IIIa		SD 22-24	Div. IIIa + SD 22-24
		Fleet C	Fleet D	Fleet F	Total
2004	1	13.5	2.8	20.4	36.7
	2	2.8	3.3	10.4	16.5
	3	8.2	10.8	2.4	21.4
	4	5.9	5.0	8.6	19.4
	Total	30.3	22.0	41.7	93.9
2005	1	16.6	6.1	20.4	43.1
	2	3.4	1.9	15.6	20.9
	3	23.4	3.4	1.9	28.7
	4	12.0	2.6	5.8	20.5
	Total	55.4	14.1	43.7	113.3
2006	1	15.3	5.9	15.1	36.2
	2	2.6	0.1	17.2	19.9
	3	15.7	0.8	3.0	19.5
	4	8.3	2.4	6.5	17.3
	Total	41.9	9.3	41.9	93.0
2007	1	7.7	3.0	18.8	29.5
	2	3.8	0.1	10.5	14.4
	3	22.4	0.8	1.7	24.9
	4	7.7	1.8	9.5	18.9
	Total	41.6	5.7	40.5	87.7
2008	1	8.2	3.9	18.4	30.5
	2	2.7	0.3	11.3	14.3
	3	14.9	0.6	6.0	21.5
	4	6.5	1.0	8.4	16.0
	Total	32.3	5.9	44.1	82.3
2009	1	11.1	2.7	19.5	33.2
	2	3.1	0.1	6.8	10.1
	3	14.3	0.9	1.4	16.6
	4	6.0	0.7	3.3	10.0
	Total	34.5	4.3	31.0	69.9
2010	1	8.4	1.1	10.2	19.8
	2	3.9	0.7	5.4	10.1
	3	13.4	0.4	0.4	14.3
	4	9.2	0.1	1.8	11.1
	Total	35.0	2.3	17.9	55.2
2011	1	7.0	0.5	7.8	15.3
	2	0.5	0.2	4.1	4.8
	3	6.5	1.0	0.8	8.3
	4	3.4	0.9	3.2	7.4
	Total	17.4	2.6	15.8	35.9
2012	1	4.5	1.8	14.0	20.3
	2	0.3	0.7	2.5	3.5
	3	12.3	1.7	1.1	15.0
	4	5.2	1.1	3.5	9.9
	Total	22.3	5.4	21.1	48.8
2013	1	8.5	0.8	11.7	20.9
	2	1.7	0.6	8.5	10.8
	3	8.4	1.0	1.1	10.4
	4	9.8	0.5	4.3	14.7
	Total	28.4	2.9	25.5	56.7
2014	1	6.2	0.2	10.8	17.3
	2	2.3	0.5	2.3	5.1
	3	10.7	2.4	0.8	14.0
	4	5.7	0.8	4.4	10.9
	Total	24.9	4.0	18.3	47.2
2015	1	9.0	1.9	14.2	25.1
	2	1.0	0.1	2.8	3.9
	3	7.5	1.5	0.9	9.9
	4	4.1	2.8	4.3	11.1
	Total	21.6	6.3	22.1	50.0
2016	1	7.9	0.7	15.5	24.0
	2	0.4	0.3	3.5	4.1
	3	15.7	1.3	1.4	18.5
	4	3.4	0.3	4.7	8.3
	Total	27.4	2.5	25.1	55.0

Table 2.2.1 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: 2016 Country: ALL

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.48	15	0.48	16	0.96	16
	2	76.14	43	6.13	36	82.27	43
	3	9.00	84	0.16	81	9.16	84
	4	1.90	125			1.90	125
	5	0.69	121			0.69	121
	6	1.05	166			1.05	166
	7	0.10	171			0.10	171
	8+	0.24	195			0.24	195
	Total	89.60		6.77		96.38	
	SOP		4,612		239		4,850
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.05	27	3.04	9	3.09	10
	2	3.52	56	1.52	56	5.04	56
	3	0.40	147	0.00		0.40	147
	4	0.06	173	0.00		0.06	173
	5	0.05	189	0.76	78	0.81	85
	6	0.21	193	0.00		0.21	193
	7	0.03	209	0.00		0.03	209
	8+	0.14	226	0.00		0.14	226
	Total	4.47		5.32		9.79	
	SOP		357		173		530
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			91.82	6	91.82	6
	1	6.32	63	13.33	26	19.65	38
	2	43.04	109	0.24	62	43.28	108
	3	21.48	147			21.48	147
	4	7.02	174			7.02	174
	5	6.94	189			6.94	189
	6	7.14	214			7.14	214
	7	2.09	215			2.09	215
	8+	4.53	243			4.53	243
	Total	98.57		105.39		203.97	
	SOP		13,858		909		14,767
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			2.99	13	2.99	13
	1	0.58	62	0.40	42	0.97	54
	2	3.51	108	0.08	73	3.59	107
	3	1.80	149			1.80	149
	4	0.44	171			0.44	171
	5	0.51	182			0.51	182
	6	0.43	198			0.43	198
	7	0.12	194			0.12	194
	8+	0.18	217			0.18	217
	Total	7.55		3.47		11.02	
	SOP		997		62		1,059
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0			94.81	6	94.81	6
	1	7.43	59	17.25	23	24.68	34
	2	126.21	68	7.97	41	134.19	66
	3	32.69	130	0.16	81	32.85	130
	4	9.42	164			9.42	164
	5	8.19	183	0.76	78	8.95	174
	6	8.82	207			8.82	207
	7	2.34	212			2.34	212
	8+	5.09	239			5.09	239
	Total	200.19		120.95		321.15	
	SOP		19,823		1,382		21,205

Table 2.2.2 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: 2016 Country: ALL

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	0.59	23	0.92	16	1.51	19
	2	39.89	42	11.61	36	51.50	40
	3	6.65	87	0.31	81	6.96	87
	4	1.60	121			1.60	121
	5	1.12	149			1.12	149
	6	2.94	180			2.94	180
	7	0.24	195			0.24	195
	8+	0.22	195			0.22	195
	Total	53.26		12.83		66.08	
	SOP		3,241		452		3,694
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
2	1	0.0004	23	4.24	19	4.2402	19
	2	0.0299	42			0.0299	42
	3	0.0050	87			0.0050	87
	4	0.0012	121			0.0012	121
	5	0.0008	149			0.0008	149
	6	0.0022	180			0.0022	180
	7	0.0002	195			0.0002	195
	8+	0.0002	195			0.0002	195
	Total	0.04		4.24		4.28	
	SOP		2		79		81
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
3	0			53.24	7	53.24	7
	1	4.14	55	2.27	24	6.41	44
	2	7.79	97			7.79	97
	3	2.78	138			2.78	138
	4	1.27	172			1.27	172
	5	0.94	198			0.94	198
	6	0.27	202			0.27	202
	7	0.19	230			0.19	230
	8+	0.08	233			0.08	233
	Total	17.46		55.51		72.97	
	SOP		1,890		424		2,314
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
4	0			9.13	13	9.13	13
	1	12.44	54	1.21	42	13.66	53
	2	14.33	87	0.25	73	14.58	87
	3	2.28	120			2.28	120
	4	0.54	149			0.54	149
	5	0.26	193			0.26	193
	6	0.26	188			0.26	188
	7	0.16	205			0.16	205
	8+	0.01	233			0.01	233
	Total	30.28		10.59		40.87	
	SOP		2,408		189		2,597
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
Total	0			62.37	8	62.37	8
	1	17.17	53	8.64	23	25.81	43
	2	62.04	59	11.86	36	73.90	56
	3	11.72	105	0.31	81	12.02	105
	4	3.41	144			3.41	144
	5	2.32	174			2.32	174
	6	3.47	182			3.47	182
	7	0.60	209			0.60	209
	8+	0.31	206			0.31	206
	Total	101.04		83.17		184.21	
	SOP		7,542		1,144		8,686

Table 2.2.3 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: 2016 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.
1	1	0.43	8	0.02	14	4.46	14	4.91	14
	2	0.04	40	0.09	39	21.40	40	21.53	40
	3	0.59	88	0.11	72	55.41	80	56.12	80
	4	0.46	105	0.02	95	26.91	104	27.39	104
	5	0.32	132	0.01	112	20.72	136	21.06	136
	6	0.14	166	0.00	148	12.99	173	13.14	173
	7	0.07	175	0.00	124	6.52	182	6.59	182
	8+	0.06	181	0.00	176	4.61	190	4.68	190
	Total	2.12		0.26		153.03		155.41	
	SOP		195		17		15,269		15,480
		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.
2	1	0.00	13	0.00	14	0.34	21	0.34	21
	2	0.01	39	0.02	39	1.53	42	1.56	42
	3	0.09	78	0.02	72	13.65	77	13.76	77
	4	0.11	96	0.00	95	6.95	89	7.06	89
	5	0.06	133	0.00	112	4.37	120	4.43	120
	6	0.03	137	0.001	148	2.38	142	2.40	142
	7	0.03	158	0.000	124	2.94	160	2.97	160
	8+	0.03	168	0.000	176	2.50	157	2.53	157
	Total	0.35		0.05		34.66		35.06	
	SOP		38		3		3,469		3,511
		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.
3	0	2.96	11			9.05	8	12.01	9
	1	0.16	27			2.49	31	2.65	31
	2	0.00	41	0.01	154	2.69	41	2.70	41
	3	0.000	67	0.35	153	6.50	62	6.85	66
	4	0.001	115	0.21	163	6.02	49	6.23	53
	5	0.002	152	0.25	170	1.88	69	2.13	81
	6	0.001	156	0.05	200	1.14	64	1.19	69
	7	0.001	172	0.03	194	0.38	41	0.41	52
	8+	0.001	177	0.02	178	0.42	54	0.44	61
	Total	3.13		0.92		30.56		34.61	
	SOP		38		151		1,202		1,391
		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.
4	0	7.23	11			0.77	20	8.00	12
	1	0.39	27			14.04	42	14.44	42
	2	0.02	130	0.01	154	11.43	78	11.46	78
	3	0.06	123	0.44	153	16.63	112	17.13	113
	4	0.06	116	0.26	163	4.68	106	5.00	109
	5	0.02	145	0.31	170	2.59	124	2.92	129
	6	0.01	134	0.06	200	0.63	141	0.69	146
	7	0.01	141	0.03	194	0.44	116	0.48	122
	8+	0.01	170	0.03	178	0.57	133	0.60	135
	Total	7.81		1.14		51.78		60.74	
	SOP		116		188		4,387		4,691
		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.
Total	0	10.20	11			9.82	9	20.01	10
	1	0.99	19	0.02	14	21.33	35	22.34	34
	2	0.07	65	0.13	57	37.06	52	37.25	52
	3	0.75	89	0.93	142	92.19	84	93.86	85
	4	0.63	105	0.49	159	44.56	94	45.68	95
	5	0.40	133	0.58	169	29.56	129	30.54	130
	6	0.18	160	0.11	198	17.14	160	17.42	160
	7	0.11	168	0.07	191	10.28	168	10.46	168
	8+	0.10	176	0.05	178	8.10	169	8.26	169
	Total	13.42		2.37		270.03		285.82	
	SOP		388		359		24,327		25,073

Table 2.2.4 WESTERN BALTIC SPRING SPAWNING HERRING.

Samples of commercial catch by quarter and area for 2016 available to the Working Group.

	Country	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Skagerrak	**Denmark**	**1**	0.24	No data available		
		2	0.18	5	7	6
		3	3.07	11	885	466
		4	0.06	No data available		
	Total		3.55	16	892	472
	Germany	**1**	0.0001	No data available		
		2	-	-		
		3	-	-		
		4	0.12	No data available		
	Total		0.12			
	Norway	**1**	0.42	1	50	49
		2	0.20	No data available		
		3	3.14	No data available		
		4	0.20	No data available		
	Total		3.96	1	50	49
	Faroe Islands	**1**	-	-		
		2	-	-		
		3	0.06	No data available		
		4	0.25	No data available		
	Total		0.32	0	0	0
	Netherlands	**1**	-	-		
		2	-	-		
		3	-	-		
		4	-	-		
	Total		0.00	0	0	0
	Sweden	**1**	4.19	14	700	700
		2	0.15	4	687	687
		3	8.49	11	656	656
		4	0.42	No data available		
	Total		13.26	29	2,043	2,043
Kattegat	**Denmark**	**1**	0.45	2	84	84
		2	0.08	2	15	15
		3	1.58	13	655	215
		4	0.34	3	317	200
	Total		2.45	20	1,071	514
	Sweden	**1**	3.24	12	700	699
		2	-	-		
		3	0.74	No data available		
		4	2.26	3	380	379
	Total		6.24	15	1,080	699

continued

Table 2.2.4 **WESTERN BALTIC SPRING SPAWNING HERRING.**

(continued) **Samples of commercial catch by quarter and area for 2016 available to the Working Group.**

	Country	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Subdivision 22	**Denmark**	**1**	0.003	2	98	98
		2	0.009	No data available		
		3	0.038	No data available		
		4	0.089	3	58	58
	Total		0.139	5	156	156
	Sweden	**1**	-	-		
		2	-	-		
		3	-	-		
		4	0.0026	No data available		
	Total		0.00	0	0	0
	Germany	**1**	0.1917	4	1,845	290
		2	0.0292	2	1,254	166
		3	0.0009	No data available		
		4	0.0240	1	428	80
	Total		0.2458	7	3,527	536
Subdivision 23	**Denmark**	**1**	0.0002	No data available		
		2	0.0031	No data available		
		3	0.0054	2	255	108
		4	0.0178	No data available		
	Total		0.0265	2	255	108
	Sweden	**1**	0.0163	No data available		
		2	-	-		
		3	0.1454	No data available		
		4	0.1703	No data available		
	Total		0.3321	0	0	0
Subdivision 24	**Denmark**	**1**	3.67	6	790	282
		2	0.02	2	22	5
		3	0.28	1	34	34
		4	1.61	1	228	59
	Total		5.58	10	1,074	380
	Germany	**1**	9.7090	19	7,672	1,560
		2	2.2776	7	2,859	587
		3	0.0004	No data available		
		4	2.1938	5	2,317	531
	Total		14.1808	31	12,848	2,678
	Poland	**1**	0.65	8	1,211	435
		2	1.16	7	1,953	434
		3	0.93	1	669	98
		4	0.18	2	614	187
	Total		2.91	18	4,447	1154
	Sweden	**1**	1.24667	5	845	844
		2	0.01650	No data available		
		3	0.00005	No data available		
		4	0.39595	4	491	491
	Total		1.65916	9	1,336	1,335
Total	**Skagerrak**	**1-4**	**21.2**	**46**	**2,985**	**2,564**
	Kattegat	**1-4**	**8.7**	**35**	**2,151**	**1,213**
	Subdivision 22	**1-4**	**0.4**	**12**	**3,683**	**692**
	Subdivision 23	**1-4**	**0.4**	**2**	**255**	**108**
	Subdivision 24	**1-4**	**24.3**	**68**	**19,705**	**5,547**
	Total	**1-4**	**55.0**	**163**	**28,779**	**10,124**

Table 2.2.5 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 2016.

	Country	Quarter	Fleet	Sampling
Skagerrak	**Denmark**	1	C	Sweden Q1
		2	C	Sweden Q2
		3	C	Denmark Q3
		4	C	No landings
	Germany	1	C	Sweden Q1
		2	C	No landings
		3	C	No landings
		4	C	Sweden Q3
	Sweden	1	C	Sweden Q1
		2	C	Sweden Q2
		3	C	Sweden Q3
		4	C	Sweden Q3
	Denmark	1	D	Denmark Q1
		2	D	Denmark Q2
		3	D	Denmark Q3
		4	D	Denmark Q4
	Netherlands	1	C	No landings
		2	C	No landings
		3	C	No landings
		4	C	No landings
	Faroe Islands	1	C	No landings
		2	C	No landings
		3	C	Sweden Q3
		4	C	Sweden Q3
	Norway	1	C	Norway Q1
		2	C	National imputation
		3	C	National imputation
		4	C	National imputation
Kattegat	**Denmark**	1	C	Sweden Q1
		2	C	Sweden Q1
		3	C	Denmark Q3 Skagerrak Fleet C
		4	C	Denmark Q3 Skagerrak Fleet C
	Sweden	1	C	Sweden Q1
		2	C	Sweden Q1
		3	C	Sweden Q4
		4	C	Sweden Q4
	Germany	1	C	No landings
		2	C	No landings
		3	C	No landings
		4	C	No landings
	Denmark	1	D	Denmark Q1
		2	D	Denmark Q2
		3	D	Denmark Q3
		4	D	Denmark Q4
Subdivision 22	**Denmark**	1	F	Denmark Q1
		2	F	Germany Q2
		3	F	Denmark Q4
		4	F	Denmark Q4
	Sweden	1	F	No landings
		2	F	No landings
		3	F	No landings
		4	F	Denmark Q4
	Germany	1	F	Germany Q1 (WD1 Gröhsler)
		2	F	Germany Q2 (WD1 Gröhsler)
		3	F	German sampling as in WD1 Gröhsler
		4	F	Germany Q4 (WD1 Gröhsler)

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

Table 2.2.5 WESTERN BALTIC SPRING SPAWNING HERRING.

Continued Samples of catch by quarter and area used to estimate catch in numbers and mean weight at age as W-ringers for 2016.

	Country	Quarter	Fleet	Sampling
Subdivision 23	**Denmark**	1	F	Denmark Q1 SD 24 fleet-F
		2	F	Denmark Q1 SD 24 fleet-F
		3	F	Denmark Q3
		4	F	Denmark Q3
	Sweden	1	F	Denmark Q1 SD 24 fleet-F
		2	F	No landings
		3	F	Denmark Q3
		4	F	Denmark Q3
Subdivision 24	**Denmark**	1	F	Denmark Q1
		2	F	Denmark Q2
		3	F	Denmark Q3
		4	F	Denmark Q4
	Germany	1	F	Germany Q1 (WD1 Gröhsler)
		2	F	Germany Q2 (WD1 Gröhsler)
		3	F	German sampling as in WD1 Gröhsler
		4	F	Germany Q4 (WD1 Gröhsler)
	Poland	1	F	Poland Q1
		2	F	Poland Q2
		3	F	Poland Q3
		4	F	Poland Q4
	Sweden	1	F	Sweden Q1
		2	F	Germany Q2
		3	F	Poland Q3
		4	F	Sweden Q4

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

Table 2.2.6 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: 2016

		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
1	1	100.00%	0.00%	4	100.00%	0.00%	13
	2	22.45%	77.55%	49	25.88%	74.12%	124
	3	8.33%	91.67%	48	20.33%	79.67%	50
	4	7.14%	92.86%	14	7.14%	92.86%	14
	5	0.47%	99.53%	2	0.00%	100.00%	8
	6	0.47%	99.53%	1	0.00%	100.00%	25
	7	0.47%	99.53%	0	0.00%	100.00%	2
	8	0.47%	99.53%	0	0.00%	100.00%	1
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
2	1	45.03%	54.97%	20	33.33%	66.67%	15
	2	63.70%	36.30%	51	63.70%	36.30%	0
	3	11.36%	88.64%	17	11.36%	88.64%	0
	4	11.36%	88.64%	1	11.36%	88.64%	0
	5	11.36%	88.64%	1	11.36%	88.64%	0
	6	11.36%	88.64%	1	11.36%	88.64%	0
	7	11.36%	88.64%	0	11.36%	88.64%	0
	8	11.36%	88.64%	0	11.36%	88.64%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
3	0	89.84%	10.16%	128	77.04%	22.96%	196
	1	53.97%	46.03%	57	18.75%	81.25%	16
	2	19.85%	80.15%	185	19.85%	80.15%	0
	3	13.43%	86.57%	133	13.43%	86.57%	0
	4	2.84%	97.16%	63	2.84%	97.16%	0
	5	2.21%	97.79%	57	2.21%	97.79%	0
	6	2.23%	97.77%	16	2.23%	97.77%	0
	7	0.84%	99.16%	13	0.84%	99.16%	0
	8	0.84%	99.16%	7	0.84%	99.16%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
4	0	80.81%	19.19%	0	80.81%	19.19%	172
	1	42.73%	57.27%	0	42.73%	57.27%	72
	2	13.17%	86.83%	0	13.17%	86.83%	54
	3	11.54%	88.46%	0	11.54%	88.46%	26
	4	4.05%	95.95%	0	4.05%	95.95%	5
	5	4.05%	95.95%	0	4.05%	95.95%	1
	6	4.05%	95.95%	0	4.05%	95.95%	3
	7	4.05%	95.95%	0	4.05%	95.95%	1
	8	4.05%	95.95%	0	4.05%	95.95%	0

when *n for an age <12 data were borrowed according to the below table
borrowing either a mean of age groups or ages borrowed individually

Q	ages	Skagerrak	ages	Kattegat
1	5-8+	mean(4-8+)	5-8+	mean(4-8+)
2	3-8+	mean(3-8+)	2-8+	Sk(age)
3	7-8+	mean(7-8+)	2-8+	Sk(age)
4	0-8+	Ka(age)	4-8+	mean(4-8+)

Table 2.2.7 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: 2016 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.59	23	0.92	16	1.51	19
	2	10.32	42	3.00	36	13.33	40
	3	1.35	87	0.06	81	1.41	87
	4	0.11	121			0.11	121
	5					0.00	
	6					0.00	
	7					0.00	
	8+					0.00	
	Total	12.38		3.98		16.36	
	SOP		578		127		704
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.00015	23	1.41	19	1.41	19
	2	0.01907	42			0.02	42
	3	0.00057	87			0.00	87
	4	0.00014	121			0.00	121
	5	0.00010	149			0.00	149
	6	0.00025	180			0.00	180
	7	0.00002	195			0.00	195
	8+	0.00002	195			0.00	195
	Total	0.02		1.41		1.43	
	SOP		1		26		27
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			41.02	7	41.02	7
	1	0.78	55	0.43	24	1.20	44
	2	1.55	97			1.55	97
	3	0.37	138			0.37	138
	4	0.04	172			0.04	172
	5	0.02	198			0.02	198
	6	0.01	202			0.01	202
	7	0.00	230			0.00	230
	8+	0.00	233			0.00	233
	Total	2.76		41.44		44.21	
	SOP		257		294		551
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			7.38	13	7.38	13
	1	5.32	54	0.52	42	5.84	53
	2	1.89	87	0.03	73	1.92	87
	3	0.26	120			0.26	120
	4	0.02	149			0.02	149
	5	0.01	193			0.01	193
	6	0.01	188			0.01	188
	7	0.01	205			0.01	205
	8+	0.00	233			0.00	233
	Total	7.52		7.93		15.45	
	SOP		493		121		614
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.00		48.40	8	48.40	8
	1	6.68	52	3.27	22	9.96	42
	2	13.78	54	3.04	36	16.81	51
	3	1.99	101	0.06	81	2.05	100
	4	0.17	135	0.00		0.17	135
	5	0.03	196	0.00		0.03	196
	6	0.02	193	0.00		0.02	193
	7	0.01	209	0.00		0.01	209
	8+	0.00	232	0.00		0.00	232
	Total	22.68		54.77		77.45	
	SOP		1,328		569		1,896

Table 2.2.8 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: 2016 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	0.48	15	0.48	16	0.96	16
	2	17.09	43	1.38	36	18.47	43
	3	0.75	84	0.01	81	0.76	84
	4	0.14	125			0.14	125
	5	0.00	121			0.00	121
	6	0.00	166			0.00	166
	7	0.00	171			0.00	171
	8+	0.00	195			0.00	195
	Total	18.47		1.87		20.34	
	SOP		827		58		884
2	1	0.02	27	1.37	9	1.39	10
	2	2.24	56	0.97	56	3.21	56
	3	0.05	147			0.05	147
	4	0.01	173			0.01	173
	5	0.01	189	0.09	78	0.09	85
	6	0.02	193			0.02	193
	7	0.00	209			0.00	209
	8+	0.02	226			0.02	226
	Total	2.37		2.42		4.79	
	SOP		145		74		219
3	0			82.49	6	82.49	6
	1	3.41	63	7.19	26	10.61	38
	2	8.54	109	0.05	62	8.59	108
	3	2.89	147			2.89	147
	4	0.20	174			0.20	174
	5	0.15	189			0.15	189
	6	0.16	214			0.16	214
	7	0.02	215			0.02	215
	8+	0.04	243			0.04	243
	Total	15.41		89.74		105.14	
	SOP		1,679		679		2,358
4	0			2.42	13	2.42	13
	1	0.25	62	0.17	42	0.42	54
	2	0.46	108	0.01	73	0.47	107
	3	0.21	149			0.21	149
	4	0.02	171			0.02	171
	5	0.02	182			0.02	182
	6	0.02	198			0.02	198
	7	0.00	194			0.00	194
	8+	0.01	217			0.01	217
	Total	0.98		2.60		3.58	
	SOP		109		40		149
Total	0	0.00		84.91	6	84.91	6
	1	4.16	57	9.21	24	13.38	34
	2	28.34	65	2.40	45	30.75	63
	3	3.89	135	0.01	81	3.90	135
	4	0.36	156	0.00		0.36	156
	5	0.18	187	0.09	78	0.27	152
	6	0.21	209	0.00		0.21	209
	7	0.03	210	0.00		0.03	210
	8+	0.06	235	0.00		0.06	235
	Total	37.23		96.63		133.86	
	SOP		2,760		851		3,610

Table 2.2.9 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: 2016 Country: All

Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1						
	2	29.57	42	8.60	36	38.17	40
	3	5.30	87	0.24	81	5.54	87
	4	1.48	121			1.48	121
	5	1.12	149			1.12	149
	6	2.94	180			2.94	180
	7	0.24	195			0.24	195
	8+	0.22	195			0.22	195
	Total	40.88		8.85		49.72	
	SOP		2,664		326		2,990

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.00	23	2.83	19	2.83	19
	2	0.01	42			0.01	42
	3	0.00	87			0.00	87
	4	0.00	121			0.00	121
	5	0.00	149			0.00	149
	6	0.00	180			0.00	180
	7	0.00	195			0.00	195
	8+	0.00	195			0.00	195
	Total	0.02		2.83		2.85	
	SOP		1		53		54

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			12.22	7	12.22	7
	1	3.36	55	1.84	24	5.21	44
	2	6.24	97			6.24	97
	3	2.41	138			2.41	138
	4	1.23	172			1.23	172
	5	0.91	198			0.91	198
	6	0.26	202			0.26	202
	7	0.19	230			0.19	230
	8+	0.08	233			0.08	233
	Total	14.70		14.07		28.77	
	SOP		1,634		129		1,763

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			1.75	13	1.75	13
	1	7.13	54	0.69	42	7.82	53
	2	12.44	87	0.22	73	12.66	87
	3	2.02	120			2.02	120
	4	0.52	149			0.52	149
	5	0.25	193			0.25	193
	6	0.25	188			0.25	188
	7	0.16	205			0.16	205
	8+	0.01	233			0.01	233
	Total	22.77		2.66		25.43	
	SOP		1,915		68		1,983

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.00		13.98	8	13.98	8
	1	10.49	54	5.36	24	15.86	44
	2	48.27	61	8.82	36	57.09	57
	3	9.73	106	0.24	81	9.97	106
	4	3.24	145	0.00		3.24	145
	5	2.29	173	0.00		2.29	173
	6	3.45	182	0.00		3.45	182
	7	0.59	209	0.00		0.59	209
	8+	0.31	206	0.00		0.31	206
	Total	78.36		28.40		106.77	
	SOP		6,214		575		6,790

Table 2.2.10 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: 2016 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1						
	2	59.05	43	4.75	36	63.80	43
	3	8.25	84	0.15	81	8.40	84
	4	1.76	125			1.76	125
	5	0.69	121			0.69	121
	6	1.04	166			1.04	166
	7	0.10	171			0.10	171
	8+	0.24	195			0.24	195
	Total	71.13		4.90		76.03	
	SOP		3,785		181		3,966
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.03	27	1.67	9	1.70	10
	2	1.28	56	0.55	56	1.83	56
	3	0.36	147			0.36	147
	4	0.05	173			0.05	173
	5	0.04	189	0.67	78	0.72	85
	6	0.19	193			0.19	193
	7	0.03	209			0.03	209
	8+	0.12	226			0.12	226
	Total	2.10		2.90		4.99	
	SOP		212		99		311
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			9.33	6	9.33	6
	1	2.91	63	6.13	26	9.05	38
	2	34.50	109	0.20	62	34.69	108
	3	18.60	147			18.60	147
	4	6.82	174			6.82	174
	5	6.78	189			6.78	189
	6	6.98	214			6.98	214
	7	2.08	215			2.08	215
	8+	4.50	243			4.50	243
	Total	83.16		15.66		98.82	
	SOP		12,179		229		12,408
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			0.57	13	0.57	13
	1	0.33	62	0.23	42	0.56	54
	2	3.05	108	0.07	73	3.12	107
	3	1.59	149			1.59	149
	4	0.42	171			0.42	171
	5	0.48	182			0.48	182
	6	0.41	198			0.41	198
	7	0.11	194			0.11	194
	8+	0.17	217			0.17	217
	Total	6.57		0.87		7.44	
	SOP		888		22		910
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.00		9.90	6	9.90	6
	1	3.27	62	8.03	23	11.30	35
	2	97.87	68	5.57	39	103.44	67
	3	28.80	129	0.15	81	28.95	129
	4	9.06	165	0.00		9.06	165
	5	8.00	183	0.67	78	8.68	175
	6	8.62	207	0.00		8.62	207
	7	2.31	212	0.00		2.31	212
	8+	5.03	239	0.00		5.03	239
	Total	162.96		24.33		187.29	
	SOP		17,064		531		17,595

Table 2.2.11 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: 2016 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	1.07	20	1.40	16	2.47	18
	2	27.42	43	4.38	36	31.80	42
	3	2.10	86	0.08	81	2.18	86
	4	0.25	123			0.25	123
	5	0.00	121			0.00	121
	6	0.00	166			0.00	166
	7	0.00	171			0.00	171
	8+	0.00	195			0.00	195
	Total	30.85		5.85		36.70	
	SOP		1,404		185		1,589
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
2	1	0.02	27	2.78	14	2.81	14
	2	2.26	56	0.97	56	3.23	56
	3	0.05	146			0.05	146
	4	0.01	172			0.01	172
	5	0.01	188	0.09	78	0.09	85
	6	0.02	193			0.02	193
	7	0.00	209			0.00	209
	8+	0.02	225			0.02	225
	Total	2.39		3.84		6.23	
	SOP		146		100		246
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
3	0			123.51	6	123.51	6
	1	4.19	61	7.62	26	11.81	39
	2	10.09	107	0.05	62	10.14	107
	3	3.26	146			3.26	146
	4	0.24	174			0.24	174
	5	0.17	190			0.17	190
	6	0.17	214			0.17	214
	7	0.02	216			0.02	216
	8+	0.04	243			0.04	243
	Total	18.17		131.18		149.35	
	SOP		1,935		974		2,909
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
4	0			9.79	13	9.79	13
	1	5.56	55	0.69	42	6.25	53
	2	2.35	91	0.04	73	2.39	91
	3	0.47	133			0.47	133
	4	0.04	159			0.04	159
	5	0.03	185			0.03	185
	6	0.03	194			0.03	194
	7	0.01	200			0.01	200
	8+	0.01	218			0.01	218
	Total	8.50		10.52		19.02	
	SOP		602		161		762
Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
Total	0	0.00		133.30	7	133.30	7
	1	10.85	54	12.49	23	23.33	37
	2	42.12	61	5.44	40	47.56	59
	3	5.88	124	0.08	81	5.95	123
	4	0.53	149	0.00		0.53	149
	5	0.21	188	0.09	78	0.30	157
	6	0.22	208	0.00		0.22	208
	7	0.03	209	0.00		0.03	209
	8+	0.06	235	0.00		0.06	235
	Total	59.91		151.39		211.30	
	SOP		4,087		1,419		5,506

Table 2.2.12 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: 2016 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1					0.00	
	2	88.62	43	13.35	36	101.97	42
	3	13.55	85	0.39	81	13.94	85
	4	3.25	123			3.25	123
	5	1.81	138			1.81	138
	6	3.98	176			3.98	176
	7	0.34	188			0.34	188
	8+	0.46	195			0.46	195
	Total	112.01		13.74		125.75	
	SOP		6,449		507		6,956
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.03	27	4.50	15	4.53	15
	2	1.29	56	0.55	56	1.84	56
	3	0.36	146			0.36	146
	4	0.05	172			0.05	172
	5	0.05	188	0.67	78	0.72	85
	6	0.19	193			0.19	193
	7	0.03	209			0.03	209
	8+	0.12	225			0.12	225
	Total	2.12		5.72		7.84	
	SOP		214		152		365
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			21.55	6	21.55	6
	1	6.28	58	7.98	26	14.25	40
	2	40.74	107	0.20	62	40.94	107
	3	21.00	146			21.00	146
	4	8.06	174			8.06	174
	5	7.70	190			7.70	190
	6	7.24	214			7.24	214
	7	2.27	216			2.27	216
	8+	4.58	243			4.58	243
	Total	97.86		29.73		127.59	
	SOP		13,813		358		14,171
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			2.33	13	2.33	13
	1	7.46	55	0.92	42	8.38	53
	2	15.49	91	0.29	73	15.78	91
	3	3.61	133			3.61	133
	4	0.94	159			0.94	159
	5	0.73	185			0.73	185
	6	0.66	194			0.66	194
	7	0.27	200			0.27	200
	8+	0.18	218			0.18	218
	Total	29.33		3.53		32.87	
	SOP		2,803		90		2,893
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.00		23.88	7	23.88	7
	1	13.76	56	13.40	23	27.16	40
	2	146.14	66	14.39	37	160.53	63
	3	38.53	124	0.39	81	38.92	123
	4	12.30	160	0.00		12.30	160
	5	10.29	181	0.67	78	10.96	174
	6	12.07	200	0.00		12.07	200
	7	2.91	211	0.00		2.91	211
	8+	5.34	237	0.00		5.34	237
	Total	241.32		52.73		294.05	
	SOP		23,278		1,107		24,385

Table 2.2.13 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 1993-2016.

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

Data for 1995 to 2001 was revised in 2003. [C] values have been corrected in 2007.

Table 2.2.14 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 Table 2.2.1-2.2.5)

Division: IV + 3.a + 22-24 Year:: 2016 Country: All

Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	1	0.0001	58.00			4.91	13.75	4.91	13.75
	2	0.210	78.50	101.97	41.80	21.53	39.55	123.71	41.47
	3			13.94	85.16	56.12	80.08	70.06	81.09
	4			3.25	123.32	27.39	103.63	30.64	105.71
1	5	0.255	146.80	1.81	138.26	21.06	136.36	23.13	136.62
	6			3.98	176.11	13.14	172.69	17.11	173.49
	7			0.34	187.92	6.59	182.11	6.93	182.39
	8+	0.310	186.59	0.46	195.00	4.68	190.10	5.45	190.32
	Total	0.775		125.75		155.41		281.94	
	SOP		112		6,956		15,480		22,548
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	1	0.020	122.00	4.53	15.20	0.34	21.12	4.89	16.04
	2	0.717	136.40	1.84	56.22	1.56	42.00	4.12	64.80
	3	3.125	157.30	0.36	146.22	13.76	76.88	17.25	92.90
	4	0.461	172.50	0.05	171.54	7.06	89.11	7.58	94.76
2	5	0.421	185.90	0.72	84.91	4.43	120.47	5.57	120.82
	6			0.19	192.93	2.40	142.26	2.59	145.92
	7	0.114	205.80	0.03	209.10	2.97	160.44	3.11	162.51
	8+			0.12	225.47	2.53	157.49	2.66	160.67
	Total	4.857		7.84		35.06		47.75	
	SOP		773		365		3,511		4,649
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0			21.55	6.48	12.01	9.16	33.56	7.44
	1			14.25	40.24	2.65	30.96	16.91	38.79
	2	0.28	114.80	40.94	106.69	2.70	41.37	43.91	102.73
	3	0.98	142.30	21.00	146.40	6.85	66.40	28.84	127.25
	4	0.56	175.60	8.06	174.11	6.23	52.73	14.84	123.24
3	5	0.46	197.70	7.70	190.20	2.13	81.25	10.29	167.98
	6	1.04	211.40	7.24	213.73	1.19	69.32	9.47	195.34
	7	0.58	222.60	2.27	215.96	0.41	51.89	3.26	196.40
	8+	0.66	242.58	4.58	242.72	0.44	61.01	5.68	228.52
	Total	4.56		127.59		34.61		166.76	
	SOP		869		14,171		1,391		16,431
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0			2.33	13.14	8.00	12.04	10.33	12.28
	1			8.38	53.22	14.44	41.88	22.81	46.04
	2			15.78	90.83	11.46	78.17	27.24	85.50
	3			3.61	132.53	17.13	112.68	20.75	116.13
	4	0.016	177.20	0.94	158.76	5.00	108.79	5.95	116.85
4	5			0.73	185.41	2.92	129.34	3.65	140.59
	6	0.143	198.80	0.66	194.11	0.69	145.67	1.49	172.07
	7			0.27	200.27	0.48	122.17	0.75	150.03
	8+	0.242	224.87	0.18	218.13	0.60	135.38	1.03	170.96
	Total	0.402		32.87		60.74		94.01	
	SOP		86		2,893		4,691		7,670
		Division IV		Division IIIa		Subdivision 22-24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0	0.00		23.88	7.13	20.01	10.31	43.891	8.58
	1	0.02	121.80	27.16	40.07	22.34	34.09	49.520	37.40
	2	1.21	121.31	160.53	63.33	37.25	51.67	198.981	61.50
	3	4.11	153.71	38.92	123.18	93.86	84.56	136.892	97.62
	4	1.03	174.24	12.30	159.52	45.68	95.01	59.012	109.84
Total	5	1.14	181.92	10.96	174.38	30.54	129.54	42.636	142.47
	6	1.18	209.87	12.07	199.93	17.42	160.36	30.672	177.84
	7	0.69	219.83	2.91	211.15	10.46	168.06	14.050	179.51
	8+	1.21	224.69	5.34	237.37	8.26	169.17	14.807	198.30
	Total	10.59		294.05		285.82		590.460	
	SOP		1,839		24,385		25,073		51,298

Table 2.2.15 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 1993-2016.

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

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

C values have been corrected in 2007.

Table 2.2.16 WESTERN BALTIC SPRING SPAWNING HERRING.

Mean weight (g) and SOP (t) of *Western Baltic Spring Spawners* in Division 3.a + North Sea + Subdivisions 22-24 in the years 1993-2016.

	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

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

C values have been corrected in 2007.

Table 2.2.17 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 1993-2016.

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

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

Table 2.3.1 WESTERN BALTIC SPRING SPAWNING HERRING.

German acoustic survey (GERAS) on the Spring Spawning Herring in Subdivisions 21 (Southern Kattegat, 41G0-42G2) - 24 in autumn 1993-2016 (September/October).

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Numbers in millions									*	**			***	***	***	***	***	***	***	***	***	***	****	*****
W-rings																								
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	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	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	558.851	392.737	270.959	534.633	1,206.762	755.034	893.837	769.320	440.738	493.366
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	260.402	165.347	95.866	305.540	360.354	294.242	456.204	242.590	509.769	155.417
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	117.412	166.301	43.553	214.539	210.455	193.974	307.567	279.650	221.344	196.061
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	76.782	102.018	17.761	107.364	115.984	124.548	262.908	332.660	129.795	60.953
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	43.919	82.174	9.016	85.635	57.840	70.135	87.114	317.240	95.579	30.490
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	12.144	29.727	3.227	47.140	50.844	45.017	32.684	211.600	86.150	14.980
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	9.262	11.443	1.947	25.021	29.234	22.520	22.565	85.630	47.093	3.300
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	8.839	9.262	1.704	15.309	14.774	21.404	11.300	56.590	37.886	0.000
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	3,676.532	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
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	268.357	400.924	77.208	495.007	479.131	477.597	724.139	1,283.370	617.846	305.784
Biomass ('000 tonnnes)																								
W-rings																								
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	25.202	23.699	29.449	36.791	35.064	46.955	85.185	61.713	8.179	24.072
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	22.782	17.602	10.473	21.336	46.384	29.825	38.404	30.377	16.822	18.553
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	20.202	10.446	7.069	24.593	29.560	20.380	30.587	21.490	38.573	10.579
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	11.366	15.297	4.433	23.540	24.382	22.068	27.349	32.448	22.841	18.068
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	9.679	11.077	1.961	15.193	16.361	18.653	27.350	58.819	15.196	5.859
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	6.724	11.584	1.385	15.433	9.867	11.450	10.934	63.755	14.581	3.417
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	2.001	4.823	0.616	9.018	8.391	7.985	4.849	45.705	14.304	1.723
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	1.703	1.756	0.384	4.728	5.295	4.448	3.751	18.709	8.433	0.450
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	1.798	1.303	0.284	3.013	3.015	3.876	1.821	13.498	7.108	0.000
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	101.456	97.588	56.055	153.646	178.320	165.640	230.231	346.513	146.035	82.722
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	33.270	45.840	9.064	70.926	67.312	68.480	76.055	232.933	82.462	29.518
Mean weight (g)																								
W-rings																								
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	9.7	11.0	10.4	8.1	12.0	11.4	9.5	11.3	9.2	9.1
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	40.8	44.8	38.7	39.9	38.4	39.5	43.0	39.5	38.2	37.6
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	77.6	63.2	73.7	80.5	82.0	69.3	67.0	88.6	75.7	68.1
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	96.8	92.0	101.8	109.7	115.9	113.8	88.9	116.0	103.2	92.2
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	126.1	108.6	110.4	141.5	141.1	149.8	104.0	176.8	117.1	96.1
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	153.1	141.0	153.6	180.2	170.6	163.3	125.5	201.0	152.5	112.1
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	164.8	162.2	190.9	191.3	165.0	177.4	148.4	216.0	166.0	115.0
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	183.8	153.5	197.4	189.0	181.1	197.5	166.2	218.5	179.1	136.4
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	203.4	140.7	166.9	196.8	204.1	181.1	161.1	238.5	187.6	-
Total	46.1	30.9	32.2	40.7	39.5	41.9	24.5	47.4	49.0	33.6	29.7	35.8	39.0	36.6	27.6	31.4	17.2	26.1	35.8	29.4	20.8	44.6	59.5	23.0
							small revision in 2015										small revision in 2015						small revision in 2017 (<0.5 %)	

*incl. mean for Sub-division 23, which was not covered by RV SOLEA

**incl. mean for Sub-division 21, which was not covered by RV SOLEA

***** 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 (Gröhsler et al. 2013) & excl. mature herring in SD 23 (stages>=6)**

******* excl. Central Baltic Herring in SD 22, SD 24 (SD 23) based on SF (Gröhsler et al. 2013)**

Table 2.3.2 WESTERN BALTIC SPRING SPAWNING HERRING.

Acoustic surveys (HERAS) on the Western Baltic Spring Spawning Herring in the North Sea/Division 3.a in 1991-2016 (July).

		*	*	*	*	*			**																	
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
	Numbers in millions																									
W-rings																										
0		3,853	372	964														112				1		314	2	203
1		277	103	5	2,199	1,091	128	138	1,367	1,509	66	3,346	1,833	1,669	2,687	2,081	3,918	5,852	565	999	2,980	1,018	49	513	1,949	425
2	1,864	2,092	2,768	413	1,887	1,005	715	1,682	1,143	1,891	641	1,577	1,110	930	1,342	2,217	3,621	1,160	398	511	473	1,081	627	415	1,244	255
3	1,927	1,799	1,274	935	1,022	247	787	901	523	674	452	1,393	395	726	464	1,780	933	843	205	254	259	236	525	176	446	381
4	866	1,593	598	501	1,270	141	166	282	135	364	153	524	323	307	201	490	499	333	161	115	163	87	53	248	224	99
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184	103	180	154	274	82	65	70	76	30	28	171	40
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72	84	27	34	176	86	24	53	33	12	37	82	40
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22	37	10	26	45	39	28	22	14	8	26	89	12
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18	21	0.1	14	44	65	34	46	60	15	42	115	28
Total	**5,177**	**10,509**	**5,779**	**3,339**	**6,867**	**2,673**	**2,088**	**3,248**	**3,201**	**4,696**	**1,481**	**7,002**	**3,807**	**3,926**	**4,939**	**6,786**	**9,199**	**8,839**	**1,601**	**2,030**	**4,066**	**2,606**	**1,319**	**1,799**	**4,322**	**1,483**
3+ group	**5,177**	**4,287**	**2,536**	**1,957**	**2,781**	**577**	**1,245**	**1,428**	**691**	**1,295**	**774**	**2,079**	**864**	**1,328**	**910**	**2,487**	**1,660**	**1,715**	**638**	**520**	**613**	**506**	**643**	**557**	**1,127**	**600**
	Biomass ('000 tonnnes)																									
W-rings																										
0		34.3	1	8.7																		0.0		1.0	0.03	1.00
1		26.8	7	0.4	77.4	52.9	4.7	7.1	74.8	61.4	3.5	137.2	79.0	63.9	105.9	112.6	193.2	284.4	26.8	53.0	90.0	44.0	3.0	26.0	61.5	16.0
2	177.1	169.0	139	33.2	108.9	87.0	52.2	136.1	101.6	138.1	55.8	107.2	91.5	75.6	100.1	160.5	273.4	100.9	48.8	34.0	47.0	87.0	51.0	48.0	106.2	20.0
3	219.7	206.3	112	114.7	102.6	27.6	81.0	84.8	59.5	68.8	51.2	126.9	41.4	89.4	46.6	158.6	90.9	101.8	30.6	28.0	31.0	26.0	59.0	21.0	54.7	51.0
4	116.0	204.7	69	76.7	145.5	17.9	21.5	35.2	14.7	45.3	21.5	55.9	41.7	41.5	28.9	56.3	59.6	47.1	29.4	17.0	25.0	12.0	7.0	43.0	33.8	15.0
5	51.1	83.3	65	41.8	33.9	17.8	9.8	13.1	3.4	25.1	17.9	12.8	13.9	29.3	16.5	23.7	18.5	45.3	17.5	11.0	12.0	13.0	4.0	6.0	30.3	7.0
6	19.0	36.6	26	38.1	27.4	5.8	9.8	6.9	0.5	10.0	6.9	7.4	4.2	11.7	14.9	4.1	4.6	30.9	21.4	5.0	10.0	6.0	2.0	8.0	16.7	8.0
7	13.0	24.4	16	13.1	6.7	3.3	14.9	4.8	0.3	1.4	4.7	3.5	2.0	4.1	7.5	1.6	2.6	9.4	10.6	6.0	5.0	3.0	1.0	6.0	17.7	3.0
8+	2.0	5.0	2	7.8	3.8	2.7	13.6	9.0	0.1	1.3	2.7	3.1	0.9	3.2	4.9	0.0	1.9	8.7	19.8	8.0	10.0	14.0	3.0	11.0	25.2	6.0
Total	597.9	756.1	436.5	325.8	506.2	215.1	207.5	297.0	254.9	351.4	164.2	454.0	274.5	318.8	325.3	517.5	644.7	628.5	204.9	162.0	230.0	205.0	130.0	169.0	346.0	126.0
3+ group	420.9	560.3	291.0	292.3	319.9	75.2	150.6	153.7	78.5	151.9	104.9	209.6	104.0	179.3	119.3	244.4	178.2	243.2	129.3	75.0	93.0	74.0	76.0	95.0	178.3	90.0
	Mean weight (g)																									
W-rings																										
0		8.9	4.0	9.0														6.3				3.0		4.3	14.2	4.0
1		96.8	66.3	80.0	35.2	48.5	36.9	51.9	54.7	40.7	54.0	41.0	43.1	38.3	39.4	54.1	49.3	48.6	47.5	52.7	30.2	42.9	58.1	51.6	31.5	37.0
2	95.0	80.8	50.1	80.3	57.7	86.6	73.0	80.9	88.9	73.1	87.0	68.0	82.5	81.3	74.6	72.4	75.5	87.0	122.7	65.8	98.8	80.4	80.8	114.9	85.4	79.0
3	114.0	114.7	87.9	122.7	100.4	111.9	103.0	94.1	113.8	102.2	113.2	91.1	104.9	123.2	100.5	89.1	97.4	120.8	149.1	111.4	121.2	110.6	111.7	122.4	122.7	134.0
4	134.0	128.5	116.2	153.0	114.6	126.8	129.6	124.7	109.1	124.4	140.5	106.6	128.8	135.2	143.7	114.8	119.5	141.4	182.9	150.9	150.6	142.9	128.5	175.0	150.9	151.0
5	146.0	149.8	149.9	175.1	132.9	149.4	145.0	118.7	120.0	135.4	185.2	145.8	134.2	159.4	160.9	131.6	120.0	165.5	213.3	175.6	168.7	170.8	138.3	210.6	177.1	173.0
6	216.0	185.7	169.6	205.0	157.2	157.3	143.1	135.8	179.9	179.2	182.6	186.5	165.4	162.9	177.7	153.2	136.6	175.6	248.3	198.0	190.8	182.0	157.2	220.2	202.3	194.0
7	181.0	199.7	256.9	212.0	172.9	166.8	185.6	156.4	179.9	208.8	206.3	198.7	167.2	191.6	202.3	169.2	101.5	208.5	272.1	215.9	211.0	194.0	155.5	213.3	198.9	214.0
8+	200.0	252.0	164.2	230.3	183.1	212.9	178.0	168.0	181.7	135.2	226.9	183.4	170.3	178.0	229.2	178.0	138.3	196.7	304.7	234.8	228.5	228.6	198.5	244.1	218.9	215.0
Total	115.6	123.9	75.8	100.2	73.7	80.5	99.4	91.4	78.5	74.8	110.9	64.8	72.1	81.2	65.9	76.3	70.1	71.1	128.0	79.8	56.6	78.5	97.9	94.6	80.1	50.0

* 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 2.3.3 WESTERN BALTIC SPRING SPAWNING HERRING.

N20 Larval Abundance Index.

Estimation of 0-Group herring reaching 20 mm in length in Greifswalder Bodden and adjacent waters (March/April to June).

YEAR	N20 (MILLIONS)
1992	1,060
1993	3,044
1994	12,515
1995	7,930
1996	21,012
1997	4,872
1998	16,743
1999	20,364
2000	3,026
2001	4,845
2002	11,324
2003	5,507
2004	5,640
2005	3,887
2006	3,774
2007*	1,829
2008*	1,622
2009	6,464
2010	7,037
2011	4,444
2012	1,140
2013	3,021
2014	539
2015	2,478
2016	442

*** small revision during HAWG 2010**

TABLE 2.6.1 WESTERN BALTIC SPRING SPAWNING HERRING.

Catch in number (CANUM, thousands)

year

Wr	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	118958	145090	206102	263202	541302	171144	376795	549774	569599
1	825969	456707	530707	249398	1660683	638877	668616	623072	616124
2	541246	602624	495950	364980	438136	400585	289336	430903	334339
3	564430	364864	415108	382650	226810	199681	276919	182860	246212
4	279767	333993	260950	267033	194870	144155	75283	146685	90259
5	177486	183200	210497	168142	84123	130086	43119	45322	55919
6	46487	139835	102768	118416	60096	65274	39916	23759	15481
7	13241	52660	63922	49504	32878	30705	21211	15400	9478
8	4933	22574	24535	33088	20459	25111	24134	14112	6084

year

Wr	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	152581	756285	150271	53489	243554	106906	7946	10721	9610
1	934545	523163	659130	126876	457754	305171	148909	172044	149436
2	496396	488816	281840	264855	197812	319225	187674	184735	136988
3	186615	257837	321311	161251	164766	177833	233214	143904	135753
4	128625	108097	172285	189432	93214	130394	150654	126861	92305
5	71727	68376	57160	103648	91242	60639	98751	64996	89436
6	38262	39092	38532	29117	48957	65695	42459	30199	45930
7	13777	18307	13842	17452	14876	31231	32418	21256	17216
8	10689	6687	8329	8819	11013	12620	17312	14759	17410

year

Wr	2009	2010	2011	2012	2013	2014	2015	2016
0	20734	12394	11813	2000	1029	31157	29979	43891
1	181083	75083	98516	76854	72606	66799	103995	49520
2	243007	136419	46282	130803	88827	60110	132720	198981
3	101330	82970	38787	64468	114676	66362	59489	136892
4	69937	46833	49324	47322	67175	82074	62543	59012
5	48091	29979	27630	35444	33067	26620	44432	42636
6	39750	18589	22632	18169	26718	15751	19713	30672
7	20907	10996	12236	11238	11974	8869	10535	14050
8	12529	11262	9335	17001	12005	9088	13018	14807

TABLE 2.6.2 WESTERN BALTIC SPRING SPAWNING HERRING.

Weight at age as W-ringers in the catch (WECA, kg)

year

Wr	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	0.02957	0.01519	0.01535	0.01458	0.01010	0.01056	0.02962	0.01426	0.01112
1	0.03476	0.03447	0.02545	0.03704	0.02092	0.02458	0.02748	0.03333	0.03433
2	0.06685	0.06732	0.06797	0.08328	0.06843	0.08090	0.06845	0.06634	0.06583
3	0.09490	0.09435	0.10204	0.10323	0.09841	0.09702	0.11807	0.09423	0.09814
4	0.12342	0.11630	0.11428	0.12213	0.12349	0.11254	0.13420	0.11779	0.11642
5	0.13901	0.14169	0.13615	0.14115	0.15196	0.13283	0.16198	0.13673	0.14713
6	0.15560	0.16511	0.16795	0.15648	0.17041	0.13687	0.18170	0.16628	0.15660
7	0.17091	0.17576	0.18228	0.17046	0.20626	0.15425	0.19671	0.16523	0.15382
8	0.18256	0.19152	0.19890	0.18596	0.21696	0.19100	0.20872	0.18701	0.15756

year

Wr	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	0.02113	0.01229	0.01053	0.01325	0.00618	0.01401	0.01700	0.01389	0.01776
1	0.02550	0.02432	0.02127	0.03152	0.02754	0.02719	0.03605	0.05062	0.06466
2	0.05775	0.05931	0.06998	0.06711	0.06419	0.07208	0.07283	0.07092	0.07879
3	0.09501	0.08618	0.09678	0.09075	0.10017	0.09378	0.09818	0.08538	0.09601
4	0.13013	0.10886	0.11956	0.10792	0.10596	0.11057	0.11527	0.11409	0.11525
5	0.14280	0.15673	0.14003	0.12234	0.13139	0.12280	0.15345	0.12879	0.14036
6	0.14633	0.15597	0.18763	0.13188	0.15228	0.14933	0.15811	0.15640	0.14807
7	0.15829	0.15560	0.18141	0.16029	0.16768	0.16192	0.18654	0.16734	0.16671
8	0.15908	0.17132	0.17170	0.16252	0.15295	0.17355	0.18485	0.19030	0.17041

year

Wr	2009	2010	2011	2012	2013	2014	2015	2016
0	0.01260	0.00928	0.01033	0.01141	0.01368	0.01065	0.00811	0.00858
1	0.04789	0.04619	0.03199	0.02822	0.02467	0.04051	0.02476	0.03740
2	0.07105	0.07688	0.07699	0.07024	0.07742	0.07370	0.05830	0.06150
3	0.10319	0.10873	0.10092	0.10790	0.11481	0.10243	0.09197	0.09762
4	0.13903	0.13535	0.12051	0.12513	0.13497	0.15254	0.11769	0.10984
5	0.15341	0.16464	0.14385	0.15666	0.14451	0.17006	0.15392	0.14247
6	0.17088	0.18078	0.15263	0.17606	0.14852	0.17210	0.17620	0.17784
7	0.19236	0.19751	0.16584	0.18626	0.16263	0.17931	0.15166	0.17951
8	0.21459	0.20551	0.17326	0.20851	0.18474	0.19196	0.16838	0.19830

TABLE 2.6.3 WESTERN BALTIC SPRING SPAWNING HERRING.

Weight at age as W-ringers in the stock (WEST, kg)

Wr	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
1	0.03085	0.02029	0.01563	0.01855	0.01305	0.01815	0.01310	0.02209	0.02106
2	0.05277	0.04513	0.04020	0.05288	0.04590	0.05456	0.05147	0.05578	0.05668
3	0.07873	0.08176	0.09671	0.08357	0.07081	0.09051	0.10633	0.08293	0.08705
4	0.10412	0.10751	0.10793	0.10767	0.13269	0.11703	0.13334	0.11280	0.10813
5	0.12447	0.13127	0.14087	0.13921	0.16745	0.11974	0.16618	0.13378	0.14801
6	0.14492	0.15934	0.16715	0.15656	0.18923	0.15383	0.19429	0.16779	0.16015
7	0.15943	0.17102	0.18273	0.17676	0.20970	0.14667	0.20895	0.16832	0.14394
8	0.16398	0.18693	0.18906	0.20275	0.23377	0.12803	0.22635	0.18432	0.15043

Wr	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
1	0.01398	0.01686	0.01645	0.01444	0.01306	0.01260	0.01846	0.01500	0.01800
2	0.04313	0.05088	0.06368	0.04447	0.04561	0.05136	0.06210	0.05500	0.06800
3	0.08370	0.07829	0.09046	0.07926	0.08106	0.08000	0.09527	0.08000	0.08600
4	0.12504	0.11594	0.12388	0.10509	0.10925	0.10657	0.11740	0.11400	0.11000
5	0.14365	0.16904	0.17365	0.12681	0.14399	0.13221	0.16593	0.14300	0.13900
6	0.16287	0.17627	0.19830	0.15061	0.16285	0.15733	0.17102	0.17100	0.14300
7	0.16503	0.16808	0.19801	0.17287	0.19321	0.16766	0.18584	0.17500	0.14100
8	0.18311	0.18052	0.20363	0.18471	0.20759	0.18205	0.18708	0.18800	0.15800

Wr	2009	2010	2011	2012	2013	2014	2015	2016
0	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
1	0.02300	0.01404	0.00900	0.01200	0.01400	0.01600	0.01500	0.01375
2	0.05200	0.06265	0.05800	0.05000	0.05600	0.05200	0.04900	0.04147
3	0.09000	0.09735	0.09500	0.09200	0.09500	0.08100	0.08800	0.08109
4	0.13000	0.12833	0.12600	0.11400	0.12900	0.13000	0.11600	0.10571
5	0.15600	0.16176	0.15600	0.15800	0.14300	0.16500	0.15700	0.13662
6	0.17400	0.18131	0.17300	0.17800	0.16100	0.17400	0.18000	0.17349
7	0.18500	0.20229	0.18500	0.19100	0.17900	0.19000	0.16900	0.18239
8	0.19900	0.20447	0.19200	0.20100	0.19900	0.20500	0.19400	0.19032

TABLE 2.6.4 WESTERN BALTIC SPRING SPAWNING HERRING.

Natural mortality (NATMOR)

Wr	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Wr	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

TABLE 2.6.5 WESTERN BALTIC SPRING SPAWNING HERRING.

Proportion mature (MATPROP)

Wr \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
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	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	0.00
2	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
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	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
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

Wr \ year	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
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
5	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
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 2.6.6 WESTERN BALTIC SPRING SPAWNING HERRING.

Fraction of harvest before spawning (FPROP)

Wr \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Wr \ year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

TABLE 2.6.7 WESTERN BALTIC SPRING SPAWNING HERRING.

Fraction of natural mortality before spawning (MPROP)

Wr \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
3	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
5	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
6	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
7	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
8	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

Wr \ year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
3	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
5	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
6	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
7	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
8	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

TABLE 2.6.8 WESTERN BALTIC SPRING SPAWNING HERRING.

Survey indices/ HERAS (number)

Wr \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	-1	277000	103000	5000	2199000	1091000	128000	138000	-1
2	1864000	2092000	2768000	413000	1887000	1005000	715000	1682000	-1
3	1927000	1799000	1274000	935000	1022000	247000	787000	901000	-1
4	866000	1593000	598000	501000	1270000	141000	166000	282000	-1
5	350000	556000	434000	239000	255000	119000	67000	111000	-1
6	88000	197000	154000	186000	174000	37000	69000	51000	-1
7	72000	122000	63000	62000	39000	20000	80000	31000	-1
8	10000	20000	13000	34000	21000	13000	77000	53000	-1

Wr \ year	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	1509200	65500	3346200	1833100	1668600	2687000	2081100	3918000	5852000
2	1891100	641200	1576600	1110000	929600	1342100	2217000	3621000	1160000
3	673600	452300	1392800	394600	726000	463500	1780400	933000	843000
4	363900	153100	524300	323400	306900	201300	490000	499000	333000
5	185700	96400	87500	103400	183700	102500	180400	154000	274000
6	55600	37600	39500	25200	72100	83600	27000	34000	176000
7	6900	23000	17800	12000	21500	37200	9500	26000	45000
8	9600	11900	17100	5400	18000	21400	100	14000	44000

Wr \ year	2009	2010	2011	2012	2013	2014	2015	2016
1	565000	999000	2980000	1018000	49000	513000	1949000	425000
2	398000	511000	473000	1081000	627000	415000	1244000	255000
3	205000	254000	259000	236000	525000	176000	446000	381000
4	161000	115000	163000	87000	53000	248000	224000	99000
5	82000	65000	70000	76000	30000	28000	171000	40000
6	86000	24000	53000	33000	12000	37000	82000	40000
7	39000	28000	22000	14000	8000	26000	89000	12000
8	65000	34000	46000	60000	15000	42000	115000	28000

Continued

TABLE 2.6.8 WESTERN BALTIC SPRING SPAWNING HERRING.

continued Survey indices/GERAS (number in thousands)

Wr \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	-1	-1	-1	5474540	5107780	1833130	2859220	2490090	5993820
1	-1	-1	-1	415730	1675340	1439460	1955400	801350	1338710
2	-1	-1	-1	883810	328610	590010	738180	678530	287240
3	-1	-1	-1	559720	357960	434090	394530	394070	232510
4	-1	-1	-1	443730	353850	295170	162430	236830	155950
5	-1	-1	-1	189420	253510	305550	118910	100190	51940
6	-1	-1	-1	60400	126760	119260	99290	50980	8130
7	-1	-1	-1	23510	46430	46980	33280	23640	1470
8	-1	-1	-1	2330	27240	18910	47850	9330	2100

Wr \ year	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	1008910	-1	4102588	3776780	2554680	3055595	4159311	2588922	2150306
1	1429880	-1	837549	1238480	968860	750199	940892	558851	392737
2	453980	-1	421393	222530	592360	590756	226959	260402	165347
3	328960	-1	575356	217270	346230	295659	279618	117412	166301
4	201590	-1	341119	260350	163150	142778	212201	76782	102018
5	78930	-1	63678	96960	143320	78541	139813	43919	82174
6	38610	-1	24520	38040	79030	79018	97261	12144	29727
7	5920	-1	9690	8580	22600	25564	66937	9262	11443
8	4190	-1	13380	9890	11770	15013	27789	8839	9262

Wr \ year	2009	2010	2011	2012	2013	2014	2015	2016
0	2821022	4561405	2929434	4103180	8996225	5473400	888081	2638277
1	270959	534633	1206762	755034	893837	769320	440738	493366
2	95866	305540	360354	294242	456204	242590	509769	155417
3	43553	214539	210455	193974	307567	279650	221344	196061
4	17761	107364	115984	124548	262908	332660	129795	60953
5	9016	85635	57840	70135	87114	317240	95579	30490
6	3227	47140	50844	45017	32684	211600	86150	14980
7	1947	25021	29234	22520	22565	85630	47093	3300
8	1704	15309	14774	21404	11300	56590	37886	0

Survey indices/N20 (number in millions)

Wr \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	1060	3044	12515	7930	21012	4872	16743	20364	3026	4845	11324	5507

Wr \ year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	5640	3887	3774	1829	1622	6464	7037	4444	1140	3021	539	2478

Wr \ year	2016
0	442

Survey indices/IBTS Q1 (number per hour)

Wr \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	32.72	69.61	400.08	101.33	90.41	165.10	528.05	53.90	93.69	284.45
2	224.30	29.12	87.09	60.93	17.51	177.97	30.31	159.97	35.79	45.18
3	103.73	10.57	10.13	37.13	7.71	44.62	46.90	34.76	15.44	4.49
4	19.78	6.12	1.99	3.60	5.57	10.64	2.22	13.21	3.79	1.19

Wr \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	106.82	506.44	201.08	69.75	97.88	150.21	145.01	58.44	788.51	57.17
2	140.29	27.52	186.59	47.76	180.02	27.11	66.55	20.38	67.17	42.41
3	14.57	29.60	6.28	8.75	11.93	15.55	8.80	4.24	1.87	9.24
4	0.53	3.13	1.27	1.00	1.99	2.00	1.72	0.58	1.53	2.43

Wr \ year	2011	2012	2013	2014	2015	2016
1	165.62	84.87	33.89	130.98	351.46	28.69
2	167.28	318.00	31.71	30.05	41.49	49.11
3	55.92	18.96	23.89	8.02	4.60	7.57
4	14.29	3.56	3.32	7.11	1.07	7.87

TABLE 2.6.8 WESTERN BALTIC SPRING SPAWNING HERRING.

continued Survey indices/IBTS Q3 (number per hour)

Wr	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	21.99	74.44	297.95	37.82	87.31	130.24	12.04	33.14	41.43	0.05
2	16.87	26.36	26.94	24.10	21.56	46.97	20.98	16.92	10.17	0.04
3	18.81	16.12	3.54	17.32	13.28	4.03	12.72	3.85	3.08	0.00
4	6.33	12.70	3.48	6.26	13.91	1.96	2.18	3.68	1.15	0.00

Wr e	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	18.00	382.77	80.78	283.34	53.07	110.21	81.35	37.05	203.14	33.32
2	24.12	22.42	37.34	50.12	41.63	25.04	17.03	7.75	62.45	12.88
3	6.98	12.64	10.45	13.03	10.59	14.63	4.43	4.55	12.78	6.93
4	1.81	2.43	3.64	2.38	2.42	1.63	4.13	1.20	4.29	3.25

Wr e	2011	2012	2013	2014	2015	2016
1	224.61	59.27	139.43	134.13	197.30	45.86
2	15.49	38.08	114.24	19.35	30.31	36.84
3	4.92	4.37	13.44	14.32	7.89	14.18
4	3.05	0.81	2.83	2.73	5.11	2.67

TABLE 2.6.9 WESTERN BALTIC SPRING SPAWNING HERRING.

STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
0	8	8	1991	2016	3	6

TABLE 2.6.10 WESTERN BALTIC SPRING SPAWNING HERRING.

FLSAM CONFIGURATION SETTINGS

```
An object of class "FLSAM.control"
Slot "name":
[1] "WBSSher"
Slot "desc":
character(0)
Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1991      2016         3         6
Slot "fleets":
  catch   HERAS   GerAS     N20 IBTS Q1 IBTS Q3
      0       2       2       2       2       2
Slot "plus.group":
plusgroup
     TRUE
Slot "states":
         age
fleet      0  1  2  3  4  5  6  7  8
  catch    1  2  3  4  5  6  6  6  6
  HERAS   NA NA NA NA NA NA NA NA NA
  GerAS   NA NA NA NA NA NA NA NA NA
  N20     NA NA NA NA NA NA NA NA NA
  IBTS Q1 NA NA NA NA NA NA NA NA NA
  IBTS Q3 NA NA NA NA NA NA NA NA NA
Slot "logN.vars":
0 1 2 3 4 5 6 7 8
1 1 1 1 1 1 1 1 1
Slot "catchabilities":
         age
fleet      0  1  2  3  4  5  6  7  8
  catch   NA NA NA NA NA NA NA NA NA
  HERAS   NA  1  2  3  4  5  6  7  7
  GerAS    8  9 10 11 12 13 14 15 15
  N20     16 NA NA NA NA NA NA NA NA
  IBTS Q1 NA 17 18 19 20 NA NA NA NA
  IBTS Q3 NA 21 22 23 24 NA NA NA NA
Slot "power.law.exps":
         age
fleet      0  1  2  3  4  5  6  7  8
  catch   NA NA NA NA NA NA NA NA NA
  HERAS   NA NA NA NA NA NA NA NA NA
  GerAS   NA NA NA NA NA NA NA NA NA
  N20     NA NA NA NA NA NA NA NA NA
  IBTS Q1 NA NA NA NA NA NA NA NA NA
  IBTS Q3 NA NA NA NA NA NA NA NA NA
Slot "f.vars":
         age
fleet      0  1  2  3  4  5  6  7  8
  catch    1  2  2  2  2  2  2  2  2
  HERAS   NA NA NA NA NA NA NA NA NA
  GerAS   NA NA NA NA NA NA NA NA NA
  N20     NA NA NA NA NA NA NA NA NA
  IBTS Q1 NA NA NA NA NA NA NA NA NA
  IBTS Q3 NA NA NA NA NA NA NA NA NA
Slot "obs.vars":
         age
fleet      0  1  2  3  4  5  6  7  8
  catch    1  2  2  2  2  3  3  3  3
  HERAS   NA  4  5  6  6  6  6  7  7
  GerAS    8  8  8  8  9  9 10 10 10
  N20     11 NA NA NA NA NA NA NA NA
  IBTS Q1 NA 12 12 12 12 NA NA NA NA
  IBTS Q3 NA 13 13 14 14 NA NA NA NA
```

continued

Contiued TABLE 2.6.10 WESTERN BALTIC SPRING SPAWNING HERRING.

FLSAM CONFIGURATION SETTINGS

```
Slot "srr":
[1] 0
Slot "cor.F":
[1] TRUE
Slot "nohess":
[1] FALSE
Slot "timeout":
[1] 3600
Slot "sam.binary":
[1] "model/sam"
```

TABLE 2.6.11 WESTERN BALTIC SPRING SPAWNING HERRING.

FLR, R SOFTWARE VERSIONS

```
Package: FLSAM
Type: Package
Title: FLSAM, an implementation of the State-space Assessment Model for
        FLR
Version: 1.02
Date: 2016-04-06
Author: M.R. Payne <mpa@aqua.dtu.dk>, N.T. Hintzen
        <niels.hintzen@wur.nl>
Maintainer: M.R. Payne <mpa@aqua.dtu.dk>, N.T. Hintzen
        <niels.hintzen@wur.nl>
Description: FLR wrapper to the SAM state-space assessment model
Depends: R(>= 2.13.0), FLCore(>= 2.4), utils, MASS
Suggests: methods, reshape, plyr, ellipse
License: GPL
LazyLoad: yes
NeedsCompilation: no
Packaged: 2017-02-03 11:22:59 UTC; mosquia
Built: R 3.2.2; ; 2017-03-14 12:46:55 UTC; unix
-- File: /usr/local/lib/R322/lib/R/library/FLSAM/Meta/package.rds
```

TABLE 2.6.12 WESTERN BALTICv SPRING SPAWNING HERRING.

STOCK SUMMARY

	Year	Recruitment	TSB	SSB	F3-6	Landings
[1,]	1991	3909813	537257.4	302140.24	0.3931735	191573
[2,]	1992	3667424	460465.8	309873.84	0.5252393	194411
[3,]	1993	3544827	389784.7	276412.95	0.5738427	185010
[4,]	1994	4222762	327465.9	224539.75	0.6089819	172438
[5,]	1995	4065308	281280.7	192439.73	0.5671453	150831
[6,]	1996	3964935	248645.0	134373.59	0.6410667	121266
[7,]	1997	3779113	241484.6	146209.34	0.5831737	115588
[8,]	1998	3972873	228449.3	114588.06	0.5788457	107032
[9,]	1999	4028884	223414.4	112594.23	0.4887958	97240
[10,]	2000	3378695	217240.5	120890.18	0.5883476	109914
[11,]	2001	3321742	235185.9	128741.33	0.5678700	105803
[12,]	2002	2940235	268057.0	161637.04	0.5314038	106191
[13,]	2003	2884898	203838.0	129998.71	0.4747888	78309
[14,]	2004	2473142	211739.7	137661.25	0.4644037	76815
[15,]	2005	2130783	214815.1	132985.74	0.5134933	88406
[16,]	2006	1867292	237338.6	155774.27	0.5374373	90549
[17,]	2007	1709993	181665.5	121812.41	0.4926710	68997
[18,]	2008	1631483	164030.3	105021.04	0.5309822	68484
[19,]	2009	1615250	150925.0	93898.18	0.5232872	67262
[20,]	2010	1785127	139671.6	90669.18	0.3617193	42214
[21,]	2011	1672784	130465.1	88314.07	0.3112529	27771
[22,]	2012	1594387	141845.8	90241.60	0.3386119	38648
[23,]	2013	1699764	155540.8	102910.59	0.3513579	43827
[24,]	2014	1624970	152720.3	103606.78	0.2913357	37358
[25,]	2015	1377802	156128.4	101760.34	0.3349168	37491
[26,]	2016	1376425	141357.2	97239.76	0.4068507	51298

TABLE 2.6.13 WESTERN BALTIC SPRING SPAWNING HERRING.

ESTIMATED FISHING MORTALITY

```
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
Wr       1991      1992      1993      1994      1995      1996      1997
  0 0.0323772 0.0615750 0.0766504 0.0876766 0.0831341 0.1094158 0.0892869
  1 0.2220839 0.2765953 0.3015559 0.3222589 0.3305161 0.3654594 0.3343724
  2 0.2999618 0.3789087 0.4041335 0.4290036 0.4208074 0.4587683 0.4209084
  3 0.3435578 0.4325056 0.4682982 0.4917770 0.4804030 0.5353631 0.4893731
  4 0.3802524 0.4807298 0.5214666 0.5562708 0.5376863 0.6029265 0.5454741
  5 0.4244420 0.5938610 0.6528029 0.6939398 0.6252461 0.7129885 0.6489238
  6 0.4244420 0.5938610 0.6528029 0.6939398 0.6252461 0.7129885 0.6489238
  7 0.4244420 0.5938610 0.6528029 0.6939398 0.6252461 0.7129885 0.6489238
  8 0.4244420 0.5938610 0.6528029 0.6939398 0.6252461 0.7129885 0.6489238
   year
wr       1998      1999      2000      2001      2002      2003      2004
  0 0.0896448 0.0586540 0.0852046 0.0712472 0.0528763 0.0329521 0.0282122
  1 0.3346734 0.2829458 0.3233888 0.2963542 0.2594477 0.2072354 0.1969708
  2 0.4278468 0.3711311 0.4303829 0.4042224 0.3688114 0.3165418 0.3028856
  3 0.4879170 0.4223082 0.4874537 0.4608973 0.4261346 0.3711088 0.3594069
  4 0.5456377 0.4640421 0.5440142 0.5248777 0.4901862 0.4350780 0.4266889
  5 0.6409140 0.5344164 0.6609613 0.6428525 0.6046473 0.5464841 0.5357595
  6 0.6409140 0.5344164 0.6609613 0.6428525 0.6046473 0.5464841 0.5357595
  7 0.6409140 0.5344164 0.6609613 0.6428525 0.6046473 0.5464841 0.5357595
  8 0.6409140 0.5344164 0.6609613 0.6428525 0.6046473 0.5464841 0.5357595
   year
Wr       2005      2006      2007      2008      2009      2010      2011
  0 0.0304186 0.0275129 0.0205047 0.0230521 0.0220929 0.0084787 0.0053669
  1 0.2034571 0.1950694 0.1754678 0.1802339 0.1728208 0.1148762 0.0928008
  2 0.3269003 0.3345062 0.3139568 0.3394597 0.3413319 0.2344765 0.1886994
  3 0.3890646 0.4008532 0.3764651 0.4026853 0.3963173 0.2734326 0.2261176
  4 0.4678863 0.4845474 0.4546534 0.4939060 0.4955882 0.3535607 0.3053795
  5 0.5985112 0.6321744 0.5697828 0.6136687 0.6006217 0.4099418 0.3567571
  6 0.5985112 0.6321744 0.5697828 0.6136687 0.6006217 0.4099418 0.3567571
  7 0.5985112 0.6321744 0.5697828 0.6136687 0.6006217 0.4099418 0.3567571
  8 0.5985112 0.6321744 0.5697828 0.6136687 0.6006217 0.4099418 0.3567571
   year
Wr       2012      2013      2014      2015      2016
  0 0.0063303 0.0071905 0.0053370 0.0083575 0.0140014
  1 0.0954932 0.0958376 0.0797467 0.0906001 0.1055574
  2 0.2006687 0.2071732 0.1791020 0.2116968 0.2611396
  3 0.2433633 0.2534471 0.2173601 0.2505993 0.3034617
  4 0.3357125 0.3565788 0.3086646 0.3554396 0.4250493
  5 0.3876858 0.3977029 0.3196592 0.3668141 0.4494458
  6 0.3876858 0.3977029 0.3196592 0.3668141 0.4494458
  7 0.3876858 0.3977029 0.3196592 0.3668141 0.4494458
  8 0.3876858 0.3977029 0.3196592 0.3668141 0.4494458
```

TABLE 2.6.14 WESTERN BALTIC SPRING SPAWNING HERRING.

ESTIMATED POPULATION ABUNDANCE

An object of class "FLQuant"
, , unit = unique, season = all, area = unique

Wr \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	3909813	3667424	3544827	4222762	4065308	3964935	3779113	3972873	4028884
1	4049079	2984671	2607754	2010713	3492052	2706048	2867640	2433887	2853338
2	2135049	1931872	1628223	1181151	968012	1474751	1095805	1291093	1027871
3	1929941	1274418	1074107	1033023	643708	509406	784655	596002	665970
4	925417	1093616	691072	576655	569207	309279	234920	384616	301643
5	572633	503833	531788	357897	256786	261974	124742	111190	169906
6	169228	313953	230268	228891	150995	119850	94561	55548	46677
7	50767	101620	135808	96471	84796	66569	46958	35739	23790
8	16508	42235	59101	72766	58513	58513	50767	34996	22880

Wr \ year	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	3378695	3321742	2940235	2884898	2473142	2130783	1867292	1709993	1631483
1	3210701	2262543	2497998	1810294	2380926	1756792	1477704	1265528	1217122
2	1364093	1528810	998491	1104607	942226	1262999	813418	753889	578967
3	566935	769118	927270	548532	652131	608042	768350	460469	428909
4	360051	280408	451351	501320	310209	371016	365127	407176	249447
5	169906	175080	143344	247212	271305	171957	202197	189662	213416
6	85991	77653	83868	70123	126500	144206	90490	81389	102437
7	24539	37684	32860	39815	35703	64280	66703	44445	38600
8	22181	17624	22203	23624	29555	30699	38910	41564	39855

Wr \ year	2009	2010	2011	2012	2013	2014	2015	2016
0	1615250	1785127	1672784	1594387	1699764	1624970	1377802	1376425
1	1182333	1010545	1436902	1164730	1045494	1294972	1280806	896273
2	631593	561856	490902	812605	606221	508388	768350	703624
3	318061	362943	309898	326766	540365	381551	335709	514011
4	220356	179692	222126	186652	208772	322868	238232	205459
5	122884	111972	103985	128027	108989	115382	174381	125744
6	91126	61574	68460	61821	72258	63070	71611	93246
7	46537	38600	38988	37835	35918	38832	38330	40255
8	32565	35811	38832	48533	43261	41316	47763	47099

units: NA

TABLE 2.6.15 WESTERN BALTIC SPRING SPAWNING HERRING.

SURVIVORS AFTER TERMINAL YEAR

[1] NA NA NA NA NA NA NA NA NA

TABLE 2.6.16 WESTERN BALTIC SPRING SPAWNING HERRING.

FITTED SELECTION PATTERN

Wr	1991	1992	1993	1994	1995	1996	1997
0	0.08234844	0.1172322	0.1335740	0.1439725	0.1465835	0.1706777	0.1531052
1	0.56484960	0.5266080	0.5255027	0.5291765	0.5827714	0.5700802	0.5733667
2	0.76292482	0.7214020	0.7042584	0.7044604	0.7419745	0.7156328	0.7217548
3	0.87380697	0.8234448	0.8160742	0.8075396	0.8470544	0.8351131	0.8391550
4	0.96713636	0.9152585	0.9087275	0.9134440	0.9480573	0.9405052	0.9353544
5	1.07952833	1.1306484	1.1375991	1.1395082	1.1024441	1.1121909	1.1127453
6	1.07952833	1.1306484	1.1375991	1.1395082	1.1024441	1.1121909	1.1127453
7	1.07952833	1.1306484	1.1375991	1.1395082	1.1024441	1.1121909	1.1127453
8	1.07952833	1.1306484	1.1375991	1.1395082	1.1024441	1.1121909	1.1127453

Wr	1998	1999	2000	2001	2002	2003	2004
0	0.1548682	0.1199969	0.1448201	0.1254639	0.09950305	0.06940373	0.06074935
1	0.5781739	0.5788630	0.5496560	0.5218698	0.48823083	0.43647913	0.42413693
2	0.7391380	0.7592764	0.7315113	0.7118221	0.69403216	0.66670026	0.65220332
3	0.8429138	0.8639767	0.8285131	0.8116247	0.80190352	0.78162928	0.77391059
4	0.9426308	0.9493579	0.9246475	0.9242920	0.92243628	0.91636116	0.91878886
5	1.1072277	1.0933327	1.1234197	1.1320416	1.13783010	1.15100478	1.15365028
6	1.1072277	1.0933327	1.1234197	1.1320416	1.13783010	1.15100478	1.15365028
7	1.1072277	1.0933327	1.1234197	1.1320416	1.13783010	1.15100478	1.15365028
8	1.1072277	1.0933327	1.1234197	1.1320416	1.13783010	1.15100478	1.15365028

Wr	2005	2006	2007	2008	2009	2010	2011
0	0.05923861	0.05119277	0.0416195	0.0434140	0.04221941	0.02343996	0.01724298
1	0.39622155	0.36296208	0.3561560	0.3394349	0.33025994	0.31758394	0.29815246
2	0.63662038	0.62240959	0.6372544	0.6393053	0.65228400	0.64822780	0.60625758
3	0.75768182	0.74586034	0.7641307	0.7583781	0.75736102	0.75592501	0.72647564
4	0.91118280	0.90158865	0.9228336	0.9301744	0.94706720	0.97744515	0.98112998
5	1.16556769	1.17627550	1.1565178	1.1557238	1.14778589	1.13331492	1.14619719
6	1.16556769	1.17627550	1.1565178	1.1557238	1.14778589	1.13331492	1.14619719
7	1.16556769	1.17627550	1.1565178	1.1557238	1.14778589	1.13331492	1.14619719
8	1.16556769	1.17627550	1.1565178	1.1557238	1.14778589	1.13331492	1.14619719

Wr	2012	2013	2014	2015	2016
0	0.0186950	0.02046477	0.01831892	0.02495386	0.03441403
1	0.2820138	0.27276349	0.27372780	0.27051524	0.25945010
2	0.5926216	0.58963581	0.61476138	0.63208789	0.64185626
3	0.7187086	0.72133602	0.74608101	0.74824349	0.74587974
4	0.9914376	1.01485911	1.05948073	1.06127728	1.04473065
5	1.1449269	1.13190244	1.09721913	1.09523961	1.10469480
6	1.1449269	1.13190244	1.09721913	1.09523961	1.10469480
7	1.1449269	1.13190244	1.09721913	1.09523961	1.10469480
8	1.1449269	1.13190244	1.09721913	1.09523961	1.10469480

TABLE 2.6.17 WESTERN BALTIC SPRING SPAWNING HERRING.

PREDICTED CATCH IN NUMBERS

Wr	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	107721	189454	226364	306815	280913	355934	279652	294961	198551	238852	197817
1	640305	574238	540906	441706	784263	661523	650047	552219	560004	707505	462499
2	504085	555653	494103	376247	303550	495340	343520	410200	290686	435565	464028
3	511499	408440	367030	366737	224403	193184	277396	210176	209421	199905	259367
4	266892	381322	256632	224987	216577	128220	90292	147975	102293	138151	104684
5	180828	206447	233655	164210	109294	122431	54551	48190	64305	75312	76069
6	53445	128721	101144	105040	64293	56005	41345	24086	17672	38105	33742
7	16022	41660	59641	44254	36098	31114	20545	15489	9003	10873	16363
8	5211	17307	25949	33386	24904	27362	22199	15166	8663	9828	7655

Wr	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	131046	80886	59504	55193	43800	29995	32141	30513	13020	7734	8689
1	454158	268874	337763	256581	207773	161426	159070	148702	86708	100559	83843
2	280857	273211	224314	320841	210702	184998	151903	166475	106831	76757	134309
3	293813	155034	179477	178796	231492	131729	129768	94902	79095	57079	64267
4	159851	161426	98322	126678	128104	135822	88850	78700	48767	53237	48489
5	59522	95225	102909	70870	86795	75395	89617	50813	34355	28436	37549
6	34843	26992	47997	59474	38816	32357	43002	37677	18901	18734	18130
7	13650	15328	13537	26508	28613	17667	16203	19238	11843	10661	11093
8	9224	9099	11212	12651	16705	16518	16735	13460	10993	10627	14225

Wr	2013	2014	2015	2016
0	10519	7474	9908	16539
1	75456	78378	87597	70927
2	103187	75804	133346	147178
3	110095	67778	67731	122504
4	57062	78128	64971	64939

5	32630	28776	48845	41569
6	21626	15729	20051	30826
7	10752	9679	10728	13310
8	12955	10299	13367	15572

TABLE 2.6.18 WESTERN BALTIC SPRING SPAWNING HERRING.

SURVEY STANDARDIZED RESIDUALS/HERAS

Wr	1991	1992	1993	1994	1995	1996	1997	1998	2000
1	NA	-0.7545	-1.2325	-2.8018	0.3566	0.1152	-1.1508	-1.0144	0.1875
2	-0.3658	0.0725	0.8442	-1.7473	1.0881	-0.6108	-0.7222	0.4290	0.5342
3	-0.0664	0.7653	0.4502	-0.0784	1.0697	-1.3143	0.1318	0.9794	0.4790
4	0.2326	1.2776	0.2531	0.3065	2.2328	-0.9689	-0.1348	-0.0599	0.6031
5	-0.2614	1.1818	0.6322	0.2707	1.0038	-0.5009	-0.2377	1.0346	1.2474
6	-0.3756	0.2326	0.4413	0.8971	1.5314	-1.0796	0.6172	1.0808	0.3822
7	0.8571	0.7961	-0.1135	0.2365	-0.1394	-0.5085	1.1787	0.5021	-0.6070
8	0.0098	-0.1297	-0.8563	-0.0811	-0.3862	-0.8095	1.0635	1.0571	-0.1776

Wr	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	-1.4117	0.7617	0.5837	0.3700	0.8176	0.7673	1.2095	1.4625	0.1433
2	-1.4720	0.6861	-0.1166	-0.1606	-0.0122	1.5546	2.4712	1.0497	-0.8626
3	-1.0102	0.8844	-0.7088	0.1796	-0.5666	1.7500	1.4409	1.4109	-0.9032
4	-0.6961	0.8209	-0.4667	0.4077	-0.7836	1.1129	0.8866	1.1138	-0.1313
5	-0.1948	-0.0298	-0.8888	0.0948	-0.0870	0.7902	0.5144	1.5201	0.1478
6	-0.2406	-0.3469	-0.9808	-0.0417	0.0747	-1.2546	-0.6406	2.3442	1.0860
7	0.1536	0.0106	-0.6090	0.0735	0.0724	-1.3018	0.0653	0.7798	0.4425
8	0.2538	0.3609	-0.8848	0.0843	0.2584	-5.3001	-0.4841	0.7253	1.3067

Wr	2010	2011	2012	2013	2014	2015	2016
1	0.5370	0.9518	0.4596	-1.2081	0.0029	0.7744	0.1150
2	-0.3655	-0.3177	0.2291	-0.1816	-0.6024	0.5650	-1.8606
3	-0.8936	-0.5875	-0.8674	-0.2394	-1.8271	0.4042	-0.7341
4	-0.5880	-0.3676	-1.2672	-2.4977	-0.2696	0.2099	-1.0839
5	-0.3857	-0.1476	-0.3696	-1.9463	-2.3089	0.6422	-1.5800
6	-0.9905	0.3608	-0.3687	-2.7708	-0.2614	1.1844	-0.7407
7	0.1805	-0.1025	-0.5039	-1.0029	0.0446	1.3122	-0.6808
8	0.4480	0.6352	0.6975	-0.5625	0.4602	1.3484	0.0066

TABLE 2.6.19 WESTERN BALTIC SPRING SPAWNING HERRING.

SURVEY STANDARDIZED RESIDUALS/GERAS

Wr	1994	1995	1996	1997	1998	1999	2000	2002	2003
0	-0.0118	-0.0865	-2.1319	-1.1368	-1.5288	0.2275	-3.0861	0.0827	-0.0840
1	-1.5121	0.2613	0.5372	1.0044	-0.5180	0.1353	0.0944	-0.6067	0.7981
2	1.4542	-0.2122	0.1963	1.2223	0.7143	-0.7019	-0.2373	0.1566	-1.4781
3	0.4199	0.4550	1.4392	0.2604	0.8310	-0.6153	0.5558	0.5930	-0.4361
4	0.7315	0.3725	1.1268	0.5505	0.3677	-0.0083	0.2171	0.6195	-0.0371
5	0.1853	1.0771	1.4489	1.0517	0.9533	-0.8749	-0.0607	-0.2006	-0.4699
6	-0.5500	0.6582	0.9221	0.9246	0.7693	-1.1450	0.0039	-0.5158	0.1112
7	-0.2745	0.5524	0.9077	0.8554	0.7733	-1.9179	-0.3144	-0.1439	-0.5384
8	-2.4989	0.3748	0.0512	1.1685	-0.2224	-1.4848	-0.5825	0.6392	0.1889

Wr	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	-0.5876	0.1027	1.0189	0.1995	-0.0866	0.5004	1.2743	0.4792	1.2862
1	-0.3062	-0.1936	0.6269	-0.1708	-0.8181	-1.5467	0.1057	1.0357	0.4972
2	0.8795	0.3023	-0.7653	-0.3531	-0.7093	-2.0278	0.4625	1.0128	-0.4443
3	0.1568	0.0218	-0.5640	-1.3486	-0.4292	-2.6149	0.2362	0.4472	0.1947
4	-0.0277	-0.4668	0.2010	-1.6010	-0.3384	-2.8827	0.0809	-0.1912	0.2317
5	-0.0161	-0.1649	0.5268	-1.2668	-0.4139	-3.0304	0.4068	-0.1588	-0.1453
6	0.2557	0.1670	0.9358	-1.2837	-0.5155	-2.8329	0.3684	0.2884	0.2939
7	0.6332	0.1782	1.2229	-0.5552	-0.1298	-2.2877	0.5488	0.6620	0.4355
8	0.1247	0.4055	0.8491	-0.5327	-0.3969	-2.0423	0.0921	-0.0824	0.1072

Wr	2013	2014	2015	2016
0	2.7953	1.8466	-1.6061	0.6824
1	1.0781	0.2888	-0.8339	0.1738
2	1.0954	0.0956	0.8398	-1.3769
3	0.1248	0.5938	0.4272	-0.6279
4	1.2537	0.8780	-0.0619	-0.9280
5	0.4603	2.2988	-0.1706	-1.3451
6	-0.2184	1.9083	0.8261	-1.3079
7	0.5036	1.8114	1.2119	-1.6831
8	-0.4585	1.2894	0.7325	NA

TABLE 2.6.20 WESTERN BALTIC SPRING SPAWNING HERRING.

SURVEY STANDARDIZED RESIDUALS/N20

Wr	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	-2.0614	-0.7448	0.7502	0.2442	1.4594	-0.2508	1.1743	1.3783	-0.6898	-0.1111

Wr	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	1.0479	0.1943	0.4058	0.1387	0.2607	-0.5081	-0.595	1.0791	1.055	0.579	-0.9986

Wr	2013	2014	2015	2016
0	0.0966	-1.9232	0.1113	-1.9578

TABLE 2.6.21 WESTERN BALTIC SPRING SPAWNING HERRING.

SURVEY STANDARDIZED RESIDUALS/IBTS Q1

Wr	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	-2.3982	-1.1822	0.9702	-0.2964	-1.0553	-0.0718	1.1836	-1.2323	-0.7909
2	0.5430	-1.6601	-0.2125	-0.2502	-1.4466	0.7243	-0.9615	0.7496	-0.7065
3	0.9749	-1.1438	-0.9929	0.5368	-0.7183	1.5587	1.1170	1.0890	0.0269
4	1.0288	-0.4858	-1.2374	-0.3499	0.1592	1.6027	0.1216	1.5925	0.4343

Wr	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.3471	-0.3751	1.2820	0.5887	-0.9333	-0.1987	0.4855	0.6195	-0.3714
2	-0.7551	0.4031	-0.9733	1.0866	-0.2880	0.8952	-0.7611	0.3470	-0.6986
3	-1.1891	-0.1978	0.3918	-0.7847	-0.6055	-0.1683	-0.1309	-0.1997	-0.9484
4	-1.0774	-1.7175	-0.2401	-1.3960	-1.1222	-0.5364	-0.5097	-0.8101	-1.4858

Wr	2009	2010	2011	2012	2013	2014	2015	2016
1	2.6281	-0.1942	0.6147	0.0912	-0.8318	0.4632	1.6037	-0.8446
2	0.5629	0.1569	1.8692	2.0292	-0.2658	-0.1305	-0.2287	0.0714
3	-1.5411	0.1120	2.3389	1.0473	0.7393	-0.1135	-0.5974	-0.5070
4	-0.2377	0.5030	2.2748	0.8927	0.6883	1.0521	-0.7543	1.7001

TABLE 2.6.22 WESTERN BALTIC SPRING SPAWNING HERRING:

SURVEY STANDARDIZED RESIDUALS/IBTS Q3

Wr	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	-1.0541	-0.1093	0.8234	-0.2629	-0.0873	0.3236	-1.1676	-0.4540	-0.4349
2	-0.5960	-0.2347	-0.1085	0.0281	0.0782	0.3099	-0.0132	-0.2406	-0.4327
3	-0.7421	-0.1658	-2.5768	0.4147	0.7795	-0.9048	0.3513	-1.3266	-2.0112
4	-0.5393	0.5390	-0.9366	0.5027	1.9588	-0.4259	0.2049	0.2593	-1.5098

Wr	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	-4.5666	-0.7949	0.9854	0.2176	0.8084	-0.0204	0.5243	0.4268	-0.0245
2	-3.9409	-0.1374	0.0635	0.2916	0.5616	0.2807	0.2421	0.0467	-0.2614
3	NA	-0.7385	-0.0377	0.5110	0.5843	0.3671	0.5435	-0.7282	-0.5211
4	NA	-0.4808	-0.8515	-0.3684	-0.2773	-0.5274	-1.1988	0.2630	-1.0521

Wr	2009	2010	2011	2012	2013	2014	2015	2016
1	1.0222	-0.0010	0.9346	0.2545	0.8395	0.6797	0.9249	0.2622
2	0.9522	0.0253	0.2016	0.4462	1.2924	0.3116	0.3457	0.5364
3	1.8998	0.4025	0.0123	-0.2807	0.8624	1.5716	0.7557	1.1087
4	1.4972	1.2024	0.6450	-1.4189	0.6803	-0.2354	1.5147	0.6805

TABLE 2.6.23 WESTERN BALTIC SPRING SPAWNING HERRING.

FIT PARAMETERS

	name	value	std.dev
1	logFpar	-0.5689900	0.360900
2	logFpar	0.3977100	0.128000
3	logFpar	0.3703500	0.104920
4	logFpar	0.1842500	0.104810
5	logFpar	0.0239750	0.105650
6	logFpar	-0.0825940	0.109540
7	logFpar	-0.1208900	0.153690
8	logFpar	0.5756500	0.115560
9	logFpar	-0.1952500	0.113010
10	logFpar	-0.4825600	0.112030
11	logFpar	-0.2603700	0.111510
12	logFpar	-0.1232800	0.143400
13	logFpar	-0.0394350	0.144530
14	logFpar	-0.1155300	0.202900
15	logFpar	-0.4461500	0.153210
16	logFpar	-6.2899000	0.173990
17	logFpar	-9.5328000	0.176760
18	logFpar	-9.5746000	0.175930
19	logFpar	-10.6180000	0.175620
20	logFpar	-11.5820000	0.175470
21	logFpar	-9.9338000	0.326360
22	logFpar	-10.4530000	0.326030
23	logFpar	-10.7920000	0.117090
24	logFpar	-11.2340000	0.117010
25	logSdLogFsta	-0.7809900	0.332960
26	logSdLogFsta	-1.7611000	0.187130
27	logSdLogN	-1.9851000	0.171650
28	logSdLogObs	0.0555630	0.169780
29	logSdLogObs	-1.4149000	0.114380
30	logSdLogObs	-1.8162000	0.194640
31	logSdLogObs	0.5617900	0.145420
32	logSdLogObs	-0.5037800	0.148070
33	logSdLogObs	-0.7273300	0.079759
34	logSdLogObs	0.0043572	0.101980
35	logSdLogObs	-0.7377500	0.082650
36	logSdLogObs	-0.4497400	0.111930
37	logSdLogObs	-0.0915750	0.090472
38	logSdLogObs	-0.1844300	0.145700
39	logSdLogObs	-0.1315200	0.071395
40	logSdLogObs	0.5000300	0.098915
41	logSdLogObs	-0.6000500	0.107060
42	rho	0.8299400	0.112060

TABLE 2.9.1 WESTERN BALTIC SPRING SPAWNING HERRING.

Input table for short term predictions

2017

wr	N	M	Mat	PF	PM	Sel	SWt	CWt
0	1589611	0.3	0.00	0.25	0.1	0.027	0.000	0.009
1	1161240	0.5	0.00	0.25	0.1	0.267	0.015	0.034
2	489159	0.2	0.20	0.25	0.1	0.631	0.047	0.064
3	443681	0.2	0.75	0.25	0.1	0.747	0.083	0.097
4	310686	0.2	0.90	0.25	0.1	1.054	0.117	0.127
5	109969	0.2	1.00	0.25	0.1	1.100	0.153	0.155
6	65680	0.2	1.00	0.25	0.1	1.100	0.176	0.175
7	48706	0.2	1.00	0.25	0.1	1.100	0.180	0.170
8	45628	0.2	1.00	0.25	0.1	1.100	0.196	0.186

2018

wr	N	M	Mat	PF	PM	Sel	SWt	CWt
0	1589611	0.3	0.00	0.25	0.1	0.027	0.000	0.009
1		0.5	0.00	0.25	0.1	0.267	0.015	0.034
2		0.2	0.20	0.25	0.1	0.631	0.047	0.064
3		0.2	0.75	0.25	0.1	0.747	0.083	0.097
4		0.2	0.90	0.25	0.1	1.054	0.117	0.127
5		0.2	1.00	0.25	0.1	1.100	0.153	0.155
6		0.2	1.00	0.25	0.1	1.100	0.176	0.175
7		0.2	1.00	0.25	0.1	1.100	0.180	0.170
8		0.2	1.00	0.25	0.1	1.100	0.196	0.186

2019

wr	N	M	Mat	PF	PM	Sel	SWt	CWt
0	1589611	0.3	0.00	0.25	0.1	0.027	0.000	0.009
1		0.5	0.00	0.25	0.1	0.267	0.015	0.034
2		0.2	0.20	0.25	0.1	0.631	0.047	0.064
3		0.2	0.75	0.25	0.1	0.747	0.083	0.097
4		0.2	0.90	0.25	0.1	1.054	0.117	0.127
5		0.2	1.00	0.25	0.1	1.100	0.153	0.155
6		0.2	1.00	0.25	0.1	1.100	0.176	0.175
7		0.2	1.00	0.25	0.1	1.100	0.180	0.170
8		0.2	1.00	0.25	0.1	1.100	0.196	0.186

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)
Sel =	Exploit. Pattern
CWT =	Weight in catch (kg)

$N_{2017/2018/2019}$ wr 0:	Geometric Mean of wr 0 (Table 3.6.14) for the years 2011-2015
Natural Mortality (M):	Average for 2014-2016
Weight in the Catch/Stock (CWt/SWt):	Average for 2014-2016
Expoitation pattern (Sel):	Average for 2014-2016

TABLE 2.9.2 WESTERN BALTIC SPRING SPAWNING HERRING.

Short-term prediction multiple option table, TAC constraint.

R function 'fwd' within FLR
Run: Intermediate year: WBSS_TAC constraint_quota-transfer
Western Baltic Herring (combined sex; plus group)
Time and date:20/03/2017
Fbar age (wr) range: 3-6

2017 Biomass	SSB	FMult	FBar	Catch	GM Recr. 2011-2015 (x1000)
145,719	101,440	1.2600	0.435	50,428	1,589,611

2018	SSB	FMult	FBar	Catch	2019 Biomass	SSB
	97,467	0.00	0.000	0	189,546	135,428
	97,134	0.10	0.034	4,507	184,423	130,947
	96,802	0.20	0.069	8,881	179,471	126,625
	96,471	0.30	0.103	13,128	174,681	122,454
	96,141	0.40	0.138	17,251	170,050	118,430
	95,813	0.50	0.172	21,253	165,570	114,548
	95,485	0.60	0.207	25,140	161,236	110,801
	95,159	0.70	0.241	28,914	157,044	107,185
	94,834	0.80	0.275	32,579	152,989	103,696
	94,510	0.90	0.310	36,139	149,065	100,328
	94,187	1.00	0.344	39,597	145,268	97,077
	93,865	1.10	0.379	42,957	141,593	93,940
	93,545	1.20	0.413	46,220	138,036	90,911
	93,225	1.30	0.448	49,391	134,594	87,987
	92,907	1.40	0.482	52,473	131,261	85,164
	92,590	1.50	0.517	55,468	128,034	82,438
	92,274	1.60	0.551	58,378	124,910	79,806
	91,959	1.70	0.585	61,208	121,885	77,265
	91,645	1.80	0.620	63,958	118,955	74,811
	91,332	1.90	0.654	66,632	116,117	72,441
	91,020	2.00	0.689	69,232	113,369	70,152
F_{MSY}-framework	95,264	0.67	0.230	27,714	158,375	108,332
	95,169	0.70	0.240	28,800	157,171	107,294
	95,075	0.73	0.250	29,876	155,978	106,267
	94,980	0.76	0.260	30,943	154,797	105,250
	94,886	0.78	0.270	32,002	153,627	104,244
	94,792	0.81	0.280	33,051	152,468	103,248
	94,697	0.84	0.290	34,091	151,320	102,263
	94,603	0.87	0.300	35,123	150,183	101,287
	94,509	0.90	0.310	36,146	149,057	100,321
F_{3-6}=F_{MSY}	**94,416**	**0.93**	**0.320**	**37,161**	**147,942**	**99,366**
	94,322	0.96	0.330	38,167	146,837	98,420
	94,228	0.99	0.340	39,164	145,742	97,483
	94,134	1.02	0.350	40,153	144,658	96,556
	94,041	1.05	0.360	41,134	143,585	95,639
	93,948	1.07	0.370	42,107	142,521	94,731
	93,854	1.10	0.380	43,071	141,468	93,833
	93,761	1.13	0.390	44,028	140,424	92,943
	93,668	1.16	0.400	44,976	139,390	92,063
	93,575	1.19	0.410	45,917	138,366	91,191
$F=F_{MSY}*SSB_{2017}$MSY Btrigger	94,649	0.86	0.295	34,618	150,739	101,764
F_{2016}	93,604	1.18	0.407	45,622	138,688	91,465
F_{pa}	93,204	1.31	0.450	49,602	134,366	87,793
F_{lim}	92,558	1.51	0.520	55,763	127,717	82,170
B_{pa}	95,414	0.62	0.214	25,973	160,309	110,000
B_{lim}	93,446	1.23	0.424	47,206	136,965	90,000

output in tonnes

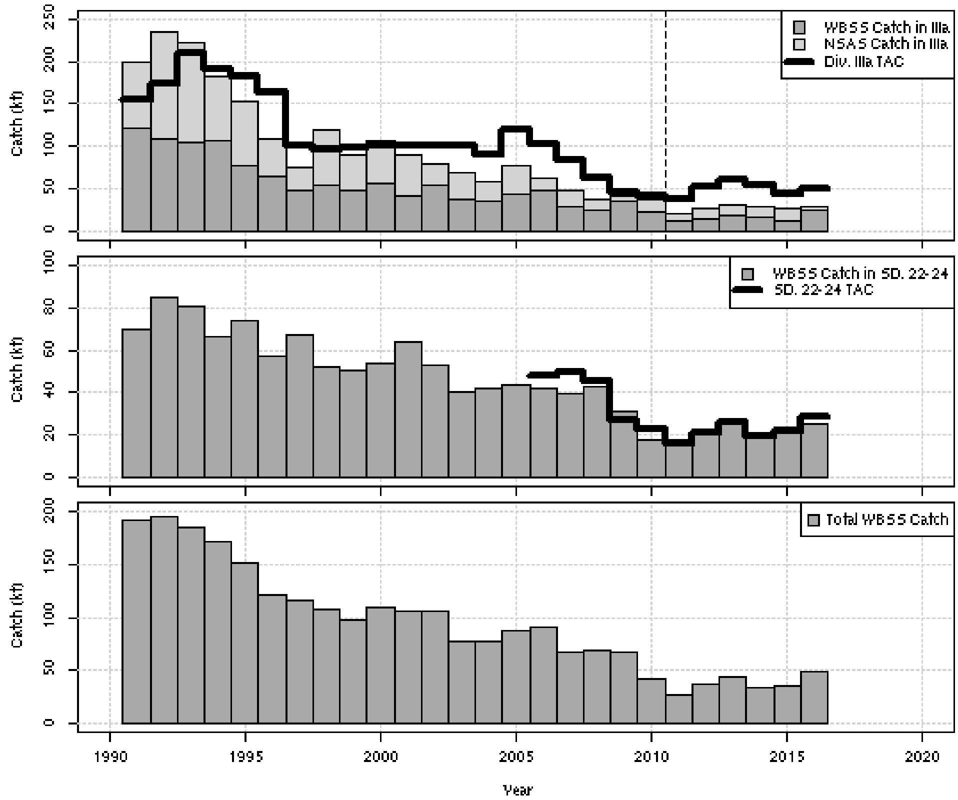


Figure 2.1.1 Western Baltic Spring Spawning Herring.

CATCH and TACs (1000 t) by area.

Top panel: **Total catch of Western Baltic Spring Spawning (WBSS) and North Sea Autumn Spawning (NSAS) herring in Division 3.a and the total TAC for both stocks.**

Middle panel: **Total catch and TACs of WBSS herring in Subdivisions 22-24.**

Bottom panel: **Total catch of WBSS herring in Div. 4.a, Div. 3.a and Subdivisions 22-24.**

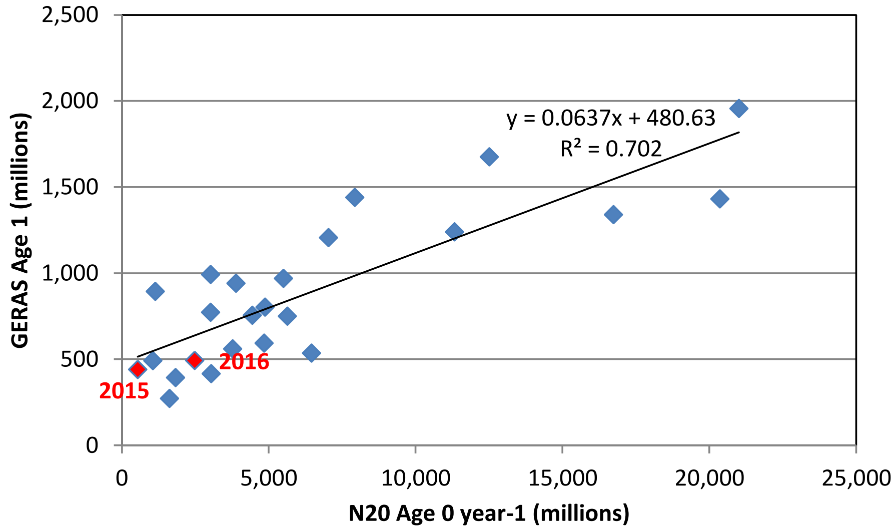


Figure 2.5.1 Western Baltic Spring Spawning Herring.

Correlation of 1-wr herring from GERAS with the N20 larvae index.

Note: The one-year lag phase between indices.

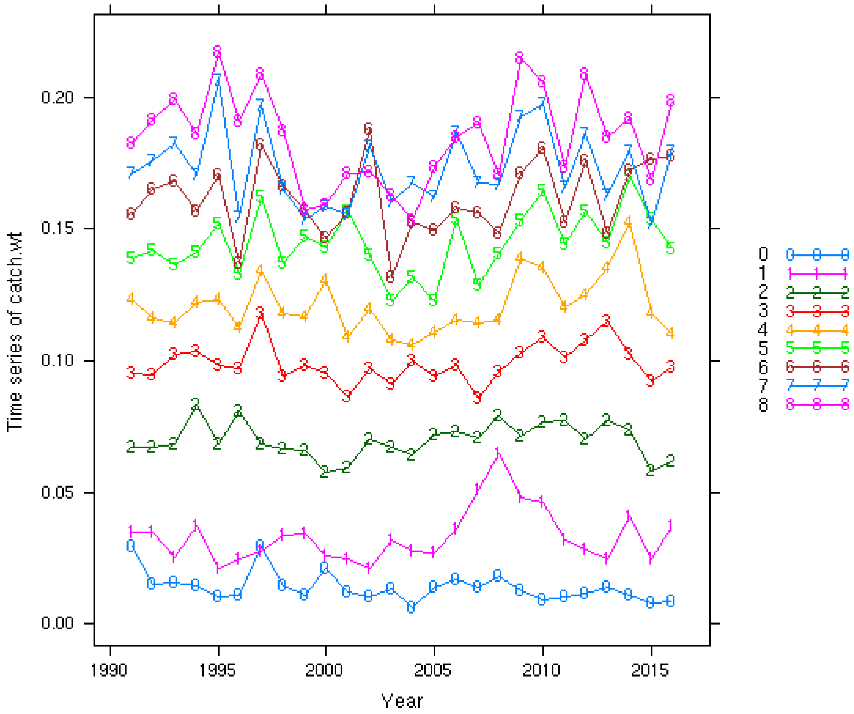


Figure 2.6.1.1 Western Baltic Spring Spawning Herring.

Weight at age as W-ringers (kg) in the catch (WECA).

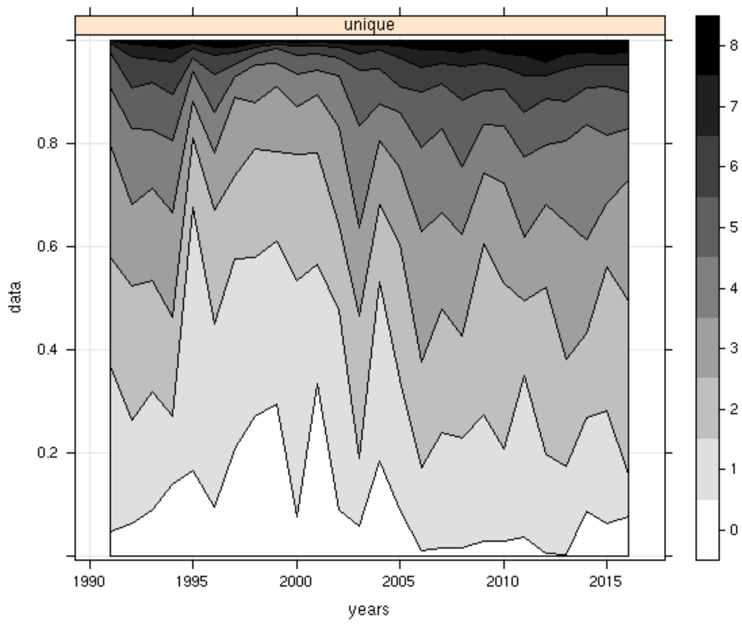


Figure 2.6.1.2 Western Baltic Spring Spawning Herring.

Proportion (by numbers) of a given age as W-ringers in the catch.

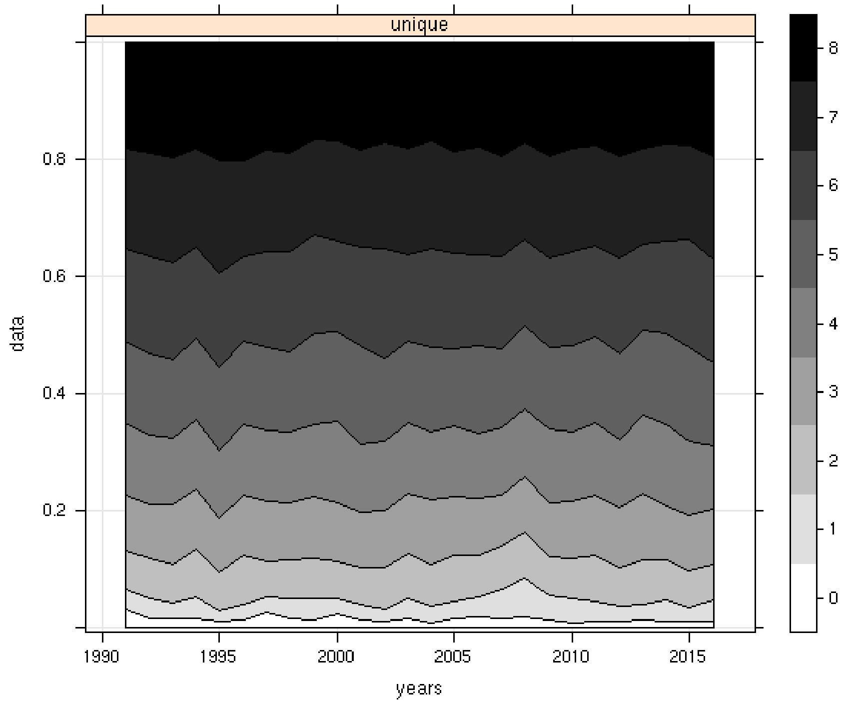


Figure 2.6.1.3 **Western Baltic Spring Spawning Herring.**

Proportion (by weight) of a given age as W-ringers in the catch.

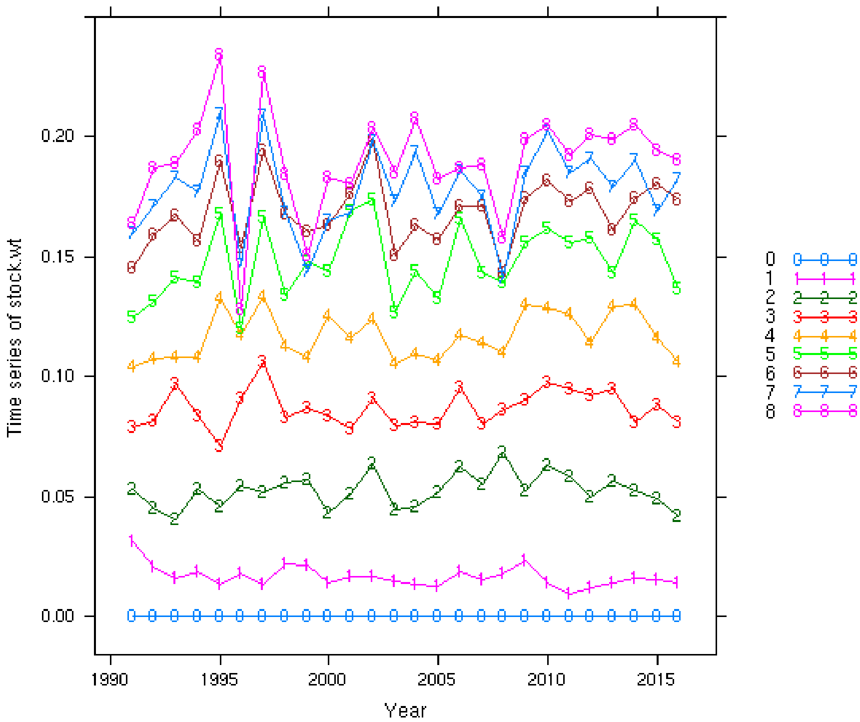


Figure 2.6.1.4 **Western Baltic Spring Spawning Herring.**

Weight at age as W-ringers (kg) in the stock (WEST).

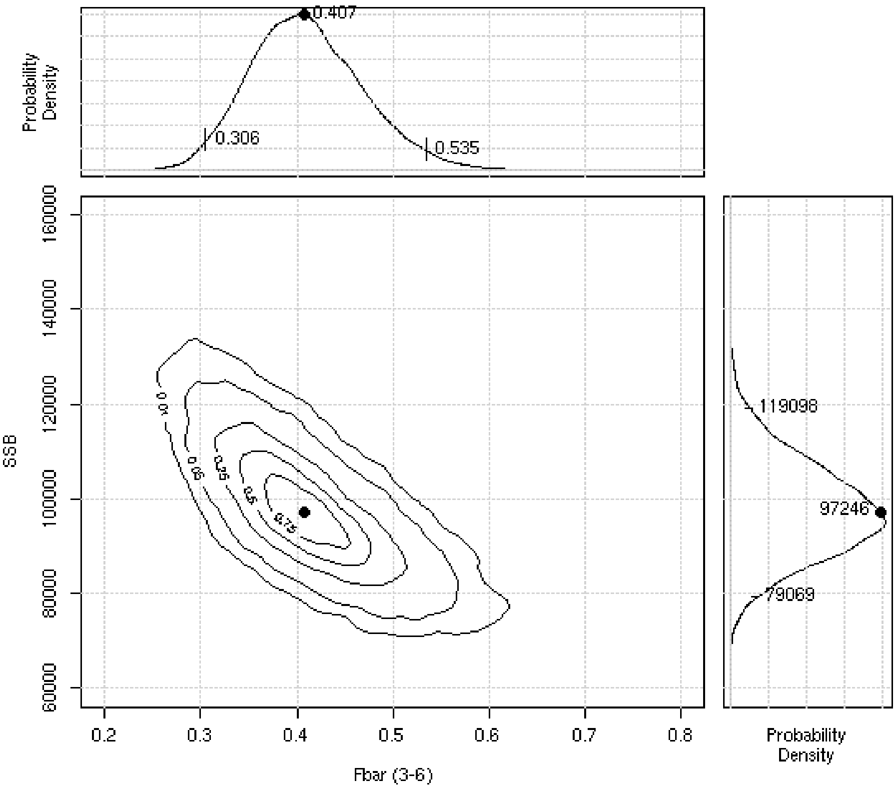


Figure 2.6.4.1 WESTERN BALTIC SPRING SPAWNING HERRING.

"Otolith" plot. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two estimated parameters and are estimated from a parametric bootstrap based on the variance covariance matrix in the parameters returned by the assessment model. The plots to the right and top of the main plot give the probability distribution in the SSB and mean fishing mortality respectively. The SSB (t) and fishing mortality estimated by the method is plotted on all three plots with a heavy dot. 95% confidence intervals, with their corresponding values, are given on the plots to the right and top of the main plot.

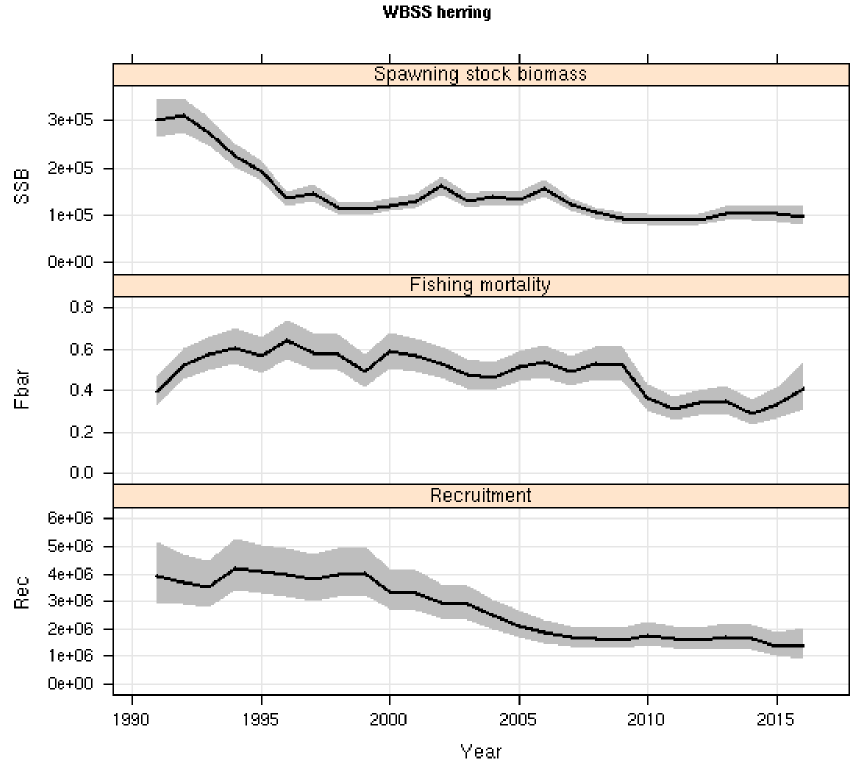


Figure 2.6.4.2 WESTERN BALTIC SPRING SPAWNING HERRING.

Stock summary plot. Top panel: Spawning stock biomass. Second panel: Recruitment (at age as 0-wr) as a function of time. Bottom panel: Mean annual fishing mortality on 3-6 ringers as a function of time.

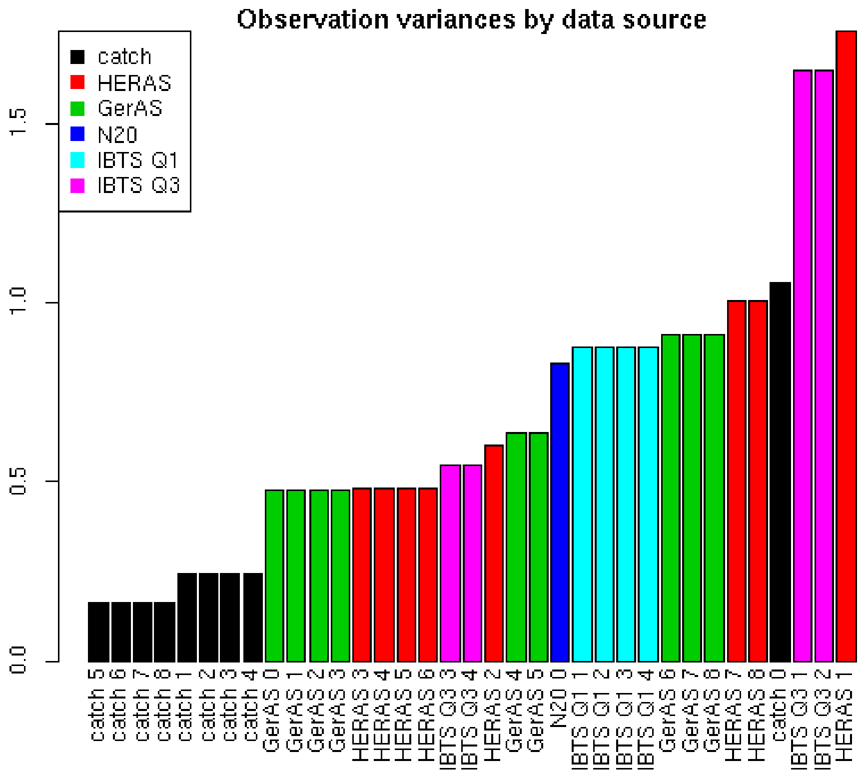


Figure 2.6.4.3 WESTERN BALTIC SPRING SPAWNING HERRING.

Estimated observation variance for the WBSS assessment.

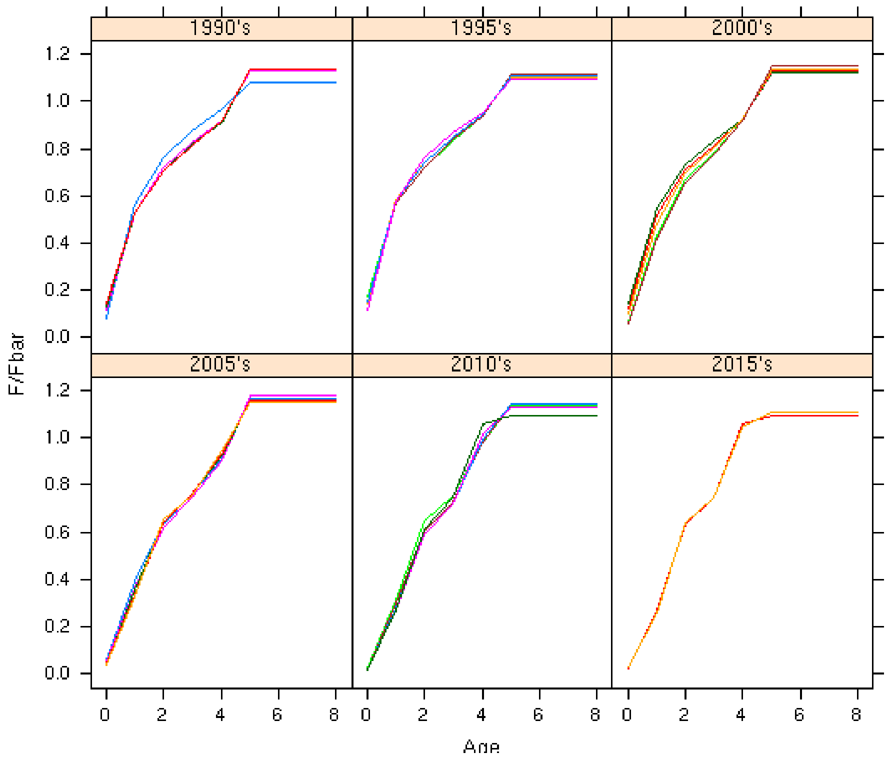


Figure 2.6.4.4 WESTERN BALTIC SPRING SPAWNING HERRING. Estimated selection pattern at age as W-ringers of the fisheries for the whole time period of the assessment.

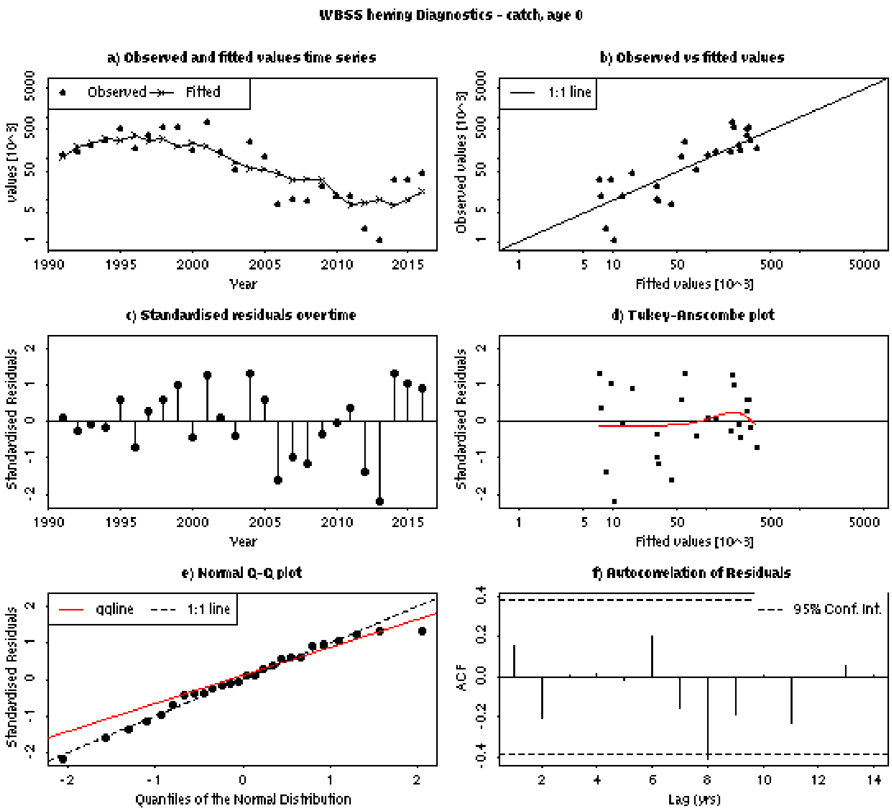


Figure 2.6.4.5 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the commercial landings fit at 0 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

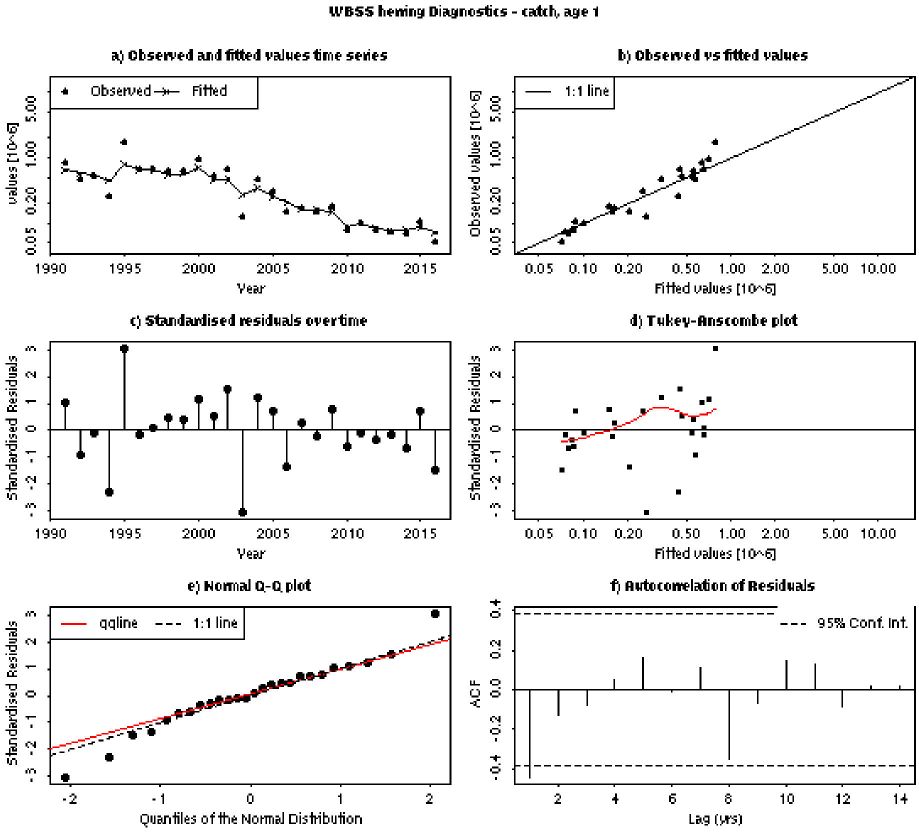


Figure 2.6.4.6 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the commercial landings fit at 1 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

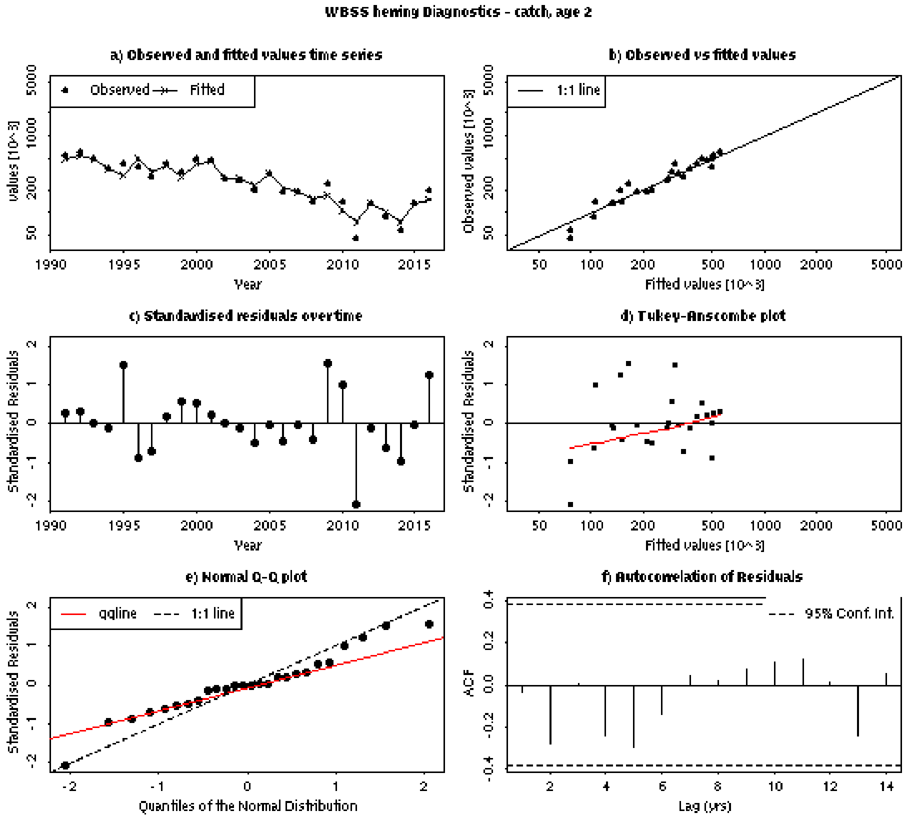


Figure 2.6.4.7 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the commercial landings fit at 2 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

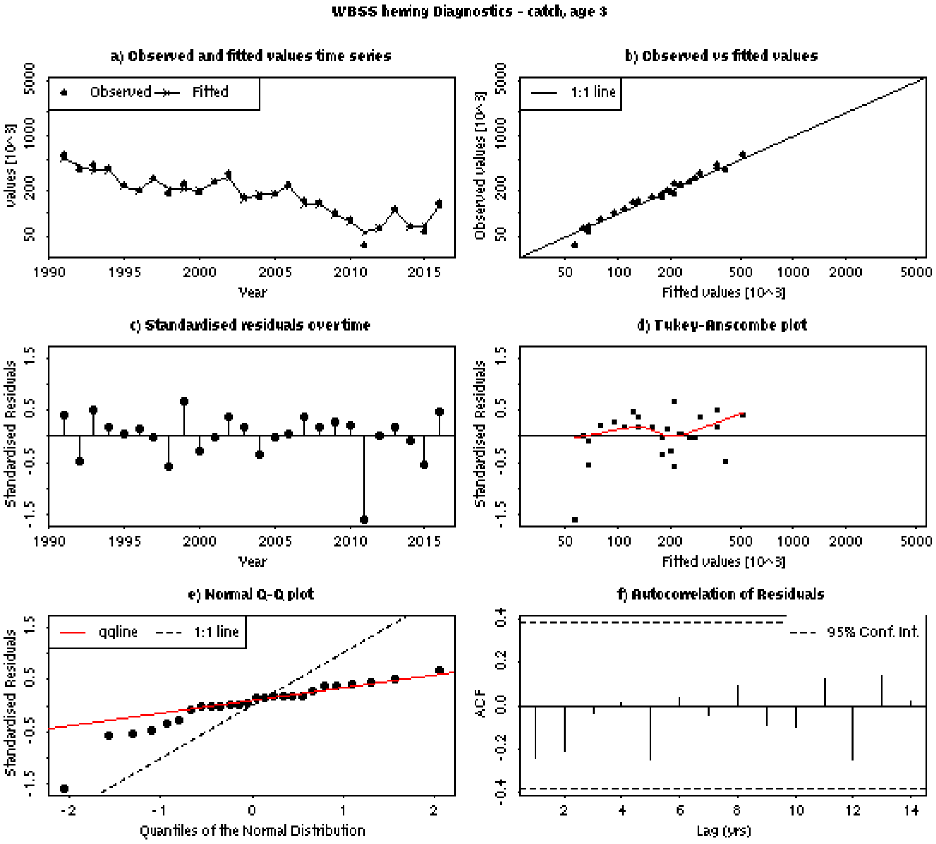


Figure 2.6.4.8 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the commercial landings fit at 3 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

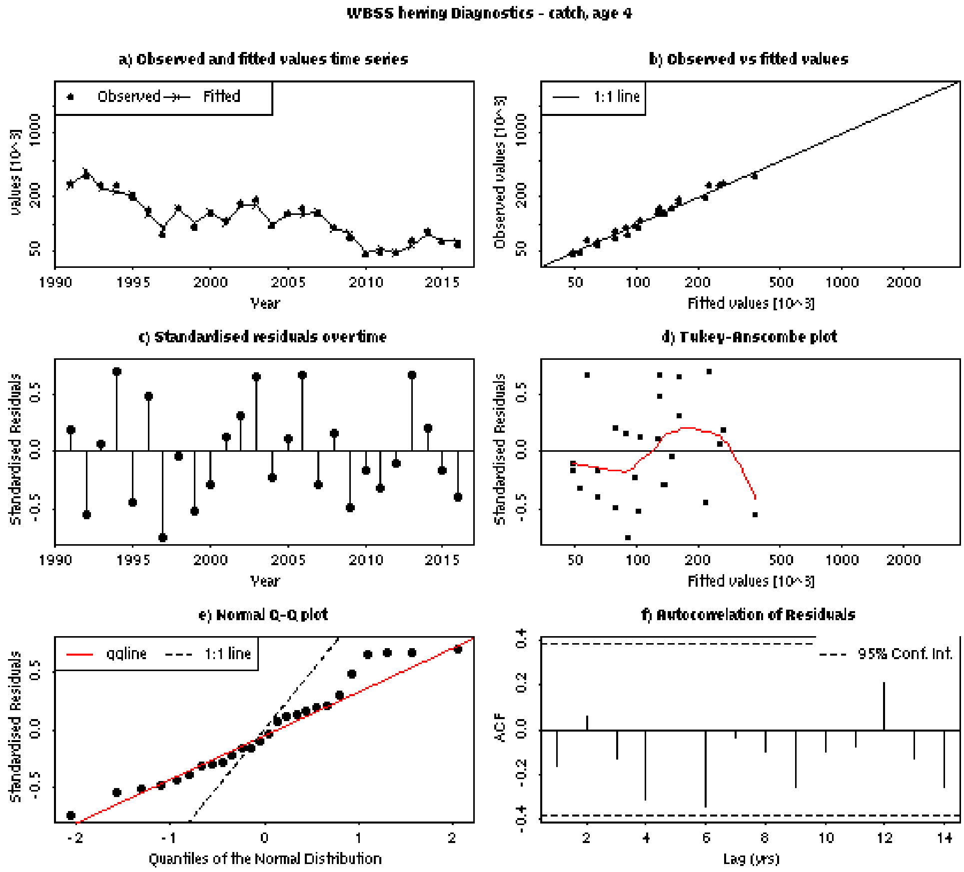


Figure 2.6.4.9 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the commercial landings fit at 4 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

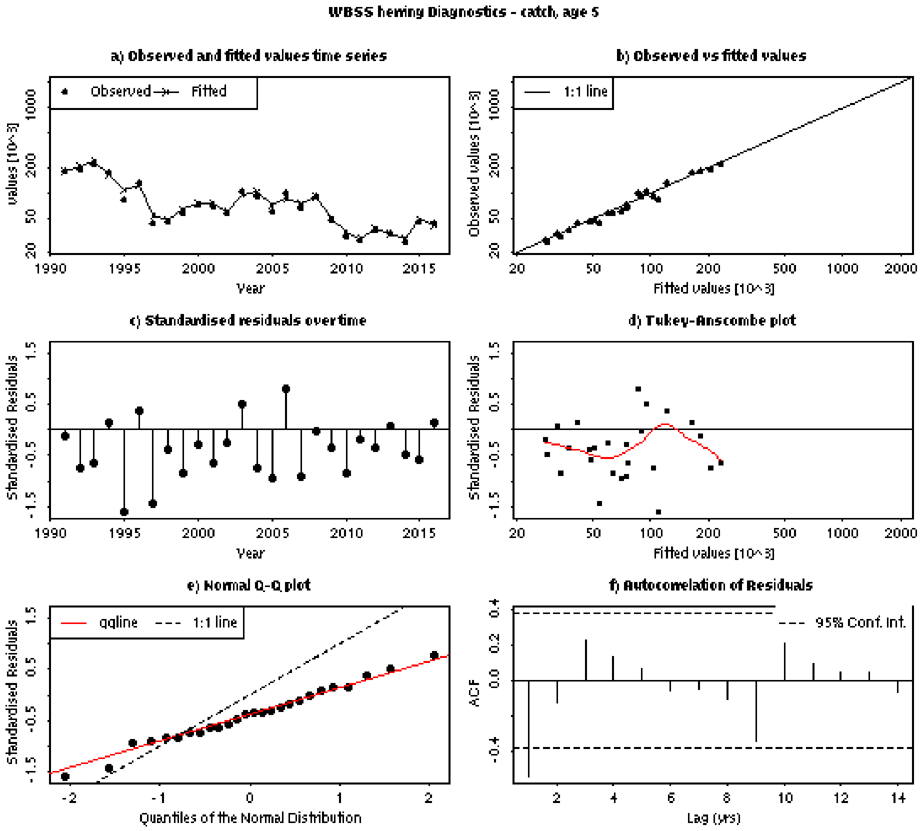


Figure 2.6.4.10 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the commercial landings fit at 5 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

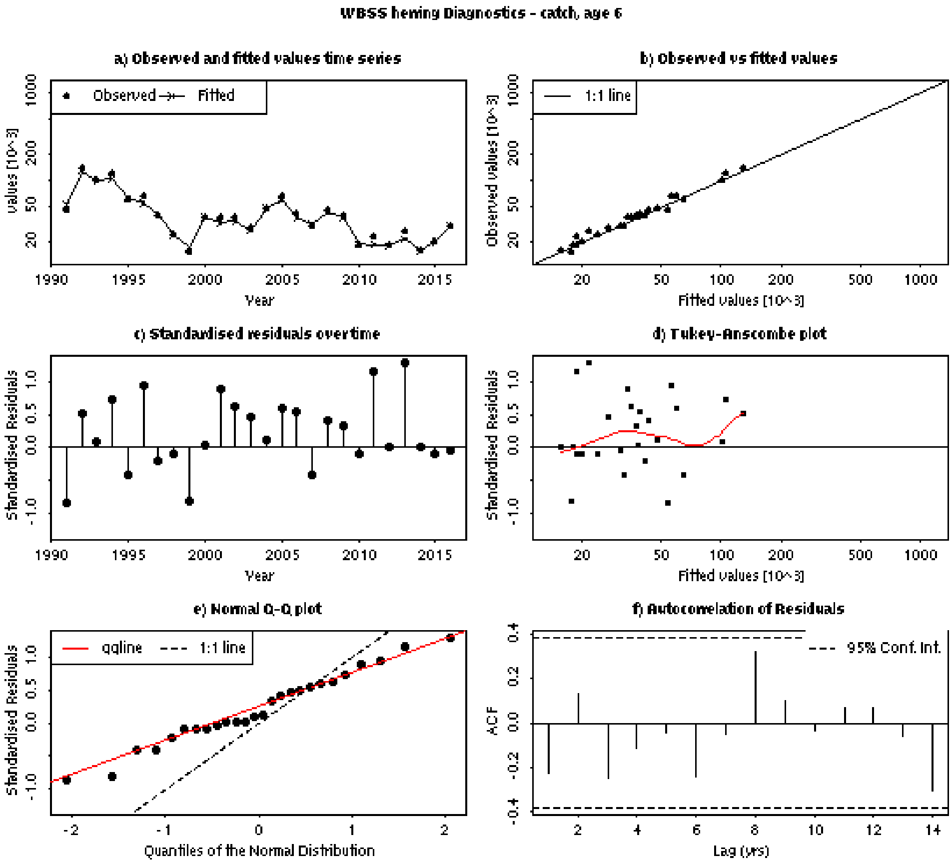


Figure 2.6.4.11 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the commercial landings fit at 6 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

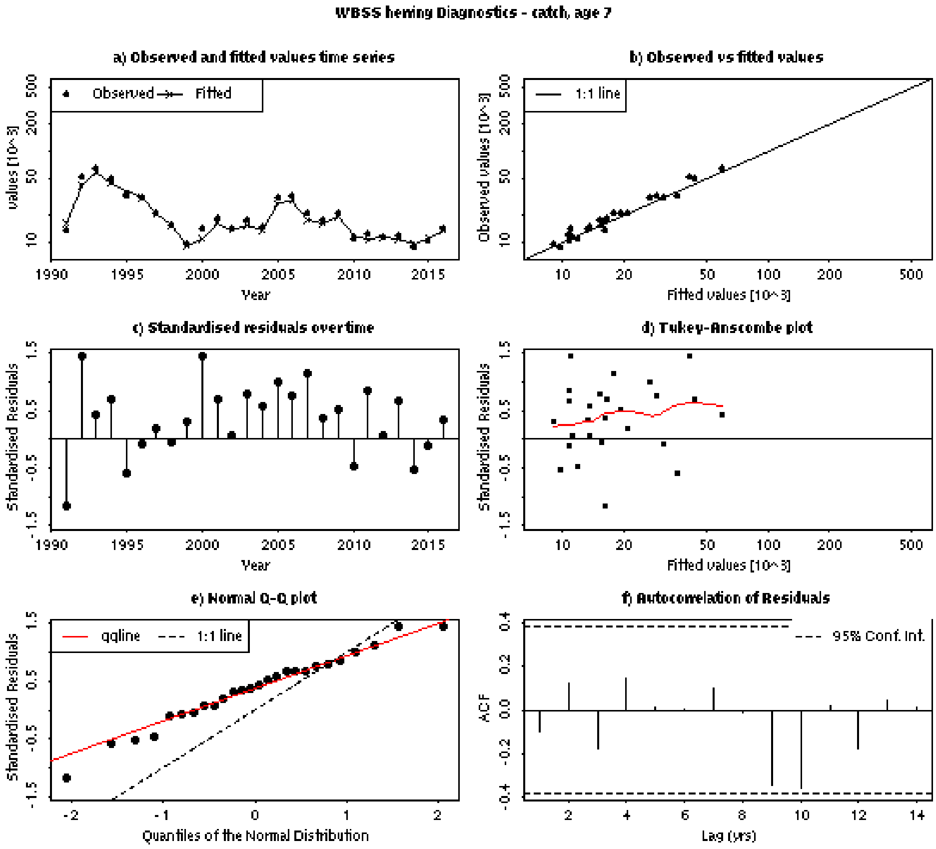


Figure 2.6.4.12 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the commercial landings fit at 7 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

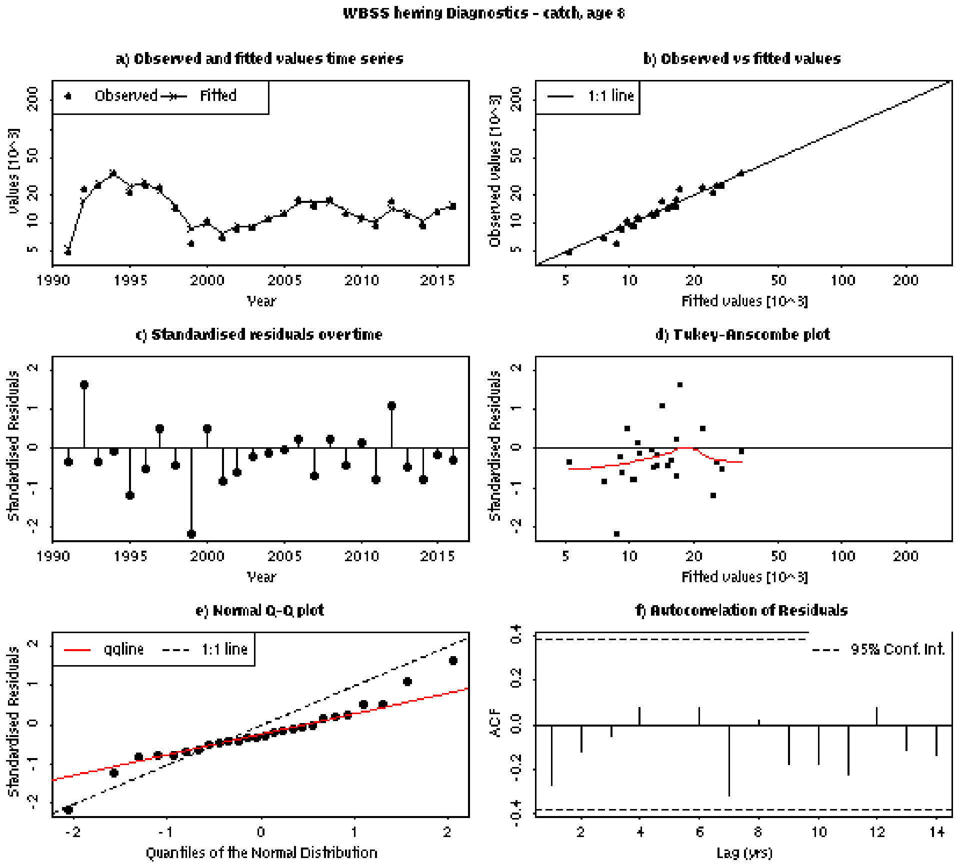


Figure 2.6.4.13 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the commercial landings fit at 8 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

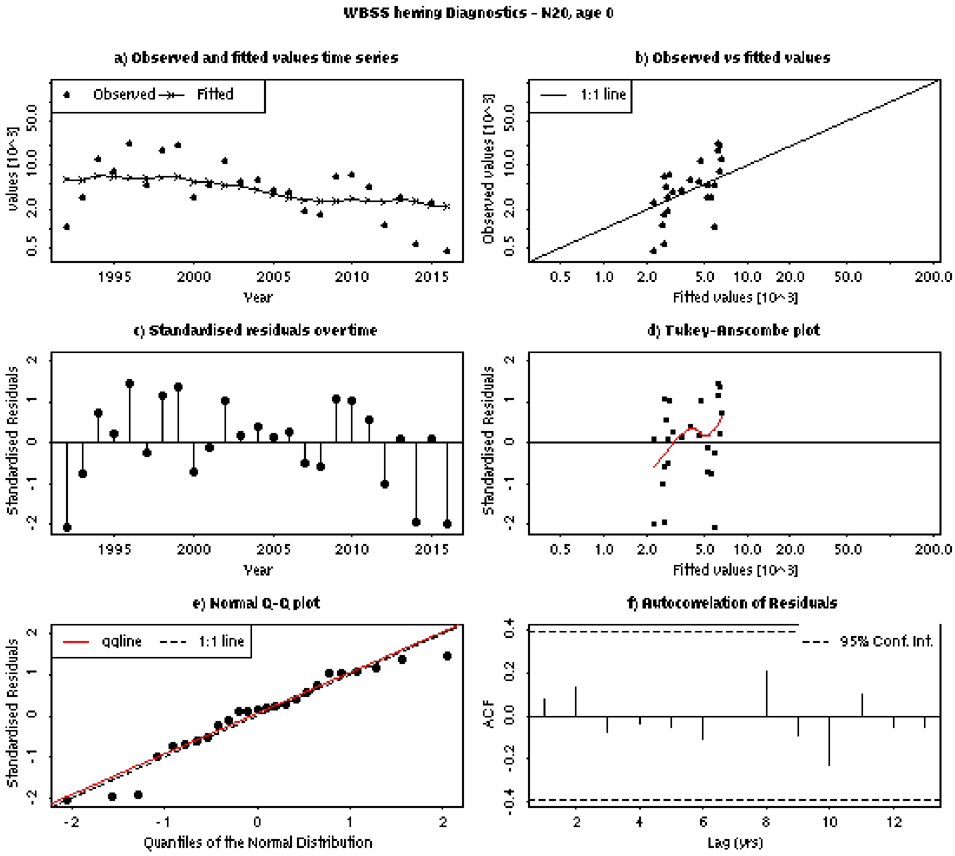


Figure 2.6.4.14 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the N20 larval index.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

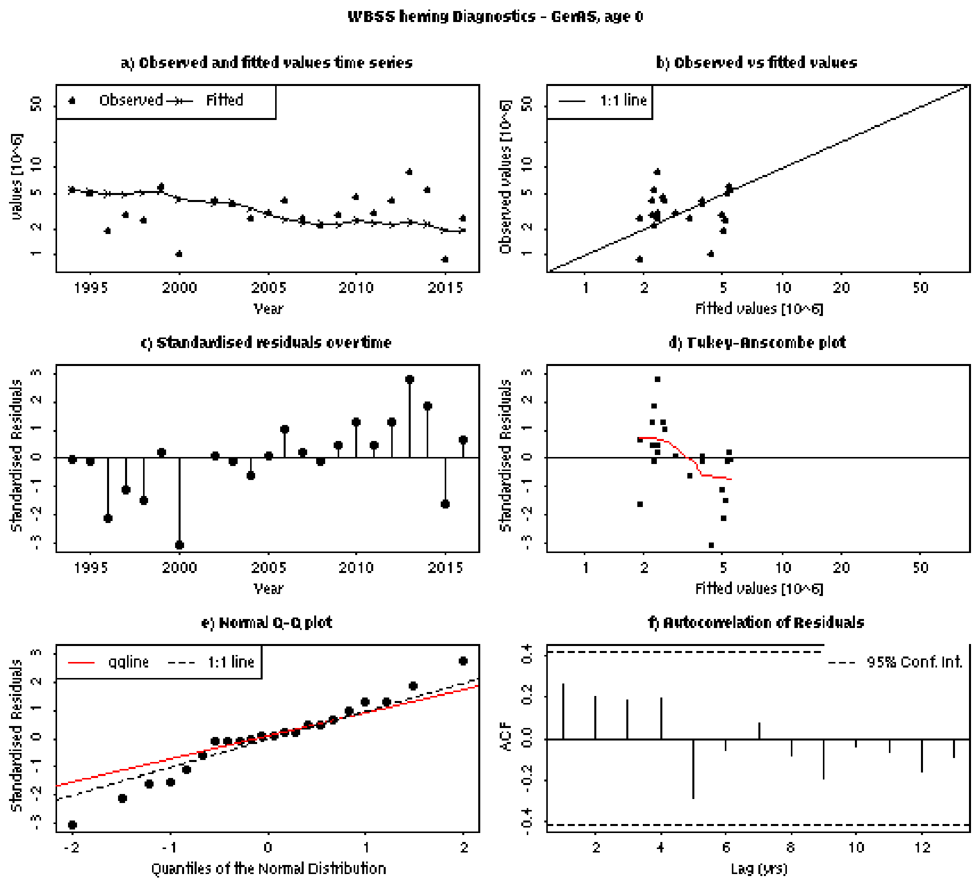


Figure 2.6.4.15 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 0 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

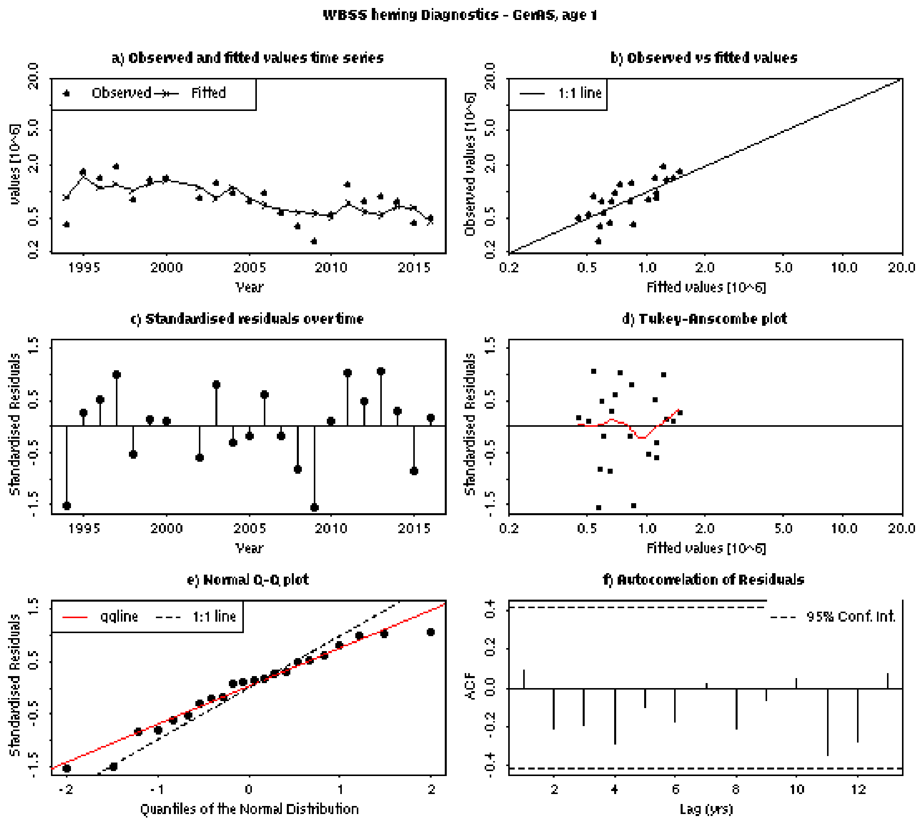


Figure 2.6.4.16 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 1 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

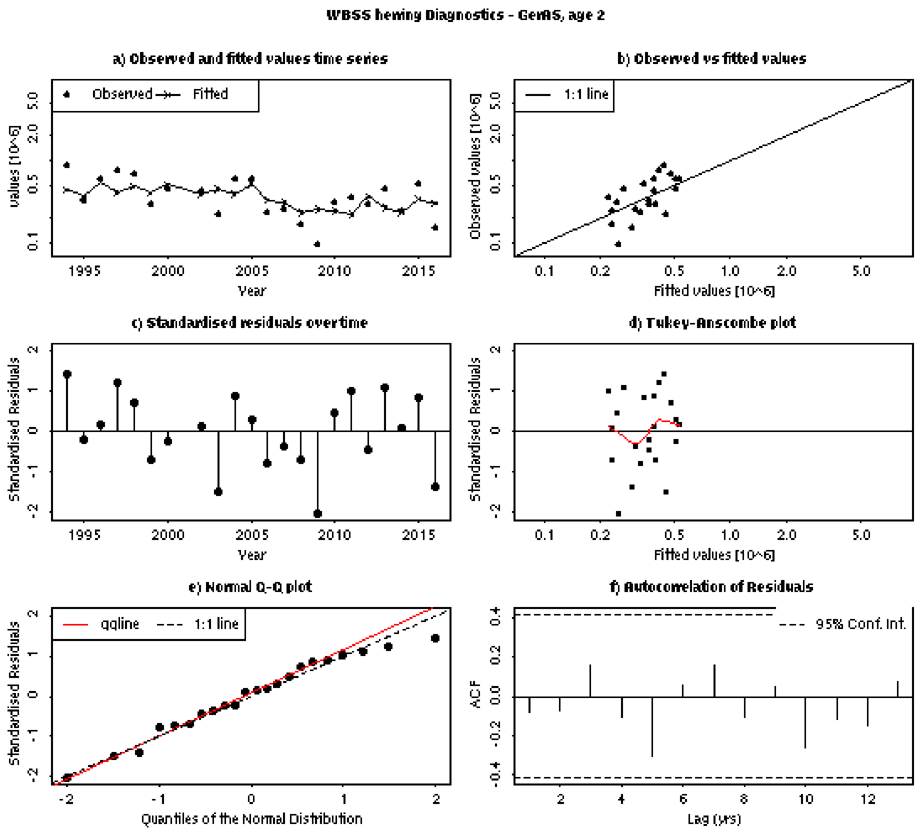


Figure 2.6.4.17 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 2 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

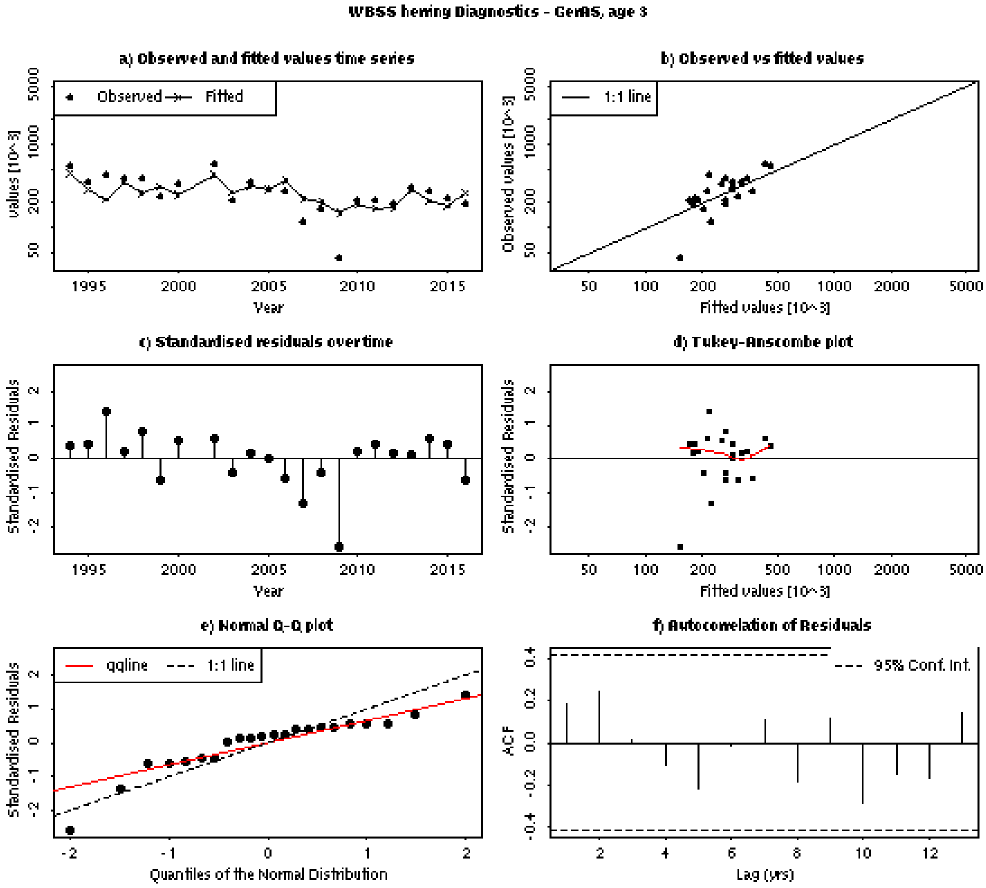


Figure 2.6.4.18 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 3 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

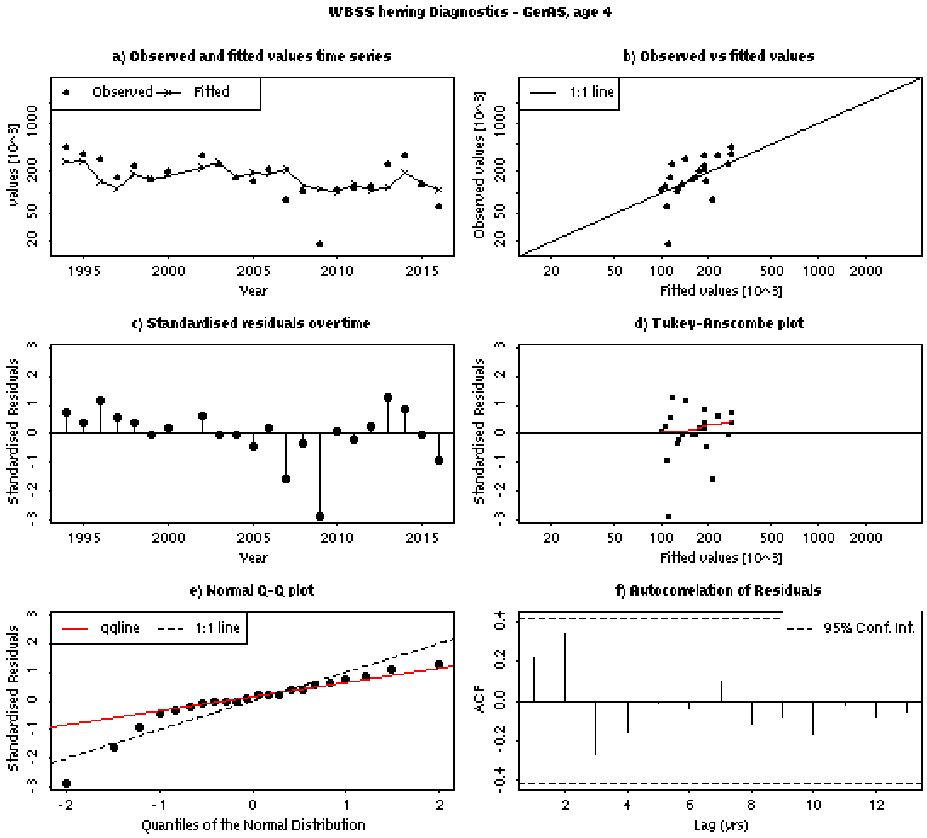


Figure 2.6.4.19 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 4 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

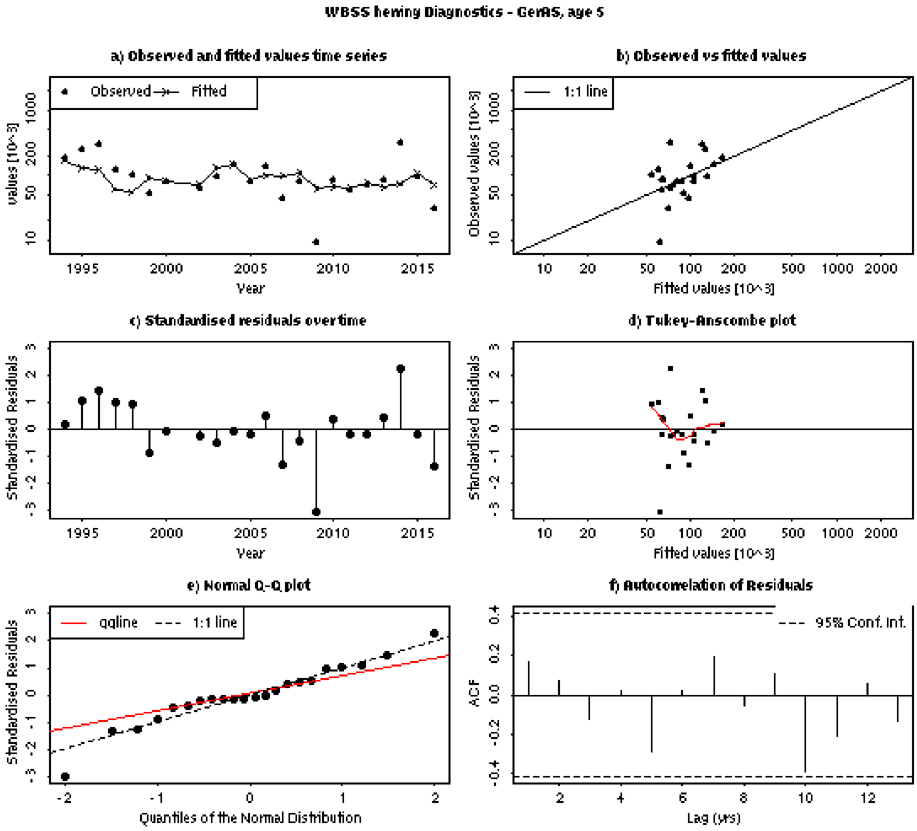


Figure 2.6.4.20 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 5 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

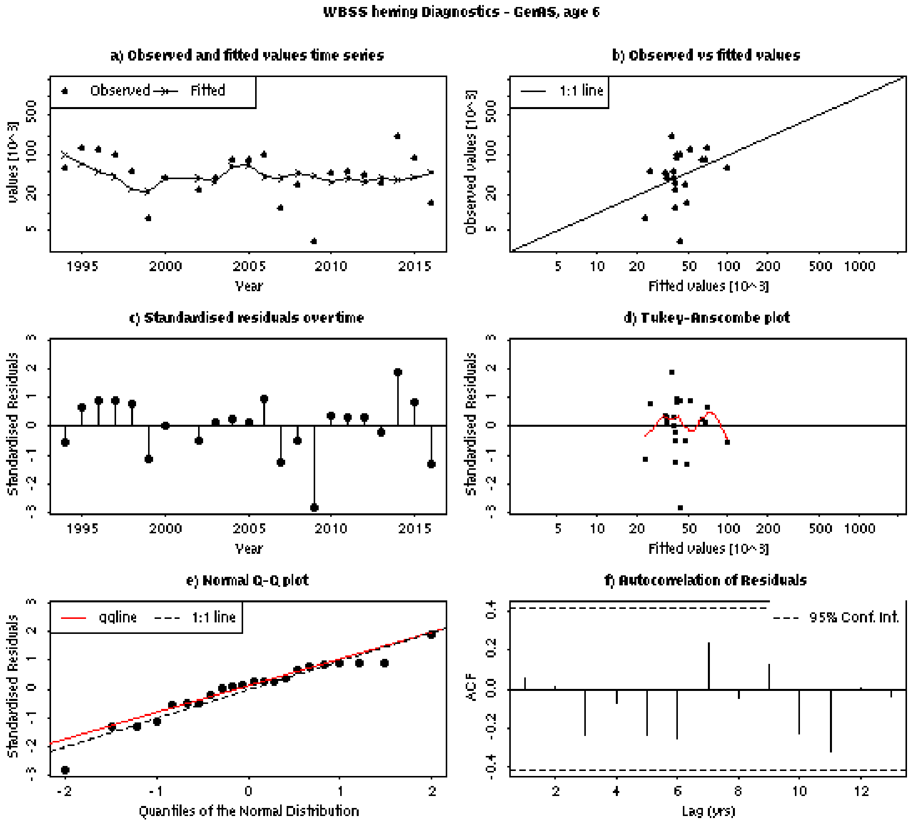


Figure 2.6.4.21 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 6 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

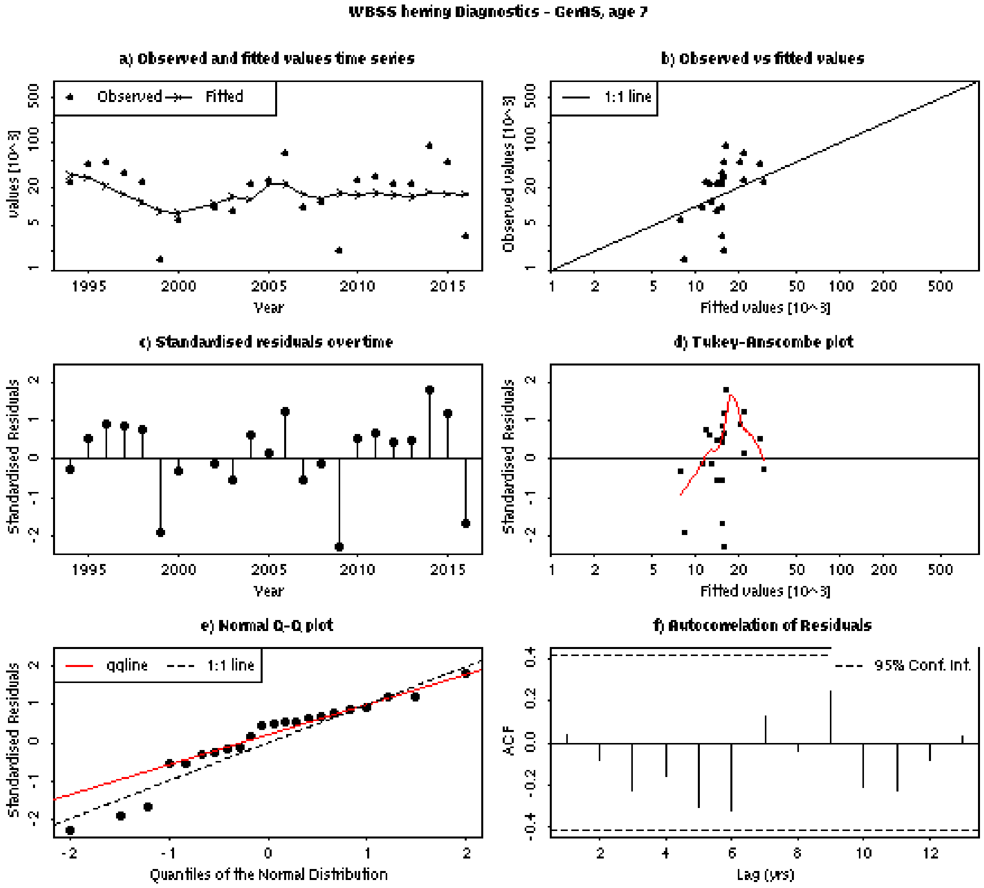


Figure 2.6.4.22 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 7 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

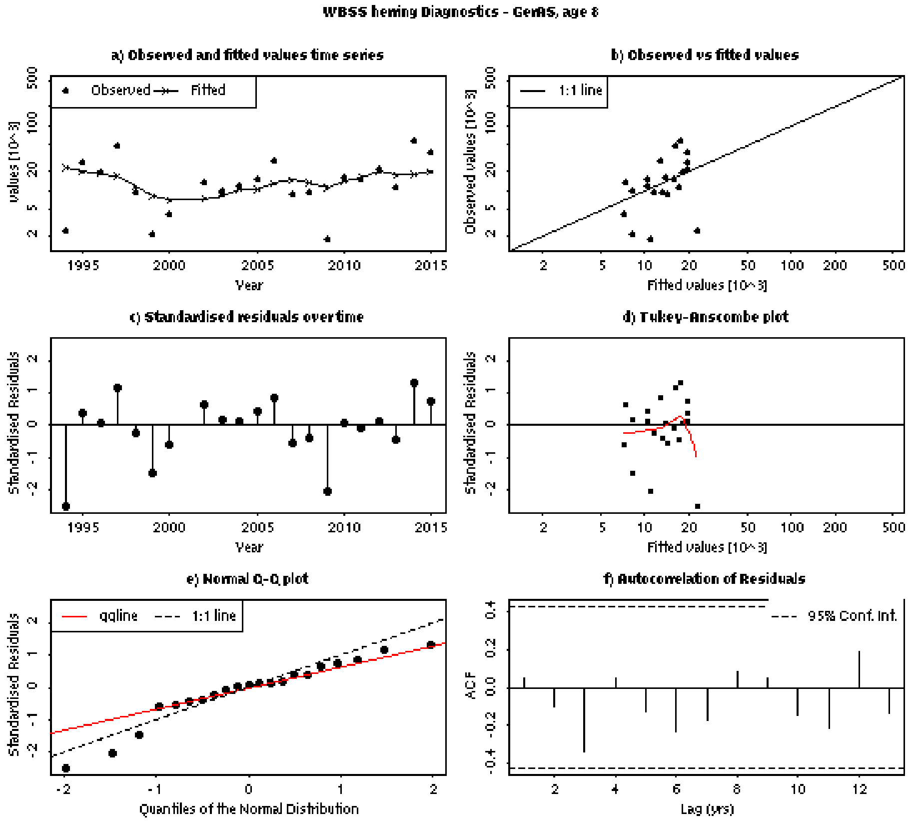


Figure 2.6.4.23 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the German acoustic survey in subdivision 21-24 (GERAS) fit at 8 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

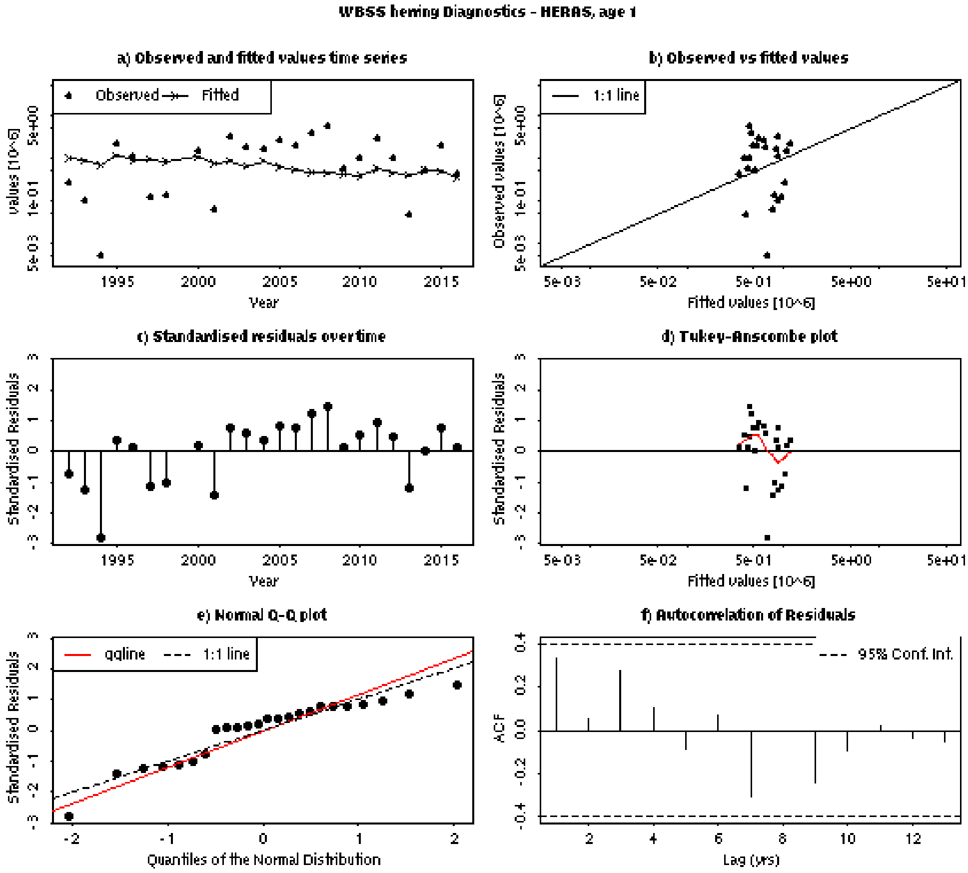


Figure 2.6.4.24 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 1 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

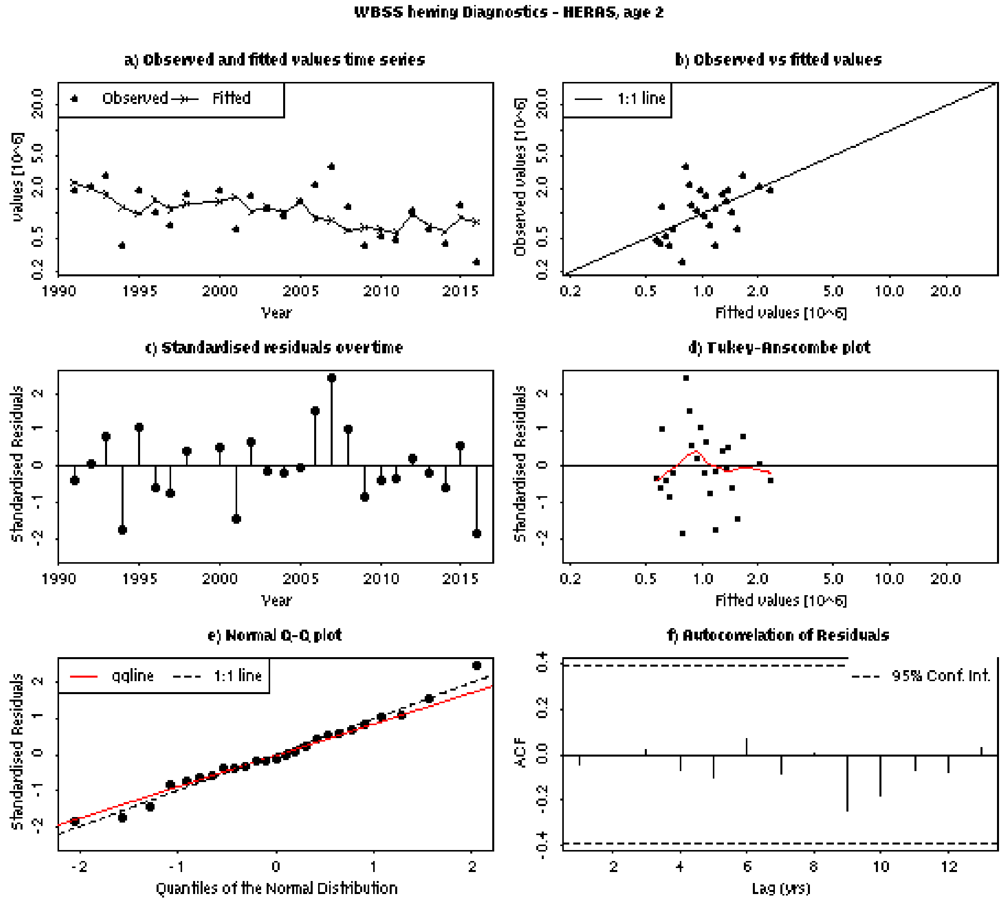


Figure 2.6.4.25 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 2 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

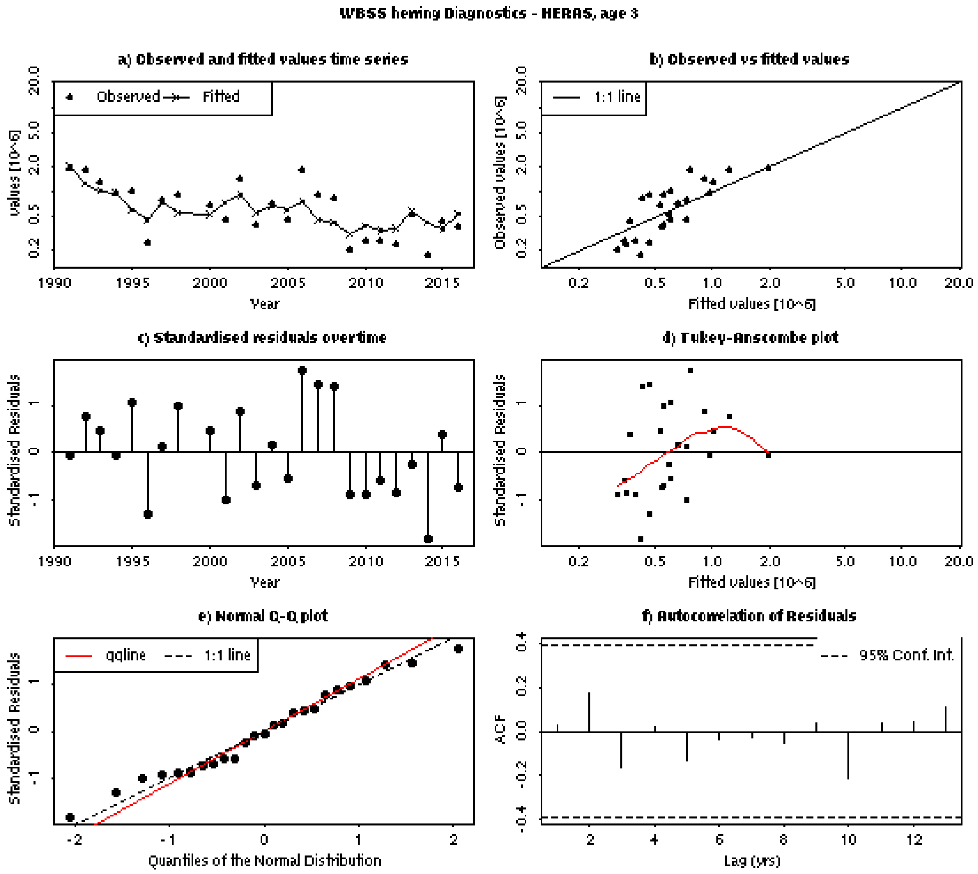


Figure 2.6.4.26 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 3 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

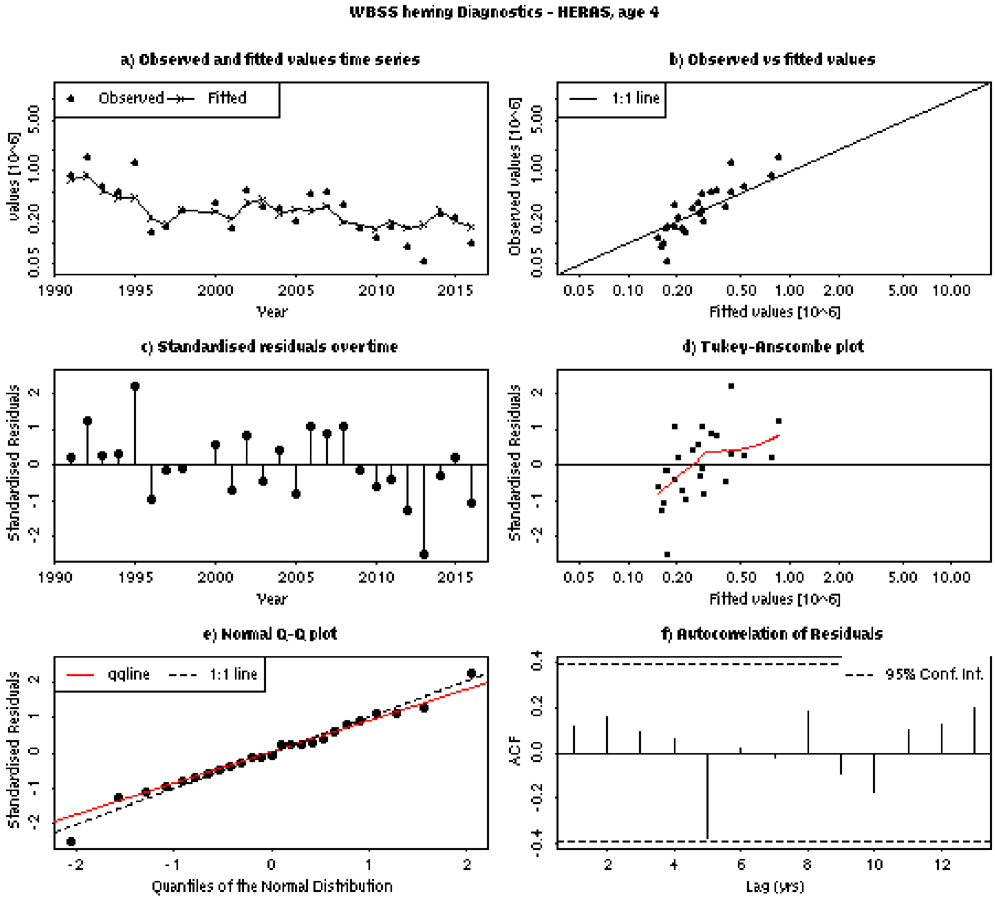


Figure 2.6.4.27 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 4 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

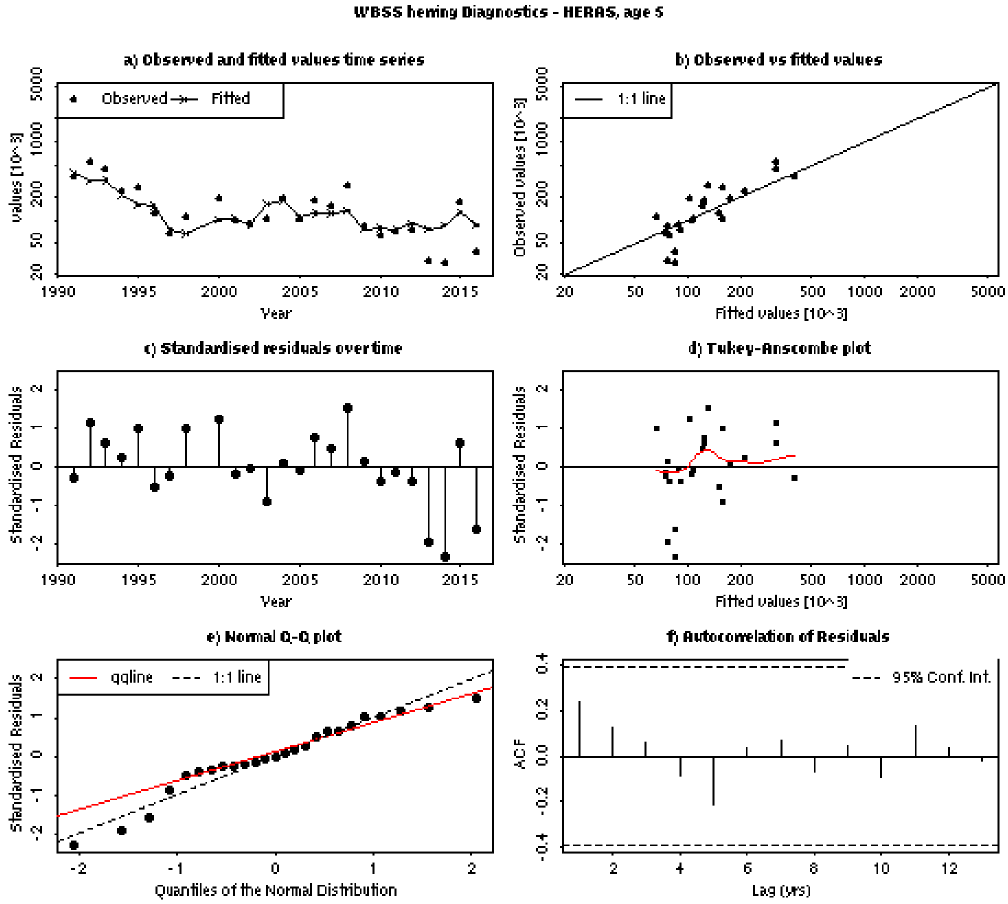


Figure 2.6.4.28 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 5 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line) f) Temporal autocorrelation of residuals..

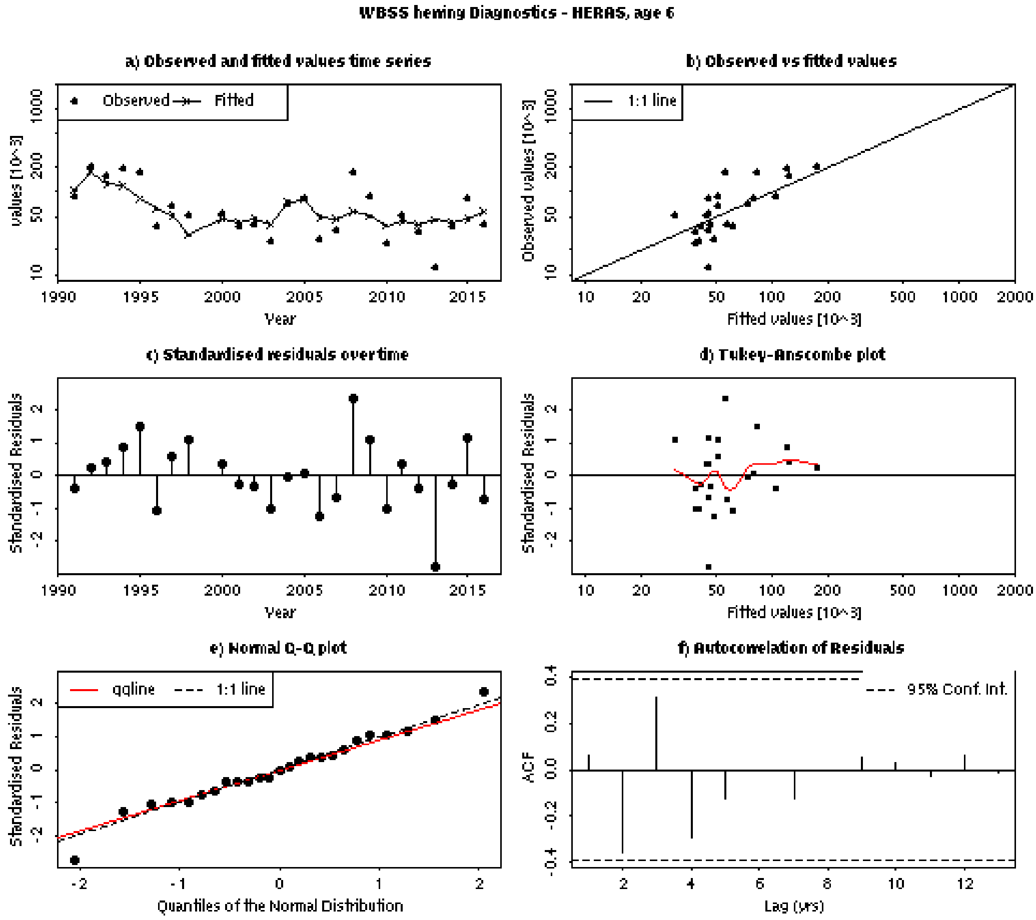


Figure 2.6.4.29 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 6 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

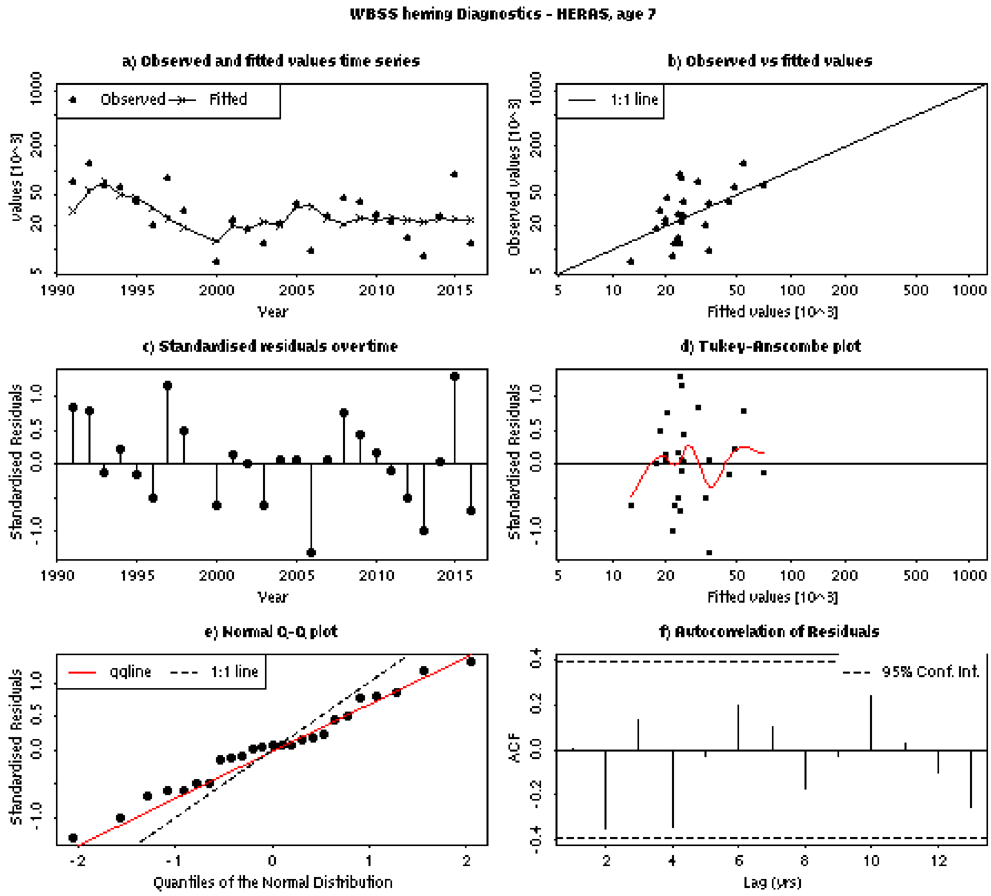


Figure 2.6.4.30 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 7 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

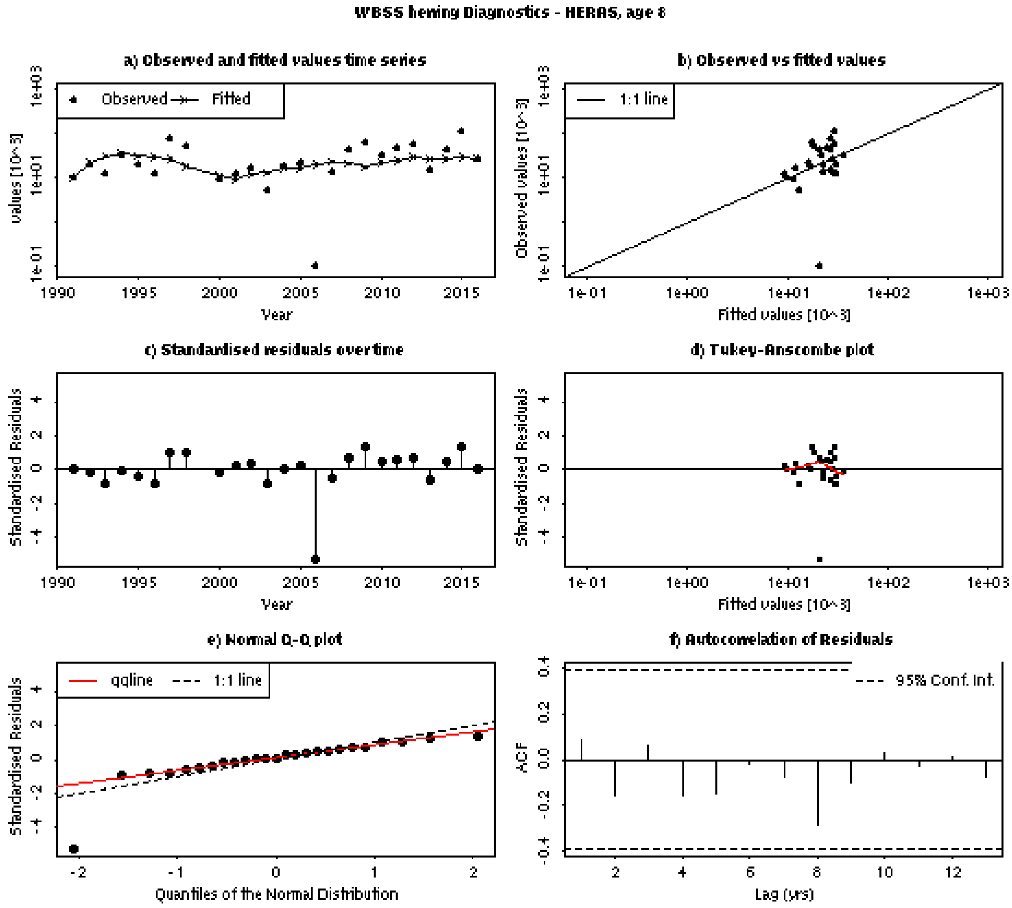


Figure 2.6.4.31 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the Herring acoustic survey in the North Sea and division 3.a (HERAS) fit at 8 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

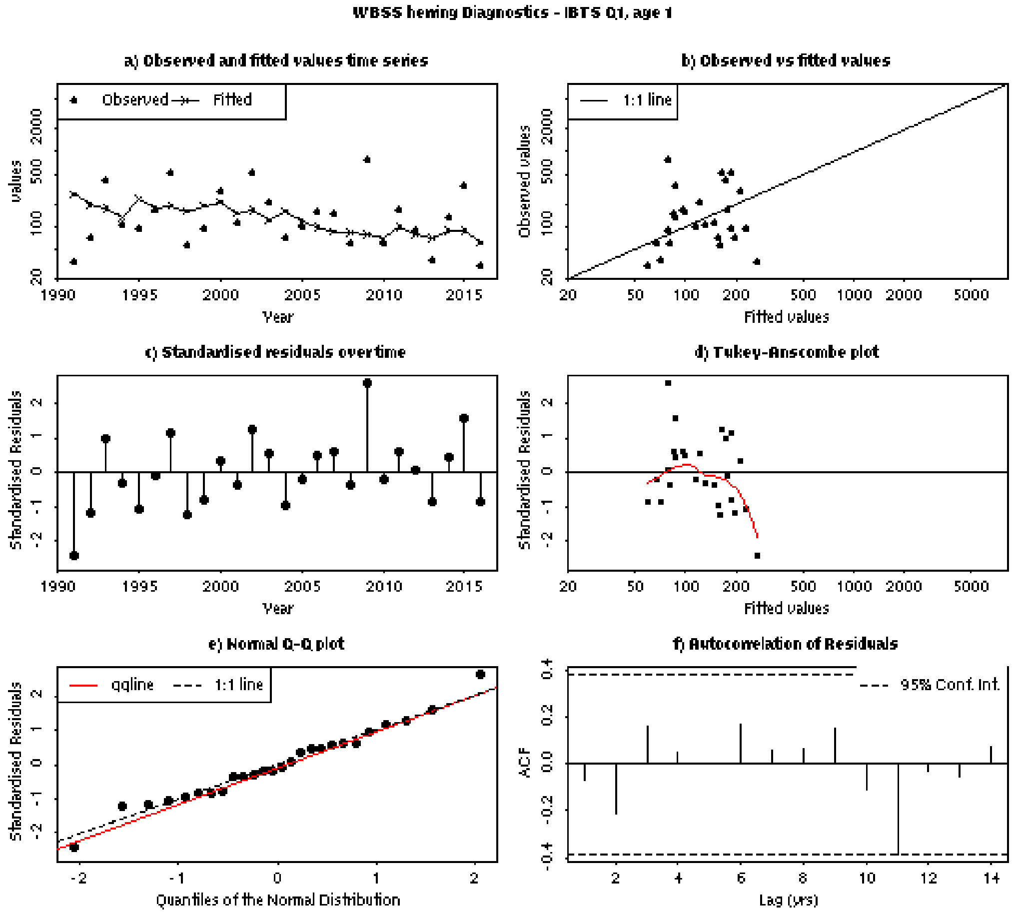


Figure 2.6.4.32 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 1 (IBTS Q1) fit at 1 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

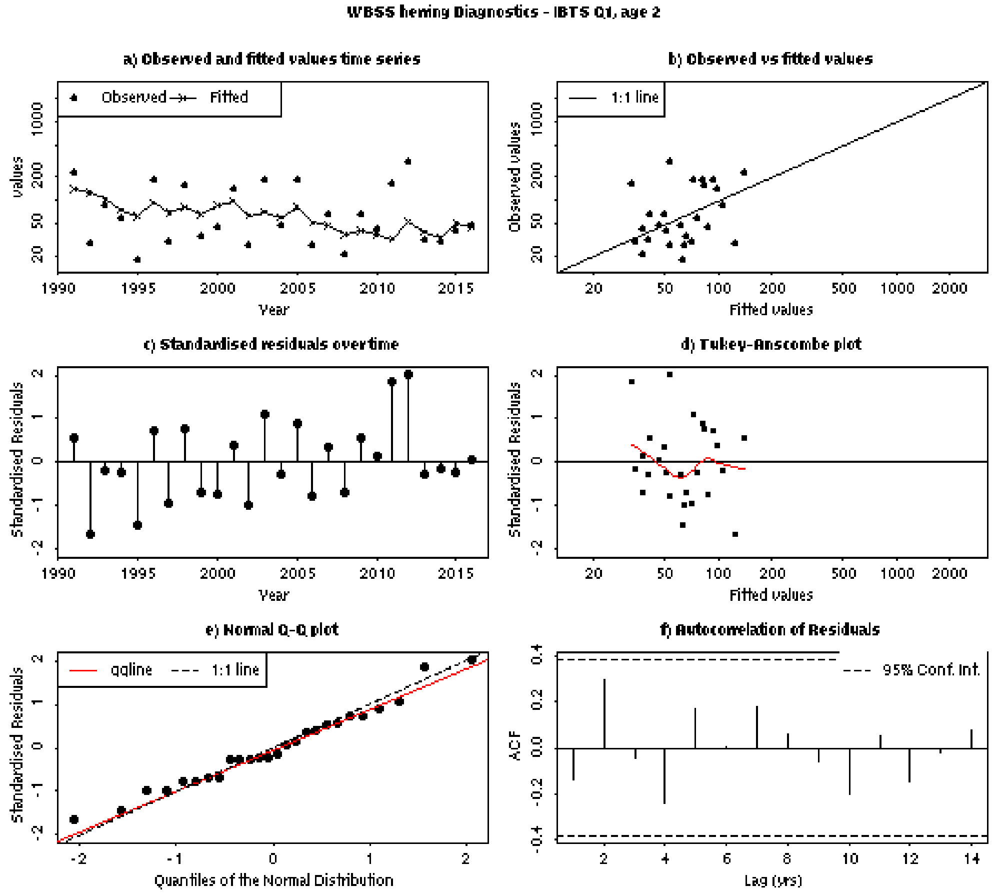


Figure 2.6.4.33 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 1 (IBTS Q1) fit at 2 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

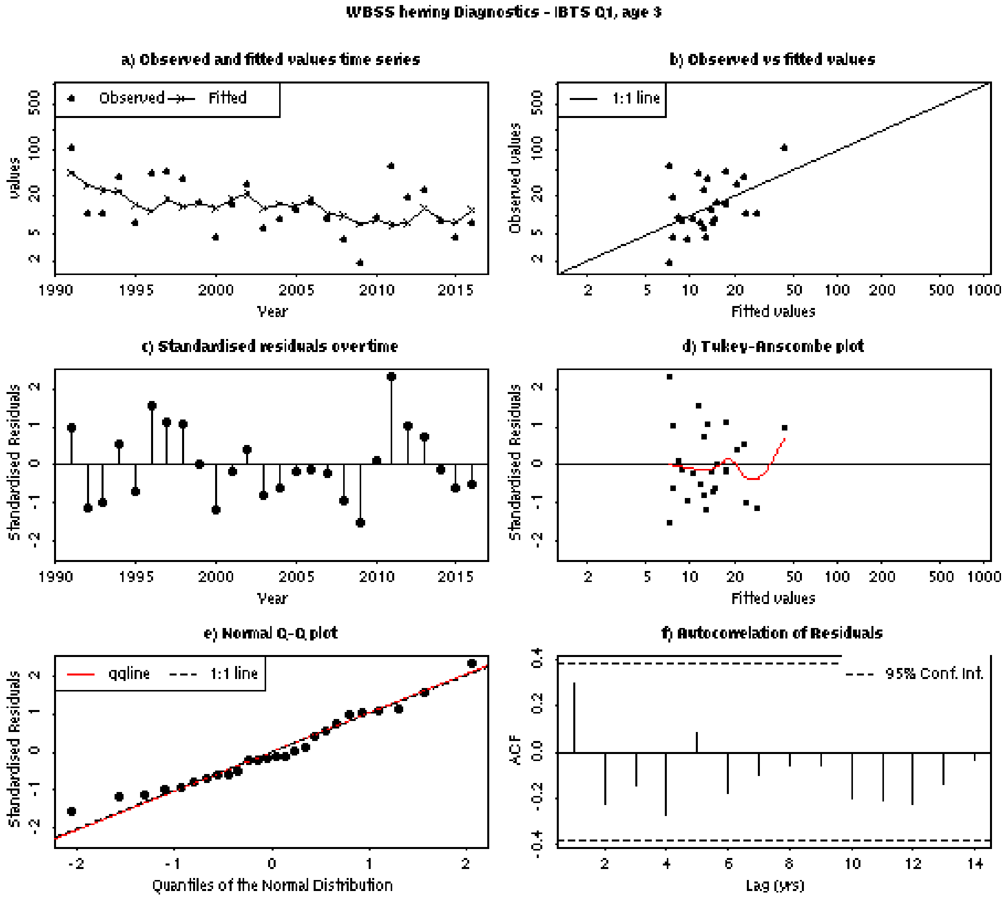


Figure 2.6.4.34 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 1 (IBTS Q1) fit at 3 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

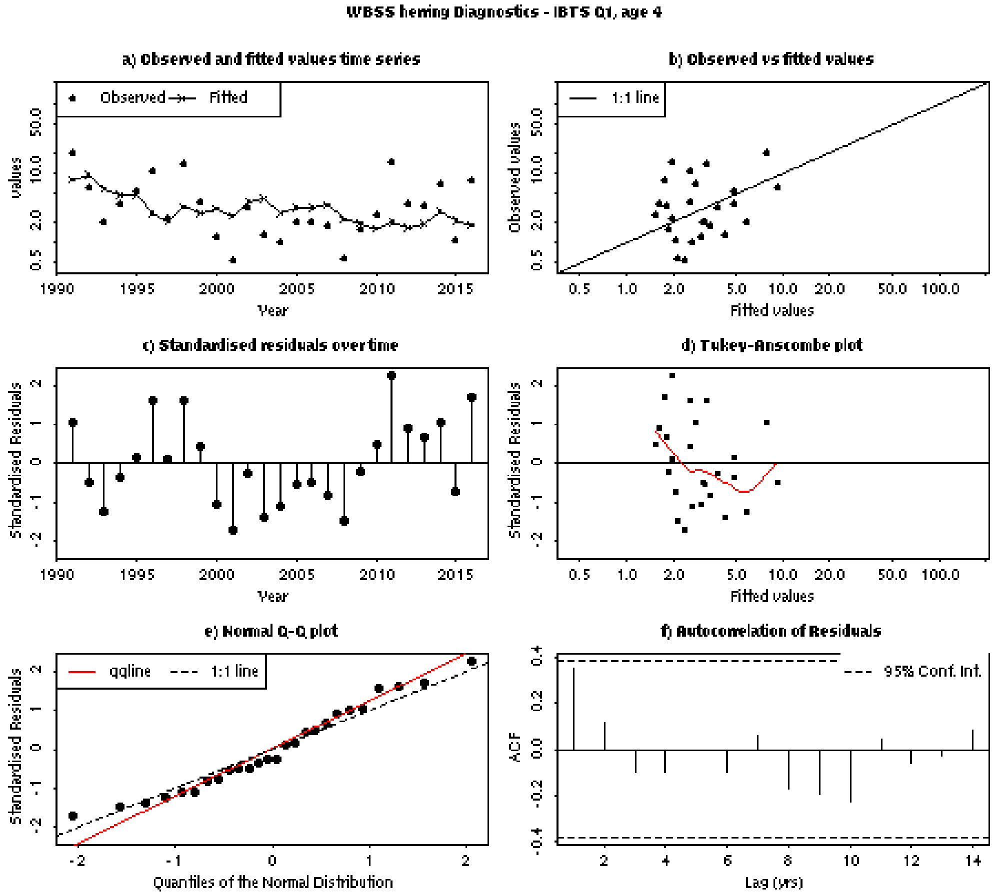


Figure 2.6.4.35 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 1 (IBTS Q1) fit at 4 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

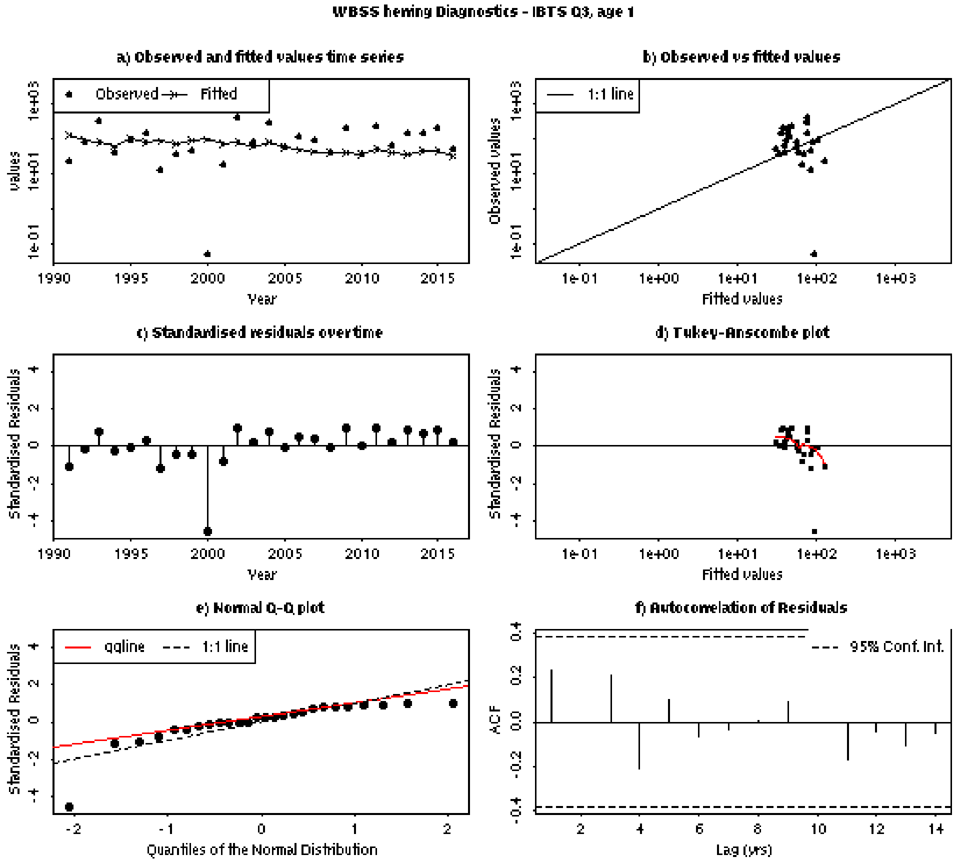


Figure 2.6.4.36 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 3 (IBTS Q3) fit at 1 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

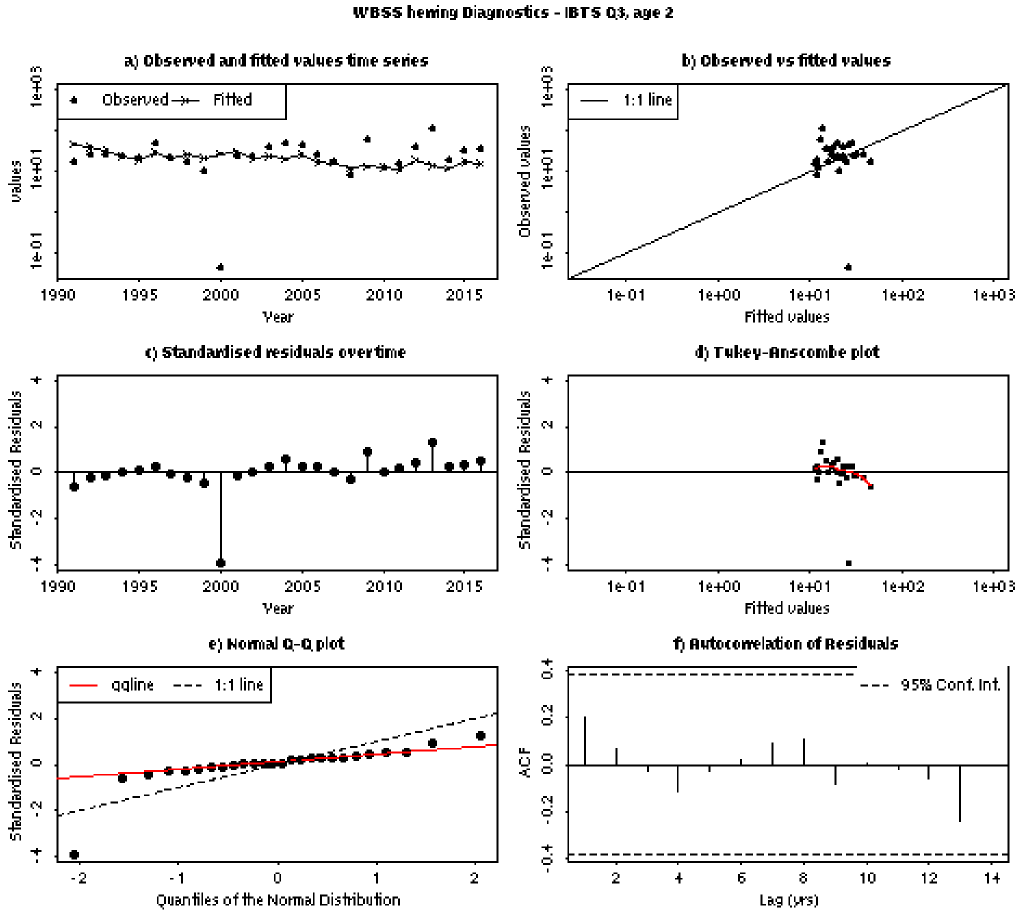


Figure 2.6.4.37 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 3 (IBTS Q3) fit at 2 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

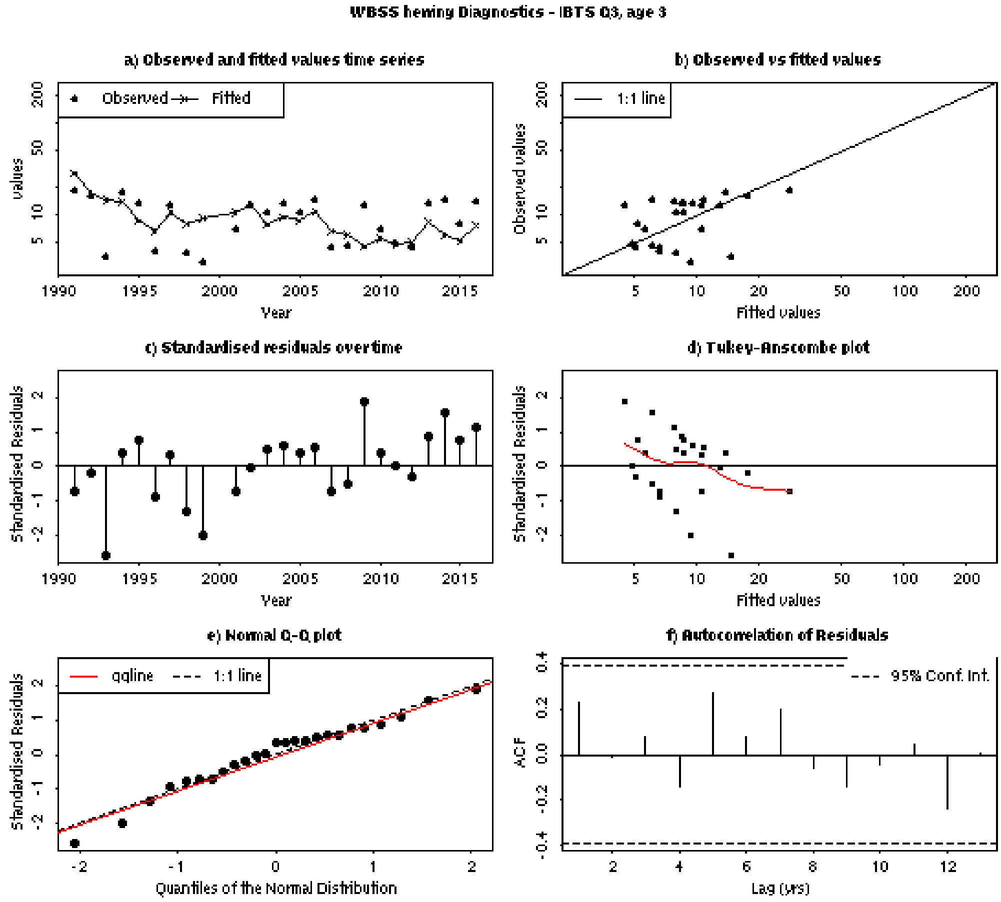


Figure 2.6.4.38 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 3 (IBTS Q3) fit at 3 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

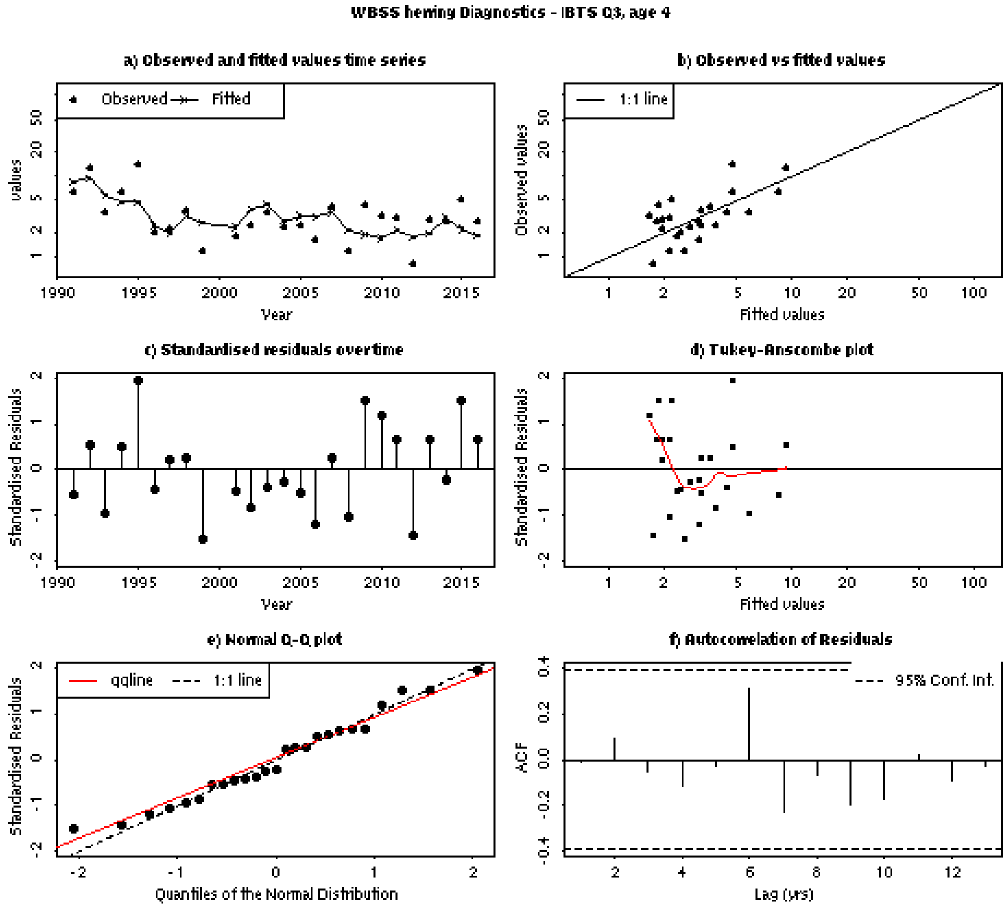


Figure 2.6.4.39 WESTERN BALTIC SPRING SPAWNING HERRING.

Diagnostics of the International Bottom Trawl Survey in Division 3.a in quarter 3 (IBTS Q3) fit at 4 wr from the assessment.

a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus model estimates of stock numbers at age as W-ringers. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by the model as a function of time. d) Log residuals from the catchability model against the estimated stock size at age as W-ringers. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line). f) Temporal autocorrelation of residuals.

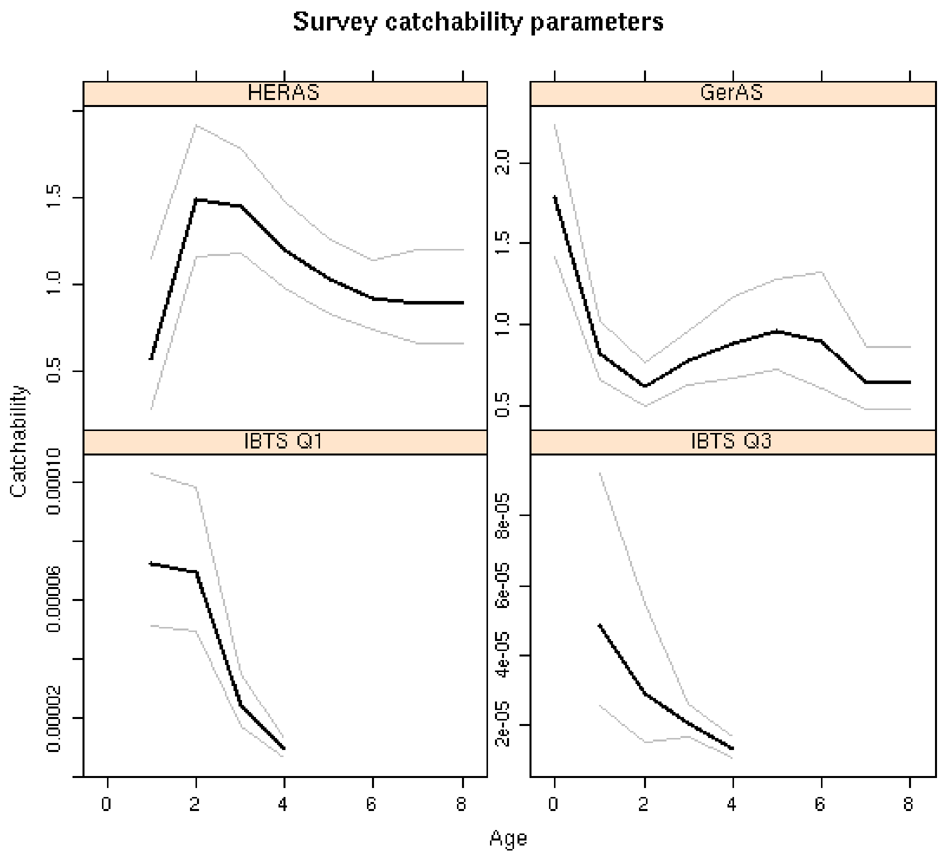


Figure 2.6.4.40 WESTERN BALTIC SPRING SPAWNING HERRING.

Estimated survey catchabilities with 95% CI.

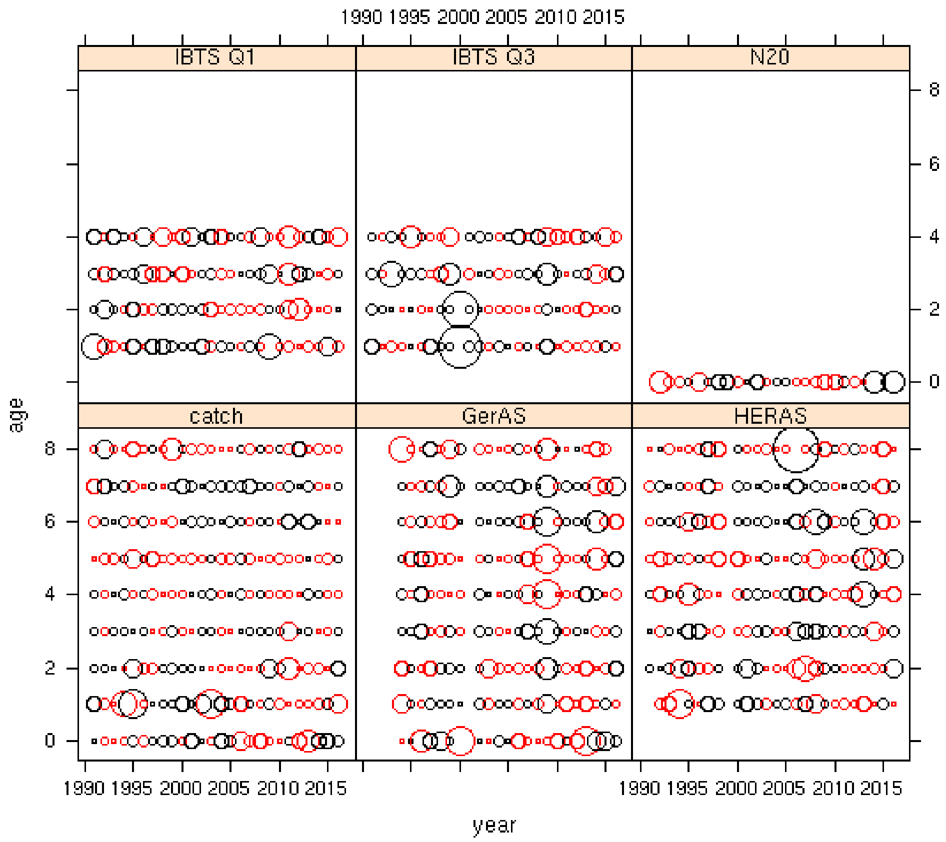


Figure 2.6.4.41 WESTERN BALTIC SPRING SPAWNING HERRING.

Bubble plot showing the weighted residuals for each piece of fitted information. Individual values are weighted following the procedures employed internally with SAM in calculating the objective function. The bubble scale is consistent between all panels (age as W-ringers).

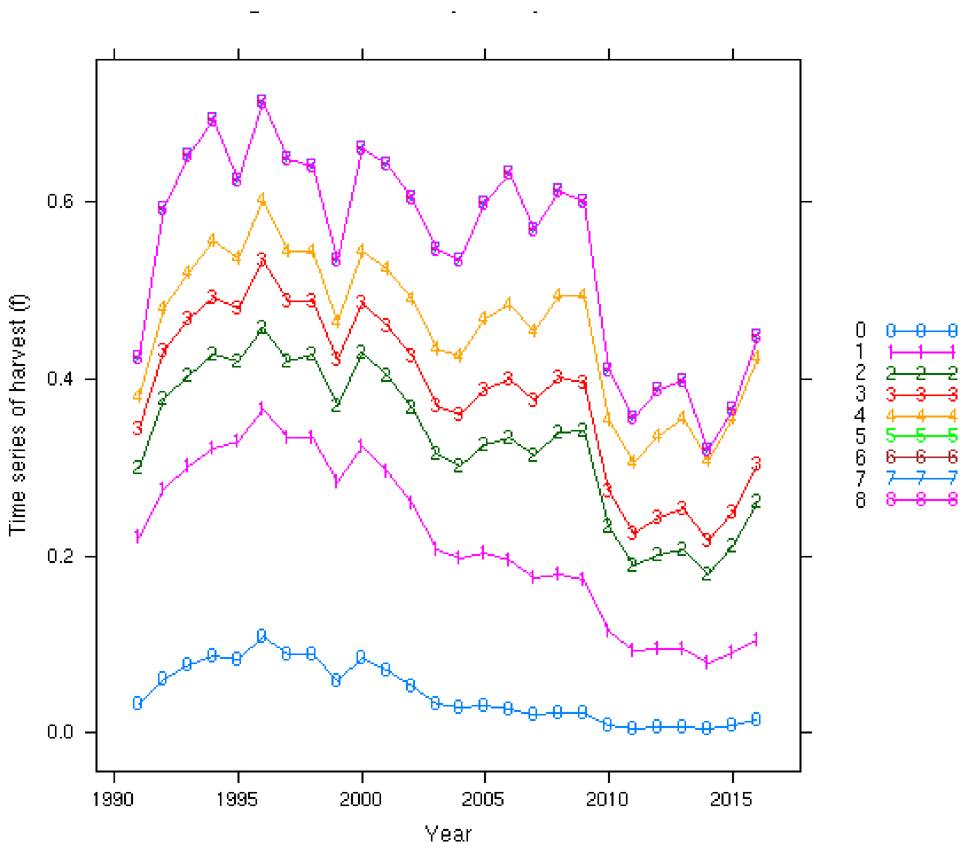


Figure 2.6.4.42 WESTERN BALTIC SPRING SPAWNING HERRING.

Time-series of fishing mortality-at-age as estimated by the assessment model.

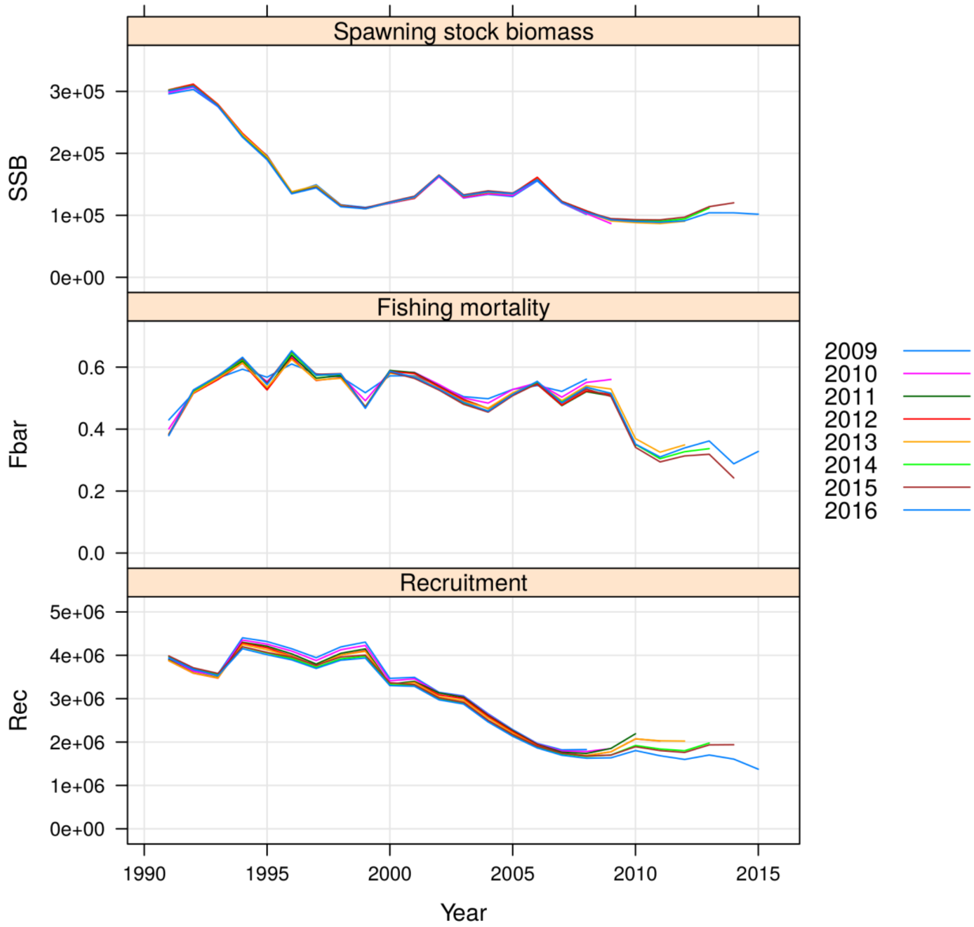


Figure 2.6.4.43 WESTERN BALTIC SPRING SPAWNING HERRING.

Analytical retrospective pattern over 5 years, in the assessment for spawning stock biomass, recruitment (0 wr) and mean fishing mortality in the ages 3-6 ringer.

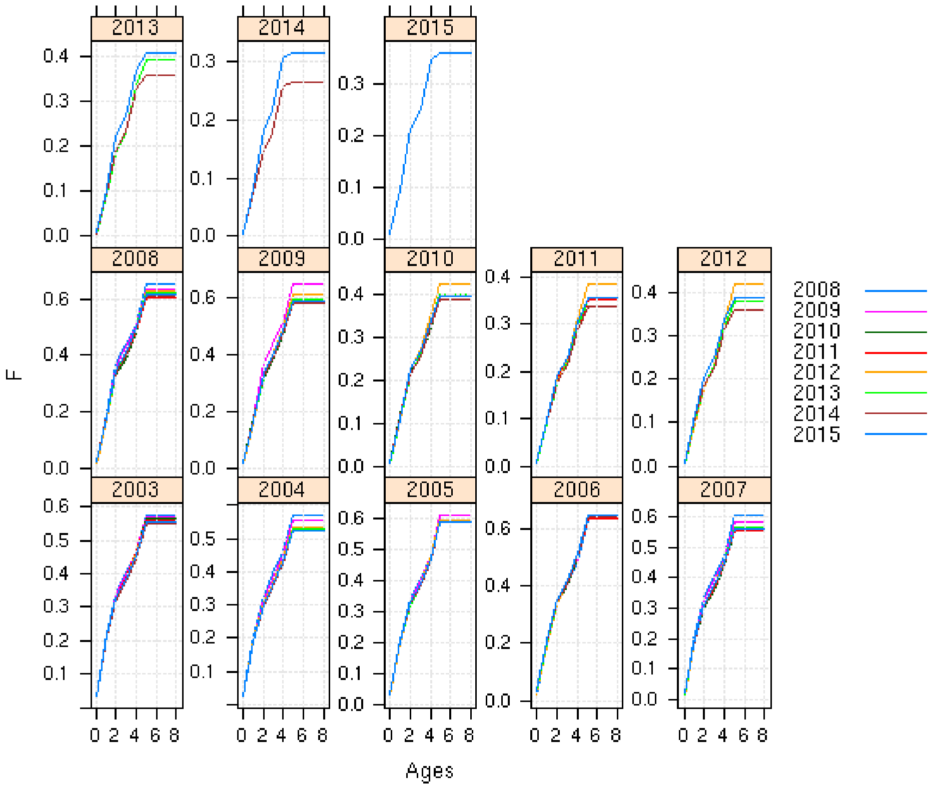


Figure 2.6.4.44 WESTERN BALTIC SPRING SPAWNING HERRING.

Retrospective selectivity pattern at age as W-ringers.

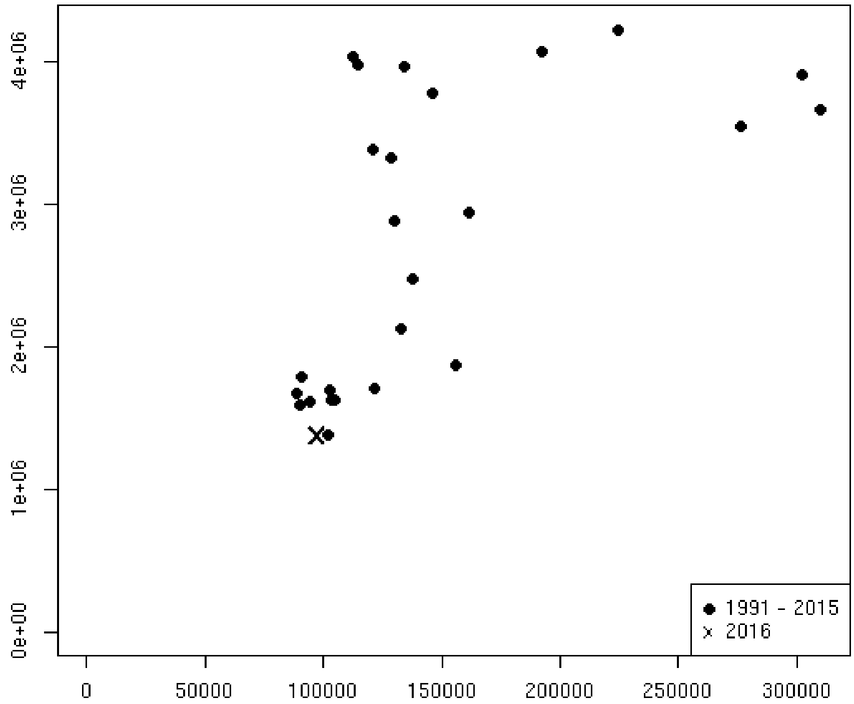


Figure 2.6.4.45 WESTERN BALTIC SPRING SPAWNING HERRING.

Recruitment at age 0-wr (in thousands) is plotted against spawning stock biomass (tonnes) as estimated by the assessment.

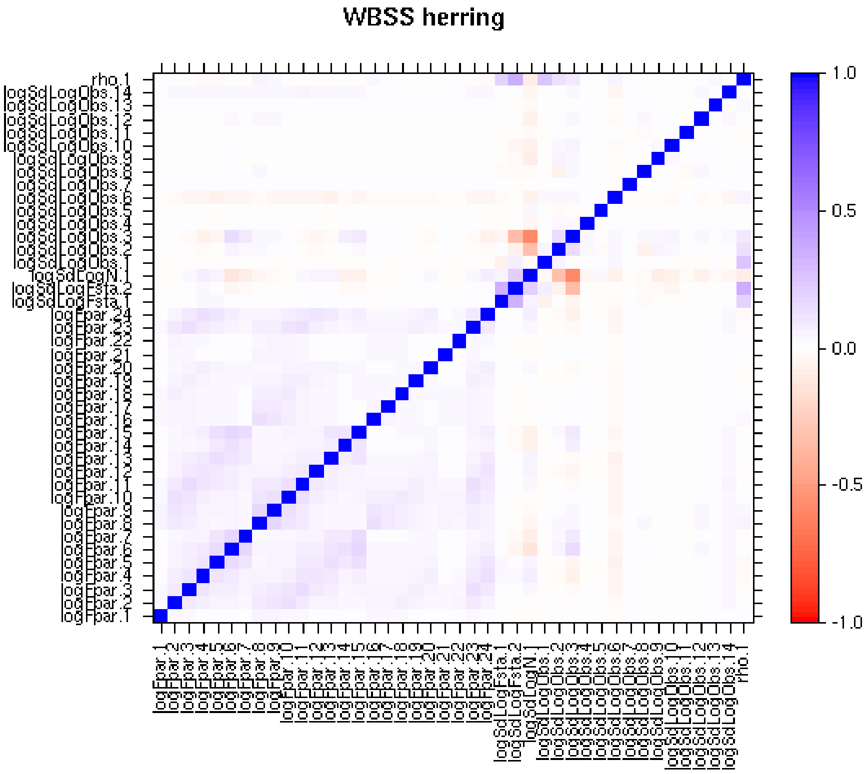


Figure 2.6.4.46 WESTERN BALTIC SPRING SPAWNING HERRING.

Plot of all the estimated parameters cross-correlation.

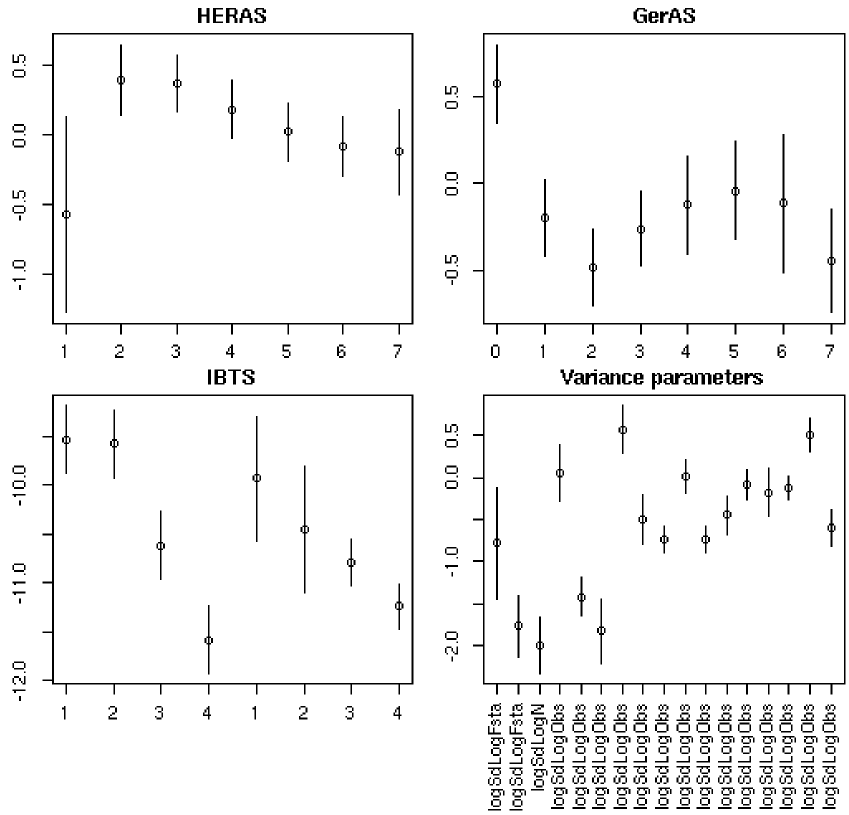


Figure 2.6.4.47 WESTERN BALTIC SPRING SPAWNING HERRING.

Plot of the model estimates (in log scale) with associated 95% CI.

2.15 Audit of Herring in Subdivisions 20–24, spring spawners

Date: 21-03-2017

Auditor: Claus Reedtz Sparrevohn

General

- 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.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment:** analytical
3) **Forecast:** Presented
4) **Assessment model:** Age-based analytical assessment SAM – tuned by 5 surveys.
5) **Data issues:** All data are available and their use is well documented. Survey numbers going into the assessment can be found in the report tables. Similar for catch numbers and other biological information
6) **Consistency:** The 2016 assessment did produce a smaller perception of the stocksize and an upward revision of F (see general comment).
7) **Stock status**: The stock is assessed to have been below MSYBtrigger but above Blim for the last three years. F is higher than Fmsy and has been that for two years. The prediction is that the 2017 SSB will be below MSY btrigger, therefore the ICES standard HCR are applied.
8) **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

A very well organized report and a well-documented assessment.

It is a concern that the changed SSB perception observed this year, resulted in that the 2015 SSB estimated now are outside the 95% confidence bound of the 2015 SSB, estimated last year. This indicates that the CV associated with the assessment might not be appropriate.

Technical comments

The combination of stable recruitment plus SSB trajectories and a very precise assessment might lead to the concern on if the actual uncertainty in the assessment are reflected in the associated CV. It might be worth to look into the process error of this assessment.

Conclusions

The assessment has been performed correctly according to the stock annex.

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

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

3.1 The Fishery

3.1.1 ICES advice and management applicable to 2016 and 2017

According to the management plan agreed between the EU and Norway every effort should be made to maintain a minimum level of spawning stock biomass (SSB) of North Sea Autumn Spawning herring greater than 800 000 tonnes. The management plan is given in Stock Annex 3.

The final TAC adopted by the management bodies for 2016 was 531 624 t for Area 4 and Division 7d, where no more than 57 007 t should be caught in Division 4c and 7d. For 2017, the total TAC was decreased by 7 % to 492 983 t (481 608 t for the A-Fleet), including a TAC of 52 954 t for Division 4c and 7d.

The by-catch TAC for the B-Fleet in the North Sea (and Div. 2.a) was 13 328 t in 2016 and has decreased by 15% to 11 375 t for 2017. As North Sea autumn spawners are also caught in Division 3a, 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 3.7.2.

3.1.2 Catches in 2016

Total landings and estimated catches are given in the Table 3.1.1 for the North Sea and for each Division in tables 3.1.2 to 3.1.5. Total Working Group (WG) catches per statistical rectangle and quarter are shown in figures 3.1.1 (a-d), the total for the year in Figure 3.1.1(e). Each nation provided most of their catch data (either official landings or Working Group catch) by statistical rectangle. The catch figures in tables 3.1.1–3.1.5 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 559 926 t in 2016. Official catches by the human consumption fishery were 545 222 t, corresponding to a slight overshoot of 5 % of the TAC for the human consumption fishery (518 242 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 45 840 t. The separate TAC for this area was 57 007 t, so 19 % of the TAC remains in Division 4.c and 7.d (but due to catch regulations, 50% of the TAC could have been taken in Division 4.b). The reduced catch continues to relieve the fishing pressure on the Downs stock component, as observed since 2012.

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

Landings of herring as by-catch in the Danish small-meshed fishery in the North Sea were relatively low in 2015 (7 909 t), but have increased substantially to 14 526 t in 2016. The by-catch ceiling (13 382 t) was fully taken. Since the introduction of yearly by-catch ceilings in 1996, these ceilings have only fully been taken in 2014 and in 2016.

The total North Sea TAC and catch estimates for the years 2011 to 2016 are shown in the table below (adapted from Table 3.1.6).

YEAR	2011	2012	2013	2014	2015	2016
TAC HC ('000 t)	200	405	478	470	445	518
"Official" landings HC ('000 t) *	209	414	490	490	472	545
Working Group catch HC ('000 t)	209	414	490	493	474	545
Excess of landings over TAC HC ('000 t)	9	9	12	23	28	27
By-catch ceiling ('000 t) **	17	18	14	13	16	13
Reported by-catches ('000 t) ***	9	11	8	14	8	15
Working Group catch North Sea ('000 t)	218	425	498	507	482	560

HC = human consumption fishery

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

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

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

3.1.3 Regulations and their effects

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

In 2017, half of the EU quota for Division 3.a can be taken in the North Sea (4); based on correspondence with the Pelagic RAC, HAWG notes that this transfer will be in the same order of magnitude as in 2016 (46%). Norway can take up to 50% of its quota for Division 3.a in the North Sea (4).

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

Half of the EU quota for Division 4.c and 7.d can be taken in Division 4.b. According to the (preliminary) FIDES 2016 overview of EU quota and uptake, a total of around 7500 tonnes was transferred from 4c-7d to 4b (ref. FIDES 2016).

In 2014, an agreed record between EU and Norway was applied, enabling an inter-annual quota flexibility of 10% of the TAC. Each party could transfer non-utilised quota of up to 10% of its quota into the next year, where it is added to the quota allocated to the party concerned in the following year (or borrow 10% of the TAC, to be subtracted the following year). This inter-annual flexibility has changed in 2015 so that 25 % of the TAC can be transferred into the next year, while up to 10 % can be borrowed.

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

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

3.1.4 Changes in fishing technology and fishing patterns.

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

The fishery concentrated in the north-western part of the North Sea, around the Fladen Ground area (Fig 3.1.1 a-e). The majority of catches is still taken in Subdivision 4.aW, in the order of 60 % of the total. After a drop in Subdivision 4.aE down to 9% in 2014, catches re-increased and their proportion of the total North Sea catch was 18 % in 2015 and 2016.

After a sharp reduction in the catches taken in Division 4.b in 2010, the proportion of catches in this area have increased again and contributed roughly 20-25% to the total catches. However, in 2015 and 2016, this area yielded 15% of the catches. The utilisation of catches in Divisions 4.c and 7.d has decreased since 2010. As in 2014 and 2015, the southern North Sea contributed only 8% to the 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 2 738 t in 2016.

As in former years, most of the catches in the B-Fleet are taken in Division 4.b (> 80%). The by-catch ceiling for this fleet has fully been taken in 2016.

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

3.2 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 3.2.1 to 3.2.5. Data are given for the whole year and by quarter. Except in cases where the necessary data are missing, data are displayed separately by area for herring caught in the North Sea, for Western Baltic spring spawners (only in 4.aE), and for the total NSAS stock, including catches in Division 3.a.

Biological information on the NSAS caught in Division 3.a was obtained using splitting procedures described in Section 3.2 and in the Stock Annex.

The tables are laid out as follows:

- Table 3.2.6: Total catches of NSAS (SOP figures), mean weights- and numbers-at-age by fleet
- Table 3.2.7: Data on catch numbers-at-age and SOP catches for the period 2001–2016 (herring caught in the North Sea)
- Table 3.2.8: WBSS taken in the North Sea (see below)

- Table 3.2.9: NSAS caught in Division 3.a
- Table 3.2.10: Total numbers of NSAS
- Table 3.2.11: Mean weights-at-age, separately for the different Divisions where NSAS are caught, for the period 2006-2016.

Note that SOP catch estimates may deviate in some instances slightly from the WG catch used for the assessment.

3.2.1 Catch in numbers-at-age

The total number of herring taken in the North Sea is 4.5 billion fish and NSAS amounts to 4.7 billion fish in 2016. The proportion of 0- and 1-ringers of herring taken in the North Sea is 34 % of the total catch in numbers in 2016 (Table 3.2.5), compared to 23% in 2015. Most of these young herring are still taken in the B-Fleet in Division 4.b. Here, 0- and 1-ringers amount to 73 % of the total catch in numbers.

The proportion of 3+ winterring herring is 54 % of the total catch in numbers taken in the North Sea (compared to 63 % in 2015).

Western Baltic (WBSS) and local Division 3.a spring-spawners are taken in the eastern North Sea during the summer feeding migration (see Stock Annex and Section 3.2.2). These catches are included in Table 3.1.1 and listed as WBSS. Table 3.2.8 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 2001-2016. After splitting the herring caught in the North Sea and 3.a between stocks, the total catch of North Sea Autumn spawners amounts to 563 911 tonnes.

AREA	ALLOCATED	UNALLOCATED	BMS	TOTAL
4.a West	330 313	-	100	330 413
4.a East	98 415	-	-	98 415
4.b	85 258	-	-	85 258
4.c/7.d	45 770	8	70	45 840
	Total catch in the North Sea			559 926
	Autumn spawners caught in Division 3.a (SOP)			5 525
	Baltic spring spawners caught in the North Sea (SOP)			-1 839
	Blackwater spring spawning herring			-1
	Other spring spawners			0
	Total catch NSAS used for the assessment			563 911

3.2.2 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 3.1.1 to 3.1.6, 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 further decreased to 216 t in 2016.

Blackwater herring are caught in the Thames estuary under a separate quota and included in the catch figure for England & Wales. In 2016, catches were low and less than 1 t.

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

3.2.3 Data revisions

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

3.2.4 Quality of catch and biological data

Annual misreporting and unallocation of catches were often substantial, but have reduced in the recent decade and are meanwhile regarded as a minor issue in the North Sea herring fishery. In 2016, unallocated catches were only 8 t. The **Working Group catch**, which include estimates of all fleets (and misreported or unallocated catches; see Section 1.5), is thus estimated to be almost the same as the official catch.

Since 2015, a landing obligation is in place for pelagic fleets operating in the North Sea and the Baltic. All catches have to be landed into port. One nation reported catches in the BMS category (below minimum landing size, including any fishes lost or damaged during processing procedures), while some countries stated these to be zero, and other countries have not reported catches in this category. The BMS catches in the North Sea in 2016 sums to 170 t. This is less than 0.1 % of the total catch. In accordance with the landing obligation, no discards were reported in the 2016 North Sea herring fishery.

The sampling of commercial landings covers 89 % of the total catch (2015: 86 %). The number of herring aged is higher than in 2015 (+7 %), while herring length measured have decreased considerably by 30 % (Table 3.2.12).

More important than a sufficient overall sampling level is an appropriate spread of sampling effort over the different metiers (here defined as each combination of fleet/nation/area and quarter). Of 109 different reported metiers, 42 were sampled in 2016. The recommended sampling level of more than 1 sample per 1 000 t catch has been met for 21 metiers. With regards to age readings, 20 metiers appear to be sampled sufficiently (recommended level >25 fish aged per 1 000 t catch).

However, some of the metiers yielded very little catch. In 60 metiers the catch is below 1 000 t. The total catch in these metiers sums to 9 571 t, so the remaining 49 metiers represent 550 356 t of the working group catch (98%). Of these 49 metiers 31 were sampled. Only 12 fulfil the recommended level of more than 1 sample per 1 000 t catch; additionally 11 fulfil the criteria of 25 age readings per 1 000 t catch.

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

The WG recommends that all metiers with substantial catch should be sampled (including by-catches in the industrial fisheries), and that catches landed abroad should be sampled based on criteria provided above, and information on these samples should be made available to the national laboratories (see Section 1.5).

3.3 Fishery independent information

3.3.1 Acoustic Surveys in the North Sea (HERAS), West of Scotland 6.a(N) and the Malin Shelf area (MSHAS) in June–July 2016

Six surveys were carried out during late June and July covering most of the continental shelf north of 52°N in the North Sea and to the west of Scotland and Ireland to a northern limit of 62°N. The eastern edge of the survey area was bounded by the Norwegian, Danish, Swedish and German coastline and to the west by the shelf slope around 200 m depth. The survey methods and full results are given in the report of the Working

Group for International Pelagic Surveys (WGIPS; ICES CM 2015/SSGIEOM:05). The vessels, areas and dates of cruises are given in Table 3.3.1.1 and in Figure 3.3.1.1.

The global survey results provide spatial distributions of herring, abundance by number and biomass-at-age by strata and distributions of mean weight- and proportion mature-at-age.

The estimate of North Sea autumn spawning herring spawning stock biomass has increased from 2.3 million tonnes in 2015 to 2.6 million tonnes this year.

The abundance of mature fish has increased from 14 222 million in 2015 to 17 499 this year (Table 3.3.1.2) and is largely responsible for the increase in SSB. The mean weight of mature fish continues to decrease and is now 151.3 g compared to 160.3 g last year. This is largely due to the large amount of 2 and 3 winter ring fish maturing and entering the SSB combined with a decrease in weight of the 2 winter ring fish from 121 g to 112 g this year. The increase in weight for all other ages this year has offset the effect of this to some extent. The large increase in 2 and 3 winter ring fish continues to shift the abundance to a larger amount of smaller fish.

The large increase in 2 winter ringers confirms the strength of a large 2013 year class and the 2012 year class also continues to be strong (3 wr this year).

The time series of abundance of North Sea autumn spawning herring is given in Table 3.3.1.3.

The spatial distribution of herring from the survey is shown in Figures 3.3.1.2a and 3.3.1.2b. The distribution of adult herring in the North Sea is still concentrated in the areas east and north of Scotland. Similarly to last year the distribution is stretching south in the western North Sea.

Immature herring was largely distributed in the southern and east central North Sea and less abundant along the Danish west coast.

The 2007 year class (8-winter rings this year) continues to grow very slow and mean weight continues to be below that of the following year class (Table 3.3.1.2).

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

Five survey areas were covered within the framework of the International Herring Larval Surveys in the North Sea during the sampling period 2016/2017. They monitored the abundance and distribution of newly hatched herring larvae in the Buchan area and the central North Sea in the second half of September and in the southern North Sea in the second half of December 2016 as well as in the first and second half of January 2017 (Fig 3.3.2.1. – 3.3.2.2).

The survey around the Orkneys, planned for September 2016, had to be cancelled due to unforeseen technical problems of the research vessel scheduled for the survey. When this became obvious, the remaining time to the beginning of the survey was too short to charter a replacement vessel. Thus, for the first time in the series of IHLS survey, there is no estimate for the Orkney/Shetland area available.

The total number of newly hatched larvae in Buchan area and the Central North Sea indicate successful hatching of larger quantities of herring larvae, in the same order of magnitude as in the year before.

The abundance of newly hatched larvae in the southern North Sea is strikingly high in the first survey of the most recent sampling period. Hardly any newly hatched larvae were observed in the eastern part of the English Channel (east of 002°30′ E). 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 small larvae is high when hatching started in December, but much lower when the spawning season progressed. A peak of spawning in December is clearly seen in the length distribution of larvae of the three surveys (Fig 3.3.2.3).

The Multiplicative Larvae Abundance Index (MLAI) is estimated to obtain an SSB index of North Sea autumn spawning herring. For the most recent year, the MLAI has doubled compared to 2015, reflecting the increase in larvae abundance in the southern North Sea (Tab. 3.3.2.1). The corresponding SSB is found to be around 2.8 million tonnes.

During the most recent benchmark of the North Sea herring assessment (ICES, WKPELA 2012), it was decided to replace the MLAI model by the Spawning Component Abundance Index (SCAI) model (Payne 2010). This index also monitors dynamics on a component level in addition to the total stock dynamics. The most recent SCAI index is almost record high. It has increased as compared to 2014 and 2015 (Tab. 3.3.2.1). More details on the SCAI are given in section 3.11.

3.3.3 International Bottom Trawl Survey (IBTS-Q1)

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

3.3.3.1 The 0-ringer abundance (IBTS0 survey)

The total abundance of 0-ringers in the survey area is used as a recruitment index for the stock. This year, 655 depth-integrated hauls were completed with the MIK-net. The coverage of the survey area was very good with at least 2 hauls in most of ICES rectangles in the North Sea as well as in Kattegat and Skagerrak. Few rectangles were only sampled once, and there was one rectangle (41E9) that couldn't be sampled at all. Index values were calculated as described in detail in the Stock Annex. This year, there were 32 hauls from the area south of 54° N with mean larval length <20mm which had to be excluded from the index calculation as specified in the calculation procedure. The index is, thus, calculated from the results of 623 hauls, and 2 rectangles, 31F2 and 32F2, in the Southern Bight are not accounted for in the index calculation. These small larvae in the southern area are thought to be larvae of the Downs component of North Sea herring. The exclusion of these stations from the index should ensure that the Downs component is not accounted for in the IBTS0 index.

Larvae, in the 2017 survey, measured between 7 and 39 mm standard length (SL). Again, and as in most years, the smallest larvae < 10 mm were the most numerous and were caught in their 10 thousands, while larger larvae > 18 mm SL were much rarer (Fig. 2.3.3.1). The smallest larvae were chiefly caught in 7.d and in the Southern Bight. The large larvae appeared chiefly and in low quantities in the western central and in the southern North Sea. The potential herring larvae nursery area of the German Bight and west of Denmark remained virtually devoid of large herring larvae. Also in the Kattegat and Skagerrak area, herring larvae remained relatively rare.

3.3.3.1.1 The 0-wr abundance according to the standard estimation method

The time series of IBTS0 estimates according to the standard index calculation algorithms is shown in Table 3.3.3.1.1. The new index value of 0-wr abundance of the 2016 year-class is estimated at 22.8. This index is less than last year's estimate for the 2015 year-class. It is 22.1 % of the long-term mean, and is the second lowest after the 2014 year-class since 1992.

3.3.3.1.2 The 0-wr abundance according to the newly proposed estimation method

Following the recommendations/suggestions of WGISDAA and WKHERLARS (see section **x.x.x.x**) a new exclusion rule to reliably remove the Downs herring larvae from the index calculation was introduced. The rules can be summarized as follows:

1. The herring larvae data of every station are used

2. The exclusion rule is applied only in the area that is potentially affected by drift of Downs larvae, i.e. south of 54°N and west of 6°E and south of 57°N and east of 6° E

3. In the area defined above, only larvae > 18 mm SL are included in the index calculation.

4. These rules are applied each year to produce a preliminary index. A final index will be produced later the same year utilizing drift models in order to apply necessary modifications to boundaries and critical length stated in rules 2. and 3.

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 3.3.3.1.2. For most of the time series the new algorithm produced comparable index values. However, for some years the results differ substantially from each other. For those year classes, where it was apparent that increased drift of small Downs larvae influenced the index (2013 and 2015), the index decreased (from 164.8 to 113.8, and from 99.8 to 81.2, respectively). This year's index was slightly increased by application of the new algorithm (27.8 instead of 22.8).

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

The 1-wr recruitment estimate (IBTS-1 index) is based on GOV catches in the entire survey area. The time series for year classes 1977 to 2015 is shown in Table 3.3.3.2. The index from the 2017 survey of 2390 is 22.9 % above the long-term mean. Figure 3.3.3.3 illustrates the spatial distribution of 1-wr fish as estimated by trawling in January/February 2015, 2016 and 2017. For the 2015 year-class, the majority of the 1-wr fish were distributed in the central part of the southeastern North Sea, in the southern German Bight and the Kattegat. Again, it appears noteworthy, that the three recent 1-wr abundances correspond very well to their 3 respective 0-wr fish indices.

3.4 Mean weights-at-age, maturity-at-age and natural mortality

3.4.1 Mean weights-at-age

Table 3.4.1.1 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 2016 for comparison. The data for 2016 were sourced from Table 3.3.1.2. and Table 3.2.2. In the third quarter most fish are approaching their peak weights just prior to spawning.

The mean weights in the acoustic survey in 2016 were lighter for all groups from 2-wr onwards compared to those in the catch (Figure 3.4.1.1).

In 2016, the mean weight-at-age in the acoustic survey is lower for 1 and 2-wr fish as compared to the previous year, but higher for all older age groups. Fish in age group 6, 7 and 9+ are found to be at almost the same weight at age.

A general trend towards smaller mean weight at age can be observed in the acoustic survey, while this tendency is not that obvious in the mean weight-at-age in the catches in the 3rd quarter. The mean weight-at-age of the 8-wr were lower than the 7-wr in both the survey and catch. This cohort (2007 year class) 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.

3.4.2 Maturity ogive

The percentages at age of North Sea autumn spawning herring that were considered mature in 2016 were estimated from the North Sea acoustic survey (Table 3.4.2.1). The method and justification for the use of values derived from a single year's data was described fully in ICES (1996/ACFM:10). Maturity estimates are highly comparable to those seen in the year before and not strikingly low. They were still in the range of those found in previous years. 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 two most recent years.

3.4.3 Natural mortality

One of the improvements of the latest 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 (Figure 3.4.3.1). 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 keyrun of the SMS model covering the period 1963–2010 (WGSAM 2011).

The natural mortality time series has been revised during the 2016 assessment following the new SMS model North Sea 2015 key run (WGSAM 2015). Main changes in the North Sea key run that particularly affected the natural mortality of herring were the truncation of the time series to 1974–2014, lower cod abundance, lower whiting abundance and inclusion of hake into the multispecies model. Detailed explanation regarding the natural mortality estimates used to 2015 can be found in the Stock Annex.

3.5 Recruitment

Information on the development in North Sea herring recruitment comes from the International Bottom Trawl Surveys, from which IBTS0 and the IBTS-1 indices are derived. Further, the SAM assessment provides estimates of the recruitment of herring in which information from the catch and from all fishery independent indices is incorporated. The recruitment trends from the assessment are dealt with in section 3.6.

3.5.1 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 3.5.1 and described by the fitted linear regression. Over the time series there has generally been very good agreement between the indices in their description of temporal trends in recruitment (Figure 3.5.2), but for the 2009 and the 2006–2007 year classes, the predicted levels of recruitment have deviated between the two indices. Since 2013 year class there is once again good agreement between 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 is the first strong year class observed since 2002. The 2015 IBTS0 index indicated that the 2014 year class is another poor year class and this was also confirmed in the IBTS-1 index this year (Figure 3.5.2).

3.6 Assessment of North Sea herring

3.6.1 Data exploration and preliminary results

The last benchmark (2012) decided on revised input data sources and assessment methods which are described in the WKPELA report (ICES, WKPELA 2012) and in the Stock Annex. 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), IBTS0 and SCAI larval (IHLS) 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 3.6.1.1. The input data and the performance of the assessment have been scrutinised to check for potential problems.

The proportion mature of 2, 3 and 4-wr in 2016 was 0.71, 0.89 and 0.95 respectively. These values are similar to those from last year (see Figure 3.6.1.1). Proportional catch numbers-at-age are given in Figure 3.6.1.2 and time series of natural mortality-at-age is given in Figure 3.6.1.3.

Survey indices are shown in Figure 3.6.1.4. The SCAI estimate for 2016 is still high and shows an increase. Though, it remains lower than the highest values of 2013. The latest observations from the IBTS0 index show a very weak 2017 yearclass, almost at the level of the 2015 yearclass (yearclass with the lowest index to date).

The pattern of the IBTS-Q1 1-wr confirms the strong 2014 yearclass and the weak 2015 yearclass. The 2016 yearclass is average.

The numbers at age over all ages in the acoustic survey can still be considered relatively high in the recent time period (see Figure 3.6.1.4 and 3.6.1.4b). The internal consistency of the acoustic survey remains high, as it has been for a long period (see Figure 3.6.1.5).

The SAM model fits the catch and the surveys well and residuals are random and small for all ages (figures 3.6.1.6 to 3.6.1.25). 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 (Figure 3.6.1.14). 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 SCAI survey fit shows a clear residual pattern (Figure 3.6.1.15), which can partly be explained by the fact that the SCAI indices in individual years are not independent of each other, but instead are the output of an auto-correlated random-walk model. All other surveys fit well inside the model. Further visualisation of residuals for the catch data and the acoustic index can be observed in Figure 3.6.1.26 and 3.6.1.27.

A feature of the assessment model is the estimation of an observation variance parameter for each data set (see Figure 3.6.1.28). 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 SCAI index and IBTS0 are perceived 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 3.6.1.29). However, the CV quantities do not indicate a lack of convergence of the assessment model.

The analytical retrospective pattern shows a very similar perception in F for the years 2006—2016 (Figure 3.6.1.30).

Figure 3.6.1.31 shows the model uncertainty plot, representing the parametric uncertainty of the fit of the assessment model in terminal F and SSB.

Further data screening of the input data on mature – immature biomass ratios, survey CPUEs, proportion of catch numbers- and weights-at-age and proportion of IBTS and acoustic survey ages have been executed, as well as correlation coefficient analyses for the acoustic and IBTS survey and assessment parameters (see Figure 3.6.1.32).

3.6.2 Exploratory Assessment for NS herring

No exploratory assessment was carried out for North Sea herring this year.

3.6.3 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 3.6.3.1—3.6.3.11, the SAM output is presented in tables 3.6.3.13—3.6.3.26, the stock summary in Table 3.6.3.12 and Figure 3.6.3.1 and model fit and parameter estimates in Table 3.6.3.25. Figure 3.6.3.2 shows the agreed management plan including the biomass trigger points and contains the $F_{2\text{-}6}$ estimates of the past 10 years.

The spawning stock at spawning time in 2016 is estimated at approximately 2.2 million tonnes, which is an increase of 18% in comparison to the 2015.

The abundance of 0-wr fish in 2017 (2016 year class) is estimated to be at approximately 30 billion, which is 58% below the long term geometric mean (see Table 3.6.3.14).

Mean $F_{2\text{-}6}$ in 2016 is estimated at approximately 0.26, which is below the management agreement target F. The mean $F_{0\text{-}1}$ is 0.049, which is just below the agreed ceiling.

3.6.4 State of the Stock

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as being at full reproductive capacity and is being harvested sustainably. Fishing mortality is below the estimated F_{MSY} (0.33) and the management plan target (0.26).

The SSB in autumn 2016 was estimated at 2.2 million tonnes, which is above B_{pa} (1.0 million t) and the biomass trigger in the management plan (1.5 million t).

The 2016 year class is estimated to be 58% lower than the long term geometric mean recruitment.

As for 2016, a remarkable feature of the assessment this year is the high fishing mortality on older ages in recent year. According to the assessment, the fishing mortality at age 7 is around 0.91, which is substantially higher than mean fishing mortality. The same signal is observed when using only the acoustic survey and the catch data. Apparently, the catches at the older ages are relatively high compared to the estimated stock size at those ages (figures 3.6.1.2 and 3.6.1.4b).

3.7 Short term predictions

Short term predictions for the years 2017, 2018 and 2019 were done with code developed in R software. In HAWG 2015, a modification to the code had to be made to allow for the estimation of the C-fleet outtake. Because of the 2015 EU-Norway management rule, the C-fleet no longer takes a fixed catch outtake, but the outtake is calculated as 5.7% of the sum of the A fleet TAC in the forecast year and 41% of the Western Baltic Spring Spawning TAC both multiplied with the proportion of NSAS in the catch.

In the short term predictions, recruitment is assumed constant for the years 2018 and 2019 following the same recruitment regime since 2002 (geometric mean of 2004 to 2014 year classes). The recruitment estimate of the 2016 year class, obtained from the assessment served as the estimate for 2017.

For the intermediate year (2017), no overshoot for the A fleet was assumed, as there was minimal deviation from the TAC in 2015. 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. In 2015, the pelagic AC was requested to estimate the percentage of the 3a herring TAC that would be taken in the North Sea under this regulation. The pelagic AC estimated it at 46%. The same proportion has been used in this forecast.

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 23500t).

For the B-fleet, 60% of the agreed by-catch ceiling in 2015 has been used.

For the C and D fleets, the fraction of North Sea Autumn Spawning (NSAS) herring caught in 3a is used to derive C and D fleet NSAS catches, based on projected TACs in 3a for these fleets. See Table 3.7.1—3.7.11 for other inputs.

Since the current management plan(s) only stipulates overall fishing mortalities for juveniles and adults, making fleet-wise predictions for four fleets that are more or less independent, could potentially result in many different options for 2018. The seven scenarios presented (Table 3.7.12) are based on an interpretation of the harvest control rule or other options and are only illustrative. **All predictions are for North Sea autumn spawning herring only.**

1 Management plan (0% transfer in C fleet)

2 F_{msy}

3 No fishing

4 No change in TAC (for A fleet)

5 TAC increase of 15%

6 TAC reduction of 15%

7 As 1, with 50% transfer in C fleet

For 2017, the C and D fleets are assumed to have a North Sea autumn spawner catch of 9 and 4.7 thousand tonnes respectively. In 2018 and 2019 the D-fleet is assumed to have a North Sea autumn spawner catch of 4.7 thousand tonnes. The C-fleet catch depends on the A & B fleet outtakes. The results are presented in Table 3.7.12.

3.7.1 Comments on the short-term projections

From 2017 to 2019, SSB is expected to decrease due to the weak 2014 and 2016 year-classes (Table 3.7.13). Under all scenarios, except for the no-fishing scenario, SSB is predicted to decrease in 2018. In the management plan scenario, the SSB is expected to go just below $B_{trigger}$ in 2019. The management plan scenario corresponds to an increase in the catch of the A-fleet catch compared to the prediction in 2016. This is because the strong 2013 estimate is now estimated to have been higher than the 2016 estimate of that yearclass. The 2013 year class makes an important contribution to the spawning stock and the catches in the prediction.

The predicted catch according to the management plan for 2016 implies an increase in TAC of 11%, which is below the 15% inter annual variation limit implemented in the plan.

3.7.2 Exploratory short-term projections

No exploratory short-term projections were considered.

3.8 Medium term predictions and HCR simulations

No medium term prediction or HCR simulations were carried out during the Working Group. The most recent HCR evaluation of the 2014 North Sea herring management plan and the 2014 management rule for 3a fisheries is in the 2015 WKHERTAC report (ICES CM 2015/ACOM:47).

3.9 Precautionary and Limit Reference Points and FMSY targets

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

The analysis carried out by the 2012 benchmark meeting (ICES, WKPELA 2012) implied that the reference points had shifted under the new perception of the stock assessment which was driven by the inclusion of dynamic natural mortality on herring. Due to this change in perception, the EU and Norway formulated a request to ICES to re-evaluate the precautionary and limit reference points as well as to evaluate precautionary management plan designs (WKHELP, ICES CM 2012/ACOM:72). The derivation of reference points and the history of the reference points for North Sea herring are further described in the Stock Annex.

In 2016, the reference points for NSAS herring were again updated following the change in perception of stock dynamics after the implementation of new natural mortality time series. The current reference points for NSAS herring are as follows:

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

3.10 Quality of the assessment

The data used within the assessment, the assessment methods and settings were carefully scrutinized during the 2012 benchmark (ICES, WKPELA 2012) 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 2017 assessment was classified as an update assessment and was carried out following these procedures and settings.

During the benchmark in 2012, dynamic natural mortality values for herring were introduced, based on the 2011 North Sea key-run. The North Sea herring Stock Annex, that was written at the end of the benchmark, concluded that: "there is currently no agreed approach about how to handle revisions to the natural mortality time series: this issue will need to be reviewed when new estimates become available." The working group concluded that the intention had been to update natural mortality estimates when they become available, even when the inclusion of the new natural mortality estimates (WGSAM 2015) did change the overall level of the stock and the fishing mortality. The current perception of SSB, F_{2-6} and recruitment over the past three years has changed in comparison to last year's assessment even though the retrospective assessment does not show substantial model revisions. (Figure 3.10.1).

The 2017 assessment has lowered the estimates of the 2014–2016 recruitments by around 22% compared to the 2016 assessment. The SSB has been lowered by around 11% for 2016 and the fishing mortality is estimated to be lower by around 20% (see text table below).

	2016 Assessment				2017 Assessment				%change 2017/2016			
Year	Rec	SSB	Catch	F2-6	Rec	SSB	Catch	F2-6	Rec	SSB	Catch	F2-6
2014	38340	1947	505	0. 227	46688	1963	505	0. 223	21.8%	0.8%	0%	-1.8%
2015	13524	1803	479	0. 242	15776	1836	479	0. 239	16.7%	1.8%	0%	-1.2%
2016	23394*	1959*	563*	0.320*	29532	2178	558	0. 257	26.2%	-11.2%	-0.9%	-19.7%

***projected values from the intermediate year in the short term projection. Recruits are defined as age 0 (wr)**

3.11 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.

3.11.1 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 3.6.3.8 and can be observed in Figure 3.11.1 (index values) and Figure 3.11.2 (proportions).

From 2010 to 2014, the Downs component has decreased consistently. However, the SCAI in the Downs component has been impacted by missing LAI observations in two sampling unit of the IHLS in the English Channel. These missing observations had certainly contributed to the substantial decline in index value but there are several years of data (2010-2016) to support the decrease in proportion for the Downs component.

Conversely, the Orkney/Shetland index has increased consistently since 2008 and has returned to being the largest component.

3.11.2 IBTS0 Larval Index

The ring net hauls for 0-ringers during the IBTS in the eastern English Channel also include Downs herring larvae and additional sampling in this region has been performed since 2007 (Section 3.3.3.1). As in the 2016 survey, concentrations of smaller larvae which are thought to be of the Downs component were found in 2017. Nevertheless, these small larvae (separated as < 20 mm) have until now been excluded from the standard estimation of 0-ringer recruitment (IBTS0 index).

3.11.3 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.

3.12 Ecosystem considerations

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

3.13 Changes in the environment

For all herring stocks in the working group, the mean weight at age in the catch and in the stock for the whole year and for the for the oldest ages (6-8) is shown in Figure 3.13.1. This indicates that for a number of stocks the mean weight at age in the catch 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 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 (Figure 3.13.2). The fisheries often target certain weight classes of herring which could be of an older age in the recent years.

This stock has, since 2002, produced a series of below average year classes, a situation which has not been observed previously (Payne *et al.*, 2009): the most recent year class also appears to represent a continuation of this trend. This low recruitment has occurred in spite of a spawning stock biomass that is well above the B_{lim} of 800 000 tonnes (where impaired recruitment is expected to set in) (Figure 3.13.3).

Stock productivity, as represented by the number of recruits-per-spawner from the assessment, has been low for the last decade (Figure 3.13.4). 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 both the recent period and also during the entire time series.

Year-class strength in this stock is determined during the larvae phase (Dickey-Collas and Nash 2005; Payne *et.* al 2009). Updating these analyses with the most recent data sets suggests that the trend of reduced larval survival between the early (as indicated by the SCAI index) and the late- (as indicated by the IBTS0 index) larval stages has continued in the most recent years (Figure 3.13.5). 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 (ie excluding the Downs). However, this refined metric shows a very similar trend (Figure 3.13.6) with continued poor survival.

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

Table 3.1.1: Herring caught in the North Sea. Total catch in tonnes by country, 2007—2016. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

COUNTRY	2007	2008	2009	2010	2011
Belgium	1	-	-	-	4
Denmark *	84697	62864	46238	45869	58726
Faroe Islands	2891	2014	1803	3014	-
France	24909	30347	18114	17745	16693
Germany	14893	8095	5368	7670	9427
Netherlands	66393	23122	24552	23872	34708
Norway	100050	59321	50445	46816	60705
Lithuania	-	-	-	90	-
Sweden	15448	13840	5299	4395	8086
Ireland	-	-	-	-	-
UK (England)	15993	11717	652	10770	11468
UK (Scotland)	35115	16021	14006	14373	18564
UK (N.Ireland)	638	331	-	-	17
Unallocated landings	26641	17151	-726	-	-
Total landings	387669	244823	165751	174614	218398
Discards	93	224	91	13	-
Total catch	387762	245047	165842	174627	218398
Parts of the catches which have been allocated to spring spawning stocks					
WBSS	1070	124	3941	774	308
Thames estuary **	2	7	48	85	2
Norw. Spring Spawners ***	685	2721	44560	56900	12178
COUNTRY	2012	2013	2014	2015	2016
Belgium	3	14	27	18	26
Denmark *	105707	117367	124423	113481	133962
Faroe Islands	-	-	118	981	833
France	23819	30122	29679	30269	35177
Germany	24515	46922	36767	44377	44231
Netherlands	72344	80462	74647	70076	98859
Norway	119253	143718	142002	134349	150183
Lithuania	-	-	9830	-	-
Sweden	14092	15615	15583	13184	16625
Ireland	-	221	68	183	127
UK (England)	25346	19079	19287	18897	20485
UK (Scotland)	34414	39243	45119	48332	59240
UK (N.Ireland)	4794	5738	6612	5948	-
Unallocated landings	321	-	3292	1516	8
Total landings	424608	498501	507454	481611	559756
Discards	-	-	31	-	170
Total catch	424608	498501	507485	481611	559926
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
WBSS	2095	452	2953	2204	1839
Thames estuary **	63	20	10	10	1
Norw. Spring Spawners ***	9619	3150	2307	2191	216

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

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

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

Table 3.1.2: 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	2007	2008	2009	2010	2011
Denmark *	45948	28426	16550	25092	26523
Faroe Islands	1118	2	288	1110	-
France	8570	13068	7067	6412	7885
Germany	4985	498	-	505	2642
Netherlands	42622	11634	11017	13593	15202
Norway	40279	40304	25926	38897	45200
Lithuania	-	-	-	90	-
Sweden	7658	7025	1435	2310	5121
Ireland	-	-	-	-	-
UK (England)	11833	8355	578	7384	4555
UK (Scotland)	35115	14727	10249	13567	17909
UK (N. Ireland)	638	331	-	-	17
Unallocated landings **	22215	14952	-977	0	0
Total Landings	220981	139322	72133	108960	125054
Discards	93	194	91	13	-
Total catch	221074	139516	72224	108973	125054
Country	2012	2013	2014	2015	2016
Denmark *	42867	80874	74719	68017	81080
Faroe Islands	-	-	118	981	811
France	11131	9750	12620	13401	15073
Germany	13060	19323	23245	32253	27926
Netherlands	46654	18418	37380	44309	66740
Norway	72581	49517	89974	47010	57056
Lithuania	-	-	8129	-	-
Sweden	6065	12280	7760	10388	9933
Ireland	-	221	68	183	127
UK (England)	18289	10874	10085	12249	13010
UK (Scotland)	33352	37889	41844	46931	58557
UK (N. Ireland)	4794	5738	6021	4878	-
Unallocated landings **	-3416	0	3292	1939	0
Total Landings	245377	244884	315255	282539	330313
Discards/BMS	-	-	31	-	100
Total catch	245377	244884	315286	282539	330413

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

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

Table 3.1.3: 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	2007	2008	2009	2010	2011
Denmark *	2646	1587	499	-	1590
Faroe Islands	577	400	700	719	-
France	-	-	-	-	-
Germany	-	-	-	-	-
Netherlands	263	-	-	-	-
Norway	54424	17474	6981	7362	12922
UK (Scotland)	-	-	-	-	167
Sweden	640	-	1735	1505	150
Unallocated landings **	-96	0	0	0	0
Total landings	58454	19461	9915	9586	14829
Discards	-	-	-	-	-
Total catch	58454	19461	9915	9586	14829
Norw. Spring Spawners ***	685	2721	44560	56900	12178
Country	2012	2013	2014	2015	2016
Denmark *	1822	1162	-	16739	16305
Faroe Islands	-	-	-	-	-
France	-	-	30	-	-
Germany	-	15	-	-	-
Netherlands	-	-	-	-	-
Norway	32714	76894	44060	67254	78125
UK (Scotland)	-	-	124	1369	-
Sweden	815	865	940	570	3985
Unallocated landings	0	0	0	-423	0
Total landings	35351	78936	45154	85509	98415
Discards/BMS	-	-	-	-	-
Total catch	35351	78936	45154	85509	98415
Norw. Spring Spawners ***	9619	3150	2307	2191	216

*** 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 3.1.4: 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	2007	2008	2009	2010	2011
Denmark*	35990	32230	29164	19671	30498
Faroe Islands	1196	1612	815	1185	-
France	8421	9687	4316	2349	1687
Germany	2205	2415	1061	1994	1778
Netherlands	8550	904	3164	830	7314
Norway	5347	1543	17538	557	2537
Sweden	7150	6815	2129	580	2815
UK (England)	577	833	2	1577	4748
UK (Scotland)	-	1293	3757	805	488
Unallocated landings**	-203	-904	-166	0	0
Total landings	69233	56428	61780	29548	51865
Discards	-	30	-	-	-
Total catch	69233	56458	61780	29548	51865
Country	2012	2013	2014	2015	2016
Denmark*	60503	34707	49118	28551	36149
Faroe Islands	-	-	-	-	22
France	3898	8728	7839	6342	6225
Germany	4187	17701	4424	107	3419
Lithuania	-	-	1701	-	-
Netherlands	9202	43339	22628	10606	17233
UK (N. Ireland)	-	-	591	1070	-
Norway	13958	17307	7968	20077	15002
Sweden	7212	2470	6883	2226	2705
UK (England)	3045	4391	4498	3484	3820
UK (Scotland)	1062	1312	3151	32	683
Unallocated landings**	411	42	0	0	0
Total landings	103478	129955	108801	72495	85258
Discards	-	-	-	-	-
Total catch	103478	129997	108801	72495	85258

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

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

Table 3.1.5: 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	2007	2008	2009	2010	2011
Belgium	1	-	-	-	4
Denmark*	113	621	25	1106	115
France	7918	7592	6731	8984	7121
Germany	7703	5182	4307	5171	5007
Netherlands	14958	10584	10371	9449	12192
Norway	-	-	-	-	46
UK (England)	3583	2529	72	1809	2165
UK (Scotland)	-	1	-	1	-
Unallocated landings	4725	3103	417	0	0
Total landings	39001	29612	21923	26520	26650
Discards	-	-	-	-	-
Total catch	39001	29612	21923	26520	26650
Coastal spring spawners included above **	2	7	48	85	2
COUNTRY	2012	2013	2014	2015	2016
Belgium	3	14	27	18	26
Denmark*	515	624	586	174	428
France	8790	11644	9190	10526	13879
Germany	7268	9883	9098	12017	12886
Netherlands	16488	18705	14639	15161	14886
Norway	-	-	-	8	-
Sweden	-	-	-	-	2
UK (England)	4012	3814	4704	3164	3655
UK (Scotland)	-	42	-	-	-
Unallocated landings***	3326	-42	0	0	8
Total landings	40402	44684	38244	41068	45770
Discards/BMS	-	-	-	-	70
Total catch	40402	44684	38244	41068	45840
Coastal spring spawners included above**	63	20	10	10	1

*** 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 3.1.6 ("The Wonderful Table"): Herring caught in the North Sea. Catch in thousand tonnes in Subarea 4, Division 7.d and Division 3.a.

YEAR	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Sub-Area 4 and Division 7.d: TAC (4 and 7.d)													
Agreed Divisions 4.a,b	460.7	404.7	303.5	174.6	147.4	149.0	173.5	360.4	427.7	418.3	396.3	461.2	428.7
Agreed Div. 4.c, 7.d	74.3	50.0	37.5	26.7	23.6	15.3	26.5	44.6	50.3	51.7	49.0	57.0	53.0
Bycatch ceiling in the small mesh fishery *	50.0	42.5	31.9	18.8	16.0	13.6	16.5	17.9	14.4	13.1	15.7	13.4	11.4
CATCH (4 and 7.d)													
National catch Divisions 4.a,b **	502.3	439.2	326.8	201.2	145.0	148.1	191.7	387.2	453.8	465.9	439	514.0	
Unallocated catch Divisions 4.a,b	49.6	13.3	21.9	14.0	-1.1	0.0	0.0	-3.0	0.0	3.3	1.5	0.0	
Discard/slipping Divisions 4.a,b ***	12.8	1.5	0.1	0.2	0.1	0.0	-	-	-	0.0	-	0.1	
Total catch Divisions 4.a,b #	564.6	454.0	348.8	215.4	143.9	148.1	191.7	384.2	453.9	469.2	440.5	514.1	
National catch Divisions 4.c, 7.d **	66.1	51.2	34.3	26.5	21.5	26.5	26.7	37.1	44.7	38.2	41.1	45.8	
Unallocated catch Divisions 4.c,7.d	8.2	5.4	4.7	3.1	0.4	0.0	0.0	3.3	0.0	0.0	0.0	0.0	
Discard/slipping Divisions 4.c, 7.d ***	-	-	-	-	-	-	-	-	-	-	-	0.1	
Total catch Divisions 4.c, 7.d	74.3	56.6	39.0	29.6	21.9	26.5	26.7	40.4	44.7	38.2	41.1	45.8	
Total catch 4 and 7.d as used by ICES #	638.9	510.6	387.8	245.0	165.8	174.6	218.4	424.6	498.5	507.5	481.6	559.9	
CATCH BY FLEET/STOCK (4 and 7.d) ##													
North Sea autumn spawners directed fisheries (Fleet A)	610.0	487.1	379.6	236.3	152.1	164.8	209.2	411.8	489.9	490.5	471.5	543.6	
North Sea autumn spawners industrial (Fleet B)	21.8	11.9	7.1	8.6	9.8	9.1	8.9	10.6	8.1	14.0	7.9	14.5	
North Sea autumn spawners in 4 and 7.d total	631.9	499.0	386.7	244.9	161.9	173.9	218.1	422.5	498.1	504.5	479.4	558.1	
Baltic-3.a-type spring spawners in 4	7.0	11.0	1.1	0.1	3.9	0.8	0.3	2.1	0.5	3.0	2.2	1.8	
Coastal-type spring spawners	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	
Norw. Spring Spawners caught under a separate quota in 4 ###	0.4	0.6	0.7	2.7	44.6	56.9	12.2	9.6	3.2	2.3	2.2	0.2	
Division 3.a: TAC (3.a)													
Agreed herring TAC	96.0	81.6	69.4	51.7	37.7	33.9	30.0	45.0	55.0	46.8	43.6	51.1	
Bycatch ceiling in the small mesh fishery	24.2	20.5	15.4	11.5	8.4	7.5	6.7	6.7	6.7	6.7	6.7	6.7	

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CATCH (3.a)													
National catch	90.8	88.9	47.3	38.2	38.8	37.3	20.0	27.7	31.2	28.9	27.8	29.9	
Catch as used by ICES	69.6	51.2	47.4	38.2	38.8	37.3	20.0	27.7	31.2	28.9	27.8	29.9	
CATCH BY FLEET/STOCK (3.a) ##													
Autumn spawners human consumption (Fleet C)	22.9	11.6	16.4	9.2	5.1	12.0	6.6	7.8	11.8	9.5	10.2	4.1	
Autumn spawners mixed clupeoid (Fleet D)	9.0	3.4	3.4	3.7	1.5	1.8	1.8	4.4	1.6	3.3	4.4	1.4	
Autumn spawners in 3.a total	31.9	15.0	19.8	12.9	6.5	13.8	8.4	12.2	13.4	12.8	14.7	5.5	
Spring spawners human consumption (Fleet C)	32.5	30.2	25.3	23.0	29.4	23.0	10.8	14.5	16.6	15.4	11.3	23.3	
Spring spawners mixed clupeoid (Fleet D)	5.1	5.9	2.3	2.2	2.9	0.5	0.8	1.0	1.3	0.6	1.8	1.1	
Spring spawners in 3.a total	37.6	36.1	27.6	25.2	32.3	23.5	11.6	15.5	17.9	16.1	13.1	24.4	
North Sea autumn spawners Total as used by ICES	663.8	514.6	406.5	257.9	168.4	187.6	226.5	434.6	511.4	517.3	494.1	563.6	

Table 3.2.1: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2016. Catch in numbers (millions) at age (CANUM), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBBS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	133.3	0.0	0.0	0.0	86.8	1340.9	22.5	0.0	1427.7	22.5	1583.6	1450.3
1	23.3	0.9	0.0	0.8	0.9	64.5	19.6	0.0	66.2	19.6	109.1	85.8
2	47.6	60.1	1.2	58.9	345.9	134.1	3.6	35.5	538.8	39.1	625.5	579.1
3	6.0	136.6	4.1	132.5	431.3	147.1	3.9	97.8	710.9	101.8	818.6	816.7
4	0.5	56.3	1.0	55.3	178.2	32.6	0.8	26.0	266.1	26.8	293.4	293.9
5	0.3	36.6	1.1	35.4	188.7	31.5	1.7	22.9	255.6	24.6	280.5	281.3
6	0.2	78.1	1.2	76.9	220.9	42.4	1.3	26.1	340.2	27.4	367.8	368.8
7	0.0	50.3	0.7	49.6	205.2	21.3	2.5	28.8	276.1	31.2	307.3	308.0
8	0.1	64.7	0.4	64.2	83.4	10.5	1.4	26.3	158.2	27.7	185.9	186.3
9+	0.0	61.5	0.8	60.7	77.0	17.2	0.2	18.0	154.9	18.2	173.2	173.9
Sum	211.3	545.0	10.6	534.4	1818.2	1842.1	57.7	281.2	4194.7	338.8	4744.9	4544.1
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	2.5	0.0	0.0	0.0	0.0	5.3	19.5	0.0	5.3	19.5	27.3	24.8
2	31.8	5.8	0.2	5.6	5.6	14.4	2.7	0.0	25.5	2.7	60.0	28.4
3	2.2	11.4	0.0	11.4	14.1	9.8	0.3	10.4	35.3	10.8	48.2	46.0
4	0.3	6.5	0.0	6.5	5.8	1.0	0.1	5.6	13.3	5.8	19.3	19.1
5	0.0	3.5	0.3	3.3	4.8	1.0	0.2	2.9	9.1	3.2	12.3	12.5
6	0.0	7.7	0.0	7.7	5.7	1.7	0.2	3.5	15.0	3.7	18.8	18.8
7	0.0	2.5	0.0	2.5	4.3	1.0	0.4	2.8	7.7	3.2	10.9	10.9
8	0.0	0.3	0.0	0.2	0.5	0.2	0.2	3.7	0.9	3.9	4.8	4.8
9+	0.0	2.9	0.3	2.7	2.1	0.5	0.0	0.9	5.3	0.9	6.2	6.5
Sum	36.7	40.5	0.8	39.7	42.9	34.8	23.7	29.9	117.4	53.6	207.7	171.8
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	2.8	0.8	0.0	0.8	0.1	16.1	0.1	0.0	17.0	0.1	19.9	17.1
2	3.2	49.7	0.7	49.0	38.4	3.9	0.0	0.0	91.3	0.0	94.6	92.1
3	0.0	118.5	3.1	115.4	39.7	2.6	0.0	0.2	157.6	0.2	157.9	160.9
4	0.0	46.4	0.5	46.0	9.8	0.8	0.0	0.1	56.6	0.1	56.7	57.2
5	0.1	29.8	0.4	29.4	4.3	0.6	0.0	0.0	34.2	0.1	34.4	34.7
6	0.0	63.9	0.0	63.9	6.3	1.3	0.0	0.1	71.5	0.1	71.6	71.6
7	0.0	43.2	0.1	43.0	6.4	0.4	0.0	0.0	49.9	0.1	50.0	50.1
8	0.0	60.1	0.0	60.1	3.9	0.2	0.0	0.1	64.2	0.1	64.2	64.2
9+	0.0	53.3	0.0	53.3	3.3	0.3	0.0	0.0	56.8	0.0	56.8	56.8
Sum	6.2	465.8	4.9	460.9	112.2	26.1	0.2	0.5	599.1	0.7	606.0	604.7
Quarter: 3												
0	123.5	0.0	0.0	0.0	0.0	1035.7	0.0	0.0	1035.7	0.0	1159.2	1035.7
1	11.8	0.0	0.0	0.0	0.0	42.9	0.0	0.0	42.9	0.0	54.7	42.9
2	10.1	4.2	0.3	3.9	207.0	93.8	0.0	0.0	304.8	0.0	314.9	305.1
3	3.3	5.2	1.0	0.0	237.2	88.6	0.0	0.0	325.8	0.0	329.1	331.0
4	0.2	2.7	0.6	0.0	113.9	24.5	0.0	0.0	138.3	0.0	138.6	141.0
5	0.2	2.1	0.5	0.0	127.4	22.4	0.0	0.0	149.7	0.0	149.9	151.8
6	0.2	5.0	1.0	0.0	144.9	24.5	0.0	0.0	169.4	0.0	169.6	174.4
7	0.0	3.8	0.6	0.0	135.2	14.1	0.0	0.0	149.3	0.0	149.3	153.1
8	0.0	3.4	0.3	0.0	55.8	3.7	0.0	0.0	59.5	0.0	59.5	62.9
9+	0.0	4.5	0.4	0.0	51.9	8.1	0.0	0.0	60.0	0.0	60.0	64.5
Sum	149.4	30.8	4.6	3.9	1073.2	1358.2	0.1	0.0	2435.4	0.1	2584.8	2462.4
Quarter: 4												
0	9.8	0.0	0.0	0.0	86.8	305.3	22.5	0.0	392.0	22.5	424.4	414.6
1	6.3	0.0	0.0	0.0	0.8	0.2	0.0	0.0	1.0	0.0	7.3	1.0
2	2.4	0.4	0.0	0.4	94.9	22.0	0.9	35.5	117.2	36.3	155.9	153.5
3	0.5	1.5	0.0	1.5	140.3	46.1	3.5	87.2	188.0	90.8	279.2	278.7
4	0.0	0.7	0.0	0.7	48.7	6.3	0.6	20.2	55.8	20.9	76.7	76.6
5	0.0	1.2	0.0	1.2	52.2	7.5	1.5	19.9	60.9	21.4	82.3	82.2
6	0.0	1.5	0.1	1.4	64.0	15.0	1.1	22.5	80.3	23.6	103.9	104.0
7	0.0	0.9	0.0	0.9	59.3	5.8	2.0	25.9	66.0	28.0	94.0	94.0
8	0.0	0.9	0.1	0.8	23.2	6.5	1.2	22.5	30.5	23.8	54.2	54.4
9+	0.0	0.8	0.1	0.7	19.7	8.4	0.2	17.1	28.8	17.3	46.0	46.2
Sum	19.0	7.9	0.4	7.5	589.9	423.0	33.6	250.8	1020.5	284.4	1323.9	1305.3

Table 3.2.2: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2016. Mean weight-at-age (kg) in the catch (WECA), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(W)	IVb	IVc	VIId	IVa & IVb all	IVc & VIId	Total NSAS	Herring caught in the North Sea
Quarters: 1-4											
0	**0.007**	**0.000**	**0.000**	**0.010**	**0.007**	**0.010**	**0.000**	**0.007**	**0.010**	**0.007**	**0.007**
1	**0.038**	**0.121**	**0.121**	**0.086**	**0.025**	**0.010**	**0.000**	**0.027**	**0.010**	**0.027**	**0.023**
2	**0.059**	**0.129**	**0.129**	**0.138**	**0.126**	**0.093**	**0.116**	**0.134**	**0.114**	**0.127**	**0.132**
3	**0.123**	**0.153**	**0.153**	**0.161**	**0.161**	**0.130**	**0.127**	**0.159**	**0.127**	**0.155**	**0.155**
4	**0.149**	**0.167**	**0.167**	**0.189**	**0.192**	**0.139**	**0.137**	**0.185**	**0.137**	**0.180**	**0.180**
5	**0.157**	**0.183**	**0.183**	**0.215**	**0.211**	**0.170**	**0.165**	**0.210**	**0.166**	**0.206**	**0.206**
6	**0.208**	**0.195**	**0.195**	**0.227**	**0.218**	**0.187**	**0.177**	**0.218**	**0.177**	**0.215**	**0.215**
7	**0.211**	**0.205**	**0.205**	**0.242**	**0.236**	**0.198**	**0.199**	**0.235**	**0.199**	**0.231**	**0.231**
8	**0.235**	**0.216**	**0.216**	**0.233**	**0.236**	**0.191**	**0.194**	**0.226**	**0.193**	**0.221**	**0.221**
9+	**0.000**	**0.229**	**0.229**	**0.250**	**0.253**	**0.242**	**0.216**	**0.242**	**0.216**	**0.239**	**0.239**
Quarter: 1											
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**	**0.000**
1	0.018	0.058	0.107	0.051	0.018	0.010	0.000	0.018	0.010	**0.012**	**0.012**
2	0.042	0.079	0.088	0.089	0.055	0.086	0.000	0.068	0.000	**0.055**	**0.070**
3	0.085	0.106	0.127	0.112	0.095	0.099	0.086	0.105	0.000	**0.100**	**0.101**
4	0.123	0.124	0.144	0.136	0.158	0.121	0.106	0.132	0.106	**0.124**	**0.124**
5	0.138	0.147	0.159	0.150	0.180	0.123	0.119	0.152	0.119	**0.144**	**0.144**
6	0.176	0.163	0.178	0.163	0.199	0.159	0.129	0.167	0.130	**0.160**	**0.160**
7	0.000	0.165	0.194	0.170	0.212	0.152	0.144	0.174	0.145	**0.165**	**0.165**
8	0.195	0.182	0.201	0.198	0.246	0.154	0.143	0.202	0.143	**0.155**	**0.155**
9+	0.000	0.187	0.210	0.197	0.233	0.000	0.162	0.195	0.162	**0.190**	**0.190**
Quarter: 2											
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**	**0.000**
1	0.015	0.122	0.122	0.120	0.018	0.010	0.000	0.024	0.010	**0.022**	**0.024**
2	0.056	0.136	0.136	0.125	0.137	0.104	0.000	0.132	0.104	**0.129**	**0.132**
3	0.146	0.157	0.157	0.149	0.171	0.129	0.086	0.155	0.089	**0.155**	**0.155**
4	0.172	0.173	0.173	0.167	0.191	0.152	0.106	0.172	0.108	**0.172**	**0.172**
5	0.085	0.186	0.186	0.186	0.210	0.162	0.119	0.186	0.125	**0.186**	**0.186**
6	0.193	0.197	0.197	0.191	0.226	0.183	0.128	0.197	0.132	**0.197**	**0.197**
7	0.209	0.206	0.206	0.212	0.245	0.189	0.143	0.207	0.150	**0.207**	**0.207**
8	0.225	0.215	0.215	0.213	0.252	0.201	0.143	0.215	0.146	**0.215**	**0.215**
9+	0.000	0.229	0.229	0.227	0.254	0.275	0.161	0.229	0.165	**0.229**	**0.229**
Quarter: 3											
0	0.006	0.000	0.000	0.000	0.006	0.000	0.000	0.006	0.000	**0.006**	**0.006**
1	0.040	0.000	0.000	0.000	0.029	0.096	0.000	0.029	0.096	**0.031**	**0.029**
2	0.107	0.115	0.115	0.145	0.136	0.120	0.116	0.142	0.120	**0.141**	**0.142**
3	0.146	0.142	0.142	0.169	0.172	0.148	0.131	0.170	0.147	**0.170**	**0.170**
4	0.174	0.176	0.176	0.201	0.195	0.164	0.145	0.200	0.163	**0.200**	**0.200**
5	0.190	0.198	0.198	0.230	0.215	0.191	0.166	0.227	0.190	**0.227**	**0.227**
6	0.214	0.211	0.211	0.244	0.232	0.205	0.175	0.241	0.202	**0.241**	**0.241**
7	0.216	0.223	0.223	0.261	0.246	0.222	0.191	0.259	0.221	**0.259**	**0.259**
8	0.243	0.233	0.233	0.243	0.259	0.231	0.207	0.244	0.229	**0.244**	**0.244**
9+	0.000	0.250	0.250	0.263	0.271	0.259	0.216	0.263	0.248	**0.263**	**0.263**
Quarter: 4											
0	0.013	0.000	0.000	0.010	0.010	0.010	0.000	0.010	0.010	**0.010**	**0.010**
1	0.053	0.119	0.119	0.084	0.094	0.062	0.000	0.086	0.062	**0.058**	**0.086**
2	0.091	0.142	0.142	0.129	0.123	0.114	0.116	0.128	0.116	**0.125**	**0.125**
3	0.133	0.163	0.163	0.154	0.154	0.133	0.132	0.154	0.132	**0.147**	**0.147**
4	0.159	0.177	0.177	0.170	0.183	0.142	0.146	0.172	0.146	**0.165**	**0.165**
5	0.185	0.189	0.189	0.187	0.204	0.177	0.172	0.189	0.173	**0.185**	**0.185**
6	0.194	0.199	0.199	0.197	0.197	0.193	0.184	0.197	0.185	**0.194**	**0.194**
7	0.200	0.208	0.208	0.207	0.214	0.207	0.205	0.208	0.205	**0.207**	**0.207**
8	0.218	0.216	0.216	0.211	0.222	0.197	0.202	0.213	0.202	**0.208**	**0.208**
9+	0.000	0.235	0.235	0.226	0.237	0.241	0.219	0.230	0.219	**0.226**	**0.226**

Table 3.2.3: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2016. Mean length-at-age (cm) in the catch, by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(W)	IVb	IVc	VIId	IVa & IVb all	IVc & VIId	Herring caught in the North Sea
Quarters: 1-4										
0	**n.d.**	**0.0**	**n.d.**	**12.0**	**10.3**	**11.8**	**0.0**	**10.4**	**11.8**	**10.4**
1	**n.d.**	**23.0**	**n.d.**	**21.6**	**15.2**	**12.2**	**0.0**	**15.4**	**12.2**	**14.7**
2	**n.d.**	**24.0**	**n.d.**	**25.1**	**24.1**	**24.1**	**24.2**	**24.7**	**24.2**	**24.7**
3	**n.d.**	**25.5**	**n.d.**	**26.5**	**26.3**	**25.3**	**25.1**	**26.2**	**25.1**	**26.1**
4	**n.d.**	**26.5**	**n.d.**	**27.8**	**27.7**	**26.1**	**25.8**	**27.5**	**25.8**	**27.4**
5	**n.d.**	**27.3**	**n.d.**	**29.0**	**28.8**	**27.9**	**27.5**	**28.7**	**27.5**	**28.6**
6	**n.d.**	**27.9**	**n.d.**	**29.5**	**29.1**	**29.2**	**28.2**	**29.1**	**28.2**	**29.0**
7	**n.d.**	**28.4**	**n.d.**	**30.2**	**29.7**	**29.4**	**29.1**	**29.8**	**29.1**	**29.8**
8	**n.d.**	**28.7**	**n.d.**	**29.8**	**29.6**	**29.8**	**29.4**	**29.3**	**29.5**	**29.3**
9+	**n.d.**	**29.4**	**n.d.**	**30.6**	**30.4**	**30.8**	**29.7**	**30.1**	**29.7**	**30.1**
Quarter: 1										
0	n.d.	0.0	n.d.	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1	n.d.	13.7	n.d.	12.7	14.5	12.2	0.0	14.5	12.2	**12.7**
2	n.d.	22.9	n.d.	23.2	19.4	24.0	0.0	21.0	0.0	**21.3**
3	n.d.	25.2	n.d.	25.3	24.3	25.1	24.1	25.0	0.0	**24.8**
4	n.d.	26.6	n.d.	26.8	27.3	26.8	25.4	26.7	25.4	**26.3**
5	n.d.	27.9	n.d.	27.7	28.5	27.4	26.8	27.9	26.8	**27.6**
6	n.d.	29.1	n.d.	28.6	29.5	30.0	27.6	28.9	27.7	**28.7**
7	n.d.	29.1	n.d.	29.0	30.0	29.4	28.4	29.2	28.5	**29.0**
8	n.d.	29.2	n.d.	30.5	31.7	29.2	29.3	30.4	29.3	**29.5**
9+	n.d.	30.3	n.d.	30.6	31.2	0.0	29.6	30.5	29.6	**30.4**
Quarter: 2										
0	n.d.	0.0	n.d.	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1	n.d.	23.1	n.d.	23.2	13.8	12.2	0.0	14.3	12.2	**14.3**
2	n.d.	24.2	n.d.	23.9	24.9	24.1	0.0	24.1	24.1	**24.1**
3	n.d.	25.5	n.d.	25.5	26.8	25.7	24.1	25.5	24.2	**25.5**
4	n.d.	26.4	n.d.	26.6	27.8	27.2	25.4	26.5	25.5	**26.5**
5	n.d.	27.1	n.d.	27.7	28.7	27.9	26.8	27.2	27.0	**27.2**
6	n.d.	27.8	n.d.	27.8	29.5	29.6	27.6	27.8	27.7	**27.8**
7	n.d.	28.3	n.d.	28.7	30.3	29.6	28.4	28.4	28.6	**28.4**
8	n.d.	28.6	n.d.	29.1	30.2	29.9	29.3	28.7	29.3	**28.7**
9+	n.d.	29.3	n.d.	29.7	30.4	31.3	29.6	29.4	29.7	**29.4**
Quarter: 3										
0	n.d.	0.0	n.d.	0.0	9.8	0.0	0.0	9.8	0.0	**9.8**
1	n.d.	0.0	n.d.	0.0	15.8	22.3	0.0	15.8	22.3	**15.8**
2	n.d.	23.2	n.d.	25.2	24.8	24.5	24.1	25.1	24.4	**25.1**
3	n.d.	25.1	n.d.	26.4	26.8	25.9	25.1	26.5	25.8	**26.5**
4	n.d.	26.7	n.d.	28.0	27.9	26.8	25.9	27.9	26.7	**27.9**
5	n.d.	27.8	n.d.	29.3	28.9	28.2	27.1	29.2	28.1	**29.2**
6	n.d.	28.3	n.d.	29.7	29.7	29.1	27.6	29.7	28.9	**29.7**
7	n.d.	28.9	n.d.	30.5	30.2	29.6	28.4	30.5	29.6	**30.5**
8	n.d.	29.4	n.d.	29.7	30.6	30.4	29.1	29.8	30.3	**29.8**
9+	n.d.	30.1	n.d.	30.6	31.0	31.1	29.5	30.6	30.7	**30.6**
Quarter: 4										
0	n.d.	0.0	n.d.	12.0	12.0	11.8	0.0	12.0	11.8	**12.0**
1	n.d.	22.7	n.d.	21.6	21.2	20.0	0.0	21.5	20.0	**21.5**
2	n.d.	25.4	n.d.	25.3	24.1	24.5	24.2	25.1	24.2	**24.9**
3	n.d.	26.6	n.d.	26.9	25.6	25.4	25.2	26.5	25.2	**26.1**
4	n.d.	27.5	n.d.	27.8	27.0	25.9	25.9	27.7	25.9	**27.2**
5	n.d.	28.1	n.d.	28.7	28.6	27.9	27.6	28.6	27.6	**28.4**
6	n.d.	28.7	n.d.	29.2	28.1	29.0	28.3	29.0	28.3	**28.8**
7	n.d.	29.1	n.d.	29.8	28.6	29.4	29.2	29.7	29.2	**29.5**
8	n.d.	29.6	n.d.	30.0	29.0	29.9	29.5	29.8	29.5	**29.7**
9+	n.d.	30.5	n.d.	30.8	29.7	30.8	29.7	30.5	29.7	**30.2**

Table 3.2.4: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Division 3.a in 2016. Catches (tonnes) at-age (SOP figures), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	0.9	0.0	0.0	0.0	0.9	9.3	0.2	0.0	10.1	0.2	11.2	10.3
1	0.9	0.1	0.0	0.1	0.1	1.6	0.2	0.0	1.8	0.2	2.9	2.0
2	2.8	7.8	0.2	7.6	47.6	16.8	0.3	4.1	72.0	4.4	79.3	76.6
3	0.7	20.8	0.6	20.2	69.2	23.7	0.5	12.4	113.1	12.9	126.8	126.7
4	0.1	9.4	0.2	9.2	33.7	6.2	0.1	3.6	49.1	3.7	52.9	53.0
5	0.0	6.7	0.2	6.5	40.5	6.6	0.3	3.8	53.6	4.1	57.7	57.9
6	0.0	15.2	0.2	15.0	50.0	9.3	0.2	4.6	74.3	4.9	79.1	79.3
7	0.0	10.3	0.1	10.2	49.7	5.0	0.5	5.7	64.9	6.2	71.1	71.2
8	0.0	14.0	0.1	13.9	19.4	2.5	0.3	5.1	35.7	5.4	41.1	41.2
9+	0.0	14.1	0.2	13.9	19.3	4.4	0.1	3.9	37.5	3.9	41.5	41.6
Sum	5.5	98.4	1.8	96.5	330.3	85.4	2.7	43.2	512.2	45.9	563.6	559.9
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.1	0.2	0.3	0.3
2	1.3	0.5	0.0	0.4	0.5	0.8	0.2	0.0	1.7	0.2	3.3	2.0
3	0.2	1.2	0.0	1.2	1.6	0.9	0.0	0.9	3.7	0.9	4.8	4.6
4	0.0	0.8	0.0	0.8	0.8	0.2	0.0	0.6	1.8	0.6	2.4	2.4
5	0.0	0.5	0.0	0.5	0.7	0.2	0.0	0.3	1.4	0.4	1.8	1.8
6	0.0	1.3	0.0	1.3	0.9	0.3	0.0	0.5	2.5	0.5	3.0	3.0
7	0.0	0.4	0.0	0.4	0.7	0.2	0.1	0.4	1.3	0.5	1.8	1.8
8	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.5	0.2	0.6	0.7	0.7
9+	0.0	0.5	0.1	0.5	0.4	0.1	0.0	0.1	1.0	0.1	1.2	1.2
Sum	1.6	5.2	0.1	5.1	5.8	2.9	0.6	3.4	13.7	4.0	19.3	17.9
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.1	0.0	0.1	0.0	0.3	0.0	0.0	0.4	0.0	0.4	0.4
2	0.2	6.8	0.1	6.7	4.8	0.5	0.0	0.0	12.0	0.0	12.2	12.1
3	0.0	18.6	0.5	18.2	5.9	0.4	0.0	0.0	24.5	0.0	24.5	25.0
4	0.0	8.0	0.1	7.9	1.6	0.2	0.0	0.0	9.7	0.0	9.7	9.8
5	0.0	5.5	0.1	5.5	0.8	0.1	0.0	0.0	6.4	0.0	6.4	6.5
6	0.0	12.6	0.0	12.6	1.2	0.3	0.0	0.0	14.1	0.0	14.1	14.1
7	0.0	8.9	0.0	8.9	1.4	0.1	0.0	0.0	10.3	0.0	10.3	10.4
8	0.0	12.9	0.0	12.9	0.8	0.0	0.0	0.0	13.8	0.0	13.8	13.8
9+	0.0	12.2	0.0	12.2	0.7	0.1	0.0	0.0	13.0	0.0	13.0	13.0
Sum	0.2	85.7	0.8	84.9	17.3	2.0	0.0	0.1	104.2	0.1	104.6	105.1
Quarter: 3												
0	0.7	0.0	0.0	0.0	0.0	6.2	0.0	0.0	6.2	0.0	7.0	6.2
1	0.5	0.0	0.0	0.0	0.0	1.2	0.0	0.0	1.2	0.0	1.7	1.2
2	1.1	0.5	0.0	0.5	30.0	12.8	0.0	0.0	43.3	0.0	44.3	43.3
3	0.5	0.7	0.1	0.6	40.2	15.2	0.0	0.0	56.0	0.0	56.5	56.2
4	0.0	0.5	0.1	0.0	22.9	4.8	0.0	0.0	27.7	0.0	28.1	28.2
5	0.0	0.4	0.1	0.3	29.2	4.8	0.0	0.0	34.4	0.0	34.4	34.5
6	0.0	1.1	0.2	0.0	35.3	5.7	0.0	0.0	41.0	0.0	41.9	42.0
7	0.0	0.8	0.1	0.7	35.3	3.5	0.0	0.0	39.5	0.0	39.5	39.6
8	0.0	0.8	0.1	0.7	13.6	1.0	0.0	0.0	15.3	0.0	15.3	15.3
9+	0.0	1.1	0.1	1.0	13.6	2.2	0.0	0.0	16.9	0.0	16.9	17.0
Sum	2.9	5.9	0.9	3.8	220.2	57.3	0.0	0.0	281.4	0.0	285.5	283.5
Quarter: 4												
0	0.1	0.0	0.0	0.0	0.9	3.1	0.2	0.0	3.9	0.2	4.3	4.1
1	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.4	0.1
2	0.2	0.1	0.0	0.1	12.2	2.7	0.1	4.1	15.0	4.2	19.4	19.2
3	0.1	0.2	0.0	0.2	21.6	7.1	0.5	11.5	28.9	12.0	41.0	40.9
4	0.0	0.1	0.0	0.1	8.3	1.2	0.1	3.0	9.6	3.1	12.6	12.6
5	0.0	0.2	0.0	0.2	9.8	1.5	0.3	3.4	11.5	3.7	15.2	15.2
6	0.0	0.3	0.0	0.3	12.6	3.0	0.2	4.1	15.8	4.4	20.2	20.2
7	0.0	0.2	0.0	0.2	12.3	1.2	0.4	5.3	13.7	5.7	19.5	19.4
8	0.0	0.2	0.0	0.2	4.9	1.4	0.2	4.5	6.5	4.8	11.3	11.3
9+	0.0	0.2	0.0	0.2	4.5	2.0	0.1	3.7	6.6	3.8	10.4	10.4
Sum	0.8	1.5	0.1	1.4	87.0	23.2	2.1	39.8	111.6	41.8	154.2	153.5

Table 3.2.5: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2016. Percentage age composition (based on numbers, 3+ group summarised), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	63.1%	0.0%	0.0%	0.0%	4.8%	72.8%	39.1%	0.0%	34.0%	6.7%	33.4%	31.9%
1	11.0%	0.2%	0.2%	0.2%	0.0%	3.5%	34.0%	0.0%	1.6%	5.8%	2.3%	1.9%
2	22.5%	11.0%	11.4%	11.0%	19.0%	7.3%	6.3%	12.6%	12.8%	11.5%	13.2%	12.7%
3	2.8%	25.1%	38.8%	24.8%	23.7%	8.0%	6.8%	34.8%	16.9%	30.0%	17.3%	18.0%
4	0.3%	10.3%	9.8%	10.3%	9.8%	1.8%	1.4%	9.2%	6.3%	7.9%	6.2%	6.5%
5	0.1%	6.7%	10.7%	6.6%	10.4%	1.7%	3.0%	8.1%	6.1%	7.3%	5.9%	6.2%
6	0.1%	14.3%	11.2%	14.4%	12.1%	2.3%	2.3%	9.3%	8.1%	8.1%	7.8%	8.1%
7	0.0%	9.2%	6.5%	9.3%	11.3%	1.2%	4.3%	10.2%	6.6%	9.2%	6.5%	6.8%
8	0.0%	11.9%	4.1%	12.0%	4.6%	0.6%	2.5%	9.3%	3.8%	8.2%	3.9%	4.1%
9+	0.0%	11.3%	7.3%	11.4%	4.2%	0.9%	0.4%	6.4%	3.7%	5.4%	3.6%	3.8%
Sum 3+	3.4%	88.8%	88.4%	88.8%	76.2%	16.4%	20.6%	87.4%	51.5%	76.0%	51.1%	53.5%
Quarter: 1												
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1	6.7%	0.0%	0.0%	0.0%	0.0%	15.1%	82.3%	0.0%	4.5%	36.4%	13.1%	14.4%
2	86.6%	14.2%	27.1%	14.0%	13.0%	41.4%	11.2%	0.0%	21.7%	5.0%	28.9%	16.5%
3	5.9%	28.1%	0.0%	28.7%	32.8%	28.2%	1.4%	34.9%	30.0%	20.1%	23.2%	26.8%
4	0.7%	16.0%	0.0%	16.3%	13.5%	3.0%	0.6%	18.9%	11.3%	10.8%	9.3%	11.1%
5	0.0%	8.7%	32.9%	8.2%	11.2%	3.0%	1.0%	9.9%	7.7%	5.9%	5.9%	7.3%
6	0.0%	19.0%	0.0%	19.3%	13.3%	4.8%	1.0%	11.8%	12.8%	7.0%	9.0%	10.9%
7	0.0%	6.1%	0.0%	6.2%	10.0%	2.7%	1.7%	9.3%	6.6%	5.9%	5.2%	6.3%
8	0.0%	0.6%	3.3%	0.6%	1.3%	0.5%	0.8%	12.3%	0.8%	7.2%	2.3%	2.8%
9+	0.0%	7.3%	36.8%	6.7%	5.0%	1.4%	0.0%	3.1%	4.5%	1.7%	3.0%	3.8%
Sum 3+	6.6%	85.7%	72.9%	86.0%	87.0%	43.5%	6.5%	100.0%	73.8%	58.6%	58.0%	69.0%
Quarter: 2												
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1	45.1%	0.2%	0.4%	0.2%	0.1%	61.7%	50.5%	0.0%	2.8%	14.0%	3.3%	2.8%
2	51.9%	10.7%	14.8%	10.6%	34.3%	15.0%	25.2%	0.0%	15.2%	7.0%	15.6%	15.2%
3	0.7%	25.4%	64.3%	25.0%	35.4%	9.8%	9.1%	34.8%	26.3%	27.7%	26.0%	26.6%
4	0.1%	10.0%	9.5%	10.0%	8.7%	3.1%	2.8%	18.8%	9.4%	14.3%	9.4%	9.5%
5	1.5%	6.4%	8.7%	6.4%	3.8%	2.2%	4.1%	9.8%	5.7%	8.2%	5.7%	5.7%
6	0.4%	13.7%	0.0%	13.9%	5.6%	4.9%	2.0%	11.8%	11.9%	9.1%	11.8%	11.8%
7	0.0%	9.3%	2.3%	9.3%	5.7%	1.6%	4.2%	9.4%	8.3%	7.9%	8.2%	8.3%
8	0.3%	12.9%	0.0%	13.0%	3.5%	0.6%	1.7%	12.4%	10.7%	9.4%	10.6%	10.6%
9+	0.0%	11.4%	0.0%	11.6%	2.9%	1.0%	0.3%	3.1%	9.5%	2.3%	9.4%	9.4%
Sum 3+	3.0%	89.1%	84.8%	89.2%	65.7%	23.3%	24.3%	100.0%	81.9%	79.0%	81.1%	81.9%
Quarter: 3												
0	82.7%	0.0%	0.0%	0.0%	0.0%	76.3%	0.0%	0.0%	42.5%	0.0%	44.8%	42.1%
1	7.9%	0.0%	0.0%	0.0%	0.0%	3.2%	0.3%	0.0%	1.8%	0.3%	2.1%	1.7%
2	6.8%	13.7%	6.2%	100.0%	19.3%	6.9%	16.2%	19.1%	12.5%	16.3%	12.2%	12.4%
3	2.2%	16.9%	21.6%	0.0%	22.1%	6.5%	34.4%	36.3%	13.4%	34.5%	12.7%	13.4%
4	0.2%	8.6%	12.2%	0.0%	10.6%	1.8%	7.9%	8.6%	5.7%	7.9%	5.4%	5.7%
5	0.1%	6.8%	10.1%	0.0%	11.9%	1.6%	13.9%	4.9%	6.1%	13.4%	5.8%	6.2%
6	0.1%	16.2%	22.8%	0.0%	13.5%	1.8%	5.6%	8.8%	7.0%	5.8%	6.6%	7.1%
7	0.0%	12.3%	12.6%	0.0%	12.6%	1.0%	13.4%	4.1%	6.1%	12.8%	5.8%	6.2%
8	0.0%	11.1%	6.3%	0.0%	5.2%	0.3%	6.5%	7.9%	2.4%	6.6%	2.3%	2.6%
9+	0.0%	14.5%	8.2%	0.0%	4.8%	0.6%	1.9%	10.3%	2.5%	2.4%	2.3%	2.6%
Sum 3+	2.6%	86.3%	93.8%	0.0%	80.7%	13.7%	83.5%	80.9%	43.2%	83.4%	40.9%	43.8%
Quarter: 4												
0	51.5%	0.0%	0.0%	0.0%	14.7%	72.2%	67.0%	0.0%	38.4%	7.9%	32.1%	31.8%
1	32.9%	0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%	0.5%	0.1%
2	12.6%	4.5%	0.0%	4.8%	16.1%	5.2%	2.6%	14.1%	11.5%	12.8%	11.8%	11.8%
3	2.5%	18.8%	0.0%	19.8%	23.8%	10.9%	10.5%	34.8%	18.4%	31.9%	21.1%	21.4%
4	0.2%	9.3%	4.0%	9.6%	8.3%	1.5%	1.9%	8.1%	5.5%	7.3%	5.8%	5.9%
5	0.2%	14.8%	0.0%	15.6%	8.9%	1.8%	4.3%	7.9%	6.0%	7.5%	6.2%	6.3%
6	0.1%	19.3%	35.7%	18.4%	10.8%	3.5%	3.2%	9.0%	7.9%	8.3%	7.9%	8.0%
7	0.1%	11.5%	0.0%	12.2%	10.1%	1.4%	6.1%	10.3%	6.5%	9.8%	7.1%	7.2%
8	0.0%	11.5%	32.1%	10.4%	3.9%	1.5%	3.6%	9.0%	3.0%	8.4%	4.1%	4.2%
9+	0.0%	10.1%	28.2%	9.2%	3.3%	2.0%	0.6%	6.8%	2.8%	6.1%	3.5%	3.5%
Sum 3+	3.1%	95.3%	100.0%	95.1%	69.1%	22.6%	30.3%	85.9%	50.0%	79.3%	55.6%	56.4%

Table 3.2.6: 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.

2014	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	51.8	0.018	1051.9	0.007	0.3	0.014	284.5	0.009	**1'388.5**	**0.007**
1	123.5	0.084	185.5	0.030	50.3	0.065	10.8	0.022	**370.1**	**0.052**
2	301.3	0.137	0.4	0.147	60.1	0.090	20.1	0.024	**381.9**	**0.124**
3	378.0	0.173	0.9	0.170	5.0	0.117	0.9	0.064	**384.8**	**0.172**
4	612.2	0.186	1.6	0.188	0.5	0.162	0.0	0.000	**614.4**	**0.186**
5	482.9	0.215	2.4	0.214	0.5	0.191	0.0	0.000	**485.8**	**0.215**
6	282.5	0.212	0.8	0.206	0.2	0.209	0.0	0.000	**283.5**	**0.212**
7	190.2	0.226	0.8	0.227	0.0	0.221	0.0	0.000	**191.0**	**0.226**
8	91.0	0.244	0.3	0.238	0.1	0.228	0.0	0.000	**91.4**	**0.244**
9+	121.5	0.242	0.9	0.222	0.0	0.000	0.0	0.000	**122.4**	**0.241**
TOTAL	2'635.0		1'245.6		116.9		316.4		4'313.9	
SOP catch	**490.2**		**14.0**		**9.5**		**3.3**		**517.0**	

Figures for A fleet include unsampled bycatch in the industrial fishery

2015	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	0.0	0.000	507.5	0.008	2.0	0.015	28.7	0.016	**538.2**	**0.009**
1	22.1	0.075	203.2	0.018	50.7	0.042	118.9	0.024	**394.9**	**0.026**
2	454.2	0.123	0.0	0.000	77.9	0.071	19.6	0.055	**551.8**	**0.113**
3	240.6	0.154	0.0	0.000	6.9	0.133	0.1	0.095	**247.6**	**0.154**
4	281.6	0.188	0.0	0.000	1.3	0.157	0.0	0.000	**282.8**	**0.188**
5	456.1	0.200	0.0	0.000	4.9	0.180	0.0	0.147	**461.0**	**0.200**
6	430.9	0.221	0.0	0.000	1.1	0.196	0.0	0.000	**432.0**	**0.221**
7	270.1	0.217	0.0	0.000	1.2	0.197	0.0	0.000	**271.3**	**0.217**
8	167.2	0.226	0.0	0.000	0.4	0.215	0.0	0.000	**167.5**	**0.226**
9+	170.3	0.243	0.0	0.000	0.0	0.000	0.0	0.000	**170.3**	**0.243**
TOTAL	2'493.1		710.7		146.3		167.3		3'517.4	
SOP catch	**472.4**		**7.8**		**10.2**		**4.4**		**494.8**	

Figures for A fleet include unsampled bycatch in the industrial fishery

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

Figures for A fleet include unsampled bycatch in the industrial fishery

Table 3.2.7: Catch at age (numbers in millions) of North Sea herring, 2001-2016.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2001	1025	58	678	473	279	319	92	39	18	2	2982
2002	319	490	513	913	294	136	164	47	34	7	2917
2003	347	172	1022	507	809	244	106	121	37	8	3375
2004	627	136	274	1333	517	721	170	100	70	22	3970
2005	919	408	203	487	1326	480	577	116	108	39	4664
2006	844	72	354	309	475	1017	257	252	65	44	3689
2007	553	46	142	413	284	307	628	147	133	23	2677
2008	713	148	260	183	199	137	118	215	74	43	2090
2009	533	98	253	108	96	88	40	58	112	34	1421
2010	526	84	243	234	124	84	63	34	59	56	1508
2011	575	124	306	271	218	130	63	52	60	66	1865
2012	627	110	412	671	403	306	151	104	89	109	2982
2013	461	327	239	482	571	422	327	145	153	160	3287
2014	1104	309	303	380	616	487	284	192	92	123	3890
2015	508	225	454	241	282	456	431	270	167	170	3204
2016	1450	86	578	813	293	280	368	307	186	173	4534

Table 3.2.8: 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, 2001-2016.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2001	0.0	0.0	11.3	10.2	6.1	7.2	2.7	1.6	0.4	0.0	39.9
2002	0.0	0.0	7.6	14.8	10.6	3.3	2.9	1.0	0.5	0.1	40.8
2003	0.0	0.0	0.0	3.1	6.0	3.5	1.2	1.3	0.5	0.1	15.7
2004	0.0	0.0	15.1	27.9	3.5	4.1	1.0	0.5	0.1	0.0	52.3
2005	0.0	0.0	6.6	17.4	12.7	2.6	3.8	1.1	0.4	0.3	44.8
2006	0.0	0.1	3.5	8.8	14.0	22.4	5.1	5.3	2.1	1.0	62.2
2007	0.0	0.0	0.1	2.6	1.3	0.6	0.8	0.4	0.5	0.2	6.3
2008	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.2	0.0	0.0	0.7
2009	0.0	0.0	1.0	2.1	3.4	1.4	1.7	4.5	1.8	1.4	17.2
2010	0.0	0.0	0.0	0.5	1.0	0.4	0.5	0.3	0.3	0.7	3.8
2011	0.0	0.0	0.1	0.4	0.4	0.2	0.1	0.1	0.1	0.2	1.6
2012	0.0	0.0	0.0	0.2	0.4	0.0	1.4	0.0	1.1	6.3	9.4
2013	0.0	0.0	0.1	0.4	0.2	0.5	0.3	0.1	0.2	0.5	2.2
2014	0.0	0.0	2.5	3.4	5.4	0.8	2.1	1.0	0.5	1.1	16.8
2015	0.0	0.0	0.1	0.9	1.4	3.9	1.8	1.4	0.9	1.2	11.7
2016	0.0	0.0	1.2	4.1	1.0	1.1	1.2	0.7	0.4	0.8	10.6

Table 3.2.9: Catch at age (numbers in millions) of NSAS taken in 3.a, and transferred to the assessment of NSAS, 2001-2016.

Year/rings	0	1	2	3	4	5	6	7	8+	Total
2001	808	557	140	15	1	0	0	0	0	1521.5
2002	411	345	48	5	1	0	0	0	0	811.0
2003	22	445	182	13	16	2	1	1	0	682.4
2004	88	71	180	21	6	10	2	2	1	380.4
2005	96	307	159	16	5	2	2	0	0	589.9
2006	35	150	50	10	3	3	1	0	0	253.3
2007	68	189	77	2	0	1	0	1	0	338.7
2008	86	87	72	2	0	0	0	0	0	247.0
2009	117	78	7	0	0	0	0	0	0	202.0
2010	49	197	43	0	0	0	0	0	0	289.6
2011	204	35	61	3	0	0	0	0	0	304.6
2012	146	175	44	2	1	0	0	0	0	368.0
2013	1	86	86	2	0	0	0	0	0	175.9
2014	285	61	80	6	1	0	0	0	0	433.3
2015	31	170	98	7	1	5	1	1	0	313.6
2016	133	23	48	6	1	0	0	0	0	211.3

Table 3.2.10: Catch at age (numbers in millions) of the total NSAS stock 2001–2016.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2001	1833	614	806	477	274	312	89	37	17	2	4463
2002	730	835	553	903	284	133	161	46	33	7	3687
2003	369	617	1204	517	820	243	106	120	37	8	4042
2004	716	207	439	1326	520	726	171	101	71	22	4298
2005	1016	716	355	486	1318	480	576	115	108	39	5209
2006	879	222	401	311	465	999	253	249	63	44	3885
2007	621	236	219	412	283	308	628	147	132	23	3009
2008	798	235	332	185	199	137	118	215	74	43	2336
2009	650	176	259	107	93	86	38	53	110	33	1606
2010	575	281	287	233	123	83	63	34	59	55	1794
2011	779	160	368	274	218	130	63	52	60	65	2168
2012	773	285	455	673	404	306	150	104	88	102	3341
2013	462	413	325	484	571	422	327	145	152	160	3461
2014	1389	371	383	386	617	488	285	192	92	123	4323
2015	538	395	552	248	283	461	432	271	168	170	3517
2016	1584	109	625	819	293	280	368	307	186	173	4745

Table 3.2.11: 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 2006–2016.

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
3.a	2006	0.079	0.117	0.140	0.186	0.191	0.216	0.207	-
	2007	0.071	0.108	0.125	0.152	0.184	0.175	0.154	-
	2008	0.087	0.109	0.139	0.168	0.176	0.204	0.198	-
	2009	0.101	0.082	0.206	0.000	0.000	0.000	0.269	-
	2010	0.077	0.122	0.149	0.191	0.221	0.216	0.205	-
	2011	0.084	0.114	0.134	0.191	0.193	0.234	0.248	-
	2012	0.067	0.124	0.169	0.175	0.200	0.221	0.216	-
	2013	0.075	0.134	0.160	0.201	0.000	0.000	0.000	-
	2014	0.074	0.109	0.162	0.191	0.209	0.221	0.228	-
	2015	0.068	0.133	0.157	0.180	0.196	0.197	0.215	-
	2016	0.059	0.123	0.149	0.157	0.208	0.211	0.235	-
4.a(E)	2006	0.125	0.149	0.164	0.175	0.214	0.224	0.229	0.254
	2007	0.156	0.148	0.156	0.186	0.184	0.204	0.226	0.239
	2008	0.138	0.173	0.172	0.174	0.216	0.210	0.253	0.266
	2009	0.139	0.167	0.208	0.219	0.232	0.245	0.253	0.288
	2010	0.131	0.154	0.201	0.201	0.210	0.223	0.248	0.235
	2011	0.142	0.162	0.180	0.204	0.215	0.209	0.216	0.222
	2012	0.146	0.185	0.195	0.203	0.216	0.225	0.225	0.232
	2013	0.129	0.147	0.184	0.191	0.205	0.215	0.215	0.228
	2014	0.146	0.161	0.167	0.195	0.200	0.216	0.227	0.224
	2015	0.127	0.148	0.163	0.178	0.191	0.203	0.212	0.227
	2016	0.129	0.153	0.167	0.183	0.195	0.205	0.216	0.229
4.a(W)	2006	0.145	0.156	0.180	0.193	0.230	0.251	0.247	0.286
	2007	0.150	0.156	0.166	0.196	0.191	0.227	0.241	0.264
	2008	0.142	0.187	0.187	0.188	0.230	0.219	0.262	0.281
	2009	0.152	0.180	0.211	0.223	0.266	0.251	0.252	0.278
	2010	0.137	0.166	0.195	0.223	0.220	0.216	0.236	0.252
	2011	0.141	0.161	0.185	0.195	0.216	0.223	0.220	0.243
	2012	0.132	0.184	0.186	0.206	0.226	0.240	0.242	0.254
	2013	0.139	0.158	0.201	0.197	0.218	0.234	0.234	0.251
	2014	0.143	0.172	0.184	0.215	0.212	0.227	0.246	0.242
	2015	0.124	0.158	0.198	0.211	0.233	0.228	0.239	0.252
	2016	0.138	0.161	0.189	0.215	0.227	0.242	0.233	0.250
4.b	2006	0.097	0.141	0.172	0.183	0.202	0.220	0.232	0.239
	2007	0.145	0.160	0.180	0.201	0.210	0.246	0.234	0.252
	2008	0.142	0.172	0.185	0.191	0.222	0.228	0.265	0.223
	2009	0.140	0.188	0.228	0.219	0.223	0.243	0.255	0.255
	2010	0.134	0.176	0.182	0.229	0.237	0.235	0.232	0.265
	2011	0.145	0.162	0.187	0.206	0.235	0.234	0.240	0.268
	2012	0.131	0.141	0.178	0.209	0.214	0.245	0.250	0.258
	2013	0.125	0.162	0.205	0.206	0.228	0.251	0.261	0.246
	2014	0.133	0.187	0.208	0.233	0.240	0.249	0.256	0.277
	2015	0.140	0.162	0.189	0.203	0.208	0.216	0.227	0.250
	2016	0.126	0.161	0.192	0.211	0.218	0.236	0.236	0.253

Table 3.2.11 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 2006–2016.

		Age (Rings)							
Division	Year	2	3	4	5	6	7	8	9+
4.a & 4.b	2006	0.123	0.150	0.174	0.187	0.222	0.239	0.238	0.269
	2007	0.149	0.155	0.165	0.196	0.192	0.227	0.238	0.257
	2008	0.142	0.182	0.185	0.188	0.226	0.220	0.262	0.275
	2009	0.142	0.183	0.217	0.221	0.248	0.248	0.253	0.277
	2010	0.136	0.167	0.192	0.224	0.222	0.220	0.236	0.250
	2011	0.142	0.161	0.184	0.198	0.220	0.224	0.224	0.243
	2012	0.132	0.171	0.185	0.207	0.222	0.239	0.243	0.248
	2013	0.132	0.158	0.198	0.198	0.217	0.234	0.235	0.244
	2014	0.138	0.174	0.187	0.216	0.213	0.227	0.246	0.243
	2015	0.129	0.157	0.190	0.203	0.223	0.219	0.228	0.245
	2016	0.134	0.159	0.185	0.210	0.218	0.235	0.226	0.242
4.c & 7.d	2006	0.119	0.125	0.153	0.152	0.178	0.205	0.209	0.219
	2007	0.129	0.131	0.154	0.158	0.173	0.196	0.209	0.218
	2008	0.120	0.157	0.156	0.173	0.188	0.192	0.215	0.247
	2009	0.156	0.162	0.197	0.197	0.211	0.192	0.219	0.244
	2010	0.145	0.167	0.187	0.204	0.207	0.207	0.223	0.216
	2011	0.122	0.154	0.179	0.189	0.195	0.205	0.209	0.217
	2012	0.119	0.165	0.186	0.202	0.212	0.234	0.209	0.226
	2013	0.126	0.144	0.180	0.196	0.206	0.216	0.218	0.226
	2014	0.119	0.148	0.166	0.183	0.208	0.222	0.227	0.233
	2015	0.114	0.127	0.154	0.157	0.183	0.197	0.204	0.210
	2016	0.114	0.127	0.137	0.166	0.177	0.199	0.193	0.216
Total	2006	0.122	0.145	0.172	0.181	0.220	0.237	0.235	0.262
North Sea	2007	0.149	0.152	0.164	0.194	0.190	0.224	0.235	0.252
Catch	2008	0.141	0.180	0.181	0.183	0.216	0.216	0.256	0.273
	2009	0.145	0.181	0.216	0.216	0.239	0.243	0.248	0.273
	2010	0.138	0.167	0.192	0.222	0.219	0.217	0.234	0.245
	2011	0.141	0.160	0.183	0.197	0.217	0.221	0.223	0.240
	2012	0.130	0.171	0.185	0.206	0.222	0.239	0.239	0.247
	2013	0.131	0.156	0.198	0.198	0.215	0.233	0.234	0.241
	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

Table 3.2.12: Sampling of commercial landings of North Sea herring (Division 4 and 7.d) in 2016 by quarter. Sampled catch means the proportion of the reported catch to which sampling was applied. It is not possible to judge the quality of the sampling by this figure alone. Note that only one nation sampled their by-catches in the industrial fishery (Denmark, fleet B). Metiers are each reported combination of nation/fleet/area/quarter.

Country (fleet)	Quarter	No of metiers	Metiers sampled	Sampled Catch %	Official landings	No. of samples	No. fish aged	No. fish measured	>1 sample per 1 kt catch
Belgium	1	2	0	0%	12	0	0	0	n
	2	3	0	0%	4	0	0	0	n
	3	1	0	0%	0	0	0	0	n
	4	3	0	0%	12	0	0	0	n
total		9	0	0%	27	0	0	0	n
Denmark (A)	1	3	2	76%	8222	6	157	802	n
	2	3	2	89%	14904	23	621	2731	y
	3	3	2	97%	68097	34	896	4178	n
	4	3	2	100%	28214	17	452	2448	n
total		12	8	95%	119437	80	2126	10159	n
Denmark (B)	1	4	2	96%	1022	2	24	24	y
	2	3	2	100%	473	2	12	12	y
	3	3	1	94%	7806	65	290	1912	y
	4	3	2	65%	5224	16	71	71	y
total		13	7	84%	14526	85	397	2019	y
England & Wales	1	3	2	100%	647	8	200	1785	y
	2	4	2	100%	956	12	300	2050	y
	3	4	2	100%	15804	28	699	3541	y
	4	4	1	97%	3079	2	50	327	n
total		15	7	99%	20487	50	1249	7703	y
France	1	2	0	0%	3003	0	0	0	n
	2	4	1	98%	4153	10	259	2463	y
	3	4	0	0%	15321	0	0	0	n
	4	4	0	0%	12699	0	0	0	n
total		14	1	12%	35176	10	259	2463	n
Germany	1	1	0	0%	8	0	0	0	n
	3	2	2	100%	27789	46	839	21167	y
	4	4	2	97%	16434	30	376	10082	y
total		7	4	99%	44231	76	1215	31249	y
Ireland	4	1	0	0%	127	0	0	0	n
total		1	0	0%	127	0	0	0	n
Netherlands	1	1	1	100%	106	2	50	377	y
	3	3	2	100%	79667	60	1500	8013	n
	4	5	2	98%	19255	3	75	477	n
total		9	5	100%	99028	65	1625	8867	n
Norway	1	2	2	100%	4722	4	159	246	n
	2	3	2	100%	77221	26	1256	1592	n
	3	3	2	76%	8204	3	128	161	n
	4	3	2	98%	60036	15	470	867	n
total		11	8	98%	150182	48	2013	2866	n
Scotland	1	1	0	0%	0	0	0	0	n
	2	1	1	100%	2295	2	92	291	n
	3	2	1	99%	55324	29	1320	4313	n
	4	1	0	0%	1621	0	0	0	n
total		5	2	96%	59240	31	1412	4604	n
Sweden	1	1	0	0%	0	0	0	0	n
	2	3	0	0%	5151	0	0	0	n
	3	2	0	0%	5267	0	0	0	n
	4	3	0	0%	6207	0	0	0	n
total		9	0	0%	16624	0	0	0	n
Faroese	3	2	0	0%	178	0	0	0	n
	4	2	0	0%	654	0	0	0	n
total		4	0	0%	832	0	0	0	n
grand total		109	42	89%	559919	445	10296	69930	n
Period total	1	20	9	72%	17742	22	590	3234	y
Period total	2	24	10	93%	105157	75	2540	9139	n
Period total	3	29	12	91%	283457	265	5672	43285	n
Period total	4	36	11	83%	153563	83	1494	14272	n
Total for stock 2016		109	42	89%	559919	445	10296	69930	n
Human Cons. only		96	35	89%	545393	360	9899	67911	n
Total for stock 2014		97	35	83%	504190	369	8794	57454	n
Total for stock 2015		107	34	86%	480093	526	9629	99748	n
Human Cons. only 2015		96	30	86%	472184	401	9347	98730	n

Table 3.3.1.1. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June-July 2016. Vessels, areas and cruise dates.

VESSEL	PERIOD	CONTRIBUTING TO STOCKS	STRATA
Celtic Explorer (IRL) EIGB	18 June – 06 July	MSHAS, WoS	2, 3, 4, 5, 6
Scotia (SCO) MXHR6	25 June – 15 July	MSHAS,WoS, NSAS, Sprat NS	1a, 1b, 91 (north of 58°30'N), 101
Scottish Charter (SCO)	25 June – 15 July	NSAS	111, 121
Johan Hjort (NOR) LDGJ	27 June – 14 July	NSAS, WBSS	11, 141
Tridens (NED) PBVO	27 June – 122 July	NSAS, Sprat NS	81, 91 (south of 58°30'N)
Solea (GER) DBFH	29 June – 19 July	NSAS, Sprat NS	51, 61, 71, 131
Dana (DEN) OXBH	22 June – 5 July	NSAS, WBSS, Sprat NS, Sprat IIIa	21, 31, 41, 151

Table 3.3.1.2. North Sea herring. Acoustic Surveys in the North Sea (HERAS) in June-July 2016. 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	21044	98	0.00	4.6	8.4
1	9034	330	0.01	36.5	16.7
2	12011	1342	0.71	111.7	23.2
3	5832	924	0.89	158.3	26.0
4	1273	238	0.95	186.9	27.3
5	822	184	0.97	223.3	28.7
6	909	213	0.98	234.7	29.2
7	395	96	1.00	243.0	29.7
8	220	51	1.00	232.1	29.7
9+	146	35	0.99	236.4	30.0
Immature	34187	862		25.2	12.3
Mature	17499	2648		151.3	25.4
Total	51686	3509	0.34	67.9	16.7

Table 3.3.1.3. Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1986—2016. 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 2016 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
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

Table 3.3.2.1: North Sea herring – LAI, MLAI, and SCAI 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			MLAI	SCAI
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			3299
1973	2029	822	3	4	492	830	1213			1	13.1	3227
1974	758	421	101	284	81		1184		10		7.6	2195
1975	371	50	312			90	77	1	2		2.9	1386
1976	545	81		1	64	108			3		2.5	1238
1977	1133	221	124	32	520	262	89	1			6.2	1635
1978	3047	50		162	1406	81	269	33	3		7.4	2131
1979	2882	2362	197	10	662	131	507		111	89	13.7	3195
1980	3534	720	21	1	317	188	9	247	129	40	9.3	3494
1981	3667	277	3	12	903	235	119	1456		70	13.7	3959
1982	2353	1116	340	257	86	64	1077	710	275	54	19.8	5027
1983	2579	812	3647	768	1459	281	63	71	243	58	24.9	7715
1984	1795	1912	2327	1853	688	2404	824	523	185	39	45.5	12038
1985	5632	3432	2521	1812	130	13039	1794	1851	407	38	69.7	15061
1986	3529	1842	3278	341	1611	6112	188	780	123	18	36.3	14569
1987	7409	1848	2551	670	799	4927	1992	934	297	146	64.1	18359
1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112	128.0	25735
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512	127.7	21812
1990		10144	4590	2045	19955	1239	975	2552	1204		165.9	20219
1991	1021	2397		2032	4823	2110	1249	4400	873		87.8	13878
1992	189	4917		822	10	165	163	176	1616		40.0	7485
1993		66		174		685	85	1358	1103		29.3	5090
1994	26	1179				1464	44	537	595		20.1	4462
1995		8688					43	74	230	164	20.3	5562
1996		809		184		564		337	675	691	40.0	7021
1997		3611		23				9374	918	355	51.5	9851
1998		8528		1490	205	66		1522	953	170	64.4	13063
1999		4064		185		134	181	804	1260	344	55.0	14210
2000		3352	28	83		376		7346	338	106	37.3	16304
2001		11918		164		1604		971	5531	909	125.1	21446
2002		6669		1038			3291	2008	260	925	102.3	25831
2003		3199		2263		12018	3277	12048	3109	1116	246.9	33061
2004		7055		3884		5545		7055	2052	4175	306.9	36345
2005		3380		1364		5614		498	3999	4822	183.9	31877
2006	6311	2312		280		2259		10858	2700	2106	112.0	29625
2007		1753		1304		291		4443	2439	3854	159.6	30817
2008	4978	6875		533		11201		8426	2317	4008	178.2	37451
2009		7543		4629		4219		15295	14712	1689	458.0	46670
2010		2362		1493		2317		7493	13230	8073	375.4	47238
2011		3831		2839		17766		5461	6160	1215	309.9	49554
2012		19552		5856		517		22768	11103	3285	650.9	57550
2013		21282		8618		7354		5	9314	2957	310.7	59197
2014		6604		5033		1149				1851	285.8	54568
2015		9631		3496		3424		2011	1200	645	149.0	53458
2016				3872		3288		20710	1442	1545	324.6	58176

Table 3.3.3.1 North Sea herring. Density and abundance estimates of 0-wr fish caught in February during the IBTS. Values given for the 1995 to 2016 year classes by areas are density estimates in numbers per square metre. Total abundance is found by multiplying density by area and summing up. Data for the period 1976 to 1994 are recorded in the stock annex.

Area	North west	North east	Central west	Central east	South west	South east	Division 3.a	South'Bight	IBTS-0 index
Area m2 x 109	83	34	86	102	37	93	31	31	
Year class									no. in 109
1995	0.26	0.086	0.699	0.092	0.266	0.018	0.001	0.02	106.2
1996	0.003	0.004	0.935	0.135	0.436	0.379	0.039	0.032	148.1
1997	0.042	0.021	0.338	0.064	0.178	0.035	0.023	0.083	53.1
1998	0.1	0.056	1.15	0.592	0.998	0.265	0.28	0.127	244.0
1999	0.045	0.011	0.799	0.2	0.514	0.22	0.107	0.026	137.1
2000	0.284	0.011	1.052	0.197	1.156	0.376	0.063	0.006	214.8
2001	0.08	0.019	0.566	0.473	0.567	0.247	0.209	0.226	161.8
2002	0.141	0.04	0.287	0.028	0.121	0.045	0.003	0.157	54.4
2003	0.045	0.005	0.284	0.074	0.106	0.021	0.022	0.154	47.3
2004	0.017	0.010	0.189	0.089	0.268	0.187	0.027	0.198	61.3
2005	0.013	0.018	0.327	0.081	0.633	0.184	0.007	0.131	83.1
2006	0.004	0.001	0.240	0.025	0.098	0.018	0.040	0.228	37.2
2007	0.013	0.009	0.184	0.029	0.067	0.047	0.018	0.007	27.8
2008	0.145	0.139	0.277	0.241	0.101	0.093	0.160	0.433	95.8
2009	0.077	0.085	0.228	0.073	0.350	0.253	0.000	0.139	77.1
2010	0.024	0.004	0.586	0.063	0.187	0.090	0	0.080	77.0
2011	0.008	0.001	0.345	0.136	0.215	0.129	0.076	0.040	68.0
2012	0.018	0.005	0.198	0.094	0.108	0.181	0.006	0.038	50.4
2013	0.132	0.151	0.240	0.254	0.389	0.678	0.037	0.759	164.5
2014	0.010	0.006	0.150	0.047	0.038	0.002	0.009	0.007	20.8
2015	0.015	0.015	0.137	0.088	0.083	0.712	0.006	0.259	99.8
2016	0.005	0.001	0.143	0.020	0.084	0.035	0.020	0.028	22.8

Table 3.3.3.1.2 North Sea herring. Density and abundance estimates of 0-wr fish caught in February during the IBTS. Values given for the 1991 to 2016 year classes by areas are density estimates in numbers per square metre according to the newly proposed index calculation algorithm. Total abundance is found by multiplying density by area and summing up. Data for the period 1976 to 1994 are recorded in the stock annex.

Area	North west	North east	Central west	Central east	South west	South east	Division 3.A	South'Bight	IBTS-0 index
Area m2 x 109	83	34	86	102	37	93	31	31	
Year class									no. in 109
1991	0.227	0.074	0.364	0.444	0.466	0.329	0.330	0.259	164.0
1992	0.191	0.037	0.576	0.387	0.638	0.300	0.359	0.871	195.8
1993	0.574	0.231	0.545	0.178	0.117	0.140	0.223	0.322	155.1
1994	0.131	0.023	0.438	0.359	0.360	0.174	0.503	1.277	170.5
1995	0.222	0.053	0.644	0.069	0.246	0.015	0.015	0.424	107.0
1996	0.026	0.003	0.878	0.099	0.443	0.298	0.040	0.034	134.5
1997	0.039	0.021	0.295	0.059	0.181	0.035	0.021	0.186	51.7
1998	0.095	0.054	1.074	0.543	0.994	0.296	0.242	0.839	255.5
1999	0.042	0.011	0.725	0.149	0.316	0.141	0.105	0.043	111.1
2000	0.237	0.005	0.764	0.161	0.813	0.790	0.065	4.354	342.0
2001	0.076	0.018	0.528	0.456	0.487	0.301	0.261	NA	152.9
2002	0.117	0.031	0.241	0.030	0.127	0.058	0.003	0.841	70.9
2003	0.044	0.004	0.248	0.068	0.119	0.019	0.036	0.145	43.9
2004	0.016	0.008	0.205	0.097	0.511	0.228	0.053	0.399	83.3
2005	0.013	0.018	0.315	0.079	0.291	0.154	0.011	0.068	64.5
2006	0.004	0.001	0.213	0.038	0.133	0.020	0.065	0.698	52.9
2007	0.013	0.009	0.185	0.031	0.084	0.058	0.019	0.320	39.5
2008	0.145	0.138	0.281	0.253	0.158	0.139	0.160	0.279	99.2
2009	0.073	0.074	0.194	0.052	0.390	0.291	0.000	0.042	73.5
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

Table 3.3.3.2. North Sea herring. Indices of 1-wr fish from the IBTS 1st Quarter for the 1995 to 2015 year classes (the data for the 1977 to 1994 year classes can be found in the stock annex). Estimation of the small sized component (possibly Downs herring) in different areas. "North Sea" = total area of sampling minus 3.a.

Year class	Year of sampling	All 1-ringers in total area (IBTS-1 index) (no/hour)	Small<13cm 1-ringers in total area (no/hour)	Proportion of small in total area vs. all sizes	Small<13cm 1-ringers in North Sea (no/hour)	Proportion of small in North Sea vs. all sizes	Proportion of small in 3.a vs small in total area
1995	1997	4403	1356	0.31	1089	0.25	0.25
1996	1998	2276	1322	0.58	1399	0.61	0.02
1997	1999	753	152	0.2	149	0.20	0.09
1998	2000	3304	1068	0.32	939	0.28	0.18
1999	2001	2499	328	0.13	307	0.12	0.13
2000	2002	3881	1520	0.39	1436	0.37	0.12
2001	2003	2837	664	0.23	180	0.06	0.75
2002	2004	979	665	0.68	710	0.73	0.01
2003	2005	1015	341	0.34	357	0.35	0.02
2004	2006	900	115	0.13	121	0.13	0.02
2005	2007	1322	303	0.23	304	0.23	0.07
2006	2008	1792	417	0.23	444	0.25	0.01
2007	2009	2339	734	0.31	623	0.27	0.21
2008	2010	1206	279	0.23	286	0.24	0.05
2009	2011	2939	1331	0.45	1407	0.48	0.02
2010	2012	1353	279	0.21	288	0.21	0.04
2011	2013	1665	747	0.45	796	0.48	0.01
2012	2014	2615	1297	0.5	1245	0.48	0.11
2013	2015	3918	1808	0.46	1105	0.28	0.43
2014	2016	782	368	0.47	364	0.47	0.08
2015	2017	2390	1307	0.55	1010	0.42	0.28

Table 3.4.1.1. North Sea herring. Mean stock weight-at-age (wr) in the third quarter, in divisions 4.a, 4.b and 3.a. Mean catch weight-at-age for the same quarter and area is included for comparison. AS = acoustic survey, 3Q = catch.

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

Table 3.4.2.1. 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 2016. In the period 1988-2014, maturity of age 5+ were set to 100%.

YEAR \ RING	2	3	4	5	6	7+
1988	65.6	87.7	100	100	100	100
1989	78.7	93.9	100	100	100	100
1990	72.6	97.0	100	100	100	100
1991	63.8	98.0	100	100	100	100
1992	51.3	100	100	100	100	100
1993	47.1	62.9	100	100	100	100
1994	72.1	85.8	100	100	100	100
1995	72.6	95.4	100	100	100	100
1996	60.5	97.5	100	100	100	100
1997	64.0	94.2	100	100	100	100
1998	64.0	89.0	100	100	100	100
1999	81.0	91.0	100	100	100	100
2000	66.0	96.0	100	100	100	100
2001	77.0	92.0	100	100	100	100
2002	86.0	97.0	100	100	100	100
2003	43.0	93.0	100	100	100	100
2004	69.8	64.9	100	100	100	100
2005	76.0	97.0	96.0	100	100	100
2006	66.0	88.0	98.0	100	100	100
2007	71.0	92.0	93.0	100	100	100
2008	86.0	98.0	99.0	100	100	100
2009	89.0	100	100	100	100	100
2010	45.0	90.0	100	100	100	100
2011	87.0	84.0	99.0	100	100	100
2012	91.0	99.0	100	100	100	100
2013	83.0	96.0	98.0	100	100	100
2014	85.0	100	100	100	100	100
2015	70.0	90.0	96.0	98.0	99.0	100
2016	71.0	89.0	95.0	97.0	98.0	100

Table 3.6.1.1 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
SCAI (Larvae survey)	SSB	1972-2016	1973-2016
IBTS 1st Quarter (Trawl survey)	1-wr	1971-2017	1984-2017
Acoustic (+trawl)	1wr	1995-2016	1997-2016
	2-9+wr	1984-2016	1989-2016
IBTS0	0wr	1977-2016	1992-2017

Table 3.6.3.1 North Sea Herring. Catch in numbers.

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	1964
0	96000	279000	97000	0	194600	1269200	141800	442800	496900
1	1697000	1483000	4279000	1609000	2392700	336000	2146900	1262200	2971700
2	1860000	1644000	1029000	4934000	1142300	1889400	269600	2961200	1547500
3	1221000	736000	999000	488000	1966700	479900	797400	177200	2243100
4	516000	644000	322000	497000	165900	1455900	335100	158300	148400
5	249000	344000	461000	233000	167700	124000	1081800	80600	149000
6	194000	207000	147000	249000	112900	157900	126900	229700	95000
7	104000	147000	73000	120000	125800	61400	145100	22400	256300
8	292000	253000	118000	301000	270600	143500	173100	93000	84000

age \ year	1965	1966	1967	1968	1969	1970	1971	1972	1973
0	157100	374500	645400	839300	112000	898100	684000	750400	289400
1	3209300	1383100	1674300	2425000	2503300	1196200	4378500	3340600	2368000
2	2217600	2569700	1171500	1795200	1883000	2002800	1146800	1440500	1344200
3	1324600	741200	1364700	1494300	296300	883600	662500	343800	659200
4	2039400	450100	371500	621400	133100	125200	208300	130600	150200
5	145100	889800	297800	157100	190800	50300	26900	32900	59300
6	151900	45300	393100	145000	49900	61000	30500	5000	30600
7	117600	64800	67900	163400	42700	7900	26800	200	3700
8	491400	331800	254400	105500	52500	24200	12500	1500	2000

age \ year	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	996100	263800	238200	256800	NA	NA	1262700	9519700	11956700
1	846100	2460500	126600	144300	NA	NA	245100	872000	1116400
2	772600	541700	901500	44700	NA	NA	134000	284300	299400
3	362000	259600	117300	186400	NA	NA	91800	56900	230100
4	126000	140500	52000	10800	NA	NA	32200	39500	33700
5	56100	57200	34500	7000	NA	NA	21700	28500	14400
6	22300	16100	6100	4100	NA	NA	2300	22700	6800
7	5000	9100	4400	1500	NA	NA	1400	18700	7800
8	3100	4800	1400	700	NA	NA	500	6600	4700

age \ year	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	13296900	6973300	4211000	3724700	8229200	3164800	3057800	1302800	2386600
1	2448600	1818400	3253000	4801400	6836300	7867000	3145900	3020000	2138900
2	573800	1146200	1326300	1266700	2137200	2232500	1593700	899300	1132800
3	216400	441400	1182400	840800	667900	1090700	1363800	779100	556700
4	105100	201500	368500	465900	467100	383700	809300	861000	548900
5	26200	81100	124500	129800	245800	255800	211800	387500	501200
6	22800	22600	43600	62100	74700	128100	123700	80200	205300
7	12800	25200	20200	20500	23800	38000	61000	54400	39300
8	23100	29700	29200	28400	16200	23800	28200	40700	38600

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	10331300	10265400	4498900	7438469	2311226	431175	259526	1566349	1105085
1	2303100	3826800	1785200	1664874	1606393	479702	977680	303520	1171677
2	1284900	1176300	1783200	1444061	642084	687920	1220105	616354	622853
3	442700	609000	489100	816703	525601	446909	537932	1058716	463170
4	361500	305500	347600	231794	172099	284920	276333	294066	646814
5	360500	215600	109000	118536	57586	109178	175817	135648	213466
6	375600	226000	91800	55128	22534	31389	88927	69299	82481
7	152400	188000	76400	41409	9264	11832	15232	27998	35706
8	62500	129000	116600	98200	21143	24467	20550	12228	17087

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	1832691	730279	369074	715597	1015554	878637	621005	798284	650043
1	614469	837557	617021	206648	715547	222111	235553	235022	175923
2	842635	579592	1221992	447918	355453	401087	219115	331772	259434
3	485628	970577	529386	1366155	485746	310602	417452	184771	106738
4	278884	292205	835552	543376	1318647	464620	285746	199069	93321
5	321743	140701	244780	753231	479961	997782	309454	137529	86137
6	90918	174570	107751	169324	576154	252150	629187	118349	37951
7	38252	48908	123291	104945	115212	247042	147830	215542	53130
8	20602	43322	46715	97142	146808	106412	156750	117258	143131

Table 3.6.3.1 (continued). North Sea Herring. Catch in numbers.

age \ year	2010	2011	2012	2013	2014	2015	2016
0	574895	778927	773241	461571	1388685	538228	1583568
1	280728	159504	284906	413000	370590	394878	109135
2	293887	367820	455259	324920	382990	551802	625483
3	236804	275016	673465	485185	386131	247555	818585
4	126241	218711	404265	571269	616563	282813	293372
5	83893	130127	306234	422765	487582	461041	280451
6	61542	62938	152577	327213	284562	432034	367844
7	33305	52081	104461	145330	191729	271280	307347
8	113675	125734	205427	313638	214513	337811	359076

Table 3.6.3.2 North Sea Herring. Weight at age in the catch.

Units : kg

age \ year	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
0	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500
1	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000
2	0.12200	0.12200	0.12800	0.12800	0.13400	0.13700	0.13700	0.13900	0.14000	0.14000
3	0.14000	0.14000	0.14500	0.15100	0.15700	0.16500	0.16700	0.16900	0.17000	0.17200
4	0.15600	0.15600	0.16100	0.16600	0.17600	0.18300	0.19000	0.19300	0.19500	0.19700
5	0.17100	0.17100	0.17600	0.18000	0.18900	0.19900	0.20500	0.21100	0.21400	0.21600
6	0.18500	0.18500	0.18900	0.19300	0.20100	0.21000	0.21800	0.22300	0.22800	0.23100
7	0.19700	0.19700	0.20100	0.20400	0.21100	0.21900	0.22600	0.23300	0.23800	0.24200
8	0.24200	0.24200	0.24350	0.24500	0.24750	0.25100	0.25400	0.25650	0.25950	0.26100

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
0	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500
1	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000
2	0.14100	0.14100	0.14300	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600
3	0.17300	0.17400	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600
4	0.19800	0.19900	0.20100	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100
5	0.21800	0.21900	0.22100	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300
6	0.23300	0.23400	0.23600	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100
7	0.24400	0.24500	0.24700	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700
8	0.26250	0.26350	0.26450	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100

age \ year	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
0	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500	0.01500
1	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000	0.05000
2	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600	0.12600
3	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600	0.17600
4	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100	0.21100
5	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300	0.24300
6	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100	0.25100
7	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700	0.26700
8	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100	0.27100

age \ year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	0.01500	0.01500	0.01500	0.01500	0.00700	0.01000	0.01000	0.01000	0.00900	0.00600
1	0.05000	0.05000	0.05000	0.05000	0.04900	0.05900	0.05900	0.05900	0.03600	0.06700
2	0.12600	0.12600	0.12600	0.12600	0.11800	0.11800	0.11800	0.11800	0.12800	0.12100
3	0.17600	0.17600	0.17600	0.17600	0.14200	0.14900	0.14900	0.14900	0.16400	0.15300
4	0.21100	0.21100	0.21100	0.21100	0.18900	0.17900	0.17900	0.17900	0.19400	0.18200
5	0.24300	0.24300	0.24300	0.24300	0.21100	0.21700	0.21700	0.21700	0.21100	0.20800
6	0.25100	0.25100	0.25100	0.25100	0.22200	0.23800	0.23800	0.23800	0.22000	0.22100
7	0.26700	0.26700	0.26700	0.26700	0.26700	0.26500	0.26500	0.26500	0.25800	0.23800
8	0.27100	0.27100	0.27100	0.27100	0.27100	0.27423	0.27452	0.27463	0.28213	0.25721

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	0.01100	0.01100	0.01700	0.01900	0.01700	0.01000	0.01000	0.00600	0.00900	0.01500
1	0.03500	0.05500	0.04300	0.05500	0.05800	0.05300	0.03300	0.05600	0.04200	0.01800
2	0.09900	0.11100	0.11500	0.11400	0.13000	0.10200	0.11500	0.13000	0.13000	0.11200
3	0.15000	0.14500	0.15300	0.14900	0.16600	0.17500	0.14500	0.15900	0.16900	0.15600
4	0.18000	0.17400	0.17300	0.17700	0.18400	0.18900	0.18900	0.18100	0.19800	0.18800
5	0.21100	0.19700	0.20800	0.19300	0.20300	0.20700	0.20400	0.21400	0.20700	0.20400
6	0.23400	0.21600	0.23100	0.22900	0.21700	0.22300	0.22800	0.24000	0.24300	0.21200
7	0.25800	0.23700	0.24700	0.23600	0.23500	0.23700	0.24400	0.25500	0.24700	0.26100
8	0.28814	0.25657	0.26315	0.26082	0.26304	0.26317	0.27346	0.27620	0.28092	0.28149

age \ year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	0.01500	0.02100	0.00900	0.01500	0.01200	0.01200	0.01400	0.01400	0.01100	0.01000
1	0.04400	0.05100	0.04500	0.03300	0.04800	0.03700	0.03700	0.03600	0.04400	0.04900
2	0.10800	0.11400	0.11500	0.11300	0.11800	0.11800	0.10400	0.10000	0.09900	0.11700
3	0.14800	0.14500	0.15100	0.15700	0.14900	0.15300	0.15800	0.13800	0.15300	0.14400
4	0.19500	0.18300	0.17100	0.17900	0.17700	0.17000	0.17400	0.18300	0.16600	0.17200
5	0.22700	0.21900	0.20700	0.20100	0.19800	0.19900	0.18400	0.20100	0.20800	0.18100
6	0.22600	0.23800	0.23300	0.21600	0.21300	0.21400	0.20500	0.21600	0.22300	0.22000
7	0.23500	0.24700	0.24500	0.24600	0.23800	0.22800	0.22200	0.22800	0.24000	0.23700
8	0.25494	0.28790	0.26772	0.27313	0.26974	0.25040	0.23665	0.25451	0.26537	0.24601

Table 3.6.3.2 (continued). North Sea Herring. Weight at age in the catch.

age \ year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	0.01240	0.00790	0.00940	0.00750	0.00800	0.01060	0.00770	0.00750	0.00870	0.00710
1	0.06380	0.05350	0.05140	0.05710	0.04130	0.04630	0.04680	0.05220	0.02610	0.02650
2	0.12140	0.12880	0.14400	0.12920	0.13170	0.12430	0.11620	0.12400	0.11350	0.12670
3	0.15130	0.17960	0.18110	0.16690	0.15930	0.17060	0.15630	0.17190	0.15380	0.15490
4	0.16340	0.18120	0.21580	0.19120	0.18310	0.18540	0.19770	0.18610	0.18830	0.18030
5	0.19330	0.18320	0.21620	0.22030	0.19700	0.20580	0.19800	0.21480	0.20010	0.20590
6	0.19000	0.21570	0.23900	0.21930	0.21670	0.22150	0.21540	0.21180	0.22120	0.21510
7	0.22320	0.21610	0.24280	0.21600	0.22110	0.23870	0.23340	0.22640	0.21700	0.23130
8	0.23749	0.26208	0.25327	0.23839	0.23192	0.24272	0.23784	0.24265	0.23472	0.22992

Table 3.6.3.3 North Sea Herring. Weights at age in the stock.

Units : kg

age \ year	1947	1948	1949	1950	1951	1952	1953	1954
0	0.0150000	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	0.0500000
2	0.1220000	0.1220000	0.1240000	0.1260000	0.1300000	0.1330000	0.1360000	0.1376667
3	0.1400000	0.1400000	0.1416667	0.1453333	0.1510000	0.1576667	0.1630000	0.1670000
4	0.1560000	0.1560000	0.1576667	0.1610000	0.1676667	0.1750000	0.1830000	0.1886667
5	0.1710000	0.1710000	0.1726667	0.1756667	0.1816667	0.1893333	0.1976667	0.2050000
6	0.1850000	0.1850000	0.1863333	0.1890000	0.1943333	0.2013333	0.2096667	0.2170000
7	0.1970000	0.1970000	0.1983333	0.2006667	0.2053333	0.2113333	0.2186667	0.2260000
8	0.2625000	0.2625000	0.2630000	0.2640000	0.2658333	0.2683333	0.2713333	0.2743333

age \ year	1955	1956	1957	1958	1959	1960	1961	1962
0	0.0150000	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	0.0500000
2	0.1386667	0.1396667	0.1403333	0.1406667	0.1416667	0.1463333	0.1510000	0.1550000
3	0.1686667	0.1703333	0.1716667	0.1730000	0.1743333	0.1790000	0.1833333	0.1870000
4	0.1926667	0.1950000	0.1966667	0.1980000	0.1993333	0.2076667	0.2156667	0.2230000
5	0.2100000	0.2136667	0.2160000	0.2176667	0.2193333	0.2263333	0.2330000	0.2390000
6	0.2230000	0.2273333	0.2306667	0.2326667	0.2343333	0.2486667	0.2626667	0.2760000
7	0.2323333	0.2376667	0.2413333	0.2436667	0.2453333	0.2636667	0.2816667	0.2990000
8	0.2771667	0.2795000	0.2815000	0.2828333	0.2840000	0.2936240	0.3034146	0.3090087

age \ year	1963	1964	1965	1966	1967	1968	1969	1970
0	0.0150000	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	0.0500000
2	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000
3	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000
4	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000
5	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000
6	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000
7	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000
8	0.3092903	0.3101214	0.3069573	0.3102731	0.3100755	0.3112209	0.3088686	0.3090248

age \ year	1971	1972	1973	1974	1975	1976	1977	1978
0	0.0150000	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	0.0500000
2	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000
3	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000
4	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000
5	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000
6	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000
7	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000
8	0.3119520	0.3076000	0.3078000	0.3081290	0.3077500	0.3077143	0.3060000	0.3096000

age \ year	1979	1980	1981	1982	1983	1984	1985	1986
0	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0173333	0.0156667	0.0140000
1	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0566667	0.0563333	0.0610000
2	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1503333	0.1380000	0.1300000
3	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1903333	0.1870000	0.1833333
4	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2296667	0.2323333	0.2316667
5	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2433333	0.2466667	0.2520000
6	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2820000	0.2746667	0.2730000
7	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000	0.3106667	0.3210000	0.3146667
8	0.3068571	0.3072000	0.3070000	0.3074043	0.3091429	0.3435118	0.3543824	0.3627746

age \ year	1987	1988	1989	1990	1991	1992	1993	1994
0	0.0090000	0.0080000	0.0086667	0.0123333	0.0113333	0.0103333	0.0056667	0.0073333
1	0.0503333	0.0483333	0.0436667	0.0520000	0.0590000	0.0636667	0.0610000	0.0600000
2	0.1216667	0.1230000	0.1223333	0.1256667	0.1390000	0.1366667	0.1340000	0.1263333
3	0.1700000	0.1663333	0.1653333	0.1743333	0.1836667	0.1940000	0.1843333	0.1916667
4	0.2123333	0.2083333	0.2046667	0.2116667	0.2120000	0.2140000	0.2130000	0.2143333
5	0.2300000	0.2290000	0.2283333	0.2436667	0.2386667	0.2343333	0.2343333	0.2396667
6	0.2420000	0.2483333	0.2523333	0.2706667	0.2653333	0.2530000	0.2616667	0.2746667
7	0.2746667	0.2586667	0.2613333	0.2836667	0.2796667	0.2716667	0.2726667	0.2913333
8	0.3056296	0.2853571	0.2885957	0.3078845	0.3095389	0.2987045	0.3079364	0.3205237

Table 3.6.3.3 (continued). North Sea Herring. Weights at age in the stock.

age \ year	1995	1996	1997	1998	1999	2000	2001	2002
0	0.0060000	0.0060000	0.0050000	0.0056667	0.0060000	0.0056667	0.0060000	0.0063333
1	0.0573333	0.0540000	0.0486667	0.0473333	0.0506667	0.0513333	0.0506667	0.0473333
2	0.1293333	0.1296667	0.1233333	0.1160000	0.1160000	0.1156667	0.1216667	0.1280000
3	0.1856667	0.1993333	0.1833333	0.1873333	0.1793333	0.1836667	0.1716667	0.1716667
4	0.2106667	0.2273333	0.2303333	0.2413333	0.2263333	0.2213333	0.2100000	0.2053333
5	0.2243333	0.2343333	0.2373333	0.2643333	0.2560000	0.2483333	0.2326667	0.2283333
6	0.2680000	0.2736667	0.2566667	0.2836667	0.2733333	0.2786667	0.2553333	0.2483333
7	0.2933333	0.3006667	0.2803333	0.2866667	0.2760000	0.2860000	0.2746667	0.2703333
8	0.3261402	0.3270679	0.3100401	0.3083390	0.2781188	0.2841712	0.2744942	0.2865212

age \ year	2003	2004	2005	2006	2007	2008	2009	2010
0	0.0066667	0.0066667	0.0056667	0.0066667	0.0060000	0.0080000	0.0073333	0.0073333
1	0.0470000	0.0420000	0.0413333	0.0410000	0.0513333	0.0576667	0.0613333	0.0520000
2	0.1230000	0.1193333	0.1180000	0.1256667	0.1280000	0.1303333	0.1373333	0.1423333
3	0.1730000	0.1653333	0.1643333	0.1553333	0.1606667	0.1643333	0.1810000	0.1903333
4	0.2023333	0.2026667	0.1980000	0.1910000	0.1796667	0.1806667	0.1966667	0.2160000
5	0.2220000	0.2230000	0.2246667	0.2160000	0.2070000	0.1953333	0.2100000	0.2236667
6	0.2423333	0.2476667	0.2480000	0.2420000	0.2236667	0.2176667	0.2226667	0.2343333
7	0.2656667	0.2676667	0.2650000	0.2523333	0.2380000	0.2260000	0.2336667	0.2400000
8	0.2849461	0.2804902	0.2848518	0.2701506	0.2563910	0.2555622	0.2557340	0.2606509

age \ year	2011	2012	2013	2014	2015	2016
0	0.0066667	0.0060000	0.0060000	0.0056667	0.0053333	0.0050000
1	0.0430000	0.0403333	0.0403333	0.0433333	0.0436667	0.0433333
2	0.1456667	0.1380000	0.1356667	0.1286667	0.1273333	0.1210000
3	0.1873333	0.1820000	0.1746667	0.1766667	0.1613333	0.1603333
4	0.2250000	0.2113333	0.2086667	0.2036667	0.2000000	0.1886667
5	0.2396667	0.2330000	0.2213333	0.2156667	0.2116667	0.2160000
6	0.2436667	0.2410000	0.2420000	0.2286667	0.2246667	0.2243333
7	0.2506667	0.2426667	0.2493333	0.2413333	0.2290000	0.2243333
8	0.2572710	0.2525108	0.2517943	0.2465725	0.2393581	0.2337207

Table 3.6.3.4 North Sea Herring. Natural mortality.

Units : NA

age \ year	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
0	0.89656	0.89655	0.89655	0.89655	0.89656	0.89656	0.89655	0.89655	0.89655	0.89656
1	0.70702	0.70702	0.70703	0.70703	0.70702	0.70702	0.70703	0.70703	0.70702	0.70701
2	0.39709	0.39709	0.39709	0.39709	0.39709	0.39709	0.39709	0.39709	0.39709	0.39709
3	0.36639	0.36639	0.36639	0.36639	0.36640	0.36640	0.36639	0.36639	0.36639	0.36640
4	0.34207	0.34207	0.34207	0.34207	0.34207	0.34207	0.34207	0.34207	0.34207	0.34207
5	0.32235	0.32235	0.32234	0.32234	0.32235	0.32235	0.32234	0.32234	0.32234	0.32235
6	0.31620	0.31620	0.31620	0.31620	0.31620	0.31620	0.31620	0.31620	0.31620	0.31621
7	0.29324	0.29324	0.29324	0.29324	0.29324	0.29324	0.29324	0.29323	0.29324	0.29325
8	0.29324	0.29324	0.29324	0.29324	0.29324	0.29324	0.29324	0.29323	0.29324	0.29325

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
0	0.89656	0.89653	0.89654	0.89658	0.89661	0.89657	0.89637	0.89655	0.89677	0.89678
1	0.70701	0.70706	0.70704	0.70698	0.70695	0.70704	0.70730	0.70695	0.70666	0.70680
2	0.39709	0.39708	0.39708	0.39710	0.39710	0.39709	0.39704	0.39709	0.39715	0.39715
3	0.36640	0.36638	0.36639	0.36641	0.36642	0.36640	0.36631	0.36640	0.36650	0.36650
4	0.34207	0.34207	0.34207	0.34207	0.34208	0.34208	0.34205	0.34206	0.34209	0.34211
5	0.32235	0.32234	0.32234	0.32235	0.32237	0.32235	0.32228	0.32234	0.32242	0.32243
6	0.31621	0.31619	0.31619	0.31621	0.31623	0.31621	0.31610	0.31621	0.31632	0.31632
7	0.29324	0.29322	0.29322	0.29326	0.29328	0.29324	0.29307	0.29325	0.29344	0.29342
8	0.29324	0.29322	0.29322	0.29326	0.29328	0.29324	0.29307	0.29325	0.29344	0.29342

age \ year	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
0	0.89637	0.89539	0.89744	0.89788	0.89682	0.89433	0.89049	0.90768	0.90007	0.89152
1	0.70747	0.70863	0.70519	0.70523	0.70748	0.71080	0.71446	0.68800	0.70539	0.71877
2	0.39704	0.39677	0.39734	0.39746	0.39715	0.39646	0.39541	0.40023	0.39804	0.39560
3	0.36630	0.36583	0.36685	0.36704	0.36649	0.36529	0.36349	0.37193	0.36799	0.36375
4	0.34207	0.34190	0.34211	0.34226	0.34222	0.34186	0.34107	0.34311	0.34305	0.34203
5	0.32229	0.32192	0.32264	0.32283	0.32247	0.32157	0.32010	0.32624	0.32377	0.32070
6	0.31609	0.31557	0.31672	0.31692	0.31630	0.31496	0.31298	0.32243	0.31792	0.31319
7	0.29304	0.29222	0.29414	0.29439	0.29329	0.29114	0.28813	0.30376	0.29562	0.28780
8	0.29304	0.29222	0.29414	0.29439	0.29329	0.29114	0.28813	0.30376	0.29562	0.28780

age \ year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	0.88187	0.87132	0.85937	0.84615	0.83276	0.81877	0.80438	0.78899	0.77239	0.75730
1	0.72740	0.73272	0.73410	0.73153	0.72735	0.71532	0.70110	0.69372	0.68724	0.67924
2	0.39303	0.39016	0.38692	0.38334	0.37930	0.37478	0.36993	0.36505	0.36007	0.35452
3	0.35930	0.35448	0.34924	0.34361	0.33752	0.33127	0.32461	0.31593	0.30595	0.29735
4	0.34005	0.33710	0.33311	0.32809	0.32214	0.31480	0.30652	0.29613	0.28397	0.27373
5	0.31702	0.31275	0.30787	0.30237	0.29629	0.28932	0.28171	0.27238	0.26170	0.25275
6	0.30828	0.30309	0.29768	0.29205	0.28601	0.27991	0.27340	0.26471	0.25468	0.24604
7	0.28035	0.27312	0.26622	0.25963	0.25307	0.24741	0.24178	0.23376	0.22464	0.21708
8	0.28035	0.27312	0.26622	0.25963	0.25307	0.24741	0.24178	0.23376	0.22464	0.21708

Table 3.6.3.4 (continued). North Sea Herring. Natural mortality.

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	0.74141	0.72659	0.71729	0.71108	0.70660	0.70259	0.70008	0.69767	0.69561	0.69837
1	0.67188	0.66385	0.65157	0.63779	0.62443	0.60397	0.58400	0.56975	0.55531	0.54862
2	0.34451	0.33457	0.32776	0.32090	0.31685	0.31775	0.31973	0.32086	0.32330	0.32703
3	0.28610	0.27597	0.27211	0.27031	0.27089	0.27767	0.28564	0.29129	0.29838	0.30481
4	0.26125	0.25014	0.24657	0.24579	0.24678	0.25356	0.26137	0.26621	0.27218	0.27720
5	0.24274	0.23383	0.23008	0.22836	0.22847	0.23339	0.23937	0.24343	0.24848	0.25305
6	0.23614	0.22718	0.22276	0.21999	0.21922	0.22330	0.22847	0.23180	0.23608	0.24024
7	0.20934	0.20255	0.19964	0.19854	0.19869	0.20239	0.20686	0.20929	0.21208	0.21499
8	0.20934	0.20255	0.19964	0.19854	0.19869	0.20239	0.20686	0.20929	0.21208	0.21499

age \ year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	0.70941	0.72345	0.74314	0.76873	0.78794	0.80173	0.81298	0.81627	0.81586	0.81680
1	0.55337	0.56293	0.58283	0.61207	0.63330	0.65335	0.66963	0.66717	0.65762	0.64954
2	0.32995	0.33458	0.34606	0.36094	0.37323	0.38863	0.40217	0.40562	0.40612	0.40475
3	0.30895	0.31353	0.32028	0.32748	0.33427	0.34495	0.35449	0.35771	0.35931	0.35925
4	0.27857	0.28031	0.28452	0.28870	0.29381	0.30449	0.31481	0.32037	0.32548	0.32835
5	0.25527	0.25813	0.26344	0.26925	0.27573	0.28668	0.29723	0.30381	0.31006	0.31393
6	0.24283	0.24621	0.25215	0.25889	0.26575	0.27629	0.28631	0.29202	0.29707	0.30026
7	0.21578	0.21759	0.22354	0.23082	0.23842	0.25023	0.26169	0.26891	0.27577	0.28023
8	0.21578	0.21759	0.22354	0.23082	0.23842	0.25023	0.26169	0.26891	0.27577	0.28023

age \ year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	0.81920	0.82042	0.82044	0.81916	0.81731	0.81567	0.81372	0.81726	0.81646	0.81556
1	0.64244	0.63342	0.62373	0.61204	0.59942	0.58719	0.57454	0.59939	0.59330	0.58705
2	0.40124	0.39547	0.38774	0.37769	0.36557	0.35184	0.33631	0.36383	0.35785	0.35124
3	0.35744	0.35405	0.34919	0.34273	0.33466	0.32515	0.31420	0.33318	0.32918	0.32467
4	0.32893	0.32799	0.32540	0.32125	0.31541	0.30785	0.29871	0.31372	0.31080	0.30732
5	0.31543	0.31536	0.31352	0.31010	0.30486	0.29771	0.28885	0.30301	0.30038	0.29714
6	0.30157	0.30150	0.29995	0.29698	0.29249	0.28648	0.27905	0.29099	0.28875	0.28600
7	0.28234	0.28283	0.28141	0.27832	0.27338	0.26647	0.25778	0.27147	0.26899	0.26588
8	0.28234	0.28283	0.28141	0.27832	0.27338	0.26647	0.25778	0.27147	0.26899	0.26588

Table 3.6.3.5 North Sea Herring. Proportion mature.

Units : NA

age \ year	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
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	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	0.00	0.00
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	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	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	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	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	1.00

age \ year	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
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	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	0.00	0.00
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.82	0.82	0.82	0.82	0.82	0.82	0.82
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	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	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	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	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	1.00

age \ year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
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	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	0.00	0.00
2	0.82	0.82	0.82	0.82	0.82	0.82	0.70	0.75	0.80	0.85	0.82	0.91	0.86	0.50	0.47	0.73
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.93	0.94	0.97	0.99	0.99	0.61	0.93
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	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	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	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	1.00

age \ year	1995	1996	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	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	0.00	0.00
2	0.67	0.61	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	0.95	0.98	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	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	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	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	1.00

Table 3.6.3.5 (continued). North Sea Herring. Proportion mature.

	year					
age	2011	2012	2013	2014	2015	2016
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.01
2	0.87	0.91	0.83	0.85	0.70	0.71
3	0.84	0.99	0.96	1.00	0.90	0.89
4	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
6	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
8	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.6.3.6 North Sea Herring. Fraction of harvest before spawning.

Units : NA

	year													
age	1947	1948	1949	………..								2013	2014	2015
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	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	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

Table 3.6.3.7 North Sea Herring. Fraction of natural mortality before spawning.

Units : NA

	year														
age	1947	1948	1949	……….									2013	2014	2015
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	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	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

Table 3.6.3.8 North Sea Herring. Survey indices.

SCAI - Configuration

Spawning component abundance index

min	max	plusgroup	minyear	maxyear	startf	endf
NA	NA	NA	1972	2016	NA	NA

Index type : biomass

SCAI - Index Values

Units : NA

	year									
age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
all	3299.3	3227.2	2195.2	1386.4	1237.7	1635.4	2131.5	3195.1	3494.0	3959.0
age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
all	5027.2	7715.2	12037.8	15061.0	14568.6	18359.0	25734.9	21812.3	20219.1	13878.0
age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
all	7485.1	5089.6	4461.6	5561.5	7020.5	9851.0	13062.6	14209.7	16303.9	21445.9
age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
all	25831.2	33060.9	36345.4	31876.9	29624.9	30817.0	37450.6	46669.7	47238.2	49554.1
age	2012	2013	2014	2015	2016					
all	57549.7	59197.0	54568.0	53458.5	58175.8					

Table 3.6.3.8 (continued). North Sea Herring. Survey indices.

HERAS - Configuration

Herring in Sub-area 4, Divisions 7.d & 3.a (autumn-spawners) . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	8.00	8.00	1989.00	2016.00	0.54	0.56

Index type : number

HERAS - Index Values

Units : NA

age \ year	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	-1	-1	-1	-1	-1	-1	-1	-1	9361000
2	4090000	3306000	2634000	3734000	2984000	3185000	3849000	4497000	5960000
3	3903000	3521000	1700000	1378000	1637000	839000	2041000	2824000	2935000
4	1633000	3414000	1959000	1147000	902000	399000	672000	1087000	1441000
5	492000	1366000	1849000	1134000	741000	381000	299000	311000	601000
6	283000	392000	644000	1246000	777000	321000	203000	99000	215000
7	120000	210000	228000	395000	551000	326000	138000	83000	46000
8	66000	176000	145000	218000	296000	350000	212000	339000	237000

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	4449000	5087000	24736000	6837000	23055000	9829400	5183700	3114100	6822800
2	5747000	3078000	2923000	12290000	4875000	18949400	3415900	2055100	3772300
3	2520000	4725000	2156000	3083000	8220000	3081000	9191800	3648500	1997200
4	1625000	1116000	3140000	1462000	1390000	4188900	2167300	5789600	2097500
5	982000	506000	1007000	1676000	794600	675100	2590700	1212900	4175100
6	445000	314000	483000	450000	1031000	494800	317100	1174900	618200
7	170000	139000	266000	170000	244400	568300	327600	139900	562100
8	166000	141000	217000	157000	270500	323200	527650	233200	154700

age \ year	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	6261000	3714000	4655000	14577000	10119000	7437000	6388000	11634000	6714000
2	2750000	2853000	5632000	4237000	4166000	4719000	2683000	4918000	9495000
3	1848000	1709000	2553000	4216000	2534000	4067000	3031000	2827000	2831000
4	898000	1485000	1023000	2453000	2173000	1738000	2895000	2939000	1591000
5	806000	809000	1077000	1246000	1016000	1209000	1546000	1791000	1549000
6	1323000	712000	674000	1332000	651000	593000	849000	1236000	926000
7	243000	1749000	638000	688000	688000	247000	464000	669000	520000
8	217000	455000	1720000	2729000	1737000	696000	842000	461000	496000

age \ year	2016
1	9034000
2	12011000
3	5832000
4	1273000
5	822000
6	909000
7	395000
8	366000

IBTS-Q1 - Configuration

Herring in Sub-area 4, Divisions 7.d & 3.a (autumn-spawners) . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	1.00	NA	1984.00	2017.00	0.08	0.17

Index type : number

IBTS-Q1 - Index Values

Units : NA

age \ year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	1515.63	2097.28	2662.81	3692.97	4394.17	2331.57	1061.57	1286.75	1268.14	2794.01

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	1752.05	1312.79	1888.99	4410.41	2275.84	752.86	3721.31	2499.35	3881.43	2969.87

age \ year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	933.93	1006.13	903.60	1322.35	1761.48	2339.20	1206.33	2943.20	1357.44	1665.73

age \ year	2014	2015	2016	2017
1	2615.02	3917.63	782.25	2398.06

IBTS0 - Configuration

Herring in Sub-area 4, Divisions 7.d & 3.a (autumn-spawners) . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
0.00	0.00	NA	1992.00	2017.00	0.08	0.17

Index type : number

Table 3.6.3.8 (continued). North Sea Herring. Survey indices.

IBTS0 - Index Values

```
Units  :  NA
   year
age 1992  1993  1994  1995  1996  1997  1998  1999  2000  2001  2002  2003  2004
  0 200.7 190.1 101.7 127.0 106.5 148.1  53.1 244.0 137.1 214.8 161.8  54.4  47.3
   year
age 2005  2006  2007  2008  2009  2010  2011  2012  2013  2014  2015  2016  2017
  0  61.3  83.1  37.2  27.8  95.8  77.1  77.0  68.0  50.4 164.5  20.9  99.8  22.8
```

Table 3.6.3.9 North Sea Herring. Stock object configuration.

```
min        max plusgroup   minyear   maxyear   minfbar   maxfbar
  0          8         8      1947      2016         2         6
```

Table 3.6.3.10 North Sea Herring. sam Configuration settings.

```
name           : Final Assessment
desc           :
range          :       min       max plusgroup   minyear   maxyear   minfbar   maxfbar
range          :         0         8         8      1947      2017         2         6
fleets         :   catch    SCAI   HERAS IBTS-Q1   IBTS0
fleets         :       0       3       2       2       2
plus.group     : TRUE
states         :          age
states         : fleet      0  1  2  3  4  5  6  7  8
states         :   catch    1  2  3  4  5  6  7  8  8
states         :   SCAI    NA NA NA NA NA NA NA NA NA
states         :   HERAS   NA NA NA NA NA NA NA NA NA
states         :   IBTS-Q1 NA NA NA NA NA NA NA NA NA
states         :   IBTS0   NA NA NA NA NA NA NA NA NA
logN.vars      : 1 2 2 2 2 2 2 2 2
catchabilities :          age
catchabilities : fleet      0  1  2  3  4  5  6  7  8
catchabilities :   catch   NA NA NA NA NA NA NA NA NA
catchabilities :   SCAI    NA NA NA NA NA NA NA NA NA
catchabilities :   HERAS   NA  3  3  4  4  5  5  5  5
catchabilities :   IBTS-Q1 NA  1 NA NA NA NA NA NA NA
catchabilities :   IBTS0    2 NA NA NA NA NA NA NA NA
power.law.exps :          age
power.law.exps : fleet      0  1  2  3  4  5  6  7  8
power.law.exps :   catch   NA NA NA NA NA NA NA NA NA
power.law.exps :   SCAI    NA NA NA NA NA NA NA NA NA
power.law.exps :   HERAS   NA NA NA NA NA NA NA NA NA
power.law.exps :   IBTS-Q1 NA NA NA NA NA NA NA NA NA
power.law.exps :   IBTS0   NA NA NA NA NA NA NA NA NA
f.vars         :          age
f.vars         : fleet      0  1  2  3  4  5  6  7  8
f.vars         :   catch    1  1  2  2  3  3  4  4  4
f.vars         :   SCAI    NA NA NA NA NA NA NA NA NA
f.vars         :   HERAS   NA NA NA NA NA NA NA NA NA
f.vars         :   IBTS-Q1 NA NA NA NA NA NA NA NA NA
f.vars         :   IBTS0   NA NA NA NA NA NA NA NA NA
obs.vars       :          age
obs.vars       : fleet      0  1  2  3  4  5  6  7  8
obs.vars       :   catch    3  4  4  4  4  4  5  5  5
obs.vars       :   SCAI    NA NA NA NA NA NA NA NA NA
obs.vars       :   HERAS   NA  6  7  7  7  7  8  8  8
obs.vars       :   IBTS-Q1 NA  1 NA NA NA NA NA NA NA
obs.vars       :   IBTS0    2 NA NA NA NA NA NA NA NA
srr            : 0
cor.F          : FALSE
nohess         : FALSE
timeout        : 3600
sam.binary     : character()
```

Table 3.6.3.11 North Sea Herring. FLR, R Software versions.

```
FLSAM.version  "1.02"
FLCore.version "2.6.0.20170228"
R.version      "R version 3.3.2 (2016-10-31)"
platform       "i386-w64-mingw32"
run.date       "2017-03-16 16:35:17"
```

Table 3.6.3.12 North Sea Herring. Stock summary.

Year	Recruitment Age 0	TSB (Ages 2-6)	SSB	Fbar f	Landings tonnes	Landings SOP
1947	58176962	8675383	4901246	0.1340	581760	1.4609
1948	55617030	7679001	4057185	0.1330	502100	1.3326
1949	49130963	7452052	3953058	0.1451	508500	1.4502
1950	68066791	7437163	3894205	0.1526	491700	1.3073
1951	60309488	7587404	3685807	0.1836	600400	1.3238
1952	58351755	7385285	3674766	0.1892	664400	1.2720
1953	60309488	7102803	3460764	0.1983	698500	1.1979
1954	56797337	6906683	3236490	0.2214	762900	1.2509
1955	48690768	6491473	3166065	0.2188	806400	1.0598
1956	35783591	5861992	2922646	0.2208	675200	1.2712
1957	92525977	6004381	2655119	0.2343	682900	1.1575
1958	34243249	5909076	2171655	0.2433	670500	1.1674
1959	39745214	6343873	3282120	0.2605	784500	1.5186
1960	15886814	5214741	2749693	0.2285	696200	1.1830
1961	75678147	5357457	2615589	0.2632	696700	1.1348
1962	34622004	4970346	1846865	0.2900	627800	1.1705
1963	44992214	5515098	2766241	0.2068	716000	0.8602
1964	48013847	5537203	2530684	0.2969	871200	1.0656
1965	23487995	4925814	2022814	0.4870	1168800	1.1496
1966	23842971	3696881	1576945	0.5030	895500	1.0707
1967	31108760	2899358	1002493	0.6627	695500	1.1757
1968	31705477	2488026	549080	0.9925	717800	1.2551
1969	15294441	1897409	484077	0.9021	546700	0.9674
1970	32056162	1867292	460008	0.9609	563100	0.9657
1971	24593679	1741052	319017	1.3070	520100	1.0747
1972	16936811	1518145	321901	0.6893	497500	0.9197
1973	8376997	1181151	280688	0.8998	484000	0.9575
1974	15966447	876770	188716	0.9146	275100	0.9680
1975	3328392	699415	108554	1.0883	312800	0.9343
1976	4164055	485046	148449	0.8517	174800	0.9530
1977	4694959	335373	103363	0.3949	46000	1.1979
1978	4955457	384231	130483	0.2866	11000	1.2152
1979	9369778	496828	163081	0.2363	25100	1.0056
1980	14374984	680784	181861	0.2096	70764	1.0936
1981	32736460	1208632	269413	0.2317	174879	1.0081
1982	51187197	1813919	377377	0.2091	275079	0.9786
1983	47726626	2443642	570918	0.2598	387202	1.0771
1984	43793677	3081725	922645	0.3422	428631	1.0543
1985	52064818	3495545	981660	0.4401	613780	1.0419
1986	59888796	3941217	1000490	0.4243	671488	1.1373
1987	62645349	3957013	1160081	0.4174	792058	1.0173
1988	31737198	3964935	1477704	0.4056	887686	1.1641
1989	26509136	3341733	1531870	0.3897	787899	1.0335
1990	21574012	3246214	1591202	0.3279	645229	1.0515
1991	23394231	3020703	1386094	0.3581	658008	1.0197
1992	46085089	3044965	1069819	0.3988	716799	0.9950
1993	40144660	2822123	760704	0.4564	671397	1.0231
1994	28317768	2478093	805324	0.4782	568234	1.0498
1995	37393221	2419327	845768	0.4191	579371	1.0084
1996	34209023	2548460	965113	0.2472	275098	0.9987
1997	23558565	2733245	1115708	0.2187	264313	1.0006
1998	16835495	2934360	1341099	0.2461	391628	1.0018
1999	54624879	2957929	1395830	0.2360	363163	1.0000
2000	38034340	3726574	1398625	0.2375	388157	1.0004
2001	65989091	4214325	1899308	0.2066	374065	0.9901
2002	34935009	4915972	2191288	0.1936	394709	0.9974
2003	16634676	5330737	2246761	0.2218	482281	1.0153
2004	20095370	4510867	2206681	0.2696	587698	0.9985
2005	18384160	3809468	2090680	0.2883	663813	1.0033
2006	21552449	3162900	1641301	0.2561	514597	0.9950
2007	21189154	2684486	1305374	0.2231	406482	1.0056
2008	21987837	2746945	1379180	0.1432	257870	1.0040
2009	27840434	3169232	1709993	0.0834	168443	1.0023
2010	27453384	3667424	1785127	0.0880	187611	1.0034
2011	23582135	3722850	2107473	0.1150	226478	0.9938
2012	26062290	3794260	2287568	0.1800	434710	1.0109
2013	32056162	3678443	2047234	0.2151	511416	1.0014
2014	46688106	3913724	1963030	0.2232	517356	1.0029
2015	15775994	4114385	1835817	0.2385	494099	1.0017
2016	29532444	4139146	2178180	0.2566	563610	1.0000
2017	12127668					

Table 3.6.3.13 North Sea Herring. Estimated fishing mortality.

Units : f

age	1947	1948	1949	1950	1951
0	0.0039699571	0.0039703541	0.0039723398	0.003967576	0.003969163
1	0.0001933517	0.0001933517	0.0009309546	0.004482385	0.021540939
2	0.0482721736	0.0357215904	0.0447439070	0.060277282	0.090410036
3	0.1019676166	0.1168925666	0.1179729403	0.133014119	0.159183127
4	0.1098104040	0.1203681880	0.1288250496	0.158801545	0.215822277
5	0.1486441626	0.1574417076	0.1645073548	0.163768735	0.217468775
6	0.2614009091	0.2344764787	0.2692540288	0.247016535	0.235063403
7	0.2718785010	0.2621076452	0.3354105417	0.264741871	0.236265289
8	0.2718785010	0.2621076452	0.3354105417	0.264741871	0.236265289

age	1952	1953	1954	1955	1956	1957
0	0.003969957	0.003969163	0.00548905	0.005040248	0.004234458	0.00454558
1	0.041519171	0.061827935	0.08341726	0.133054029	0.127952011	0.16347422
2	0.127173879	0.153385641	0.18231852	0.215671255	0.270333202	0.25784414
3	0.145555183	0.179873761	0.22663828	0.229994473	0.235911157	0.24154488
4	0.191111166	0.185667099	0.19093924	0.193902466	0.204395180	0.21173919
5	0.210493606	0.206408100	0.22192850	0.196184448	0.186076016	0.23438271
6	0.271769771	0.266308465	0.28524695	0.258257017	0.207546473	0.22595939
7	0.327031102	0.312016253	0.36045073	0.199787695	0.223845320	0.23119356
8	0.327031102	0.312016253	0.36045073	0.199787695	0.223845320	0.23119356

age	1958	1959	1960	1961	1962	1963
0	0.004733928	0.009056251	0.01748696	0.0211736	0.007937952	0.01388564
1	0.146270154	0.181300392	0.19805708	0.1015301	0.096164020	0.12940607
2	0.280607046	0.304647472	0.30875722	0.3403775	0.211739189	0.24625197
3	0.271824131	0.268259630	0.22770599	0.2579215	0.339357892	0.24499928
4	0.203375755	0.239668155	0.19803728	0.2470412	0.291650241	0.19797787
5	0.259447736	0.237069958	0.17740855	0.2258239	0.274913164	0.18012576
6	0.201170997	0.253092562	0.23080086	0.2447299	0.332139572	0.16490265
7	0.147179846	0.256276074	0.27604262	0.2168173	0.290660314	0.17011170
8	0.147179846	0.256276074	0.27604262	0.2168173	0.290660314	0.17011170

age	1964	1965	1966	1967	1968	1969
0	0.01498209	0.0117512	0.02275205	0.0308907	0.03482917	0.01483153
1	0.25319382	0.2471648	0.22454032	0.2918837	0.31267218	0.32742377
2	0.32484732	0.5067893	0.49198355	0.4880390	0.94164117	0.73676964
3	0.32497728	0.5118570	0.54076526	0.7066004	1.35068247	0.84133951
4	0.29614680	0.4966648	0.48602754	0.6762719	0.81141146	0.78347980
5	0.27817635	0.4761035	0.60777532	0.7067559	0.89350799	0.85514862
6	0.26048761	0.4436852	0.38850470	0.7356874	0.96501947	1.29371769
7	0.21350394	0.4777441	0.57488227	0.9754552	1.19001986	1.04995153
8	0.21350394	0.4777441	0.57488227	0.9754552	1.19001986	1.04995153

age	1970	1971	1972	1973	1974	1975
0	0.03800263	0.04432972	0.06406225	0.05880667	0.09299589	0.1206695
1	0.30922071	0.59643203	0.60857203	0.67221974	0.48796578	0.5865602
2	0.79960294	0.76486189	0.74291028	0.86263812	0.90539044	1.0172094
3	1.01330473	0.94910675	0.75034663	1.01380441	0.86784687	1.1185017
4	0.98592894	0.96658794	0.70590120	0.79981886	0.83345964	1.0001535
5	0.85563619	0.77250253	0.57700174	0.78647842	1.00913477	1.3199317
6	1.15018178	3.08175734	0.67045412	1.03626406	0.95720663	0.9857160
7	0.99720651	1.43714715	0.36912129	0.61738035	0.83326797	1.5899300
8	0.99720651	1.43714715	0.36912129	0.61738035	0.83326797	1.5899300

age	1976	1977	1978	1979	1980	1981
0	0.09276369	0.08893051	0.1113808	0.1310731	0.15834169	0.4391694
1	0.20137227	0.13701019	0.1259085	0.1203321	0.10750693	0.2358640
2	0.70046562	0.19962793	0.2079828	0.2239349	0.24517084	0.2250348
3	0.98178101	0.53557733	0.3480184	0.3066648	0.28013042	0.2313555
4	0.91651028	0.34438330	0.2792075	0.2168173	0.20131187	0.2236216
5	0.96636468	0.51982139	0.3770000	0.3150890	0.24937437	0.2584896
6	0.69341265	0.37497347	0.2211089	0.1191348	0.07208567	0.2198522
7	1.09467991	0.48159585	0.4036609	0.2840798	0.15717428	0.4642556
8	1.09467991	0.48159585	0.4036609	0.2840798	0.15717428	0.4642556

Table 3.6.3.13 (continued). North Sea Herring. Estimated fishing mortality.

age	1982	1983	1984	1985	1986	1987	1988
0	0.4039880	0.4490415	0.2551254	0.1309421	0.1040067	0.1790661	0.1556104
1	0.2004280	0.2360291	0.2169909	0.3388831	0.3475662	0.4080278	0.5419833
2	0.2043543	0.2237334	0.2499986	0.3108639	0.3348073	0.3380370	0.3103980
3	0.2992428	0.2648478	0.3249123	0.4454947	0.3970592	0.3638549	0.3318740
4	0.2208658	0.2858466	0.3923739	0.4952760	0.4358182	0.4314386	0.4200086
5	0.1686550	0.2546157	0.3948063	0.4643299	0.4285234	0.4576731	0.4691747
6	0.1524681	0.2700630	0.3489942	0.4844021	0.5254186	0.4958013	0.4962775
7	0.2219063	0.3870815	0.5477042	0.5839208	0.6023239	0.4639493	0.5019926
8	0.2219063	0.3870815	0.5477042	0.5839208	0.6023239	0.4639493	0.5019926

age	1989	1990	1991	1992	1993	1994	1995
0	0.1612338	0.1016215	0.1607669	0.3328711	0.4030720	0.2704955	0.2681792
1	0.4122522	0.4490684	0.3306483	0.3714021	0.3736858	0.2177299	0.2253276
2	0.3147426	0.3041300	0.4093642	0.4266121	0.4659113	0.4576731	0.3387476
3	0.3203952	0.2836824	0.3263777	0.3607753	0.4585115	0.4824442	0.4430423
4	0.4268298	0.3418101	0.3375303	0.3806138	0.4794431	0.6291598	0.4367301
5	0.4439559	0.3817536	0.3506734	0.3863506	0.4136107	0.4012944	0.4784852
6	0.4424535	0.3280793	0.3663742	0.4393935	0.4646411	0.4201767	0.3982641
7	0.4626659	0.3685238	0.2922926	0.4164620	0.5060904	0.4085300	0.3643283
8	0.4626659	0.3685238	0.2922926	0.4164620	0.5060904	0.4085300	0.3643283

age	1996	1997	1998	1999	2000	2001
0	0.09578013	0.03016117	0.02444817	0.03875483	0.04185684	0.03962877
1	0.16071864	0.04652805	0.11391531	0.05738915	0.06180321	0.05521062
2	0.18719583	0.15709572	0.17631202	0.17029893	0.15999703	0.09199694
3	0.26492726	0.22152939	0.23602914	0.24519536	0.22700119	0.20486583
4	0.23933285	0.24270708	0.24825471	0.24867710	0.25622482	0.24026807
5	0.26150549	0.24101406	0.26844748	0.26490076	0.28439249	0.24407005
6	0.28317222	0.23105488	0.30125446	0.25069957	0.25996715	0.25155340
7	0.13699649	0.18003572	0.16256132	0.14815445	0.15286502	0.16936485
8	0.13699649	0.18003572	0.16256132	0.14815445	0.15286502	0.16936485

age	2002	2003	2004	2005	2006	2007
0	0.03229638	0.03485356	0.05269156	0.07655851	0.06090135	0.04609734
1	0.03908955	0.05729167	0.04552926	0.10379889	0.04592710	0.03732470
2	0.09985861	0.08770293	0.09777367	0.12358823	0.10909895	0.08656151
3	0.15892864	0.16078294	0.15645294	0.16026926	0.17373919	0.17835131
4	0.23579323	0.22859578	0.25655813	0.24558799	0.25362461	0.24251299
5	0.23473454	0.35116468	0.36027055	0.39932486	0.31812846	0.29733376
6	0.23856821	0.28049483	0.47665611	0.51278429	0.42620280	0.31073961
7	0.21644907	0.24443643	0.36696089	0.68241998	0.60833473	0.48948082
8	0.21644907	0.24443643	0.36696089	0.68241998	0.60833473	0.48948082

age	2008	2009	2010	2011	2012	2013
0	0.05046375	0.03611309	0.03314379	0.04620349	0.04146523	0.02489471
1	0.03229638	0.02476559	0.03025481	0.01860919	0.03993109	0.04921288
2	0.08984224	0.06085264	0.06767083	0.07111905	0.08373485	0.08781702
3	0.11093620	0.05970139	0.07485518	0.10202882	0.15326298	0.14335947
4	0.15028827	0.09747104	0.08858436	0.11491070	0.18805891	0.21498221
5	0.18936101	0.10935017	0.11417762	0.14871850	0.23075471	0.29013760
6	0.17569601	0.08956416	0.09458087	0.13805543	0.24416770	0.33932396
7	0.22880161	0.12024788	0.09082688	0.12281207	0.29214647	0.42722264
8	0.22880161	0.12024788	0.09082688	0.12281207	0.29214647	0.42722264

age	2014	2015	2016	2017
0	0.04200360	0.05236588	0.07564530	0.07626051
1	0.03092470	0.02522550	0.02215261	0.02210393
2	0.08330056	0.06706453	0.06037984	0.06037984
3	0.14903114	0.11440620	0.14123925	0.14123925
4	0.23740209	0.21080958	0.22051270	0.22051270
5	0.31123719	0.33484083	0.37163986	0.37163986
6	0.33497479	0.46552476	0.48905027	0.48905027
7	0.43922652	0.64464855	0.91453641	0.91453641
8	0.43922652	0.64464855	0.91453641	0.91453641

Table 3.6.3.14 North Sea Herring. Estimated population abundance.

Units : NA

age	1947	1948	1949	1950	1951	1952	1953
0	58176962	55617030	49130963	68066791	60309488.2	58351755.4	60309488
1	19019969	23724053	22748278	19288122	28630982.7	24348967.4	23582135
2	12006996	9379153	13336297	11273890	9138437.7	13283058.7	11206449
3	5219958	7131271	6948247	9899551	7370528.7	5352102.3	7319115
4	7341105	3378695	3988796	4950504	6913592.8	4205904.8	3305175
5	4483883	4780234	2178180	2366683	3478111.4	4000780.4	2448534
6	3711698	2839107	3008644	1350520	1495543.1	2118036.4	2376169
7	2069878	2063677	1692979	1662778	776071.6	896272.7	1197803
8	6274473	4727939	3957013	2993638	2665760.7	2126525.5	1676133

Table 3.6.3.14 (continued). North Sea Herring. Estimated population abundance.

age	year 1954	1955	1956	1957	1958	1959
0	56797337	48690767.9	35783591.2	92525977.4	34243249.2	39745214.4
1	25342668	22454464.1	19855666.7	13443415.6	43618852.0	13362996.6
2	10799388	12019008.5	9120179.1	8841790.9	5131969.2	21660480.9
3	6293324	5980411.9	6837960.0	4197501.4	4828275.9	2426596.0
4	4012801	3239728.2	3269017.4	3890312.3	2145750.6	2571500.1
5	2028891	2242271.6	1804871.6	1874776.5	2264806.8	1240468.9
6	1467396	1158921.0	1304069.1	1115708.3	1034056.5	1222000.7
7	1349170	801307.5	637940.3	779961.6	651478.7	616614.9
8	1654484	1541089.2	1506048.7	1298863.2	1201402.3	1288513.8

age	year 1960	1961	1962	1963	1964	1965
0	15886813.8	75678147.2	34622004.3	44992213.5	48013846.7	23487995.1
1	17452614.1	5070753.6	32933469.2	14636076.0	17680979.2	19975158.8
2	5267150.1	7159852.9	1928012.0	16370639.3	6776694.5	6331197.8
3	11840068.8	2568929.9	3054113.7	1065548.2	9606975.4	3584035.6
4	1177612.9	7557114.5	1408449.5	1219559.2	671990.8	5416714.5
5	1330413.0	705033.1	4629687.8	669977.9	722881.1	407583.1
6	675359.2	861129.3	412091.2	2380925.9	455886.9	411267.9
7	654089.8	380788.7	528606.7	198988.0	1550363.5	282377.5
8	1120180.1	947895.9	783871.2	709276.0	559053.2	1372301.8

age	year 1966	1967	1968	1969	1970	1971
0	23842970.6	31108759.7	31705477.0	15294441.20	32056162.48	24593678.59
1	9626208.6	9065621.9	12360296.5	12249552.94	6343872.85	12736723.59
2	7865526.2	3941216.5	3175577.3	4457060.38	4265201.57	2470670.18
3	2237791.5	3288690.4	1905014.2	704328.40	1521184.70	1247934.07
4	1446995.7	869783.8	1215906.0	306201.91	218818.96	375870.52
5	2249008.5	668639.3	299239.6	382314.94	98913.40	56443.76
6	188151.0	851708.8	249696.1	82867.65	118539.32	29851.79
7	186465.2	100911.6	284076.8	70685.80	15870.23	29260.68
8	810981.1	436699.2	155282.3	97343.38	43914.51	16613.98

age	year 1972	1973	1974	1975	1976
0	16936811.3928	8376996.539	15966446.748	3328392.458	4164055.345
1	9840331.9184	6426881.588	3063289.817	6769921.165	1018661.430
2	3351772.9413	2679122.839	1558134.764	942225.586	1871030.675
3	802109.1702	1115708.291	763753.216	425491.394	212351.882
4	321579.4773	296855.272	267266.081	238708.877	91308.577
5	95894.1253	120451.204	99012.363	82867.647	61451.283
6	18013.9187	42744.679	40700.677	26582.277	14742.651
7	921.6818	7584.030	11098.886	11497.674	7100.355
8	7561.3120	4627.167	5342.773	5595.959	2504.890

age	year 1977	1978	1979	1980	1981
0	4694959.292	4955457.240	9369778.363	14374983.546	32736460.02
1	1595982.353	1823010.840	1772674.534	3534208.753	5454764.47
2	372875.551	702218.579	792541.382	720715.682	1661115.63
3	558494.472	258590.239	399912.079	433219.584	351863.99
4	50061.123	219476.402	160011.345	211927.603	225482.99
5	21837.850	27917.248	113323.292	114576.729	131662.88
6	16066.634	9071.564	15484.580	57814.796	82867.65
7	5073.570	7865.961	5150.247	11271.131	44891.33
8	2305.148	3398.196	5475.835	5617.826	13163.46

age	year 1982	1983	1984	1985	1986
0	51187196.99	47726626.13	43793676.82	52064817.98	59888795.97
1	8710153.74	15681621.82	13072220.97	15066736.63	21856305.08
2	2000684.64	3419483.25	6230704.71	5649061.60	5219958.45
3	965112.54	1137109.42	1874776.48	3506047.88	2937296.03
4	205458.63	495340.16	686938.47	1008525.58	1545719.41
5	124119.49	131662.88	270222.24	359690.78	434086.89
6	70685.80	92318.52	83116.62	129443.53	169396.94
7	52365.33	47334.75	58982.73	47762.69	58046.52
8	29114.74	60900.70	65447.27	63386.11	54230.57

age	year 1987	1988	1989	1990	1991	1992
0	62645349.08	31737198.34	26509136.36	21574012.0	23394230.7	46085088.7
1	27017625.30	24865702.44	12877600.95	10627972.5	10069282.4	9635839.6
2	8461186.75	9801049.21	6851649.61	4248174.8	3722849.8	4282296.5
3	2518061.71	4403895.29	5449312.44	3730302.9	2242271.6	1711704.1
4	1491063.23	1271871.51	2458347.66	3402428.5	2191287.9	1296268.1
5	746387.36	749378.89	641138.00	1355932.5	1933804.8	1241710.0
6	217292.58	362217.45	365126.81	344207.5	741180.9	1132570.1
7	76267.33	104297.22	171613.48	191951.9	198988.0	427624.2
8	49168.08	64344.07	82454.34	143057.2	173511.6	223239.4

Table 3.6.3.14 (continued). North Sea Herring. Estimated population abundance.

age	1993	1994	1995	1996	1997	1998
0	40144660.5	28317767.7	37393221.4	34209023.08	23558564.85	16835494.8
1	15807577.9	12310954.1	10407112.2	13362996.64	15572233.77	10907923.4
2	3649132.4	5454764.5	5559395.8	4746888.93	5926829.66	8571900.3
3	1886059.0	1445549.4	2465733.8	2782888.57	2744199.58	3026750.0
4	921723.0	773746.8	712831.3	1048635.13	1522706.65	1467396.1
5	703624.4	393171.0	313326.2	313953.45	598391.20	844077.8
6	676711.3	331704.6	191760.0	119970.36	191185.61	361132.4
7	555709.0	307736.8	158577.7	89143.26	63959.16	119491.4
8	340101.7	390038.2	317108.7	243531.12	203617.80	155748.8

age	1999	2000	2001	2002	2003	2004
0	54624879.2	38034340.2	65989091.1	34935008.7	16634676.2	20095370.0
1	7459507.9	25751411.5	15248626.6	30860882.5	14709439.7	6749641.8
2	4676217.0	4501854.6	12890485.0	7088611.2	18310770.6	5992384.7
3	5487591.4	2657775.4	2972755.9	8162001.7	4180744.9	11240119.1
4	1547265.9	3226795.2	1519664.3	1616865.6	4867057.0	2676445.1
5	685566.0	942225.6	1742793.8	836515.2	891802.5	2887784.0
6	405550.2	407990.8	487477.8	1006510.5	527550.6	456343.0
7	179871.9	233048.1	223686.3	271034.1	584785.3	322545.7
8	144639.5	183872.9	209818.9	269682.3	308970.2	484077.4

age	2005	2006	2007	2008	2009	2010
0	18384160.3	21552448.8	21189153.9	21987837.1	27840434.5	27453384.1
1	8877228.9	6962157.7	8736323.4	9879772.1	9919370.3	12055119.7
2	3446948.8	4588207.6	3365206.9	4316692.3	5774718.1	5320085.9
3	3902000.8	2260281.7	2752444.5	2030921.1	2543368.6	3925483.2
4	7074448.2	2380925.9	1404230.5	1674457.9	1247934.1	1857979.2
5	1565944.9	4303761.6	1285939.3	893587.9	1073033.2	935653.0
6	1513597.8	785440.5	2357235.3	783871.2	601992.3	836515.2
7	215130.5	677388.3	391210.1	1515112.1	543073.5	464167.1
8	376246.6	227521.5	380408.1	447306.8	1449892.5	1591201.6

age	2011	2012	2013	2014	2015	2016
0	23582135.2	26062290.0	32056162.5	46688106.0	15775994.4	29532443.6
1	12372663.0	9323046.4	10853519.9	16337930.7	21062399.6	6622609.3
2	6484984.6	6569839.8	4465983.4	5564958.0	10252170.5	12839026.0
3	3371944.0	4995259.9	4265201.6	3087894.4	2957929.2	6962157.7
4	2450983.7	2495500.8	3345076.1	3188305.0	1788700.6	1713416.7
5	1129177.4	1624970.1	1804871.6	2078173.6	1857979.2	1020700.8
6	596598.7	737484.2	1078411.8	1153140.9	1179970.5	1033023.0
7	562980.3	371758.6	461390.5	643064.3	646934.3	568638.4
8	1354577.3	1083817.4	891802.5	657368.5	684196.2	565236.8

age	2017
0	12127667.9
1	12929214.5
2	3602000.7
3	8512106.5
4	4368804.7
5	1010544.6
6	522823.9
7	475917.6
8	348362.9

Table 3.6.3.15 North Sea Herring. Predicted catch numbers at age.

Units : NA

age	1947	1948	1949	1950	1951	1952	1953
0	NA	NA	NA	NA	NA	NA	157865.7
1	NA	3288.938	NA	NA	438011.3	711549.3	1017541.5
2	467801.8	271875.631	482337.8	545304.7	653959.0	1314937.9	1322322.2
3	425108.6	661126.184	649657.1	1036334.0	912734.2	609503.5	1014797.9
4	648748.2	325689.581	409667.0	618220.2	1143266.4	622749.7	476965.8
5	531415.8	598092.079	283821.3	306845.6	584376.1	652521.9	392581.7
6	737336.8	511959.091	613232.9	254995.2	270195.2	435086.4	479356.6
7	430111.6	415068.979	421594.8	337459.2	142386.4	218381.8	280435.8
8	1302765.7	950458.710	985200.1	607374.0	488942.4	518036.0	392228.6

age	1954	1955	1956	1957	1958	1959
0	205314.9	161700.3	99857.56	277312.4	106841.32	NA
1	1461830.5	2020387.7	1722866.45	1467249.3	4292157.16	1605747.6
2	1494048.3	1937870.0	1798205.89	1672617.0	1045493.94	4742144.4
3	1076149.6	1035608.8	1211657.72	760020.0	969756.22	481952.1
4	593801.3	486455.2	514937.08	632351.1	336414.73	467240.8
5	347111.0	343279.4	263234.36	336987.1	445387.51	225280.1
6	314393.3	227726.4	210744.13	194658.1	162429.61	235837.9
7	357038.9	126424.4	111513.40	140294.6	77551.69	121600.9
8	437617.3	242995.9	263234.36	233678.1	142942.82	254129.7

Table 3.6.3.15 (continued). North Sea Herring. Predicted catch numbers at age.

age	1960	1961	1962	1963	1964	1965
0	182079.7	1049054.7	180900.1	410323.03	471842.25	181262.22
1	2275021.4	353133.0	2176873.0	1283370.01	2878845.78	3180344.24
2	1167062.0	1723383.4	305743.0	2973945.26	1567982.00	2111269.54
3	2033359.7	492771.1	743333.4	195282.01	2254638.03	1220779.32
4	180250.0	1410140.6	304400.6	186614.45	147119.43	1820278.37
5	185758.0	122577.7	958667.9	94901.99	151145.77	133692.81
6	120018.4	161296.6	100710.0	311794.63	90255.52	127758.88
7	137612.9	64686.0	116401.4	27105.72	259652.64	94004.69
8	235672.9	160958.2	172560.0	96538.77	93648.15	456936.63

age	1966	1967	1968	1969	1970	1971
0	354654.73	626372.17	718988.04	148850.84	790720.631	706444.56
1	1405635.40	1672449.71	2420537.06	2500996.97	1231939.112	4242655.80
2	2562259.39	1276586.15	1648209.33	1963423.12	1988517.611	1117941.94
3	795320.14	1425452.69	1229846.59	343932.26	835846.280	658552.81
4	478350.98	368833.28	585780.25	143903.76	119395.883	202561.74
5	889575.80	295168.01	154786.19	192182.36	49721.862	26502.65
6	52433.45	387627.46	135876.27	53295.12	71489.081	26162.96
7	71610.72	55748.18	176310.16	40814.80	8885.624	19991.25
8	311701.10	241349.17	96326.62	56195.95	24582.744	11353.37

age	1972	1973	1974	1975	1976	1977
0	698087.6870	318188.738	938745.792	251802.417	245880.273	267105.7697
1	3325065.7290	2336115.348	879140.496	2229526.970	134054.270	146341.7619
2	1486150.8303	1315069.403	787642.826	512625.070	796036.247	56156.6283
3	362833.7430	613907.780	379724.018	247805.638	114588.187	197718.5829
4	140603.6193	141633.781	130927.629	131360.404	47591.050	12484.8352
5	36523.0921	57325.452	55143.822	53664.125	33412.989	7690.6455
6	7681.0382	24311.384	21972.347	14640.838	6443.905	4364.8539
7	249.0217	3080.077	5524.898	8224.148	4211.356	1709.9681
8	2042.9089	1879.122	2659.385	4002.682	1485.668	776.9065

age	1980	1981	1982	1983	1984
0	1436471.0442	8131858.068	11938750.354	12221411.35	6936445.32
1	257249.0601	826041.258	1143266.415	2403171.79	1861698.87
2	131202.8660	280435.772	310487.835	577232.26	1163449.67
3	90282.5973	62081.294	214121.738	227612.52	449818.75
4	33136.8091	38874.742	35143.677	106819.95	194930.82
5	21958.2895	26131.585	16793.715	25938.92	77870.31
6	3494.9698	14294.498	8750.534	19232.56	21676.20
7	1448.7118	14873.554	9273.443	13598.30	22426.53
8	722.0613	4361.669	5157.669	17503.92	24862.10

age	1985	1986	1987	1988	1989	1990
0	4487471.68	4174478.51	7329369.11	3282119.63	2843937.23	1501086.89
1	3193729.77	4746414.27	6744244.28	7830993.94	3267383.27	2910396.84
2	1279141.87	1262873.20	2073191.99	2241598.98	1590565.23	961067.57
3	1098218.63	841044.63	673470.86	1094709.95	1317043.49	812279.69
4	347041.62	482627.30	464120.73	389453.60	763371.43	879052.59
5	118693.52	134914.97	245536.28	252432.71	207129.61	387549.94
6	44329.25	62050.26	76420.02	127937.87	117959.90	86977.09
7	19134.92	23870.53	25750.26	37586.49	58046.52	53970.88
8	25377.04	22299.06	16595.05	23190.55	27911.67	40247.37

age	1991	1992	1993	1994	1995	1996
0	2514790.35	9554282.11	9801049.2	4906149.62	6434598.47	2260281.68
1	2144463.58	2285282.03	3802616.7	1855936.54	1628549.01	1537856.31
2	1083383.96	1288384.93	1177848.5	1734448.41	1377526.42	694883.86
3	551005.46	456388.64	609686.4	485531.77	771737.70	562248.95
4	560228.49	365528.67	311981.8	321675.97	222927.08	196025.49
5	514525.30	357396.11	213779.4	116261.82	106563.89	64151.32
6	205499.73	363778.34	226726.6	102395.70	56556.76	26441.76
7	45967.96	132839.91	201088.4	93769.98	43932.08	10291.77
8	40058.65	69334.65	123130.5	118812.27	87798.53	28121.79

age	1997	1998	1999	2000	2001	2002
0	502173.020	289786.58	1468423.60	1090994.26	1779423.51	765052.70
1	544759.668	902478.37	316127.22	1158225.90	608711.68	870392.90
2	737189.307	1182805.83	621878.49	561518.50	947801.15	559892.46
3	471747.894	549739.61	1028076.36	463193.42	470617.06	1019170.89
4	287880.286	282971.09	298283.60	637111.53	282773.08	294607.72
5	113709.246	176169.17	141040.17	205828.79	331704.57	153092.87
6	35171.803	83742.34	79921.49	82735.16	95702.53	187718.73
7	9507.251	16155.08	22247.84	29584.33	31101.15	46891.89
8	30269.625	21059.77	17892.02	23348.78	29173.03	46634.69

Table 3.6.3.15 (continued). North Sea Herring. Predicted catch numbers at age.

age \ year	2003	2004	2005	2006	2007	2008
0	391014.53	707434.27	931358.92	873794.06	653566.8	740958.58
1	598810.22	219717.96	645318.97	230383.36	236570.1	232884.99
2	1269330.30	460330.51	330710.95	391562.33	230567.7	307275.49
3	525024.39	1375186.62	487867.92	304309.33	379951.9	180159.89
4	858549.83	521988.06	1323380.49	457988.80	259496.9	199985.47
5	230429.45	760248.02	447754.33	1015203.86	285957.9	132919.64
6	112972.53	151842.64	531841.08	237898.64	547928.5	109469.36
7	112162.05	87623.11	94419.23	273156.45	133399.0	271223.91
8	59278.38	131452.39	165098.91	91729.56	129806.5	80145.58

age \ year	2009	2010	2011	2012	2013	2014	2015
0	675426.76	612619.93	729781.17	726068.8	540364.9	1315464.0	551998.2
1	180809.63	269224.26	171664.97	276454.1	397559.5	374969.5	396130.9
2	283055.99	290686.31	373808.91	445744.0	319623.8	373921.1	560284.5
3	124691.75	240313.60	278841.83	608529.1	490656.7	365090.3	273402.4
4	99180.83	135009.44	228982.30	370089.4	562192.7	582043.2	293930.9
5	95702.53	87055.40	135022.94	291239.1	397678.8	483206.8	460560.7
6	44662.97	65453.81	66923.13	139678.7	272992.6	286989.2	385578.5
7	53798.45	35238.69	57085.19	83208.1	142628.7	202258.1	273402.4
8	143573.16	120837.26	137324.22	242704.5	275763.8	206715.8	289207.6

age \ year	2016
0	1477999.4
1	109886.1
2	635775.0
3	785676.2
4	293431.6
5	276592.3
6	351723.3
7	305284.7
8	303397.8

Table 3.6.3.16 North Sea Herring. Catch at age residuals.

Units : NA

age \ year	1947	1948	1949	1950	1951	1952
0	NA	NA	NA	NA	NA	NA
1	NA	-0.6626790	NA	NA	0.3845300	0.10484900
2	0.39283600	-0.6912540	-0.0653862	-0.1375180	0.0663753	0.16823700
3	-0.17337100	0.1172890	-0.0628398	0.0181858	0.3564280	-0.40732600
4	-0.12023100	0.0507187	-0.2447270	-0.0144043	0.6722670	-0.14901200
5	-0.07394150	0.0349309	0.0802418	-0.4071490	0.5416240	-0.00568623
6	0.09544220	-0.1907510	0.2340580	-0.0149206	-0.1175890	0.24587300
7	0.00794951	-0.1411860	0.3496140	-0.0737490	-0.0103601	0.29626300
8	0.02407860	-0.1367740	0.1956710	-0.0656927	-0.3598140	0.25627500

age \ year	1953	1954	1955	1956	1957	1958
0	-0.2239800	0.28320100	0.0619363	-0.1729260	0.0267794	-0.4238260
1	0.0386183	-0.05351270	0.1816980	-0.1086820	0.0767072	-0.0224646
2	-0.0018093	-0.00493132	-0.0253675	0.2435810	-0.1242330	-0.1144150
3	-0.0844495	0.22962800	-0.0250854	0.0551426	-0.2311760	0.2138490
4	-0.0447545	-0.03400090	-0.1112650	0.0150678	0.1317130	-0.3156670
5	-0.1218370	0.28249000	-0.1330410	-0.4009830	0.1483300	0.2480860
6	-0.0510696	0.18491000	0.0711460	-0.3163220	0.2345930	-0.3810010
7	-0.0334413	0.22814100	-0.1992970	-0.2664760	0.1784640	-0.2309060
8	-0.0021554	0.59193400	-0.4674150	0.3959850	0.3032640	-0.7324870

age \ year	1959	1960	1961	1962	1963	1964
0	NA	0.291522	0.8353450	-1.068010	0.3340520	0.2267320
1	0.0144442	0.363316	-0.3584010	-0.100001	-0.1198220	0.2285990
2	0.2860400	-0.154221	0.6630140	-0.906625	-0.0308246	-0.0949276
3	0.0897024	-0.240175	-0.1904970	0.506101	-0.6999210	-0.0369553
4	0.4447350	-0.597597	0.2303480	0.692408	-1.1858900	0.0626940
5	0.2424950	-0.737100	0.0830781	0.870740	-1.1768500	-0.1029740
6	0.2075650	-0.233352	-0.0814499	0.882720	-1.1671800	0.1956430
7	-0.0505876	-0.342867	-0.1991530	0.841579	-0.7281470	-0.0496988
8	0.6462730	0.527839	-0.4383840	0.012087	-0.1427680	-0.4151300

age \ year	1965	1966	1967	1968	1969	1970
0	-0.6275650	0.23898800	0.13145800	0.6784850	-1.24743000	0.5584410
1	0.0650765	-0.11677700	0.00806419	0.0134172	0.00655837	-0.2123660
2	0.3539050	0.02091720	-0.61890200	0.6153280	-0.30140000	0.0517032
3	0.5880710	-0.50816200	-0.31371900	1.4036300	-1.07447000	0.4006880
4	0.8190110	-0.43867800	0.05167020	0.4256510	-0.56276900	0.3421640
5	0.5901030	0.00205576	0.06367200	0.1065910	-0.05190010	0.0832675
6	0.6609290	-0.55850200	0.05338820	0.2481540	-0.25135000	-0.6061450
7	0.8552500	-0.38167200	0.75308300	-0.2905580	0.17248100	-0.4490010
8	0.2776010	0.23847000	0.20113800	0.3472610	-0.25970300	-0.0597621

Table 3.6.3.16 (continued). North Sea Herring. Catch at age residuals.

age \ year	1971	1972	1973	1974	1975	1976
0	-0.141526	0.3168130	-0.4157030	0.2602680	0.204222	-0.139113
1	0.226844	0.0333594	0.0976469	-0.2761560	0.710419	-0.412208
2	0.183443	-0.2246980	0.1578410	-0.1387980	0.397805	0.896779
3	0.043120	-0.3886490	0.5129120	-0.3443060	0.334974	0.168680
4	0.201252	-0.5321520	0.4233940	-0.2765120	0.484827	0.638378
5	0.107182	-0.7528420	0.2443600	0.1239700	0.460019	0.230389
6	0.585596	-1.6396100	0.8785710	0.0565327	0.362832	-0.209478
7	1.119410	-0.8372310	0.7003460	-0.3812580	0.386484	0.167339
8	0.367433	-1.1797600	0.2380720	0.5854770	0.693737	-0.226837

age \ year	1977	1980	1981	1982	1983	1984
0	-0.172519	-0.5653630	0.6912780	0.00677838	0.3698570	0.0230666
1	-0.101359	-0.3484580	0.3901200	-0.17163000	0.1346850	-0.1697310
2	-1.644480	0.1517660	0.0982919	-0.26185100	-0.0427895	-0.1079100
3	-0.424780	0.1203630	-0.6279890	0.51862600	-0.3642090	-0.1359130
4	-1.044740	-0.2063760	0.1152410	-0.30248300	-0.1168000	0.2392100
5	-0.678076	-0.0852841	0.6253790	-1.10819000	0.0720696	0.2927570
6	-0.239062	-1.5979600	1.7662800	-0.96313400	0.6498200	0.1594040
7	-0.500324	-0.1306160	0.8743350	-0.66082800	-0.2310690	0.4453140
8	-0.398112	-1.4035000	1.5819100	-0.35486800	1.0594400	0.6790200

age \ year	1985	1986	1987	1988	1989	1990
0	-0.2788300	-0.49980200	0.50789800	-0.15950200	0.3179220	-0.6213840
1	0.1326780	0.08316130	0.09793540	0.03273490	-0.2728860	0.2661930
2	0.2607590	0.02205780	0.21919500	-0.02940440	0.0143182	-0.4784390
3	0.5324400	-0.00208803	-0.05980350	-0.02623430	0.2517130	-0.3002210
4	0.4323300	-0.25433000	0.04616830	-0.10739500	0.4207640	-0.1498370
5	0.3442690	-0.27857800	0.00788964	0.09526170	0.1603460	-0.0009239
6	-0.0633258	0.00320857	-0.08704900	0.00479286	0.1816260	-0.3096260
7	0.2068680	-0.58135200	-0.30096500	0.04163610	0.1897060	0.0301332
8	0.5360930	0.92376600	-0.09202570	0.09902100	0.0393679	0.0425569

age \ year	1991	1992	1993	1994	1995	1996
0	-0.22940300	0.3430940	0.20322800	-0.3800630	0.6356270	0.0976146
1	-0.01862520	0.0557858	0.04585850	-0.2798610	0.1586230	0.3139220
2	0.32122600	-0.0197616	-0.00975659	0.1994770	0.3400370	-0.5696400
3	0.07398970	-0.2193610	-0.00804641	0.0530767	0.4083110	-0.4856590
4	-0.14745900	-0.0796654	-0.15163300	0.5587910	0.2810220	-0.9379380
5	-0.18903600	0.0621844	0.06140910	-0.4646810	0.7672640	-0.7783500
6	-0.00356246	0.1222040	-0.01236630	-0.4169820	-0.0978158	-0.6109270
7	-0.59837700	0.5246430	-0.25712600	-0.7822270	-0.2260240	-0.4018180
8	-0.14164200	-0.3961560	0.17771900	-0.0717243	0.4276490	-1.0895200

age \ year	1997	1998	1999	2000	2001	2002
0	-0.6685420	-0.4836210	0.2831030	0.05649820	0.1293060	-0.2038240
1	-0.9163490	0.5771440	-0.2935620	0.08310630	0.0680712	-0.2772480
2	-0.4981890	0.2237480	-0.0645402	0.74711500	-0.8476980	0.2495290
3	-0.3898050	-0.1562620	0.2115770	-0.00063617	0.2260970	-0.3522310
4	-0.0745839	-0.1713220	-0.1024780	0.10886100	-0.0997365	-0.0590637
5	-0.2929750	-0.0144423	-0.2808050	0.26282100	-0.2195810	-0.6082360
6	-0.4347270	0.2292970	-0.5446730	-0.01190630	-0.1959420	-0.2772350
7	0.8354510	-0.2247010	0.8778230	0.71834200	0.7904490	0.1606450
8	-0.8126190	-0.0935840	-1.4536400	-1.19243000	-1.3285200	-0.2815400

age \ year	2003	2004	2005	2006	2007	2008
0	-0.2531610	0.0501429	0.3794380	0.0241177	-0.2239140	0.3269270
1	0.2162320	-0.4420130	0.7446120	-0.2635800	-0.0311543	0.0658887
2	-0.2740050	-0.1967960	0.5202150	0.1735300	-0.3673120	0.5526610
3	0.0593804	-0.0477585	-0.0310565	0.1476450	0.6783010	0.1819870
4	-0.1958330	0.2896810	-0.0255931	0.1036000	0.6942910	-0.0330323
5	0.4350550	-0.0669780	0.5007750	-0.1249410	0.5691100	0.2455360
6	-0.1809020	0.4160460	0.3054690	0.2221930	0.5280920	0.2977350
7	0.3612380	0.6890450	0.7602500	-0.3839400	0.3922390	-0.8775180
8	-0.9095570	-1.1552400	-0.4485580	0.5671430	0.7201770	1.4533800

age \ year	2009	2010	2011	2012	2013	2014
0	-0.1680970	-0.2786670	0.2858320	0.275847	-0.6910190	0.2376970
1	-0.1971720	0.3012210	-0.5298500	0.216794	0.2746940	-0.0844039
2	-0.6281020	0.0790646	-0.1167400	0.151955	0.1187000	0.1728690
3	-1.1203200	-0.1057070	-0.0994012	0.730834	-0.0806059	0.4036280
4	-0.4389770	-0.4836230	-0.3304440	0.636692	0.1151530	0.4152980
5	-0.7589370	-0.2665390	-0.2664680	0.361706	0.4408770	0.0653046
6	-0.6219940	-0.2355080	-0.2344560	0.337351	0.6919830	-0.0323488
7	-0.0477157	-0.2154060	-0.3503080	0.868823	0.0715430	-0.2041500
8	-0.0117868	-0.2334290	-0.3365750	-0.636836	0.4916300	0.1412750

Table 3.6.3.16 (continued). North Sea Herring. Catch at age residuals.

age \ year	2015	2016
0	-0.11089000	0.3027580
1	-0.02295890	-0.0493562
2	-0.11028400	-0.1172670
3	-0.71569200	0.2958620
4	-0.27770200	-0.0014309
5	0.00786679	0.0998449
6	0.43440500	0.1711990
7	-0.02990750	0.0257988
8	0.59320900	0.6434090

Table 3.6.3.17 North Sea Herring. Predicted index at age SCAI.

Units : NA

age \ year	1972	1973	1974	1975	1976	1977	1978
all	4527.658	3949.286	2652.665	1526.282	2086.785	1454.053	1835.551

age \ year	1979	1980	1981	1982	1983	1984	1985
all	2293.238	2558.125	3788.858	5304.867	8030.002	12969.94	13804.92

age \ year	1986	1987	1988	1989	1990	1991	1992
all	14069.72	16309.29	20787.56	21553.64	22386.2	19483.44	15048.45

age \ year	1993	1994	1995	1996	1997	1998	1999
all	10697.98	11319.7	11897.46	13575.34	15694.88	18859.46	19624.81

age \ year	2000	2001	2002	2003	2004	2005	2006
all	19669.41	26702.17	30825.58	31599.61	31042.11	29416.18	23088.73

age \ year	2007	2008	2009	2010	2011	2012	2013
all	18352.11	19392.08	24059.86	25109.46	29634.66	32179.99	28796.24

age \ year	2014	2015	2016
all	27598.04	25806.97	30631.98

Table 3.6.3.19 North Sea Herring. Index at age residuals SCAI.

Units : NA

age \ year	1972	1973	1974	1975	1976	1977	1978
all	-0.713297	-0.455045	-0.426575	-0.216622	-1.17728	0.264818	0.336862

age \ year	1979	1980	1981	1982	1983	1984	1985
all	0.747449	0.702605	0.0990308	-0.121161	-0.0901338	-0.168076	0.19627

age \ year	1986	1987	1988	1989	1990	1991	1992
all	0.078517	0.266808	0.481159	0.0268947	-0.229498	-0.764586	-1.57392

age \ year	1993	1994	1995	1996	1997	1998	1999
all	-1.67417	-2.09828	-1.71384	-1.48614	-1.04968	-0.827699	-0.727659

age \ year	2000	2001	2002	2003	2004	2005	2006
all	-0.422927	-0.493949	-0.398384	0.101957	0.355403	0.181138	0.561849

age \ year	2007	2008	2009	2010	2011	2012	2013	2014
all	1.16815	1.4833	1.49325	1.42426	1.15862	1.31017	1.62401	1.53632

age \ year	2015	2016
all	1.64134	1.4455

Table 3.6.3.20 North Sea Herring. Predicted index at age IBTS-Q1.

Units : NA

age	1984	1985	1986	1987	1988	1989	1990
1	1924.266	2186.943	3169.725	3895.666	3528.683	1859.402	1530.623

age	1991	1992	1993	1994	1995	1996	1997	1998
1	1473.993	1406.866	2314.41	1841.103	1557.878	2016.926	2382.749	1652.608

age	1999	2000	2001	2002	2003	2004	2005	2006
1	1135.774	3906.082	2308.446	4668.626	2215.249	1018.28	1332.057	1052.77

age	2007	2008	2009	2010	2011	2012	2013	2014
1	1323.507	1499.04	1509.208	1836.028	1888.447	1421.475	1656.795	2491.898

age	2015	2016	2017
1	3215.377	1012.533	1976.554

Table 3.6.3.21 North Sea Herring. Index at age residuals IBTS-Q1.

Units : NA

age	1984	1985	1986	1987	1988	1989	1990
1	-0.851192	-0.149282	-0.621373	-0.190545	0.782158	0.806882	-1.30481

age	1991	1992	1993	1994	1995	1996	1997
1	-0.484454	-0.370175	0.671516	-0.176766	-0.610374	-0.233667	2.19548

age	1998	1999	2000	2001	2002	2003	2004
1	1.14104	-1.46621	-0.172798	0.283317	-0.658447	1.04533	-0.308341

age	2005	2006	2007	2008	2009	2010	2011
1	-1.0006	-0.544812	-0.00311914	0.575257	1.56262	-1.49772	1.58227

age	2012	2013	2014	2015	2016	2017
1	-0.164351	0.0191833	0.171967	0.704392	-0.920088	0.689276

Table 3.6.3.22 North Sea Herring. Predicted index at age HERAS.

Units : NA

age	1989	1990	1991	1992	1993	1994	1995
1	NA	NA	NA	NA	NA	NA	NA
2	4830690.62	3026144.7	2507508.0	2855621.3	2379259.8	3569728.1	3879434.7
3	4553014.05	3183526.2	1868973.7	1394714.1	1449457.6	1093397.1	1899307.7
4	1964798.00	2849915.8	1840043.9	1059280.0	709630.7	547490.3	558606.2
5	562698.93	1232432.0	1786734.1	1121861.6	624683.2	350459.3	267052.4
6	321804.66	323773.7	682556.1	999589.5	587305.3	294548.8	171974.2
7	151478.65	178545.7	193107.1	386891.7	477204.3	278423.9	146869.5
8	72845.79	133145.8	168282.6	201914.6	292201.8	352780.0	293519.7

age	1996	1997	1998	1999	2000	2001
1	NA	11241243.19	7545787.4	5267150.1	17856890.2	10487556.3
2	3593366.27	4553469.37	6496018.4	3534208.8	3395290.9	10018059.8
3	2356056.96	2373081.79	2590599.8	4656618.0	2268660.2	2557651.5
4	913830.15	1322851.25	1270473.2	1336146.1	2767071.2	1310999.0
5	300589.25	579024.46	803152.6	651478.7	883458.9	1664274.7
6	114313.51	187193.85	339558.0	391014.5	389804.3	466027.5
7	93339.62	65381.85	123192.1	186297.5	239833.4	227112.3
8	255071.71	208167.85	160604.5	149806.5	189283.3	213053.8

age	2002	2003	2004	2005	2006	2007
1	21174326.7	9901531.5	4579040.3	5867270.0	4768774.9	6035082.0
2	5440056.5	14042514.0	4561673.0	2586458.2	3474287.6	2584906.8
3	7163433.8	3644027.2	9809874.1	3395290.9	1951287.6	2372844.5
4	1390953.4	4179908.9	2256893.8	5981608.1	2002285.8	1187665.3
5	798507.8	793493.0	2547696.1	1347147.6	3865493.8	1167178.7
6	964051.5	491049.4	380218.0	1232062.3	669375.2	2140178.9
7	266598.8	562642.7	289120.8	161393.4	528395.3	325168.9
8	265136.5	297360.4	433739.8	282208.1	177442.2	316411.9

age	2008	2009	2010	2011	2012	2013	2014
1	6877047.7	6974003.4	8507000.7	8840906.7	6628572.3	7736809.9	11604459.2
2	3319749.9	4529852.8	4183672.5	5123764.6	5189770.3	3551568.9	4371426.7
3	1820460.4	2352525.5	3613545.6	3071264.7	4445487.1	3838913.7	2742005.1
4	1490019.9	1144868.1	1716675.3	2240478.5	2200070.6	2918849.2	2726692.8
5	860871.0	1081111.2	941754.6	1118612.9	1544483.3	1669108.2	1883797.0
6	766047.9	617725.8	857091.5	598451.0	699905.1	975885.0	1038408.7
7	1452795.2	553656.6	481422.2	575445.6	347527.8	402157.9	553158.6
8	429295.2	1477556.1	1650848.6	1384292.9	1013682.2	777547.5	565406.4

Table 3.6.3.22 (continued). North Sea Herring. Predicted index at age HERAS.

age \ year	2015	2016
1	15048667.4	4757819.3
2	8152213.1	10285030.0
3	2683949.6	6235691.3
4	1554866.1	1483181.5
5	1665440.1	898067.0
6	990237.4	857777.5
7	497524.5	377679.0
8	526286.0	375344.7

Table 3.6.3.23 North Sea Herring. Index at age residuals HERAS.

Units : NA

age \ year	1989	1990	1991	1992	1993	1994
1	NA	NA	NA	NA	NA	NA
2	-0.869989	0.462488	0.257327	1.4019200	1.1837700	-0.5960100
3	-0.805412	0.526927	-0.495598	-0.0629906	0.6358480	-1.3844200
4	-0.966817	0.943824	0.327405	0.4159680	1.2537100	-1.6541100
5	-0.701794	0.538039	0.179196	0.0560183	0.8926190	0.4367240
6	-0.522410	0.777218	-0.236273	0.8956140	1.1378400	0.3494130
7	-0.947149	0.659486	0.675241	0.0844775	0.5845590	0.6414070
8	-0.401007	1.134150	-0.605446	0.3114950	0.0525038	-0.0321355

age \ year	1995	1996	1997	1998	1999	2000
1	NA	NA	-0.437890	-1.264040	-0.0832325	0.779739
2	-0.0412308	1.172650	1.407030	-0.640501	-0.7224210	-0.782719
3	0.3758650	0.947169	1.111100	-0.144659	0.0761536	-0.266019
4	0.9660500	0.906934	0.447206	1.286720	-0.9412650	0.661115
5	0.5905520	0.178170	0.194616	1.050840	-1.3209200	0.684316
6	0.6742220	-0.584800	0.562826	1.099510	-0.8915560	0.871436
7	-0.2533170	-0.477368	-1.429310	1.309070	-1.1904200	0.420936
8	-1.3224900	1.156450	0.527472	0.134499	-0.2464620	0.555404

age \ year	2001	2002	2003	2004	2005	2006
1	-1.0237900	0.2035290	-0.0174469	0.2968280	-1.515690	0.857034
2	1.0686300	-0.5731950	1.5667600	-1.5122900	-1.202150	0.430018
3	0.9765420	0.7189740	-0.8774490	-0.3402350	0.376098	0.121396
4	0.5700000	-0.0035334	0.0110425	-0.2118590	-0.170415	0.242643
5	0.0365452	-0.0258707	-0.8446130	0.0877278	-0.548604	0.402581
6	-0.1423020	0.2730510	0.0308037	-0.7380380	-0.193295	-0.323256
7	-1.1775500	-0.3532430	0.0406562	0.5079580	-0.580822	0.251214
8	-1.2409000	0.0815694	0.3388460	0.7965310	-0.775548	-0.557398

age \ year	2007	2008	2009	2010	2011	2012
1	0.0878306	-1.4740600	-0.9673630	1.2886800	0.323193	0.275305
2	0.3237910	-0.7920850	1.1385800	0.0659974	-1.081540	-0.497085
3	-1.3066500	-0.3302890	0.4272920	0.8062180	-1.005260	-0.465024
4	-1.4616700	-0.0175195	-0.5882310	1.8658500	-0.159854	-1.232210
5	-1.9357500	-0.3246480	-0.0196937	1.4635400	-0.502759	-1.280020
6	-1.9552300	-0.2973670	0.3545370	1.7921600	0.342248	-0.673629
7	-1.1840900	0.7542770	0.5765180	1.4515800	0.726159	-1.387860
8	-1.5332200	0.2364170	0.6176990	2.0432400	0.922719	-1.528360

age \ year	2013	2014	2015	2016
1	-0.4584980	0.00603064	-1.931300	1.534280
2	-1.4658000	0.61583100	0.796957	0.810843
3	-1.2354700	0.15949100	0.278762	-0.349770
4	-0.0427188	0.39200300	0.120024	-0.798746
5	-0.4006660	-0.26423800	-0.379038	-0.462648
6	-0.5661500	0.70811600	-0.272493	0.235811
7	0.5813660	0.77288800	0.179471	0.182416
8	0.3238850	-0.82967100	-0.240975	-0.102512

Table 3.6.3.24 North Sea Herring. Predicted index at age IBTS0.

Units : NA

age \ year	1992	1993	1994	1995	1996	1997	1998
0	136.0796	117.5507	84.32008	111.3992	104.0821	72.19206	51.52824

age \ year	1999	2000	2001	2002	2003	2004	2005	2006
0	166.4725	115.5334	200.0825	105.7661	50.30176	60.59183	55.2921	64.92352

age \ year	2007	2008	2009	2010	2011	2012	2013
0	63.91027	66.30001	84.08767	82.99248	71.15994	78.73832	97.04939

age \ year	2014	2015	2016	2017
0	140.9126	47.56941	88.76656	36.46526

Table 3.6.3.25 North Sea Herring. Index at age residuals IBTS0.

```
Units  :  NA
   year
age    1992    1993     1994     1995      1996    1997      1998     1999
  0 0.91465 1.13146 0.441123 0.308514 0.0540626 1.69138 0.0707233 0.899977
   year
age     2000     2001    2002     2003      2004     2005     2006
  0 0.402866 0.167067 1.00071 0.184372 -0.582932 0.242794 0.581015
   year
age     2007     2008     2009      2010     2011      2012     2013
  0 -1.27384 -2.04587 0.306961 -0.173358 0.185655 -0.345136 -1.54233
   year
age     2014     2015     2016     2017
  0 0.364316 -1.93591 0.275771 -1.10538
```

Table 3.6.3.27 North Sea Herring. Fit paramteres.

```
           name       value  std.dev
1       logFpar  -8.7098000 0.067269
2       logFpar -12.6030000 0.103630
3       logFpar   0.0042002 0.060861
4       logFpar   0.1464700 0.057347
5       logFpar   0.2398700 0.075178
6  logSdLogFsta  -0.5557600 0.094144
7  logSdLogFsta  -1.1334000 0.122510
8  logSdLogFsta  -1.1511000 0.114520
9  logSdLogFsta  -0.6718600 0.102580
10    logSdLogN  -0.5366300 0.115970
11    logSdLogN  -1.8113000 0.116620
12  logSdLogObs  -1.2714000 0.157000
13  logSdLogObs  -0.8560600 0.176290
14  logSdLogObs  -1.4783000 0.516490
15  logSdLogObs  -1.9750000 0.325470
16  logSdLogObs  -1.3400000 0.172560
17  logSdLogObs  -0.8724700 0.178990
18  logSdLogObs  -1.6539000 0.107800
19  logSdLogObs  -1.4024000 0.123020
20  logScaleSSB  -4.2642000 0.078190
21     logSdSSB  -0.8123800 0.110280
```

Table 3.6.3.28 North Sea Herring. Negative likelihood.

```
669.066
```

Table 3.7.1 North Sea herring. Weights at age in the catch.

Units : kg

, , unit = A

age	2014	2015	2016	2017	2018	2019
0	0.0075000	0.0087000	0.0071000	0.01800000	0.01800000	0.01800000
1	0.0522000	0.0261000	0.0265000	0.08294214	0.08294214	0.08294214
2	0.1240000	0.1135000	0.1267000	0.13147878	0.13147878	0.13147878
3	0.1719000	0.1538000	0.1549000	0.16015807	0.16015807	0.16015807
4	0.1861000	0.1883000	0.1803000	0.18517125	0.18517125	0.18517125
5	0.2148000	0.2001000	0.2059000	0.20730796	0.20730796	0.20730796
6	0.2118000	0.2212000	0.2151000	0.21669316	0.21669316	0.21669316
7	0.2264000	0.2170000	0.2313000	0.22496167	0.22496167	0.22496167
8	0.2426541	0.2347182	0.2299244	0.23467238	0.23467238	0.23467238

, , unit = B

age	2014	2015	2016	2017	2018	2019
0	0.0075000	0.0087000	0.0071000	0.00721681	0.00721681	0.00721681
1	0.0522000	0.0261000	0.0265000	0.02327973	0.02327973	0.02327973
2	0.1240000	0.1135000	0.1267000	0.05686992	0.05686992	0.05686992
3	0.1719000	0.1538000	0.1549000	0.09171033	0.09171033	0.09171033
4	0.1861000	0.1883000	0.1803000	0.14720305	0.14720305	0.14720305
5	0.2148000	0.2001000	0.2059000	0.21400000	0.21400000	0.21400000
6	0.2118000	0.2212000	0.2151000	0.17613183	0.17613183	0.17613183
7	0.2264000	0.2170000	0.2313000	0.22700000	0.22700000	0.22700000
8	0.2426541	0.2347182	0.2299244	0.22600000	0.22600000	0.22600000

, , unit = C

age	2014	2015	2016	2017	2018	2019
0	0.0075000	0.0087000	0.0071000	0.01486957	0.01486957	0.01486957
1	0.0522000	0.0261000	0.0265000	0.05347475	0.05347475	0.05347475
2	0.1240000	0.1135000	0.1267000	0.07511801	0.07511801	0.07511801
3	0.1719000	0.1538000	0.1549000	0.12541668	0.12541668	0.12541668
4	0.1861000	0.1883000	0.1803000	0.15626615	0.15626615	0.15626615
5	0.2148000	0.2001000	0.2059000	0.18129987	0.18129987	0.18129987
6	0.2118000	0.2212000	0.2151000	0.19945285	0.19945285	0.19945285
7	0.2264000	0.2170000	0.2313000	0.19734824	0.19734824	0.19734824
8	0.2426541	0.2347182	0.2299244	0.21950871	0.21950871	0.21950871

, , unit = D

age	2014	2015	2016	2017	2018	2019
0	0.0075000	0.0087000	0.0071000	0.008776475	0.008776475	0.008776475
1	0.0522000	0.0261000	0.0265000	0.023787926	0.023787926	0.023787926
2	0.1240000	0.1135000	0.1267000	0.039358372	0.039358372	0.039358372
3	0.1719000	0.1538000	0.1549000	0.068040917	0.068040917	0.068040917
4	0.1861000	0.1883000	0.1803000	0.000000000	0.000000000	0.000000000
5	0.2148000	0.2001000	0.2059000	0.078000000	0.078000000	0.078000000
6	0.2118000	0.2212000	0.2151000	0.000000000	0.000000000	0.000000000
7	0.2264000	0.2170000	0.2313000	0.000000000	0.000000000	0.000000000
8	0.2426541	0.2347182	0.2299244	0.000000000	0.000000000	0.000000000

Table 3.7.2 North Sea herring. Weights at age in the stock.

```
Units  :  kg
, , unit = A

   year
age        2014        2015       2016       2017       2018       2019
  0 0.005666667 0.005333333 0.00500000 0.00500000 0.00500000 0.00500000
  1 0.043333333 0.043666667 0.04333333 0.04333333 0.04333333 0.04333333
  2 0.128666667 0.127333333 0.12100000 0.12100000 0.12100000 0.12100000
  3 0.176666667 0.161333333 0.16033333 0.16033333 0.16033333 0.16033333
  4 0.203666667 0.200000000 0.18866667 0.18866667 0.18866667 0.18866667
  5 0.215666667 0.211666667 0.21600000 0.21600000 0.21600000 0.21600000
  6 0.228666667 0.224666667 0.22433333 0.22433333 0.22433333 0.22433333
  7 0.241333333 0.229000000 0.22433333 0.22433333 0.22433333 0.22433333
  8 0.246572539 0.239358137 0.23372066 0.23372066 0.23372066 0.23372066

, , unit = B

   year
age        2014        2015       2016       2017       2018       2019
  0 0.005666667 0.005333333 0.00500000 0.00500000 0.00500000 0.00500000
  1 0.043333333 0.043666667 0.04333333 0.04333333 0.04333333 0.04333333
  2 0.128666667 0.127333333 0.12100000 0.12100000 0.12100000 0.12100000
  3 0.176666667 0.161333333 0.16033333 0.16033333 0.16033333 0.16033333
  4 0.203666667 0.200000000 0.18866667 0.18866667 0.18866667 0.18866667
  5 0.215666667 0.211666667 0.21600000 0.21600000 0.21600000 0.21600000
  6 0.228666667 0.224666667 0.22433333 0.22433333 0.22433333 0.22433333
  7 0.241333333 0.229000000 0.22433333 0.22433333 0.22433333 0.22433333
  8 0.246572539 0.239358137 0.23372066 0.23372066 0.23372066 0.23372066

, , unit = C

   year
age        2014        2015       2016       2017       2018       2019
  0 0.005666667 0.005333333 0.00500000 0.00500000 0.00500000 0.00500000
  1 0.043333333 0.043666667 0.04333333 0.04333333 0.04333333 0.04333333
  2 0.128666667 0.127333333 0.12100000 0.12100000 0.12100000 0.12100000
  3 0.176666667 0.161333333 0.16033333 0.16033333 0.16033333 0.16033333
  4 0.203666667 0.200000000 0.18866667 0.18866667 0.18866667 0.18866667
  5 0.215666667 0.211666667 0.21600000 0.21600000 0.21600000 0.21600000
  6 0.228666667 0.224666667 0.22433333 0.22433333 0.22433333 0.22433333
  7 0.241333333 0.229000000 0.22433333 0.22433333 0.22433333 0.22433333
  8 0.246572539 0.239358137 0.23372066 0.23372066 0.23372066 0.23372066

, , unit = D

   year
age        2014        2015       2016       2017       2018       2019
  0 0.005666667 0.005333333 0.00500000 0.00500000 0.00500000 0.00500000
  1 0.043333333 0.043666667 0.04333333 0.04333333 0.04333333 0.04333333
  2 0.128666667 0.127333333 0.12100000 0.12100000 0.12100000 0.12100000
  3 0.176666667 0.161333333 0.16033333 0.16033333 0.16033333 0.16033333
  4 0.203666667 0.200000000 0.18866667 0.18866667 0.18866667 0.18866667
  5 0.215666667 0.211666667 0.21600000 0.21600000 0.21600000 0.21600000
  6 0.228666667 0.224666667 0.22433333 0.22433333 0.22433333 0.22433333
  7 0.241333333 0.229000000 0.22433333 0.22433333 0.22433333 0.22433333
  8 0.246572539 0.239358137 0.23372066 0.23372066 0.23372066 0.23372066
```

Table 3.7.3 North Sea herring. Stock in number.

```
Units  :  NA
, , unit = A

   year
age             2014             2015             2016             2017 2018
  0 46688105.9676567 15775994.3865129 29532443.5987433 12127667.8566581
  1 16337930.7125849 21062399.6147455  6622609.2713014 12929214.5166874
  2 5564958.02507853 10252170.5284078 12839026.0429978 3602000.70340569
  3 3087894.42269329 2957929.23882236 6962157.70951105 8512106.48098897
  4 3188305.04596486 1788700.61355759  1713416.6911467 4368804.67540453
  5  2078173.6228203  1857979.1935712 1020700.79166381  1010544.6490944
  6 1153140.90607261 1179970.50456726 1033022.98646661 522823.913036082
  7 643064.301144597 646934.285293967 568638.394192235 475917.595724011
  8 657368.484859891 684196.201656699 565236.778877865 348362.889028806
   year
age 2019
  0
  1
  2
  3
  4
  5
  6
  7
  8

, , unit = B

   year
age             2014             2015             2016             2017 2018
  0 46688105.9676567 15775994.3865129 29532443.5987433 12127667.8566581
  1 16337930.7125849 21062399.6147455  6622609.2713014 12929214.5166874
  2 5564958.02507853 10252170.5284078 12839026.0429978 3602000.70340569
  3 3087894.42269329 2957929.23882236 6962157.70951105 8512106.48098897
  4 3188305.04596486 1788700.61355759  1713416.6911467 4368804.67540453
  5  2078173.6228203  1857979.1935712 1020700.79166381  1010544.6490944
  6 1153140.90607261 1179970.50456726 1033022.98646661 522823.913036082
  7 643064.301144597 646934.285293967 568638.394192235 475917.595724011
  8 657368.484859891 684196.201656699 565236.778877865 348362.889028806
   year
age 2019
  0
  1
  2
  3
  4
  5
  6
  7
  8
```

Table 3.7.3 (continued). North Sea herring. Stock in number.

```
, , unit = C

   year
age             2014             2015             2016             2017 2018
  0 46688105.9676567 15775994.3865129 29532443.5987433 12127667.8566581
  1 16337930.7125849 21062399.6147455  6622609.2713014 12929214.5166874
  2 5564958.02507853 10252170.5284078 12839026.0429978 3602000.70340569
  3 3087894.42269329 2957929.23882236 6962157.70951105 8512106.48098897
  4 3188305.04596486 1788700.61355759  1713416.6911467 4368804.67540453
  5  2078173.6228203  1857979.1935712 1020700.79166381  1010544.6490944
  6 1153140.90607261 1179970.50456726 1033022.98646661 522823.913036082
  7 643064.301144597 646934.285293967 568638.394192235 475917.595724011
  8 657368.484859891 684196.201656699 565236.778877865 348362.889028806
   year
age 2019
  0
  1
  2
  3
  4
  5
  6
  7
  8

, , unit = D

   year
age             2014             2015             2016             2017 2018
  0 46688105.9676567 15775994.3865129 29532443.5987433 12127667.8566581
  1 16337930.7125849 21062399.6147455  6622609.2713014 12929214.5166874
  2 5564958.02507853 10252170.5284078 12839026.0429978 3602000.70340569
  3 3087894.42269329 2957929.23882236 6962157.70951105 8512106.48098897
  4 3188305.04596486 1788700.61355759  1713416.6911467 4368804.67540453
  5  2078173.6228203  1857979.1935712 1020700.79166381  1010544.6490944
  6 1153140.90607261 1179970.50456726 1033022.98646661 522823.913036082
  7 643064.301144597 646934.285293967 568638.394192235 475917.595724011
  8 657368.484859891 684196.201656699 565236.778877865 348362.889028806
   year
age 2019
  0
  1
  2
  3
  4
  5
  6
  7
  8
```

Table 3.7.4 North Sea herring. Fishing mortality at age in the stock.

Units : f

, , unit = A

age \ year	2014	2015	2016
0	0.0420035979034456	0.0523658823449604	0.0756452976474225
1	0.0309247019061951	0.0252254972588298	0.0221526090358218
2	0.0833005605950044	0.0670645292474746	0.0603798402772052
3	0.149031140236087	0.114406200652205	0.141239252548874
4	0.237402088371065	0.210809583673834	0.220512697658588
5	0.311237186475763	0.334840828124058	0.371639864429107
6	0.334974791246146	0.465524757002676	0.489050266652451
7	0.439226523556024	0.644648546396657	0.914536408022505
8	0.439226523556024	0.644648546396657	0.914536408022505

age \ year	2017	2018	2019
0	0		
1	0.000462708371154638		
2	0.0531344720817672		
3	0.137396634135935		
4	0.217368212693548		
5	0.368120069591905		
6	0.483601943400888		
7	0.906740667132449		
8	0.906682622194588		

, , unit = B

age \ year	2014	2015	2016
0	0.0420035979034456	0.0523658823449604	0.0756452976474225
1	0.0309247019061951	0.0252254972588298	0.0221526090358218
2	0.0833005605950044	0.0670645292474746	0.0603798402772052
3	0.149031140236087	0.114406200652205	0.141239252548874
4	0.237402088371065	0.210809583673834	0.220512697658588
5	0.311237186475763	0.334840828124058	0.371639864429107
6	0.334974791246146	0.465524757002676	0.489050266652451
7	0.439226523556024	0.644648546396657	0.914536408022505
8	0.439226523556024	0.644648546396657	0.914536408022505

age \ year	2017	2018	2019
0	0.0814978150772265		
1	0.0199422192140777		
2	0.00260268779358251		
3	0.00194662339114086		
4	0.0010610124220469		
5	0		
6	0.00123633651151081		
7	0		
8	0		

Table 3.7.4 (continued). North Sea herring. Fishing mortality at age in the stock.

, , unit = C

year

age	2014	2015	2016
0	0.0420035979034456	0.0523658823449604	0.0756452976474225
1	0.0309247019061951	0.0252254972588298	0.0221526090358218
2	0.0833005605950044	0.0670645292474746	0.0603798402772052
3	0.149031140236087	0.114406200652205	0.141239252548874
4	0.237402088371065	0.210809583673834	0.220512697658588
5	0.311237186475763	0.334840828124058	0.371639864429107
6	0.334974791246146	0.465524757002676	0.489050266652451
7	0.439226523556024	0.644648546396657	0.914536408022505
8	0.439226523556024	0.644648546396657	0.914536408022505

year

age	2017	2018	2019
0	0		
1	0.00627556225095518		
2	0.0115727785210255		
3	0.00287783128450952		
4	0.00113564165518455		
5	0.000805138554506882		
6	0.000838572343577751		
7	0.000291226531072981		
8	0.0004581649013112		

, , unit = D

year

age	2014	2015	2016
0	0.0420035979034456	0.0523658823449604	0.0756452976474225
1	0.0309247019061951	0.0252254972588298	0.0221526090358218
2	0.0833005605950044	0.0670645292474746	0.0603798402772052
3	0.149031140236087	0.114406200652205	0.141239252548874
4	0.237402088371065	0.210809583673834	0.220512697658588
5	0.311237186475763	0.334840828124058	0.371639864429107
6	0.334974791246146	0.465524757002676	0.489050266652451
7	0.439226523556024	0.644648546396657	0.914536408022505
8	0.439226523556024	0.644648546396657	0.914536408022505

year

age	2017	2018	2019
0	0.027115145480554		
1	0.0107879562527631		
2	0.00223158580149345		
3	5.52083204196089e-05		
4	0		
5	0.000485435801079152		
6	0		
7	0		
8	0		

Table 3.7.5 North Sea herring. Natural mortality.

Units : NA

, , unit = A

age \ year	2014	2015	2016	2017	2018	2019
0	0.8172596	0.8164639	0.8155641	0.8157344	0.8157344	0.8157344
1	0.5993861	0.5933003	0.5870521	0.5882947	0.5882947	0.5882947
2	0.3638303	0.3578530	0.3512400	0.3522141	0.3522141	0.3522141
3	0.3331844	0.3291830	0.3246688	0.3252771	0.3252771	0.3252771
4	0.3137208	0.3108021	0.3073193	0.3076788	0.3076788	0.3076788
5	0.3030087	0.3003801	0.2971416	0.2974192	0.2974192	0.2974192
6	0.2909866	0.2887470	0.2860034	0.2862520	0.2862520	0.2862520
7	0.2714712	0.2689877	0.2658760	0.2661175	0.2661175	0.2661175
8	0.2714712	0.2689877	0.2658760	0.2661175	0.2661175	0.2661175

, , unit = B

age \ year	2014	2015	2016	2017	2018	2019
0	0.8172596	0.8164639	0.8155641	0.8157344	0.8157344	0.8157344
1	0.5993861	0.5933003	0.5870521	0.5882947	0.5882947	0.5882947
2	0.3638303	0.3578530	0.3512400	0.3522141	0.3522141	0.3522141
3	0.3331844	0.3291830	0.3246688	0.3252771	0.3252771	0.3252771
4	0.3137208	0.3108021	0.3073193	0.3076788	0.3076788	0.3076788
5	0.3030087	0.3003801	0.2971416	0.2974192	0.2974192	0.2974192
6	0.2909866	0.2887470	0.2860034	0.2862520	0.2862520	0.2862520
7	0.2714712	0.2689877	0.2658760	0.2661175	0.2661175	0.2661175
8	0.2714712	0.2689877	0.2658760	0.2661175	0.2661175	0.2661175

, , unit = C

age \ year	2014	2015	2016	2017	2018	2019
0	0.8172596	0.8164639	0.8155641	0.8157344	0.8157344	0.8157344
1	0.5993861	0.5933003	0.5870521	0.5882947	0.5882947	0.5882947
2	0.3638303	0.3578530	0.3512400	0.3522141	0.3522141	0.3522141
3	0.3331844	0.3291830	0.3246688	0.3252771	0.3252771	0.3252771
4	0.3137208	0.3108021	0.3073193	0.3076788	0.3076788	0.3076788
5	0.3030087	0.3003801	0.2971416	0.2974192	0.2974192	0.2974192
6	0.2909866	0.2887470	0.2860034	0.2862520	0.2862520	0.2862520
7	0.2714712	0.2689877	0.2658760	0.2661175	0.2661175	0.2661175
8	0.2714712	0.2689877	0.2658760	0.2661175	0.2661175	0.2661175

, , unit = D

age \ year	2014	2015	2016	2017	2018	2019
0	0.8172596	0.8164639	0.8155641	0.8157344	0.8157344	0.8157344
1	0.5993861	0.5933003	0.5870521	0.5882947	0.5882947	0.5882947
2	0.3638303	0.3578530	0.3512400	0.3522141	0.3522141	0.3522141
3	0.3331844	0.3291830	0.3246688	0.3252771	0.3252771	0.3252771
4	0.3137208	0.3108021	0.3073193	0.3076788	0.3076788	0.3076788
5	0.3030087	0.3003801	0.2971416	0.2974192	0.2974192	0.2974192
6	0.2909866	0.2887470	0.2860034	0.2862520	0.2862520	0.2862520
7	0.2714712	0.2689877	0.2658760	0.2661175	0.2661175	0.2661175
8	0.2714712	0.2689877	0.2658760	0.2661175	0.2661175	0.2661175

Table 3.7.6 North Sea herring. Proportion mature.

Units : NA

, , unit = A

year

age	2014	2015	2016	2017	2018	2019
0	0.00	0.00	0.00	0.000000000	0.000000000	0.000000000
1	0.00	0.00	0.01	0.003333333	0.003333333	0.003333333
2	0.85	0.70	0.71	0.753333333	0.753333333	0.753333333
3	1.00	0.90	0.89	0.930000000	0.930000000	0.930000000
4	1.00	0.96	0.95	0.970000000	0.970000000	0.970000000
5	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000
6	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000
7	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000
8	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000

, , unit = B

year

age	2014	2015	2016	2017	2018	2019
0	0.00	0.00	0.00	0.000000000	0.000000000	0.000000000
1	0.00	0.00	0.01	0.003333333	0.003333333	0.003333333
2	0.85	0.70	0.71	0.753333333	0.753333333	0.753333333
3	1.00	0.90	0.89	0.930000000	0.930000000	0.930000000
4	1.00	0.96	0.95	0.970000000	0.970000000	0.970000000
5	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000
6	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000
7	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000
8	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000

, , unit = C

year

age	2014	2015	2016	2017	2018	2019
0	0.00	0.00	0.00	0.000000000	0.000000000	0.000000000
1	0.00	0.00	0.01	0.003333333	0.003333333	0.003333333
2	0.85	0.70	0.71	0.753333333	0.753333333	0.753333333
3	1.00	0.90	0.89	0.930000000	0.930000000	0.930000000
4	1.00	0.96	0.95	0.970000000	0.970000000	0.970000000
5	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000
6	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000
7	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000
8	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000

, , unit = D

year

age	2014	2015	2016	2017	2018	2019
0	0.00	0.00	0.00	0.000000000	0.000000000	0.000000000
1	0.00	0.00	0.01	0.003333333	0.003333333	0.003333333
2	0.85	0.70	0.71	0.753333333	0.753333333	0.753333333
3	1.00	0.90	0.89	0.930000000	0.930000000	0.930000000
4	1.00	0.96	0.95	0.970000000	0.970000000	0.970000000
5	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000
6	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000
7	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000
8	1.00	1.00	1.00	1.000000000	1.000000000	1.000000000

Table 3.7.7. North Sea herring. Fraction of harvest before spawning.

```
Units  :  NA
, , unit = A

   year
age 2014 2015 2016 2017 2018 2019
  0 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
  2 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
  4 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
  6 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
  8 0.67 0.67 0.67 0.67 0.67 0.67

, , unit = B

   year
age 2014 2015 2016 2017 2018 2019
  0 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
  2 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
  4 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
  6 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
  8 0.67 0.67 0.67 0.67 0.67 0.67

, , unit = C

   year
age 2014 2015 2016 2017 2018 2019
  0 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
  2 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
  4 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
  6 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
  8 0.67 0.67 0.67 0.67 0.67 0.67

, , unit = D

   year
age 2014 2015 2016 2017 2018 2019
  0 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
  2 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
  4 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
  6 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
  8 0.67 0.67 0.67 0.67 0.67 0.67
```

Table 3.7.8. North Sea Herring. Fraction of natural mortality before spawning.

```
Units  :  NA
, , unit = A

   year
age 2014 2015 2016 2017 2018 2019
  0 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
  2 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
  4 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
  6 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
  8 0.67 0.67 0.67 0.67 0.67 0.67

, , unit = B

   year
age 2014 2015 2016 2017 2018 2019
  0 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
  2 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
  4 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
  6 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
  8 0.67 0.67 0.67 0.67 0.67 0.67

, , unit = C

   year
age 2014 2015 2016 2017 2018 2019
  0 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
  2 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
  4 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
  6 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
  8 0.67 0.67 0.67 0.67 0.67 0.67

, , unit = D

   year
age 2014 2015 2016 2017 2018 2019
  0 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
  2 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
  4 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
  6 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
  8 0.67 0.67 0.67 0.67 0.67 0.67
```

Table 3.7.9. North Sea herring. Recruitment in 2016.

```
25868225
```

Table 3.7.10. North Sea herring. Recruitment in 2017.

```
25868225
```

Table 3.7.11. North Sea herring. FLR, R software versions.

```
R version 3.3.3 (2017-03-06)

Package  : FLSAM
Version  : 1.02
Packaged : 2017-02-03 11:22:59 UTC; mosquia
Built    : R 3.3.2; ; 2017-02-06 09:12:44 UTC; windows

Package  : FLCore
Version  : 2.6.0.20170228
Packaged : 2017-02-28 08:48:05 UTC; mosquia
Built    : R 3.3.2; ; 2017-02-28 10:05:06 UTC; windows
```

Table 3.7.12. North Sea herring. Management options for North Sea herring.

Outlook assuming a TAC constraint for fleet A in 2017, proportion of 2016 by-catch ceiling taken applied to 2017 for fleet B

Basis: Intermediate year (2017) with catch constraint

F fleet A	F fleet B	F fleet C	F fleet D	F2-6	F0-1	Catch fleet A	Catch fleet B	Catch Fleet C	Catch fleet D	SSB 2017
0.25	0.05	0.003	0.02	0.26	0.07	502423	11375	9042	4661	2033511

[1]Includes a transfer of 46% of 3.a TAC from the C-fleet to the A-fleet

3.7.13. North Sea Herring. Scenarios for prediction year (2018). Weights in tonnes.

Basis	F values by fleet and total						Catches by fleet					Biomass*			
	A-fleet Fages (wr) 2–6	B-fleet Fages (wr) 0–1	C-fleet Fages (wr) 0–1	D-fleet Fages (wr) 0–1	Fages (wr) 2–6	Fages (wr) 0–1	A-fleet	B-fleet	C-fleet	D-fleet	Total stock catch	SSB 2018	%SSB change ***	SSB 2019**	%TAC change A-fleet ^
Management strategy ^^	0.278	0.028	0.006	0.016	0.286	0.050	533106	7556	14540	4661	559864	1863636	-8%	1458031	11%
Other options															
F = FMSY	0.322	0.028	0.006	0.016	0.33	0.051	600729	7556	15812	4661	628759	1816271	-11%	1377206	25%
F = 0	0	0	0	0	0	0	0	0	0	0	0	2223416	9%	2226726.5	-100%
No change in A-fleet TAC	0.247	0.028	0.007	0.016	0.255	0.051	481608	7556	16744	4661	510570	1897229	-7%	1517058	0%
A-fleet TAC increase of 15%	0.292	0.028	0.008	0.016	0.301	0.052	553849	7556	19256	4661	585323	1846256	-9%	1426731	15%
A-fleet TAC reduction of 15%	0.204	0.028	0.006	0.016	0.212	0.050	409367	7556	14233	4661	435817	1947587	-4%	1611071	-15%
F = F2017	0.250	0.028	0.005	0.016	0.257	0.050	487099	7556	13675	4661	512991	1895556	-7%	1514795	1%
Fpa	0.332	0.028	0.007	0.016	0.340	0.051	615671	7556	16093	4661	643982	1805733	-11%	1359759	28%
Flim	0.381	0.028	0.007	0.016	0.390	0.052	687700	7556	17448	4661	717365	1754563	-14%	1277709	43%
SSB2018 = Bpa	1.502	0.029	0.017	0.016	1.522	0.064	1661661	7556	35768	4661	1709646	1000000	-51%	463477	245%
SSB2018 = Blim	2.038	0.029	0.020	0.016	2.062	0.068	1896766	7556	40191	4661	1949174	800000	-61%	336018	294%
SSB2018 = MSY Btrigger	0.663	0.028	0.010	0.016	0.676	0.055	1033818	7556	23959	4661	1069994	1500000	-26%	928495	115%

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

**** Assuming same catch option in 2019 as in 2018.**

***** SSB (2018) relative to SSB (2017).**

^ A-fleet catches (2018) relative to TAC 2017 for the A-fleet (481608 tonnes).

^^ The maximum 10% deviation from the F_{target} ($F_{ages\ (wr)\ 2–6}$ = 0.26) allowed for in the Management strategy determined the Management strategy catch option as corresponding to $F_{ages\ (wr)\ 2–6}$ = 0.286 in 2018.

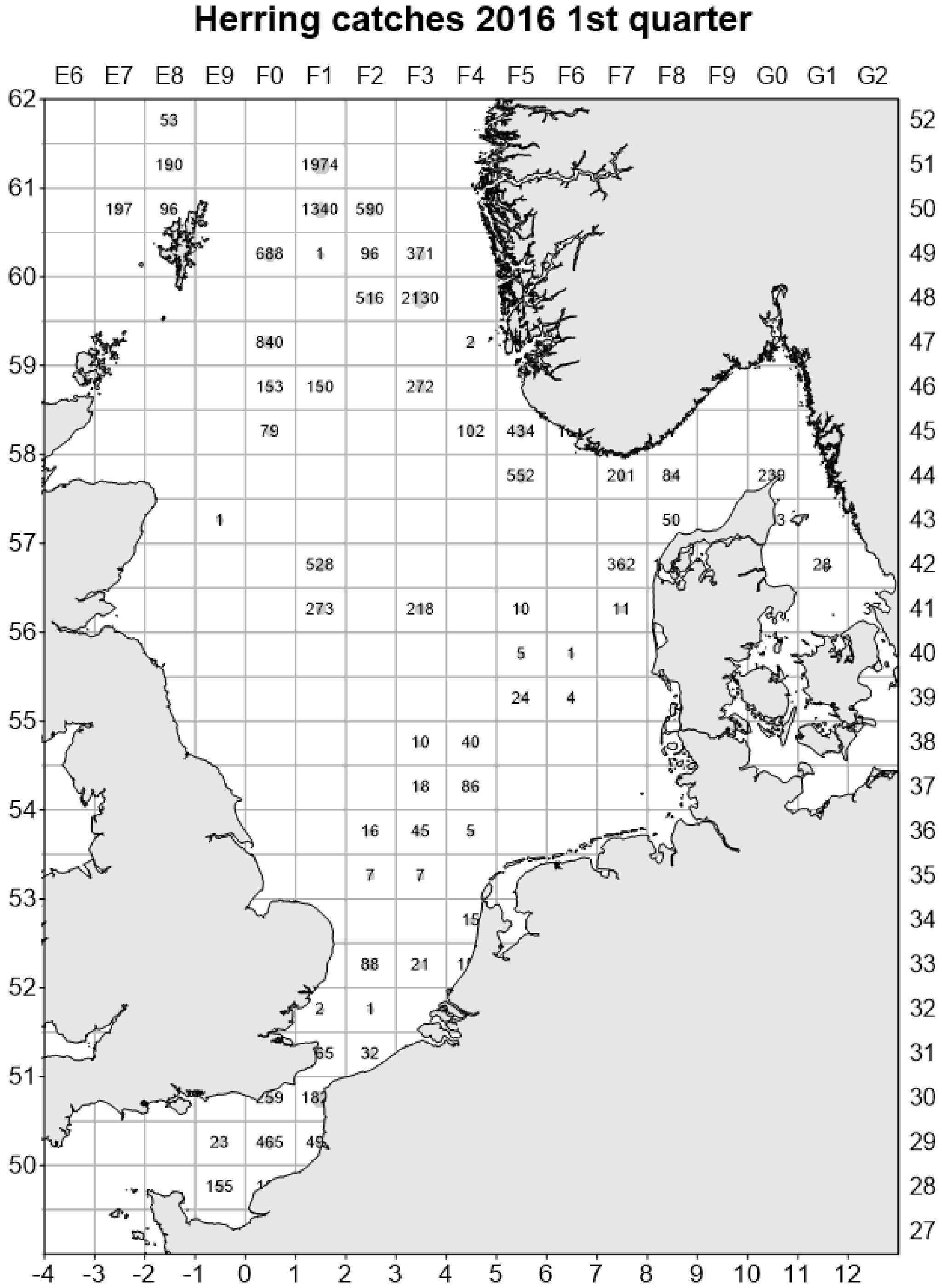


Figure 3.1.1a: Herring catches in the North Sea in the 1st quarter of 2016 (in tonnes) by statistical rectangle.

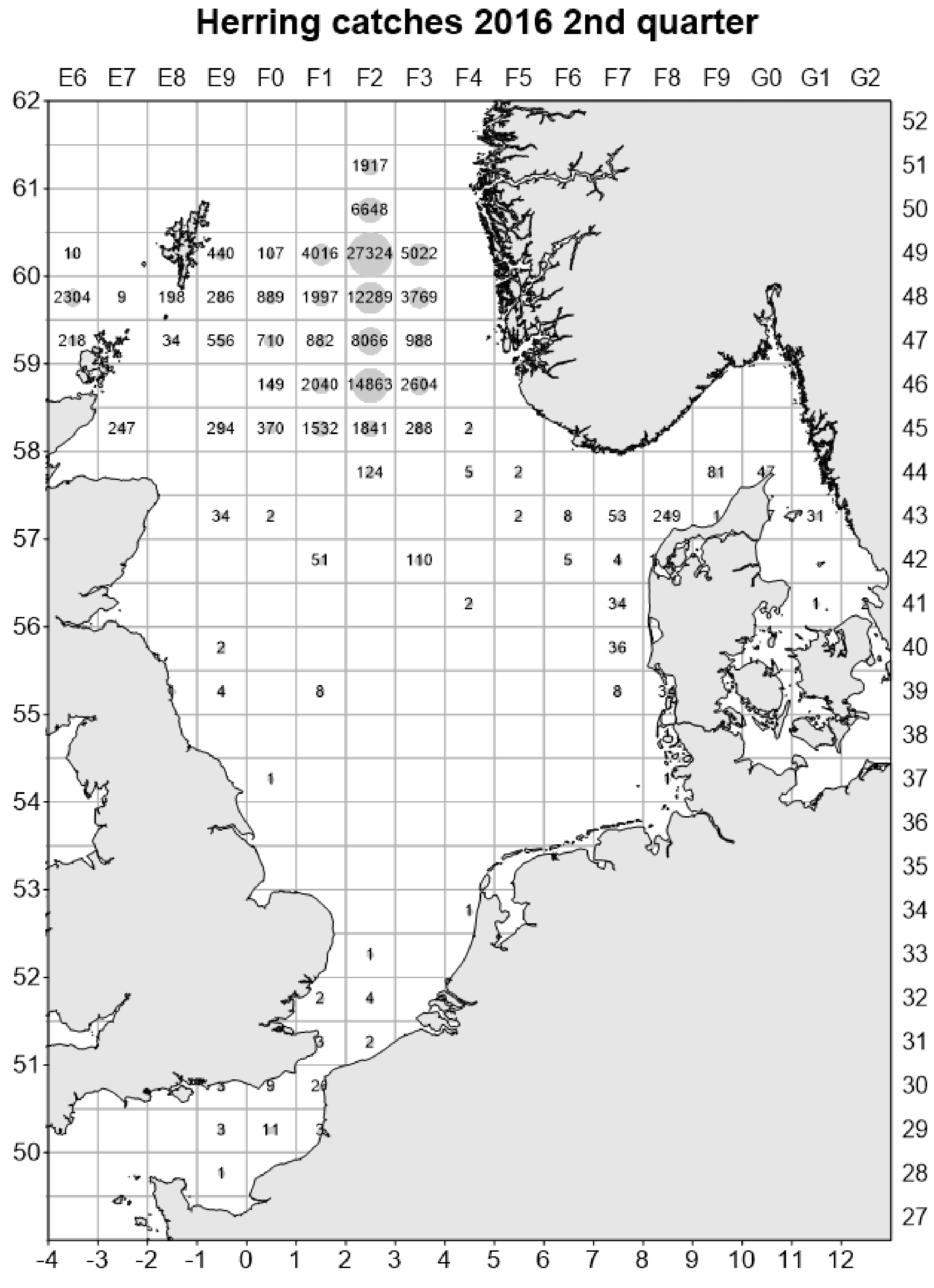


Figure 3.1.1b: Herring catches in the North Sea in the 2nd quarter of 2016 (in tonnes) by statistical rectangle.

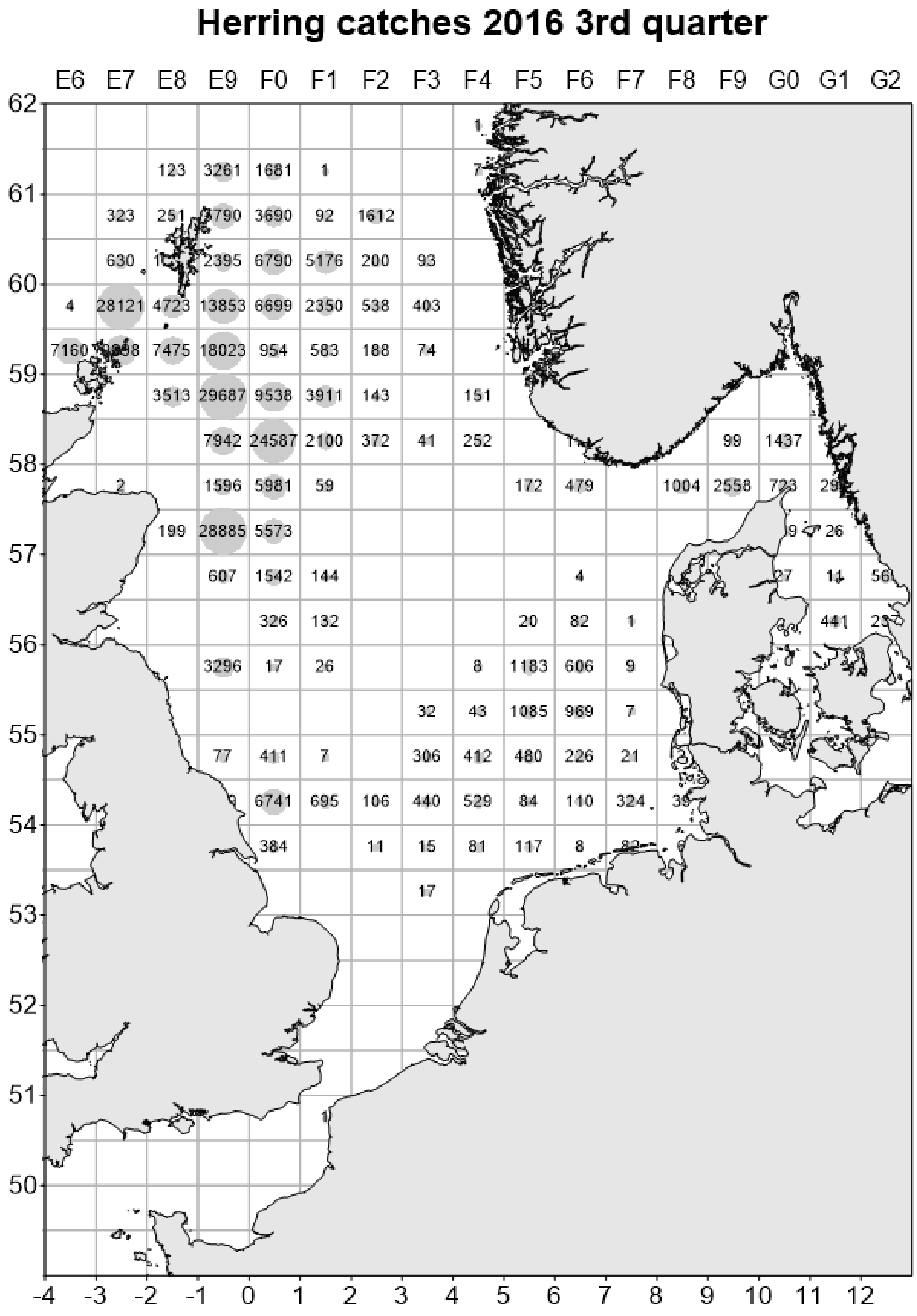


Figure 3.1.1c: Herring catches in the North Sea in the 3rd quarter of 2016 (in tonnes) by statistical rectangle.

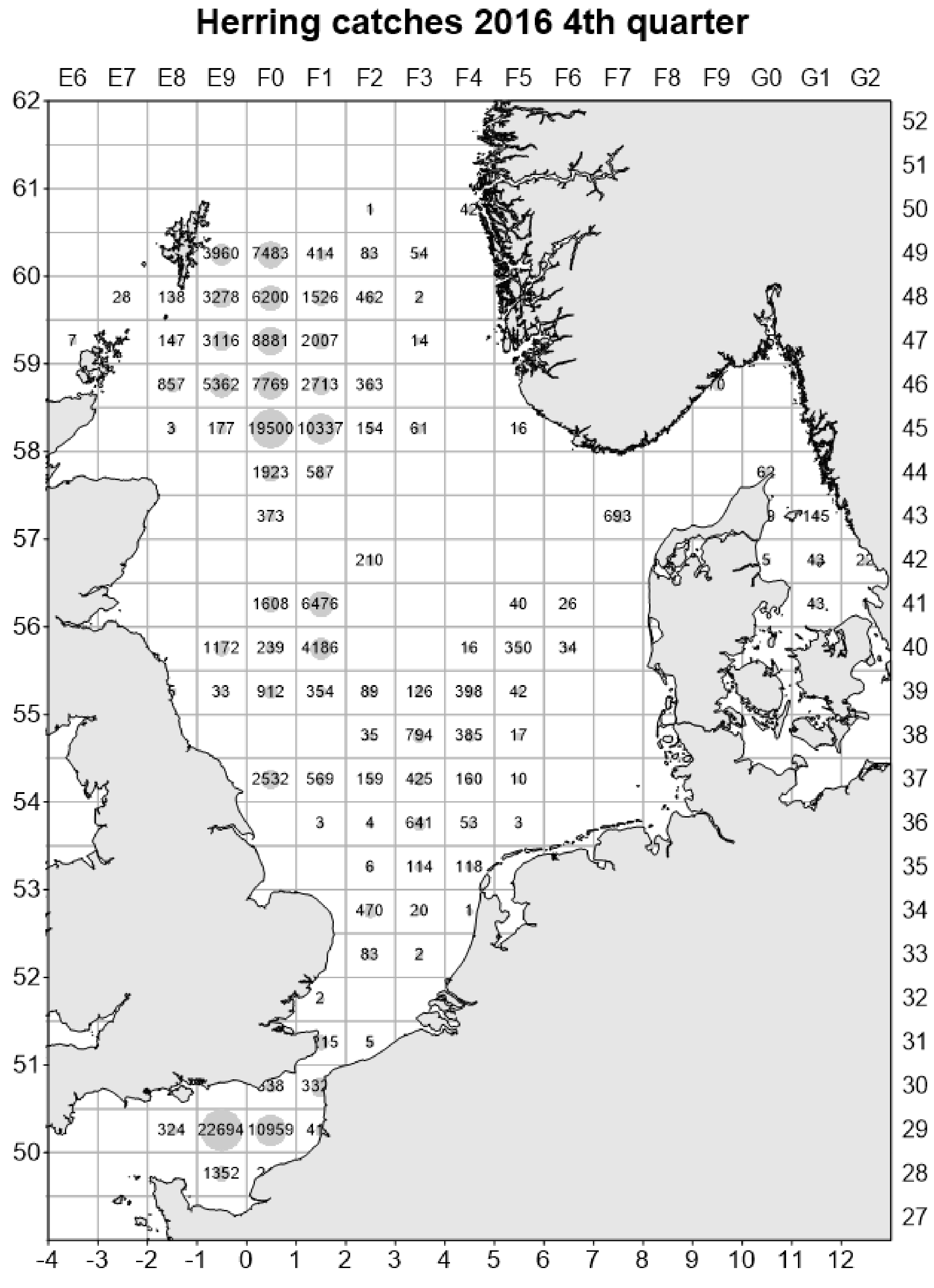


Figure 3.1.1d: Herring catches in the North Sea in the 4th quarter of 2016 (in tonnes) by statistical rectangle.

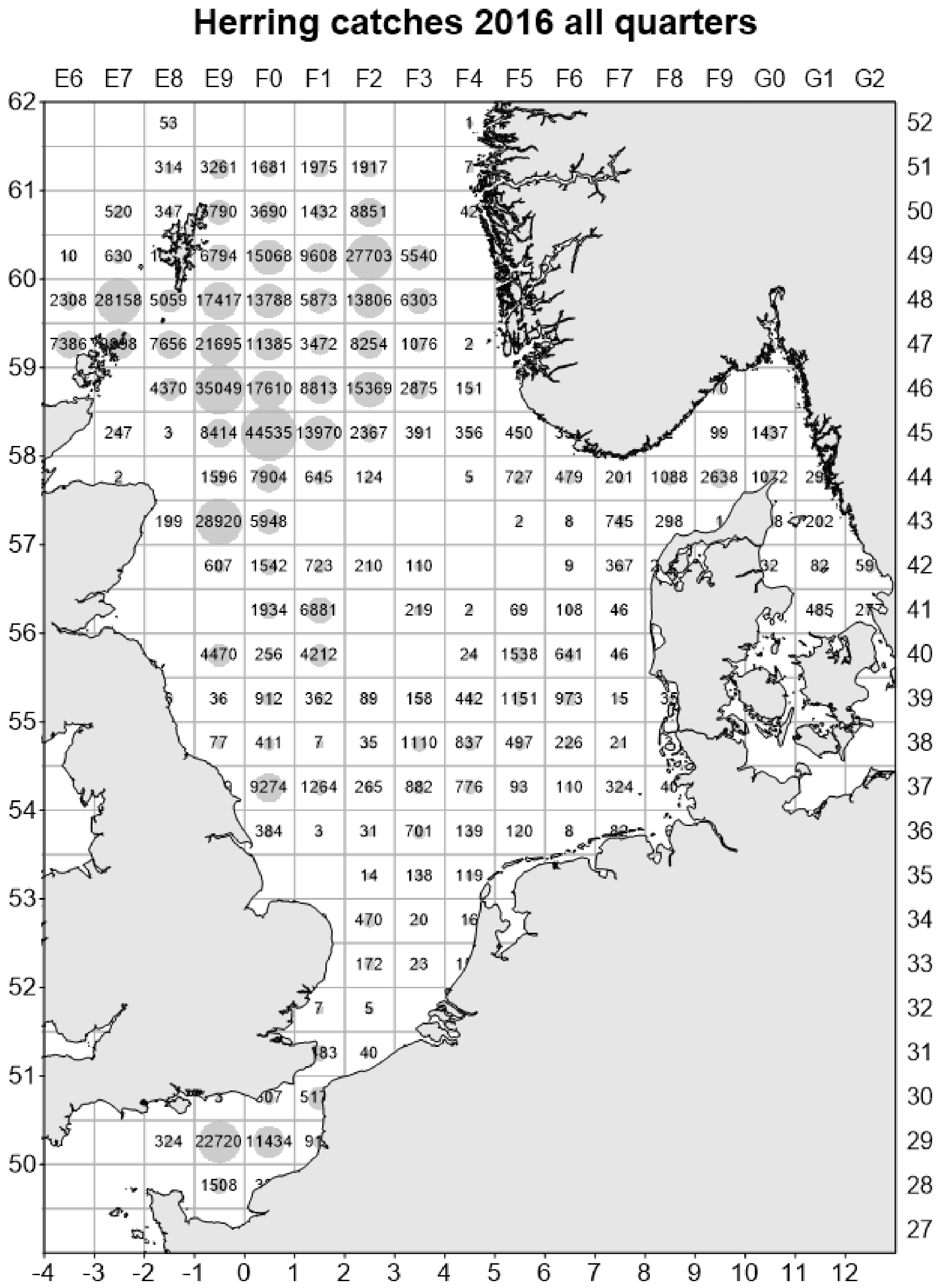


Figure 3.1.1e: Herring catches in the North Sea in all quarters of 2016 (in tonnes) by statistical rectangle.

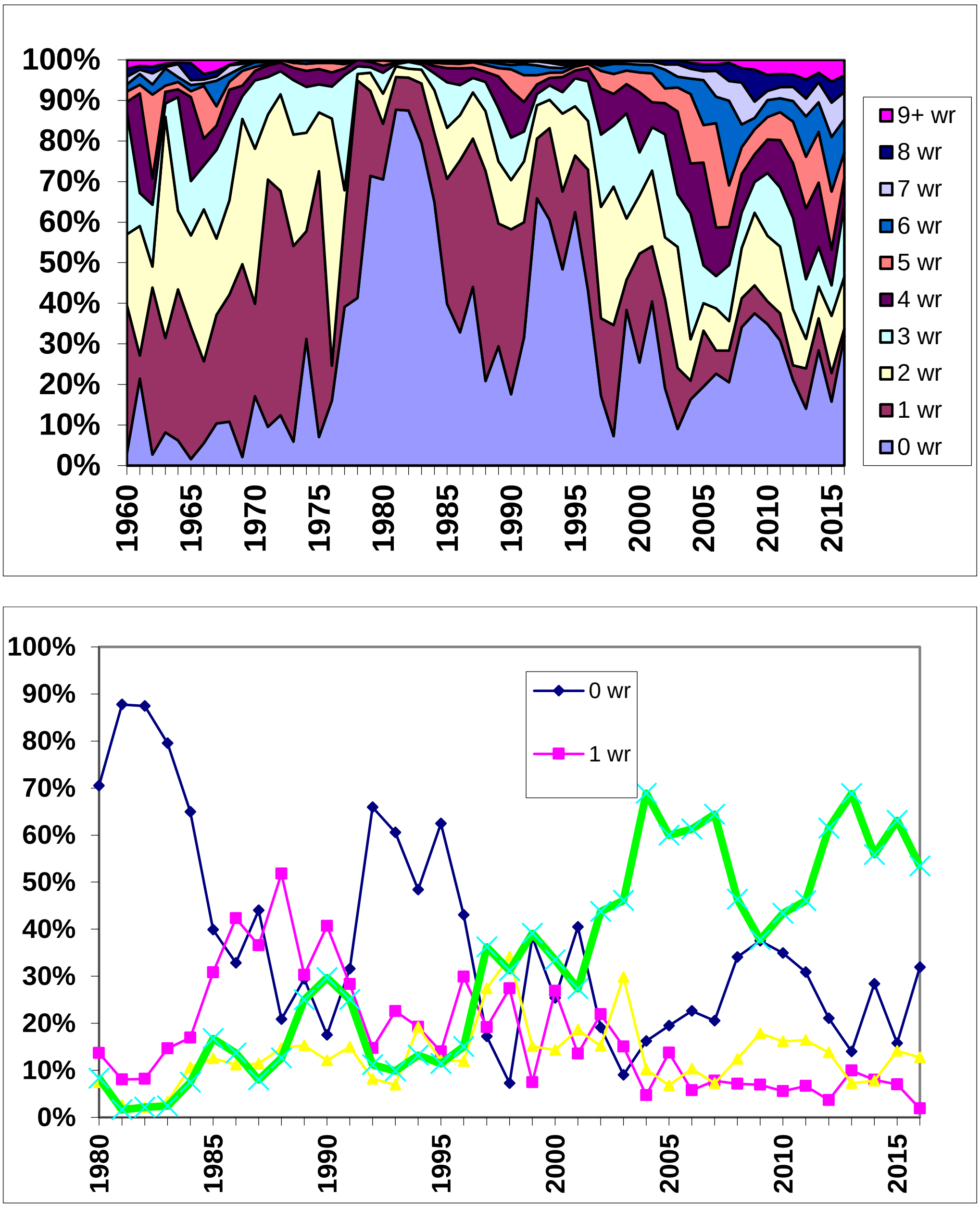


Figure 3.2.1: Proportions of age groups (numbers) in the total catch of herring caught in the North Sea (upper, 1960–2015, and lower panel, 1980–2016).

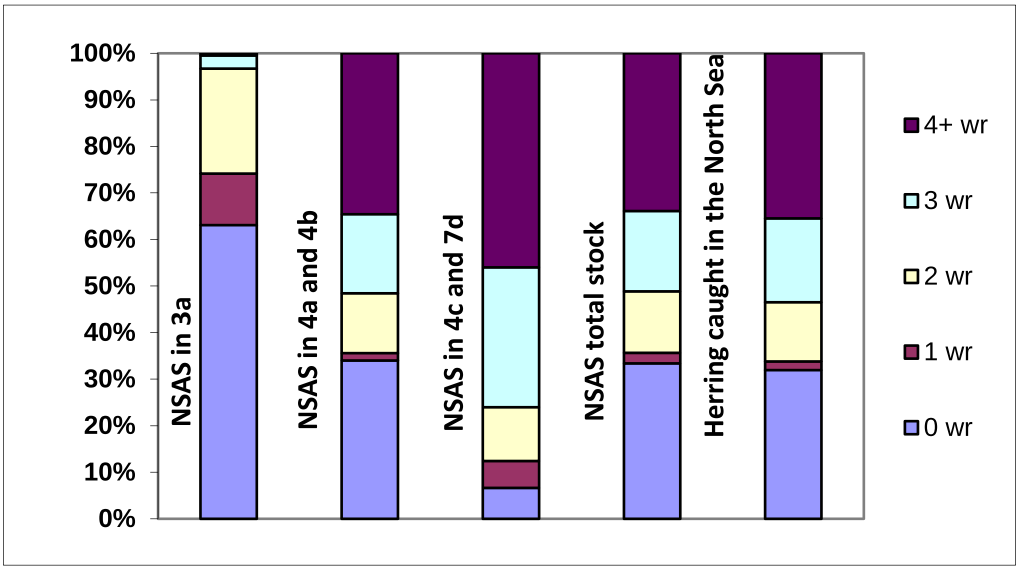


Figure 3.2.2: Proportion of age groups (numbers) in the total catch of NSAS and herring caught in the North Sea in 2016.

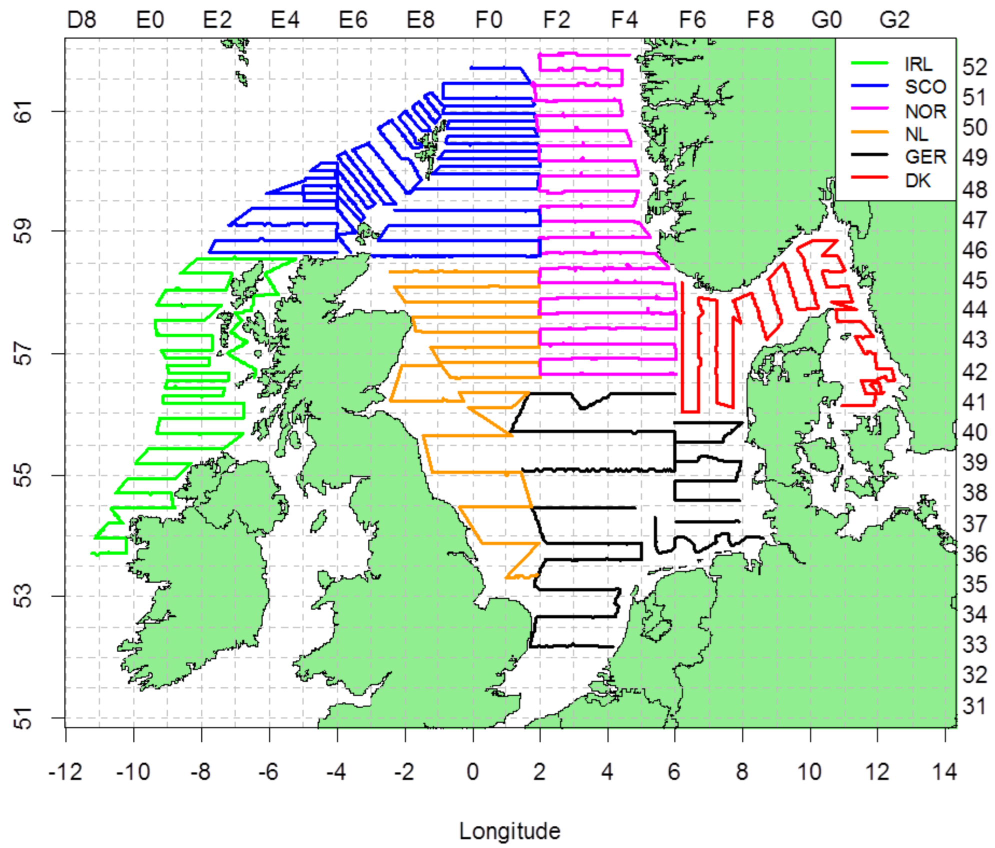


Figure 3.3.1.1. Cruise tracks and survey area coverage in the HERAS acoustic surveys in 2016 by nation.

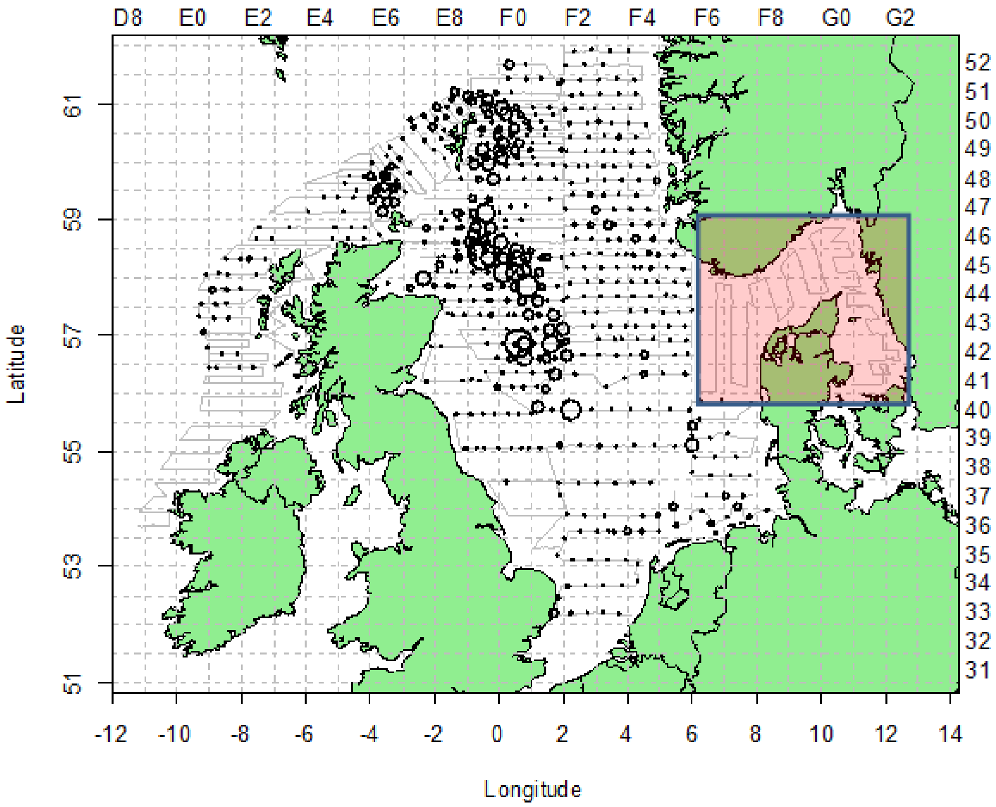


Figure 3.3.1.2a. Distribution of NASC attributed to herring in HERAS 2016. Cruise tracks are outlined in light grey with circles representing size and location of herring aggregations. NASC values are resampled at 15 nm intervals along the cruise track. Distribution displayed here is for all herring encountered in the HERAS survey regardless of stock identity. Herring abundances in the strata covered by Denmark are displayed in Figure 3.3.1.2b.

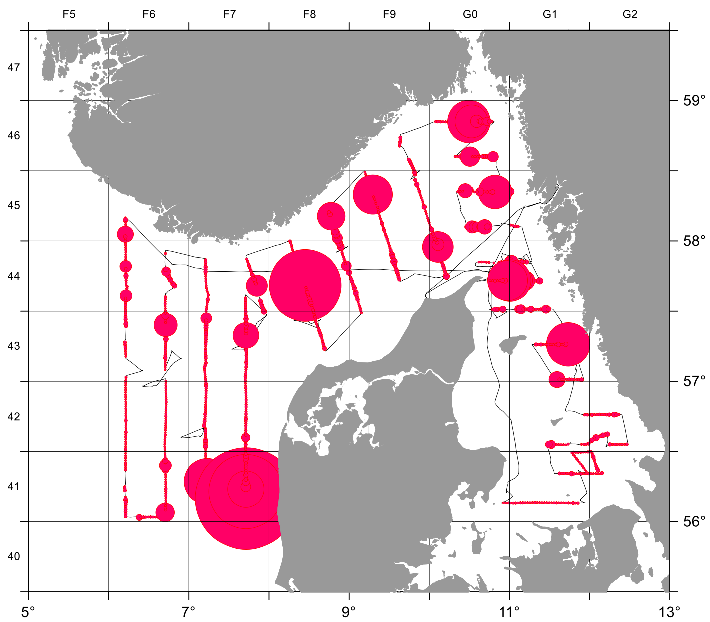


Figure 3.3.1.2b. Distribution of herring in HERAS in 2016 in area covered by Denmark. Circles representing size and location of herring aggregations as herring numbers relative to total NASC per EDSU. The size of the circles are NOT to same scale as Figure 3.3.1.2a.

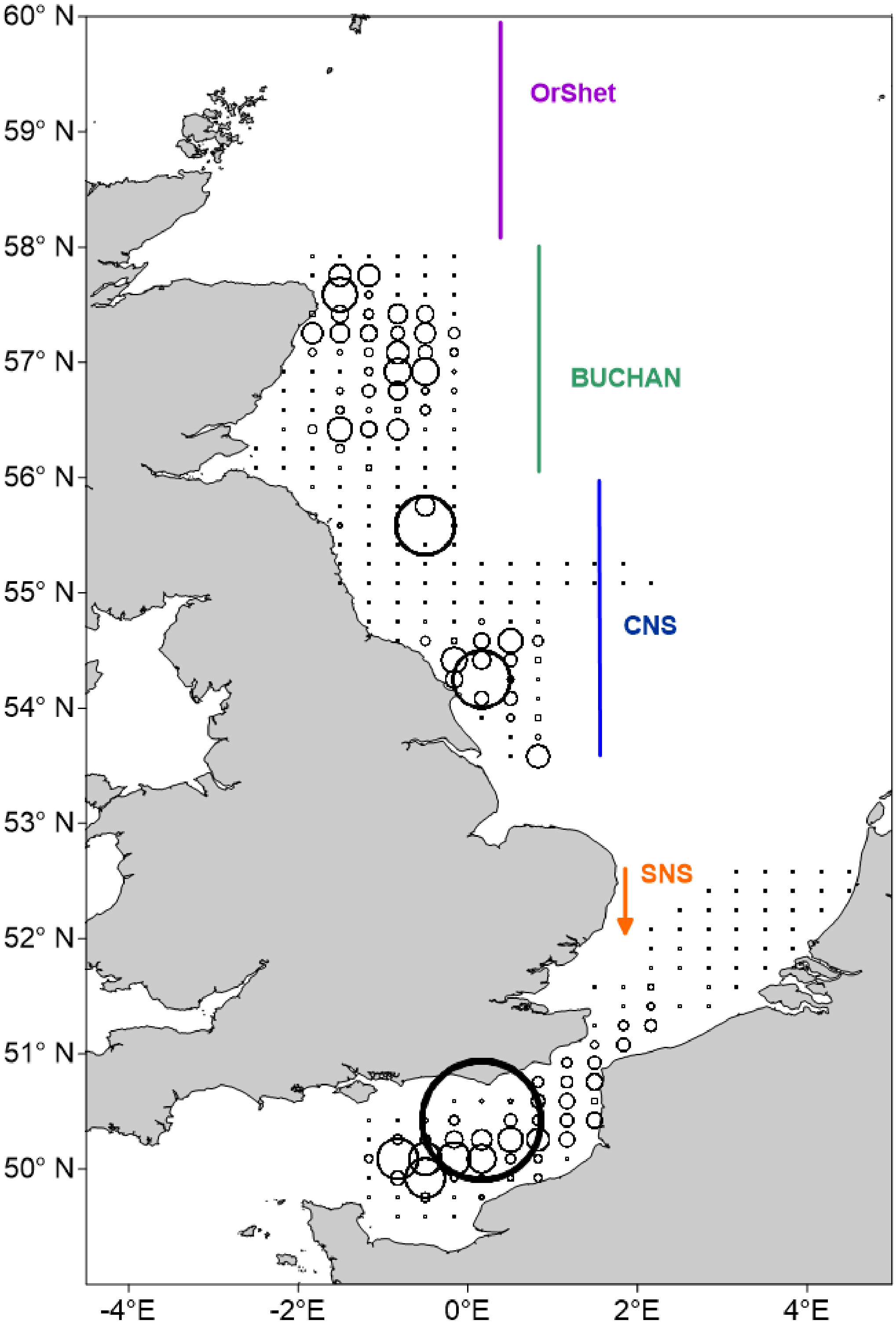


Figure 3.3.2.1: North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Buchan, Central and Southern North Sea as obtained from the International Herring Larvae Surveys in autumn and winter 2016 / 2017 (maximum circle size = 20 000 n/m²). The survey around the Orkneys was cancelled due to technical problem of the research vessel. The abundance in the Southern North Sea is given as the mean of the three surveys done in December 2016 and January 2017.

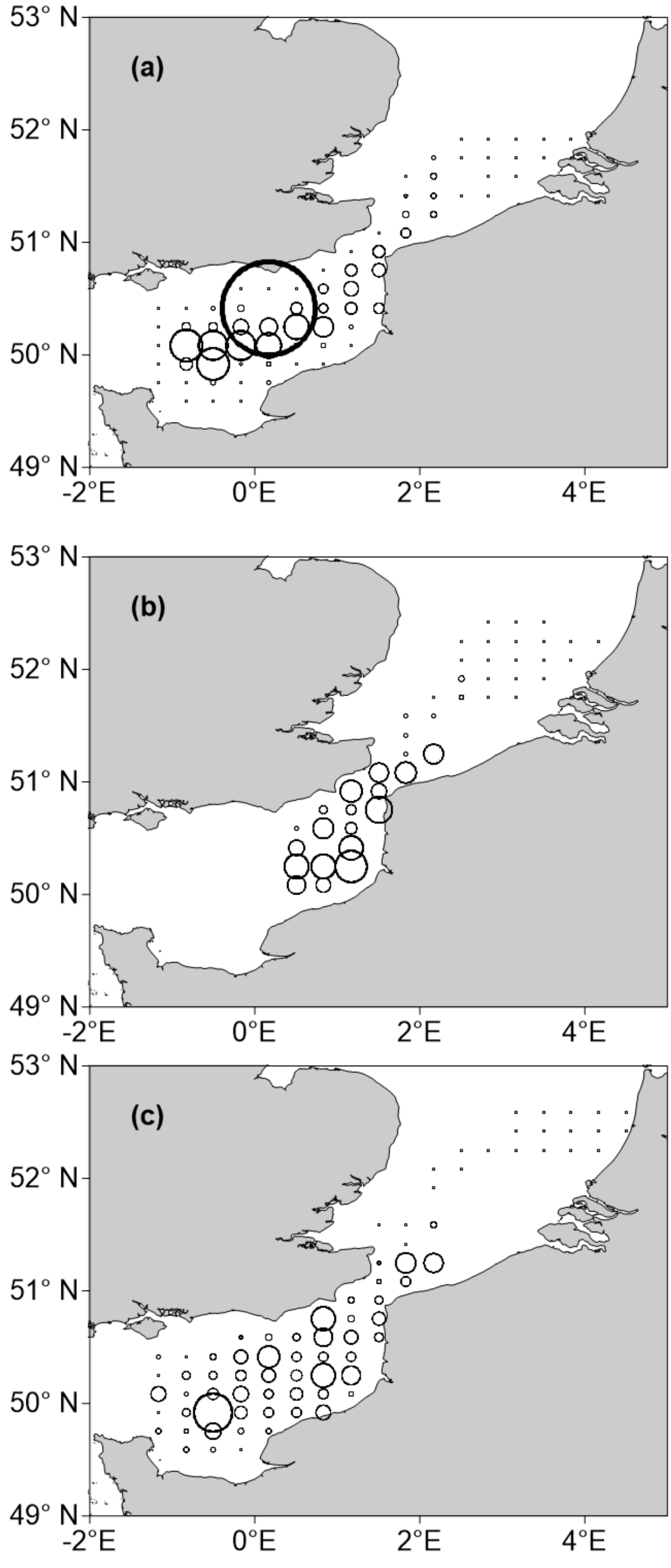


Figure 3.3.2.2 a-c: North Sea herring - Abundance of larvae < 11 mm (n/m²) in the southern North Sea as obtained from the International Herring Larvae Survey in the second half of December 2016 (a, maximum circle = 30 000 n/m²) and in the first (b) and the second half (c) of January 2017 (maximum circle size = 2 000 n/m²).

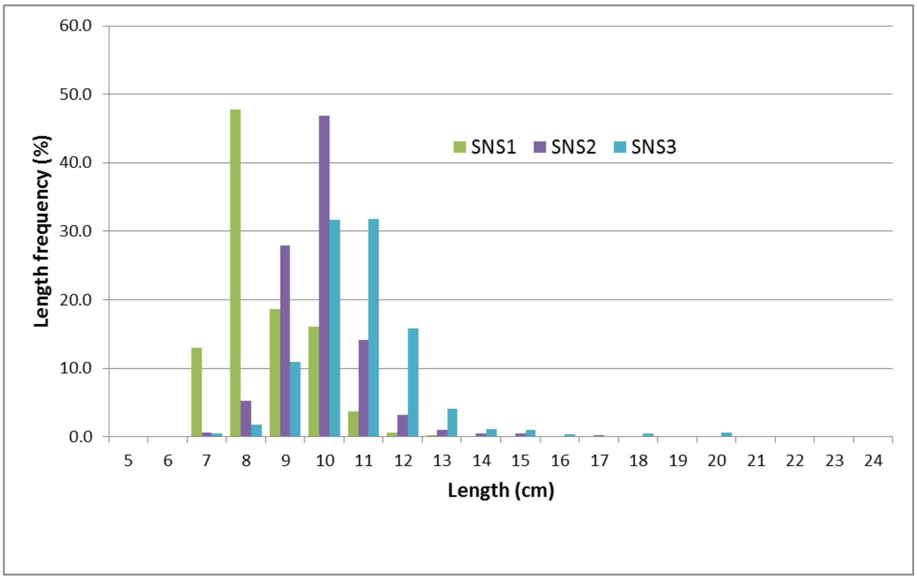


Figure 3.3.2.3: North Sea herring – Length frequency distribution of all herring larvae caught during the three separate surveys in the Southern North Sea (SNS1, SNS2, SNS3).

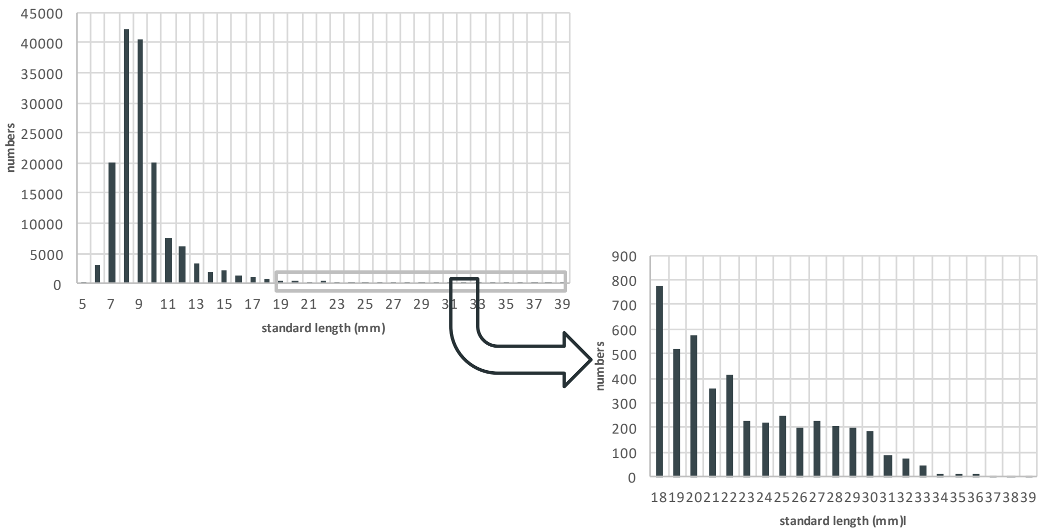


Figure 3.3.3.1. North Sea herring. Length distribution of all herring larvae caught during the 2017 Q1 IBTS.

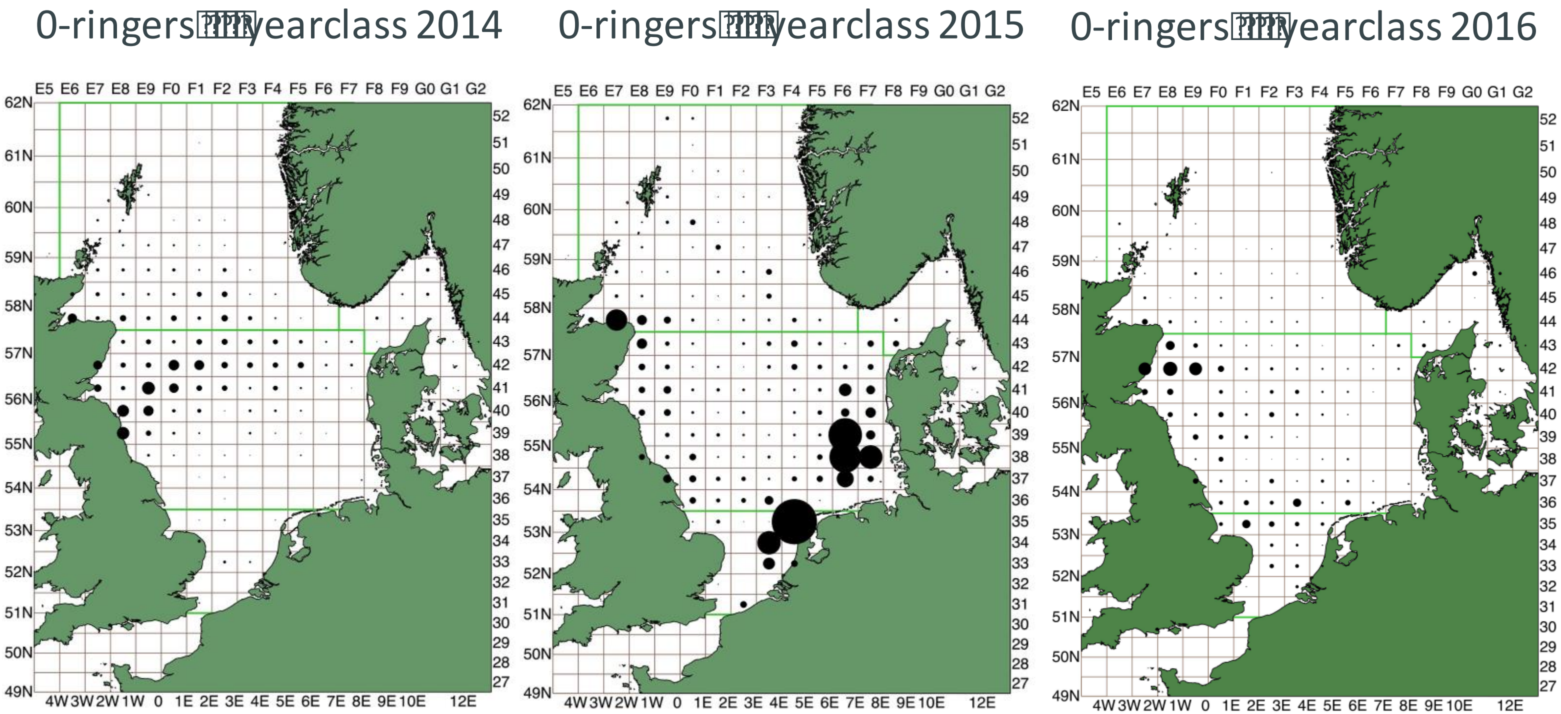


Figure 3.3.3.2. North Sea herring. Distribution of 0-wr herring, year classes 2014-2016. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in January/February 2015-2017. Areas of filled circles illustrate densities in no m^{-2}, the area of the largest circle represents a density of 7.59 m^{-2}. All circles are scaled to the same order of magnitude of the square root transformed densities.

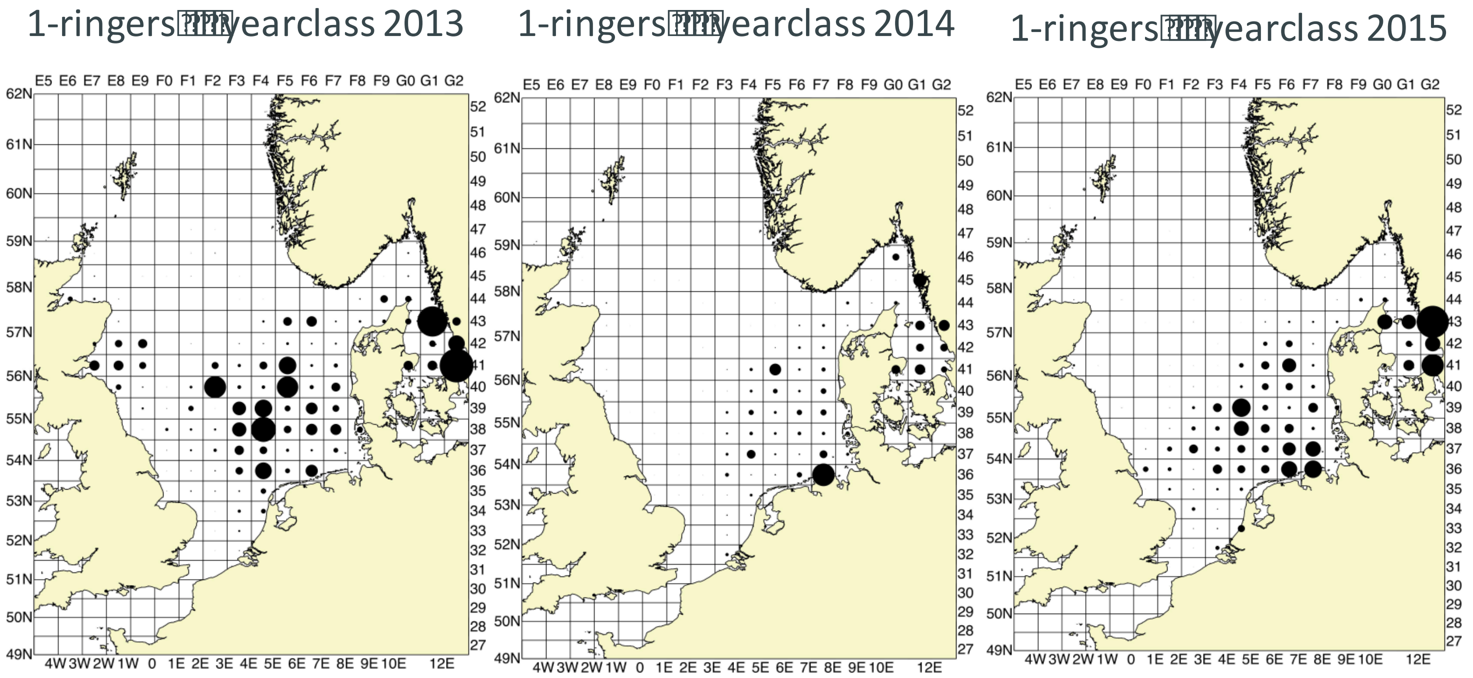
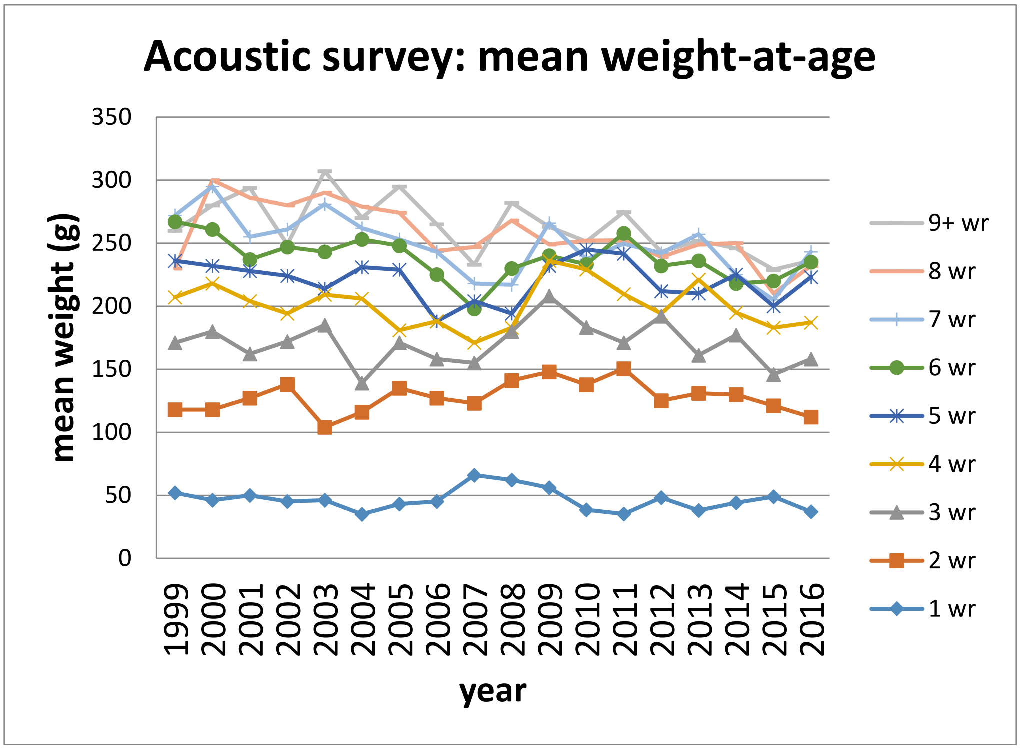


Figure 3.3.3.3. . North Sea herring. Distribution of 1-wr herring, year classes 2013-2015. Density estimates of 1-wr fish within each statistical rectangle are based on GOV catches during IBTS in January/February 2015-2017. Areas of filled circles illustrate numbers per hour, scaled proportionally to the square root transformed CPUE data, the area of the larges circle extending across the border of a rectangle represents 99045 h^{-1}.



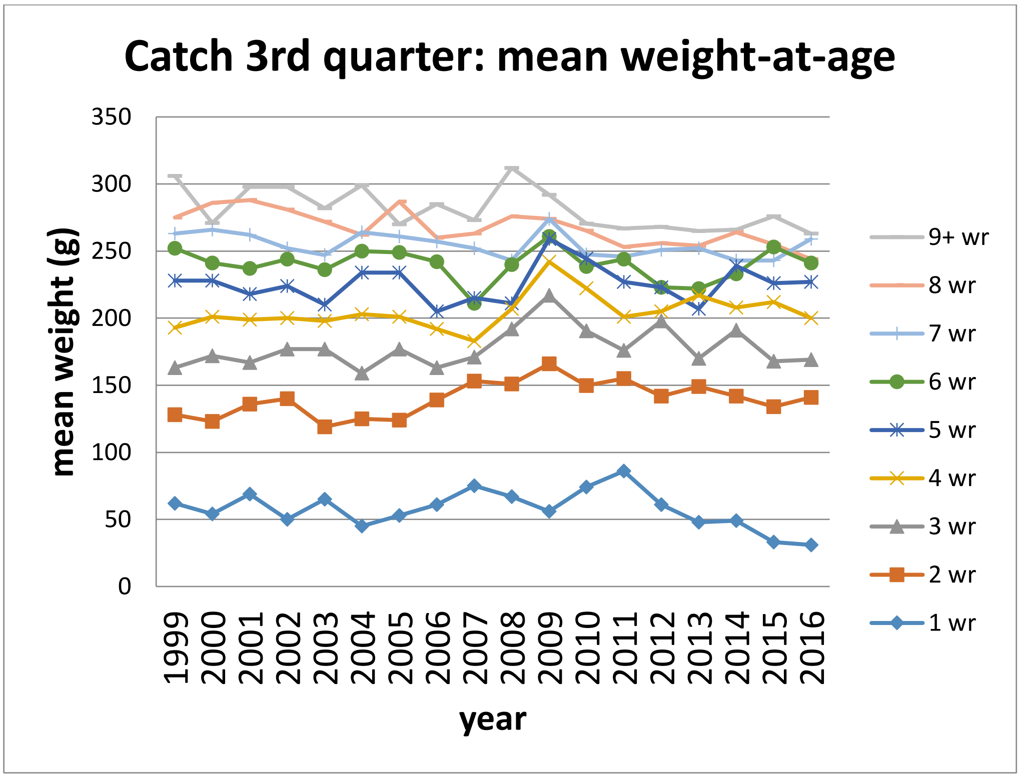


Figure 3.4.1.1. North Sea Herring. Mean weights-at-age for the 3rd quarter in Divisions 4 and 3.a from the acoustic survey (upper panel) and mean weights-in-the-catch (lower panel) for comparison.

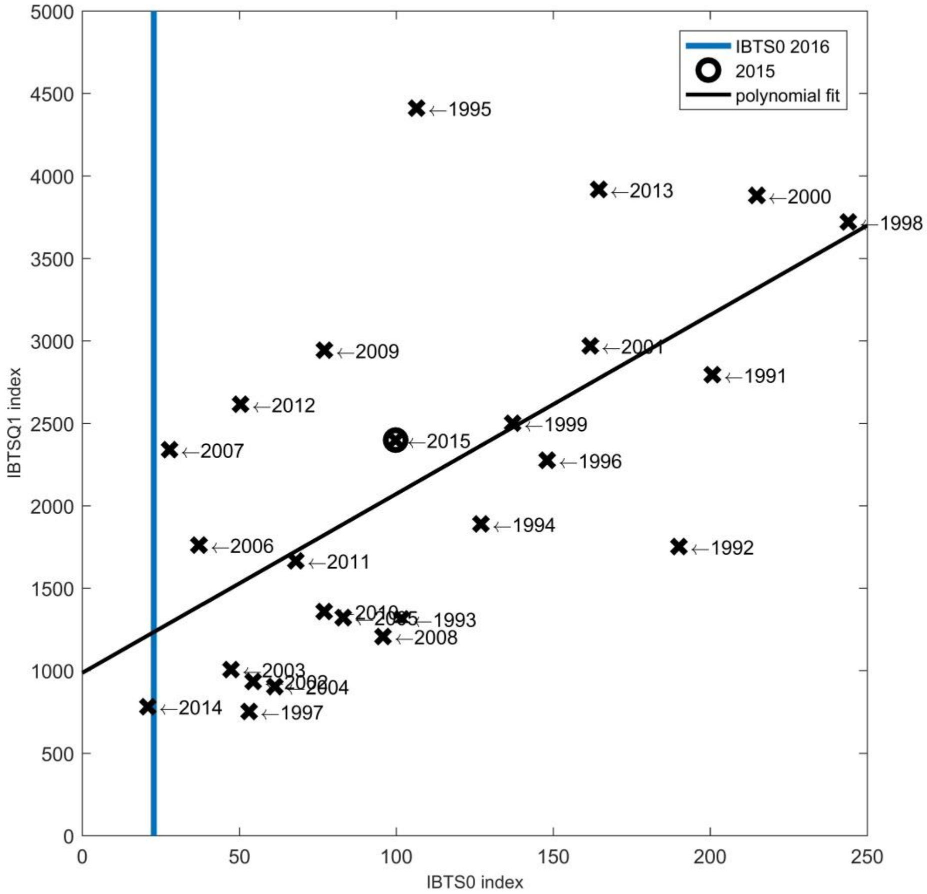


Figure 3.5.1. North Sea herring. Relationship between indices of 0-ringers and 1-ringers for year classes 19991 to 2016. The 2015 year class relation is the marker circled in black. the present 0-ringer index for year class 2016 is indicated as the vertical blue line.

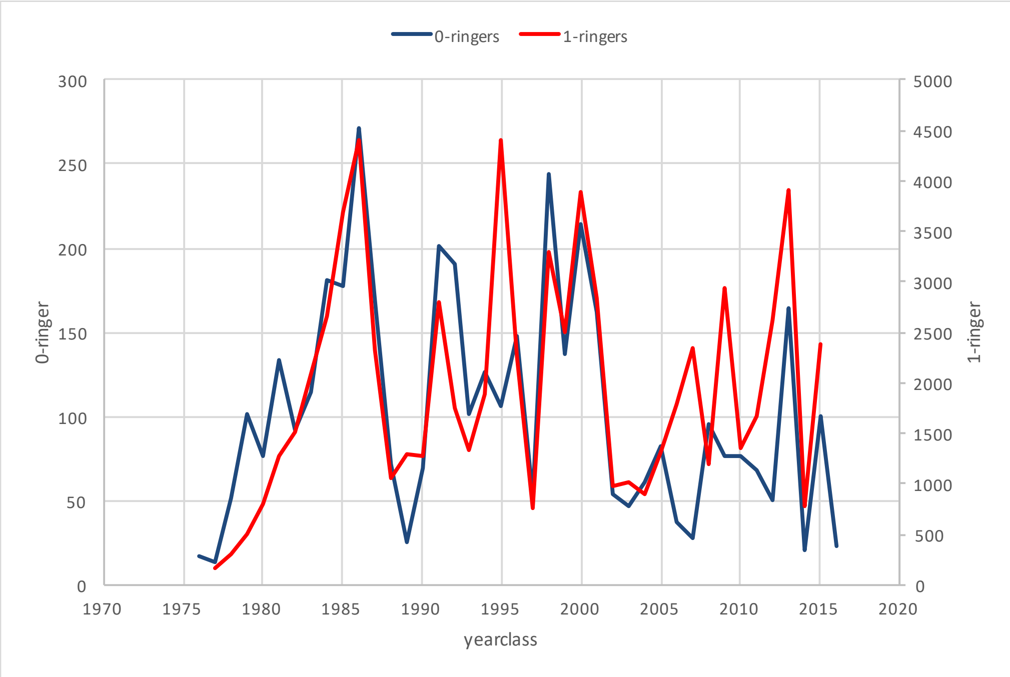


Figure 3.5.2 North Sea herring. Time series of 0-wr and 1-wr indices. Year classes 1976 to 2016 for 0-wr fish, year classes 1977-2015 for 1-wr fish.

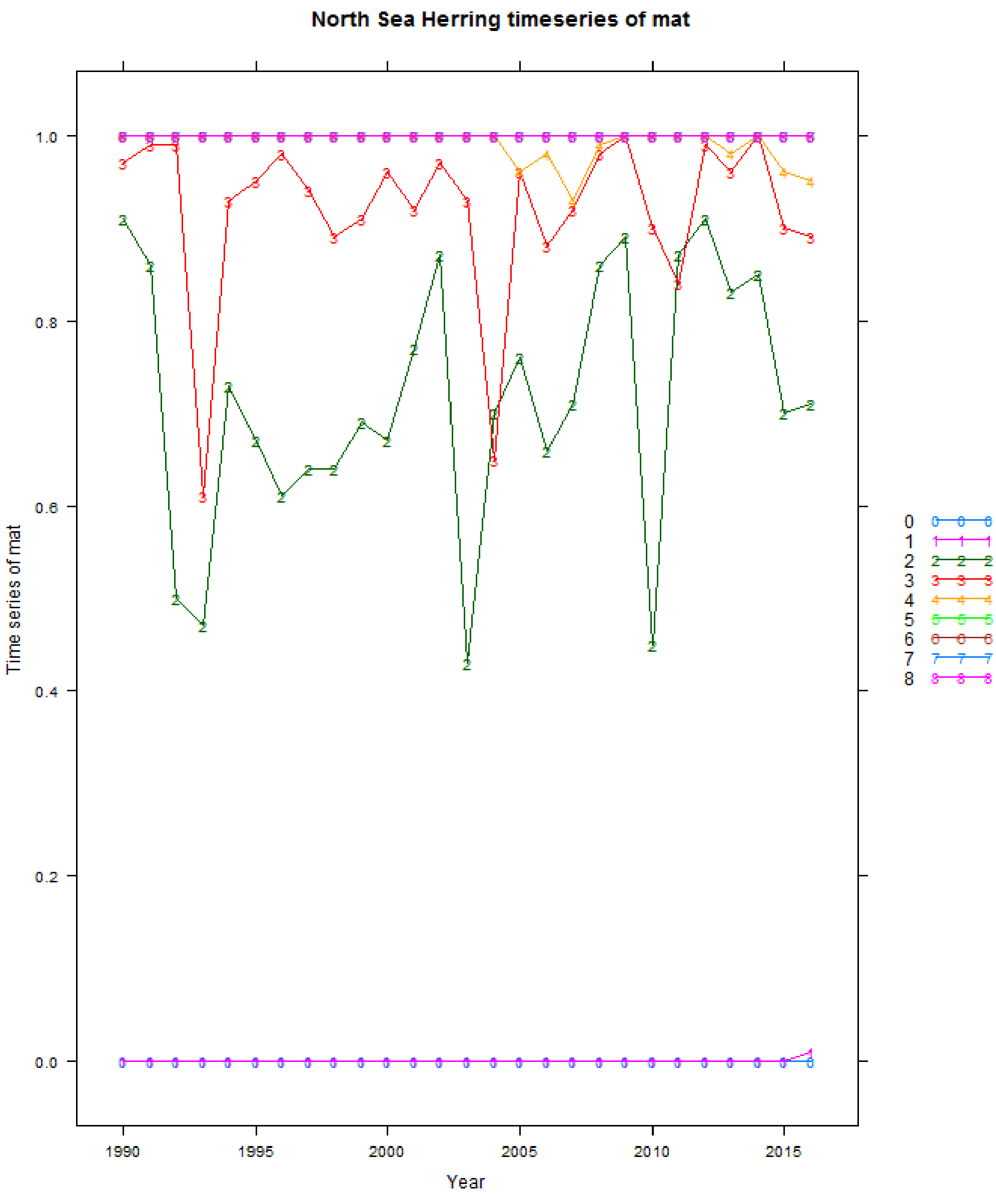


Figure 3.6.1.1 North Sea Herring. Time series of proportion mature at ages 0 to 8+ as used in the North Sea herring assessment.

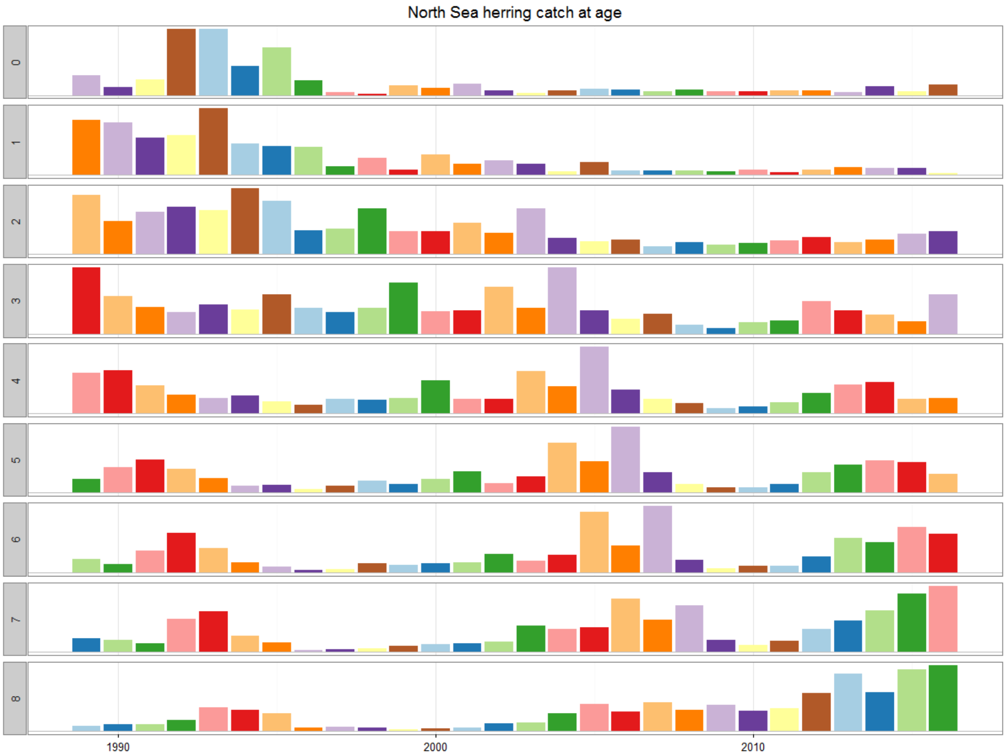


Figure 3.6.1.2. North Sea Herring. Time series of catch-at-age proportion at ages 0-8+ as used in the North Sea herring assessment. Colours indicate year-classes. All ages are scaled independently and therefore the size of the bars can only be compared within an age.

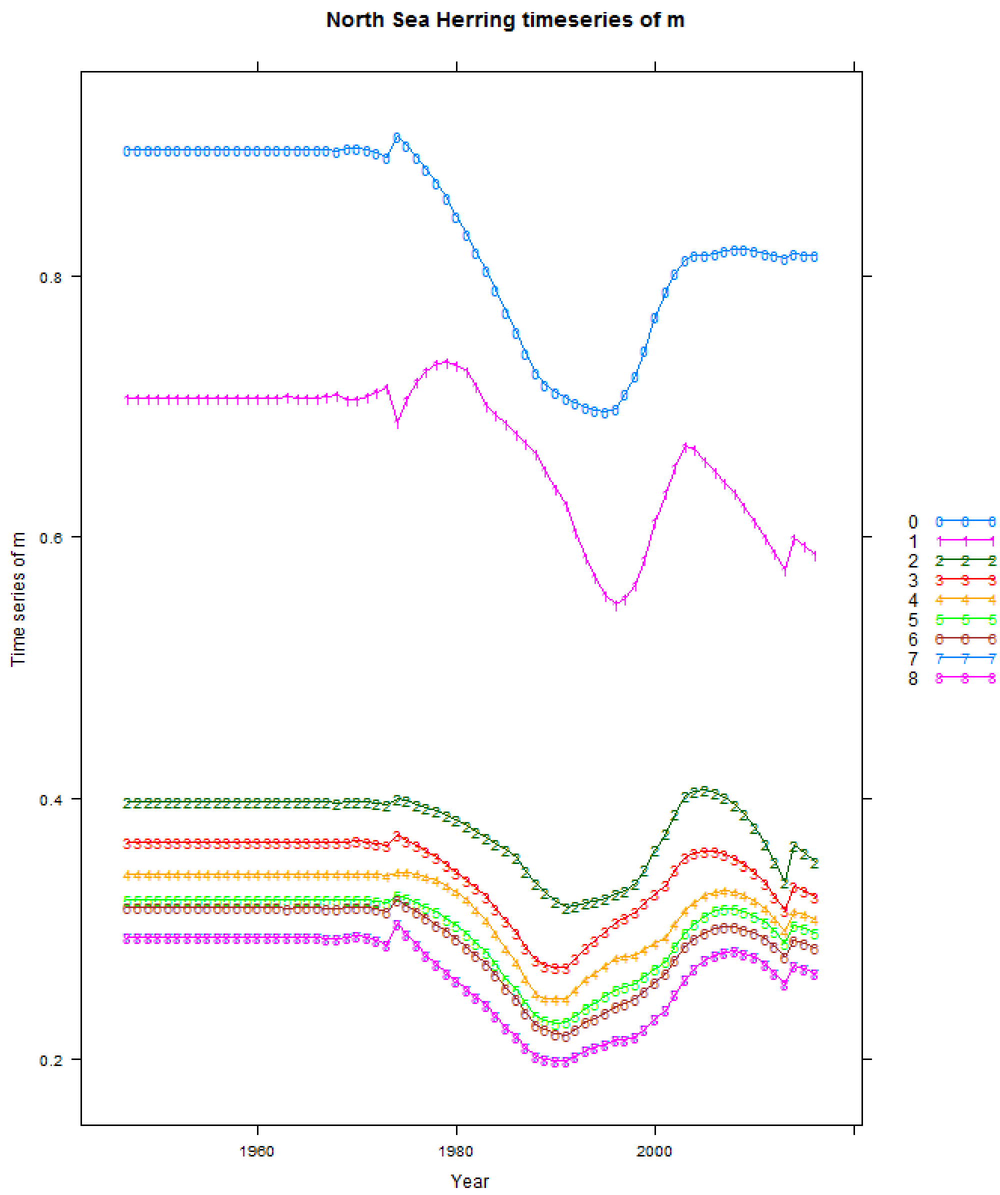


Figure 3.6.1.3. North Sea Herring. Time series of absolute natural mortality values at age 0-8+ as used in the North Sea herring assessment. Natural mortality values are based on the 2015 North Sea key-run (WGSAM 2015).

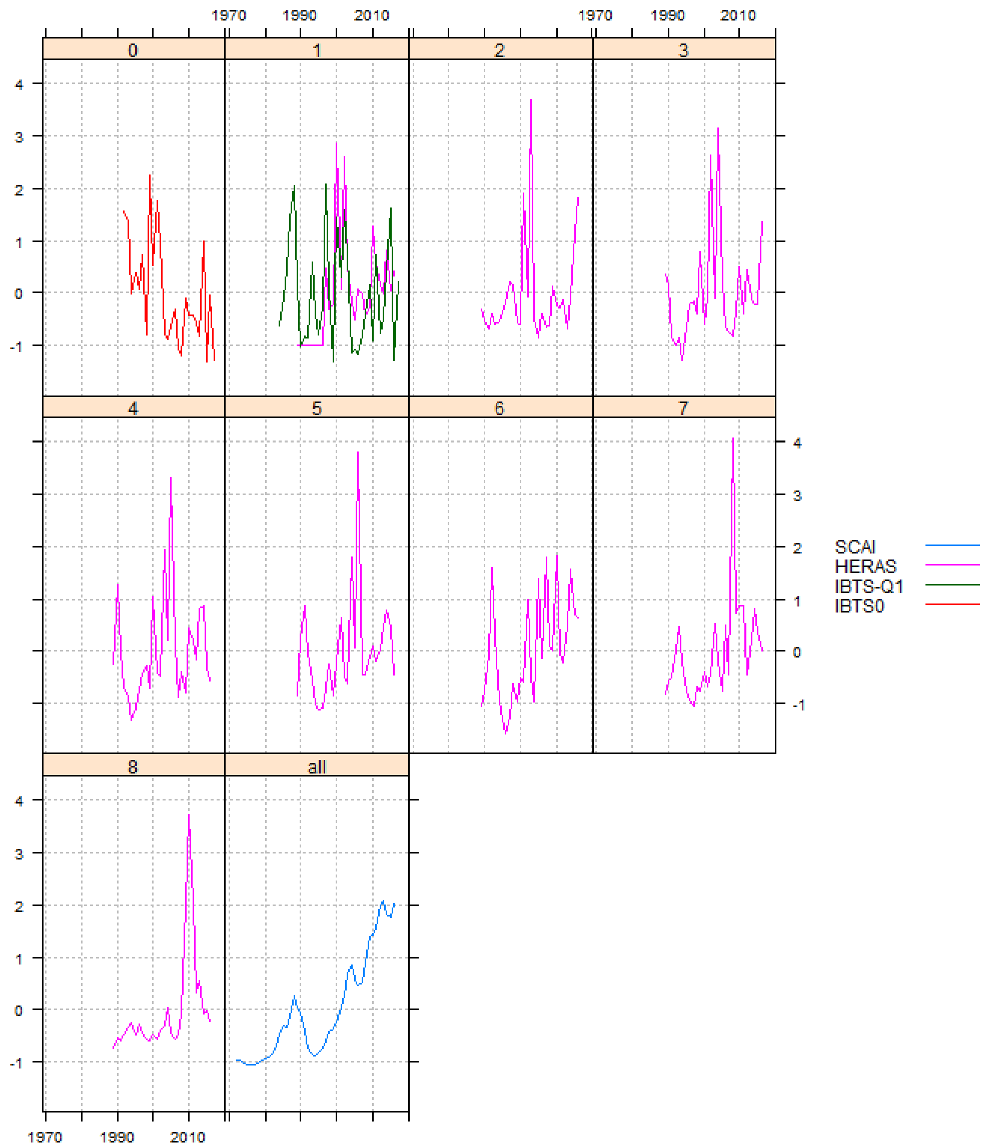


Figure 3.6.1.4. North Sea Herring. Time series of the standardized tuning series by ages 0-8+ (Acoustic survey: HERAS, IBTS quarter 1 survey: IBTS-Q1 and IBTS MIK net survey in quarter 1: IBTS0) and SSB tuning series (IHLS survey: SCAI).

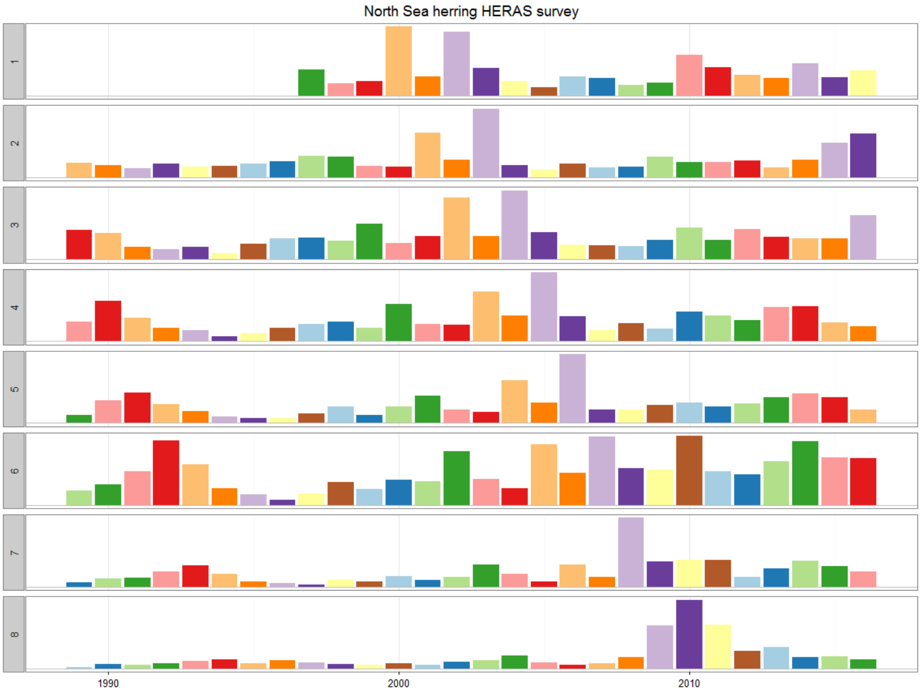


Figure 3.6.1.4b. North Sea Herring. Time series of the HERAS acoustic index by age 0-8+. Colours indicate year-classes. All ages are scaled independently and cannot be compared between ages.

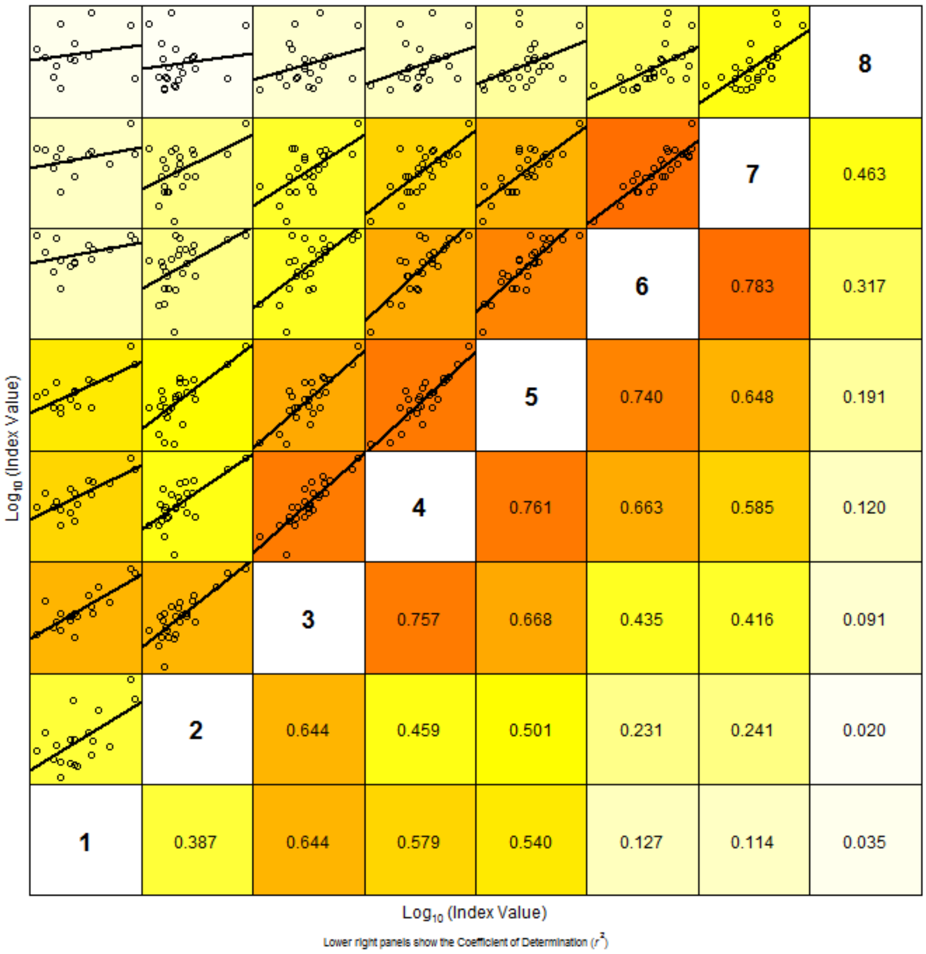


Figure 3.6.1.5. North Sea herring. Internal consistency plot of the acoustic survey (HERAS). Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the r^2 value that is associated with the linear regression is given.

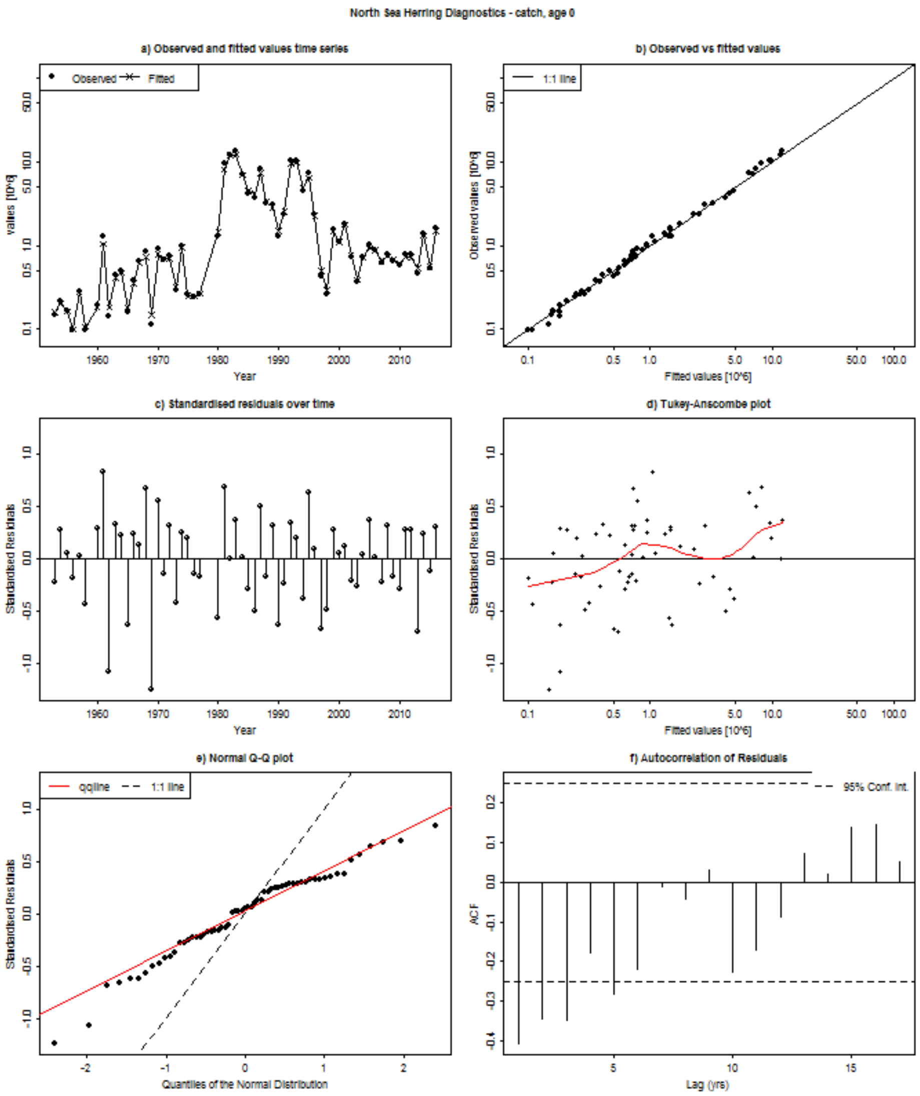


Figure 3.6.1.6 North Sea herring. Diagnostics of the assessment model fit to the catch at age 0 time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from catch abundance at 0 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the catch at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

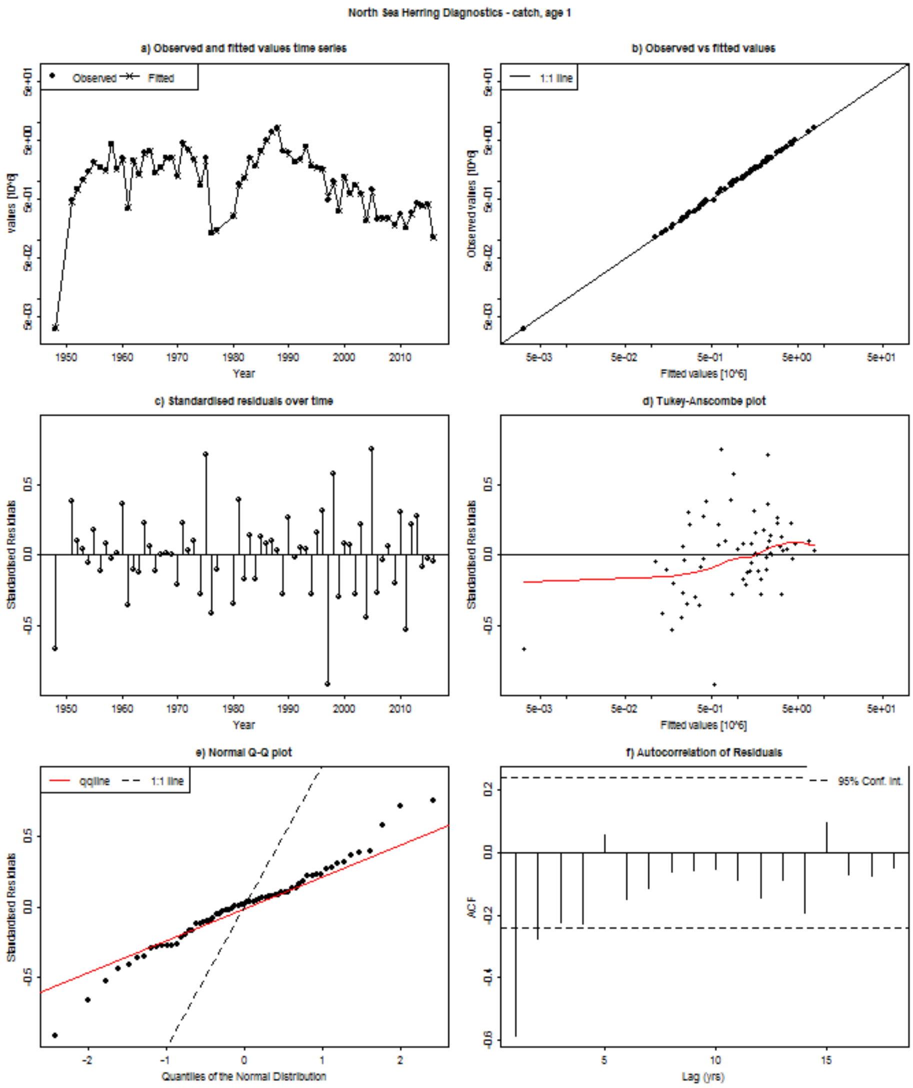


Figure 3.6.1.7 North Sea herring. Diagnostics of the assessment model fit to the catch at age 1 time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from catch abundance at 1 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 1 wr. Middle left: Time series of standardized residuals of the catch at 1 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

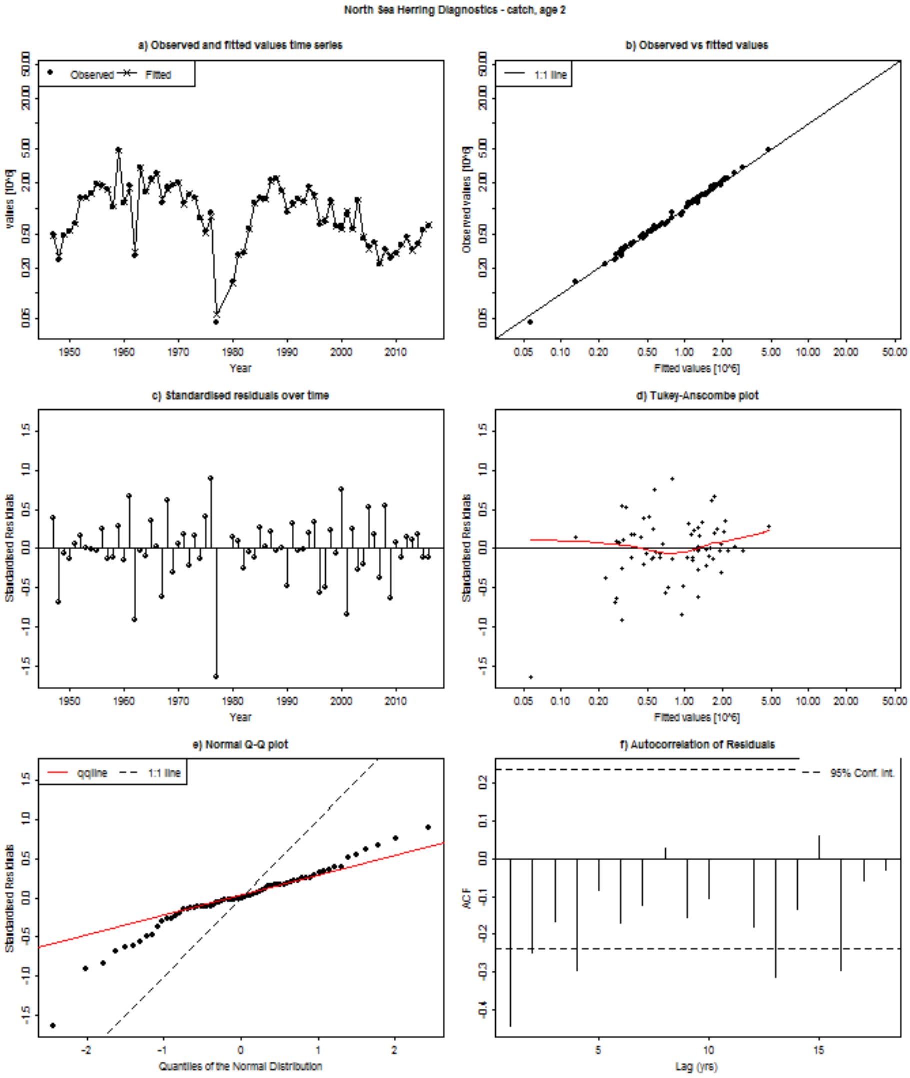


Figure 3.6.1.8 North Sea herring. Diagnostics of the assessment model fit to the catch at age 2 time series. Top left: Estimates of numbers at 2 wr (line) and numbers predicted from catch abundance at 2 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 2 wr. Middle left: Time series of standardized residuals of the catch at 2 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

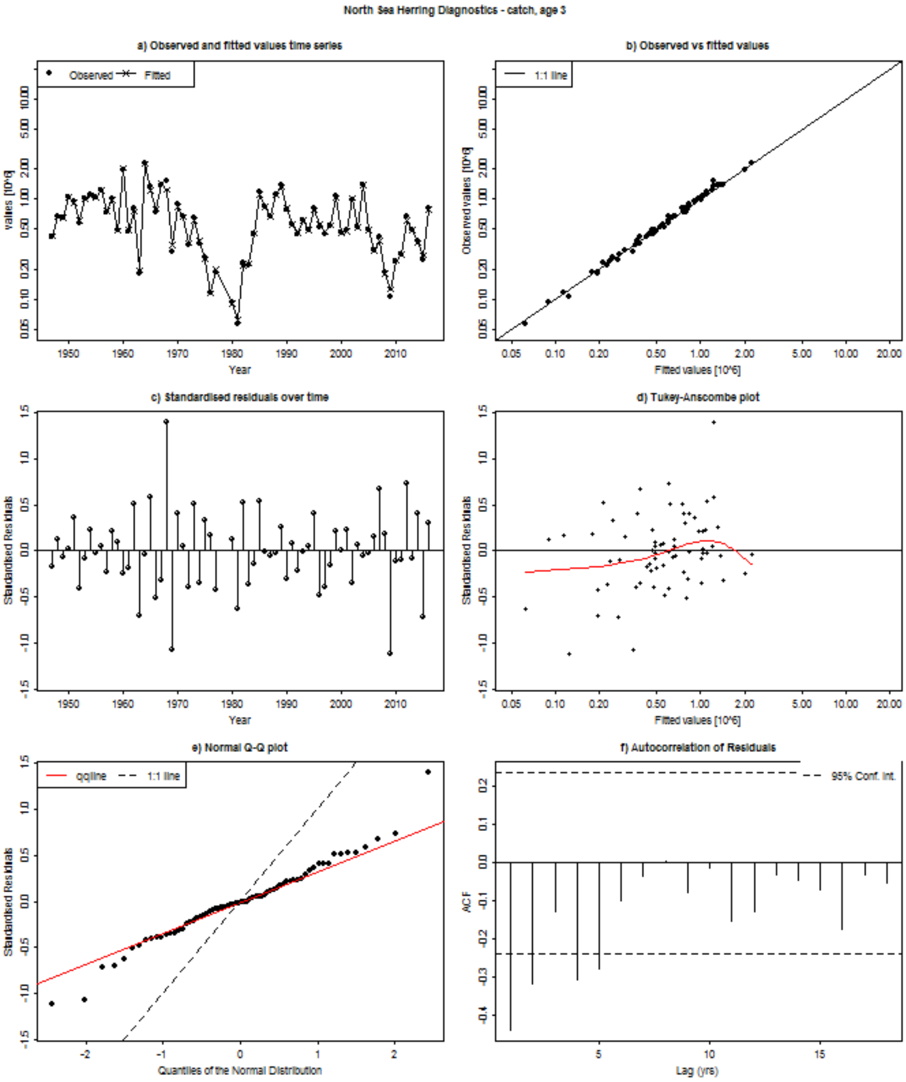


Figure 3.6.1.9 North Sea herring. Diagnostics of the assessment model fit to the catch at age 3 time series. Top left: Estimates of numbers at 3 wr (line) and numbers predicted from catch abundance at 3 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 3 wr. Middle left: Time series of standardized residuals of the catch at 3 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

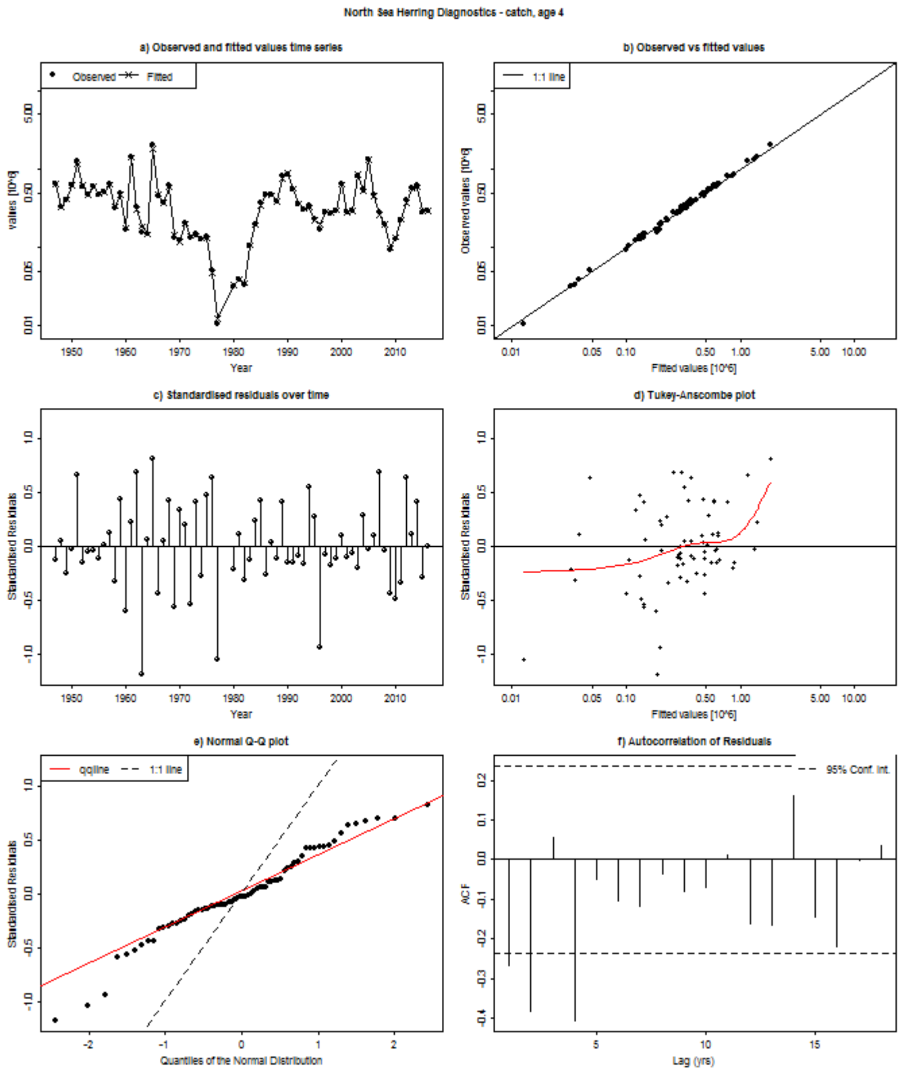


Figure 3.6.1.10 North Sea herring. Diagnostics of the assessment model fit to the catch at age 4 time series. Top left: Estimates of numbers at 4 wr (line) and numbers predicted from catch abundance at 4 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 4 wr. Middle left: Time series of standardized residuals of the catch at 4 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

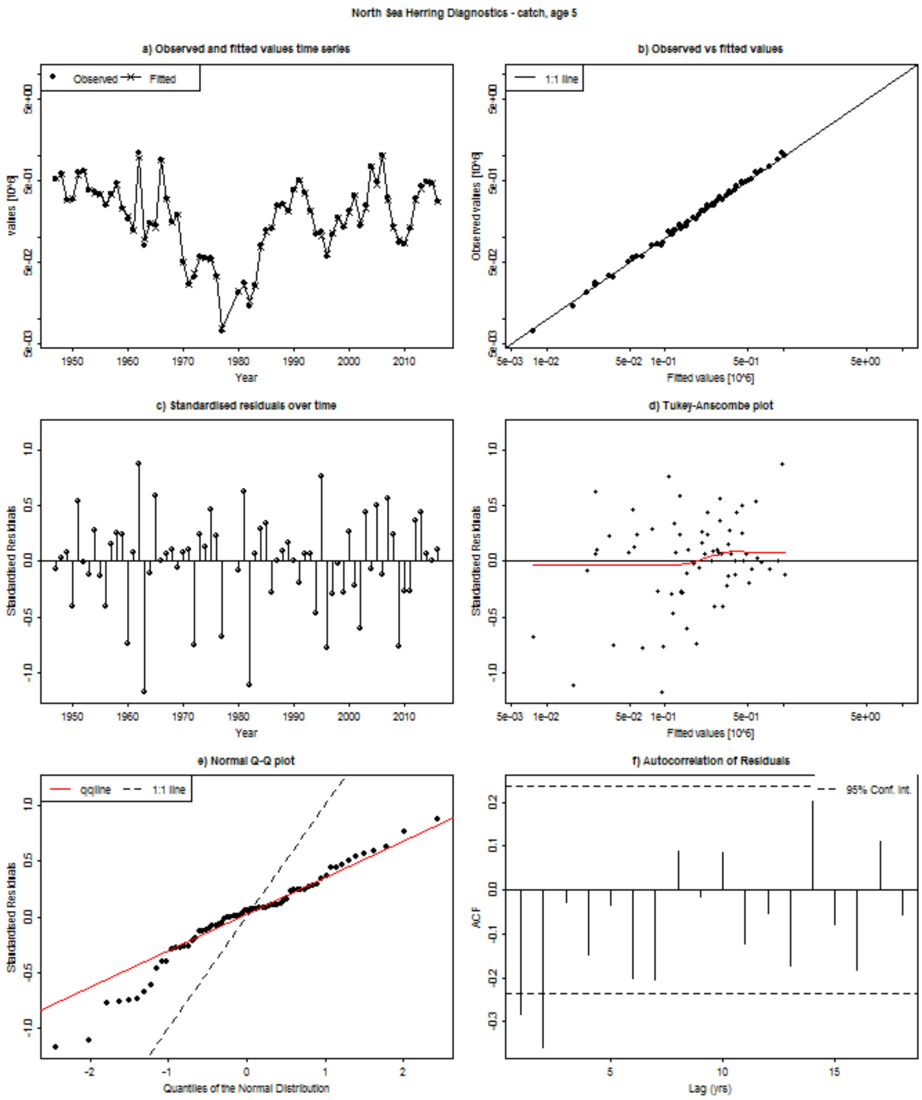


Figure 3.6.1.11 North Sea herring. Diagnostics of the assessment model fit to the catch at age 5 time series. Top left: Estimates of numbers at 5 wr (line) and numbers predicted from catch abundance at 5 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 5 wr. Middle left: Time series of standardized residuals of the catch at 5 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

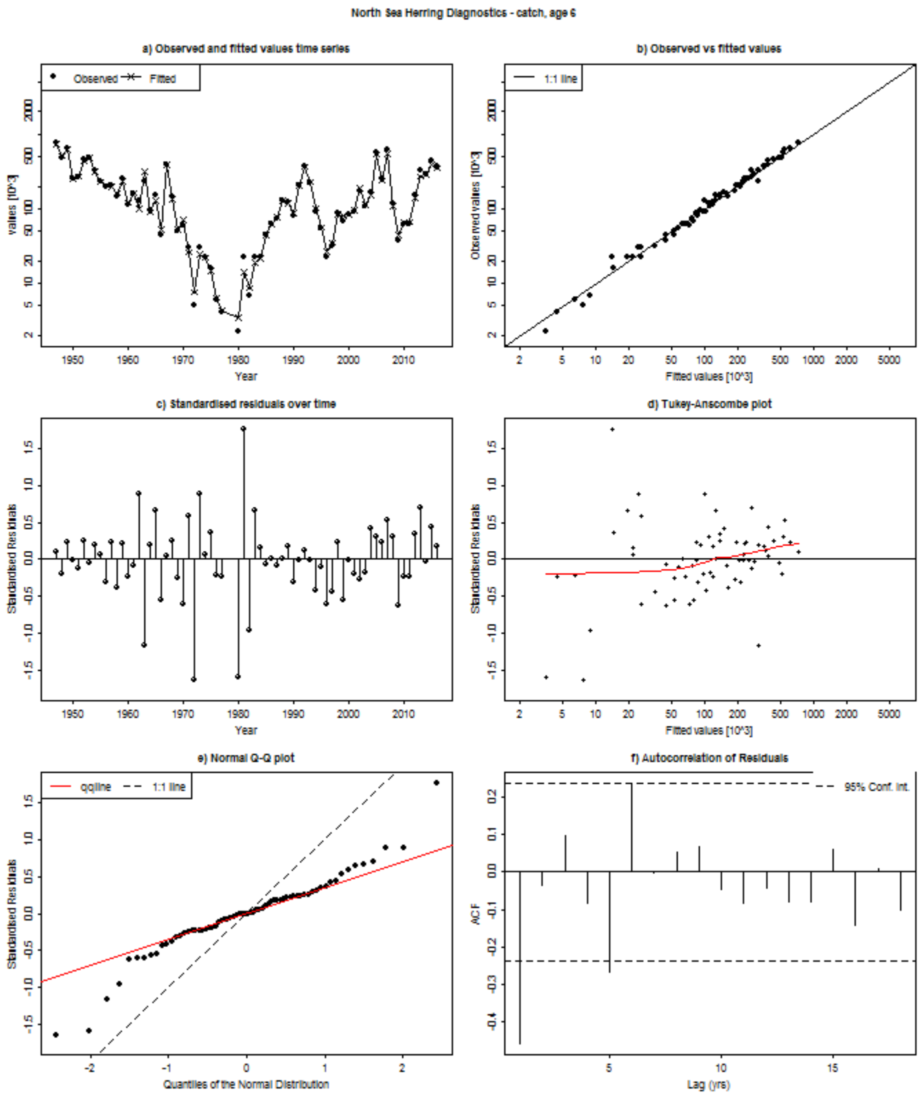


Figure 3.6.1.12 North Sea herring. Diagnostics of the assessment model fit to the catch at age 6 time series. Top left: Estimates of numbers at 6 wr (line) and numbers predicted from catch abundance at 6 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 6 wr. Middle left: Time series of standardized residuals of the catch at 6 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

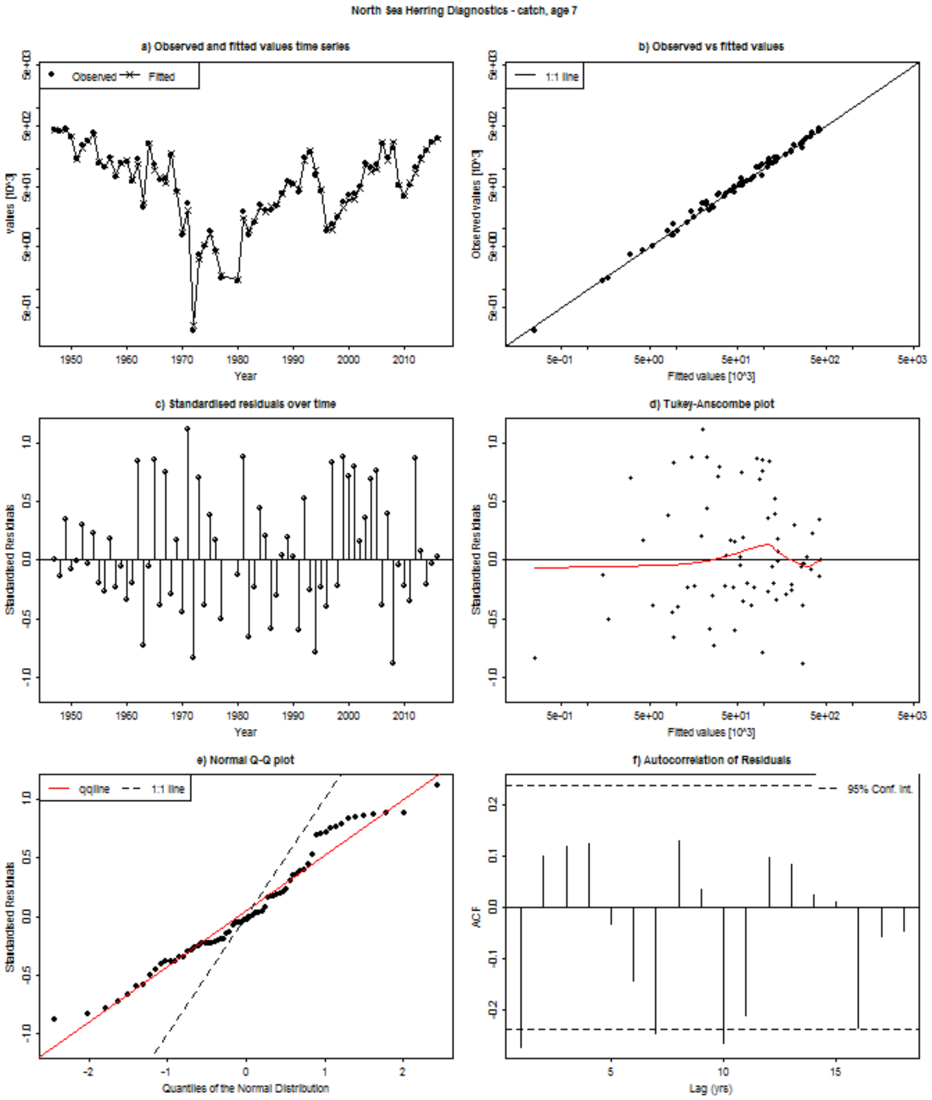


Figure 3.6.1.13 North Sea herring. Diagnostics of the assessment model fit to the catch at age 7 time series. Top left: Estimates of numbers at 7 wr (line) and numbers predicted from catch abundance at 7 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 7 wr. Middle left: Time series of standardized residuals of the catch at 7 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

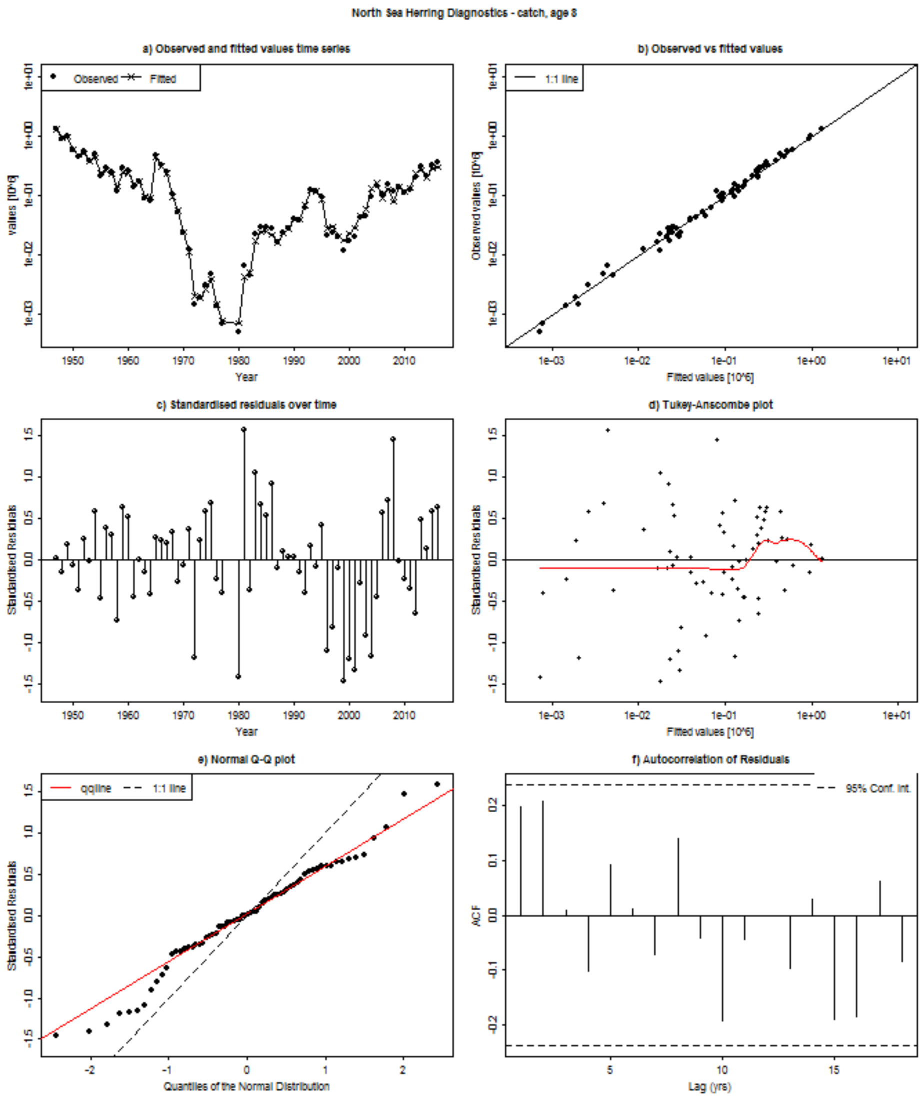


Figure 3.6.1.14. North Sea herring. Diagnostics of the assessment model fit to the catch at age 8+ time series. Top left: Estimates of numbers at 8+ wr (line) and numbers predicted from catch abundance at 8+ wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 8+ wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 8+ wr. Middle left: Time series of standardized residuals of the catch at 8+ wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

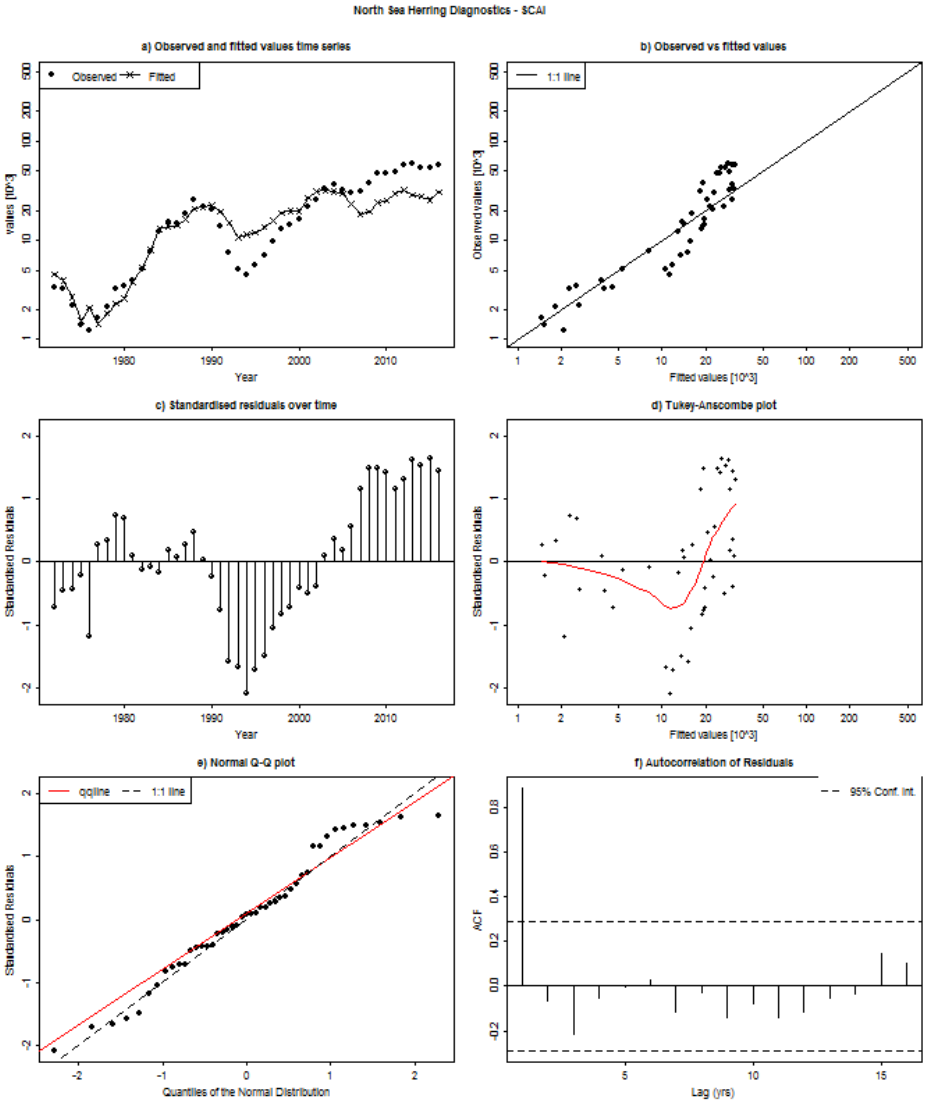


Figure 3.6.1.15. North Sea herring. Diagnostics of the assessment model fit to the SCAI SSB index time series. Top left: Estimates of SSB (line) and SSB predicted from assessment model. Top right: scatterplot of SSB observations versus assessment model estimates with the best-fit catchability model (linear function). Middle right: SSB observation versus standardized residuals. Middle left: Time series of standardized residuals of the SSB. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

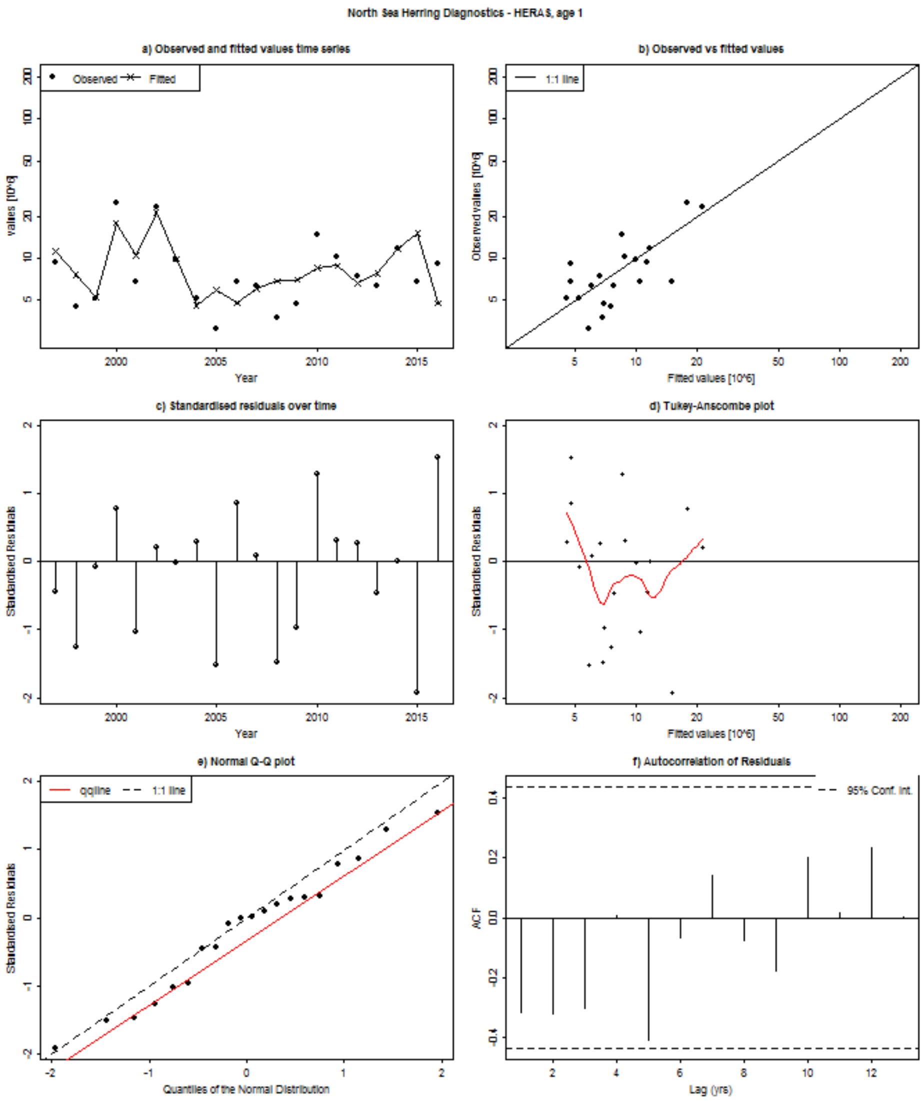


Figure 3.6.1.16. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 1 wr time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 1 wr. Middle left: Time series of standardized residuals of the index at 1 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

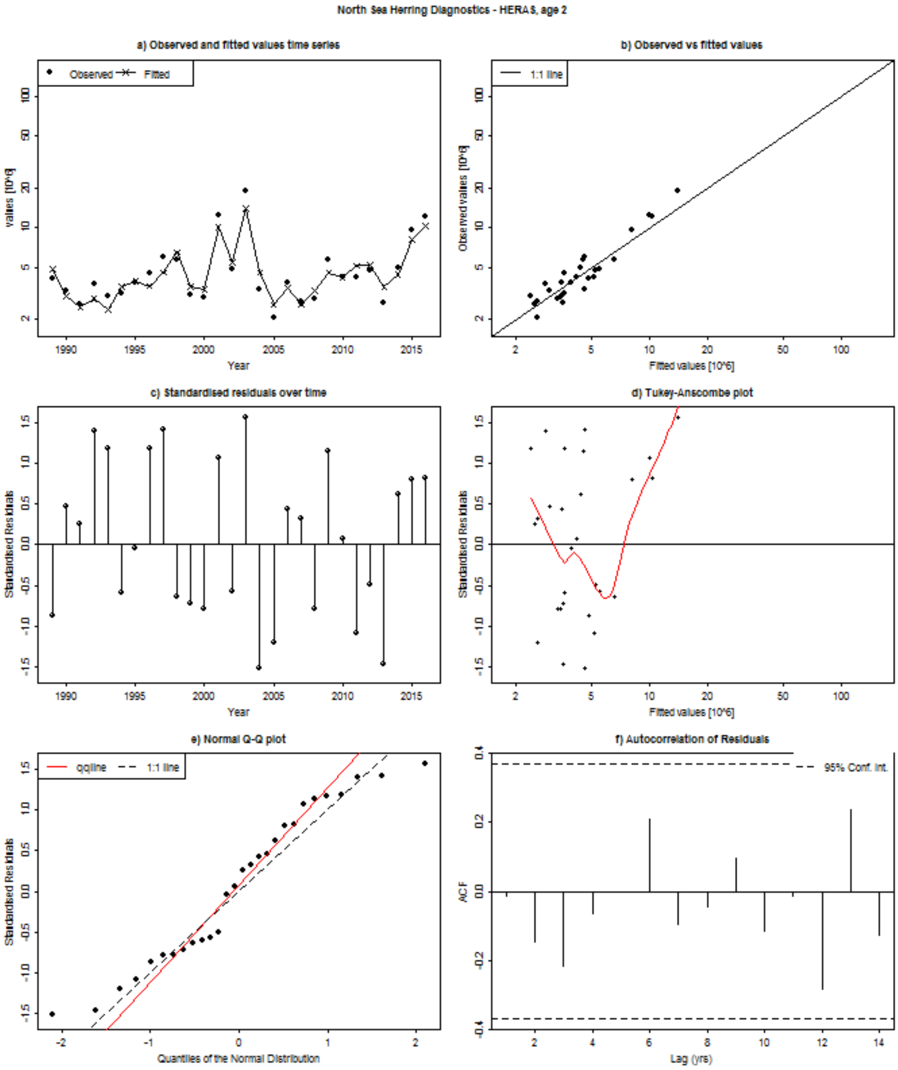


Figure 3.6.1.17. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 2 wr time series. Top left: Estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 2 wr. Middle left: Time series of standardized residuals of the index at 2 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

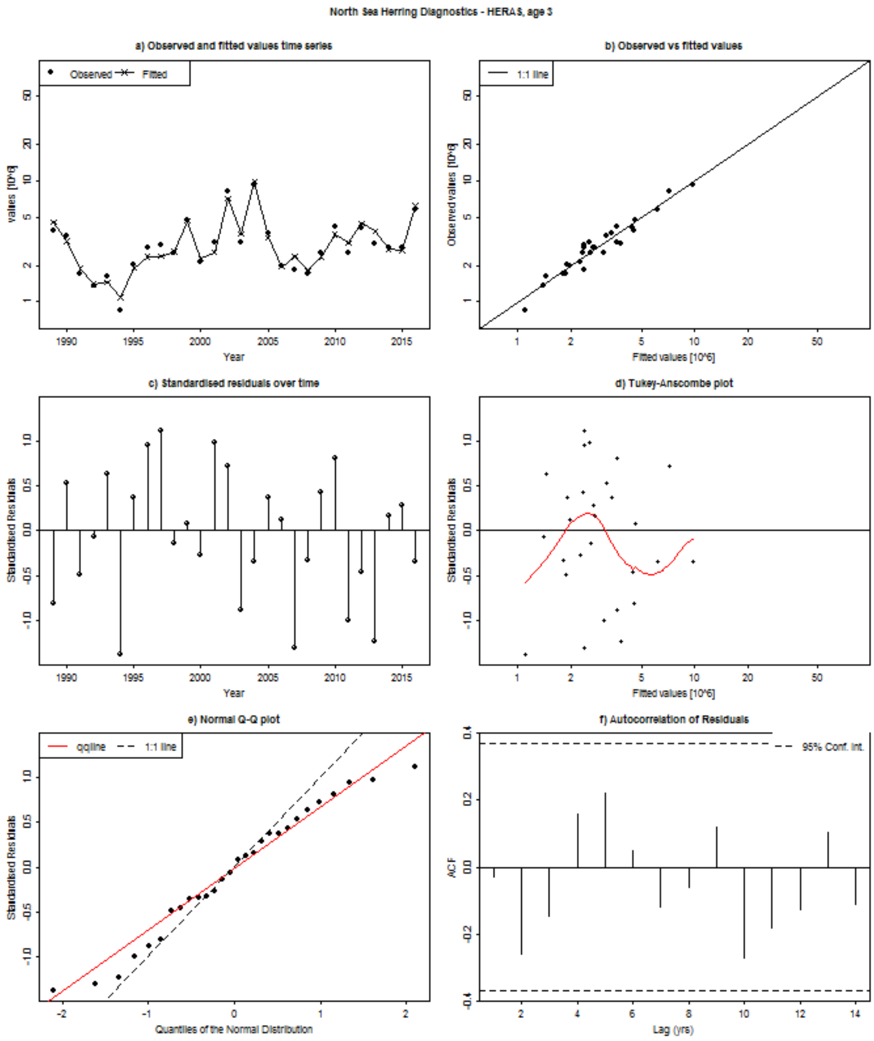


Figure 3.6.1.18. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 3 wr time series. Top left: Estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 3 wr. Middle left: Time series of standardized residuals of the index at 3 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

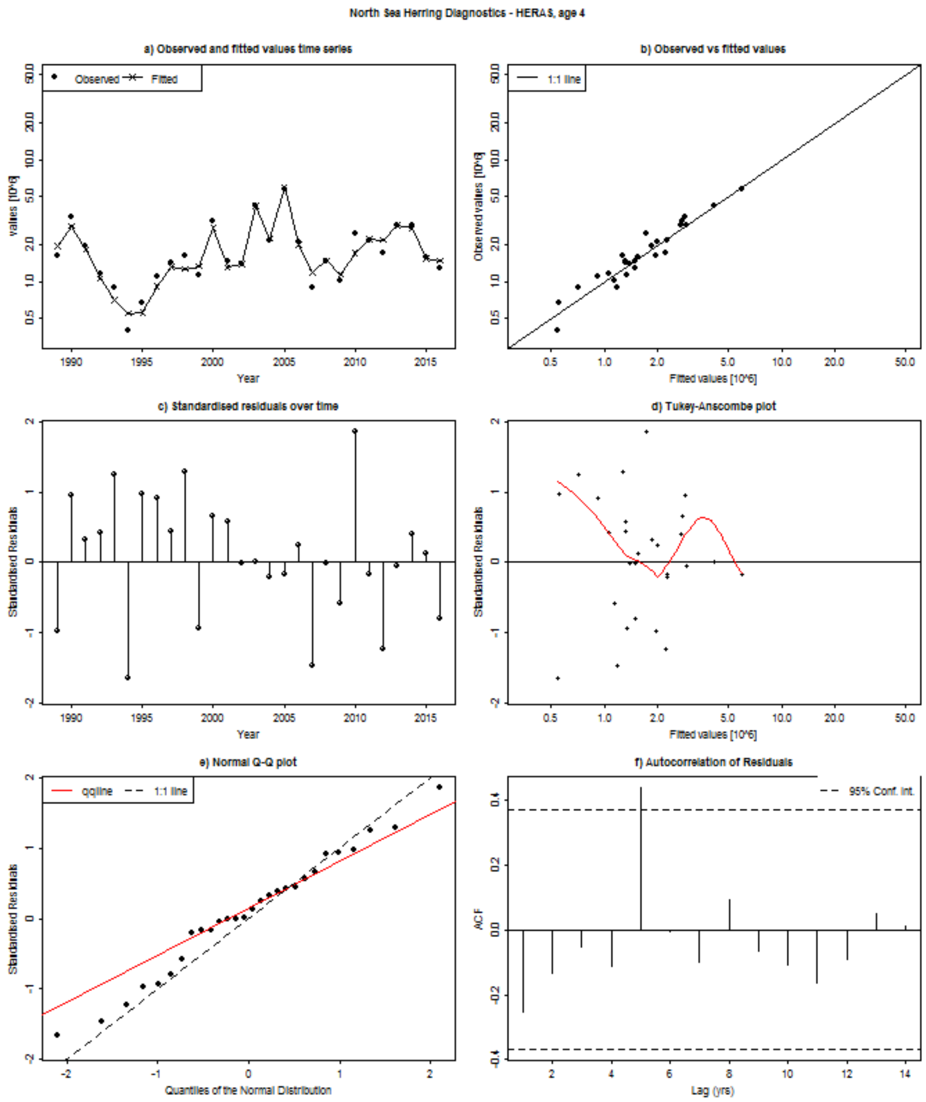


Figure 3.6.1.19. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 4 wr time series. Top left: Estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 4 wr. Middle left: Time series of standardized residuals of the index at 4 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

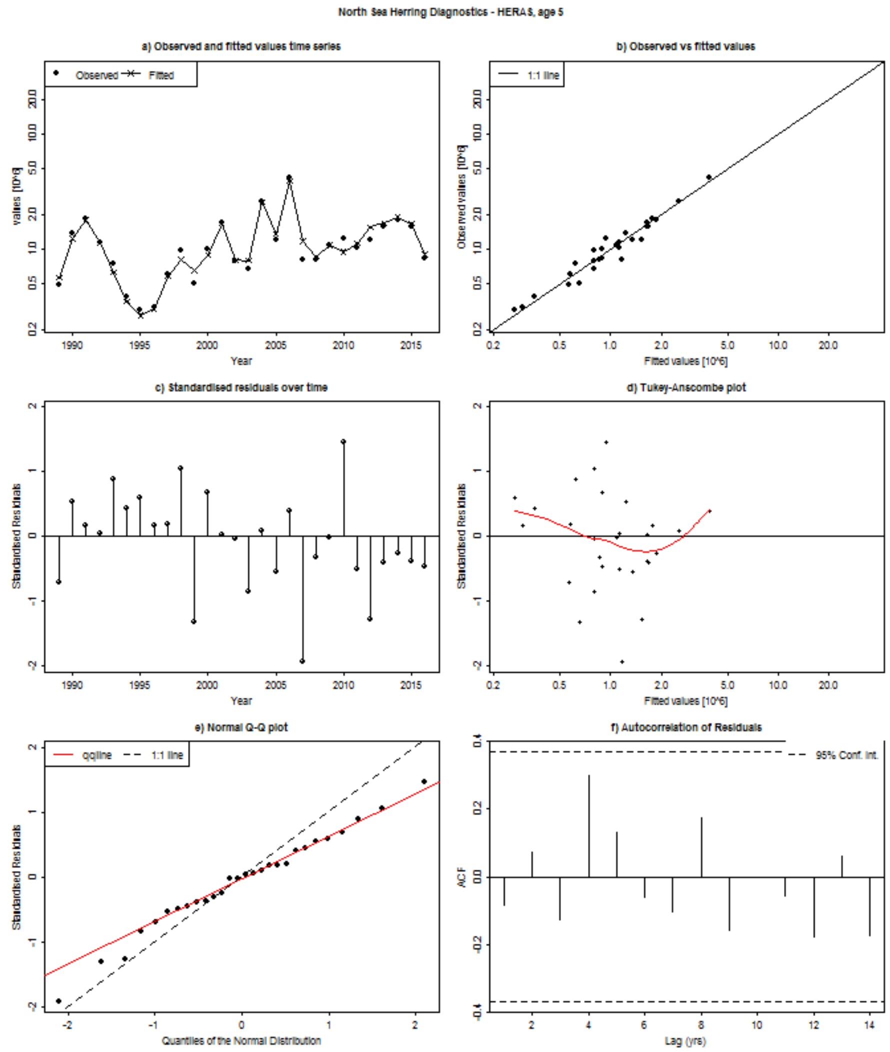


Figure 3.6.1.20. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 5 wr time series. Top left: Estimates of numbers at 5 wr (line) and numbers predicted from index abundance at 5 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 5 wr. Middle left: Time series of standardized residuals of the index at 5 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

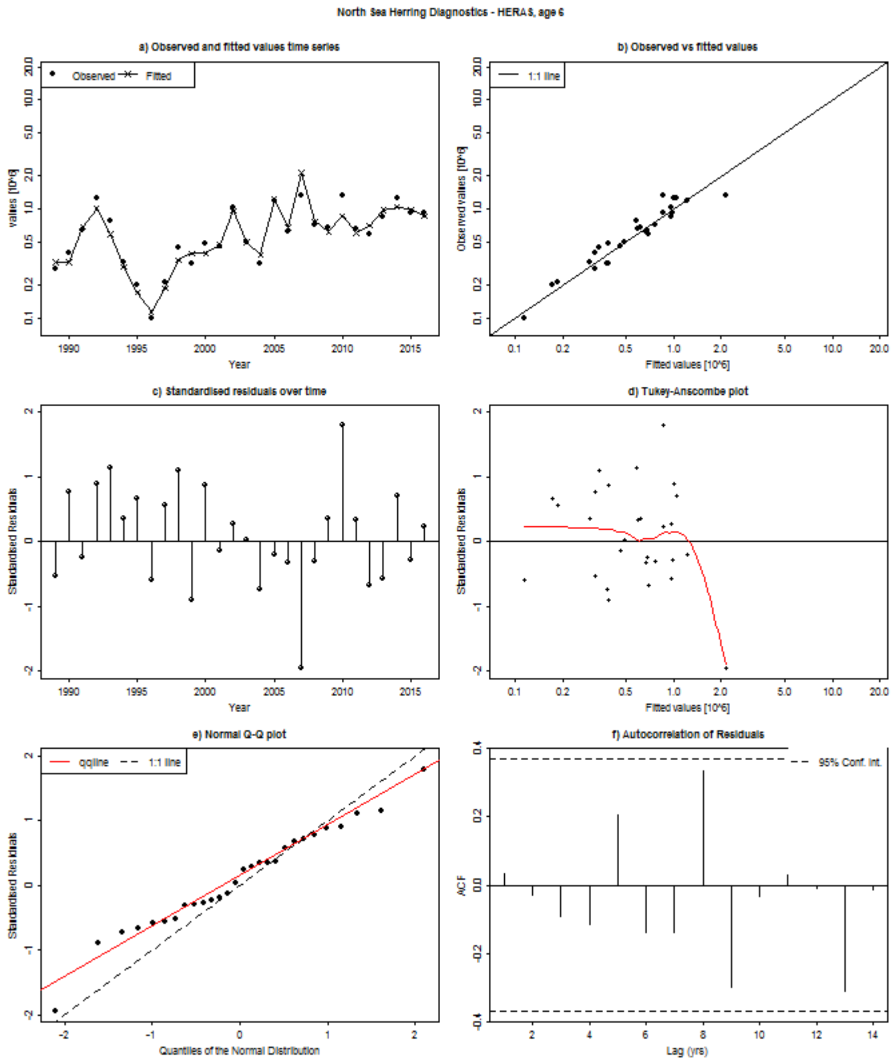


Figure 3.6.1.21. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 6 wr time series. Top left: Estimates of numbers at 6 wr (line) and numbers predicted from index abundance at 6 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 6 wr. Middle left: Time series of standardized residuals of the index at 6 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

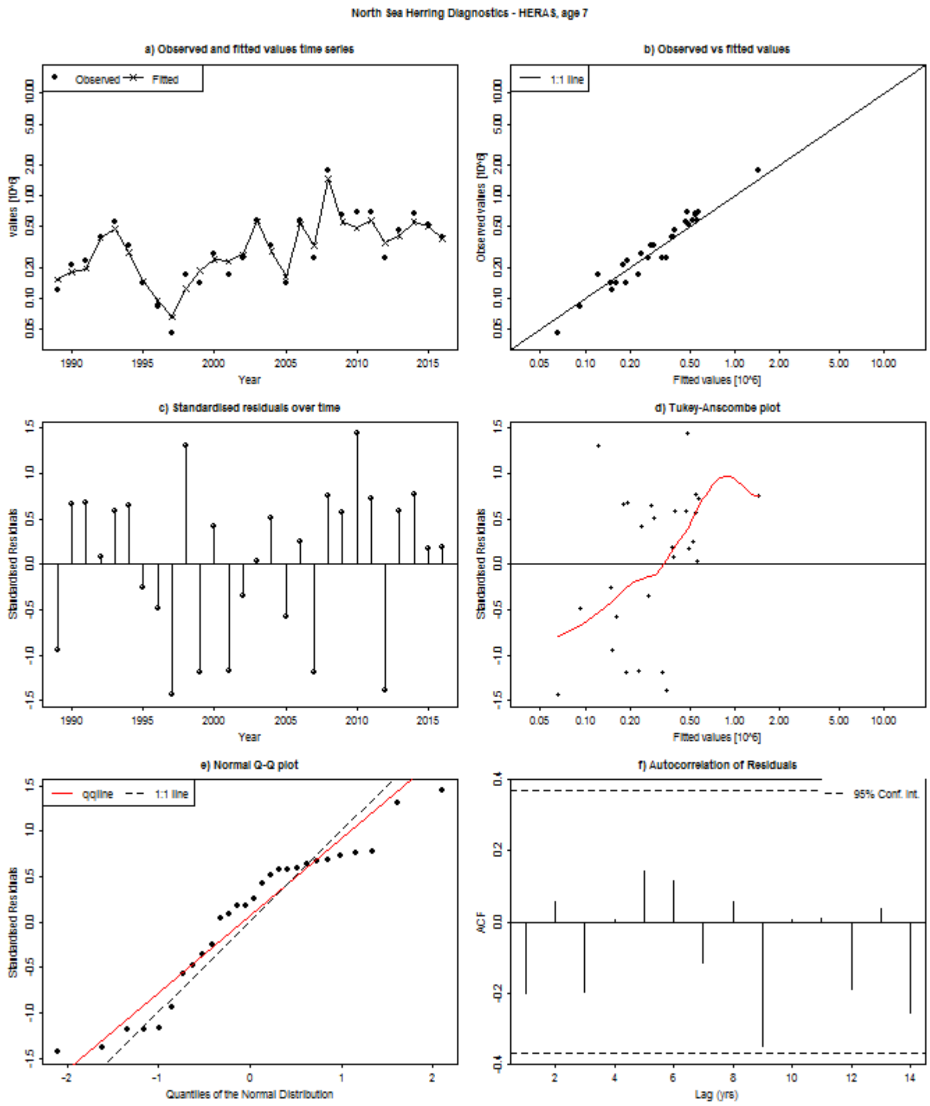


Figure 3.6.1.22. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 7 wr time series. Top left: Estimates of numbers at 7 wr (line) and numbers predicted from index abundance at 7 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 7 wr. Middle left: Time series of standardized residuals of the index at 7 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

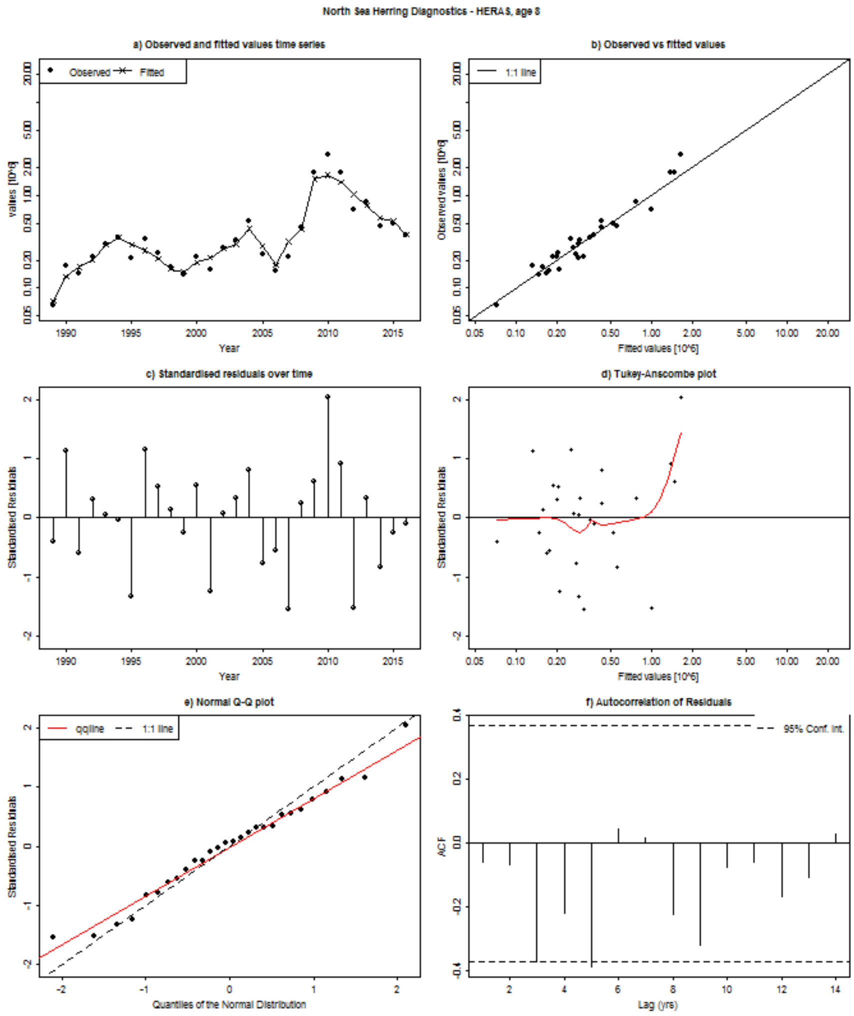


Figure 3.6.1.23. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 8+ wr time series. Top left: Estimates of numbers at 8+ wr (line) and numbers predicted from index abundance at 8+ wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 8+ wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 8+ wr. Middle left: Time series of standardized residuals of the index at 8+ wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

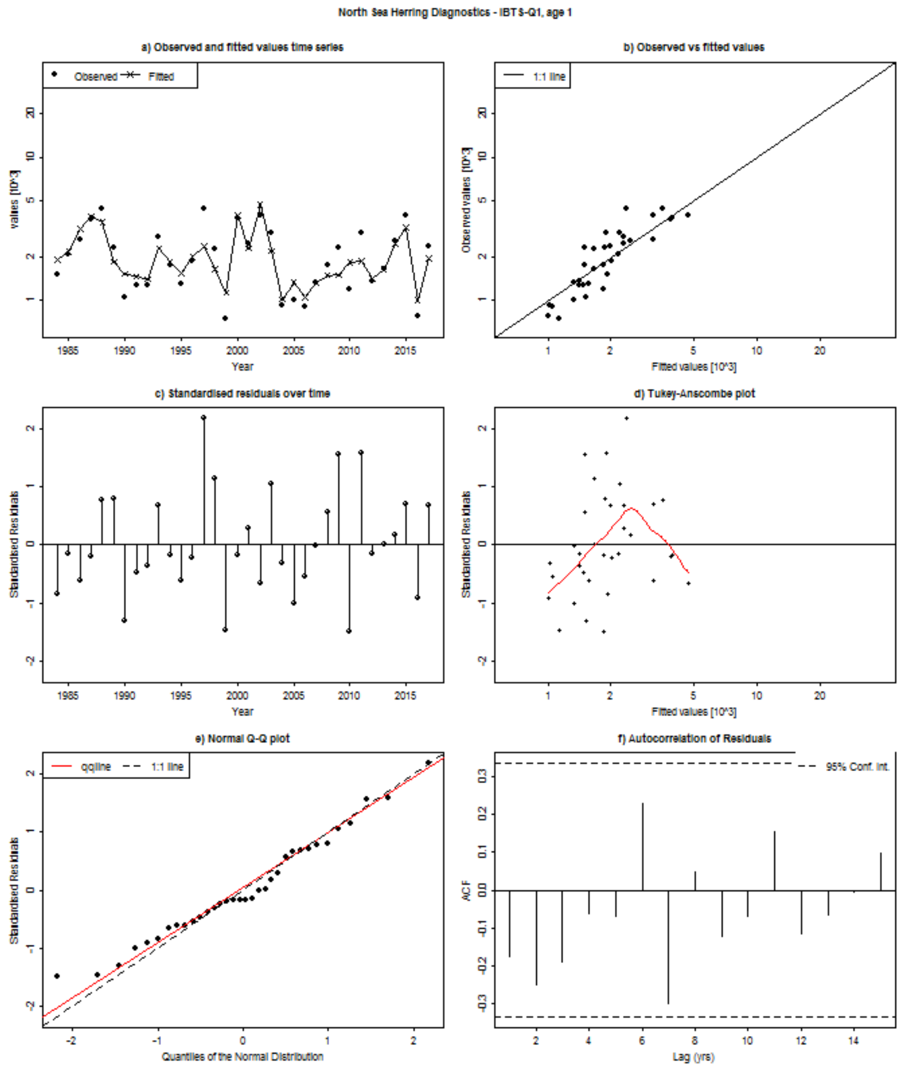


Figure 3.6.1.24. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q1 index at age 1 wr time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 1 wr. Middle left: Time series of standardized residuals of the index at 1 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

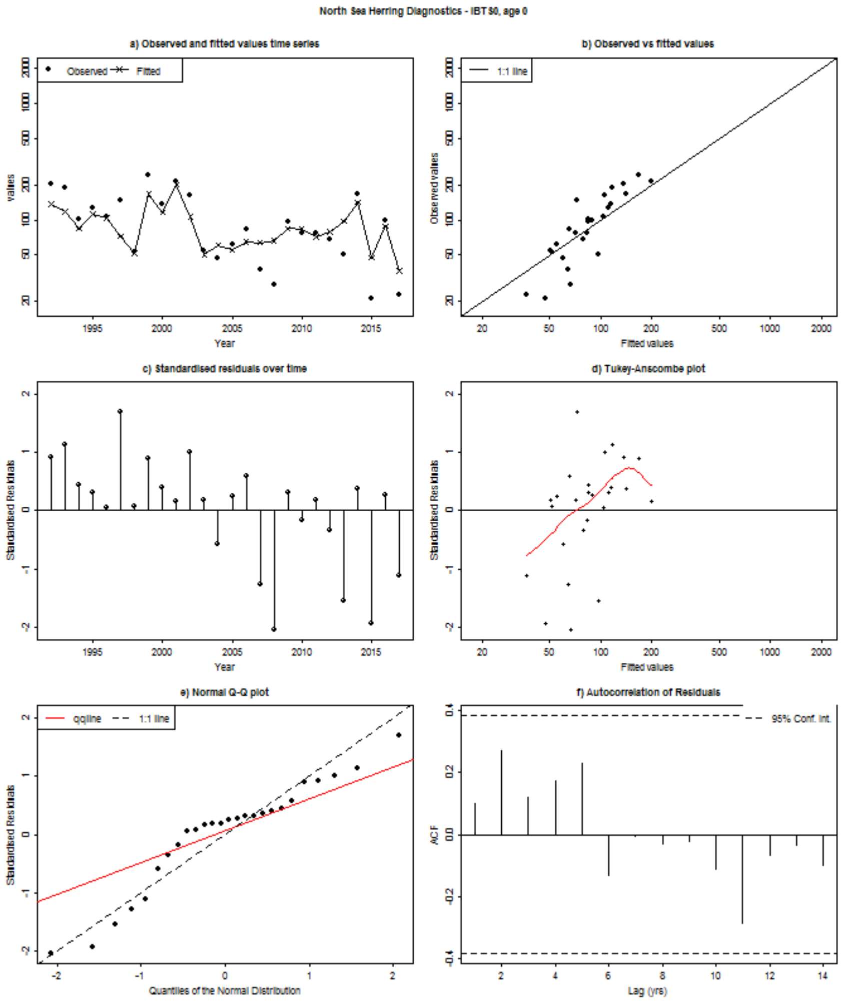


Figure 3.6.1.25. North Sea herring. Diagnostics of the assessment model fit to the IBTS0 index at age 0 wr time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

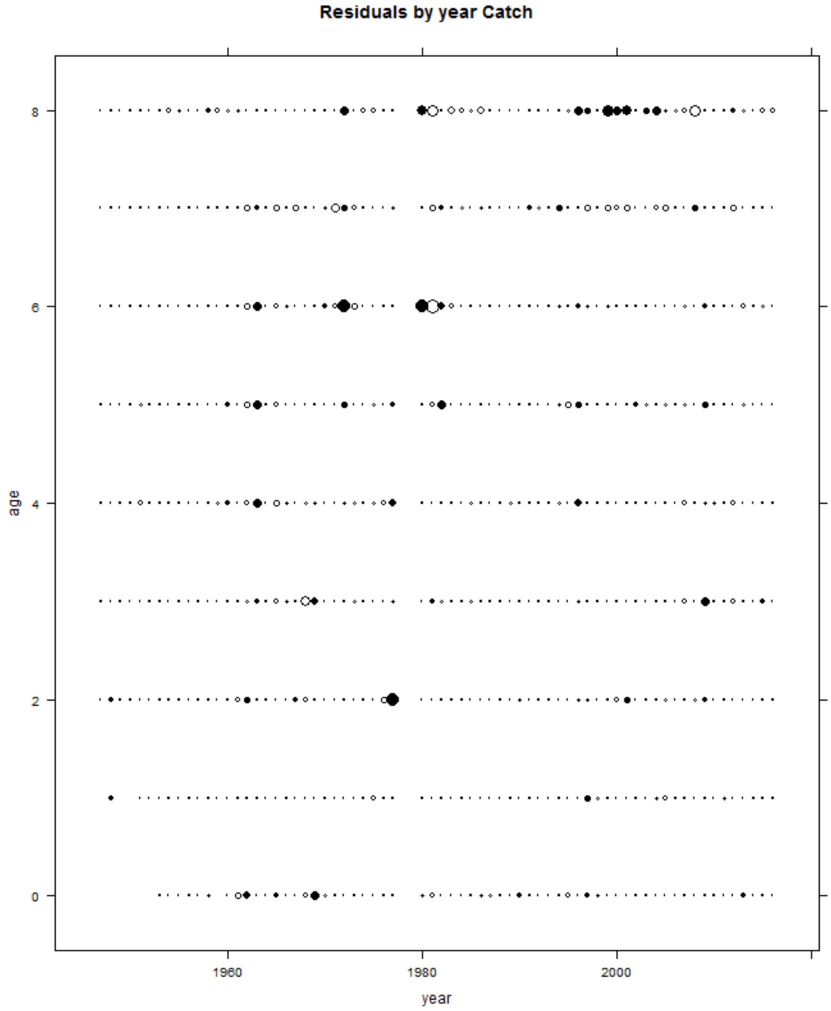


Figure 3.6.1.26. North Sea herring. Bubble plot of standardised catch residual.

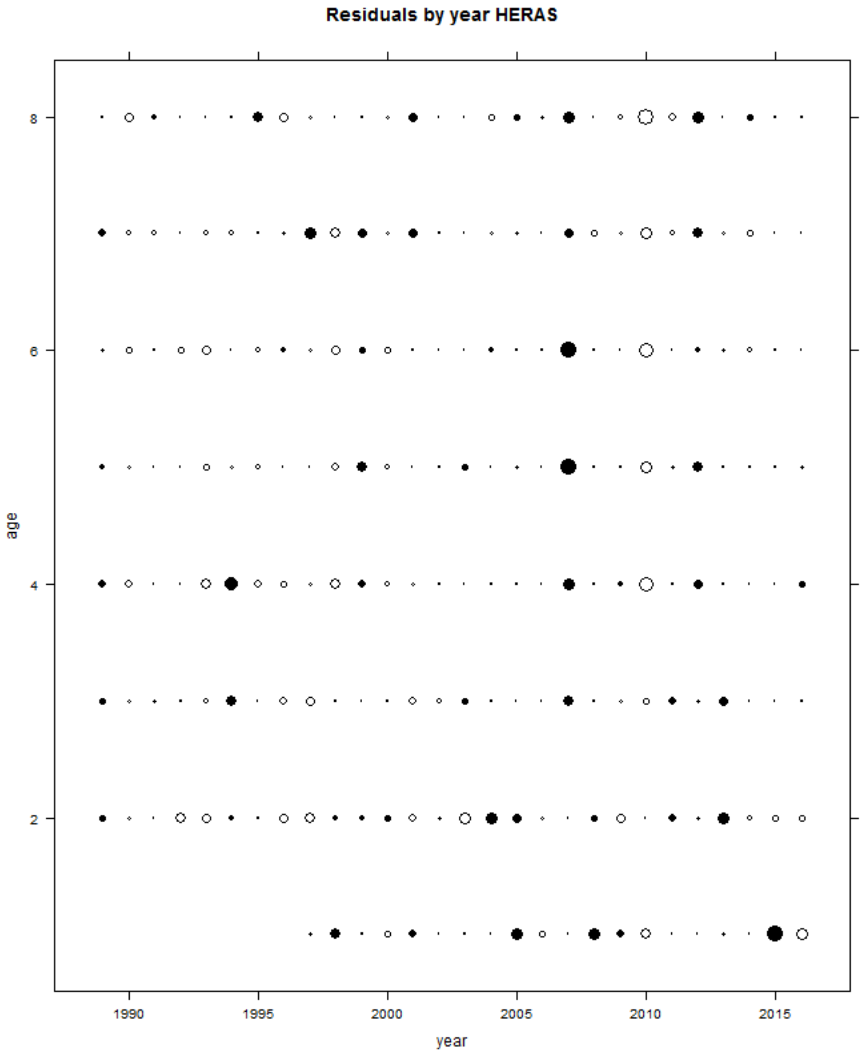


Figure 3.6.1.27. North Sea herring. Bubble plot of standardised acoustic survey residuals.

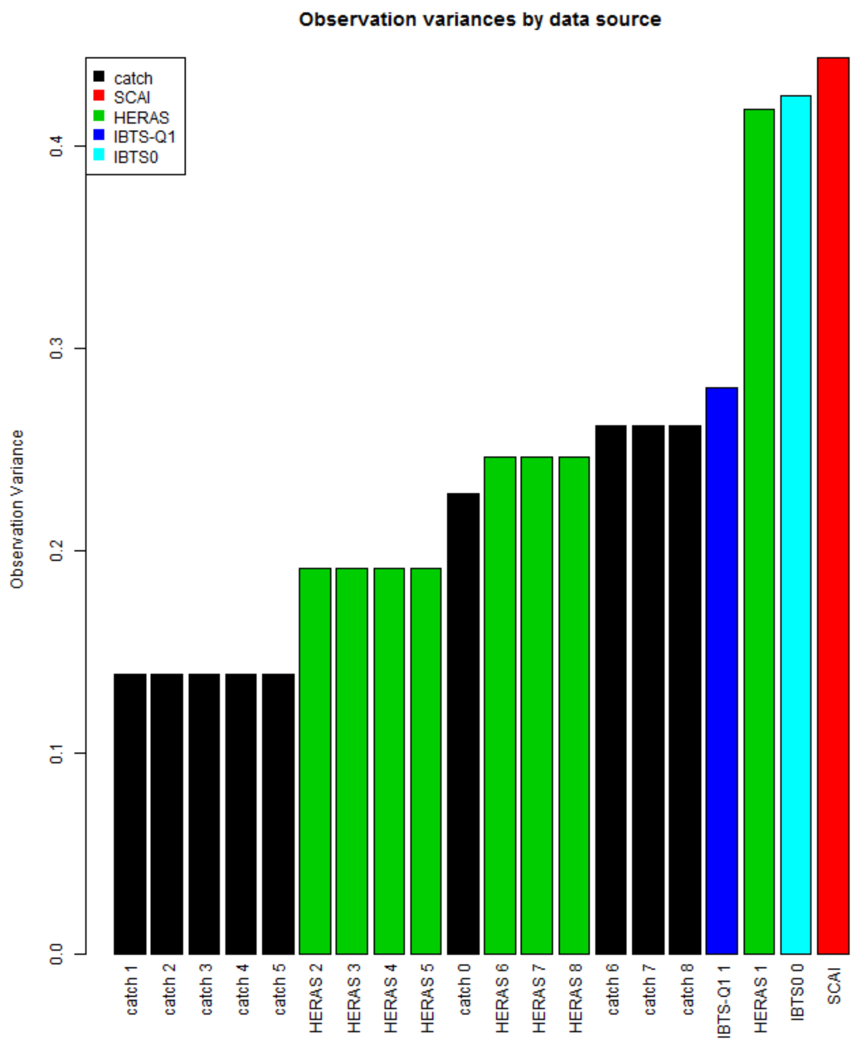


Figure 3.6.1.28. North Sea herring. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for each data source thereby reducing the parameters needed to be estimated in the assessment model. In these cases of parameter bindings, observation variances have equal values.

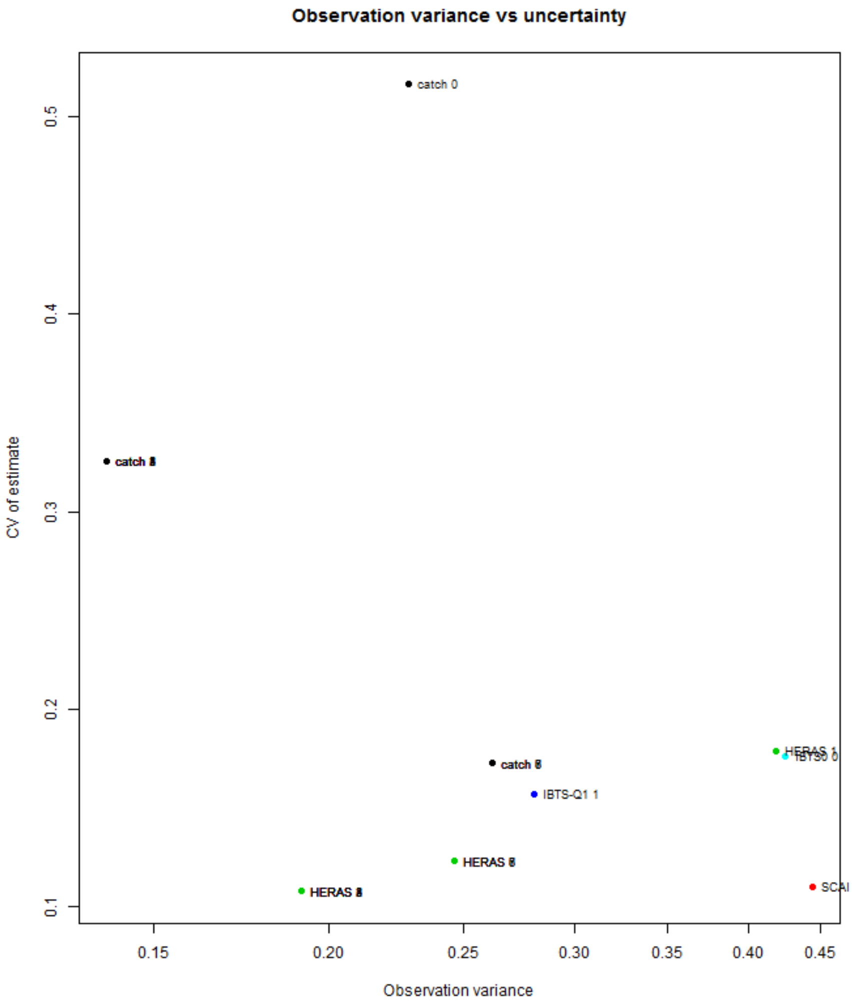


Figure 3.6.1.29. North Sea herring. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

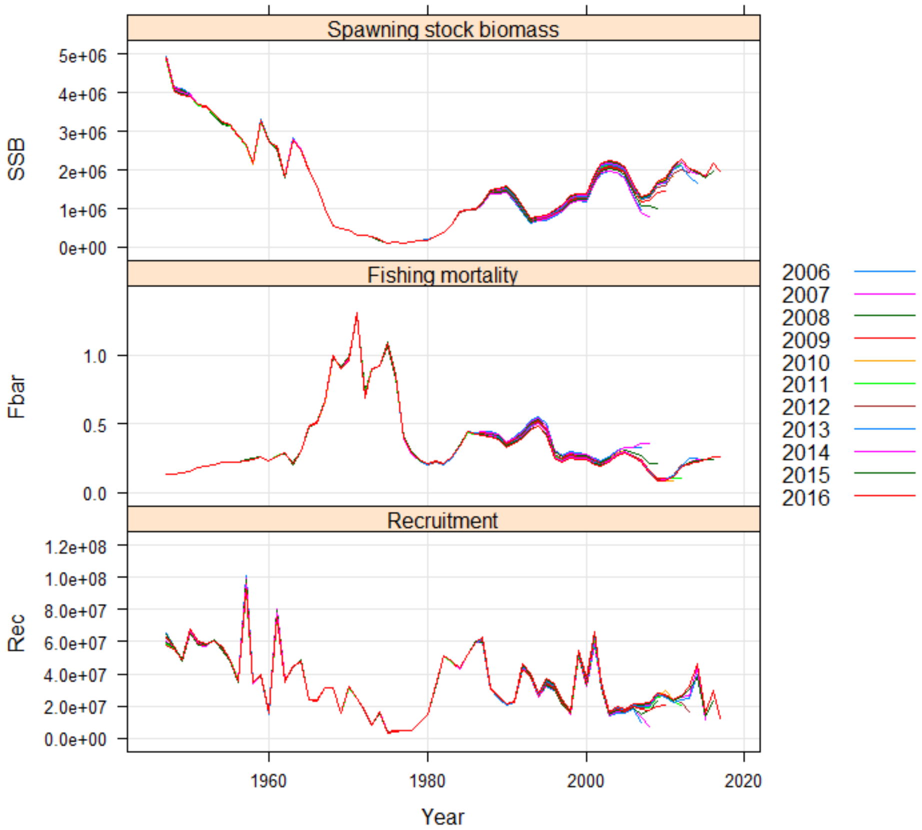


Figure 3.6.1.30. North Sea herring. Assessments retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel) from 2006 to 2016.

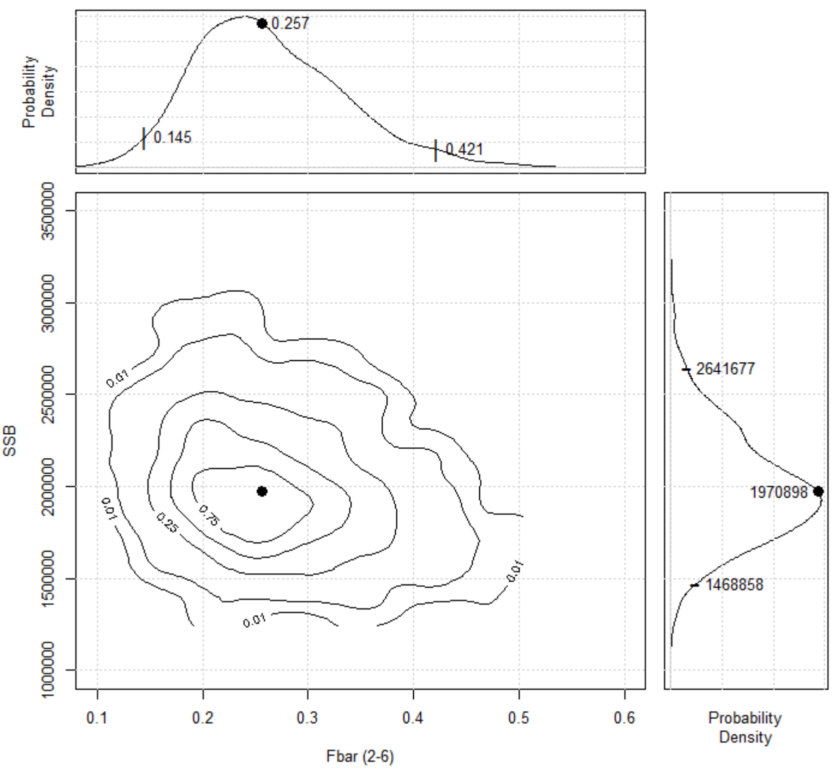


Figure 3.6.1.31. North Sea herring. Model uncertainty; distribution and quantiles of estimated SSB and $F_{2\text{-}6}$ in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLSAM estimated variance / covariance estimates from the model.

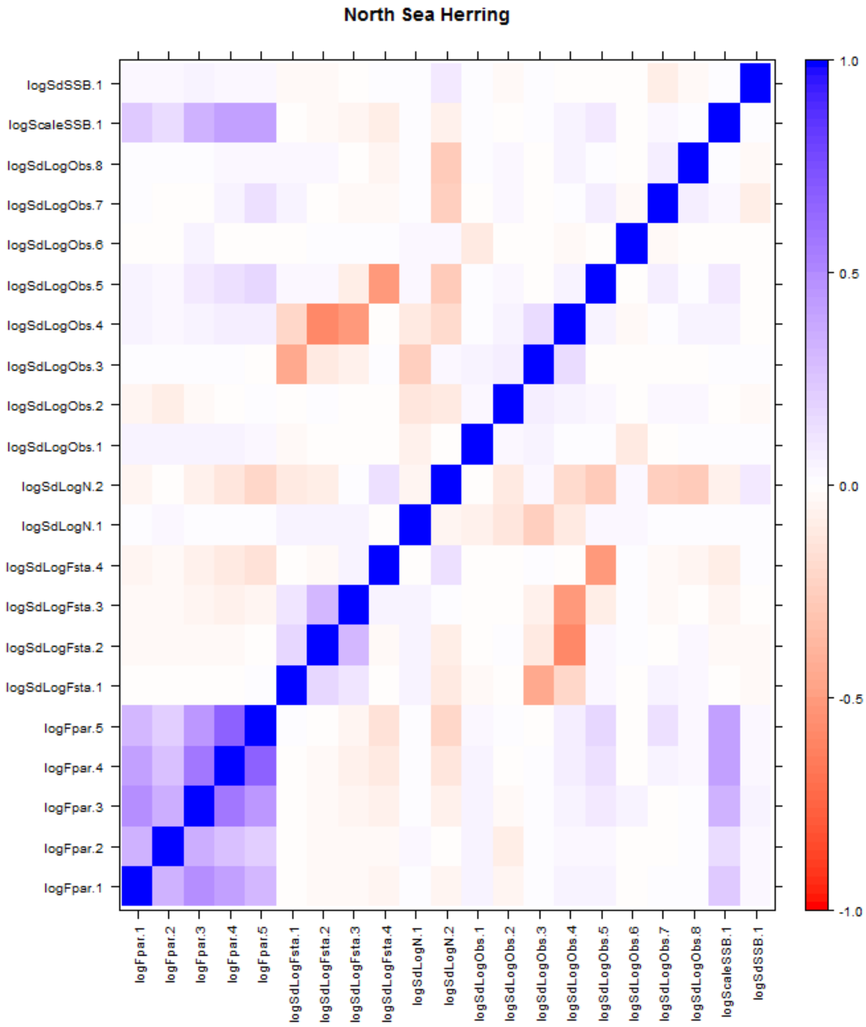


Figure 3.6.1.32. North Sea herring. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

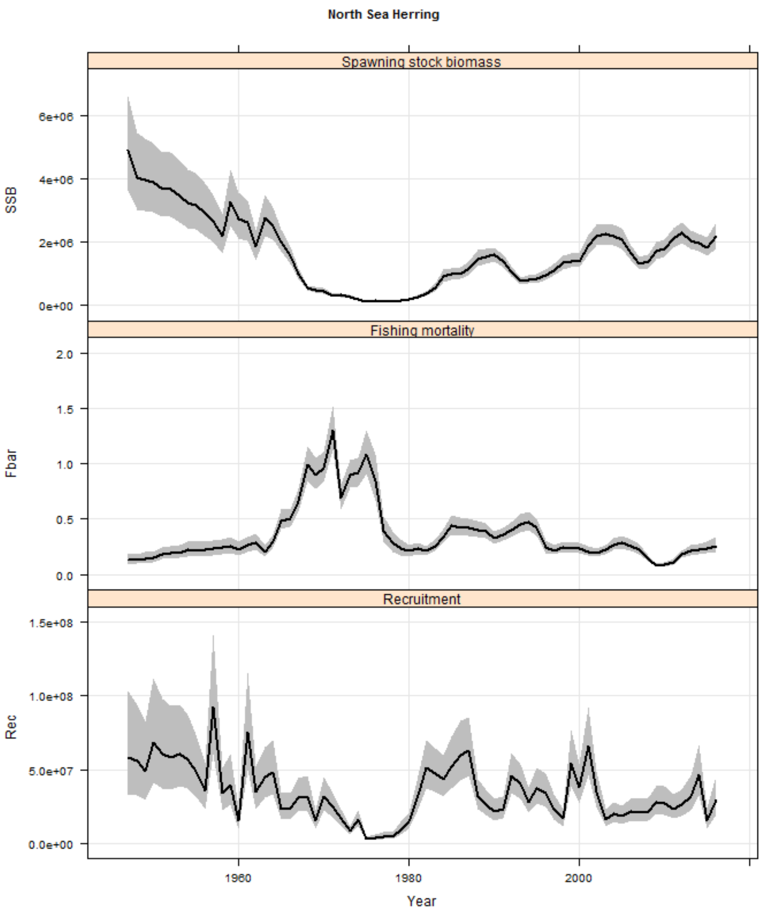


Figure 3.6.3.1 North Sea herring. Stock summary plot of North Sea herring with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

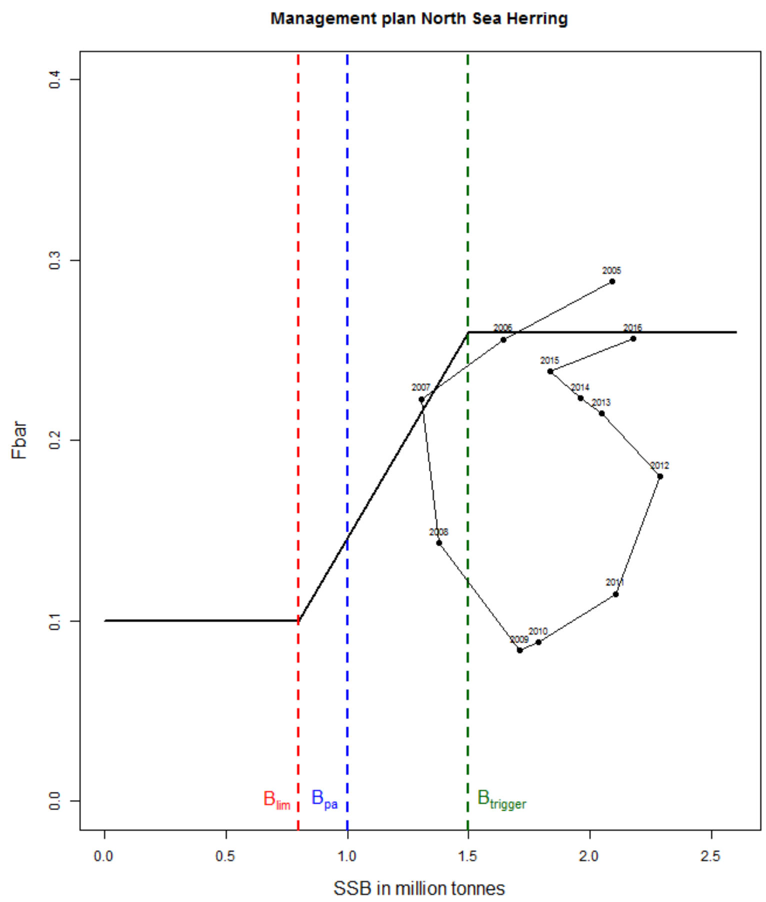


Figure 3.6.3.2. North Sea herring. Agreed management plan for North Sea herring including the most recent 10 years of SSB and F as estimated within the assessment in relation with the management plan.

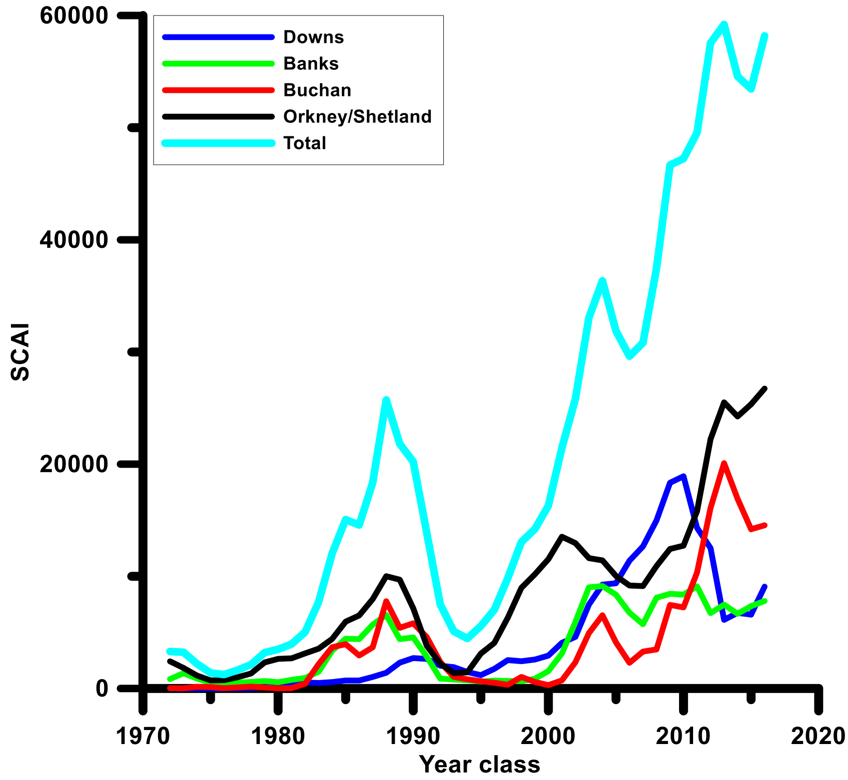


Figure 3.11.1: North Sea herring. SCAI indices for the individual North Sea spawning components.

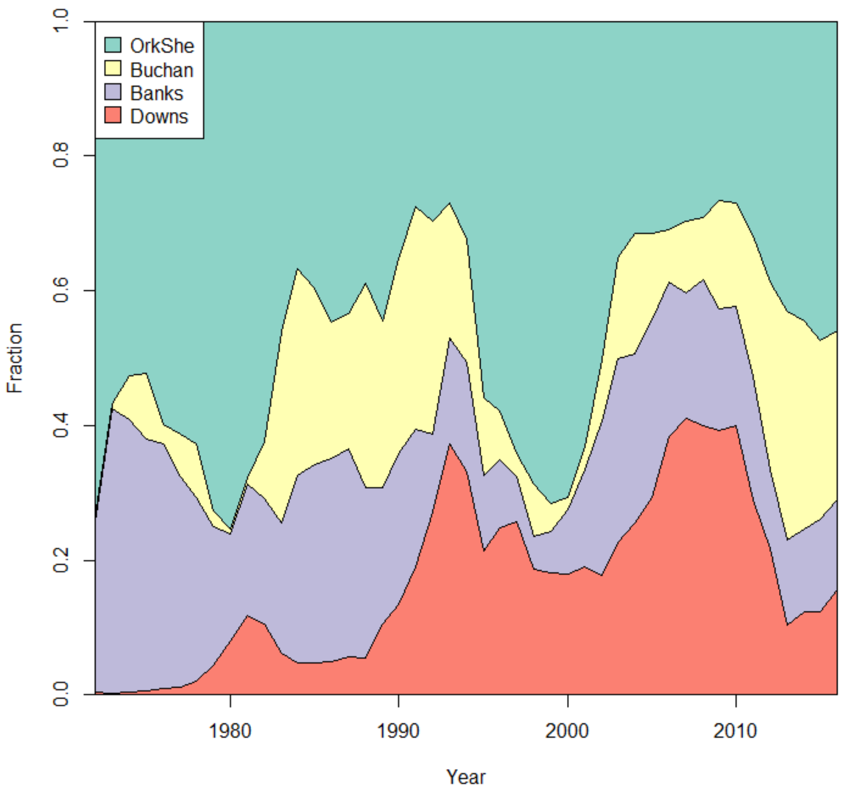


Figure 3.11.2. North Sea herring. Time-series of the contribution of each spawning component to the total stock, as estimated from the SCAI index (Payne, 2010). Areas are arranged from top to bottom according to the north-to-south arrangement of the components.

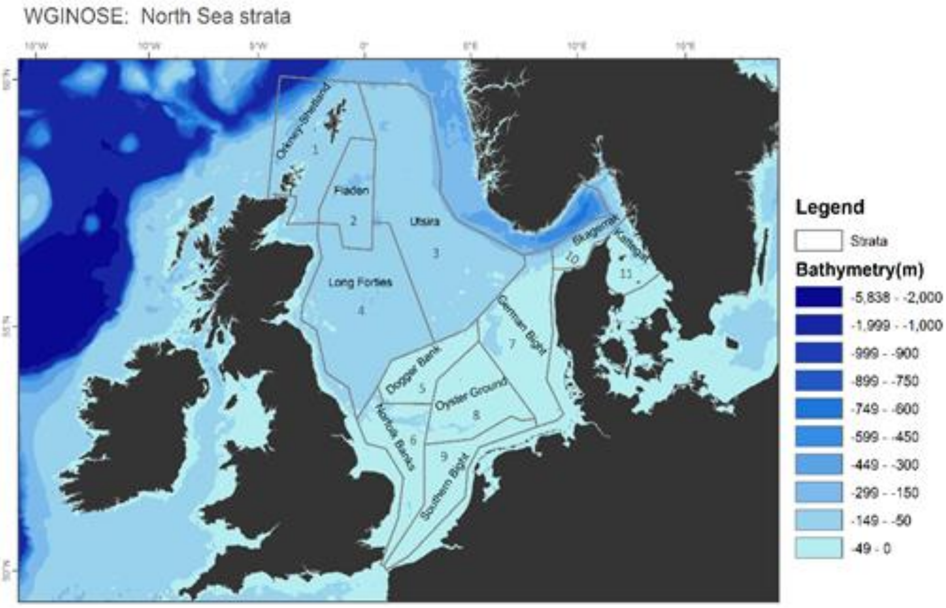


Fig 3.12.1. North Sea herring. Spatial strata used by WGINOSE (ICES WGINOSE 2016) for subregional ecosystem status in the North Sea ecoregion.

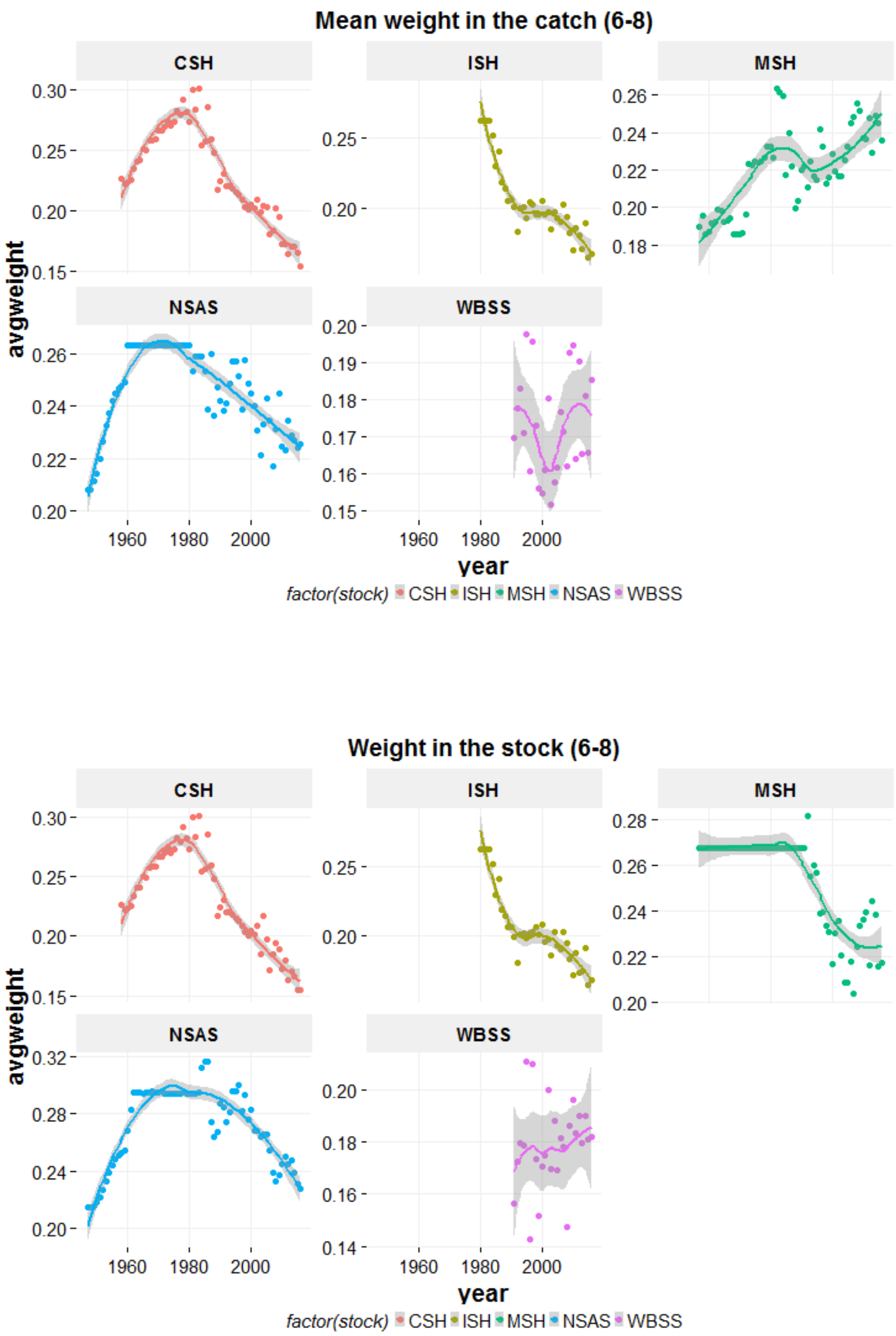


Figure 3.13.1: North Sea Herring. Average weight for fish aged 6+ in the catch (top figure) and in the stock (bottom figure). In each figure, this is presented for: Celtic Sea Herring (CSH, top left plot); Irish Sea Herring (ISH, top middle plot); Malin Shelf Herring (MSH, top right plot); Nort Sea Autumn Spawning Herring (NSAS, bottom left plot); Western Baltic Spring Spawning Herring (WBSS, bottom middle plot).

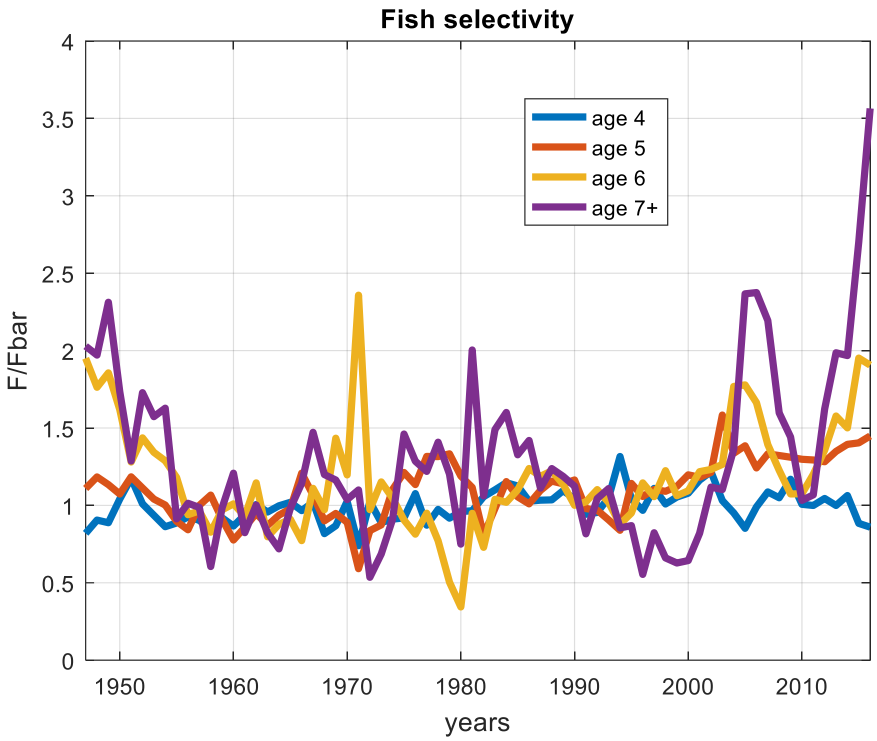


Figure 2.13.2: North Sea Herring. Fish selectivity from 1947 to 2016 for age 4 to 7+. A strong increase is noticeable in the recent years for the 7+ age group.

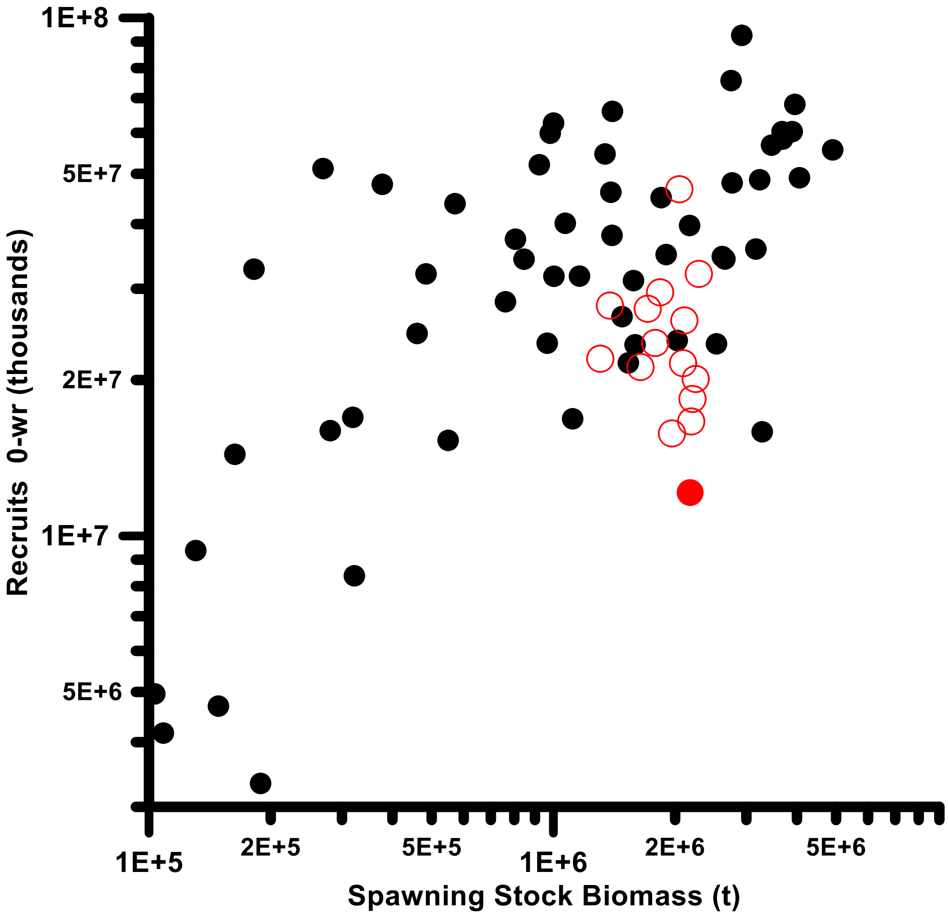


Figure 3.13.3. North Sea Autumn Spawning Herring. Stock recruitment curve, plotting estimated spawning stock biomass against the resulting recruitment. Year classes spawned after 2001 are plotted with open red circles, to highlight the years of recent poor recruitment. The most recent year class is plotted in solid red. Note the logarithmic scaling on both axes.

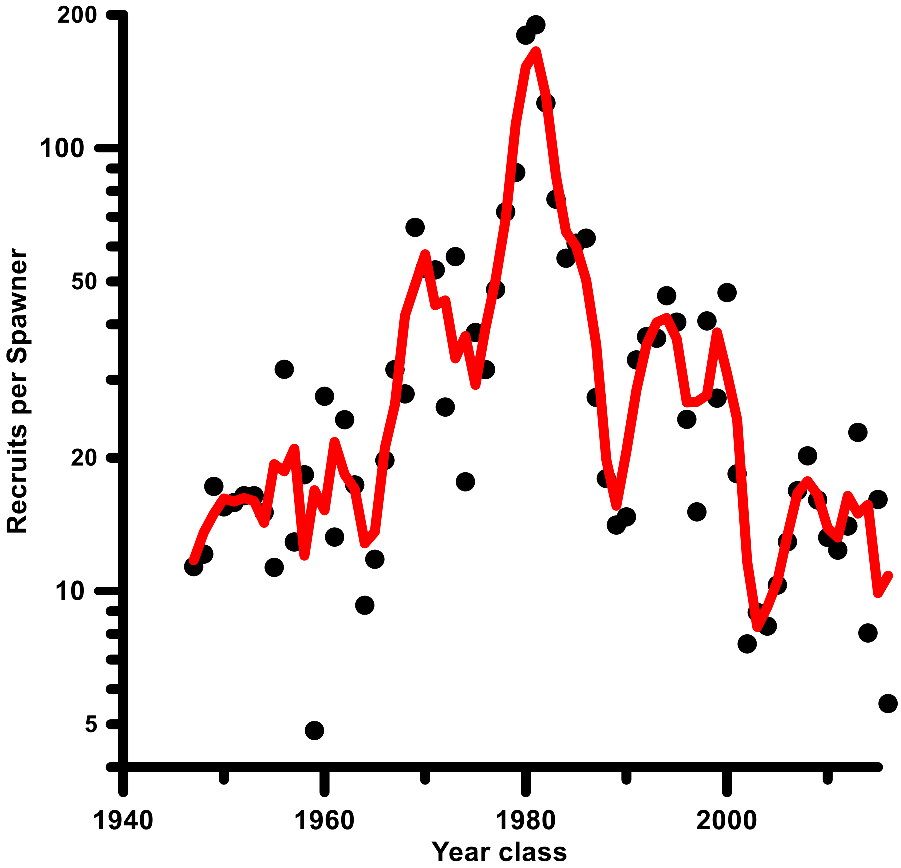


Figure 3.13.4. North Sea Autumn Spawning Herring. Time series of recruits per spawner (RPS). RPS is calculated as the estimated number of recruits from the assessment divided by the estimated number of mature fish at the time of spawning and is plotted against the year in which spawning occurred. Black points: RPS in a given year. Red line: Smoother to aid visual interpretation. Note the logarithmic scale on the vertical axis.

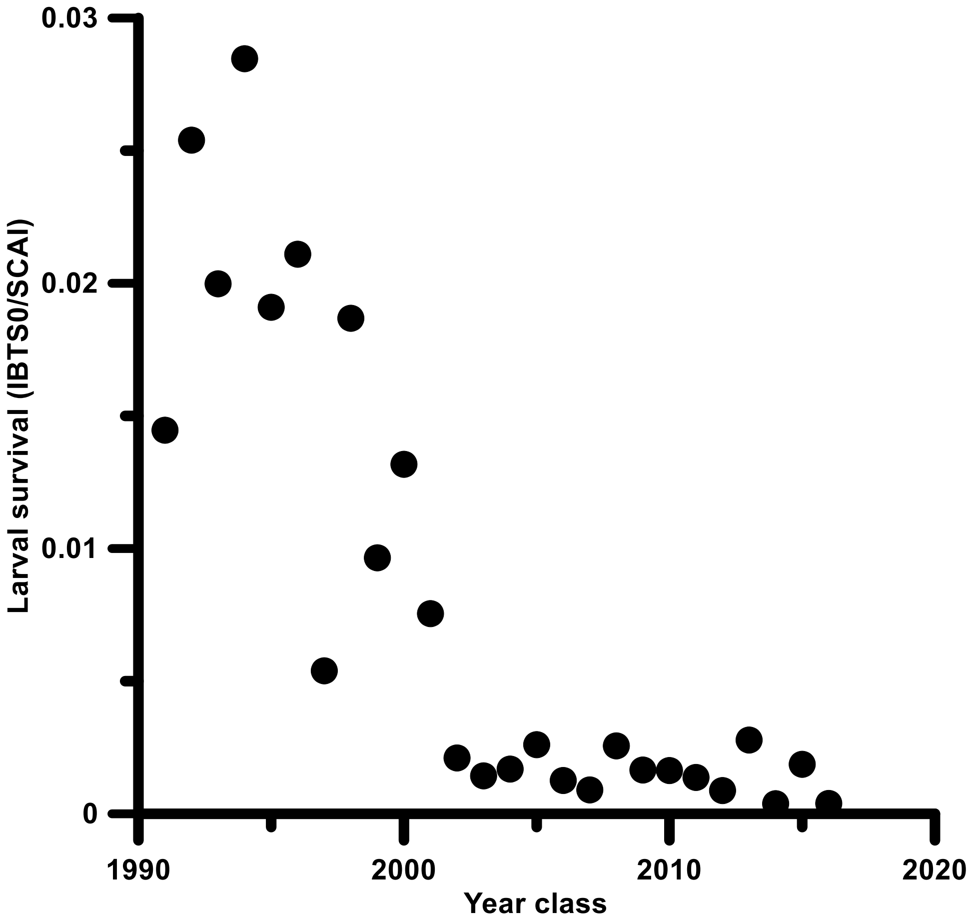


Figure 3.13.5. North Sea Autumn Spawning Herring. Time series of larval survival ratio (Dickey-Collas & Nash 2005; Payne et al. 2009), defined as the ratio of the SCAI index (representing larvae less than 10–11mm) and the IBTS0 index (representing the late larvae, of approximately 20–30 mm). Survival ratio is plotted against the year in which the larvae are spawned.

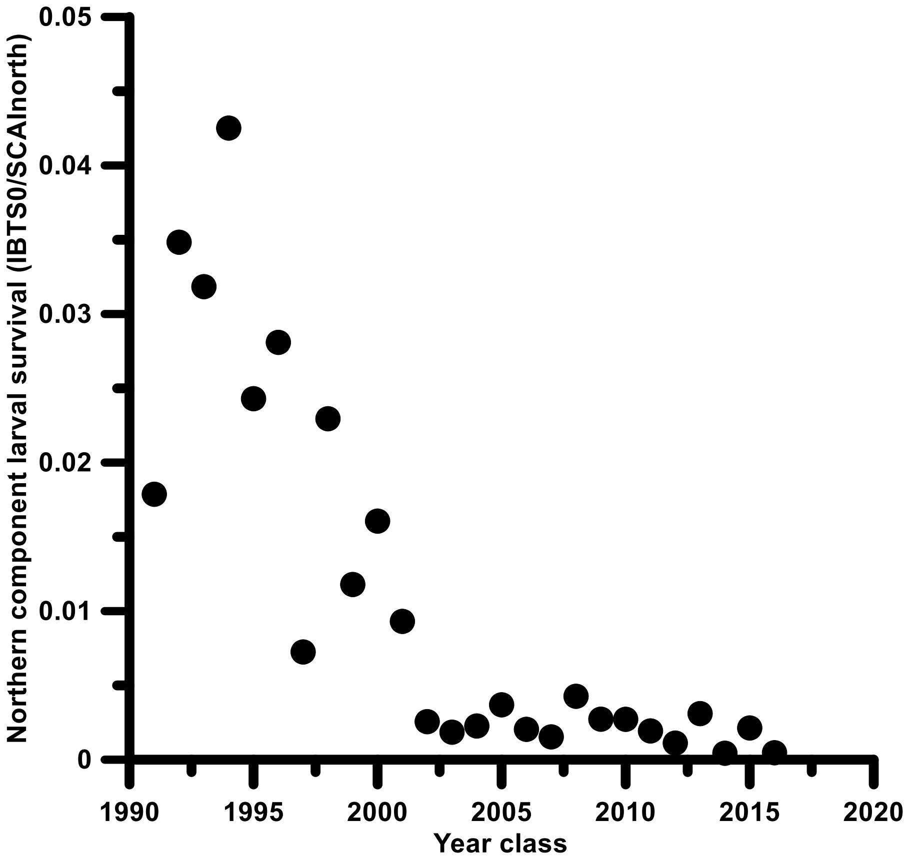


Figure 3.13.6. North Sea Autumn Spawning Herring. Time series of larval survival ratio (Dickey-Collas & Nash 2005; Payne *et al.* 2009) for the northern-most spawning components (Banks, Buchan, Orkney-Shetland), defined as the ratio of the sum of the SCAI indices for these components (representing larvae less than 10–11mm) and the IBTS0 index (representing the late larvae, of approximately 20–30 mm). Survival ratio is plotted against the year in which the larvae are spawned.

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

This is the third 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

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 in 2015. The management plans in place for either stock were no longer applicable for the combined stocks. Considering the low SSB and low recruitment in recent years estimated for the combined stocks, 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. However, 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. In June 2016, ICES advised on a scientific monitoring TAC of 4 840 t (with a TAC split of 3 480 t to be taken in 6.aN and 1 360 t in 6.aS and 7b,c, ICES 2016b). 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 5 800 t (TAC split of 4 170 t in 6.aN and 1 630 t in 6.aS and 7.b-c; EU 2016/0203).

4.1.2 Changes in the fishery

There have been no significant changes in the fishing technology of the fleets in this area in recent years. In 6.aN, the fishery has become restricted to the northern part of the area since 2006. Prior to 2006 there was a much more even distribution of effort, both temporally and spatially. In 6.aS, only two main areas have been fished in the recent past. There has been little effort in 7.b in recent years.

In 6.aN there are three fisheries, (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 ring nets in coastal waters.

In 2016 the fishery was pursued as a monitoring fishery with a combined TAC of 5 800 t, a significant reduction on the 2015 TAC of 22 690 t (which was only applicable to 6.aN; for 6.aS and 7b-c the TAC was already zero in 2015). The monitoring fishery was designed to mimic as far as possible recent temporal and spatial distribution of fishing effort. For a detailed description of the individual fisheries in 6.aN and 6.aS/7.b-c see section 06, this report.

4.1.3 Regulations and their affects

The 4^{o} 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 occur across the boundary. The north-south boundary between 6.aN and 6.aS (56th parallel) is not appropriate as a boundary, because it traverses the spawning and feeding grounds of 6.aS herring. Trans-boundary catches occur along this line.

4.1.4 Catches in 2016

The Working Group's best estimate of removals from the stock is shown in Table 5.1.2 for the 5.aS and 7.b and 7.c constituent stock and in Table 5.2.2 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 and 7.c assessment. Catch number- and weight-at-age information is given in the stock assessment stock report section 4.6 (cf tables 4.6.1 and 4.6.2 respectively).

4.3 Fishery Independent Information

4.3.1 Acoustic surveys

An acoustic survey has been carried out in Division 6.aN in June-July since 1991 by Marine Scotland Science. It originally covered an area bounded by the 200m depth contour in the north and west, to the 4°W in the eastand 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 (Table 4.3.1.1; WGIPS ICES 2015b). 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 2016 as well as maintaining coverage of the original survey area in 6.aN.

The 2016 SSB estimate of 87 713 t and 483 200 herring for the Malin Shelf area (6.aN-S and 7.b-c) is significantly lower than the 2015 estimate (430 000 t and 2 181 million herring; Table 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 and 7.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 of the areas able to be surveyed by the large vessels carrying out the summer acoustic surveys.

In 2016, 75% of the herring was distributed on the shelf area off of the Outer Hebrides and the remaining 25% in the area North of the Hebrides up to the 4°W line of longitude which delineates the stock management area (WGIPS, ICES 2017).

A small proportion of total herring biomass (typically less than 10%) is normally observed within 7.b and 7.c. in the survey. In 2016 no herring aggregations were observed in this area of the survey for the first time in the time series (2008-present). In 2015, the biomass of herring in south of 56°N was 55 315 t (4.5% of total biomass in the survey; (WGIPS, ICES 2016).

The 2016 pattern of distribution and large reduction in survey biomass are not easily explained considering both survey effort and timing were comparable between years. The 2015 estimate was almost 150 000 t higher than in 2014 and this was attributed in the main to a high abundance of herring observed along the 4°W bordering line of longitude. Herring are often found in high densities in the vicinity of the 4°W line in association with specific bathymetric features. Small inter-annual changes in the distribution of herring aggregations around the line at the time of the survey has the ability to strongly influence the annual estimate of abundance of the Malin Shelf survey. This is particularly the case at the low overall abundances observed recently, when these aggregations are large relative to the overall stock size. In 2016 high densities were observed in the vicinity of the 4°W line, on the eastern side and therefore assigned to the North Sea Herring stock. In 2016 the patterns in year class proportions in the catch and the survey were not entirely consistent (Figure 4.3.1.1). The survey showed high proportions of 3, 4, 5 and 6 ring fish. In the catches however was dominated by 2 and 3 winter ring fish. Both survey and catches had only a negligible proportion of 1 wr fish and ages above 7 winter rings were almost absent in both.

The Malin Shelf survey time series showed reasonable internal consistency for the older ages (6- to 9 rings), but less so for ages 1- to 5 rings. However in 2016, the very low abundance overall and the almost complete absence of older fish degraded this relationship (Figure 4.3.1.2).

4.3.1.1 Industry-Science Acoustic survey

In 2016 a new acoustic survey was initiated as part of the monitoring fishery on this stock. It covers known active spawning grounds in both 6.aN and 6.aS at spawning time and aims to provide estimates of minimum spawning stock size in each of the areas. Full results from the survey can be found in (WGIPS, ICES 2017) and a summary for each of the components is in section 06 of this report.

4.3.2 Scottish Bottom trawl surveys

Marine Scotland Science carries out two annual bottom trawl surveys in western waters covering the herring stocks in ICES Division 6.a. The Scottish West Coast Ground fish survey in quarter 1 has been carried out in a consistent manner since 1987 and in quarter 4 since 1996.

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

The abundance of 2 winter ring fish were at higher levels earlier in the time-series particularly in quarter 1, but since 2003 older fish have been numerically more abundant in the index in both quarters (figures 4.3.2.3 and Figure 4.3.2.4). In the period after 2010 it appears that older fish are decreasing in abundance again, this trend is at the moment not carried into the assessment as the time series used in the assessment only runs to 2010 when the survey design was changed. 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 tables 4.3.1.2 (for the current year) and 4.6.3 (for the time series).The weights-at-age in the stock have been declining steadily since 2010 particularly for younger ages (Table 4.6.3). Weights-at-age in the catches are given in Table 4.6.2 and are also used in the assessment. The weights-at-age in the catch in 2016 are similar to 2015. There are no apparent trends in these weights in recent years.

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 2016 (cf. Table 4.6.5). For earlier years, the maturity ogive is as per the 6.aN stock, and is taken from the geographic split 6.aN old acoustic tuning series (MSHAS_N; HAWG, ICES 2014). The proportion mature of ages 2- and 3-wr in 2016 were higher than in 2015 and as high as earlier in the time series (Figure 4.4.2.1). Few immature fish were encountered in the survey in 2016.

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 multi-species 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 and 7.c (WKWEST 2015) agreed to use the natural mortalities for North Sea herring from the current North Sea multi-species model, as it is deemed the best available proxy for natural mortality of herring in 6.a and 7.b and 7.c. The input data to the assessment of herring in Division 6.a and 7.b and 7.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-ring, both the fishery and survey encounter this age group only incidentally. The first reliable appearance of a cohort appears at 2-ring in both the catch and the stock.

4.6 Assessment of 6.a and 7.b-c herring

This is the third assessment carried out on the combined 6.a and 7.b-c herring stock after the 2015 benchmark (ICES, WKWEST 2015). The assessment presented here follows the same procedure as the final assessment carried out at the extension to the WKWEST workshop during May 2015. There are no new data sources to consider since the benchmark extension concluded.

The data for this combined assessment were pooled from the separate data for 6.aN and 6.aS/7.b-c. The text table below sets out the basis of the input data.

Type	Description
Catch in tonnes (caton)	Addition of 6.aN and 6.aS/7.b and 7.c data
Catch in numbers (canum)	As above
Mean catch weights (weca)	Sum products of canum and weca per stock, divided by combined canum
Mean stock weights (west)	As per 6.aN stock for all years (from 6.aN component of Malin Shelf Acoustic Survey)
Natural mortality (natmor)	ICES WKWEST 2015 extension (average 1974–2010 NS-SMS 2011 key run)
Maturity (matprop)	As per 6.aN, 1957-2007; from Malin Shelf Acoustic Survey 2008–2016
Proportions of F and M before spawning (fprop and mprop)	As per 6.aN and 6.aS/7.b and 7.c
Surveys (fleet)	See section 4.3

Input data sources and the assessment method used to assess the 6.a and 7.b–c herring are thoroughly described in the report from WKWEST 2015 (ICES, WKWEST 2015) and in the Stock Annex. The tool for the assessment of herring in the 6.a and 7.b–c is FLSAM, an implementation of the State-space assessment model (www.stockassessment.org), embedded inside the FLR library (Kell *et al.* 2007).

Two acoustic indices and two bottom trawl indices are available for the assessment of herring in 6.a and 7.b-c. The surveys and the years for which they are included in the assessment are given in the text table below.

Type	Name	Year range	Age range (wr)
Tuning fleet	SWC-IBTS Q1	1987–2010	2-9+
Tuning fleet	SWC-IBTS-Q4	1996–2009	2-9+
Tuning fleet	Malin Shelf acoustic	2008–2016	1-9+
Tuning fleet	West of Scotland acoustic	1991–2007	1-9+

The 2008 year class is still relatively strong as is the 2010 cohort. This is apparent in both the catch and survey data in 2016. None of these are large compared to those prior to 2000 however. The dominant year class in the catches in 2016 is 2013 (age 2wr), and given the high maturity level of this age group as well as the 3 winter ringers in 2016, this will have a positive influence of stock development in the short-term predictions. The year class did not contribute very much to the estimate from the acoustic survey at all (~6%).

The two trawl surveys and the West of Scotland acoustic surveys were not updated and the dynamics in those have not changed since the benchmark (WKWEST, ICES 2015). 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). Similar for the West of Scotland acoustic survey which has a marked year effect in 2005.

The estimated observation variance parameter for each data set fitted by the model are presented in Figure 4.6.8. The model is influenced largely by information from the catch and the West of Scotland acoustic survey (WoS HERAS). These are perceived by the SAM model as being more precise than the IBTS surveys and the Malin Shelf Acoustic survey. The youngest age in both catch and all surveys have a higher variance compared to older ages and contribute less to the model fit.

The Malin Shelf herring acoustic survey is the only extant survey series in the assessment and up to last year this survey was influencing the model more than the trawl surveys. However, this year it is perceived by the model as the least precise of the surveys.

The survey shows very poor internal consistency for all but the oldest ages after the recent 2016 survey, partly due to the very low abundances observed across the survey area for all ages this year.

A group of strong negative residuals at older ages in the survey also continues to be present in the final years in the assessment and are increasing over time (Figure 4.6.1). Although both catch and survey information in the latest year indicate a big decrease in these older ages the model is unable to fit to this steeply decreasing observed abundance.

As a consequence overall, the SAM model is fitting less well to the Malin Shelf survey as indicated by the increased observation variances. The observation variance parameters are bound together for all ages above 1 in the model and this does not allow the model to accurately follow the changes in abundance of older fish which is rapidly declining compared to younger ages. It would possibly benefit the model fit to unbind the observation variances for ages 8 and 9+.

The survey catchability at age for both acoustic surveys is presented in Figure 4.6.7. The trend in both surveys is the same with constant catchability estimated from age 3–9 winter rings. The catchability estimates are within a reasonable level.

Figure 4.6.10 shows the fishery selectivity by period with a clear shift evident in the mid-1990s. Selection changes progressively to more of aa dome shape in the late 2000s, representing a change in exploitation away from older fish and indicates full recruitment to the fishery at age 3 wr.

The SAM model fits the catch relatively well and residuals are generally random and small for ages 2–8, but with a group relatively large negative residuals since 1999 in the age 9+ wr (figures 4.6.15 to 4.6.23). There does not appear to be any clear age or year effects present (Figure 4.6.5). One ringers are often poorly estimated in the catch, but have been poorly represented in recent years especially.

The uncertainty associated with the parameters estimated is low for most data sources where only the CV of the Malin Shelf acoustic survey (MS HERAS) at age 1 is very high (Figure 4.6.9). The CVs do not indicate a lack of convergence of the assessment model.

Figure 4.6.12 shows the trajectories for SSB, recruitment and mean F over the complete time series from 1957–2016. SSB peaked in the early 1970s and has been declining steadily since 2004. The estimate for SSB in the terminal year is around 151 146t, which is well below B_{lim}. 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. In the early 2000s F began declining and has stabilised around 0.1. The zero TAC advice in 2016 and the resulting monitoring fishery brought F down to 0.049 in 2016.

The 2017 assessment resulted in a downwards revision of the SSB and recruitment time series compared to the 2016 assessment (Figure 4.6.57). The SSB for 2015 was estimated ~29% lower in the 2017 assessment compared to the 2016 assessment. The overall trend of a steady decline from 2004 is maintained.

The analytical retrospective for this stock (Figure 4.6.14) shows some deviation in SSB and recruitment between years with no clear retrospective pattern emerging. The estimates of F are more consistent between years.

Figure 4.6.13 shows the model uncertainty plot, representing the parametric uncertainty of the fit of the assessment model in terminal F and SSB.

4.6.1 Exploratory Assessment for 6.a (combined) and 7.b and 7.c herring

No exploratory assessments were performed in 2017.

4.6.2 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 (SAM, in the FLR environment). The input data and model settings are shown in tables 4.6.1–4.6.10, the SAM output is presented in tables 4.6.13–4.6.28, the stock summary in Table 4.6.12 and Figure 4.6.12 and model fit and parameter estimates in Table 4.6.27. The spawning stock at spawning time in 2016 is estimated at approximately 151 Kt [62 – 368Kt (95% CI)]. Recruitment is estimated to be one of the lowest in the series, and has declined to very low levels since 2010. Mean $F_{3\text{–}6}$ in 2016 is estimated at approximately 0.049 [0.020–0.118 yr-1 (95% CI)].

4.6.3 State of the combined stocks

The assessment is rather uncertain, with wide confidence intervals. Fishing mortality continues to be low, 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 2002. SSB in 2016 is estimated to be the lowest in the time series and well below B_{lim}.

Recruitment has been low in recent years; the most recent cohort that appeared stronger was in 2008. Since 2012 recruitment has been very low, and the lowest in the series. Recent catches have been amongst the lowest in the time series and with the monitoring TAC in place in 2016 has been reduced even further.

4.7 Short Term Projections

4.7.1 Short-term projections

Short-term forecasts are conducted using the standard projection routines developed under FLR package Flash (version 2.0.0).

Input data are stock numbers on 1 January in 2017 from the 2017 SAM assessment (Section 4.6.1, Table 4.7.1.1). Recruitment in 2017–2019 was estimated as the geometric mean of recruitment over the period 2012–2016. This period was considered to best reflect the recent recruitment regime. Data for maturity, natural mortality, mean weights-at-age in the catch and in the stock are means of the three previous years (i.e., 2014–2016).

Based on the agreed monitoring TAC for 2017 (EU 2016/0203), a catch constraint of 5 800 t in 2017 was used for the basis for the intermediate year in the projection, resulting in an F of 0.041.

The results of the short-term projection using the F constraint are given in Table 4.7.1.2. The catch option consistent with the ICES generic MSY harvest control rule is F = 0.052 (F_{msy} * SSB2017 / MSY $B_{trigger}$). This corresponds to a catch option in 2018 of 7 091 t. However, this option is not precautionary as SSB would remain below B_{lim} under such a scenario (SSB 2018 = 130 370 t). Consequently the precautionary approach takes precedence. Given that no catch option can restore the SSB to B_{pa} by 2018, the precautionary catch option is for a catch of 0 t in 2018.

4.7.2 Yield Per Recruit

No yield per recruit analysis was conducted at HAWG 2017.

4.8 Precautionary and Yield Based Reference Points

B_{lim} is set at 250 000 t. This is based on the median change point in a segmented regression of the entire time series of stock and recruitment (WKWEST, ICES 2015). B_{pa} is set at 410 000 t based on B_{lim} raised by $exp^{1.645*\sigma)}$, where σ denotes the uncertainty in estimation of terminal SSB from the benchmarked assessment.

F_{msy} was estimated from stochastic simulations using Beverton and Holt, Ricker and segmented regression stock recruitment models, with a median estimate of F = 0.16 (ICES WKWEST, 2015). MSY $B_{trigger}$ was set as equal to B_{pa}. Using a $B_{trigger}$ of 410 000 t, F_{pa} was estimated at 0.18 from stochastic simulations using a Ricker stock–recruitment relationship. The Input data was from the 2015 assessment, with a 2 year time lag because the fish are autumn/winter spawners. The stock recruitment relationship was modelled for the time series 1957–2012. F_{cv} was set to 0.30 and F_{phi} to 0.30. The biological years used were 2004–2014 (the last 10 years).

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 assessment has quite wide confidence intervals on estimation of SSB and F. However, it is considered the best assessment that can be accomplished for the combined stocks at present (WKWEST; ICES 2015). Individual assessments of the constituent stocks are not possible, because the input data cannot be segregated by stock. The combined assessment does not give any information on the individual stocks. However it does demonstrate that the combined stocks meta-population is at a low and decreasing level and that it is predicted to decline further even at very low fishing pressure.

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. For this reason, the low overall estimate of current F should be treated with caution. The combined SSB estimates are thought to be a reasonable indicator of the combined stocks' size. However it remains unclear what the relative strength of each stock is. Recruitment is estimated to be the lowest in the series. This reflects very low numbers of 1-ring fish in the catches in recent years. In the past two years, no 1-ringers have been observed in the 6.aN fishery, and very few in the 6.aS/7.b and 7.c fishery.

The trawl survey data included only up to 2010, because the survey design changed after that. The trawl survey since 2010 shows a decline in stock abundance, and this is an additional indicator that the combined stocks' abundance is in decline.

The precision of the assessment estimated through parametric bootstrap is shown in Figure 4.6.13.

4.10 Management Considerations

There is anecdotal evidence that the stocks are not the same size and managers are advised to ensure that any exploitation pattern imposed in this area ensures that the smaller, more vulnerable, stock is not over-exploited. There is a clear need to determine the relative stock sizes and to ensure that the smaller / weaker stock is adequately assessed and protected from over exploitation.

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

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 and 7.c). The monitoring TAC taken in 2016 and agreed for 2017 based on the HAWG Special Request Advice from 2016 (ICES, 2016 - http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2016/Special_Requests/EU_her-6a7bc_monitoring_fishery.pdf) is associated with an F that is lower than any previously observed value for the two stocks combined.

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 6a, 7bc 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 by-catch of other fish. Scottish pelagic discard observer programs since 1999 and more recently Dutch observers indicate that discarding of herring in these directed fisheries is at a low level. The Scottish pelagic discard observer program has recorded occasional catches of seals and zero catches of cetaceans in the past. Unfortunately the Scottish pelagic discard observer program 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 4.3.1.1. Herring in Divisions 6.a (combined) and 7.b and 7.c. Abundance from Scottish acoustic surveys conducted in 6.aN before Malin Shelf series began in 2008.

Year\Age (Rings)	1	2	3	4	5	6	7	8	9
1991	338	294	328	368	488	176	99	90	58
1992	74	503	211	258	415	240	106	57	63
1993	2	579	690	689	565	900	296	158	161
1994	494	542	608	286	307	268	407	174	132
1995	441	1103	473	450	153	187	169	237	202
1996	41	576	803	329	95	61	77	78	115
1997	792	642	286	167	66	50	16	29	24
1998	1222	795	667	471	179	79	28	14	37
1999	534	322	1388	432	308	139	87	28	35
2000	448	316	337	900	393	248	200	95	65
2001	313	1062	218	173	438	133	103	52	35
2002	425	436	1437	200	162	424	152	68	60
2003	439	1039	933	1472	181	129	347	114	75
2004	564	275	760	442	577	56	62	82	76
2005	50	243	230	423	245	153	13	39	27
2006	112	835	388	285	582	415	227	22	59
2007	0	126	294	203	145	347	243	164	32

Table 4.3.1.2. Herring in Divisions 6.a (combined) and 7.b and 7.c. Total numbers (millions) and biomass (thousands of tonnes) of Malin Shelf herring (6.aN-S, 7.b and 7.c) June-July 2016. Mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	0	0			
1	0	0			
2	30	4	0.97	137	24.4
3	108	15	0.99	140	25.0
4	88	15	1.00	175	26.8
5	112	23	1.00	202	28.3
6	79	16	1.00	208	28.7
7	62	13	1.00	209	29.0
8	6	1	1	210	29.3
9+	1	0	1	242	30.3
Immature	2	0		119	23.4
Mature	483	88		182	27.2
Total	485	88	1.00	181	27.2

Table 4.3.1.3. Herring in Divisions 6.a (combined) and 7.b and 7.c. Numbers at age (millions) and SSB (thousands of tonnes) of Malin Shelf herring acoustic survey (6.aN-S, 7.b and 7.c) time series. Age (rings) from acoustic surveys 2008 to 2016.

Year/Age	1	2	3	4	5	6	7	8	9+	SSB
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

Table 4.6.1 Herring in 6.a (combined) and 7.b-c. Catch in number.

Units : thousands

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	6496	15695	54063	3940	14473	55278	11890	26609	299701	211675	207947
2	80817	33616	74615	115501	50809	99167	82849	87652	23351	517616	28648
3	66094	152801	38547	65703	72914	27189	57688	74309	72085	45317	273723
4	26882	43895	124307	25388	38321	76706	13310	29583	67768	70793	49755
5	38989	28108	27898	50558	24455	49002	42796	8857	24525	38471	48320
6	21547	32025	18942	12196	14296	22707	28698	27075	7001	22691	36143
7	9643	19986	18833	11096	5791	27787	10171	21347	28806	12656	15226
8	1658	10795	8158	6770	5370	7614	14585	10109	21475	20790	10397
9	4817	8887	9364	4856	2887	8435	7885	17655	23515	33175	33967

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

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

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

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	2463	5050	1787	1401	392	730	207	483	2126	11345	1788	6122
2	105035	71122	66151	22358	37756	28727	58903	20163	24083	33847	54795	27797
3	37149	131724	75580	56475	54133	45886	61713	32700	22553	36458	25098	63034
4	27103	27896	77956	49142	47489	44226	29954	33911	28683	16499	19448	13746
5	43625	29737	16895	57400	21012	63024	28003	14330	20906	22196	10576	9873
6	19498	38231	9521	9076	15235	36862	36040	11678	10928	13102	8851	6865
7	8555	11787	15343	9647	2363	23391	23342	17570	9555	6885	6035	4415
8	5769	3153	10111	9999	2053	3874	13816	8887	12647	6050	3591	1233
9	1537	2067	1711	4589	1674	5458	4374	9236	9461	13388	7321	4035

age \ year	2013	2014	2015	2016
1	61	34	258	81
2	16799	9171	12697	10131
3	22714	23970	14536	7593
4	65355	27799	18270	4566
5	13347	54375	21086	5816
6	8885	9537	22306	4906
7	5524	3989	6493	3972
8	4707	3291	1942	782
9	5234	3715	1251	440

Table 4.6.2 Herring in 6.a (combined) and 7.b-c. Weights at age in the catch.

Units : kg

year

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

year

age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.080	0.079	0.079	0.079	0.092	0.090	0.091	0.094	0.092	0.096	0.109	0.100
2	0.108	0.111	0.104	0.105	0.122	0.123	0.122	0.122	0.125	0.125	0.129	0.129
3	0.136	0.133	0.131	0.134	0.158	0.159	0.160	0.160	0.159	0.162	0.165	0.165
4	0.164	0.161	0.159	0.161	0.177	0.176	0.180	0.182	0.182	0.179	0.191	0.191
5	0.174	0.170	0.168	0.170	0.188	0.190	0.189	0.198	0.199	0.200	0.209	0.209
6	0.181	0.181	0.177	0.185	0.209	0.208	0.210	0.209	0.213	0.215	0.222	0.222
7	0.184	0.186	0.191	0.195	0.222	0.221	0.222	0.222	0.221	0.227	0.231	0.231
8	0.187	0.186	0.189	0.208	0.227	0.228	0.229	0.230	0.228	0.229	0.237	0.237
9	0.192	0.189	0.189	0.197	0.234	0.234	0.236	0.234	0.237	0.236	0.241	0.241

year

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

year

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

year

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.107	0.103	0.116	0.111	0.109	0.084	0.064	0.087	0.083	0.105	0.078	0.091
2	0.134	0.142	0.157	0.157	0.159	0.145	0.146	0.141	0.140	0.145	0.138	0.140
3	0.156	0.146	0.157	0.172	0.191	0.177	0.171	0.187	0.168	0.169	0.178	0.162
4	0.172	0.169	0.174	0.176	0.219	0.203	0.197	0.204	0.192	0.191	0.198	0.192
5	0.192	0.194	0.195	0.188	0.218	0.223	0.221	0.216	0.199	0.215	0.209	0.200
6	0.212	0.213	0.216	0.216	0.231	0.225	0.223	0.227	0.209	0.227	0.229	0.212
7	0.215	0.240	0.215	0.244	0.249	0.230	0.233	0.239	0.228	0.241	0.238	0.227
8	0.248	0.253	0.261	0.277	0.252	0.238	0.239	0.278	0.234	0.251	0.245	0.249
9	0.256	0.273	0.301	0.286	0.273	0.255	0.252	0.247	0.247	0.278	0.269	0.256

Table 4.6.3. Herring in 6.a (combined) and 7.b and 7.c. Weights at age in the stock.

Units : kg

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

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

age \ year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.068
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.152
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.186
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.206
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.233
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.253
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.273
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.299
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.302

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.073	0.052	0.042	0.045	0.054	0.066	0.054	0.062	0.062	0.062	0.064	0.059
2	0.164	0.150	0.144	0.140	0.142	0.138	0.137	0.141	0.132	0.153	0.138	0.138
3	0.196	0.192	0.191	0.180	0.180	0.176	0.166	0.173	0.170	0.177	0.176	0.159
4	0.206	0.220	0.202	0.209	0.199	0.194	0.188	0.183	0.190	0.198	0.190	0.180
5	0.225	0.221	0.225	0.219	0.213	0.214	0.203	0.194	0.198	0.212	0.204	0.189
6	0.234	0.233	0.227	0.222	0.222	0.226	0.219	0.204	0.212	0.215	0.213	0.202
7	0.253	0.241	0.247	0.229	0.231	0.234	0.225	0.211	0.220	0.225	0.217	0.213
8	0.259	0.270	0.260	0.242	0.242	0.225	0.235	0.222	0.236	0.243	0.223	0.214
9	0.276	0.296	0.293	0.263	0.263	0.249	0.245	0.230	0.254	0.259	0.228	0.206

age \ year	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

age \ year	2015	2016
1	0.06373333	0.06373333
2	0.15500000	0.13700000
3	0.18300000	0.14000000
4	0.19500000	0.17500000
5	0.20400000	0.20200000
6	0.21100000	0.20800000
7	0.21700000	0.20900000
8	0.21500000	0.21000000
9	0.22000000	0.24200000

Table 4.6.4. Herring in 6.a (combined) and 7.b-c. Natural mortality.

Units : NA

age \ year	1957	1958	………	………	………	2014	2015	2016
1	0.767005	0.767005	0.767005	0.767005	0.767005	0.767005	0.767005	0.767005
2	0.384728	0.384728	0.384728	0.384728	0.384728	0.384728	0.384728	0.384728
3	0.355633	0.355633	0.355633	0.355633	0.355633	0.355633	0.355633	0.355633
4	0.338791	0.338791	0.338791	0.338791	0.338791	0.338791	0.338791	0.338791
5	0.319385	0.319385	0.319385	0.319385	0.319385	0.319385	0.319385	0.319385
6	0.313574	0.313574	0.313574	0.313574	0.313574	0.313574	0.313574	0.313574
7	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805
8	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805
9	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805	0.306805

Table 4.6.5. Herring in 6.a (combined) and 7.b-c. Proportion mature.

Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.47	0.93	0.59	0.21	0.76	0.55	0.85	0.57	0.45	0.93
3	0.96	0.96	0.96	0.96	0.96	1.00	0.96	0.93	0.98	0.94	0.95	0.97	0.98	0.92	0.99
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.92	0.76	0.83	0.84	0.81	1	0.91	0.67	0.88	0.50	0.62	0.35	0.18	0.48	0.97
3	1.00	1.00	0.97	1.00	0.97	1	0.99	0.99	0.99	0.93	0.99	0.72	0.73	0.85	0.99
4	1.00	1.00	1.00	1.00	1.00	1	1.00	1.00	1.00	1.00	1.00	0.98	0.99	0.99	1.00
5	1.00	1.00	1.00	1.00	1.00	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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	……								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

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	……								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

Table 4.6.8. Herring in 6.a (combined) and 7.b-c. Survey indices.

MS HERAS - Configuration

Malin Shelf assessment (14/Mar/2017 22:47) . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	9.00	9.00	2008.00	2016.00	0.52	0.57

Index type : number

MS HERAS - Index Values

Units : NA

age \ year	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	50389	772520	132551	62834	796012	-1	1012160	-1	-1
2	267367	265151	375531	257258	549590	209403	277504	212467	29593
3	997573	273910	373804	899637	832257	435049	242596	396545	108126
4	719782	443603	242388	484732	517544	671542	502471	747121	87773
5	363484	380436	173333	212913	249024	194706	534430	423139	111676
6	331462	225046	145891	227515	114507	70507	148258	476249	79130
7	743706	192866	101960	205093	111385	61392	32565	90102	62045
8	386202	500074	100421	113298	56526	28597	18677	23931	5530
9	273892	456113	297021	263837	104571	37398	13002	2086	957

WoS HERAS - Configuration

Malin Shelf assessment (14/Mar/2017 22:47) . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	9.00	9.00	1991.00	2007.00	0.52	0.57

Index type : number

WoS HERAS - Index Values

Units : NA

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

age \ year	2001	2002	2003	2004	2005	2006	2007
1	313100	424700	438800	564000	50200	112300	-1
2	1062000	436000	1039400	274500	243400	835200	126000
3	217700	1436900	932500	760200	230300	387900	294400
4	172800	199800	1471800	442300	423100	284500	202500
5	437500	161700	181300	577200	245100	582200	145300
6	132600	424300	129200	55700	152800	414700	346900
7	102800	152300	346700	61800	12600	227000	242900
8	52400	67500	114300	82200	39000	21700	163500
9	34700	59500	75200	76300	26800	59300	32100

Table 4.6.8 (cont'd). Herring in 6.a (combined) and 7.b-c. Survey indices.

IBTS_Q1 - Configuration

Malin Shelf assessment (14/Mar/2017 22:47) . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
2.00	9.00	9.00	1987.00	2010.00	0.00	0.25

Index type : number

IBTS_Q1 - Index Values

Units : NA

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995
2	46.731	3438.321	25.140	58.847	631.824	53.058	122.721	116.670	965.178
3	336.260	430.836	1075.835	83.597	885.241	132.183	294.270	377.264	169.909
4	209.288	134.714	145.932	344.779	567.790	122.177	128.267	104.271	117.504
5	215.407	82.220	87.593	97.848	998.826	152.380	169.440	65.612	38.275
6	43.763	47.236	66.886	66.287	294.298	135.749	192.090	68.307	55.458
7	9.183	13.417	17.304	65.323	187.461	46.193	146.600	49.543	38.004
8	10.353	2.682	6.474	10.261	105.718	32.468	49.505	12.015	43.710
9	6.284	1.586	1.824	3.787	22.696	21.117	17.329	2.941	15.584

age \ year	1996	1997	1998	1999	2000	2001	2002	2003	2004
2	383.453	417.688	11.914	189.848	765.224	49.296	1758.926	245.946	730.099
3	248.635	382.687	113.931	307.107	104.293	123.270	368.190	158.991	624.188
4	43.605	134.279	41.107	135.236	106.222	94.196	104.680	198.292	398.109
5	46.867	50.933	22.230	63.084	56.808	189.256	62.439	59.814	470.369
6	27.309	50.221	6.916	30.863	35.995	93.351	130.905	50.395	149.337
7	16.139	21.929	7.377	23.276	32.187	69.284	73.802	71.241	127.694
8	27.261	37.923	5.146	12.944	9.561	30.127	51.218	29.538	100.189
9	54.021	45.719	14.489	20.234	17.026	25.699	57.611	34.697	85.306

age \ year	2005	2006	2007	2008	2009	2010
2	185.102	378.437	31.209	66.197	55.510	22.061
3	138.260	198.644	135.312	72.550	344.224	165.554
4	273.585	76.948	106.356	82.434	338.236	115.321
5	297.606	235.485	86.229	54.089	219.906	88.455
6	269.862	243.195	186.224	47.992	122.567	67.458
7	67.092	183.140	138.694	75.033	123.955	96.971
8	67.482	35.001	76.793	100.226	328.967	81.877
9	59.980	89.679	54.908	46.867	338.018	254.166

IBTS_Q4 - Configuration

Malin Shelf assessment (14/Mar/2017 22:47) . Imported from VPA file.

min	max	plusgroup	minyear	maxyear	startf	endf
2.00	9.00	9.00	1996.00	2009.00	0.75	1.00

Index type : number

IBTS_Q4 - Index Values

Units : NA

age \ year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
2	65.191	23.234	23.441	13.030	14.581	183.761	7.749	329.065	53.062	13.928
3	90.015	36.181	29.796	22.109	9.441	57.258	10.613	66.029	118.066	12.961
4	18.107	27.526	27.177	18.793	14.501	36.430	1.290	65.713	96.276	24.377
5	15.804	18.355	28.670	13.005	7.548	62.726	2.155	8.094	106.528	26.049
6	5.792	11.855	13.800	16.471	7.410	36.270	3.151	11.257	14.917	16.079
7	4.813	3.001	3.173	6.424	4.527	22.954	2.089	11.194	19.443	1.609
8	9.257	7.461	1.384	1.738	2.358	12.784	1.584	5.998	13.908	3.818
9	13.181	10.209	6.996	4.634	2.087	4.980	0.848	6.118	7.874	4.864

age \ year	2006	2007	2008	2009
2	39.061	45.410	9.684	76.799
3	22.908	41.669	36.972	34.133
4	22.019	25.189	23.107	36.367
5	38.832	43.059	17.782	26.475
6	41.902	42.058	18.095	9.901
7	26.687	39.495	33.708	14.979
8	5.658	10.882	18.720	22.104
9	10.420	3.489	15.816	27.149

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      2016         3         6
```

Table 4.6.10 Herring in 6.a (combined) and 7.b-c. SAM configuration settings

```
name           :
desc           :
range          :       min       max plusgroup   minyear   maxyear   minfbar
maxfbar
range          :         1         9         9      1957      2016         3
6
fleets         :     catch  MS HERAS WoS HERAS   IBTS_Q1   IBTS_Q4
fleets         :         0         2         2         2         2
plus.group     : TRUE
states         :            age
states         : fleet       1  2  3  4  5  6  7  8  9
states         :   catch     1  2  3  4  5  6  7  8  8
states         :   MS HERAS  NA NA NA NA NA NA NA NA NA
states         :   WoS HERAS NA NA NA NA NA NA NA NA NA
states         :   IBTS_Q1   NA NA NA NA NA NA NA NA NA
states         :   IBTS_Q4   NA NA NA NA NA NA NA NA NA
logN.vars      : 1 2 2 2 2 2 2 2 2
catchabilities :            age
catchabilities : fleet       1  2  3  4  5  6  7  8  9
catchabilities :   catch     NA NA NA NA NA NA NA NA NA
catchabilities :   MS HERAS   1  2  3  3  3  3  3  3  3
catchabilities :   WoS HERAS  4  5  6  6  6  6  6  6  6
catchabilities :   IBTS_Q1   NA  7  7  7  7  7  7  7  7
catchabilities :   IBTS_Q4   NA  8  8  8  8  8  8  8  8
power.law.exps :            age
power.law.exps : fleet       1  2  3  4  5  6  7  8  9
power.law.exps :   catch     NA NA NA NA NA NA NA NA NA
power.law.exps :   MS HERAS  NA NA NA NA NA NA NA NA NA
power.law.exps :   WoS HERAS NA NA NA NA NA NA NA NA NA
power.law.exps :   IBTS_Q1   NA NA NA NA NA NA NA NA NA
power.law.exps :   IBTS_Q4   NA NA NA NA NA NA NA NA NA
f.vars         :            age
f.vars         : fleet       1  2  3  4  5  6  7  8  9
f.vars         :   catch     1  2  2  2  2  2  2  2  2
f.vars         :   MS HERAS  NA NA NA NA NA NA NA NA NA
f.vars         :   WoS HERAS NA NA NA NA NA NA NA NA NA
f.vars         :   IBTS_Q1   NA NA NA NA NA NA NA NA NA
f.vars         :   IBTS_Q4   NA NA NA NA NA NA NA NA NA
obs.vars       :            age
obs.vars       : fleet       1  2  3  4  5  6  7  8  9
obs.vars       :   catch     1  2  2  2  2  2  2  3  3
obs.vars       :   MS HERAS  4  5  5  5  5  5  5  5  5
obs.vars       :   WoS HERAS 6  7  7  7  7  7  7  7  7
obs.vars       :   IBTS_Q1   NA  8  9  9  9  9  9  9  9
obs.vars       :   IBTS_Q4   NA 10 11 11 11 11 11 11 11
srr            : 0
cor.F          : TRUE
nohess         : FALSE
timeout        : 3600
sam.binary     :
```

Table 4.6.11 Herring in 6.a (combined) and 7.b-c. FLR, R software versions.

```
FLSAM.version                        1.02
FLCore.version             2.6.0.20170228
R.version      R version 3.3.3 (2017-03-06)
platform                  i386-w64-mingw32
run.date               2017-03-14 23:27:36
```

Table 4.6.12 Herring in 6.a (combined) and 7.b-c. Stock summary.

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 3-6) f	Landings tonnes	Landings SOP
1957	1215906	712119	356112	0.1386	48508	0.7531
1958	2045187	732340	356468	0.1847	66494	0.7733
1959	3087894	823237	334703	0.1827	70447	0.7446
1960	2215525	862853	390038	0.1356	69160	0.6012
1961	3017683	917126	426343	0.0999	52535	0.6332
1962	3555478	1013581	428480	0.1357	65594	0.7990
1963	3308482	1042362	459549	0.1034	54089	0.7245
1964	2237792	1013581	506358	0.1003	70403	0.6145
1965	6934365	1310606	468364	0.1099	76685	0.8730
1966	2285282	1602379	717121	0.1546	112834	1.0130
1967	3786679	1451343	756910	0.1445	109281	0.8399
1968	4135009	1518145	747134	0.1197	105345	0.8364
1969	3817094	1464464	705738	0.1678	126777	0.7945
1970	5142243	1573794	671991	0.2401	186236	0.7750
1971	7992387	1869161	611090	0.3956	222211	1.0255
1972	4139146	1762070	693842	0.2756	188230	1.0349
1973	2280716	1538010	753135	0.3641	246989	1.0331
1974	2681803	1096902	461390	0.4886	214749	1.1069
1975	2937296	836515	288370	0.4807	152765	0.9806
1976	1891726	689692	246225	0.4752	126409	0.9888
1977	1861699	542531	212564	0.2885	61908	0.9200
1978	2094866	543617	207316	0.1984	41871	0.9961
1979	1880409	534453	215993	0.1098	22668	0.9380
1980	2026863	622190	274581	0.1304	30430	1.0375
1981	2887784	796514	319656	0.2444	76342	0.9699
1982	2299035	813418	321258	0.3271	111569	1.0235
1983	4016816	842391	265667	0.3454	96511	1.0182
1984	2605148	905280	343520	0.2324	83462	0.9756
1985	3308482	974812	414157	0.1971	62485	1.0078
1986	2744200	1039240	465096	0.2267	99549	1.0389
1987	3395630	1000490	414571	0.2565	92960	1.0148
1988	1769133	964148	466494	0.1809	64691	1.0126
1989	1897409	981660	538208	0.1494	63236	1.0086
1990	1996687	1023767	554599	0.1739	88662	0.9933
1991	1945442	976764	532320	0.1413	66229	1.0315
1992	2741457	878525	463703	0.1322	60841	1.0024
1993	2671098	946949	532853	0.1387	68541	0.9932
1994	3087894	815046	413743	0.1291	58338	0.9999
1995	1986729	722881	329720	0.1385	57367	0.9748
1996	2315185	605010	333034	0.1629	58639	1.0233
1997	2905163	611702	263287	0.2254	62458	1.0033
1998	2725057	695231	332369	0.2380	72248	0.9994
1999	2652465	712119	361132	0.1364	55845	0.9998
2000	3933342	776848	331042	0.1086	43008	0.9990
2001	3131429	834844	463703	0.0997	40007	1.0028
2002	3122049	907093	516071	0.1160	50740	0.9998
2003	1984743	895377	537670	0.0897	44583	1.0021
2004	2118036	768350	469771	0.0826	40186	1.0119
2005	1701465	707151	426770	0.0655	30360	1.0021
2006	1762070	754643	451351	0.0995	46539	0.9990
2007	1289803	730146	475442	0.1053	47407	0.9990
2008	1451343	677388	450449	0.0733	29394	1.0008
2009	1867292	693149	420416	0.0761	28976	1.0312
2010	2673770	698716	380028	0.0894	30118	0.9960
2011	1728907	601391	305590	0.0768	24678	0.9992
2012	1123546	576655	346279	0.0693	25087	1.0017
2013	593623	473071	276786	0.0883	26947	0.9978
2014	617849	360051	214058	0.0983	27123	1.0091
2015	751630	310209	175431	0.0985	19885	0.9982
2016	684881	240626	151146	0.0490	6937	1.0011

Table 4.6.13 Herring in 6.a (combined) and 7.b and 7.c. Estimated fishing mortality

Units : f

age \ year	1957	1958	1959	1960	1961	1962
1	0.01281806	0.02161863	0.02166191	0.01307177	0.007907845	0.01408704
2	0.07109772	0.09629874	0.09831290	0.07597127	0.057682583	0.07847305
3	0.11507168	0.15222433	0.14903114	0.11058177	0.081317015	0.10972259
4	0.12772190	0.17146090	0.17161529	0.12714845	0.094391901	0.12901843
5	0.15280388	0.20386444	0.20264492	0.15170764	0.112152021	0.14995800
6	0.15864282	0.21118938	0.20746347	0.15306387	0.111838434	0.15410825
7	0.19793828	0.26598909	0.26339512	0.19544036	0.143675212	0.19594917
8	0.21974225	0.29668034	0.29405160	0.21860256	0.162171640	0.22386771
9	0.21974225	0.29668034	0.29405160	0.21860256	0.162171640	0.22386771

age \ year	1963	1964	1965	1966	1967	1968
1	0.008956283	0.008808836	0.01057460	0.01949690	0.01677946	0.01157277
2	0.059379870	0.057148622	0.06103548	0.08667411	0.07839462	0.06489401
3	0.084339918	0.082035762	0.08947464	0.12550621	0.11674071	0.09805762
4	0.098973811	0.097471037	0.10896811	0.15443222	0.14527889	0.11962421
5	0.112455240	0.107356522	0.11597275	0.16067043	0.14959854	0.12407116
6	0.117949348	0.114337578	0.12498019	0.17778150	0.16646004	0.13717470
7	0.148882184	0.145948713	0.16129827	0.22697850	0.20894170	0.17111833
8	0.173253403	0.171049892	0.18866167	0.26476835	0.24590746	0.20123136
9	0.173253403	0.171049892	0.18866167	0.26476835	0.24590746	0.20123136

age \ year	1969	1970	1971	1972	1973	1974	1975
1	0.01975991	0.03502126	0.07959532	0.04051431	0.0620137	0.09835224	0.09048239
2	0.08898388	0.12730112	0.21459559	0.15505118	0.2078788	0.28130944	0.28365403
3	0.13909474	0.20550190	0.34659442	0.24046037	0.3127973	0.41019197	0.39984032
4	0.16513367	0.23428897	0.38060241	0.26025327	0.3433517	0.46045507	0.45163543
5	0.17515219	0.24919987	0.40764850	0.28396622	0.3744002	0.50191726	0.49349132
6	0.19172370	0.27141670	0.44759790	0.31790585	0.4258066	0.58182242	0.57774655
7	0.23828210	0.33273796	0.53507947	0.37295034	0.4828013	0.64642377	0.64169639
8	0.27990640	0.39052629	0.63178256	0.44186539	0.5786370	0.77663096	0.77381690
9	0.27990640	0.39052629	0.63178256	0.44186539	0.5786370	0.77663096	0.77381690

age \ year	1976	1977	1978	1979	1980	1981
1	0.08401163	0.03269935	0.01594835	0.005265917	0.006662237	0.01899461
2	0.28490485	0.17240654	0.11877789	0.064576804	0.075065066	0.14123925
3	0.39237785	0.23539272	0.16055800	0.088540075	0.106714312	0.20205810
4	0.44812637	0.27356938	0.19107295	0.105125543	0.123798504	0.22925967
5	0.48601295	0.29505308	0.20286795	0.112669108	0.135470686	0.25357389
6	0.57431917	0.35021781	0.23895023	0.132841313	0.155734912	0.29284846
7	0.64144618	0.39339543	0.27335062	0.155299464	0.185222032	0.34369522
8	0.77214726	0.46957840	0.32726010	0.182738337	0.215261868	0.39719815
9	0.77214726	0.46957840	0.32726010	0.182738337	0.215261868	0.39719815

age \ year	1982	1983	1984	1985	1986	1987
1	0.03004978	0.03156204	0.01496262	0.01084122	0.01331718	0.01597708
2	0.18992994	0.19734536	0.13212590	0.11049334	0.12642576	0.14114042
3	0.27033320	0.28667675	0.19489389	0.16524931	0.18943677	0.21358936
4	0.30397798	0.31670010	0.21097830	0.17705409	0.20396640	0.23172592
5	0.34119538	0.36138912	0.24280418	0.20595450	0.23828210	0.27090150
6	0.39306118	0.41674948	0.28085971	0.24014797	0.27513318	0.30971585
7	0.45846102	0.48807802	0.32870322	0.28004639	0.31905238	0.36403692
8	0.53360469	0.56631207	0.37997113	0.32010699	0.36106402	0.41149846
9	0.53360469	0.56631207	0.37997113	0.32010699	0.36106402	0.41149846

age \ year	1988	1989	1990	1991	1992	1993
1	0.008237981	0.005769326	0.007326188	0.00490402	0.004134454	0.004323025
2	0.099003508	0.082636815	0.097529537	0.08082249	0.077181152	0.084415858
3	0.151540858	0.126375202	0.147666341	0.12106835	0.115290529	0.122346267
4	0.164935630	0.137669417	0.162447566	0.13269527	0.125820373	0.133440446
5	0.190901059	0.157883162	0.183049257	0.14793238	0.136722767	0.143919667
6	0.216254354	0.175696009	0.202320946	0.16363777	0.151147364	0.155128729
7	0.252738480	0.206325554	0.232398897	0.18314080	0.164919138	0.170486358
8	0.283398853	0.230985579	0.259343977	0.20127161	0.178262161	0.178226512
9	0.283398853	0.230985579	0.259343977	0.20127161	0.178262161	0.178226512

Table 4.6.13 (cont'd) Herring in 6.a (combined) and 7.b and 7.c. Estimated fishing mortality.

age	1994	1995	1996	1997	1998	1999
1	0.003578899	0.003744003	0.004748151	0.007950663	0.008237981	0.002900129
2	0.079706830	0.084737249	0.098450637	0.134552611	0.140591044	0.081146428
3	0.115440504	0.124294690	0.146959241	0.203172481	0.219588487	0.130223900
4	0.124083569	0.134377806	0.159933048	0.223554510	0.239141465	0.138789067
5	0.134162973	0.143502905	0.167127213	0.233493743	0.246572305	0.140436479
6	0.142887167	0.151889803	0.177710404	0.241327584	0.246843684	0.136176969
7	0.151646974	0.157001487	0.181772386	0.246301225	0.244901302	0.130197858
8	0.159151293	0.159087645	0.175292372	0.218974499	0.208628525	0.108891860
9	0.159151293	0.159087645	0.175292372	0.218974499	0.208628525	0.108891860

age	2000	2001	2002	2003	2004	2005
1	0.001830804	0.001492803	0.001846432	0.001124406	0.000933565	0.000593781
2	0.064171249	0.058047131	0.065828658	0.050327683	0.045821585	0.037016186
3	0.105388685	0.097043107	0.113233865	0.088451580	0.081920993	0.066790128
4	0.111024986	0.101580875	0.118303727	0.092107399	0.085511877	0.068391960
5	0.112253003	0.104017097	0.122627987	0.094940965	0.086734808	0.067501869
6	0.105737042	0.096173637	0.109821386	0.083092569	0.076191909	0.059261229
7	0.098657601	0.089028387	0.100993411	0.077622341	0.071190208	0.055083779
8	0.081130201	0.070665345	0.077910075	0.059071896	0.053466499	0.041126607
9	0.081130201	0.070665345	0.077910075	0.059071896	0.053466499	0.041126607

age	2006	2007	2008	2009	2010	2011
1	0.001208591	0.00131858	0.0006936799	0.0007420455	0.0009830014	0.0007356177
2	0.055949823	0.06093790	0.0424045335	0.0438316114	0.0514625974	0.0440513183
3	0.100188687	0.10558911	0.0722444335	0.0740288794	0.0862504505	0.0730142976
4	0.104246186	0.11032773	0.0771040092	0.0791745793	0.0919233685	0.0788979527
5	0.103105762	0.10950336	0.0765585095	0.0800823339	0.0949599552	0.0818554821
6	0.090391956	0.09595269	0.0674411441	0.0710692873	0.0845510318	0.0735639635
7	0.083142440	0.08752770	0.0608830785	0.0634311635	0.0748027971	0.0651606187
8	0.062424341	0.06571684	0.0454610211	0.0467098601	0.0546557967	0.0469205281
9	0.062424341	0.06571684	0.0454610211	0.0467098601	0.0546557967	0.0469205281

age	2012	2013	2014	2015	2016
1	0.0005926539	0.0008569766	0.0009876324	0.0009748763	0.0002809876
2	0.0392894203	0.0488647012	0.0536003329	0.0542636883	0.0274881576
3	0.0650304277	0.0812601128	0.0907270255	0.0915655655	0.0458124221
4	0.0707501940	0.0903467711	0.1000185110	0.0997787544	0.0496180798
5	0.0741622514	0.0953596258	0.1072813989	0.1075499380	0.0534130597
6	0.0673400583	0.0864317668	0.0953500903	0.0951310371	0.0471651503
7	0.0590364635	0.0757891603	0.0838940991	0.0840200347	0.0412254292
8	0.0421888209	0.0544920750	0.0600666800	0.0587949096	0.0287591299
9	0.0421888209	0.0544920750	0.0600666800	0.0587949096	0.0287591299

Table 4.6.14 Herring in 6.a (combined) and 7.b and 7.c. Estimated population abundance.

Units : NA

age	1957	1958	1959	1960	1961	1962
1	1215905.96	2045187.44	3087894.42	2215525.10	3017683.37	3555477.75
2	1550363.53	489921.28	997492.59	1742793.77	916209.20	1463000.47
3	661986.21	1222000.71	344551.90	727958.99	1113479.10	351160.97
4	269682.33	338067.21	816677.86	263814.11	514011.03	738222.09
5	313326.17	178974.75	179692.08	405955.98	238708.88	400312.19
6	164062.05	185535.22	115035.95	98321.70	195633.83	169058.49
7	63959.16	93620.06	92688.53	70898.18	54885.25	166708.16
8	10270.18	41481.38	42616.64	43044.94	42701.96	38793.19
9	33996.06	30393.98	37722.05	34682.83	35136.65	49761.66

age	1963	1964	1965	1966	1967	1968
1	3308481.89	2237791.50	6934364.70	2285282.03	3786679.23	4135008.74
2	1703166.97	1730636.82	625933.87	5683057.85	573779.24	1797666.51
3	807743.63	1105711.97	1013580.84	472597.81	3285403.39	342490.77
4	177371.20	410035.90	702218.58	614153.39	376623.01	2460807.24
5	466027.54	107581.07	258848.96	352921.17	404739.93	215776.84
6	284930.34	300438.99	76038.87	160813.41	249446.56	273758.06
7	93901.35	187212.57	209609.17	66635.98	93246.33	141917.33
8	108988.76	66702.65	128926.79	120210.54	44134.63	52785.93
9	55659.05	117594.79	130222.53	161296.57	161781.19	111524.55

Table 4.6.14 (cont'd) Herring in 6.a (combined) and 7.b and 7.c. Estimated population abundance

age \ year	1969	1970	1971	1972	1973	1974
1	3817094.16	5142243.39	7992386.83	4139145.82	2280716.03	2681803.30
2	1797666.51	1575368.86	2128653.12	4980296.57	1662777.58	815046.14
3	909818.13	1599177.51	1245440.70	1097999.01	3433188.57	722158.56
4	224582.86	654089.85	1012567.76	395932.89	589482.32	1684534.80
5	1744537.44	159691.64	367691.67	401514.93	252963.38	283225.87
6	161457.95	956465.50	96182.24	161135.35	224134.14	136489.09
7	217945.43	98420.07	570346.87	50412.78	89679.73	110857.40
8	99409.21	113891.33	50564.25	301341.67	24416.15	52365.33
9	108445.17	103984.80	100911.58	63386.11	205664.20	111413.08

age \ year	1975	1976	1977	1978	1979	1980
1	2937296.03	1891725.63	1861698.87	2094865.69	1880409.26	2026863.33
2	1116824.56	1461538.20	719275.69	806129.76	1006510.54	827363.98
3	414985.97	501320.05	632224.61	394746.87	335373.46	744151.56
4	315211.78	202602.25	205869.96	315527.15	246964.53	250446.35
5	636665.70	154199.11	99012.36	114119.34	119372.01	185906.66
6	108879.82	245978.64	77574.96	54611.51	73644.15	71825.87
7	46397.46	39854.87	93713.73	34787.03	39379.47	43914.51
8	45844.02	17003.93	14579.91	43001.92	22765.47	24173.20
9	71754.08	45206.67	20110.55	17214.37	29881.65	30424.39

age \ year	1981	1982	1983	1984	1985	1986
1	2887784.05	2299034.94	4016815.57	2605147.88	3308481.89	2744199.58
2	885581.70	1569079.97	875018.23	2446086.60	1067681.46	1662777.58
3	820771.47	460929.32	705033.08	491884.89	1674457.85	744896.08
4	515555.38	519176.92	237518.31	331704.57	246224.75	1143952.58
5	177016.81	299838.72	271034.12	122149.38	178438.63	172991.89
6	111636.13	111079.34	150241.61	122393.92	73057.35	118420.84
7	58162.73	53156.73	59159.95	65841.13	70756.52	38407.19
8	20694.02	37123.30	26529.17	24294.37	35454.31	34856.68
9	27750.25	22426.53	27973.14	21501.97	20098.49	23813.31

age \ year	1987	1988	1989	1990	1991	1992
1	3395630.45	1769132.73	1897409.32	1996687.27	1945442.47	2741456.76
2	1094709.95	2037023.03	722881.08	875893.69	920801.72	728687.32
3	856834.45	731607.90	1878529.79	525970.29	605009.84	660003.22
4	442413.39	519176.92	446413.08	1608801.42	417483.37	464631.55
5	712831.25	280688.28	320936.96	340441.98	1135972.87	332036.44
6	101620.44	403931.26	178974.75	217075.39	234685.12	779961.63
7	64990.73	52417.72	223686.32	143630.60	150693.01	129314.15
8	23647.20	25745.11	29319.26	119850.45	100810.72	86768.59
9	33223.08	21683.35	25796.65	30001.42	77574.96	90400.04

age \ year	1993	1994	1995	1996	1997	1998	1999
1	2671097.51	3087894.4	1986728.8	2315184.64	2905162.83	2725057.26	2652465.12
2	1467396.06	1288513.8	1624970.1	844922.34	1105711.97	1461538.20	1176435.90
3	459089.29	770658.0	658684.5	882046.45	479260.71	712831.25	1266794.18
4	478781.68	264871.5	372875.6	335709.00	432786.58	362579.85	496331.83
5	331704.57	277895.4	194269.2	162267.26	198988.04	256786.43	219476.40
6	262760.96	203414.3	167376.3	120571.71	116308.33	113436.67	132587.75
7	533385.66	178795.9	129702.7	91126.14	75584.01	63767.57	58162.73
8	95415.85	259367.2	131662.9	95894.13	53798.45	33024.34	31952.32
9	96471.22	111190.5	192336.2	180592.79	100207.67	59159.95	41357.13

age \ year	2000	2001	2002	2003	2004	2005	2006
1	3933341.98	3131428.98	3122048.77	1984743.01	2118036.4	1701464.66	1762070.33
2	1017643.28	2120155.51	1372301.75	1615249.51	759184.4	1035091.10	780741.98
3	632224.61	493856.37	1409858.64	1013580.84	1010544.6	717838.58	578966.56
4	833175.85	352568.43	282659.99	1043405.04	707858.9	802911.68	483110.17
5	318698.25	545795.70	250196.03	201591.77	743407.8	450448.94	693148.82
6	148004.80	236333.68	382697.45	158102.68	129055.8	369534.73	460008.39
7	82043.10	112870.90	151145.77	241832.35	138690.5	58982.73	322868.37
8	39695.77	66970.00	62755.41	120330.81	150542.4	76726.31	50161.35
9	42108.29	42531.49	53263.15	63386.11	106404.2	93901.35	109425.58

Table 4.6.14 (cont'd) Herring in 6.a (combined) and 7.b and 7.c. Estimated population abundance.

age	2007	2008	2009	2010	2011	2012	2013
1	1289802.9	1451343.2	1867292.4	2673769.9	1728907.04	1123545.65	593623.17
2	952647.3	579545.8	690381.8	784655.5	1476226.90	805324.03	463239.74
3	652783.0	586542.3	387317.5	490902.1	443299.10	1147389.59	417901.07
4	347666.9	487477.8	437573.5	237755.9	298940.55	258848.96	846613.88
5	315842.8	236570.1	320295.7	270222.2	162105.07	171785.18	175080.30
6	481181.6	220797.2	181135.4	186465.2	152359.78	118420.84	111859.62
7	334034.6	362579.8	179333.1	118420.8	106617.19	93807.49	80579.54
8	225708.6	241349.2	298045.1	124991.4	81226.76	52733.17	64472.88
9	88610.0	221460.6	312387.6	334703.4	220356.07	141492.22	98223.42

age	2014	2015	2016
1	617849.39	751630.41	684880.74
2	247458.95	295670.22	395537.15
3	325136.38	187025.45	195047.81
4	331704.57	224807.55	112983.83
5	557936.26	228205.09	134188.39
6	121540.16	280969.11	129184.90
7	57930.54	81552.32	129314.15
8	45569.78	32597.80	39576.86
9	65381.85	34996.38	26291.47

Table 4.6.15 Herring in 6.a (combined) and 7.b and 7.c. Predicted catch numbers at age.

Units : NA

age	1957	1958	1959	1960	1961	1962	1963
1	10825.503	30601.368	46272.356	20111.157	16601.030	34762.691	20621.923
2	88539.141	37462.661	77761.366	106043.005	42706.226	91876.448	81682.904
3	60736.493	145801.298	40336.014	64337.632	73328.161	30816.329	55127.282
4	27526.377	45387.862	109809.245	26803.828	39379.474	76084.512	14213.536
5	38150.723	28404.419	28370.354	49104.207	21744.149	47910.981	42539.996
6	20754.741	30485.304	18597.641	12021.596	17820.237	20811.271	27304.314
7	9938.685	18958.165	18612.339	10896.969	6350.380	25678.260	11224.678
8	1754.589	9239.010	9414.911	7320.471	5525.947	6742.189	15000.068
9	5810.489	6767.994	8337.428	5896.239	4547.032	8646.069	7660.634

age	1964	1965	1966	1967	1968	1969	1970
1	13712.046	50975.479	30856.42	44050.853	33266.295	52260.70	123908.66
2	79905.503	30834.825	392817.34	35986.531	94004.694	127414.39	157015.53
3	73445.580	73196.289	47065.71	305529.006	26984.017	99867.54	251550.74
4	32383.360	61672.907	74854.39	43373.329	236239.169	29146.79	116634.45
5	9401.927	24340.575	45017.20	48339.292	21633.753	241107.94	30339.32
6	27939.591	7697.339	22577.29	32981.431	30221.232	24299.23	196516.17
7	21973.446	26989.414	11716.81	15224.938	19304.818	40022.62	24202.23
8	9067.846	19185.499	24253.11	8340.513	8330.011	21059.56	32013.08
9	15995.936	19366.499	32542.43	30561.612	17596.759	22973.58	29231.44

age	1971	1972	1973	1974	1975	1976	1977
1	429509.87	115070.47	96182.240	176557.17	178456.47	107023.10	41898.278
2	343657.22	596539.06	260693.326	167326.12	231168.00	303610.22	95101.498
3	310177.50	198809.03	782931.119	207026.07	116471.28	138510.30	112296.728
4	274827.80	77543.94	146722.746	533865.92	98439.75	62874.75	42108.294
5	106478.67	85613.65	68329.714	96906.32	215087.46	51456.91	21819.951
6	30148.79	37983.23	67453.922	52480.66	41647.64	93648.15	19861.729
7	206344.01	13639.70	29926.510	46203.00	19223.33	16515.09	26513.253
8	20715.55	93694.99	9375.076	24839.74	21698.75	8032.09	4761.605
9	41344.72	19713.32	78944.472	52854.60	33958.69	21347.93	6567.641

age	1978	1979	1980	1981	1982	1983	1984
1	23178.954	6902.162	9406.724	37998.425	47624.376	87316.96	27029.929
2	75207.031	52339.153	49786.543	97246.085	226613.228	130849.10	252306.526
3	49503.567	23982.987	63601.988	127108.966	92623.670	149163.75	73739.950
4	46821.604	20960.186	24814.911	90174.323	116413.059	55193.47	53809.214
5	18031.040	10920.751	20228.747	34159.636	74899.313	71040.12	22685.926
6	10023.323	7894.882	8926.592	24516.460	31297.703	44426.88	25905.226
7	7212.133	4899.263	6423.253	14691.289	17022.989	19914.23	16011.140
8	10426.543	3289.464	4055.260	5901.194	13396.249	10021.42	6676.439
9	4171.997	4318.572	5102.470	7915.594	8097.495	10568.47	5910.053

Table 4.6.15 (cont'd) Herring in 6.a (combined) and 7.b and 7.c. Predicted catch numbers at age.

age \ year	1985	1986	1987	1988	1989	1990
1	24919.353	25366.888	37627.860	10136.013	7624.103	10177.452
2	93060.026	164505.618	120162.467	159851.414	47710.177	67798.815
3	215776.839	108727.497	139483.278	86959.694	188376.896	61022.626
4	34060.717	179979.818	78096.459	67285.497	48893.513	205602.506
5	28592.508	31602.768	145903.394	41948.586	40287.640	48991.397
6	13470.670	24631.958	23423.615	67805.595	24867.077	34303.408
7	14994.069	9111.294	17228.668	10148.082	36116.316	25788.914
8	8434.283	9185.854	6941.895	5510.992	5241.013	23737.230
9	4779.542	6269.864	9757.485	4641.023	4610.170	5938.133

age \ year	1991	1992	1993	1994	1995	1996	1997
1	6650.119	7895.988	8044.871	7704.809	5182.537	7660.251	16072.580
2	59492.171	45057.737	98913.400	82174.474	109853.177	65992.739	116099.168
3	58232.564	60687.923	44662.969	70954.918	65016.736	101854.439	74637.624
4	44147.872	46742.075	50904.164	26315.147	39934.664	42268.610	74035.501
5	134268.929	36471.996	38188.893	29983.425	22307.986	21477.905	35689.079
6	30534.119	94324.854	32535.920	23325.443	20331.974	16924.711	21544.159
7	21823.442	17006.145	72337.649	21746.106	16295.267	13107.240	14298.930
8	15906.610	12262.977	13476.598	32988.028	16743.744	13331.834	9157.147
9	12244.229	12773.398	13621.436	14144.060	24467.476	25119.507	17067.818

age \ year	1998	1999	2000	2001	2002	2003	2004
1	15610.827	5362.148	5025.248	3260.742	4021.218	1557.489	1380.374
2	159867.400	76328.372	52622.549	99429.089	72692.973	65920.187	28279.714
3	119014.427	130666.036	53359.110	38564.984	127452.624	72402.782	67030.298
4	65860.885	54748.213	74481.049	28966.637	26836.012	78073.034	49350.343
5	48339.292	24703.495	29042.048	46276.984	24809.948	15667.284	52981.602
6	21430.277	14535.221	12784.132	18644.566	34269.122	10841.320	8140.688
7	11999.737	6133.863	6654.110	8299.744	12534.624	15585.402	8224.230
8	5384.932	2846.826	2668.762	3940.961	4057.694	5954.009	6760.350
9	9648.715	3682.731	2831.551	2502.862	3443.660	3136.178	4775.529

age \ year	2005	2006	2007	2008	2009	2010	2011
1	704.9593	1485.371	1187.078	702.5805	967.2432	1833.753	887.8653
2	31260.1687	35316.304	46849.705	19994.8496	24619.6455	32721.905	52859.8843
3	39093.0508	46569.449	55232.123	34468.4606	23302.1288	34221.179	26328.3083
4	45111.8392	40696.607	30890.377	30745.5332	28330.6631	17756.022	19288.2234
5	25207.5794	58284.997	28124.602	14954.5368	21155.1785	21018.116	10933.0982
6	18286.7128	34214.335	37884.601	12379.2876	10685.7889	13000.460	9290.1502
7	2725.2352	22221.154	24153.873	18476.7784	9510.1031	7365.778	5803.6366
8	2664.9751	2617.435	12386.717	9251.3059	11720.6790	5733.778	3210.3011
9	3259.9593	5710.546	4860.857	8483.2592	12295.5170	15347.072	8711.5935

age \ year	2012	2013	2014	2015	2016
1	464.9547	354.9937	425.5915	511.3376	134.3220
2	25783.7570	18360.9242	10739.3517	12987.8554	8908.9351
3	60906.7935	27507.1156	23784.7524	13812.3721	7359.7408
4	15032.5030	62211.8018	26849.4335	18163.8748	4645.4801
5	10526.9088	13663.0447	48703.1993	19978.4606	5984.1525
6	6628.6736	7966.5755	9511.3395	21934.5873	5114.5771
7	4636.9866	5074.3819	4025.1602	5672.9810	4500.9781
8	1877.6194	2948.8484	2292.0686	1604.6164	966.8274
9	5041.0516	4493.2880	3285.9136	1722.9789	642.5149

Table 4.6.16 Herring in 6.a (combined) and 7.b and 7.c. Catch at age residuals

Units : NA

year

age	1957	1958	1959	1960	1961	1962	1963
1	-0.461730	-0.6036690	0.140679	-1.4737300	-0.1240200	0.4193340	-0.4978340
2	-0.539579	-0.6406020	-0.244060	0.5050950	1.0266700	0.4512960	0.0840643
3	0.499670	0.2770090	-0.268411	0.1241410	-0.0337073	-0.7404520	0.2685840
4	-0.139901	-0.1979020	0.732801	-0.3210460	-0.1609400	0.0480220	-0.3882200
5	0.128271	-0.0619432	-0.099399	0.1724950	0.6945200	0.1328710	0.0352211
6	0.221437	0.2912540	0.108439	0.0851309	-1.3025500	0.5153340	0.2941990
7	-0.178535	0.3120740	0.069650	0.1070020	-0.5450500	0.4665040	-0.5826810
8	-0.169999	0.4673090	-0.430206	-0.2347100	-0.0859481	0.3650990	-0.0842329
9	-0.562967	0.8177920	0.348612	-0.5827460	-1.3638000	-0.0742067	0.0866610

year

age	1964	1965	1966	1967	1968	1969	1970
1	0.5993800	1.6015500	1.7409700	1.40303000	1.711400	-0.260883	0.5914980
2	0.5467290	-1.6435100	1.6307400	-1.34814000	0.673525	-1.021670	-0.9311390
3	0.0692944	-0.0906996	-0.2240170	-0.64960500	-0.212596	-0.983214	0.6275310
4	-0.5345140	0.5568580	-0.3298760	0.81168400	0.174180	-0.321318	0.4160300
5	-0.3529180	0.0444136	-0.9287590	-0.00231516	-0.559805	0.548656	0.2474030
6	-0.1858240	-0.5605290	0.0295206	0.54086800	-0.360155	0.353269	-0.4348140
7	-0.1710000	0.3849420	0.4557610	0.00043151	-0.513342	0.811057	0.0941776
8	0.3263170	0.3384540	-0.4625530	0.66169700	-0.406568	0.847913	-0.3237230
9	0.2962880	0.5827180	0.0578169	0.31703400	-0.604204	0.726069	-0.3524520

year

age	1971	1972	1973	1974	1975	1976
1	-0.6529430	1.390950	-0.4636760	0.5159100	0.00900106	-0.2012440
2	-0.0412789	0.509837	0.3377040	-0.4772640	0.30490400	0.8172980
3	1.7893800	-0.094192	0.5249110	-0.4410410	-0.11712700	0.0231256
4	0.7698240	-1.477340	0.0648577	0.3221360	-0.34270800	-0.0784377
5	0.2343410	-0.561429	0.1850380	0.2047240	-0.08754230	-0.1093990
6	-0.1295970	-0.354194	-0.0379165	0.6482400	-0.04917510	-0.1510500
7	-0.3350820	0.396097	-0.5144490	-0.0869041	-0.32141900	-0.1409050
8	-0.2431600	0.282752	-0.3030370	0.8294000	0.10873600	-0.2017790
9	-0.5732580	0.180655	0.1577110	-0.0727936	0.89337800	0.7838600

year

age	1977	1978	1979	1980	1981	1982
1	-0.05743940	0.311019	-0.101963	-0.4773370	0.00858143	-1.1035300
2	-0.18015600	0.833807	-0.245186	-1.2443300	0.17841400	0.9945010
3	-0.16392700	-0.223805	-1.302870	0.1319820	0.87495300	-0.2235630
4	-0.40906400	0.843298	-0.280749	0.0891738	0.16994200	0.2655520
5	0.12648900	-0.155119	-0.910361	0.5333690	0.02158130	0.1427720
6	0.64057400	-0.513744	0.387658	-0.8301450	0.20224300	0.0754321
7	0.00311794	-0.733943	0.626467	0.4693120	0.14026400	-0.5140930
8	-0.43598300	-0.150730	0.889625	0.2072050	-1.13464000	0.7263600
9	-0.45928100	0.463223	-0.163273	0.1332190	-0.57038700	-0.4795860

year

age	1983	1984	1985	1986	1987	1988
1	-0.0410376	-1.5254900	0.636743000	0.282900	-0.1575240	-1.6099500
2	-0.4384270	0.4064800	-0.606217000	0.599776	-0.5163640	-0.4351240
3	-0.2795800	0.3687590	-0.000840789	0.274147	-0.6164280	0.0725976
4	-0.0664463	-0.1059180	-0.756477000	0.170117	-0.3563560	0.1856650
5	0.2666480	-0.1444080	-0.459774000	0.341145	0.1376820	0.1658640
6	0.1590700	-0.4018880	0.340310000	0.316689	0.0583633	0.5363130
7	0.4264770	-0.2786140	0.417729000	-0.569836	0.8657160	0.0290176
8	0.4818480	-0.1105860	0.772704000	-0.881369	0.9701850	-0.4753480
9	0.5598720	0.0348303	-0.277881000	-1.276740	1.5165400	-0.2124100

year

age	1989	1990	1991	1992	1993	1994
1	0.093735900	0.3609790	1.2691700	-0.00585834	0.723558	0.5028150
2	-0.521612000	-0.1730300	-0.2063440	-0.70532500	0.934537	0.7132240
3	-0.000952829	-0.0727102	-0.5523680	0.62494900	-0.451635	0.0386238
4	-0.481340000	0.5661490	-0.4903260	0.46552500	0.232199	-0.8259030
5	-0.103540000	0.2236700	0.1605900	-0.34870600	-0.243665	-0.1553390
6	-0.566036000	-0.1456710	0.1753320	0.75503000	-0.814629	-0.4148010
7	0.593189000	0.0914907	0.1662700	-0.78708300	1.053750	-0.7632450
8	0.322319000	0.6666960	0.4048800	0.06226590	-0.254332	0.8570250
9	1.050280000	0.3408200	-0.0315967	-0.23874100	-1.002990	1.0846700

Table 4.6.16 (cont'd) Herring in 6.a (combined) and 7.b and 7.c. Catch at age residuals

age	1995	1996	1997	1998	1999	2000	2001
1	-2.02796000	-0.1173170	-0.560023	0.0516653	0.565875	0.4870100	-0.253665
2	0.35483700	-0.3425000	-0.205035	-0.4982770	0.740098	0.5265400	0.324086
3	0.07172050	-0.0964022	-1.200990	-0.1934560	1.018410	0.7667180	-0.220933
4	-0.00678418	-0.2749850	-0.297545	0.3799180	0.539290	0.5773410	-0.393270
5	0.55635600	-1.2616100	0.324471	0.5484220	-0.306262	-0.0392665	-0.348549
6	-0.01338120	0.3030240	0.507879	0.5474860	-0.473651	-0.5051790	0.264562
7	-0.66803900	-0.1135120	1.580470	0.8787550	-1.055280	-1.2762300	0.179083
8	-0.03385550	1.3528200	-0.177672	0.4515890	-0.584769	-0.1650480	1.144110
9	-0.05758630	1.2095200	-0.563507	-1.2946300	-1.776430	-0.7878450	-1.463930

age	2002	2003	2004	2005	2006	2007	2008
1	0.205953	0.1242800	0.0134069	-0.530586	-0.6422360	-1.579000	-0.3387940
2	-0.129278	0.0209263	-1.3889700	1.115780	-1.2205900	1.353500	0.0494786
3	0.194757	0.2540750	-1.0126300	1.924230	-0.0872626	0.655645	-0.3114920
4	0.228876	-0.0090088	-0.0249357	0.303295	0.4917540	-0.182169	0.5794740
5	1.070770	0.4459750	0.4735740	-1.076290	0.4619810	-0.025431	-0.2521450
6	0.646910	-0.7676730	0.6428760	-1.079230	0.4403090	-0.295296	-0.3447170
7	-0.363533	-0.0926508	0.9431660	-0.843037	0.3033170	-0.202200	-0.2974720
8	-0.757353	1.5899000	1.1751400	-0.783274	1.1771700	0.327862	-0.1206250
9	-1.532490	-1.8191700	-0.1196160	-2.001020	-0.1357980	-0.316855	0.2552350

age	2009	2010	2011	2012	2013	2014	2015
1	0.7120030	1.6476000	0.6328810	2.330440	-1.592280	-2.2847100	-0.6184490
2	-0.1300900	0.1999040	0.2125360	0.444511	-0.525542	-0.9332040	-0.1338920
3	-0.1929300	0.3742890	-0.2828970	0.203085	-1.131760	0.0460654	0.3018580
4	0.0731138	-0.4340320	0.0487725	-0.528829	0.291351	0.2055350	0.0344546
5	-0.0700284	0.3222970	-0.1962880	-0.379103	-0.138324	0.6511220	0.3189240
6	0.1324890	0.0459758	-0.2862160	0.207101	0.644970	0.0159533	0.0992630
7	0.0278338	-0.3990270	0.2310700	-0.289959	0.501843	-0.0533709	0.7980390
8	0.2283860	0.1611840	0.3364680	-1.262640	1.403980	1.0860500	0.5729440
9	-0.7867650	-0.4100060	-0.5221250	-0.668330	0.458130	0.3684970	-0.9610620

age	2016
1	-0.457276
2	0.759879
3	0.184426
4	-0.101988
5	-0.168485
6	-0.246130
7	-0.739018
8	-0.636970
9	-1.136710

Table 4.6.18 Herring in 6.a (combined) and 7.b and 7.c. Predicted index at age IBTS_Q1.

Units : NA

age	1987	1988	1989	1990	1991	1992	1993
2	350.927623	656.281623	233.392130	282.412848	297.36490	235.53276	473.83540
3	273.048654	235.050410	605.466963	169.066140	195.03324	213.01658	148.07368
4	140.966180	166.904201	144.003845	517.412278	134.66766	150.02471	154.44839
5	226.716423	90.098183	103.483274	109.453522	366.83788	107.41180	107.11575
6	32.175651	129.388564	57.624049	69.647026	75.66911	252.00275	84.80971
7	20.443398	16.730276	71.831996	45.935581	48.52553	41.73833	172.04740
8	7.396967	8.183419	9.385913	38.218512	32.37285	27.96434	30.73924
9	10.397132	6.891577	8.256163	9.560595	24.91924	29.12829	31.06960

age	1994	1995	1996	1997	1998	1999	2000
2	416.25165	524.30837	272.37233	354.85172	468.54399	379.95773	329.34967
3	248.74543	212.33389	283.46821	153.05847	227.04767	408.05012	204.17756
4	85.59441	120.35913	107.95452	138.14032	115.46991	159.97219	269.54086
5	89.90738	62.73817	52.28137	63.55782	81.87634	70.91628	103.31680
6	65.73687	54.06949	38.80309	37.14875	36.19171	42.88491	48.07874
7	57.78620	41.89766	29.35169	24.14337	20.36769	18.84825	26.69617
8	83.72436	42.51343	30.88838	17.23513	10.60176	10.38446	12.94410
9	35.89723	62.12261	58.19678	32.12421	18.99622	13.43361	13.73366

Table 4.6.18 (cont'd) Herring in 6.a (combined) and 7.b and 7.c. Predicted index at age IBTS_Q1.

age	2001	2002	2003	2004	2005	2006	2007
2	686.55751	443.77159	523.59579	246.35658	336.08026	252.82309	308.42232
3	159.80111	455.13314	328.19567	327.34347	232.94911	187.10127	210.96664
4	114.20556	91.35747	338.37001	229.87139	261.19572	156.48498	112.45914
5	177.13993	81.06814	65.50392	241.79494	146.86591	225.03816	102.46180
6	76.83959	124.25924	51.48446	42.06264	120.77991	149.73993	156.49280
7	36.78095	49.16638	78.90306	45.29787	19.29160	105.23017	108.81944
8	21.86528	20.47102	39.36157	49.28156	25.14854	16.39194	73.77353
9	13.88654	17.37339	20.73307	34.81262	30.76323	35.76286	28.95057

age	2008	2009	2010
2	187.99023	224.03001	254.28355
3	190.27302	125.59344	158.98025
4	158.35827	142.20931	77.10437
5	77.05504	104.33533	87.86486
6	72.04205	59.08931	60.69978
7	118.57314	58.62962	38.65592
8	79.09107	97.56609	40.90122
9	72.52490	102.35120	109.47651

Table 4.6.19 Herring in 6.a (combined) and 7.b and 7.c. Index at age residuals IBTS_Q1.

Units : NA

age	1987	1988	1989	1990	1991	1992	1993
2	-1.2568300	1.032400	-1.3890400	-0.9777160	0.469806	-0.929114	-0.842143
3	0.2902250	0.844504	0.8012020	-0.9815820	2.108300	-0.665069	0.957208
4	0.5507920	-0.298629	0.0185349	-0.5657730	2.005520	-0.286169	-0.258884
5	-0.0713237	-0.127527	-0.2323490	-0.1562220	1.396050	0.487407	0.639157
6	0.4286790	-1.404420	0.2077370	-0.0689163	1.893010	-0.862220	1.139460
7	-1.1154100	-0.307590	-1.9838400	0.4907480	1.883620	0.141335	-0.223091
8	0.4685830	-1.554790	-0.5176550	-1.8327300	1.649430	0.208121	0.664160
9	-0.7017810	-2.047530	-2.1044500	-1.2907200	-0.130252	-0.448266	-0.813741

age	1994	1995	1996	1997	1998	1999	2000
2	-0.7928930	0.3804010	0.213222	0.1016330	-2.288970	-0.432520	0.525536
3	0.5805160	-0.3106650	-0.182734	1.2772300	-0.961083	-0.396099	-0.936293
4	0.2750870	-0.0334587	-1.263480	-0.0395098	-1.439500	-0.234125	-1.297840
5	-0.4390530	-0.6887530	-0.152375	-0.3086300	-1.817110	-0.163113	-0.833622
6	0.0534473	0.0353400	-0.489594	0.4202210	-2.306630	-0.458485	-0.403432
7	-0.2145110	-0.1359480	-0.833617	-0.1340740	-1.415470	0.294088	0.260690
8	-2.7057700	0.0386903	-0.174108	1.0991100	-1.007390	0.307067	-0.422226
9	-3.4870100	-1.9273600	-0.103774	0.4918610	-0.377495	0.570876	0.299508

age	2001	2002	2003	2004	2005	2006	2007
2	-1.6418700	0.8584780	-0.4710250	0.677233	-0.3718040	0.2514430	-1.4280000
3	-0.3617440	-0.2954550	-1.0101300	0.899578	-0.7270860	0.0834341	-0.6189820
4	-0.2684710	0.1897320	-0.7448150	0.765447	0.0645868	-0.9893150	-0.0777680
5	0.0922143	-0.3639100	-0.1266490	0.927428	0.9843330	0.0632438	-0.2403940
6	0.2712930	0.0726176	-0.0298102	1.765930	1.1204900	0.6759160	0.2424220
7	0.8825700	0.5661010	-0.1423760	1.444450	1.7371500	0.7722700	0.3380940
8	0.4467200	1.2781700	-0.4001620	0.988875	1.3757000	1.0572700	0.0559136
9	0.8578960	1.6707800	0.7176690	1.249160	0.9305870	1.2813000	0.8920940

age	2008	2009	2010
2	-0.650651	-0.869742	-1.52392000
3	-1.343830	1.405240	0.05646390
4	-0.909922	1.207600	0.56106100
5	-0.493233	1.039160	0.00933592
6	-0.566165	1.016880	0.14712600
7	-0.637777	1.043470	1.28185000
8	0.330070	1.693990	0.96734200
9	-0.608535	1.665090	1.17392000

Table 4.6.20 Herring in 6.a (combined) and 7.b and 7.c. Predicted index at age WoS HERAS

Units : NA

age	1991	1992	1993	1994	1995	1996	1997
1	169312.26	238470.29	232373.20	268820.7	172870.84	201430.56	252331.76
2	393564.40	312200.22	626121.67	551115.7	692733.05	357825.24	459135.20
3	457805.64	501219.80	347388.84	585253.3	497723.51	658157.80	347076.33
4	316791.78	353946.13	363233.08	202076.2	282942.79	251073.25	312793.97
5	864494.31	254307.64	252862.21	213096.4	148123.25	122210.47	144494.97
6	177584.17	594514.27	199745.63	155624.3	127516.37	90526.69	84381.21
7	113266.64	98174.32	403729.35	136680.3	98883.73	68555.57	54879.77
8	74989.25	65408.01	71897.73	197402.5	100247.76	72337.65	39632.31
9	57728.14	68131.84	72671.17	84643.2	146488.18	136298.14	73865.41

age	1998	1999	2000	2001	2002	2003	2004
1	236522.83	230913.86	342833.44	272828.86	272011.60	173009.19	184702.19
2	604707.41	502775.99	438932.10	917309.31	591016.96	701867.56	330876.34
3	511345.11	954172.74	482434.29	378889.54	1071853.55	780976.24	781132.45
4	259756.52	375344.67	639857.00	272202.08	216208.82	809684.54	551556.74
5	185108.98	167644.34	247137.47	425193.65	193087.74	157834.14	584668.33
6	82018.49	101813.70	115612.57	185516.67	298283.60	124978.87	102405.94
7	46327.92	44985.70	64569.67	89321.72	118800.39	192528.60	110824.15
8	24484.61	25009.22	31536.47	53508.72	49946.11	96799.78	121479.40
9	43870.61	32350.99	33463.15	33982.47	42387.13	50985.68	85810.79

age	2005	2006	2007
1	148315.94	153522.13	NA
2	453023.83	338101.02	411597.0
3	559388.78	443033.20	498420.8
4	631276.98	372540.11	267052.4
5	358004.20	540418.98	245389.0
6	296143.67	362398.60	377830.1
7	47519.72	256170.88	264421.6
8	62311.42	40251.40	180918.2
9	76221.59	87824.87	70997.5

Table 4.6.21 Herring in 6.a (combined) and 7.b and 7.c. Index at age residuals WoS HERAS

Units : NA

age	1991	1992	1993	1994	1995	1996	1997
1	0.4616390	-0.777584	-3.061660	0.4059740	0.6248640	-1.058060	0.763091
2	-0.5413760	0.892114	-0.145115	-0.0309455	0.8690580	0.890384	0.625456
3	-0.6230520	-1.615510	1.279920	0.0703074	-0.0939905	0.370192	-0.360345
4	0.2788490	-0.589653	1.194620	0.6458620	0.8675690	0.505338	-1.171210
5	-1.0664700	0.913146	1.500620	0.6801550	0.0604908	-0.463259	-1.460090
6	-0.0129951	-1.692690	2.811370	1.0157400	0.7167910	-0.749297	-0.995053
7	-0.2562970	0.137318	-0.582020	2.0364200	1.0029100	0.226103	-2.268850
8	0.3370580	-0.266440	1.468350	-0.2384730	1.6041000	0.145212	-0.583717
9	0.0102279	-0.133198	1.490260	0.8279620	0.5972150	-0.320258	-2.064970

age	1998	1999	2000	2001	2002	2003	2004
1	1.0949800	0.559338	0.177834	0.0917933	0.297150	0.6206430	0.7444600
2	0.5099150	-0.829625	-0.612307	0.2733650	-0.567928	0.7330630	-0.3486780
3	0.4955220	0.699779	-0.669222	-1.0346000	0.547237	0.3310310	-0.0506444
4	1.1113300	0.262378	0.635836	-0.8483350	-0.147396	1.1157300	-0.4122330
5	-0.0622101	1.135600	0.867864	0.0532051	-0.331157	0.2587480	-0.0239100
6	-0.0636005	0.577308	1.421930	-0.6268610	0.657971	0.0619969	-1.1369200
7	-0.9367230	1.220630	2.106180	0.2624630	0.463831	1.0982100	-1.0904600
8	-1.0636900	0.184116	2.058720	-0.0390914	0.562369	0.3103410	-0.7291680
9	-0.3296280	0.168143	1.239670	0.0389843	0.633171	0.7255340	-0.2193150

age	2005	2006	2007
1	-0.722438	-0.208513	NA
2	-1.159910	1.688330	-2.210090
3	-1.656930	-0.248171	-0.983005
4	-0.747019	-0.503381	-0.516577
5	-0.707281	0.139121	-0.978359
6	-1.235440	0.251762	-0.159538
7	-2.478360	-0.225725	-0.158507
8	-0.874854	-1.153580	-0.188944
9	-1.951510	-0.733172	-1.481930

Table 4.6.22 Herring in 6.a (combined) and 7.b and 7.c. Predicted index at age IBTS_Q4.

Units : NA

age	1996	1997	1998	1999	2000	2001	2002
2	47.557999	60.304094	79.264471	67.209190	59.003101	123.565329	79.403306
3	48.779981	25.251107	36.999707	71.104455	36.247485	28.547518	80.325731
4	18.631059	22.729645	18.778827	28.049477	48.255992	20.591534	16.266373
5	9.105968	10.532334	13.435628	12.601174	18.750680	32.347606	14.598664
6	6.734139	6.146667	5.963574	7.678007	8.806675	14.176136	22.691264
7	5.104283	4.000183	3.378190	3.406993	4.941110	6.857000	9.084140
8	5.397576	2.914738	1.806895	1.907337	2.427486	4.132861	3.848333
9	10.169571	5.432666	3.237593	2.467385	2.575557	2.624738	3.266013

age	2003	2004	2005	2006	2007	2008	2009
2	94.782046	44.746803	61.447921	45.574119	55.388390	34.23334	40.75261
3	59.009001	59.145470	42.570009	33.345739	37.447127	34.62964	22.82714
4	61.443620	41.948807	48.281091	28.157958	20.143870	29.08114	26.07508
5	12.043439	44.730697	27.563984	41.122688	18.633853	14.36393	19.39800
6	9.592102	7.877417	22.908316	27.745676	28.876554	13.58070	11.10872
7	14.836050	8.558458	3.689201	19.704755	20.309931	22.57674	11.14198
8	7.504854	9.435791	4.859910	3.117496	13.995978	15.23461	18.77545
9	3.953060	6.665467	5.944937	6.801546	5.492371	13.96983	19.69648

Table 4.6.23 Herring in 6.a (combined) and 7.b and 7.c. Index at age residuals IBTS_Q4.

Units : NA

age	1996	1997	1998	1999	2000	2001	2002
2	0.2710680	-0.819788	-1.0471500	-1.4100800	-1.201490	0.341113	-2.00007
3	0.8295380	0.486981	-0.2931940	-1.5817000	-1.821550	0.942385	-2.74051
4	-0.0386351	0.259242	0.5004990	-0.5422570	-1.627910	0.772477	-3.43166
5	0.7465050	0.752078	1.0262500	0.0427062	-1.232060	0.896672	-2.59040
6	-0.2040690	0.889356	1.1360000	1.0334300	-0.233814	1.271990	-2.67316
7	-0.0795541	-0.389128	-0.0848417	0.8587250	-0.118510	1.635940	-1.99017
8	0.7303910	1.272640	-0.3610200	-0.1258850	-0.039323	1.528980	-1.20193
9	0.3511960	0.854151	1.0432700	0.8533750	-0.284798	0.867168	-1.82580

age	2003	2004	2005	2006	2007	2008	2009
2	1.0698100	0.146494	-1.2757700	-0.1325500	-0.170734	-1.0853300	0.544651
3	0.1521890	0.935951	-1.6101800	-0.5083500	0.144642	0.0886231	0.544734
4	0.0909611	1.124860	-0.9253190	-0.3329860	0.302632	-0.3113590	0.450458
5	-0.5380700	1.174930	-0.0765427	-0.0776043	1.134100	0.2890350	0.421138
6	0.2167100	0.864532	-0.4792990	0.5581890	0.509132	0.3885790	-0.155835
7	-0.3814030	1.111050	-1.1235500	0.4106960	0.900502	0.5427010	0.400688
8	-0.3034640	0.525292	-0.3267090	0.8070360	-0.340747	0.2789590	0.220979
9	0.5913540	0.225613	-0.2717140	0.5775860	-0.614373	0.1680680	0.434504

Table 4.6.24 Herring in 6.a (combined) and 7.b and 7.c. Predicted index at age MS HERAS.

Units : NA

age	2008	2009	2010	2011	2012	2013	2014
1	255429.1	328732.6	470428.8	304370.20	197857.03	NA	108684.01
2	233001.5	277478.9	313953.4	592851.96	324356.99	185590.89	98923.29
3	518865.5	342216.9	431015.8	392150.12	1019068.98	367912.35	284674.02
4	434000.1	389414.7	210007.8	266066.09	231422.43	748779.63	291676.33
5	212968.6	287937.9	240963.3	145553.65	154786.19	155982.64	493757.61
6	200365.8	164094.9	167610.8	137778.14	107441.31	100448.46	108640.55
7	331638.2	163799.8	107484.3	97294.72	85836.53	73079.27	52328.69
8	222637.5	274498.2	114691.4	74846.90	48703.20	59159.95	41697.65
9	204147.9	287966.7	306999.1	203109.39	130757.53	90147.27	59778.42

age	2015	2016
1	NA	NA
2	118160.60	160347.72
3	163799.76	175080.30
4	197797.69	102129.82
5	202015.56	122357.21
6	251148.58	118551.17
7	73644.15	119467.54
8	29827.92	36823.81
9	32029.10	24472.37

Table 4.6.25 Herring in 6.a (combined) and 7.b and 7.c. Index at age residuals MS HERAS.

Units : NA

age	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	-1.034180	0.5443960	-0.8070140	-1.005250	0.8869310	NA	1.4216500	NA	NA
2	0.172217	-0.0569293	0.2241050	-1.044750	0.6598990	0.151102	1.2908500	0.734272	-2.114630
3	0.818006	-0.2786760	-0.1781580	1.039160	-0.2534560	0.209793	-0.2001900	1.106440	-0.603107
4	0.633039	0.1630280	0.1794210	0.750597	1.0072400	-0.136238	0.6806310	1.663060	-0.189601
5	0.669010	0.3486130	-0.4122890	0.475898	0.5950260	0.277548	0.0990651	0.925244	-0.114356
6	0.629934	0.3953170	-0.1736640	0.627612	0.0796758	-0.442966	0.3891030	0.800804	-0.505825
7	1.010690	0.2044180	-0.0660073	0.933219	0.3260820	-0.218054	-0.5935910	0.252362	-0.819905
8	0.689275	0.7505900	-0.1662860	0.518850	0.1864420	-0.909700	-1.0051100	-0.275659	-2.372650
9	0.367719	0.5755200	-0.0412949	0.327403	-0.2796310	-1.100980	-1.9091000	-3.418060	-4.056430

Table 4.6.27 Herring in 6.a (combined) and 7.b and 7.c. Fit parameters.

	name	value	std.dev
1	logFpar	-1.318800	0.724880
2	logFpar	-0.678080	0.431010
3	logFpar	0.110820	0.360320
4	logFpar	-2.021300	0.429730
5	logFpar	-0.596320	0.244580
6	logFpar	-0.018612	0.242090
7	logFpar	-7.979800	0.225350
8	logFpar	-9.362700	0.263260
9	logSdLogFsta	-0.594020	0.179400
10	logSdLogFsta	-1.170300	0.106010
11	logSdLogN	-0.745490	0.212160
12	logSdLogN	-1.343400	0.096171
13	logSdLogObs	0.100840	0.108240
14	logSdLogObs	-1.776800	0.132880
15	logSdLogObs	-1.099400	0.125460
16	logSdLogObs	0.450790	0.296860
17	logSdLogObs	-0.224270	0.111290
18	logSdLogObs	0.405130	0.181460
19	logSdLogObs	-0.624330	0.073076
20	logSdLogObs	0.472610	0.147670
21	logSdLogObs	-0.331990	0.064773
22	logSdLogObs	0.151390	0.197420
23	logSdLogObs	-0.303060	0.076486
24	rho	0.962210	0.016713

Table 4.6.28 Herring in 6.a (combined) and 7.b and 7.c. Negative log-likelihood.

1040.72

Table 4.7.1.1 Herring in 6.a (combined) and 7.b and 7.c. Input data as used in the FLR short term forecast 2017.

2017								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	733366	0.77	0	0.67	0.67	0.06	0.00	0.09
2	317971	0.38	0.54	0.67	0.67	0.13	0.05	0.14
3	261917	0.36	0.86	0.67	0.67	0.16	0.08	0.17
4	130556	0.34	0.99	0.67	0.67	0.18	0.08	0.19
5	76618	0.32	1	0.67	0.67	0.20	0.09	0.21
6	92430	0.31	1	0.67	0.67	0.21	0.08	0.22
7	90063	0.31	1	0.67	0.67	0.22	0.07	0.24
8	91306	0.31	1	0.67	0.67	0.22	0.05	0.25
9	47092	0.31	1	0.67	0.67	0.24	0.05	0.27
2018								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	733366	0.77	0	0.67	0.67	0.06	0.00	0.09
2	-	0.38	0.54	0.67	0.67	0.13	0.05	0.14
3	-	0.36	0.86	0.67	0.67	0.16	0.08	0.17
4	-	0.34	0.99	0.67	0.67	0.18	0.08	0.19
5	-	0.32	1	0.67	0.67	0.20	0.09	0.21
6	-	0.31	1	0.67	0.67	0.21	0.08	0.22
7	-	0.31	1	0.67	0.67	0.22	0.07	0.24
8	-	0.31	1	0.67	0.67	0.22	0.05	0.25
9	-	0.31	1	0.67	0.67	0.24	0.05	0.27
2019								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	733366	0.77	0	0.67	0.67	0.06	0.00	0.09
2	-	0.38	0.54	0.67	0.67	0.13	0.05	0.14
3	-	0.36	0.86	0.67	0.67	0.16	0.08	0.17
4	-	0.34	0.99	0.67	0.67	0.18	0.08	0.19
5	-	0.32	1	0.67	0.67	0.20	0.09	0.21
6	-	0.31	1	0.67	0.67	0.21	0.08	0.22
7	-	0.31	1	0.67	0.67	0.22	0.07	0.24
8	-	0.31	1	0.67	0.67	0.22	0.05	0.25
9	-	0.31	1	0.67	0.67	0.24	0.05	0.27

Table 4.7.1.2 Herring in 6.a (combined) and 7.b and 7.c. Output from FLR short term forecast.

Catch (2018)	Basis	F (2018)	SSB (2018)	% SSB change relative to 2017	% TAC change relative to 2017
0	Zero catch	0	134 158	-1%	-100%
5 681	F2017	0.041	131 126	-0.92%	-2%
5 800	2017 Monitoring TAC")	0.042	131 063	-0.97%	0%
21 050	FMSY	0.16	122 785	-7.22%	+262%
6 869	F = 0.05	0.05	130 489	-1.4%	+18%

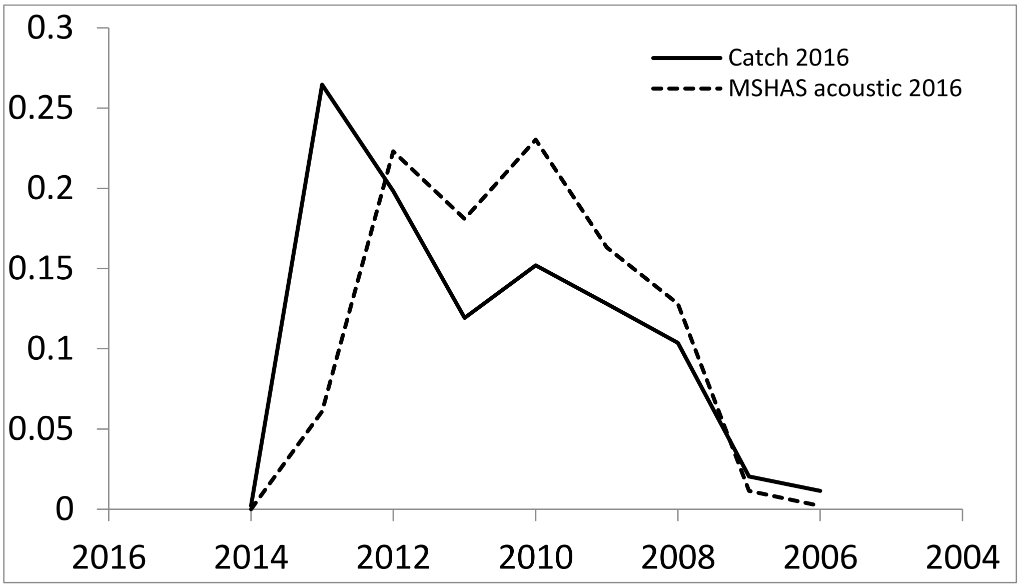


Figure 4.3.1.1. Herring in 6.a (combined) and 7.b and 7.c. Comparison of the proportions-at-age, by year class, in the 2016 acoustic survey (MSHAS) and the 2016 catch.

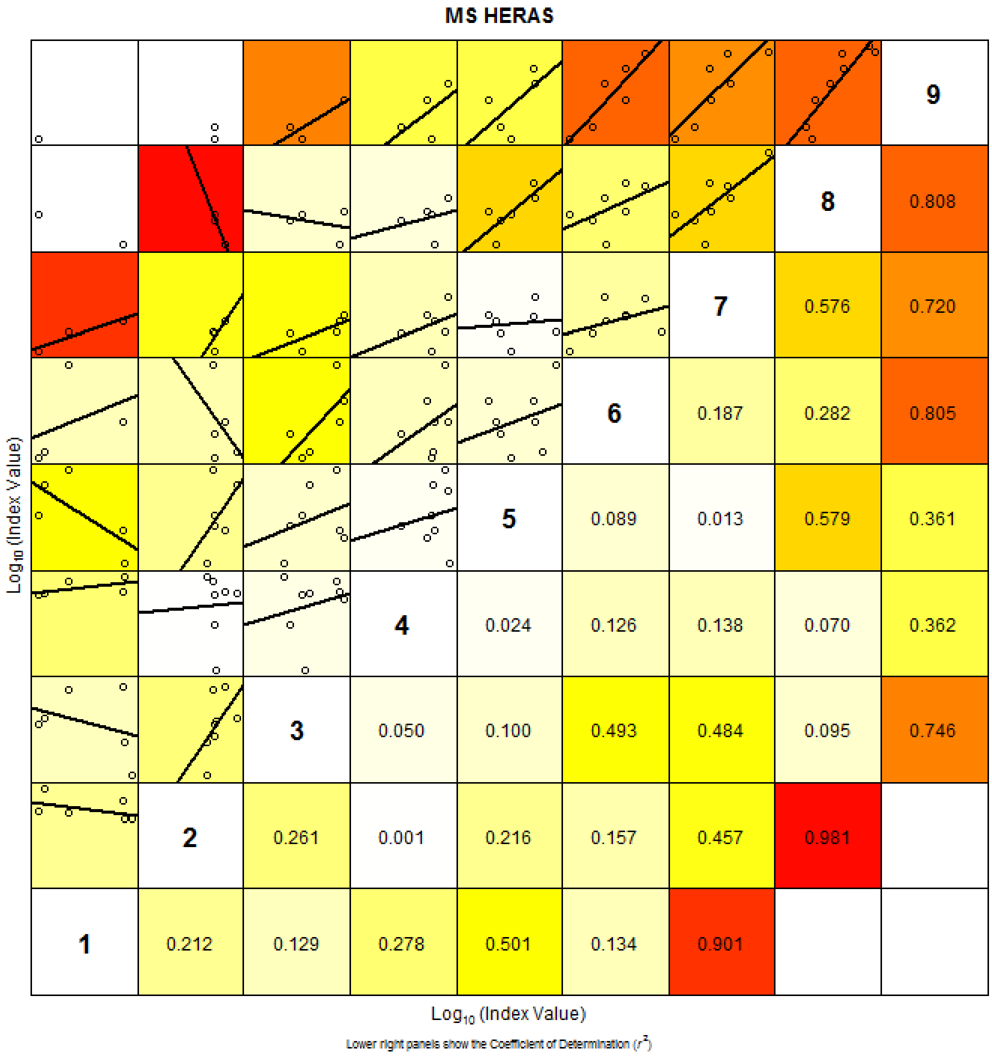


Figure 4.3.1.2. Herring in 6.a (combined) and 7.b and 7.c. Internal consistency between ages (rings) in the Malin Shelf herring acoustic survey time series (2008–2016).

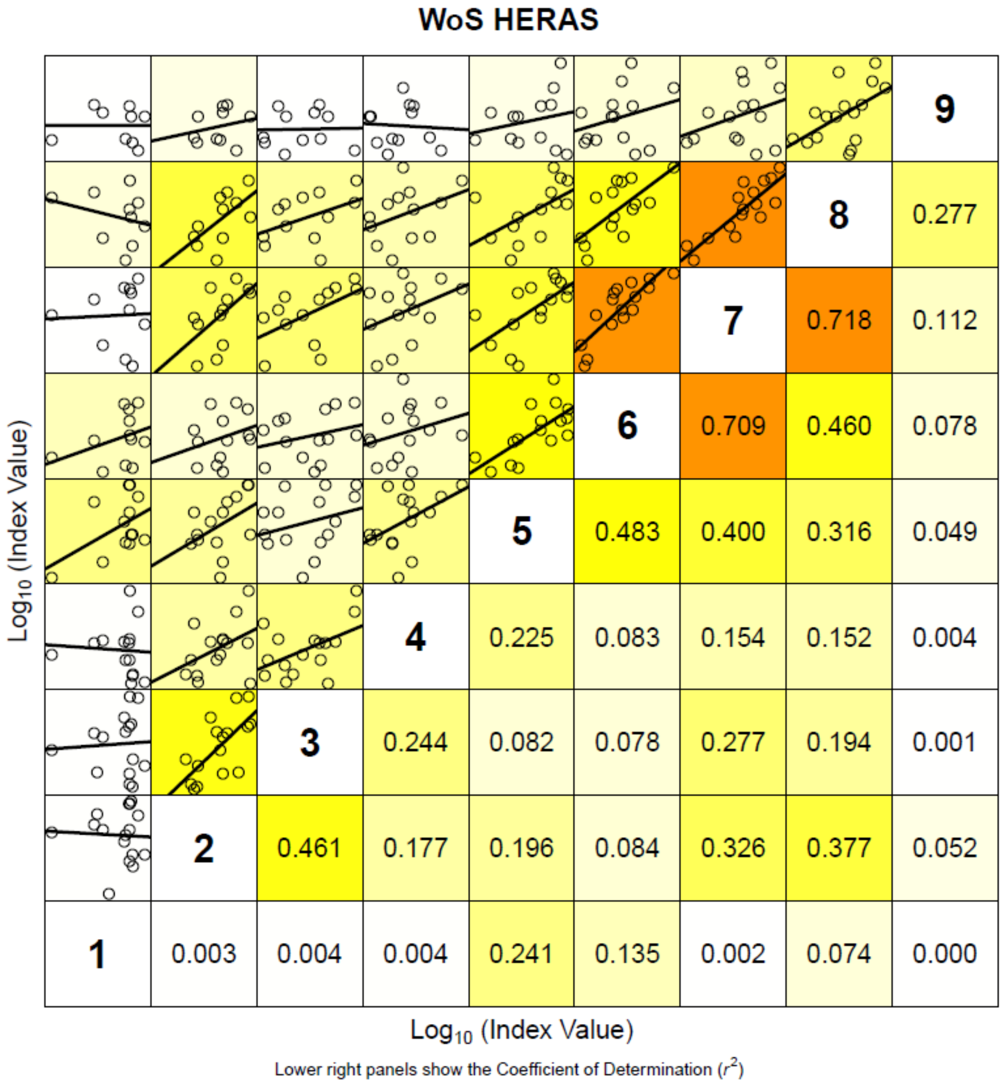


Figure 4.3.1.3. Herring in 6.a (combined) and 7.b and 7.c. Internal consistency between ages (rings) in the West of Scotland acoustic survey time series (MSHAS_N; 1991 to 2007).

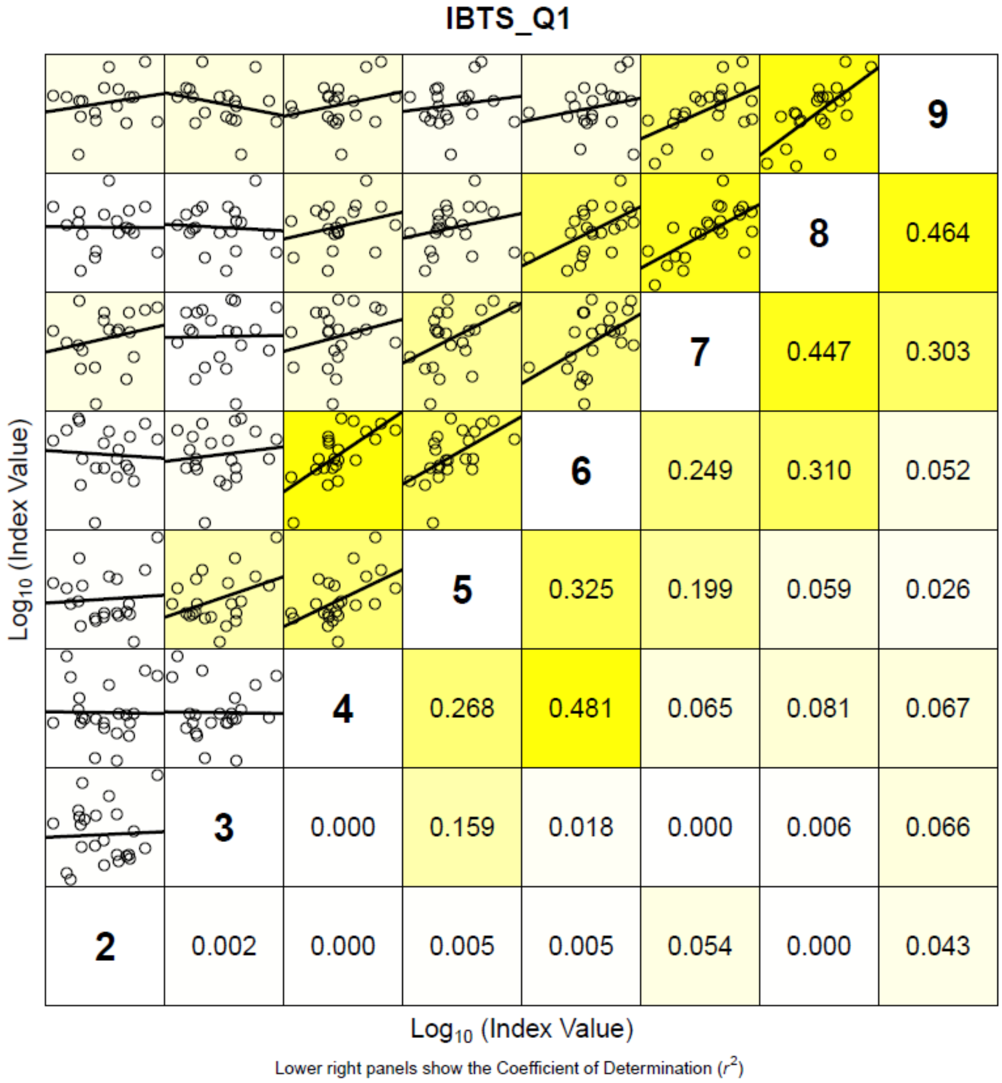


Figure 4.3.2.1. Herring in Division 6.a (combined) and 7.b and 7.c. Internal consistency plot of the quarter 1 Scottish bottom trawl survey (1987–2010). Above the numbered diagonal the linear regression is shown including the observations (in points) while under the numbered diagonal the r^2 value that is associated with the linear regression is given.

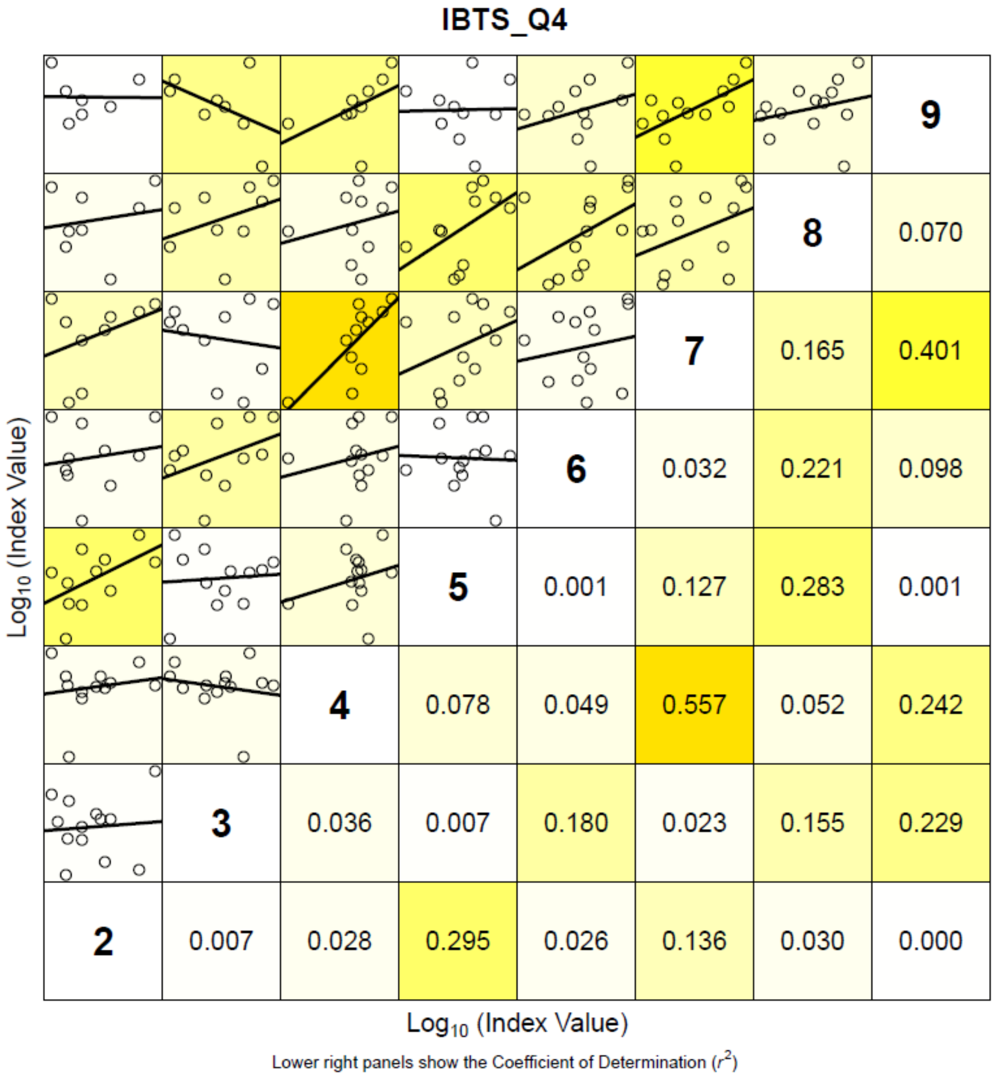


Figure 4.3.2.2. Herring in Division 6.a (combined) and 7.b and 7.c. Internal consistency plot of the quarter 4 Scottish bottom trawl survey in (1996–2009). Above the numbered diagonal the linear regression is shown including the observations (in points) while under the numbered diagonal the r^2 value that is associated with the linear regression is given.

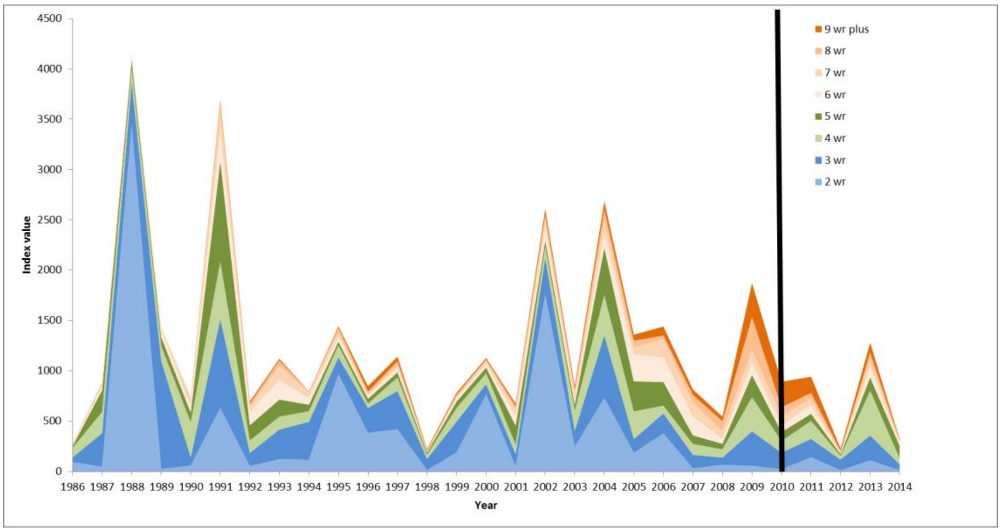


Figure 4.3.2.3. Herring in 6.a (combined) and 7.b and 7.c. Trends in stock composition from abundance at age index from Scottish ground fish survey in Quarter 1. The time series is only used in the assessment up to and including 2010 (black vertical line).

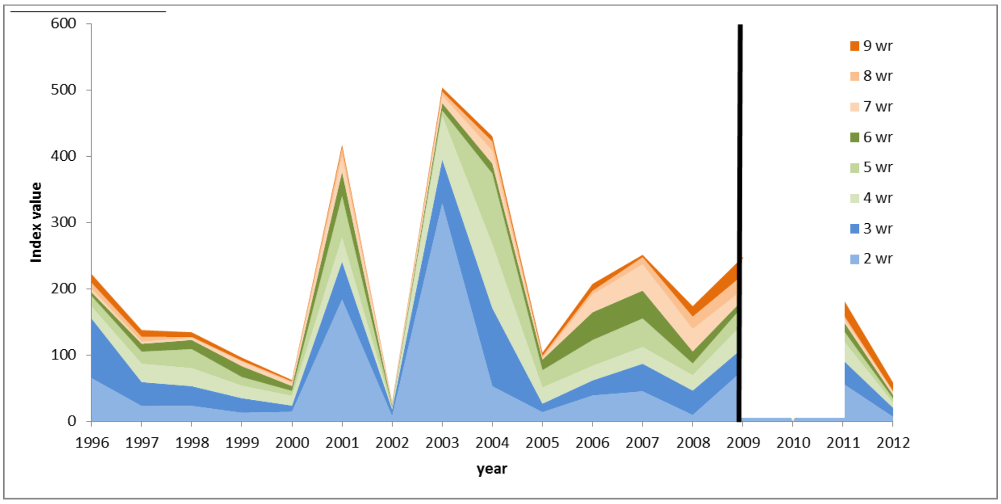


Figure 4.3.2.4. Herring in 6.a (combined) and 7.b and 7.c. Trends in stock composition from abundance at age index from Scottish ground fish survey in Quarter 4. The time series is only used in the assessment up to and including 2009 (black vertical line). There was no survey in 2010 and in 2013 only half of the survey was completed.

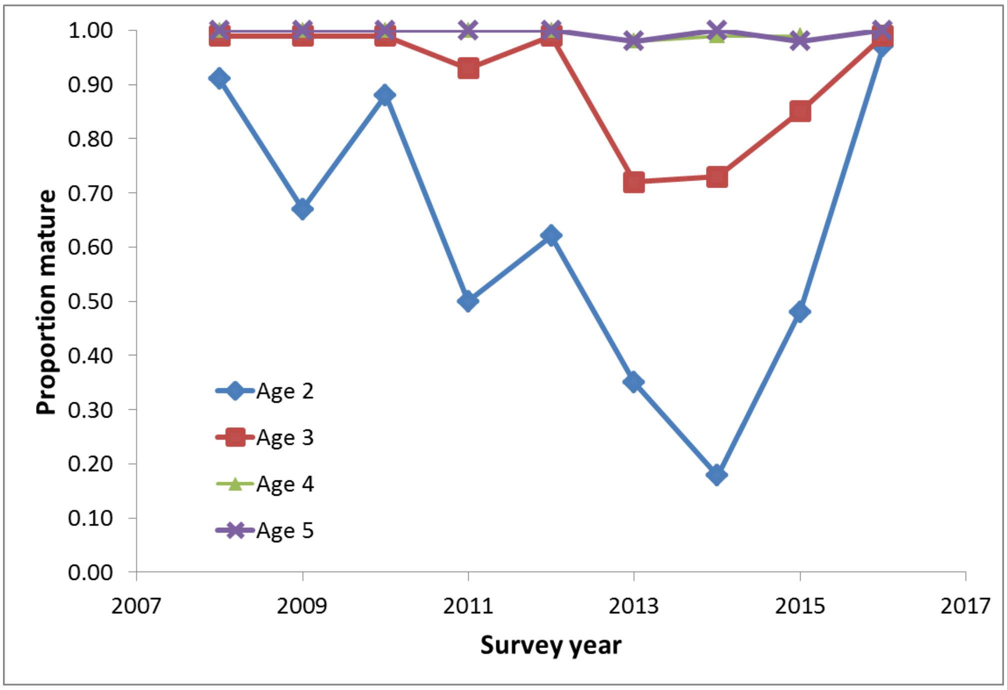


Figure 4.4.2.1. Herring in 6.a (combined) and 7.b and 7.c. Maturity ogive for the years 1993 to 2016.

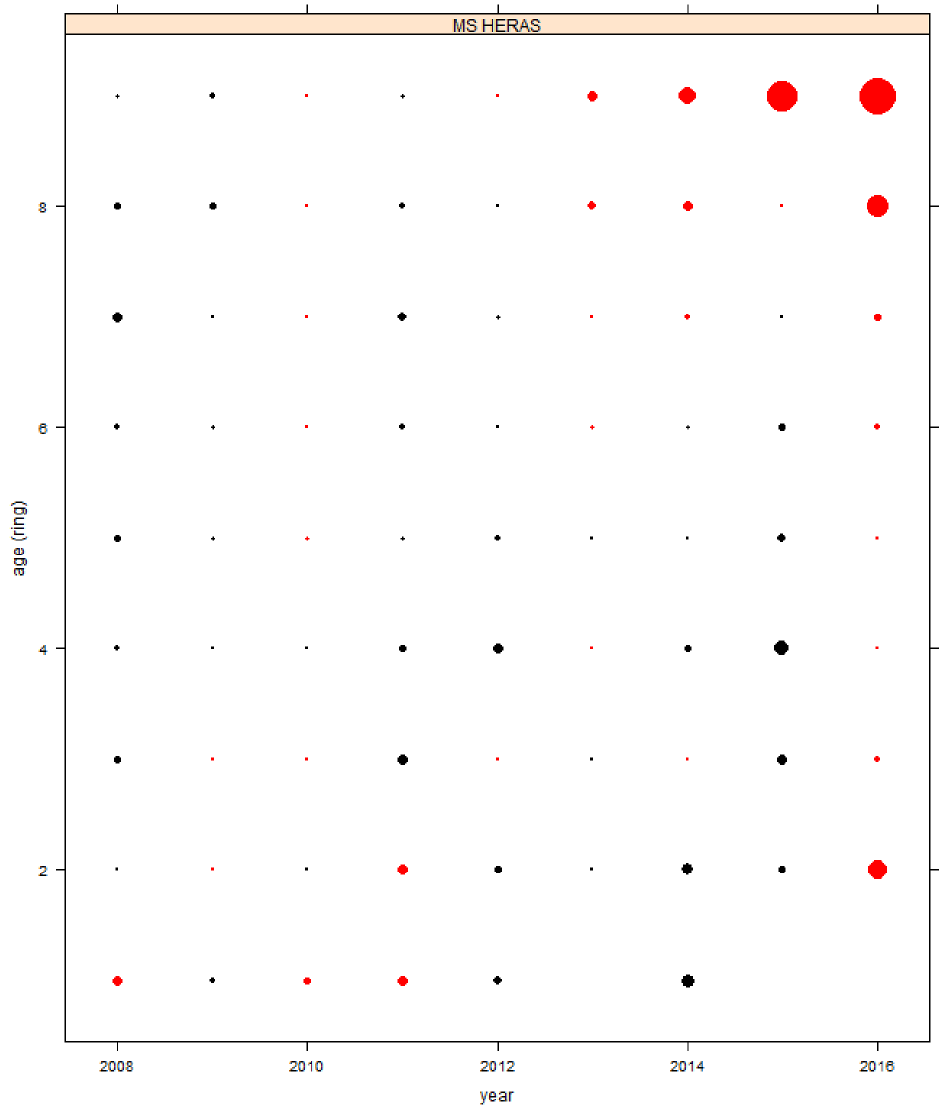


Figure 4.6.1: Herring in 6.a (combined) and 7.b and 7.c. Bubble plot of standardised survey residuals from the Malin Shelf acoustic survey (2008–2016).

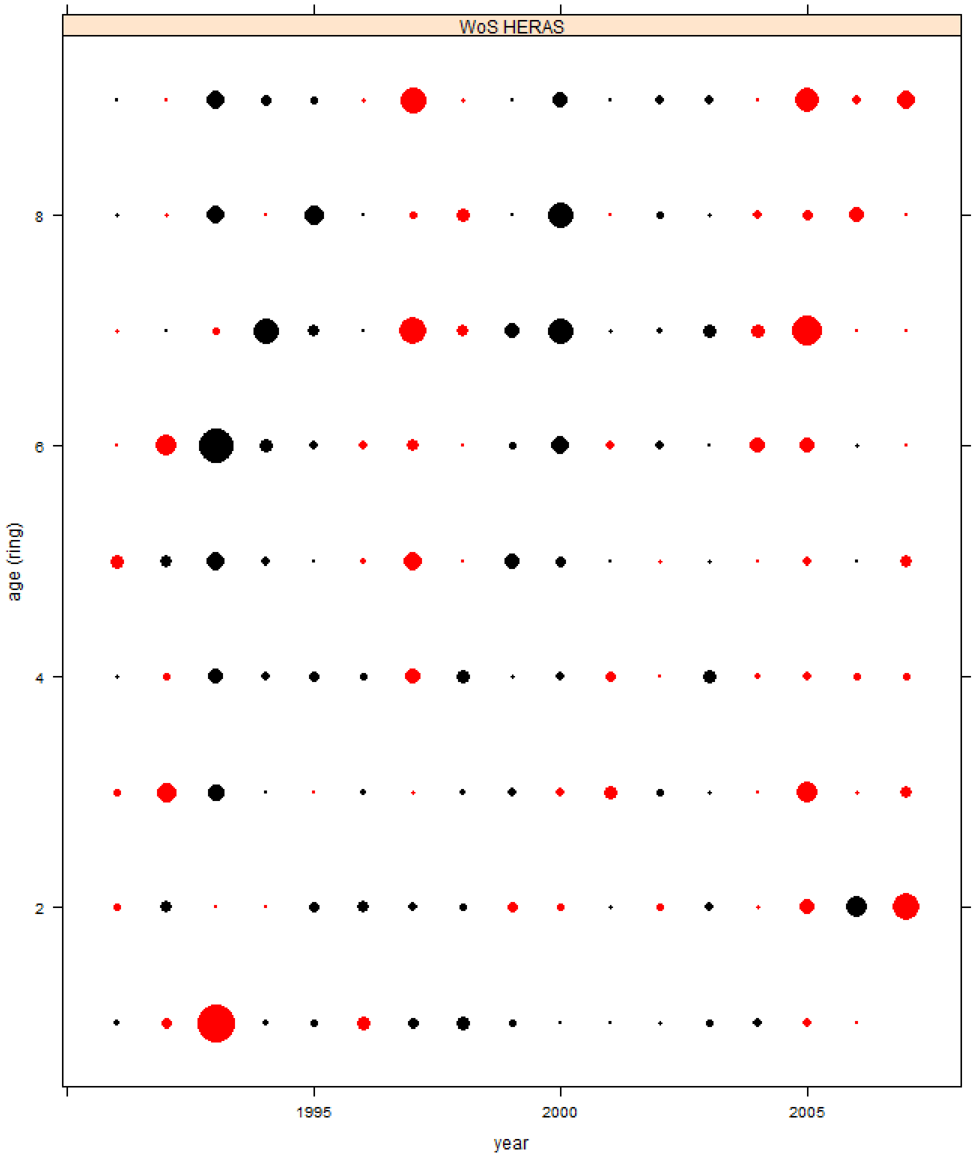


Figure 4.6.2: Herring in 6.a (combined) and 7.b and 7.c. Bubble plot of standardised survey residuals from the West of Scotland geographical area (6.aN) acoustic survey (1991–2007).

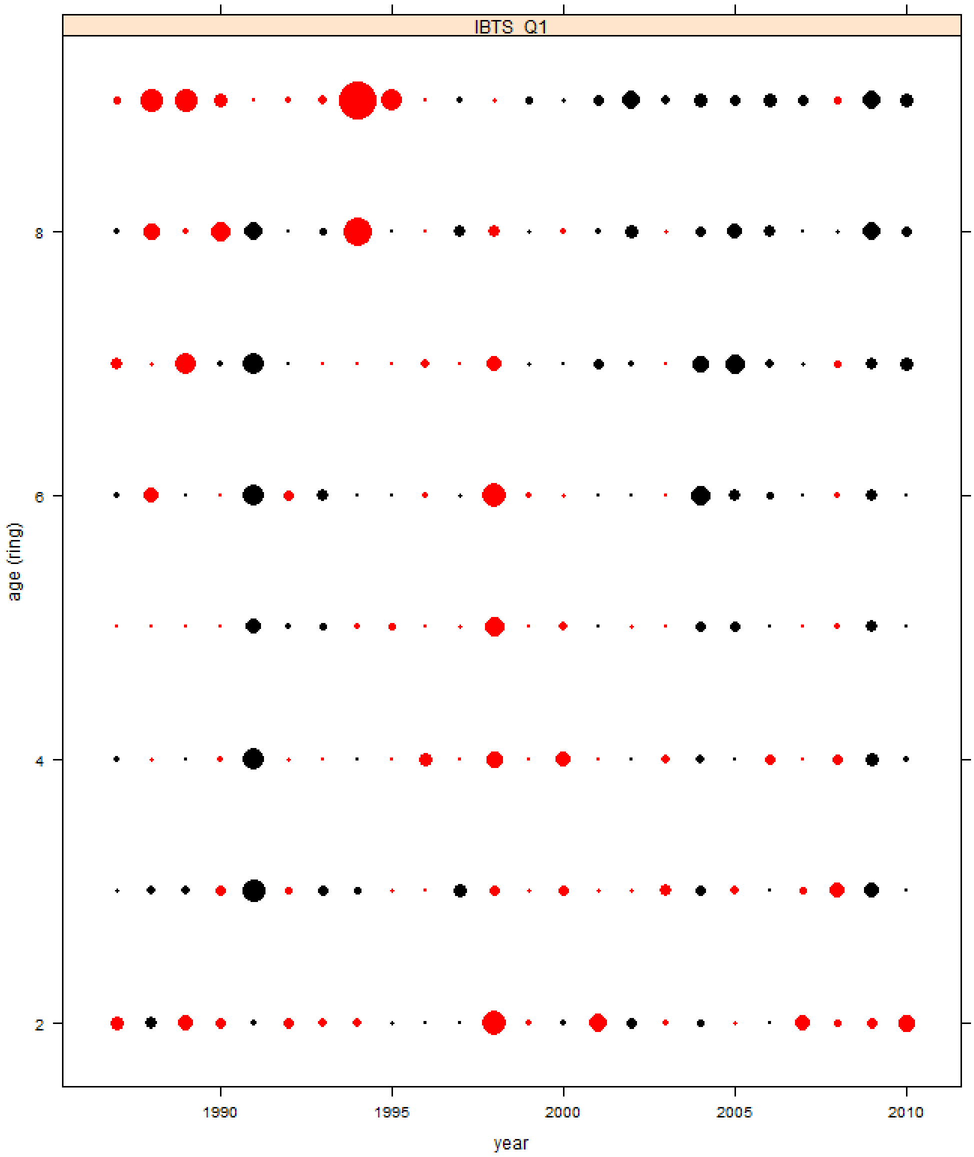


Figure 4.6.3: Herring in 6.a (combined) and 7.b and 7.c. Bubble plot of standardised survey residuals from the Scottish bottom trawl survey in quarter 1 (1987–2010).

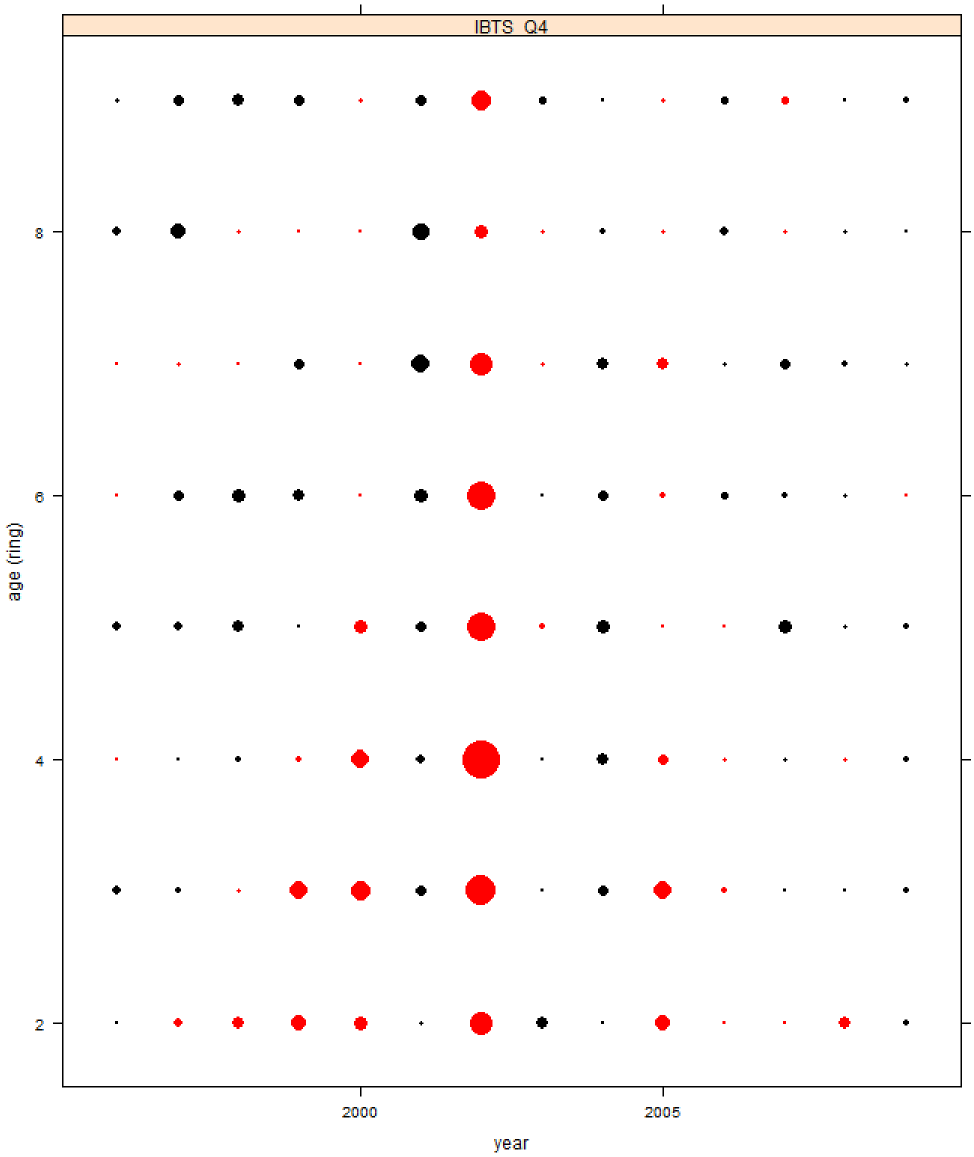


Figure 4.6.4: Herring in 6.a (combined) and 7.b and 7.c. Bubble plot of standardised survey residuals from the Scottish bottom trawl survey in quarter 4 (1996–2009).

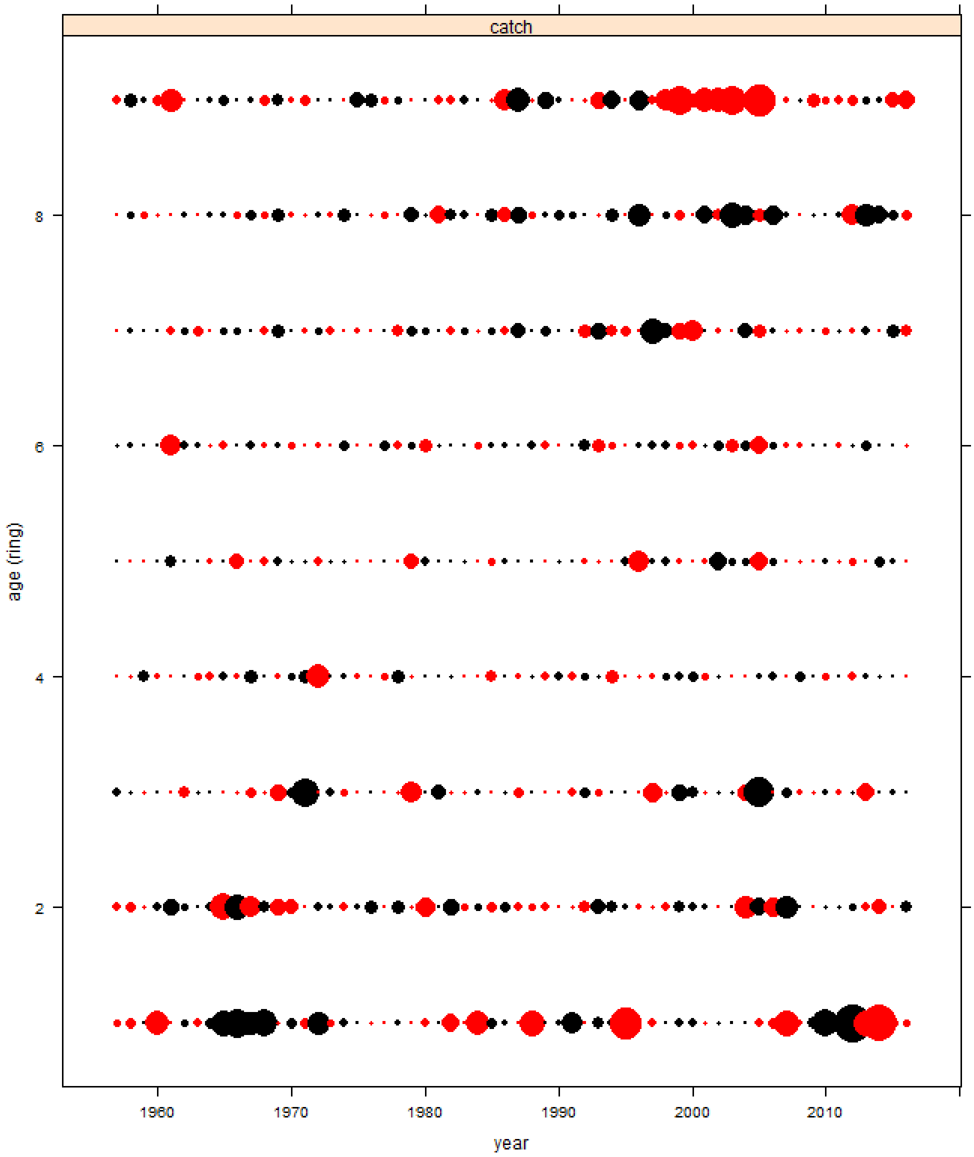


Figure 4.6.5: Herring in 6.a (combined) and 7.b and 7.c. Bubble plot of standardised catch residuals (1957–2016).

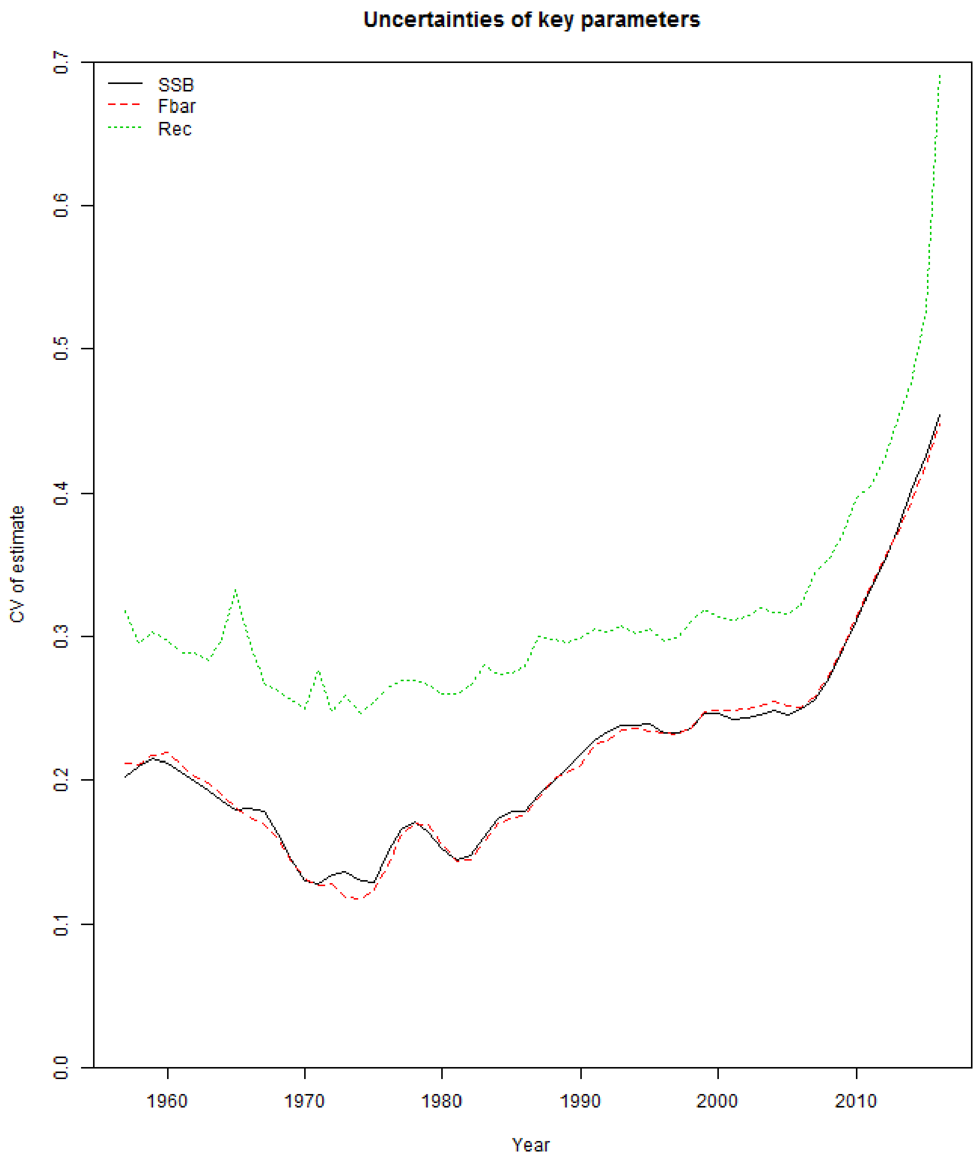


Figure 4.6.6: Herring in 6.a (combined) and 7.b and 7.c. Uncertainty estimates in SSB, F_{bar} and recruitment parameters (1957–2016).

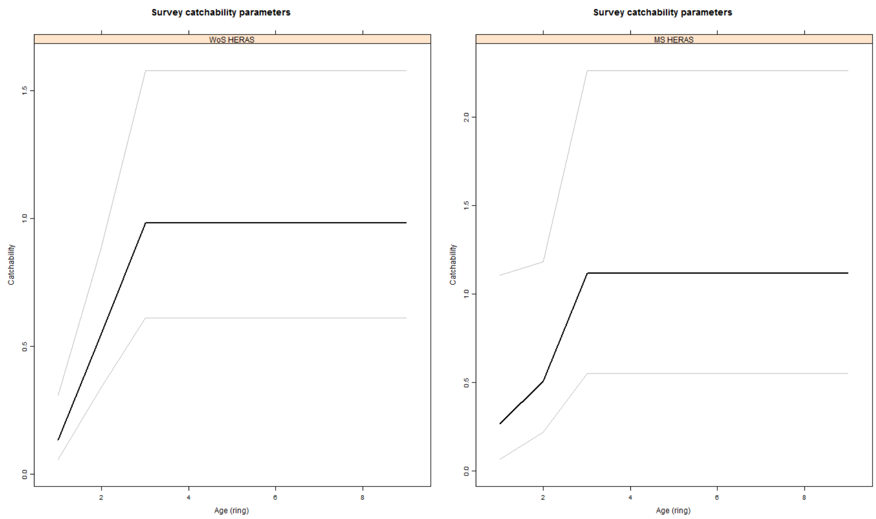


Figure 4.6.7: Herring in 6.a (combined) and 7.b and 7.c. Survey catchability parameters from the Malin Shelf acoustic survey (right) and the West of Scotland geographical area (6.aN) acoustic survey (left).

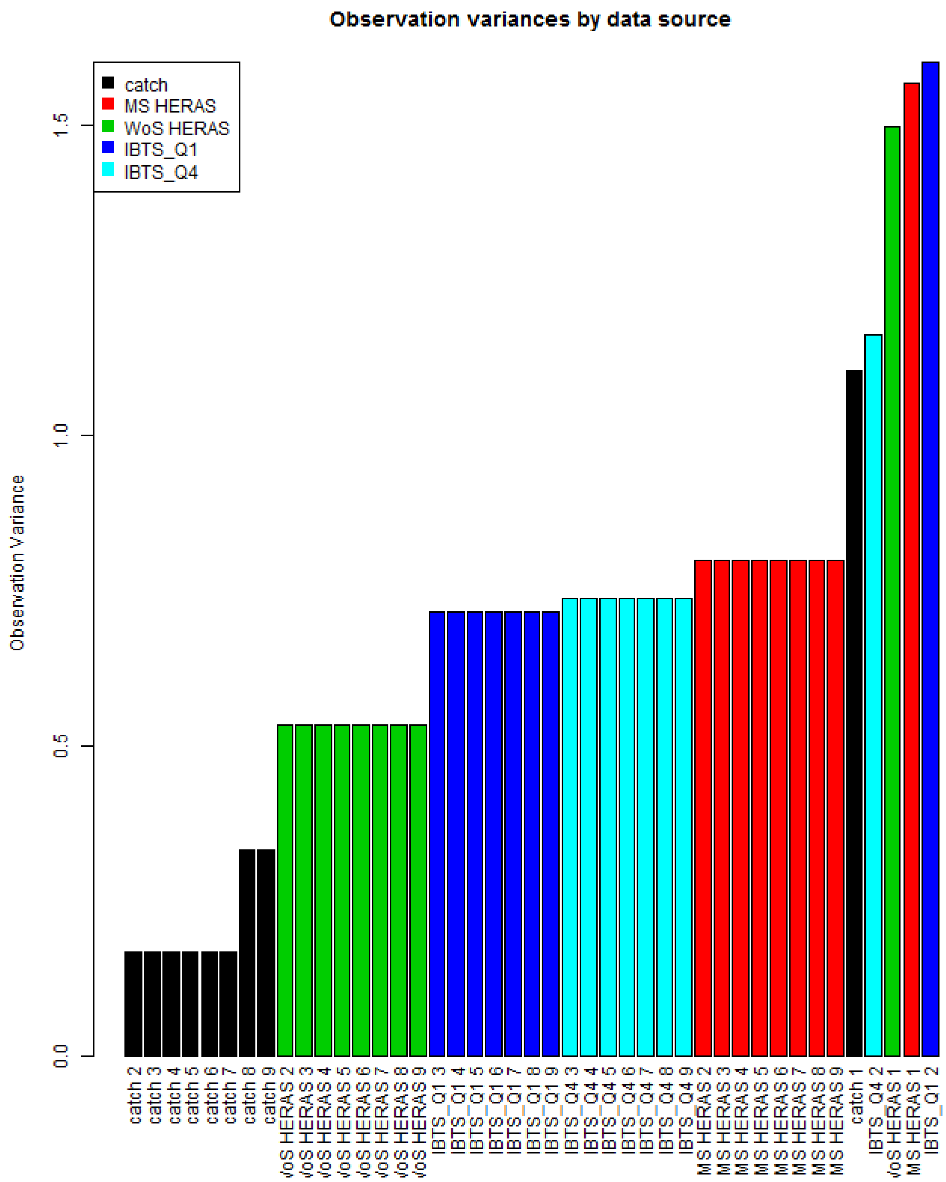


Figure 4.6.8: Herring in 6.a (combined) and 7.b and 7.c. Observation variance by data source - ordered from least (left) to most (right). Colours indicate the different data sources. In cases where parameters are bound, observation variances have equal values.

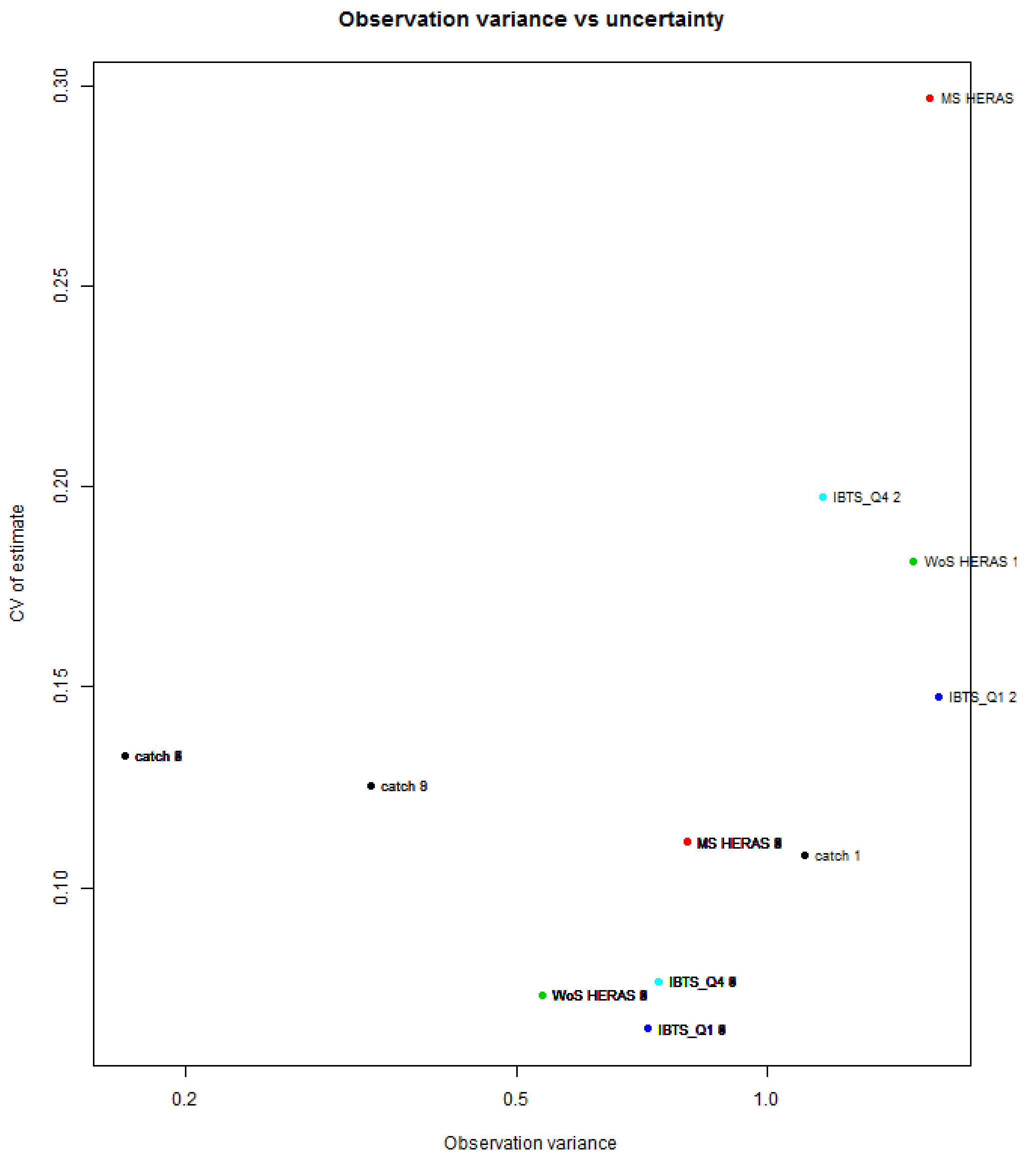


Figure 4.6.9: Herring in 6.a (combined) and 7.b and 7.c. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

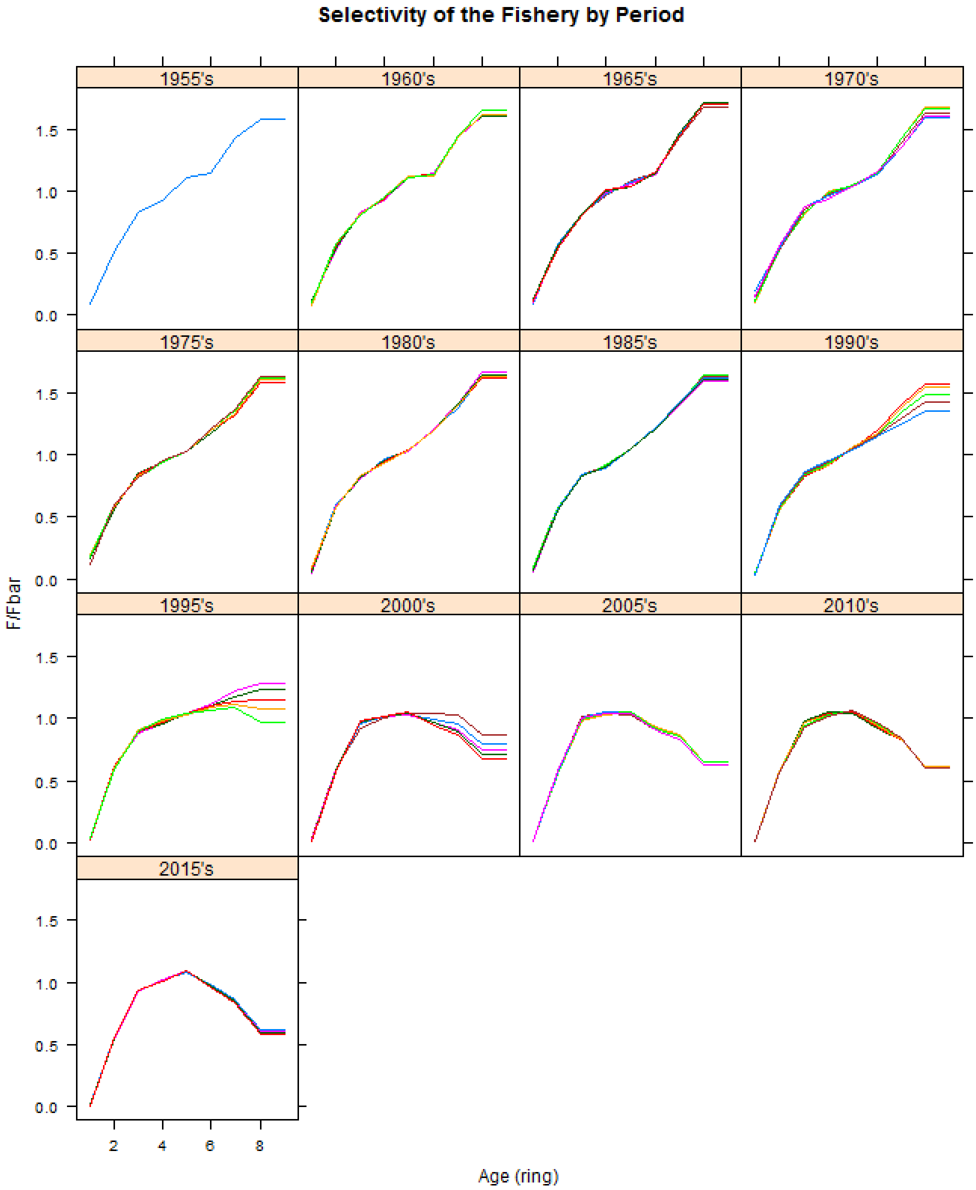


Figure 4.6.10: Herring in 6.a (combined) and 7.b and 7.c. Selectivity of the fishery at age (winter rings) by 5-year period.

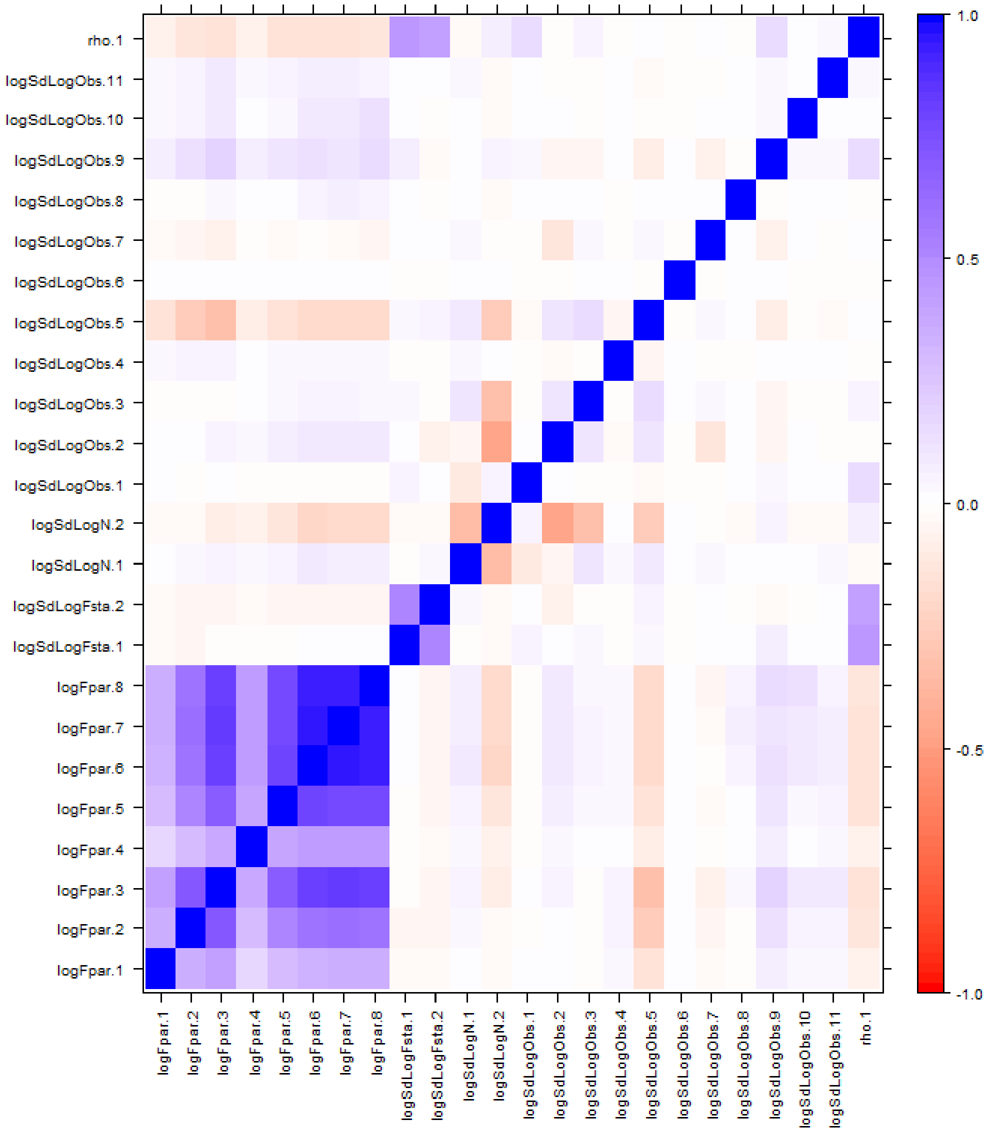


Figure 4.6.11: Herring in 6.a (combined) and 7.b and 7.c. Correlation plot of the parameters estimated in the model. The horizontal and vertical axes show the parameters fitted by the model (labelled with names stored and fitted by FLSAM). The colouring of each pixel indicates the Pearson correlation between the two parameters. The diagonal represents the correlation with the data source itself.

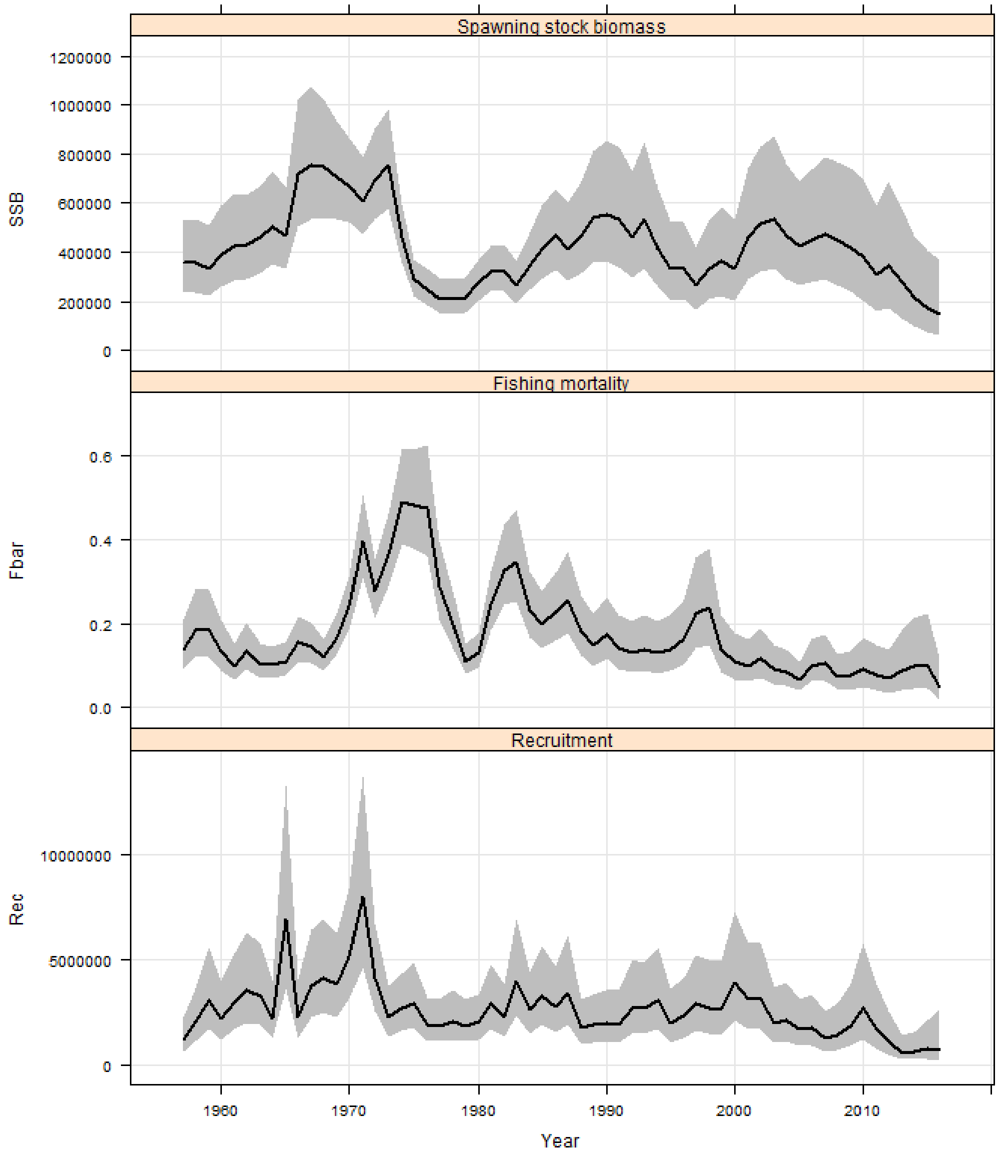


Figure 4.6.12: Herring in 6.a (combined) and 7.b and 7.c. Stock summary plot with associated uncertainty for SSB (top panel), F ages 2–6 (middle panel) and recruitment (bottom panel).

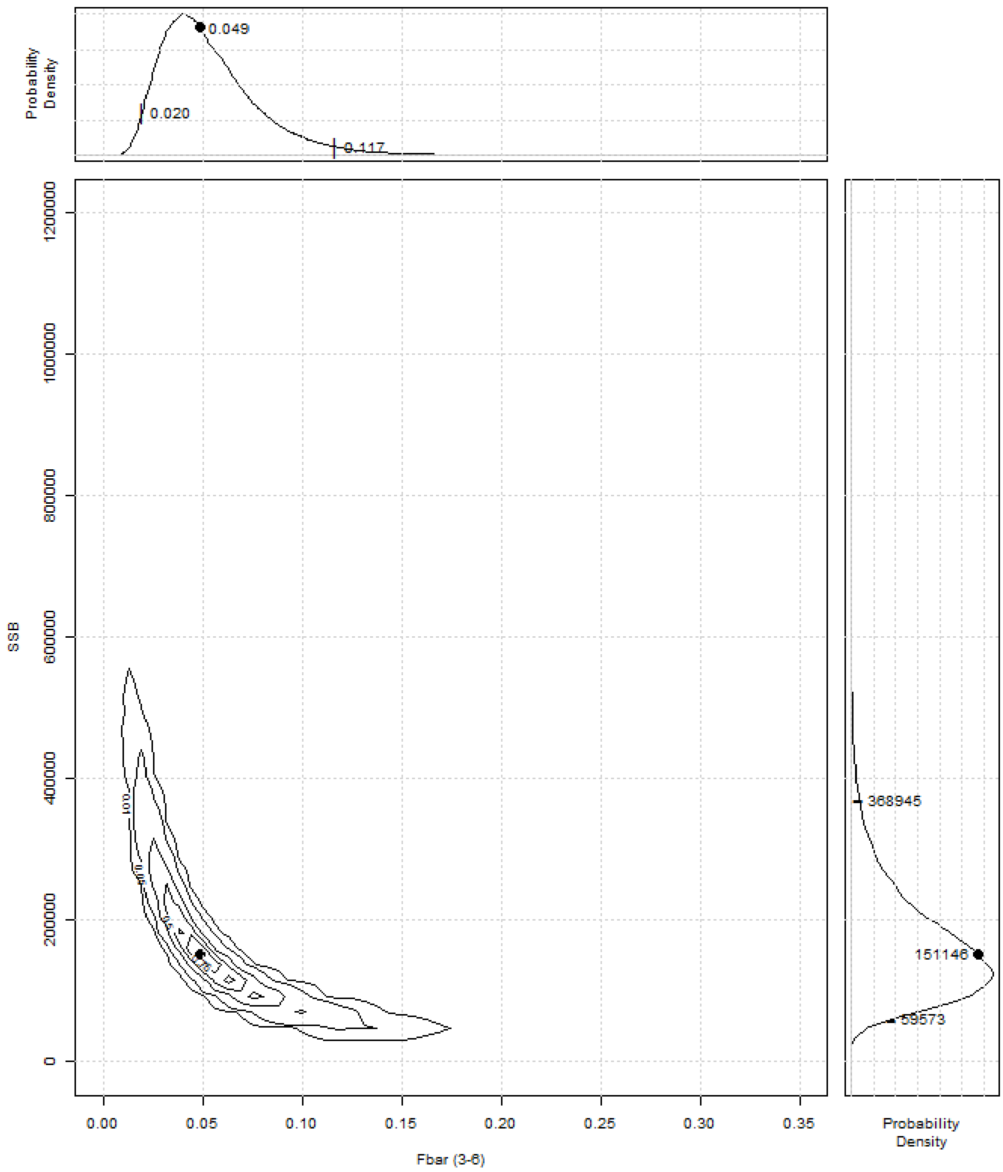


Figure 4.6.13: Herring in 6.a (combined) and 7.b and 7.c. Model uncertainty; distribution and quantiles of estimated SSB and F3–6 in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the model estimated variance/covariance estimates.

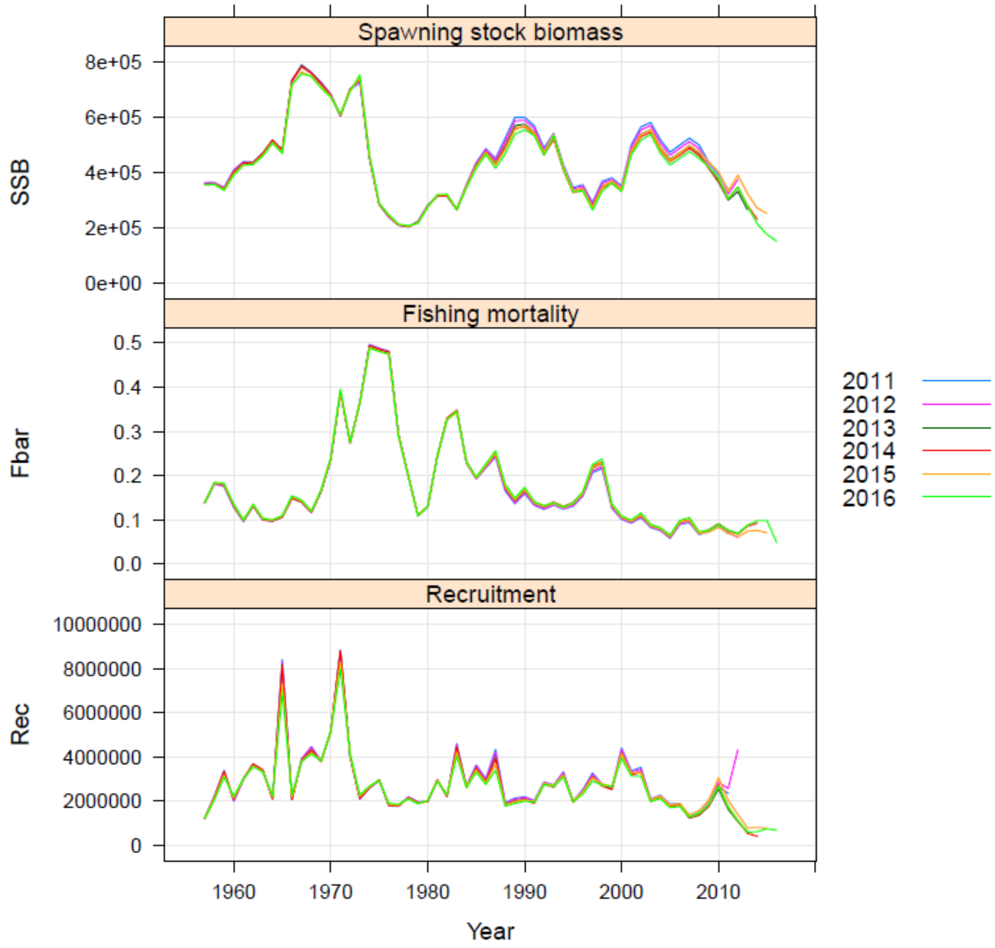


Figure 4.6.14: Herring in 6.a (combined) and 7.b and 7.c. Analytical retrospective of the estimated spawning stock biomass (top panel), fishing mortality (middle panel) and recruitment (bottom panel) as estimated over the years 2010–2016.

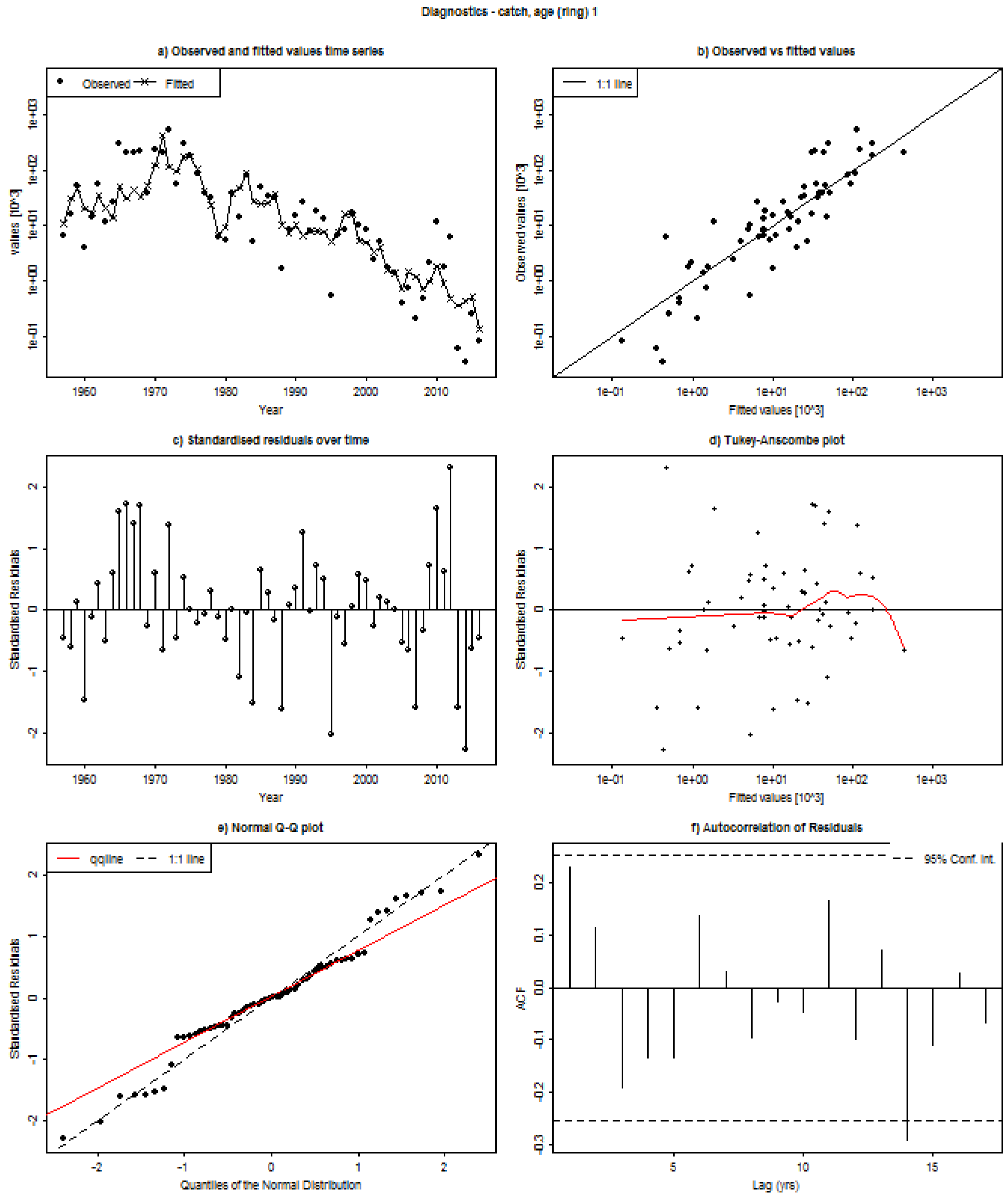


Figure 4.6.15: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 1-winter ring time series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from catch abundance at 1-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 1-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 1-winter ring. Middle right: catch observation versus standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

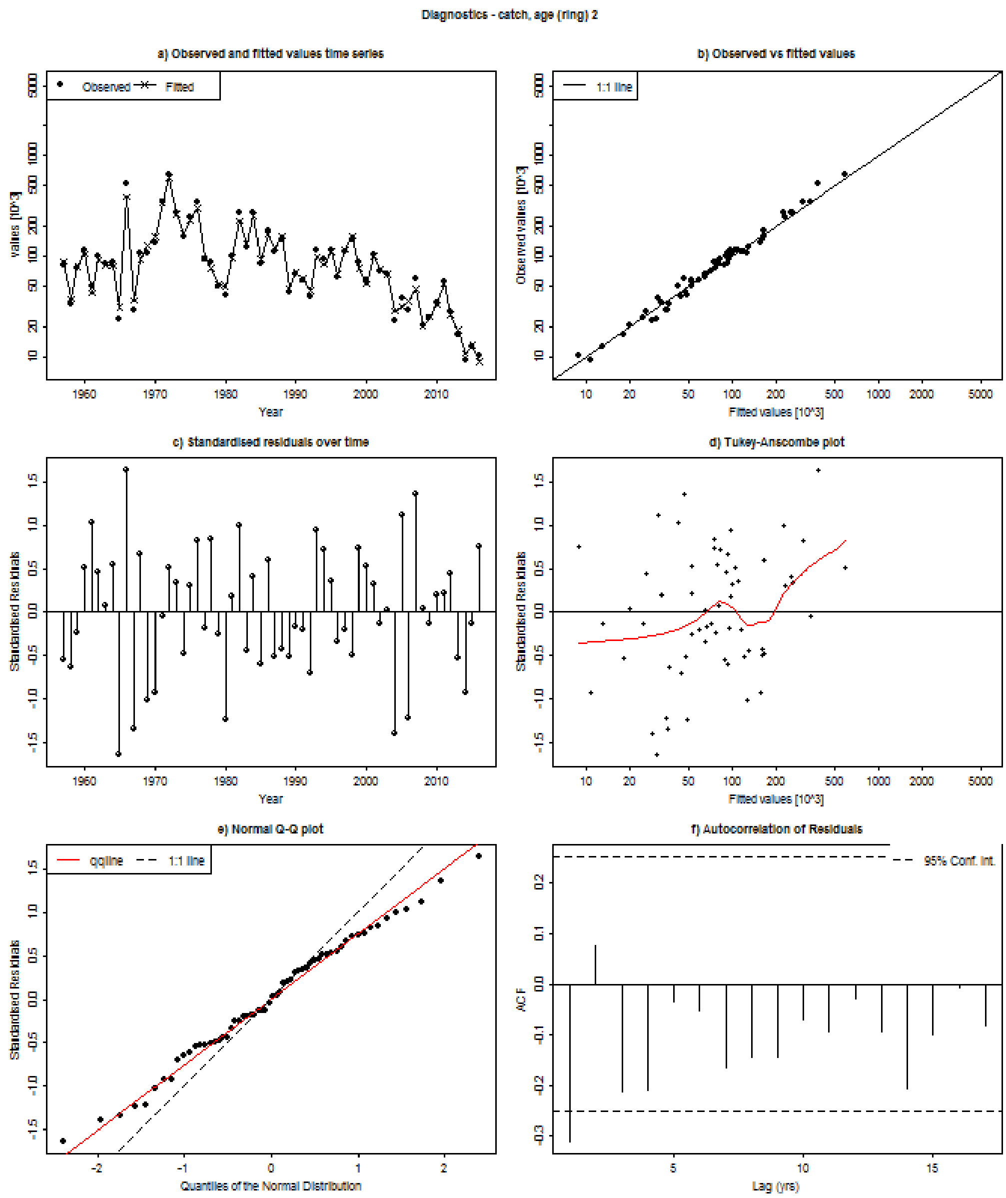


Figure 4.6.16: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 2-winter ring time series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from catch abundance at 2-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 2-winter ring. Middle right: catch observation versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

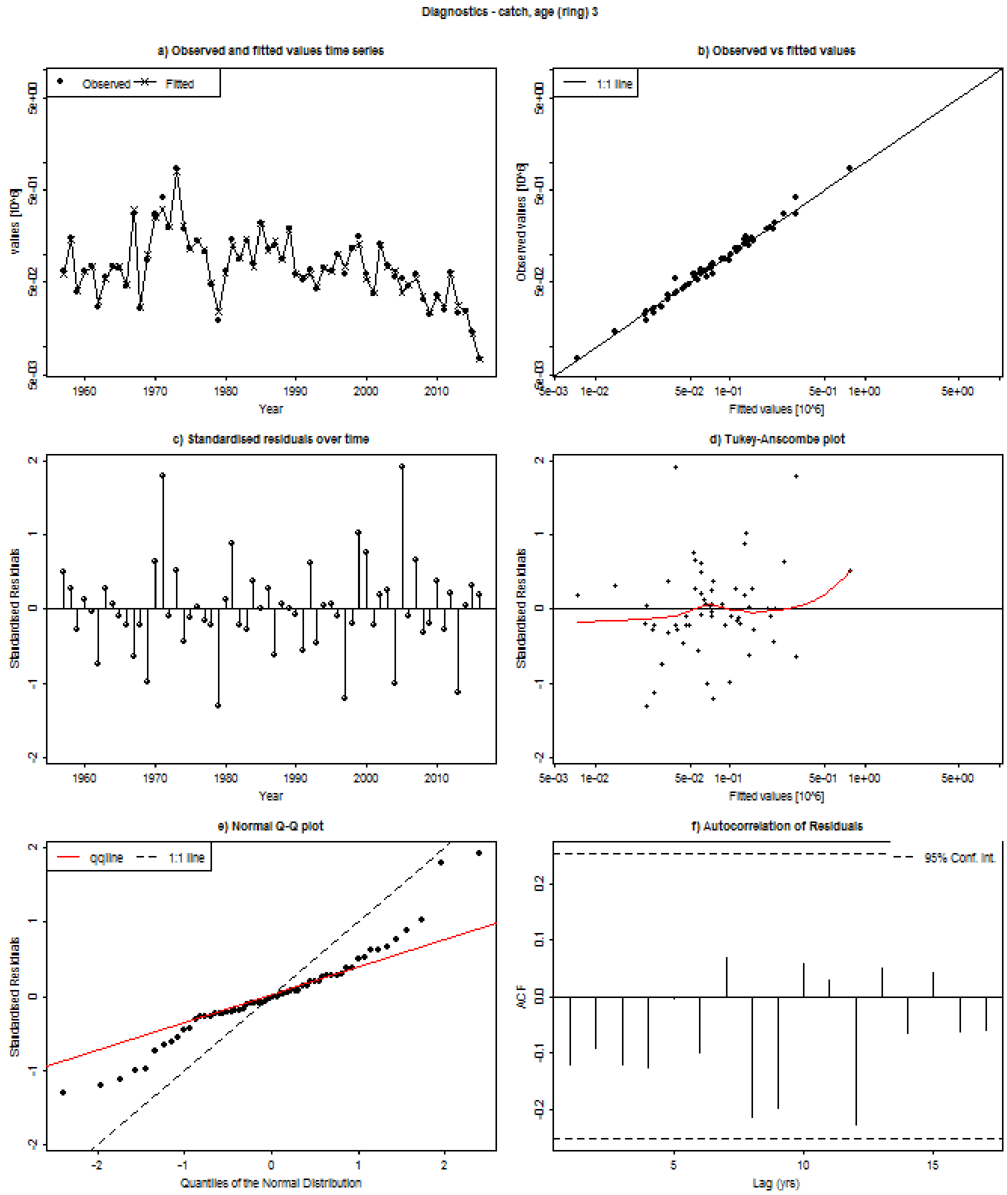


Figure 4.6.17: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 3-winter ring time series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from catch abundance at 3-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 3-winter ring. Middle right: catch observation versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

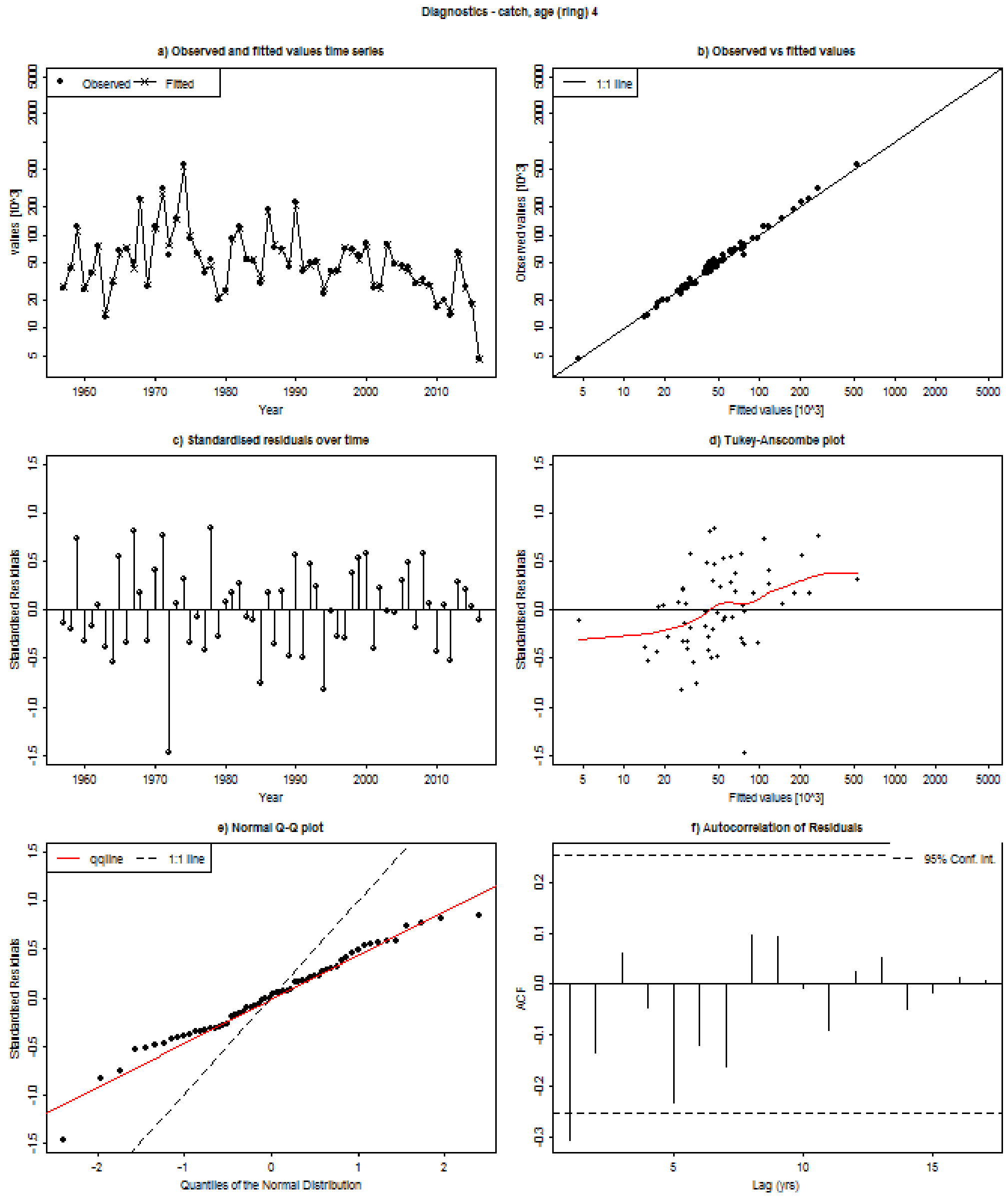


Figure 4.6.18: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 4-winter ring time series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from catch abundance at 4-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 4-winter ring. Middle right: catch observation versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

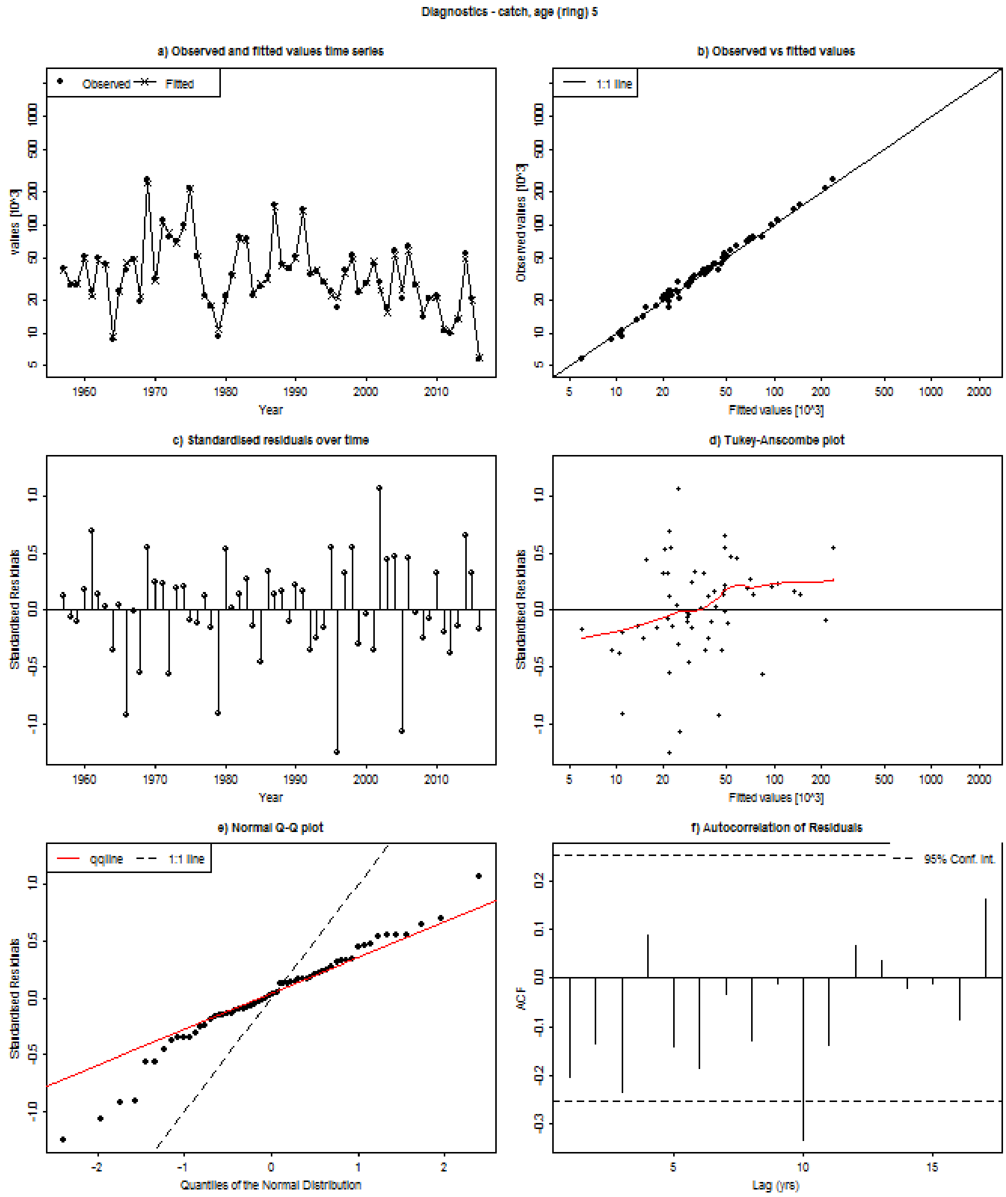


Figure 4.6.19: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 5-winter ring time series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from catch abundance at 5-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 5-winter ring. Middle right: catch observation versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

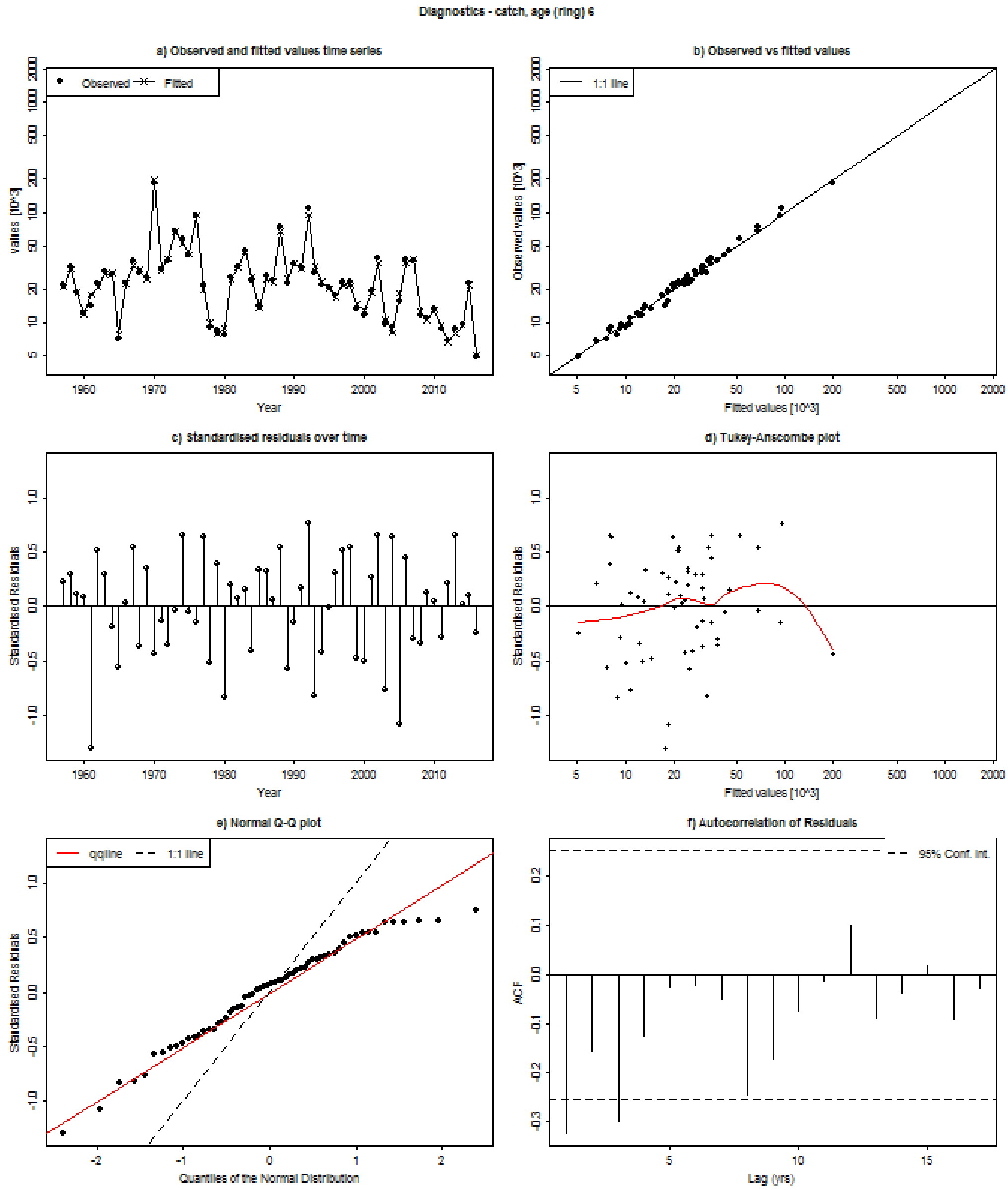


Figure 4.6.20: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 6-winter ring time series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from catch abundance at 6-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 6-winter ring. Middle right: catch observation versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

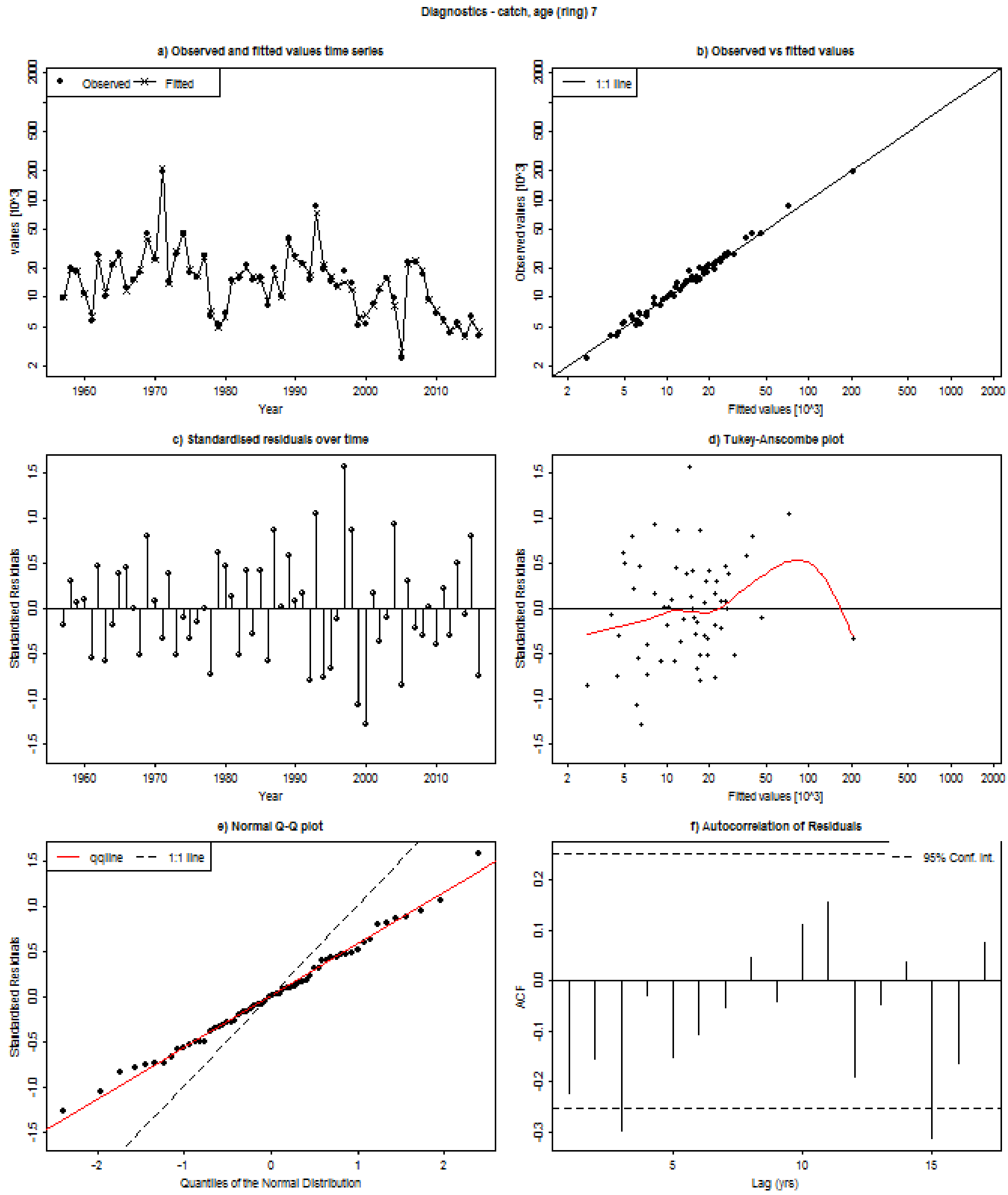


Figure 4.6.21: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 7-winter ring time series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from catch abundance at 7-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 7-winter ring. Middle right: catch observation versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

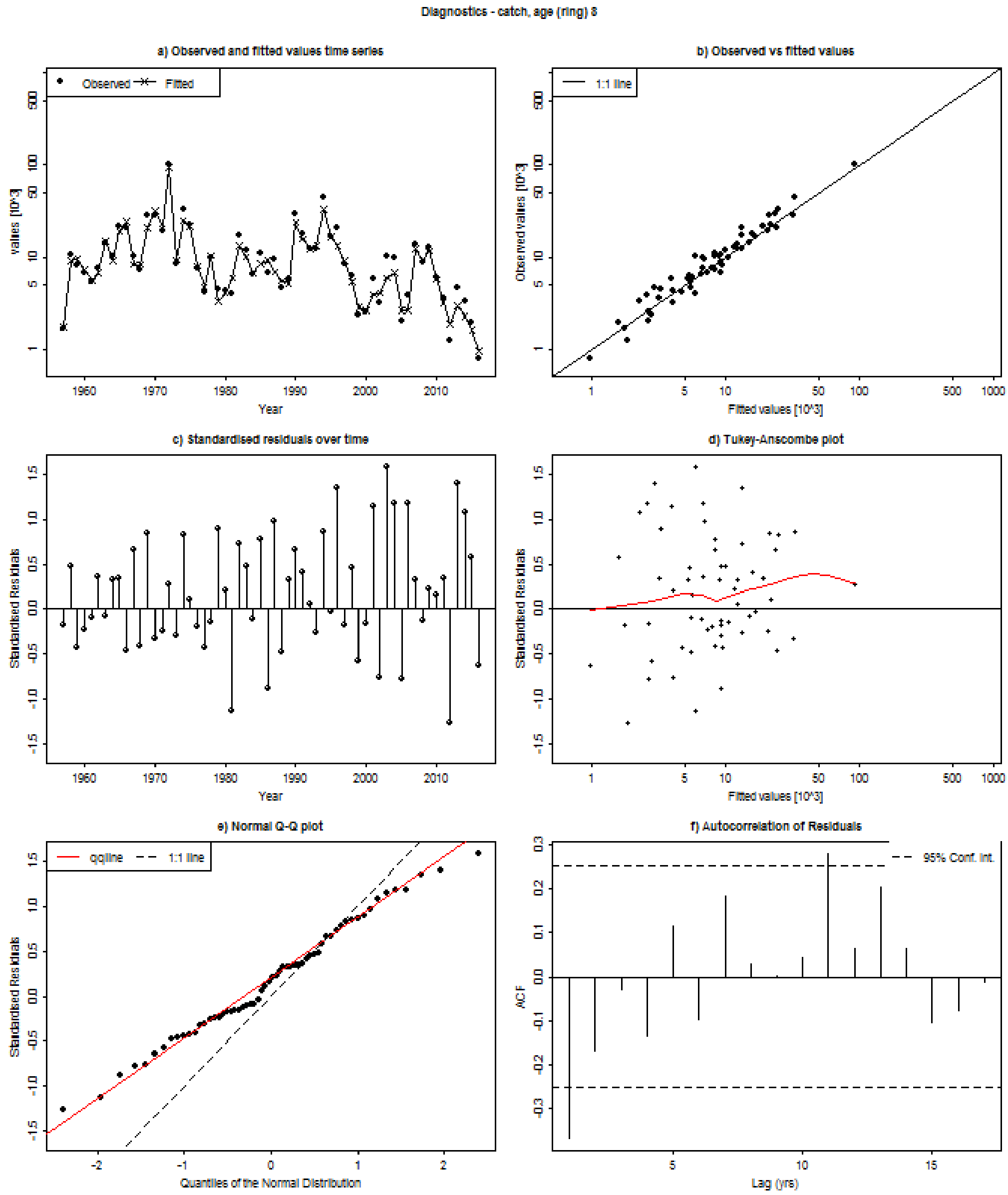


Figure 4.6.22: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 8-winter ring time series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from catch abundance at 8-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 8-winter ring. Middle right: catch observation versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

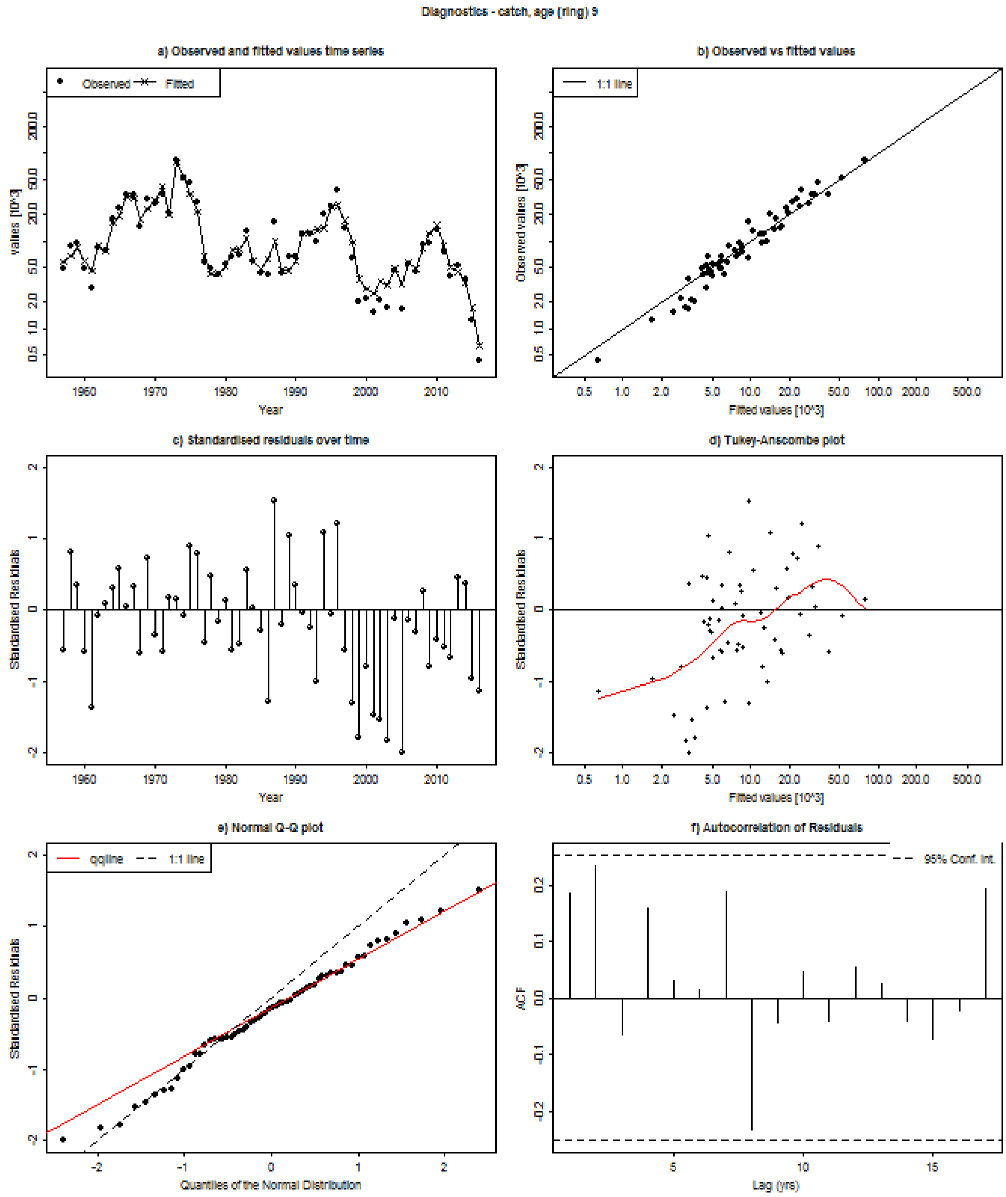


Figure 4.6.23: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the catch at 9-winter ring time series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from catch abundance at 9-winter ring. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the catch at 9-winter ring. Middle right: catch observation versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

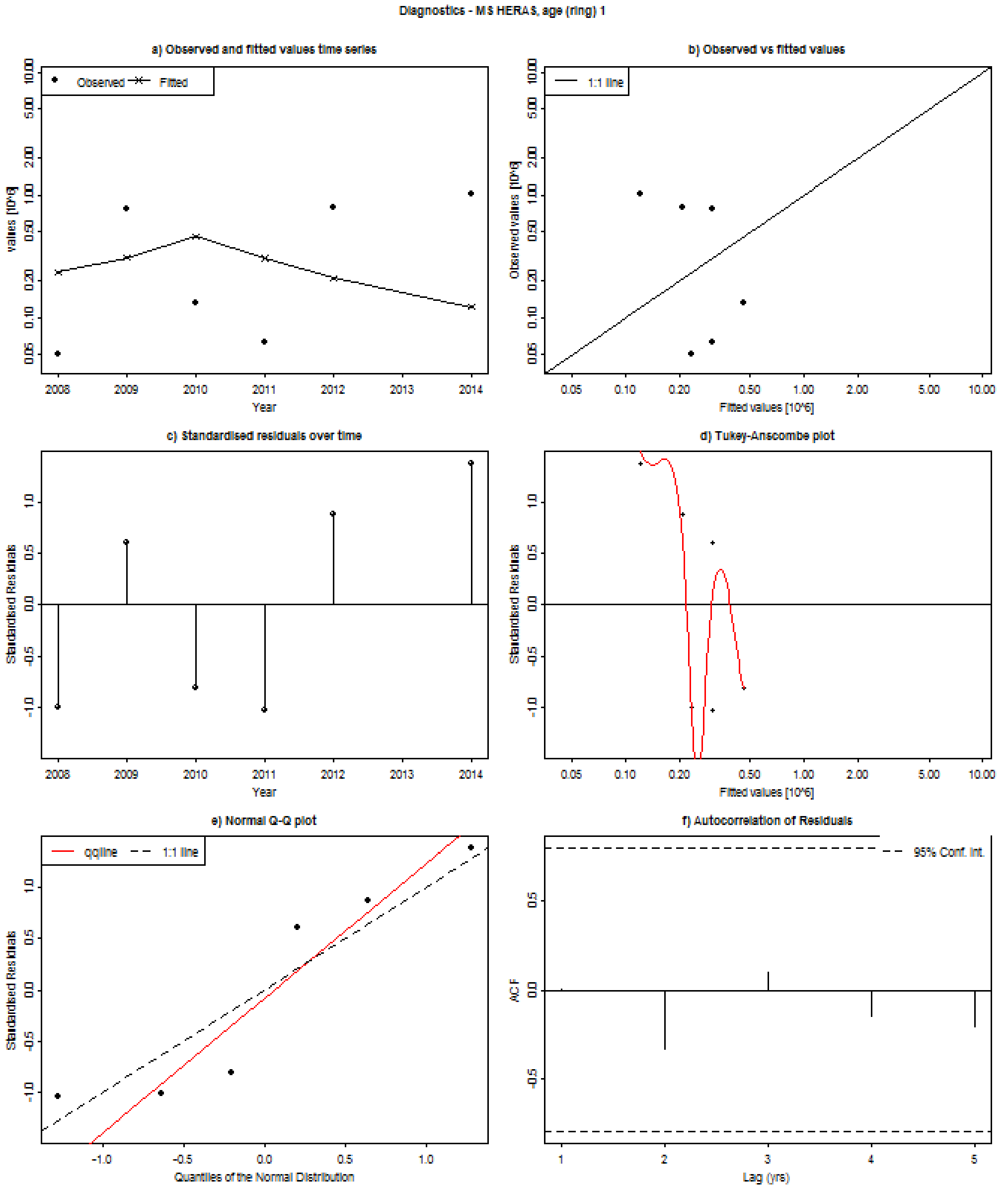


Figure 4.6.24: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 1-winter ring time series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from index abundance at 1-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 1-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 1-winter ring. Middle right: index observation versus standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot. There were no observations of 1 winter ring fish in this survey in 2015 and 2016, therefore the figure stops at 2014.

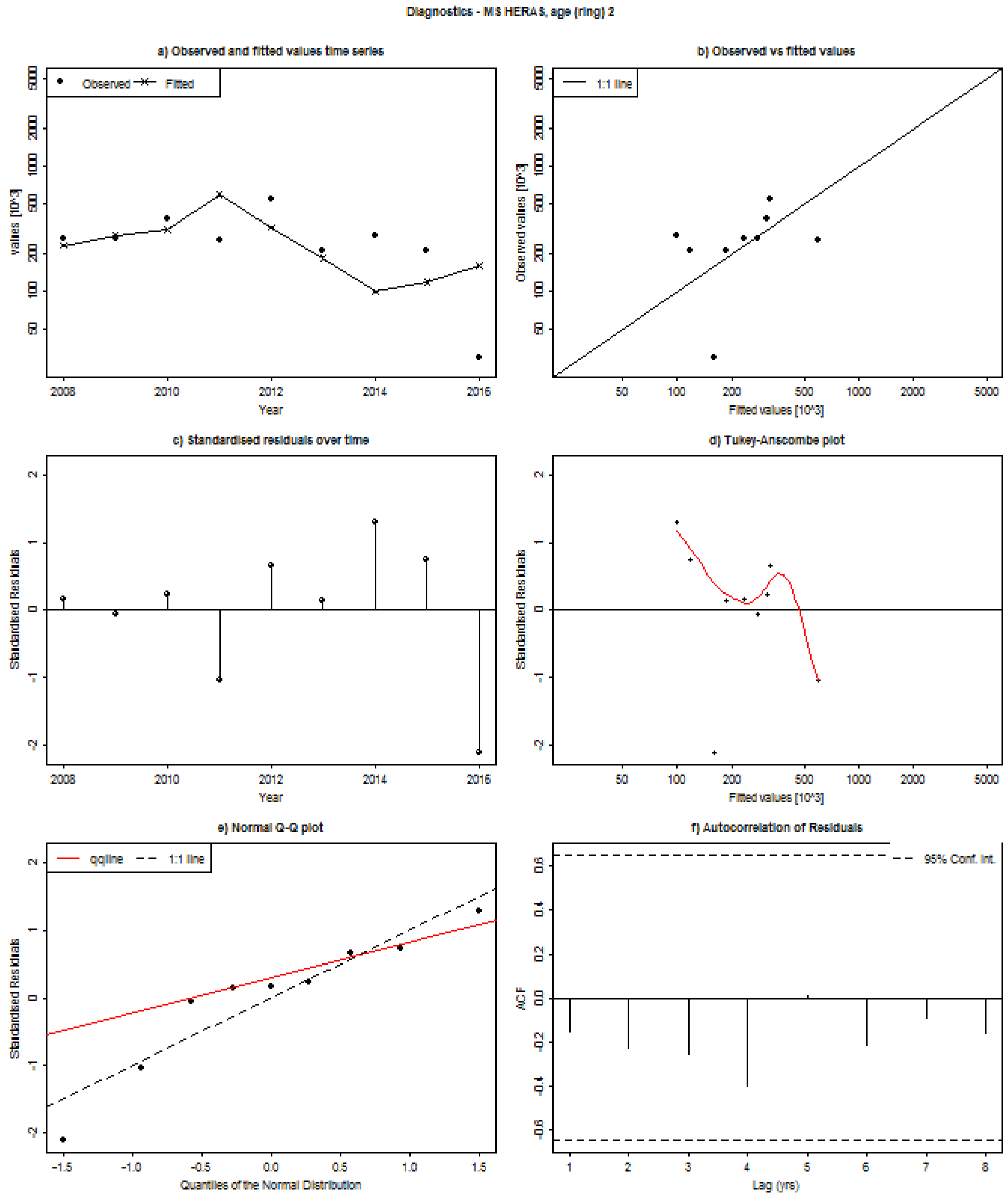


Figure 4.6.25: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 2-winter ring time series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 2-winter ring. Middle right: index observation versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

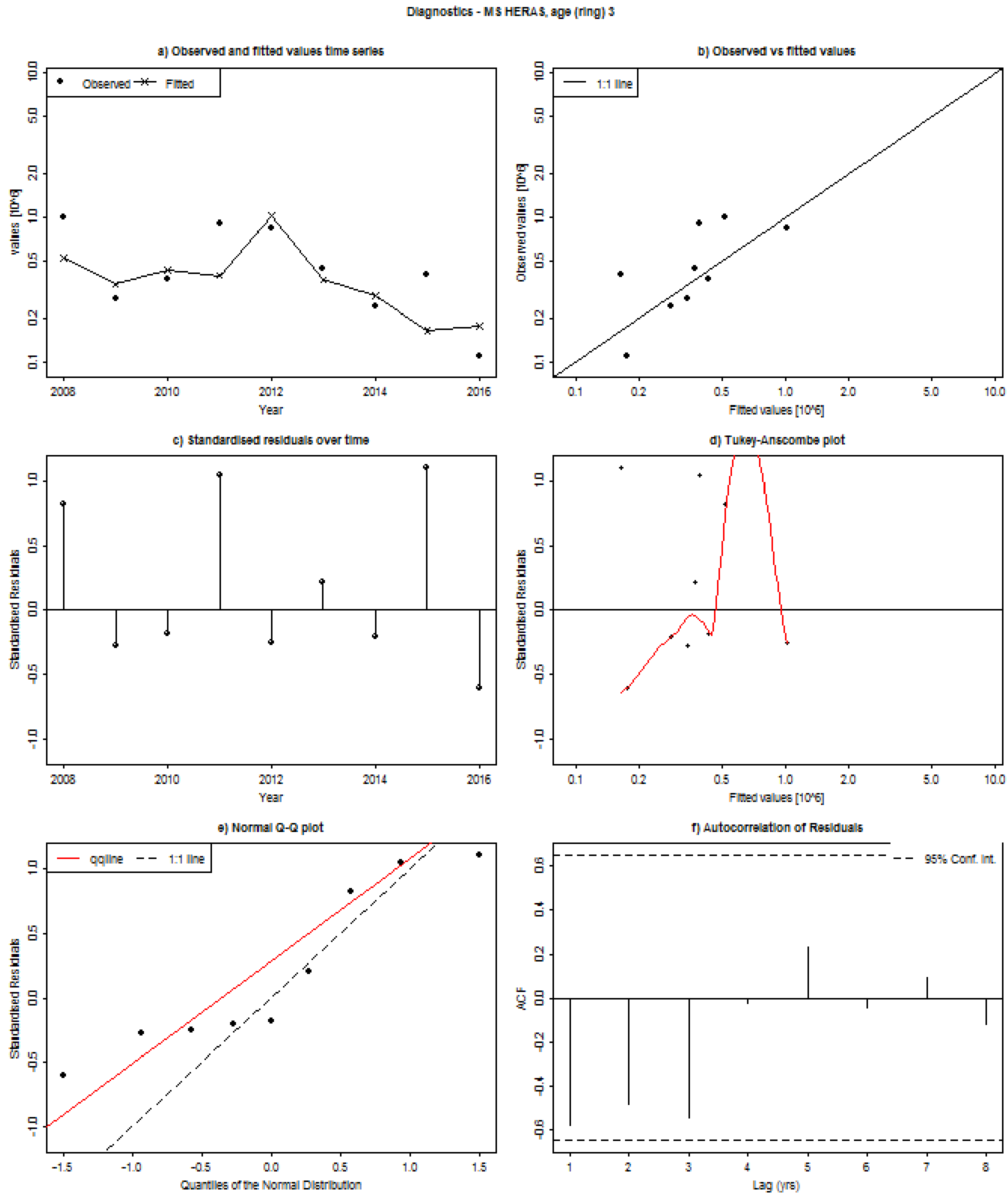


Figure 4.6.26: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 3-winter ring time series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 3-winter ring. Middle right: index observation versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

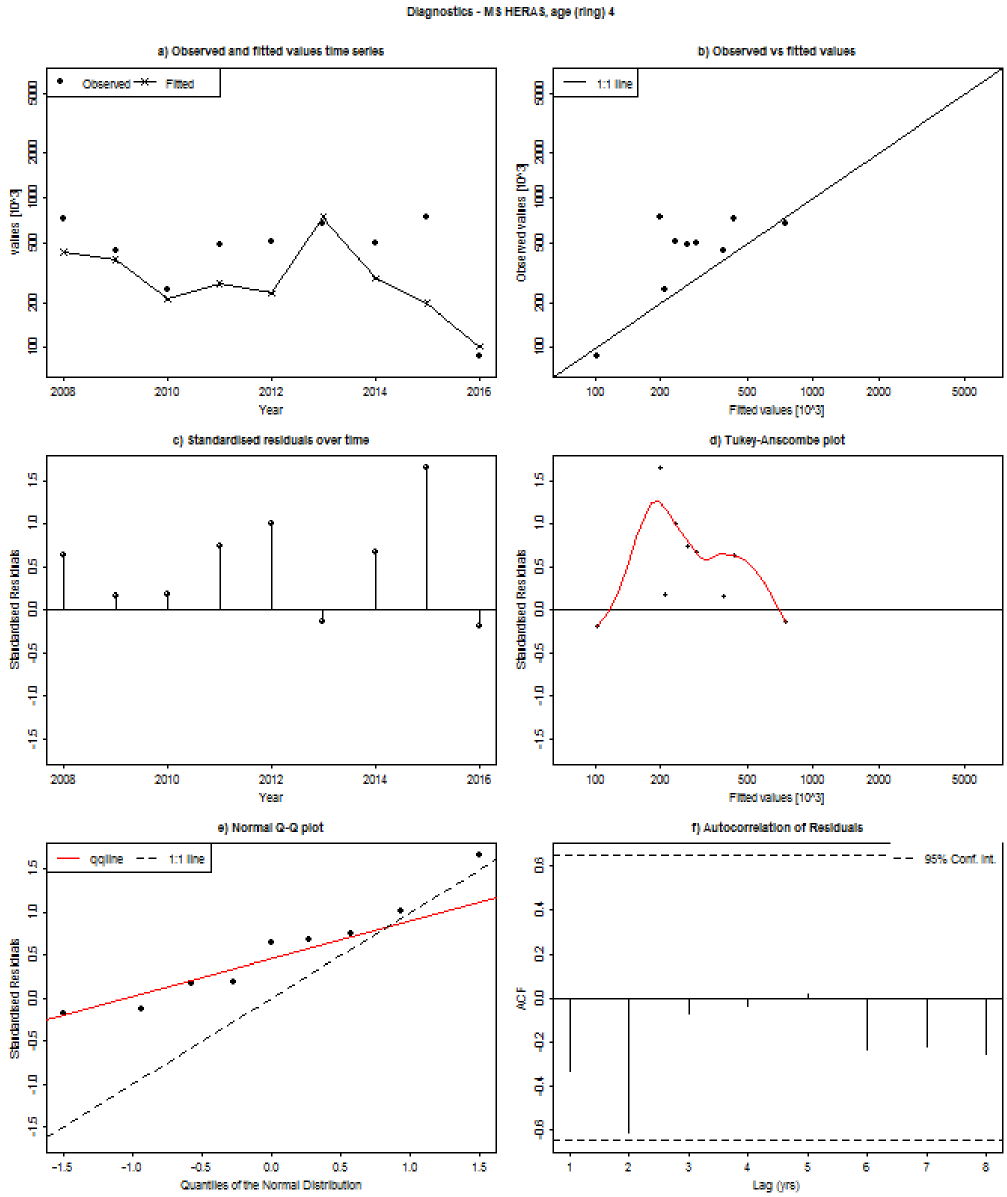


Figure 4.6.27: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 4-winter ring time series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 4-winter ring. Middle right: index observation versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

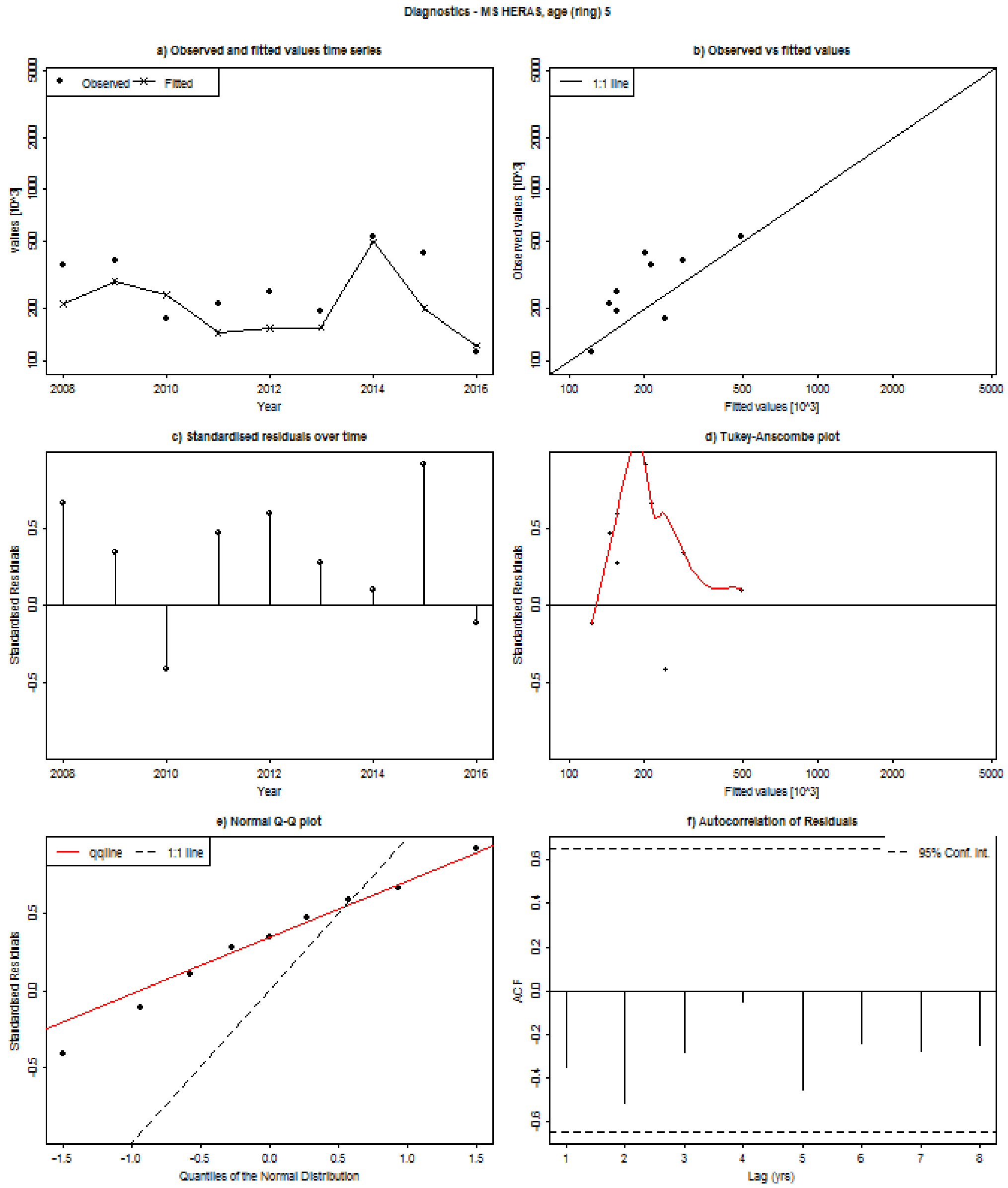


Figure 4.6.28: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 5-winter ring time series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 5-winter ring. Middle right: index observation versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

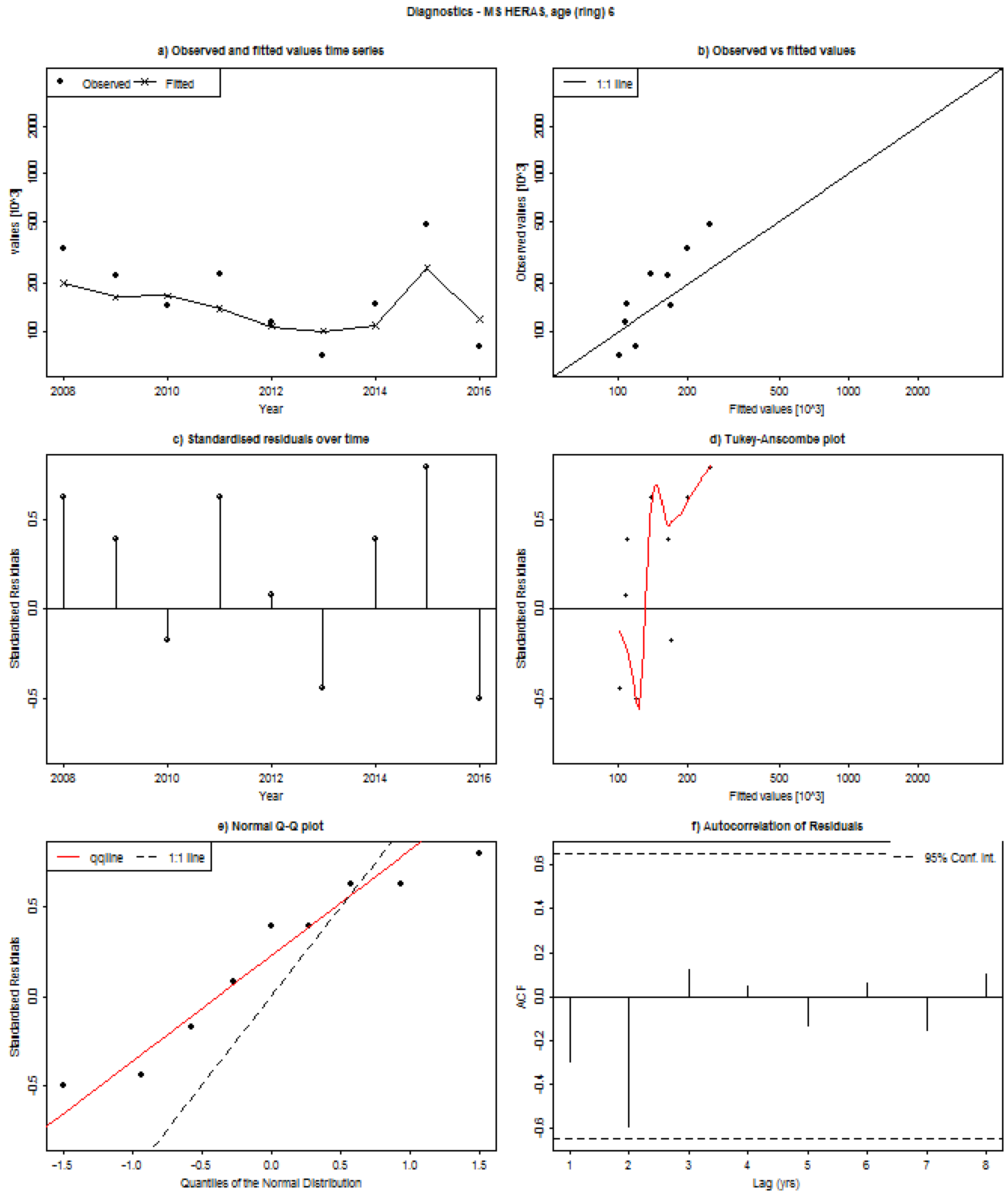


Figure 4.6.29: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 6-winter ring time series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 6-winter ring. Middle right: index observation versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

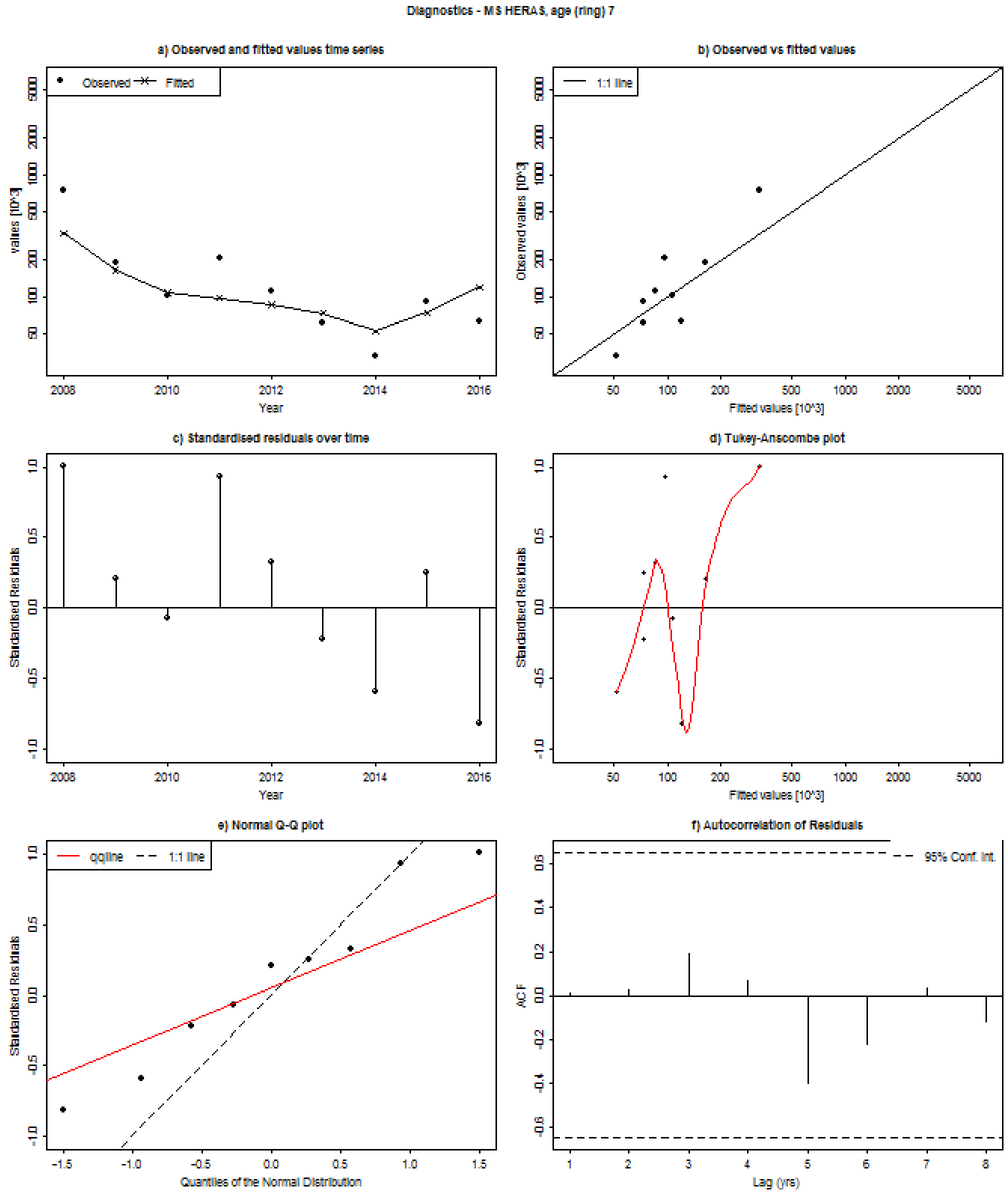


Figure 4.6.30: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 7-winter ring time series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 7-winter ring. Middle right: index observation versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

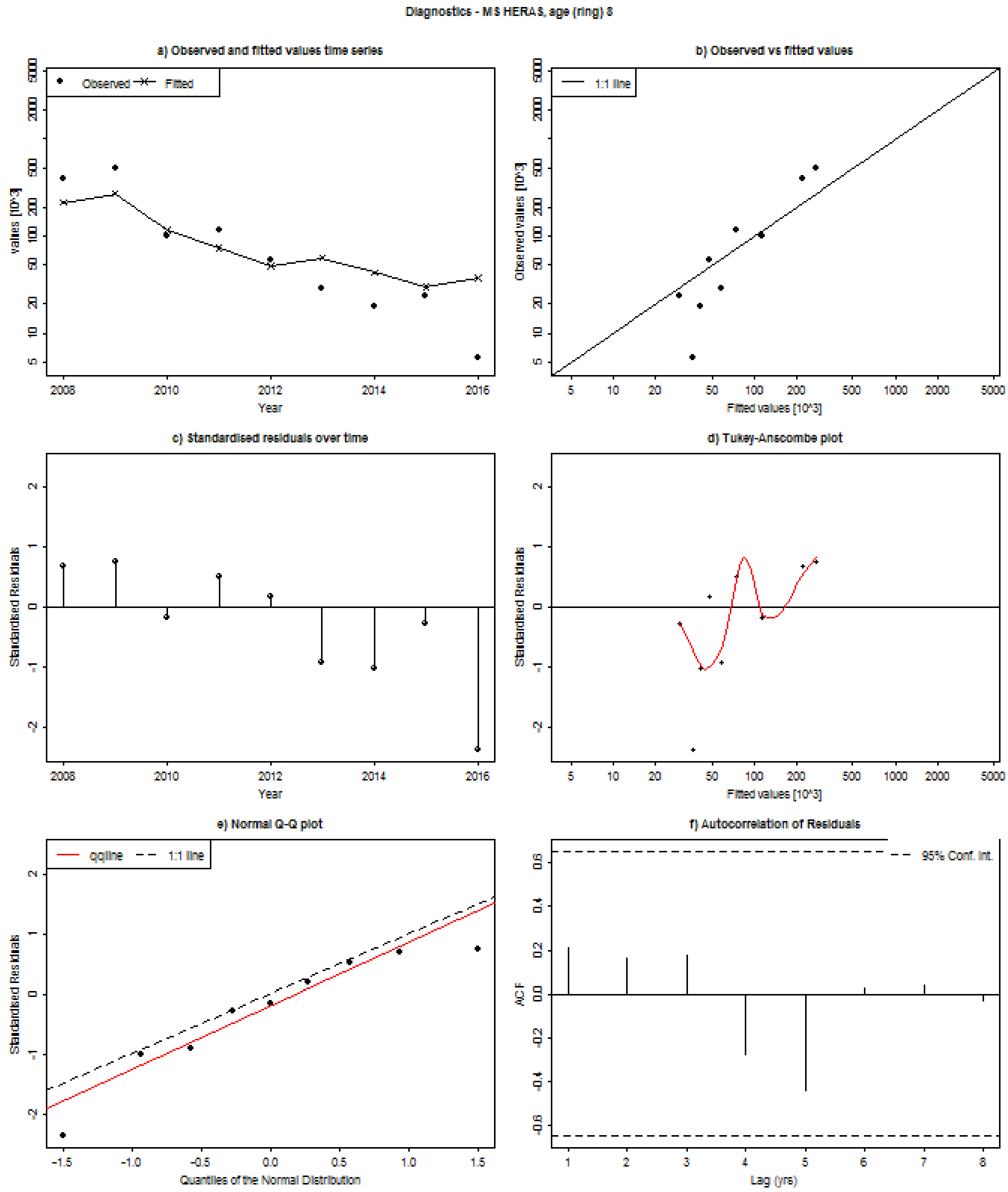


Figure 4.6.31: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 8-winter ring time series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 8-winter ring. Middle right: index observation versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

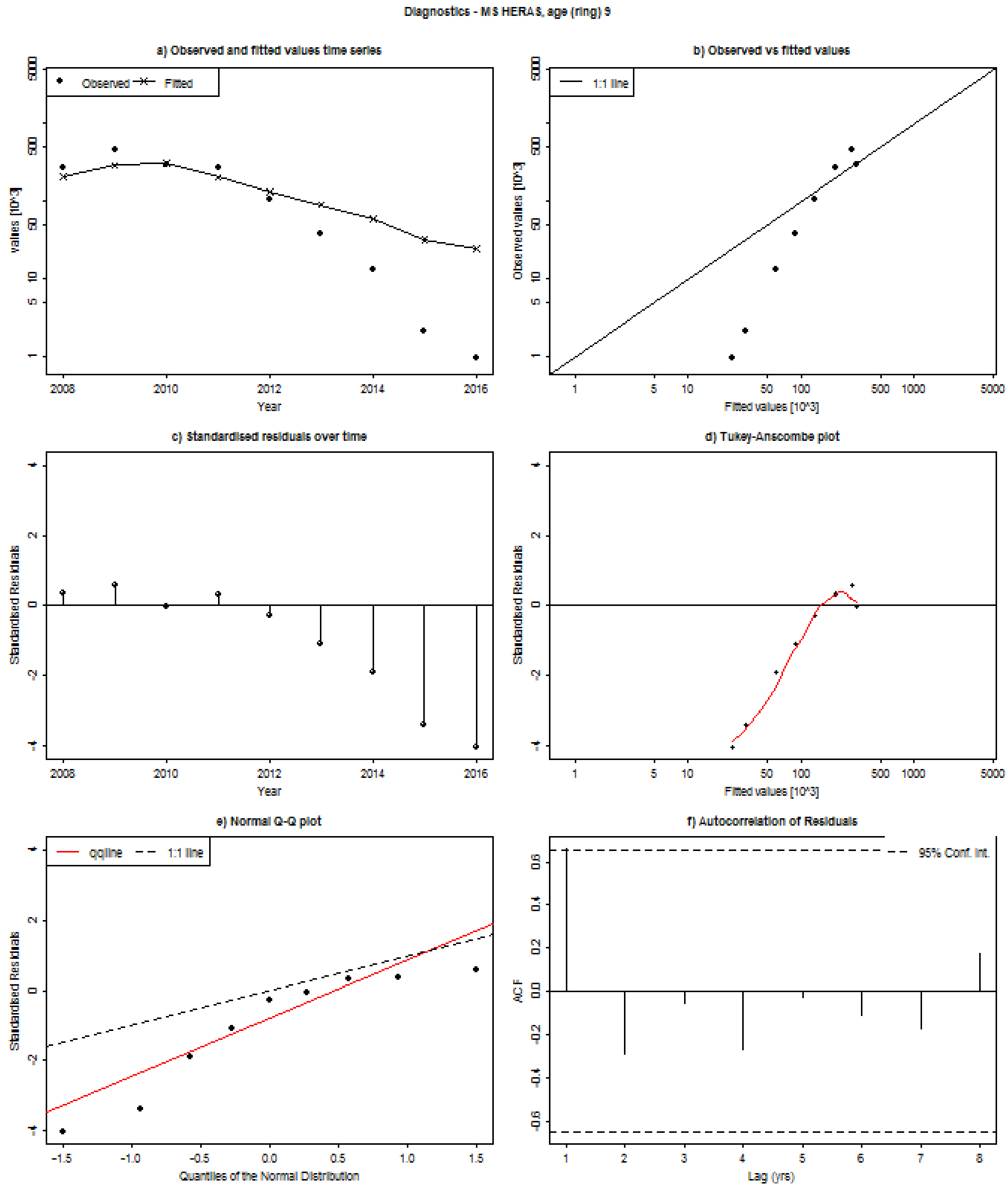


Figure 4.6.32: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Malin Shelf acoustic survey index at 9-winter ring time series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 9-winter ring. Middle right: index observation versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

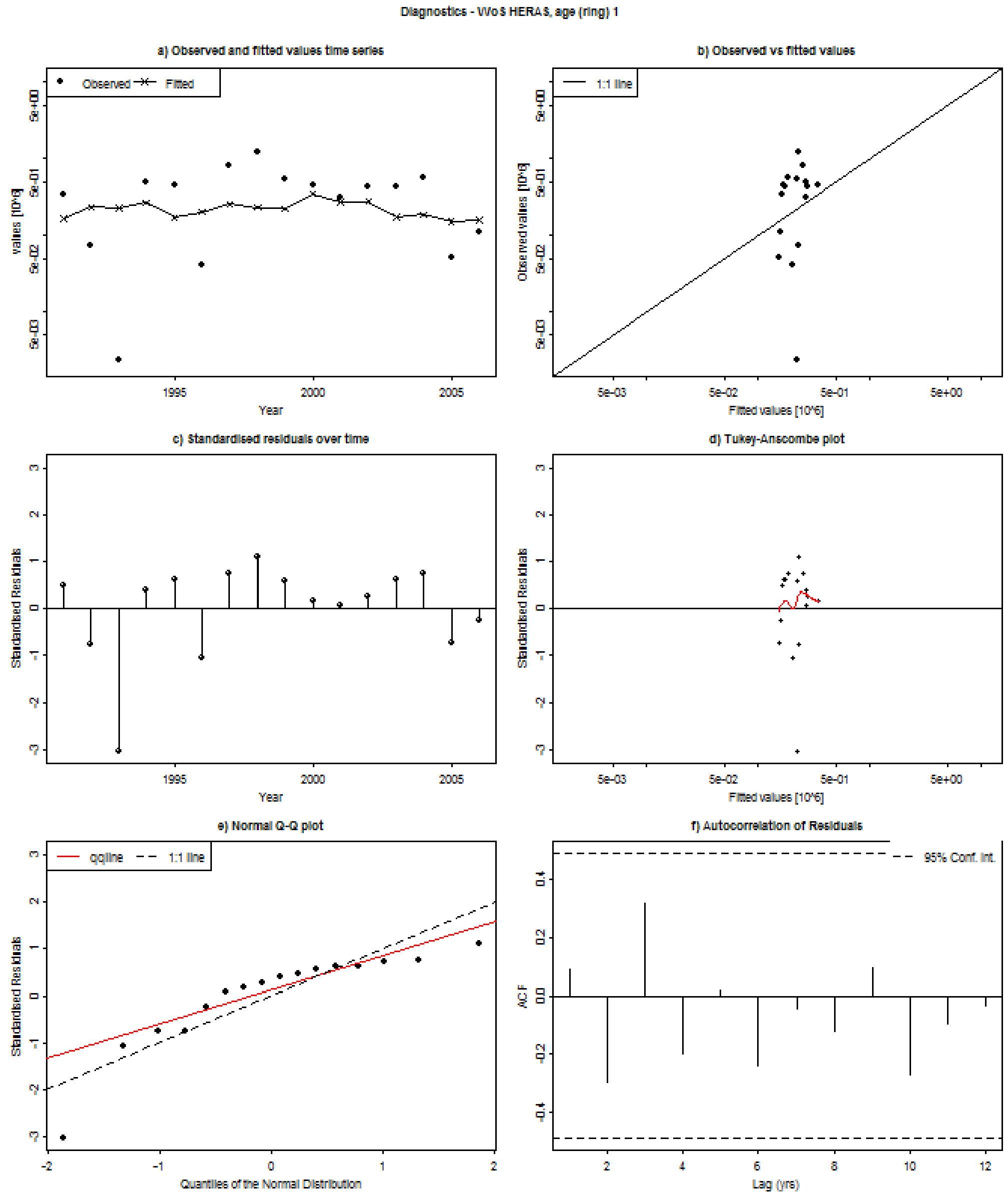


Figure 4.6.33: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 1-winter ring time series. Top left: Estimates of numbers at 1-winter ring (line) and numbers predicted from index abundance at 1-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 1-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 1-winter ring. Middle right: index observation versus standardized residuals at 1-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

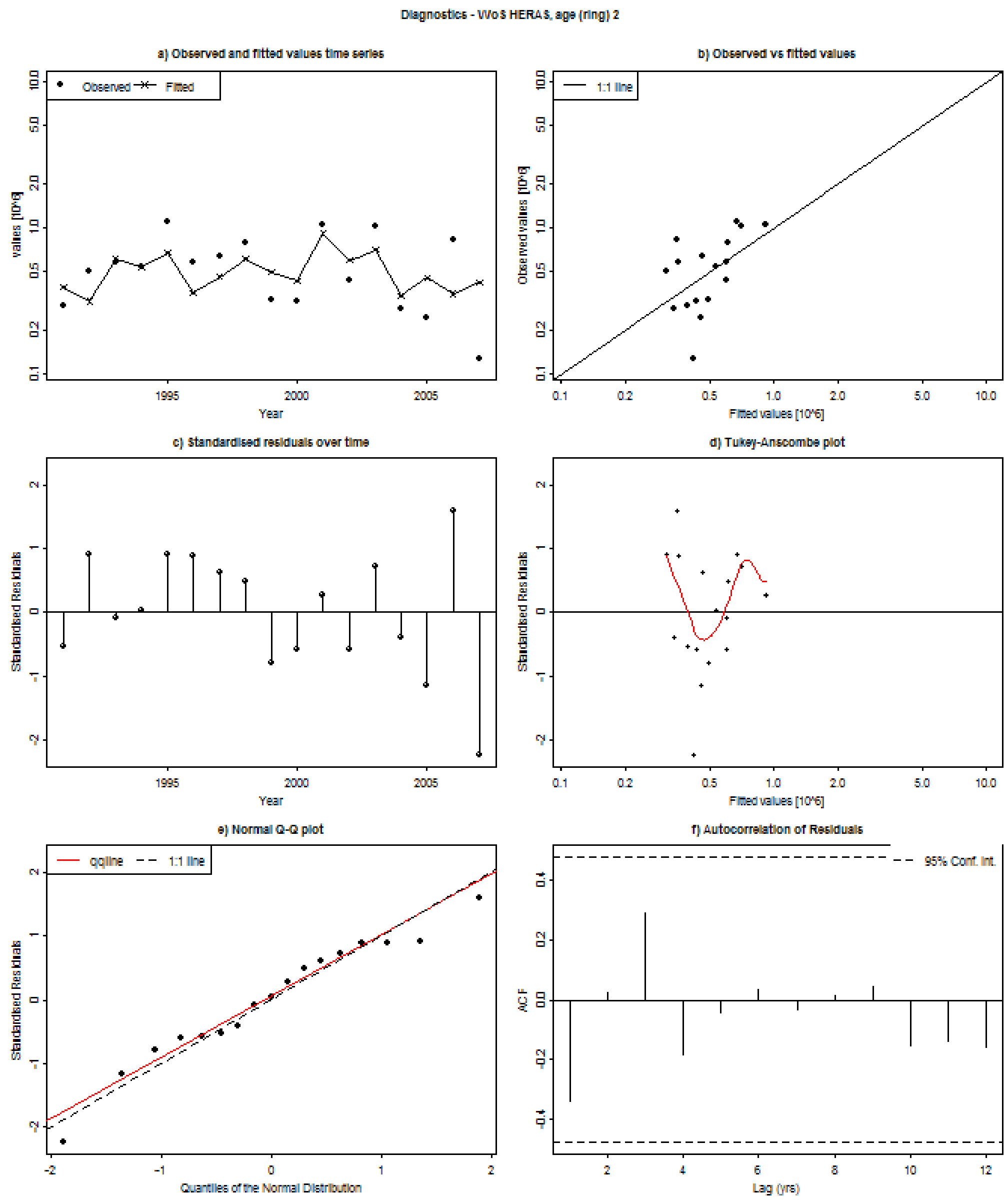


Figure 4.6.34: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 2-winter ring time series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 2-winter ring. Middle right: index observation versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

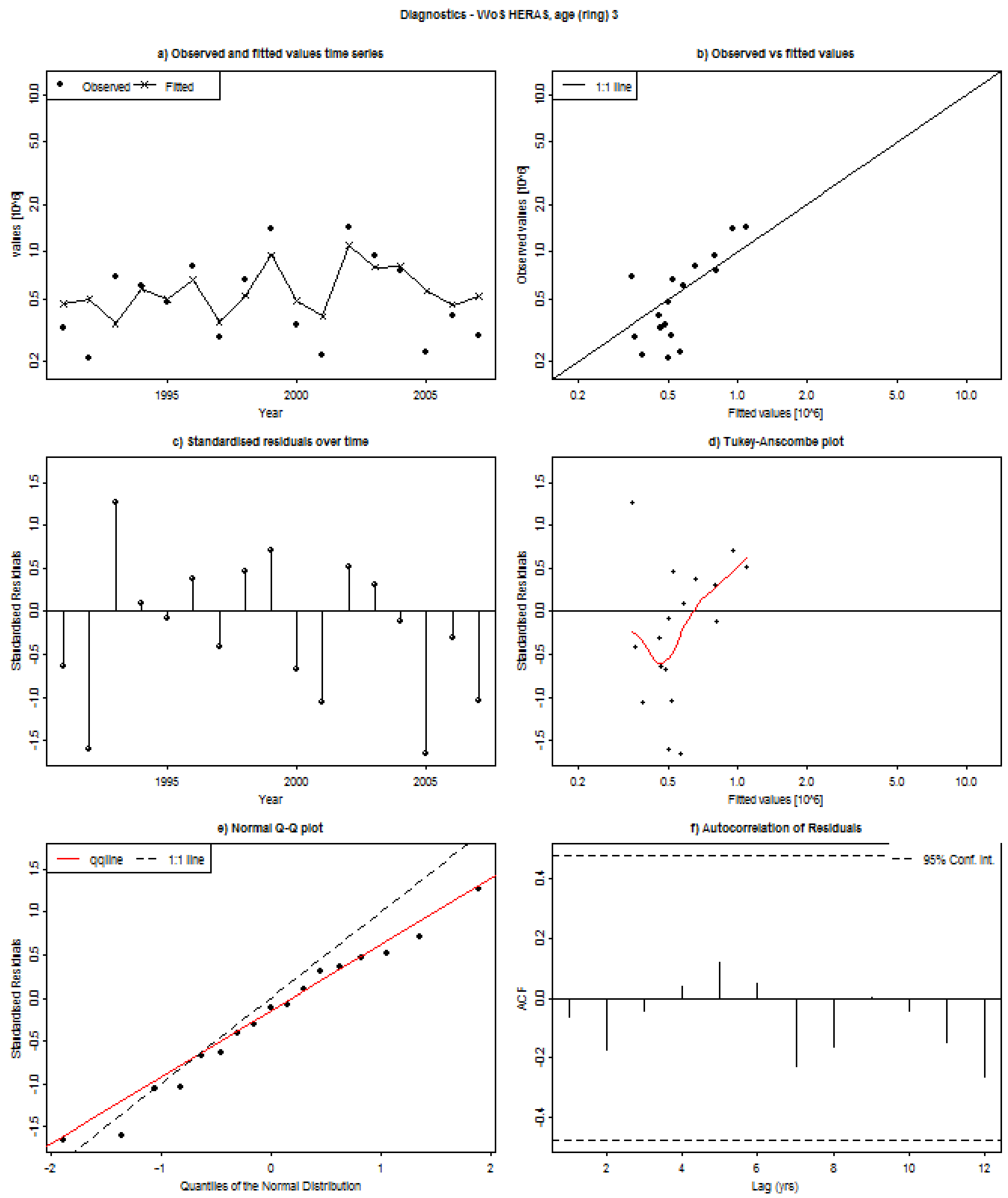


Figure 4.6.35: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 3-winter ring time series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 3-winter ring. Middle right: index observation versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

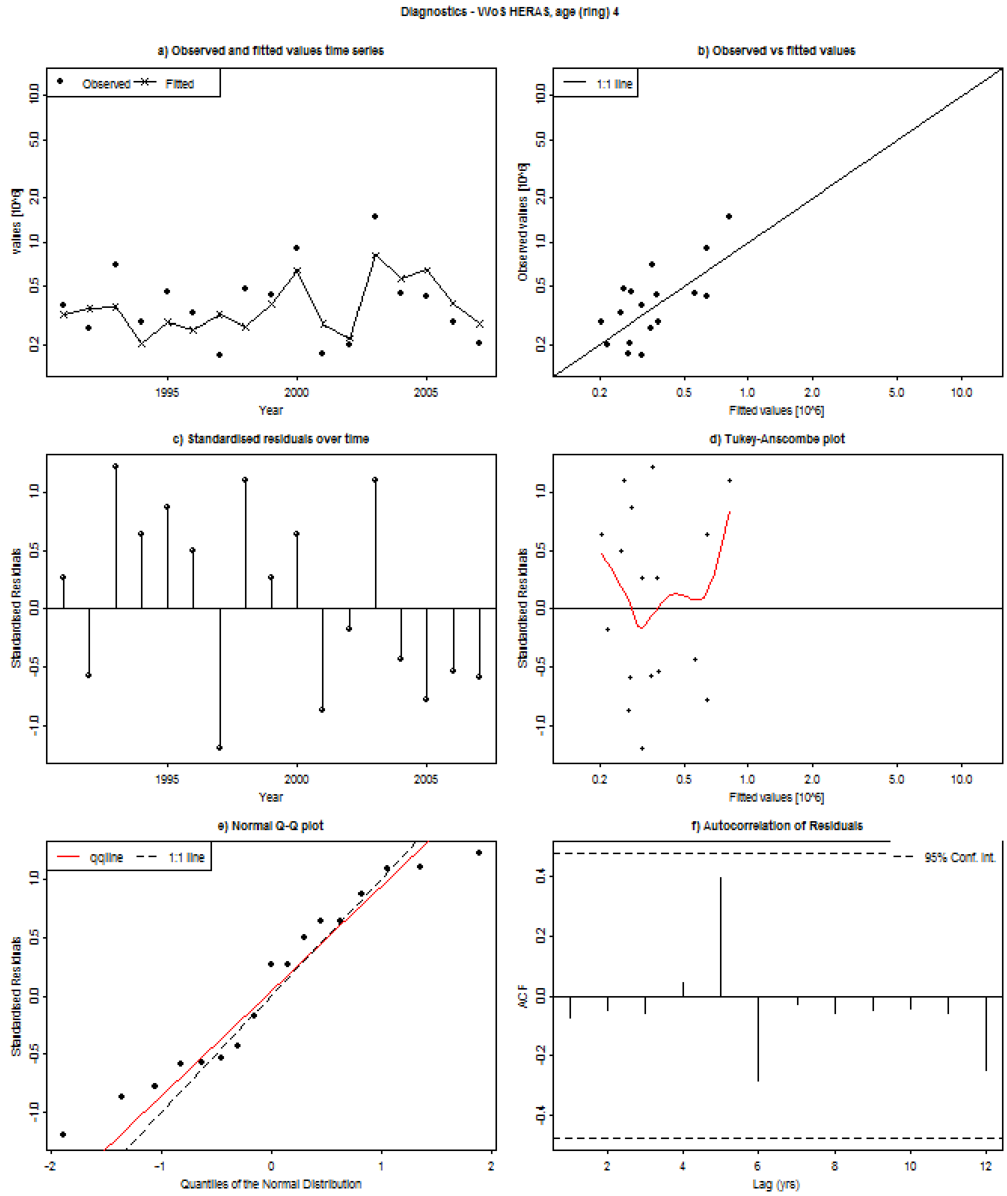


Figure 4.6.36: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 4-winter ring time series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 4-winter ring. Middle right: index observation versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

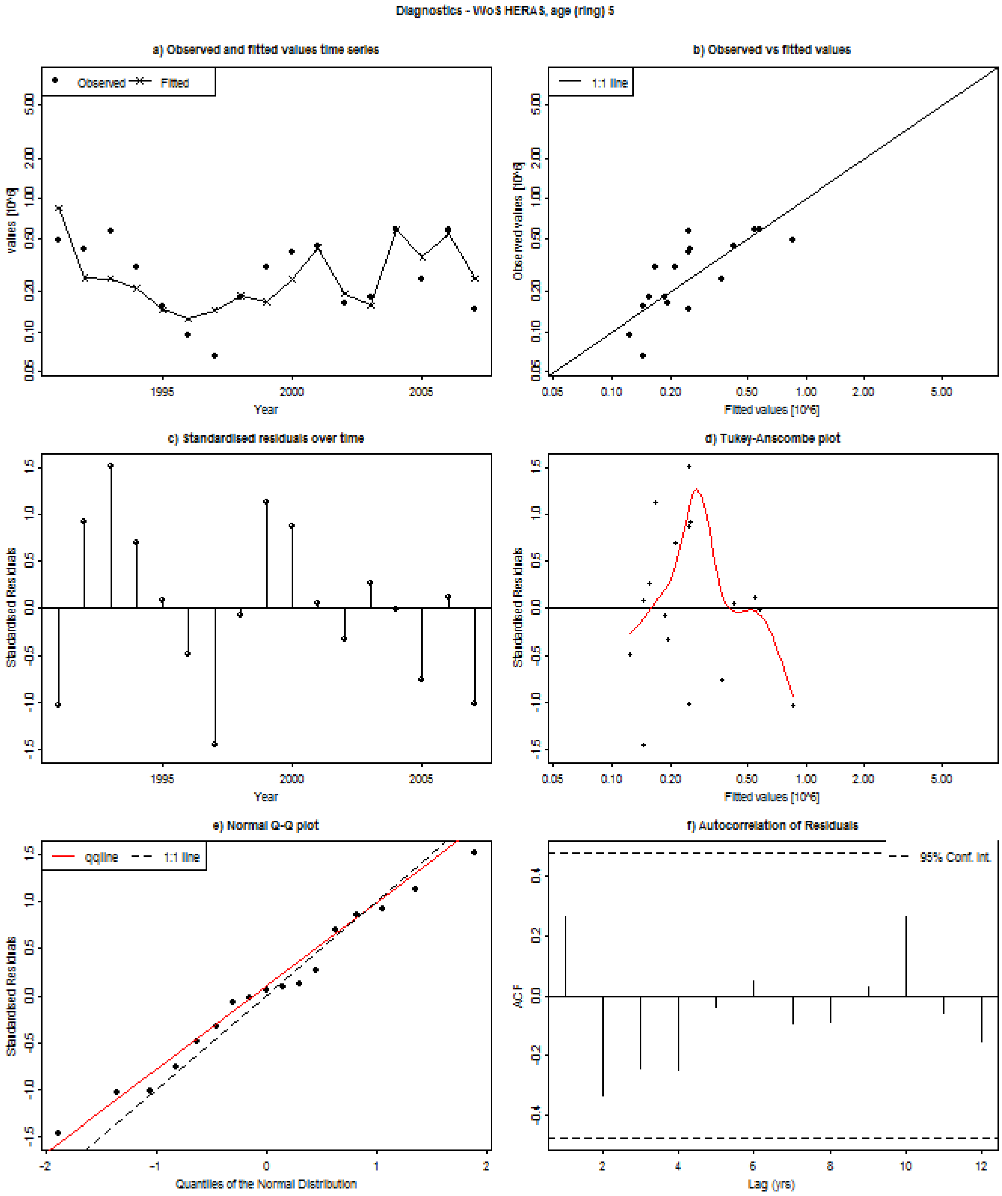


Figure 4.6.37: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 5-winter ring time series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 5-winter ring. Middle right: index observation versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

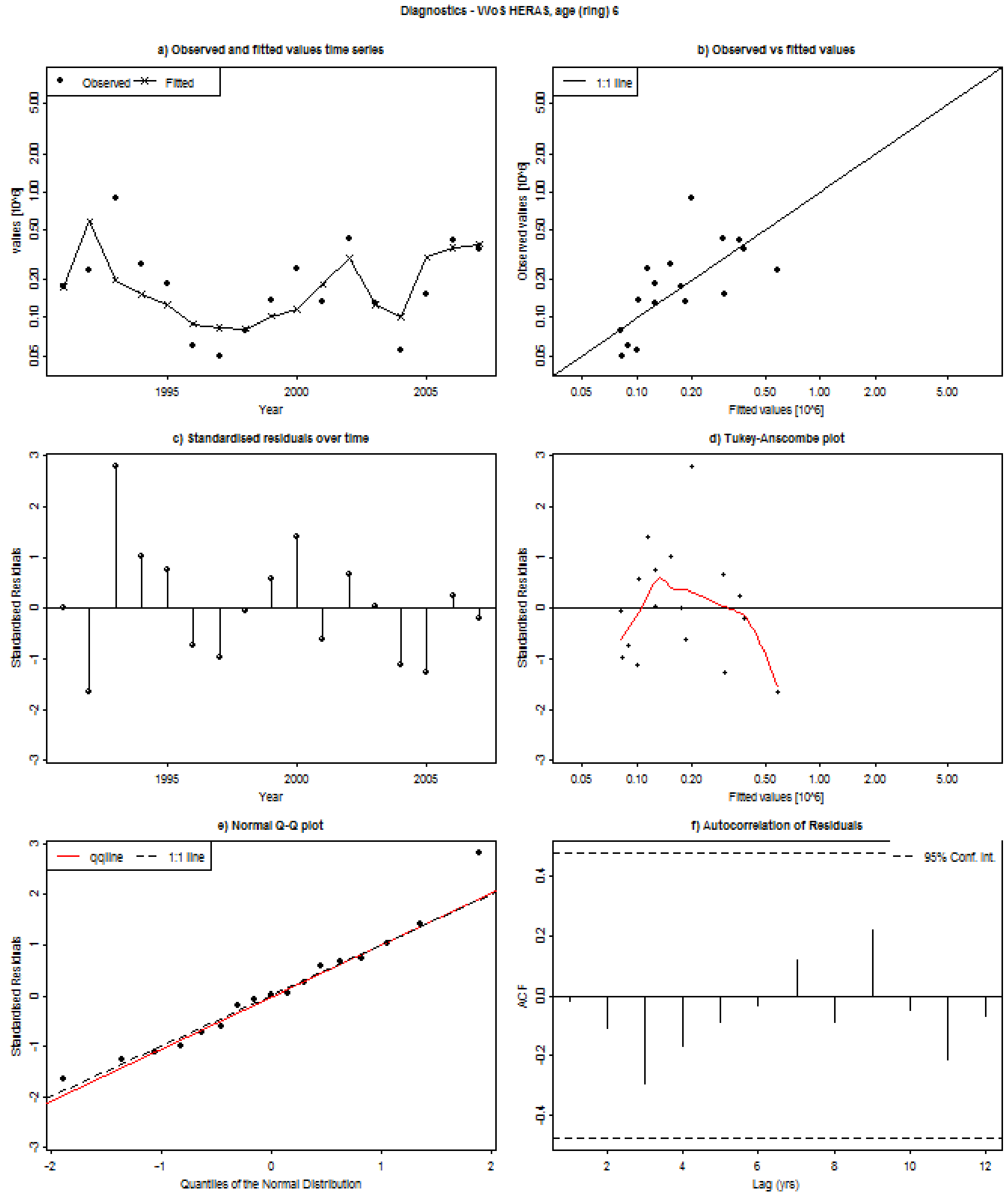


Figure 4.6.38: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 6-winter ring time series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 6-winter ring. Middle right: index observation versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

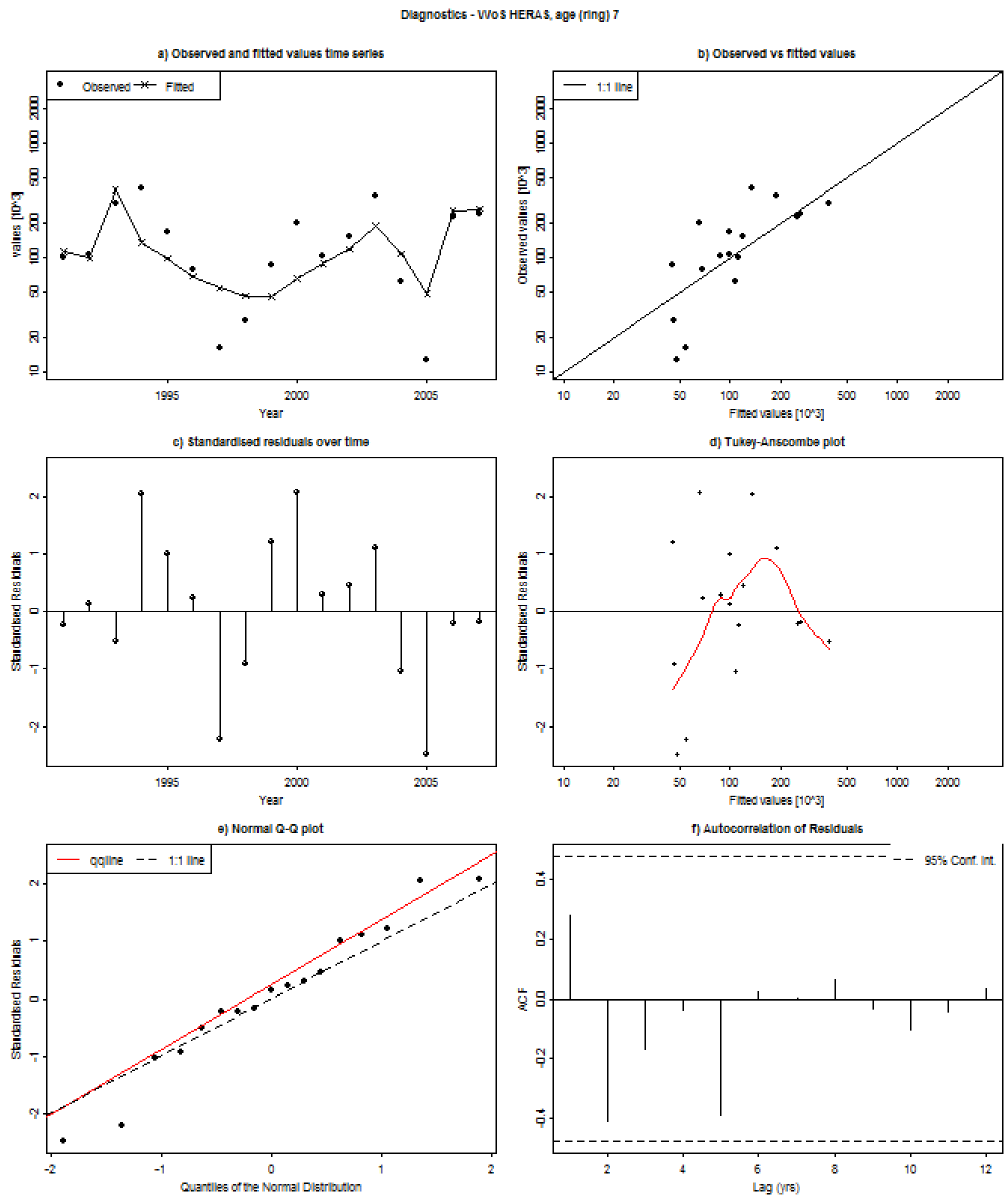


Figure 4.6.39: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 7-winter ring time series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 7-winter ring. Middle right: index observation versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

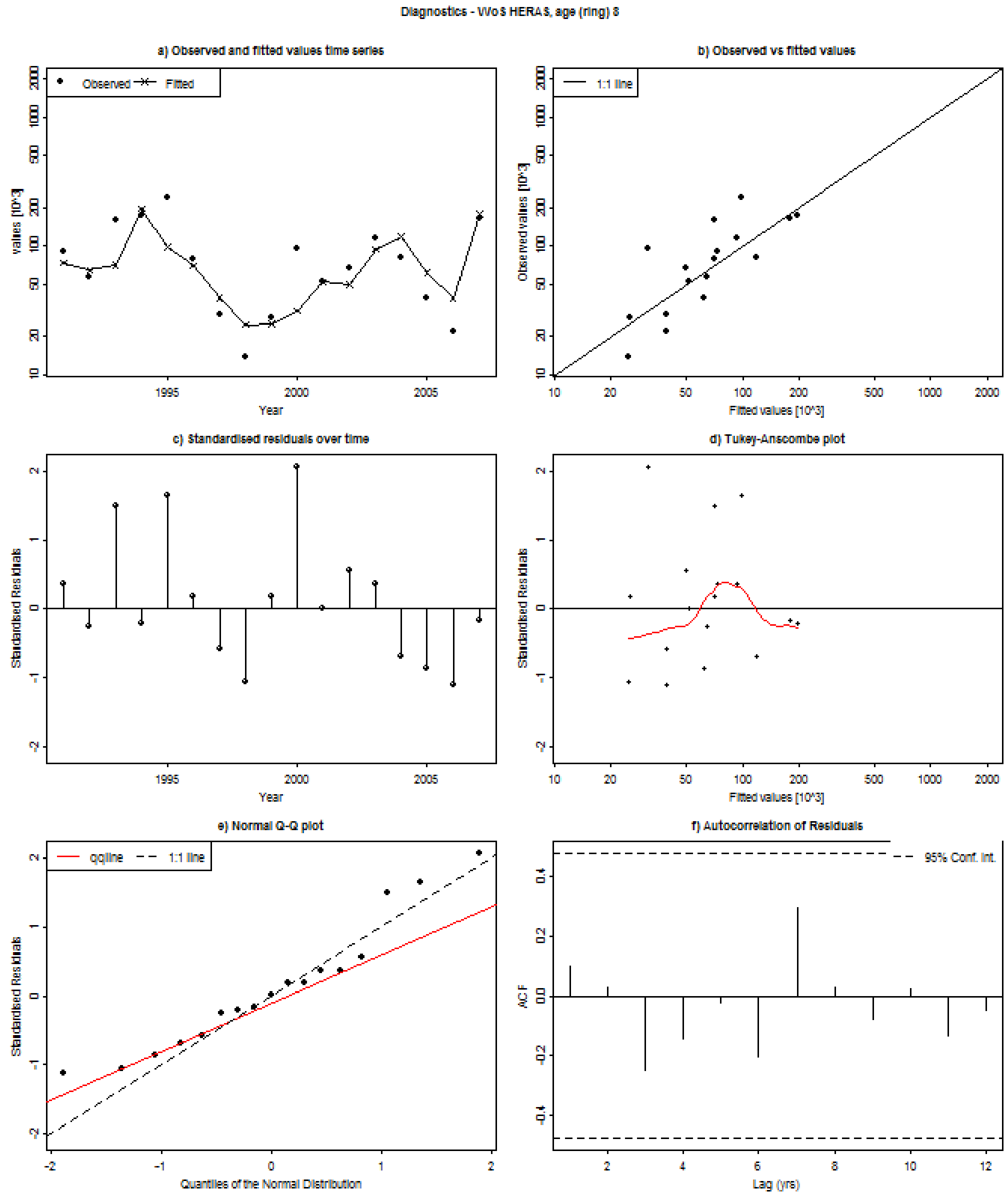


Figure 4.6.40: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 8-winter ring time series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 8-winter ring. Middle right: index observation versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

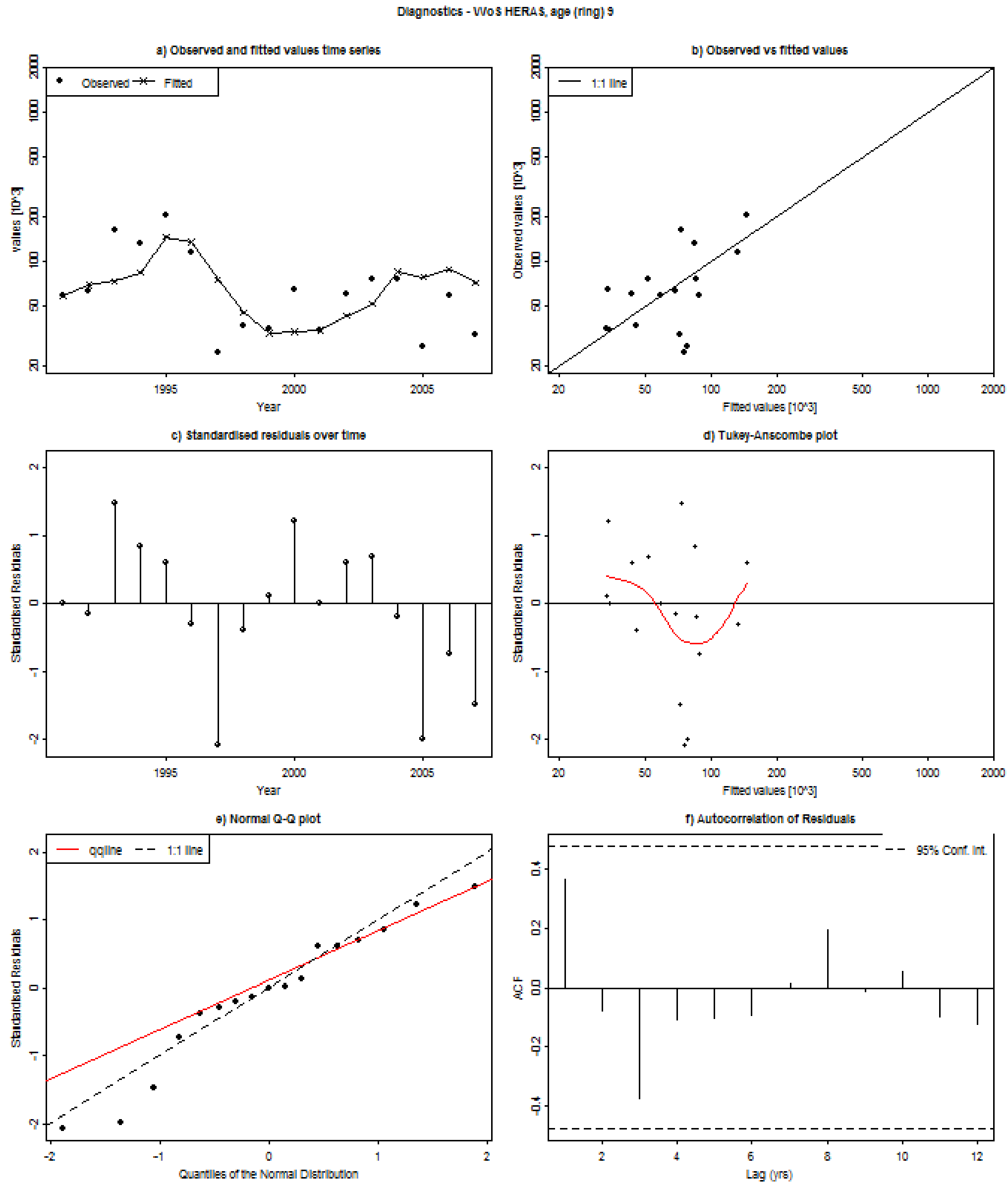


Figure 4.6.41: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the West of Scotland geographical area (6.aN) acoustic survey index at 9-winter ring time series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 9-winter ring. Middle right: index observation versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

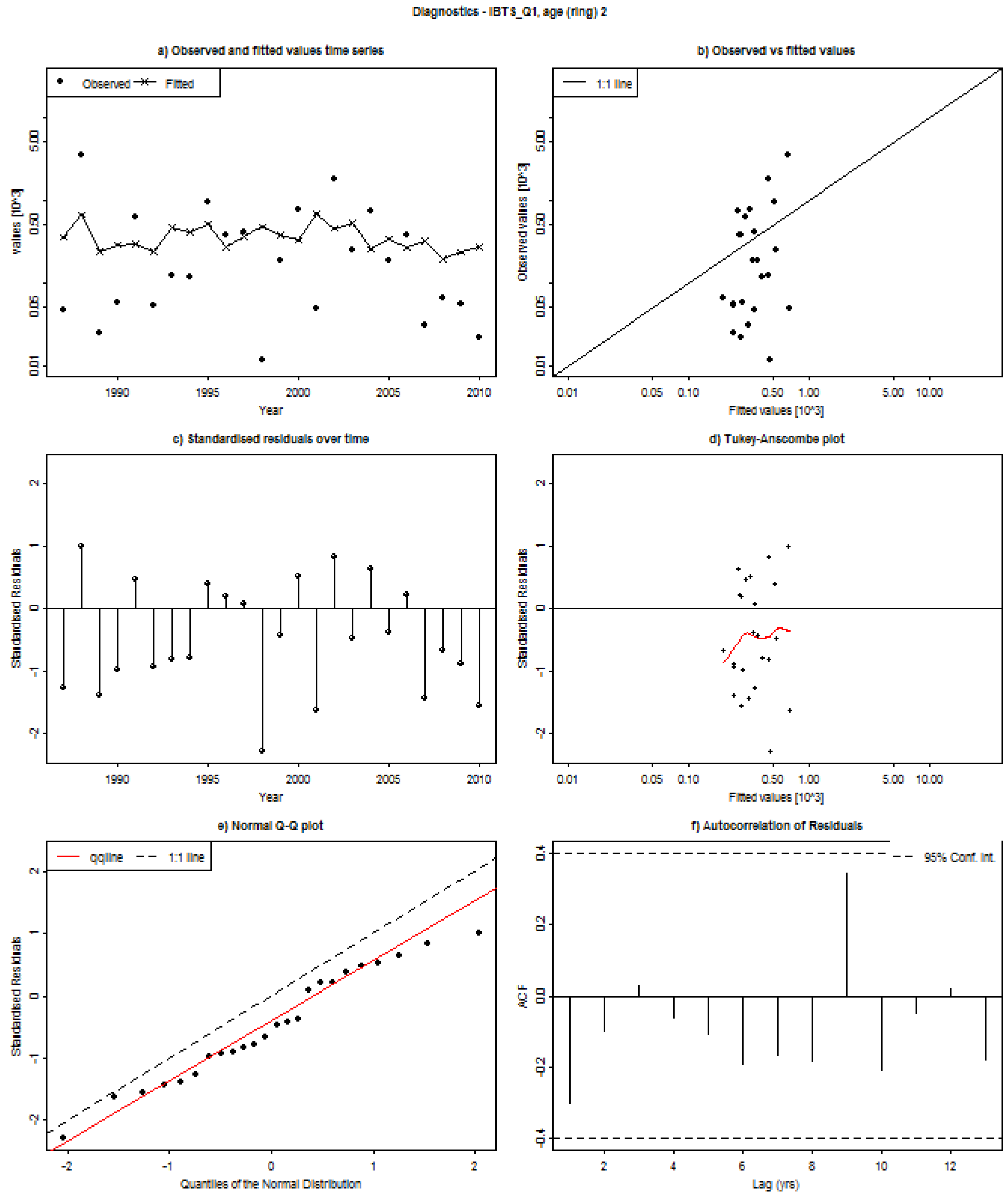


Figure 4.6.42: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 2-winter ring time series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 2-winter ring. Middle right: index observation versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

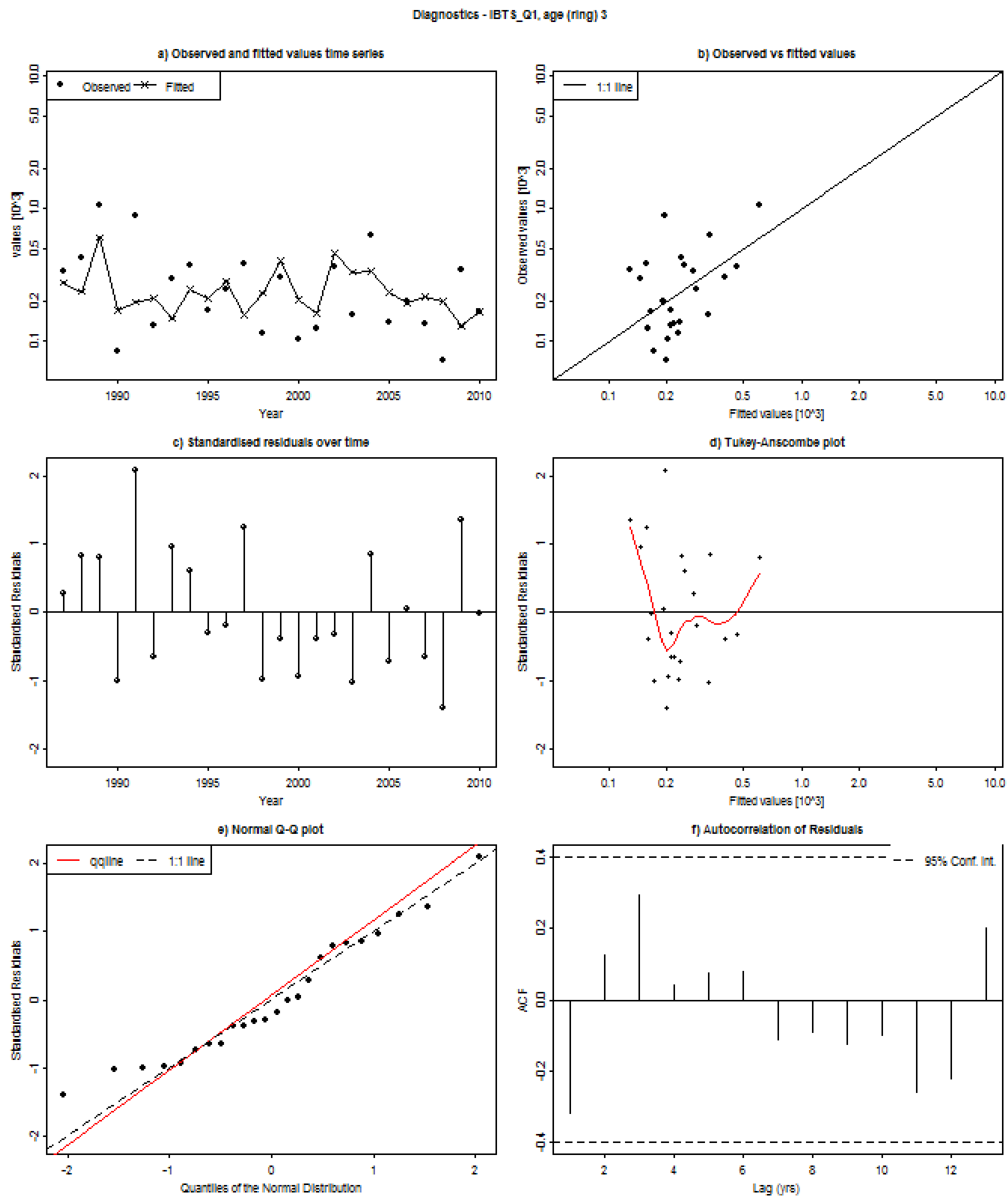


Figure 4.6.43: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 3-winter ring time series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 3-winter ring. Middle right: index observation versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

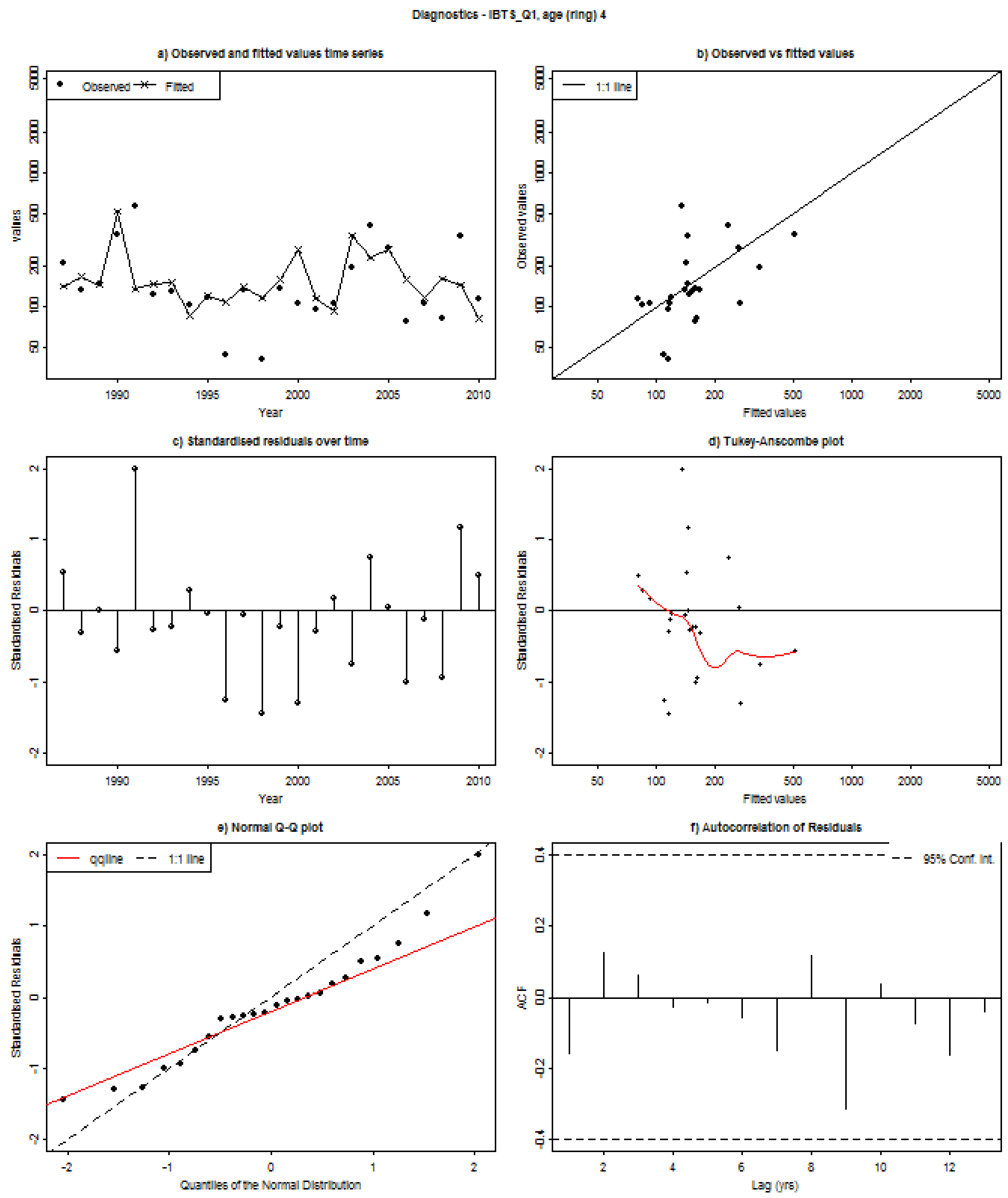


Figure 4.6.44: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 4-winter ring time series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 4-winter ring. Middle right: index observation versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

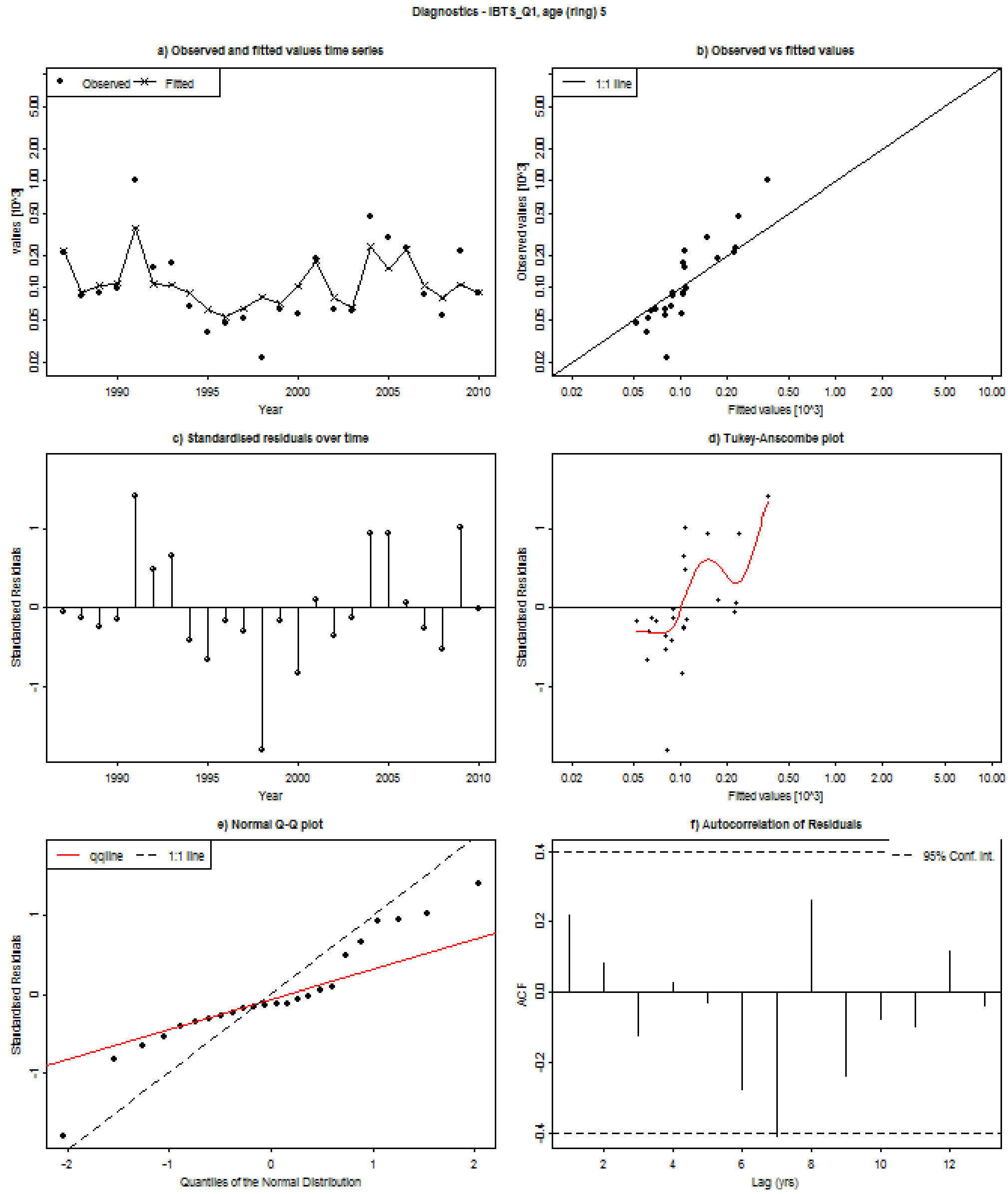


Figure 4.6.45: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 5-winter ring time series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 5-winter ring. Middle right: index observation versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

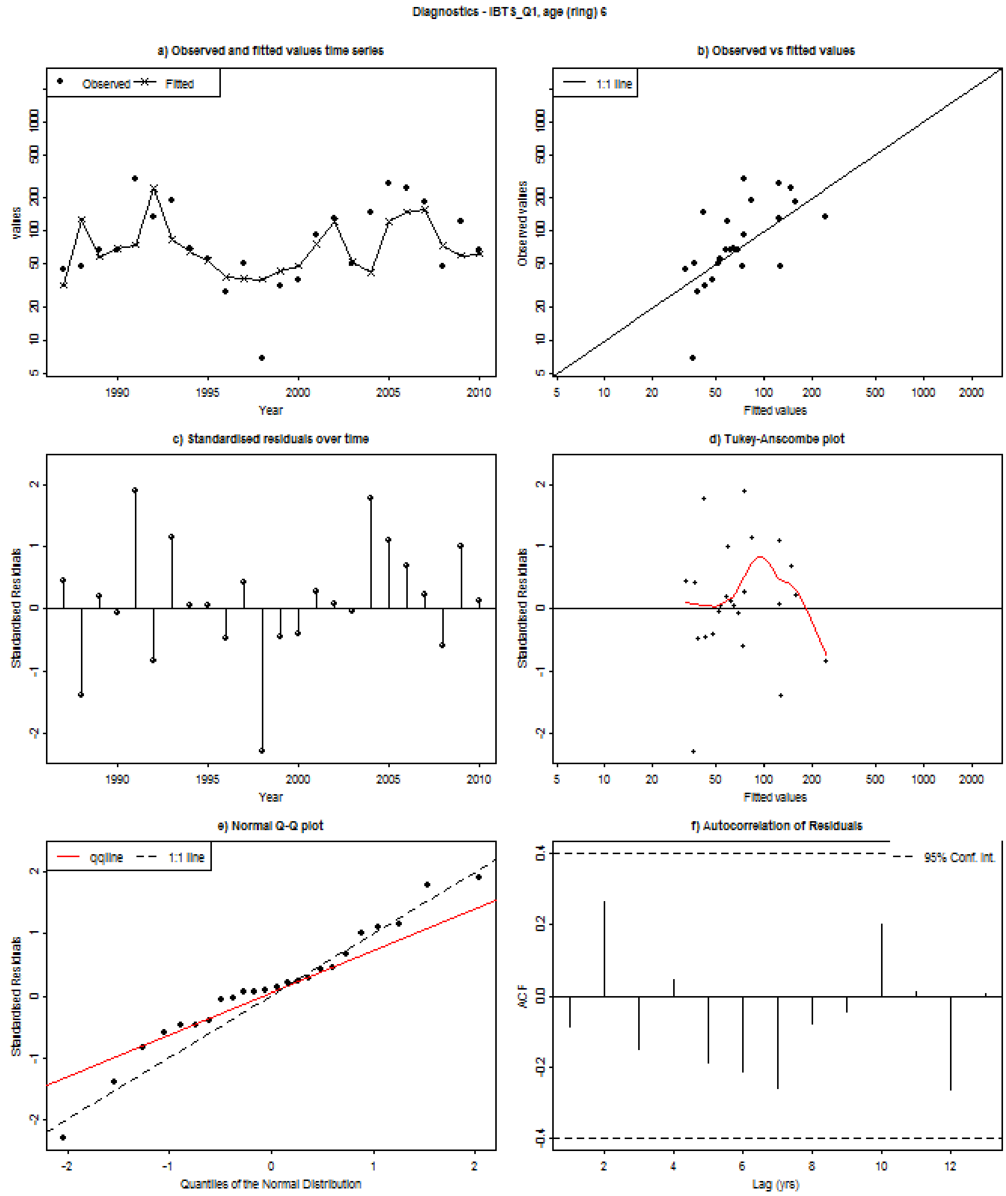


Figure 4.6.46: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 6-winter ring time series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 6-winter ring. Middle right: index observation versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

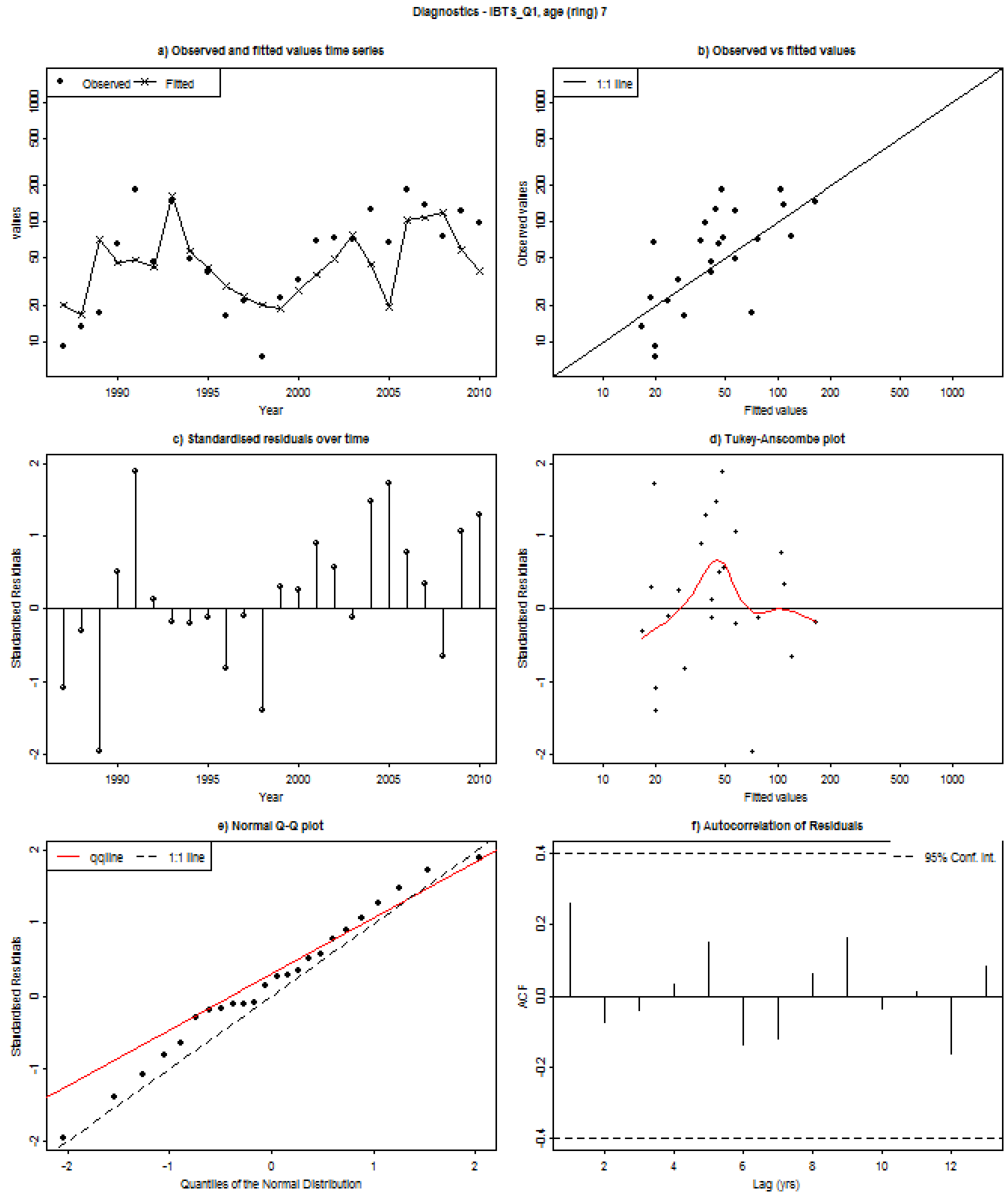


Figure 4.6.47: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 7-winter ring time series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 7-winter ring. Middle right: index observation versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

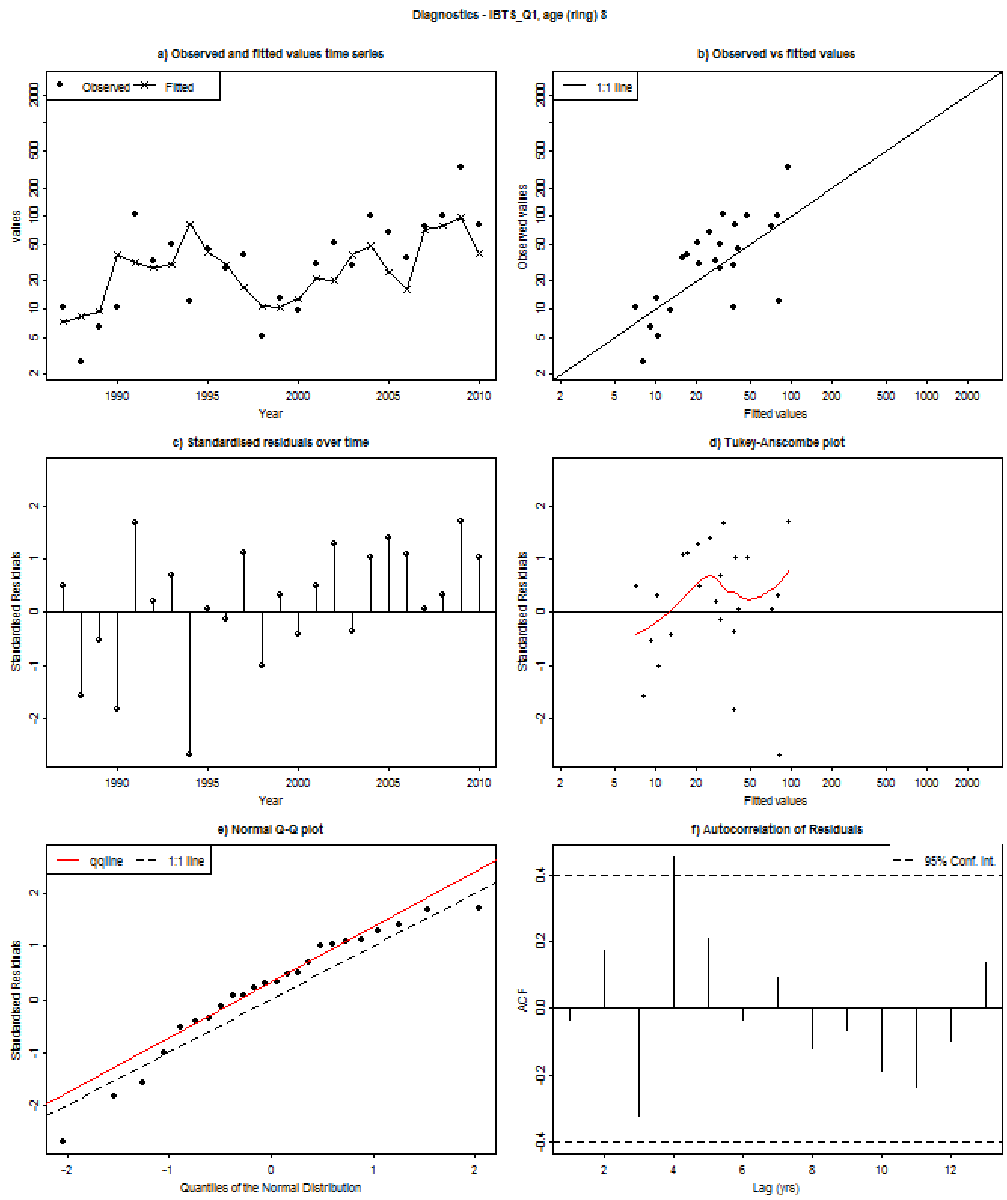


Figure 4.6.48: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 8-winter ring time series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 8-winter ring. Middle right: index observation versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

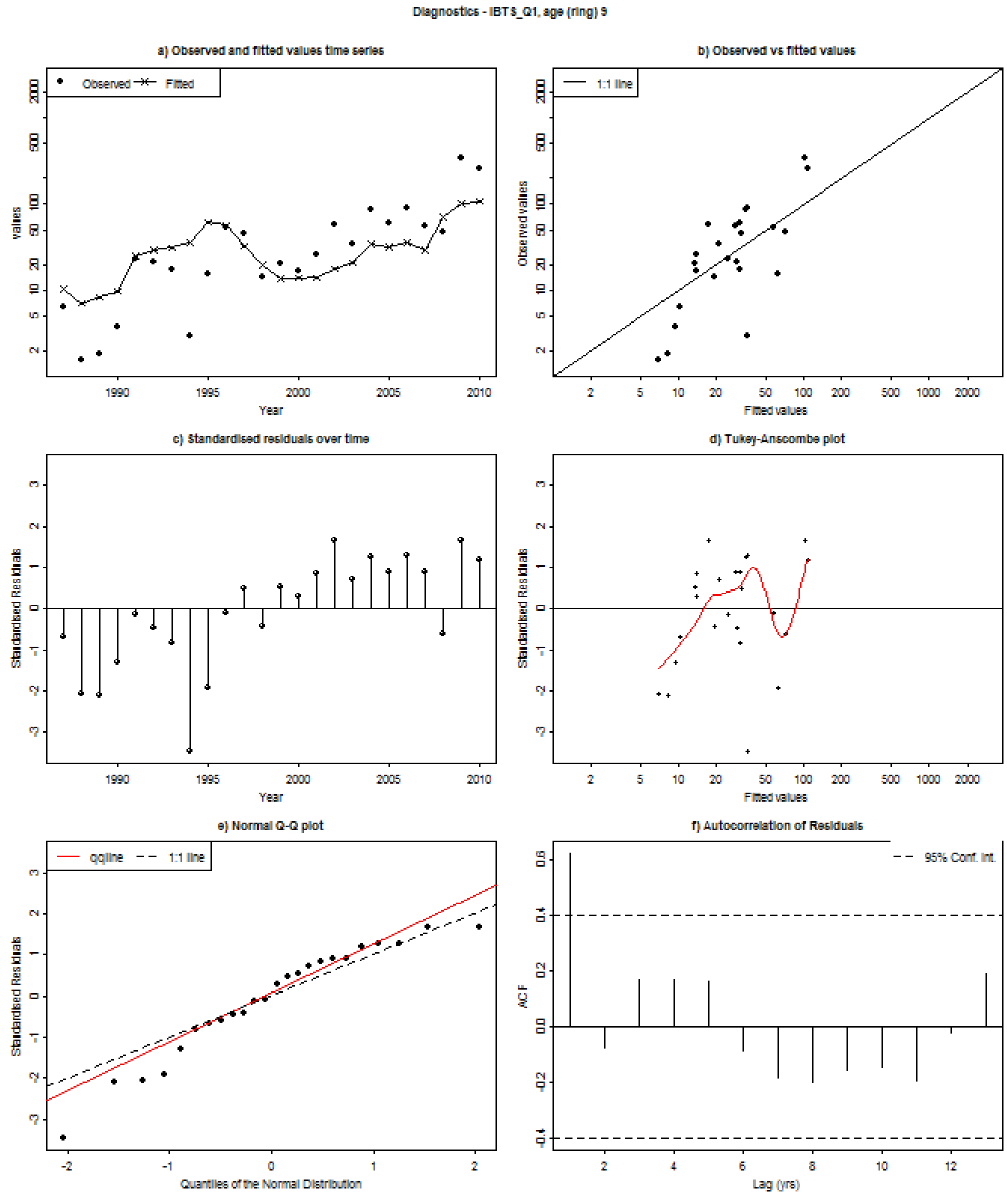


Figure 4.6.49: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 1 at 9-winter ring time series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 9-winter ring. Middle right: index observation versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

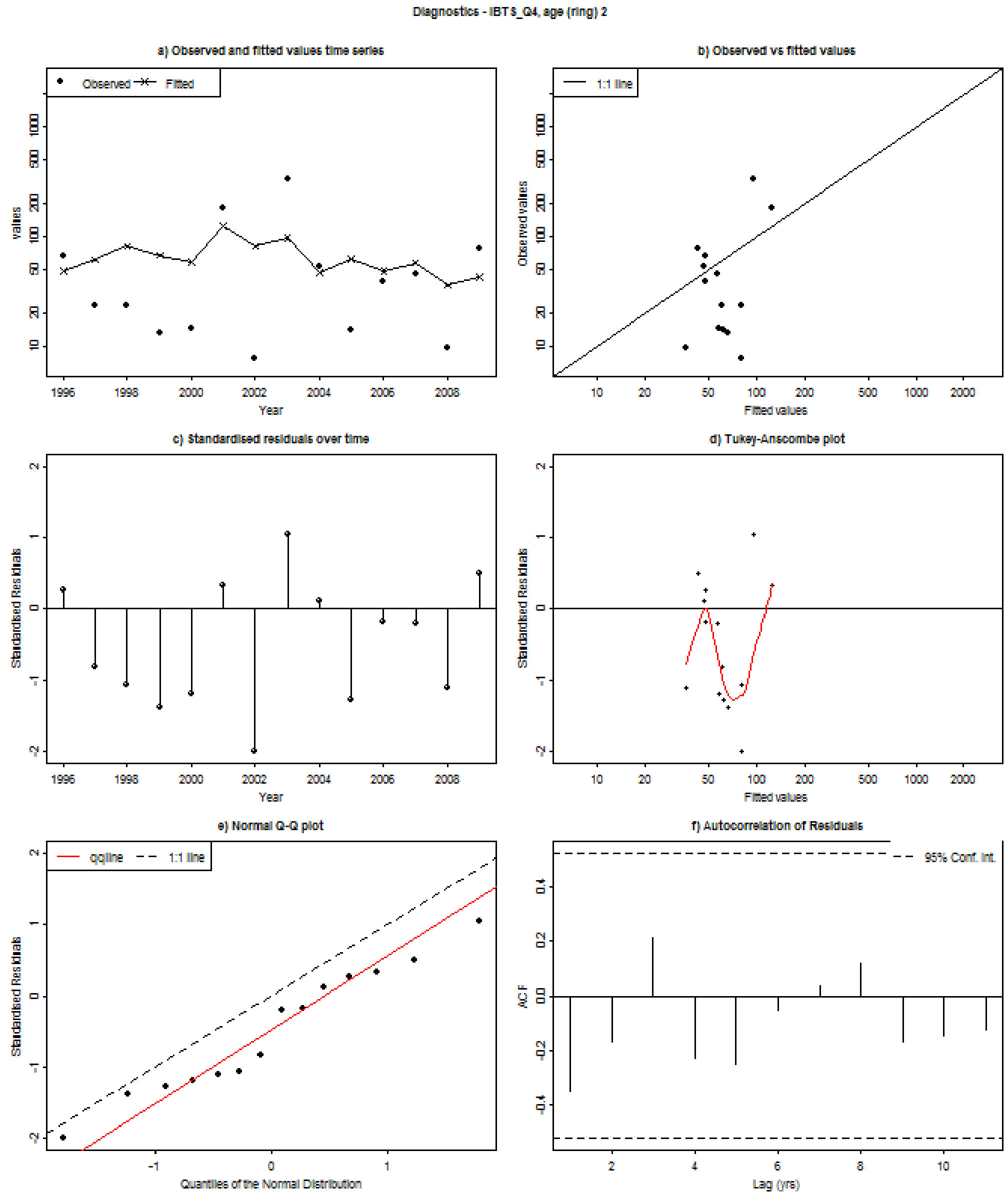


Figure 4.6.50: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 2-winter ring time series. Top left: Estimates of numbers at 2-winter ring (line) and numbers predicted from index abundance at 2-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 2-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 2-winter ring. Middle right: index observation versus standardized residuals at 2-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

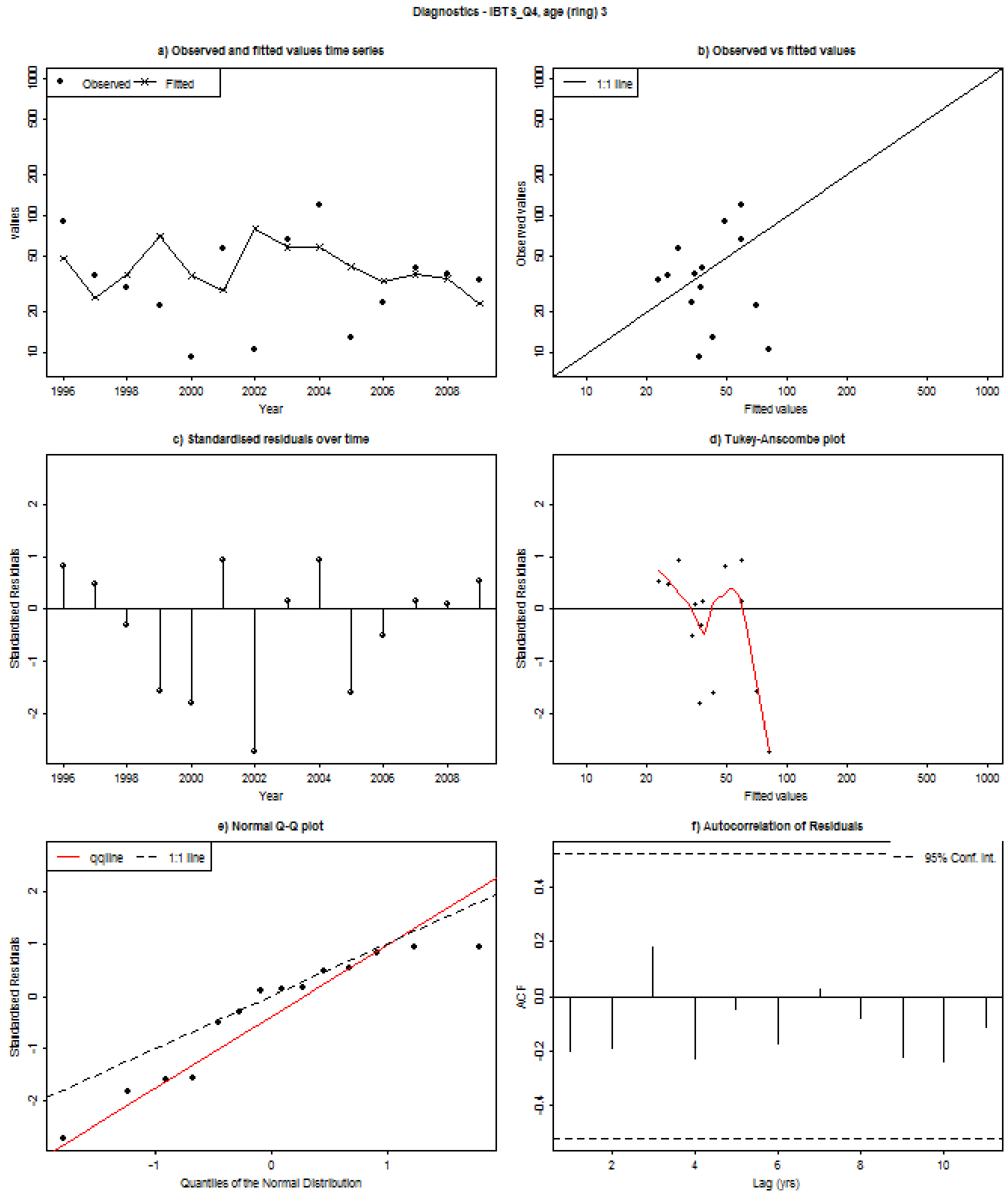


Figure 4.6.51: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 3-winter ring time series. Top left: Estimates of numbers at 3-winter ring (line) and numbers predicted from index abundance at 3-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 3-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 3-winter ring. Middle right: index observation versus standardized residuals at 3-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

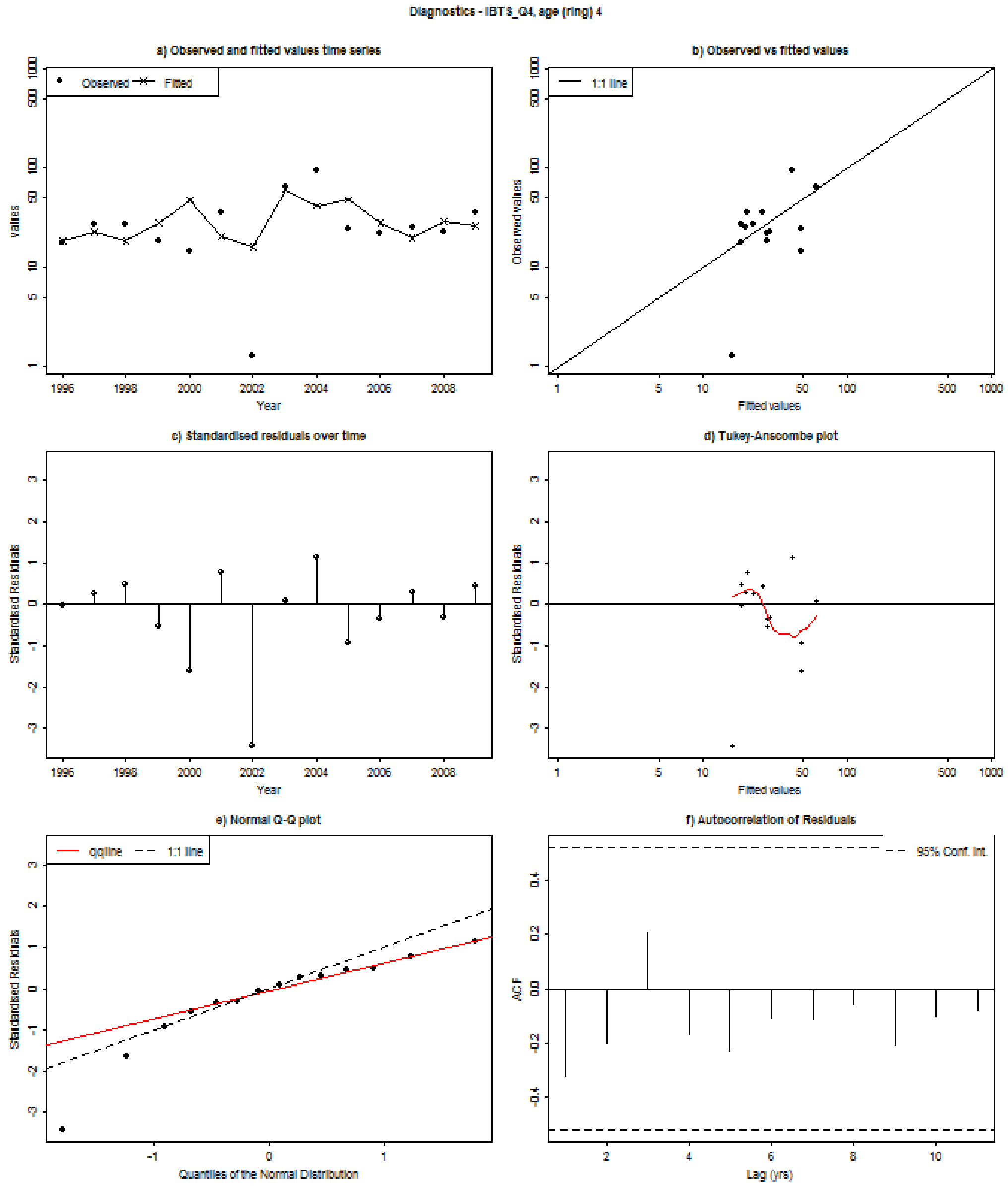


Figure 4.6.52: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 4-winter ring time series. Top left: Estimates of numbers at 4-winter ring (line) and numbers predicted from index abundance at 4-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 4-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 4-winter ring. Middle right: index observation versus standardized residuals at 4-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

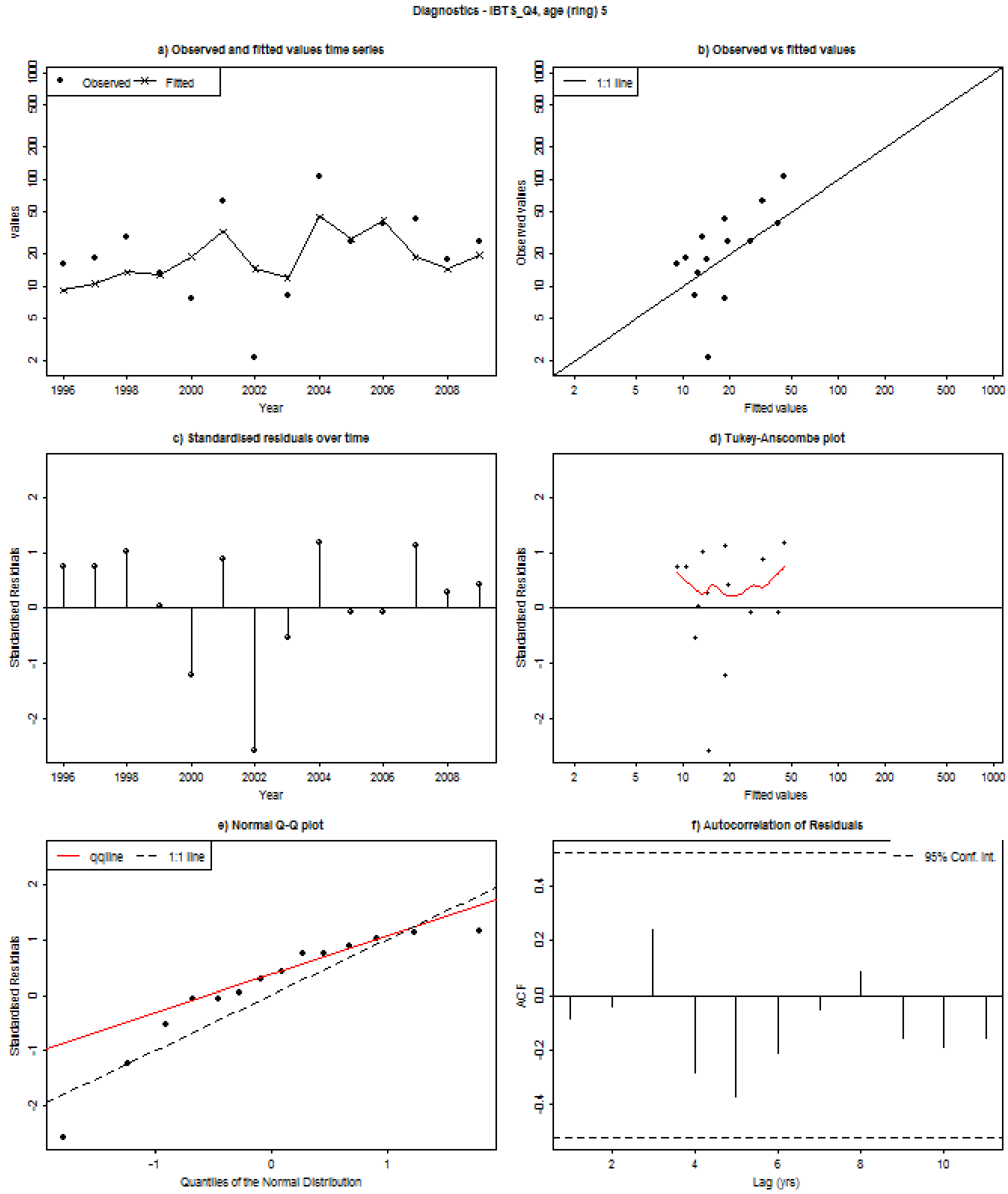


Figure 4.6.53: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 5-winter ring time series. Top left: Estimates of numbers at 5-winter ring (line) and numbers predicted from index abundance at 5-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 5-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 5-winter ring. Middle right: index observation versus standardized residuals at 5-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

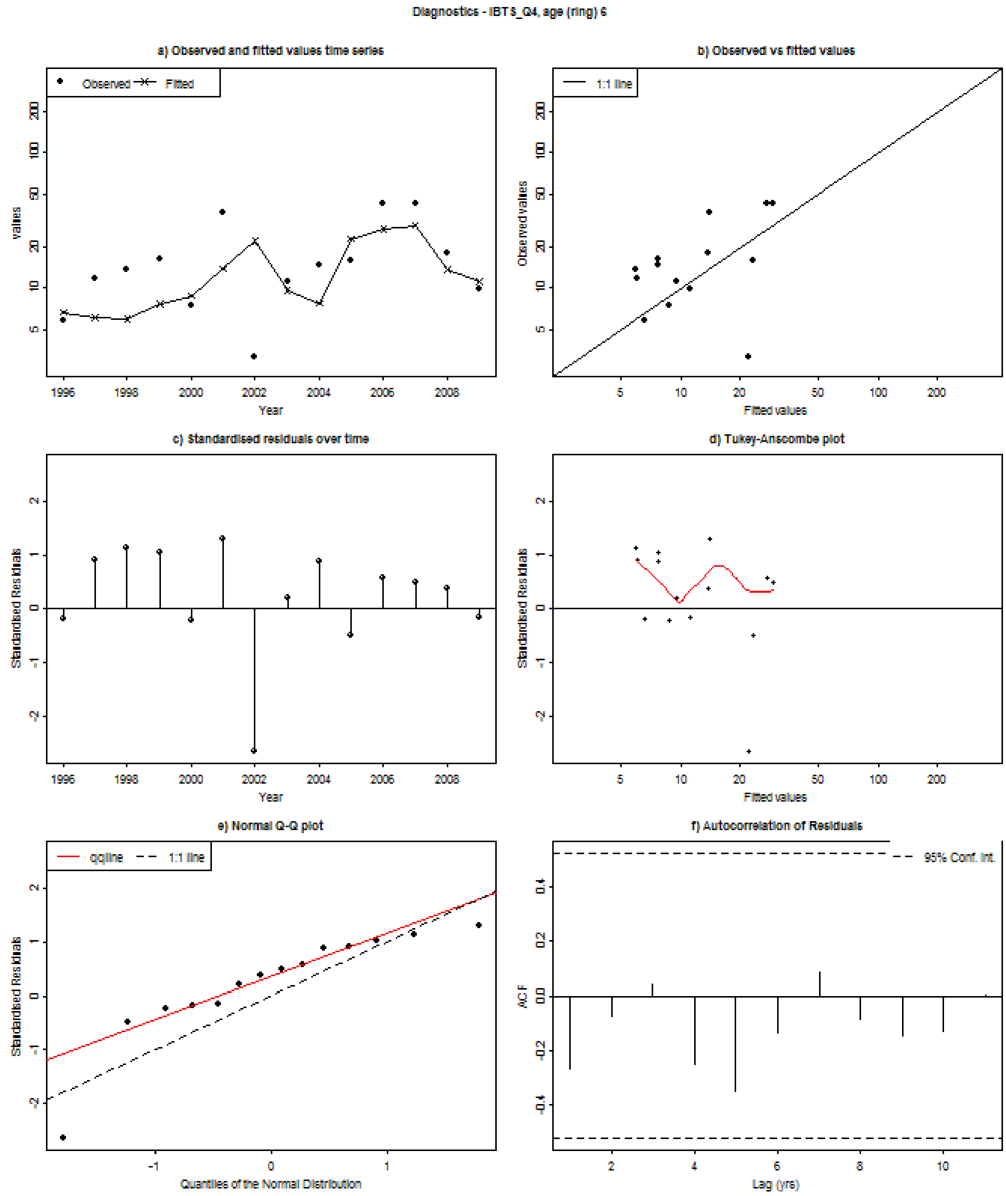


Figure 4.6.54: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 6-winter ring time series. Top left: Estimates of numbers at 6-winter ring (line) and numbers predicted from index abundance at 6-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 6-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 6-winter ring. Middle right: index observation versus standardized residuals at 6-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

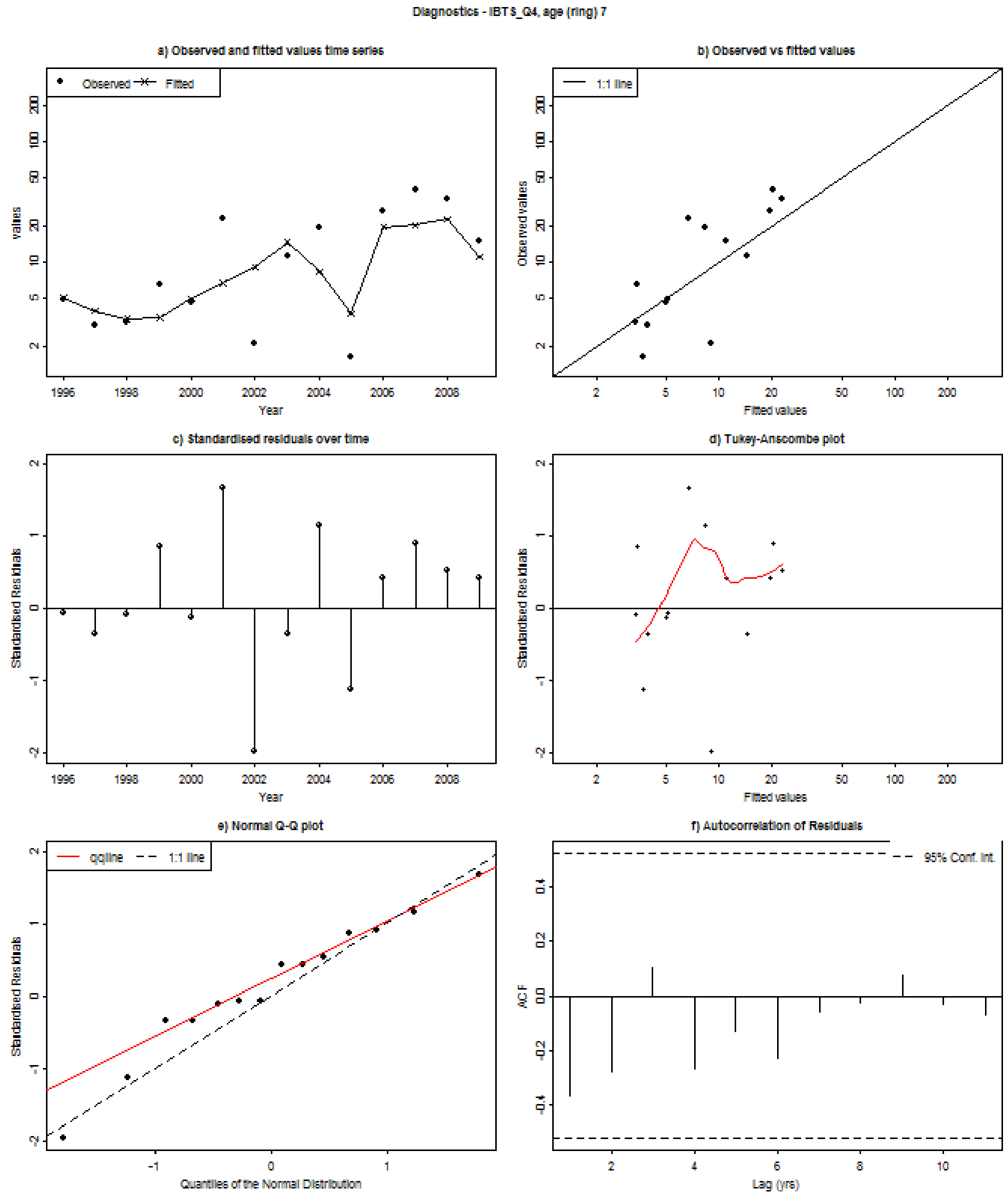


Figure 4.6.55: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 7-winter ring time series. Top left: Estimates of numbers at 7-winter ring (line) and numbers predicted from index abundance at 7-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 7-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 7-winter ring. Middle right: index observation versus standardized residuals at 7-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

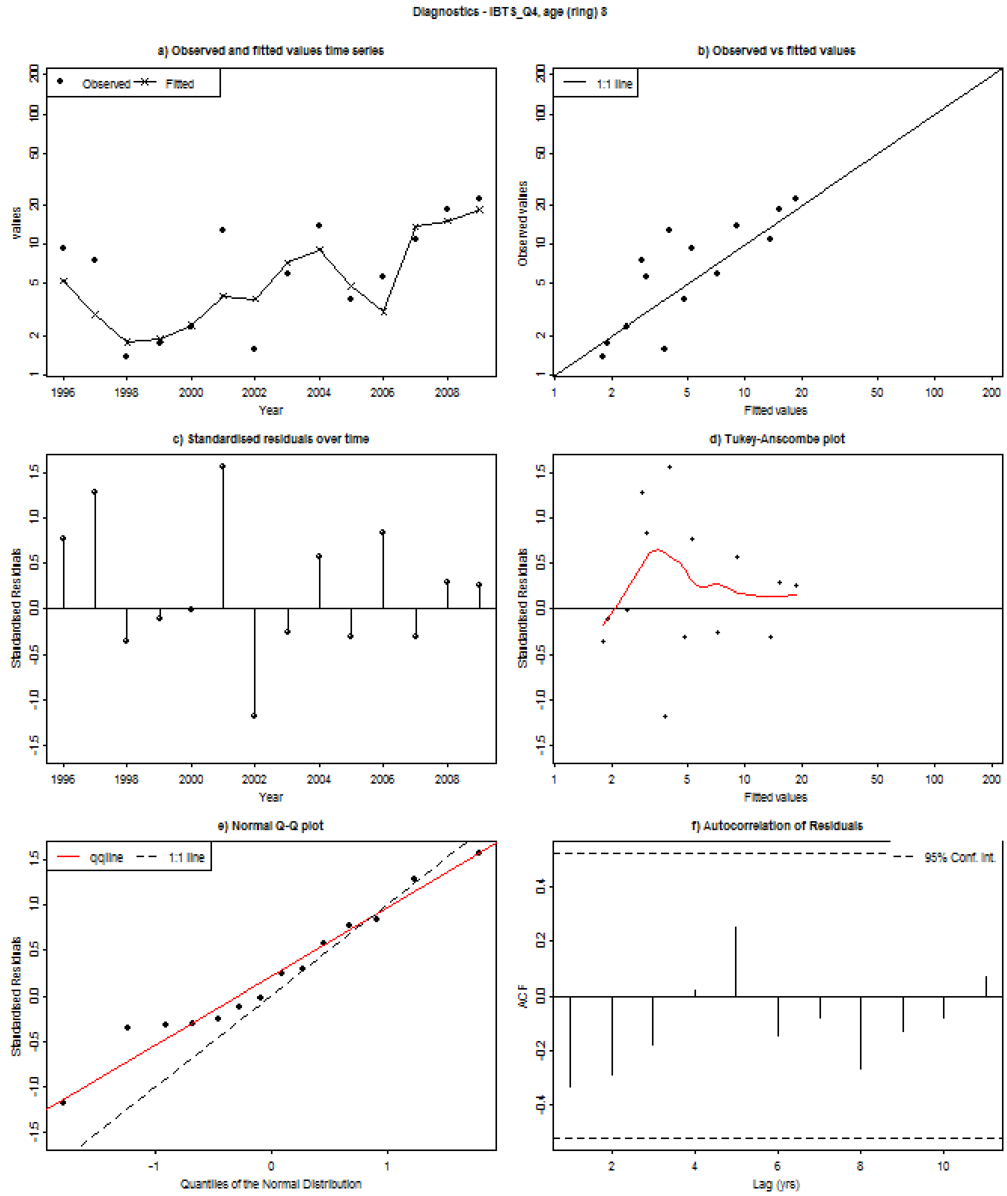


Figure 4.6.56: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 8-winter ring time series. Top left: Estimates of numbers at 8-winter ring (line) and numbers predicted from index abundance at 8-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 8-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 8-winter ring. Middle right: index observation versus standardized residuals at 8-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

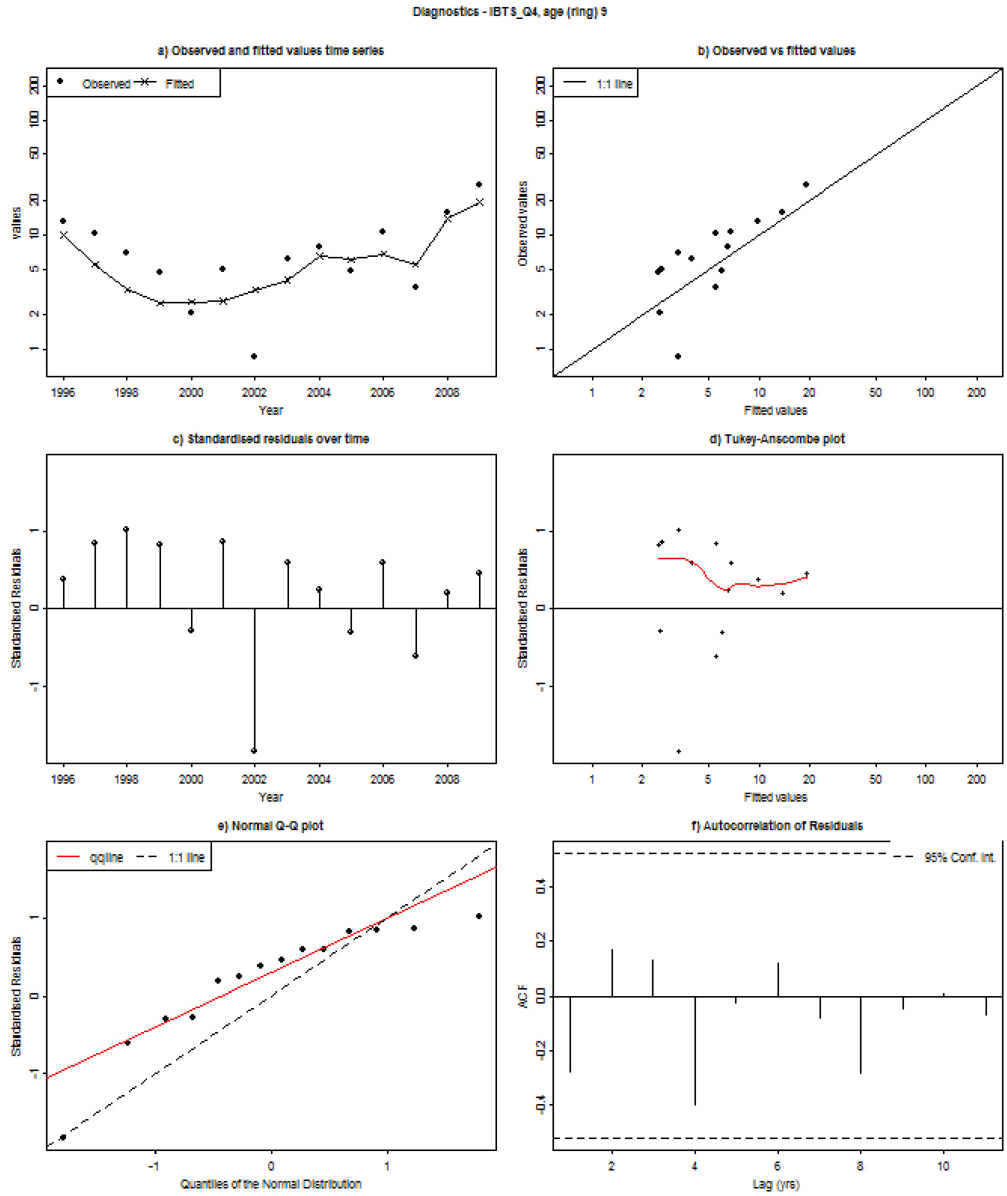


Figure 4.6.57: Herring in 6.a (combined) and 7.b and 7.c. Diagnostics of the assessment model fit to the Scottish bottom trawl survey index in quarter 4 at 9-winter ring time series. Top left: Estimates of numbers at 9-winter ring (line) and numbers predicted from index abundance at 9-winter ring. Top right: scatterplot of index observations versus assessment model estimates of numbers at 9-winter ring with the best-fit catchability model (linear function). Middle left: Time series of standardized residuals of the index at 9-winter ring. Middle right: index observation versus standardized residuals at 9-winter ring. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation of residuals plot.

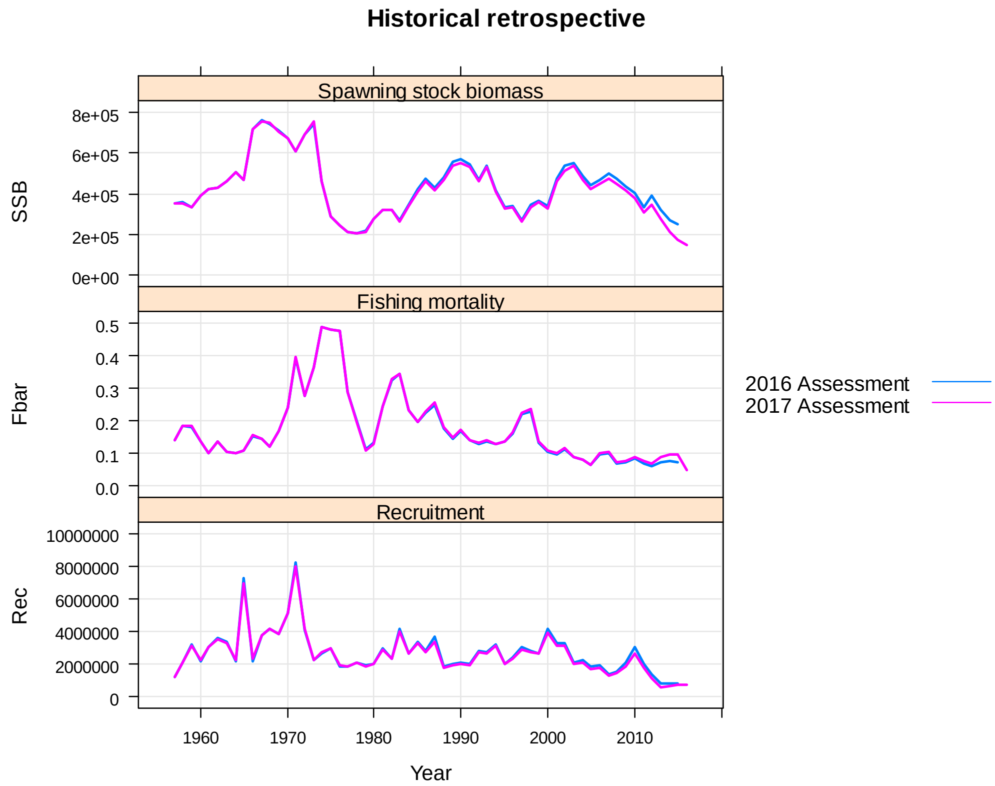


Figure 4.6.57: Herring in 6.a (combined) and 7.b and 7.c. Perception of stock estimates in 2016 and 2017 assessment.

4.13 Audit of Herring (Clupea harengus) in divisions 6.a and 7.b–c (West of Scotland, West of Ireland)

Date: 22-03-2017

Auditor: Henrik Mosegaard

General

- Joint assessment of herring in Division 6.aN and 6.aS/7.b and 7.c following the benchmark workshop, ICES WKWEST (2015). The assessment is complicated by the combining of two independent stocks with a mixture of autumn, winter and spring spawning components with potential individual population dynamics that at present cannot be separated. The stocks are assessed together as a meta-population since the combined survey indices cannot be successfully split.
- There is work ongoing including genetics, morphology and other metrics to recover the composition of the underlying stock components. Linked assessments based on individual stock components with potentially different dynamics but utilizing correlations in data may have a positive effect on the quality of the advice.
- Recent catch data comes from the limited monitoring fishery (TAC 5 800 t).
- There are 3 survey time series available producing 4 tuning indices, where only one is applied up to the most recent year. There is potential information in both IBTS surveys between 2010 and now that is presently not included but should be looked at in a coming benchmark.

For single stock summary sheet advice:

- This stock was last benchmarked in 2015 (WKWEST; ICES 2015).
- The acoustic surveys were in 2008 expanded into a larger coordinated summer survey to cover all of ICES Divisions VIa and VIIb (MSHAS 2008-2016). The MSHAS survey time series shows a break down of internal consistency for all but the oldest ages after the recent 2016 survey. Strong and increasing age residuals are apparent for the 9+ group.
- The IBTS Q1 is only used up to 2010 due to change in survey design. IBTS Q4 only miss indices from two recent years (2010 and 2014), but according to the stock annex and settings from the text table in section 5.6 the tuning series is set to 1996-2009. Thus there apparently is no complete long time series of survey data that also includes recent years.
- Natural mortality is not expected to follow the North Sea variation. Therefor a time invariant and age variant natural mortality rate was applied, still using the average annual M from the 2011 SMS key run for each age (from the North Sea multispecies model in the period 1974 – 2010).
- Updated survey indices, along with updated biological parameters e.g. mean weight, catches etc. are all used.

1) **Assessment type:** update
2) **Assessment:** analytical
3) **Forecast:** short term projection (deterministic stock projection using FLR package, FLash) text and numbers needs to be updated (report section 5.7)

4) **Assessment model:** "state-space" modelling approach (SAM, in the FLR environment) with tuning by 4 survey indices making up 3 time series, with only the acoustic MSHAS covering the most recent years.

5) **Data issues:** All data were available to the working group and there did not appear to be any issues.

6) **Consistency:** The model and the methods were essentially the same as last year. They were accepted last year and should be this year.

7) **Stock status:** B<Blim<(MSYBtrigger = Bpa). The 2017 assessment resulted in a downward revision of SSB 2015 of 30% compared to last year. There was only a limited monitoring fishery with a combined (North + South) TAC of 5 800 t, and F< FMSY <Fpa.

8) **Management Plan:** There is no agreed management plan for the combined stocks. There was a management plan for herring in Division 6.a North; this plan is not appropriate for the combined stocks.

General comments

In general the chapter was well documented and clear (however bits of text and numbers need updating). It would be preferable to duplicate the documentation of sampling from the chapter of individual stocks (6) also to the chapter containing the assessment (5).

Technical comments

The assessment has been completed according to the Stock Annex. The forecast section needs updating with the analysis following the consequences of the monitoring fishery. There is only information in the stock annex about the availability of hauls from the IBTS Q4 for the period 1986-2014.

Conclusions

The assessment has been performed correctly according to the stock annex.

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.aN (Section 5.2) for assessment and advisory purposes. This management unit existed since 1982 when it was separated from 6.aN. Until that time, 7.b–c was also a separate management unit. The stock comprises autumn, winter, and spring spawning components.

The WG noted that the use of "age", "winter rings", "rings" and "ringers" still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using "rings", "ringers", "winter ringers" or "wr" instead of "age" throughout this section. However, if the word "age" is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks, there is a difference of one year between "age" and "rings", which is not the case for the spring spawners. Further elaboration on the rationale behind this, specific to Area 6.aS, 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 2016

In 2016 ICES advised TAC of 0 t and that a stock recovery plan be developed for herring stocks in 6a and 7bc stocks (ICES 2016a). However in February 2016, the European Commission asked ICES to advise on a TAC of sufficiently small size to enable ongoing collection of fisheries dependent data. In June 2016, ICES advised on a scientific monitoring TAC of 1 360 t for this stock (ICES 2016b). The EC set a TAC slightly higher than this advice, at 1 630 t was established by the EC (EU 2016/0203).

Rebuilding plan

A rebuilding plan was developed by the Federation of Irish Fishermen's Organisations and the Pelagic RAC in 2013 (Table 5.1.1), based on comments received from STECF (2012). The new plan contains a harvest control rule. F is reduced towards zero as SSB decreases below B_{pa}. STECF evaluated the plan judging it to be precautionary and capable of rebuilding the stock, if trans-boundary catches in 6.aN can be managed. The plan cannot be implemented at present because no separate advice is available for the stock.

5.1.1.2 Catches in 2016

The Working Group estimates of landings from 1991–2016 are given in Table 5.1.2. The catch has declined from 19 000 t in 2006 to 2 200 t in 2016. This is an increase from 1000 t caught the previous year. Catches in 2015 and 2016 are the lowest and second lowest in the series, respectively. Catches over time are shown in Figure 5.1.1.

In 2016 the majority of the catch was taken in the fourth quarter. Subdivision 6.aS accounted for the vast majority of catch (Figure 5.1.12).

5.1.1.3 Regulations and their effects

Within the Irish fishery, the monitoring TAC was allocated on a different basis to individual vessels on a different basis to previous years. The quota was allocated, in smaller quantities, to a wide spectrum of small and large vessels. This resulted in more fishing opportunities per quota than in previous years.

5.1.1.4 Changes in fishing technology and fishing pattern

The monitoring TAC, introduced in 2016 has led to a change in the pattern of the fishery. In previous years, larger vessels dominated in the fishery and took their larger quotas often in one haul, in a somewhat opportunistic basis. It is thought that that behaviour explains the lack of cohort tracking in the catch at age matrix in previous years (see 5.1.2.1 below).

5.1.2 Biological composition of the catch

5.1.2.1 Catch in numbers-at-age

Catch-at-age data for this fishery are shown in Table 5.1.3 and in percentage terms since 1992 in Table 5.1.4. In 2016 the fishery was dominated by 3-ringers (2012 cohort), accounting for 31% of the catch, followed by 5-ringer (2010 cohort) at 22% (Table 5.1.4). These cohorts have featured prominently in previous years too.

5.1.2.2 Quality of the catch and biological data

The stock is very well sampled, with sufficient samples to achieve the precision level sought by the ICES advice on the monitoring fishery. The numbers of samples and the associated biological data are shown in Table 5.1.7. The catch at age matrix tracks cohorts well in the past two years.

Mixing of autumn, winter and spring spawners takes place in this area which may lead to ageing difficulties regarding counting of winter rings.

5.1.3 Fishery Independent Information

5.1.3.1 Acoustic Surveys

The Irish Marine Institute conducted acoustic surveys in 6.aS 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.aN 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.aN 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 2014 as well as maintaining coverage of the original survey area in 6.aN.

5.1.3.2 Acoustic survey in 2016

An acoustic survey was conducted in 2016, dedicated to this stock alone. It is hoped to be the first in a new series. It ran from the 28th November to the 7th December 2016, on FV *Atlantic Challenge* (O'Malley, *et al.* 2017 http://hdl.handle.net/10793/1203). In total 1,649nmi of cruise track was completed using 41 transects, with a total area coverage of approximately 4,500 nmi². Transect spacing was set at 3nmi. Coverage extended from inshore coastal areas to the 100 m contour in the west and north. (Figure 5.1.5.). A mini survey was carried out in Lough Swilly using a zig-zag design due to the shallow water depths found there. The additional survey track in Lough Swilly was designed using the deepest part of the channel as the centreline for the strata area. 500m either side of this centre line was delineated as the boundary area; zig-zag transects were then placed within the strata boundaries. An elementary distance sampling unit (EDSU) of 1nmi was used during the analysis throughout the survey data. The survey was carried out over 24 hours each day.

Herring TSB (total stock biomass) and abundance (TSN) estimates were 35 475 t and 223 491 million individuals respectively. Sampled fish were 100% mature, therefore the SSB was also 35,475 t. The CV estimate on biomass and abundance was 0.37 for the survey. This relatively high CV estimate is most likely caused by the over-reliance on a few acoustic marks of herring in Lough Swilly and Donegal Bay in particular. Many of the possible bias considerations are common to all acoustic surveys and should be dealt with and reduced if possible at the survey design stage.

A total of three hauls were completed in 2016, however, only one contained herring (Figure 5.1.6). In some areas where marks of herring were observed, the vessel was unable to fish due to the shallow water depth (e.g. <20m in Lough Swilly) and size of the trawl net. The monitoring fishery was being conducted at the same time as the survey, on smaller boats in the same areas. Biological samples from some of these vessels were used to augment the sample from the survey. Samples were taken from boats fishing in Lough Swilly and Donegal Bay as close spatially and temporally as possible to the survey in these areas.

Three and five winter-ring herring dominated the estimate (2012 and 2010 cohorts respectively). This pattern agrees closely with that of the monitoring fishery and – to a lesser extent - the Malin Shelf Acoustic Survey (MSHAS). These were the main cohorts in the fishery in 2015 also (Figure 5.1.4).

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 2016 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 in weights at age (rings).

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). Trends over the recent and longer time series are similar to those in the catches.

5.1.4.2 Maturity Ogive

One ringers are considered to be immature. All older ages are assumed to be 100% mature.

5.1.5 Recruitment

There is little information on terminal year recruitment in the catch-at-age data and there are as yet no recruitment indices from the surveys. Numbers of 1-ringers in the catches vary widely but, with the exception of 2012 (2010 cohort), have been consistently low in recent years. Since the mid-1990s recruitment has been low, based on exploratory assessments. However there is evidence from surveys that the 2007, 2008 and 2010 year classes were stronger than those in the previous 10 years.

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 2016 assessment for 6.a (combined) and 7.b–c are outlined in Section 5.6. No separate assessment is presented in 2017. However the previous separate assessment (sVPA) procedure was followed to derive crude mortality estimates for the 6.a.S/7.b-c component.

Figure 5.1.9 shows mean F trajectories over time for 5 scenarios of terminal fishing mortality in the text table below.

F = 0.02	lowest observed f in combined 6a/7bc assessment
F = 0.06	Catch2016 / Survey TSB2016
F = 0.13	Catch2016 / (Survey TSB2016 ÷ 2)
F = 0.2	As per previous assessments for this stock separately
F = 0.4	As per previous assessments for this stock separately
F = 0.6	As per previous assessments for this stock separately

It can be seen that only the most optimistic scenario (terminal F = 0.02) is associated with recent $F<F_{msy}$.

Figure 5.1.10 shows log catch ratio mortality signals over time, by cohort, for the main age groups. The increase in total mortality towards the end of the series is quite striking. The cohorts hatched in the mid-2000s appear to have experienced considerably higher mortality than in previous years. This effect is also visible in cohort estimates of total mortality Z (3-8 winter ring) in Figure 5.1.11.

If the acoustic survey conducted in 2016 for this stock (Section 5.1.3.2) is assumed to be an accurate biomass estimate, then the harvest rate in 2016 was F=0.06. This rate of fishing mortality may be slightly lower given that the stock was not fully contained.

5.1.5.2 State of the stock

Not analytically determined.

5.1.6 Short term projections

Not undertaken.

5.1.7 Medium term simulations

Not undertaken.

5.1.8 Long term simulations

Not undertaken.

5.1.9 Precautionary and yield based reference points

Not determined.

5.1.10 Quality of the assessment

Not ascertained.

5.1.11 Management considerations

There is no new information to alter the previous perception that this stock is in a state of collapse.

Fishing mortality should be as close to zero to allow rebuilding. The monitoring TAC should be maintained allowing sampling to continue. However available mortality signals should be monitored to ensure that F is very close to zero. As an upper limit, F=0.05, a minimum F that simulation has shown to be consistent with rebuilding in other herring stocks, could be considered.

The overall metapopulation (the two stocks in 6.a, 7.b–c) is not in a healthy state and is below B_{lim} value. However the working group advocates maintaining separate management of each component.

5.1.12 Environment

5.1.12.1 Ecosystem considerations

Grainger (1978; 1980) found significant negative correlations between sea surface temperature (SST) and catches from the west of Ireland component of this stock at a time lag of 3–4 years later. This indicates that recruitment responds favourably to cooler temperatures. Cannaby and Hosrevoglu (2009) present long time series of sea surface temperature for this stock area, showing an increasing trend. Their data when compared with herring biology and fisheries data show that strong historic herring recruitments/fisheries correspond with 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, 1991–2016. 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	22,500	26,000	27,600	24,400	25,450	23,800	24,400	25,200	16,325
Netherlands	600	900	2,500	2,500	1,207	1,800	3,400	2,500	1,868
UK (N. Ireland)	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	50	24	-	-	-	-
UK (Scotland)	+	-	200	-	-	-	-	-	-
Total landings	23,100	27,150	30,300	26,950	26,692	25,600	27,800	27,700	18,193
Unallocated/ area misreported	11,200	4,600	6,250	6,250	1,100	6,900	-700	11,200	7,916
Discards	3,400	100	250	700	-	-	50		-
WG catch	37,700	31,850	36,800	33,900	27,792	32,500	27,150	38,900	26,109

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008
France	-	-	515	-	-	-	-	-	-
Germany, Fed. Rep.	-	-	-	-	-	-	-	-	-
Ireland	10,164	11,278	13,072	12,921	10,950	13,351	14,840	12,662	10,237
Netherlands	1,234	2,088	366	-	64	-	353	13	-
UK (N. Ireland)	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	6	-	-
Total landings	11,398	13,366	13,953	12,921	11,014	13,351	15,199	12,675	10,237
Unallocated/ area misreported	8,448	1,390	3,873	3,581	2,813	2,880	4,000	5,116	3,103
Discards	-	-	-	-	-	-	-	-	-
WG catch	19,846	14,756	17,826	16,502	13,827	16,231	19,199	17,791	13,340

Country	2019	2010	2011	2012	2013	2014	2015	2016
France	-	-	-	-	-	-	-	-
Germany, Fed. Rep.	-	-	-	-	-	-	-	-
Ireland	8,533	7,513	4,247	3,791	1,460	2,933	73	1,171
Netherlands	-	-	-	-	40	-	+	72
UK (N. Ireland)	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	5	-
Total landings	8,533	7,513	4,247	3,791	1,500	2,933	78	1,243
Unallocated/ area misreported	1,935	2,728	2,672	2,780	2,468	2,163	1,000	971
Discards	-	-	-	-	-	-	-	-
WG catch	10,468	10,241	6,919	6,571	3,968	5,096	1,078	2,214

Table 5.1.3. Herring in divisions 6.a(S) and 7.b–c. Catch in numbers-at-age (winter rings) from 1970–2016.

	1	2	3	4	5	6	7	8	9
1970	135	35114	26007	13243	3895	40181	2982	1667	1911
1971	883	6177	7038	10856	8826	3938	40553	2286	2160
1972	1001	28786	20534	6191	11145	10057	4243	47182	4305
1973	6423	40390	47389	16863	7432	12383	9191	1969	50980
1974	3374	29406	41116	44579	17857	8882	10901	10272	30549
1975	7360	41308	25117	29192	23718	10703	5909	9378	32029
1976	16613	29011	37512	26544	25317	15000	5208	3596	15703
1977	4485	44512	13396	17176	12209	9924	5534	1360	4150
1978	10170	40320	27079	13308	10685	5356	4270	3638	3324
1979	5919	50071	19161	19969	9349	8422	5443	4423	4090
1980	2856	40058	64946	25140	22126	7748	6946	4344	5334
1981	1620	22265	41794	31460	12812	12746	3461	2735	5220
1982	748	18136	17004	28220	18280	8121	4089	3249	2875
1983	1517	43688	49534	25316	31782	18320	6695	3329	4251
1984	2794	81481	28660	17854	7190	12836	5974	2008	4020
1985	9606	15143	67355	12756	11241	7638	9185	7587	2168
1986	918	27110	27818	66383	14644	7988	5696	5422	2127
1987	12149	44160	80213	41504	99222	15226	12639	6082	10187
1988	0	29135	46300	41008	23381	45692	6946	2482	1964
1989	2241	6919	78842	26149	21481	15008	24917	4213	3036
1990	878	24977	19500	151978	24362	20164	16314	8184	1130
1991	675	34437	27810	12420	100444	17921	14865	11311	7660
1992	2592	15519	42532	26839	12565	73307	8535	8203	6286
1993	191	20562	22666	41967	23379	13547	67265	7671	6013
1994	11709	56156	31225	16877	21772	13644	8597	31729	10093
1995	284	34471	35414	18617	19133	16081	5749	8585	14215
1996	4776	24424	69307	31128	9842	15314	8158	12463	6472
1997	7458	56329	25946	38742	14583	5977	8351	3418	4264
1998	7437	72777	80612	38326	30165	9138	5282	3434	2942
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

Table 5.1.4. Herring in divisions 6.a(S) and 7.b–c. Percentage age composition (winter rings).

YEAR	1	2	3	4	5	6	7	8	9+
1992	1%	8%	22%	14%	6%	37%	4%	4%	3%
1993	0%	10%	11%	21%	12%	7%	33%	4%	3%
1994	6%	28%	15%	8%	11%	7%	4%	16%	5%
1995	0%	23%	23%	12%	13%	11%	4%	6%	9%
1996	3%	13%	38%	17%	5%	8%	4%	7%	4%
1997	5%	34%	16%	23%	9%	4%	5%	2%	3%
1998	3%	29%	32%	15%	12%	4%	2%	1%	1%
1999	1%	30%	36%	21%	6%	3%	1%	1%	1%
2000	3%	27%	30%	24%	10%	2%	1%	1%	1%
2001	2%	23%	23%	18%	19%	10%	2%	1%	1%
2002	3%	27%	31%	16%	10%	9%	2%	1%	1%
2003	2%	31%	27%	23%	9%	5%	2%	1%	0%
2004	2%	18%	38%	23%	10%	6%	2%	1%	0%
2005	0%	27%	29%	26%	10%	5%	1%	1%	0%
2006	0%	18%	29%	25%	18%	7%	2%	1%	0%
2007	0%	22%	39%	21%	12%	5%	2%	0%	0%
2008	1%	15%	24%	35%	14%	7%	3%	1%	0%
2009	0%	22%	21%	21%	22%	9%	4%	1%	0%
2010	2%	23%	34%	11%	13%	11%	4%	1%	0%
2011	0%	32%	21%	21%	8%	9%	7%	2%	0%
2012	12%	31%	40%	10%	4%	1%	1%	0%	0%
2013	0%	13%	19%	50%	7%	7%	2%	2%	1%
2014	0%	1%	27%	21%	38%	7%	3%	1%	1%
2015	0%	25%	8%	34%	23%	9%	1%	0%	0%
2016	0%	15%	31%	10%	22%	15%	6%	0%	0%

Table 5.1.5. Herring in divisions 6.a(S) and 7.b–c. Mean weights at age in the catches 1970–2016.

	1	2	3	4	5	6	7	8	9+
1970	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1971	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1972	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1973	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1974	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1975	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1976	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1977	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1978	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1979	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1980	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1981	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1982	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1983	0.090	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1984	0.106	0.141	0.181	0.210	0.226	0.237	0.243	0.247	0.248
1985	0.077	0.122	0.161	0.184	0.196	0.206	0.212	0.225	0.230
1986	0.095	0.138	0.164	0.194	0.212	0.225	0.239	0.208	0.288
1987	0.085	0.102	0.150	0.169	0.177	0.193	0.205	0.215	0.220
1988		0.098	0.133	0.153	0.166	0.171	0.183	0.191	0.201
1989	0.080	0.130	0.141	0.164	0.174	0.183	0.192	0.193	0.203
1990	0.094	0.138	0.148	0.160	0.176	0.189	0.194	0.208	0.216
1991	0.089	0.134	0.145	0.157	0.167	0.185	0.199	0.207	0.230
1992	0.095	0.141	0.147	0.157	0.165	0.171	0.180	0.194	0.219
1993	0.112	0.138	0.153	0.170	0.181	0.184	0.196	0.229	0.236
1994	0.081	0.141	0.164	0.177	0.189	0.187	0.191	0.204	0.220
1995	0.080	0.140	0.161	0.173	0.182	0.198	0.194	0.206	0.217
1996	0.085	0.135	0.172	0.182	0.199	0.209	0.220	0.233	0.237
1997	0.093	0.135	0.155	0.181	0.201	0.217	0.217	0.231	0.239
1998	0.095	0.136	0.145	0.173	0.191	0.196	0.202	0.222	0.217
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

Table 5.1.6. Herring in divisions 6.a(S) and 7.b–c. Mean weights at age in the stock at spawning time 1970–2016.

	1	2	3	4	5	6	7	8	9+
1970	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1971	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1972	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1973	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1974	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1975	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1976	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1977	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1978	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1979	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1980	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1981	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1982	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1983	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1984	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1985	0.100	0.150	0.196	0.227	0.238	0.251	0.252	0.269	0.284
1986	0.098	0.169	0.209	0.238	0.256	0.276	0.280	0.287	0.312
1987	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1988	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1989	0.138	0.157	0.168	0.182	0.200	0.217	0.227	0.238	0.245
1990	0.113	0.152	0.170	0.180	0.200	0.217	0.225	0.233	0.255
1991	0.102	0.149	0.174	0.190	0.195	0.206	0.226	0.236	0.248
1992	0.102	0.144	0.167	0.182	0.194	0.197	0.214	0.218	0.242
1993	0.118	0.166	0.196	0.205	0.214	0.220	0.223	0.242	0.258
1994	0.098	0.156	0.192	0.209	0.216	0.223	0.226	0.230	0.247
1995	0.090	0.144	0.181	0.203	0.217	0.226	0.227	0.239	0.246
1996	0.086	0.137	0.186	0.206	0.219	0.234	0.233	0.249	0.253
1997	0.094	0.135	0.169	0.194	0.210	0.224	0.231	0.230	0.239
1998	0.095	0.136	0.145	0.173	0.191	0.196	0.202	0.222	0.217
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

Table 5.1.7. Herring in divisions 6.a(S) and 7.b–c. Sampling intensity of catches in 2016.

Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
6.a.S	4	1807	31	2003	6284	1108
6.a.N	4	63	3	230	808	3651
7.b	4	335	1	56	194	167
Total		2205	35	2289	7286	1038

Table 5.1.8. Herring in divisions 6.a(S) and 7.b–c. Details of acoustic surveys dedicated to the 6aS/7bc stock alone.

Year	Type	Biomass	SSB
1994	Feeding phase	-	353,772
1995	Feeding phase	137,670	125,800
1996	Feeding phase	34,290	12,550
1997	-	-	-
1998	-	-	-
1999	Autumn	23,762	22,788
2000	Autumn	21,000	20,500
2001	Autumn	11,100	9,800
2002	Winter	8,900	7,200
2003	Winter	10,300	9,500
2004	Winter	41,700	41,399
2005	Winter	71,253	66,138
2006	Winter	27,770	27,200
2007	Winter	14,222	13,974
2016	Winter	35,475	35,475

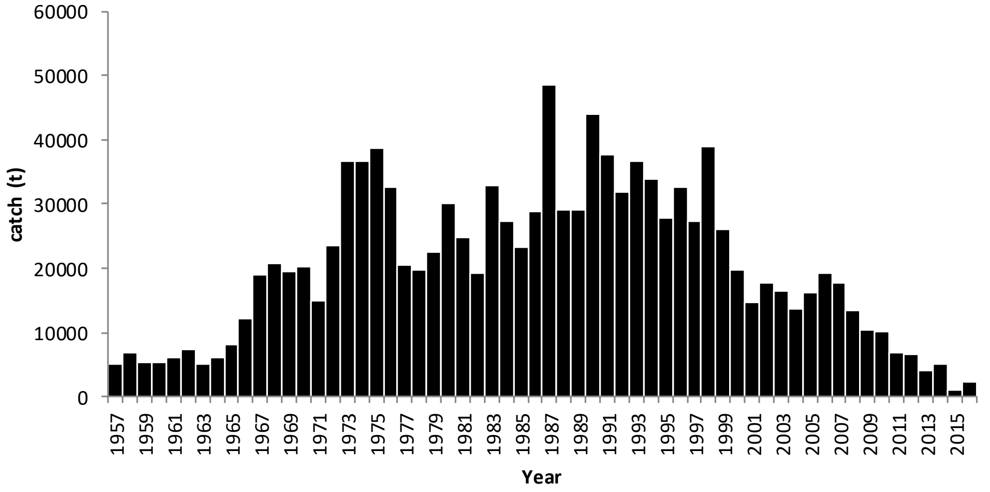


Figure 5.1.1. Herring in divisions 6.a(S) and 7.b–c. Working group estimate of catches from 1957–2016.

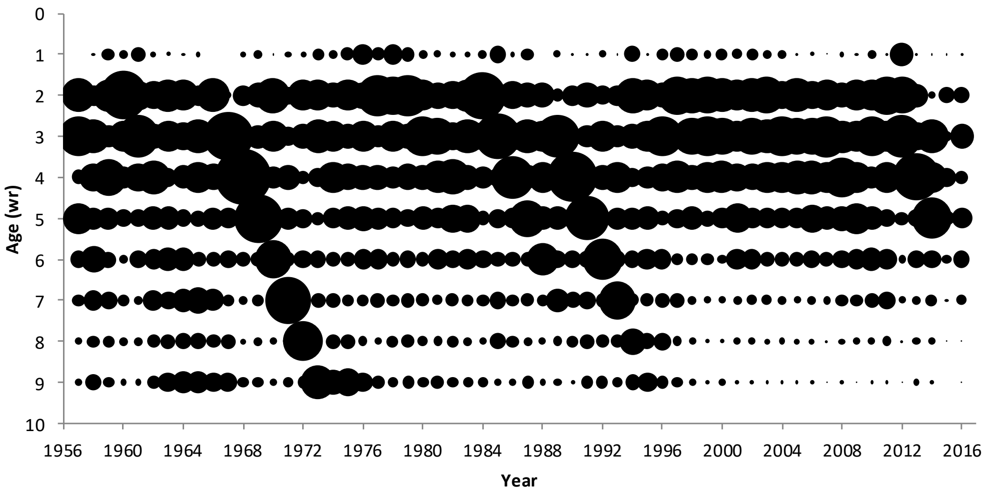


Figure 5.1.2. Herring in divisions 6.a(S) and 7.b–c. Mean standardised catch numbers at age standardised by year for the fishery 1957-2016.

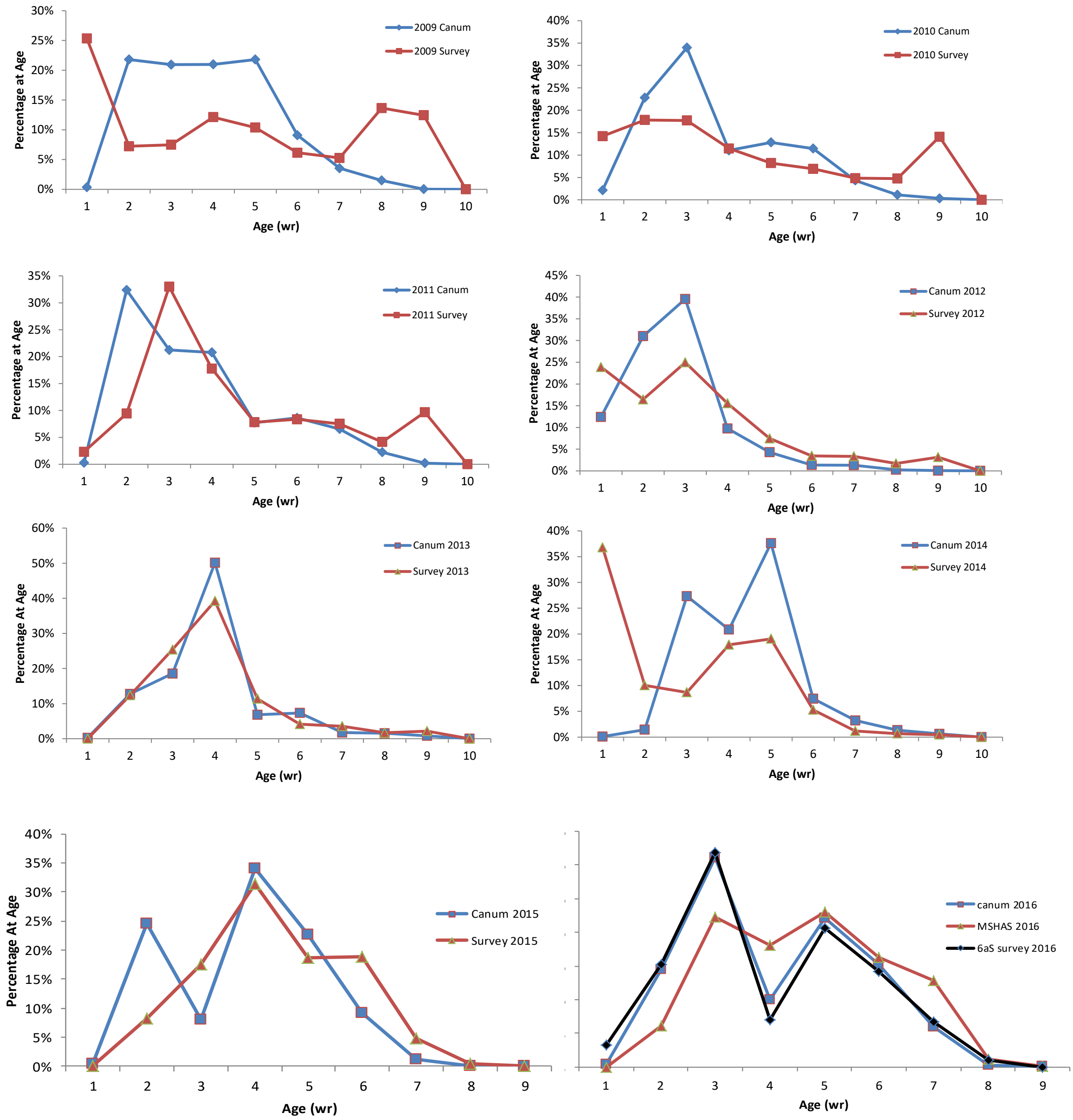


Figure 5.1.4. Herring in divisions 6.a(S) and 7.b–c. Percentages at age in the catch and survey data, MSHAS 2008–2016.

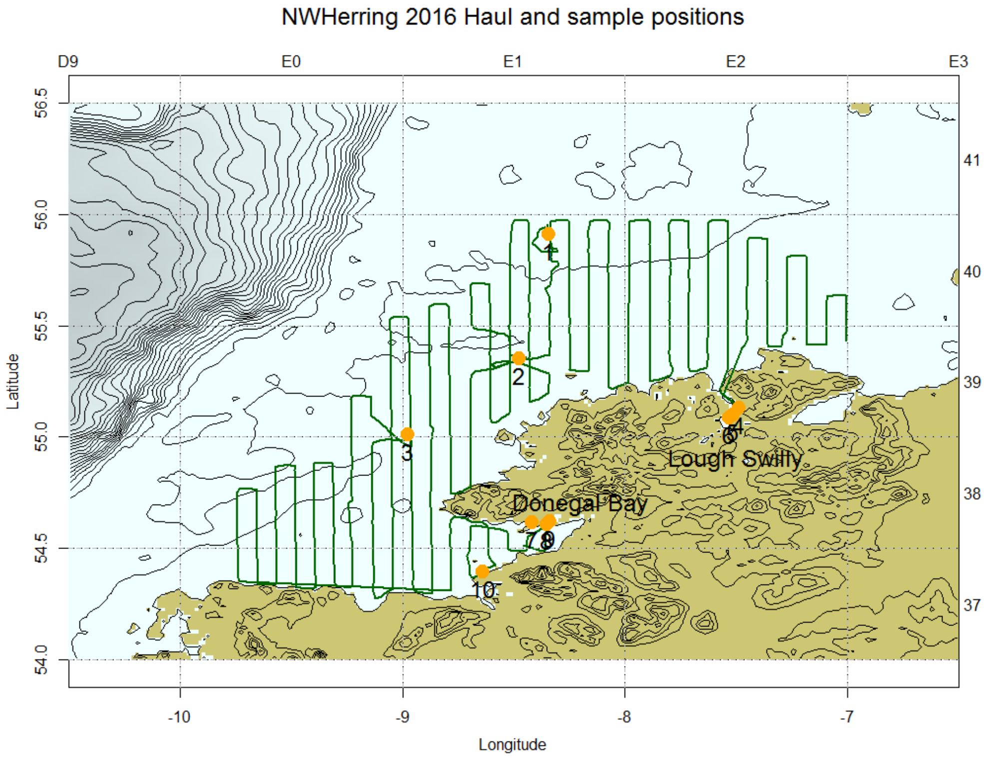


Figure 5.1.5. Herring in divisions 6.a(S) and 7.b–c. Acoustic survey in 2016: distribution of biological samples and acoustic transect data in 6aS - all samples and acoustics.

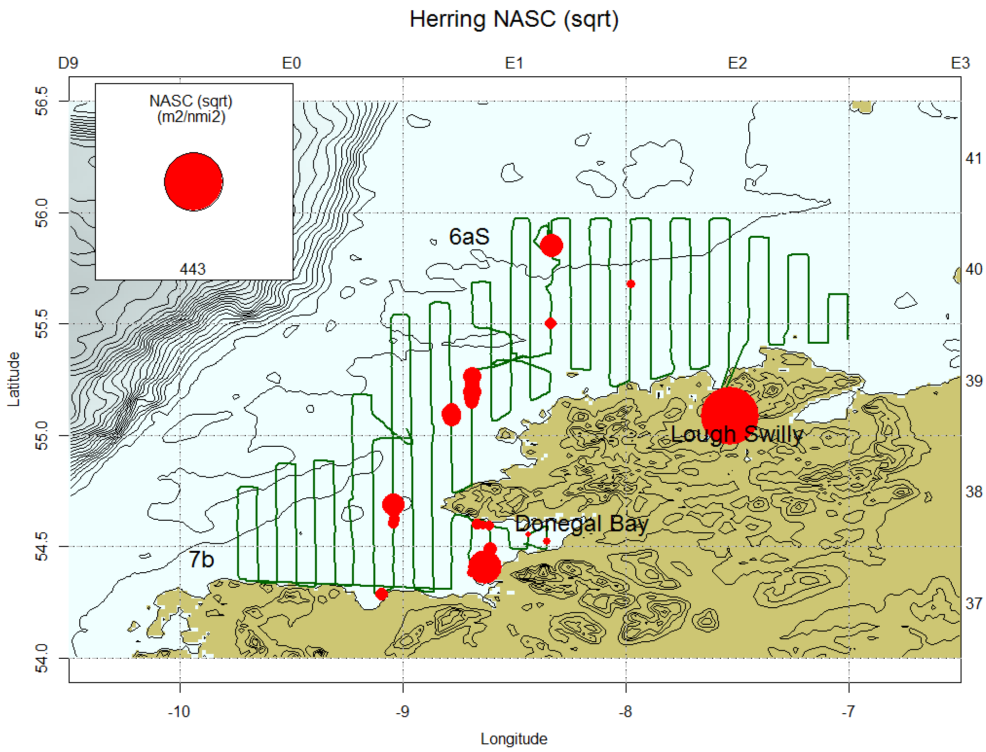


Figure 5.1.6. Herring in divisions 6.a(S) and 7.b–c. Acoustic survey in 2016: NASC of herring.

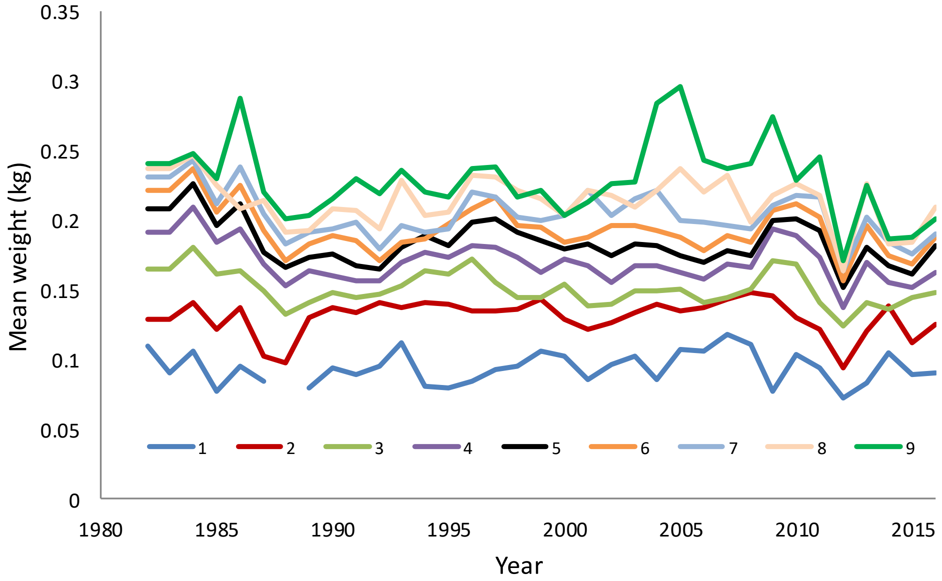


Figure 5.1.7. Herring in divisions 6.a(S) and 7.b–c. Mean Weights in the Catch (kg) by age in winter rings. For years before 1981 fixed at 1981 used.

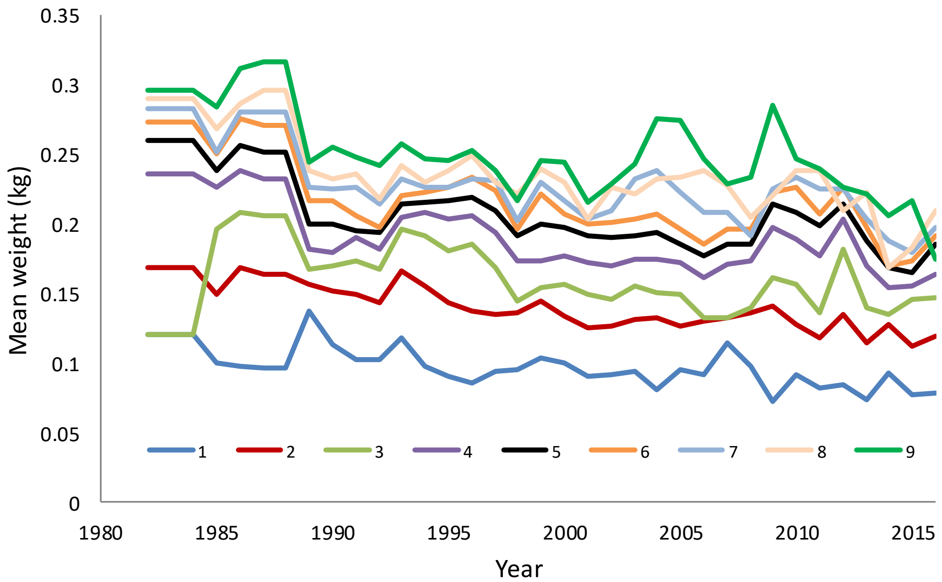


Figure 5.1.8. Herring in divisions 6.a(S) and 7.b–c. Mean weights in the stock (kg) at spawning time by age in winter rings. For years before 1981, the 1981 values are substituted in the assessment.

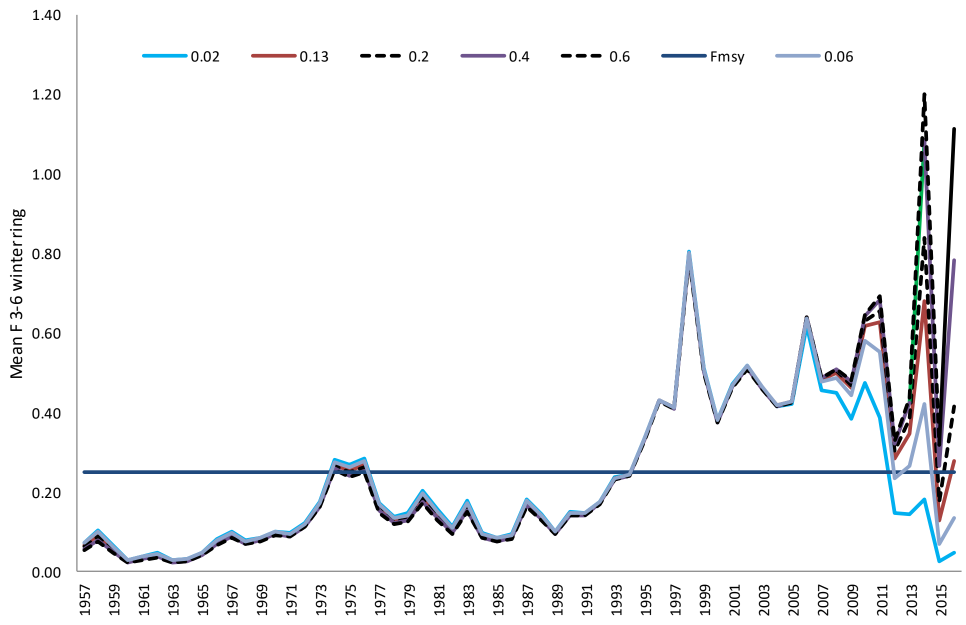


Figure 5.1.9. Herring in divisions 6.a(S) and 7.b–c. Mean F (3-6 winter ring) over time from 6 sVPAs with differing initial terminal F, F_{msy} (=0.25) for this stock also indicated.

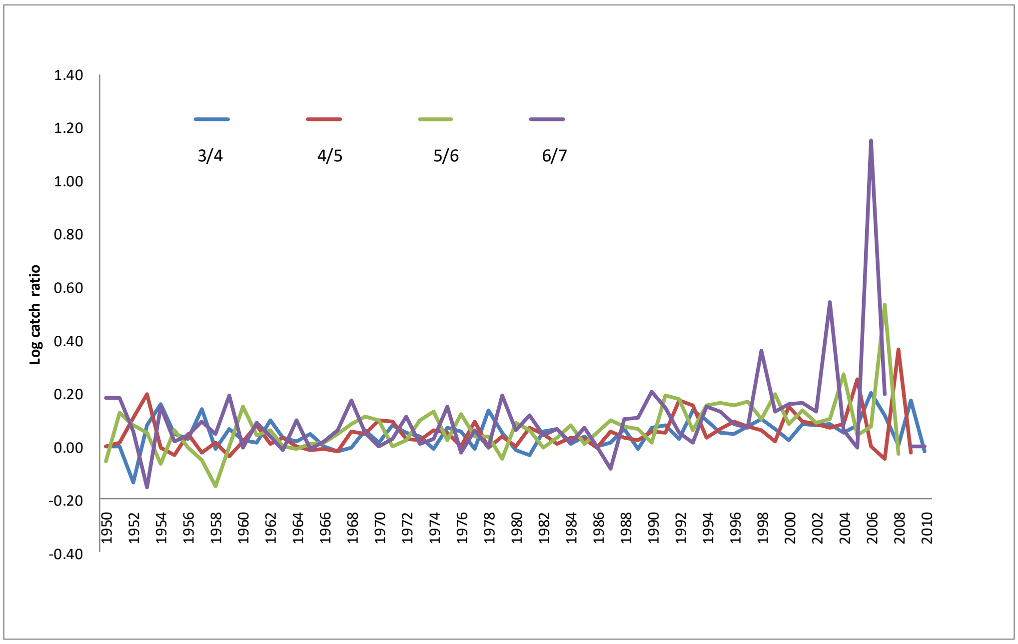


Figure 5.1.10. Herring in divisions 6.a(S) and 7.b–c. Log catch ratios [ln(catch y/ catch y+1) by cohort for main fully selected ages.

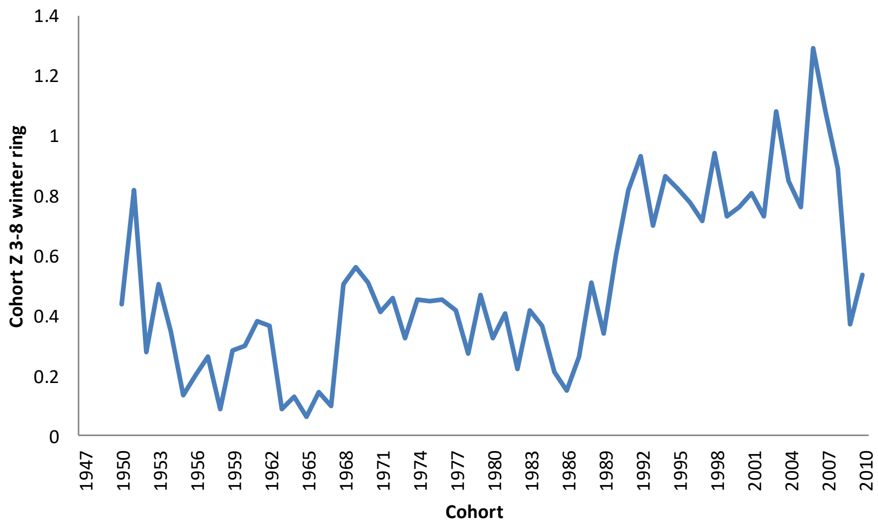


Figure 5.1.11. Herring in divisions 6.a(S) and 7.b–c. Catch curve derived estimates of total mortality Z (3-8 winter rings) for fully represented cohorts in the fishery to date.

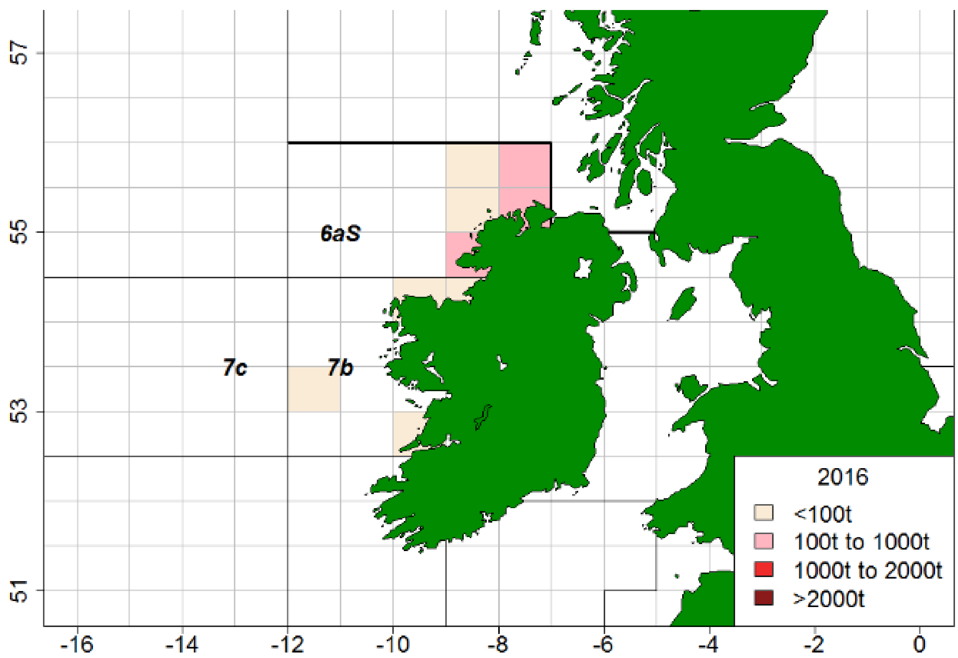


Figure 5.1.12. Herring in divisions 6.a(S) and 7.b–c. Irish official catches in 2016.

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, 6aN existed as a distinct management unit since 1982 when it was separated from 6.aS, 7.b-c.

The location of the area occupied by the stock is shown in Figure 5.2.1. For assessment purposes the stock is considered as an autumn spawning stock only, despite spring spawning components occurring in the area.

The WG noted that the use of “age”, “winter rings”, “rings” and “ringers” still causes confusion outside the group (and sometimes even among WG members). The WG tries to avoid this by consequently using “rings”, “ringers”, “winter ringers” or “wr” instead of “age” throughout this section. However, if the word “age” is used it is qualified in brackets with one of the ring designations. It should be observed that, for autumn and winter spawning stocks, there is a difference of one year between “age” and “rings”, which is not the case for the spring spawners. Further elaboration on the rationale behind this, specific to Division 6.aN autumn spawners, can be found in the Stock Annex. It is the responsibility of any user of age based data for any of these herring stocks to consult the stock annex and if in doubt consult a relevant member of the Working Group.

5.2.1 The Fishery

5.2.1.1 Advice and management applicable to 2016

In 2016 ICES advised 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 2016a). However, 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. In June 2016, ICES advised on a scientific monitoring TAC of 3 480 t for the 6.aN stock component (ICES 2016b), 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 4 170 t (EU 2016/0203).

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 6aN and 6aS. 7b-c, and submit relevant data to ICES to assist in assessing the herring stocks and contribute to establishing a rebuilding plan.

Using ICES advice on the design for a monitoring fishery (ICES 2016b), four areas were selected for surveying in 6aN (Figure 5.2.1), the limits of which were defined by the geographic overlap between known active herring spawning areas and the spatial distribution of commercial catches in recent years. Areas 2-4 are considered to be active spawning areas and Area 1 a pre-spawning aggregation area that contains an unknown mixture of stocks of Western and potentially North Sea herring, where a large proportion of catches has been taken in recent years (ICES 2016b).

A discard derogation was granted to the vessels during the period of the scientific survey to account for any by-catch of other species and any non-retained catches that could not be landed in marketable condition, this particularly being the case for the 3 Scottish refrigerated-sea-water (RSW) vessels.

All vessels completed their scientific survey duties prior to returning to the fishing grounds to catch their allocated quota. Acoustic surveys (see section 2.2) were conducted only in areas 2-4 in 6aN. Samples for biological, morphometric and genetic data were taken from all areas. Each of the 5 vessels involved in the survey were assigned specific objectives and provided with a vessel-specific survey manual describing the aims, methods and sampling protocols.

Details of the survey are reported in WGIPS, ICES (2017) and Mackinson *et al*. 2017.

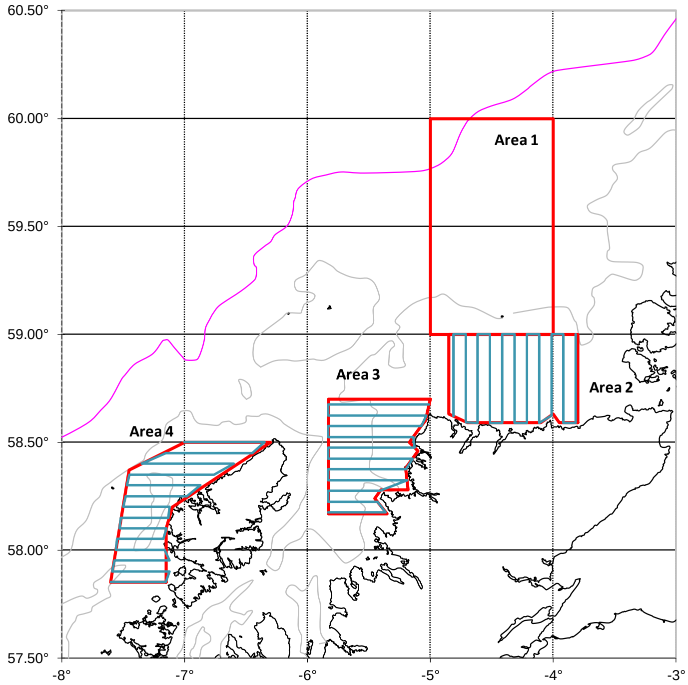


Figure 5.2.1. Limits of survey areas used in the 6aNorth surveys. Area 1- North pre-spawning mixing area, Area 2 -East of Cape Wrath, Area 3 – West of Cape Wrath, Area 4 – Outer Hebrides.

5.2.1.3 Stock recovery plan

Following ICES advice on the need for a stock recovery plan for herring in 6a/7bc, a draft recovery plan is under development under the auspices of the Pelagic Advisory Council.

5.2.1.4 Catches in 2016

Historically, catches have been taken from this area by Scottish and Northern Irish pelagic refrigerated sea water (RSW) trawler 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 2016 resulted in the 6.aN TAC being split equally between the 5 participating pelagic vessels.

The 2016 official catches of herring in 6aN total 5 174 t, compared with the 4 170 t monitoring TAC. The Working Group's estimates of reallocated catches are 450 t giving a catch of 4 724 t. The additional catches above the TAC were taken using "banked" quota from 2015 and were used to cover incidental catches of herring taken during the fishery for horse mackerel in 2016. There were 49 t of non-retained herring catch during the monitoring fishery in 2016 under the discard derogation and no other reported discards.

5.2.1.5 Regulations and their affects

There are no new changes to the regulations relevant to the fishery in 6.a (North).

5.2.1.6 Changes in fishing technology and fishing pattern

Implementation of the scientific monitoring fishery in 2016 resulted in the 6aN TAC being split equally between the 5 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

Biological data from commercial hauls taken during the monitoring fishery were used in generating the catch-at-age data for the 2017 assessment.

Catch and sample data, by country and by period (quarter), are detailed in Table 5.2.4. The number of samples used to allocate an age-distribution for the 6.a (N) catches decreased to 22 in 2016, from 32 in 2015. Most samples (19) were collected during the monitoring fishery in Q3, 14 taken by scientists on-board and 5 on-shore at processors as vessels were landing. Samples covered the Scottish (7), English (5), German (7) and Irish (3) fleets respectively. 51.3% of the catch was taken by the Scottish RSW fleet; 39.4% was taken by the international freezer trawler fleet; the remaining 9.3% was caught by the Dutch, Irish and Danish fleets. Whilst there were fewer samples than previous years due to the zero TAC and limited monitoring fishery this sample coverage of fleets was in line with the distribution of previous years. 19 of the 22 samples obtained came from quarter 3 and 3 from quarter 4. The available samples were used to allocate catch-at-age(winter rings) (using the sample number weighting) to unsampled catches, in the same or adjacent quarters. Quarter 3 samples were allocated to unsampled quarter 3 catches, quarter 4 samples were used for quarter 4 unsampled catches and combined quarter 3 and 4 catches were used for unsampled quarter 1 and 2 catches. The allocation of age distributions to unsampled catches, and the calculation of total international catch-at-age and mean weight-at-age in the catches were done following established raising methods. A detailed description of the process in 2016 can be found in (WD02, HAWG 2017)).

The 2013 year class (2-ringers in 2016) dominated the catch in 6.aN (33% of the catch) (Figure 5.2.8, Table 5.2.7). This year class is also coming through very strongly in the neighbouring North Sea autumn spawning stock. The 2008 year class (7-ringers in 2016) was the last strong cohort and still contributes to the catch. There is almost no fish older than 7-winter rings in the catches this year. 1-ring herring were present in very small numbers in the catches in 6.aN and are generally observed intermittently only. They 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 Anon (2010). The 2016 survey values are shown in Table 5.2.5.

Full details of the 2016 survey are available in the Report of the Working Group for International Pelagic Surveys (WGIPS, ICES 2017, Annex 4c).

Table 5.2.1 The 2016 acoustic survey in 6.aN

VESSEL	PERIOD	STRATA
Celtic Explorer (IRL) EIGB	18 June – 06 July	2, 3, 4
Scotia (SCO) MXHR6	25 June – 15 July	1a, 1b

The spawning stock biomass estimate for the acoustic survey in the area historically used for the 6.a (North) spawning stock biomass (Table 5.2.6) has decreased dramatically by approximately 77% from 2015 (from 387 000 tonnes to 87 907 tonnes).

The proportions of each year class in the catch and the survey are shown in Figure 5.2.8. The high proportion of 2-ringers observed in the catches was not seen in the acoustic survey results. The 2010 year class was along with the 2012 year class the most prominent in the survey in line with last year. The acoustic survey detected almost no herring above age 7 (wr) similar to the pattern in the catches. 1-ringers were absent from the survey.

5.2.3.2 Acoustic survey –6a Herring industry-science survey 2016

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 pre-spawning/ spawning herring in 6aN. Total herring biomass was estimated to be 27 440 t (Table 5.2.2, Figure 5.2.3) The survey methods and results were reviewed by ICES WGIPS, who recommends to data users that the results provide reliable estimates of the minimum biomass of herring within the principal active spawning areas and the locations of reported commercial fishing activity conducted in August-September in recent years (WGIPS, ICES 2017). It is anticipated that the survey provides the first data point in a new SSB survey series.

5.2.4 Mean Weights-At-Age and Maturity-At-Age

5.2.4.1 Mean weight-at-age

Weights-at-age in the stock are obtained from the acoustic surveys (WGIPS, ICES 2017) and are given in Table 5.2.5 (for the current year). The weights-at-age in the stock in 2016 have decreased particularly for ages 2, 3 and 4 winter rings with 12%, 23% and 10% respectively (Table 5.2.9). This continues a trend of decreasing weights-at-age in the stock for those ages over the last 10 years.

The weights-at-age in the catch has been relatively stable over the last 5 years (Table 5.2.8). In 2016 weights in the catch were comparable to 2015 for all ages (rings) apart from 9+ ringers which were slightly lower compared to the previous year.

5.2.4.2 Maturity ogive

The maturity ogive is obtained from the acoustic survey (Table 5.2.5; WGIPS, ICES 2017). The survey provides estimated values for the period 1992 to 2016 (Table 5.2.10). Up to 2015 the trend in recent years has been towards lower maturity at age. However, in 2015, the majority of herring above age 2 winter ring were mature. And in 2016 very few immature fish at all were observed in the survey (97% mature at age 2 winter ring and 99% mature at age 3.

5.2.5 Recruitment

There are no specific recruitment indices for this stock. Although both catch and acoustic survey can have some catches at 1-ring, both the fishery and survey encounter this age group only incidentally. The first reliable appearance of a cohort appears at 2-ring in both the catch and the survey for this stock. In 2016 the proportion of 2-ringers was very high in the catches and potentially indicative of a strong year class (Figure 5.2.8). This same pattern was not apparent in the acoustic survey results however.

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 was examined in detail by the benchmark group WKWEST (ICES, 2015/ACOM:34). Details of the 2016 assessment for 6.a (combined) and 7.b–c are outlined in Section 5.6 in 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 5.2.8). The 2013 year class was strong in the 2016 catches but this was not confirmed in the survey. This year class was exceptionally large in the neighbouring North Sea herring also. There is an almost complete absence in the stock now of 8 and 9+ winter ring fish in both the catches and the acoustic survey the last couple of years. The acoustic survey index has been decreasing steadily since 2008 and the 2016 value was the lowest on record for this stock.

The overall meta-population (the two stocks in 6.a, 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 was instated in 2016 and this should be maintained to allow sampling for stock separation and maintaining the time series of catch composition. However, mortality signals should be monitored to ensure that F is very low. As an upper limit, F=0.05, a minimum F that simulation has shown to be consistent with rebuilding in Norwegian spring spawning herring and other stocks.

5.2.11 Ecosystem Considerations

Herring fisheries tend to be clean with little bycatch of other fish. Observers monitor some of the fleets. Scottish discard observer programs since 1999 and more recently Dutch observers indicate that discarding of herring in these directed fisheries is at a low level. The Scottish discard observer program has recorded occasional catches of seals and zero catches of cetaceans in the past. The Scottish pelagic discard observer program is no longer active, it was terminated in 2011.

Herring are an important prey species in the ecosystem west of the Bristish 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 5.2.2. Total Abundance and overall biological composition of herring in 6a North from the acoustic survey. *Spawning herring is a subset of the mature herring.

Age	Abundance ('000s)	Mature	Spawning	Biomass (t)	Mean length (cm)	Mean weight (g)
1	4764	3%	0%	277	-	-
2	62298	98%	41%	8456	25.1	135.7
3	22221	100%	67%	3957	27.2	178.1
4	17828	100%	74%	3651	28.3	204.8
5	12393	100%	72%	2740	29.1	221.1
6	15779	100%	72%	3624	29.5	229.7
7	12829	100%	80%	3038	29.9	236.8
8	4466	100%	83%	1068	30.2	239.1
9	1775	100%	89%	455	30.9	256.4
10	583	100%	98%	145	30.7	249.7
11	7	100%	100%	1	31.5	197.0
12	32	100%	100%	8	30.0	262.0
13	0	-	-	0	-	-
14	32	100%	100%	9	30.5	278
Immature	6220	-	-	433	20.2	69.6
Mature	148712	-	-	26995	27.3	181.5
Spawning*	90208	-	-	17627	28.0	195.4
TOTAL	154942	96%	58%	27440	27.0	177.0

Table 5.2.3. Herring in 6.a (North). Catch in tonnes by country, 1991–2016. 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
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
Country	2009	2010	2011	2012	2013	2014	2015	2016	
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	
Lithuania						770			
Norway							0.98		
Netherlands	5675	3600	1684	3523	1775	1641	956	300	
UK	11076	12018	11696	12249	15906	16769	15260	3254	
Unallocated									
Discards*		95			30				
Total	21306	22510	21358	21296	25446	26115	21307	5174	
Area-Misreported	-2798	-2728	-3599	-2780	-2468	-4088	-2506	-450	
WG Estimate	18508	19877	17759	18516	22978	22027	18801	4724	
Source (WG)	2010	2011	2012	2013	2014	2015	2016	2017	

*** Unraised discards**

$ Revised at WKWEST 2015

Table 5.2.4. Herring in 6.a (North). Catch and sampling effort by nations participating in the fishery in 2016..

Area: 6.a(n)

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Denmark	0.00	23.30	0	0	0	0.00
Germany	1009.11	1028.19	7	1519	653	98.14
Ireland	513.20	568.69	3	808	230	90.24
Netherlands	0.00	299.75	0	0	0	0.00
UK(England)	830.56	830.92	5	1070	405	99.96
UK(Scotland)	2398.28	2423.35	7	827	398	98.97
Period Total	4751.15	5174.20	22	3416	1686	91.82

SUM OF OFFICIAL CATCHES:	**5174.20**
MISREPORTED CATCH:	**-450.00**
WORKING GROUP CATCH:	**4724.20**

Quarter 1

Country	Sampled Catch	Official Catch	No. samples	No. measured	No. aged	SOP %
Denmark	0.00	20.16	0	0	0	0.00
Germany	0.00	19.08	0	0	0	0.00
Ireland	0.00	55.22	0	0	0	0.00
Netherlands	0.00	145.19	0	0	0	0.00
UK(England)	0.00	0.36	0	0	0	0.00
UK(Scotland)	0.00	19.34	0	0	0	0.00
Period Total	0.00	259.35	0	0	0	0.00

SUM OF OFFICIAL CATCHES:	**259.35**
MISREPORTED CATCH:	**0.00**
WORKING GROUP CATCH:	**259.35**

Quarter 2						
Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Netherlands	0.00	5.55	0	0	0	0.00
Period Total	0.00	5.55	0	0	0	0.00

Sum of Official Catches:	**5.55**
Misreported Catch:	**0.00**
Working Group Catch:	**5.55**

Quarter 3						
Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Germany	1009.11	1009.11	7	1519	653	100.00
Ireland	0.00	0.27	0	0	0	0.00
Netherlands	0.00	75.62	0	0	0	0.00
UK(England & Wales)	830.56	830.56	5	1070	405	100.00
UK(Scotland)	2398.28	2398.28	7	827	398	100.00
Period Total	2077.95	4313.83	19	4208	1456	48.17

Sum of Official Catches:	4313.83
Unallocated Catch:	0.00
Working Group Catch:	4313.83

quarter 4						
Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Denmark	0.00	3.14	0	0	0	0.00
Ireland	513.20	513.20	3	808	230	100.00
Netherlands	0.00	73.39	0	0	0	0.00
UK(Scotland)	0.00	5.73	0	0	0	0.00
Period Total	513.20	595.46	3	808	230	86.19

SUM OF OFFICIAL CATCHES:	**595.46**
MISREPORTED CATCH:	**-450.00**
WORKING GROUP CATCH:	**145.46**

Table 5.2.5. Total numbers (millions) and biomass (thousands of tonnes) of autumn spawning West of Scotland herring in the area surveyed in the acoustic surveys July 2016, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	0	0.0		0	0.0
1	0	0.0		0	0.0
2	30	4.1	0.97	137	24.4
3	108	15.2	0.99	140	25.0
4	88	15.3	1	175	26.8
5	112	22.5	1	202	28.3
6	79	16.5	1	208	28.7
7	62	13.0	1	209	29.0
8	6	1.2	1	210	29.3
9+	1	0.2	1	242	30.3
Immature	2	0.2		119	23.4
Mature	483	87.7		182	27.2
Total	485	87.9	1	181	27.2

Table 5.2.6. Herring in 6.a (North). Estimates of abundance and SSB for the time series of acoustic surveys in the historically surveyed area of 6.a (N), not including Clyde and North Channel. 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

Table 5.2.7 Herring in 6.a (North). Catch in number.

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	15716.6	3197
5	8332.17	14608.15	7190.29	8097.30	11681.99	42229.47	19386.7	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

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
1	0.0000	0.0769	0.100
2	0.1451	0.1425	0.144
3	0.1877	0.1795	0.178
4	0.2030	0.2059	0.204
5	0.2279	0.2136	0.219
6	0.2449	0.2307	0.229
7	0.2608	0.2386	0.237
8	0.2614	0.2454	0.251
9	0.2835	0.2685	0.257

Table 5.2.9 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
1	0.065	0.064
2	0.155	0.137
3	0.183	0.140
4	0.195	0.175
5	0.204	0.202
6	0.211	0.208
7	0.217	0.209
8	0.215	0.210
9	0.220	0.242

Table 5.2.10 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
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	0.92	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
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
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
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
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	0.97	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

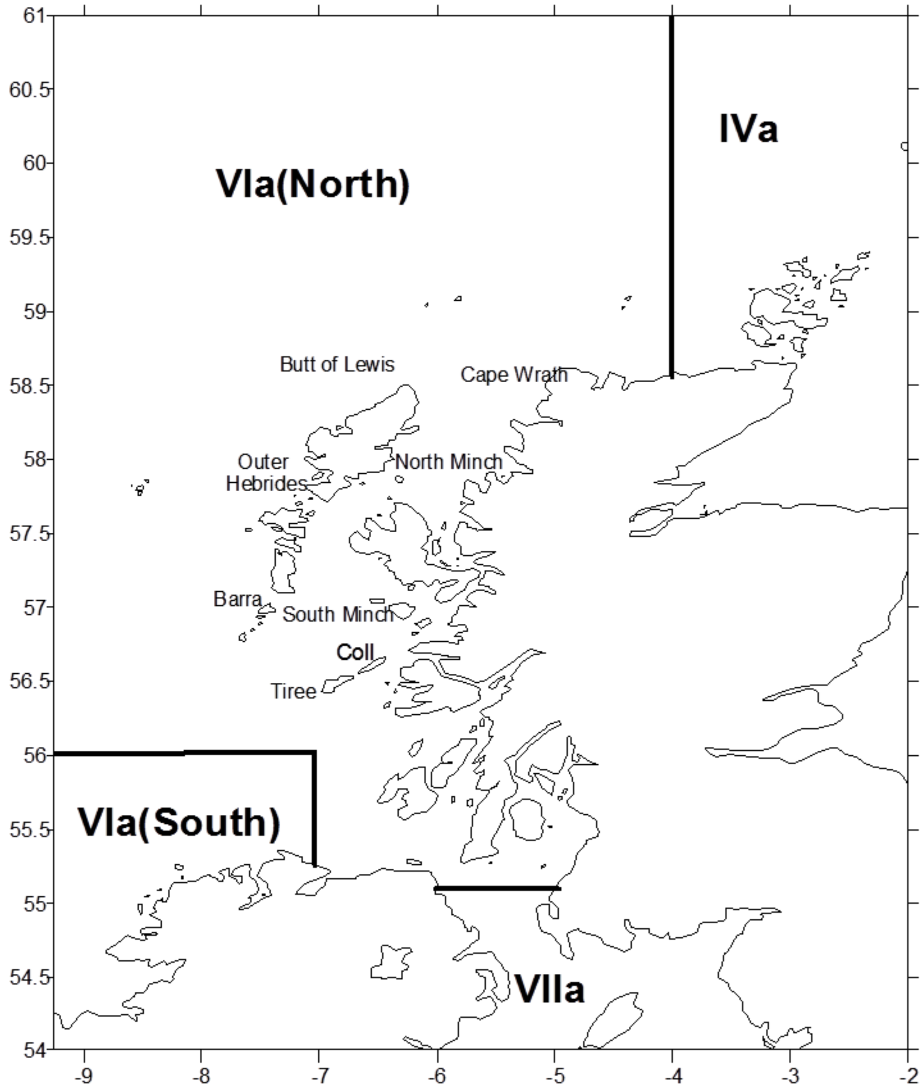


Figure 5.2.1. Location of ICES area 6.a (North) and adjacent areas, with place names.

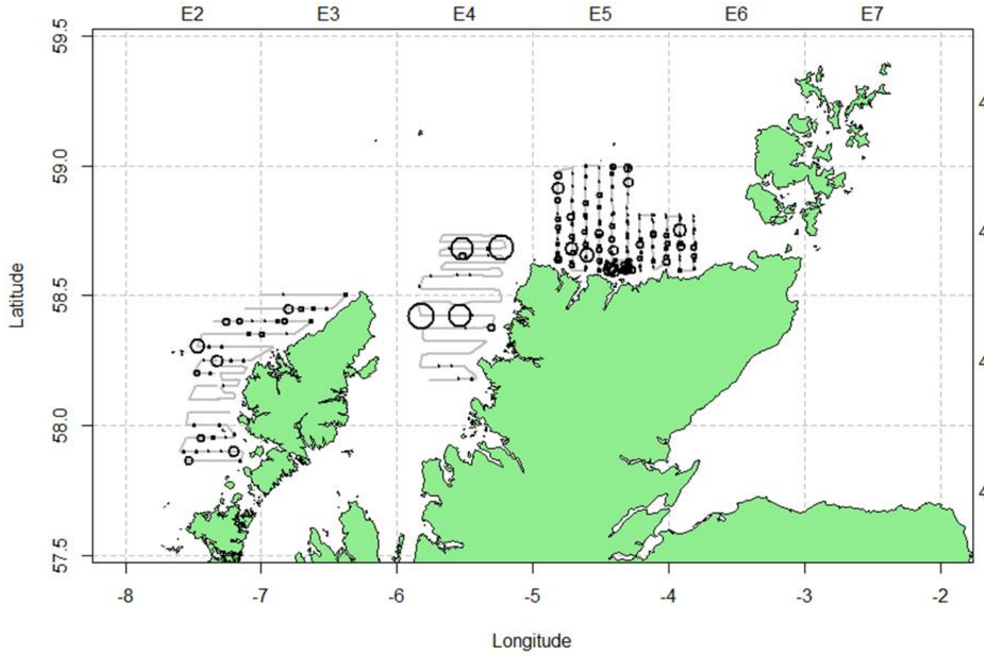


Figure 5.2.3. Relative acoustic density (NASC m²/mn²) recorded during the 6aN herring industry-science survey.

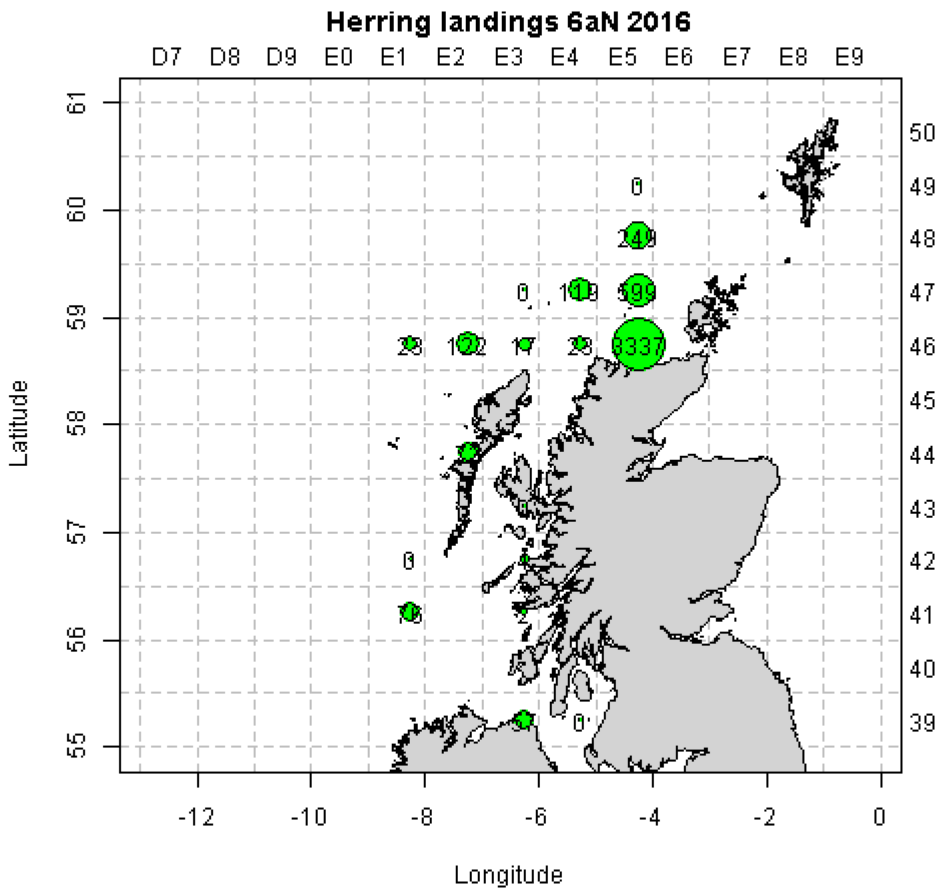


Figure 5.2.5. Herring in 6.a (North). Herring catches in tonnes in all quarters in 2016 by statistical rectangle. WG estimates

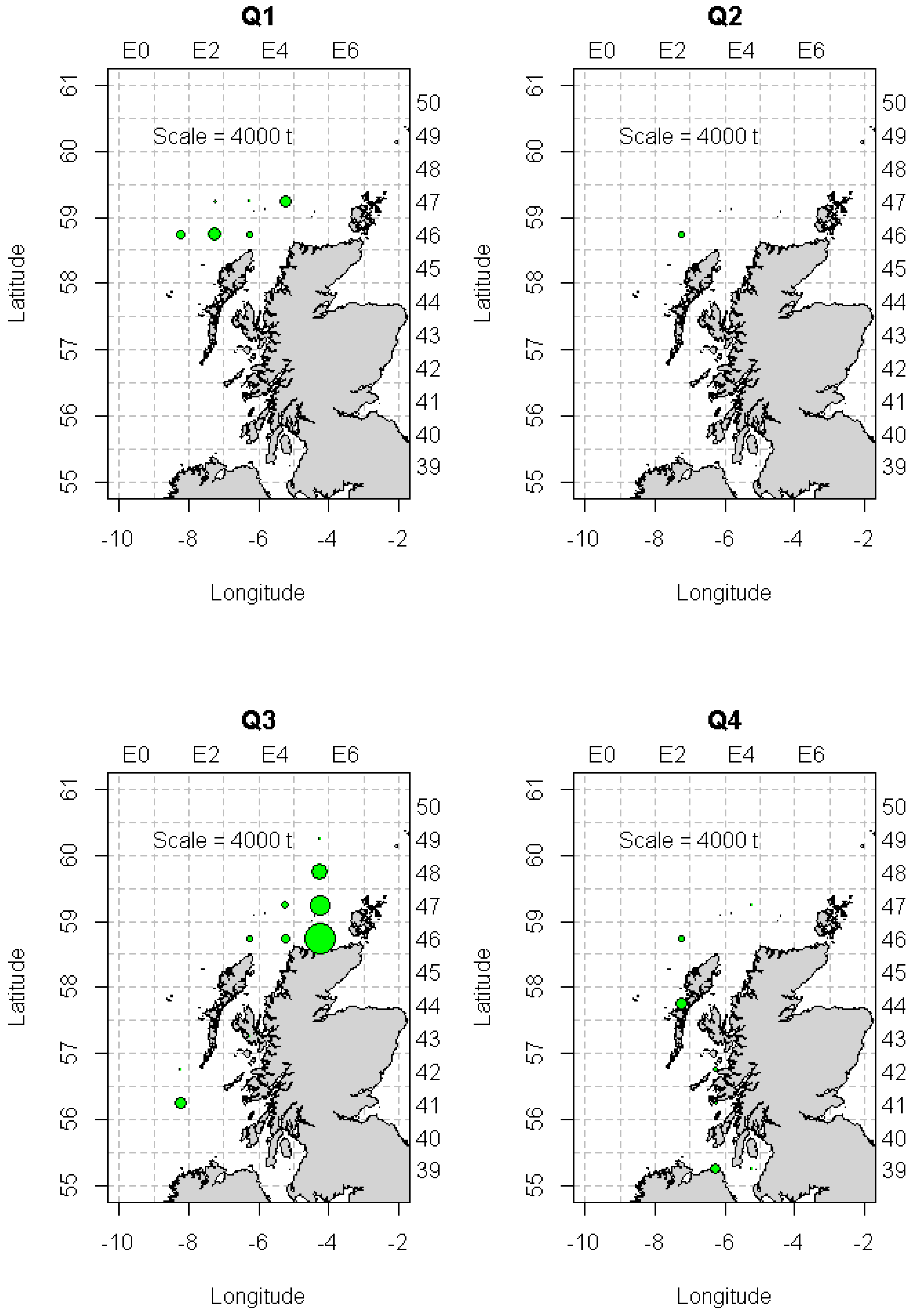


Figure 5.2.6. Herring in 6.a (North). Herring catches in tonnes by quarters in 2016 by statistical rectangle (Radius of bubbles of 0.25 degrees latitude = 4 000 t). WG estimates.

Figure 5.2.7. Herring in 6.a (North). Mean standardised catch numbers-at-age standardised by age, 1986 to 2016

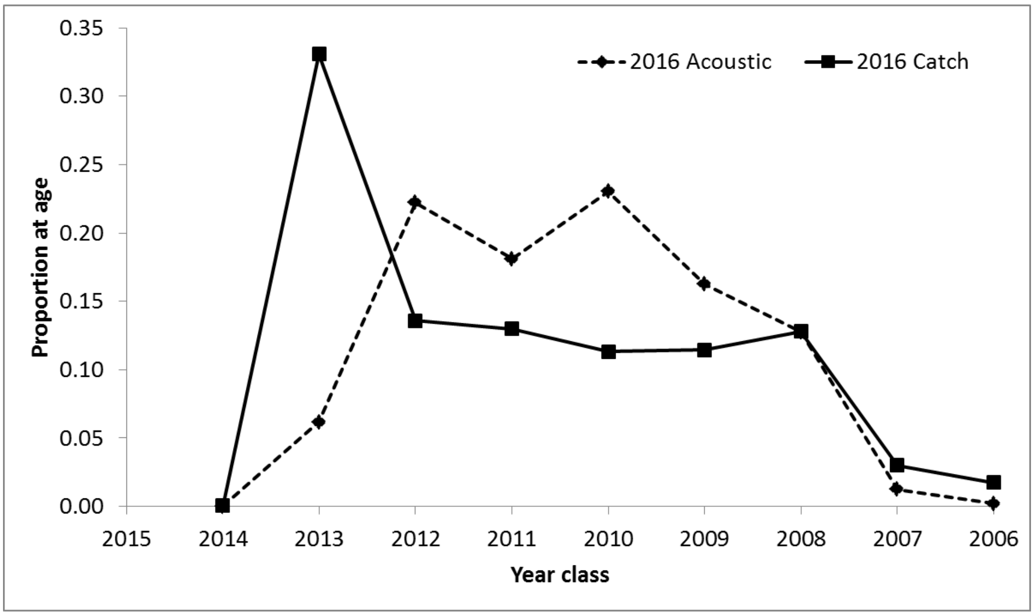


Figure 5.2.8. Herring in 6.a (North). Comparison of the proportions-at-age, by year class, in the 2016 acoustic survey (MSHAS_N) and the 2016 catch.

6 Herring in the Celtic Sea (Division 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 —31 March. Unless otherwise stated, year and year class are referred to by the first year in the season i.e. 2015 refers to the 2015/2016 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 2016–2017

The TAC is set by calendar year and in 2016 was 15 442 t (agreed by the Council of the European Union, based on the long term management plan). The TAC for 2017 is 14 467 t. Carryover of unused quota took place in 2015 and 2016, meaning that the final TAC was higher than the initial level.

Long Term Management Plan

A long term management plan has been proposed by the Pelagic RAC. This plan was evaluated by ICES in 2012, and again in 2015 (ICES, HAWG, 2015) and found to be consistent with the precautionary approach. It was also found to deliver long term sustainable yield, at the expense of maximising yield in any one year. The proposed target F is 0.23 and the trigger biomass point is 61 000 t. The plan has not been enshrined in legislation, owing to the inter-institutional deadlock that arises from the EU’s Treaty of Lisbon. However it has been used by the Council of the European Union in every year since 2012. Upon request of the European Commission, the catch option consistent with the plan is included each year in the advice sheet.

6.1.2 The fishery in 2016/2017

The Irish fishery took place in the third and fourth quarter of 2016 and in the first quarter of 2017. In the third quarter, fishing took place in 7.g only, and in the fourth quarter it occurred in mainly in 7.g.

The Netherlands reported catches of just over 1 000 t, Germany just over 400 t, and the UK-Northern Ireland nearly 600 t. As usual, the there was a small catch were from Division 7.h. This is part of the management area, but it is unclear if it is part of the stock area.

The distribution of the Irish landings is presented in Figure 6.1.2.1.

The estimated catches from 1988–2016 for the combined areas by year and by season (1 April–31 March) are given in Table 6.1.3.1 and Table 6.1.3.2 respectively. The catch taken during the 2016/2017 season decreased to about 16 000 t (Figure 6.1.3.1).

The catch data include discards in the directed fishery until 1997, and again from 2012. Discards (from Irish observed trips) were raised to the total international catch using a weighted average of 1.13% derived from O'Dwyer et al. (2016).

6.1.3 Regulations and their effects

Under the rebuilding plan, the closure of Subdivision 7.a.S 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.a.S to vessels under 50 feet, but the total quota allocation increased from 8% to 11%. Therefore from 2012 there was a slight increase in landings from this area.

There is evidence that closure of Subdivision 7.a.S, under the rebuilding plan, helped to reduce fishing mortality (Clarke and Egan, 2017). The exact mechanisms for this are unclear. Under the long term management plan if the SSB falls below 41 000 t Subdivision 7.a.S will be closed with only a small scale sentinel fishery permitted.

6.1.4 Changes in fishing technology and fishing patterns

The fishery in the past 3 seasons has been very different to previous years. In the recent seasons, herring have been found only very close to the bottom, in the main fishery, offshore in Division 7.g. The fishery reports that herring are rarely visible on the echo-sounders. Tow duration has increased markedly because it takes longer to catch the desired quantity of herring. It was difficult for the Irish fleet to catch its quotas.

Vessels greater than 50 feet total length are excluded from 7.a.S under local Irish legislation. This has shifted effort onto the Smalls ground, just south of the 52°N line, which straddles the boundary between the Irish and UK exclusive economic zones (EEZs). This has become the main fishing area in the past 4 years. If 7.a.S was open to Irish vessels (>50 feet TL) then it is unlikely there would be any Irish effort in the Smalls ground. Previously, there was no history of fishing herring in this area. It is not clear if herring always occurred here, and are only being fished now, or whether they existed there unbeknownst to the fishery.

The small-vessel fishery in 7.a.S also reported difficulty in catching the quota available.

The increases in the TAC in recent years have attracted more Irish vessels, and some non-Irish vessels to fish this stock. Irish quota is allocated to vessels on a weekly basis. The large number of vessels involved has led to individual quotas being reduced. This led to increased discarding risk due to vessels being unable to catch their small allocations without extra-quota catches that are often slipped. However in 2012, flexibility was introduced to the system, whereby a vessel could use some of the following week's quota to mitigate slippage.

6.1.5 Discarding

It is thought that discarding has declined since 2012 due to the flexibility incorporated into the weekly quota system. Estimates of discarding from observed trips for the purposes of marine mammal by-catch studies, reported 1% discarding in 2012, 0.8% in 2013 (McKeogh and Berrow, 2013), 3.4% in 2014 (McKeogh and Berrow, 2014), 1.4% in

2015 in the main fishery and 1.5% in the 7.a.S small boat fishery (Pinfield and Berrow, 2015,) and 1.13% O'Dwyer et al. (2016) .

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 a new flexibility mechanism being introduced in quota allocation, since 2012. Available evidence is that the discard rate is negligible in directed fisheries.

Since 2015, this stock is now 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 2016. The same year classes dominated the catches in 2016 as in 2015. However there was less resolution between their individual strengths as in 2015 (Table 6.2.1.1). The yearly mean standardised catch numbers-at-age are shown in Figure 6.2.1.1. There is a wide representation of ages, unlike the situation 10 years ago when few older fish were present.

The overall proportions-at-age in all sampled metiers (division*quarter) are presented in Figure 6.2.1.3. The fisheries age profiles generally show good agreement. The number of 1-ringers is very low in the fishery, however, there was an increase in 1 wr fish in the acoustic survey in 2016; these are not used in the assessment. Table 6.2.1.2 and Figure 6.2.1.4 show the length frequency data by area and quarter. Length frequencies were very similar in 7.g in Q3 and Q4 in 2016; the median length frequency distribution in 7.a.S Q4 was slightly smaller.

6.2.2 Quality of catch and biological data

Biological sampling of the catches was comprehensive throughout the area exploited by the Irish fishery (Table 6.2.2.1). Under the Data Collection Framework the sampling of this stock is well above that required by the Minimum Programme (Section 1.5).

The quality of catch data has varied over time. A rudimentary history of the Irish fishery, and data quality, since 1958 is presented in the Stock Annex.

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 2002–2016, excluding certain years and is presented in Table 6.3.1.1.

The acoustic survey of the 2016/2017 season was carried out from 7–27th October 2016, on the *Celtic Explorer* **http://hdl.handle.net/10793/1194**. Survey effort (3,092 nmi of transects for acoustic integration) and geographical coverage (over 10,000 nmi²) was extended from 2015 for all core areas (Figure 6.3.1.1a).

The 2014 and 2015 survey estimates from the CSHAS were omitted from the assessment at the recommendation of WGIPS. The main reason was the concern over the offshore distribution of the migrating herring and the possibility that some of the stock still lay outside the boundary of the survey (WGIPS 2015, 2016; and HAWG 2015, 2016). During the 2016 survey the distribution of herring was again mainly offshore and only a few schools were observed in the inshore spawning areas (Figure 4.3.1.1b). An adaptive survey design similar to the 2015 survey was carried out with the inclusion of mini-surveys in areas where fish were known to be distributed from information coming from the fleet (Figure 6.3.1.1c). Combined, the four adaptive surveys accounted for 587 nmi of transects covering an area of 312 nmi^2. Herring schools were mostly in close proximity to the bottom throughout the survey in 2016, making it difficult to resolve echo traces from the bottom echo. WGIPS (2017) again recommended that the estimates from the survey in 2016 be treated with caution, mainly because of this issue. Resolving the issue of reduced catchability in the survey in recent years is a priority for this survey.

A total of 29 trawl hauls were carried out during the survey (Figure 4.3.1.1a), with 7 hauls containing > 50% herring by weight of catch. A total of 400 herring were aged from survey samples in addition to 2,384 length measurements and 792 length-weights recorded. Herring age samples ranged from 0-9 winter-rings. Age composition of Pass 1 was dominated by 1 winter ring fish representing 21.2% of the total stock biomass (TSB) and 38.6% of total stock numbers (TSN), followed by 5 winter ring (20.2% TSB and 14.8% TSN) and 4 winter ring (16.4% TSB and 12.9% TSN) herring respectively. Combined these age cohorts accounted for 57.9% of TSB and 65.9% of TSB. Immature fish accounted over 16% (65 t) of the 375 t estimate. The age composition of Pass 2 was comparable, with 1, 4 and 5 winter ring fish dominating. However, the contribution of 1 winter ring, immature fish was much higher accounting for 60.9% of TSB and 78.2% of TSN. The biomass estimate for pass 2 was significantly larger than pass 1 (10, 621 t) and was composed of 49% immature fish representing 5,412 t. Mini surveys 2 and 3 achieved comparable results. Age structure was composed of mature fish with 4, 3 and 5 winter ring fish dominating. Mini survey 4 had an age structure that was notably different from survey 2 and 3 considering aggregations were within 15 nmi of each other. Survey 4 contained fish aged from 1 to 5 winter rings with the largest proportion (68.7% TSB) composed of 1 winter ring fish.

The 2016 survey consisted of replicate surveys (2 broad-scale, and 2 mini replicate surveys) covering the same area and one stand-alone mini survey. The biomass estimates from each of the replicates (pass 2 and mini survey 3) and mini survey 4 (not replicated) were summed and used to estimate numbers at age for the assessment. The replicate surveys with the maximum estimates (TSB) were used in the 2017 assessment. The method of dealing with replicate surveys to estimate overall biomass for the survey will be revisited in the upcoming Celtic Sea herring inter-benchmark tabled for 2018. Herring TSB (total stock biomass) and abundance (TSN) estimates were 30 058 t and 302 million individuals respectively.

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 Figures 6.4.1.1–2 respectively. There has been an overall downward trend in mean weights-at-age in the catch since the mid-1980s. After a slight increase around 2008 they have declined again. Mean weights in the stock at spawning time were calculated from biological samples from the fourth quarter (Figure 6.4.1.2). The overall trends in stock weights are as in the catch weights.

In the assessment, 50% of 1-ringers are considered mature. Sampling data from the Celtic Sea catches suggest that greater than 50% of 1-ringers are mature (Lynch, 2011). However, the 2014 benchmark (ICES 2014/ACOM: in prep.) concluded that there was insufficient information to change the maturity ogive.

Following the final procedure of ICES HAWG 2015, the 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. However the acoustic survey age range has now been extended to include 1 ringers (Section 4.6). This offers an independent estimate of recruits, and suggests a large increase in recruitment in recent years.

6.6 Assessment

This stock was benchmarked in 2015 by WKWEST (ICES, 2015).

6.6.1 Data exploration

Given the difficulties in the assessment, due to the lack of tuning in the past 2 years, some additional analyses of the input data were performed. This is also in preparation for the proposed Inter-benchmark and the benchmark.

Catch curve analyses of the ln-transformed catch numbers of age, by cohort were performed (Figure 6.6.1.1). These show that overall morality (Z) signal has reduced greatly in recent years. A slight increase in Z is apparent for the most recent fully represented cohorts, but overall the level is much lower than previously. Negative mortality is apparent over 2-5 winter ring. This is because there has been a switch in full selection from 2-ring to 3-ring, since 2006. This has two implications for future assessments. Firstly mean F should be calculated from 3-ring rather than 2. Secondly future assessments should consider modelling a change in selection around that time.

Log catch ratio analyses were performed (Figure 6.6.1.2). These are derived as follows:

$$\ln\,(catch_{y,a} \,/\, catch_{y+1,a+1})$$

These also show the switch in full selection from 2-ring to 3-ring from 2006 onwards. This may be due to the closure of 7.a.S, as part of the rebuilding measures. The reduction in overall mortality is apparent over the time series, where historic Z is much higher than that experienced by recently hatched cohorts.

In order to examine the data whilst removing the effect of the acoustic time series, two separable VPAs (Darby and Flatman, 1994) were performed. The terminal Fs used to initiate the runs were as follows:

Optimistic: current F_{msy} = 0.26

Pessimistic historical F ~ 0.45

These runs are presented in Figure 6.6.1.3. They show that the large stock size recorded in 2012 is independent of the acoustic survey, though the survey also recorded a spike in that year (Table 6.3.1.1.). The two sVPA runs show a decline in stock size since 2012, driven by a series of below average recruitments from 2013 onwards. Catches from 2013 onwards have been rather stable, and this translates as an increasing F, as SSB declines.

Finally an analysis was performed using a slight adaptation of the current accepted assessment formulation in ASAP. The adaptation is to split the acoustic times series in 2, pre- and post-2014. This was to deal with the change in fish behaviour as observed in the CSHAS survey since 2014. The split indices generate separate estimators of catchability (q) and these are presented in Figure 6.6.1.4. The lower q for the second series implies that the relationship between the survey and stock abundance has changed since 2014. This underlines that the update assessment is no longer fit for purpose, given the changes in behaviour affecting the fishery and the survey. This should be considered in the forthcoming Inter-benchmark.

6.6.2 Stock Assessment

This update assessment was carried out using ASAP. The assessment was tuned using the Celtic Sea herring acoustic survey (CSHAS) ages 2–9 winter ring, excluding surveys 2014 and 2015, but including 2016. The 2014 and 2015 survey data were rejected by HAWG, upon recommendations from WGIPS, that there was lack of containment of the stock. A more extensive survey grid in 2016 provided strong evidence that there was no lack of containment, and hence there is no reason to exclude the 2016 estimates. The ASAP settings are as per the 2015 benchmark and are presented in (Table 6.6.2.3). The input data are presented in Tables 6.6.2.1 and 6.6.2.2. The stock summary is presented in Table 6.6.2.4.

Figure 6.6.2.1 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 for the older ages in the earlier part of the time series. Overall there are no clear patterns in the residuals. Figure 6.6.2.2 shows the observed and predicted catches. In general, the model followed the observed catches quite closely. Figure 6.6.2.3 shows the residuals of the index proportions-at-age. These survey residuals show negative residuals at older ages (6-9) and positive residuals in the younger ages.

The selection pattern for the final assessment run is shown in Figure 6.6.2.4. 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 for this fishery. The model predicts a drop in selection at age 9-wr. This may be the case given the lower abundance of 9-wr in the catch data.

The analytical retrospective from ASAP is shown in Figure 6.6.2.5. An analytical retrospective pattern has developed in recent years, with rho (Mohn 1999) calculated as 0.3 for 5 year peels. Figure 4.6.2.8 shows uncertainties over time in the assessment estimates.

State of the stock

The stock summary plots from the final update ASAP assessment is presented in Figure 6.6.2.6 and the stock summary is in Table 4.6.2.4. The stock is estimated to be declining and is estimated as 46 048 t. Mean F (2–5 ring) in 2016 is estimated as being 0.40, having increased from 0.07 in 2009. Overall there had been a substantial decrease in F from 0.42 in 2004, but this is increasing again in recent years. Recruitment was good for several years with strong cohorts in 2005, 2007, 2009, 2010, 2011 and 2012 having entered the stock. Recruitment has been lower in recent years, with an increase in 2016 with respect to 2015.

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 2017 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 Y-2 (the final year – 2 years). As this SSB value (103 650) is above the change-point (52 818), the plateau recruitment estimated from the regression is used (496 445 thousands).

Interim year catch was taken to be the full TAC, plus carryover on the national quotas (data provided as an output from the FIIDES database. Non-Irish intermediate year catches were further adjusted for recent quota uptake. A small quarter 1 fishery is assumed to take place in 2018. Discards, based on the 2016 estimate of 1.13% was assumed. Thus, the interim catch was estimated as 15 817 t.

A deterministic short term forecast was performed using in FLR. The input data are presented in Table 4.7.1.1.

The results of the short term projection are presented in Table 6.7.1.2. Fishing according to the long term management plan, implies catches of 10 127 t in 2018, resulting in a realised F of 0.36. Fishing in accordance with the MSY approach implies a fishing mortality of F=0.18 in 2018, resulting in a catch of 5 390. All scenarios, apart from F=0 in 2018 show SSB below B_{lim} in 2019.

6.7.2 Multi-annual short term forecasts

No multi-annual simulations were conducted in 2017.

6.7.3 Yield Per Recruit

No yield per recruit analyses were conducted in 2017.

6.8 Long term simulations

No long term simulations were performed in 2017.

6.9 Precautionary and yield based reference points

Reference points in use were first established by HAWG 2015, following the approach taken by ICES WKWEST (2015) which was in turn analogous to that followed by WKPELA, in 2014 and HAWG 2014. Examination of the stock recruit relationship from the final ASAP run showed wide range of recruitments, from very low to very high at low stock size, and a rather clear plateau, excepting four abnormally high values. This follows the recommendations of ICES RG/ADGCSHER (2012) and ICES SGBRP (2003), and is using the same basis to the procedure used for western Baltic spring spawning herring reference point proposals of 2013. Based on these considerations, B_{lim} is proposed as 33 000 t (B_{loss}). B_{pa} is based on B_{lim} raised by assessment uncertainty (σ) in estimation of terminal SSB, capped σ = 0.3 (ICES SGPA 1997). This results in a proposed B_{pa} of 54 000 t. This value is also a candidate for ICES MSY $B_{trigger}$.

For F_{msy} the same procedure was used as in ICES HAWG (2010 and 2013) using HCS 10–3 (Skagen, 2010; 2013). This approach performs stochastic simulations from a segmented regression stock recruitment relationship (Figure 6.9.1) where the plateau level of recruitment was 541 287 individuals and the breakpoint was estimated by applying the method of Julios. Then the changepoint was fixed at as 33 219 t, which is B_{lim}. This follows the procedures of ICES ADGCELTIC (2012). No errors or biases were incorporated into these simulations, following the procedure of HAWG 2013. Results showed that the highest F consistent with low (< 5%) risk of SSB < breakpoint in any year (ICES Risk 2) is F = 0.26.

In 2016, the working group was tasked to propose F_{pa} reference points for all stocks. Precautionary F reference points were never previously defined for this stock, although a proposal for F_{pa} ~ 0.4 was made by ICES HAWG 1998. The approach taken was to follow the procedures used by ICES WKWEST in 2015. The *EqSim* application was used to fit a segmented regression with a breakpoint specified at B_{lim} based on the full stock and recruit dataset and to estimate F_{lim}, the fishing mortality (F) that in equilibrium will maintain the stock above B_{lim} with a 50% probability. For this purpose, *EqSim* was run with a $B_{trigger}$ parameter set to zero and no assessment/advice error (F_{cv}, F_{phi} = 0) error, in line with ACOM Leadership guidelines (2016). A candidate value for F_{lim} of 0.61 was then used as a basis for calculating F_{pa} taking account of assessment uncertainty in the final year (σ, capped at 0.3) (ACOM Leadership, 2016; ICES SGPA 1997). This results in a proposed F_{pa} of F = 0.37. The *EqSim* output is shown in Figure 6.9.1.

6.10 Quality of the Assessment

Figure 6.6.2.8 shows uncertainties over time in the assessment estimates. The uncertainties for the key parameters (SSB, recruitment and F) are between 0.1 and 0.3 for the majority of the time-series; uncertainties have increased in the final years.

The short term forecast are compared with this year's assessment in the text table below and are shown in the historical retrospective in Figure 6.6.2.7. There has been a drastic change in stock perception since last year. This is due to the inclusion of the 2016 survey estimate, after two years of having not including survey data in the assessment.

2016 Assessment				2017 Assessment				% change in the estimates	
Year	SSB	Catch	F 2-5	Year	SSB	Catch	F 2-5	SSB	F 2-5
2014	156,272	19,574	0.12	2014	103,650	19574	0.20	-34%	67%
2015	133,362	18,355	0.16	2015	69,979	18355	0.27	-48%	69%
2016*	101,382	16,318	0.19	2016*	46,048	16318	0.40	-55%	111%

***from intermediate year in STF.**

The stock assessment is not fit for purpose as presently formulated. The changes in distribution of the herring in the past 3 seasons have changed the availability of the fish to the acoustic transducer. Therefore, assuming constant q across the time series 2003—2016 is invalid. Further work will be done to address this problem in the inter-benchmark, in 2018. By the time the inter-benchmark is conducted, a fourth acoustic survey will be available to extend the post-2014 series to 4 data years. This would constitute a separate new index of sufficient duration to be used for tuning - assuming that behaviour in 2017 remains as in 2014—2016.

Another problem with the assessment, as it is currently established, is that it is inflexible to year effects in the surveys and other such changes that take place from time to time. An improved assessment procedure would remove over-reliance on only one tuning index, and be adaptable to changes in fishing patterns.

6.11 Management Considerations

The state of the stock is not fully apparent from the results of the update assessment. Clearly, the stock has declined substantially from a high in 2012, as older cohorts disappeared and were not replaced - as recruitment has been below average since 2013. However the sudden change in fish behaviour as observed by the survey from 2014, with very differing availability of fish to the acoustic transducer, has meant that the assessment, following the Annex, cannot adequately track recent stock development. The update estimates SSB to have declined precipitously from a 40-year high to below B_{lim} in 4 years, and there must be considerable doubt about this result.

Managers should await the results of the 2018 inter-benchmark and the update assessment in 2018 before deciding on management options for 2018/2019. This fishery is conducted in quarters 3 and 4 (with only minor Irish catches in some years in quarter 1). Therefore, management advice for 2018/2019 is not urgently required until June 2018. After the publication each June of the ICES advice, the European Union routinely issues revisions to the TACs for the remainder of year ahead. Therefore, in-year advice could be issued in 2018. Meanwhile, the catch forecast presented by HAWG 2017 might serve as the basis for setting a preliminary TAC for 2018. Also, quarter 1, 2018 is actually subject to the advice provided by ICES last year, given that the assessment year runs from April 1st to March 31st the following year.

The stock should continue to be managed according to the long term management plan. Evaluations conducted in 2015 by HAWG show that the long term plan is still precautionary and can be a basis for management of the stock. The plan has specific actions to apply when $SSB<B_{lim}$. B_{lim} in the LTMP is defined as 41 000 t, but has been revised downwards to 33 000 t in the 2015 benchmark.

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. 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 clean with little bycatch of other fish. Mega-fauna by catch is unquantified, though anecdotal reports suggest that seals, blue sharks, tunas, and whitefish are caught from time to time, and the latter species was confirmed as by-catch in recent work (e.g. O'Dwyer et al. 2017 WD).

In 2016 there was a substantial landed by-catch of haddock. This was because of the long tow durations in the herring fishery due to the herring being found to the bottom. This meant that groundfish species were caught. Among these, the haddock could not be discarded because the Landings Obligation applied to that species from 2016 onwards.

6.13 Changes in the environment

Weights in the catch and in the stock at spawning time have shown considerable 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 of this time 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), whilst weight was linked more 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 fishermen 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 6.1.3.1. Herring in the Celtic Sea. Landings by quota year (t), 1988–2016. (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	U.K.	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

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

Table 6.1.3.2. Herring in the Celtic Sea. Landings (t) by assessment year (1 April–31 March) 1988/1989–2016/2017. (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	U.K.	Unallocated	Discards	Total
1988/1989	-	-	17 000	-	-	-	3400	20 400
1989/1990	+	-	15 000	1 900	-	2600	3600	23 100
1990/1991	+	-	15 000	1 000	200	700	1700	18 600
1991/1992	500	100	21 400	1 600	-	-100	2100	25 600
1992/1993	-	-	18 000	1 300	-	-100	2000	21 200
1993/1994	-	-	16 600	1 300	+	-1100	1800	18 600
1994/1995	+	200	17 400	1 300	+	-1500	1900	19 300
1995/1996	200	200	20 000	100	+	-200	3000	23 300
1996/1997	1 000	-	17 900	1 000	-	-1800	750	18 800
1997/1998	1 300	-	19 900	1 400	-	-2100	-	20 500
1998/1999	+	-	17 700	1 200	-	-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	1,025	559	-451	182	16 319

*** 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 1970–2016/2017. Age is in winter rings.

Year	1	2	3	4	5	6	7	8	9
1970	1%	24%	33%	17%	12%	5%	4%	1%	2%
1971	8%	15%	24%	27%	12%	7%	3%	3%	1%
1972	4%	67%	9%	8%	7%	2%	1%	1%	0%
1973	16%	26%	38%	5%	7%	4%	2%	2%	1%
1974	5%	43%	17%	22%	4%	4%	3%	1%	1%
1975	18%	22%	25%	11%	13%	5%	2%	2%	2%
1976	26%	22%	14%	14%	6%	9%	4%	2%	3%
1977	20%	31%	22%	13%	4%	5%	3%	1%	1%
1978	7%	35%	31%	14%	4%	4%	1%	2%	1%
1979	21%	26%	23%	16%	5%	2%	2%	1%	1%
1980	11%	47%	18%	10%	4%	3%	2%	2%	1%
1981	40%	22%	22%	6%	5%	4%	1%	0%	1%
1982	20%	55%	11%	6%	2%	2%	2%	0%	1%
1983	9%	68%	18%	2%	1%	0%	0%	1%	0%
1984	11%	53%	24%	9%	1%	1%	0%	0%	0%
1985	14%	44%	28%	12%	2%	0%	0%	0%	0%
1986	3%	39%	29%	22%	6%	1%	0%	0%	0%
1987	4%	42%	27%	15%	9%	2%	1%	0%	0%
1988	2%	61%	23%	7%	4%	2%	1%	0%	0%
1989	5%	27%	44%	13%	5%	2%	2%	0%	0%
1990	2%	35%	21%	30%	7%	3%	1%	1%	0%
1991	1%	40%	24%	11%	18%	3%	2%	1%	0%
1992	8%	19%	25%	20%	7%	13%	2%	5%	0%
1993	1%	72%	7%	8%	3%	2%	5%	1%	0%
1994	10%	29%	50%	3%	2%	4%	1%	1%	0%
1995	6%	49%	14%	23%	2%	2%	2%	1%	1%
1996	3%	46%	29%	6%	12%	2%	1%	1%	1%
1997	3%	26%	37%	22%	6%	4%	1%	1%	0%
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%

Table 6.2.1.2. Herring in the Celtic Sea. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2016/2017 season.

Length (cm)	Quarter 3 2016	Quarter 4 2016	Quarter 1 2017	All year
16.5		16		16
17	17	16		33
17.5	17	16		33
18	101	80		181
18.5	135	80		215
19	101	174	20	296
19.5	68	64	31	162
20	68	128	20	216
20.5	135	160	102	398
21	51	346	154	550
21.5	118	386	348	852
22	219	904	471	1594
22.5	118	1110	225	1453
23	118	1625	338	2081
23.5	625	2195	194	3014
24	895	5300	225	6420
24.5	1199	7306	174	8679
25	1840	10965	205	13010
25.5	1806	12746	102	14654
26	2026	17605	133	19764
26.5	1756	13428	113	15296
27	1114	9581	194	10890
27.5	591	4133	41	4764
28	135	1465	102	1702
28.5	68	488	0	556
29	17	108	0	125
29.5		44	10	54
TOTAL	**13336**	**90469**	**3203**	**107008**

Table 6.2.2.1. Herring in the Celtic Sea. Sampling intensity of commercial catches (2016/2017). Only Ireland provides samples of this stock.

Division	Year	Quarter	Landings (t)	No. Samples	No. Measured	No. aged	Aged/1000 t
7.g	2016	3	1 761	4	790	231	131
7.g	2016	4	10 092	22	4 846	1 015	101
7.a.S	2016	4	1652	9	924	449	272
7.a.S	2017	1	305	3	396	119	390
			13810	**38**	**6956**	**1814**	**131**

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). 2–9 ring abundances are used in tuning. 2014 and 2015 (shaded) were excluded, not being recommended for tuning by ICES WGIPS.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
0	0	24	-	2	-	1	99	239	5	0	31	4
1	42	13	-	65	21	106	64	381	346	342	270	698
2	185	62	-	137	211	70	295	112	549	479	856	291
3	151	60	-	28	48	220	111	210	156	299	615	197
4	30	17	-	54	14	31	162	57	193	47	330	43
5	7	5	-	22	11	9	27	125	65	71	49	38
6	7	1	-	5	1	13	6	12	91	24	121	10
7	3	0	-	1	-	4	5	4	7	33	25	5
8	0	0	-	0	-	1		6	3	4	23	0
9	0	0	-	0	-	0		1		2	3	1
Nos.	423	183	-	312	305	454	769	1,147	1,414	1,300	2,322	1,286
SSB	41	20	-	33	36	46	90	91	122	122	246	71
CV	.49	.34	-	.48	.35	.25	.20	.24	.20	.28	.25	.28
Design*	AR	AR		R	R	R	R	R	R	AR	AR	AR

	2014	2015	2016
	2015	2016	2017
0	0	0	0
1	41	0	125
2	117	40	21
3	112	48	43
4	69	41	40
5	20	38	36
6	24	7	25
7	7	6	5
8	17	5	6
9	1	0	0
Nos.	408	184	301
SSB	48	25	30
CV	.59	.18	.33
Design*	ARM	ARM	ARM

*** AR Adaptive random; R random; ARM Adaptive random with mini surveys**

Table 6.6.2.1. Herring in the Celtic Sea: Natural mortality inputs to the ASAP model. Age is in winter rings.

1	2	3	4	5	6	7	8	9
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307

1	2	3	4	5	6	7	8	9
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307

1	2	3	4	5	6	7	8	9
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307
0.767	0.385	0.356	0.339	0.319	0.314	0.307	0.307	0.307

Table 6.6.2.1. (continued). Herring in the Celtic Sea: Maturity inputs to the ASAP model. Age is in winter rings.

1	2	3	4	5	6	7	8	9
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1

1	2	3	4	5	6	7	8	9
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1
0.5	1	1	1	1	1	1	1	1

Table 6.6.2.1. (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
0.096	0.115	0.162	0.185	0.205	0.217	0.227	0.232	0.23
0.087	0.119	0.166	0.185	0.2	0.21	0.217	0.23	0.231
0.093	0.122	0.156	0.191	0.205	0.207	0.22	0.225	0.239
0.098	0.127	0.156	0.185	0.207	0.212	0.22	0.235	0.235
0.109	0.146	0.17	0.187	0.21	0.227	0.232	0.237	0.24
0.103	0.139	0.194	0.205	0.217	0.23	0.237	0.245	0.251
0.105	0.139	0.182	0.215	0.225	0.23	0.237	0.245	0.253
0.103	0.143	0.18	0.212	0.232	0.243	0.243	0.256	0.26
0.122	0.154	0.191	0.212	0.237	0.248	0.24	0.253	0.257
0.119	0.158	0.185	0.217	0.243	0.251	0.256	0.259	0.264
0.119	0.166	0.196	0.215	0.235	0.248	0.256	0.262	0.266
0.122	0.164	0.2	0.217	0.237	0.245	0.264	0.264	0.262
0.128	0.162	0.2	0.225	0.24	0.253	0.264	0.276	0.272
0.117	0.166	0.2	0.225	0.245	0.253	0.262	0.267	0.283
0.132	0.17	0.194	0.22	0.245	0.259	0.264	0.27	0.285
0.125	0.174	0.205	0.215	0.245	0.262	0.262	0.285	0.285
0.141	0.18	0.21	0.225	0.237	0.259	0.262	0.288	0.27
0.137	0.187	0.215	0.24	0.251	0.26	0.27	0.279	0.284
0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293
0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298
0.127	0.189	0.217	0.24	0.279	0.276	0.291	0.297	0.302
0.127	0.174	0.212	0.23	0.253	0.273	0.291	0.279	0.284
0.117	0.174	0.207	0.237	0.259	0.276	0.27	0.27	0.275
0.115	0.172	0.21	0.245	0.267	0.276	0.297	0.309	0.315
0.115	0.154	0.194	0.237	0.262	0.273	0.279	0.288	0.293
0.109	0.148	0.198	0.22	0.276	0.282	0.276	0.319	0.325
0.093	0.142	0.185	0.213	0.213	0.245	0.246	0.263	0.262
0.104	0.14	0.17	0.201	0.234	0.248	0.256	0.26	0.263
0.112	0.155	0.172	0.187	0.215	0.248	0.276	0.284	0.332
0.096	0.138	0.186	0.192	0.204	0.231	0.255	0.267	0.284
0.097	0.132	0.168	0.203	0.209	0.215	0.237	0.257	0.283
0.106	0.129	0.151	0.169	0.194	0.199	0.21	0.221	0.24
0.099	0.137	0.153	0.167	0.188	0.208	0.209	0.229	0.251
0.092	0.128	0.168	0.182	0.19	0.206	0.229	0.236	0.251
0.096	0.123	0.15	0.177	0.191	0.194	0.212	0.228	0.248
0.092	0.129	0.155	0.18	0.201	0.204	0.21	0.225	0.24
0.097	0.135	0.168	0.179	0.19	0.21	0.218	0.217	0.227
0.088	0.126	0.151	0.178	0.188	0.198	0.207	0.227	0.227
0.088	0.118	0.147	0.159	0.185	0.196	0.207	0.219	0.231
0.093	0.124	0.141	0.157	0.172	0.192	0.206	0.216	0.22
0.099	0.121	0.153	0.163	0.173	0.185	0.199	0.204	0.225
0.09	0.12	0.149	0.167	0.18	0.183	0.202	0.209	0.208
0.092	0.111	0.148	0.168	0.185	0.187	0.197	0.21	0.224

1	2	3	4	5	6	7	8	9
0.082	0.107	0.139	0.162	0.177	0.19	0.185	0.204	0.229
0.096	0.115	0.139	0.156	0.185	0.196	0.203	0.211	0.226
0.089	0.102	0.128	0.146	0.165	0.184	0.195	0.202	0.214
0.08	0.13	0.134	0.151	0.159	0.174	0.203	0.215	0.225
0.077	0.102	0.142	0.147	0.158	0.168	0.181	0.208	0.252
0.093	0.105	0.127	0.151	0.155	0.165	0.174	0.186	0.198
0.074	0.106	0.123	0.141	0.166	0.162	0.17	0.171	0.229
0.091	0.12	0.144	0.156	0.172	0.191	0.194	0.199	0.224
0.078	0.122	0.146	0.16	0.169	0.185	0.187	0.197	0.211
0.076	0.111	0.131	0.145	0.158	0.159	0.163	0.178	0.19
0.07	0.104	0.127	0.141	0.154	0.161	0.167	0.18	0.179
0.072	0.094	0.124	0.138	0.152	0.157	0.164	0.164	0.171
0.062	0.101	0.122	0.142	0.153	0.164	0.17	0.166	0.18
0.067	0.1	0.127	0.14	0.153	0.161	0.163	0.179	0.176
0.071	0.102	0.122	0.137	0.143	0.151	0.158	0.167	0.182
0.061	0.095	0.119	0.131	0.140	0.144	0.151	0.157	0.162

Table 6.6.2.1. (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
0.096	0.115	0.162	0.185	0.205	0.217	0.227	0.232	0.23
0.087	0.119	0.166	0.185	0.2	0.21	0.217	0.23	0.231
0.093	0.122	0.156	0.191	0.205	0.207	0.22	0.225	0.239
0.098	0.127	0.156	0.185	0.207	0.212	0.22	0.235	0.235
0.109	0.146	0.17	0.187	0.21	0.227	0.232	0.237	0.24
0.103	0.139	0.194	0.205	0.217	0.23	0.237	0.245	0.251
0.105	0.139	0.182	0.215	0.225	0.23	0.237	0.245	0.253
0.103	0.143	0.18	0.212	0.232	0.243	0.243	0.256	0.26
0.122	0.154	0.191	0.212	0.237	0.248	0.24	0.253	0.257
0.119	0.158	0.185	0.217	0.243	0.251	0.256	0.259	0.264
0.119	0.166	0.196	0.215	0.235	0.248	0.256	0.262	0.266
0.122	0.164	0.2	0.217	0.237	0.245	0.264	0.264	0.262
0.128	0.162	0.2	0.225	0.24	0.253	0.264	0.276	0.272
0.117	0.166	0.2	0.225	0.245	0.253	0.262	0.267	0.283
0.132	0.17	0.194	0.22	0.245	0.259	0.264	0.27	0.285
0.125	0.174	0.205	0.215	0.245	0.262	0.262	0.285	0.285
0.141	0.18	0.21	0.225	0.237	0.259	0.262	0.288	0.27
0.137	0.187	0.215	0.24	0.251	0.26	0.27	0.279	0.284
0.137	0.174	0.205	0.235	0.259	0.27	0.279	0.288	0.293
0.134	0.185	0.212	0.222	0.243	0.267	0.259	0.292	0.298
0.127	0.189	0.217	0.24	0.279	0.276	0.291	0.297	0.302
0.127	0.174	0.212	0.23	0.253	0.273	0.291	0.279	0.284

1	2	3	4	5	6	7	8	9
0.117	0.174	0.207	0.237	0.259	0.276	0.27	0.27	0.275
0.115	0.172	0.21	0.245	0.267	0.276	0.297	0.309	0.315
0.115	0.154	0.194	0.237	0.262	0.273	0.279	0.288	0.293
0.109	0.148	0.198	0.22	0.276	0.282	0.276	0.319	0.325
0.093	0.142	0.185	0.213	0.213	0.245	0.246	0.263	0.262
0.104	0.14	0.17	0.201	0.234	0.248	0.256	0.26	0.263
0.112	0.155	0.172	0.187	0.215	0.248	0.276	0.284	0.332
0.096	0.138	0.186	0.192	0.204	0.231	0.255	0.267	0.284
0.097	0.132	0.168	0.203	0.209	0.215	0.237	0.257	0.283
0.106	0.129	0.151	0.169	0.194	0.199	0.21	0.221	0.24
0.099	0.137	0.153	0.167	0.188	0.208	0.209	0.229	0.251
0.092	0.128	0.168	0.182	0.19	0.206	0.229	0.236	0.251
0.096	0.123	0.15	0.177	0.191	0.194	0.212	0.228	0.248
0.092	0.129	0.155	0.18	0.201	0.204	0.21	0.225	0.24
0.097	0.135	0.168	0.179	0.19	0.21	0.218	0.217	0.227
0.088	0.126	0.151	0.178	0.188	0.198	0.207	0.227	0.227
0.088	0.118	0.147	0.159	0.185	0.196	0.207	0.219	0.231
0.093	0.124	0.141	0.157	0.172	0.192	0.206	0.216	0.22
0.099	0.121	0.153	0.163	0.173	0.185	0.199	0.204	0.225
0.09	0.12	0.149	0.167	0.18	0.183	0.202	0.209	0.208
0.092	0.111	0.148	0.168	0.185	0.187	0.197	0.21	0.224
0.082	0.107	0.139	0.162	0.177	0.19	0.185	0.204	0.229
0.096	0.115	0.139	0.156	0.184	0.196	0.203	0.211	0.223
0.078	0.1	0.13	0.141	0.156	0.158	0.168	0.2	0.213
0.077	0.127	0.133	0.151	0.156	0.168	0.216	0.228	0.257
0.074	0.103	0.145	0.143	0.155	0.161	0.175	0.221	0.233
0.085	0.104	0.123	0.153	0.15	0.157	0.164	0.177	0.188
0.068	0.101	0.122	0.138	0.156	0.159	0.163	0.167	0.251
0.083	0.117	0.14	0.156	0.17	0.18	0.177	0.189	0.232
0.076	0.117	0.142	0.158	0.168	0.176	0.17	0.186	0.226
0.076	0.106	0.127	0.139	0.152	0.157	0.164	0.188	0.18
0.067	0.108	0.127	0.138	0.148	0.16	0.17	0.194	0.197
0.061	0.094	0.125	0.138	0.149	0.159	0.161	0.165	0.167
0.06	0.101	0.126	0.144	0.153	0.159	0.168	0.17	0.186
0.065	0.1	0.128	0.142	0.153	0.158	0.163	0.177	0.169
0.065	0.098	0.119	0.133	0.14	0.146	0.153	0.16	0.162
0.059	0.096	0.117	0.131	0.139	0.143	0.150	0.160	0.165

Table 6.6.2.1. (continued). Herring in the Celtic Sea: Selectivity block inputs (1-9) to the ASAP model. Age is in winter rings.

Selectivity	Block	#1	Data
0.3	1	0	1
0.5	1	0	1
1	-1	0	1
1	1	0	1
1	1	0	1
1	1	0	1
1	1	0	1
1	1	0	1
1	1	0	1

Table 6.6.2.1. (continued). Herring in the Celtic Sea: Catch numbers at age and total catch inputs to the ASAP model. Age is in winter rings.

	Fleet-1	Catch	Data							
	1	2	3	4	5	6	7	8	9	Caton
1958	1642	3742	33 094	25 746	12 551	23 949	16 093	9384	5584	22 978
1959	1203	25717	2274	19 262	11 015	5830	17 821	3745	7352	15 086
1960	2840	72 246	24 658	3779	13 698	4431	6096	4379	4151	18 283
1961	2129	16 058	32 044	5631	2034	5067	2825	1524	4947	15 372
1962	772	18 567	19 909	48 061	8075	3584	8593	3805	5322	21 552
1963	297	51 935	13 033	4179	20 694	2686	1392	2488	2787	17 349
1964	7529	15 058	17 250	6658	1719	8716	1304	577	2193	10 599
1965	57	70 248	9365	15 757	3399	4539	12 127	1377	7493	19 126
1966	7093	19 559	59 893	9924	13 211	5602	3586	8746	3842	27 030
1967	7599	39 991	20 062	49 113	9218	9444	3939	6510	6757	27 658
1968	12 197	54 790	39 604	11 544	22 599	4929	4170	1310	4936	30 236
1969	9472	93 279	55 039	33 145	12 217	17 837	4762	2174	3469	44 389
1970	1319	37 260	50 087	26 481	18 763	7853	6351	2175	3367	31 727
1971	12 658	23 313	37 563	41 904	18 759	10 443	4276	4942	2239	31 396
1972	8422	137 690	17 855	15 842	14 531	4645	3012	2374	1020	38 203
1973	23 547	38 133	55 805	7012	9651	5323	3352	2332	1209	26 936
1974	5507	42 808	17 184	22 530	4225	3737	2978	903	827	19 940
1975	12 768	15 429	17 783	7333	9006	3520	1644	1136	1194	15 588
1976	13 317	11 113	7286	7011	2872	4785	1980	1243	1769	9771
1977	8159	12 516	8610	5280	1585	1898	1043	383	470	7833
1978	2800	13 385	11 948	5583	1580	1476	540	858	482	7559
1979	11 335	13 913	12 399	8636	2889	1316	1283	551	635	10 321
1980	7162	30 093	11 726	6585	2812	2204	1184	1262	565	13 130
1981	39 361	21 285	21 861	5505	4438	3436	795	313	866	17 103
1982	15 339	42 725	8728	4817	1497	1891	1670	335	596	13 000

	Fleet-1	Catch	Data							
	1	2	3	4	5	6	7	8	9	Caton
1983	13 540	102 871	26 993	3225	1862	327	372	932	308	24 981
1984	19 517	92 892	41 121	16 043	2450	1085	376	231	180	26 779
1985	17 916	57 054	36 258	16 032	2306	228	85	173	132	20 426
1986	4159	56 747	42 881	32 930	8790	1127	98	29	12	25 024
1987	5976	67 000	43 075	23 014	14 323	2716	1175	296	464	26 200
1988	2307	82 027	30 962	9398	5963	3047	869	297	86	20 447
1989	8260	42 413	68 399	19 601	8205	3837	2589	767	682	23 254
1990	2702	41 756	24 634	35 258	8116	3808	1671	695	462	18 404
1991	1912	63 854	38 342	16 916	28 405	4869	2588	954	593	25 562
1992	10 410	26 752	35 019	27 591	10 139	18 061	3021	6285	689	21 127
1993	1608	94 061	9372	10 221	4491	2790	5932	855	508	18 618
1994	12 130	35 768	61 737	3289	3025	4773	1713	1705	474	19 300
1995	9450	79 159	22 591	36 541	3686	3420	2651	1859	842	23 305
1996	3476	61 923	38 244	7943	16 114	2077	1586	1507	1025	18 816
1997	3849	37 440	53 040	31 442	8318	6142	1148	827	603	20 496
1998	5818	41 510	27 102	28 274	13 178	3746	2675	597	387	18 041
1999	14 274	34 072	36 086	14 642	15 515	8877	1865	2012	551	18 485
2000	9953	77 378	18 952	12 060	5230	6227	2320	662	578	17 191
2001	15 724	62 153	35 816	5953	4249	1774	1145	466	386	15 269
2002	3495	26 472	18 532	5309	1416	1269	437	154	201	7465
2003	2711	37 006	24 444	14 763	5719	3363	2335	388	542	11 536
2004	4276	9470	46 243	21 863	8638	1412	473	191	75	12 743
2005	15 419	30 710	5766	18 666	7349	1923	435	77	60	9494
2006	1460	33 894	10 914	2469	6261	2331	561	57	48	6944
2007	8043	11 028	36 223	5509	1365	2040	410	56	4	7636
2008	1288	12 468	8144	15 565	2328	518	321	58	11	5872
2009	10 171	4465	12 859	4887	8458	971	279	247	80	5745
2010	2468	20 929	8183	15 917	4846	10 080	919	273	321	8370
2011	6384	17 151	33 453	7301	13 087	5347	5165	1089	141	11 470
2012	11 712	62 528	44 819	37 500	6303	11 811	5549	3540	347	21 820
2013	6191	30 471	42 133	22 649	16 687	3305	5463	1778	535	16 247
2014	16 664	24 120	39 102	33 320	22 450	11 165	3047	2774	1022	19 574
2015	286	12 247	23 835	32 140	27 382	19 861	9820	4207	3279	18 355
2016	2023	9822	25 030	22 800	25 310	22 447	10 484	4684	1464	16 318

Table 6.6.2.1. (continued). Herring in the Celtic Sea: Index selectivity inputs (1-9) to the ASAP model. Age is in winter rings.

Index-1	Selectivity	Data	
0	-4	0	0
0.5	4	0	1
0.5	4	0	1
0.5	4	0	1
1	-1	0	1
1	-1	0	1
1	-1	0	1
1	-1	0	1
1	-1	0	1

Table 6.6.2.2. Herring in the Celtic Sea. Survey data input to ASAP. Age is in winter rings.

Year	Abundance	CV	1	2	3	4	5	6	7	8	9	Sample size
2002	381 900	0.49	-1	185 200	150 600	29 700	6600	7100	2700	0	0	20
2003	88 000	0.34	-1	3000	60 400	17 200	5400	1400	300	300	0	20
2004	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0
2005	246 700	0.47	-1	137 100	28 200	54 200	21 600	4900	700	0	0	45
2006	284 999	0.35	-1	211 000	48 000	14 000	11 000	1000	-1	0	0	34
2007	347 140	0.25	-1	69 800	220 000	30 600	8970	13 100	3650	1020	0	37
2008	606 000	0.2	-1	295 000	111 000	162 000	27 000	6000	5000	0	0	32
2009	526 600	0.24	-1	112 040	209 850	57 490	124 630	11 710	3650	6350	880	30
2010	1 063 870	0.2	-1	548 940	155 860	193 030	65 240	91 040	6650	3110	0	21
2011	959 000	0.28	-1	479 000	299 000	47 000	71 000	24 000	33 000	4000	2000	22
2012	2 021 260	0.25	-1	856 000	615 000	330 000	48 500	121 000	24 800	22 700	3260	20
2013	587 000	0.28	-1	291 400	197 400	43 700	37 900	9800	4700	0	2100	21
2014	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2015	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2016	175 701	0.33	-1	20629	42736	39835	36124	24590	5462	6166	159	10

Table 6.6.2.3. 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	2002-2013 (no survey in 2004. 2014.2015 survey not included)
Index age (wr)range	1-9
Index Selectivity	0.5,0.5,0.5,0.5,1,1,1,1,1 Fixed from ages 5-9-wr
Index CV	Calculated annually
Sample size	No of 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
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 6.6.2.4. Herring in the Celtic Sea. Update assessment stock summary table. Recruitment is at 1-winter rings.

Year	Catch (t)	SSB (t)	TSB (t)	F (2–5 rings)	Recruitment (thousands)
1958	22978	164767	232203.8	0.150374	416132
1959	15086	166792	286645.2	0.125799	1556490
1960	18283	164858	227301.4	0.135753	360855
1961	15372	141465	199697.5	0.124793	388774
1962	21552	141843	235138.6	0.200257	832844
1963	17349	133336	193625.5	0.158909	402677
1964	10599	155841	277029.7	0.098607	1373820
1965	19126	162655	231376.8	0.142096	418496
1966	27030	159801	259754	0.201389	737645
1967	27658	154947	255645	0.228178	771353
1968	30236	159294	271640.9	0.245485	903588
1969	44389	139707	227459.9	0.367975	467116
1970	31727	105402	164334.9	0.332666	253033
1971	31396	96520.1	191512.9	0.457575	822709
1972	38203	84564.1	147479.4	0.568608	281054
1973	26936	63401.1	116937.4	0.523534	325801
1974	19940	49201.7	85331.48	0.501117	162111
1975	15588	38958.6	73138.58	0.522329	203103
1976	9771	36255.7	67917.08	0.392477	226247
1977	7833	37006.6	64001.12	0.293641	185503
1978	7559	35919.9	58886.27	0.270054	147208
1979	10321	35947.4	70746.18	0.427757	280881
1980	13130	32988	60098.16	0.550278	167500
1981	17103	36292.9	86567.39	0.851749	464006
1982	13000	57056.5	125879.4	0.469843	721610
1983	24981	75684.1	158037.9	0.573156	781099
1984	26779	78063.5	147453.1	0.486699	662563
1985	20426	83967.1	152396.3	0.328071	637792
1986	25024	91661.3	168660.6	0.37733	648198
1987	26200	103654	208692.7	0.403662	1189280
1988	20447	107080	168324.6	0.239719	473219
1989	23254	94036.7	162265.7	0.292773	572427
1990	18404	87666.9	145282.9	0.254926	501415
1991	25562	69598.1	110092	0.391072	207514
1992	21127	69382.8	150729.5	0.502893	954574
1993	18618	72004.9	117550.7	0.338547	358080
1994	19300	78742.2	149565.2	0.331115	762863
1995	23305	80166.9	147631.4	0.400682	714985
1996	18816	70750.2	114557.9	0.318836	349939
1997	20496	58228.3	102788.1	0.423264	368348
1998	18041	46259.5	81054.44	0.466561	244887
1999	18485	39744.7	84373.08	0.66692	467131
2000	17191	38858.1	82315.53	0.69758	449799
2001	15269	37397	76461.86	0.605788	451961

2002	7465	47722.9	89668.94	0.241479	490296
2003	11536	37602.3	59050.01	0.356627	143963
2004	12743	35015.4	65580.07	0.422611	359862
2005	9494	52586.1	115933.3	0.32884	1087700
2006	6944	66860.9	103166.4	0.135984	370229
2007	7636	72267.5	123881.6	0.128072	823782
2008	5872	89064.5	127074.8	0.07402	348151
2009	5745	107503	188725.1	0.068246	1274910
2010	8370	124130	198571.3	0.084808	1006760
2011	11470	141733	228858.2	0.103645	1325620
2012	21820	136910	209867.6	0.190997	905675
2013	16247	127485	180057.3	0.149353	494823
2014	19574	103650	149183	0.204775	357287
2015	18355	69979	99431.07	0.272632	132033
2016	16318	46048.2	74490.67	0.40513	263363

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

2017 Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	496445	0.767005	0.5	0.551	0.5	0.063	0.019667	0.066333
2	119048.2	0.384728	1	0.551	0.5	0.098	0.224333	0.099
3	30085.02	0.355633	1	0.551	0.5	0.121333	0.317333	0.122667
4	40953.18	0.338791	1	0.551	0.5	0.135333	0.317333	0.136
5	31819.59	0.319385	1	0.551	0.5	0.144	0.317333	0.145333
6	35282.27	0.313574	1	0.551	0.5	0.149	0.317333	0.152
7	31314.57	0.306805	1	0.551	0.5	0.155333	0.317333	0.157333
8	15231.53	0.306805	1	0.551	0.5	0.165667	0.317333	0.167667
9	29573.58	0.306805	1	0.551	0.5	0.165333	0.126333	0.173333
2018								
1	496445	0.767005	0.5	0.551	0.5	0.063	0.019667	0.066333
2	-	0.384728	1	0.551	0.5	0.098	0.224333	0.099
3	-	0.355633	1	0.551	0.5	0.121333	0.317333	0.122667
4	-	0.338791	1	0.551	0.5	0.135333	0.317333	0.136
5	-	0.319385	1	0.551	0.5	0.144	0.317333	0.145333
6	-	0.313574	1	0.551	0.5	0.149	0.317333	0.152
7	-	0.306805	1	0.551	0.5	0.155333	0.317333	0.157333
8	-	0.306805	1	0.551	0.5	0.165667	0.317333	0.167667
9	-	0.306805	1	0.551	0.5	0.165333	0.126333	0.173333
2019								
1	496445	0.767005	0.5	0.551	0.5	0.063	0.019667	0.066333
2	-	0.384728	1	0.551	0.5	0.098	0.224333	0.099
3	-	0.355633	1	0.551	0.5	0.121333	0.317333	0.122667
4	-	0.338791	1	0.551	0.5	0.135333	0.317333	0.136
5	-	0.319385	1	0.551	0.5	0.144	0.317333	0.145333
6	-	0.313574	1	0.551	0.5	0.149	0.317333	0.152
7	-	0.306805	1	0.551	0.5	0.155333	0.317333	0.157333
8	-	0.306805	1	0.551	0.5	0.165667	0.317333	0.167667
9	-	0.306805	1	0.551	0.5	0.165333	0.126333	0.173333

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

Rationale	Fbar (2017)	Catch (2017)	SSB (2017)	Fbar (2018)	Catch (2018)	SSB (2018)	SSB (2019)
Catch(2018) = Zero	0.56	15817	37796	0	0	45789	57778
Catch(2018) = 2017 TAC -15%	0.56	15817	37796	0.46	12297	38842	43047
Catch(2018) = 2017 TAC	0.56	15817	37796	0.56	14467	37504	41614
Catch(2018) = 2017 TAC +15%	0.56	15817	37796	0.67	16637	36126	40190
Catch(2018) = 2017 TAC +30%	0.56	15817	37796	0.78	18807	34703	38774
Catch(2018) = 2017 TAC -30%	0.56	15817	37796	0.36	10127	40142	44485
Fbar(2018) = Fmsy	0.56	15817	37796	0.26	7547	41643	46204
Fbar(2018) = Fmgt	0.56	15817	37796	0.23	6754	42095	46734
Fbar(2018) = Fpa	0.56	15817	37796	0.37	10299	40040	44371
Fbar(2018) = Flim	0.56	15817	37796	0.61	15545	36824	40906
Fbar(2018) = 0.14	0.56	15817	37796	0.14	4259	43491	48406
Fbar(2018) = 0.94	0.56	15817	37796	0.94	21367	33000	37116
Fbar(2018) = 0.18	0.56	15817	37796	0.18	5390	42863	47647

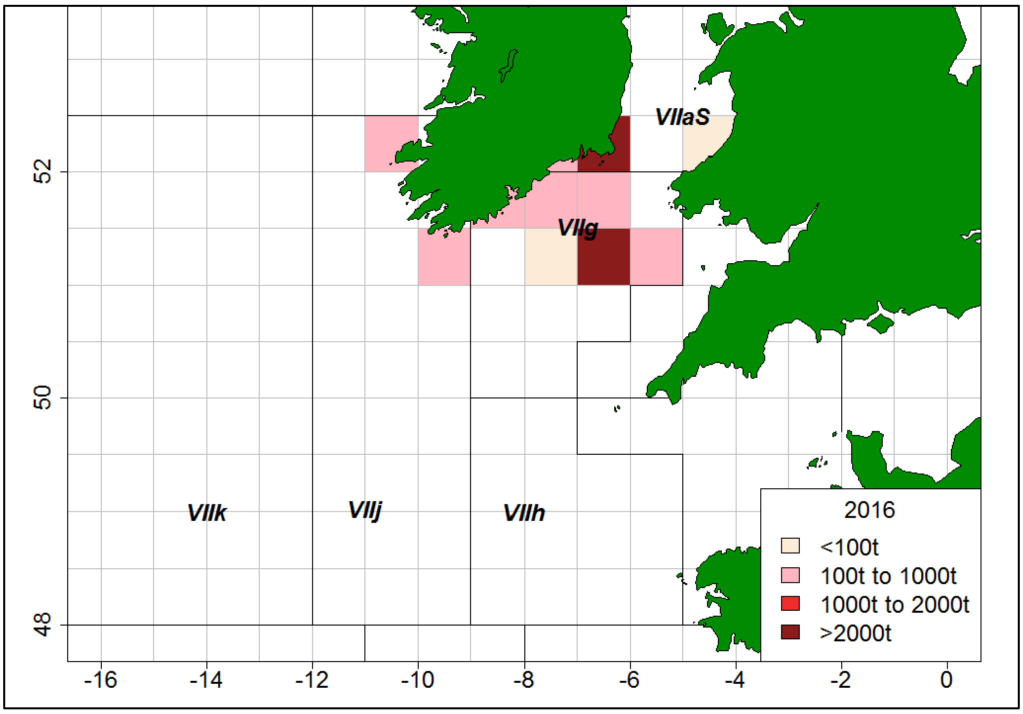


Figure 6.1.2.1. Herring in the Celtic Sea. Irish official herring catches by statistical rectangle in 2015/2016.

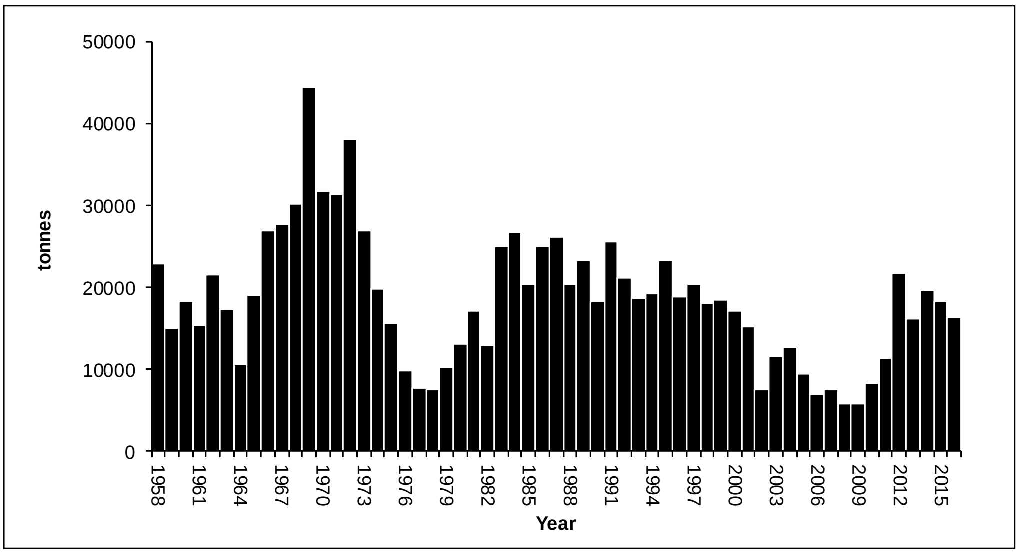


Figure 6.1.3.1. Herring in the Celtic Sea. Working Group estimates of herring catches per season.

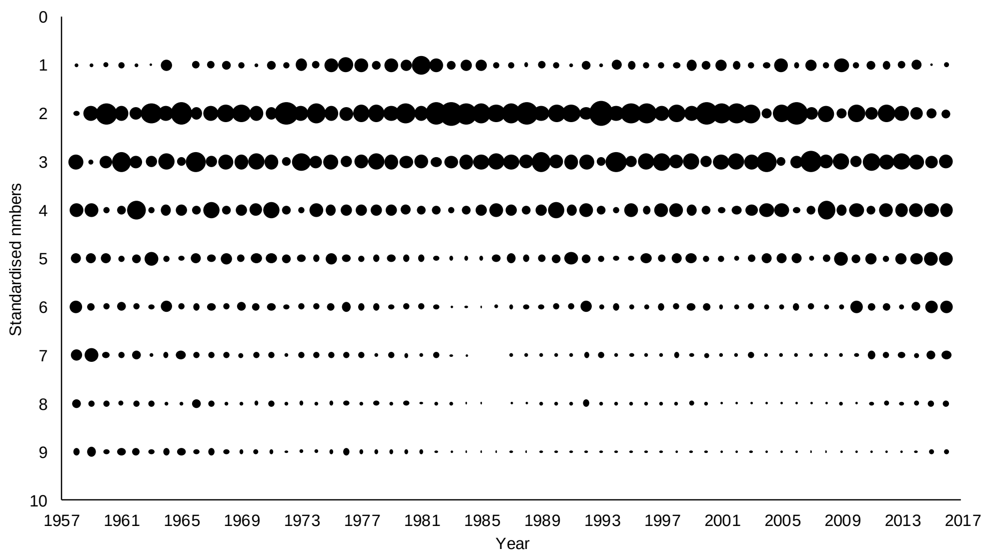


Figure 6.2.1.1. Herring in the Celtic Sea. Catch numbers-at-age standardised by yearly mean. 9-ringer is the plus group. Age in winter rings.

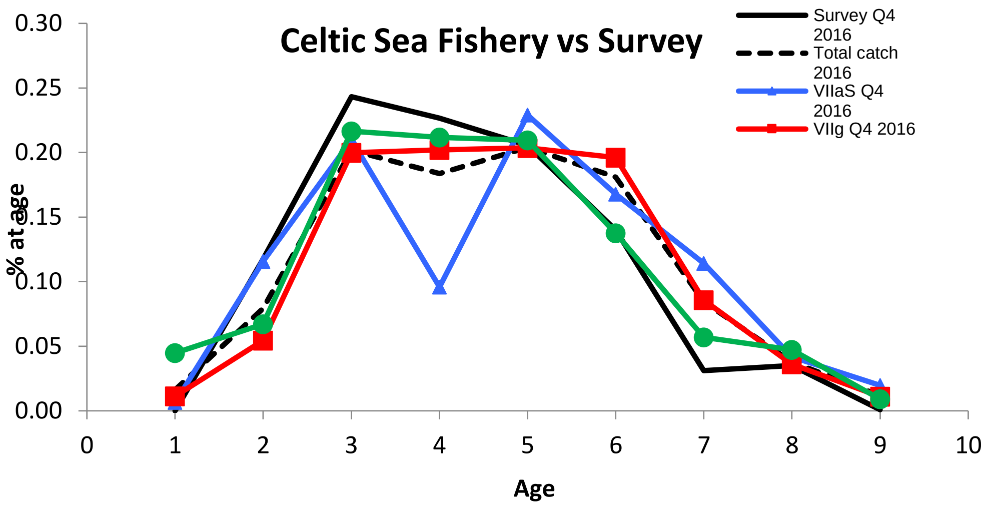


Figure 6.2.1.3. Herring in the Celtic Sea. Percentage age composition in the survey (2-9 wr) and the commercial fishery (1-9 wr) 2016/2017. Age in winter rings.

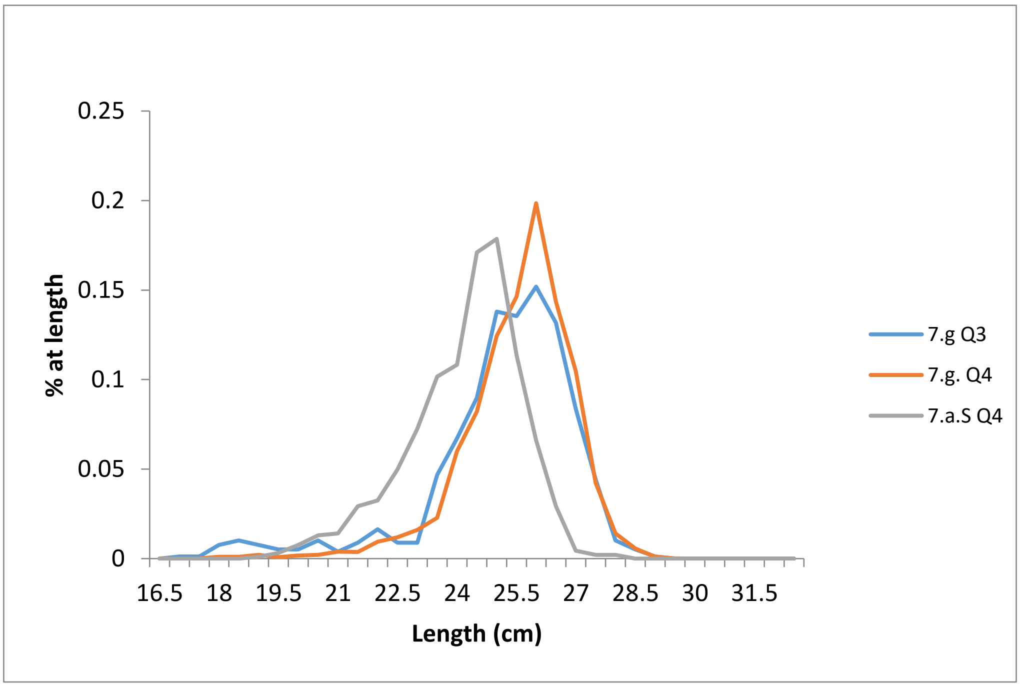


Figure 6.2.1.4. Herring in the Celtic Sea. Length-frequency data from sampling in 2015/2016.

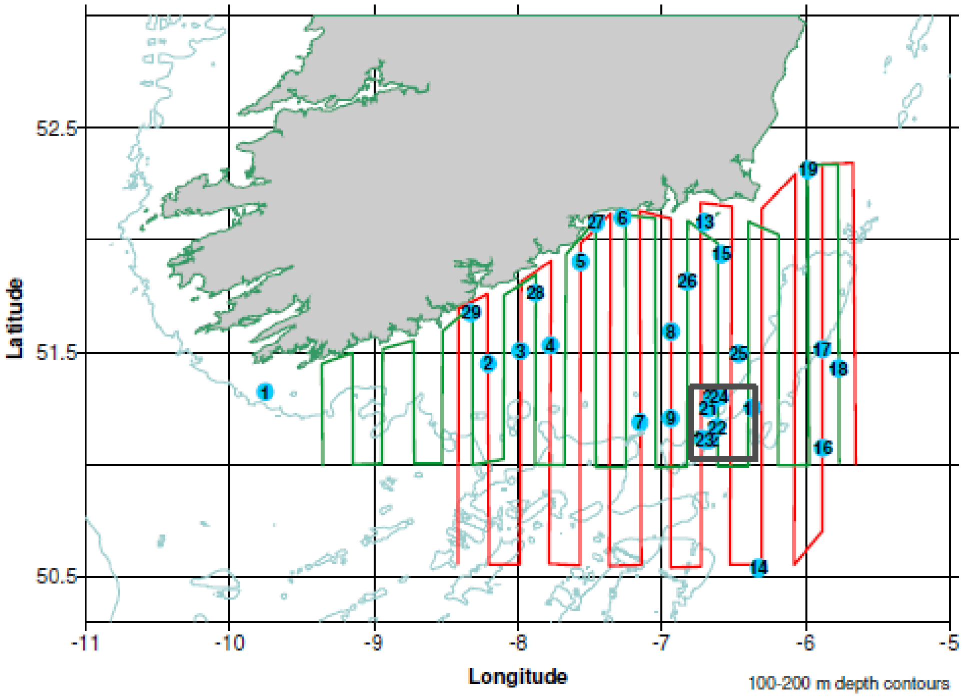


Figure 6.3.1.1a. Herring in the Celtic Sea. Acoustic survey track (1stt pass = red; 2nd pass = red), haul positions are numbered, and the adaptive mini-survey strata highlighted in grey.

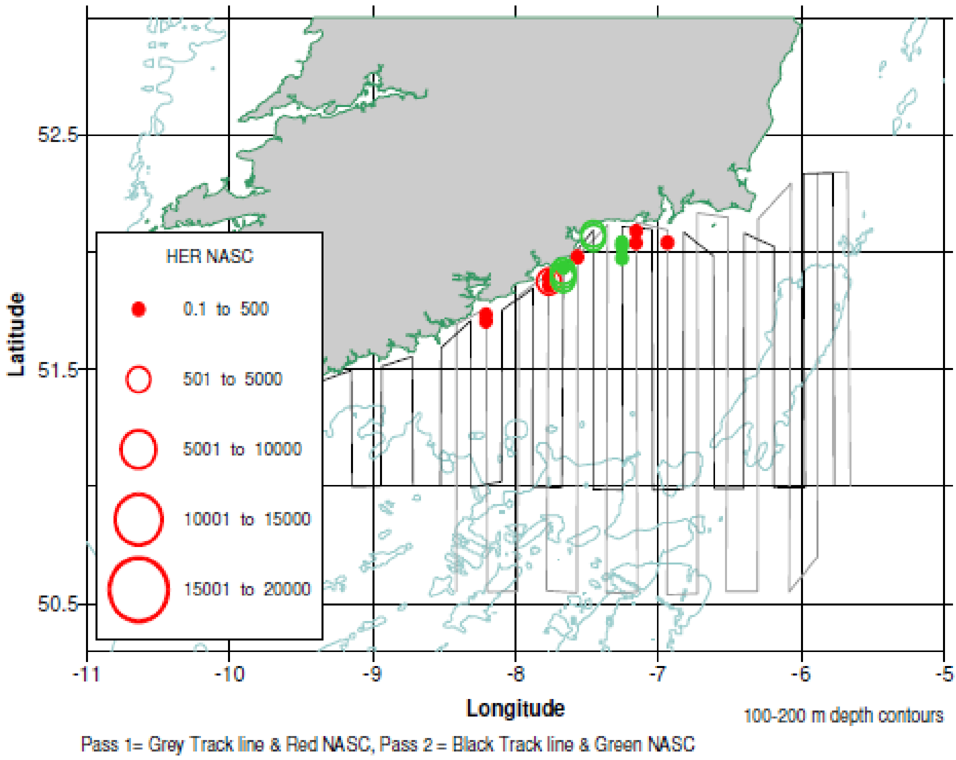


Figure 6.3.1.1b. Herring in the Celtic Sea. Weighted herring NASC (Nautical area scattering coefficient) plot of the distribution of "definitely" and "probably" categories (1st pass = red circles; 2nd pass = green circles).

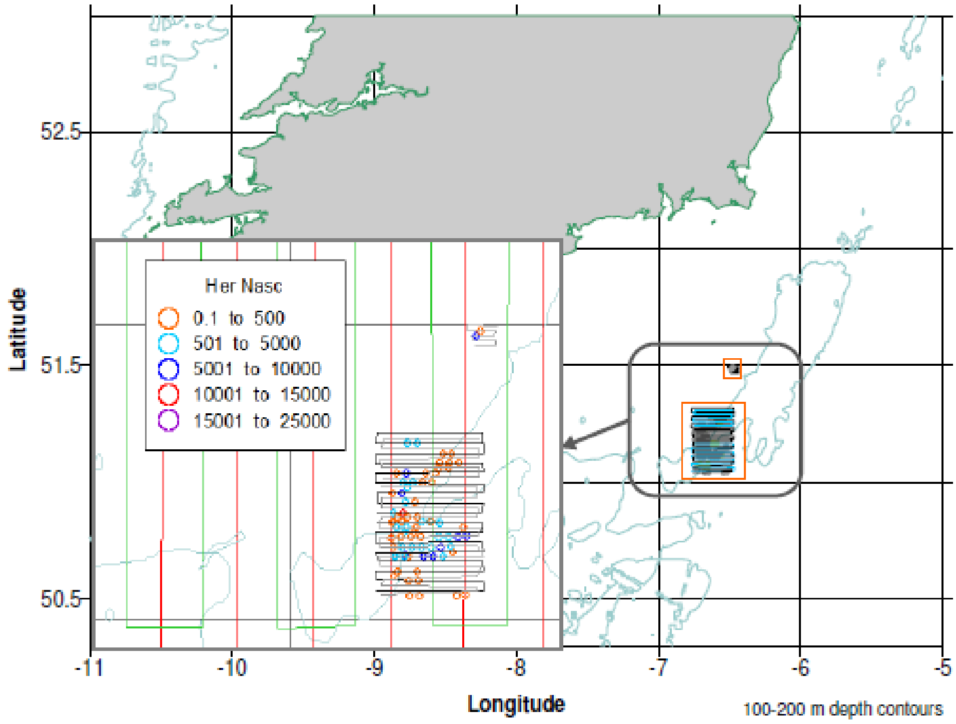


Figure 6.3.1.1c. Herring in the Celtic Sea. Weighted herring NASC (Nautical area scattering coefficient) plot of the distribution of "definitely" and "probably" categories in the adaptive mini-survey areas.

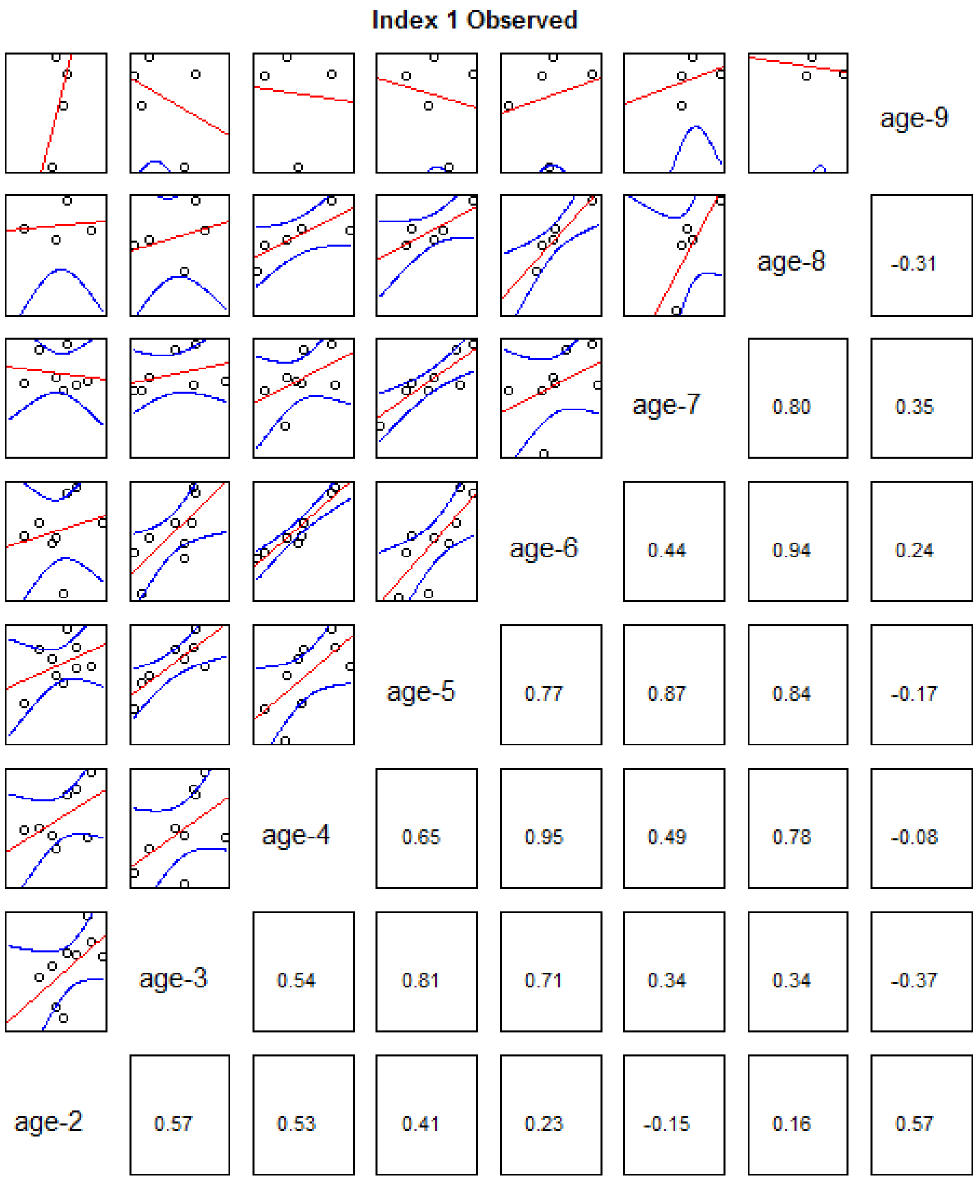


Figure 6.3.1.2. Herring in the Celtic Sea. Internal consistency between ages in the Celtic Sea Herring acoustic survey time series. Age in winter rings.

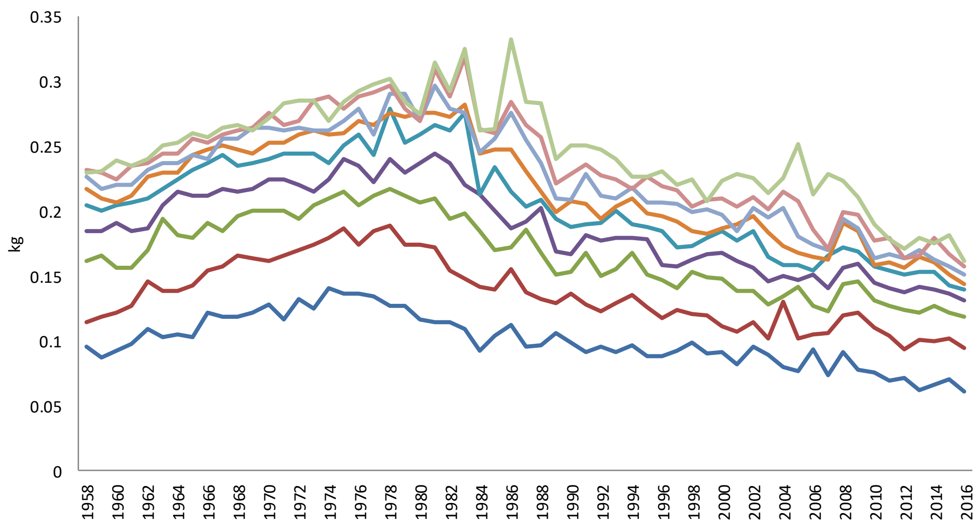


Figure 6.4.1.1. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the catch from 1958-2016 for 1-9+.

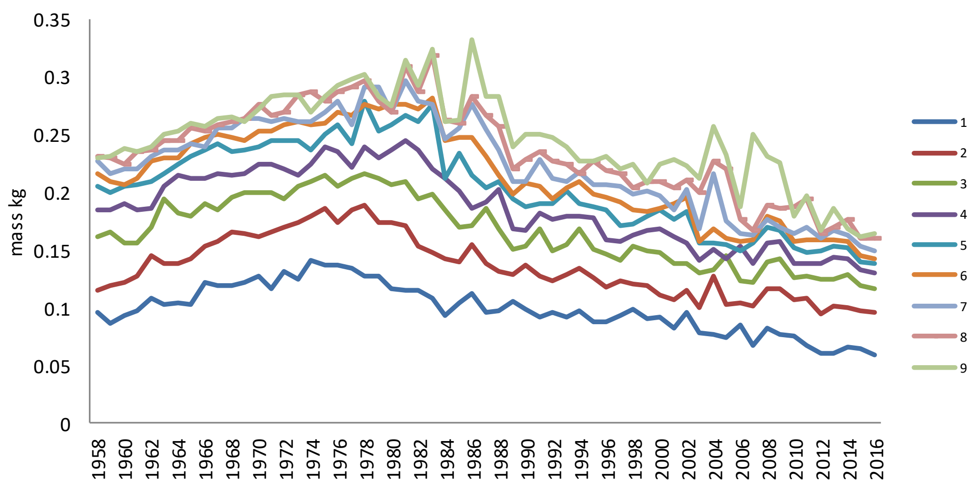


Figure 6.4.1.2. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the stock at spawning time from 1958-2016 for 1-9+. Age in winter rings.

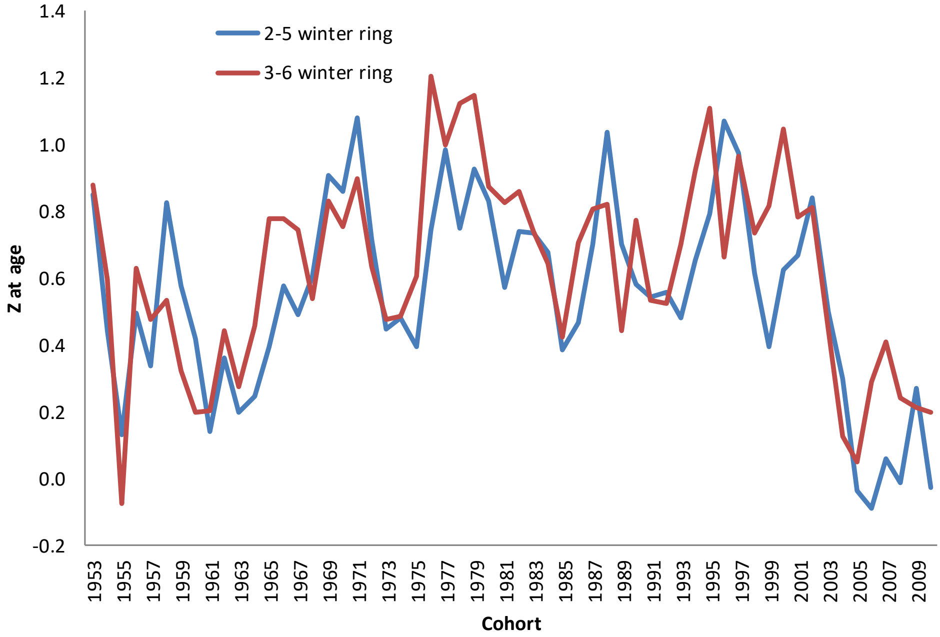


Figure 6.6.1.1. Herring in the Celtic Sea. Cohort catch curve estimates of Z-at-age over time, for cohorts hatched 1953-2010.

LCR	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
1953				0.8	0.9	0.5	-0.3	0.3
1954			0.5	0.3	1.0	-0.5	1.2	0.1
1955		0.5	-0.5	0.6	-0.6	0.9	0.9	-2.6
1956	-2.8	0.0	1.5	-0.4	1.1	0.7	-0.1	-1.0
1957	-4.1	0.8	-0.4	0.8	0.9	-0.3	0.3	0.3
1958	-1.7	-0.2	1.6	0.9	-1.0	0.2	-0.6	0.3
1959	-2.2	0.4	0.7	0.7	-0.5	0.4	1.1	-1.0
1960	-4.2	1.1	0.1	0.2	0.3	0.8	0.7	-0.4
1961	-3.9	0.5	-0.1	0.1	0.6	0.0	0.8	0.0
1962	-2.2	0.2	0.2	0.8	0.2	1.0	0.3	1.6
1963	-5.8	0.0	0.6	-0.1	0.4	0.6	0.6	0.7
1964	-1.7	0.0	0.2	0.6	0.6	1.2	0.3	1.0
1965	-2.0	0.0	0.7	0.3	1.4	0.3	1.3	-0.3
1966	-2.0	0.6	0.2	1.1	1.0	0.6	1.0	-0.4
1967	-1.4	0.0	0.9	0.5	0.9	0.8	0.3	1.0
1968	-2.9	0.3	0.9	0.5	0.2	0.6	1.6	-0.2
1969	-2.4	0.9	0.9	0.9	0.6	1.5	0.2	0.3
1970	-1.5	0.8	0.9	0.9	0.4	1.3	0.0	0.0
1971	-0.6	0.9	0.9	1.5	0.1	0.1	0.0	0.4
1972	-1.0	0.8	0.3	1.2	0.2	0.1	1.3	-0.6
1973	0.1	0.3	0.4	0.7	0.3	1.0	0.9	0.1
1974	0.1	0.0	0.3	1.1	-0.2	0.7	0.6	1.6
1975	-0.5	0.1	0.6	0.4	0.9	1.6	0.5	0.6
1976	-1.6	0.2	0.8	1.3	1.5	-0.1	0.8	2.7
1977	-1.0	0.3	1.5	1.0	0.5	2.5	1.1	-2.8
1978	-1.1	0.9	1.0	0.3	2.4	0.8	-1.1	1.2
1979	-0.1	0.5	0.5	1.9	0.7	0.0	1.4	-0.8
1980	-1.9	0.9	0.9	0.6	1.2	1.1	0.1	0.5
1981	-1.9	0.9	0.1	0.8	1.5	0.2	1.3	0.2
1982	-1.1	0.3	0.6	1.4	0.4	0.8	0.6	0.3
1983	-1.2	0.3	1.5	0.1	0.8	0.4	-0.9	2.5
1984	-2.8	0.8	0.5	0.9	0.5	0.5	1.3	0.6
1985	-2.6	0.2	0.7	0.2	0.5	1.1	1.2	0.7
1986	-2.9	0.5	0.4	0.5	1.3	0.5	-0.1	0.6
1987	-1.6	0.1	0.3	1.8	-0.1	0.6	0.6	0.9
1988	-3.2	0.6	1.2	1.2	-0.1	0.8	0.7	0.8
1989	-2.6	1.0	1.0	-0.1	0.6	0.6	0.7	0.1
1990	-2.2	0.4	0.5	0.8	1.0	0.8	0.3	1.2
1991	-3.1	0.5	1.0	0.0	0.8	0.7	1.0	0.5
1992	-1.9	0.7	0.2	0.9	0.4	1.3	1.6	0.8
1993	-1.9	0.2	0.6	0.6	0.9	1.7	2.0	-1.3
1994	-2.4	0.3	0.6	1.0	1.1	1.4	0.1	1.6
1995	-2.4	0.1	1.1	1.0	1.2	-0.6	2.5	1.2
1996	-1.8	0.6	1.2	1.4	-0.9	2.0	1.8	0.5
1997	-1.7	0.8	1.9	-0.1	1.4	1.2	2.0	2.7
1998	-1.8	1.2	0.2	0.5	1.5	1.2	2.3	1.6
1999	-0.5	0.1	0.1	1.1	1.1	1.7	2.0	-0.3
2000	-2.4	-0.2	0.9	1.1	1.1	1.8	0.3	-0.3
2001	-1.3	0.5	0.8	0.6	1.0	0.6	0.0	0.7
2002	-2.0	1.0	0.7	0.9	0.9	0.1	-0.2	1.2
2003	-0.8	-0.1	0.8	0.6	-0.2	0.7	0.4	1.9
2004	-2.0	0.3	0.5	0.0	-0.1	0.0	1.1	0.5
2005	-0.4	0.0	-0.2	0.2	0.1	0.8	0.7	-0.2
2006	-1.2	-0.6	0.1	0.2	0.6	0.1	-0.3	1.1
2007	-0.7	-0.5	-0.1	0.8	0.4	0.1	0.7	
2008	-1.9	-1.0	0.7	0.0	0.1	0.6		
2009	-2.3	0.4	0.2	0.2	0.2			
2010	-1.0	-0.3	0.2	0.2				
2011	-1.4	0.0	0.0					

LCR	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
1949-1953				0.8	0.8	0.2	1.0	-0.2
1950-1954			0.5	0.6	0.9	0.0	1.0	-0.2
1951-1955		0.5	0.0	0.6	0.5	0.2	0.9	-0.7
1952-1956	-2.8	0.3	0.5	0.4	0.6	0.3	0.6	-0.9
1953-1957	-3.4	0.5	0.3	0.5	0.7	0.3	0.4	-0.6
1954-1958	-2.9	0.3	0.5	0.5	0.3	0.2	0.4	-0.6
1955-1959	-2.7	0.3	0.6	0.5	0.0	0.4	0.3	-0.8
1956-1960	-3.0	0.4	0.7	0.4	0.2	0.4	0.3	-0.4
1957-1961	-3.2	0.5	0.4	0.5	0.1	0.2	0.5	-0.2
1958-1962	-2.9	0.4	0.5	0.5	-0.1	0.5	0.4	0.1
1959-1963	-3.7	0.4	0.3	0.3	0.2	0.6	0.7	0.2
1960-1964	-3.6	0.3	0.2	0.3	0.4	0.7	0.5	0.6
1961-1965	-3.1	0.1	0.3	0.3	0.7	0.6	0.6	0.6
1962-1966	-2.8	0.2	0.4	0.5	0.7	0.8	0.7	0.5
1963-1967	-2.6	0.1	0.5	0.5	0.9	0.7	0.7	0.4
1964-1968	-2.0	0.2	0.6	0.6	0.8	0.7	0.9	0.2
1965-1969	-2.1	0.4	0.7	0.7	0.8	0.8	0.9	0.1
1966-1970	-2.0	0.5	0.7	0.8	0.6	1.0	0.6	0.1
1967-1971	-1.7	0.6	0.9	0.9	0.4	0.9	0.4	0.3
1968-1972	-1.7	0.7	0.8	1.0	0.3	0.7	0.6	0.0
1969-1973	-1.1	0.7	0.7	1.0	0.3	0.8	0.5	0.0
1970-1974	-0.6	0.5	0.6	1.1	0.1	0.6	0.6	0.3
1971-1975	-0.4	0.4	0.5	1.0	0.2	0.7	0.7	0.4
1972-1976	-0.6	0.3	0.5	0.9	0.5	0.7	0.8	0.9
1973-1977	-0.6	0.2	0.7	0.9	0.6	1.2	0.8	0.4
1974-1978	-0.8	0.3	0.8	0.8	1.0	1.1	0.4	0.7
1975-1979	-0.8	0.4	0.9	1.0	1.2	1.0	0.5	0.2
1976-1980	-1.1	0.6	0.9	1.0	1.3	0.9	0.4	0.2
1977-1981	-1.2	0.7	0.8	0.9	1.3	0.9	0.6	-0.3
1978-1982	-1.2	0.7	0.6	1.0	1.3	0.6	0.5	0.3
1979-1983	-1.2	0.6	0.7	1.0	0.9	0.5	0.5	0.5
1980-1984	-1.8	0.6	0.7	0.8	0.9	0.6	0.5	0.8
1981-1985	-1.9	0.5	0.7	0.7	0.7	0.6	0.7	0.9
1982-1986	-2.1	0.4	0.7	0.6	0.7	0.7	0.4	0.9
1983-1987	-2.2	0.4	0.7	0.7	0.6	0.6	0.4	1.1
1984-1988	-2.6	0.4	0.6	0.9	0.4	0.7	0.7	0.7
1985-1989	-2.6	0.5	0.7	0.7	0.4	0.7	0.6	0.6
1986-1990	-2.5	0.5	0.7	0.8	0.5	0.7	0.4	0.7
1987-1991	-2.5	0.5	0.8	0.7	0.4	0.7	0.6	0.7
1988-1992	-2.6	0.7	0.8	0.5	0.5	0.8	0.8	0.7
1989-1993	-2.3	0.6	0.7	0.4	0.7	1.0	1.1	0.3
1990-1994	-2.3	0.4	0.6	0.7	0.8	1.2	1.0	0.6
1991-1995	-2.3	0.4	0.7	0.7	0.9	0.9	1.5	0.6
1992-1996	-2.1	0.4	0.7	1.0	0.5	1.2	1.6	0.6
1993-1997	-2.0	0.4	1.1	0.8	0.7	1.1	1.7	0.9
1994-1998	-2.0	0.6	1.0	0.8	0.9	1.0	1.8	1.5
1995-1999	-1.6	0.6	0.9	0.8	0.9	1.1	2.1	1.1
1996-2000	-1.6	0.5	0.9	0.8	0.9	1.6	1.7	0.8
1997-2001	-1.5	0.5	0.8	0.6	1.2	1.3	1.3	0.9
1998-2002	-1.6	0.5	0.6	0.8	1.1	1.1	0.9	0.6
1999-2003	-1.4	0.3	0.7	0.8	0.8	1.0	0.5	0.6
2000-2004	-1.7	0.3	0.8	0.6	0.5	0.6	0.3	0.8
2001-2005	-1.3	0.3	0.5	0.5	0.3	0.4	0.4	0.8
2002-2006	-1.3	0.1	0.4	0.4	0.3	0.3	0.3	0.9
2003-2007	-1.0	-0.2	0.2	0.4	0.2	0.3	0.5	0.8
2004-2008	-1.3	-0.4	0.2	0.2	0.2	0.3	0.6	0.5
2005-2009	-1.3	-0.3	0.1	0.3	0.3	0.4	0.4	0.4
2006-2010	-1.4	-0.4	0.2	0.3	0.3	0.3	0.2	1.1
2007-2011	-1.5	-0.3	0.2	0.3	0.2	0.4	0.7	

Figure 6.6.1.2. Herring in the Celtic Sea. Log catch ratios (LCR) mortality signal, from raw catch numbers at age. Left; raw LCRS, right, smoothed by 5-year running mean for cohorts hatched 1949-2011. Red indicates negative mortality.

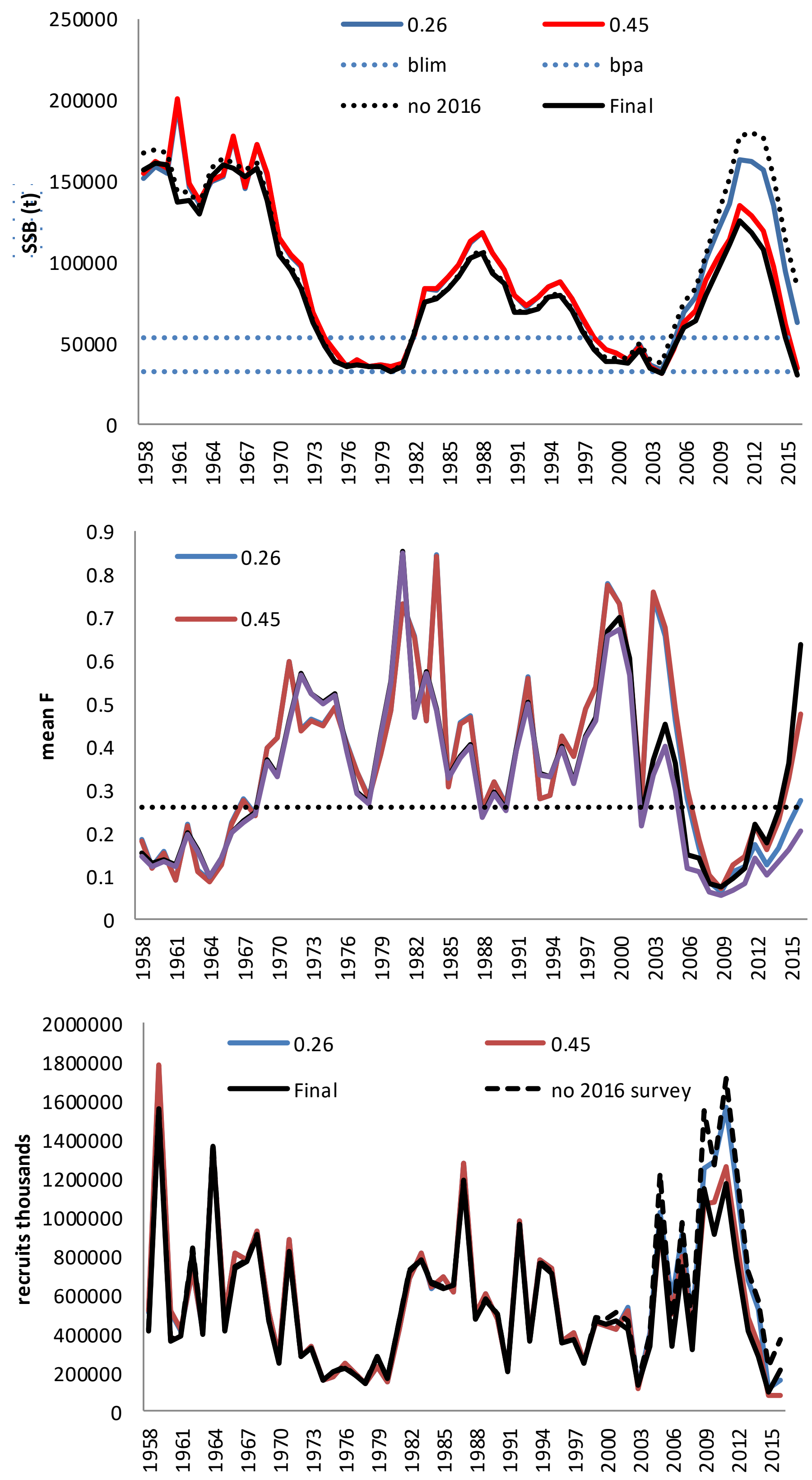


Figure 6.6.1.3. Herring in the Celtic Sea. Comparison of sVPA runs with the final update assessment and the update assessment removing the 2016 survey estimates.

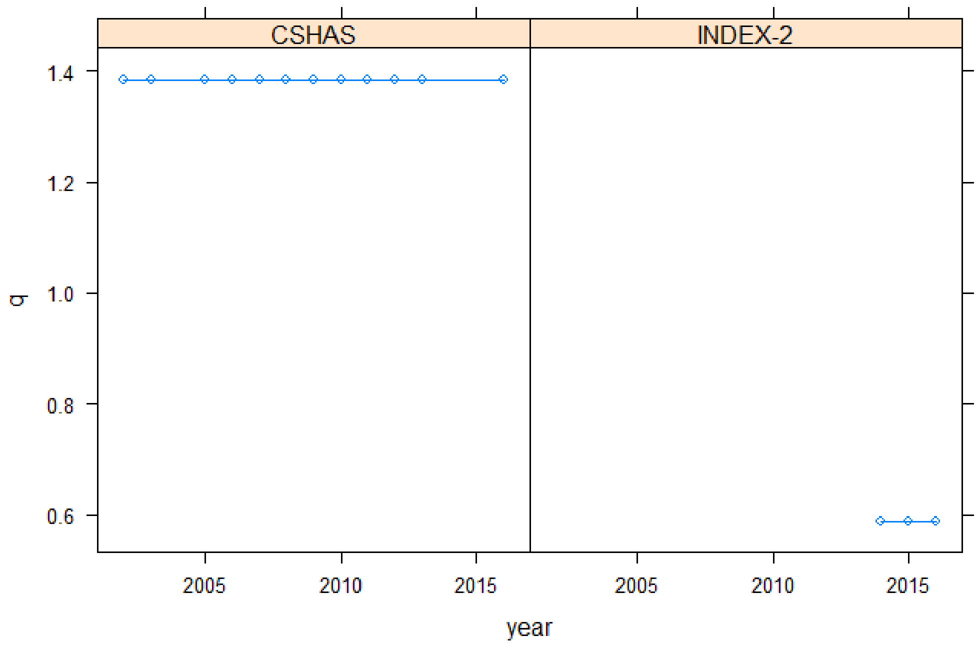


Figure 6.6.1.4. Herring in the Celtic Sea. CSHAS survey index catchability (q) for two time series (2003-2013 and 2014-2016).

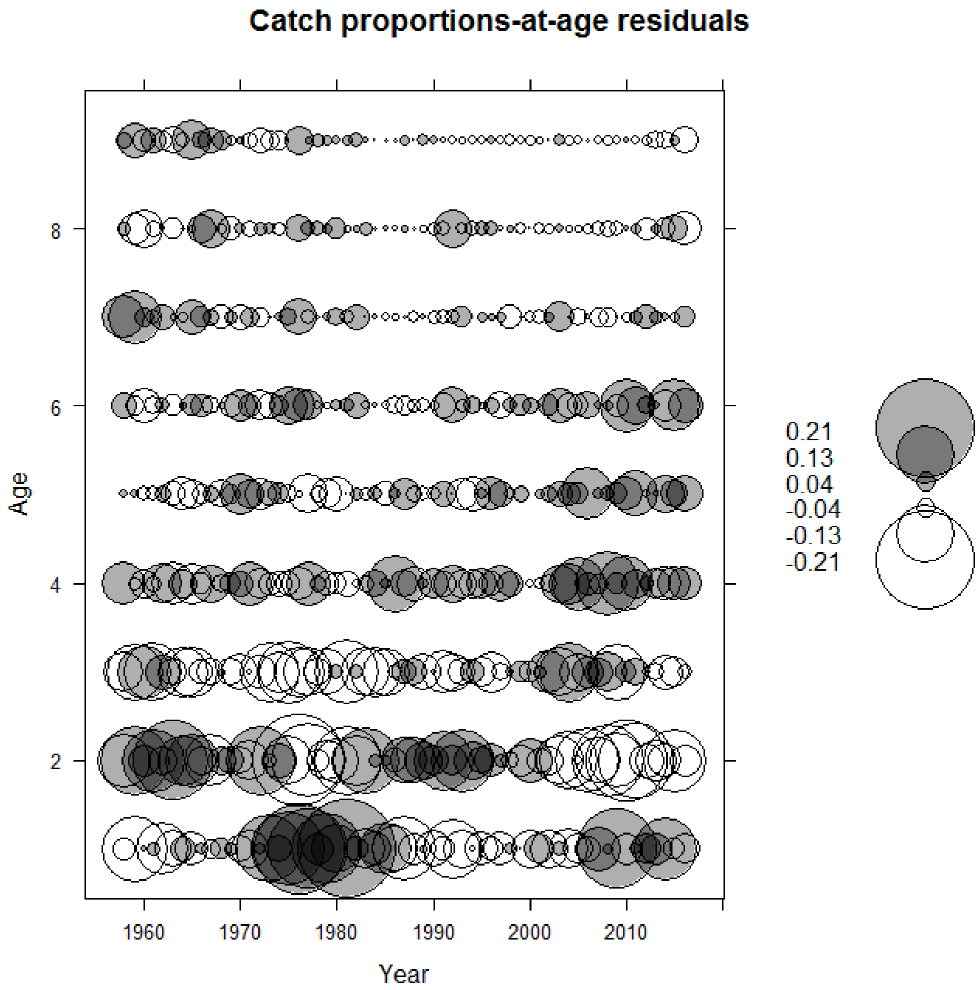


Figure 6.6.2.1. Herring in the Celtic Sea. Catch proportion at age residuals. Age in winter rings.

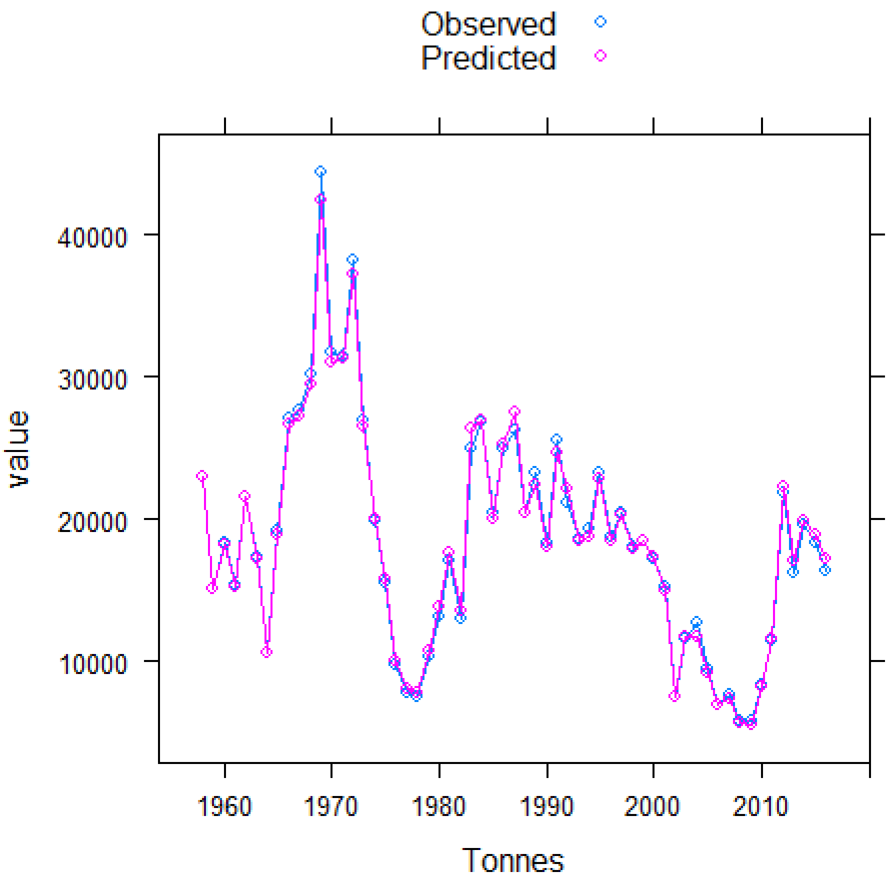


Figure 6.6.2.2. Herring in the Celtic Sea. Observed catch and predicted catch for the final ASAP assessment.

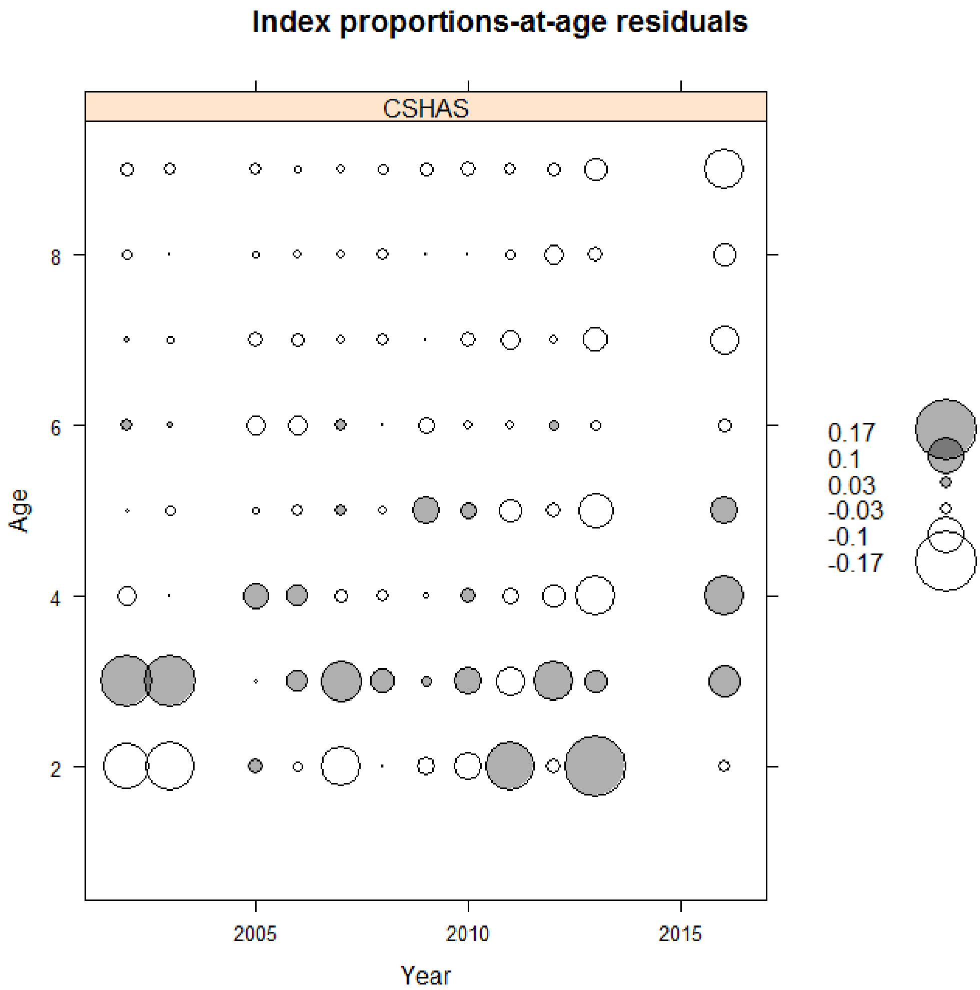


Figure 6.6.2.3. Herring in the Celtic Sea. Index proportions-at-age residuals (observed–predicted). Age in winter rings.

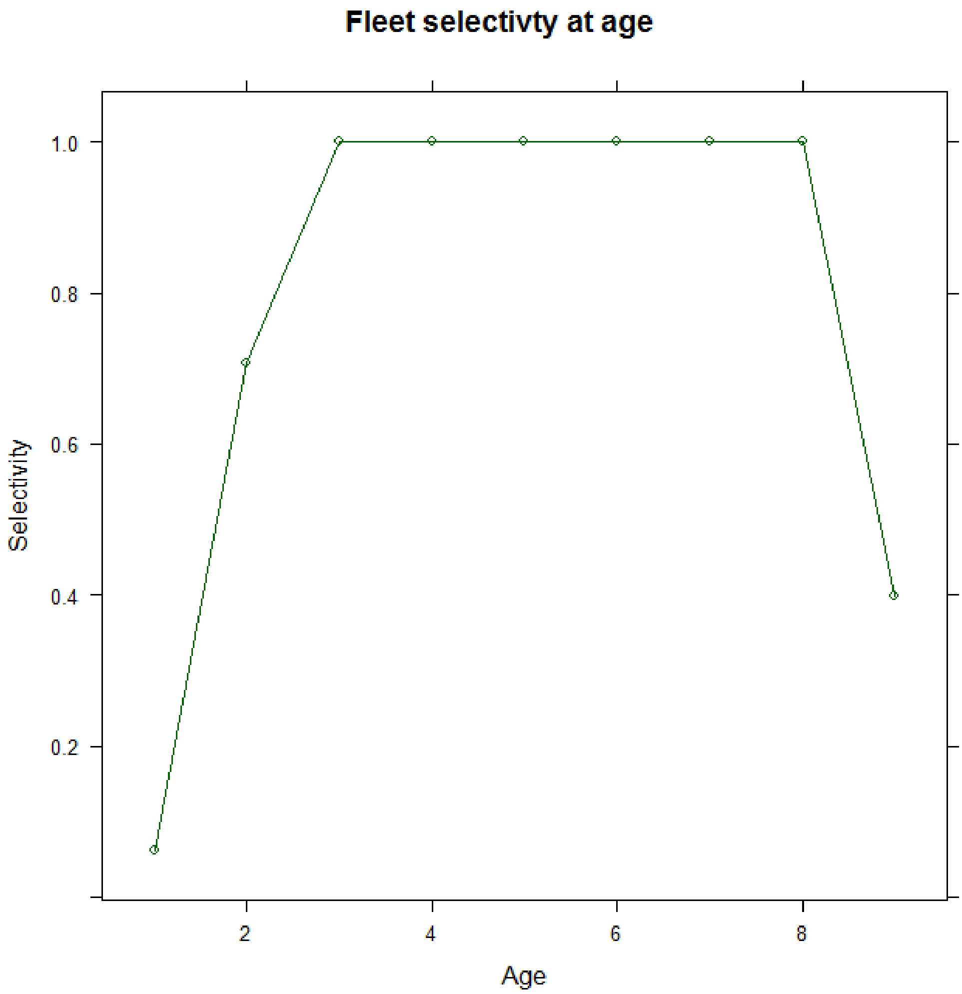


Figure 6.6.2.4. Herring in the Celtic Sea. Selectivity pattern from the final assessment run. Age in winter rings.

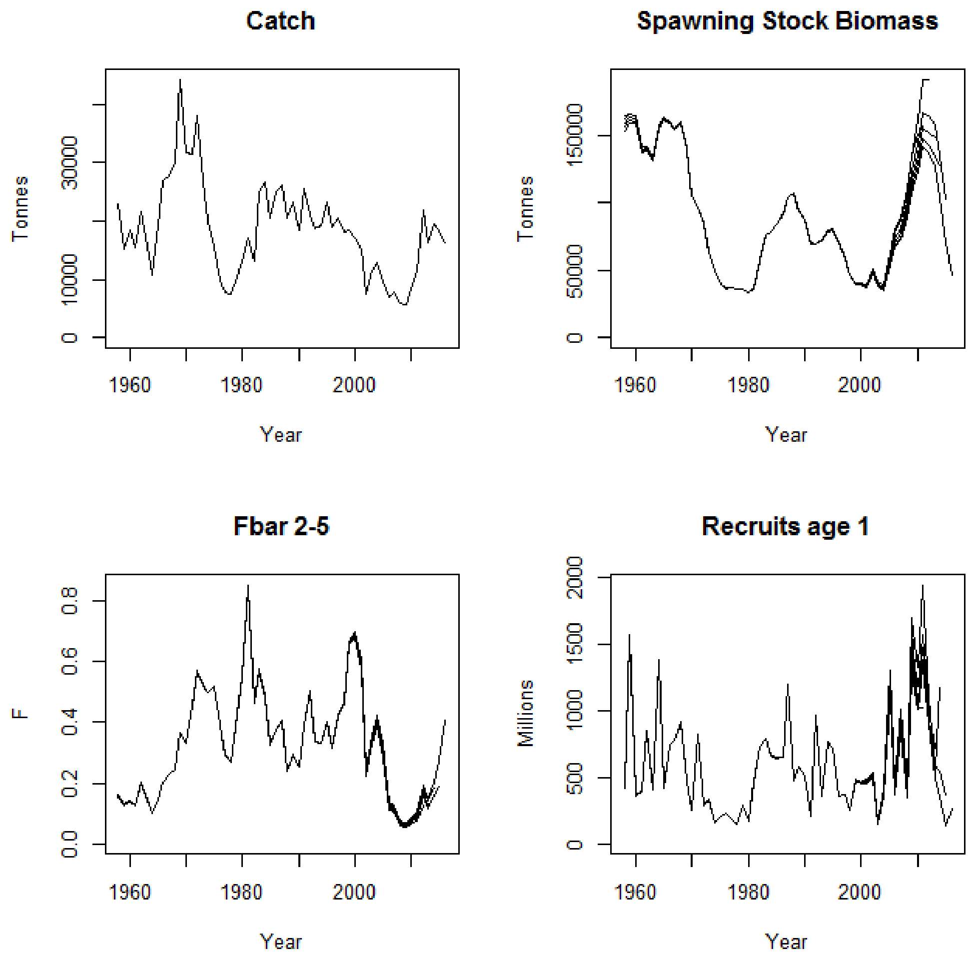


Figure 6.6.2.5. Herring in the Celtic Sea. Retrospective plots for SSB (top right), Mean F (bottom left), Recruitment (bottom right) and the catch data time series (top left). Age in winter rings.

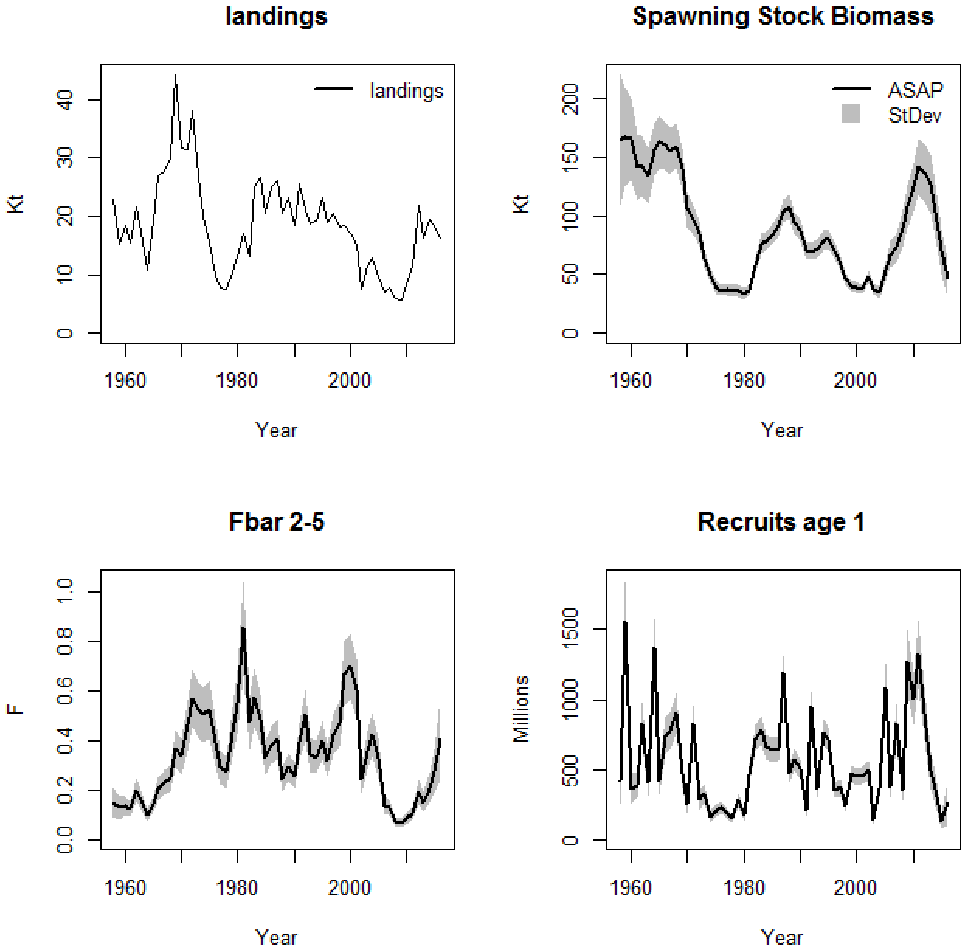


Figure 6.6.2.6. Herring in the Celtic Sea. Stock Summary from the final assessment run showing SSB (top right), Mean F (bottom left), Recruitment (bottom right) and the catch data time series (top left). Age in winter rings.

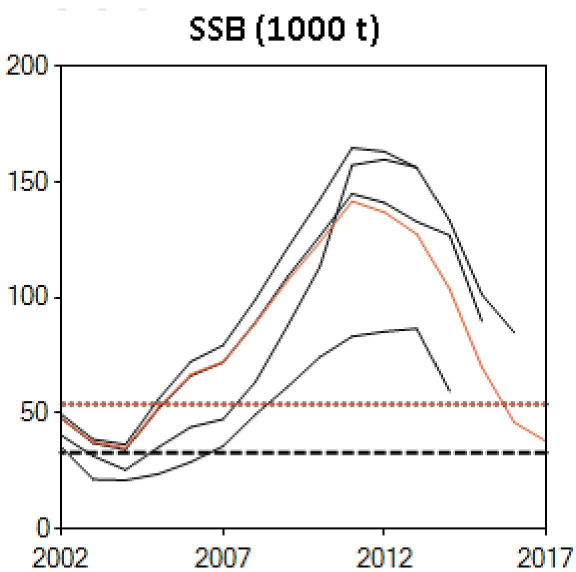


Figure 6.6.2.7a. Herring in the Celtic Sea. Comparison of historical SSB in the final assessment runs at HAWG 2017 and recent years.

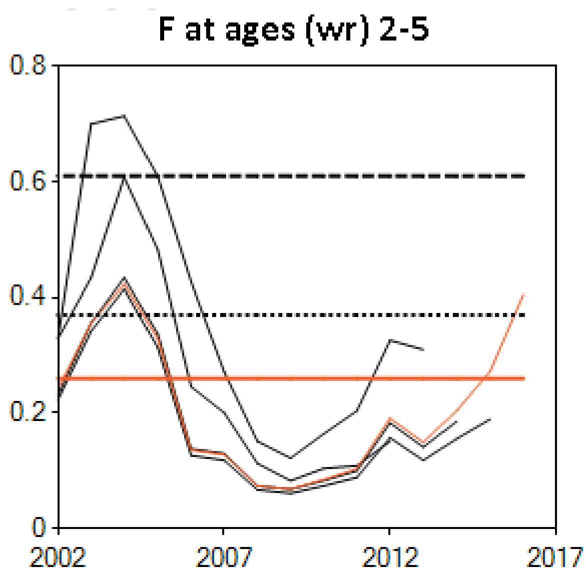


Figure 6.6.2.7b. Herring in the Celtic Sea. Comparison of historical fishing mortality in the final assessment runs at HAWG 2017 and recent years.

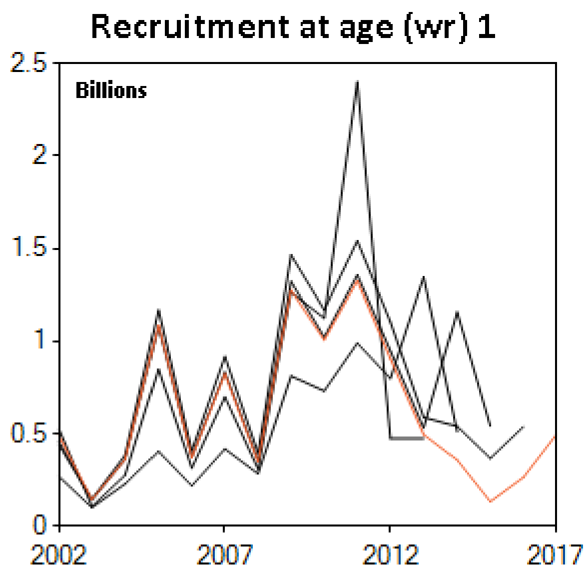


Figure 6.6.2.7c. Herring in the Celtic Sea. Comparison of historical recruitment in the final assessment runs at HAWG 2017 and recent years.

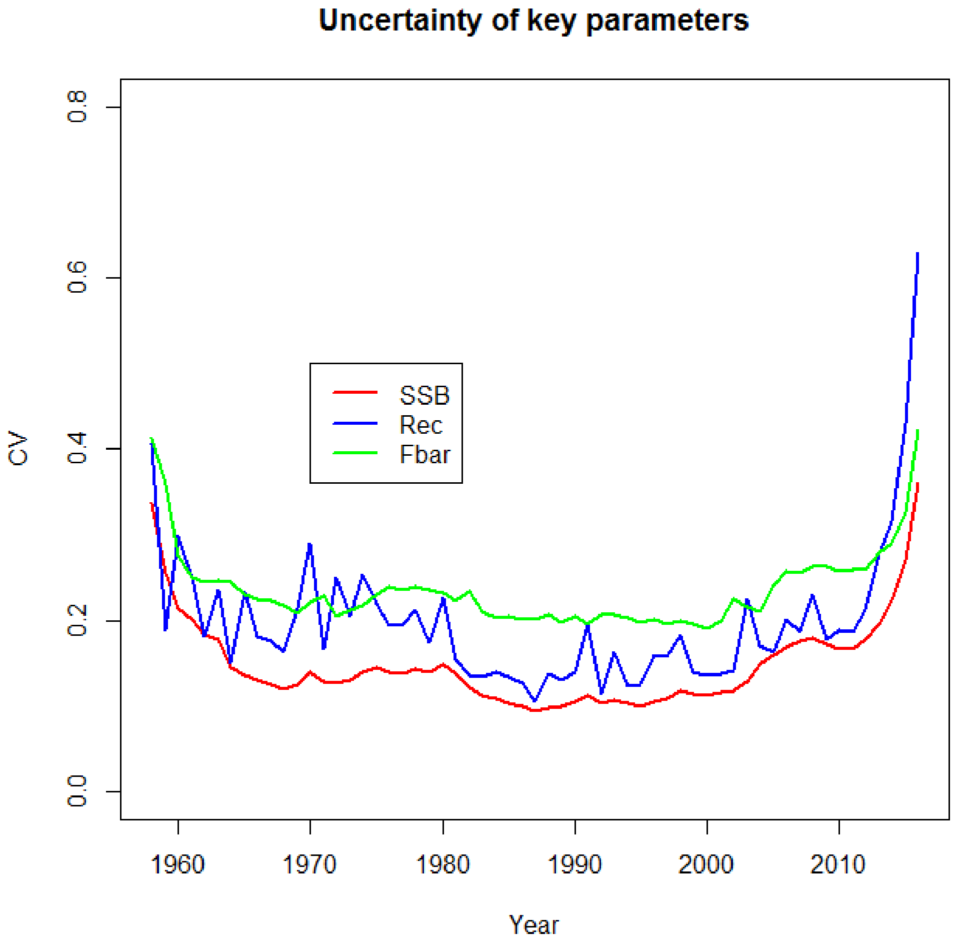


Figure 6.6.2.8. Herring in the Celtic Sea. Uncertainty of key parameters in the final assessment runs at HAWG 2017.

6.14 Audit of 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)

Date: 22 March 2017

Auditor: Cecilie Kvamme, Institute of Marine Research, Bergen

General

The 2014 and 2015 acoustic survey estimates were not used in the assessment (ICES, 2015b, 2016b) as the survey did not cover the entire distribution area of the stock. In 2016, the area coverage problem was solved. Since 2014, herring were observed close to the bottom, and unreliably estimated by the acoustic survey. The current assessment cannot deal with this change in estimation of herring by the survey, and changes to the assessment methodology are required. This means that the update assessment may not adequately track recent stock development.

The 2016 assessment shows retrospective downward revision of previous stock sizes. The downward signal in the 2016 acoustic survey index is driving down the estimate of SSB, and this accounts for the large downward revision in SSB.

For single stock summary sheet advice:

This stock was benchmarked in 2015 and incorporates commercial catches, one survey index, and natural mortalities from the SMS North Sea multispecies model supplied by WGSAM (2011). The assessment year for this stock runs from the 1st April – 31st March.

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: ASAP
5) **Data issues:** All data were available to the working group. The assessment was conducted with mortalities from WGSAM (2011). As in HAWG 2016, the 2015 acoustic survey estimates were not used, but the 2016 estimates were used – both on the recommendation of ICES WGIPS.
6) **Consistency**: The model and methods used are the same as in the benchmark 2015.
7) **Stock status**: The SSB is below the MSY $B_{trigger}$ and B_{pa}, but above B_{lim}. The stock is estimated to be declining from a high level (2011: 142 kt). SSB in 2016 is estimated at 46 kt in 2016. In 2004, the stock was at 35 kt, only slightly above Blim (33 kt). F is above F_{MSY} and Fpa, but below F_{lim}. and has been steadily increasing since 2009. Recruitment was good in 2009-2012, but has been below average since 2013.
8) **Management Plan**: A long term management plan has been proposed by the Pelagic RAC. This plan was evaluated by ICES in 2012, and again in 2015 (ICES, HAWG, 2015) and found to be consistent with the precautionary approach. It was also found to deliver long term sustainable yield, at the expense of maximising yield in any one year. The proposed target F is 0.23 and the trigger biomass point is 61 000 t.

General comments

Technical comments

An error was found in one of the acoustic survey indices (2003, Age 2: 3000 had been used whereas the correct index value should be 61 700). The survey index was corrected and the assessment rerun during the last day of HAWG.

The stock annex states that the acoustic survey index for 1-9 wr is used in the assessment, whereas the correct age range is 2-9 wr.

In the advice, F for 2016 is estimated to be above Fpa but below Flim. The traffic light should thus be changed to yellow.

The assessment has been completed according to the stock annex.

Conclusions

The assessment has been performed correctly.

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 2016 and 2017

In 2016 a TAC of 4575 t was adopted, partitioned as 3384 t to the UK and 1191 t to the Republic of Ireland. In 2016 ACOM advised on the basis of MSY approach that landings in 2017 should be equal or less than 4127 t. A TAC of was adopted for 2017 in line with the ICES advice.

7.1.2 The fishery in 2016

The catches reported from each country for the period 1987 to 2016 are given in Table 7.1.1, and total catches from 1961 to 2016 in Figure 7.1.1. Reported international landings in 2016 for the Irish Sea amounted to 4327 t with UK vessels acquiring the majority of the quota through swaps with the Republic of Ireland. The majority of catches in 2016 were taken during the 3rd quarter.

The 2016 7.a(N) herring fishery started off slowly in late August, with catches taken to the north west of the Isle of Man. Similar to 2013 and 2014, the fishery moved late to the Douglas Bank, with a resulting reduction in the proportion of total catches from the spawning aggregations. The majority of catches were taken by a pair of UK pair trawlers. October and November saw activity of the Mourne fishery, limited to boats under 40 ft. Landings for this component of the fishery have been recorded since 2006. In 2016 driftnet vessels recorded landings of ~80 t.

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, which has a derogation to fish within the Irish closed box, operated successfully again in 2016. 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 21st September to 15th November. Boats from the Republic of Ireland are not permitted to fish east of the Isle of Man. This has contributed to a mismatch in the age structure of catches and the survey.

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 21st September to 15th November, and along the east coast of Ireland all year round. Any alterations to the present closures should be considered carefully.

7.1.4 Changes in fishing technology and fishing patterns

The fishery in area 7.a(N) has not changed in recent years. A pair of UK pair trawlers takes the majority of catches during the 3rd and 4th quarters, but from 2011 to 2015 a single pelagic trawler took some of the TAC. A small local fishery continues to record landings on the traditional Mourne herring grounds during the 3rd quarter. This fishery resumed in 2006 and has seen increasing catches of herring since, peaking at ~171 t in 2009. The fishery has been restricted by the TAC since.

7.2 Biological Composition of the Catch

7.2.1 Catch in numbers

Routine sampling of the main catch component was conducted in 2016, with sampling coverage concentrated on the pelagic trawlers. There was no biological sampling of the main catch component (pair trawlers) in 2009 due to a failure to acquire samples from the landings. Catches in numbers-at-age are given in Table 7.6.3.1 for the years 1972 to 2016 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 2016, excluding 2009.

7.2.2 Quality of catch and biological data

The number of samples acquired from the main catch component was 20 in 2016, which are similar sampling levels than has been achieved in the past. The number of measurements also remained similar to past sampling levels. A further sample was also taken from the gillnet fishery operating on the Mourne ground. At sea observer data have been collected since 2010 (~10% 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 data back to 1980. Data extend 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.

7.3 Fishery-independent information

7.3.1 Acoustic surveys AC(7.aN)

The information on the time-series of acoustic surveys in the Irish Sea is given in Table 7.3.1. The SSB estimates from the survey are calculated using the (annually varying) maturity ogives from the commercial catch data.

The acoustic survey in 2016 was carried out over the period 31 August–15 September. The survey conditions were relatively good, but a number of transect interruptions were required due to adverse weather conditions. A survey design of stratified, systematic transects was employed, as in previous years (Figure 7.3.1). Relatively low abundance of 0-gp herring was observed in the eastern Irish Sea, which is usually an early indication of increased recruitment of the autumn spawning component. Sprat and 0-group herring were distributed around the periphery of the Irish Sea (Figure 7.3.1). The bulk of 1+ herring targets in 2016 were observed off the Mull of Galloway (Figure 7.3.1) and off the Northern Ireland County Down coast, where herring aggregations have now been observed consistently for a number of years. Abundance of herring was particularly high in this area. The continuing observation of herring aggregation in the western Irish Sea in distinct areas merits an investigation of possibly re-stratifying the survey area and index. A fairly scattered lower abundance was observed throughout the rest of the Irish Sea (Figure 7.3.1). The survey followed the methods described in the ICES WGIPS 2016 report. Sampling intensity was high during the 2016 survey with 38 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 is near the series high 2010 estimate (Table 7.3.1, Figure 7.3.4). The biomass estimate of 102 840 t for 1+ ringers is a significant increase from last year's biomass estimate. Similar to surveys since 2007, a large proportion of the 1+biomass estimate was to the north of the Isle of Man and North Channel, with a large part of the estimate originating from the western Irish Sea. The migration of herring toward the main spawning grounds was later in 2016 than previously observed and might explain the unusual distribution pattern.

The western and northern Irish Sea are areas of mixed size fish and the survey was mismatched with the migration of the main spawning biomass, as indicated by the high abundance of herring observed by the fishery on the Douglas Bank post survey.

The age-disaggregated acoustic estimates of the herring abundance, excluding 0-ring fish, are given in Table 7.3.2. Results of a microstructure analysis of 1-ringer+ fish (Figure 7.3.6–7) have not been updated since 2011. Winter hatched fish, of which the majority are thought to be of Celtic Sea origin, are present in the pre-spawning aggregations sampled in the Irish Sea during the acoustic survey. The presence of these winter hatched fish has implications for the estimates of 1-ringer+ biomass and SSB, as well as confounding traditional cohort type assessment methods. However, removal of the winter hatched fish, leaving only fish of autumn spawning origin, does not change the perception of a significant increase in biomass estimates (Figures 7.3.6–7). The benchmark working group (ICES, WKPELA 2012) investigated the mixing issue and its impact on the assessment. The benchmark group concluded that the data should be treated as for a mixed stock. Both the fishery and survey operate on this mixture and by using the data without adjustment for winter hatched fish, the assessment is conducted on the mixed stock. The recruitment data (1 winter rings) have the highest proportion of "alien" stock. The benchmark suggested that this is considered in the assessment model configuration and dealt with objectively within the model.

7.3.2 Spawning-stock biomass survey (7.aNSpawn)

A series of additional acoustic surveys has been conducted since 2007 by Northern Ireland, following the annual pelagic acoustic survey (conducted during the beginning of September). The enhanced survey programme was initiated to investigate the temporal and spatial variability in the population estimates from the routine acoustic survey.

The purpose was to track the spawning migration entering into the Irish Sea via the North Channel and make its way around to the main spawning grounds on the Douglas Bank. The survey only concentrates on the spawning grounds surrounding the Isle of Man and the Scottish coastal waters (Figure 7.3.4). Herring found in this area represents >75% of the SSB index generated from the routine survey.

The surveys were roughly timed every fortnight, except for the last survey. The density distributions from the surveys highlight the temporal and spatial complexity of the herring distributions. Problems with timing of the survey are further exacerbated by the significant interannual variation in the migration patterns, evident from the changes in density distributions. The results confirm the high estimate of abundance observed during the routine annual acoustic survey estimates. The survey results support the high abundance of herring in the Irish Sea. Since 2012 this extended survey series has been reduced to one repeat survey in late September to coincide with the main spawning time. The primary aim to generate an SSB index constituted from herring on or around the Irish Sea spawning ground to eliminate some of the age and mixing issues.

The 2012 benchmark (ICES, WKPELA 2012) also suggested that the survey series could be used to fine tune the main survey used as the tuning fleet in the assessment.

The survey uses a stratified design similar to the AC(7.aN. Survey methodology, data processing and subsequent analysis is exactly the same as for AC(7.aN) and follows standard protocols for surveys coordinated by WGIPS. The survey was presented to WGIPS in 2017 prior to inclusion into the benchmark. The survey in included in the assessment as a SSB index. Comparison with the SSB estimates from this survey compared to the acoustic survey that is conducted earlier confirms the high abundance of herring in the Irish Sea, but with some clear year effect (Figure 7.3.5). This index is generated from a survey where the timing mostly coinciding with the spawners being present on the Douglas Bank. The survey has been conducted on a chartered commercial vessel since 2007.

7.4 Mean weight, maturity and natural mortality-at-age

Biological sampling in 2016 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 in the last 22 years (Figure 7.4.1). No biological sampling information was available for 2009 and the weights-at-age for 2009 were replaced by averaging the weight-at-age observed in 2008 and 2010. The final agreed model from the 2012 benchmark used the natural mortality estimates from the North Sea (Table 7.6.3.4). These were again reviewed at the 2017 benchmark and although not considered ideal it is still the best available in the absence of specific Irish Sea derived natural mortality estimates. A variable maturity ogive is used based on the corresponding annual quarter 3 biological sampling from the catch (Table 7.6.3.5).

7.5 Recruitment

An estimate of total abundance of 0-ringers and 1-ringers is provided by the Northern Ireland acoustic survey, with trends also provided by the groundfish surveys. However, 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 6.6.

7.6 Assessment

7.6.1 Data exploration and preliminary modelling

The stock was benchmarked in 2017. The assessment model did not change, but the following changes have been made to the input data and model setting:

- The input dataseries was shorted 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 6.3.2). 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 had extensive discussions on the final assessment model that could form the basis for the advice. This process if described in detail in Section 1.9. Despite ongoing concerns over the catchability assumption and the mixing issues form 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 nine years of repeat surveys that specifically focussed on the spawning population within the Irish Sea. By design, acoustic surveys are aimed to produce an absolute estimate of stock biomass (with some uncertainty). This would result in a catchability of ~1. The previous assessment estimates catchability to be around ~ 2.5 for the acoustic survey. The benchmark also revealed very significant issues with the catch data, on which the previous assessment and advice is based on.

All the concerns from the benchmark have been satisfactorily addressed and did not highlight any major issues that could not be explained. In general the assessment model fit has been improved in the proposed model where the SSB survey is included at the catchability set to 1. Given that the primary aim is to provide credible scientific advice, the best proposal on this trade-off scenario (neither of which are ideal), is to base the assessment and advice on a more balanced assessment model. HAWG did, recognise that this is not an ideal scenario and further work needs to be done in the short term to improve the assessment (see Section 1.9)

2016 data were added to the new SSB survey (7.aNSPawn), the Northern Irish acoustic survey AC(7.aN) (total biomass, SSB and age-structure indices) and the 2016 catch-at-age data derived from the landings. Extensive data analyses and benchmark assessment trials were performed during the 2017 benchmark meeting (ICES, WKIRISH3 2017). Considerations to data input sources are discussed in the benchmark report and changes highlighted in the sections above. The tool for the assessment of Irish Sea herring is an implementation of the state–space assessment model (SAM, www.stock-assessment.org).

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

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

Model fit is poor for 1 ringers in the catch and survey, which is the age with the highest occurrence of fish mixing from different hatching seasons. The modelled acoustic survey catchability parameter and the selectivity of the fishery by pentad are illustrated in Figures 7.6.18–19. The variable in fishery selection reflects both the historic changes in the fishery (e.g. industrial fishery in the 1970s towards a fishery on the spawning stock in recent years) and the interannual changes in the selectivity related to the variable migration patterns and the effect of the spawning closure.

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

7.6.2 Final assessment

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

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

The retrospective pattern shows a very similar perception in SSB, F and recruitment for the years 2015–2016 (Figure 7.6.24). The retrospective bias from the model is low, except for F.

Comparison with previous assessments

A comparison of the estimates of this year's assessment with last year's is given in Figure 7.6.25. The stock was benchmarked in 2017, with updates made to the model configurations and input data sources (including a new SSB survey). The new perception of the stock provides biomass estimates more in between the acoustic survey and catch estimates. Recruitment assumptions in the assessment were changed, which resulted in higher interannual variability.

7.6.3 State of the stock

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

7.7 Short-term projections

7.7.1 Deterministic short-term projections

A deterministic short-term forecast was conducted for Irish Sea herring with code developed in R software. Population abundances, F at age and input data were taken from the final SAM accepted assessment, 1980–2016 (Table 7.7.1). Geometric mean recruitment of 1-ringers (2005–2014) replaced recruitment for 1-ringers in 2017. The forecast was based on a TAC constraint (2017 quota = 4127 t) assuming full uptake of the UK quota, and full swapping to the UK, and subsequent uptake of the Irish quota. Fishing mortality, maturity-at-age, catch weights-at-age and stock weights were averaged over the past 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 2017–2019, but is predicted to decrease.

7.7.2 Yield per recruit

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

7.8 Medium-term projections

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

7.9 Reference points

MSY evaluations

New reference points were derived using the stock-recruit pairs generated by the 2017 assessment (WKIRISH3 and HAWG 2017). B_{lim} was set to the lowest SSB that generate above average recruitment, 8500 t. B_{pa}, 11 800 t calculated from B_{lim} with assessment error ($\sigma \approx 0.201$, based on the average CV from the terminal assessment year.) $MSYB_{trigger}$ is set to B_{pa} as the stock has not been fished at or below F_{MSY} for more than five years. F_{MSY} median point estimates is 0.27 (0.266). The upper bound of the F_{MSY} range giving at least 95% of the maximum yield was estimated to 0.35(0.345) and the lower bound at 0.20(0.198). F_{lim} is estimated to be 0.40 (0.397) as F with 50% probability of SSB <B_{lim} with F_{pa} as 0.29 (0.286) calculated as F_{lim} combined with the assessment error; F_{lim} x exp(-1.645 x σ); $\sigma = 0.231$.

7.10 Quality of the assessment

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

The stock is very well sampled and catch information is representative of the fishery (with the exception of 2009 when no samples were provided). The current assessment, being a time-series model, can estimate the missing catch numbers in 2009.

The main issues with the stock are stock mixing (at younger ages from fish of different spawning season origin) and the different trends in mortality observed in the survey and the commercial catches. The majority of this variation may arise from the interannual 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 at the benchmark. The noise in the data due to juvenile stock mixing resulted in increased estimates of F, catchability estimates >1 across the younger ages in the survey, or most likely a combination of these. Most of the mixing occurs at younger ages, and this is objectively, but only partially, corrected for in the model through a high catchability (3) estimated for the acoustic survey. Currently, the model doesn't have the structure to specifically deal with the emigration of small herring from other stocks.

The F_{bar} range 4–6 is considered representative of the mortality on the autumn spawning stock in the Irish Sea, excluding most the ages with significant mixed components.

The survey data quality is good, but the survey index is variable linked to the migration and biological characteristics of the stock and the need to assess similar stock components which the fishery exploits to ensure the sustainable exploitation of the Irish Sea spawning stock.

No major validations of the assumption underpinning the assessment model were found. The final assessment model is dominated by information from the catch, but with the noise being added to the survey information as age and year effects. The model does fit the catch data significantly better despite the significant quality issues with the catch data reported at the 2017 benchmark. This is not desirable. The new survey information adds more weight to the previously observed increase abundance trend observed from the main age-disaggregated acoustic survey. The 2017 assessment model attempted to provide a more balanced model, giving more weight to the SSB survey.

SAM down-weights the 1 ring data and survey information in general. The uncertainty estimates of the model parameters, suggest the model is both appropriate for the available data and that the model describes these data reasonably well. Very little retrospective bias was also present.

7.11 Management considerations

Given the historical landings from this stock and the knowledge that fishing pressure is light and mostly confined to one pair of UK vessels it can be assumed that fishing pressure and activity has not varied considerably in recent years. The catches have been close to TAC levels and the main fishing activity has not varied considerably as shown from landing data (Figure 7.1.1).

The current assessment and forecast indicate SSB to be the highest in the time-series and fishing mortalities below F_{MSY}. The Working Group supports the development of a long-term management plan for this stock. Such a plan should be further developed with stakeholders and forwarded to ICES for evaluation.

Characteristically of most herring stocks, the Irish Sea herring represents a mixture and management of this stock should be considered as part of a metapopulation. The consequence of this needs to be further evaluated for management and advice.

7.12 Ecosystem considerations

No additional information presented (see Stock Annex).

Table 7.1.1. Herring in Division 7.a North (Irish Sea). Working Group catch estimates in tonnes by country, 1987–2015. 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						
Ireland	119	0	82						
UK	5089	4868	4245						
Unallocated	-	- 22	-						
Total	5208	4891	4327						

Table 7.2.2. Herring in Division 7.a North (Irish Sea). Catch-at-length data 1995–2016. 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
14															-					-		
14.5															-					-		
15															-					15		
15.5					10								16		-	93				14		
16	21	21	17		19	12	9					2			-	107	30		8	0		109
16.5	55	51	94		53	49	27			13	1	44	33	1	-	487	165		84	14		174
17	139	127	281	26	97	67	53			25	39	140	69	3	-	764	356	89	202	213	16	261
17.5	148	200	525	30	82	97	105			84	117	211	286	11	-	1155	851	143	470	808	32	413
18	300	173	1022	123	145	115	229			102	291	586	852	34	-	1574	1406	301	533	1644	72	326
18.5	280	415	1066	206	135	134	240	36		114	521	726	2088	64	-	1405	841	533	555	3246	64	457
19	310	554	1720	317	234	164	385	18		203	758	895	2979	85	-	866	1029	479	588	5357	136	522
19.5	305	652	1263	277	82	97	439	0	29	269	933	1246	3527	108	-	673	1026	493	680	5371	199	718
20	326	749	1366	427	218	109	523	0	73	368	943	984	3516	100	-	787	1062	298	1041	4025	271	826
20.5	404	867	1029	297	242	85	608	18	215	444	923	1443	2852	133	-	888	1502	511	1419	2905	279	1087
21	468	886	1510	522	449	115	1086	307	272	862	1256	1521	3451	192	-	1470	1874	643	2364	2608	439	1783
21.5	782	1258	1192	549	362	138	1201	433	290	1007	1380	1621	2929	217	-	1758	1396	1104	2963	2381	854	1762
22	1509	1530	2607	1354	1261	289	1748	1750	463	1495	1361	2748	3821	271	-	2363	2372	1586	3052	2906	1896	2588
22.5	2541	2190	2482	1099	2305	418	1763	1949	600	2140	1448	3629	3503	229	-	3362	2778	2404	3599	2766	2028	2675
23	4198	2362	3508	2493	4784	607	2670	2490	1158	2089	1035	4358	4196	322	-	4530	4100	3920	3432	2596	2470	2893
23.5	4547	2917	3902	2041	4183	951	2254	1552	1380	2214	1256	2920	3697	264	-	5232	3394	6024	3039	1775	1977	3110

Length (cm)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009*	2010	2011	2012	2013	2014	2015	2016
24	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054	1276	3679	3178	259	-	4559	4759	8849	3882	2161	2124	2849
24.5	3391	4077	4138	2769	3397	1783	4098	758	1249	2269	1083	2431	2136	204	-	3616	3729	7777	3985	1879	1911	2523
25	3100	4015	5031	2625	2620	2144	5566	776	1163	1749	1086	3438	1503	148	-	3083	3430	7020	3364	2282	2367	2414
25.5	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206	584	2198	952	114	-	2582	2662	5759	2693	2264	2319	2458
26	2334	2480	3871	3115	1694	1349	3814	1570	1140	823	438	1714	643	78	-	1777	2343	4835	1934	1612	1962	1936
26.5	1807	2177	2455	2641	1547	840	2243	1552	1573	587	203	605	330	42	-	950	1595	2664	1026	900	1016	1631
27	1622	1949	1711	2992	1475	616	1489	776	1607	510	165	445	147	23	-	460	1083	1716	412	498	827	826
27.5	990	1267	1131	1747	867	479	644	433	1189	383	60	155	72	10	-	216	472	629	179	326	252	283
28	834	906	638	1235	276	212	496	162	726	198	45	104	33	12	-	9	248	231	85	256	141	65
28.5	123	564	440	170	169	58	179	108	569	51	18	9	26	1	-		53	159	28	156	48	65
29	248	210	280	111	61	42	10	36	163		12	46			-	9		108		57	16	22
29.5	56	79	59	92		12	0	36	129				7		-			54		14	8	
30	40	32	8	84		6	9		43						-			17		0	8	
30.5	5	0	5	3					43						-			17		14		
31	1	2							43						-							
31.5															-							
32															-							
32.5															-							
33															-							
33.5															-							

Table 7.2.3. Herring in Division 7.a North (Irish Sea). Sampling intensity of commercial landings in 2016.

Quarter	Country	Landings (t)	No. samples	No. fish measured	No. fish aged
1	Ireland	0	-	-	-
	UK (N. Ireland)	0	0	0	0
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
2	Ireland	0	-	-	-
	UK (N. Ireland)	0	0	0	0
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
3	Ireland	0	-	-	-
	UK (N. Ireland)	4018	20	2749	991
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
4	Ireland	82	0	0	0
	UK (N. Ireland)	227	0	0	0
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-

*** no information, but catch is likely to be negligible.**

Table 7.3.1. Herring in Division 7.a North (Irish Sea). Summary of acoustic survey AC(7.aN) information for the period 1989–2016. 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
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

Year	Area	Dates	herring biomass (1+rings)	CV	herring biomass (SSB)	CV	small clupeoids (biomass)	CV
2016	Area 7.a(N)	31/08—15/09	102840	0.25	91332	0.28	240 926	0.10

[1] sprat only

[2]Data can be made available for the IoM waters only

Table 7.3.2. Herring in Division 7.a North (Irish Sea). Age-disaggregated acoustic estimates (thousands) of herring abundance from the Northern Ireland surveys in September AC(7.aN). Ages in winter rings.

AGE (RINGS)	1	2	3	4	5	6	7	8+
1994	66.8	68.3	73.5	11.9	9.3	7.6	3.9	10.1
1995	319.1	82.3	11.9	29.2	4.6	3.5	4.9	6.9
1996	11.3	42.4	67.5	9	26.5	4.2	5.9	5.8
1997	134.1	50	14.8	11	7.8	4.6	0.6	1.9
1998	110.4	27.3	8.1	9.3	6.5	1.8	2.3	0.8
1999	157.8	77.7	34	5.1	10.3	13.5	1.6	6.3
2000	78.5	103.4	105.3	27.5	8.1	5.4	4.9	2.4
2001	387.6	93.4	10.1	17.5	7.7	1.4	0.6	2.2
2002	391	71.9	31.7	24.8	31.3	14.8	2.8	4.5
2003	349.2	220	32	4.7	3.9	4.1	1	0.9
2004	241	115.5	29.6	15.4	2.1	2.3	0.2	0.2
2005	94.3	109.9	97.1	17	8	0.8	0.6	5.8
2006	374.7	96.6	15.6	10.0	0.5	0.4	0.5	0.5
2007	1316.7	251.3	46.6	21.1	20.8	1.2	0.7	0.6
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

Table 7.6.3.1. Irish Sea Herring. CATCH IN NUMBER

Units : thousands

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	5840	5050	5100	1305	1168	2429	4491	2225	2607	1156	2313	1999	12145
2	25760	15790	16030	12162	8424	10050	15266	12981	21250	6385	12835	9754	6885
3	19510	3200	5670	5598	7237	17336	7462	6146	13343	12039	5726	6743	6744
4	8520	2790	2150	2820	3841	13287	8550	2998	7159	4708	9697	2833	6690
5	1980	2300	330	445	2221	7206	4528	4180	4610	1876	3598	5068	3256
6	910	330	1110	484	380	2651	3198	2777	5084	1255	1661	1493	5122
7	360	290	140	255	229	667	1464	2328	3232	1559	1042	719	1036
8	230	240	380	59	479	724	877	1671	4213	1956	1615	815	392

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	646	1970	3204	5335	9551	3069	1810	1221	2713	179	694	3225	8692
2	14636	7002	21330	17529	21387	11879	16929	3743	11473	9021	4694	8833	13980
3	3008	12165	3391	9761	7562	3875	5936	5873	7151	1894	3345	5405	10555
4	3017	1826	5269	1160	7341	4450	1566	2065	13050	1866	2559	2161	3287
5	2903	2566	1199	3603	1641	6674	1477	558	3386	2395	882	623	1422
6	1606	2104	1154	780	2281	1030	1989	347	936	953	2945	213	415
7	2181	1278	926	961	840	2049	444	251	650	474	872	673	292
8	848	1991	1452	1364	1432	451	622	147	803	337	605	127	368

age \ year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	5669	20290	8939	NA	9588	7454	2491	3889	27377	1654	2216
2	15253	18291	18974	NA	17627	17598	9664	18916	9567	15414	19064
3	8198	4980	7487	NA	6679	8984	12247	6836	7917	4840	5992
4	6318	1655	2696	NA	6201	3982	7944	6631	1997	7376	4677
5	1325	1062	2082	NA	3200	3671	3061	2901	1759	1613	2050
6	605	325	1761	NA	925	1751	3158	1472	964	4276	1421
7	262	122	328	NA	370	690	1591	625	409	1678	896
8	246	111	216	NA	185	425	652	352	830	1112	759

Table 7.6.3.2 Irish Sea Herring. WEIGHTS-AT-AGE IN THE CATCH

Units : kg

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.074	0.074	0.074	0.074	0.076	0.087	0.068	0.058	0.070	0.081	0.096	0.073
2	0.155	0.155	0.155	0.155	0.142	0.125	0.143	0.130	0.124	0.128	0.140	0.123
3	0.195	0.195	0.195	0.195	0.187	0.157	0.167	0.160	0.160	0.155	0.166	0.155
4	0.219	0.219	0.219	0.219	0.213	0.186	0.188	0.175	0.170	0.174	0.175	0.171
5	0.232	0.232	0.232	0.232	0.221	0.202	0.215	0.194	0.180	0.184	0.187	0.181
6	0.251	0.251	0.251	0.251	0.243	0.209	0.228	0.210	0.198	0.195	0.195	0.190
7	0.258	0.258	0.258	0.258	0.240	0.222	0.239	0.218	0.212	0.205	0.207	0.198
8	0.278	0.278	0.278	0.278	0.273	0.258	0.254	0.229	0.232	0.218	0.218	0.217

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	0.062	0.089	0.070	0.075	0.067	0.064	0.080	0.069	0.064	0.067	0.085	0.081
2	0.114	0.127	0.123	0.121	0.116	0.118	0.123	0.120	0.120	0.106	0.113	0.116
3	0.140	0.157	0.153	0.146	0.148	0.146	0.148	0.145	0.148	0.139	0.144	0.136
4	0.155	0.171	0.170	0.164	0.162	0.165	0.163	0.167	0.168	0.156	0.167	0.160

age												
5	0.165	0.182	0.180	0.176	0.177	0.176	0.181	0.176	0.188	0.168	0.180	0.167
6	0.174	0.191	0.189	0.181	0.199	0.188	0.177	0.188	0.204	0.185	0.184	0.172
7	0.181	0.198	0.202	0.193	0.200	0.204	0.188	0.190	0.200	0.198	0.191	0.186
8	0.197	0.212	0.212	0.207	0.214	0.216	0.222	0.210	0.213	0.205	0.217	0.199

age \ year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.073	0.067	0.064	0.067	0.071	0.0620	0.053	0.058	0.070	0.059	0.066	0.070
2	0.107	0.103	0.105	0.112	0.110	0.1080	0.106	0.106	0.120	0.100	0.110	0.106
3	0.130	0.136	0.131	0.135	0.135	0.1330	0.131	0.134	0.138	0.130	0.146	0.136
4	0.157	0.156	0.149	0.158	0.153	0.1490	0.145	0.152	0.152	0.142	0.177	0.148
5	0.165	0.166	0.164	0.173	0.156	0.1545	0.153	0.159	0.164	0.157	0.174	0.155
6	0.187	0.180	0.177	0.183	0.182	0.1730	0.164	0.175	0.174	0.165	0.176	0.157
7	0.200	0.191	0.184	0.199	0.196	0.1855	0.175	0.187	0.179	0.170	0.196	0.167
8	0.205	0.209	0.211	0.227	0.206	0.1890	0.172	0.196	0.191	0.180	0.198	0.171

age \ year	2016
1	0.054
2	0.102
3	0.126
4	0.143
5	0.159
6	0.161
7	0.167
8	0.177

Table 7.6.3.3 Irish Sea Herring. WEIGHTS-AT-AGE IN THE STOCK

Units : kg

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.074	0.074	0.074	0.074	0.076	0.087	0.068	0.058	0.070	0.081	0.077	0.070
2	0.155	0.155	0.155	0.155	0.142	0.125	0.143	0.130	0.124	0.128	0.135	0.121
3	0.195	0.195	0.195	0.195	0.187	0.157	0.167	0.160	0.160	0.155	0.163	0.153
4	0.219	0.219	0.219	0.219	0.213	0.186	0.188	0.175	0.170	0.174	0.175	0.167
5	0.232	0.232	0.232	0.232	0.221	0.202	0.215	0.194	0.180	0.184	0.188	0.180
6	0.251	0.251	0.251	0.251	0.243	0.209	0.229	0.210	0.198	0.195	0.196	0.189
7	0.258	0.258	0.258	0.258	0.240	0.222	0.239	0.218	0.212	0.205	0.207	0.195
8	0.278	0.278	0.278	0.278	0.273	0.258	0.254	0.229	0.232	0.218	0.217	0.214

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	0.061	0.088	0.073	0.072	0.067	0.063	0.073	0.068	0.063	0.066	0.085	0.081
2	0.111	0.126	0.126	0.120	0.115	0.119	0.121	0.121	0.120	0.105	0.113	0.116
3	0.136	0.157	0.154	0.147	0.148	0.148	0.150	0.145	0.149	0.139	0.144	0.136
4	0.151	0.171	0.174	0.168	0.162	0.167	0.166	0.168	0.171	0.156	0.167	0.160
5	0.159	0.183	0.181	0.180	0.177	0.178	0.179	0.178	0.188	0.167	0.180	0.167
6	0.171	0.191	0.190	0.185	0.195	0.189	0.190	0.189	0.204	0.183	0.184	0.172
7	0.179	0.198	0.203	0.197	0.199	0.206	0.200	0.199	0.205	0.199	0.191	0.186
8	0.191	0.214	0.214	0.212	0.212	0.214	0.230	0.214	0.215	0.205	0.217	0.199

age \ year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.067	0.067	0.064	0.073	0.071	0.0660	0.060	0.057	0.059	0.057	0.069	0.070
2	0.114	0.103	0.105	0.114	0.110	0.1140	0.118	0.109	0.109	0.100	0.112	0.106

3	0.144	0.136	0.131	0.137	0.135	0.1350	0.134	0.136	0.131	0.131	0.150	0.136
4	0.161	0.156	0.149	0.158	0.153	0.1500	0.147	0.155	0.149	0.142	0.178	0.148
5	0.170	0.166	0.164	0.174	0.156	0.1550	0.153	0.162	0.153	0.157	0.174	0.155
6	0.192	0.180	0.177	0.183	0.182	0.1740	0.165	0.177	0.162	0.167	0.176	0.157
7	0.202	0.191	0.184	0.199	0.196	0.1860	0.176	0.188	0.168	0.175	0.196	0.167
8	0.214	0.209	0.211	0.227	0.206	0.1895	0.173	0.197	0.190	0.180	0.202	0.171

	year
age	2016
1	0.054
2	0.102
3	0.126
4	0.143
5	0.159
6	0.161
7	0.167
8	0.177

Table 7.6.3.4 Irish Sea Herring. NATURAL MORTALITY

Units : NA

	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	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

	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	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

	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	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

	year
age	2016

1	0.787
2	0.380
3	0.353
4	0.335
5	0.315
6	0.311
7	0.304
8	0.304

Table 7.6.3.5 Irish Sea Herring. PROPORTION MATURE

Units : NA

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.20	0.19	0.10	0.02	0.00	0.14	0.31	0.00	0.00	0.07	0.06	0.04	0.28	0.00	0.19
2	0.88	0.89	0.80	0.73	0.69	0.62	0.73	0.85	0.90	0.63	0.66	0.30	0.48	0.46	0.68
3	0.95	0.90	0.89	0.88	0.83	0.71	0.66	0.91	0.96	0.93	0.90	0.74	0.72	0.99	0.99
4	0.95	0.94	0.91	0.90	0.93	0.88	0.81	0.87	0.99	0.95	0.95	0.82	0.81	1.00	0.97
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.10	0.02	0.04	0.30	0.02	0.14	0.15	0.02	0.11	0.114	0.20	0.19	0.16	0.16	0.13
2	0.86	0.60	0.82	0.83	0.84	0.79	0.54	0.92	0.76	1.000	0.97	0.89	0.94	0.84	0.82
3	0.94	0.96	0.95	0.97	0.95	0.99	0.88	0.95	0.95	0.970	0.99	1.00	0.98	1.00	0.97
4	0.99	0.83	1.00	0.99	0.97	1.00	0.97	0.98	0.97	1.000	1.00	1.00	1.00	1.00	0.98
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.00	1.00	1.00	1.00	1.00

age \ year	2010	2011	2012	2013	2014	2015	2016
1	0.11	0.08	0.10	0.06	0.16	0.11	0.07
2	0.92	0.90	0.84	0.82	0.94	0.87	0.81
3	1.00	1.00	1.00	0.99	1.00	1.00	0.99
4	0.98	1.00	1.00	1.00	1.00	1.00	1.00
5	0.97	1.00	1.00	1.00	1.00	1.00	1.00
6	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
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 7.6.3.6 Irish Sea Herring. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

age \ year	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
1	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
3	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
5	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
7	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

Table 7.6.3.7 Irish Sea Herring. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

	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
1	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

3	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
5	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
7	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

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	2016.0	0.7	0.8

Index type : number

AC(7.aN) - Index Values

Units : NA

age \ year	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

age \ year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	94330	374731	1316673	475675	371230	580602	1927032	369094	100023	299689
2	109938	96623	251276	452364	182643	561245	330180	191900	285238	193267
3	97111	15625	46570	114210	177813	117699	43855	160980	81601	127352
4	17023	9982	21101	39076	92741	120777	14978	51363	54347	29691
5	8029	530	20818	26370	32490	34325	21896	21643	41153	43057
6	810	369	1200	17063	15071	16759	6308	19285	13441	17342
7	607	478	718	4254	13940	4336	2715	12105	11132	7848
8	5804	469	556	599	6871	6453	1959	3128	6776	12481

age \ year	2015	2016
1	491894	131512
2	141854	449316
3	25153	257152
4	17018	110196
5	10340	32232
6	8954	18312
7	1890	8157
8	4342	7042

7.aNSpawn - Configuration

```
FLT05: SSB acoustic (Catch: Unknown) (Effort: Unknown)
      min       max plusgroup   minyear   maxyear    startf      endf
       NA        NA        NA      2007      2016        NA        NA
Index type : biomass

7.aNSpawn - Index Values

Units  :  NA
     year
age       2007     2008     2009     2010     2011     2012     2013     2014
  all 47582.61 41909.97 76786.97 91388.88 61907.54 52071.02 114044.2 28396.84
     year
age       2015     2016
  all 60328.27 74275.73
```

Table 7.6.3.9 Irish Sea Herring. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        1         8         8      1980      2016         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      2016         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:/Users/PJSchon/Documents/AESD/Irish Sea her-
ring/HAWG2017/SAM/sam15.exe
```

Table 7.6.3.11 Irish Sea Herring. FLR, R SOFTWARE VERSIONS

```
FLSAM.version                          1.0
FLCore.version                2.5.20150309
R.version      R version 3.2.0 (2015-04-16)
platform                   i386-w64-mingw32
run.date                2017-03-20 20:49:10
```

Table 7.6.3.12 Irish Sea Herring. STOCK SUMMARY

Year	Recruitment Age 1	Low	High	TSB	Low	High	SSB	Low	High	Fbar (Ages 4-6) f	Low f	High f	Landings tonnes	Landings SOP
1980	179872	106297	304372	34132	26024	44768	12220	8740	17085	0.3094	0.1970	0.4861	10613	1.0308
1981	225709	127771	398717	39616	28637	54806	14108	10143	19623	0.2846	0.1896	0.4272	4377	1.0999
1982	246718	143538	424067	47287	33318	67113	16228	10980	23985	0.2556	0.1741	0.3753	4855	1.0166
1983	218600	122370	390506	51741	36095	74168	18670	12558	27758	0.2402	0.1642	0.3514	3933	1.0165
1984	140225	84233	233435	48582	36548	64577	19697	13933	27844	0.2459	0.1747	0.3461	4066	1.0392
1985	167544	99795	281286	46677	37212	58549	16808	13275	21281	0.2732	0.2070	0.3607	9187	0.9802
1986	211082	127325	349935	47099	37598	58999	18654	14921	23320	0.2850	0.2203	0.3686	7440	1.0238
1987	308353	179077	530953	48728	38090	62336	16995	13253	21794	0.2960	0.2304	0.3801	5823	0.9632
1988	127644	75083	217000	45252	35714	57337	20513	15575	27016	0.3177	0.2449	0.4122	10172	0.9505
1989	165545	98794	277397	43045	33375	55516	16133	12223	21292	0.3096	0.2408	0.3979	4949	0.9966
1990	130614	79683	214099	39066	31336	48702	15204	11803	19584	0.3088	0.2418	0.3944	6312	0.9872
1991	76573	46818	125239	29378	24161	35721	10281	8090	13067	0.3040	0.2395	0.3859	4398	0.9994
1992	233281	143726	378638	31477	24634	40220	10171	8319	12435	0.3157	0.2514	0.3964	5270	0.9890
1993	64408	40218	103149	29882	24140	36989	10300	8306	12773	0.3186	0.2541	0.3995	4409	0.9869
1994	170587	104695	277950	30915	24484	39036	11268	9115	13928	0.3277	0.2617	0.4103	4828	0.9757
1995	120692	74469	195608	28481	23044	35202	10899	8729	13608	0.3344	0.2672	0.4186	5076	1.0007
1996	80178	49872	128900	23179	18941	28365	8398	6709	10512	0.3482	0.2783	0.4355	5301	0.9999
1997	117360	74462	184971	21950	17723	27183	7551	5968	9554	0.3770	0.2981	0.4768	6651	0.9996
1998	170416	106441	272844	26344	20529	33806	8937	7254	11010	0.3969	0.3060	0.5147	4905	0.9951
1999	69148	43019	111148	21571	17434	26690	8602	6731	10993	0.3813	0.2981	0.4876	4127	1.0001
2000	67914	40680	113380	18226	14660	22659	7980	6311	10091	0.3657	0.2878	0.4646	2002	0.9993
2001	91583	53356	157197	17192	12608	23443	5634	4109	7724	0.3972	0.3008	0.5244	5461	1.0004
2002	78826	49290	126061	17475	13412	22768	5923	4286	8185	0.3945	0.2912	0.5344	2393	0.9984
2003	147709	92484	235910	21779	16429	28871	5611	4289	7340	0.3970	0.2823	0.5582	2399	1.0010

2004	142344	88157	229836	22925	17610	29846	8452	6389	11182	0.3681	0.2639	0.5134	2531	0.9979
2005	160492	99467	258957	25413	19287	33484	9721	7269	13000	0.3505	0.2485	0.4942	4387	1.0062
2006	282095	174391	456318	34201	25399	46052	11118	8481	14575	0.3119	0.2257	0.4310	4402	1.0005
2007	436699	244056	781402	56670	38986	82376	17716	13130	23902	0.2584	0.1871	0.3570	4629	1.0012
2008	227294	128379	402424	52104	37669	72072	22270	15849	31293	0.2405	0.1719	0.3365	4895	1.0008
2009	304370	177887	520788	54666	39536	75586	22071	15705	31017	0.2255	0.1575	0.3229	4594	NA
2010	358613	217899	590197	58105	42983	78545	24101	17383	33414	0.2113	0.1456	0.3065	4894	0.9989
2011	211293	116500	383214	51896	38907	69221	25463	18777	34531	0.2031	0.1391	0.2967	5202	1.0014
2012	282660	171281	466464	51534	38910	68255	22811	16619	31310	0.1980	0.1351	0.2902	5693	0.9999
2013	182225	109204	304075	44712	34287	58307	21647	15899	29472	0.1843	0.1229	0.2764	4828	0.9982
2014	343176	192158	612880	58689	43076	79959	25311	18737	34191	0.1711	0.1102	0.2656	5083	0.9405
2015	349060	170639	714040	61084	42517	87759	24563	17621	34241	0.1744	0.1136	0.2679	4891	1.0001
2016	103777	27708	388680	46677	31728	68668	25874	17428	38414	0.1714	0.1090	0.2695	4327	0.9999

Table 7.6.3.13 Irish Sea Herring. ESTIMATED FISHING MORTALITY

Units : f

age	1980	1981	1982	1983	1984	1985
1	0.02504703	0.02432866	0.02331869	0.02208846	0.02182716	0.02215039
2	0.35736415	0.29452246	0.24424096	0.20758799	0.19032921	0.19897024
3	0.41265640	0.31812846	0.25640424	0.22208391	0.21842775	0.23957231
4	0.36776909	0.34476233	0.30056237	0.25530407	0.24472993	0.27179695
5	0.29428694	0.24835403	0.20746347	0.20441562	0.22521495	0.25874817
6	0.26609550	0.26056576	0.25890347	0.26093081	0.26761658	0.28921064
7	0.24654765	0.19305117	0.16230143	0.08518755	0.16128214	0.30355271
8	0.24654765	0.19305117	0.16230143	0.08518755	0.16128214	0.30355271

age	1986	1987	1988	1989	1990	1991	1992
1	0.02252792	0.02257753	0.02342621	0.02404327	0.0256580	0.02737295	0.02875913
2	0.20684201	0.20234118	0.20169472	0.20288824	0.2183622	0.23506340	0.25548285
3	0.24460760	0.24316866	0.24972374	0.23678564	0.2372360	0.24212528	0.25807630
4	0.27373357	0.27009001	0.28667675	0.27019807	0.2616886	0.25507440	0.26895801
5	0.27491316	0.29311214	0.31940353	0.30866461	0.3095301	0.30379565	0.31758811
6	0.30629702	0.32468493	0.34701058	0.34986777	0.3551909	0.35310140	0.36052283
7	0.37733194	0.47530908	0.71009963	0.58845195	0.5613953	0.42109366	0.30801709
8	0.37733194	0.47530908	0.71009963	0.58845195	0.5613953	0.42109366	0.30801709

age	1993	1994	1995	1996	1997	1998	1999
1	0.02890618	0.02996576	0.03189838	0.03364469	0.03382686	0.0321064	0.03075508
2	0.27144384	0.30694092	0.34280277	0.38461979	0.40506813	0.3598385	0.32219446
3	0.26825963	0.28722195	0.30297651	0.31515207	0.33460652	0.3296249	0.31145513
4	0.26564353	0.26930788	0.27535338	0.28779697	0.33051607	0.3565075	0.34500375
5	0.32614931	0.34160506	0.35130517	0.36944256	0.40278595	0.4262369	0.39382840
6	0.36407332	0.37224985	0.37657803	0.38718216	0.39775462	0.4078442	0.40498713
7	0.34211785	0.42811647	0.43218134	0.55597052	0.86800309	0.6832804	0.47150763
8	0.34211785	0.42811647	0.43218134	0.55597052	0.86800309	0.6832804	0.47150763

age	2000	2001	2002	2003	2004	2005
1	0.02916167	0.02778386	0.02593142	0.02657193	0.02895246	0.03135129
2	0.29682872	0.30780156	0.28071931	0.24446088	0.23100868	0.23487543
3	0.29617642	0.32242008	0.29656170	0.29369895	0.29792902	0.28407983
4	0.34920365	0.40648429	0.41144085	0.42014726	0.38397801	0.35711408
5	0.35840201	0.38570980	0.37232803	0.37402973	0.35879647	0.34829690
6	0.38942266	0.39933285	0.39962847	0.39683687	0.36153371	0.34597111
7	0.23699885	0.52889783	0.55789751	1.03085855	0.55828260	0.49345678
8	0.23699885	0.52889783	0.55789751	1.03085855	0.55828260	0.49345678

age	2006	2007	2008	2009	2010	2011
1	0.03255254	0.03395226	0.03429005	0.03381672	0.03334658	0.03264055
2	0.22496735	0.20335542	0.18598300	0.17999972	0.17283809	0.16564638
3	0.26046156	0.22060092	0.19706927	0.19006294	0.18088388	0.17433091
4	0.30077284	0.23309714	0.21022014	0.20183596	0.19355376	0.19361183
5	0.30928256	0.24875172	0.23305053	0.21610303	0.20032785	0.18667241
6	0.32562789	0.29346409	0.27823199	0.25864469	0.23995593	0.22912215
7	0.41961402	0.22523747	0.24253724	0.18310418	0.13451225	0.17559062

8	0.41961402	0.22523747	0.24253724	0.18310418	0.13451225	0.17559062

year					
age	2012	2013	2014	2015	2016
1	0.03126675	0.03118556	0.03111081	0.02922005	0.02930492
2	0.16261009	0.16170202	0.15565706	0.15167731	0.15104160
3	0.16863815	0.16010907	0.14468447	0.13088974	0.12052477
4	0.19495237	0.18330571	0.17271715	0.18199064	0.18052247
5	0.17608297	0.15590631	0.13484895	0.13021088	0.12501769
6	0.22295173	0.21378167	0.20562524	0.21102050	0.20854509
7	0.18411403	0.09505496	0.10689588	0.16062224	0.11068134
8	0.18411403	0.09505496	0.10689588	0.16062224	0.11068134

Table 7.6.3.14 Irish Sea Herring. ESTIMATED POPULATION ABUNDANCE

Units : NA

year						
age	1980	1981	1982	1983	1984	1985
1	179871.862	225708.585	246717.688	218600.250	140224.502	167543.785
2	46536.862	78354.603	99409.206	108988.756	99907.496	63513.007
3	27038.039	20108.542	39537.308	53637.300	62818.193	62193.141
4	25539.971	11162.330	9747.830	22092.644	32370.410	38599.708
5	4461.320	12272.300	5021.580	4901.517	13285.121	20601.105
6	3704.116	2233.891	6788.600	2939.221	2958.389	8436.308
7	1742.019	2032.659	1202.551	3813.871	1674.048	1776.144
8	1146.306	1637.785	2171.558	1919.078	3883.531	3514.315

year							
age	1986	1987	1988	1989	1990	1991	1992
1	211081.586	308352.843	127643.947	165545.275	130613.780	76573.014	233281.230
2	74682.420	93060.026	140224.502	56387.343	75357.595	57930.541	33590.548
3	35954.157	40134.837	52156.287	80177.644	32532.667	42277.064	31476.610
4	35846.457	19680.823	21896.892	27529.130	46536.862	18670.500	24173.203
5	21399.011	19906.468	11095.557	11013.753	14798.780	26635.495	11057.896
6	12328.883	12036.512	11123.330	5685.077	5726.730	7756.605	15212.915
7	4831.441	6958.366	6497.677	5519.265	2886.500	2816.358	4045.256
8	2963.718	4144.345	5461.616	4390.068	4022.263	2824.255	2599.567

year							
age	1993	1994	1995	1996	1997	1998	1999
1	64408.443	170586.879	120692.347	80177.644	117359.834	170416.377	69147.695
2	100408.285	29027.531	79062.978	52104.156	36206.719	50061.123	76956.838
3	17448.344	52997.499	14517.353	40741.398	23956.621	15521.788	24809.948
4	16936.054	9367.486	27861.470	7596.934	21735.453	11895.316	7660.251
5	13170.042	9348.769	5108.188	15322.843	4281.249	11572.652	5694.181
6	6113.165	6982.763	4848.865	2670.711	7741.107	2226.086	5457.794
7	8005.627	3241.528	3500.986	2507.647	1328.094	3871.510	1103.784
8	3606.886	6269.175	4641.069	3899.876	2677.664	1209.908	1904.548

year						
age	2000	2001	2002	2003	2004	2005
1	67914.171	91582.914	78826.144	147709.088	142343.7235	160492.1001
2	29971.434	30242.394	38948.674	35954.157	67171.2092	62442.4118
3	40497.681	15514.029	13886.883	19015.315	19401.3902	38948.6737
4	13095.187	22765.466	7605.295	6817.854	9516.6674	9779.0733
5	3987.023	6950.021	10829.184	3338.243	2976.1923	4435.0759

age						
6	2629.108	2174.165	3385.307	5280.098	1547.5062	1479.4120
7	2498.385	1308.583	1106.326	1562.121	2352.1851	778.8356
8	1316.721	2183.752	1464.399	1053.739	623.4073	1259.0340

age \ year	2006	2007	2008	2009	2010	2011
1	282095.2334	436699.2404	227294.088	304370.199	358613.326	211292.773
2	70403.6227	124866.4444	183322.101	97343.379	133920.283	156060.651
3	32532.6669	37646.6782	68528.158	100709.962	53316.440	72113.749
4	20520.9173	17266.0945	21305.063	39815.040	54393.503	29260.683
5	4451.0709	10832.4333	10312.376	12472.731	22359.353	29495.707
6	2069.3711	2363.5027	6449.127	5941.400	7082.626	12722.152
7	755.2131	1027.5165	1387.002	3528.754	3260.383	4007.008
8	874.8041	761.3552	1051.528	1443.751	2837.844	3664.694

age \ year	2012	2013	2014	2015	2016
1	282659.988	182225.462	343176.441	349060.312	103777.037
2	87640.632	127899.490	82125.184	147413.966	160331.688
3	88876.229	48098.198	72185.899	48825.110	87465.525
4	41522.885	50061.123	26003.853	42234.808	32112.479
5	17014.139	22925.383	28197.821	15244.895	24760.378
6	17096.003	9910.004	13007.742	17961.754	9795.712
7	7460.666	9500.503	5609.405	7697.108	10445.223
8	4525.123	6800.830	10316.502	9831.040	10525.961

Table 7.6.3.15 Irish Sea Herring. PREDICTED CATCH NUMBERS AT AGE

Units : NA

age \ year	1980	1981	1982	1983	1984	1985	1986
1	3083.81	3761.3	3942.89	3309.46	2098.19	2543.36	3259.34
2	11766.13	16792.37	18065.33	17101.99	14491.68	9588.5	11681.95
3	7796.65	4659.86	7590.1	9060.96	10451.07	11246.81	6620.59
4	6748.06	2792.41	2168.19	4261.22	6011.8	7867.61	7346.51
5	983.23	2330.22	811.42	781.53	2311.68	4056.4	4443.91
6	748.84	443.37	1339.73	584.09	601.09	1834.54	2817.68
7	330.3	309.23	156	269.14	215.89	404.08	1321.95
8	217.33	249.15	281.69	135.43	500.8	799.5	810.94

age \ year	1987	1988	1989	1990	1991	1992	1993
1	4772.66	2049.19	2726.52	2293.19	1433.91	4586.99	1272.69
2	14277.5	21447.86	8667.8	12385.6	10167.28	6353.43	20022.06
3	7354.52	9784.36	14345.33	5828.3	7710.67	6076.35	3486.35
4	3987.98	4674.51	5577.91	9172.18	3597.56	4882.98	3382.13
5	4371.58	2624.25	2529.2	3406.87	6032.34	2602.4	3171.15
6	2891.99	2828.21	1455.39	1484.99	2001.38	3994.49	1618.36
7	2297.23	2899.55	2148.34	1084.43	843.45	931.91	2017.47
8	1368.25	2437.31	1708.81	1511.1	845.87	598.88	909.01

age \ year	1994	1995	1996	1997	1998	1999	2000
1	3494.34	2629.61	1840.2	2708.63	3734.84	1452.8	1353.66
2	6446.29	19289.77	14011.31	10159.45	12733.99	17815.07	6464.36
3	11246.36	3225.52	9369.36	5796.1	3707.71	5646.44	8818.53

	year						
age	1980	1981	1982	1983	1984	1985	1986
4	1893.36	5744.57	1627.43	5246.31	3061.41	1917.49	3311.68
5	2341.39	1310.02	4099.05	1230.44	3483.59	1606.46	1039.89
6	1883.24	1320.43	744.24	2205.63	647.54	1578.66	736.16
7	983.96	1070.94	935.11	678.92	1681.01	362.04	457.25
8	1903.1	1419.85	1454.43	1369.18	525.38	624.79	241.04
	year						
age	2001	2002	2003	2004	2005	2006	2007
1	1739.48	1399.46	2686.54	2817.91	3435.99	6268.11	10109.79
2	6732.22	8001.55	6534.36	11613.34	10951.48	11887.71	19228.71
3	3636.73	3028.76	4112.39	4248.62	8182.15	6331.48	6321.93
4	6534.49	2204.93	2010.72	2605.92	2520.32	4567.77	3070.3
5	1927.41	2915.74	902.37	776.89	1128.98	1024.06	2060.02
6	621.57	968.48	1501.56	407.27	375.15	498.37	520.58
7	469.64	413.64	888.95	879.94	264.84	225.55	179.69
8	783.91	547.66	599.79	233.25	428.09	261.26	133.14
	year						
age	2008	2010	2011	2012	2013	2014	2015
1	5313.84	8158.37	4706.64	6038.13	3879.69	7288.4	6973.27
2	26040.28	17773.43	19915.43	11001.86	15970.68	9894.75	17338.76
3	10389.28	7472.76	9769.3	11675.87	6022.15	8231.55	5064.85
4	3452.38	8179.2	4401.94	6284.11	7159.1	3521.14	5999.91
5	1850.28	3499.27	4330.29	2367.33	2849.45	3061.59	1602.26
6	1356.21	1306.74	2252.01	2953.33	1648.45	2088.62	2952.54
7	259.21	355.01	558.9	1086.87	744.69	491.74	988.91
8	196.41	309.05	511.2	659.23	533.07	904.32	1263.08
	year						
age	2016						
1	2077.71						
2	18783.61						
3	8399.02						
4	4529.7						
5	2504.41						
6	1593.61						
7	946.39						
8	953.64						

Table 7.6.3.16 Irish Sea Herring. CATCH AT AGE RESIDUALS

Units : NA

	year						
age	1980	1981	1982	1983	1984	1985	1986
1	0.752343	0.347113	0.303177	-1.09638	-0.69016	-0.0542	0.377665
2	1.9766	-0.15526	-0.30152	-0.85985	-1.36843	0.118577	0.674983
3	2.3137	-0.94804	-0.73568	-1.21473	-0.92701	1.09149	0.301788
4	0.588157	-0.00217	-0.02125	-1.04132	-1.13004	1.32187	0.382672
5	1.68122	-0.03137	-2.16081	-1.35257	-0.0961	1.38007	0.045031
6	0.468154	-0.70924	-0.45177	-0.45145	-1.10136	0.884159	0.304083
7	0.206771	-0.15421	-0.25986	-0.12963	0.141645	1.20366	0.245126
8	0.136051	-0.08987	0.718998	-1.99552	-0.10688	-0.23825	0.188084
	year						

	year						
age	1980	1981	1982	1983	1984	1985	1986
age	1987	1988	1989	1990	1991	1992	1993
1	-0.89912	0.283645	-1.01093	0.010132	0.391436	1.14718	-0.7989
2	-0.24013	-0.02337	-0.77102	0.089902	-0.10468	0.202685	-0.79041
3	-0.45281	0.782501	-0.44213	-0.04466	-0.33827	0.262952	-0.37228
4	-0.71976	1.0752	-0.42768	0.14035	-0.60267	0.794222	-0.28817
5	-0.10764	1.35319	-0.71754	0.131101	-0.41834	0.538134	-0.21219
6	-0.09745	1.40848	-0.35579	0.269035	-0.70381	0.59713	-0.01841
7	0.031944	0.260694	-0.77011	-0.09585	-0.38341	0.254299	0.18719
8	0.480059	1.31441	0.32449	0.159703	-0.08931	-1.01784	-0.16686

	year						
age	1994	1995	1996	1997	1998	1999	2000
1	-0.67523	0.232762	1.25406	1.48473	-0.23134	0.259004	-0.12152
2	0.208595	0.253621	0.565003	1.87766	-0.17532	-0.12868	-1.37832
3	0.19806	0.126193	0.103298	0.670846	0.11131	0.126144	-1.02535
4	-0.09137	-0.21797	-0.85406	0.847435	0.943468	-0.51078	-1.19142
5	0.22	-0.21268	-0.30979	0.691521	1.56147	-0.2018	-1.49509
6	0.266225	-0.32356	0.112702	0.080698	1.11471	0.554928	-1.80637
7	0.627948	-0.34924	0.065612	0.511323	0.475433	0.490124	-1.44051
8	0.108437	0.053772	-0.15417	0.107741	-0.36662	-0.01074	-1.18774

	year						
age	2001	2002	2003	2004	2005	2006	2007
1	0.523665	-2.42285	-1.5947	0.158975	1.09346	-0.11836	0.820736
2	1.34471	0.302496	-0.83441	-0.6903	0.615876	0.628776	-0.12611
3	1.70561	-1.18421	-0.521	0.607227	0.642334	0.651693	-0.60184
4	1.74477	-0.421	0.608213	-0.47225	0.669946	0.818242	-1.55881
5	1.3533	-0.47251	-0.05484	-0.53018	0.554193	0.618774	-1.59126
6	0.983181	-0.03871	1.61779	-1.55673	0.242473	0.46565	-1.13149
7	0.780548	0.327134	-0.04625	-0.64391	0.23445	0.359817	-0.93004
8	0.057771	-1.16621	0.020771	-1.46007	-0.36327	-0.14456	-0.43672

	year						
age	2008	2010	2011	2012	2013	2014	2015
1	0.612781	0.19023	0.541697	-1.04316	0.002822	1.5592	-1.69525
2	-0.79846	-0.02087	-0.31206	-0.32706	0.426937	-0.08498	-0.2968
3	-0.82637	-0.28326	-0.21138	0.120467	0.319732	-0.09828	-0.11455
4	-0.6238	-0.69843	-0.2529	0.591241	-0.1933	-1.43059	0.520858
5	0.283378	-0.21473	-0.39669	0.617186	0.043061	-1.33099	0.016045
6	0.627283	-0.82979	-0.60435	0.160913	-0.2719	-1.85691	0.889471
7	0.565286	0.099305	0.506081	0.91519	-0.42082	-0.44248	1.26992
8	0.228311	-1.23239	-0.44353	-0.02648	-0.99677	-0.20596	-0.30597

	year
age	2016
1	0.075925
2	0.037373
3	-0.85182
4	0.080737
5	-0.48086
6	-0.27534
7	-0.13143
8	-0.54827

Table 7.6.3.18 Irish Sea Herring. PREDICTED INDEX AT AGE Fleet 1

Units : NA

age	1980	1981	1982	1983	1984	1985
1	3083.8065	3761.3003	3942.8930	3309.4590	2098.1893	2543.3566
2	11766.1260	16792.3718	18065.3316	17101.9881	14491.6804	9588.5025
3	7796.6544	4659.8568	7590.0997	9060.9568	10451.0737	11246.8121
4	6748.0577	2792.4092	2168.1943	4261.2167	6011.8031	7867.6131
5	983.2270	2330.2247	811.4234	781.5272	2311.6804	4056.3953
6	748.8360	443.3679	1339.7255	584.0929	601.0932	1834.5417
7	330.3029	309.2314	155.9975	269.1422	215.8859	404.0829
8	217.3328	249.1512	281.6880	135.4253	500.7966	799.5028

age	1986	1987	1988	1989	1990	1991	1992
1	3259.3400	4772.664	2049.190	2726.516	2293.192	1433.9096	4586.9931
2	11681.9477	14277.498	21447.857	8667.797	12385.603	10167.2800	6353.4293
3	6620.5915	7354.517	9784.355	14345.334	5828.296	7710.6672	6076.3532
4	7346.5052	3987.980	4674.512	5577.913	9172.178	3597.5560	4882.9753
5	4443.9105	4371.581	2624.249	2529.204	3406.873	6032.3383	2602.4016
6	2817.6825	2891.990	2828.212	1455.391	1484.985	2001.3756	3994.4852
7	1321.9458	2297.232	2899.548	2148.338	1084.430	843.4495	931.9135
8	810.9367	1368.253	2437.309	1708.806	1511.095	845.8737	598.8793

age	1993	1994	1995	1996	1997	1998	1999
1	1272.6925	3494.3407	2629.608	1840.2008	2708.6347	3734.8390	1452.8029
2	20022.0611	6446.2897	19289.766	14011.3080	10159.4542	12733.9890	17815.0699
3	3486.3478	11246.3623	3225.522	9369.3593	5796.0968	3707.7111	5646.4370
4	3382.1267	1893.3632	5744.568	1627.4343	5246.3087	3061.4073	1917.4856
5	3171.1513	2341.3899	1310.023	4099.0479	1230.4436	3483.5947	1606.4628
6	1618.3623	1883.2419	1320.426	744.2448	2205.6334	647.5396	1578.6574
7	2017.4709	983.9647	1070.938	935.1061	678.9178	1681.0099	362.0383
8	909.0135	1903.1011	1419.855	1454.4309	1369.1837	525.3790	624.7865

age	2000	2001	2002	2003	2004	2005	2006
1	1353.6636	1739.4774	1399.4576	2686.5416	2817.9079	3435.9887	6268.1090
2	6464.3646	6732.2184	8001.5456	6534.3620	11613.3433	10951.4812	11887.7056
3	8818.5259	3636.7293	3028.7643	4112.3915	4248.6221	8182.1481	6331.4845
4	3311.6770	6534.4927	2204.9277	2010.7237	2605.9172	2520.3171	4567.7682
5	1039.8898	1927.4054	2915.7431	902.3748	776.8910	1128.9802	1024.0596
6	736.1619	621.5709	968.4821	1501.5602	407.2674	375.1478	498.3736
7	457.2544	469.6417	413.6416	888.9491	879.9367	264.8437	225.5473
8	241.0441	783.9145	547.6629	599.7902	233.2521	428.0928	261.2610

age	2007	2008	2010	2011	2012	2013	2014
1	10109.7946	5313.8399	8158.373	4706.6421	6038.1322	3879.6879	7288.4049
2	19228.7147	26040.2839	17773.431	19915.4283	11001.8641	15970.6829	9894.7540
3	6321.9311	10389.2822	7472.762	9769.2991	11675.8747	6022.1523	8231.5532
4	3070.2983	3452.3830	8179.203	4401.9372	6284.1131	7159.1032	3521.1397
5	2060.0180	1850.2758	3499.271	4330.2909	2367.3347	2849.4464	3061.5910
6	520.5833	1356.2109	1306.739	2252.0135	2953.3341	1648.4488	2088.6224
7	179.6948	259.2104	355.015	558.8997	1086.8730	744.6915	491.7399
8	133.1358	196.4131	309.046	511.1995	659.2284	533.0739	904.3170

age	2015	2016
1	6973.2732	2077.7067
2	17338.7646	18783.6108
3	5064.8510	8399.0174
4	5999.9115	4529.6955
5	1602.2593	2504.4139
6	2952.5368	1593.6145
7	988.9067	946.3950
8	1263.0819	953.6436

Table 7.6.3.19 Irish Sea Herring. INDEX AT AGE RESIDUALS Fleet 1

Units : NA

age	1980	1981	1982	1983	1984	1985	1986
1	0.752343	0.3471130	0.3031770	-1.096380	-0.6901550	-0.0541972	0.3776650
2	1.976600	-0.1552560	-0.3015160	-0.859845	-1.3684300	0.1185770	0.6749830
3	2.313700	-0.9480430	-0.7356840	-1.214730	-0.9270140	1.0914900	0.3017880
4	0.588157	-0.0021658	-0.0212464	-1.041320	-1.1300400	1.3218700	0.3826720
5	1.681220	-0.0313673	-2.1608100	-1.352570	-0.0961044	1.3800700	0.0450313
6	0.468154	-0.7092400	-0.4517670	-0.451454	-1.1013600	0.8841590	0.3040830
7	0.206771	-0.1542050	-0.2598560	-0.129628	0.1416450	1.2036600	0.2451260
8	0.136051	-0.0898699	0.7189980	-1.995520	-0.1068760	-0.2382530	0.1880840

age	1987	1988	1989	1990	1991	1992	1993
1	-0.8991220	0.2836450	-1.010930	0.0101318	0.3914360	1.147180	-0.7989010
2	-0.2401270	-0.0233737	-0.771023	0.0899018	-0.1046800	0.202685	-0.7904110
3	-0.4528060	0.7825010	-0.442134	-0.0446633	-0.3382700	0.262952	-0.3722760
4	-0.7197640	1.0752000	-0.427684	0.1403500	-0.6026670	0.794222	-0.2881730
5	-0.1076350	1.3531900	-0.717537	0.1311010	-0.4183370	0.538134	-0.2121880
6	-0.0974530	1.4084800	-0.355785	0.2690350	-0.7038120	0.597130	-0.0184091
7	0.0319438	0.2606940	-0.770105	-0.0958481	-0.3834100	0.254299	0.1871900
8	0.4800590	1.3144100	0.324490	0.1597030	-0.0893096	-1.017840	-0.1668630

age	1994	1995	1996	1997	1998	1999	2000
1	-0.6752260	0.2327620	1.2540600	1.4847300	-0.231338	0.2590040	-0.12152
2	0.2085950	0.2536210	0.5650030	1.8776600	-0.175322	-0.1286810	-1.37832
3	0.1980600	0.1261930	0.1032980	0.6708460	0.111310	0.1261440	-1.02535
4	-0.0913749	-0.2179720	-0.8540630	0.8474350	0.943468	-0.5107780	-1.19142
5	0.2200000	-0.2126780	-0.3097850	0.6915210	1.561470	-0.2017990	-1.49509
6	0.2662250	-0.3235600	0.1127020	0.0806978	1.114710	0.5549280	-1.80637
7	0.6279480	-0.3492390	0.0656116	0.5113230	0.475433	0.4901240	-1.44051
8	0.1084370	0.0537724	-0.1541690	0.1077410	-0.366622	-0.0107369	-1.18774

age	2001	2002	2003	2004	2005	2006	2007
1	0.523665	-2.4228500	-1.5947000	0.158975	1.093460	-0.118364	0.820736
2	1.344710	0.3024960	-0.8344130	-0.690301	0.615876	0.628776	-0.126112
3	1.705610	-1.1842100	-0.5209960	0.607227	0.642334	0.651693	-0.601842
4	1.744770	-0.4210010	0.6082130	-0.472250	0.669946	0.818242	-1.558810
5	1.353300	-0.4725130	-0.0548398	-0.530183	0.554193	0.618774	-1.591260
6	0.983181	-0.0387138	1.6177900	-1.556730	0.242473	0.465650	-1.131490

age							
7	0.780548	0.3271340	-0.0462451	-0.643909	0.234450	0.359817	-0.930040
8	0.057771	-1.1662100	0.0207709	-1.460070	-0.363270	-0.144560	-0.436721

age \ year	2008	2010	2011	2012	2013	2014	2015
1	0.612781	0.1902300	0.541697	-1.0431600	0.00282223	1.5592000	-1.6952500
2	-0.798455	-0.0208728	-0.312061	-0.3270580	0.42693700	-0.0849817	-0.2968040
3	-0.826370	-0.2832570	-0.211375	0.1204670	0.31973200	-0.0982751	-0.1145450
4	-0.623803	-0.6984260	-0.252900	0.5912410	-0.19329900	-1.4305900	0.5208580
5	0.283378	-0.2147320	-0.396691	0.6171860	0.04306120	-1.3309900	0.0160454
6	0.627283	-0.8297860	-0.604350	0.1609130	-0.27189800	-1.8569100	0.8894710
7	0.565286	0.0993052	0.506081	0.9151900	-0.42081700	-0.4424760	1.2699200
8	0.228311	-1.2323900	-0.443531	-0.0264782	-0.99676900	-0.2059630	-0.3059680

age \ year	2016
1	0.0759251
2	0.0373730
3	-0.8518230
4	0.0807367
5	-0.4808630
6	-0.2753350
7	-0.1314250
8	-0.5482690

Table 7.6.3.20 Irish Sea Herring. PREDICTED INDEX AT AGE Fleet 2

Units : NA

age \ year	1994	1995	1996	1997	1998	1999
1	237304.641	167644.342	111168.239	162754.7914	236570.136	96105.325
2	51565.081	136639.316	87316.960	59730.6161	85476.777	135103.982
3	66058.765	17877.353	49741.755	28807.7579	18735.211	30363.606
4	10541.762	31225.801	8431.669	23362.7932	12538.761	8143.945
5	10116.368	5487.181	16236.710	4424.8427	11752.603	5924.787
6	7406.328	5126.405	2801.135	8054.5304	2299.024	5649.374
7	3314.825	3569.390	2329.805	976.3001	3269.525	1092.692
8	6411.253	4732.316	3623.697	1968.9191	1021.850	1885.711

age \ year	2000	2001	2002	2003	2004	2005
1	94485.343	127490.866	109963.085	205972.9235	198114.4157	222904.7881
2	53631.937	53685.595	70537.517	66882.9931	126310.6970	117008.2823
3	50096.178	18827.428	17181.354	23576.3649	23982.9874	48639.9262
4	13878.831	23111.833	7692.722	6850.9321	9825.1431	10302.8929
5	4260.151	7275.880	11448.569	3525.0856	3178.5170	4773.4281
6	2752.817	2259.661	3517.761	5496.7924	1654.2946	1599.7938
7	2948.819	1240.736	1026.428	1016.2148	2180.5229	758.0732
8	1554.470	2071.007	1358.994	685.6519	578.0093	1225.3478

age \ year	2006	2007	2008	2009	2010	2011
1	391523.1797	605191.3694	314896.723	422143.254	497325.490	293167.677
2	132999.4138	239545.8217	356539.389	190041.928	262892.373	307983.041
3	41348.8546	49325.6742	91381.653	134928.461	71948.078	97772.634
4	22554.7282	19963.6820	25059.293	47103.378	64796.055	34856.677

5	4934.2699	12567.0049	12104.348	14826.628	26887.049	35846.457
6	2272.1914	2659.2782	7340.263	6861.422	8294.683	15017.929
7	776.7977	1222.7284	1629.975	4336.401	4154.220	4949.936
8	899.7977	905.9191	1235.079	1773.837	3616.348	4527.477

year

age	2012	2013	2014	2015	2016
1	392817.340	253064.582	476536.691	485726.02	144307.25
2	173494.296	253317.773	163325.431	294048.50	319975.59
3	121006.555	65907.004	100137.548	68377.56	123525.14
4	49399.718	60060.040	31448.294	50721.24	38622.88
5	20839.385	28495.458	35614.210	19328.58	31514.40
6	20274.921	11834.686	15626.446	21489.94	11745.55
7	9157.331	12465.873	7295.332	9613.08	13543.61
8	5554.257	8923.469	13416.358	12278.32	13647.34

Table 7.6.3.21 Irish Sea Herring. INDEX AT AGE RESIDUALS Fleet 2

Units : NA

year

age	1994	1995	1996	1997	1998	1999	2000
1	-1.3859400	0.703991	-2.4966500	-0.2113970	-0.833154	0.542070	-0.202368
2	0.4494620	-0.811929	-1.1567700	-0.2852020	-1.825410	-0.884669	1.050870
3	0.1713450	-0.646460	0.4878620	-1.0642700	-1.344950	0.181746	1.188360
4	0.1885140	-0.104749	0.0961634	-1.2073400	-0.483931	-0.746300	1.096550
5	-0.1347900	-0.291220	0.7818730	-1.4831900	-0.952760	0.878530	1.022500
6	0.0240815	-0.478328	0.4989880	-0.7149600	-0.322101	1.093780	0.851866
7	0.1931100	0.393781	1.1668900	-0.6722630	-0.466165	0.466954	0.636222
8	0.5718500	0.471553	0.5927550	-0.0380738	-0.338495	1.509630	0.522762

year

age	2001	2002	2003	2004	2005	2006	2007
1	1.2160000	1.3874100	0.5774080	0.214327	-0.940588	-0.0479686	0.8501810
2	0.8860320	0.0313177	1.9050200	-0.142691	-0.099759	-0.5111430	0.0765446
3	-0.9815630	0.9799810	0.4880010	0.336302	1.106200	-1.5569100	-0.0920281
4	-0.4460330	1.8730600	-0.5910160	0.718831	0.803373	-1.3041500	0.0886467
5	0.0914801	1.6079300	0.1702990	-0.688472	0.831948	-3.5695200	0.8075420
6	-0.6253390	1.8033200	-0.3708200	0.412466	-0.853013	-2.2781900	-0.9973120
7	-0.8574140	1.2379100	-0.0493188	-2.776190	-0.278553	-0.6085750	-0.6672410
8	0.1111220	1.4897500	0.3492610	-1.101610	1.949330	-0.8166320	-0.6118520

year

age	2008	2009	2010	2011	2012	2013	2014
1	0.451130	-0.1405340	0.1693470	2.059420	-0.0681443	-1.015210	-0.5073070
2	0.380916	-0.0635223	1.2134600	0.111287	0.1613910	0.189956	0.2693070
3	0.356848	0.4415460	0.7875110	-1.282810	0.4566100	0.341799	0.3846410
4	0.710780	1.0839200	0.9963140	-1.351400	0.0623725	-0.159969	-0.0920135
5	1.245790	1.2551300	0.3908060	-0.788729	0.0605387	0.588096	0.3036630
6	1.057240	0.9861930	0.8814940	-1.087170	-0.0627443	0.159513	0.1305600
7	1.202320	1.4635300	0.0536716	-0.752728	0.3497560	-0.141844	0.0915191
8	-0.906944	1.6972100	0.7257820	-1.049950	-0.7196280	-0.345042	-0.0905707

year

age	2015	2016
1	0.0137607	-0.1015170
2	-1.1663000	0.5431340

```
  3 -1.6000600  1.1731400
  4 -1.7471700  1.6773500
  5 -1.0008400  0.0360739
  6 -1.0972700  0.5565860
  7 -2.0385900 -0.6354910
  8 -1.3028300 -0.8292650
```

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     2014
  8 17715.23 22274.55 22074.98 24091.15 25471.11 22797.36 21643.27 25306.08
   year
age     2015    2016
  8 24570.46 25866.4
```

Table 7.6.3.23 Irish Sea Herring. INDEX AT AGE RESIDUALS Fleet 3

```
Units  :  NA
   year
age    2007     2008    2009    2010    2011   2012    2013     2014    2015
  8 1.56224 0.999425 1.97106 2.10816 1.40418 1.3059 2.62769 0.182137 1.42033
   year
age   2016
  8 1.6679
```

Table 7.6.3.25 Irish Sea Herring. FIT PARAMETERS

```
           name    value  std.dev
1       logFpar  0.94239 0.213210
2       logFpar  1.08950 0.160730
3       logFpar  0.70014 0.162250
4       logFpar  0.57126 0.140840
5  logSdLogFsta -1.71590 0.447290
6  logSdLogFsta -1.65980 0.330400
7  logSdLogFsta -2.05960 0.503630
8  logSdLogFsta -0.66997 0.227270
9     logSdLogN -1.94560 0.570630
10  logSdLogObs -0.16396 0.143870
11  logSdLogObs -0.92524 0.128960
12  logSdLogObs -0.87618 0.108830
13  logSdLogObs -0.08958 0.160920
14  logSdLogObs -0.46995 0.080642
15  logSdLogObs -0.22486 0.101690
```

Table 7.6.3.26 Irish Sea Herring. NEGATIVE LOG-LIKELIHOOD

```
487.441
```

Table 7.7.1. Herring in Division 7.a North (Irish Sea). Input data for short-term forecast.

2017								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	252045.2	0.787	0.113333	0.9	0.75	0.064333	0.029879	0.063333
2	45875.89	0.38	0.873333	0.9	0.75	0.106667	0.152792	0.106
3	94273.78	0.353	0.996667	0.9	0.75	0.137333	0.132033	0.136
4	54473.81	0.335	1	0.9	0.75	0.156333	0.17841	0.156
5	19177.2	0.315	1	0.9	0.75	0.162667	0.130026	0.162667
6	15946.3	0.311	1	0.9	0.75	0.164667	0.208397	0.164667
7	5826.402	0.304	1	0.9	0.75	0.176667	0.126066	0.176667
8	13852.53	0.304	1	0.9	0.75	0.183333	0.126066	0.182
2018								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	252045.2	0.787	0.113333	0.9	0.75	0.064333	0.029879	0.063333
2	-	0.38	0.873333	0.9	0.75	0.106667	0.152792	0.106
3	-	0.353	0.996667	0.9	0.75	0.137333	0.132033	0.136
4	-	0.335	1	0.9	0.75	0.156333	0.17841	0.156
5	-	0.315	1	0.9	0.75	0.162667	0.130026	0.162667
6	-	0.311	1	0.9	0.75	0.164667	0.208397	0.164667
7	-	0.304	1	0.9	0.75	0.176667	0.126066	0.176667
8	-	0.304	1	0.9	0.75	0.183333	0.126066	0.182
2019								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	252045.2	0.787	0.113333	0.9	0.75	0.064333	0.029879	0.063333
2	-	0.38	0.873333	0.9	0.75	0.106667	0.152792	0.106
3	-	0.353	0.996667	0.9	0.75	0.137333	0.132033	0.136
4	-	0.335	1	0.9	0.75	0.156333	0.17841	0.156
5	-	0.315	1	0.9	0.75	0.162667	0.130026	0.162667
6	-	0.311	1	0.9	0.75	0.164667	0.208397	0.164667
7	-	0.304	1	0.9	0.75	0.176667	0.126066	0.176667
8	-	0.304	1	0.9	0.75	0.183333	0.126066	0.182

Table 7.7.2. Herring in Division 7.a North (Irish Sea). Management options table.

Rationale	Fbar (2017)	Catch (2017)	SSB (2017)	Fbar (2018)	Catch (2018)	SSB (2018)	SSB (2019)
1	0.155337	4127	24997.93	0	0	28001.58	27854.17
1	0.155337	4127	24997.93	0.1	2815.662	25903.26	26035.26
1	0.155337	4127	24997.93	0.2	5412.693	23969.47	24366.61
1	0.155337	4127	24997.93	0.3	7809.786	22186.97	22834.99
1	0.155337	4127	24997.93	0.4	10023.97	20543.59	21428.37
1	0.155337	4127	24997.93	0.5	12070.74	19028.16	20135.8
1	0.155337	4127	24997.93	0.6	13964.26	17630.44	18947.34
1	0.155337	4127	24997.93	0.7	15717.4	16341.03	17853.92
1	0.155337	4127	24997.93	0.8	17341.92	15151.28	16847.3
1	0.155337	4127	24997.93	0.9	18848.53	14053.27	15919.98
1	0.155337	4127	24997.93	1	20247.03	13039.7	15065.12
1	0.155337	4127	24997.93	1.1	21546.32	12103.9	14276.51
1	0.155337	4127	24997.93	1.2	22754.57	11239.69	13548.47
1	0.155337	4127	24997.93	1.3	23879.21	10441.44	12875.83
1	0.155337	4127	24997.93	1.4	24927.04	9703.951	12253.9
1	0.155337	4127	24997.93	1.5	25904.28	9022.442	11678.37
1	0.155337	4127	24997.93	1.6	26816.6	8392.525	11145.34
1	0.155337	4127	24997.93	1.7	27669.19	7810.161	10651.24
1	0.155337	4127	24997.93	1.8	28466.8	7271.636	10192.81
1	0.155337	4127	24997.93	1.9	29213.77	6773.533	9767.079
1	0.155337	4127	24997.93	2	29914.09	6312.706	9371.344

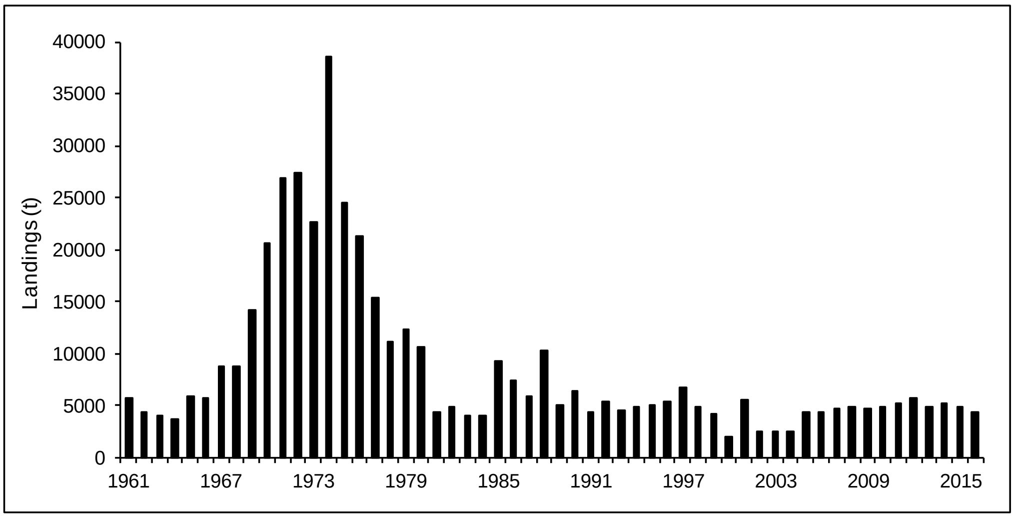


Figure 7.1.1. Herring in Division 7.a North (Irish Sea). Landings of herring from 7.a(N) from 1961 to 2016.

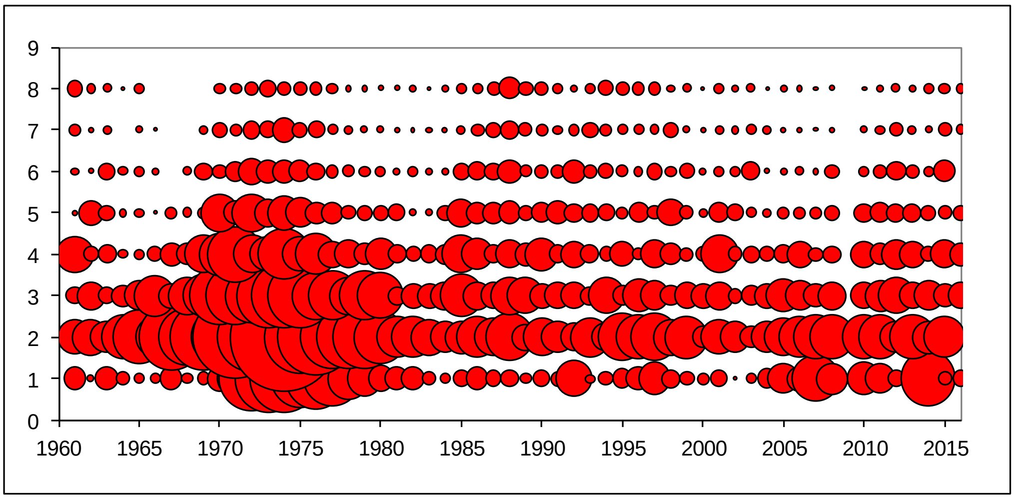


Figure 7.2.1. Herring in Division 7.a North (Irish Sea). Landings (catch-at-age) of herring from 7.a(N) from 1961 to 2016. No 2009 commercial samples.

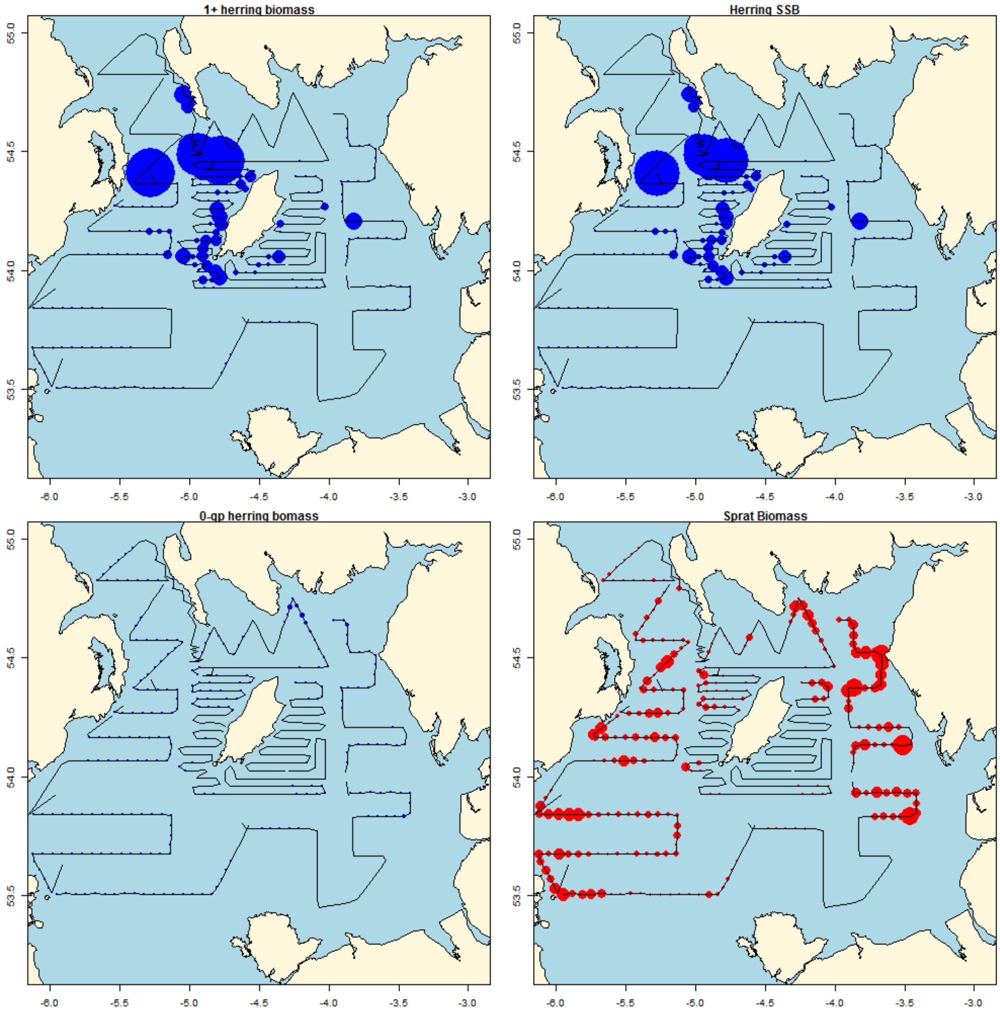


Figure 7.3.1. Herring in Division 7.a North (Irish Sea). Density distribution of 1-ring and older herring (top left panel) for the 2016 acoustic survey; SSB (top right panel); 0-ring herring (bottom left panel) and sprat biomass (bottom right panel). Note: size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval and the same scaling is used for all figures.

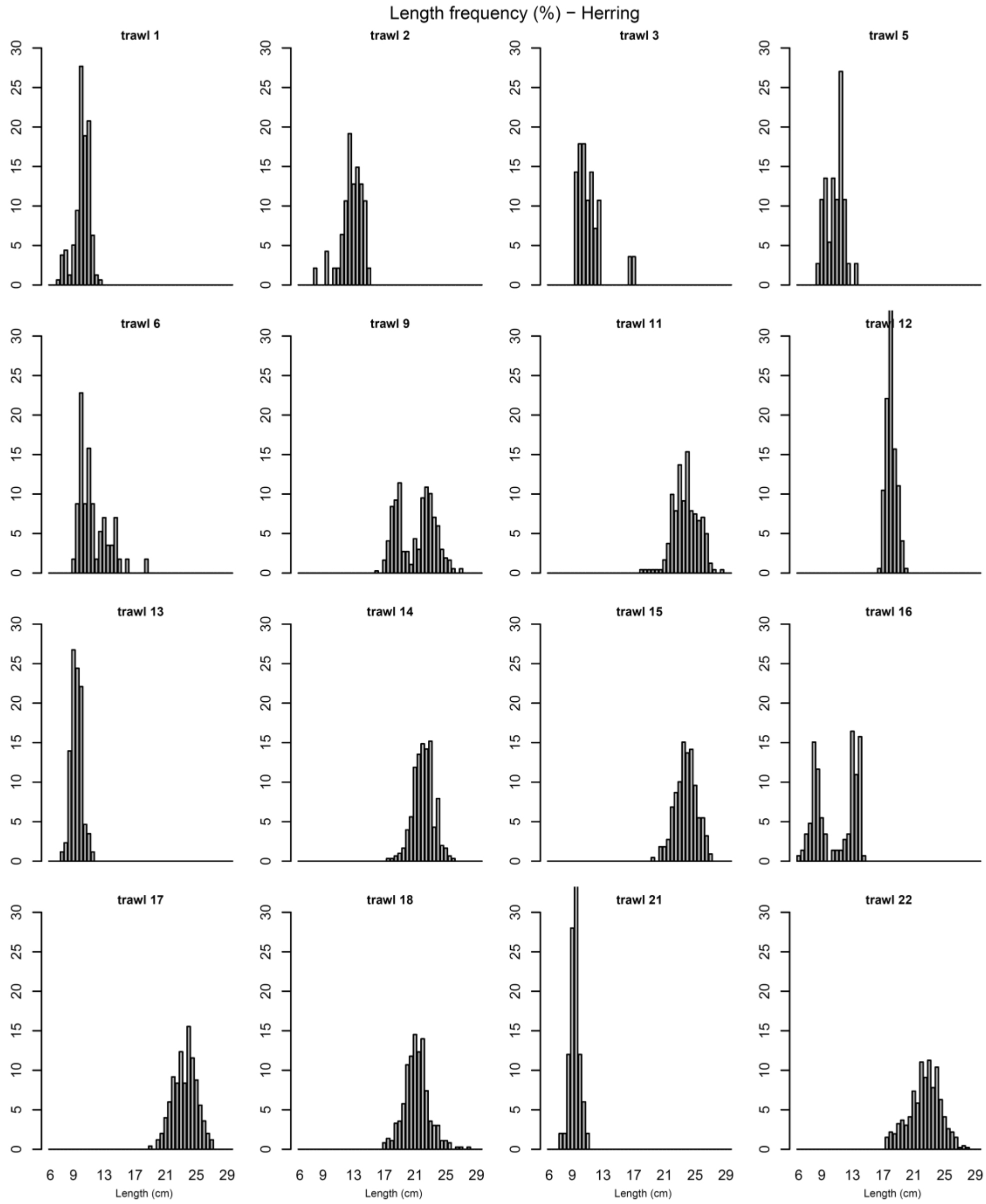


Figure 7.3.2. Herring in Division 7.a North (Irish Sea). Percentage length compositions of herring in each trawl sample in the September 2016 acoustic survey.

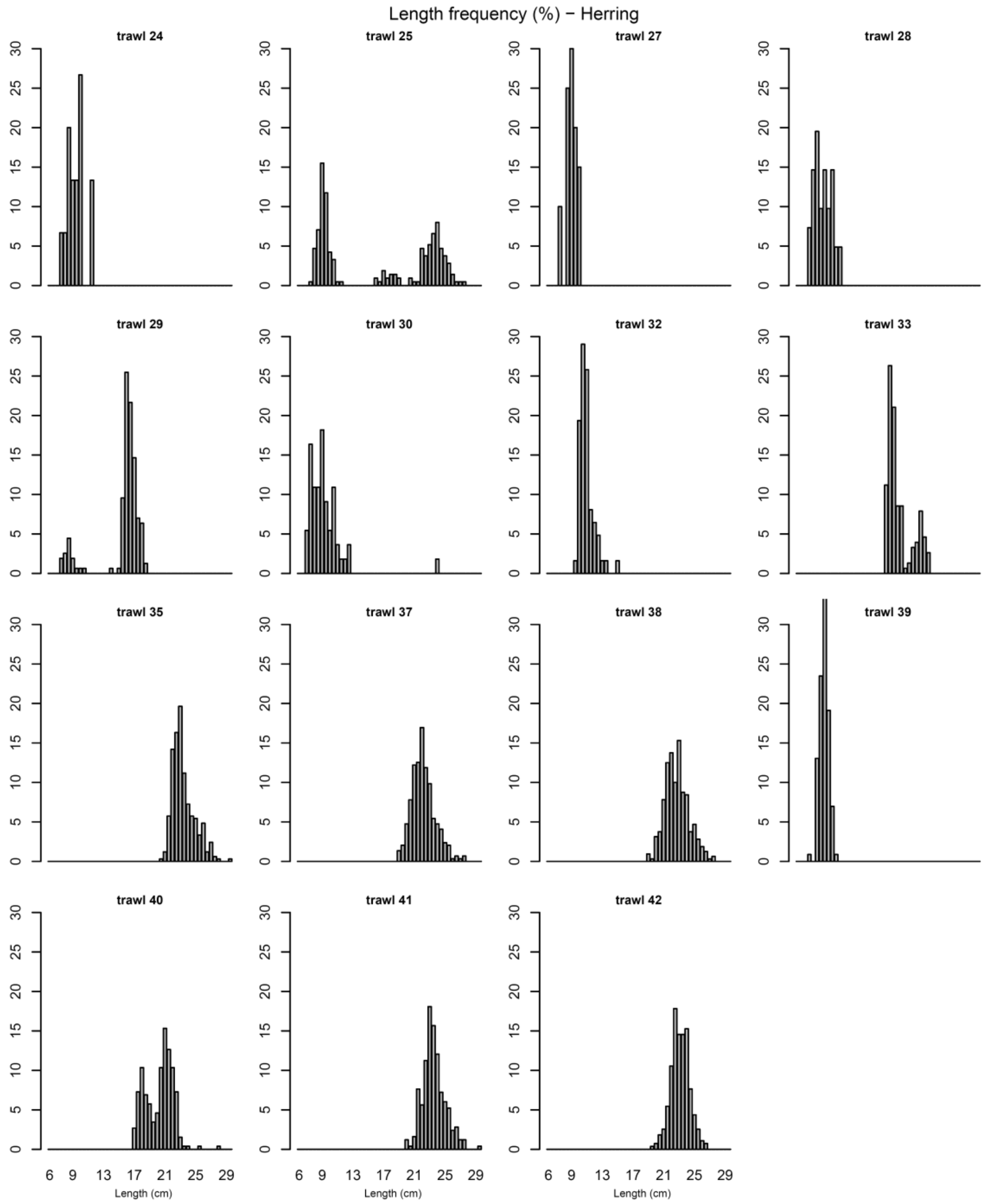


Figure 7.3.2. Herring in Division 7.a North (Irish Sea). Percentage length compositions of herring in each trawl sample in the September 2016 acoustic survey.

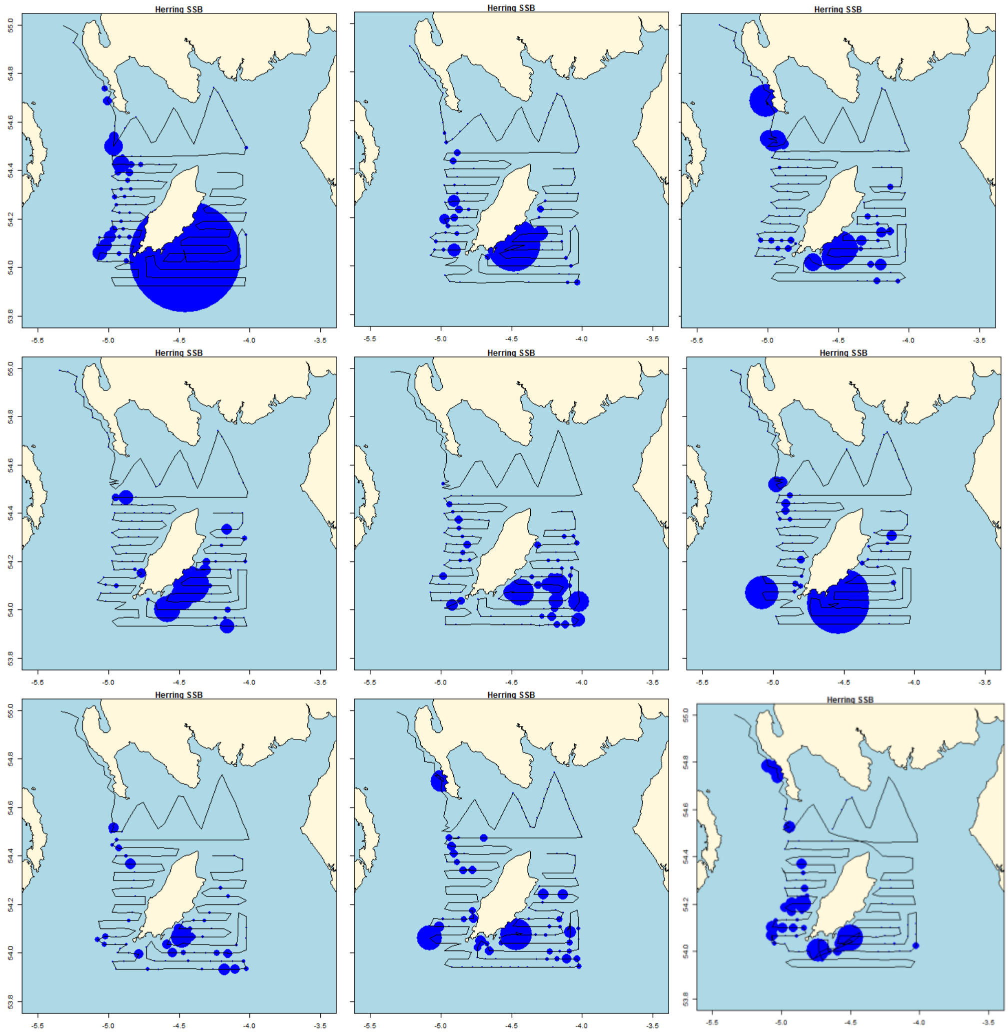


Figure 7.3.3. Herring in Division 7.a North (Irish Sea). Time-series of density distribution plots for the 7.aNSpawn survey (2008–2016) (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval).

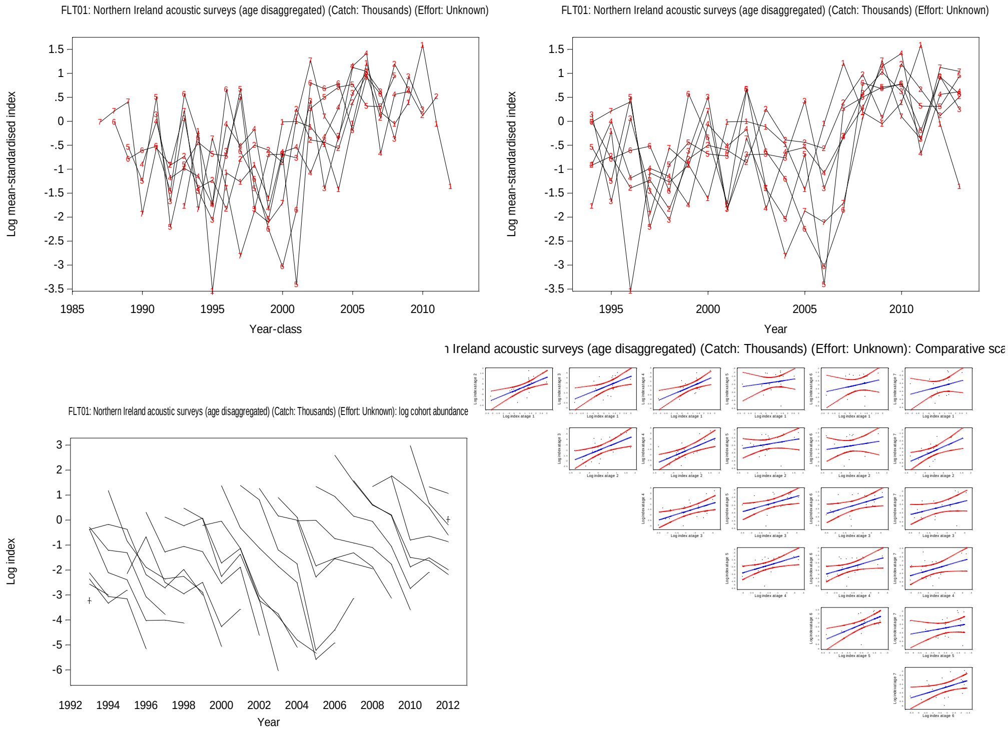


Figure 7.3.4. Herring in Division 7.a North (Irish Sea). Acoustic survey (AC(7.aN)) log mean-standardised indices by year and age class, scatter plots and catch curves.

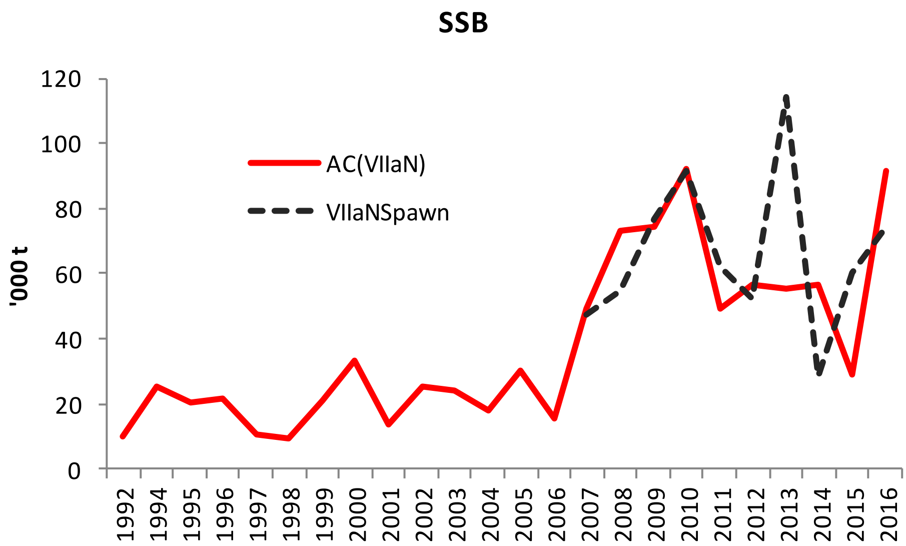


Figure 7.3.5. Herring in Division 7.a North (Irish Sea). Comparison of SSB indices from the acoustic survey estimates of SSB (red line) and the later survey 7.aNSpawn (dotted line).

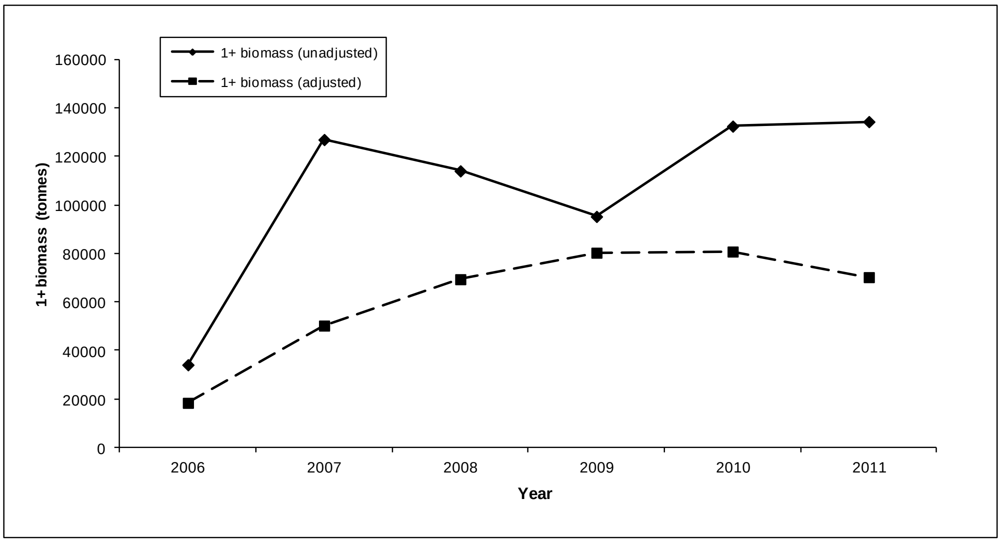


Figure 7.3.6. Herring in Division 7.a North (Irish Sea). Comparison of 1-ringer+ biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted datasets.

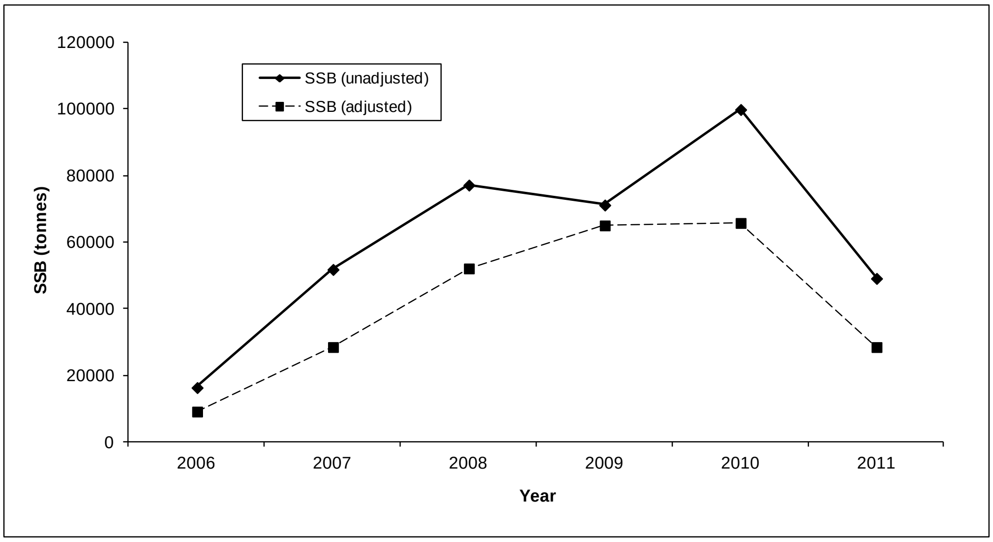


Figure 7.3.7. Herring in Division 7.a North (Irish Sea). Comparison of SSB biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted datasets.

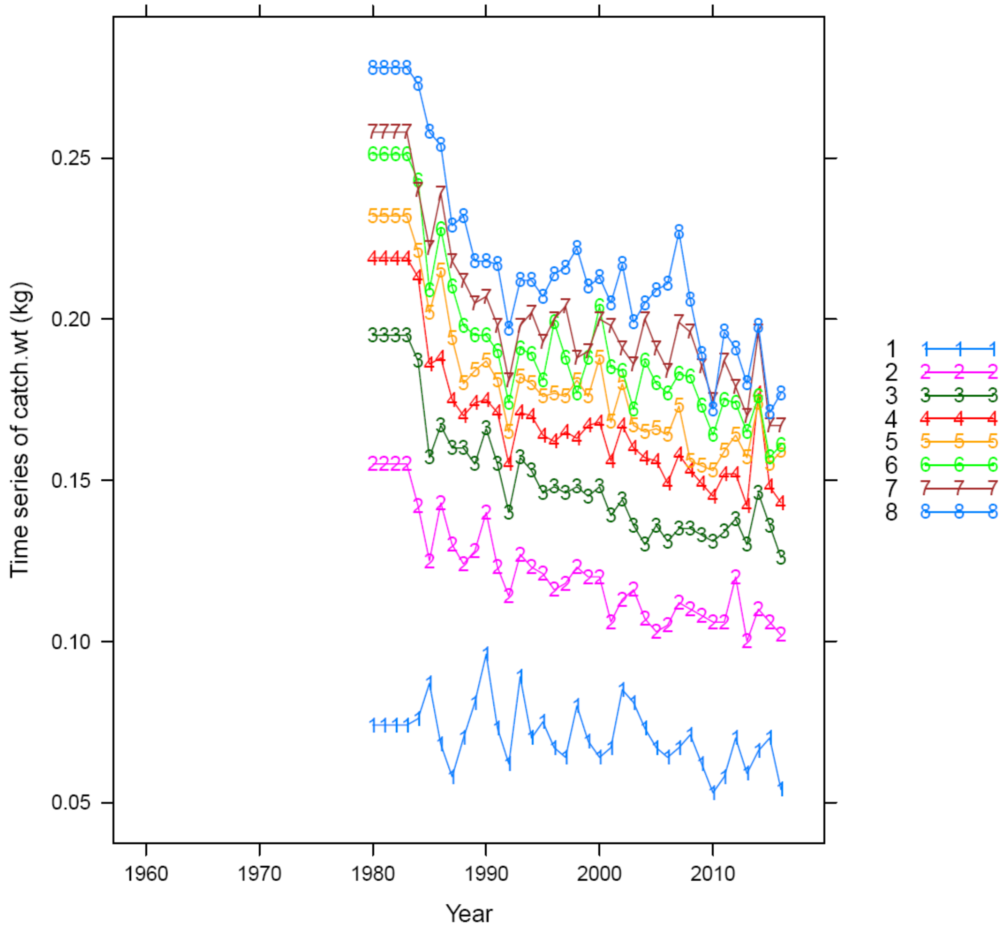


Figure 7.4.1. Herring in Division 7.a North (Irish Sea). Time-series of catch weights-at-age.

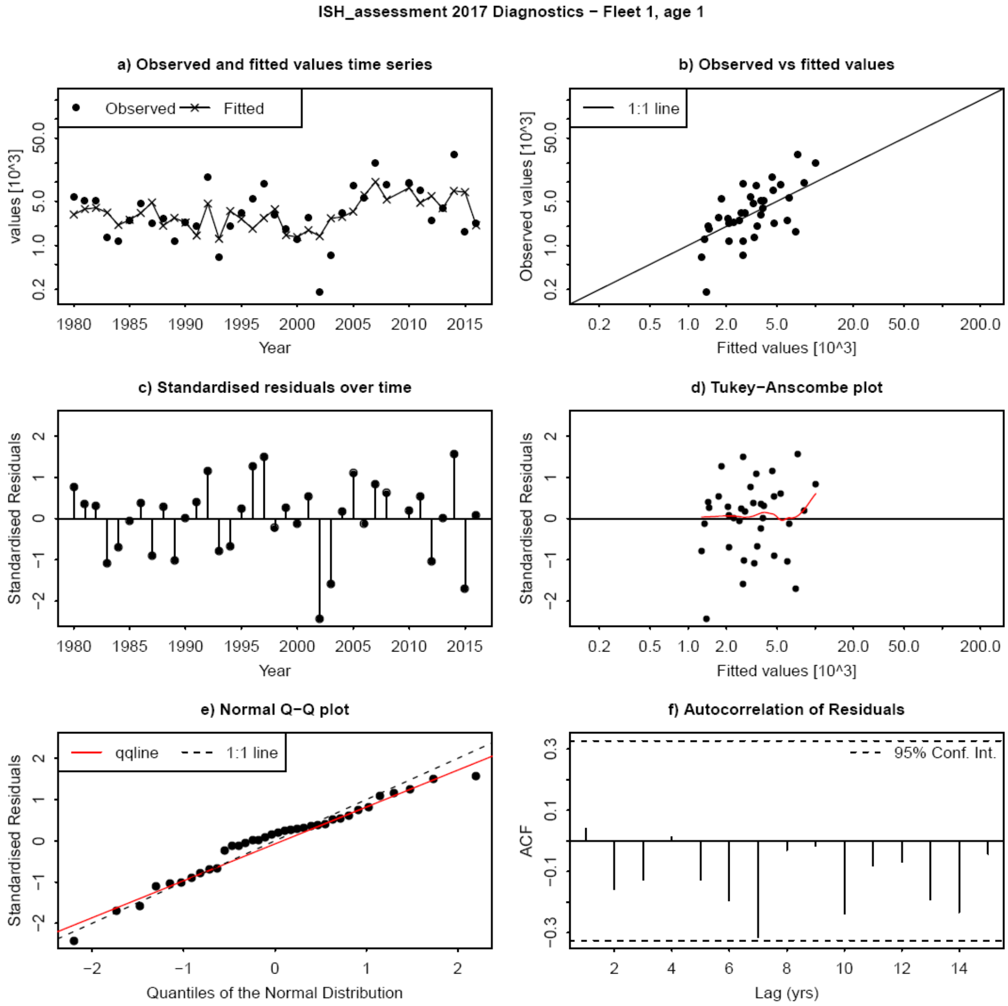


Figure 7.6.1. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age 1.

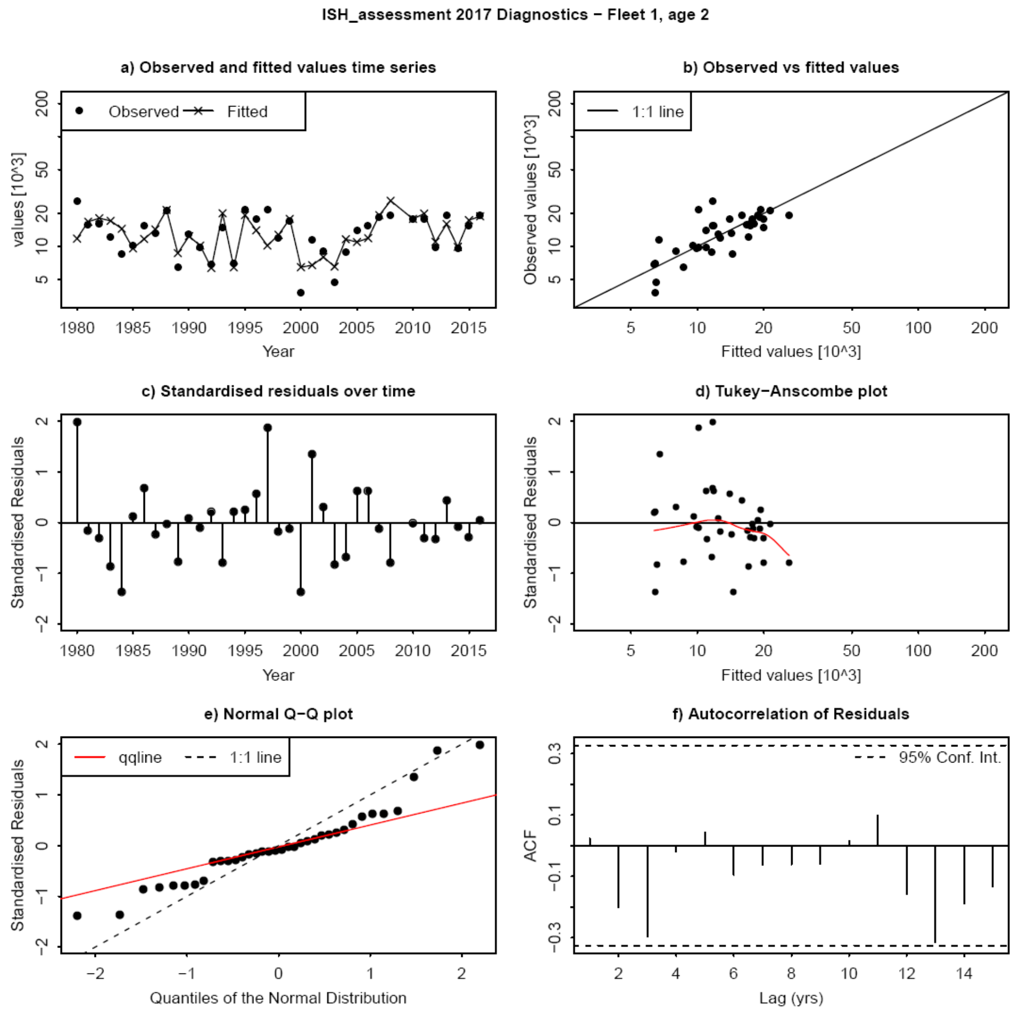


Figure 7.6.2. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age 2.

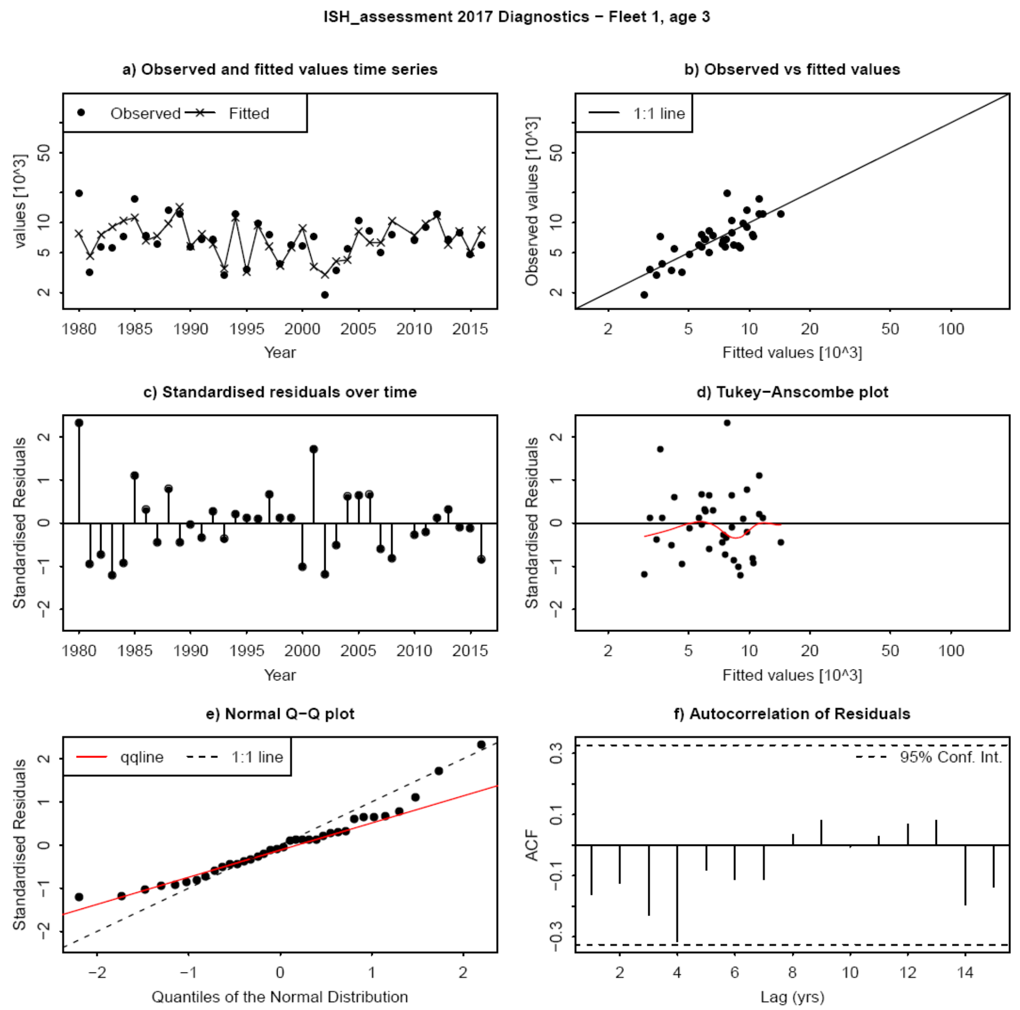


Figure 7.6.3. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age 3.

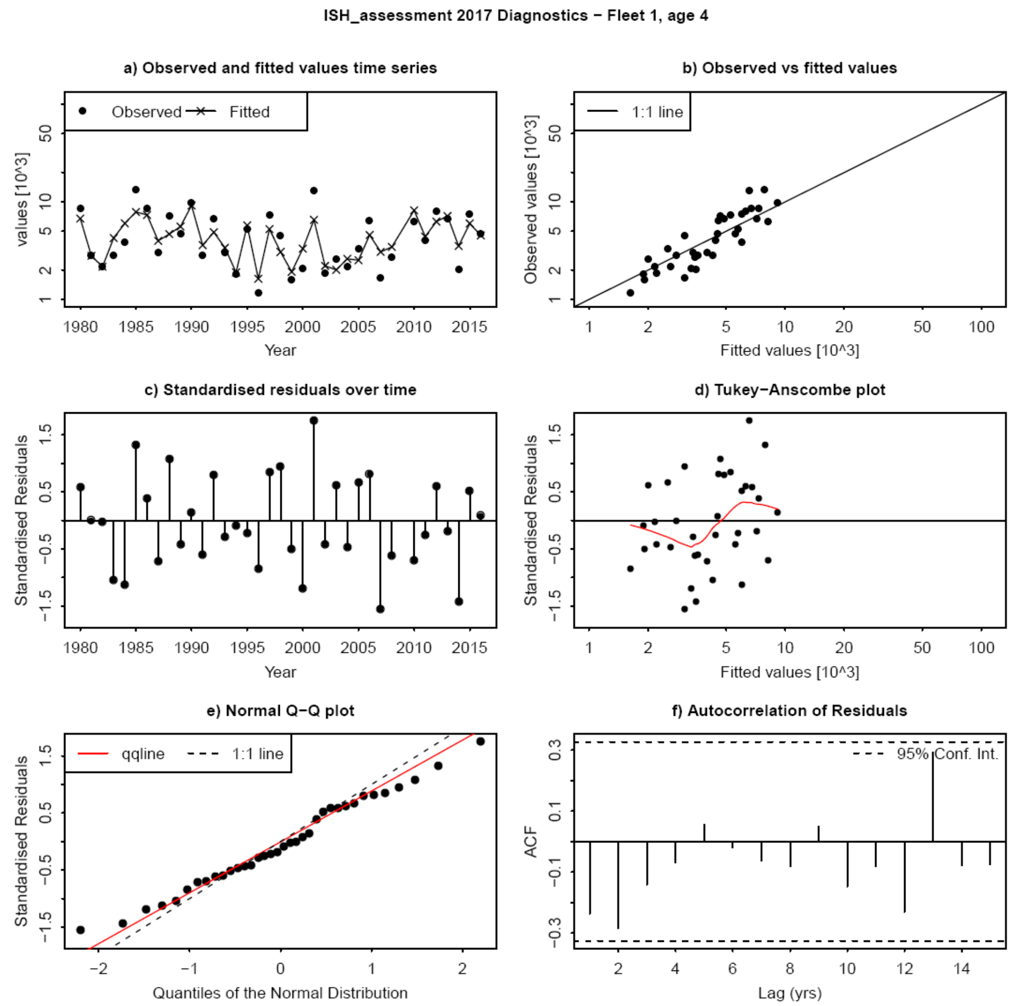


Figure 7.6.4. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age 4.

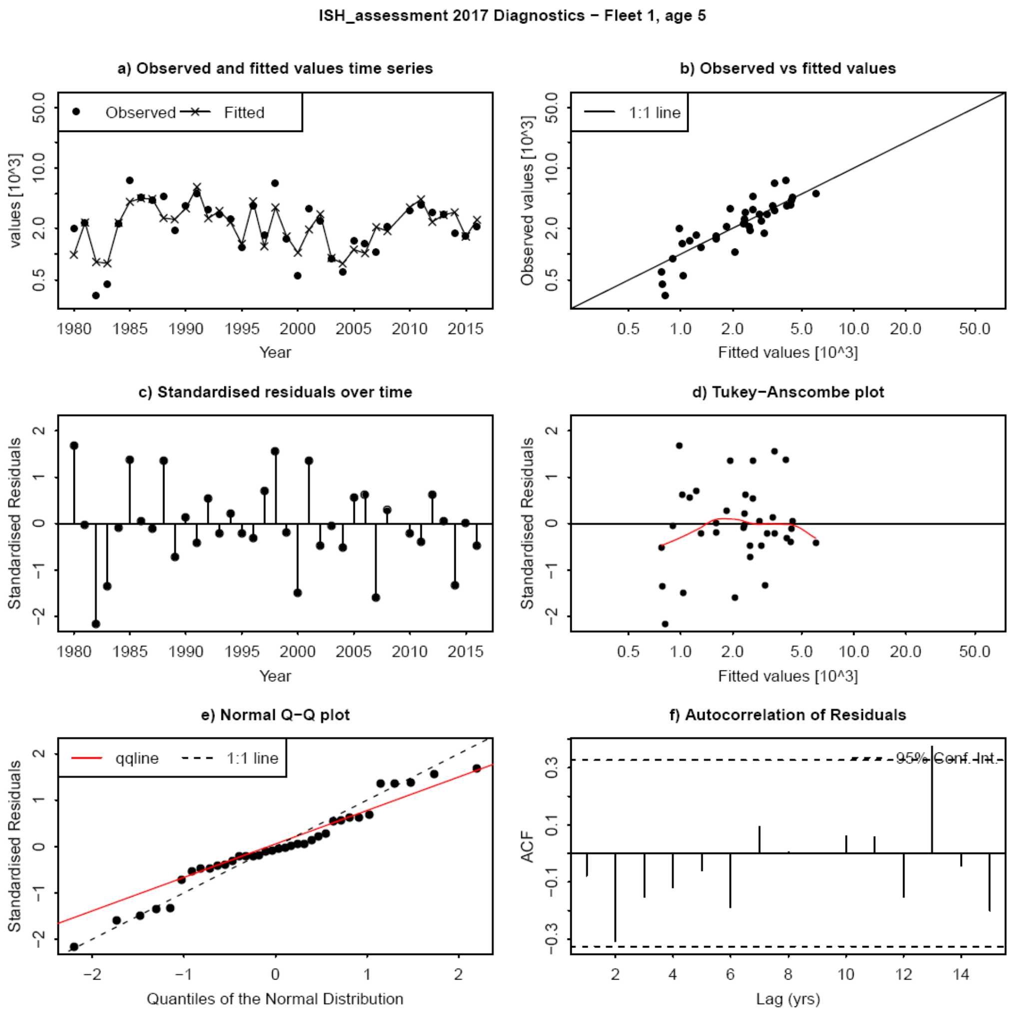


Figure 7.6.5. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age 5.

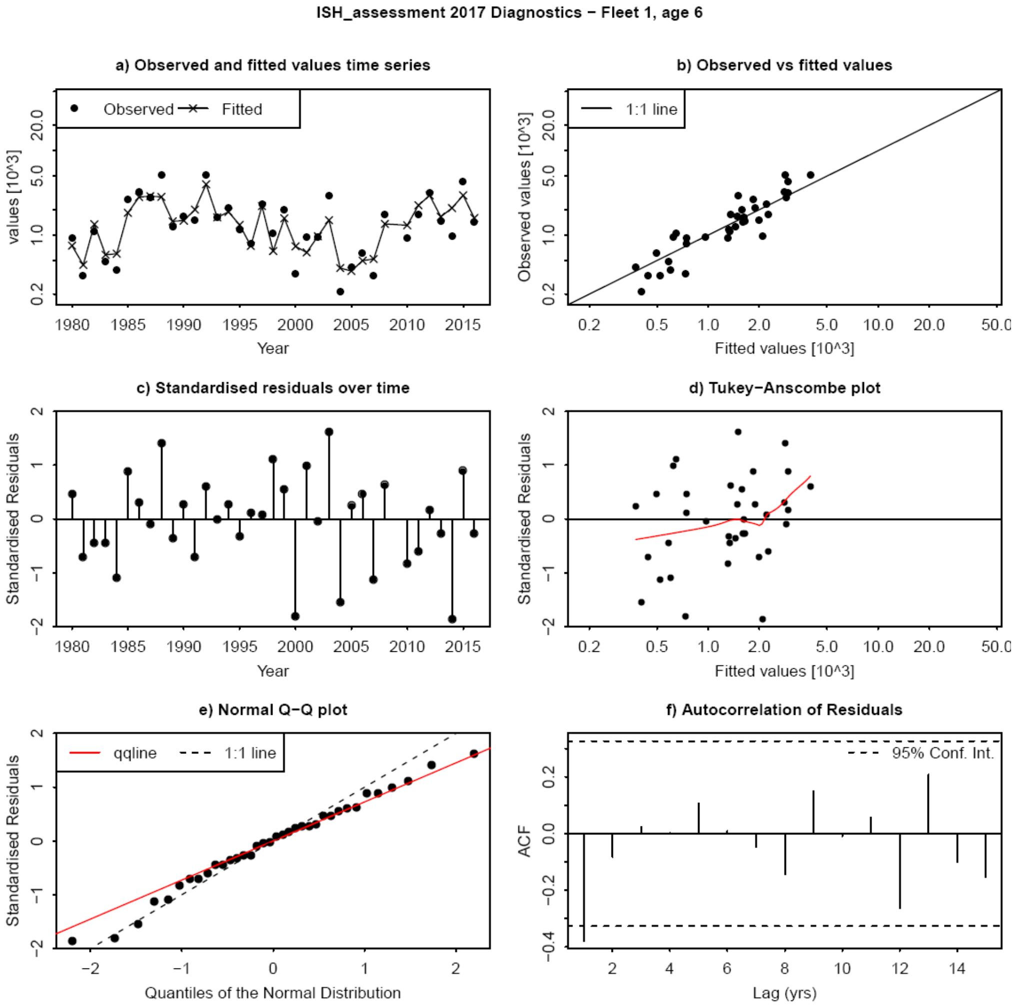


Figure 7.6.6. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age 6.

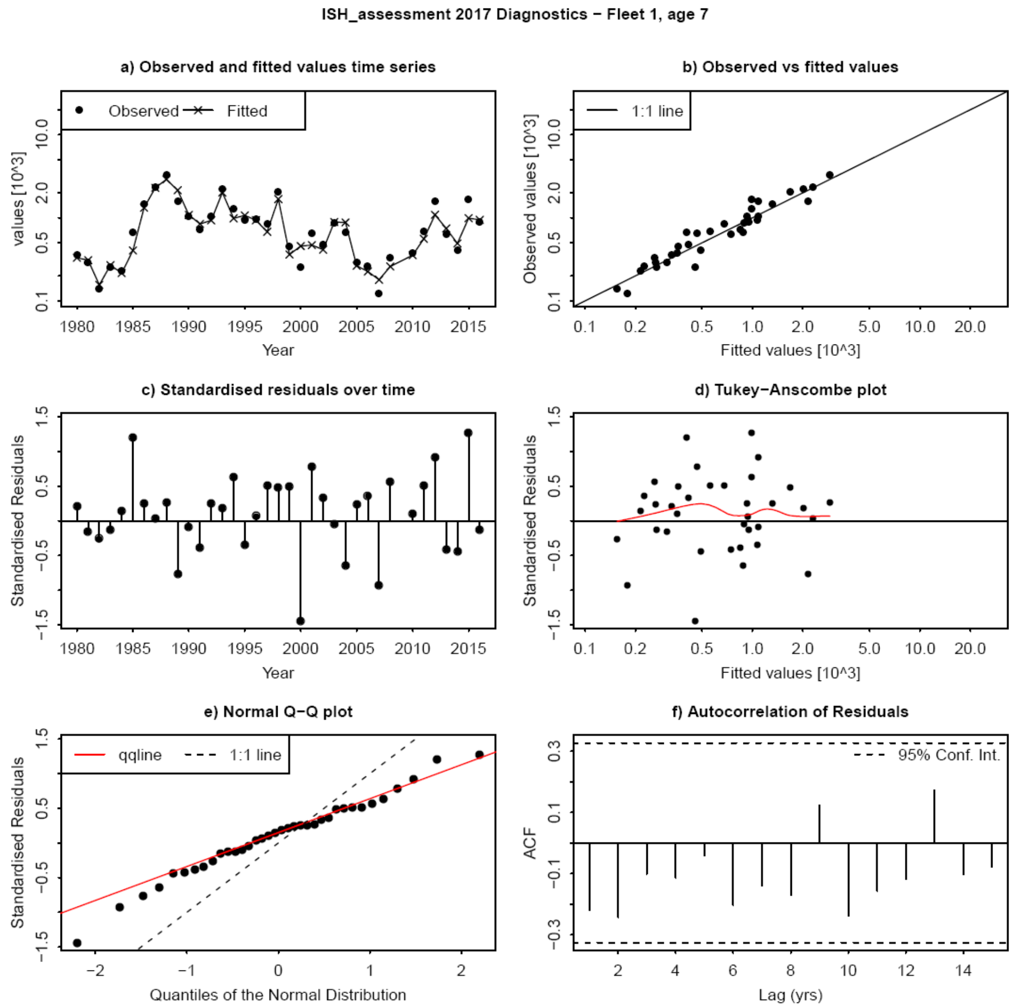


Figure 7.6.7. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age 7.

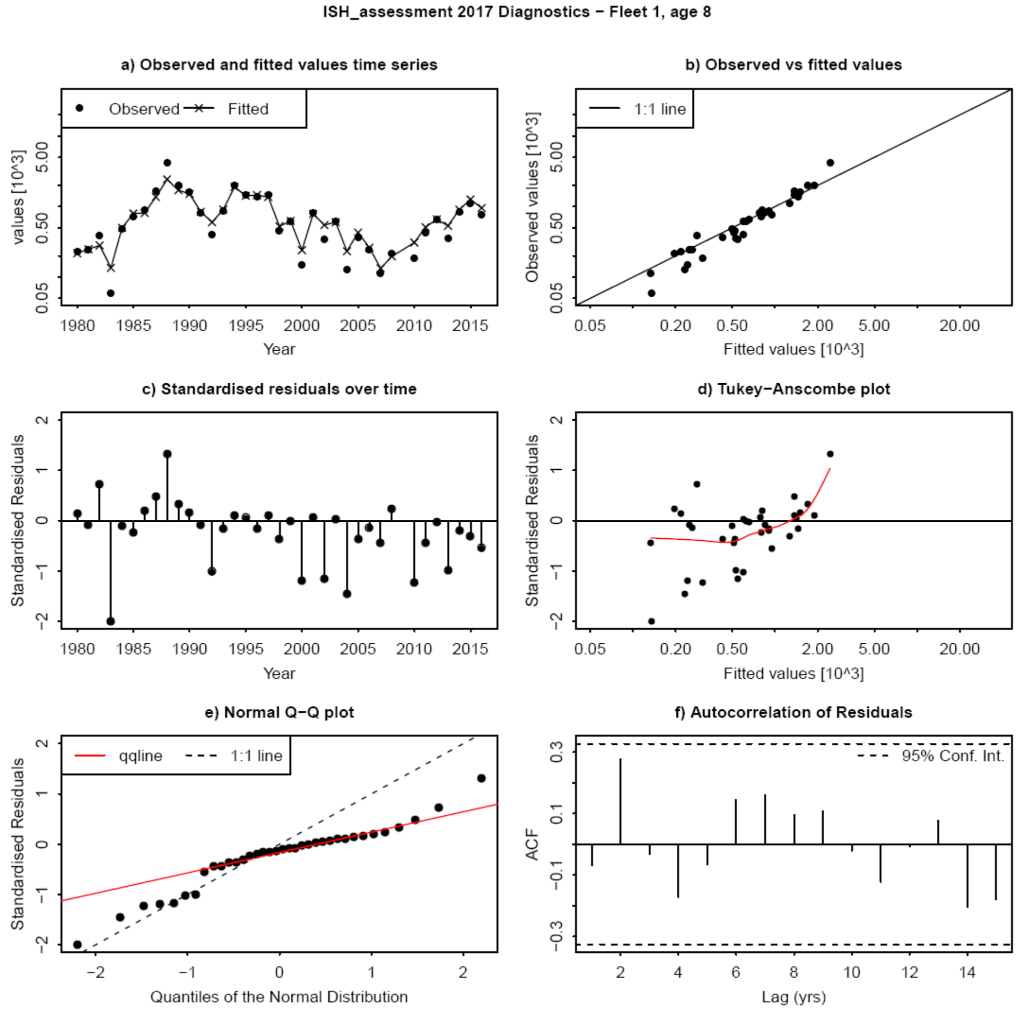


Figure 7.6.8. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age 8.

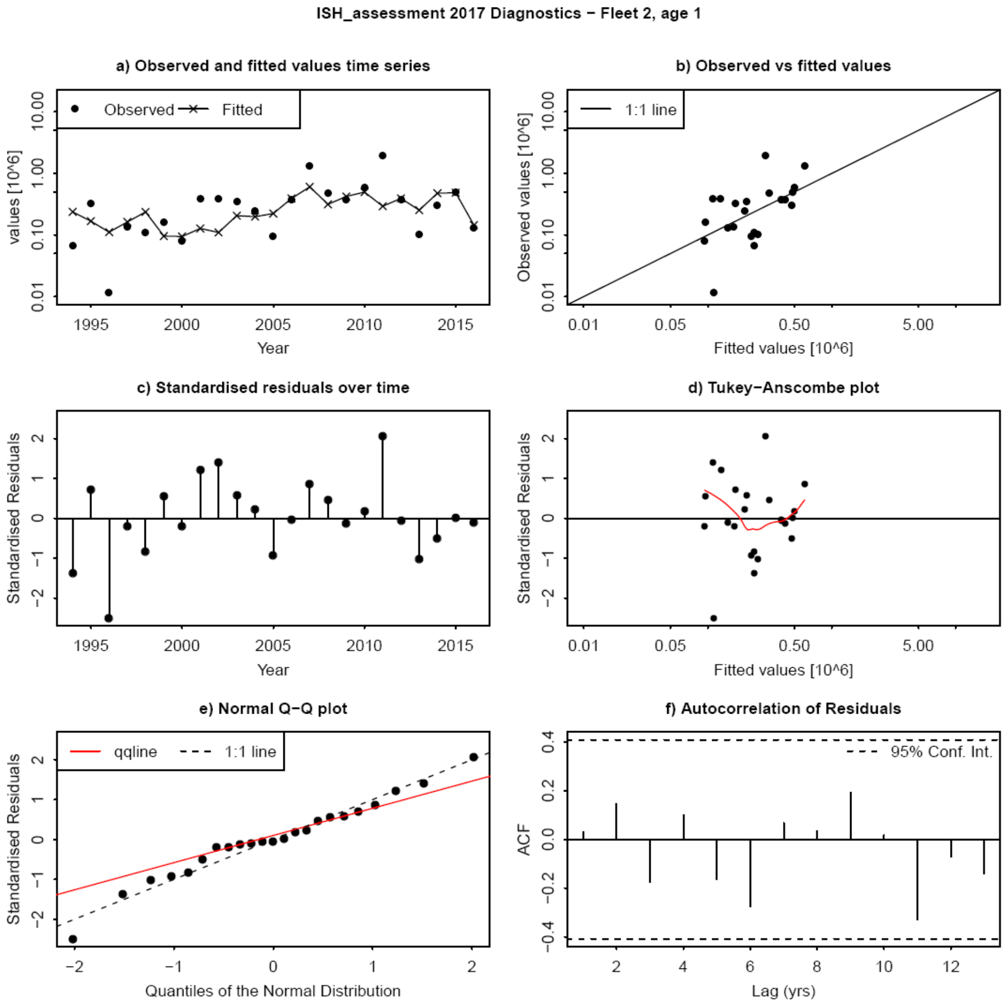


Figure 7.6.9. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age 1.

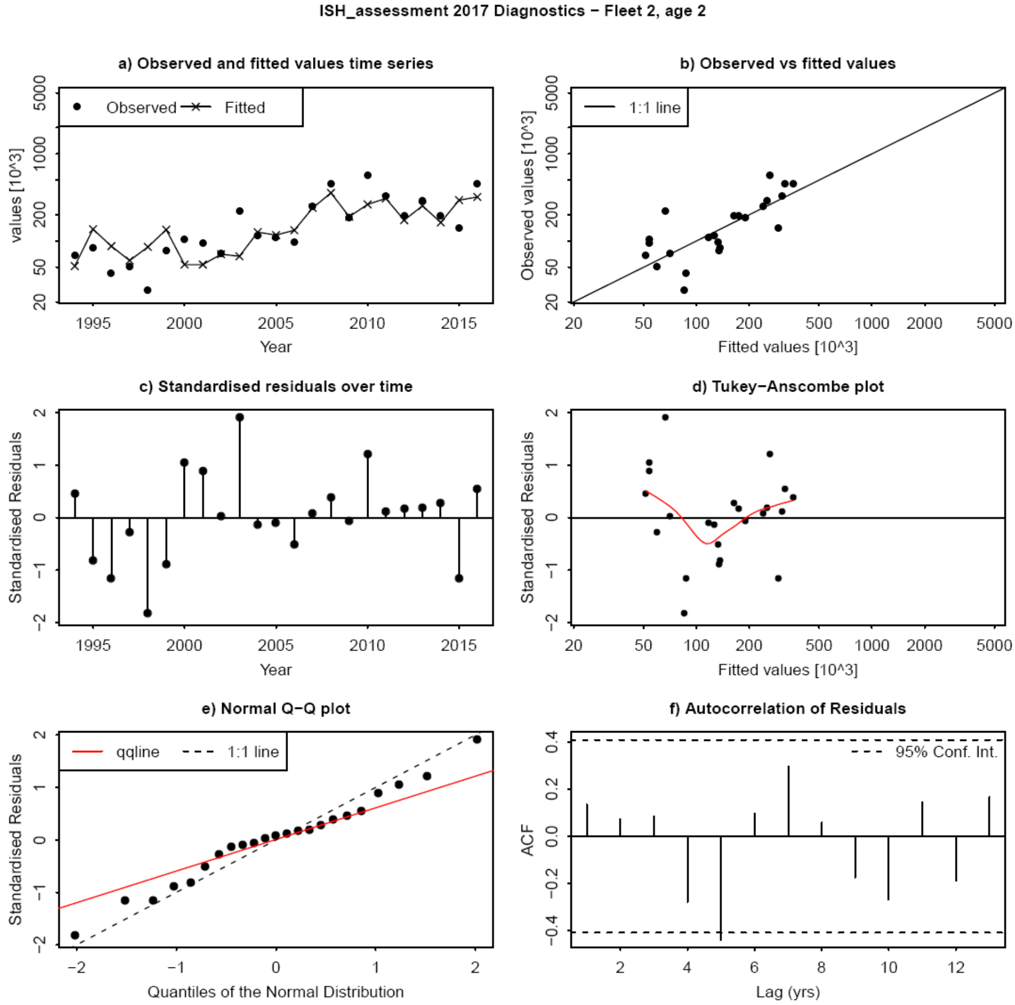


Figure 7.6.10. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age 2.

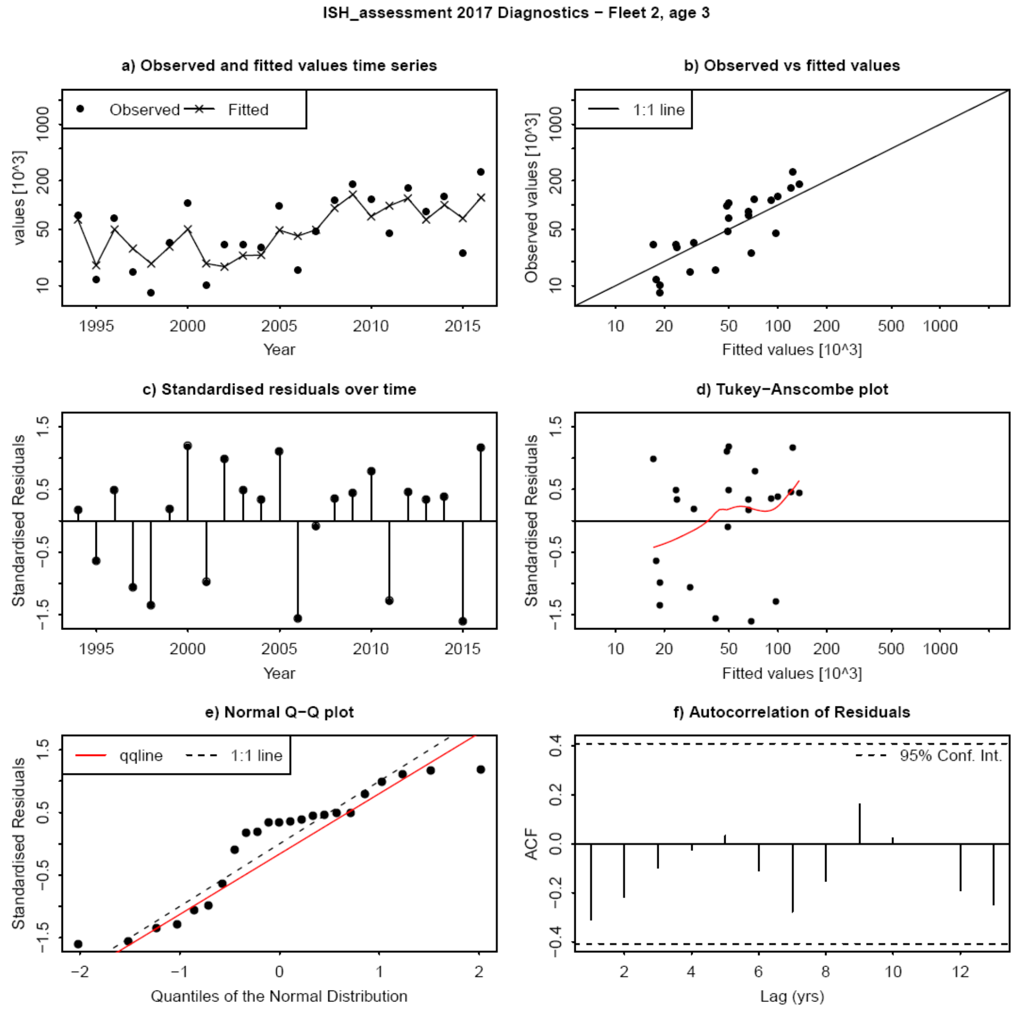


Figure 7.6.11. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age 3.

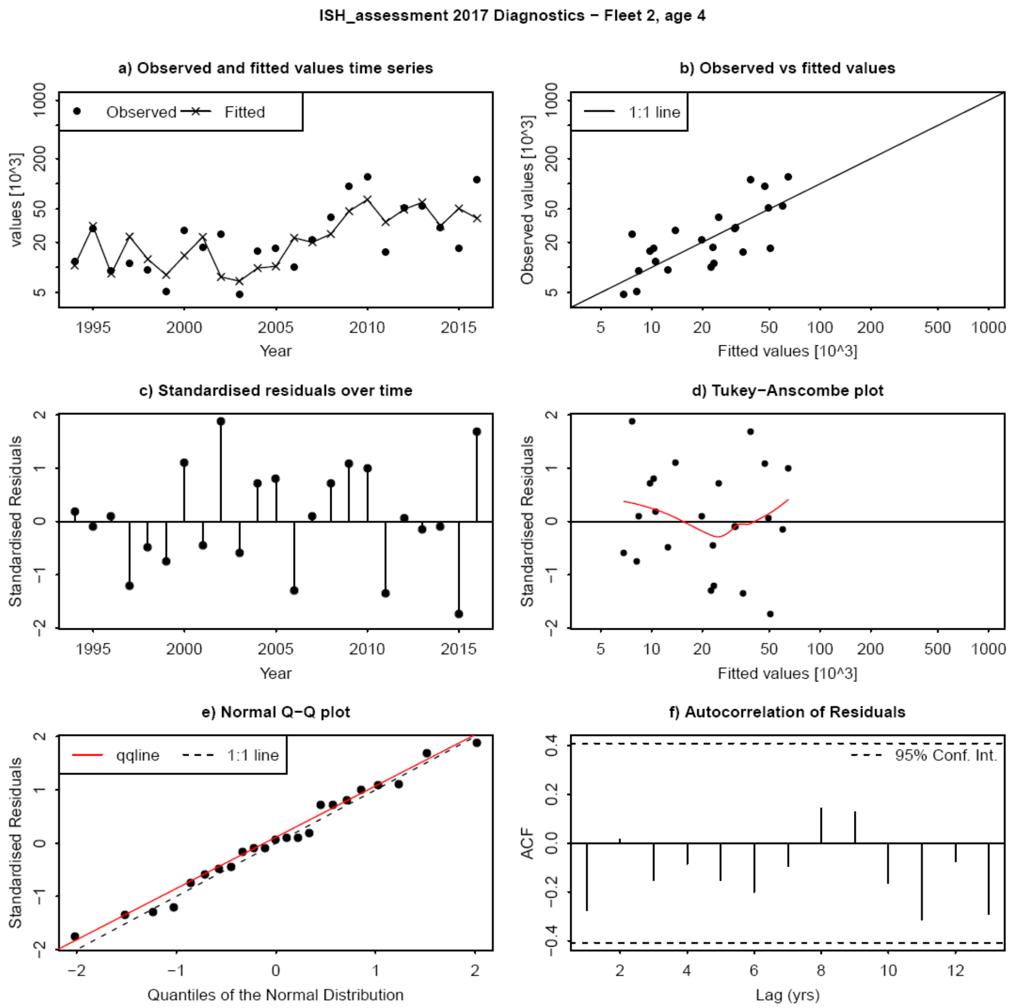


Figure 7.6.12. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age 4.

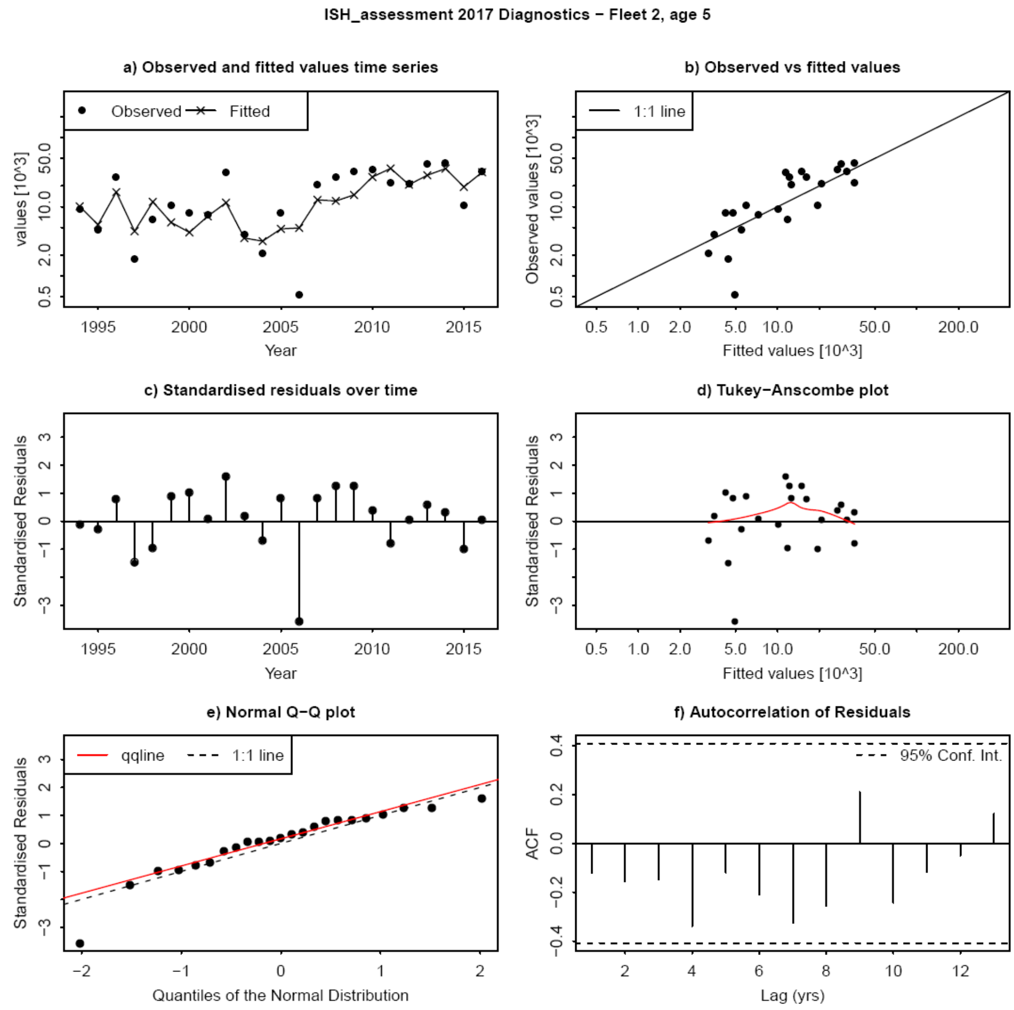


Figure 7.6.13. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age 5.

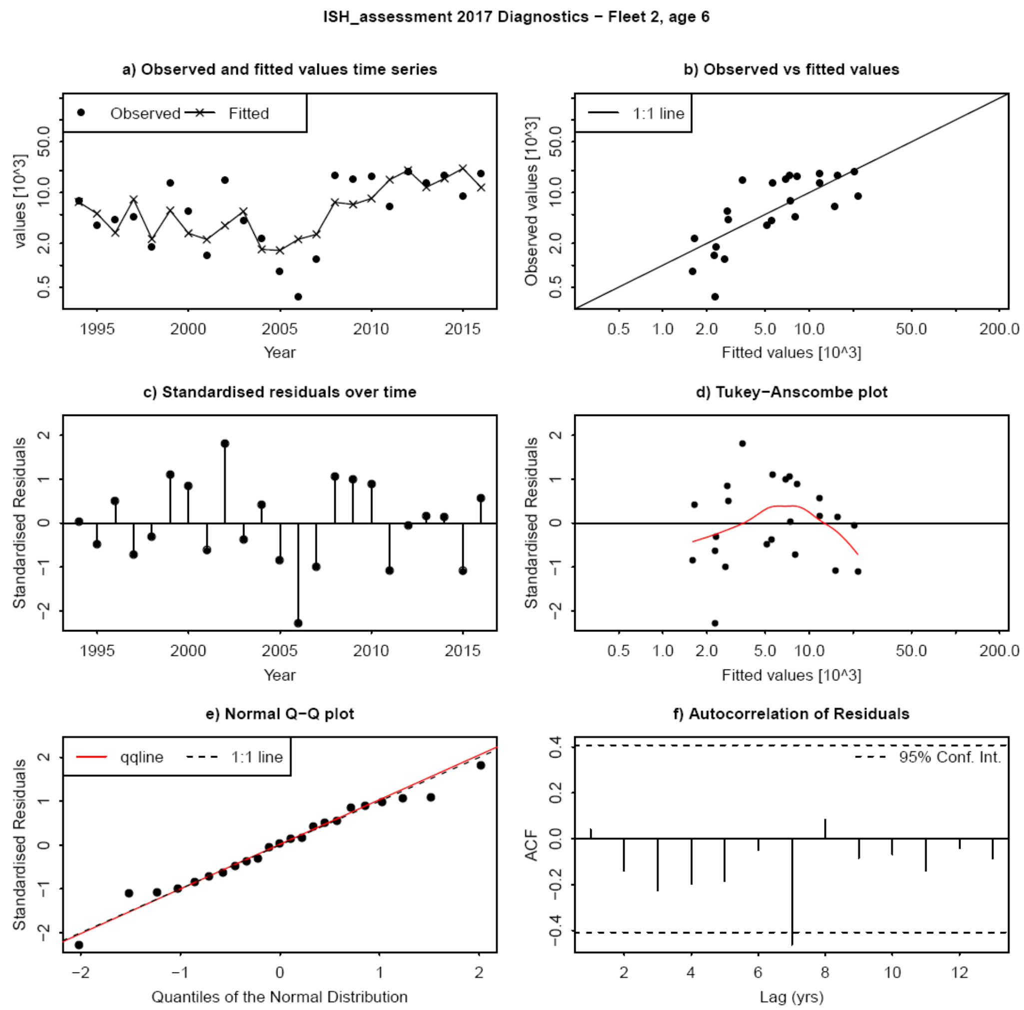


Figure 7.6.14. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age 6.

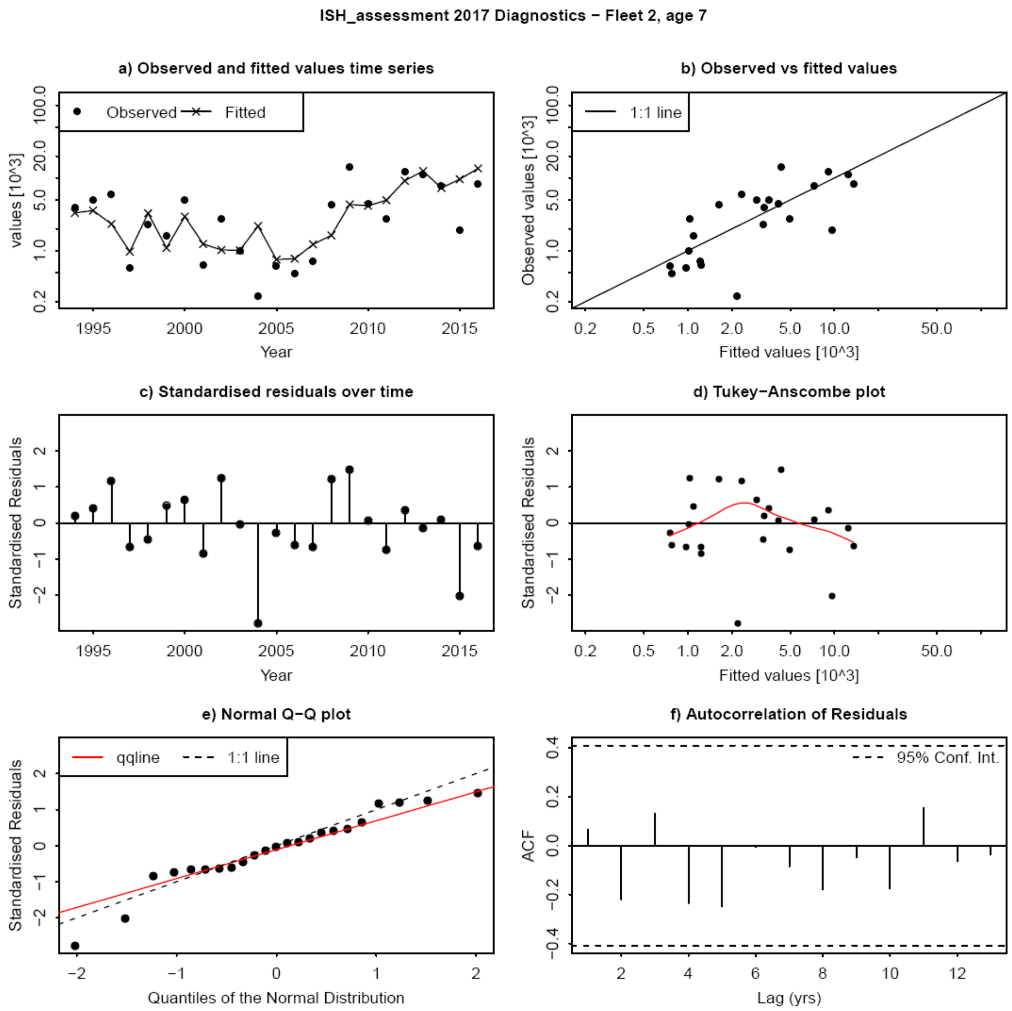


Figure 7.6.15. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age 7.

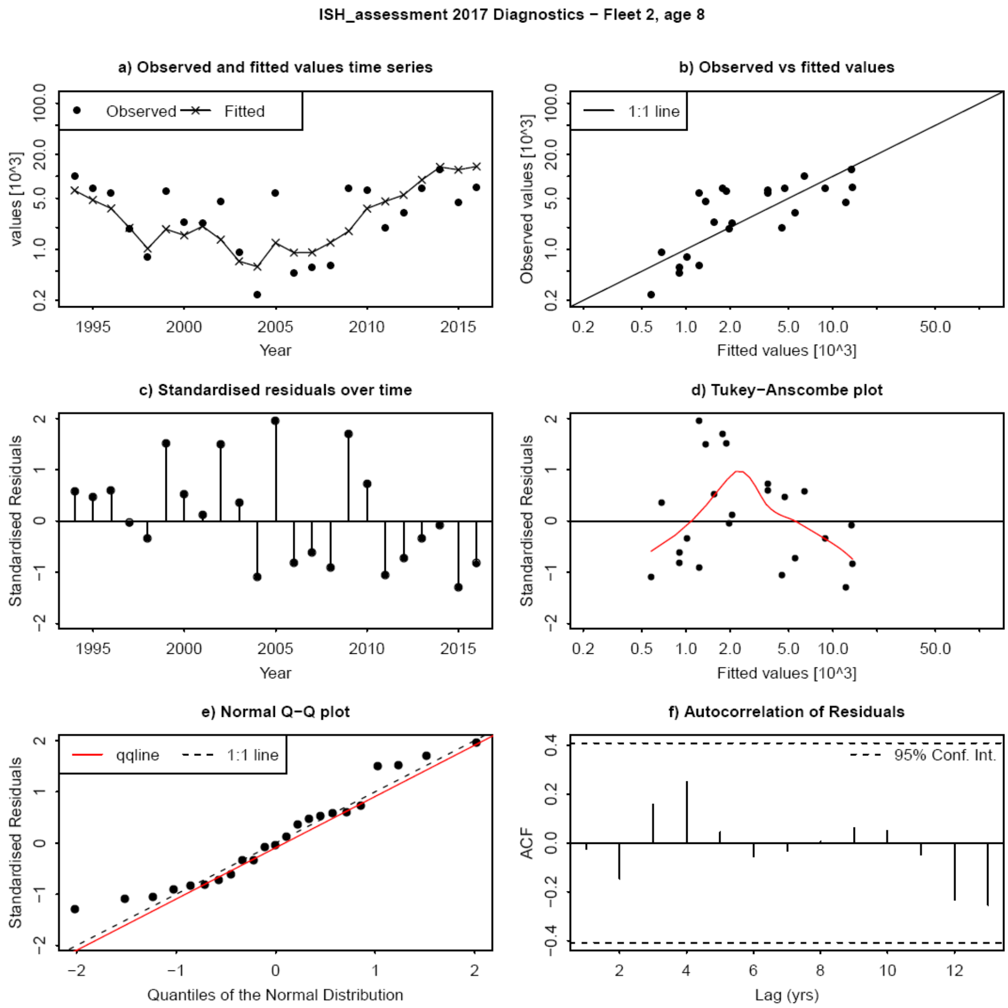


Figure 7.6.16. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(7.aN)) data at age 8.

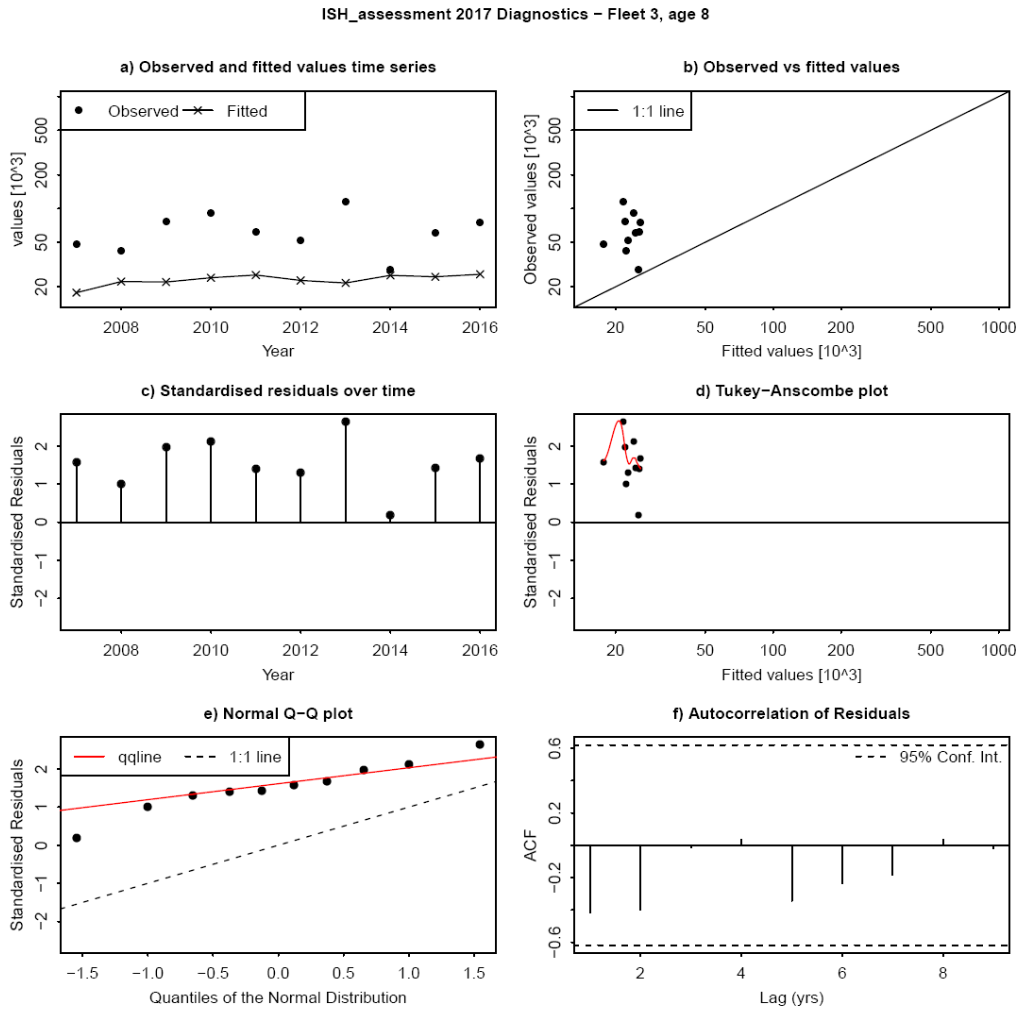


Figure 7.6.17. Herring in Division 7.a North (Irish Sea). FLSAM run output. Diagnostics of model fit to larval survey (NINEL).

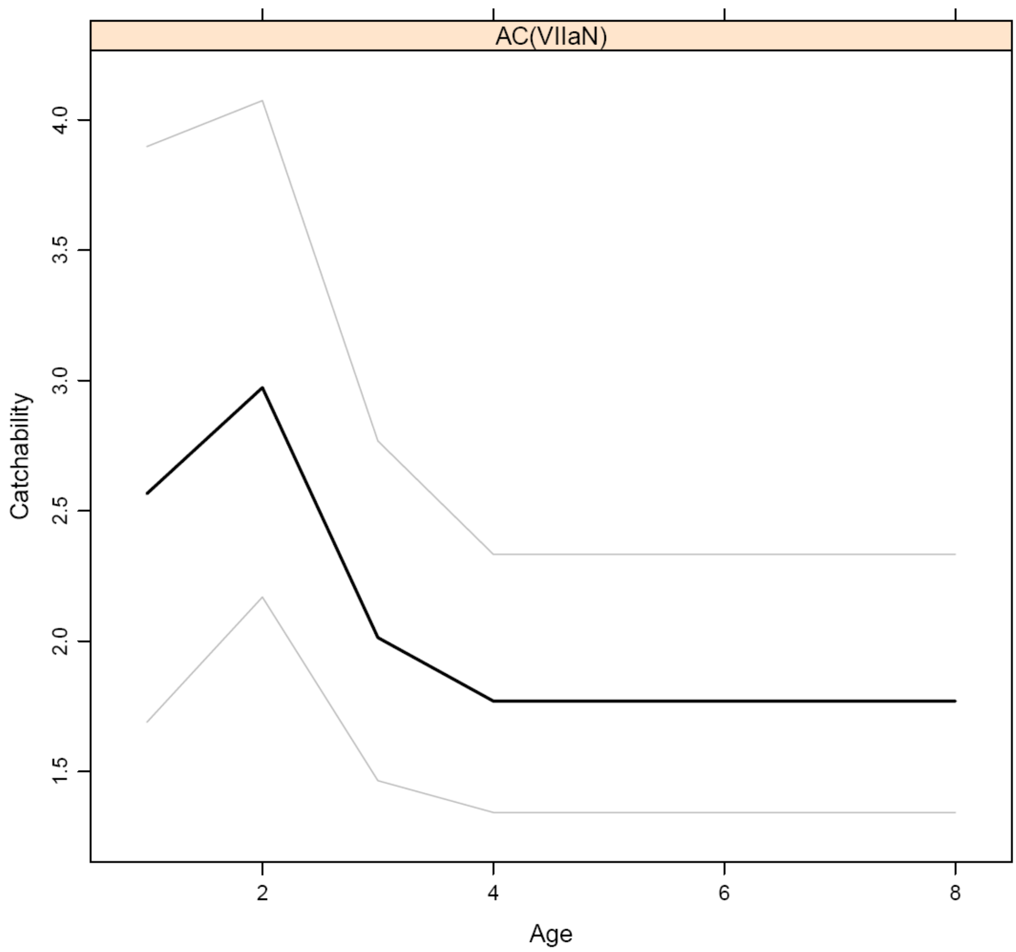


Figure 7.6.18. Herring in Division 7.a North (Irish Sea). FLSAM run output. Survey catchability parameter from the acoustic survey AC(7.aN).

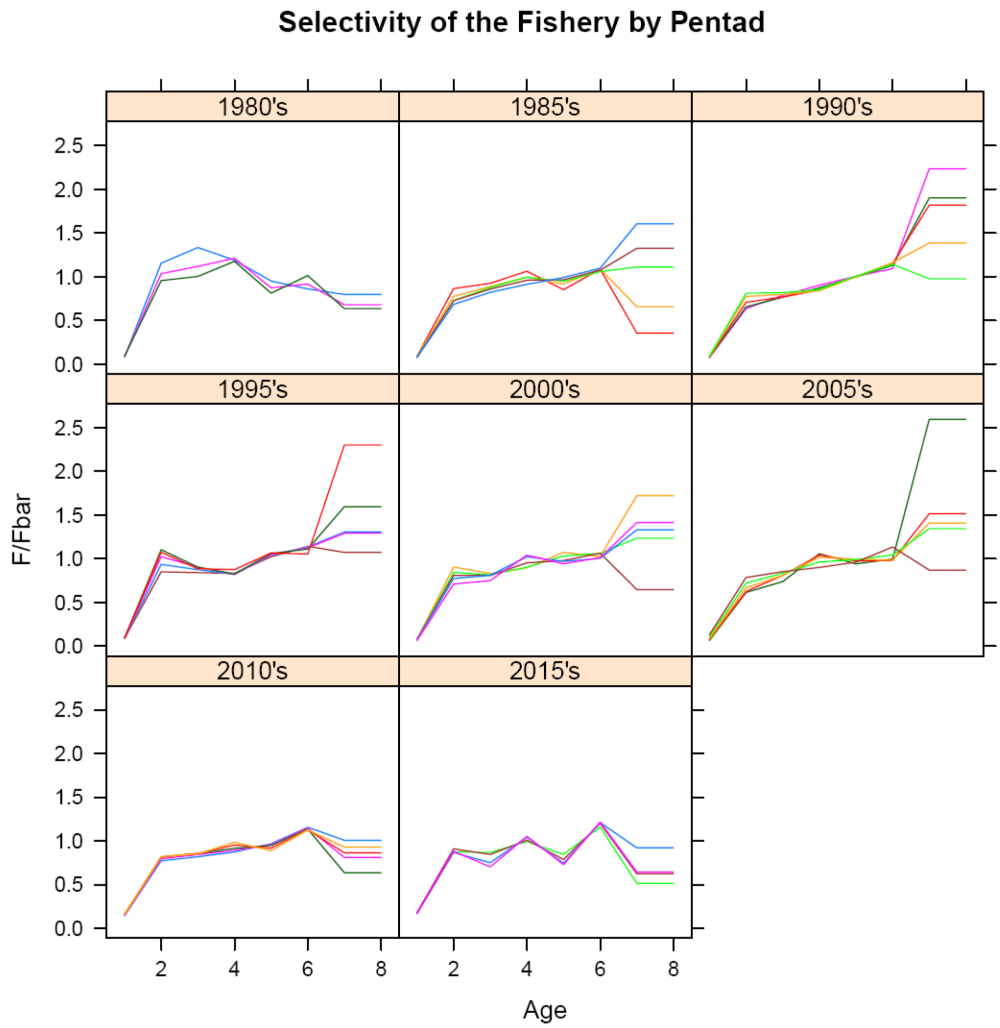


Figure 7.6.19. Herring in Division 7.a North (Irish Sea). FLSAM run output. Selectivity of the fishery by pentad.

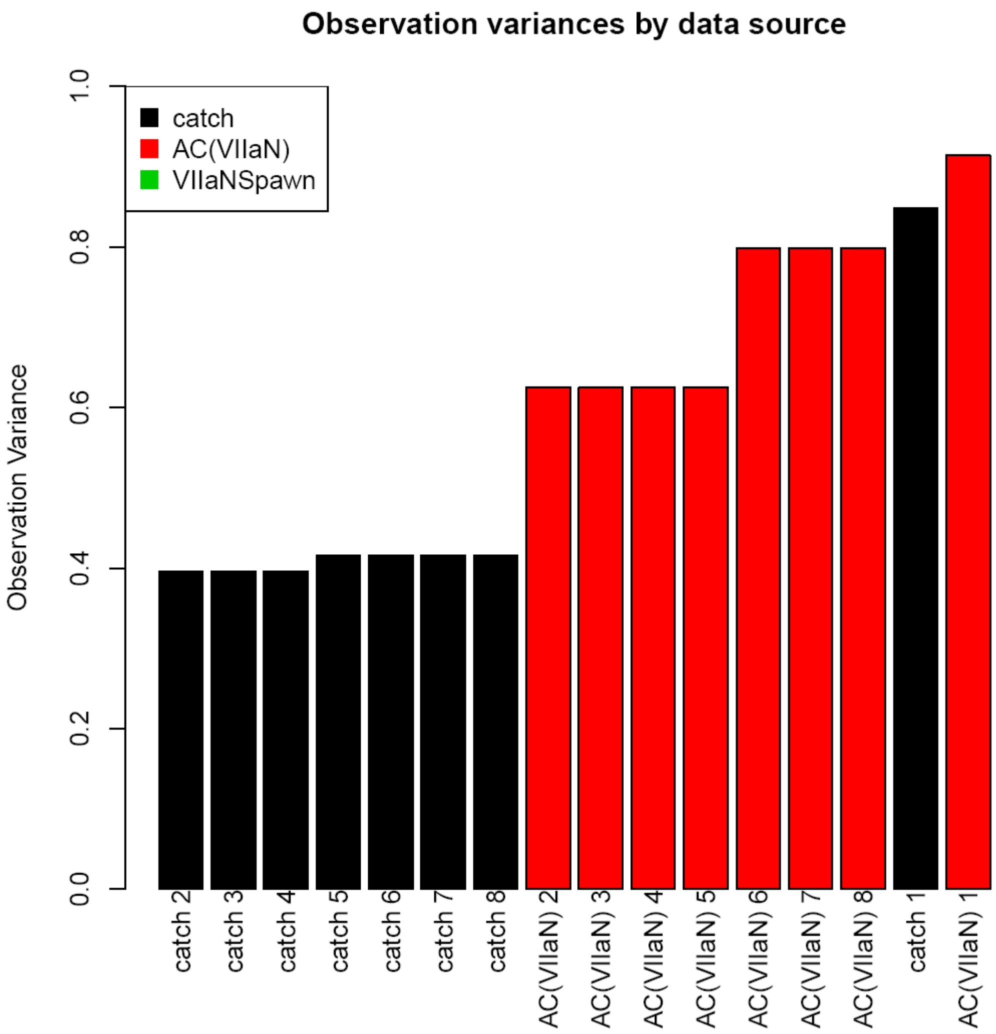


Figure 7.6.20. Herring in Division 7.a North (Irish Sea). Observation variances of all the data sources fitted in the FLSAM assessment model. The observation variance of 7.aNSpawn is fixed at 0.4.

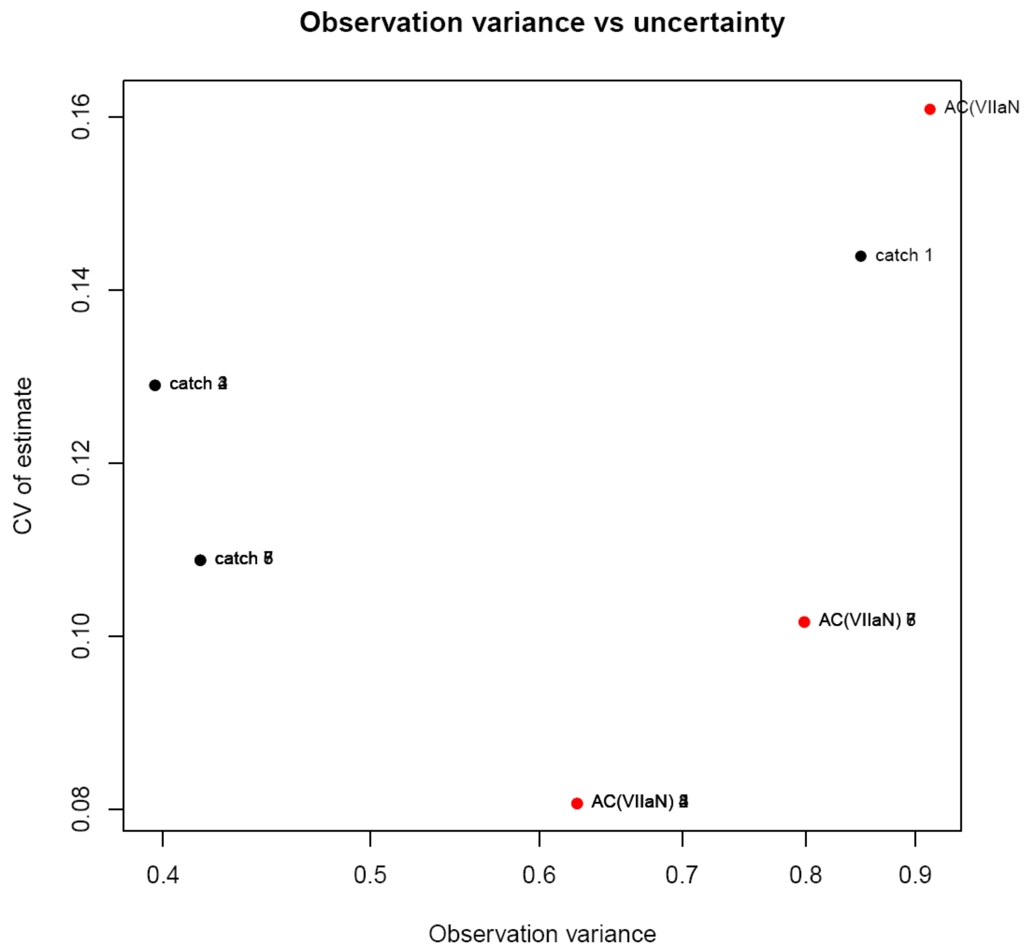


Figure 7.6.21. Herring in Division 7.a North (Irish Sea). Observation variances vs uncertainty of the data sources fitted in the FLSAM assessment model.

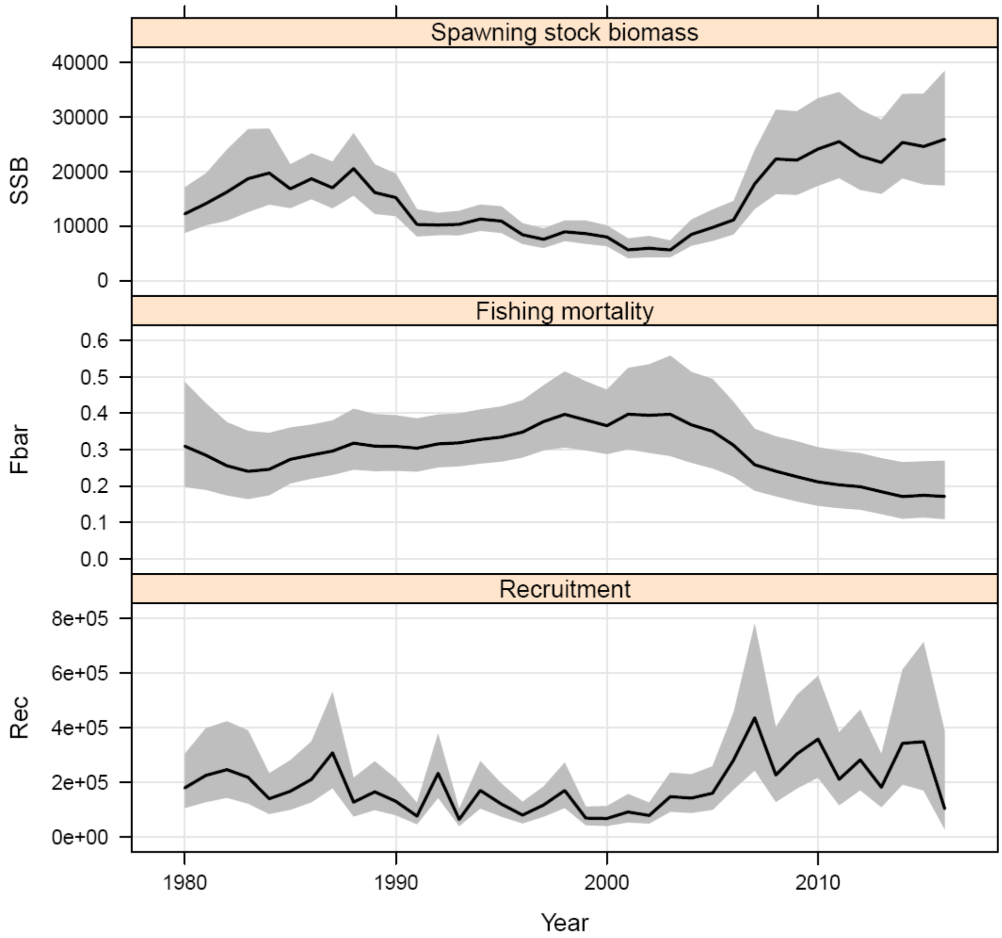


Figure 7.6.22. Herring in Division 7.a North (Irish Sea). Stock trends from the final FLSAM run, with 95% confidence intervals. Summary of estimates of spawning stock at spawning time, recruitment at 1-winter ring, mean F_{4-6}.

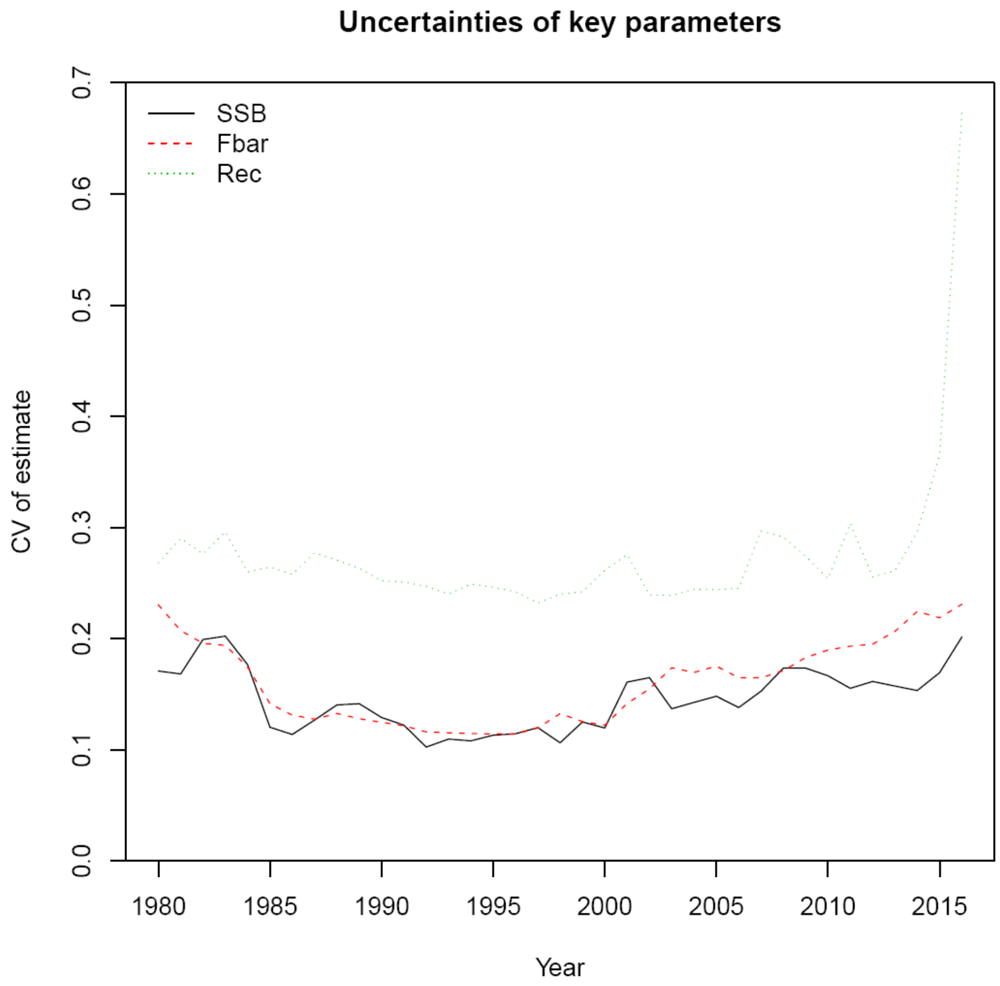


Figure 7.6.23. Herring in Division 7.a North (Irish Sea). Uncertainty of stock parameter estimates from the final FLSAM assessment. Rec = recruitment 1 winter ring.

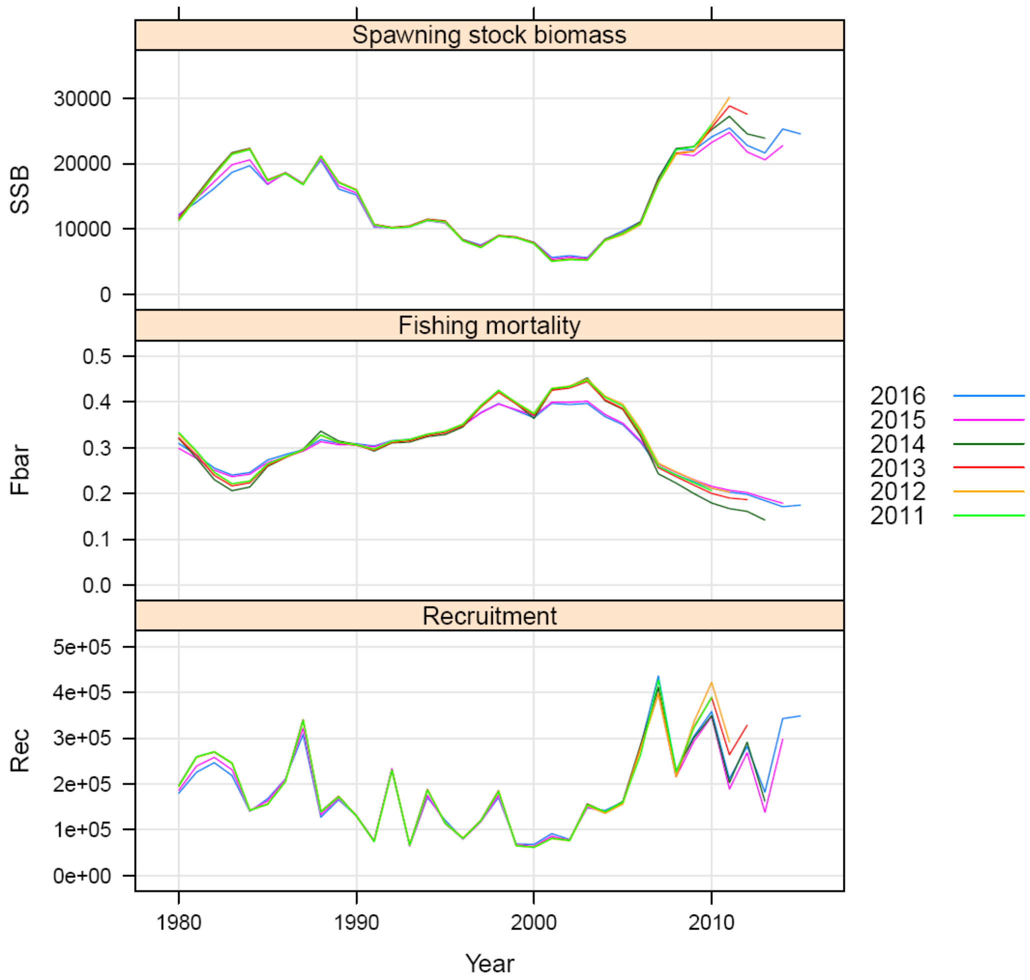


Figure 7.6.24. Herring in Division 7.a North (Irish Sea). Analytical retrospective patterns (2015 to 2005) of SSB, recruitment and mean F_{4-6} from the final FLSAM assessment.

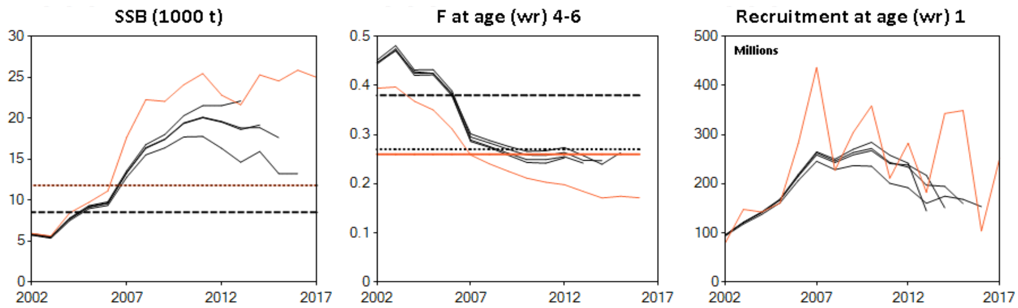


Figure 7.6.25. Herring in Division 7.a North (Irish Sea). Comparison of stock parameters between the 2016 (red line) and previous assessments.

7.13 Audit of Herring (*Clupea harengus*) in division 7.a North of 52°30'N, (Irish Sea)

Date: 12 June 2017

Auditor: Michael O'Malley, Marine Institute, Ireland

This audit was completed up to and including the assessment. The short-term forecast code and input files were not available at time of writing for the audit to be completed fully. A separate audit of the forecast will take place, separate to the audit below.

General

The audit was not completed at the HAWG meeting in March 2017 as the stock annex was not made available until Sunday 11/06/2017. The report section of the HAWG 2017 (ICES, 2017a) for Irish Sea Herring was not available for this audit. The input files presented could not be completely cross referenced. However, the input files were checked against the last available report of an assessment of this stock (ICES, HAWG 2015). The data for CANUM, FLEET, WECA, WEST and MATPROP files were verified up to 2013 (2014 data were considered provisional in the HAWG 2015 report). Data after 2013 for all input files could not be verified as correct. The CATON file was verified against information given in the stock annex. The numbers-at-age in the acoustic survey tuning index was not reported in the WGIPS 2017 report (ICES, 2017b) and therefore could not be cross-referenced either. There is no reporting in the WGIPS 2017 report of the second acoustic tuning index (SSB index) that could be cross-referenced to the input files.

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.

Some of the information and data presented in the stock annex are not required for the assessment as currently configured, and therefore surplus to requirements (e.g. information on surveys previously used).

For single stock summary sheet advice:

This stock was benchmarked in 2017 and now incorporates commercial catches, two acoustic survey indices, and natural mortalities from the SMS North Sea multispecies model supplied by WGSAM (2010). The NINEL larval survey index was replaced at the benchmark in 2017 with a new SSB acoustic survey index.

1) **Assessment type:** Benchmarked in 2017, and previously in 2012.
2) **Assessment**: analytical
3) **Forecast**: not available for audit at time of writing
4) **Assessment model**: SAM
5) **Data issues:** Data input files were available to the working group. However, these could not be cross referenced in the report as the HAWG 2017 Irish Sea section was not available. The last time Irish Sea data were reported in a HAWG report was in 2015 (ICES, 2015). There is no reporting of the new SSB index in WGIPS 2017 (ICES, 2017b) or elsewhere to cross reference the data input files for the assessment.
6) **Consistency**: The assessment model and methods used are the same as set out in the stock annex. The resulting perception is that SSB is revised substantially upwards in the past 14 years, whilst F has been revised downwards throughout the series, compared to the previous assessment, in 2016. The 2016 and 2017 assessments are not directly comparable due to the inclusion of a new SSB

index, which is treated as an absolute biomass index (q fixed equal to 1.0). Recruitment is now estimated to be more variable than previously, due to recruitment assumptions in the assessment. It would be helpful have more information on what these assumptions are.

7) **Stock status**: Unable to complete an audit of the short-term forecast as code and input data were unavailable at time of writing.
8) **Management Plan**: There is no current management plan.

General comments

The assessment in terms of parameter bindings and model configuration has been completed according to the stock annex. The lack of reporting hindered the audit. It was difficult to find documentation regarding the second acoustic SSB tuning index.

Technical comments

In the weights-at-age in the catch (WECA) input file, there is a discrepancy between the stock annex and the input file in 2009 as presented.

Conclusions

It appears that the assessment was largely performed according to the stock annex. The data in years after 2013 were not reported in the HAWG 2016 or 2017 reports (ICES, 2016; ICES, 2017a). There is no reporting of the second tuning index (SSB index) to determine if the correct data were used; no reference is made to this survey in the WGIPS 2017 report (ICES, 2017b).

The stock annex was not available on the share-point until Sunday the 11/06/2017.

The short-term forecast inputs and scripts were not made available in time for the audit. It was not possible to determine if the forecast settings were applied correctly.

References

ICES. 2015. Report of the Herring Assessment Working Group for the Area South of 62°N (HAWG), 10–19 March 2015, ICES Headquarters, Copenhagen, Denmark.

ICES. 2017a. Report of the Herring Assessment Working Group for the Area South of 62°N (HAWG), 13–23 March 2017, ICES Headquarters, Copenhagen, Denmark.

ICES. 2017b. Interim Report of the Working Group of International Pelagic Surveys (WGIPS), 16–20 January 2017, Reykjavik, Iceland. ICES CM 2017/SSGIEOM:15. 572 pp.

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 7e,f and herring in the Bay of Biscay (Sub-area 8). In this section only the times series of landings are maintained.

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 2016. No landings are reported in 2016 (Table 12.1).

Division 7e,f

Figure 12.1 shows the time series of landings over the period 1974-2016 in Division 7e and 7f. 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 7e 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 7f, it can be seen that there was a pulse of landings in the late 1970s. Since then landings have fluctuated between 50 and 200 t in recent years, without any obvious trend. Landings increased in 2016 to 227 t (Figure 12.1).

Subarea 8 (Bay of Biscay)

In the Bay of Biscay, French landings peaked at 1 700 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 8 000 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 catch statistics.

Table 12.1 Herring from the Firth of Clyde. Catch in tonnes by country, 1959–2016. Spring and autumn-spawners combined.

Year	**1959**	**1960**	**1961**	**1962**	**1963**	**1964**	**1965**	**1966**	**1967**	**1968**	**1969**	**1970**	**1971**	**1972**
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

Year	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**
All Catches														
Total	4 715	4 061	3 664	4 139	4 847	3 862	1 951	2 081	2 135	4 021	4 361	5 770	4 800	4 650

Year	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Scotland	2 895	1 568	2 135	2 184	713	929	852	608	392	598	371	779	16	1	78
Other UK	-	-	-	-	-	-	1	-	194	127	475	310	240	0	392
Unallocated*	278	110	208	75	18	-	-	-	-	-	-	-	-	-	-
Discards	4394	2454	**	**	**	**	**	**	**	-	-	-	-	-	-
Agreed TAC	3 500	3 200	3 200	2 600	2 900	2 300	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Total	3 612	1 923	2 343	2 259	731	929	853	608	586	725	846	1089	256	1	480

Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Scotland	46	88	-	-	+	163	54	266	-	90	119	21	0	0	0
Other UK	335	240	-	318	512	458	622	488	301	111	184	-	-	-	-
Unallocated*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Discards	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agreed TAC	1 000	1 000	1 000	1 000	1 000	800	800	800	720	720	720	648	648	583	
Total	381	328	0	318	512	621	676	754	301	201	303	21	0	0	0

***Calculated from estimates of weight per box and in some years estimated by-catch in the sprat fishery**

****Reported to be at a low level, assumed to be zero, for 1989-1995.**

Table 12.2. Stocks with limited data. Landings of herring in Divisions 7e and 7f. Source: ICES official landings database 2006 - 2014 , national databases and ICES preliminary catch statistics 2015 and 2016.

Division	Country	2009	2010	2011	2012	2013	2014	2015*	2016*
7e	UK (Eng,Wal,NI,Scot,Guernsey)	130	185	218	162	274	435	268	204
7e	Denmark	-	0	-	-	-	-	-	-
7e	France	489	493	486	278	7	314	3	1
7e	Germany, Fed. Rep. Of	-	0	-	-	-	-	-	-
7e	Netherlands	-	2	6	-	-	4	0	-
	Total	**619**	**678**	**710**	**440**	**275**	**753**	**271**	**205**

Division	Country	2009	2010	2011	2012	2013	2014	2015*	2016*
7f	UK (Eng, Wal, Scot, NI)	8	23	78	113	136	20	111	227
7f	Belgium	-	-	-	-	-	-	-	-
7f	France	-	-	26	-	-	-	-	-
7f	Netherlands	-	-	-	-	-	-	-	-
7f	Poland	-	-	-	-	-	-	-	-
	Total	**8**	**23**	**104**	**113**	**136**	**20**	**111**	**227**

*Preliminary data

Table 12.3. Stocks with limited data. Landings of herring in Sub-area 8.

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015*	2016*
France	14	6	12	12	34	50	82	22	7	5	5	4
Netherlands	28	12	24	24	68	502	222	-	-	-	-	-
Portugal	-	-	.	.	-	-	-	-	-	-	-	-
Spain	50	214	120	131	55	38	54	2	-	-	-	-
UK	0	0	0	0	-	-	-	-	-	-	-	-
	92	232	156	167	157	590	358	24	7	5	5	4

*Preliminary data

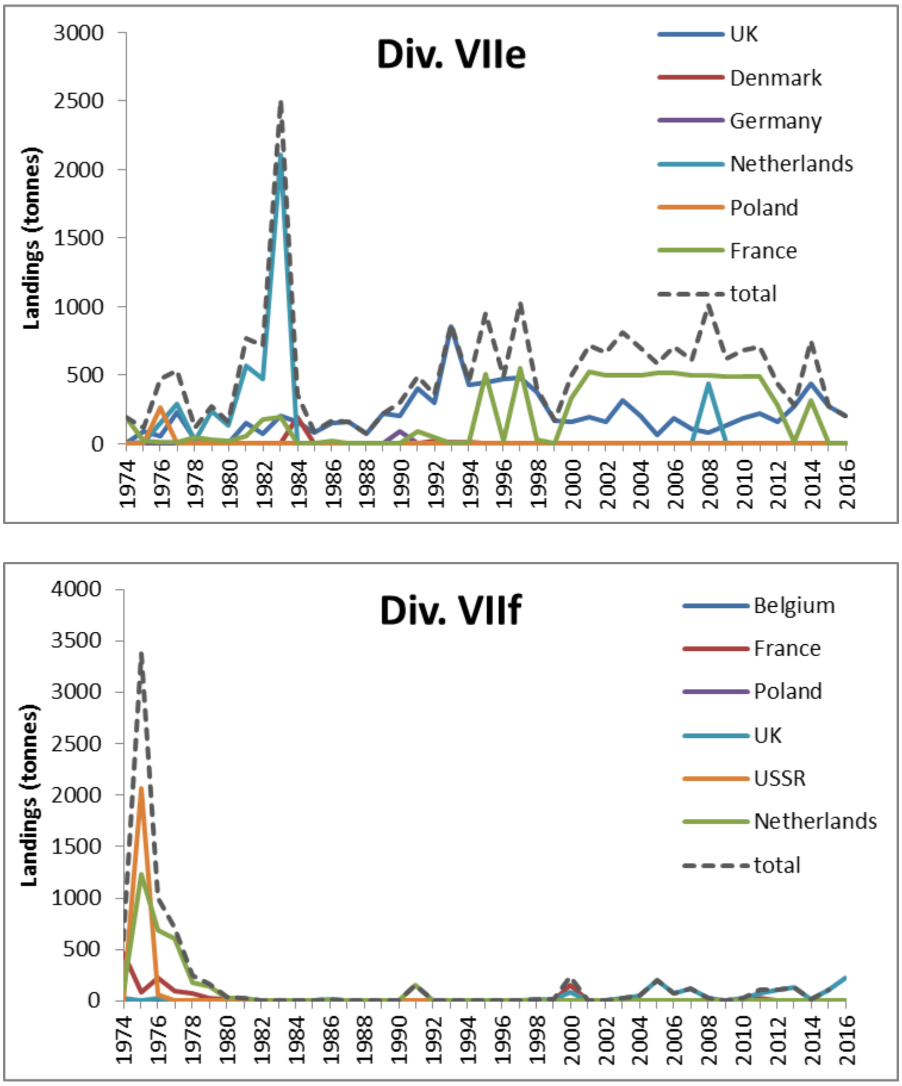


Figure 12.1. Stocks with limited data. Landings over time of herring in Divisions 7e (upper panel) and 7f (lower panel).

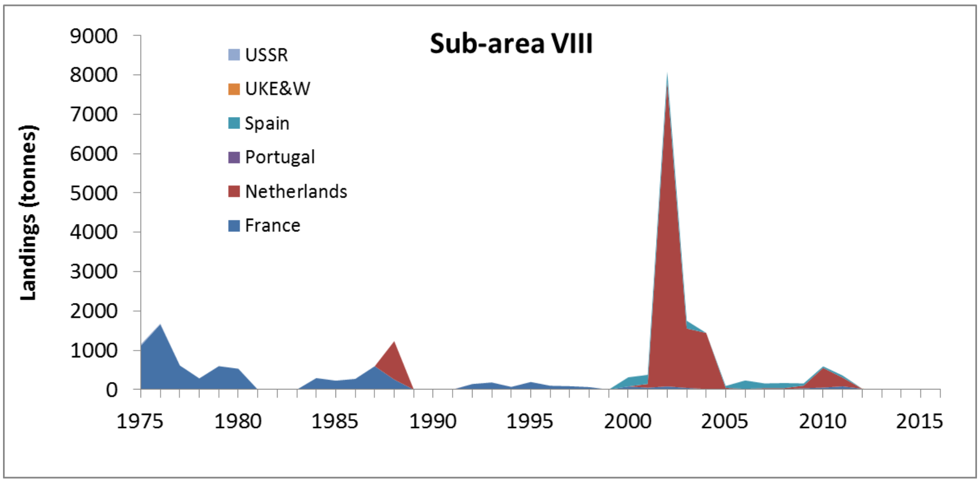


Figure 12.2. Stocks with limited data. Landings over time of herring in Sub-area 8.

9 Sandeel in Division 3.a and Subarea 4

Larval drift models and studies on recruitment and growth differences have indicated that the assumption of a single stock unit in the area is invalid. As a result, the total stock is divided in several sub-populations (ICES, 2016, Figure 9.1.1), each of which is assessed by area specific assessments. Currently fishing takes place in five out of these seven areas (sandeel area (SA) 1–4 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 1, 2, 3 and 4.

Further information on the stock areas and assessment model can be found in the Stock Annex and in the benchmark report (ICES, 2016).

9.1 General

9.1.1 Ecosystem aspects

Sandeel in the North Sea can be divided into a number of more or less reproductively isolated sub-populations (see the Stock Annex). A decline in the sandeel population in several areas in recent years concurrent with a marked change in distribution has increased the concern about local depletion, of which there has been some evidence (ICES, 2007; ICES, 2008a, ICES 2016). Since 2010 this has been accounted for by dividing the North Sea and 3.a into seven management areas.

Local depletion of sandeel aggregations at a distance less than 100 km from seabird colonies may affect some species of birds, especially black-legged kittiwake and sandwich tern, whereas the more mobile marine mammals and fish are likely to be less vulnerable to local sandeel depletion.

The Stock Annex contains a comprehensive description of ecosystem aspects.

9.1.2 Fisheries

General information about the sandeel fishery can be found in the Stock Annex.

The size distribution of the Danish fleet has changed through time, with a clear tendency towards fewer and larger vessels (ICES, 2007). During the last fifteen years, the number of Danish vessels participating in the North Sea sandeel fishery has been stable with around 100 active vessels.

The same tendency has been seen for the Norwegian vessels towards fewer and larger vessels. In 2008, 42 vessels participated in the sandeel fishery, but in 2015 and 2016 29 and 28 vessels, respectively, participated in the fishery. From 2011 to 2016 the average GRT per vessel in the Norwegian fleet increased from 1100 to 1300 t.

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 2016 was opened 1 April and was practically ended in early May. In NEEZ the fishery opened 15 April and ended 23 June.

9.1.3 ICES Advice

ICES advised that the fishery in 2016 should be allowed only if the analytical stock assessment indicated that the stock would be above B_{pa} by 2017 (Escapement strategy). This approach resulted in an advised no TAC in SA 1 and SA 2 and 123 135 t in SA 3. A monitoring TAC of 5000 was advised for SA1, SA2 and in SA 4 (based on the approach for data limited stocks in SA4).

9.1.4 Norwegian advice

Based on a recommendation from the Norwegian Institute for Marine Research, an opening TAC of 40 000 tonnes for 2016 was given, and as the acoustic survey estimates of age 1 were only medium high the TAC was not increased. Fishery was allowed in the subareas 1.b, 2.a, 3.a, 3.b, 4.a (See Stock Annex for area definitions).

9.1.5 Management

Norwegian sandeel management plan

An Area Based Sandeel Management Plan for the Norwegian EZZ 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 in 2015 and 2016 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, the Norwegian management subareas 1b, 2b and 3b were open in 2010 and 2012, and the subareas 1a, 2a and 3a were open in 2011. In 2013, subareas 2a and 3a were open. An exploratory fishery (with a quota of 2000 t) was carried out in subarea 5a between 15 May and 23 June 2012. In 2013, five vessels were allowed to fish in subarea 4a. In 2014, the subareas 2a, 3b, 3c and 4b were open for fishery. In the period 23 April–15 May, five vessels were allowed to fish in subarea 4a, but no vessel had catches in this subarea. In 2015, fishery was allowed in the subareas 2b, 3a, 3b and 4a (only five vessels) until 15 May. From 15 May, subareas 1b, 2b, 3a, 3b and 4a were open. In 2016, subareas 1b, 2a, 3a, 3b, 4a were open.

In the light of studies linking low sandeel availability to poor breeding success of kittiwake, there has been a moratorium on sandeel fisheries on Firth of Forth area along the U.K. coast since 2000. Note that a limited fishery for stock monitoring purposes occurs in May-June in this area.

9.1.6 Catch

Adjustment of official catches

Previously, there has been substantial misreporting of catches between areas (ICES, 2015, 2016b (HAWG)). Since 2015, the Danish regulation has not allowed fishing in several stock areas on a single fishing trip. This eliminated the misreporting issue for Danish catches. However, German and Swedish catches were still high in the four rectangles, and an analysis of Swedish VMS for the years 2012 to 2015 indicated that misreporting had also occurred of Swedish catches in 2014 and 2015 (see WD2, Annex 4). Because of this, the working group decided to keep the practice from last year's assessment and reallocate reported catches (14 781 t) from rectangles 41F2, 41F3 and 41F4 to SA 1 in 2015. In 2016, no Swedish and German catches were reported in this area, and no correction was made.

Catch and trends in catches

Catch statistics for Division IV are given by country in Table 9.1.1. Catch statistics and effort by assessment area are given in Tables 9.1.2–9.1.7. Figure 9.1.1 shows the areas for which catches are tabulated.

The sandeel fishery developed during the 1970s, and catches peaked in 1997 and 1998 with more than 1 million t. Since 1983 the total catches have fluctuated between 1.2 million t (1997) and 73 420 t (2016) (Figure 9.1.3).

Spatial distribution of catches

Yearly catches for the period 2000–2016 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 1 sandeel. The fishery in SA 3 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 1 and 3 have consistently been the most important with regard to sandeel catches. On average, these areas together have contributed ~75% of the total sandeel catches in the period since 1983.

The third most important area for the sandeel fishery is SA 2. In the period since 2003 catches from this area contributed 17% of the total catches on average.

SA 4 has contributed about 5% of the total catches since 1994, but there have been a few outstanding years with particular high catches (1994, 1996 and 2003 contributing 19, 17 and 20% of the total catches, respectively). Only a monitoring fishery (5000 t) was permitted in SA 4 in 2016.

Several banks in the northern areas of Norwegian EEZ have not provided catches for in period 2001-2008. From 2001 to 2008, almost all catches from the Norwegian EEZ came from the Vestbank area (management area 3 in Figure 9.1.5). From 2010, catches have been mainly taken from the Norwegian management areas 1, 2 and 3, and large catches were taken in area 4 in 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 time periods. Because the model estimates the parameter from several years of data, the time series for the most recent period is updated for all years as the parameter b is updated with the most recent data. More information can be found in the stock annex.

9.1.7 Sampling the catch

Sampling activity for commercial catches is shown in Table 9.1.8.

9.1.8 Survey indices

Abundance of sandeel is monitored by a Danish dredge survey (covering SA 1–3) and a Scottish dredge survey (SA 4) in 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 2016 was carried out as planned and nearly all planed positions were covered in accordance with the survey protocol without notable problems related to weather or other potentially obstructive factors. All data were included in the estimated dredge index by area.

9.2 Sandeel in SA 1

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 2016, the proportion 1-group was 7%, corresponding to the very low catch of 0-group in the 2015 dredge survey (Figure 9.2.1).

9.2.2 Weight at age

The methods applied to compile age-length-weight keys and mean weights at age in the catches and in the stock are described in the Stock Annex.

The mean weights at age observed in the catch are given in Table 9.2.2 and Figure 9.2.2 by half year. Mean weight at age in the first half year was decreasing in 2010–2012 and has been increasing slightly since 2013. The second half year shows a more variable mean weight, most likely due to limited sampling.

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

3-year averages of natural mortality at age from multispecies modelling of southern sandeel (SMS, WGSAM 2015) were used. The last value provided is 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. 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 in 2016 was very low.

The average CPUE in the period 1994 to 2002 was around 60 t^{-day}. In 2003, CPUE declined to the all-time lowest at 21 t^{-day}. Since 2004, the CPUE has increased and reached the all-time highest (101 t^{-day}) in 2010 followed by progressively lower CPUEs ending with CPUEs in 2014 below long term average. CPUE in 2015 and 2016 were above average.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

CPUE data from the dredge survey (Table 9.2.4 and Figure 9.2.5) in 2015 show the lowest observed index for age 0 and a lower than average index for the 1-group. In 2016, the dredge index is the 3rd largest index in the time series for age 0.

The internal consistency, i.e. the ability of the survey to follow cohorts, (Figure 9.2.4) shows a low correlation between the 0-group and 1-group. This can be a result of highly variable total mortality.

9.2.6 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 1983 to 2016. 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 three year ranges used. The "age selection" ("F, age effect" in the table) shows a change in the fishery pattern where the fishery was mainly targeting the age 2+ sandeel in the beginning of the assessment period, to a fishery targeting age 1+ in a similar way.

The CV of the dredge survey ("sqrt (Survey variance) ~CV" in the table) is low (0.45) for age 0 and moderate (0.74) for age 1. The survey residual plot (Figure 9.2.6) shows a tendency to clusters of residuals for the 0 group.

The CV of the RTM time series is moderate (0.60) for age 1 and low (0.43) 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 (0.339) for age 1 and age 2 in the first half of the year and moderate to high (> 0.68) for the remaining ages and season combinations. The catch at age residuals (Figure 9.2.7) show no alarming patterns, except for a tendency to negative residuals (observed catch is less than model catch) for age 1 in 2013–2016.

The CV of the fitted Stock recruitment relationship (Table 9.2.5) is high (0.813), 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 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 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 9.2.10) are in general small. The overall pattern with a lower F:effort ratio for older data indicates that the model assumption of no efficiency creeping is violated across periods but not within catchability periods..

9.2.7 Final assessment

The output from the assessment is presented in Tables 9.2.6 (fishing mortality at age by year), 9.2.7 (fishing mortality at age by half year), 9.2.9 (stock numbers at age) and 9.2.10 (stock summary).

9.2.8 Historic Stock Trends

The stock summary (Figure 9.2.13 and Table 9.2.10) shows that SSB have been at or below B_{lim} from 2004 to 2007 and again in 2014. Since 2008, SSB has been above B_{lim} but below B_{pa} in 2008, 2010, 2013 and 2015. SSB is estimated substantially above B_{pa} in 2016 and 2017. $F_{(1-2)}$ is estimated to have been below the long-time average since 2010. Recruitment in 2015 is estimated to be the second lowest observed in the time series.

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 2017 is the geometric mean of the recruitment 1983–2015 (135 billion at age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2016. 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 2012–2016. 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 a fishing mortality no larger than the Fcap of 0.5, a TAC of 259 915 t should be set for 2017. This will leave SSB at 232 000 t, well above the MSY $B_{trigger}$ of 145 000 t in 2018 and predicted F exactly at Fcap (0.5). The TAC according to the escapement strategy is therefore 259 915 t in 2017.

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.

9.2.11.1 Status of the Stock

Recruitment in 2014 at around long term average and the restrictive F below average in 2015 and particularly in 2016 resulted in SSB above B_{pa} in 2017. The introduction of a new high recruitment in 2016 provides confidence that the stock will maintain a stock size above MSY $B_{trigger}$.

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 meeting in 2014 (ICES, 2014a) 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}. A preliminary attempt to establish an optimal F_{cap} for SA 1 (in accordance with the concepts of a conventional management strategy evaluation and a selection criteria of 0.05 probability of SSB < B_{lim}), suggested an F_{cap} of 0.5 (ICES 2016).

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 strong indications of area misreporting for other nations in 2015, and similar management measures as used for the Danish fishery seems to be necessary for other nations as well.

Self-sampling on board the commercial vessels for biological data should be mandatory for all nations utilising a monitoring TAC. Today samples are only obtained from the Danish fishery.

9.3 Sandeel in SA 2

9.3.1 Catch data

Total catch weight by year for SA 2 is given in Tables 9.1.29–.1.4. Catch numbers at age by half-year is given in Table 9.3.1.

The proportion of the 1-group in the catch has decreased since 2013 (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.

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.

9.3.5 Effort and research vessel data

Trends in overall effort and CPUE

Table 9.1.5–9.1.7 and Figure 9.3.3 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size, and does not take changes in efficiency into account.

Total international standardized effort and CPUE in 2016 were the lowest on record.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

The dredge survey in SA 2 (Table 9.3.4 and Figure 9.3.5) increased coverage in 2010 and this is therefore used as the start year of the dredge time series for the assessment. The coverage has however varied somewhat in this period and the time series is still short. Details about the dredge survey are given in the Stock Annex and the benchmark report (ICES, 2016).

9.3.6 Data analysis

The diagnostics output from SMS-effort are shown in Table 9.3.5.

The CV of the dredge survey (Table 9.3.5) is low (0.36) 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 (0.332) in the first half of the year and medium or high 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 bias for this time series for ages 1 and 2 in the first half year.

The CV of the fitted Stock recruitment relationship (Table 9.3.5) is high (0.99) which is also indicated by the stock recruitment plot (Figure 9.3.8). The high CV of recruitment is probably due to the biological characteristics of the stock and less due to the quality of the assessment.

The retrospective analysis (Figure 9.3.9) shows consistent assessment results from one year to the next. There seems to have been a slight overestimation of SSB in 2015 as a result of an overestimation of recruitment in 2014, but there is no repeated pattern or bias.

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 2010–2016, the relation between effort and F varies between these periods. It is seen that 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).

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. SSB have been at or below B_{lim} in 1989, 2002, from 2004 to 2010 and again in 2013 and 2016. Since 2010, SSB has been below B_{pa} in all years except 2001, 2003 and 2011. F(1–2) is estimated to have been below the long-time average since 2010. Recruitment in 2016 is estimated based on the dredge survey to be the second highest observed in the time series.

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 2016 is the geometric mean of the recruitment 1983–2015 (53 billion at age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2016. 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 value for the years 2012–2016. 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 179 181 t in 2017 will result in a fishing mortality of 0.45, identical to Fcap, and leave SSB at 258 000 t, well above MSY $B_{trigger}$ of 84 000 t, in 2018. The TAC according to the escapement strategy is therefore 179 181 t in 2017.

9.3.10 Biological reference points

B_{lim} is set at 56 000 t and B_{pa} at 84 000 t. MSY $B_{trigger}$ is set at B_{pa}. Fcap is set at 0.45 (ICES 2016). Further information about biological reference points can be found in the Stock Annex.

9.3.11 Quality of the assessment

This stock was benchmarked in between the 2016 and 2017 assessments where 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 with a low retrospective pattern. The dredge survey time-series in SA2 is still short (2010-2016) and the quality of the assessment will likely improve once a longer time-series becomes available.

9.3.12 Status of the Stock

A low F in most of the years since 2010 in combination with a moderate recruitment have given a moderate increase in SSB since the historical low values in 2004 to 2010. SSB in 2016 and 2017 are estimated below B_{pim}. Recruitment in 2016 is estimated to be the second highest on record.

9.3.13 Management considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species such as sandeel is the escapement strategy, i.e. to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Management strategy evaluations (ICES, 2016) established that the escapement-strategy is not sustainable for short-lived species, unless the strategy is combined with a ceiling (F_{cap}) on the fishing mortality and estimated this F_{cap} for SA2r sandeel at 0.45. This means that if the TAC that results from the Escapement-strategy corresponds to an F_{bar} that exceeds F_{cap}, then the Escapement-strategy is disqualified and the TAC is instead determined based on a fishing mortality corresponding to F_{cap}.

9.4 Sandeel in SA 3

9.4.1 Catch data

Total catch weight by year for SA 3 is given in Tables 9.1.2–9.1.4. Catch numbers at age by half-year is given in Table 9.4.1.

The proportions of age groups in the 2013–2015 catches are quite similar with approximately 65% 1-group, but in 2016, the 2-group provided the largest contribution to the catches similar to what has been reported in 2011 when the large 2009 year class were 2 years old (Figure 9.4.1).

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 of age 3–4+ in the first half-year has increased since 2013 and is now around or above long term average.

9.4.3 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 9.4.3.

9.4.4 Natural mortality

3-year averages of natural mortality at age from multispecies modelling of southern sandeel (SMS, WGSAM 2015, ICES 2016) were used. The last value provided is used for all years following the latest data point. More details are given in the stock annex. Natural mortalities are listed in Table 9.4.8.

9.4.5 Effort and research vessel data

Trends in overall effort and CPUE

Tables 9.1.5–9.1.7 and Figure 9.4.3 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size, and does not take changes in efficiency into account. Total international standardized effort peaked in 1998, and declined thereafter and has been less than 2000 days per year since 2003.

Tuning series used in the assessments

CPUE data from the dredge survey (Table 9.4.4 and Figure 9.4.5) in 2016 show the highest observed index for age 0 and the lowest observed index for the age-1 in the time series (Table 9.4.4). The internal consistency plot (Figure 9.4.4) shows high consistency for age 0 vs. age 1. In 2014, 13 new positions were included in the survey in SA 3. 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 (2009-2016) carried out in Norwegian EEZ is used as tuning series in the assessment in sandeel area 3 (table 9.4.13 and figures 9.4.14-9.4.16). The survey covers the main sandeel grounds in area 3. The acoustic estimate in number of individuals by age and survey is presented in Table 9.4.12. The age 1 index in 2016 was very low supporting the low dredge survey estimate of the cohort. The age 2 index in 2016 is above average.

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 (0.88) and age 1 (0.78), 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 positive residuals from 2007–2011 for the 0 group followed by negative residual, while the residuals for the 1-group are more randomly distributed. The internal consistency of the survey seems to indicate the large and small yearclasses 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 low for both age 0 (0.88) and age 1 (0.78), showing an overall medium consistency between the results from the dredge survey and the overall model results. The acoustic survey residuals (Figure 9.4.15) plot shows a series of positive residuals from 2007–2011 for the 0 group followed by negative residual, while the residuals for the 1-group are more randomly distributed.

The model CV of catch at age is medium (0.63) 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. The catch residual plots for catch at age (Figure 9.4.7) confirm that the fits are generally very poor except for age 1 and 2 in the first half year. There is a tendency for cluster of negative or positive residuals for ages 1 and 2.

The CV of the fitted stock recruitment relationship (Table 9.4.5) is high (1.10), which is also indicated by the stock recruitment plot (Figure 9.4.8). The high CV of recruitment is probably due to the biological characteristics of the stock and less due to the quality of the assessment. The *a priori* weight on likelihood contributions from SSR-R observations is therefore set low (0.01 in "objective function weight" in Table 9.4.5) such that SSB-R estimates do not contribute much to the overall model likelihood and fit.

There is a large retrospective pattern in the recruitment that consistently over-estimates recruitment by more than 100%.

Uncertainties of the estimated SSB, F and recruitment (Figure 9.4.10) are in general medium, which gives wide confidence limits (Figure 9.4.11) on output variables. Please note that the confidence limits in Figure 9.4.11 assume a normally distributed F, SSB and recruitment, where an assumption of a log-normal distribution would probably be more correct. The age 0 dredge survey index for the 2016 year class is very high, but the dredge survey has a large CV as estimated by the assessment and the CV of the estimated recruitment in 2016 is 0.99.

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, 1999–2016, 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 and 2014, both produced by SSBa arouond B_{lim}, have resulted in SSB above B_{pa} in 2015 onwards.

The estimated recruitment in 2016 is the highest in the time series, whereas the recruitment in 2015 is estimated as the lowest observed.

9.4.9 Short-term forecasts

Input

Input to the short term forecast is given in Table 9.4.11. Stock numbers in the TAC year are taken from the assessment for age 2 and older. Recruitment in 2016 and 2017 is the geometric mean of the recruitment 1986–2015 (93 billion at age 0). This recruitment was used for 2016 rather than the recruitment derived from the 2016 0-group dredge index due to the very large retrospective pattern in the assessment. The exploitation pattern and F_{sq} is taken from the assessment values in 2016. 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 for the years 2012–2016. 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 159 711 t in 2017 will result in a fishing mortality of 0.30, identical to F_{cap}, and leave SSB at 272 000 t, well above MSY $B_{trigger}$ of 129 000 t, in 2018. The TAC according to the escapement strategy is therefore 159 711 t in 2017.

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 3 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 over-estimates the recruitment. The age 0 dredge survey index for the 2016 year class is high, but the dredge survey also has a large survey CV as estimated by the assessment. These patterns may be caused by a variety of issues in the assessment, most likely of which are the shift in 2011 from using Danish to using Norwegian effort data and the change in the spatial coverage of the dredge survey. Even though the new assessment for SA 3 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} in 2015, due to above average recruitment in 2013 and 2014 combined with a low fishing mortality. Recruitment estimate for 2016 is highly uncertain but is likely to be above average.

9.4.13 Management Considerations

Based on the misreporting of catches as observed in 2014, management measures to avoid area misreporting (only one fishing area per trip) have been mandatory for the Danish fishery since 2015. There are strong indications of area misreporting for other nations in 2015, and similar management measures as used for the Danish fishery seems to be necessary for other nations as well.

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 2016, the 2-group dominated the catches similar to the situation in 1998, 2001 and 2005 (Figure 9.5.1).

9.5.2 Weight at age

The methods applied to compile age-length-weight keys and mean weights at age in the catches and in the stock are described in the Stock Annex. The mean weights at age observed in the catch are given in Table 9.5.2 and Figure 9.5.2 by half year. Mean weight at age in the first half year seems to have recovered to historical levels after the very low levels in 2001 to 2005. The second half year mean weights are affected by the very limited sampling at this time of year.

9.5.3 Maturity

Maturity estimates are obtained from the average observed in the dredge survey in December as described in the Stock Annex. Maturities are listed in Table 9.5.3.

9.5.4 Natural mortality

Long term averages of natural mortality at age from multispecies modelling of northern sandeel (SMS, WGSAM 2015, ICES 2016) were used. More details are given in the stock annex. Natural mortalities are listed in Table 9.5.8.

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. Effort since 2004 has been extremely low. CPUE in later years has been around the average prior to 2004.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

CPUE data from the dredge survey (Table 9.5.4 and Figure 9.5.5) show that the 2016 year class is above the average observed since 2008 whereas the index for age 1 is low.

The internal consistency, i.e. the ability of the survey to follow cohorts, (Figure 9.5.4) shows a low correlation between the 0-group and 1-group. This can be a result of highly variable total mortality.

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 2016. 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 cacthes 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 (0.67) for age 1 and age 2. The catch at age residuals (Figure 9.5.6) show no alarming patterns, except for a tendency to positive residuals (observed catch is higher than model catch) for age 1 in the beginning of the time series.

The CV of the fitted Stock recruitment relationship (Table 9.5.5) is high (1.20), 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 and 2017. $F_{(1-2)}$ is estimated to have been very low since 2005. Recruitment in 2014 and 2016 are estimated to be above average.

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 2017 is the geometric mean of the recruitment 1993–2015 (69 billion at age 0). The exploitation pattern and F_{sq} is taken from the assessment values in 2016. 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 for the years 2012–2016. Natural mortality and maturity are as applied in the assessment in final year. The Stock Annex gives more details about the forecast methodology.

Output

The short term forecast (Table 9.5.12) shows that to obtain a fishing mortality no larger than the Fcap of 0.15, a TAC of 54 043 t should be set for 2017. This will leave SSB at 181 000 t, well above the MSY $B_{trigger}$ of 102 000 t in 2018 and predicted F exactly at F_{cap} (0.15). The TAC according to the escapement strategy is therefore 54 043 t in 2017.

Part of the sandeel banks in SA4 are closed for fisheries. Between 1983-1999 (before the fishery was closed) 51% of the catches were taken in this area. The assessment and reference points are based on the entire stock including those sandeels distributed in the closed areas. Taking the full catch in the open banks may increase the risk of local depletion. There is exchange of sandeels between the closed and open banks in sandeel area 4, but restocking distant depleted banks in the open area sourced exclusively from the closed area may take years.

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 is initiated this year 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 CVs on SSB in 2017 is high (0.43). The assessment accuracy is likely to improve if catches are increased.

9.5.10.2 Status of the Stock

Recruitment in 2014 and 2016 are both above the long term average. A very restrictive F since 2005 together with the return of recruitment to historic levels has resulted in SSB above B_{pa} in 2016 and 2017. The introduction of a new high recruitment in 2016 provides confidence that the stock will maintain a stock size above MSY $B_{trigger}$.

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 meeting in 2014 (ICES, 2014a) 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).

Part of the sandeel banks in SA4 are closed for fisheries. Between 1983–1999 (before the fishery was closed), 51% of the catches were taken in this area. The assessment and reference points are based on the entire stock including those sandeels distributed in the closed areas. Taking the full catch in the open banks will increase the risk of local depletion. There is exchange of sandeels between the closed and open banks in sandeel area 4, but restocking distant depleted banks in the open area sourced exclusively from the closed area may take years.

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 a low biomass of sandeel on Vikingbanken (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.

Table 9.1.1 Sandeel. Catches ('000 t), 1955-2016. (Data provided by Working Group Members).

YEAR	DENMARK	GERMANY	FAROES	IRELAND	NETHERLANDS	NORWAY	SWEDEN	UK	LITHUANIA	TOTAL
1952	1.6	-	-	-	-	-	-	-	-	1.6
1953	4.5	-	-	-	-	-	-	-	-	4.5
1954	10.8	-	-	-	-	-	-	-	-	10.8
1955	37.6	-	-	-	-	-	-	-	-	37.6
1956	81.9	5.3	-	-	-	1.5	-	-	-	88.7
1957	73.3	25.5	-	-	3.7	3.2	-	-	-	105.7
1958	74.4	20.2	-	-	1.5	4.8	-	-	-	100.9
1959	77.1	17.4	-	-	5.1	8	-	-	-	107.6
1960	100.8	7.7	-	-	-	12.1	-	-	-	120.6
1961	73.6	4.5	-	-	-	5.1	-	-	-	83.2
1962	97.4	1.4	-	-	-	10.5	-	-	-	109.3
1963	134.4	16.4	-	-	-	11.5	-	-	-	162.3
1964	104.7	12.9	-	-	-	10.4	-	-	-	128.0
1965	123.6	2.1	-	-	-	4.9	-	-	-	130.6
1966	138.5	4.4	-	-	-	0.2	-	-	-	143.1
1967	187.4	0.3	-	-	-	1	-	-	-	188.7
1968	193.6	-	-	-	-	0.1	-	-	-	193.7
1969	112.8	-	-	-	-	-	-	0.5	-	113.3
1970	187.8	-	-	-	-	-	-	3.6	-	191.4
1971	371.6	0.1	-	-	-	2.1	-	8.3	-	382.1
1972	329.0	-	-	-	-	18.6	8.8	2.1	-	358.5
1973	273.0	-	1.4	-	-	17.2	1.1	4.2	-	296.9
1974	424.1	-	6.4	-	-	78.6	0.2	15.5	-	524.8
1975	355.6	-	4.9	-	-	54	0.1	13.6	-	428.2
1976	424.7	-	-	-	-	44.2	-	18.7	-	487.6
1977	664.3	-	11.4	-	-	78.7	5.7	25.5	-	785.6
1978	647.5	-	12.1	-	-	93.5	1.2	32.5	-	786.8
1979	449.8	-	13.2	-	-	101.4	-	13.4	-	577.8
1980	542.2	-	7.2	-	-	144.8	-	34.3	-	728.5
1981	464.4	-	4.9	-	-	52.6	-	46.7	-	568.6
1982	506.9	-	4.9	-	-	46.5	0.4	52.2	-	610.9
1983	485.1	-	2	-	-	12.2	0.2	37	-	536.5
1984	596.3	-	11.3	-	-	28.3	-	32.6	-	668.5
1985	587.6	-	3.9	-	-	13.1	-	17.2	-	621.8
1986	752.5	-	1.2	-	-	82.1	-	12	-	847.8
1987	605.4	-	18.6	-	-	193.4	-	7.2	-	824.6
1988	686.4	-	15.5	-	-	185.1	-	5.8	-	892.8
1989	824.4	-	16.6	-	-	186.8	-	11.5	-	1039.1
1990	496.0	-	2.2	-	0.3	88.9	-	3.9	-	591.3
1991	701.4	-	11.2	-	-	128.8	-	1.2	-	842.6
1992	751.1	-	9.1	-	-	89.3	0.5	4.9	-	854.9
1993	482.2	-	-	-	-	95.5	-	1.5	-	579.2
1994	603.5	-	10.3	-	-	165.8	-	5.9	-	785.5

Year	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	Total
1995	647.8	-	-	-	-	263.4	-	6.7	-	917.9
1996	601.6	-	5	-	-	160.7	-	9.7	-	776.9
1997	751.9	-	11.2	-	-	350.1	-	24.6	-	1137.8
1998	617.8	-	11	-	-	343.3	8.5	23.8	-	1004.4
1999	500.1	-	13.2	0.4	-	187.6	22.4	11.5	-	735.1
2000	541.0	-	-	-	-	119	28.4	10.8	-	699.1
2001	630.8	-	-	-	-	183	46.5	1.3	-	861.6
2002	629.7	-	-	-	-	176	0.1	4.9	-	810.7
2003	274.0	-	-	-	-	29.6	21.5	0.5	-	325.6
2004	277.1	2.7	-	-	-	48.5	33.2	-	-	361.5
2005	154.8	-	-	-	-	17.3	-	-	-	172.1
2006	250.6	3.2	-	-	-	5.6	27.8	-	-	287.9
2007	144.6	1	2	-	-	51.1	6.6	1	-	206.3
2008	234.4	4.4	2.4	-	-	81.6	12.4	-	-	335.2
2009	285.7	12.2	2.5	-	1.8	27.4	12.4	3.6	-	345.6
2010	275.1	13	-	-	-	78	32	4	0.6	402.7
2011	278.5	9.8	-	-	-	109	32.7	6.1	1.65	437.8
2012	51.5	1.706	-	-	-	42.46	5.652	-	-	101.4
2013	208.7	7.9	-	-	0.4	30.446	26.8	2.436	1.3	278.0
2014	148.0	5.052	-	-	-	82.499	18.815	0.03	0.825	255.2
2015	163.2	9.097	-	-	-	100.859	33.439	2	-	308.6
2016	26.9	-	-	-	-	40.867	4.139	-	-	71.9

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	377473	100425	469183	58746	2952	941	5121	1014841
1999	425444	70520	193093	53334	145	132	4415	747083
2000	374724	100517	196572	37792	303	684	4371	714963
2001	540246	95833	197308	47918	1678	306	971	884260
2002	610126	117559	116310	12761	8	2386	453	859604
2003	178638	54863	35965	64048	44	900	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	43403	75391	11	4	652	0	229855
2008	236081	35123	74992	1168	0	472	0	347836
2009	309591	36709	6362	0	0	260	0	352922
2010	300893	51640	61243	275	0	132	0	414183
2011	319656	24897	92452	272	0	484	0	437761
2012	46117	12552	40134	2585	0	211	0	101599
2013	214981	47847	9844	5225	0	90	0	277989
2014	98732	65087	95464	4414	0	65	0	263762
2015	164770	37901	104631	4392	0	199	0	311894
2016	14316	9238	43973	5770	0	123	0	73420
arith. mean	309738	106655	152656	30948	6347	1430	1075	608850

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	357163	71203	350839	57212	2851	939	4472	844679
1999	395781	26753	94654	51179	145	21	2152	570684
2000	333044	81531	192521	37792	288	683	3808	649668
2001	368780	43993	60105	47492	1678	57	735	522841
2002	604549	102616	115749	12761	8	2386	101	838171
2003	155003	25479	22803	62578	44	848	187	266941
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	43402	75391	11	4	651	0	229848
2008	232262	32296	74992	1168	0	471	0	341189
2009	293416	24637	6225	0	0	259	0	324538
2010	293355	44115	60952	275	0	132	0	398830
2011	316746	23325	92452	272	0	484	0	433278
2012	46109	11389	40134	2585	0	211	0	100428
2013	207493	43207	9844	5225	0	90	0	265860
2014	93837	62468	95464	4414	0	64	0	256248
2015	164769	37136	104631	4392	0	199	0	311127
2016	14316	9190	43973	5770	0	123	0	73372
arith. mean	278995	75046	125521	25789	5822	1305	851	513328

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	20311	29222	118343	1533	101	1	649	170162
1999	29663	43767	98439	2154	0	111	2263	176399
2000	41680	18986	4051	0	15	1	562	65295
2001	171466	51840	137203	426	0	248	236	361419
2002	5576	14944	561	0	0	0	352	21433
2003	23635	29385	13162	1469	0	52	73	67777
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	1	0	7
2008	3819	2828	0	0	0	0	0	6647
2009	16175	12072	137	0	0	0	0	28384
2010	7537	7525	291	0	0	0	0	15353
2011	2910	1572	0	0	0	0	0	4483
2012	8	1163	0	0	0	0	0	1171
2013	7489	4640	0	0	0	0	0	12128
2014	4895	2619	0	0	0	0	0	7515
2015	1	765	0	0	0	0	0	767
2016	0	48	0	0	0	0	0	48
arith. mean	30742	31609	27136	5160	525	125	225	95521

Table 9.1.5 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, as estimated by ICES.

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	8992	4719	864	63	0	9	0	14649
1984	10166	4009	1378	48	212	50	37	15901
1985	10876	3570	619	655	139	65	0	15923
1986	7372	5038	4641	284	12	469	145	17962
1987	5680	1153	5094	177	64	45	0	12213
1988	7980	3876	7472	42	0	90	0	19460
1989	8553	6552	7677	57	31	44	0	22914
1990	8529	4209	5143	55	0	24	0	17960
1991	5991	5117	5864	338	19	1	0	17330
1992	8805	4944	2383	571	0	197	0	16900
1993	3893	4396	5124	1387	29	265	0	15093
1994	3149	4230	4854	1588	0	114	0	13934
1995	5899	2497	3791	437	1915	50	0	14589
1996	5497	4608	4352	1464	605	48	0	16573
1997	5366	5308	7749	622	0	60	6	19111
1998	6662	2770	10925	609	94	26	0	21087
1999	8899	1987	6163	850	0	1	0	17900
2000	7141	2558	4118	421	5	16	149	14408
2001	11021	2452	4751	669	0	2	0	18895
2002	8161	3088	2515	140	1	65	0	13970
2003	6805	2292	1652	1098	19	48	0	11914
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	861	1214	1	0	17	0	3654
2008	2878	890	1345	7	0	14	0	5136
2009	3550	791	115	0	0	10	0	4465
2010	2859	1118	1463	4	0	12	0	5455
2011	3168	713	924	7	0	18	0	4829
2012	587	467	561	67	0	13	0	1695
2013	3883	1788	273	38	0	10	0	5992
2014	2205	1424	1096	50	0	4	0	4778
2015	2071	1183	1441	40	0	6	0	4740
2016	136	413	559	73	0	6	0	1187
arith. mean	5675	2812	3178	357	92	54	10	12179

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	6095	1735	6983	575	91	26	0	15505
1999	7875	752	3204	850	0	1	0	12682
2000	6181	1970	4041	421	5	16	149	12782
2001	8041	1215	1685	656	0	2	0	11600
2002	7942	2424	2515	140	1	65	0	13085
2003	5907	1049	1246	1027	19	48	0	9296
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	861	1214	1	0	17	0	3654
2008	2793	789	1345	7	0	14	0	4950
2009	3376	590	113	0	0	10	0	4088
2010	2725	932	1453	4	0	12	0	5124
2011	3074	645	924	7	0	18	0	4667
2012	587	442	561	67	0	13	0	1670
2013	3697	1595	273	38	0	10	0	5613
2014	2122	1352	1093	50	0	4	0	4621
2015	2071	1164	1441	40	0	6	0	4721
2016	136	399	559	73	0	6	0	1173
arith. mean	4958	1941	2516	296	87	50	8	9857

Table 9.1.7 Sandeel. Effort (days fishing for a standard 200 GT vessel) by area, second half year as estimated by ICES.

	Area 1r	Area 2r	Area 3r	Area 4	Area 5r	Area 6	Area 7r	All
1983	2066	1687	126	0	0	0	0	3879
1984	2256	1538	207	0	0	4	0	4005
1985	2427	1005	110	3	0	35	0	3582
1986	804	1154	2133	3	8	32	64	4199
1987	1393	374	31	16	0	3	0	1817
1988	809	1215	1442	2	0	22	0	3490
1989	313	1700	92	0	0	1	0	2106
1990	520	828	1405	5	0	0	0	2759
1991	1403	1579	1113	227	0	0	0	4322
1992	879	1151	93	262	0	0	0	2385
1993	398	1799	1174	187	0	10	0	3567
1994	297	1133	443	178	0	16	0	2067
1995	601	970	201	1	0	0	0	1774
1996	691	2981	1205	945	163	0	0	5986
1997	1369	1868	1854	132	0	7	6	5237
1998	568	1035	3941	35	2	0	0	5582
1999	1024	1235	2959	0	0	0	0	5218
2000	960	588	78	0	0	0	0	1626
2001	2979	1237	3066	13	0	0	0	7295
2002	220	665	0	0	0	0	0	884
2003	898	1242	406	71	0	0	0	2618
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	101	0	0	0	0	0	186
2009	174	201	2	0	0	0	0	377
2010	134	186	10	0	0	0	0	331
2011	94	68	0	0	0	0	0	162
2012	0	25	0	0	0	0	0	25
2013	187	193	0	0	0	0	0	379
2014	82	72	3	0	0	0	0	157
2015	0	19	0	0	0	0	0	19
2016	0	14	0	0	0	0	0	14
arith. mean	717	870	662	61	5	4	2	2322

Table 9.1.8 Sandeel. Number of samples from commercial catches by year and area.

	Area 4	Area 6	Area 1r	Area 2r	Area 3r	Area 5r	Area 7r	All
1983	0	0	79	49	0	0	0	128
1984	0	3	116	46	13	2	0	180
1985	19	3	101	32	1	2	0	158
1986	1	1	26	17	27	0	0	72
1987	1	1	62	12	60	0	0	136
1988	0	1	42	15	67	0	0	125
1989	0	1	40	9	43	0	0	93
1990	0	2	1	4	37	0	0	44
1991	1	0	25	32	30	0	0	88
1992	4	7	56	42	24	0	0	133
1993	15	7	23	63	64	0	0	172
1994	15	4	20	38	50	0	0	127
1995	7	2	41	32	58	7	0	147
1996	27	1	43	62	113	19	0	265
1997	25	3	41	84	116	8	0	277
1998	7	2	70	34	176	0	0	289
1999	44	1	263	50	42	0	0	400
2000	59	2	102	48	47	0	0	258
2001	90	1	213	42	33	1	0	380
2002	62	1	288	99	50	0	0	500
2003	160	2	281	79	30	0	0	552
2004	47	1	451	217	26	0	0	742
2005	30	1	320	42	34	0	0	427
2006	2	2	550	56	72	0	0	682
2007	0	1	295	166	108	0	0	570
2008	1	0	290	127	49	0	0	467
2009	0	1	302	122	12	0	0	437
2010	1	3	169	270	40	0	0	483
2011	4	4	167	54	17	0	0	246
2012	21	12	220	112	31	0	0	396
2013	5	3	292	220	41	0	0	561
2014	18	5	143	133	29	0	0	328
2015	38	4	309	117	48	0	0	516
2016	35	0	154	159	42	0	0	390
Sum	739	82	5595	2684	1630	39	0	10769

Table 9.2.1 Sandeel Area-1r. Catch at age numbers (million) by half year.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	10223	1846	264	28971	3085	772	564	320	2
1984	0	47117	9241	1701	90	10002	566	333	43
1985	8524	6217	1354	31364	2305	1987	1595	211	213
1986	87	44940	4163	7553	228	1652	188	31	14
1987	187	4504	1938	23572	4173	1199	123	171	32
1988	0	1997	0	8564	162	15229	1439	2354	47
1989	0	62503	757	6364	77	1346	16	4736	58
1990	522	16846	1257	13917	417	2060	62	622	18
1991	7344	14939	6917	6870	209	983	67	338	0
1992	104	50883	3041	8451	298	845	122	524	26
1993	1624	2181	362	5882	271	1638	156	491	43
1994	0	22172	1533	2669	126	1195	55	882	78
1995	76	36677	3440	6236	940	737	109	289	28
1996	6470	10402	1064	12301	1027	4527	211	860	65
1997	19	38667	8899	2332	177	3522	164	713	56
1998	211	9387	438	28364	1384	2164	136	1505	90
1999	440	44621	2498	5433	205	10158	717	699	149
2000	7887	32625	2760	3355	170	630	84	1076	122
2001	47080	56780	3127	8549	474	1098	49	972	98
2002	16	84878	605	10772	108	1212	15	225	6
2003	2474	3843	386	13302	4390	1117	141	302	31
2004	566	30654	2479	786	110	2364	230	480	47
2005	44	11106	383	4435	211	263	14	435	27
2006	37	33600	800	2590	94	817	43	163	19
2007	0	10581	0	4674	0	315	0	172	0
2008	6	26735	281	4009	75	1205	33	214	6
2009	979	18898	2254	14265	278	1556	12	392	3
2010	10	39951	1184	2130	35	942	16	108	2
2011	5	1894	39	32692	325	1305	14	266	1
2012	0	383	0	419	0	3354	0	129	0
2013	3	18090	598	7916	131	2182	100	4301	49
2014	925	8930	131	3354	98	401	23	360	25
2015	0	25326	0	1918	0	579	0	172	0
2016	0	199	0	1116	0	91	0	16	0
arith. mean	2819	24129	1829	9318	637	2337	208	731	41

Table 9.2.2 Sandeel Area-1r. Individual mean weight (gram) at age in the catch and in the sea.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	3.3	4.9	4.0	9.7	8.3	17.2	13.2	20.5	11.6
1984	3.7	5.5	7.3	10.1	12.8	14.1	16.8	13.4	15.8
1985	3.0	5.1	5.8	9.2	10.7	16.4	12.9	17.9	16.6
1986	3.0	5.3	7.5	11.7	12.7	11.7	12.8	13.6	14.7
1987	4.0	7.2	7.8	10.6	11.2	18.5	20.2	14.7	16.1
1988	3.9	6.1	6.8	10.4	12.0	16.0	17.0	17.8	24.4
1989	6.2	5.0	9.6	8.6	15.5	9.1	17.2	12.0	28.3
1990	5.0	6.6	9.0	9.6	13.1	14.2	19.3	17.0	23.1
1991	3.8	7.8	6.1	14.2	11.8	37.8	32.0	19.6	17.2
1992	4.9	7.8	9.5	11.9	15.3	17.7	19.7	19.0	21.2
1993	4.0	7.3	7.5	11.5	10.5	14.4	13.6	20.2	18.2
1994	4.4	5.5	7.6	8.7	12.3	12.7	16.3	19.8	18.8
1995	3.8	7.6	6.8	11.3	9.9	14.1	14.1	19.0	19.0
1996	2.9	5.6	4.6	8.4	7.6	12.2	9.5	17.7	14.2
1997	3.7	7.3	8.5	8.3	14.2	9.9	15.5	14.4	16.1
1998	3.2	6.3	6.7	8.9	10.0	11.5	11.9	13.5	14.5
1999	3.4	5.3	5.9	7.5	9.6	10.3	12.8	13.1	14.7
2000	3.1	6.3	4.8	8.7	7.9	11.9	10.6	14.5	12.2
2001	3.1	4.5	5.0	8.7	12.1	11.5	16.5	16.6	23.6
2002	3.8	6.0	6.7	7.4	10.8	9.8	14.4	13.8	16.5
2003	2.2	3.6	2.7	7.2	3.6	9.5	8.4	12.8	9.1
2004	3.5	5.1	4.5	8.3	6.6	9.0	6.7	10.4	8.8
2005	3.0	6.5	5.3	8.7	8.5	10.3	11.3	12.1	13.0
2006	3.2	5.9	5.5	9.7	8.9	11.6	11.9	13.0	13.7
2007	4.1	5.6	7.0	9.4	11.3	13.5	15.1	14.7	17.3
2008	4.5	6.3	7.8	10.9	12.6	13.3	16.8	15.8	19.3
2009	2.8	6.2	4.9	9.4	7.9	12.1	10.5	13.2	12.1
2010	3.4	6.3	5.9	12.4	9.5	13.9	12.6	17.2	14.5
2011	2.8	5.3	4.9	8.7	7.8	12.7	10.4	14.8	12.0
2012	3.8	6.4	6.6	9.5	10.6	11.3	14.1	14.5	16.2
2013	3.8	4.7	6.5	6.5	10.5	10.1	14.0	11.3	16.1
2014	3.0	4.7	5.2	7.1	8.5	9.5	11.3	11.7	13.0
2015	4.0	5.5	6.9	8.3	11.1	10.6	14.8	14.0	17.0
2016	3.2	5.2	5.4	10.1	8.7	12.5	11.6	14.7	13.3
arith. mean	3.6	5.9	6.4	9.5	10.4	13.3	14.3	15.3	16.2

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 (number/hour).

Year	Age 0	Age 1
2004	86891.14	4399.102
2005	170536.02	2030.995
2006	70607.42	7621.967
2007	248676.90	3187.030
2008	21605.09	7940.210
2009	291052.79	5608.769
2010	30428.17	77238.857
2011	46666.61	16758.092
2012	83671.87	2446.926
2013	49079.17	8129.475
2014	144035.92	2099.550
2015	13845.53	8285.101
2016	187529.01	4510.240

Table 9.2.5 Sandeel Area-1r. SMS settings and statistics.

```
Date:  01/20/17    Start  time:12:02:38  run  time:3  seconds

 objective  function  (negative  log  likelihood):   0.665342
 Number              of            parameters:            75
 Maximum                 gradient:                3.44742e-005
 Akaike   information   criterion   (AIC):             151.331
 Number   of   observations   used   in   the   likelihood:
                              Catch   CPUE    S/R Stomach    Sum
                                306     56     34       0    396

 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
                  6.1    -5.9    10.0     0.0     0.0     0.00
10


 unweighted objective function contributions (per observation):
                 Catch       CPUE           S/R       Stomachs
                 0.02       -0.11          0.29           0.00


 contribution                    by                     fleet:
 ----------------------
 RTM  2007-2016          total:    -4.839      mean:    -0.161
 Dredge  survey  2004-2016     total:   -1.092    mean:   -0.042

 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
     2010-2016:                               0.000      1.000
 age:                    1                   -               4
     1983-1988:                               0.439      0.500
     1989-1998:                               0.461      0.500
     1999-2004:                               0.382      0.500
     2005-2009:                               0.284      0.500
     2010-2016:                               0.514      0.500

 F,                           age                      effect:
 --------------
                 0          1          2          3          4
 1983-1988:    0.020      0.215      0.838      1.321      1.321
 1989-1998:    0.011      0.502      0.671      0.710      0.710
```

```
1999-2004:      0.070      1.076      1.189      1.148      1.148
2005-2009:      0.006      1.269      1.968      2.003      2.003
2010-2016:      0.006      0.198      0.534      0.793      0.793


Exploitation     pattern     (scaled     to     mean     F=1)
--------------------------------------
                         0        1        2        3        4
1983-1988  season  1:        0    0.305    1.188    1.874    1.874
           season  2:    0.019    0.104    0.403    0.636    0.636

1989-1998  season  1:        0    0.822    1.099    1.163    1.163
           season  2:    0.001    0.034    0.045    0.048    0.048

1999-2004  season  1:        0    0.812    0.897    0.866    0.866
           season  2:    0.018    0.138    0.153    0.148    0.148

2005-2009  season  1:        0    0.735    1.140    1.161    1.161
           season  2:    0.000    0.049    0.076    0.077    0.077

2010-2016  season  1:        0    0.516    1.392    2.067    2.067
           season  2:    0.002    0.025    0.067    0.099    0.099


sqrt(catch            variance)            ~            CV:
-------------------------

              season
---------------------
age                         1                          2

 0                                                 1.657
 1                              0.339              0.586
 2                              0.339              0.586
 3                              0.595              0.898
 4                              0.595              0.898


Survey                                      catchability:
-------------------
                              age 0     age 1     age 2     age 3
 RTM 2007-2016                         0.749     1.372     1.799
 Dredge  survey  2004-2016                   1.994         0.817

sqrt(Survey            variance)            ~            CV:
-------------------------
                              age 0     age 1     age 2     age 3
 RTM 2007-2016                          0.60      0.43      0.53
 Dredge  survey  2004-2016                    0.45          0.74

Recruit-SSB            alfa       beta       recruit s2     recruit
s
Area-1r             1289.259   1.100e+005   0.661           0.813
```

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	0.010	0.240	0.914	1.423	1.423	0.577
1984	0.010	0.272	1.036	1.610	1.610	0.654
1985	0.011	0.293	1.112	1.728	1.728	0.702
1986	0.004	0.208	0.787	1.214	1.213	0.497
1987	0.006	0.154	0.591	0.925	0.924	0.372
1988	0.004	0.227	0.858	1.322	1.320	0.543
1989	0.001	0.804	1.052	1.095	1.095	0.928
1990	0.002	0.798	1.042	1.086	1.086	0.920
1991	0.005	0.531	0.698	0.734	0.734	0.615
1992	0.003	0.799	1.039	1.085	1.085	0.919
1993	0.001	0.352	0.457	0.478	0.478	0.404
1994	0.001	0.285	0.370	0.386	0.386	0.328
1995	0.002	0.526	0.685	0.715	0.715	0.605
1996	0.002	0.493	0.639	0.668	0.668	0.566
1997	0.005	0.463	0.606	0.637	0.636	0.534
1998	0.002	0.605	0.776	0.810	0.809	0.691
1999	0.017	1.087	1.163	1.112	1.111	1.125
2000	0.016	0.875	0.937	0.898	0.898	0.906
2001	0.051	1.339	1.447	1.392	1.392	1.393
2002	0.004	1.032	1.090	1.032	1.032	1.061
2003	0.015	0.864	0.916	0.872	0.872	0.890
2004	0.008	0.904	0.952	0.902	0.902	0.928
2005	0.000	0.919	1.341	1.341	1.341	1.130
2006	0.001	1.116	1.626	1.628	1.623	1.371
2007	0.000	0.429	0.624	0.623	0.620	0.527
2008	0.000	0.786	1.148	1.152	1.148	0.967
2009	0.001	0.972	1.424	1.435	1.435	1.198
2010	0.001	0.289	0.728	1.056	1.056	0.509
2011	0.000	0.329	0.822	1.186	1.186	0.575
2012	0.000	0.062	0.158	0.230	0.230	0.110
2013	0.000	0.387	0.963	1.386	1.386	0.675
2014	0.000	0.229	0.576	0.835	0.835	0.402
2015	0.000	0.219	0.549	0.794	0.794	0.384
2016	0.000	0.014	0.037	0.054	0.054	0.026
arith. mean	0.005	0.556	0.858	0.995	0.995	0.707

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	0.010	0.154	0.052	0.599	0.203	0.945	0.321	0.945	0.321
1984	0.010	0.176	0.057	0.684	0.222	1.079	0.350	1.079	0.350
1985	0.011	0.188	0.061	0.730	0.238	1.151	0.376	1.151	0.376
1986	0.004	0.146	0.020	0.568	0.079	0.896	0.125	0.896	0.125
1987	0.006	0.095	0.035	0.371	0.137	0.585	0.216	0.585	0.216
1988	0.004	0.159	0.020	0.620	0.080	0.978	0.126	0.978	0.126
1989	0.001	0.612	0.025	0.819	0.034	0.866	0.036	0.866	0.036
1990	0.002	0.595	0.042	0.796	0.056	0.842	0.059	0.842	0.059
1991	0.005	0.341	0.113	0.456	0.151	0.482	0.160	0.482	0.160
1992	0.003	0.589	0.071	0.788	0.095	0.833	0.100	0.833	0.100
1993	0.001	0.260	0.032	0.347	0.043	0.367	0.045	0.367	0.045
1994	0.001	0.212	0.024	0.283	0.032	0.300	0.034	0.300	0.034
1995	0.002	0.394	0.048	0.526	0.065	0.557	0.069	0.557	0.069
1996	0.002	0.357	0.056	0.477	0.074	0.505	0.079	0.505	0.079
1997	0.005	0.297	0.110	0.397	0.147	0.420	0.156	0.420	0.156
1998	0.002	0.453	0.046	0.605	0.061	0.641	0.065	0.641	0.065
1999	0.017	0.790	0.135	0.874	0.149	0.843	0.144	0.843	0.144
2000	0.016	0.620	0.126	0.686	0.140	0.662	0.135	0.662	0.135
2001	0.051	0.807	0.392	0.892	0.433	0.861	0.418	0.861	0.418
2002	0.004	0.797	0.029	0.881	0.032	0.850	0.031	0.850	0.031
2003	0.015	0.593	0.118	0.655	0.131	0.632	0.126	0.632	0.126
2004	0.008	0.662	0.060	0.732	0.066	0.706	0.064	0.706	0.064
2005	0.000	0.686	0.046	1.063	0.071	1.082	0.072	1.082	0.072
2006	0.001	0.829	0.065	1.286	0.101	1.309	0.103	1.309	0.103
2007	0.000	0.325	0.000	0.504	0.000	0.513	0.000	0.513	0.000
2008	0.000	0.582	0.031	0.902	0.048	0.918	0.049	0.918	0.049
2009	0.001	0.703	0.064	1.090	0.099	1.110	0.101	1.110	0.101
2010	0.001	0.205	0.010	0.552	0.026	0.820	0.039	0.820	0.039
2011	0.000	0.231	0.007	0.623	0.019	0.925	0.028	0.925	0.028
2012	0.000	0.044	0.000	0.119	0.000	0.177	0.000	0.177	0.000
2013	0.000	0.278	0.000	0.749	0.000	1.113	0.000	1.113	0.000
2014	0.000	0.160	0.006	0.430	0.016	0.639	0.024	0.639	0.024
2015	0.000	0.156	0.000	0.420	0.000	0.623	0.000	0.623	0.000
2016	0.000	0.010	0.000	0.028	0.000	0.041	0.000	0.041	0.000
arith. mean	0.005	0.397	0.056	0.634	0.090	0.743	0.107	0.743	0.107

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	0.599	0.385	0.580	0.346	0.527	0.254	0.472	0.254	0.472
1984	0.573	0.377	0.577	0.343	0.533	0.249	0.479	0.249	0.479
1985	0.615	0.364	0.592	0.332	0.548	0.243	0.498	0.243	0.498
1986	0.663	0.358	0.619	0.332	0.582	0.244	0.531	0.243	0.527
1987	0.675	0.374	0.630	0.347	0.592	0.250	0.542	0.249	0.538
1988	0.695	0.381	0.652	0.352	0.610	0.250	0.554	0.249	0.550
1989	0.666	0.400	0.625	0.368	0.584	0.257	0.527	0.257	0.527
1990	0.666	0.386	0.629	0.349	0.578	0.248	0.521	0.248	0.521
1991	0.621	0.380	0.598	0.335	0.536	0.239	0.482	0.239	0.482
1992	0.577	0.369	0.567	0.315	0.495	0.224	0.443	0.224	0.443
1993	0.545	0.367	0.526	0.302	0.443	0.216	0.396	0.216	0.396
1994	0.540	0.351	0.520	0.288	0.436	0.210	0.388	0.210	0.388
1995	0.517	0.352	0.501	0.288	0.423	0.209	0.377	0.209	0.377
1996	0.542	0.326	0.524	0.269	0.434	0.201	0.389	0.201	0.389
1997	0.552	0.341	0.518	0.269	0.422	0.200	0.375	0.199	0.373
1998	0.605	0.376	0.548	0.279	0.429	0.205	0.381	0.204	0.378
1999	0.618	0.398	0.544	0.290	0.425	0.207	0.375	0.206	0.373
2000	0.621	0.404	0.545	0.298	0.427	0.210	0.380	0.210	0.380
2001	0.637	0.362	0.567	0.279	0.445	0.203	0.392	0.203	0.392
2002	0.683	0.399	0.616	0.302	0.482	0.214	0.418	0.214	0.418
2003	0.714	0.418	0.656	0.319	0.507	0.216	0.436	0.216	0.436
2004	0.717	0.450	0.664	0.330	0.509	0.213	0.436	0.213	0.436
2005	0.707	0.433	0.653	0.318	0.498	0.202	0.429	0.202	0.429
2006	0.727	0.436	0.662	0.305	0.499	0.198	0.432	0.195	0.422
2007	0.747	0.420	0.677	0.300	0.519	0.202	0.459	0.199	0.449
2008	0.740	0.417	0.681	0.293	0.528	0.207	0.477	0.204	0.467
2009	0.744	0.373	0.690	0.277	0.548	0.208	0.506	0.208	0.506
2010	0.810	0.391	0.752	0.277	0.596	0.215	0.552	0.215	0.552
2011	0.876	0.443	0.814	0.310	0.645	0.229	0.592	0.229	0.592
2012	0.871	0.489	0.819	0.339	0.650	0.241	0.596	0.241	0.596
2013	0.871	0.489	0.819	0.339	0.650	0.241	0.596	0.241	0.596
2014	0.871	0.489	0.819	0.339	0.650	0.241	0.596	0.241	0.596
2015	0.871	0.489	0.819	0.339	0.650	0.241	0.596	0.241	0.596
2016	0.871	0.489	0.819	0.339	0.650	0.241	0.596	0.241	0.596
arith. mean	0.687	0.402	0.642	0.315	0.531	0.224	0.477	0.224	0.476

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	363882	16300	54834	3023	248
1984	98646	198011	5053	10268	447
1985	717819	55045	60434	850	1239
1986	108026	383781	16501	9520	216
1987	67748	55460	122341	3463	1616
1988	274136	34274	17835	28784	1034
1989	124806	136306	10192	3385	4426
1990	173179	64050	25848	1677	1447
1991	183084	88811	12276	4365	588
1992	41420	97909	21211	2800	1267
1993	160771	23189	19849	3905	821
1994	220528	93092	7092	6380	1696
1995	57490	128379	30776	2508	3181
1996	379780	34210	35159	8370	1694
1997	58238	220341	9677	10025	3112
1998	109893	33373	62111	2813	4158
1999	149452	59891	8046	15711	1921
2000	245369	79162	9258	1416	3674
2001	392533	129721	14523	1964	1272
2002	25568	197311	15447	1871	497
2003	156324	12866	31296	2830	521
2004	69668	75385	2159	6244	818
2005	159419	33749	12018	420	1708
2006	88470	78579	5484	1710	357
2007	211216	42736	10713	613	269
2008	84324	100071	10310	2853	274
2009	646362	40220	18082	1753	600
2010	46573	306968	6453	2412	343
2011	58614	20705	78966	1511	542
2012	138156	24398	4643	15996	348
2013	103457	57823	6311	1533	5930
2014	426683	43300	11838	1109	1062
2015	40745	178510	9920	2818	484
2016	322598	17053	41302	2425	767
2017		135018	4564	14944	1326

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 (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F1-2
1983	363882	670185	485730	378795	0.577
1984	98646	1282850	212220	498626	0.654
1985	717819	868867	484965	437114	0.702
1986	108026	2339030	310237	382844	0.497
1987	67748	1783590	1135940	373021	0.372
1988	274136	872752	625024	413646	0.543
1989	124806	851163	168280	446028	0.928
1990	173179	720827	256434	306240	0.920
1991	183084	1043030	328369	332204	0.615
1992	41420	1088070	290754	558599	0.919
1993	160771	470733	258232	132024	0.404
1994	220528	688051	173794	193241	0.328
1995	57490	1420810	394631	400588	0.605
1996	379780	617779	371065	265869	0.566
1997	58238	1821980	240764	426089	0.534
1998	109893	851559	534999	377073	0.691
1999	149452	567522	240533	422718	1.125
2000	245369	648560	145010	299167	0.906
2001	392533	756404	156964	531265	1.393
2002	25568	1315840	141706	606466	1.061
2003	156324	306091	214957	148039	0.890
2004	69668	463771	86060	203646	0.928
2005	159419	349522	113759	123422	1.130
2006	88470	540184	76503	240646	1.371
2007	211216	350616	98028	109624	0.527
2008	84324	781939	144580	234447	0.967
2009	646362	447420	170353	290995	1.198
2010	46573	2053020	143548	300508	0.509
2011	58614	826254	581460	318840	0.575
2012	138156	385507	221837	46117	0.110
2013	103457	394305	120983	214359	0.675
2014	426683	311360	94055	78830	0.402
2015	40745	1098060	122921	163381	0.384
2016	322598	547953	377803	13695	0.026
2017			222189		
arith. mean	191323	868694	278420	302005	0.707
geo. mean	134688				

arith. mean for the period 1983-2016

geo. mean for the period 1983-2015

Table 9.2.11 Sandeel Area-1r. Input to forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2017)	134688	135018	4564	14944	1326
Exploitation pattern 1st half		0.010	0.028	0.041	0.041
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.30	8.30	10.79	13.25
Weight in the catch 1st half		5.30	8.30	10.79	13.25
weight in the catch 2nd half	3.55	6.12	9.88	13.17	15.13
Proportion mature(2017)	0.00	0.02	0.80	0.99	1.00
Proportion mature(2018)	0.00	0.02	0.80	0.99	1.00
Natural mortality 1st half		0.49	0.34	0.24	0.24
Natural mortality 2nd half	0.87	0.82	0.65	0.60	0.60

Table 9.2.12 Sandeel Area-1r. Short term forecast (000 tonnes).

Basis: Fsq=F(2016)=0.019; Yield(2016)=14; Recruitment(2016)=323; Recruitment(2017)=geometric mean (GM 1983-2015)=135 billion;SSB(2017)=222

F multiplier	Basis	F(2017)	Catch(2017)	SSB(2018)	%SSB change*	%TAC change**
0.00	F=0	0.000	0.001	360	62 %	-100 %
15.00	Fsq*15	0.283	165.711	277	25 %	1110 %
20.00	Fsq*20	0.378	209.543	256	15 %	1430 %
26.47	Fsq*26.47	0.500	259.915	232	4 %	1798 %
30.00	Fsq*30	0.567	284.807	220	-1 %	1980 %
35.00	Fsq*35	0.661	317.365	205	-8 %	2217 %
40.00	Fsq*40	0.756	347.139	192	-14 %	2435 %
45.00	Fsq*45	0.850	374.488	179	-19 %	2635 %
50.00	Fsq*50	0.945	399.711	168	-24 %	2819 %
62.39	MSY	1.179	454.596	145	-35 %	3219 %

***SSB in 2018 relative to SSB in 2017**

****TAC in 2017 relative to catches in 2016**

Table 9.3.1 Sandeel Area-2r. Catch at age numbers (million) by half year.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	12882	4162	476	6190	877	203	104	67	0
1984	0	10284	3846	912	186	1154	193	38	10
1985	1827	1411	392	5501	768	473	387	109	50
1986	1443	24479	3495	3144	208	436	95	6	7
1987	45	831	512	2621	591	131	17	20	4
1988	5602	1030	545	3379	226	3163	775	478	31
1989	2819	23364	3809	1666	273	938	10	909	34
1990	5046	7332	854	3967	196	587	29	177	9
1991	10053	14203	3628	2099	110	451	35	156	1
1992	6830	12016	886	4066	85	475	34	298	7
1993	14083	4814	873	1294	660	642	226	475	56
1994	0	25596	4477	3619	919	341	275	199	118
1995	1798	4897	1316	1598	1777	209	211	88	159
1996	26463	2472	7161	1573	475	905	278	260	186
1997	284	29071	8330	1640	193	628	83	207	47
1998	1070	645	106	4749	1424	437	136	348	144
1999	4130	841	1113	177	102	855	501	186	149
2000	519	8160	1066	566	164	217	98	518	134
2001	5767	2625	2414	1010	563	129	73	367	228
2002	4	15855	1379	891	185	393	35	85	28
2003	3711	267	79	1723	453	136	43	67	17
2004	755	10761	2034	711	212	537	297	174	55
2005	15	2171	490	513	336	48	32	116	91
2006	8	2441	1030	276	125	100	64	27	39
2007	0	6431	0	240	0	32	0	5	0
2008	1	4621	187	434	64	90	36	15	5
2009	103	2817	1867	671	145	42	25	4	1
2010	2	6490	1308	193	35	374	27	60	4
2011	0	404	19	1474	91	236	17	59	3
2012	0	168	6	194	51	293	6	60	10
2013	0	4824	431	1158	47	296	16	99	5
2014	301	2987	141	2371	28	340	3	119	5
2015	0	2275	42	772	9	561	2	197	2
2016	4	260	1	127	3	101	0	61	0
arith. mean	3105	7088	1597	1809	341	469	122	178	48

Table 9.3.2 Sandeel Area-2r. Individual mean weight (gram) at age in the catch and in the sea.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	3.3	5.2	9.9	10.8	16.5	12.8	22.9	15.0	27.3
1984	5.9	5.6	10.2	11.1	14.1	15.6	25.8	18.8	30.1
1985	4.5	6.7	10.7	9.9	16.8	17.5	23.3	24.1	27.5
1986	3.2	5.9	9.8	10.3	15.8	12.7	15.0	15.0	17.0
1987	2.8	5.8	8.7	11.1	12.9	16.4	21.1	14.6	19.4
1988	3.5	5.5	7.2	11.1	15.3	16.1	21.0	23.1	30.6
1989	4.8	5.7	9.4	9.1	13.4	10.1	14.4	12.1	18.0
1990	4.4	7.1	8.1	9.7	11.8	14.4	17.4	17.3	20.8
1991	3.8	7.7	5.7	12.1	11.0	35.8	32.6	21.2	20.1
1992	4.7	6.9	15.0	9.9	20.6	13.5	29.3	17.9	29.2
1993	2.8	7.7	9.3	15.1	14.8	16.9	17.5	22.3	22.0
1994	3.6	5.4	7.6	10.5	18.8	15.3	23.0	19.5	20.7
1995	5.2	7.6	8.9	12.4	13.2	16.0	17.6	19.2	21.1
1996	2.7	7.0	4.9	12.4	13.2	17.0	15.8	27.9	24.5
1997	3.2	5.3	7.1	8.0	11.2	13.1	13.8	15.9	14.9
1998	3.4	6.2	6.7	11.4	14.0	14.7	16.5	17.4	18.3
1999	5.3	8.1	9.1	11.8	12.8	15.4	15.3	19.1	19.6
2000	3.1	6.8	10.2	10.0	13.0	15.2	17.9	18.1	19.5
2001	4.0	6.0	5.0	12.9	16.1	16.6	21.7	20.4	26.2
2002	3.2	5.7	8.3	8.4	13.2	9.6	15.3	17.3	17.7
2003	5.4	6.0	8.1	11.3	16.0	15.1	21.4	18.2	27.2
2004	4.8	6.5	7.4	9.4	10.9	12.4	12.2	13.1	13.7
2005	3.4	7.5	7.4	11.8	11.9	14.4	15.4	14.8	17.5
2006	4.6	7.6	9.9	11.5	15.9	13.9	20.6	14.8	23.4
2007	5.8	6.2	6.2	12.4	12.4	15.4	15.4	17.8	17.8
2008	3.4	5.5	7.5	12.5	12.0	16.1	15.6	18.0	17.7
2009	6.0	6.1	5.0	8.7	10.9	16.5	18.6	12.2	11.0
2010	2.5	5.7	5.3	10.3	8.4	11.5	11.0	13.2	12.5
2011	3.6	6.9	7.6	11.1	12.2	13.8	15.8	14.6	18.0
2012	4.4	8.2	9.4	12.4	15.1	14.8	19.6	21.8	22.3
2013	3.9	5.9	8.8	7.9	11.5	14.2	14.4	14.1	16.5
2014	3.3	5.3	7.0	9.9	11.2	12.0	14.6	18.6	16.6
2015	5.3	6.8	11.4	12.4	18.4	15.3	23.9	17.3	27.1
2016	2.6	3.3	5.5	12.2	8.8	14.6	11.5	16.0	13.1
arith. mean	4.0	6.3	8.2	10.9	13.6	15.2	18.4	17.7	20.6

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 (number/hour).

Year	Age 0	Age 1
2010	938.752	1482.382
2011	2290.448	259.021
2012	11342.580	94.156
2013	7546.966	2103.482
2014	5760.235	810.806
2015	706.350	106.920
2016	53839.804	113.297

Table 9.3.5 Sandeel Area-2r. SMS settings and statistics.

```
Date:  01/25/17     Start  time:13:25:37  run  time:1  seconds

objective  function  (negative  log  likelihood):    36.5047
Number              of              parameters:           69
Maximum                  gradient:                7.0205e-005
Akaike    information    criterion    (AIC):         211.009
Number    of    observations    used    in    the    likelihood:
                            Catch    CPUE     S/R Stomach    Sum
                              306      14      34       0    354

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
                  37.5     -2.7    16.9      0.0      0.0       0.00
52


unweighted objective function contributions (per observation):
                 Catch        CPUE            S/R        Stomachs
                  0.12       -0.19           0.50            0.00


contribution                       by                      fleet:
----------------------
Dredge  survey  2010-2016       total:   -2.716    mean:   -0.194

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
    2010-2016:                              0.000          1.000
age:                    1                     -                4
    1983-1988:                              0.480          0.500
    1989-1998:                              0.672          0.500
    1999-2004:                              0.425          0.500
    2005-2009:                              0.193          0.500
    2010-2016:                              0.529          0.500

F,                            age                        effect:
--------------
                     0          1          2          3          4
1983-1988:       0.040      0.275      0.889      1.502      1.502
1989-1998:       0.101      0.344      0.412      0.480      0.480
1999-2004:       0.041      0.600      0.729      0.744      0.744
```

```
2005-2009:      0.001       1.915       1.614       1.653       1.653
2010-2016:      0.003       0.204       0.319       0.452       0.452
```

```
Exploitation      pattern      (scaled      to      mean      F=1)
-------------------------------------------
                         0         1         2         3         4
1983-1988  season  1:         0    0.299    0.967    1.634    1.634
           season  2:    0.051    0.173    0.561    0.948    0.948

1989-1998  season  1:         0    0.722    0.864    1.007    1.007
           season  2:    0.110    0.188    0.225    0.263    0.263

1999-2004  season  1:         0    0.309    0.376    0.384    0.384
           season  2:    0.081    0.593    0.721    0.736    0.736

2005-2009  season  1:         0    0.543    0.457    0.469    0.469
           season  2:    0.001    0.543    0.457    0.468    0.468

2010-2016  season  1:         0    0.645    1.009    1.429    1.429
           season  2:    0.004    0.135    0.211    0.299    0.299
```

```
sqrt(catch             variance)             ~             CV:
---------------------------

               season
-----------------------
age                              1                            2

 0                                                        1.283
 1                                  0.332                 0.695
 2                                  0.332                 0.695
 3                                  0.726                 1.065
 4                                  0.726                 1.065
```

```
Survey                                               catchability:
---------------------
                            age     0                 age     1
 Dredge   survey   2010-2016               33.023        12.715

sqrt(Survey             variance)             ~             CV:
----------------------------
                            age     0                 age     1
 Dredge   survey   2010-2016                 0.36          0.69

Recruit-SSB            alfa      beta       recruit s2     recruit
s
Area-2r             1230.338   5.600e+004    0.993             0.996
```

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	0.036	0.364	1.168	1.965	1.963	0.766
1984	0.033	0.306	0.984	1.662	1.660	0.645
1985	0.022	0.287	0.911	1.522	1.520	0.599
1986	0.025	0.412	1.296	2.147	2.144	0.854
1987	0.008	0.091	0.291	0.489	0.489	0.191
1988	0.026	0.306	0.975	1.634	1.632	0.640
1989	0.077	0.732	0.859	0.989	0.987	0.796
1990	0.037	0.492	0.575	0.659	0.657	0.533
1991	0.071	0.555	0.654	0.755	0.754	0.605
1992	0.052	0.564	0.661	0.759	0.757	0.612
1993	0.081	0.445	0.529	0.615	0.614	0.487
1994	0.051	0.472	0.555	0.639	0.637	0.514
1995	0.044	0.257	0.305	0.354	0.353	0.281
1996	0.135	0.383	0.466	0.554	0.554	0.425
1997	0.084	0.559	0.661	0.765	0.764	0.610
1998	0.047	0.288	0.341	0.396	0.395	0.315
1999	0.037	0.373	0.465	0.488	0.489	0.419
2000	0.017	0.556	0.665	0.674	0.673	0.610
2001	0.037	0.483	0.594	0.617	0.617	0.539
2002	0.020	0.672	0.803	0.813	0.811	0.737
2003	0.037	0.445	0.549	0.572	0.572	0.497
2004	0.030	0.907	1.086	1.102	1.100	0.996
2005	0.001	1.158	0.983	1.019	1.019	1.070
2006	0.001	1.209	1.032	1.075	1.076	1.120
2007	0.000	0.743	0.609	0.610	0.607	0.676
2008	0.000	0.797	0.663	0.675	0.674	0.730
2009	0.000	0.760	0.645	0.668	0.668	0.703
2010	0.001	0.292	0.446	0.622	0.620	0.369
2011	0.001	0.188	0.286	0.396	0.395	0.237
2012	0.000	0.107	0.163	0.225	0.224	0.135
2013	0.001	0.467	0.708	0.981	0.979	0.588
2014	0.001	0.353	0.534	0.737	0.735	0.444
2015	0.000	0.310	0.468	0.644	0.642	0.389
2016	0.000	0.127	0.191	0.264	0.263	0.159
arith. mean	0.030	0.484	0.651	0.826	0.825	0.567

Table 9.3.7 Sandeel Area-2r. Fishing mortality (F) at age.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.036	0.214	0.124	0.693	0.402	1.171	0.680	1.171	0.680
1984	0.033	0.174	0.113	0.565	0.367	0.955	0.619	0.955	0.619
1985	0.022	0.182	0.074	0.588	0.241	0.993	0.408	0.993	0.408
1986	0.025	0.274	0.085	0.888	0.275	1.501	0.465	1.501	0.465
1987	0.008	0.055	0.028	0.178	0.089	0.301	0.151	0.301	0.151
1988	0.026	0.188	0.089	0.608	0.290	1.028	0.490	1.028	0.490
1989	0.077	0.503	0.131	0.602	0.157	0.701	0.183	0.701	0.183
1990	0.037	0.350	0.064	0.420	0.077	0.489	0.089	0.489	0.089
1991	0.071	0.367	0.122	0.439	0.146	0.511	0.170	0.511	0.170
1992	0.052	0.393	0.089	0.471	0.106	0.548	0.124	0.548	0.124
1993	0.081	0.269	0.139	0.322	0.166	0.375	0.194	0.375	0.194
1994	0.051	0.321	0.087	0.384	0.105	0.448	0.122	0.448	0.122
1995	0.044	0.158	0.075	0.190	0.090	0.221	0.104	0.221	0.104
1996	0.135	0.169	0.230	0.202	0.275	0.235	0.321	0.235	0.321
1997	0.084	0.356	0.144	0.427	0.173	0.497	0.201	0.497	0.201
1998	0.047	0.180	0.080	0.215	0.096	0.251	0.111	0.251	0.111
1999	0.037	0.140	0.268	0.170	0.325	0.173	0.332	0.173	0.332
2000	0.017	0.364	0.127	0.442	0.155	0.451	0.158	0.451	0.158
2001	0.037	0.225	0.268	0.273	0.326	0.279	0.332	0.279	0.332
2002	0.020	0.447	0.144	0.543	0.175	0.554	0.179	0.554	0.179
2003	0.037	0.194	0.269	0.236	0.327	0.241	0.334	0.241	0.334
2004	0.030	0.588	0.223	0.714	0.271	0.729	0.277	0.729	0.277
2005	0.001	0.576	0.576	0.486	0.486	0.498	0.497	0.498	0.497
2006	0.001	0.551	0.688	0.465	0.580	0.476	0.594	0.476	0.594
2007	0.000	0.593	0.000	0.500	0.000	0.512	0.000	0.512	0.000
2008	0.000	0.523	0.184	0.440	0.155	0.451	0.159	0.451	0.159
2009	0.000	0.385	0.367	0.325	0.309	0.333	0.317	0.333	0.317
2010	0.001	0.204	0.043	0.320	0.067	0.453	0.095	0.453	0.095
2011	0.001	0.138	0.016	0.216	0.024	0.306	0.035	0.306	0.035
2012	0.000	0.080	0.006	0.126	0.009	0.178	0.013	0.178	0.013
2013	0.001	0.342	0.044	0.536	0.069	0.759	0.098	0.759	0.098
2014	0.001	0.268	0.016	0.420	0.026	0.594	0.037	0.594	0.037
2015	0.000	0.241	0.004	0.378	0.007	0.534	0.010	0.534	0.010
2016	0.000	0.097	0.003	0.152	0.005	0.215	0.007	0.215	0.007
arith. mean	0.030	0.297	0.145	0.410	0.187	0.528	0.232	0.528	0.232

Table 9.3.8 Sandeel Area-2r. Natural mortality (M) at age.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1984	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1985	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1986	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1987	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1988	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1989	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1990	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1991	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1992	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1993	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1994	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1995	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1996	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1997	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1998	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
1999	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2000	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2001	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2002	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2003	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2004	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2005	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2006	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2007	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2008	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2009	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2010	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2011	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2012	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2013	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2014	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2015	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
2016	0.92	0.57	0.59	0.44	0.49	0.32	0.42	0.31	0.41
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	162210	15985	14243	685	36
1984	47524	62344	3573	1879	54
1985	283209	18324	14660	555	191
1986	62860	110439	4447	2524	88
1987	35719	24438	24175	548	175
1988	180975	14121	7054	7300	221
1989	87403	70264	3355	1133	787
1990	156277	32254	11684	619	382
1991	109696	59989	6682	2807	270
1992	116144	40703	11540	1469	744
1993	234423	43938	7880	2557	543
1994	108301	86121	9160	1908	840
1995	76458	41004	17948	2216	746
1996	419660	29162	10182	5357	1027
1997	15490	146151	6138	2493	1753
1998	26493	5673	27776	1330	1016
1999	76154	10075	1372	8032	786
2000	43578	29260	2102	330	2543
2001	131607	17067	5613	457	759
2002	10037	50564	3268	1217	319
2003	47639	3922	8781	629	354
2004	19021	18300	774	1973	266
2005	19226	7353	2551	114	392
2006	27624	7656	728	381	91
2007	40633	11000	695	101	77
2008	26910	16193	1905	166	51
2009	92039	10722	2503	414	57
2010	13035	36663	1585	524	118
2011	14852	5187	8976	425	178
2012	69910	5916	1395	2785	206
2013	39233	27855	1701	481	1180
2014	24831	15612	5933	367	341
2015	6354	9890	3682	1499	182
2016	311082	2532	2425	989	466
2017		123959	718	818	560

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 (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F1-2
1983	162210	245801	138793	155664	0.766
1984	47524	416817	70348	133343	0.645
1985	283209	281844	137212	110546	0.599
1986	62860	726671	84618	225470	0.854
1987	35719	422851	237327	49070	0.191
1988	180975	279098	189285	149466	0.640
1989	87403	454790	54354	223507	0.796
1990	156277	357329	114254	133874	0.533
1991	109696	647302	182643	215508	0.605
1992	116144	430422	134095	184033	0.612
1993	234423	512138	160814	139826	0.487
1994	108301	605009	134609	244939	0.514
1995	76458	585487	240681	113899	0.281
1996	419660	449953	228487	182562	0.425
1997	15490	881242	116641	242094	0.610
1998	26493	388793	300597	99814	0.315
1999	76154	236888	154066	69427	0.419
2000	43578	271375	72259	92908	0.610
2001	131607	197294	85278	90200	0.539
2002	10037	330754	45634	117388	0.737
2003	47639	138533	98693	53710	0.497
2004	19021	153429	36347	110546	0.996
2005	19226	92441	33563	34396	1.070
2006	27624	72822	14748	37860	1.120
2007	40633	79174	11420	43090	0.676
2008	26910	117227	25114	35604	0.730
2009	92039	94167	26811	35687	0.703
2010	13035	233279	25341	51670	0.369
2011	14852	144334	92034	24896	0.237
2012	69910	111559	61079	10594	0.135
2013	39233	201025	37945	47814	0.588
2014	24831	152132	61324	48033	0.444
2015	6354	139369	65402	37902	0.389
2016	311082	59713	46578	4903	0.159
2017			42569		
arith. mean	92253	309149	101742	104419	0.567
geo. mean	53229				

arith. mean for the period 1983-2016

geo. mean for the period 1983-2015

Table 9.3.11 Sandeel Area-2r. Input to forecast.

	AGE 0	AGE 1	AGE 2	AGE 3	AGE 4
Stock numbers(2017)	27335	123959	718	818	560
Exploitation pattern 1st half		0.097	0.152	0.215	0.215
Exploitation pattern 2nd half	0.000	0.003	0.005	0.007	0.007
Weight in the stock 1st half		5.89	10.97	14.18	17.54
Weight in the catch 1st half		5.89	10.97	14.18	17.54
weight in the catch 2nd half	3.89	8.43	13.02	16.81	19.13
Proportion mature(2017)	0.00	0.02	0.83	1.00	1.00
Proportion mature(2018)	0.00	0.02	0.83	1.00	1.00
Natural mortality 1st half		0.57	0.44	0.32	0.31
Natural mortality 2nd half	0.92	0.59	0.49	0.42	0.41

Table 9.3.12 Sandeel Area-2r. Short term forecast (000 tonnes).

Basis: Fsq=F(2016)=0.128; Yield(2016)=5; Recruitment(2016)=311; Recruitment(2017)=geometric mean (GM 2006-2015)=27 billion;SSB(2017)=43

F multiplier	Basis	F(2017)	Catch(2017)	SSB(2018)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	371	771 %	-100 %
2.500	Fsq*2.5	0.321	134.022	286	572 %	2634 %
3.000	Fsq*3	0.385	157.141	272	539 %	3105 %
3.500	Fsq*3.5	0.450	179.181	258	507 %	3555 %
4.000	Fsq*4	0.514	200.199	245	476 %	3983 %
4.500	Fsq*4.5	0.578	220.248	233	448 %	4392 %
5.000	Fsq*5	0.642	239.378	221	420 %	4782 %
5.500	Fsq*5.5	0.707	257.637	210	394 %	5155 %
6.000	Fsq*6	0.771	275.068	200	370 %	5510 %
14.618	MSY	1.878	479.732	84	97 %	9685 %

***SSB in 2018 relative to SSB in 2017**

****TAC in 2017 relative to catches in 2016**

Table 9.4.1 Sandeel Area-3r. Catch at age numbers (million) by half year.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	7965	18939	7987	2063	533	161	2	0	0
1987	5	33760	65	14020	4	453	0	200	0
1988	8769	6584	853	17321	233	893	144	19	13
1989	159	47004	190	1844	13	2806	0	4	0
1990	9793	9302	1377	2791	286	413	43	125	13
1991	14442	24009	942	1391	30	526	9	184	3
1992	525	7100	87	2862	8	342	3	215	1
1993	9663	15164	851	558	155	211	71	1336	12
1994	0	23742	615	4818	684	938	78	386	10
1995	1020	25037	484	1894	78	238	13	156	17
1996	6263	4319	3111	3394	97	465	33	399	248
1997	2975	66856	10388	2912	134	607	13	194	9
1998	30136	3954	992	28137	740	2553	192	290	32
1999	6444	5182	1835	1554	118	1979	401	421	169
2000	0	18793	344	3286	4	541	1	533	9
2001	18263	5327	3968	992	9	163	2	160	6
2002	0	9075	21	2680	3	387	1	135	0
2003	2755	939	61	808	53	130	2	78	1
2004	1091	1976	737	256	16	74	6	92	1
2005	0	1404	1	146	0	21	0	12	0
2006	0	769	3	47	1	27	0	4	0
2007	0	8600	0	571	0	86	0	19	0
2008	0	4077	0	2012	0	460	0	73	0
2009	1	827	12	69	2	8	0	0	0
2010	0	3042	51	740	1	1006	1	173	0
2011	0	1304	0	5224	0	825	0	24	0
2012	0	32	0	186	0	1157	0	356	0
2013	0	648	0	211	0	55	0	42	0
2014	0	5384	0	2373	0	643	0	319	0
2015	0	6451	0	2340	0	956	0	99	0
2016	0	150	0	2005	0	415	0	284	0
arith. mean	3880	11605	1128	3532	103	630	33	204	18

Table 9.4.2 Sandeel Area-3r. Individual mean weight (gram) at age in the catch and in the sea.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	4.0	6.1	12.7	9.7	21.0	12.4	18.9	15.9	20.4
1987	6.9	6.4	12.8	11.7	20.4	20.5	31.6	22.5	29.6
1988	4.1	5.1	6.4	13.1	16.1	23.0	22.5	36.2	31.5
1989	4.8	6.1	9.3	10.5	12.7	14.3	14.0	18.8	17.5
1990	4.4	7.5	7.7	9.8	11.2	15.2	16.5	20.2	19.8
1991	3.7	7.3	5.7	11.4	13.8	36.4	27.5	26.3	16.3
1992	4.6	6.1	13.4	10.3	26.7	14.7	28.7	23.0	30.9
1993	3.5	5.8	7.3	16.4	16.7	17.9	20.8	23.3	22.4
1994	3.6	6.1	13.0	14.6	20.8	20.6	35.2	21.1	27.1
1995	4.7	5.6	8.2	9.7	10.2	13.8	13.7	16.5	16.1
1996	2.5	8.8	8.0	13.3	14.0	26.1	15.7	38.5	24.0
1997	2.9	5.2	6.7	10.1	10.2	13.7	14.2	18.3	14.4
1998	3.2	5.0	7.0	10.1	15.2	13.7	17.3	20.3	20.7
1999	8.7	7.4	14.5	10.1	19.4	14.1	21.1	26.3	30.7
2000	5.2	6.9	10.8	10.5	17.4	15.3	23.7	20.5	25.6
2001	5.6	6.8	8.9	13.7	16.0	17.8	15.9	23.2	25.5
2002	9.4	8.1	19.7	12.7	31.6	14.6	43.2	19.2	46.7
2003	4.3	5.3	5.4	14.6	15.3	20.3	24.1	26.9	26.7
2004	5.8	7.3	7.3	9.5	14.1	14.5	18.4	15.1	12.7
2005	3.4	7.8	7.0	16.5	11.2	19.9	15.3	22.6	16.6
2006	11.0	7.5	23.1	13.5	36.9	17.1	50.5	26.9	54.5
2007	4.1	7.5	8.6	15.1	13.9	21.7	18.9	14.6	20.5
2008	4.1	8.0	8.6	15.0	13.9	22.0	18.9	25.8	20.5
2009	4.2	6.3	8.8	10.4	14.1	19.9	19.2	12.1	20.8
2010	2.5	7.5	5.2	17.7	8.3	20.7	11.4	24.3	12.3
2011	4.1	7.7	8.6	12.6	13.9	19.4	18.9	36.2	20.5
2012	4.1	9.9	8.6	15.2	13.9	22.7	18.9	30.0	20.5
2013	4.1	9.1	8.6	11.6	13.9	14.3	18.9	16.2	20.5
2014	4.1	8.6	8.6	12.7	13.9	13.9	18.9	18.3	20.5
2015	5.6	8.3	11.7	12.7	18.8	19.3	25.7	30.1	27.7
2016	1.5	4.0	3.1	12.4	5.0	19.8	6.8	32.1	7.4
arith. mean	4.7	6.9	9.5	12.5	16.1	18.4	21.5	23.3	23.2

Table 9.4.3 Sandeel Area-3r. Proportion mature.

	Age 1	Age 2	Age 3	Age 4
1983-2016	0.04	0.77	1	1

Table 9.4.4. Sandeel Area-3r. Dregde survey indices (number/hour).

Year	Age 0	Age 1
2005	43845.505	
2006	35373.099	792.945
2007	6751.469	2240.853
2008	10403.569	930.518
2009	22310.691	8400.206
2010	1180.243	3167.731
2011	642.712	980.922
2012	27821.517	591.034
2013	109032.750	460.506
2014	58692.111	3330.820
2015	1686.703	7006.494
2016	124974.572	189.569

Table 9.4.5 Sandeel Area-3r. SMS settings and statistics.

```
Date:  01/20/17    Start  time:12:05:10  run  time:3  seconds

 objective  function  (negative  log  likelihood):    106.796
 Number              of              parameters:           55
 Maximum                  gradient:                3.98226e-005
 Akaike   information   criterion   (AIC):            323.592
 Number   of   observations   used   in   the   likelihood:
                                Catch    CPUE    S/R Stomach    Sum
                                  279      55     31       0    365

 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
                    94.6     12.0     18.5     0.0     0.0      0.00
125


 unweighted objective function contributions (per observation):
                     Catch        CPUE            S/R        Stomachs
                    0.34          0.22            0.60           0.00


 contribution                        by                       fleet:
 ----------------------
 Acoustic  survey                 total:    4.737    mean:    0.148
 Dredge  survey  2004-2016       total:    7.279    mean:    0.316

 F,                           season                         effect:
 -----------------
 age:                                                              0
     1986-1998:                                 0.000          1.000
     1999-2016:                                 0.000          1.000
 age:                    1                       -                 4
     1986-1998:                                 0.894          0.500
     1999-2016:                                 1.070          0.500

 F,                            age                           effect:
 --------------
                     0           1           2           3           4
 1986-1998:      0.102       0.363       0.394       0.301       0.301
 1999-2016:      0.056       0.205       0.274       0.290       0.290


 Exploitation     pattern     (scaled      to      mean       F=1)
 -----------------------------------------
                             0         1         2         3         4
 1986-1998  season  1:           0     0.650     0.706     0.538     0.538
```

```
          season  2:   0.174   0.309   0.336   0.256   0.256

1999-2016  season  1:        0   0.597   0.800   0.847   0.847
           season  2:   0.140   0.258   0.345   0.365   0.365


sqrt(catch             variance)            ~           CV:
---------------------------

               season
----------------------
age                              1                        2

 0                                                    1.163
 1                                   0.630            0.998
 2                                   0.630            0.998
 3                                   1.107            1.201
 4                                   1.107            1.201


Survey                                        catchability:
--------------------
                             age  0     age  1     age  2     age  3
age                                                           4
  Acoustic survey                      2.928    5.695    3.549
3.549
  Dredge   survey   2004-2016                0.654            0.654

sqrt(Survey             variance)            ~           CV:
---------------------------
                             age  0     age  1     age  2     age  3
age                                                           4
  Acoustic survey                       0.55     0.55     0.90
0.90
  Dredge   survey  2004-2016                 0.88             0.78

Recruit-SSB           alfa      beta       recruit s2     recruit
s
Area-3r            1479.700   8.000e+004   1.217            1.103
```

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	0.446	0.478	0.363	0.364	0.462
1987	0.001	0.705	0.734	0.546	0.544	0.719
1988	0.051	0.904	0.942	0.710	0.709	0.923
1989	0.003	1.021	1.062	0.809	0.806	1.042
1990	0.050	0.573	0.602	0.458	0.457	0.587
1991	0.039	0.692	0.727	0.549	0.549	0.710
1992	0.003	0.322	0.334	0.246	0.247	0.328
1993	0.042	0.597	0.629	0.473	0.472	0.613
1994	0.016	0.638	0.669	0.493	0.490	0.654
1995	0.007	0.508	0.535	0.396	0.395	0.522
1996	0.043	0.497	0.528	0.393	0.393	0.513
1997	0.066	0.895	0.948	0.720	0.717	0.922
1998	0.140	1.133	1.211	0.923	0.918	1.172
1999	0.148	0.971	1.290	1.344	1.338	1.130
2000	0.004	1.001	1.295	1.305	1.298	1.148
2001	0.153	0.624	0.842	0.889	0.892	0.733
2002	0.000	0.660	0.844	0.886	0.881	0.752
2003	0.020	0.352	0.455	0.484	0.483	0.404
2004	0.020	0.245	0.319	0.340	0.340	0.282
2005	0.000	0.119	0.153	0.159	0.158	0.136
2006	0.000	0.051	0.065	0.067	0.067	0.058
2007	0.000	0.299	0.386	0.400	0.398	0.343
2008	0.000	0.323	0.416	0.439	0.437	0.370
2009	0.000	0.027	0.035	0.037	0.037	0.031
2010	0.000	0.350	0.456	0.474	0.470	0.403
2011	0.000	0.227	0.295	0.308	0.305	0.261
2012	0.000	0.137	0.178	0.189	0.188	0.158
2013	0.000	0.067	0.087	0.092	0.092	0.077
2014	0.000	0.267	0.346	0.367	0.364	0.306
2015	0.000	0.350	0.455	0.481	0.478	0.403
2016	0.000	0.137	0.178	0.188	0.187	0.157
arith. mean	0.028	0.488	0.564	0.501	0.499	0.526

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	0.282	0.134	0.306	0.146	0.233	0.111	0.233	0.111
1987	0.001	0.569	0.002	0.618	0.002	0.471	0.002	0.471	0.002
1988	0.051	0.678	0.091	0.736	0.098	0.561	0.075	0.561	0.075
1989	0.003	0.853	0.006	0.926	0.006	0.706	0.005	0.706	0.005
1990	0.050	0.420	0.088	0.456	0.096	0.348	0.073	0.348	0.073
1991	0.039	0.534	0.070	0.580	0.076	0.442	0.058	0.442	0.058
1992	0.003	0.257	0.006	0.280	0.006	0.213	0.005	0.213	0.005
1993	0.042	0.444	0.074	0.482	0.080	0.367	0.061	0.367	0.061
1994	0.016	0.496	0.028	0.538	0.030	0.410	0.023	0.410	0.023
1995	0.007	0.403	0.013	0.438	0.014	0.334	0.010	0.334	0.010
1996	0.043	0.354	0.076	0.384	0.082	0.293	0.063	0.293	0.063
1997	0.066	0.663	0.117	0.719	0.127	0.548	0.096	0.548	0.096
1998	0.140	0.785	0.248	0.852	0.269	0.649	0.205	0.649	0.205
1999	0.148	0.629	0.271	0.843	0.364	0.893	0.385	0.893	0.385
2000	0.004	0.794	0.007	1.063	0.010	1.126	0.010	1.126	0.010
2001	0.153	0.331	0.281	0.443	0.377	0.470	0.399	0.470	0.399
2002	0.000	0.493	0.000	0.661	0.000	0.700	0.000	0.700	0.000
2003	0.020	0.245	0.037	0.328	0.050	0.347	0.053	0.347	0.053
2004	0.020	0.169	0.037	0.227	0.049	0.240	0.052	0.240	0.052
2005	0.000	0.092	0.000	0.123	0.000	0.130	0.000	0.130	0.000
2006	0.000	0.039	0.000	0.053	0.001	0.056	0.001	0.056	0.001
2007	0.000	0.238	0.000	0.319	0.000	0.338	0.000	0.338	0.000
2008	0.000	0.264	0.000	0.353	0.000	0.374	0.000	0.374	0.000
2009	0.000	0.022	0.000	0.030	0.000	0.031	0.000	0.031	0.000
2010	0.000	0.285	0.001	0.382	0.001	0.404	0.001	0.404	0.001
2011	0.000	0.181	0.000	0.243	0.000	0.257	0.000	0.257	0.000
2012	0.000	0.110	0.000	0.147	0.000	0.156	0.000	0.156	0.000
2013	0.000	0.054	0.000	0.072	0.000	0.076	0.000	0.076	0.000
2014	0.000	0.214	0.000	0.287	0.000	0.304	0.000	0.304	0.000
2015	0.000	0.283	0.000	0.379	0.000	0.401	0.000	0.401	0.000
2016	0.000	0.110	0.000	0.147	0.000	0.156	0.000	0.156	0.000
arith. mean	0.028	0.364	0.051	0.433	0.061	0.388	0.054	0.388	0.054

Table 9.4.8 Sandeel Area-3r. Natural mortality (M) at age.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1986	1.340	0.760	0.600	0.600	0.470	0.420	0.370	0.360	0.350
1987	1.430	0.750	0.570	0.600	0.440	0.420	0.350	0.360	0.340
1988	1.540	0.710	0.580	0.570	0.430	0.390	0.350	0.350	0.340
1989	1.330	0.680	0.490	0.550	0.360	0.390	0.330	0.360	0.320
1990	1.280	0.630	0.480	0.490	0.350	0.340	0.300	0.310	0.290
1991	1.220	0.630	0.470	0.490	0.350	0.330	0.290	0.300	0.280
1992	1.190	0.650	0.520	0.490	0.390	0.330	0.290	0.300	0.290
1993	1.140	0.670	0.520	0.510	0.400	0.350	0.320	0.330	0.310
1994	1.110	0.690	0.580	0.530	0.460	0.360	0.340	0.340	0.320
1995	1.010	0.710	0.550	0.560	0.450	0.410	0.350	0.380	0.340
1996	0.990	0.660	0.570	0.530	0.470	0.390	0.360	0.360	0.350
1997	0.900	0.640	0.530	0.520	0.430	0.400	0.380	0.380	0.360
1998	0.970	0.630	0.510	0.490	0.410	0.380	0.360	0.350	0.330
1999	1.040	0.730	0.580	0.540	0.470	0.360	0.330	0.330	0.300
2000	1.120	0.800	0.650	0.610	0.550	0.420	0.390	0.390	0.370
2001	1.190	0.820	0.780	0.660	0.670	0.490	0.510	0.450	0.490
2002	1.220	0.840	0.800	0.720	0.670	0.580	0.630	0.540	0.610
2003	1.220	0.830	0.770	0.720	0.640	0.580	0.620	0.540	0.600
2004	1.210	0.850	0.700	0.710	0.570	0.560	0.550	0.510	0.530
2005	1.150	0.840	0.650	0.690	0.530	0.500	0.470	0.470	0.450
2006	1.120	0.820	0.610	0.660	0.490	0.480	0.420	0.440	0.410
2007	1.050	0.770	0.580	0.610	0.470	0.450	0.400	0.420	0.390
2008	0.990	0.680	0.500	0.550	0.400	0.430	0.380	0.400	0.370
2009	0.990	0.590	0.470	0.480	0.390	0.370	0.340	0.340	0.330
2010	1.110	0.590	0.500	0.450	0.420	0.360	0.370	0.330	0.350
2011	1.210	0.660	0.550	0.510	0.460	0.390	0.420	0.350	0.390
2012	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2013	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2014	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2015	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
2016	1.190	0.700	0.540	0.550	0.450	0.420	0.440	0.390	0.420
arith. mean	1.162	0.714	0.575	0.567	0.464	0.419	0.401	0.385	0.384

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	515734	91676	6307	256	732
1987	116729	125199	15519	1377	337
1988	365463	27904	18890	2950	502
1989	105957	74440	3561	3016	878
1990	209708	27932	9791	564	940
1991	120544	55473	5536	2434	534
1992	266501	34210	10094	1240	976
1993	195469	80808	8160	3146	972
1994	186732	59964	14648	1872	1382
1995	141499	60579	9975	3083	1066
1996	770286	51170	11334	2313	1389
1997	60909	274240	9735	2616	1244
1998	95156	23187	39048	1616	941
1999	122042	31366	2641	5175	531
2000	125898	37206	3439	288	802
2001	121662	40918	3919	369	161
2002	28195	31752	4479	456	83
2003	62362	8324	3760	576	81
2004	40453	18041	1268	661	134
2005	60910	11823	3116	267	198
2006	117906	19286	2431	813	158
2007	65038	38461	4436	730	377
2008	91243	22759	7858	1095	342
2009	149361	33904	5372	2134	444
2010	15222	55494	11487	2184	1237
2011	11436	5014	14019	3281	1119
2012	71225	3410	1247	4168	1541
2013	179774	21668	884	396	2096
2014	219853	54691	5944	303	1019
2015	3948	66874	12770	1640	429
2016	829177	1201	14588	3217	592
2017		252253	311	4633	1391

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 (MILLION)	TSB (TONNES)	SSB (TONNES)	YIELD (TONNES)	MEAN F1-2
1986	515734	637422	82034	282315	0.462
1987	116729	1021690	203407	395296	0.719
1988	365463	475972	280567	330358	0.923
1989	105957	553300	104679	350409	1.042
1990	209708	331979	108777	163224	0.587
1991	120544	572308	165762	274839	0.710
1992	266501	353644	127918	86788	0.328
1993	195469	679385	198135	175786	0.613
1994	186732	645719	244434	267281	0.654
1995	141499	494343	146730	173607	0.522
1996	770286	714475	245420	159024	0.513
1997	60909	1590440	185649	470670	0.922
1998	95156	549359	346504	462081	1.172
1999	122042	344271	115804	191253	1.130
2000	125898	312460	57714	186837	1.148
2001	121662	342735	61360	193684	0.733
2002	28195	322044	61161	116298	0.752
2003	62362	112935	57515	34673	0.404
2004	40453	154905	25558	31285	0.282
2005	60910	152938	52488	13991	0.136
2006	117906	195552	48487	7094	0.058
2007	65038	375413	82889	74972	0.343
2008	91243	333441	130026	74933	0.370
2009	149361	318485	98260	6261	0.031
2010	15222	694964	246357	61241	0.403
2011	11436	318555	240331	92452	0.261
2012	71225	193551	156624	40116	0.158
2013	179774	247639	54529	9844	0.077
2014	219853	565981	97364	90876	0.306
2015	3948	761334	188538	104631	0.403
2016	829177	268541	221546	42808	0.157
2017			194117		
arith. mean	176335	472122	144709	160159	0.526
geo. mean	98273				

arith. mean for the period 1986-2016

geo. mean for the period 1986-2015

Table 9.4.11 Sandeel Area-3r. Input to forecast.

	AGE 0	AGE 1	AGE 2	AGE 3	AGE 4
Stock numbers(2017)	98273	252253	311	4633	1391
Exploitation pattern 1st half		0.110	0.147	0.156	0.156
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		7.97	12.91	18.01	25.31
Weight in the catch 1st half		7.97	12.91	18.01	25.31
weight in the catch 2nd half	3.91	8.16	13.07	17.86	19.30
Proportion mature(2017)	0.00	0.04	0.77	1.00	1.00
Proportion mature(2018)	0.00	0.04	0.77	1.00	1.00
Natural mortality 1st half		0.70	0.55	0.42	0.39
Natural mortality 2nd half	1.19	0.54	0.45	0.44	0.42

Table 9.4.12 Sandeel Area-3r. Short term forecast (000 tonnes).

Basis: Fsq=F(2016)=0.128; Yield(2016)=43; Recruitment(2016)=829; Recruitment(2017)=geometric mean (GM 1986-2015)=98 billion;SSB(2017)=150

F multiplier	Basis	F(2017)	Catch(2017)	SSB(2018)	%SSB change*	%TAC change**
0	F=0	0.000	0.001	356	138 %	-100 %
0.75	Fsq*0.75	0.096	55.649	327	118 %	30 %
1	Fsq*1	0.128	73.237	318	112 %	71 %
1.25	Fsq*1.25	0.160	90.367	309	106 %	111 %
1.5	Fsq*1.5	0.192	107.052	300	100 %	150 %
1.75	Fsq*1.75	0.224	123.304	291	94 %	188 %
2.34	Fsq*2.34	0.300	159.711	272	82 %	273 %
2.25	Fsq*2.25	0.289	154.558	275	84 %	261 %
2.5	Fsq*2.5	0.321	169.584	267	78 %	296 %
No conversion for calculation of MSY catch		NA	NA	NA		

***SSB in 2018 relative to SSB in 2017**

****TAC in 2017 relative to catches in 2016**

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)

Table 9.5.1 Sandeel Area-4. Catch at age numbers (million) by half year.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1993	674	1235	149	6337	381	1861	122	534	39
1994	0	1070	256	1522	62	5144	257	2092	159
1995	4	2690	4	1229	1	529	0	30	0
1996	2666	754	2584	2536	3461	476	227	130	1110
1997	0	2879	1369	291	35	1683	43	413	10
1998	0	2159	61	3766	97	235	6	130	3
1999	0	1472	86	1137	46	1543	47	252	11
2000	0	6537	0	376	0	323	0	297	0
2001	0	2048	64	4961	20	601	1	377	0
2002	0	337	0	807	0	511	0	101	0
2003	145	4322	148	1002	10	2721	5	1253	1
2004	0	920	4	220	1	45	0	82	0
2005	0	49	0	145	0	32	0	17	0
2006	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0
2012	0	83	0	40	0	196	0	3	0
2013	0	182	0	100	0	71	0	133	0
2014	0	346	0	54	0	15	0	47	0
2015	0	866	0	29	0	9	0	14	0
2016	0	169	0	378	0	19	0	33	0
arith. mean	145	1172	197	1039	171	667	29	247	56

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
arith. mean	3.8	5.5	7.9	9.4	13.8	13.2	16.5	17.1	21.9

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 (number/hour).

Year	Age 0	Age 1
1999	615	494
2000	586	3170
2001	48	2656
2002	243	404
2003	580	
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

Table 9.5.5 Sandeel Area-4. SMS settings and statistics.

```
Date:  01/20/17    Start  time:12:06:16  run  time:2  seconds

 objective  function  (negative  log  likelihood):   0.149951
 Number            of            parameters:             43
 Maximum                gradient:                6.3454e-005
 Akaike   information   criterion   (AIC):           86.2999
 Number   of   observations   used   in   the   likelihood:
                             Catch   CPUE    S/R Stomach    Sum
                               216     27     24       0    267

 objective                    function                  weight:
                           Catch          CPUE              S/R
                           1.00           1.00             0.05

 unweighted   objective   function   contributions   (total):
                  Catch    CPUE    S/R   Stom.  Stom N.  Penalty
Sum
                 25.9   -26.5    16.3     0.0     0.0      0.00
16


 unweighted objective function contributions (per observation):
                  Catch       CPUE           S/R       Stomachs
                 0.12       -0.98          0.68           0.00


 contribution                     by                     fleet:
 ----------------------
 Old Dredge survey 1999-2003    total:  -9.401   mean:  -1.045
 New Dredge survey 2008-2016    total: -17.125   mean:  -0.951

 F,                        season                       effect:
 -----------------
 age:                                                        0
     1993-2016:                              0.000       1.000
 age:                   1                    -               4
     1993-2016:                              0.576       0.500

 F,                          age                        effect:
 --------------
                 0          1          2          3          4
 1993-2016:     0.003      0.103      0.175      0.227      0.227


 Exploitation     pattern     (scaled     to     mean     F=1)
 -----------------------------------------
                         0        1        2        3        4
 1993-2016  season  1:       0   0.654    1.108    1.440    1.440
           season  2:   0.005   0.088    0.149    0.194    0.194
```

```
sqrt(catch variance) ~ CV:
---------------------------

season
----------------------
age                                1          2

 0                                           2.013
 1                                 0.665     0.375
 2                                 0.665     0.375
 3                                 0.774     1.257
 4                                 0.774     1.257


Survey catchability:
--------------------
                              age 0          age 1
 Old Dredge survey 1999-2003  0.723         16.413
 New Dredge survey 2008-2016  0.479          2.322

sqrt(Survey variance) ~ CV:
---------------------------
                              age 0          age 1
 Old Dredge survey 1999-2003  0.30           0.30
 New Dredge survey 2008-2016  0.30           0.30

Recruit-SSB        alfa        beta       recruit s2   recruit
s
Area-4         1602.131   4.800e+004   1.434          1.197
```

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	0.313	0.515	0.653	0.652	0.414
1994	0.002	0.363	0.595	0.754	0.751	0.479
1995	0.000	0.107	0.175	0.219	0.218	0.141
1996	0.008	0.229	0.400	0.537	0.541	0.314
1997	0.001	0.134	0.223	0.285	0.284	0.179
1998	0.000	0.144	0.237	0.299	0.297	0.191
1999	0.000	0.208	0.339	0.426	0.424	0.274
2000	0.000	0.103	0.169	0.212	0.211	0.136
2001	0.000	0.162	0.265	0.333	0.332	0.214
2002	0.000	0.035	0.056	0.071	0.071	0.045
2003	0.001	0.259	0.424	0.535	0.533	0.342
2004	0.000	0.050	0.081	0.102	0.102	0.065
2005	0.000	0.022	0.036	0.045	0.044	0.029
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	0.002
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
2011	0.000	0.002	0.003	0.003	0.003	0.002
2012	0.000	0.017	0.027	0.034	0.034	0.022
2013	0.000	0.009	0.015	0.019	0.019	0.012
2014	0.000	0.012	0.020	0.025	0.025	0.016
2015	0.000	0.010	0.016	0.020	0.020	0.013
2016	0.000	0.018	0.029	0.037	0.037	0.024
arith. mean	0.001	0.092	0.151	0.192	0.192	0.121

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	0.231	0.031	0.392	0.053	0.509	0.069	0.509	0.069
1994	0.002	0.272	0.030	0.460	0.050	0.598	0.066	0.598	0.066
1995	0.000	0.084	0.000	0.142	0.000	0.185	0.001	0.185	0.001
1996	0.008	0.100	0.158	0.169	0.268	0.220	0.348	0.220	0.348
1997	0.001	0.094	0.022	0.160	0.037	0.208	0.048	0.208	0.048
1998	0.000	0.111	0.006	0.187	0.010	0.244	0.013	0.244	0.013
1999	0.000	0.164	0.000	0.278	0.000	0.362	0.000	0.362	0.000
2000	0.000	0.081	0.000	0.138	0.000	0.179	0.000	0.179	0.000
2001	0.000	0.127	0.002	0.214	0.004	0.279	0.005	0.279	0.005
2002	0.000	0.027	0.000	0.046	0.000	0.060	0.000	0.060	0.000
2003	0.001	0.198	0.012	0.336	0.020	0.437	0.026	0.437	0.026
2004	0.000	0.039	0.000	0.066	0.001	0.085	0.001	0.085	0.001
2005	0.000	0.017	0.000	0.029	0.000	0.038	0.000	0.038	0.000
2006	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000
2007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.001	0.000	0.002	0.000	0.003	0.000	0.003	0.000
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.001	0.000	0.001	0.000	0.002	0.000	0.002	0.000
2011	0.000	0.001	0.000	0.002	0.000	0.003	0.000	0.003	0.000
2012	0.000	0.013	0.000	0.022	0.000	0.029	0.000	0.029	0.000
2013	0.000	0.007	0.000	0.012	0.000	0.016	0.000	0.016	0.000
2014	0.000	0.010	0.000	0.016	0.000	0.021	0.000	0.021	0.000
2015	0.000	0.008	0.000	0.013	0.000	0.017	0.000	0.017	0.000
2016	0.000	0.014	0.000	0.024	0.000	0.031	0.000	0.031	0.000
arith. mean	0.001	0.067	0.011	0.113	0.018	0.147	0.024	0.147	0.024

Table 9.5.8 Sandeel Area-4. Natural mortality (M) at age.

	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1993	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1994	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1995	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1996	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1997	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1998	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
1999	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2000	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2001	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2002	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2003	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2004	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2005	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2006	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2007	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2008	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2009	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2010	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2011	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2012	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2013	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2014	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2015	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
2016	1.14	0.767	0.592	0.602	0.488	0.431	0.392	0.398	0.378
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	117704	21768	24410	7678	1705
1994	263780	37582	4302	5262	2332
1995	71239	84230	7143	868	1743
1996	388422	22783	19893	2082	983
1997	99473	123195	4522	4321	775
1998	44730	31776	28173	1248	1744
1999	243266	14301	7266	7776	1045
2000	206646	77801	3118	1850	2714
2001	25014	66089	18428	913	1724
2002	90984	7999	14926	4981	899
2003	155502	29098	2000	4794	2451
2004	13187	49701	6058	471	2034
2005	13144	4217	12279	1906	1049
2006	7685	4204	1065	4011	1271
2007	11483	2458	1080	358	2345
2008	32518	3673	631	363	1236
2009	466810	10400	942	212	726
2010	78289	149295	2672	317	427
2011	55784	25038	38328	897	335
2012	49061	17841	6424	12858	547
2013	32228	15691	4525	2113	5732
2014	358693	10307	4002	1503	3510
2015	55287	114717	2623	1324	2228
2016	168862	17682	29246	870	1580
2017		54005	4480	9602	1075

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 (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F1-2
1993	117704	597852	374695	132599	0.414
1994	263780	581282	161292	158690	0.479
1995	71239	864800	131851	52591	0.141
1996	388422	438181	262860	158490	0.314
1997	99473	920593	87883	58446	0.179
1998	44730	526991	272790	58746	0.191
1999	243266	311830	206019	53334	0.274
2000	206646	397581	90585	37714	0.136
2001	25014	367668	119834	47902	0.214
2002	90984	182167	132582	12736	0.045
2003	155502	212711	75326	63731	0.342
2004	13187	276595	67690	6882	0.065
2005	13144	120687	86716	1557	0.029
2006	7685	113978	87618	0	0.000
2007	11483	63477	49499	0	0.000
2008	32518	46912	28208	0	0.002
2009	466810	87825	25084	0	0.000
2010	78289	801350	31181	0	0.001
2011	55784	479239	285758	0	0.002
2012	49061	254632	169486	2585	0.022
2013	32228	254342	161952	5225	0.012
2014	358693	218862	134729	4314	0.016
2015	55287	576447	70671	4392	0.013
2016	168862	433182	283838	5763	0.024
2017			188096		
arith. mean	127075	380383	143450	36071	0.121
geo. mean	69287				

arith. mean for the period 1993-2016

geo. mean for the period 1993-2015

Table 9.5.11 Sandeel Area-4. Input to forecast.

	AGE 0	AGE 1	AGE 2	AGE 3	AGE 4
Stock numbers(2017)	53254	54005	4480	9602	1075
Exploitation pattern 1st half		0.014	0.024	0.031	0.031
Exploitation pattern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half		5.15	9.88	14.21	18.04
Weight in the catch 1st half		5.15	9.88	14.21	18.04
weight in the catch 2nd half	4.25	8.50	14.56	17.95	22.95
Proportion mature(2017)	0.00	0.00	0.79	0.98	1.00
Proportion mature(2018)	0.00	0.00	0.79	0.98	1.00
Natural mortality 1st half		0.77	0.60	0.43	0.40
Natural mortality 2nd half	1.14	0.59	0.49	0.39	0.38

Table 9.5.12 Sandeel Area-4. Short term forecast (000 tonnes).

Basis: Fsq=F(2016)=0.019; Yield(2016)=6; Recruitment(2016)=169; Recruitment(2017)=geometric mean (GM 2006-2015)=53 billion;SSB(2017)=188

F multiplier	Basis	F(2017)	Catch(2017)	SSB(2018)	%SSB change*	%TAC change**
0.000	F=0	0.000	0.001	214	14 %	-100 %
4.500	Fsq*4.5	0.085	31.833	194	3 %	452 %
6.000	Fsq*6	0.113	41.774	188	0 %	625 %
7.920	Fsq*7.92	0.150	54.043	181	-4 %	838 %
9.000	Fsq*9	0.170	60.728	177	-6 %	954 %
10.500	Fsq*10.5	0.198	69.762	171	-9 %	1111 %
12.000	Fsq*12	0.227	78.516	166	-12 %	1262 %
13.500	Fsq*13.5	0.255	87.000	161	-14 %	1410 %
15.000	Fsq*15	0.283	95.224	156	-17 %	1552 %
36.143	MSY	0.682	188.221	102	-46 %	3166 %

***SSB in 2018 relative to SSB in 2017**

****TAC in 2017 relative to catches in 2016**

Table 9.6.1 Acoustic survey index (Area-5) is estimated as biomass (tons) methods and acoustic target strength described in ICES (2016) (Benchmark report).

Year	Biomass (tons)
2009	256.5
2010	6320.9
2011	3300.2
2012	732.2
2013	3949.1
2014	1331.8
2015	10477.6
2016	733.2

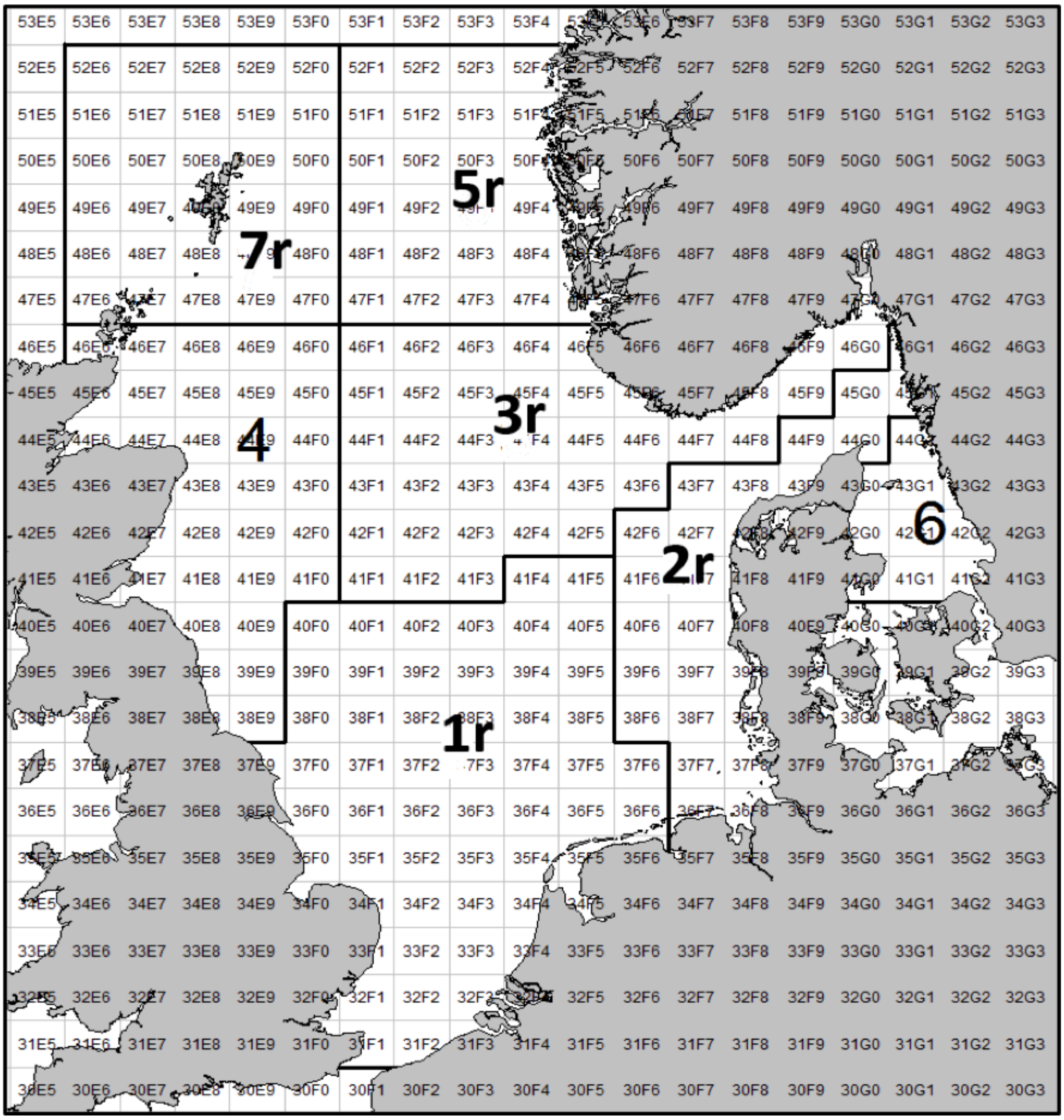


Figure 9.1.1 Sandeel in ICES div 4 and 3.a. Sandeel management areas.

Figure 9.1.2 Sandeel in ICES div 4 and 3.a. Catch by ICES rectangles 2001-2016. Area of the circles is proportional to catch by rectangle.

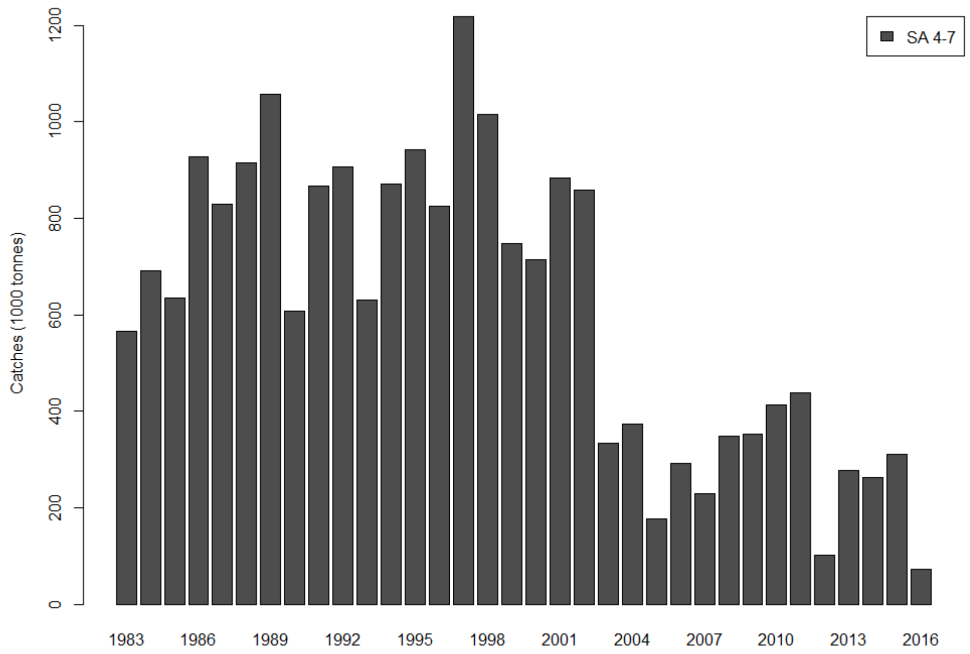


Figure 9.1.3 Sandeel in ICES div 4 and 3.a. Total catches by year and area.

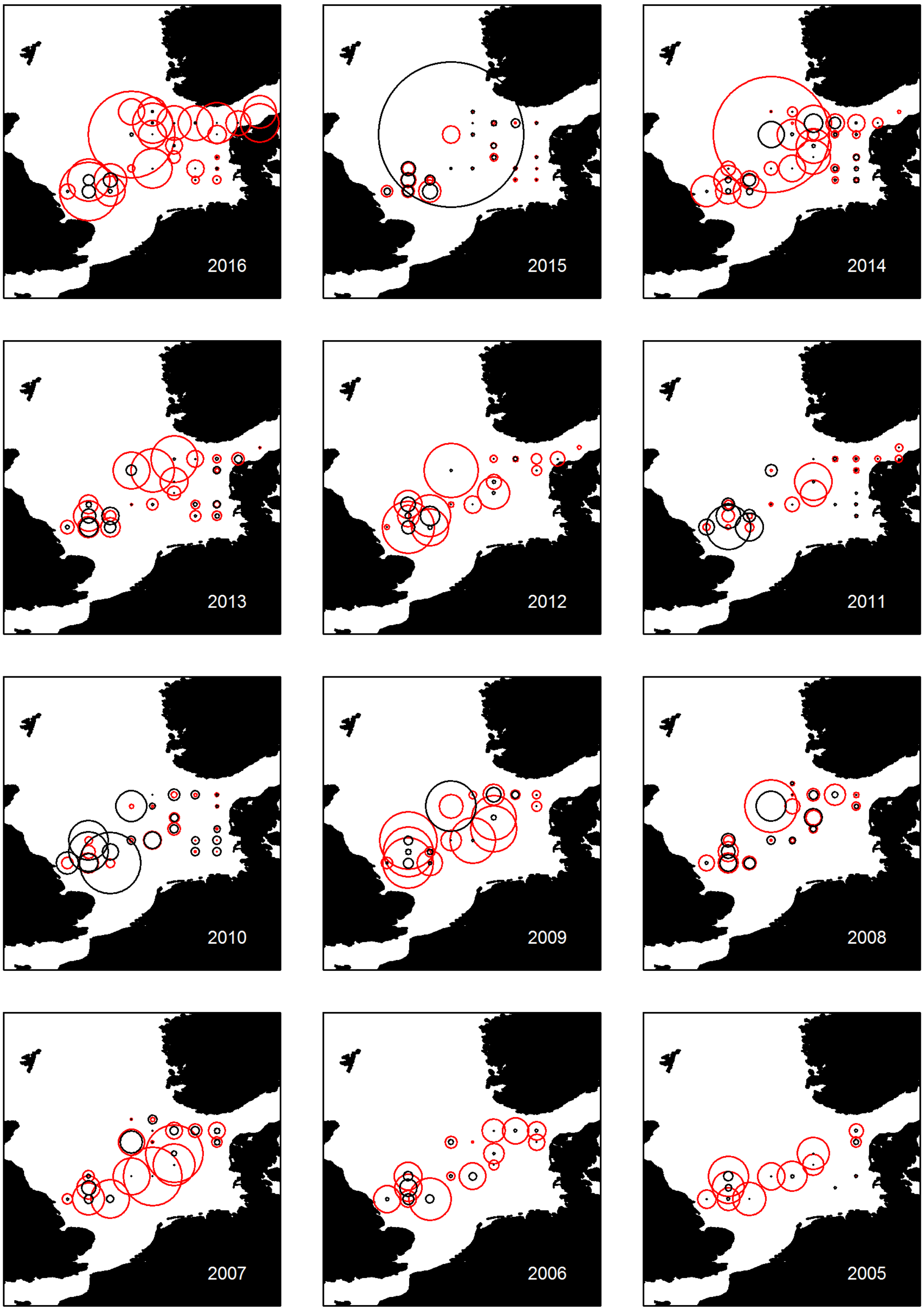


Figure 9.1.4 Sandeel in ICES div 4 and 3.a. Danish survey indices by year and ICES rectangles. Red circles: 0-group, black circles: 1-group. Area of the circles is proportional to catch numbers by rectangle.

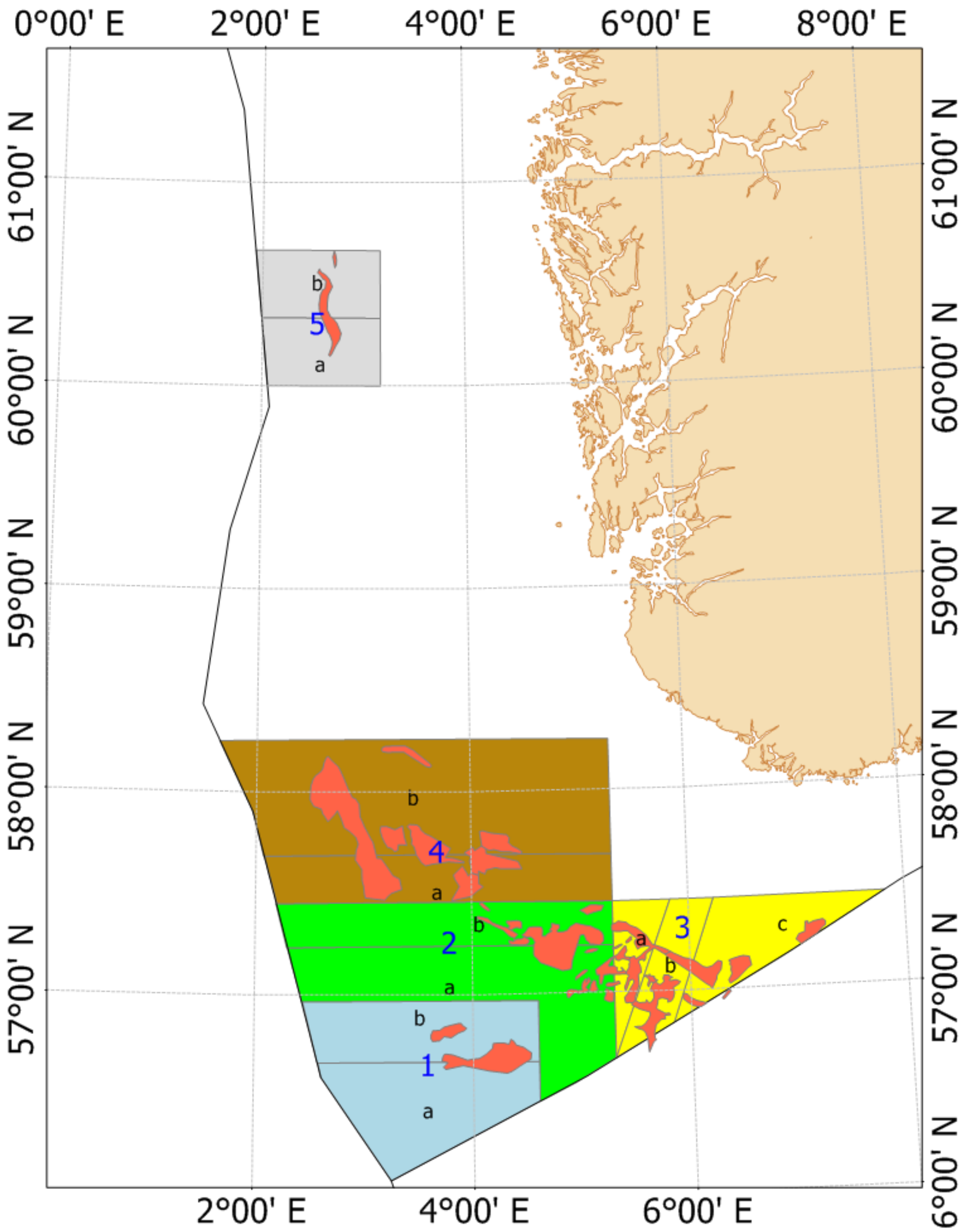


Figure 9.1.5 Sandeel in ICES div 4 and 3.a. Norwegian sandeel managemnt areas. There are 6 main areas consisting of subareas a and b. Sub Area3 consist of three subareas a, b, and c.

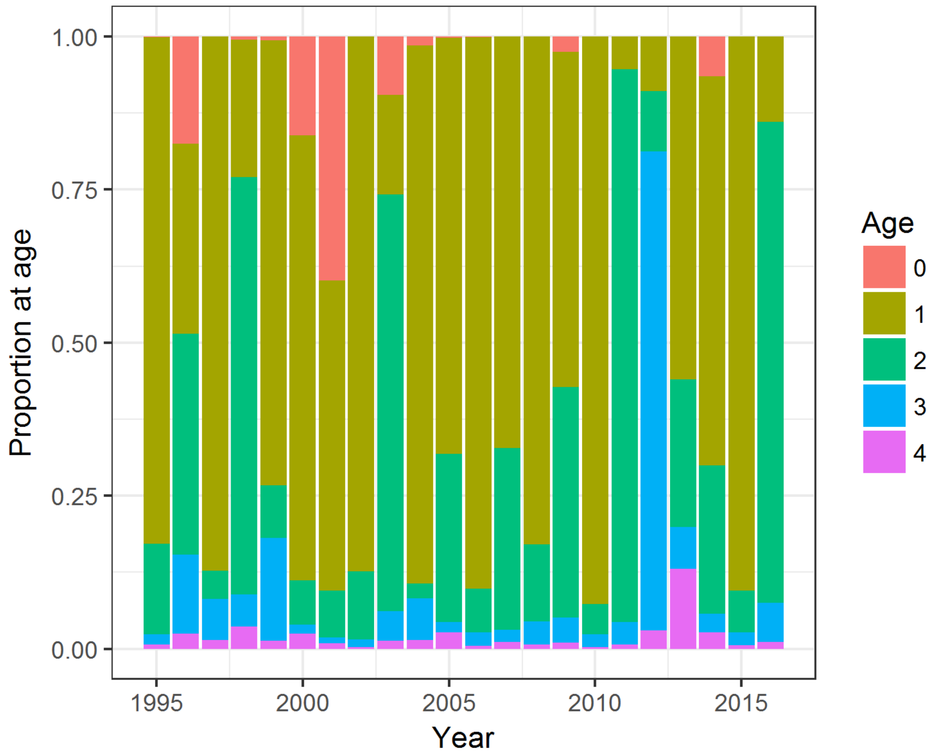


Figure 9.2.1 Sandeel Area-1r. Catch numbers, proportion at age.

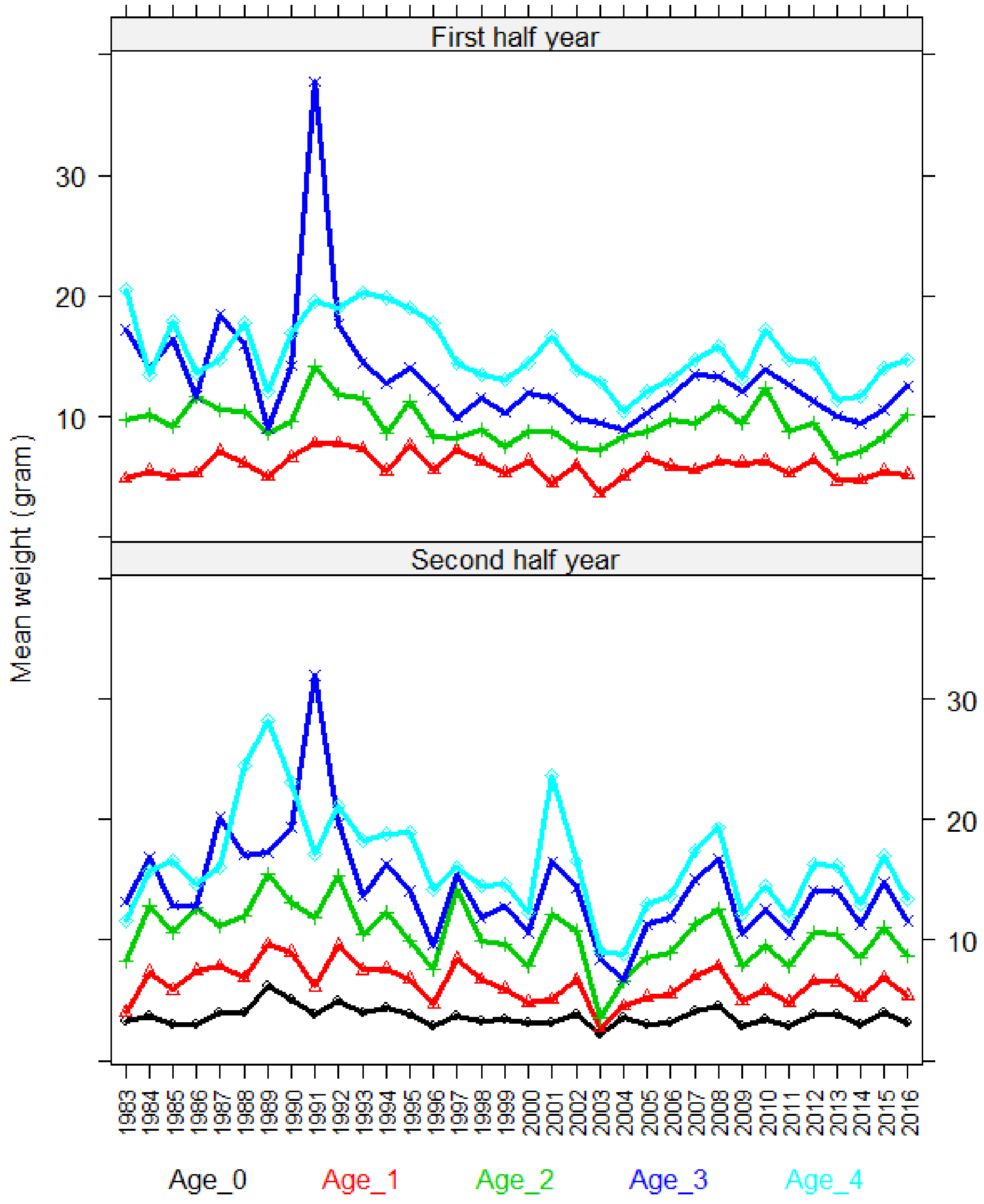


Figure 9.2.2 Sandeel Area-1r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

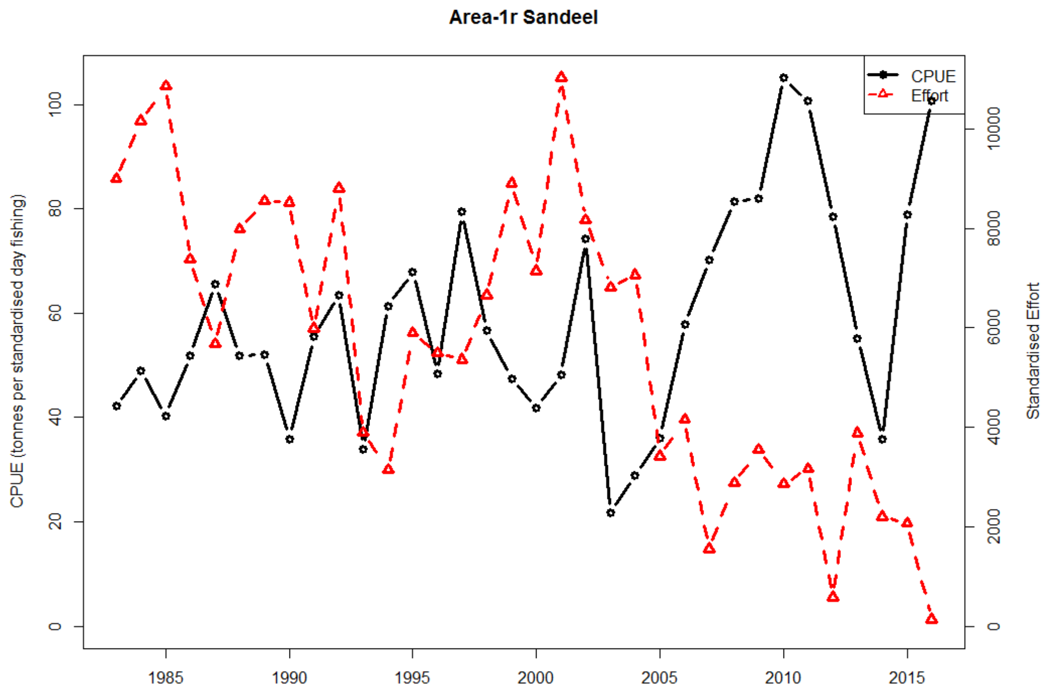


Figure 9.2.3 Sandeel Area-1r. CPUE and effort.

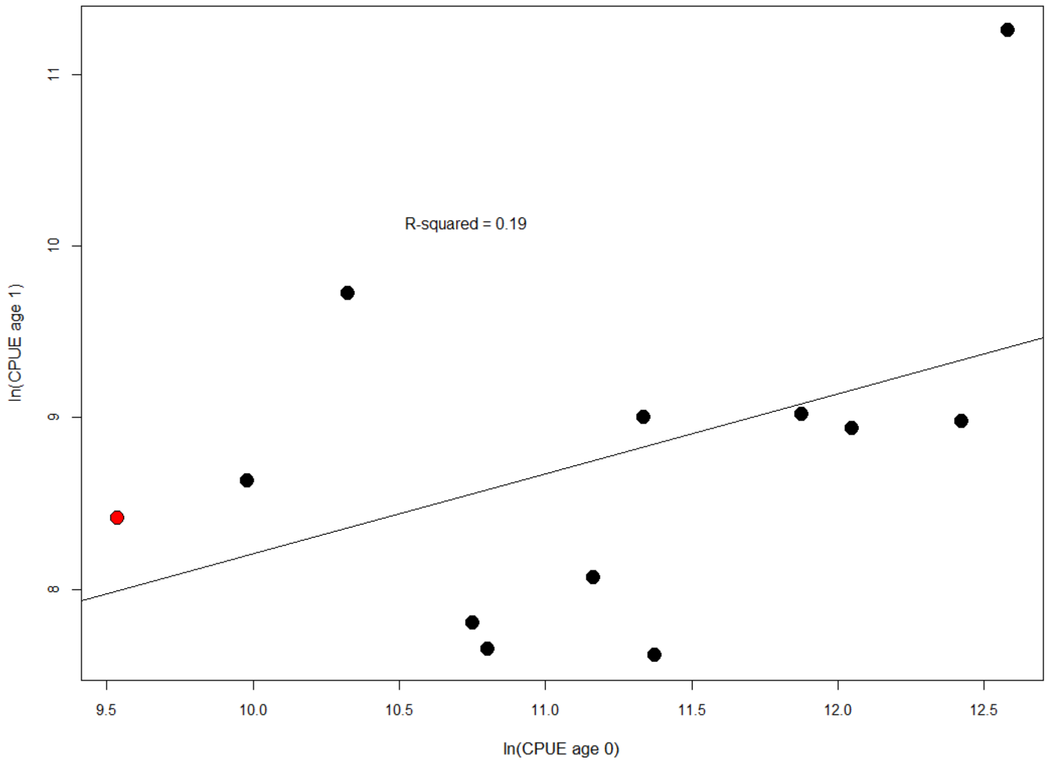


Figure 9.2.4 Sandeel Area-1r. Internal consistency by age of the dregde survey. Red dot indicates the most recent data point.

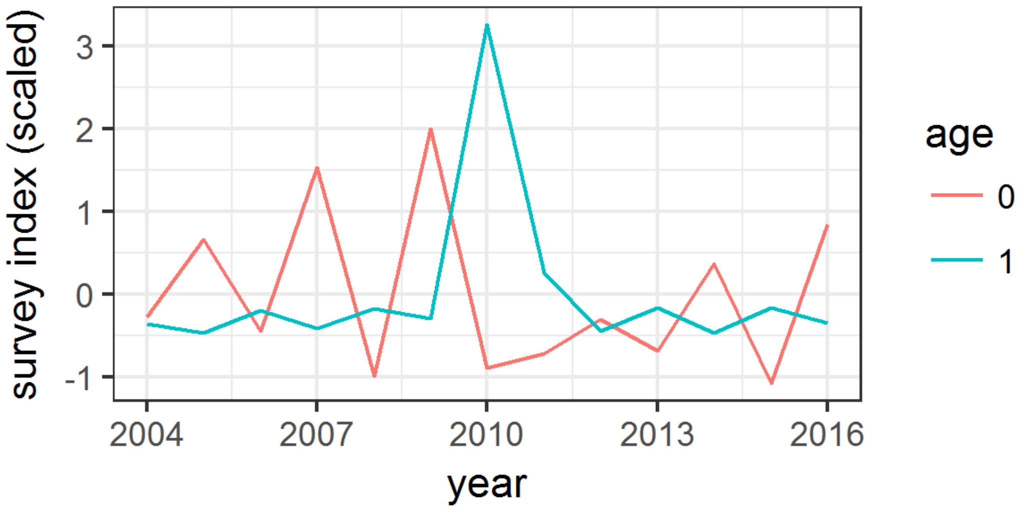


Figure 9.2.5 Sandeel Area-1r. Dredge survey index timeline.

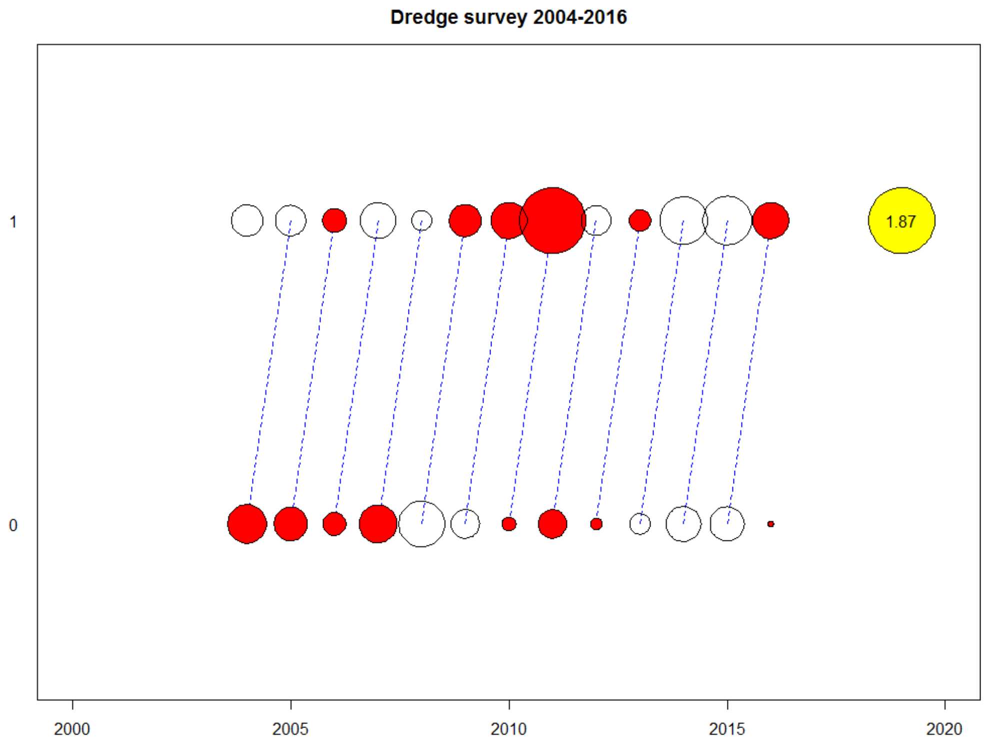


Figure 9.2.6 Sandeel Area-1r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

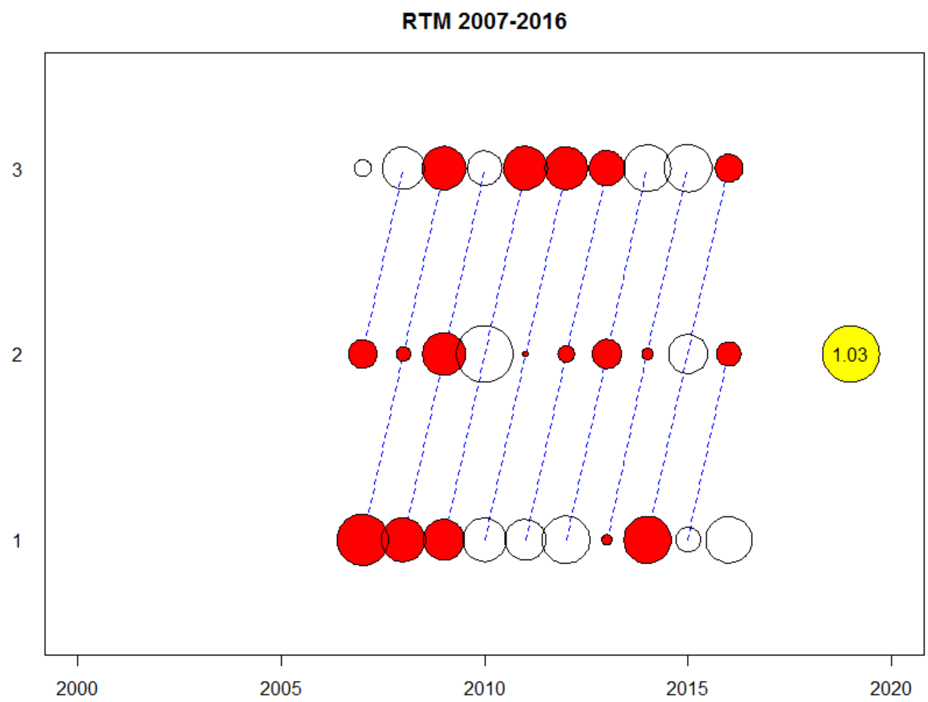
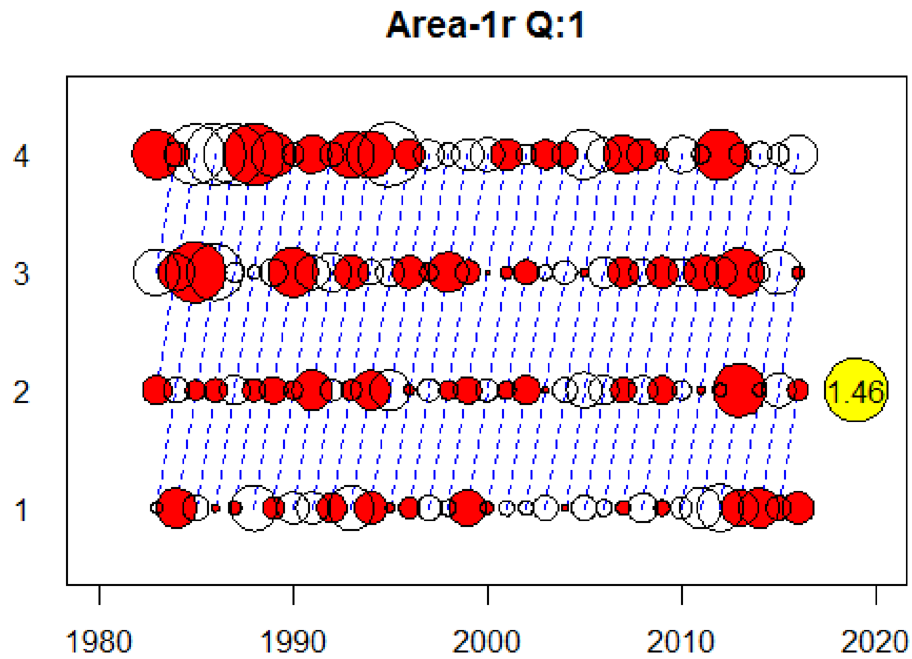


Figure 9.2.6b Sandeel Area-1r. RTM at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.



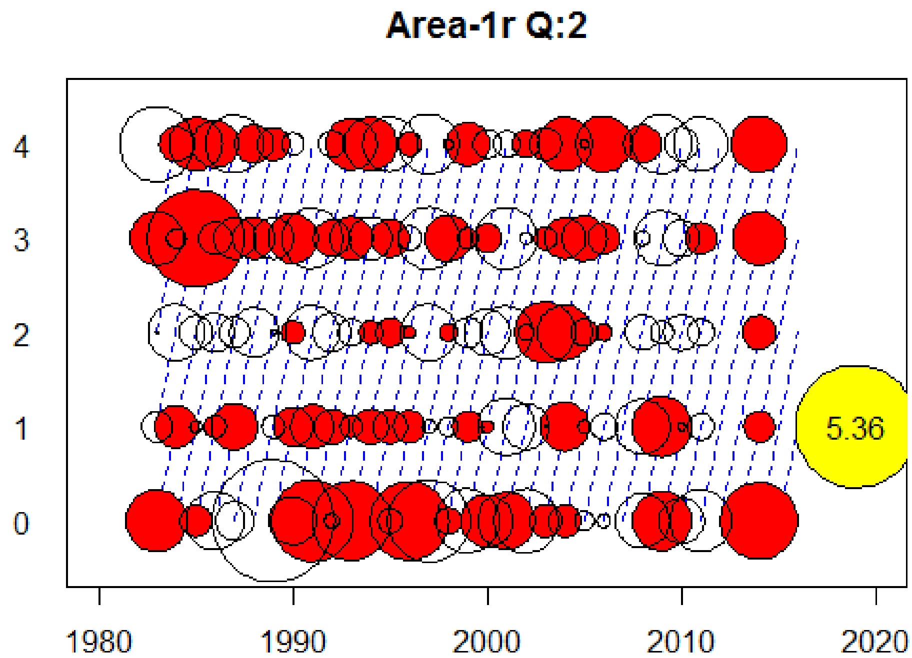


Figure 9.2.7 Sandeel Area-1r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

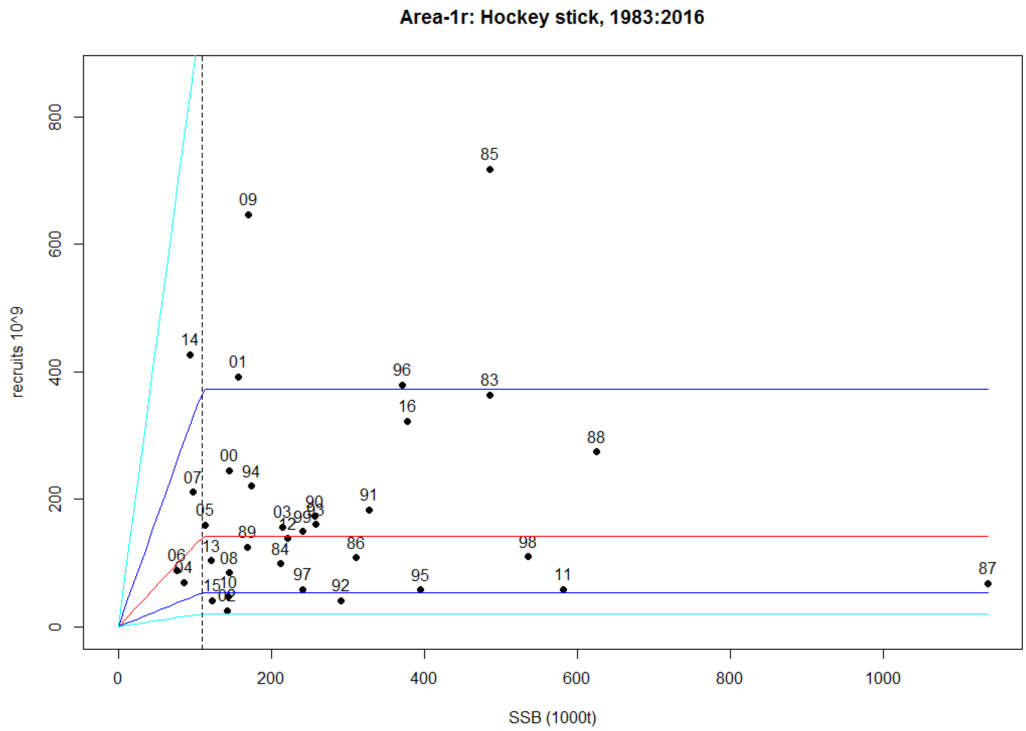


Figure 9.2.8 Sandeel Area-1r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

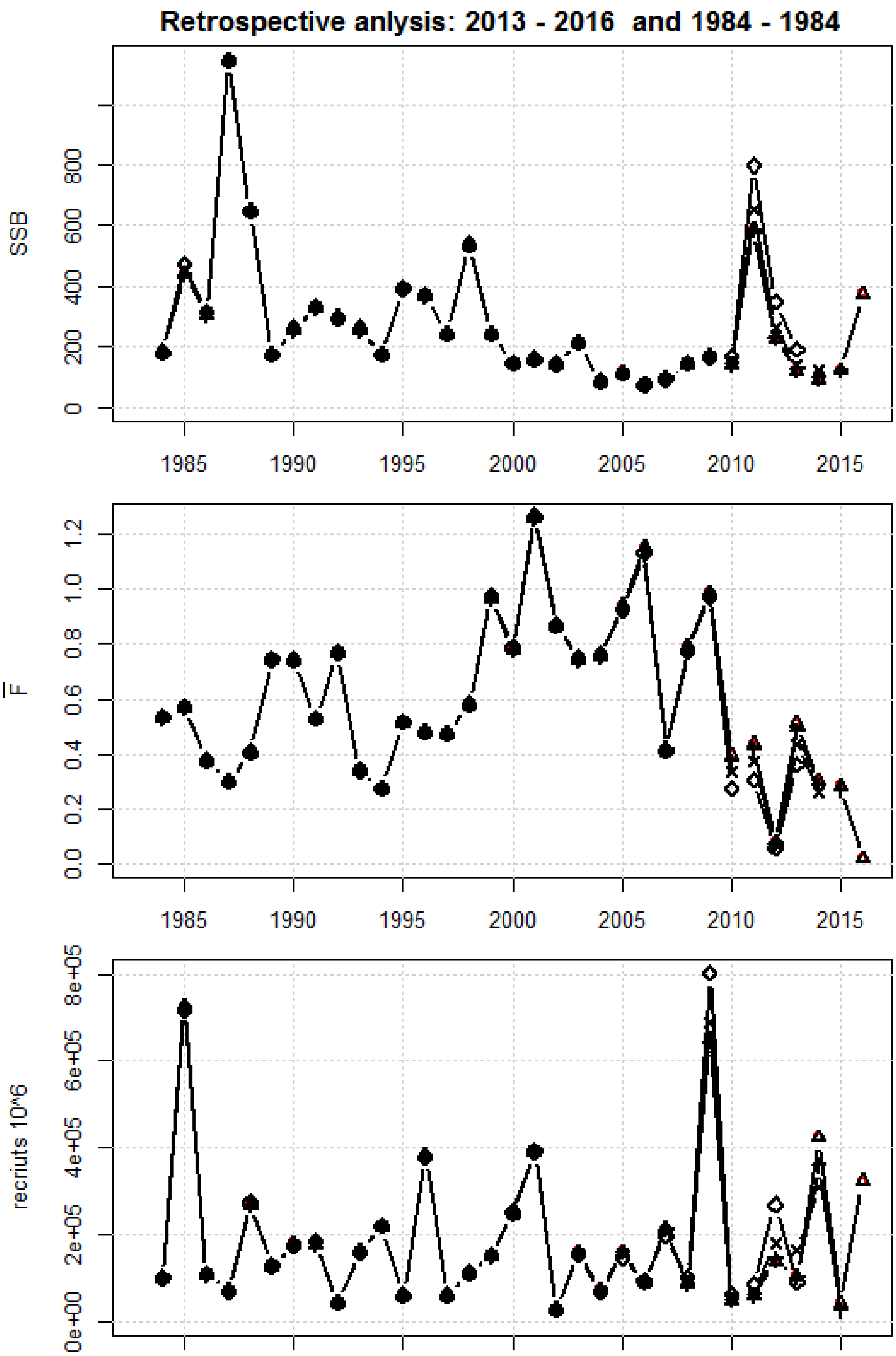


Figure 9.2.9 Sandeel Area-1r. Retrospective analysis.

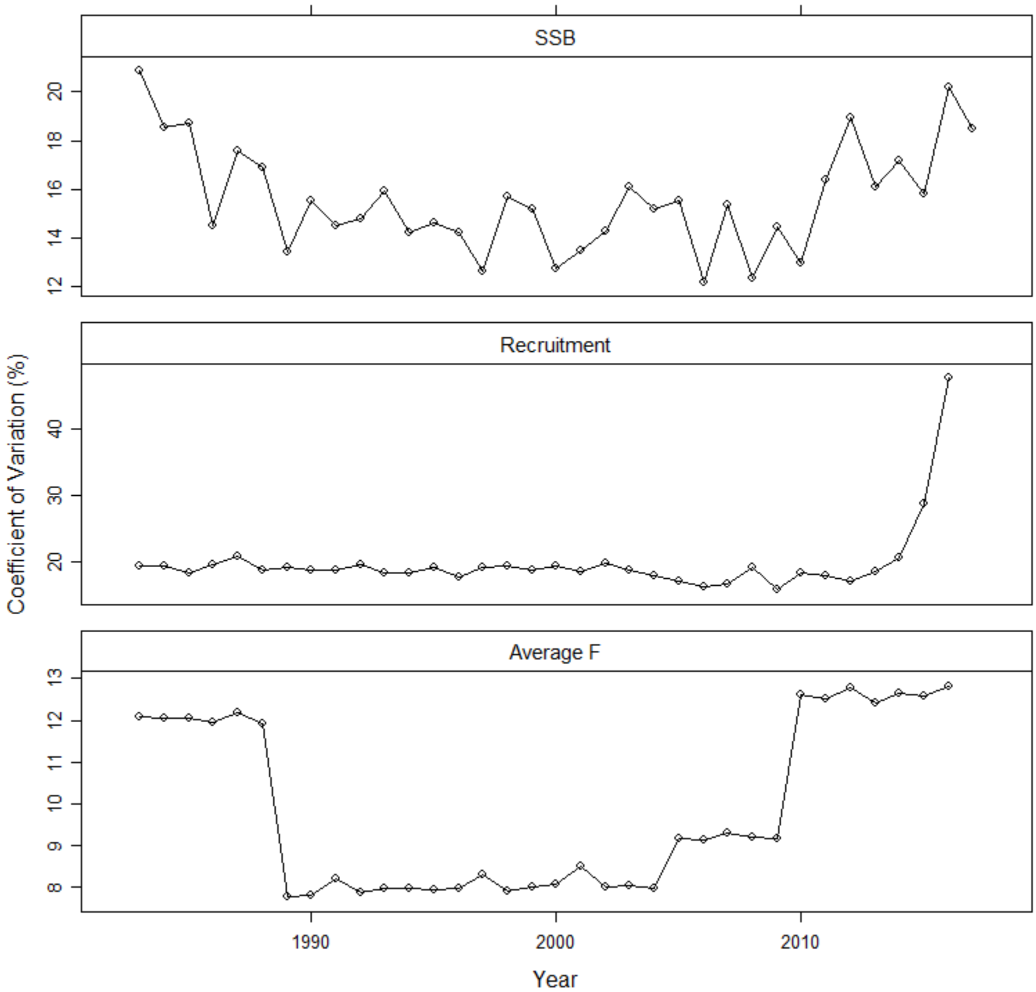


Figure 9.2.10 Sandeel Area-1r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

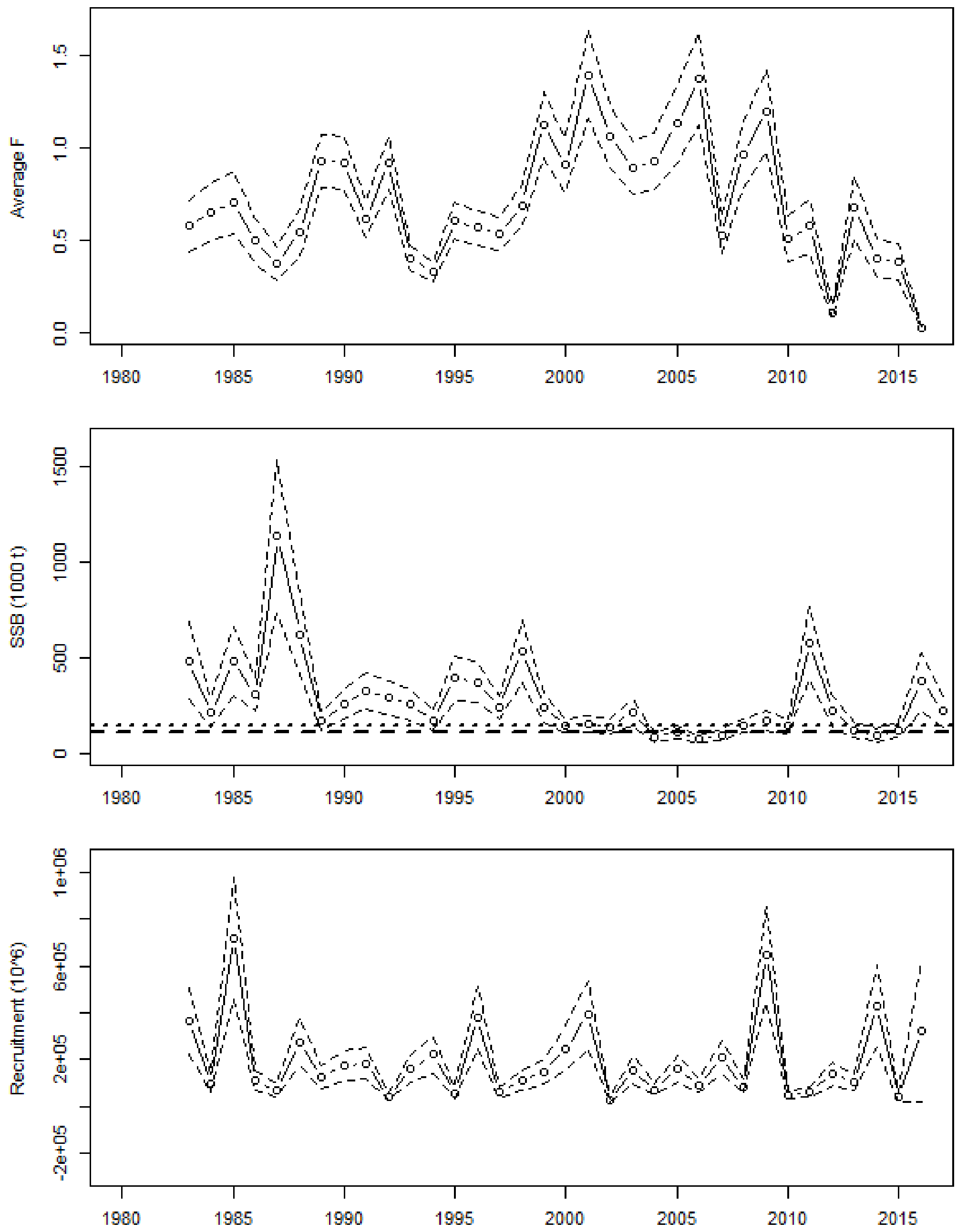


Figure 9.2.11 Sandeel Area-1r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation..

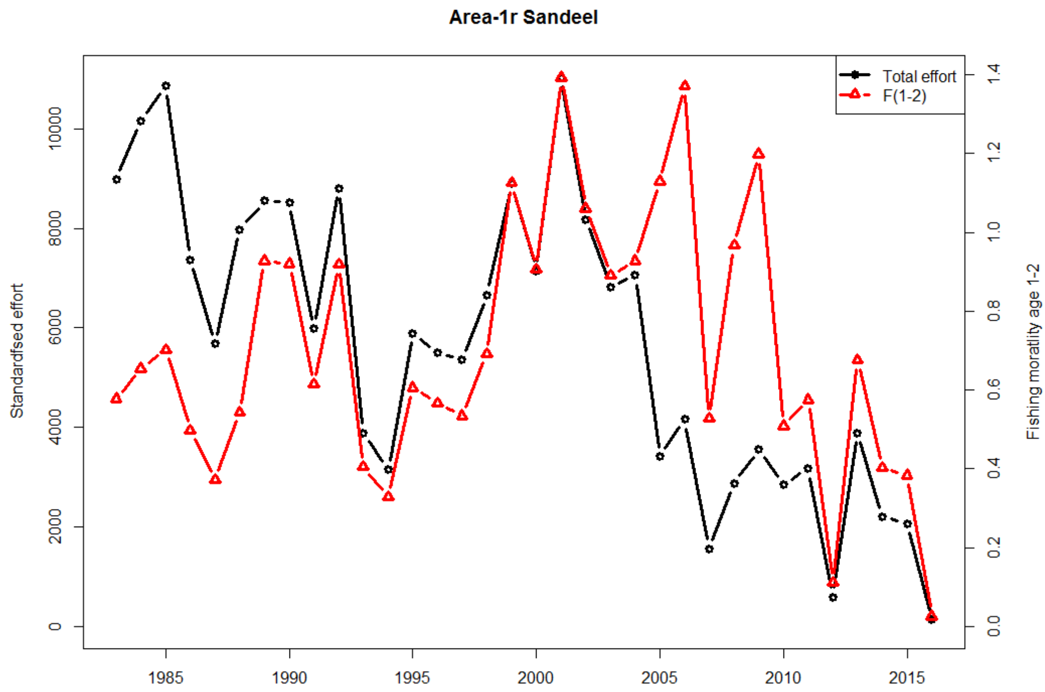


Figure 9.2.12 Sandeel Area-1r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

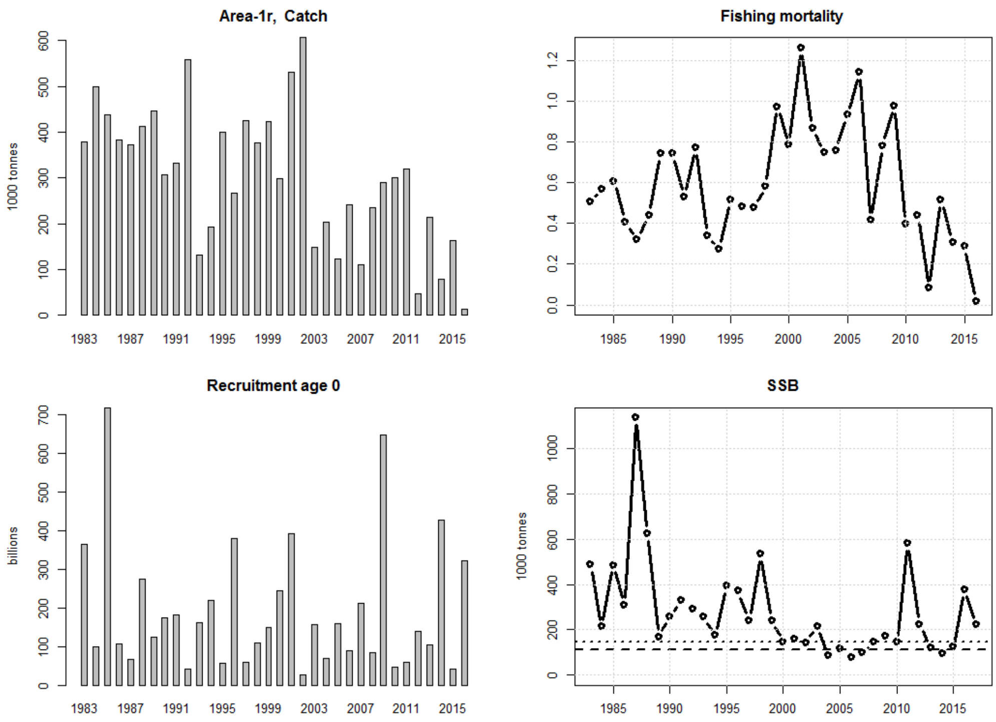


Figure 9.2.13 Sandeel Area-1r. Stock summary.

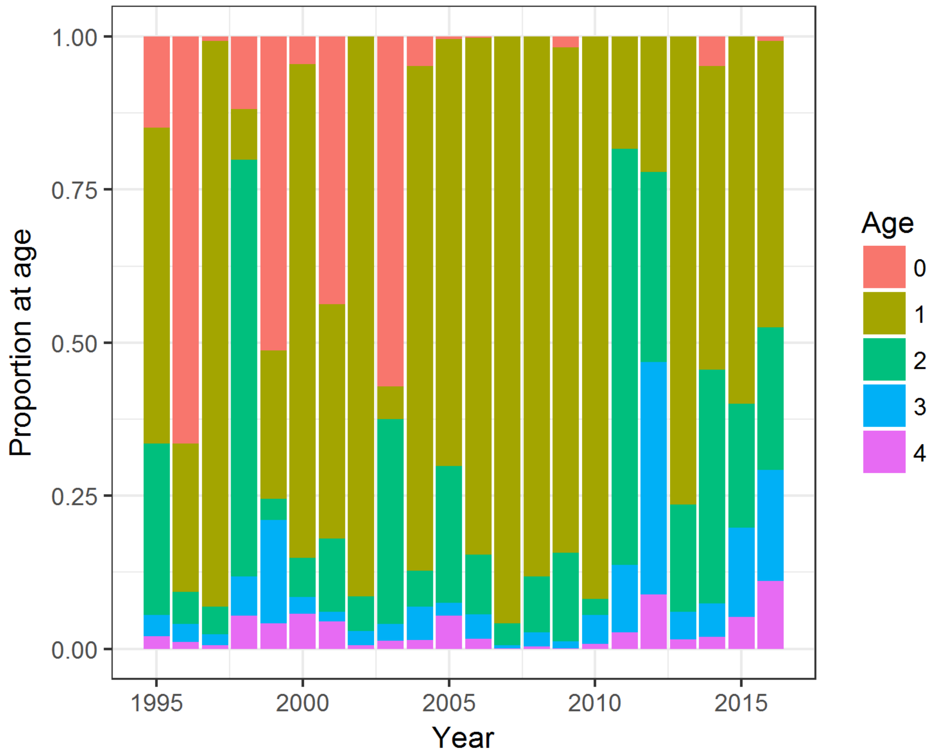


Figure 9.3.1 Sandeel Area-2r. Catch numbers, proportion at age.

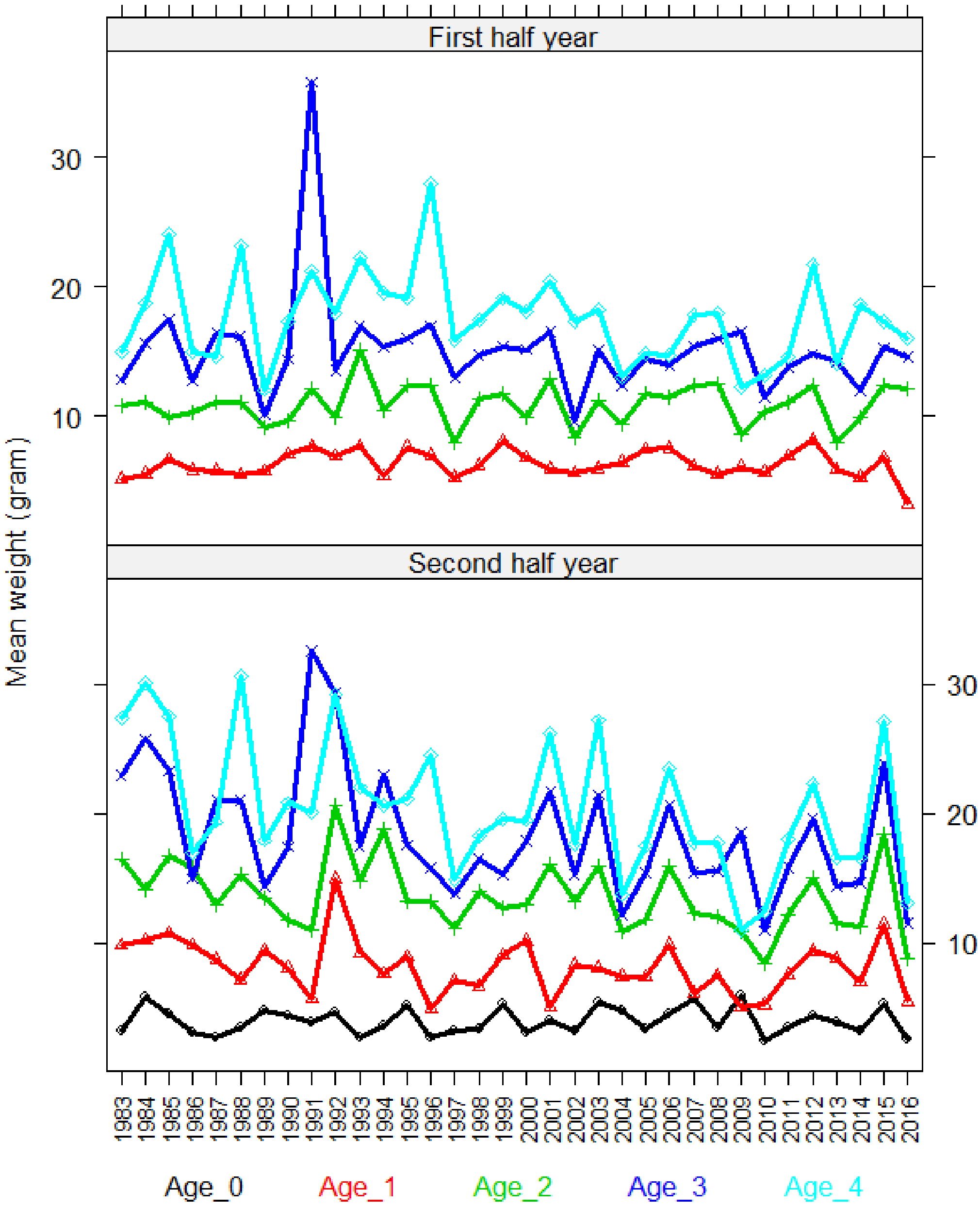


Figure 9.3.2 Sandeel Area-2r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

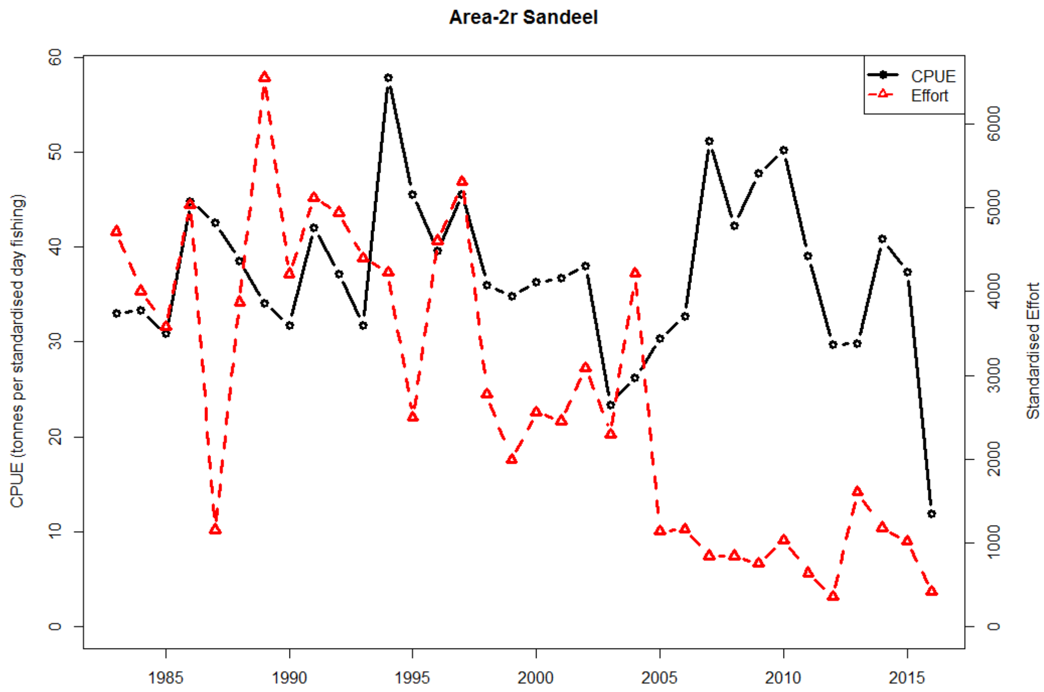


Figure 9.3.3 Sandeel Area-2r. CPUE and effort.

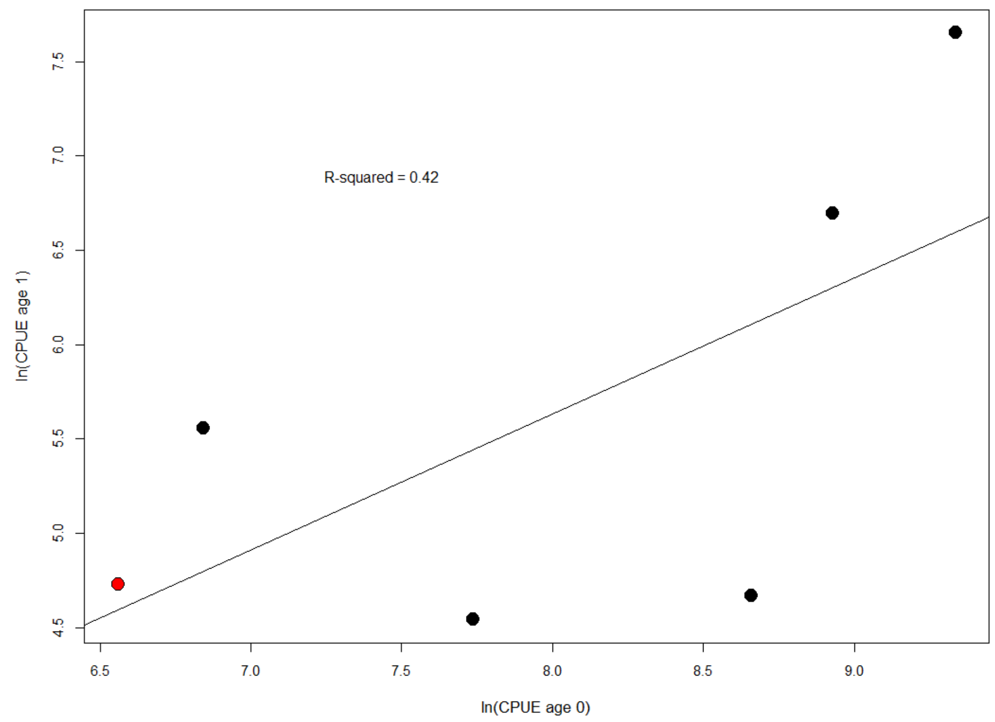


Figure 9.3.4 Sandeel Area-2r. Internal consistency by age of the dregde survey. Red dot indicates the most recent data point.

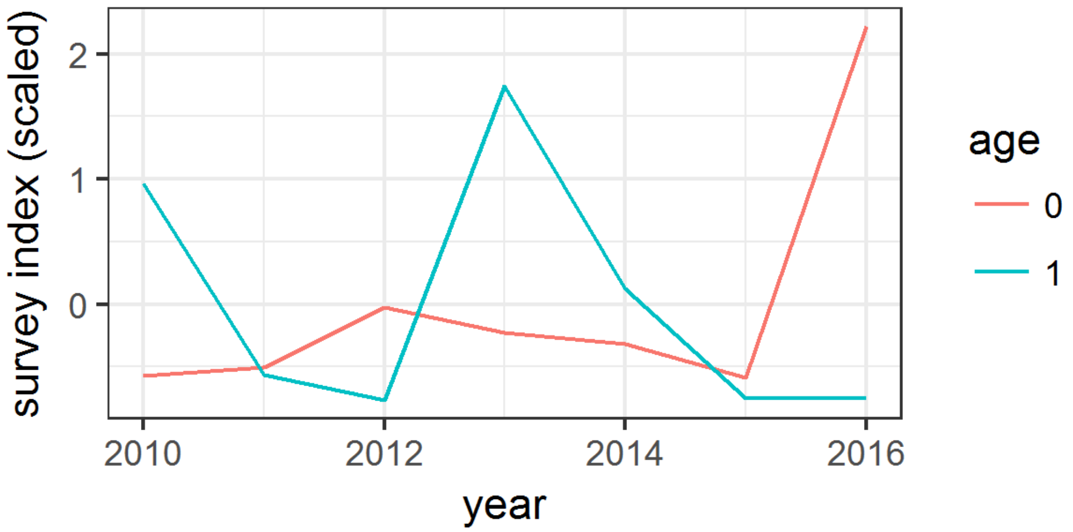


Figure 9.3.5 Sandeel Area-2r. Dredge survey index timeline.

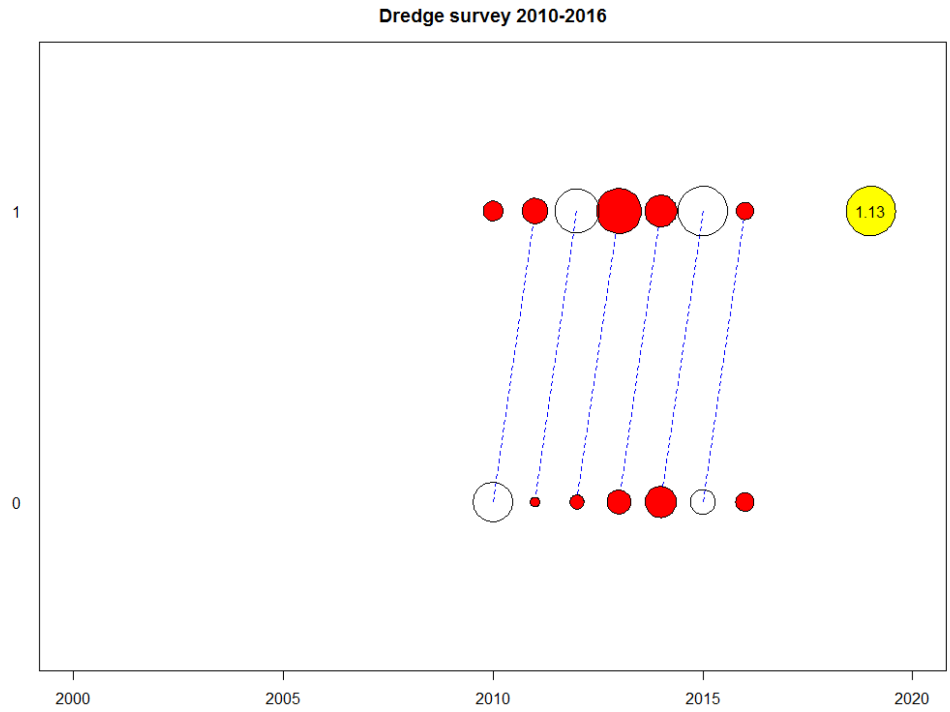


Figure 9.3.6 Sandeel Area-2r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

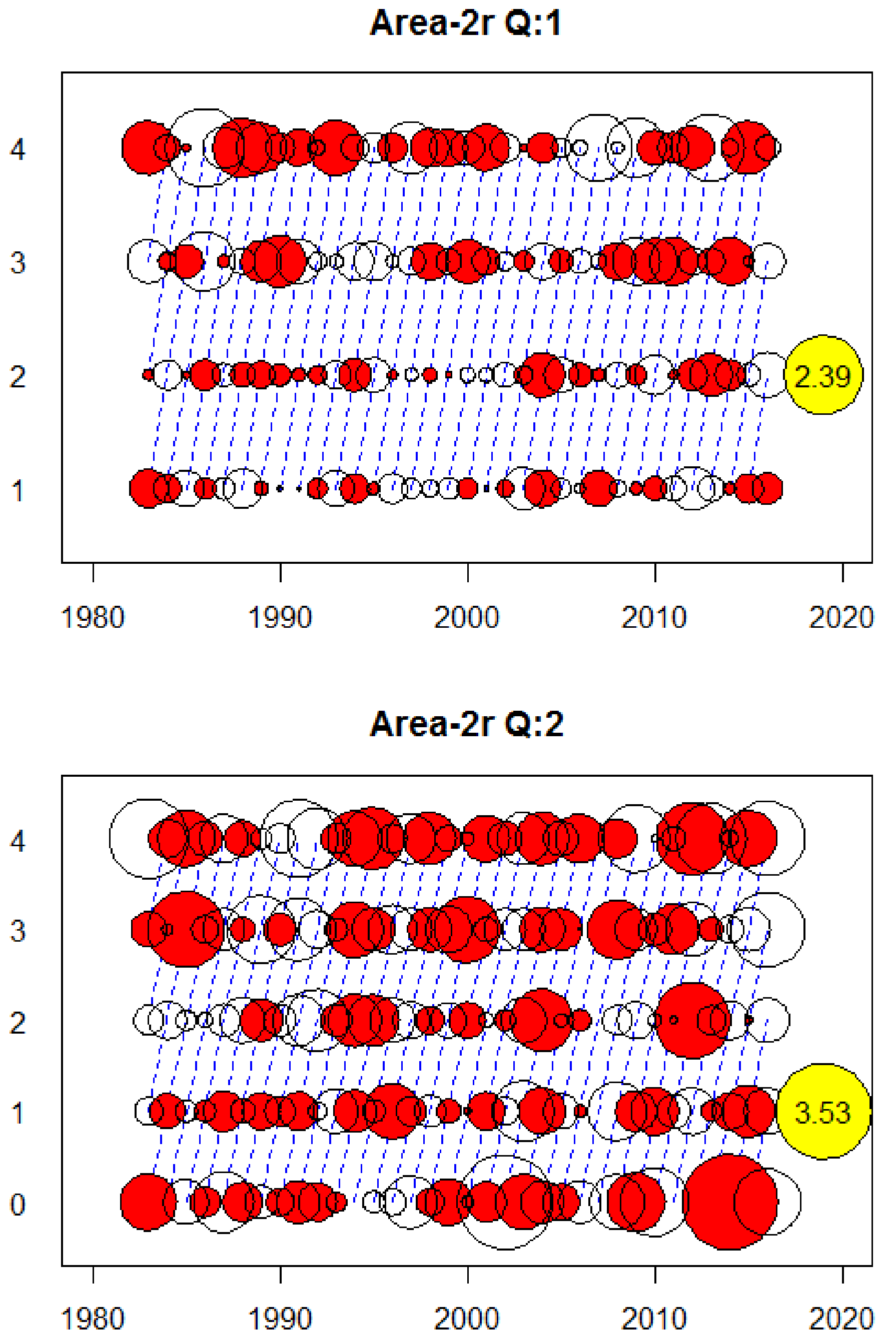


Figure 9.3.7 Sandeel Area-2r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

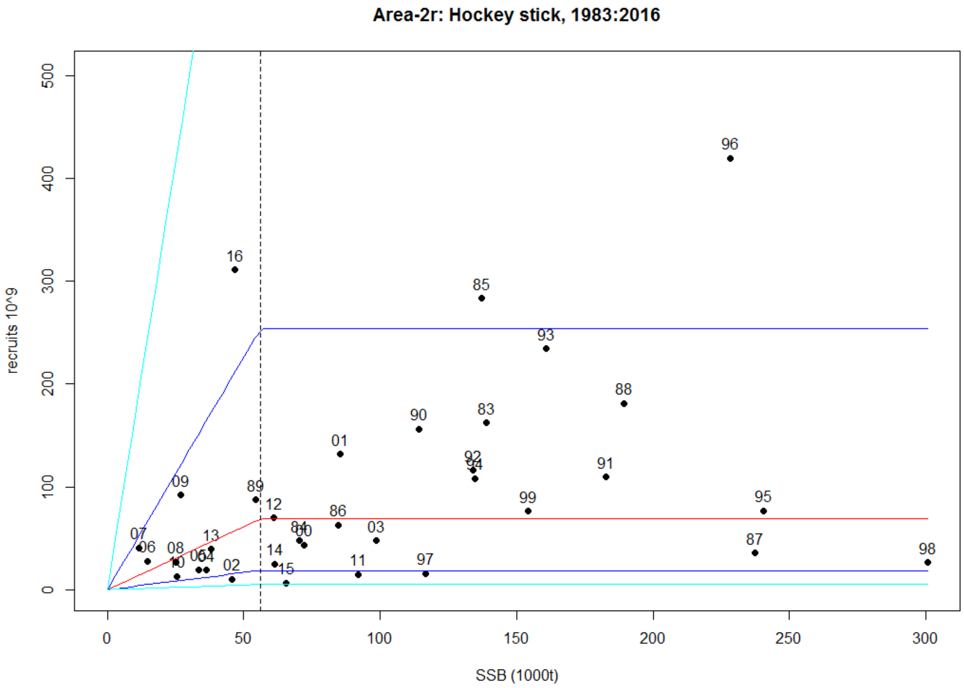


Figure 9.3.8 Sandeel Area-2r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

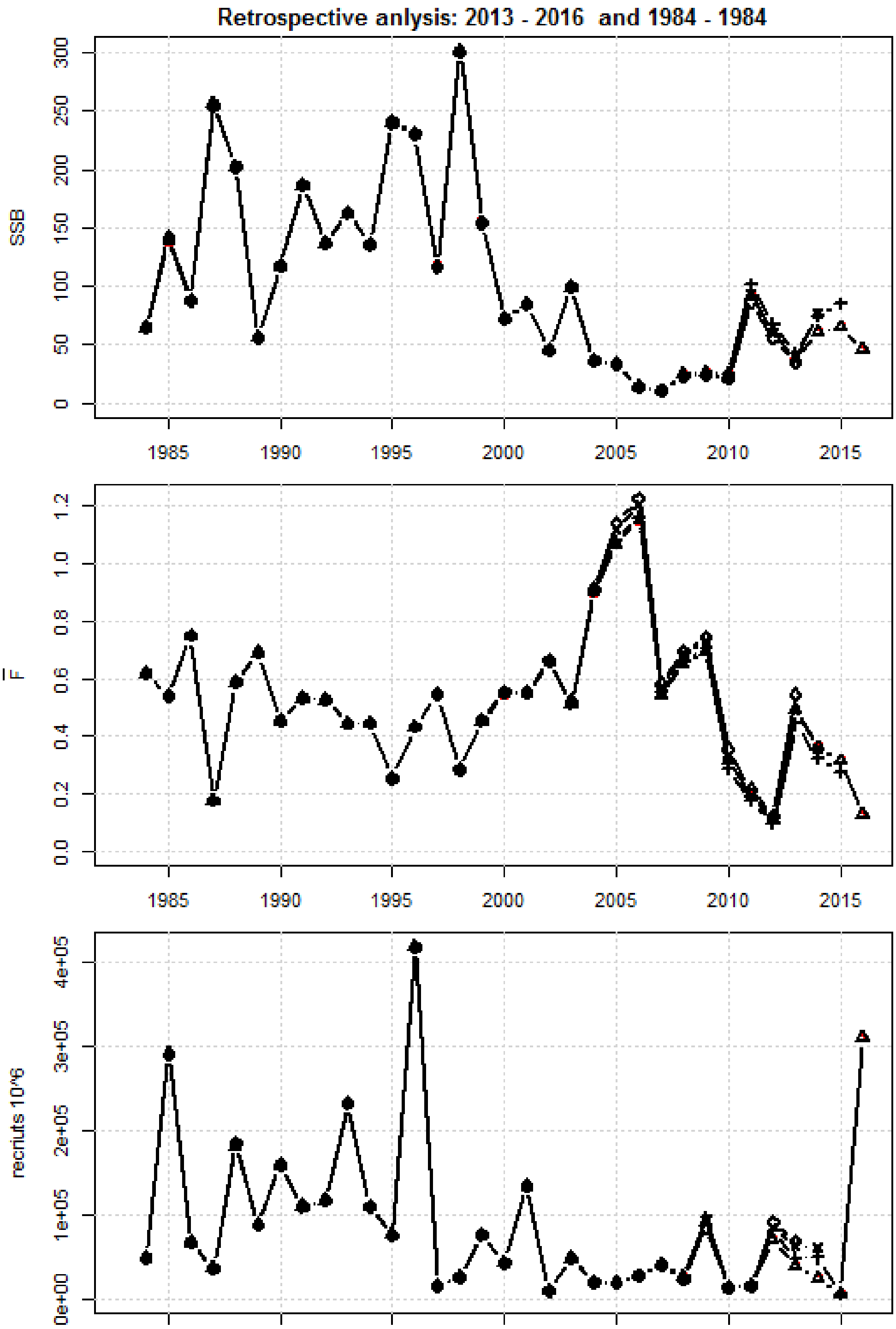


Figure 9.3.9 Sandeel Area-2r. Retrospective analysis.

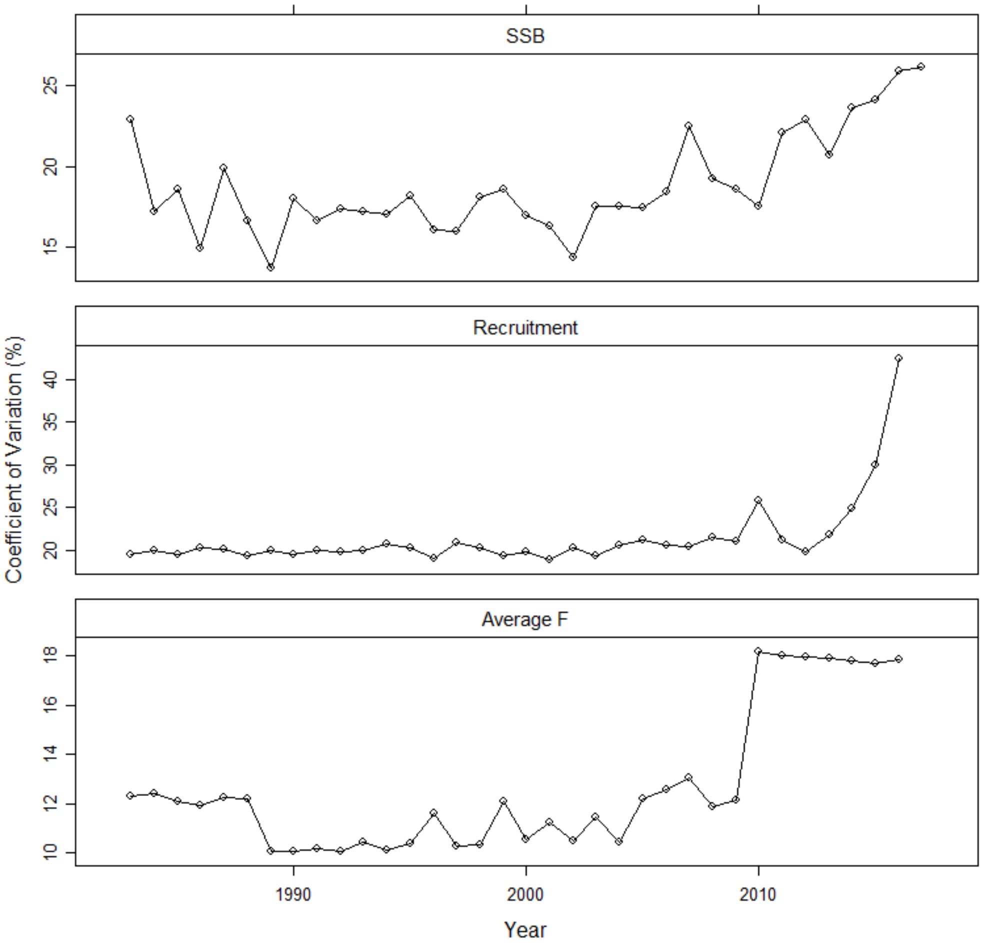


Figure 9.3.10 Sandeel Area-2r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

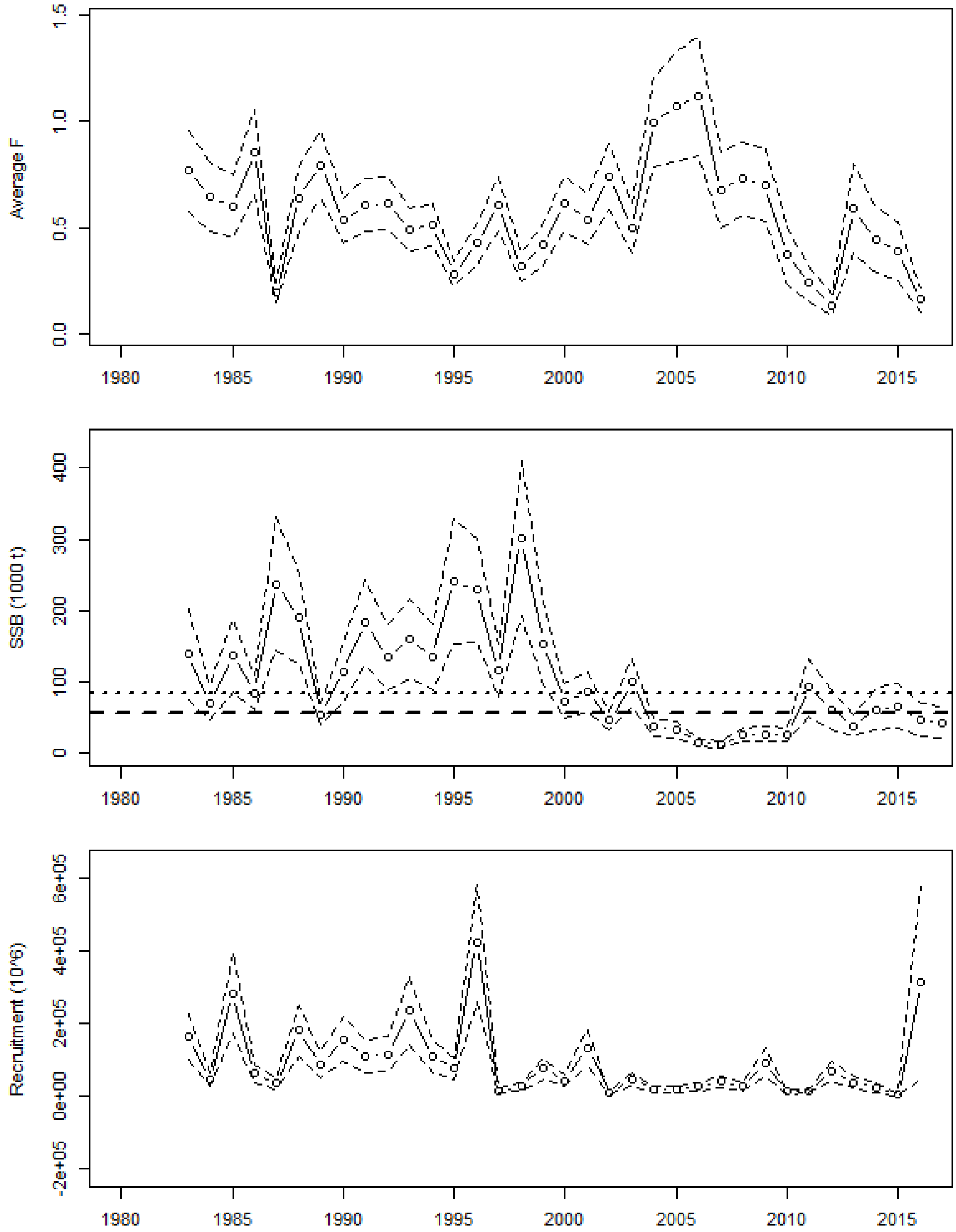


Figure 9.3.11 Sandeel Area-2r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation.

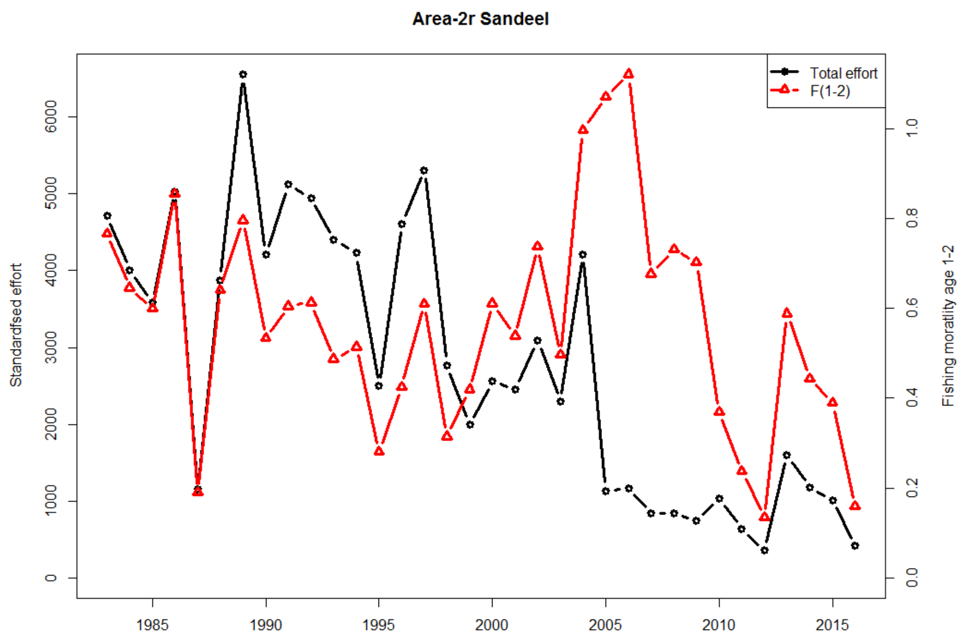


Figure 9.3.12 Sandeel Area-2r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

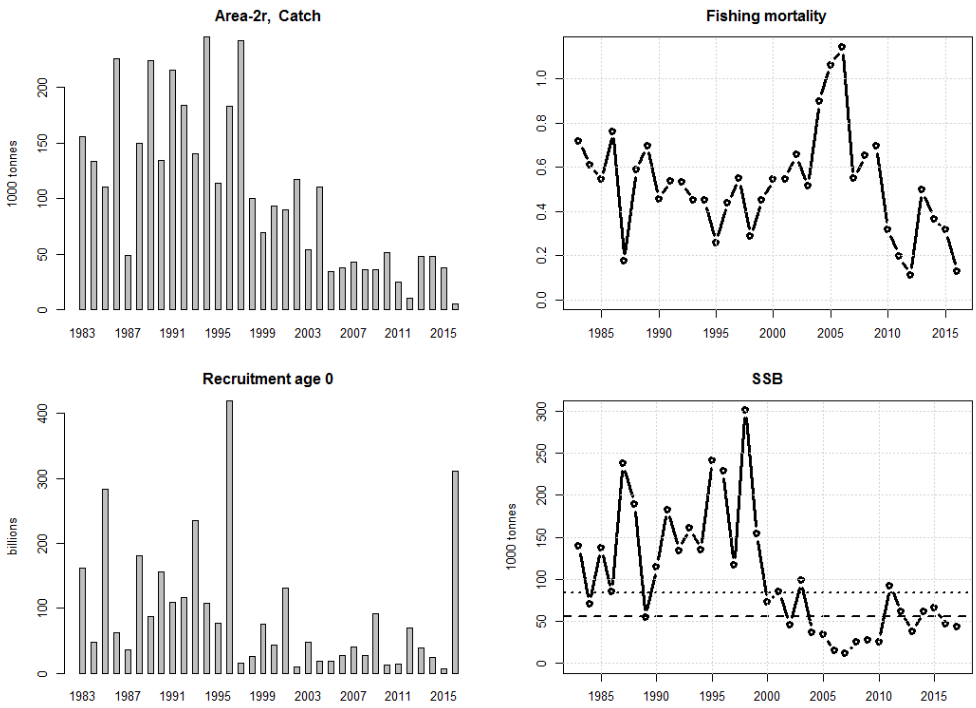


Figure 9.3.13 Sandeel Area-2r. Stock summary.

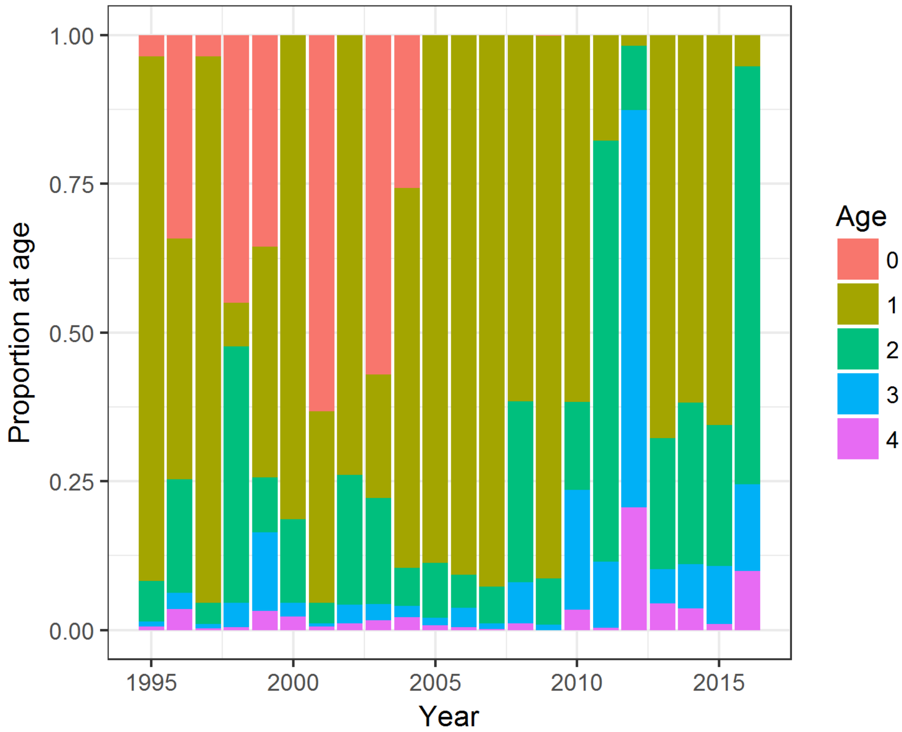


Figure 9.4.1 Sandeel Area-3r. Catch numbers, proportion at age.

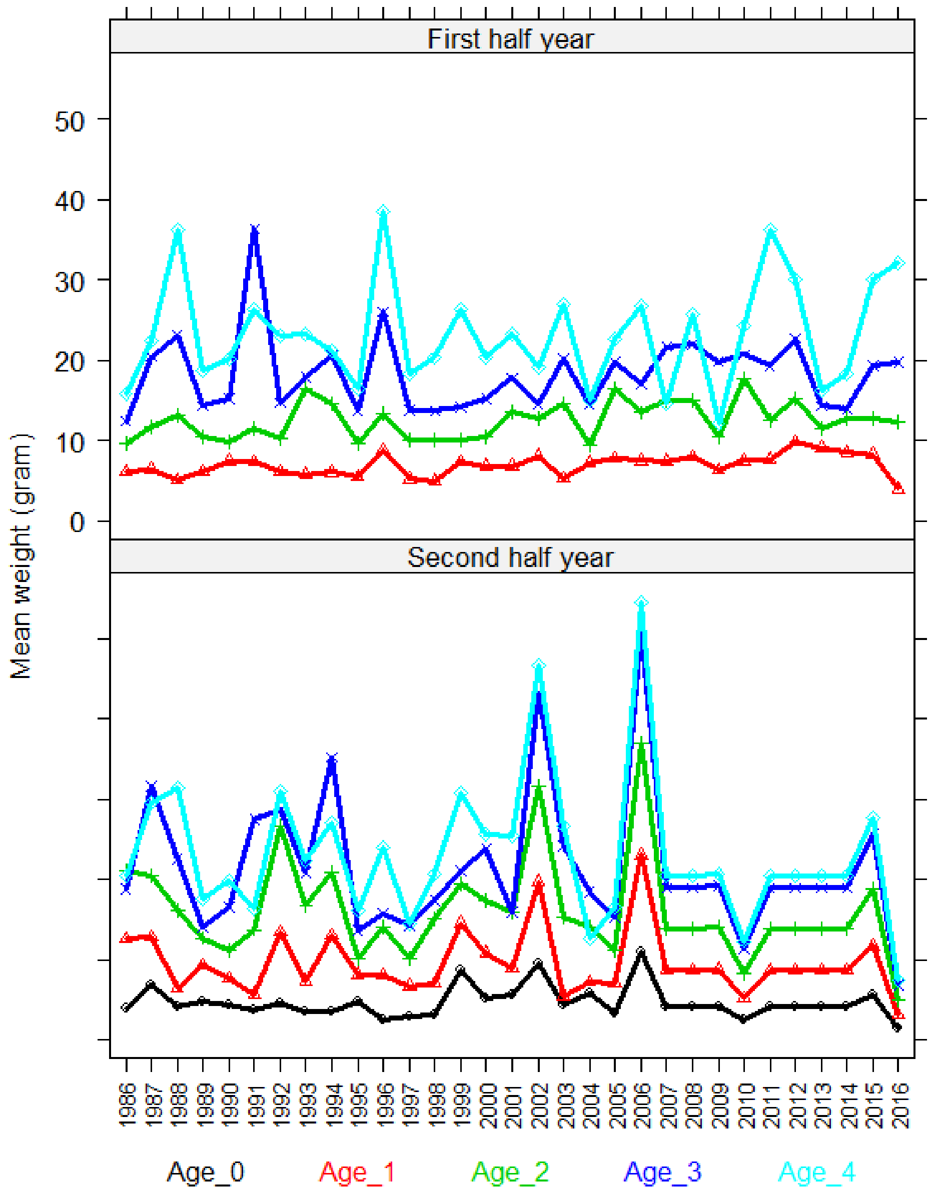


Figure 9.4.2 Sandeel Area-3r. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

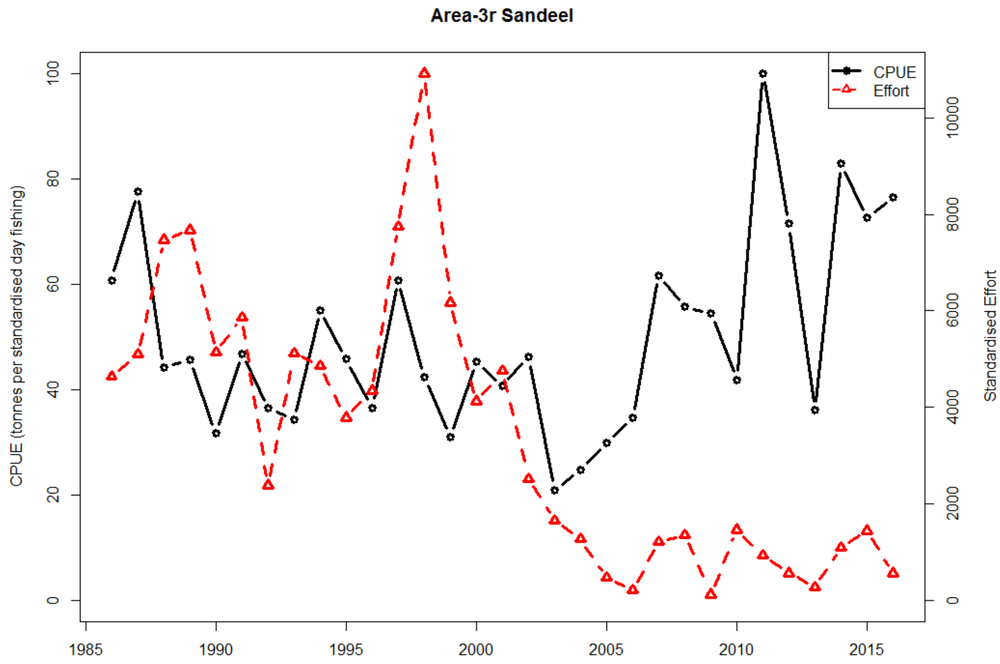


Figure 9.4.3 Sandeel Area-3r. CPUE and effort.

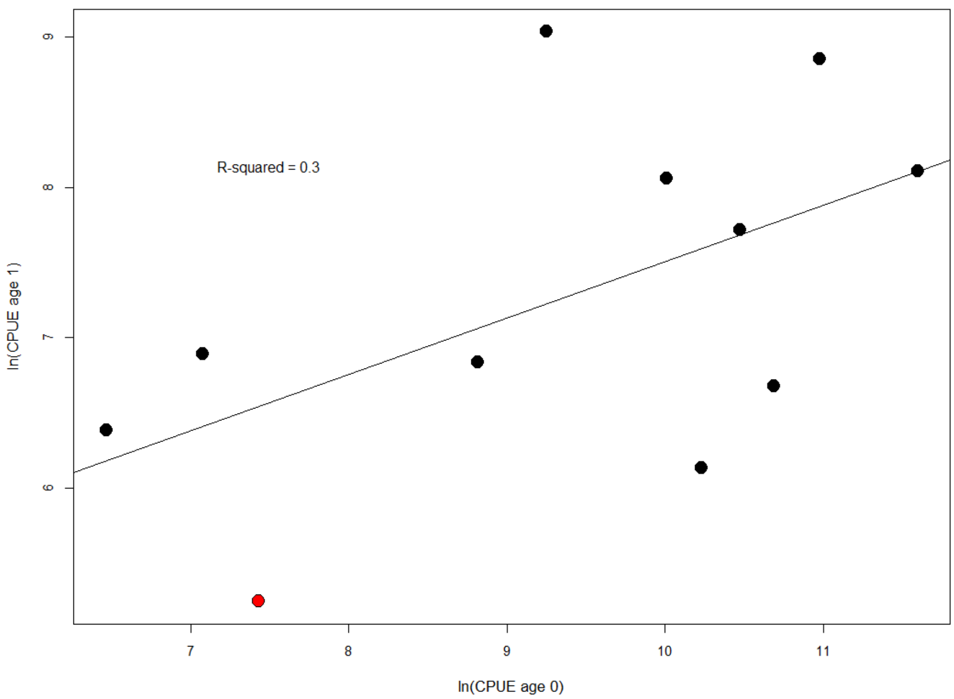


Figure 9.4.4 Sandeel Area-3r. Internal consistency by age of the dregde survey. Red dot indicates the most recent data point.

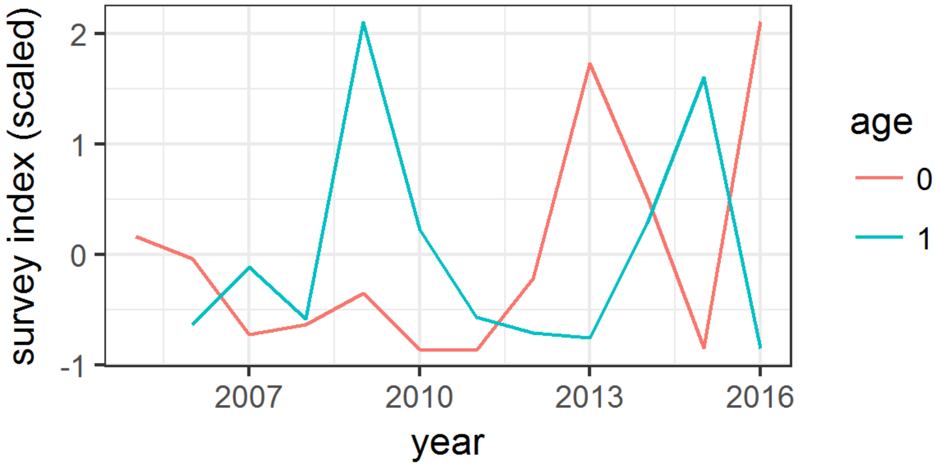


Figure 9.4.5 Sandeel Area-3r. Dredge survey index timeline.

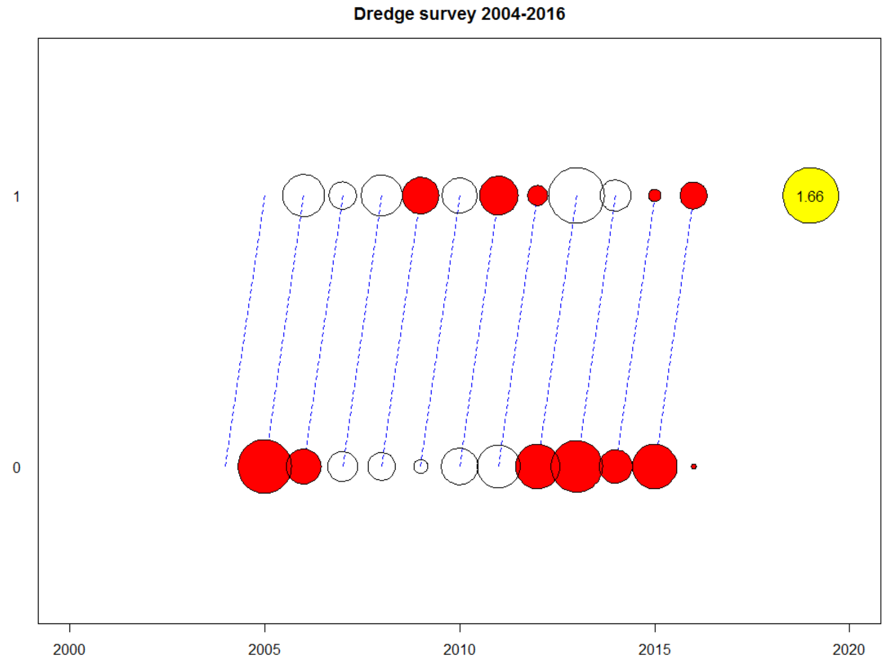


Figure 9.4.6 Sandeel Area-3r. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

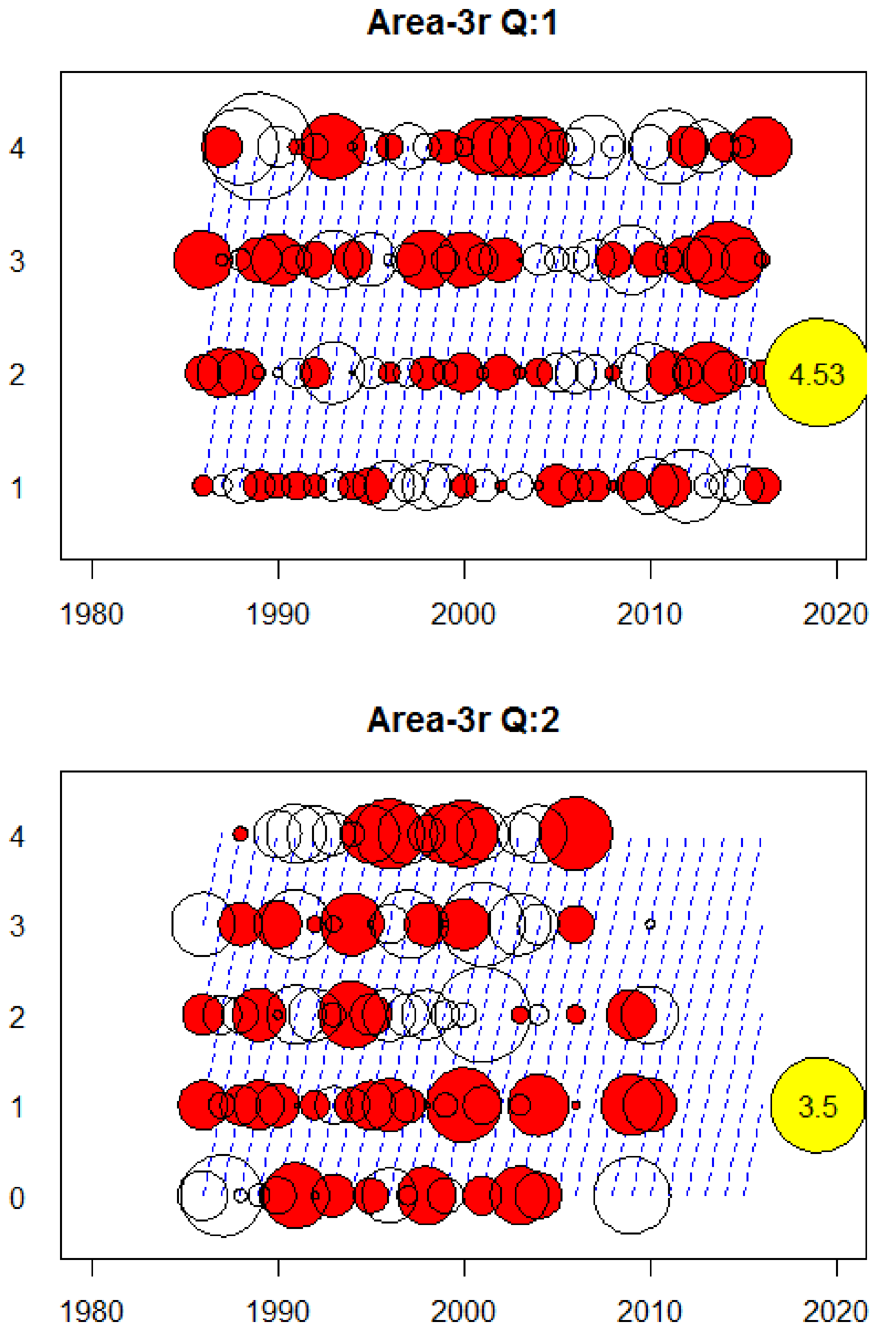


Figure 9.4.7 Sandeel Area-3r. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

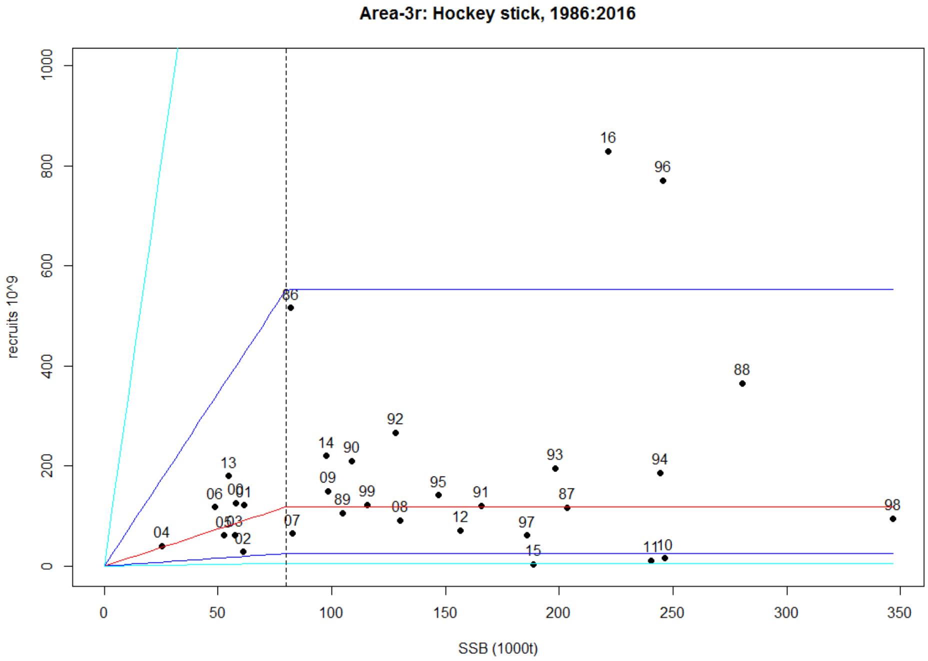


Figure 9.4.8 Sandeel Area-3r. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

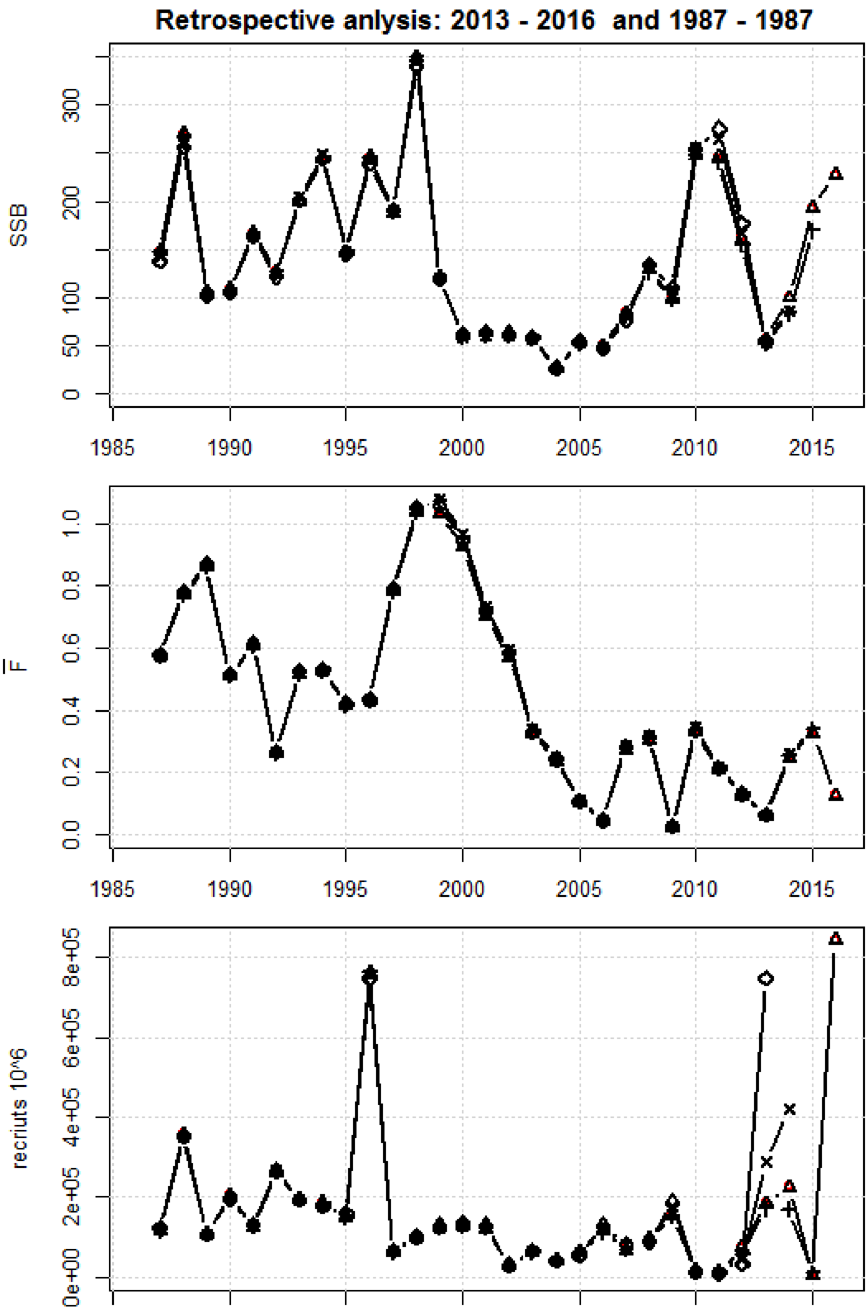


Figure 9.4.9 Sandeel Area-3r. Retrospective analysis.

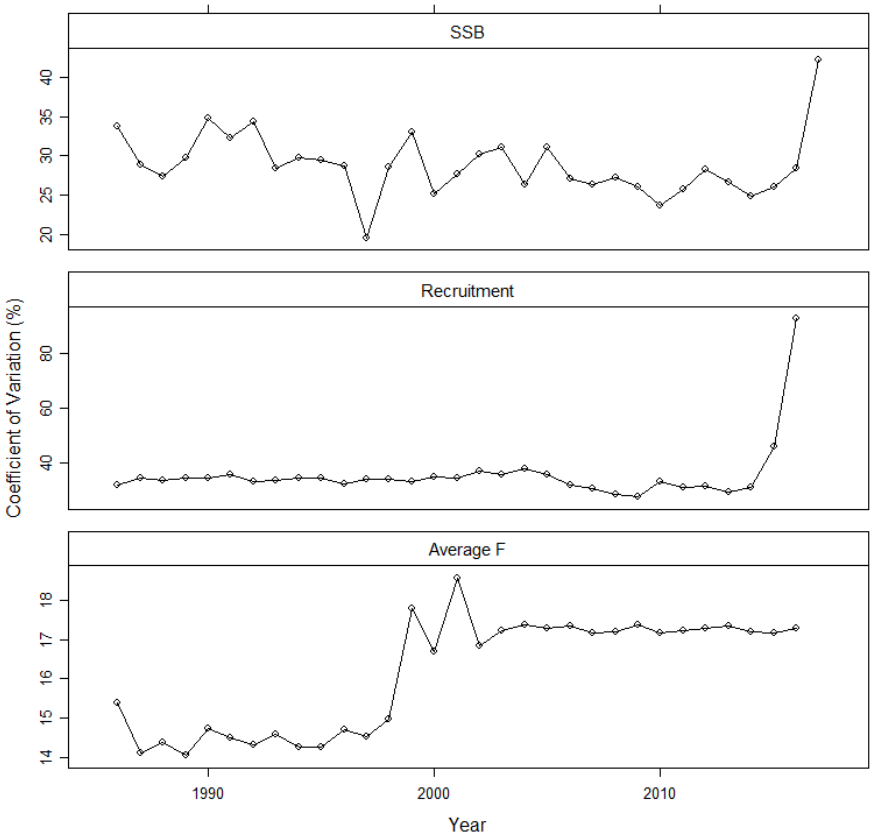


Figure 9.4.10 Sandeel Area-3r. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

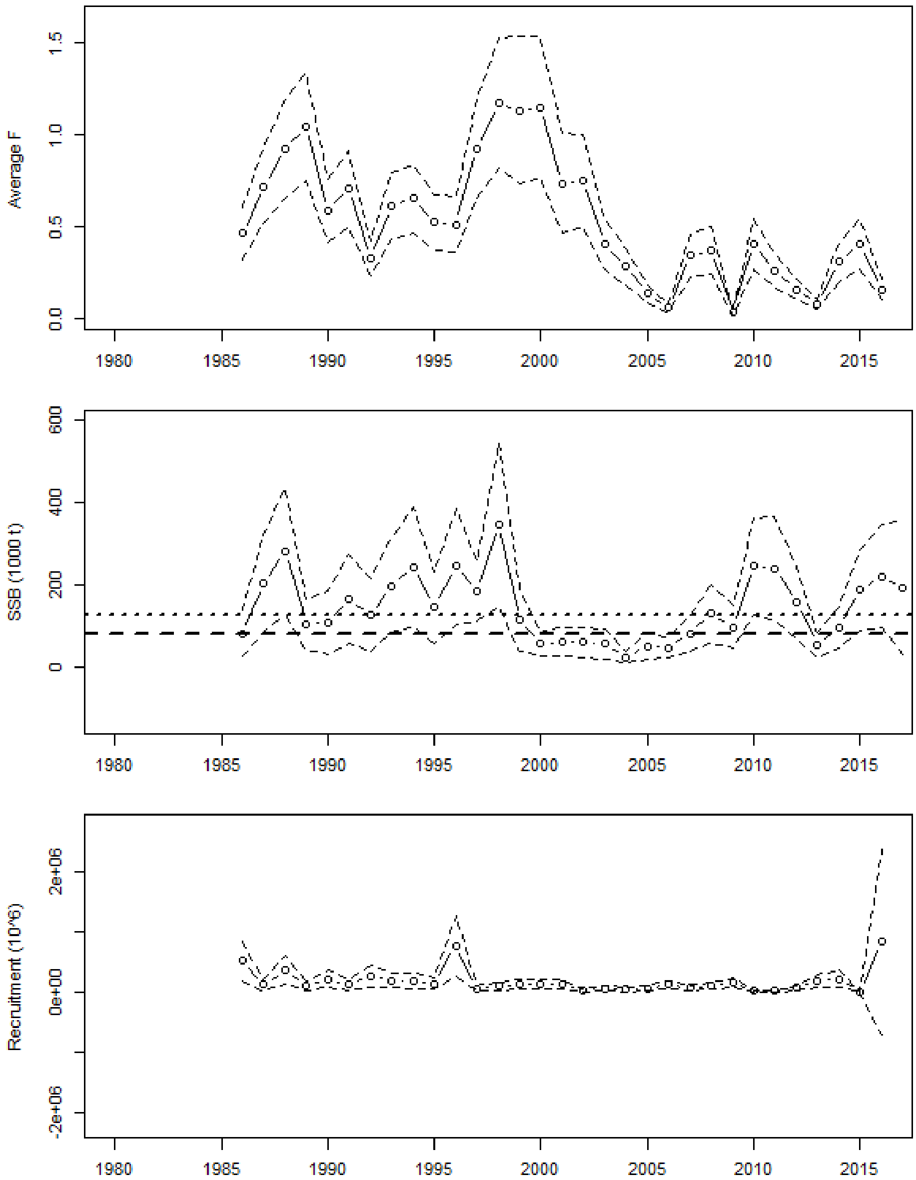


Figure 9.4.11 Sandeel Area-3r. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation..

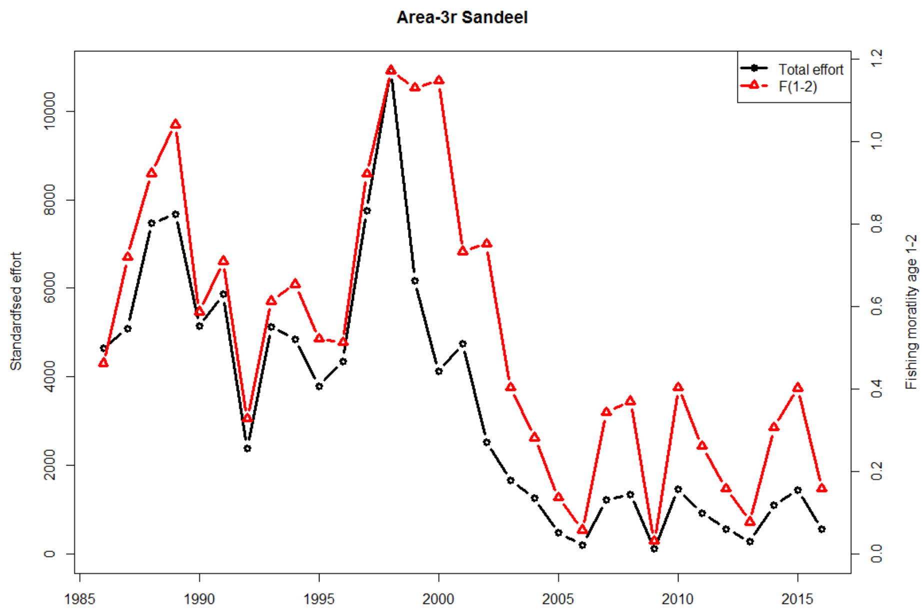


Figure 9.4.12 Sandeel Area-3r. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

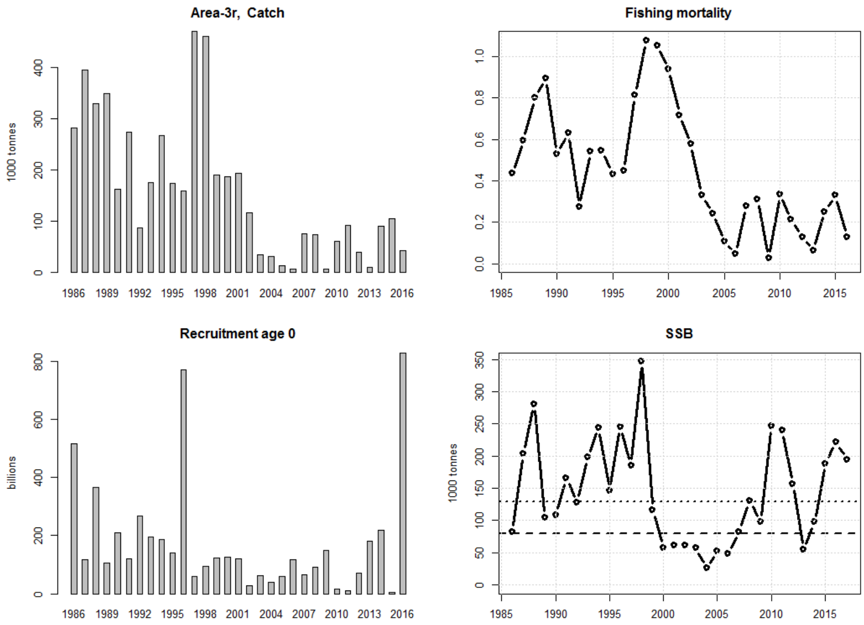


Figure 9.4.13 Sandeel Area-3r. Stock summary.

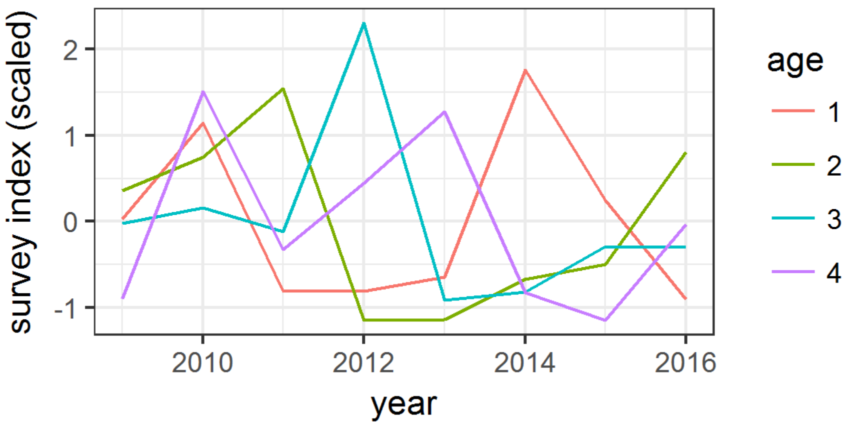


Figure 9.4.14 Sandeel Area-3r. Acoustic survey index timeline.

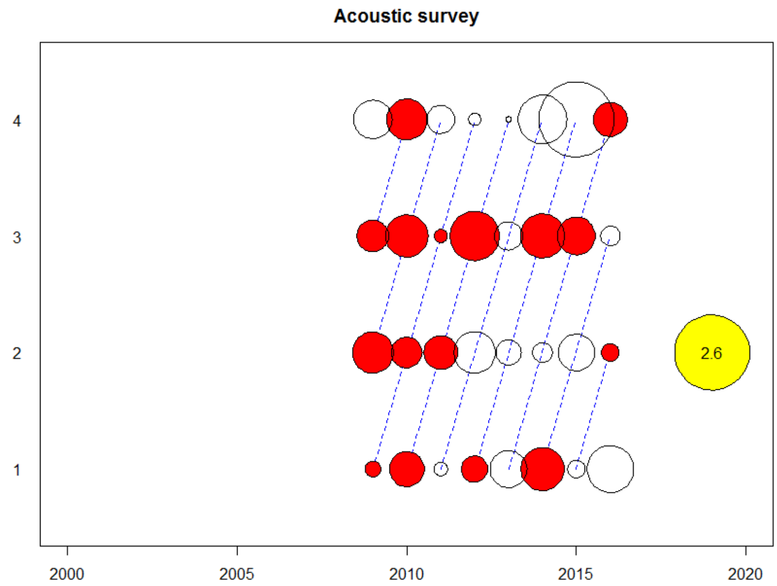


Figure 9.4.15 Sandeel Area-3r. Norwegian acoustic survey. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

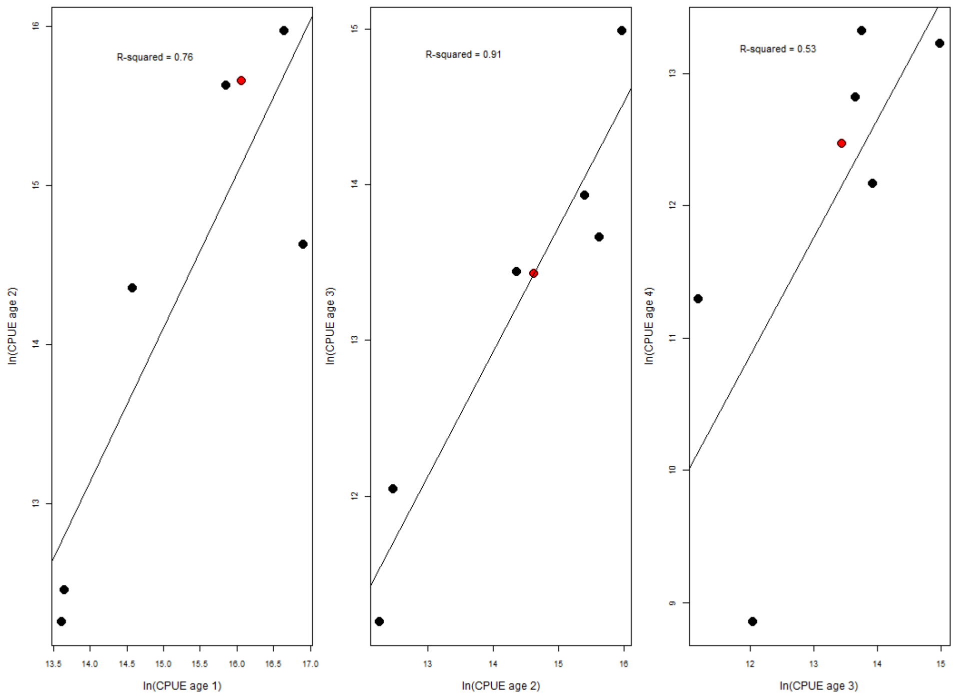


Figure 9.4.16 Sandeel Area-3r. Internal consistency by age of the acoustic survey. Red dot indicates the most recent data point.

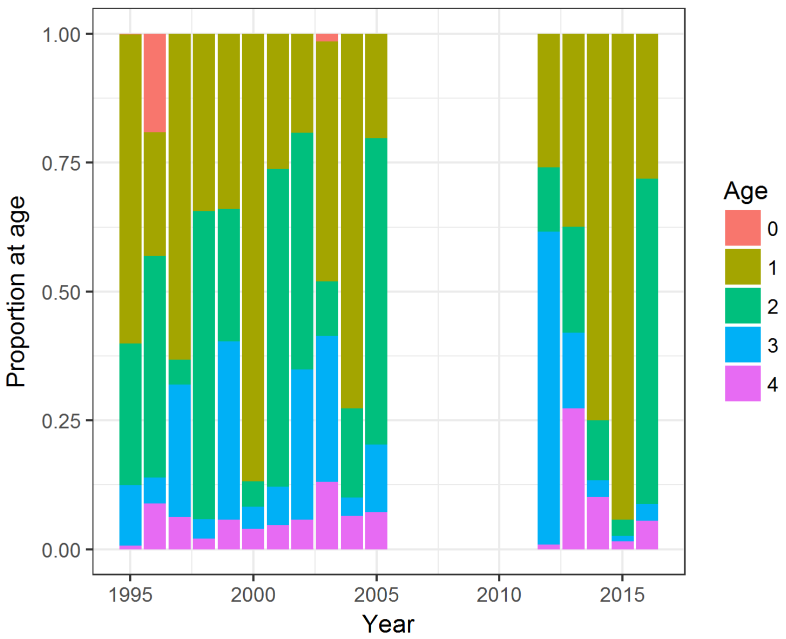


Figure 9.5.1 Sandeel Area-4. Catch numbers, proportion at age.

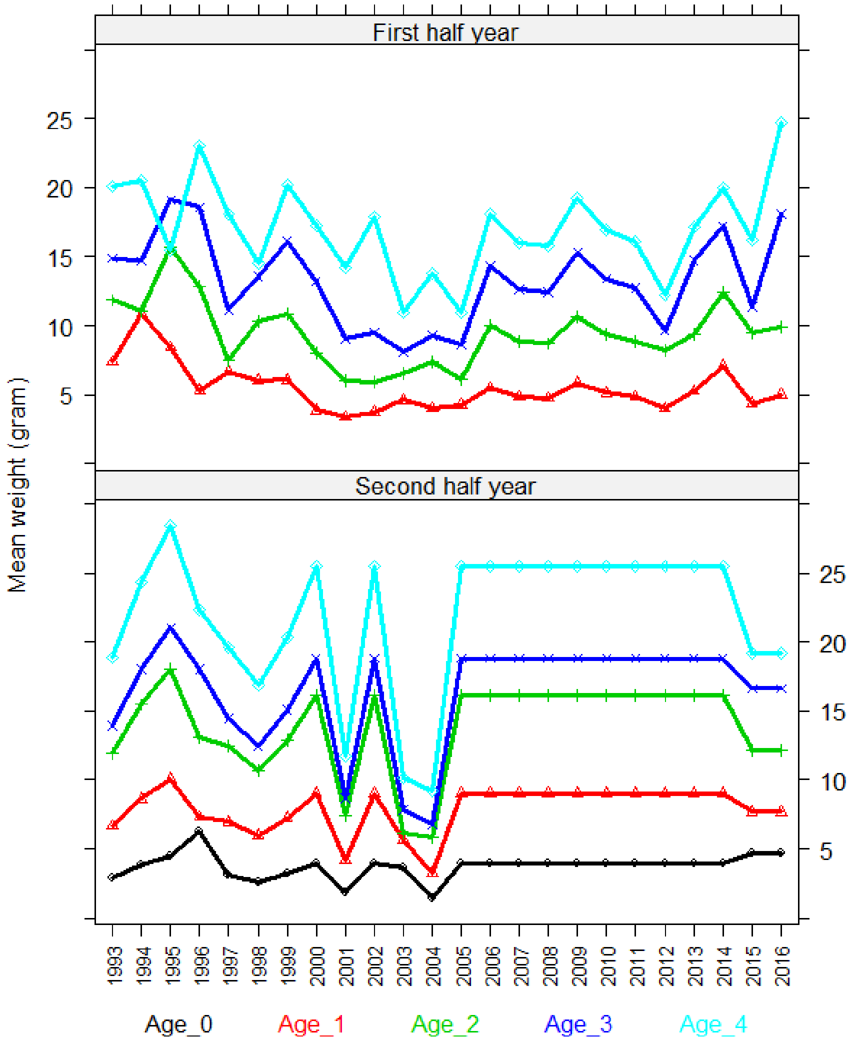


Figure 9.5.2 Sandeel Area-4. Mean weight at age in the first half year (age 1-4+) and second half year (age 0-4+).

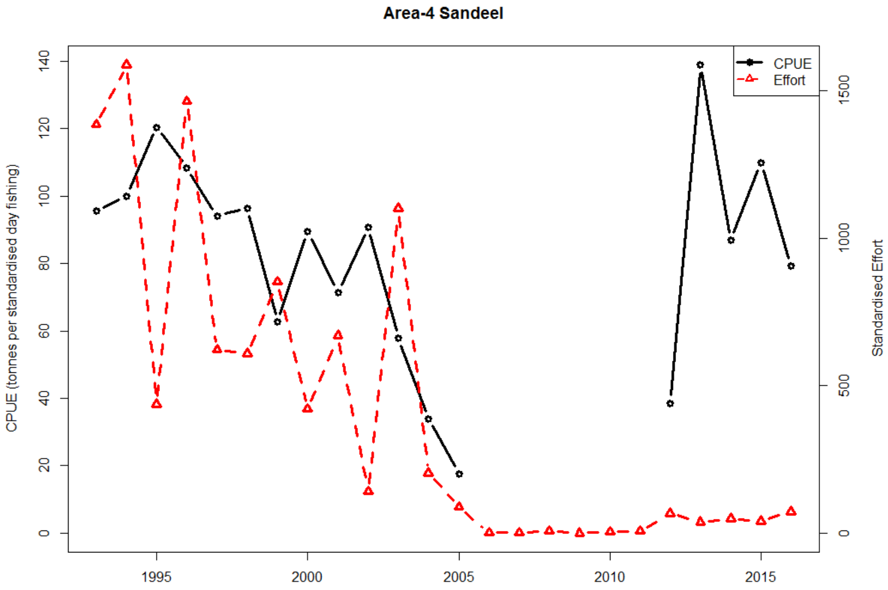


Figure 9.5.3 Sandeel Area-4. CPUE and effort.

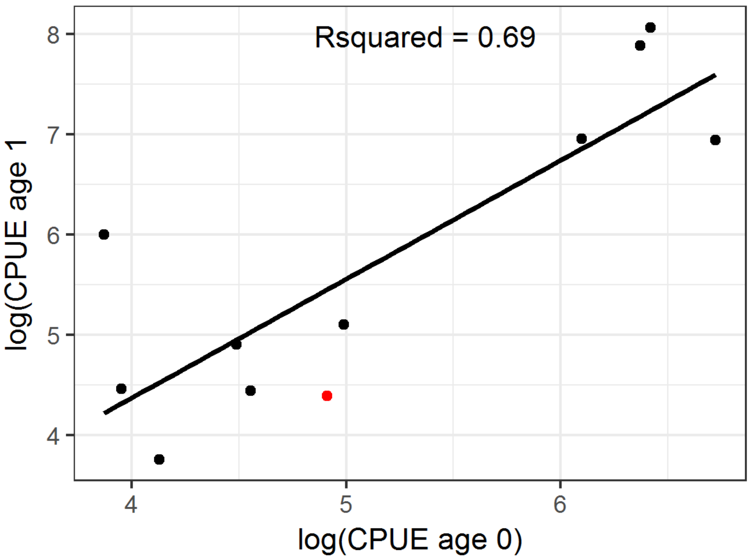


Figure 9.5.4 Sandeel Area-4. Internal consistency by age of the dregde survey. Red dot indicates the most recent data point.

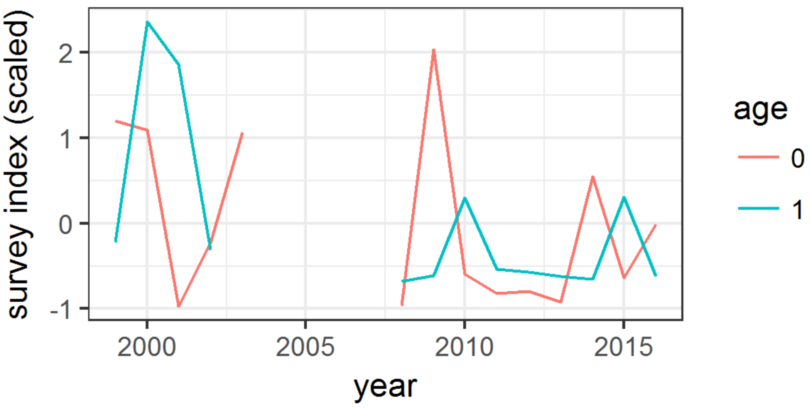


Figure 9.5.5 Sandeel Area-4. Dredge survey index timeline.

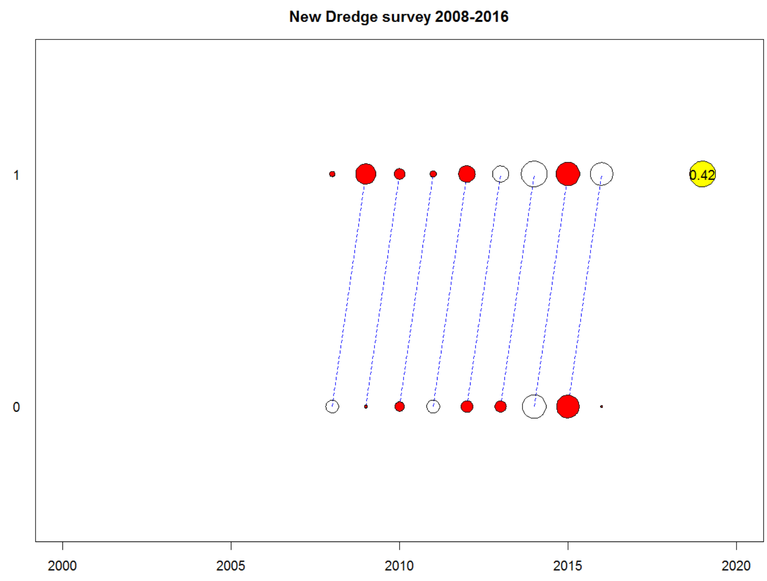


Figure 9.5.6 Sandeel Area-4. Survey CPUE at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

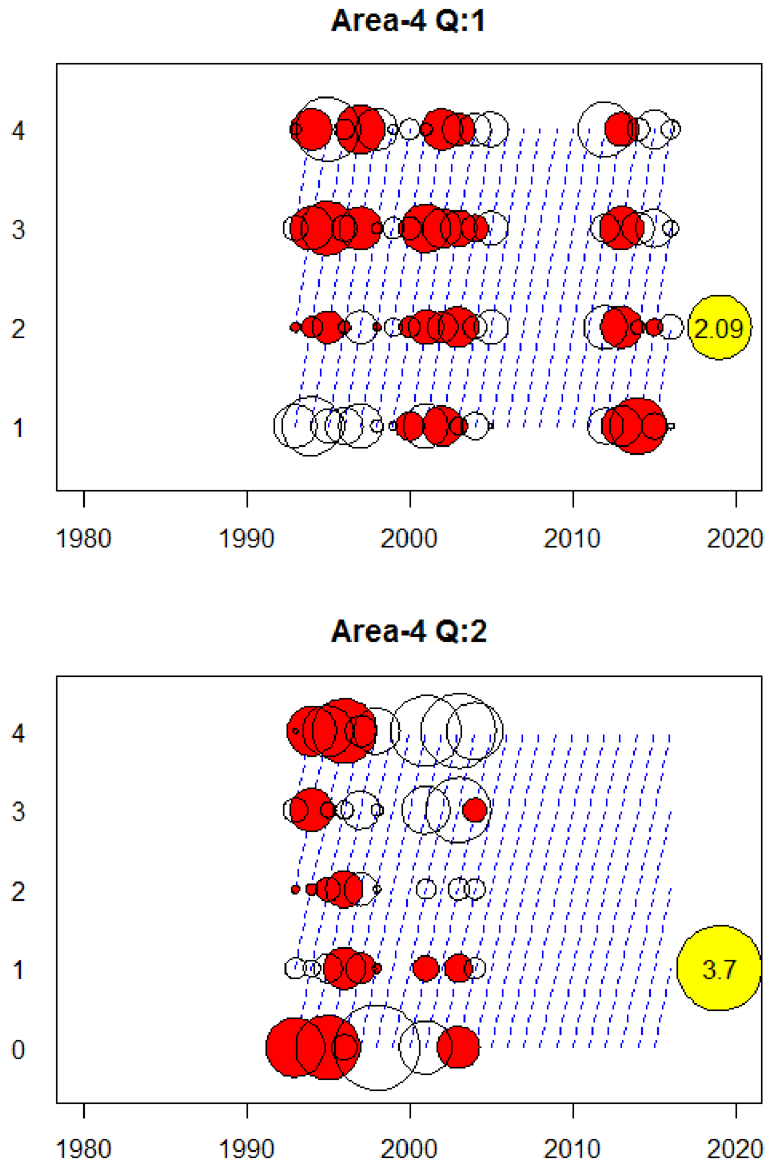


Figure 9.5.7 Sandeel Area-4. Catch at age residuals (log(observed CPUE)- log(expected CPUE). "Red" dots show a positive residual.

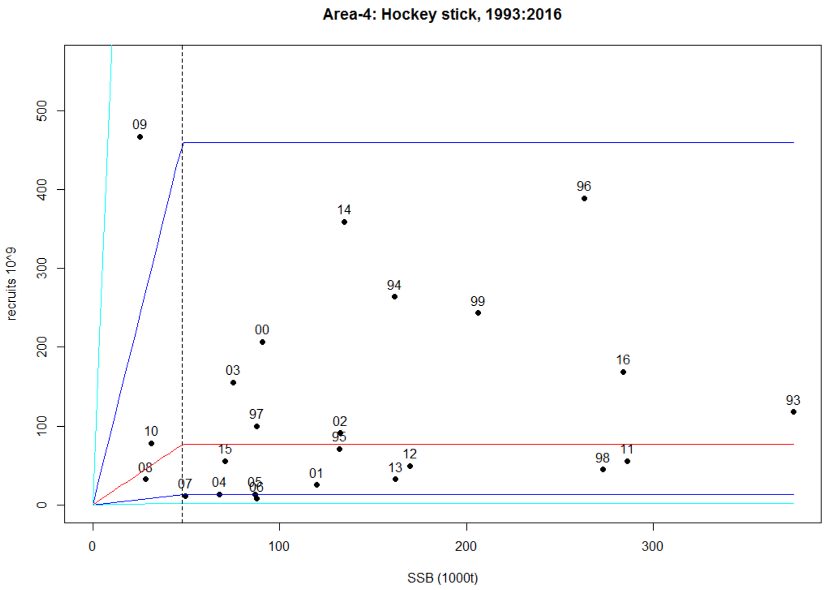


Figure 9.5.8 Sandeel Area-4. Estimated stock recruitment relation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment. Years shown in red are not used in the fit.

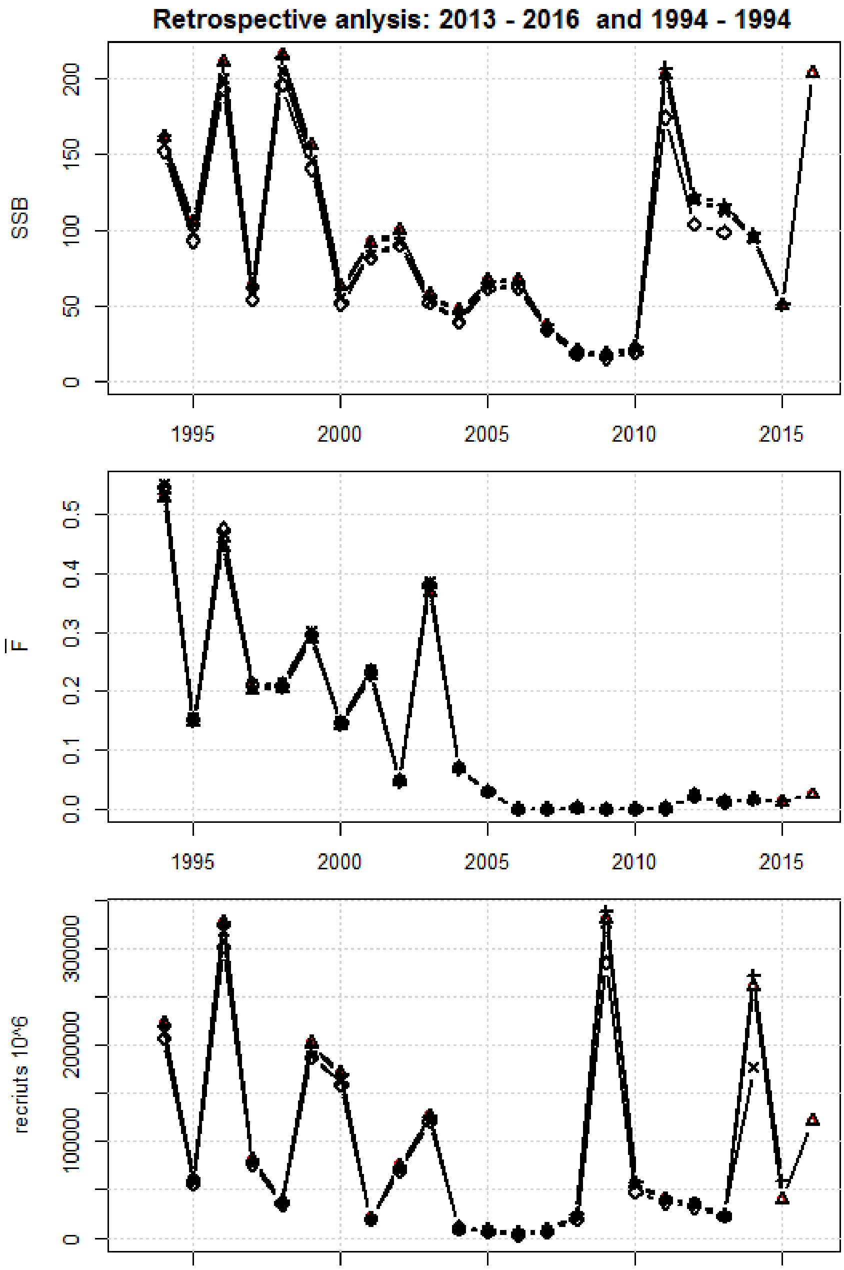


Figure 9.5.9 Sandeel Area-4. Retrospective analysis.

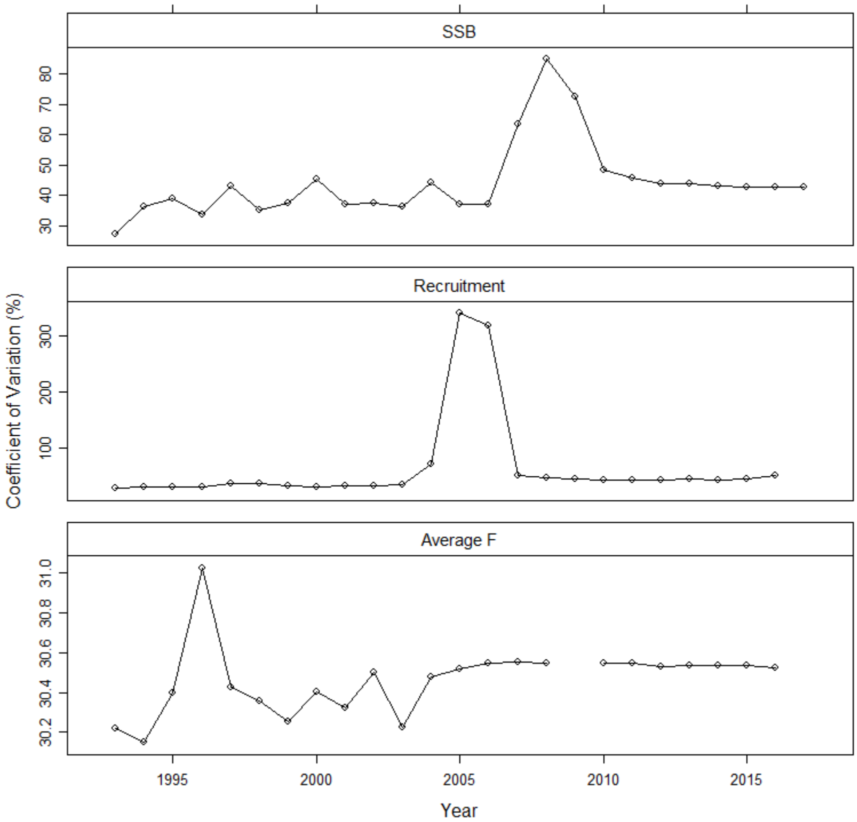


Figure 9.5.10 Sandeel Area-4. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

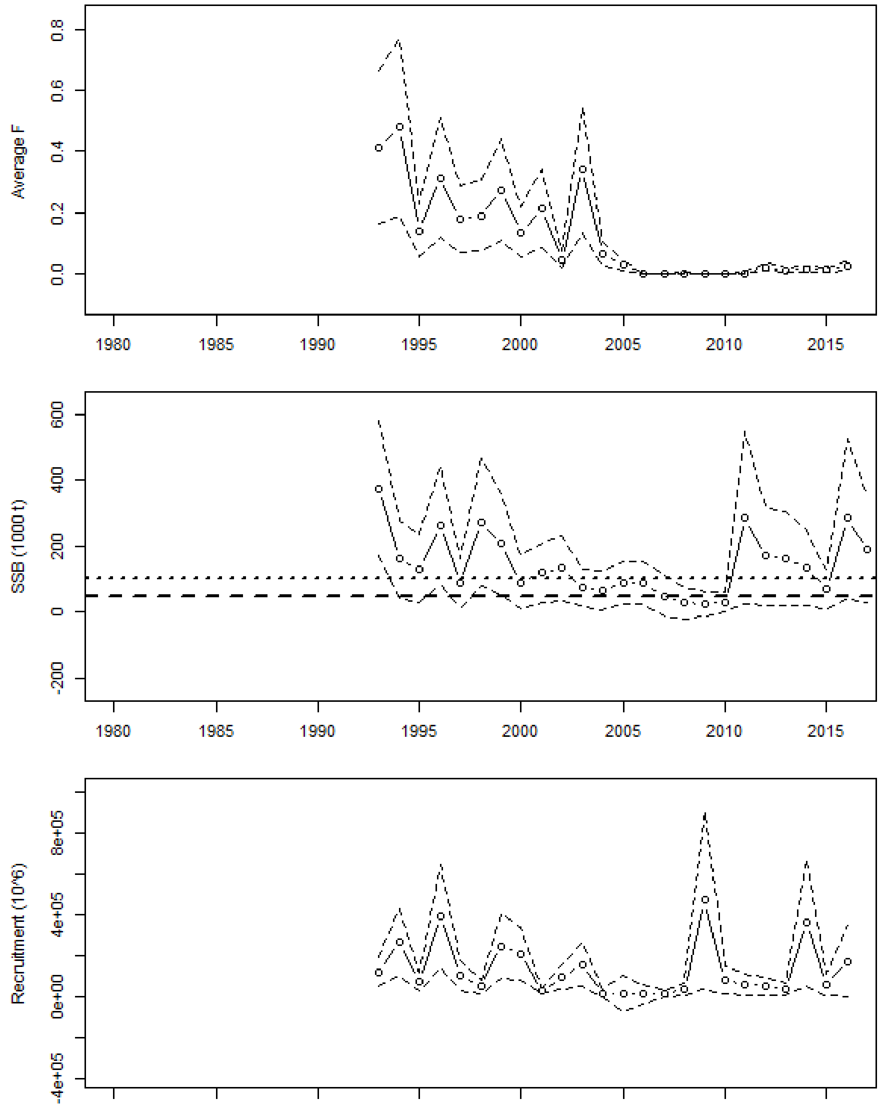


Figure 9.5.11 Sandeel Area-4. Model output (mean F, SSB and Recruitment) with mean values and plus/minus 2 * standard deviation..

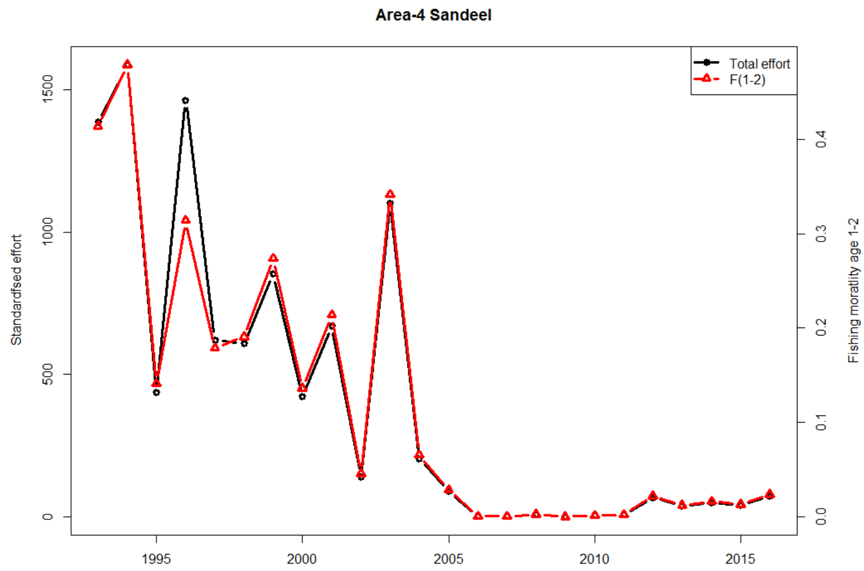


Figure 9.5.12 Sandeel Area-4. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

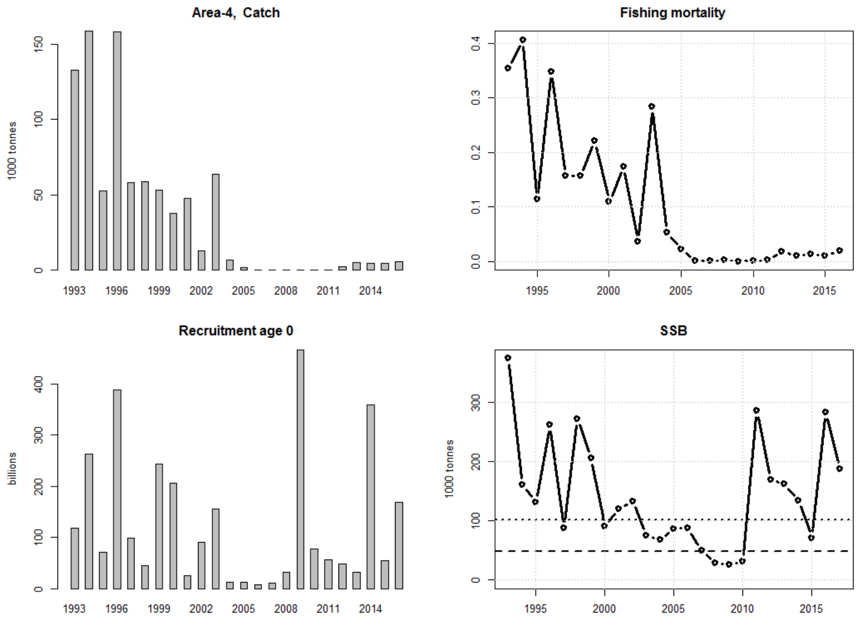


Figure 9.5.13 Sandeel Area-4. Stock summary.

9.9 Appendix:

EXPLORATIVE SESAM RUN (area 1r)

At the 2016 Benchmark-meeting in Bergen a stock assessment based on the SESAM model was presented. SESAM is short for SEasonal State space Assessment Model, which is an extention of the SAM model (Nielsen & Berg (2014) Fisheries Research, 158, 96-101). Conclusions made about the performance of the SESAM model (including configurations) and the reasoning for why it was decided to continue with the SMS model, can be found in the benchmark report (ICES 2017). However, it was decided conduct an explorative SESAM-run in area 1r each year in paralel with the SMS, to learn more about the SESAM performance and stability in respect to sandeel. Figure A1-A3 show temporal pattern in SSB, Recruitment and fishing mortality (F_{1-2}). Fig. A4 shows the stock-recruitment plot and catch residuals and survey residuals can be found in Fig. A5. The explorative SESAM run are largely identical to the SMS in the first half of the time-series, however, in the second half the SESAM model produces somewhat higher estimates of SSB and lower levels of F. This SESAM interpretation of the stock, was not evident at the benchmark, where the two models produces mostly similar results. Hence, it appears that the SESAM models is unstable and may shift between two different solutions, one with a high SSB and low F, in the second half of the time-period, and one with lower SSB and higher F (similar to the SMS result). Lastly, it is worth noting that the stock-recruitment relationship is less evident compared to the SMS result.

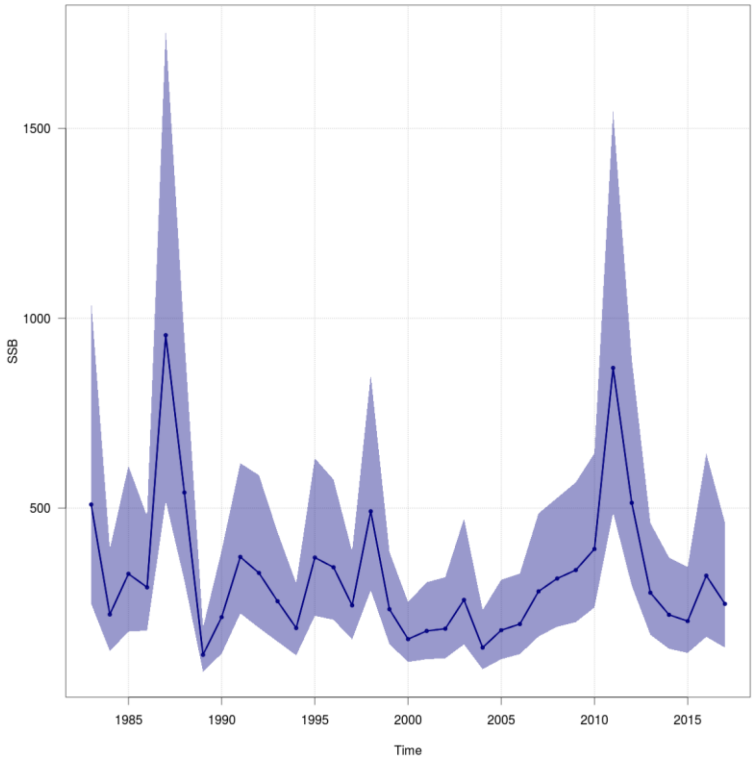


Figure A1. Spawning stock biomass.

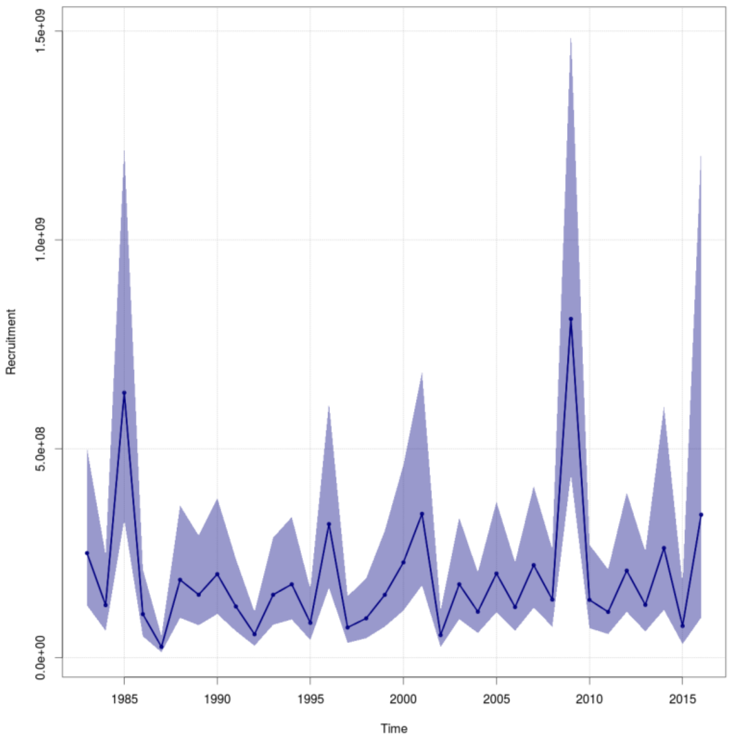


Figure A2. Recruitment.

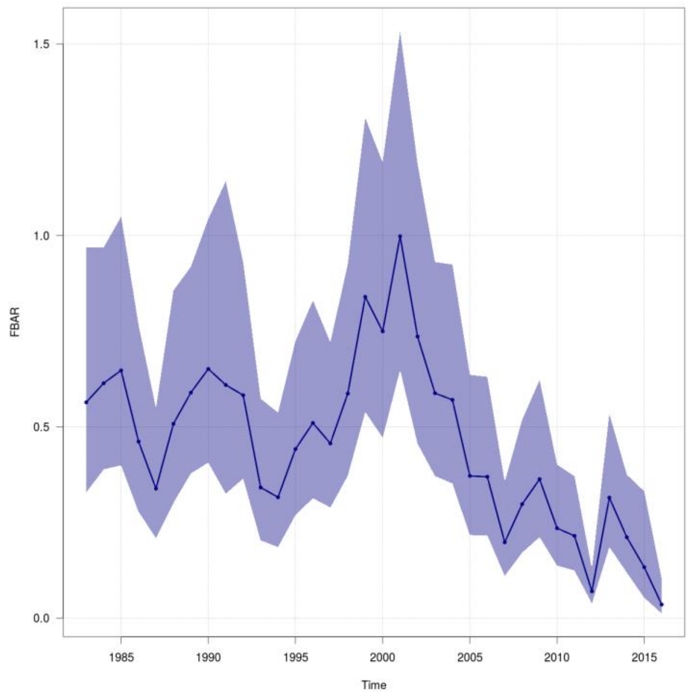


Figure A3. Fishing mortality (mean of age 1-2).

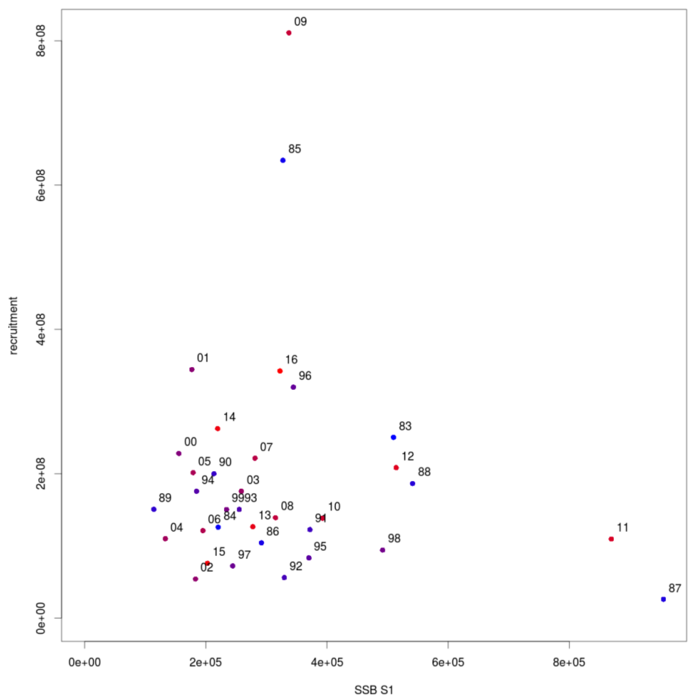


Figure A4. Stock-recruitment plot (numbers refer to years).

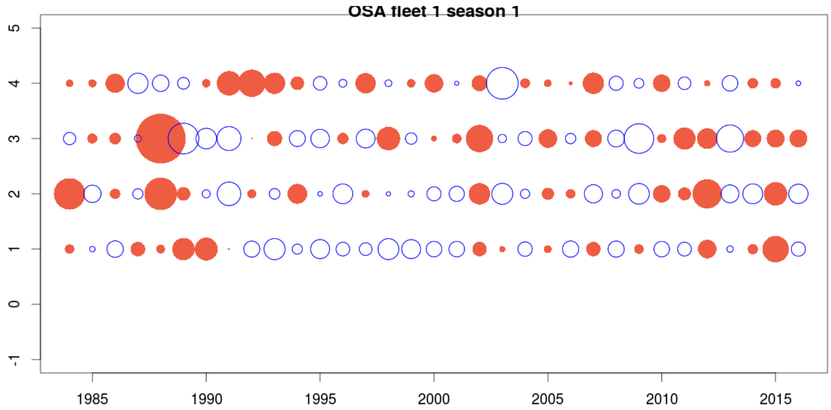


Figure A4. Catch residuals (red is negative).

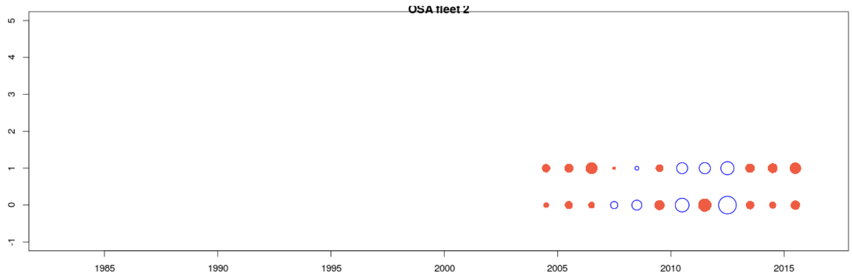


Figure A5. Survey residuals (red is negative).

9.10 F_{cap} for sandeel area 1 – 4

Mikael van Deurs 12. December 2016

Background

During MYREF2 it was evaluated to which extent the escapement strategy (using B_{pa} as target; Bpa = Blim * exp(1.645*std)) is sustainable according to the criteria put forward by ICES (i.e. the accepted probability of having the spawning biomass (SSB) falling below B_{lim} is less than 5%). The conclusion was that the strategy is only sustainable if an upper level on F is applied (F_{cap}) (i.e. the probability exceeded 5% unless an F_{cap} was implemented or B_{pa} was increased; the former resulting in a higher long-term yield). This upper level on F is needed to ensure that the stock is not overexploited in years when the uncertainty of the incoming year class is not accounted for by the B_{pa} buffer.

For illustration, we provide a hypothetical example of the forecast and MSE models here. To simplify the comparison, the example is based on a stock with no recruitment to SSB, no growth and no natural mortality. That means that in case of no fishery the "escaped" SSB the following year would be the same as the initial SSB at the beginning of the year. As the distribution of estimated initial SSB is log-normal, subtracting a TAC aiming exactly at B_{pa} results in a case where the uncertainty of escaped SSB is increasing with initial stock size (left panel in fig. 1), hereby increasing the risk to Blim with initial SSB. Introducing a cap on F provides a 'quick fix' to this issue but still results in a situation where the risk to Blim varies with initial stock size (middle panel in fig. 1) and a risk to overfish the stock. If the statistical distribution of the distribution at the end of the year is well known, the ideal situation is to determine F in the TAC year such that the risk to Blim after fishing is exactly 5% (right panel in fig. 1). However, as the exact method by which to perform this analysis is still not entirely clear, the present document addresses the task of providing a value of F-cap that ensures that the average risk of falling below Blim in a long term simulation is 5%..

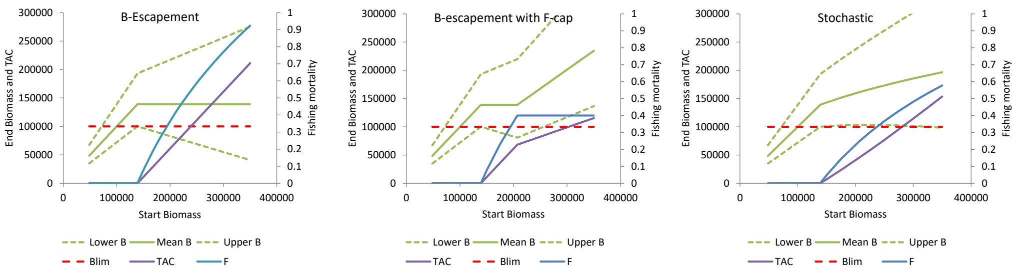


Fig. 1.

In this working document, we present F_{cap} for each of the new areas (1-4) derived from a Management Strategy Evaluation (MSE). The MSEs were carried out in accordance with ICES guidelines. The model used here is the "light" version of the MSE framework, in which the estimated uncertainties in the assessment model are used to simulate observation error, rather than running the full assessment model in each iteration loop on simulated data. The following default settings were applied: Long-term geom. recruitment, ten year average weight-at-age and maturity-at-age (the latter is constant in the assessment model), ten year average natural mortality (M) for the period where variable M is available (2003-2012, variable M is updated only until 2012), and the exploitation pattern is the same as that estimates in the agreed assessment model for the most recent separability period (see stock Annex about separability periods). Assessment uncertainty are derived as output from the SMS assessment model. Recruitment (R) uncertainty/variability is log-normal distributed and estimated based on the observed recruitment time series. F_{cap} is particularly sensitive recruitment (reflecting stock productivity) and assessment uncertainty in relation to numbers of age-1 fish. It should be noted that the assessment uncertainty (age-1) is very high in area 3 and 4 and the geometric mean R has decreased in the new area 8 assessment compared to the former area 1 assessment.

Results

The estimated values of F-cap required to obtain a long term average risk of 5% to Blim are given in the table below. They are somewhat lower than previous values (which were around 0.6 for areas 1 and 3) due to the higher recent natural mortality.

Area		Mean future F	Mean future TAC (1000t)	Average (and max) F in	Observed SSB & R (assess. model)	Fcap vs. probability
	Fcap	(predicted in MSE)	(predicted in MSE)	assessment (2010-2015)	vs. simulated future SSB & R	of falling below Blim
1r	0.50	0.43	213	0.42 (0.62)	Fig. 1a,b	Fig. 5
2r	0.45*	0.31	82	0.31 (0.51)	Fig. 2a,b	Fig. 6
3r	0.30	0.26	114	0.30 (0.56)	Fig. 3a,b	Fig. 7
4	0.15	0.09	30	0.01 (0.03)	Fig. 4a,b	Fig. 8

*** Negative trend in recruitment time-series in the assessment summery table**

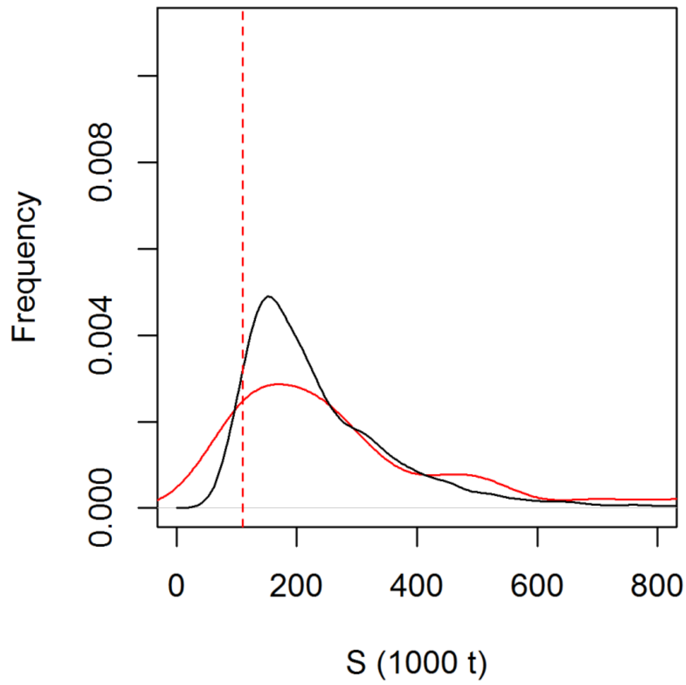


Fig. 1a. (area 1r) SSB as estimated by the assessment (Red solid) and as used by MSE (Black solid). Red dashed: B_{lim}.

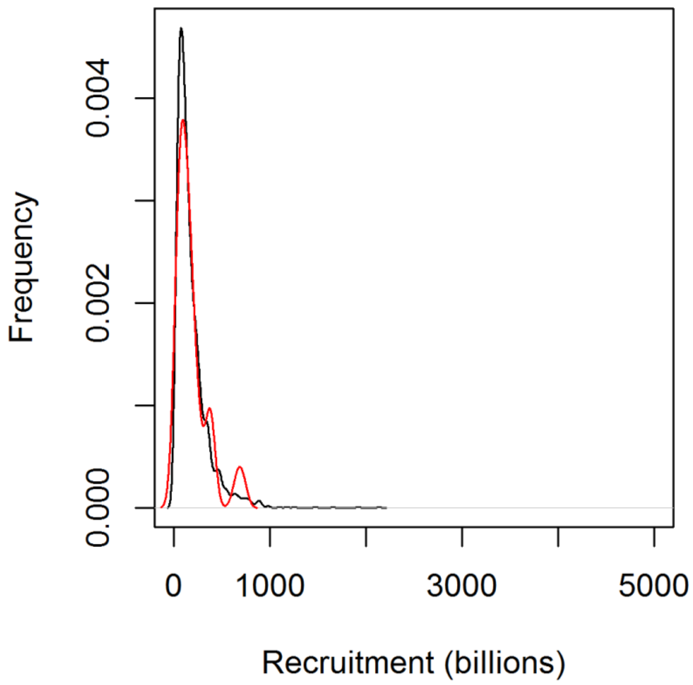


Fig. 1b. (area 1r) Recruitment as estimated by the assessment (Red solid) and as used by MSE (Black solid).

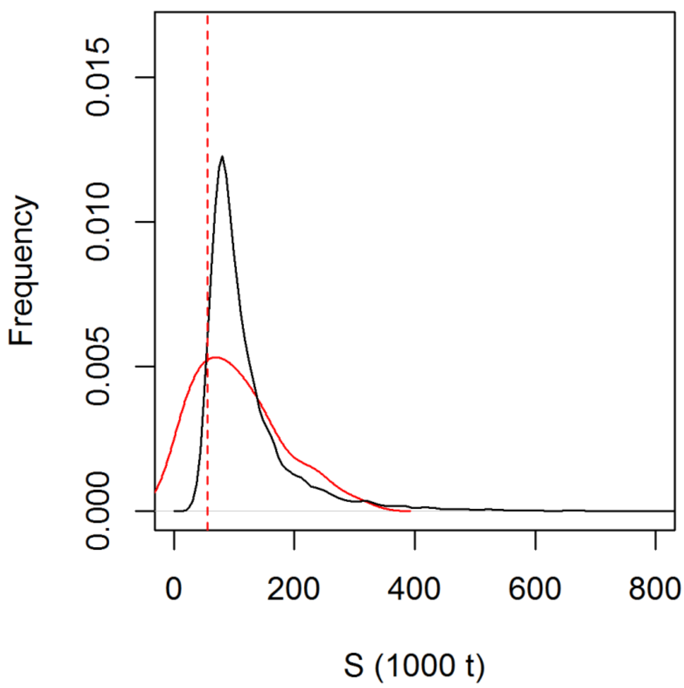


Fig. 2a. (area 2r) SSB as estimated by the assessment (Red solid) and as used by MSE (Black solid). Red dashed: B_{lim}.

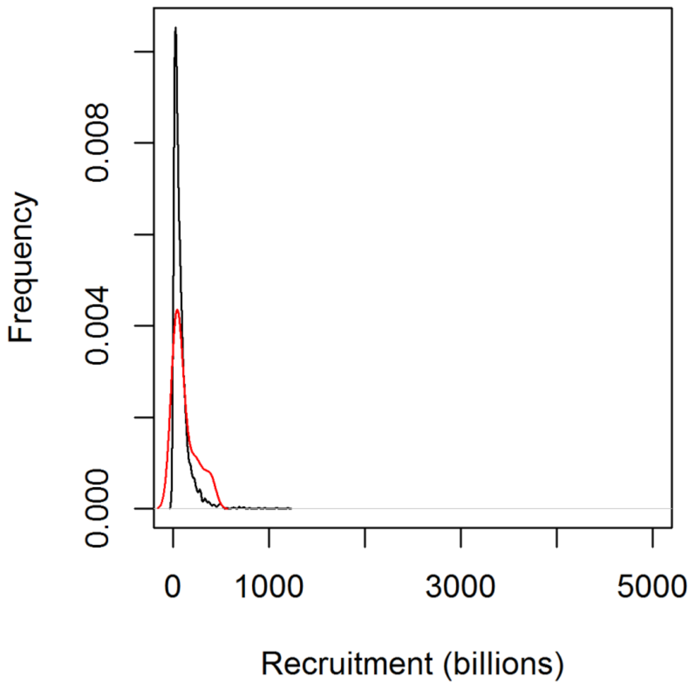


Fig. 2b. (area 2r) Recruitment as estimated by the assessment (Red solid) and as used by MSE (Black solid).

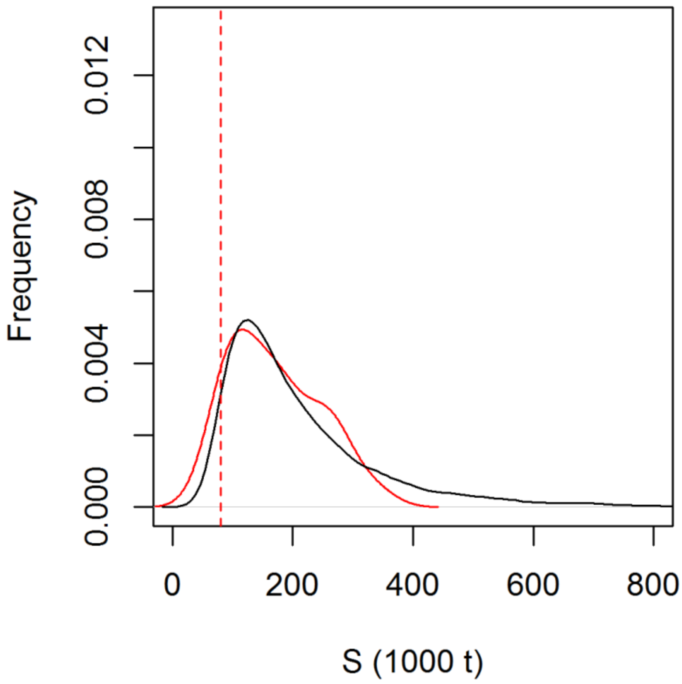


Fig. 3a. (area 3r) SSB as estimated by the assessment (Red solid) and as used by MSE (Black solid). Red dashed: B_{lim}.

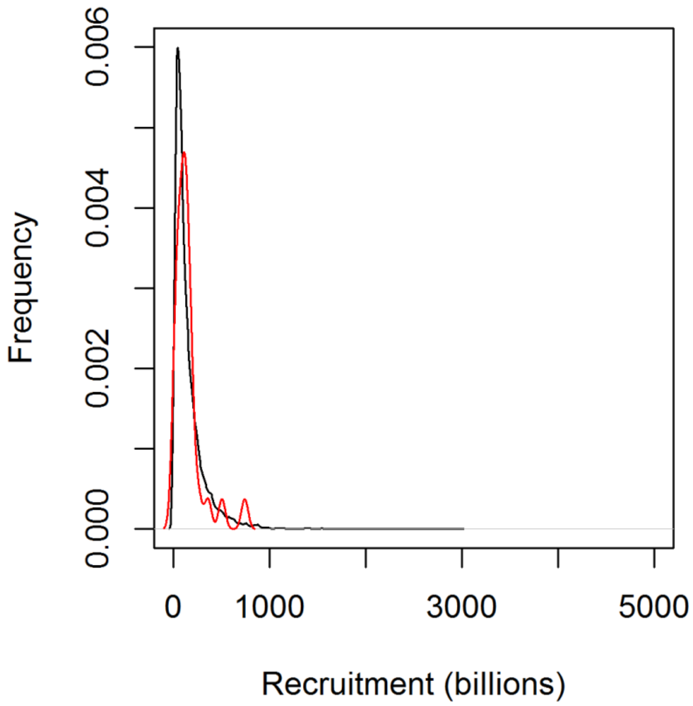


Fig. 3b. (area 3r) Recruitment as estimated by the assessment (Red solid) and as used by MSE (Black solid).

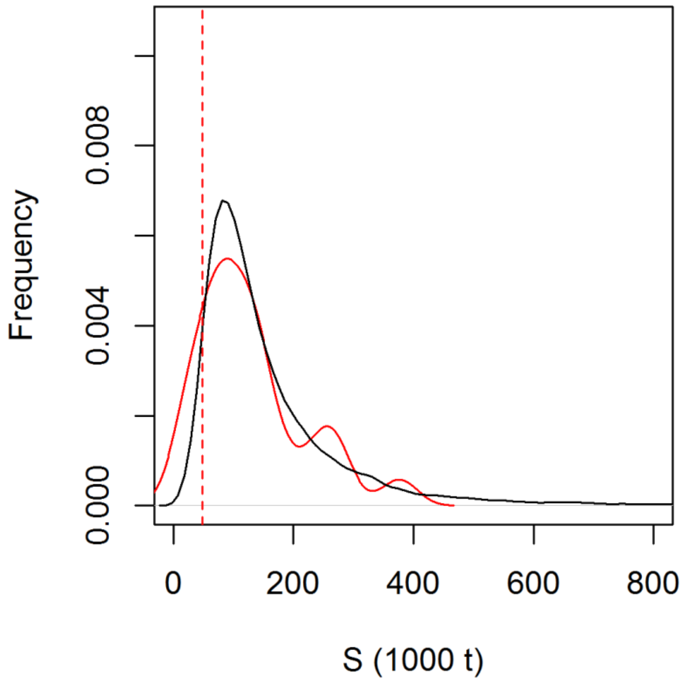


Fig. 4a. (area 4) SSB as estimated by the assessment (Red solid) and as used by MSE (Black solid). Red dashed: B_{lim}.

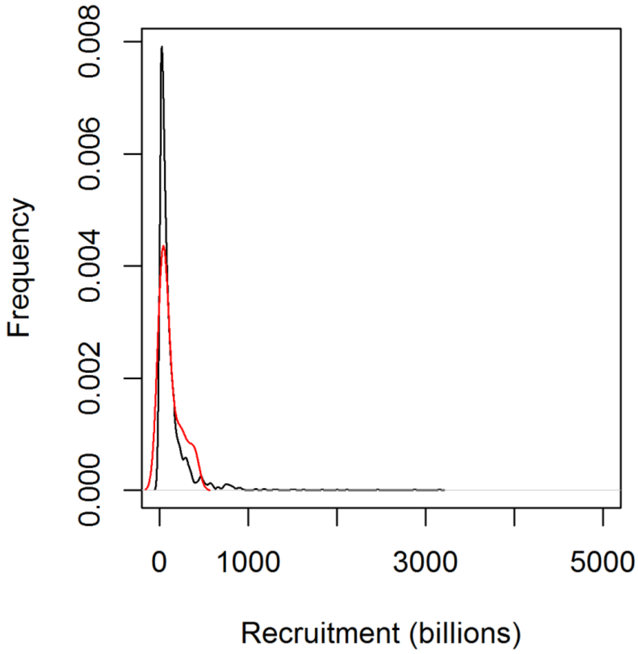


Fig. 4b. (area 4) Recruitment as estimated by the assessment (Red solid) and as used by MSE (Black solid).

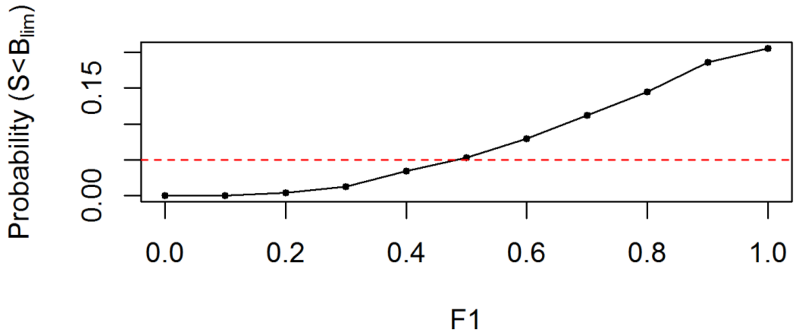


Fig. 5. (area 1r) The X-axis (F1) represents different F_{cap}-values and the Y-axis display the probability of dropping below B_{lim} when using the F_{cap}- value given on the X-axis.

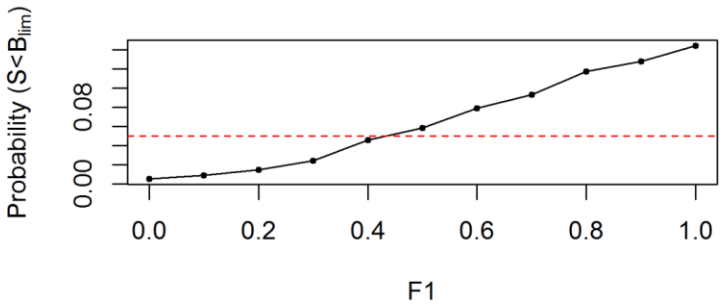


Fig. 6. (area 2r) The X-axis (F1) represents different F_{cap}-values and the Y-axis display the probability of dropping below B_{lim} when using the F_{cap}- value given on the X-axis.

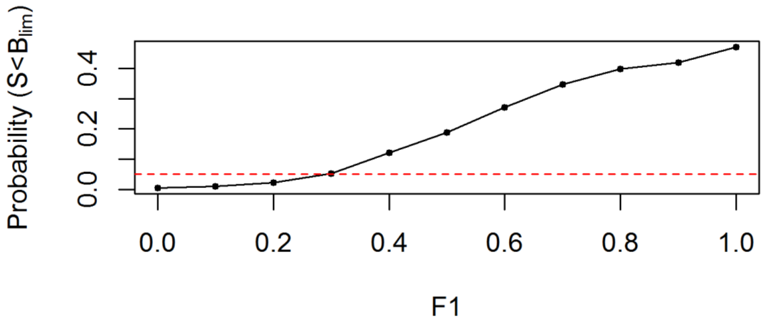


Fig. 7. (area 3r) The X-axis (F1) represents different F_{cap}-values and the Y-axis display the probability of dropping below B_{lim} when using the F_{cap}- value given on the X-axis.

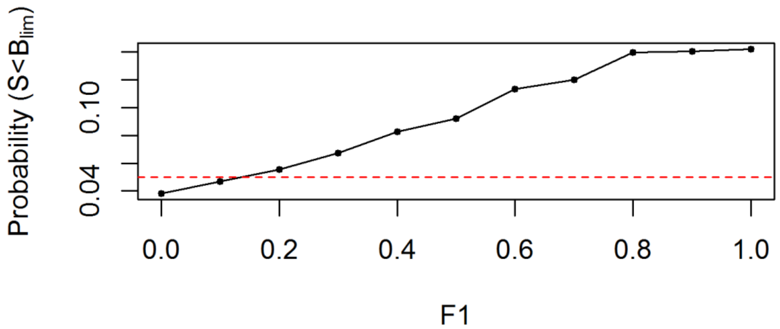


Fig. 8. (area 4) The X-axis (F1) represents different F_{cap}-values and the Y-axis display the probability of dropping below B_{lim} when using the F_{cap}- value given on the X-axis.

9.11 Audit of Sandeel in SA4

Date: 30/01/2017

Auditor: Valerio Bartolino

General

Sandeel in SA4 is one of the seven sub-populations identified and assessed in the North Sea. The assessment has been benchmarked at the end of 2016 which allowed assessing this stock for the first time. SA4 has only been fished for a monitoring TAC for several years.

For single stock summary sheet advice:

1) **Assessment type:** update (2016 benchmark is the first time the stock is assessed)
2) **Assessment:** analytical
3) **Forecast:** short-term forecast presented
4) **Assessment model:** Seasonal age-based SMS-effort + 1 dredge survey index.
5) **Data issues:** The dredge survey that is used in the assessment is of good quality but is relatively short (2008–2016).

   The second half year mean weights are affected by the very limited sampling at this time of year.

   Low consistency is found between age0 and age1 fish in the dredge survey which is interpreted as a possible result of highly variability in the total mortality.

   Technological creeping and changes in fishing pattern may have contributed to the observed increase in CPUE in recent years.
6) **Consistency:** There is very little retrospective pattern in the SSB, R and F which supports the impression of a good quality assessment. There is some tendency to have positive residuals (observed higher predicted catch) for age 1 in the beginning of the time series.
7) **Stock status**: SSB has been at or below Blim from 2007 to 2010 and above Bpa after with the exception of 2015 when it was between Blim and Bpa. SSB is estimated well above Bpa in 2016 and 2017. The 2016 year class is estimated above the average. Fishing mortality has been very low since 2006 with the stock fished only for monitoring purposes.
8) **Management Plan**: No agreed management plan for this stock.

General comments

The assessment is well documented and easy to read making good use of the stock annex for more in depth information on the treatment of the data.

In practice the stock shows good response to increase in recruitment, but there is a weak link between fishing intensity and SSB which makes advice rather challenging.

The advice reflects the status of the stock but it has inherent challenging aspects given by the presence of closed grounds which in the past contributed to almost 50% of the catches in the area. Thus, providing an advice on the full catch and a warning on potential local depletion seems justified without other available information ie, on time of depletion and spill-over with recolonization among neighboring sandeel grounds.

Technical comments

The contribution of the S-R relationship to the assessment is set low (0.05) based on a priori decision which is well justified by the lack of an evident relationship in the S-R plot.

Conclusions

The assessment appears well performed accordingly to the documentation and information available. The assessment is judged of good quality and suitable for management advice. No management plan exists for this area.

10 Sprat in Division 3.a (Skagerrak and Kattegat)

10.1 The Fishery

10.1.1 ICES advice applicable for 2016 and 2017

In 2016, the TAC for sprat was set at 33 280 t and the by-catch of herring in both the industrial and sprat fishery was limited to 6659 t. The advice in 2016 (for 1 July 2016–30 June 2017) was for a severe reduction in TAC to just 9773 t. Also for 2017, the TAC for sprat is set at 33 280 t and the herring by-catch limit 6659 t.

Sprat is mainly fished together with juvenile herring. The sprat fishery has historically been controlled by a herring by-catch TAC as well as by-catch percentage limits (Norway, Sweden and Denmark: respectively max 10%, 10% and 50% by-catch of herring in weight). Now with the implementation of the landing obligation, this rule has disappeared for the EU countries. The fishery is still regulated by the herring by-catch TAC and the Danish fishery has implemented a self-regulation rule in relation to the catch-composition of the sprat fishery.

10.1.2 Landings

The total landings in 2015 and 2016 (19 770 t and 11046 t, respectively) are above and slightly below average landings in the last 10 years, respectively (Table 10.1.1). The table presents the landings from 1996 onwards. The data prior to 1996 can be found in the HAWG report from 2006 (ICES 2006/ACFM:20). The official and ICES catches often differ considerably for this stock as official landings often include bycatch of other species. In 2014 Germany reported very small landings (<50t).

There were sprat landings in all quarters (Table 10.1.2). In 2016 the proportion of total landings from the 3rd and 4th quarters (83%) continued to be substantially above the long term average (69%). In the Norwegian fishery sprat were, as before, taken in the 1st and 4th quarter, all as part of the fishery for canning production. Very small landings (<50t) were reported by the Faroe Islands.

10.1.3 Fleets

Fleets from Denmark, Norway and Sweden carry out the sprat fishery in Division 3.a.

The Danish sprat fishery consists of trawlers using a 16 mm mesh size in the codend and all landings are used for fishmeal and oil production. In Sweden there is a pelagic trawl fishery targeting sprat for reduction and a late fall purse seine fishery for sprat to be used in human consumption. The Norwegian sprat fishery in Division 3.a is a coastal/fjord purse seine fishery for human consumption.

10.1.4 Regulations and their effects

Sprat cannot be fished without by-catches of herring except in years with high sprat abundance or low herring recruitment. Management of this stock should consider management advice given for herring in Subarea 4, Division 7.d, and Division 3.a.

Most sprat catches are taken in a small-meshed industrial fishery where catches are limited by herring by-catch restrictions.

In Norway, there is a minimum catch size for sprat within the 4 nautical mile limit from the coast. In 2015, this was increased from 9 to 10 cm.

10.1.5 Changes in fishing technology and fishing patterns

No changes in fishing technology and fishing patterns for the sprat fisheries in 3.a have been reported for 2016.

10.2 Biological Composition of the Catch

10.2.1 Catches in number and weight-at-age

During the 2013 benchmark (see WKSPRAT report: ICES CM 2013/ACOM:48), mean weights and catch-in-numbers by quarter were recalculated. The numbers in the tables differ from previous years along with a change from a 5+ group to 4+. In 2013 the 1- and 2-year-olds contributed only 43% of the total landings in numbers, reflecting the low incoming year classes (1-year-olds) seen both in 2012 and 2013 surveys (see Table 10.2.1). In 2015 and 2016, 81% and 51% of the catch consisted of 1-year olds, in accordance with the relatively high acoustic index of 1-year olds in 2015.

Mean weight-at-age (g) in the catches are presented by quarter in Table 10.2.2. Mean-weight-at-age for all ages is in the same order as the previous years. Mean weights-at-age for 1996–2003 are presented in ICES CM 2005/ACFM:16. Landings were raised using a combination of Danish, Norwegian and Swedish samples, without any differentiation in types of fleets. Details on the sampling for biological data per country and quarter are shown in Table 10.2.3.

The species composition of the Danish sprat fishery is given in Table 10.2.4.

10.3 Fishery-independent information

The survey indices available are the IBTS in the Skagerrak/Kattegat from 1983 onwards (from this year, all nations used GOV trawl), and an acoustic abundance index by age from HERAS from 2006 onwards.

One problem with the surveys in 3.a (highlighted by WKSPRAT (ICES CM 2013/ACOM:48)) is that they mainly cover the central parts of Skagerrak/Kattegat, whereas all the Norwegian and some of the Swedish catches are taken in coastal areas not covered adequately by the surveys. Also, most of the sprat is concentrated in a very small part of the survey area, meaning that only a few trawl hauls/transects give survey information about sprat, making the survey indices less precise.

Last year, WKARSPRAT determined that the age of 3a sprat was very poorly determined for ages 2 and above. This potentially contributes substantially to the low consistency of catches of different age groups in the surveys.

10.3.1 ICES co-ordinated Herring Acoustic survey (HERAS)

Acoustic estimates of sprat have been available from HERAS in Division 3.a since 2000, and from 2006 also split by age (see Table 10.3.1). At the time of the surveys in 2016, sprat were almost exclusively found in Kattegat (approx. 100%). The 2016 abundance was estimated to be 957 million individuals, a decrease compared to 2016 and still below the long-term average. The biomass was estimated to be 13 500 tonnes, above the estimated biomass in 2014 where the numbers of individuals were similar. By far the majority of sprat were 2+ group, in accordance with high catches in IBTS Q3.

10.3.2 IBTS (1st and 3rd Quarter)

The IBTS Q1 (February) sprat indices for 1984–2017 are presented in Table 10.3.2. The preliminary IBTS index for 1-groups 2017 was below the long term mean as well as the recent averages for the period 2012–16. The 2015 year class index was 2.9 times the long term average in the 2016 IBTS Q3 (Table 10.3.3).

10.3.3 Survey consistency

The estimation of average catch at age in the IBTS was explored in WKSPRAT (ICES CM 2013/ACOM:48). These data were compared with the HERAS data for internal and external consistency. Based on these analyses the survey index was estimated from a stratified mean (see WKSPRAT: ICES CM 2013/ACOM:48).

10.4 Mean weight-at-age and length-at-maturity

Data on maturity by age, mean weight- and length-at-age during the 2016 HERAS are presented in Table 5.12 in the WGIPS report (ICES CM 2017/SSGIEOM:15).

10.5 Recruitment

For this stock, the IBTS index for 1-group sprat in the first quarter is the only available recruitment index (Table 10.3.2). The 1-group index for 2017 was below long term average. The procedure for the survey did not differ from previous years.

10.6 Stock Assessment

10.6.1 Stock Assessment

The stock is assessed using the ICES data limited stock approach (Category 3/4 DLS: ICES CM 2012/ACOM 68) with input from three surveys. Together, this provides an index of the sprat which will be age 1 and 2 in the beginning of July.

10.6.2 State of the Stock

The total stock size indices for the most recent three years indicate a reduction in stock size in the most recent year. The higher proportion of 2+ fish in the catches in 2016 is reflected in IBTS Q3.

10.7 Short term projections

The IBTS Q1 age 1 is used as an indicator of the incoming year class and IBTSQ1 age 2, IBTSQ3 age 1 the previous year and HERAS age 1 the previous year as indicators of age 2. These provide in year advice for 3.a based on the ICES data limited stock approach (Category 3/4 DLS: ICES CM 2012/ACOM 68). Together, this provides an index of the sprat which will be age 1 and 2 in the beginning of July.

10.7.1 Method

The method, as identified in WKSPRAT is detailed in the Stock annex.

10.7.2 Results

The anomalies in each of the survey indices are seen in Figure 10.7.1 and the total index anomaly in Figure 10.7.2. Further, the proportion of all commercial catches (in biomass) consisting of fish with more than 2 winter rings is given in Figure 10.7.3. Applying the rule stated in the stock annex, the catch multiplier is estimated at 0.8 (without cap:

0.73). This value was driven by the negative anomaly of all surveys. Applying the benchmarked method results in a TAC advice of 7818 t.

10.8 Reference Points

The working group considered different approaches to estimating reference points for short-lived category 3 stocks (3a sprat and English Channel sprat). Firstly, HAWG considered that since the equivalent management of data rich assessed stocks was an escapement strategy, the information relevant is the current biomass relative to an biomass reference point equivalent to $B_{escapement}$, whereas F reference points were not considered relevant.

The first option considered was to apply the SPICT model. However, the contrast in English Channel sprat was insufficient to obtain a reasonable fit of the model. The other options suggested by other WGs were based on length measurements and generally are not recommended to short lived stocks as they are reliant on assumptions of steady state. HAWG therefore decided to use the principles used in these models to derive biomass reference levels to derive reference levels for 3a and English Channel sprat.

10.8.1 Estimating $B_{escapement}$

Production models generally derive B_{MSY} as half the unfished biomass:

$$B_{MSY} = \frac{B_{unfished}}{2}$$

From B_{MSY}, the limit reference point equivalent B_{lim} is often defined as:

$$B_{lim} = \frac{B_{MSY}}{2} = \frac{B_{unfished}}{4}$$

To derive $B_{escapement}$, a precautionary buffer, Pb, is multiplied to B_{lim}:

$$B_{escapement} = (1 + Pb)B_{lim} = (1 + Pb)\frac{B_{unfished}}{4}$$

In general, models are used to derive the unfished biomass or related reference points. However, without a proper model, it was considered that the two sprat stocks had historically been lightly exploited at least for parts of the period with historic data. This means that the highest observed biomasses might be indicative of $B_{unfished}$ and that the ratio of the agreed precautionary SSB reference point ($B_{escapement}$ or MSY $B_{trigger}$) to the maximum observed SSB is indicative of the precautionary buffer. Looking at a selection of short lived stocks with analytical assessments as well as two longer lived stocks, the maximum SSB and the precautionary reference point, the ratio of $B_{escapement}$ to $B_{unfished}$ can be estimated:

Stock	$B_{unfished}$ ('000 t)	$B_{escapement}$ ('000 t)	$B_{escapement}$ / $B_{unfished}$	Pb
North Sea sprat	492	142	0.29	0.15
Sandeel area 1r	1136	145	0.13	-0.49
Sandeel area 2r	301	84	0.28	0.12
Norway pout (2015)	374	150	0.40	0.60
Baltic sprat	1898	570	0.30	0.20
North Sea herring	4911	1500	0.31	0.22

This leads to an average precautionary buffer of 0.13 (0.29 if sandeel in area 1r is removed). In the following, a Pb of 0.2 was used.

Unfortunately, the maximum increases for statistical reasons as more data is collected even in unfished stocks. One way to limit this bias is to use 95% quantiles of biomass observed rather than maximum observations. However, the group agreed that this method should be considered a coarse approximation at best to determining unfished biomass, and that the resulting status is influenced both by the length and quality of the time series used to derive the unfished biomass (or indices thereof) and the uncertainty of the latest survey index.

If only an index I of biomass is known, the status of the current index relative to $I_{escapement}$ is a direct estimate of current biomass relative to $B_{escapement}$:

$$\frac{I_{current}}{I_{escapement}} = \frac{qB_{current}}{qB_{escapement}} = \frac{B_{current}}{0.3B_{unfished}} = \frac{I_{current}}{0.3I_{unfished}}$$

To derive an index of biomass, the IBTS indices (numbers at age) were multiplied by the annual weight at age from the fishery in the corresponding quarter and these biomass indices summed across ages. The biomass indices of the three surveys were divided by their mean and average within each sprat assessment year (July to June). The 95% quantiles of this biomass index were used to estimate $I_{escapement}$ and the status of the stock judged by $I_{current}/I_{escapement}$ and $I_{current}/I_{lim}$ where $I_{lim}= 0.83I_{escapement}$.

The resulting status is that the stock is above $B_{escapement}$ and has been so for the past 3 years. The stock was estimated to be below I_{lim} in 1996, 1998 and 2000. The harvest rate index ($0.0001*Catch_{current}$ *(tonnes)*/$B_{current}$) has been below the average of the time series since 2005 (Fig. 10.8.1, Table 10.8.1).

10.9 Quality of the Assessment

The stock was benchmarked and peer-reviewed in February 2013 (WKSPRAT ICES CM 2013/ACOM:48).

The advice is based on a combined abundance index from three surveys, used as an indicator of stock size. The uncertainty associated with the index values is not available. There are concerns related to the accuracy of these abundance indices as analyses show that the survey may not cover the entire stock but the current assessment is considered to reflect stock size. As sprat has a very patchy distribution, the sampling in the surveys may not be appropriate.

10.10 Management Considerations

Sprat is a short-lived species with large inter-annual fluctuations in stock biomass. The natural inter-annual variability in stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

The sprat is mainly fished together with herring. The human consumption fishery only takes a minor proportion of the total catch. Within the current management regime, where there is a by-catch ceiling limitation of herring as well as by-catch percentage limits, the sprat fishery is controlled by these factors. In the last three years, the sprat fisheries have not been limited by the sprat quota, as this has been substantially above the advised TAC.

10.11 Ecosystem Considerations

The area 3.a (Skagerrak and Kattegat) is one of four key areas in the Greater North Sea Ecoregion (ICES 2016?). This area forms the link to the Baltic Sea and is less saline and less tidal than the rest of the ecoregion. The water column is usually mixed. The dominant human activities are fishing, shipping, and wind farms. Area 3.a currently constitutes two strata in the Working Group on Integrated Assessments of the North Sea (WGINOSE), namely Skagerrak and Kattegat) (ICES, WGINOSE 2016). During 2017 a new stratum covering the Norwegian Trench (deep-water area) will be added to give complete coverage of this area. 'The Skagerrak and Kattegat appear to be dominated by abiotic factors notably strong increasing trends in seawater temperature and decreasing trends in nutrient concentrations.' – Extracted from ICES WGINOSE (2016).

In the adjacent 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 (WGSAM: ICES CM 2011/SSGSUE:10). It is considered that there are fewer predator populations in 3.a than in the North Sea. For an analytical assessment it is not possible to include annual estimates of sprat consumption by predators as done for the North Sea stock, but it may be possible to estimate average predation consumption.

A major source of uncertainty with 3.a sprats is the extent to which these fish derive from migrations of fish from the North Sea stock into 3.a, the degree to which the stock is distributed in shallow (un-surveyed) waters and the ageing uncertainty of sprat of ages 2+.

10.12 Changes in the environment

Temperatures in the Skagerrak area were relatively stable from the 1920s to the late 1980s and early 1990s when there was an increase (Johannesen *et al*., 2012). This elevated temperature (both in the summer and winter) has remained reasonably stable. The area is complex; however, both the Skagerrak and Kattegat indicate general declines in nutrients and total nitrogen over the period 1984 to 2014 (ICES WGINOSE 2016).

Table 10.1.1 Division 3.a sprat. Catches in ('000 t) 1996–2016. (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.

	Skagerrak						Kattegat			Div. IIIa total
Year	Denmark	Sweden	Norway	Germany	Faroe Islands	Total	Denmark	Sweden	Total	
1996	7,0	3,5	1,0			11,5	3,4	3,1	6,5	18,0
1997	7,0	3,1	0,4			10,5	4,6	0,7	5,3	15,8
1998	3,9	5,2	1,0			10,1	7,3	1,0	8,3	18,4
1999	6,8	6,4	0,2			13,4	10,4	2,9	13,3	26,7
2000	5,1	4,3	0,9			10,3	7,7	2,1	9,8	20,1
2001	5,2	4,5	1,4			11,2	14,9	3,0	18,0	29,1
2002	3,5	2,8	*			6,3	9,9	1,4	11,4	17,7
2003	2,3	2,4	0,8			5,6	7,9	3,1	10,9	16,5
2004	6,2	4,5	1,1			11,8	8,2	2,0	10,2	22,0
2005	12,1	5,7	0,7			18,5	19,8	2,1	21,8	40,3
2006	1,2	2,8	0,3			4,3	6,6	1,6	8,2	12,5
2007	1,4	2,8	1,6			5,9	8,5	1,3	9,8	15,7
2008	0,3	1,5	0,9			2,6	5,6	0,9	6,5	9,1
2009	1,1	1,4	0,7			3,2	5,8	0,2	6,0	9,2
2010	3,4	1,2	0,9			5,4	5,0	0,2	5,3	10,7
2011	3,5	1,8	0,7			6,0	4,5	0,3	4,8	10,7
2012	1,7	1,3	0,5			3,5	6,7	0,2	6,9	10,4
2013	0,3	0,7	0,9			1,9	1,6	0,4	2,0	3,9
2014	12,0	1,1	0,3	*		13,3	4,7	0,5	5,2	18,5
2015	7,5	0,9	0,3			8,7	4,2	0,4	4,6	13,3
2016	3,3	0,8	0,3		*	4,4	3,5	0,3	3,8	8,2
* < 50 t										

Table 10.1.2. Division 3.a sprat. Catches of sprat ('000 t) by quarter by countries, 2003–2016. (Data provided by the Working Group members).

	Quarter	Denmark	Norway	Sweden	Total		Quarter	Denmark	Norway	Sweden	Germany	Faroe Isl.	Total
2003	1	3.54	0.10	1.67	5.30	2010	1	1.45	0.05	0.02			1.51
	2	0.59		0.80	1.40		2	0.64		0.01			0.65
	3	1.00		0.72	1.72		3	3.38		0.03			3.41
	4	5.04	0.80	2.31	8.13		4	2.93	0.86	1.35			5.14
	Total	10.18	0.80	5.50	16.54		Total	8.39	0,91	1,40			10,71
2004	1	3,11		1,35	4,46	2011	1	3,20	0,09	0,02			3,31
	2	0,64		0,87	1,51		2	0,60		0,02			0,62
	3	3,70		0,44	4,14		3	2,30	*	0,01			2,31
	4	6,94	1,10	3,83	11,88		4	1,90	0,61	1,99			4,50
	Total	14,39	1,10	6,49	21,98		Total	8,00	0,71	2,03			10,74
2005	1	6,47		1,68	8,15	2012	1	4,44	0,02	0,23			4,69
	2	4,65		0,07	4,72		2	0,82		0,09			0,91
	3	18,61	0,71	0,81	20,13		3	1,63					1,63
	4	2,13		5,17	7,30		4	1,54	0,46	1,19			3,19
	Total	31,86	0,71	7,73	40,30		Total	8,43	0,48	1,50			10,42
2006	1	5,43	0,17	2,68	8,28	2013	1	0,97	0,12	0,32			1,42
	2	0,17		0,16	0,32		2	0,43		0,01			0,44
	3	1,34		0,10	1,44		3	0,21	*				0,21
	4	0,88	0,13	1,46	2,46		4	0,25	0,74	0,70			1,68
	Total	7,82	0,30	4,39	12,51		Total	1,86	0,86	1,03			3,75
2007	1	2,26	0,45	0,38	3,09	2014	1	0,34	0,14	0,04			0,52
	2	0,70		0,59	1,29		2	1,41		0,00			1,41
	3	5,15	*	0,21	5,36		3	9,25	*	0,37			9,62
	4	1,79	1,16	2,98	5,92		4	5,74	0,12	1,12	0,05		7,03
	Total	9,90	1,60	4,16	15,66		Total	16,75	0,26	1,53	0,05		18,58
2008	1	2,25	0,20	0,64	3,09	2015	1	1,08	0,12	0,37			1,56
	2	0,67		0,35	1,02		2	0,53		0,09			0,62
	3	0,45		0,19	0,64		3	6,50	*	0,03			6,53
	4	2,46	0,70	1,21	4,37		4	3,55	0,18	0,84			4,57
	Total	5,83	0,90	2,39	9,12		Total	11,66	0,30	1,32			13,27
2009	1	2,20	0,40	0,40	3,00	2016	1	0,30	0,01	0,45			0,75
	2	0,30			0,30		2	0,67	0,00	0,00			0,67
	3	3,20		0,10	3,30		3	4,49	0,03	0,18			4,69
	4	1,20	0,24	1,20	2,64		4	1,28	0,31	0,48		*	2,07
	Total	6,90	0,64	1,70	9,24		Total	6,74	0,35	1,11		*	8,19
* < 5 t													

* < 5 t

Table 10.2.1. Division 3.a sprat. Landed numbers (millions) of sprat by age groups in 2004–2016 (based on Danish, Norwegian and Swedish sampling). The landed numbers in 1996–2003 can be found in ICES CM 2007/ACFM:11.

	Quarter	Age					Total
		0	1	2	3	4+	
2004	1	0.0	705.4	38.0	30.1	27.7	801.1
	2	0.0	162.2	9.0	10.5	7.5	189.2
	3	0.0	446.5	24.0	9.9	4.5	484.8
	4	2027.5	187.2	15.4	4.5	0.6	2235.2
	Total	2027.5	1501.3	86.4	54.9	40.2	3710.3
2005	1	0.0	2212.5	114.0	20.7	8.0	2355.2
	2	0.0	1180.6	39.0	1.8	1.7	1223.1
	3	43.4	1806.8	147.7	13.4	15.1	2026.3
	4	19.1	234.8	11.0	2.8	0.7	268.5
	Total	62.5	5434.7	311.7	38.8	25.5	5873.1
2006	1	0.0	365.0	430.0	108.1	37.6	940.7
	2	0.0	16.8	14.0	2.3	0.7	33.8
	3	0.0	10.0	95.9	14.7	6.7	127.3
	4	5.2	15.1	50.7	10.9	2.0	83.9
	Total	5.2	406.9	590.7	136.1	46.9	1185.8
2007	1	0.0	62.1	18.7	40.2	3.5	124.5
	2	0.0	4.8	1.6	4.5	0.4	11.3
	3	0.0	799.2	65.8	24.0	3.5	892.5
	4	26.3	257.0	17.6	9.1	1.9	311.9
	Total	26.3	1123.1	103.7	77.7	9.3	1340.1
2008	1	0.0	12.5	128.9	27.7	59.3	228.4
	2	0.0	4.5	46.8	10.1	21.5	83.0
	3	100.1	24.8	5.8	0.8	1.5	132.8
	4	602.2	212.7	52.5	4.5	10.5	882.3
	Total	702.3	254.6	234.0	43.1	92.7	1326.6
2009	1	0.0	700.4	52.0	35.4	10.7	798.5
	2	0.0	91.3	8.2	7.3	2.8	109.6
	3	0.0	277.8	13.9	10.5	5.1	307.3
	4	0.1	111.7	5.4	5.8	2.3	125.3
	Total	0.1	1181.3	79.4	58.9	21.0	1340.7
2010	1	0.0	157.1	125.7	47.2	17.8	347.9
	2	0.0	108.8	87.0	32.7	12.3	240.8
	3	1.3	108.7	188.3	59.9	44.2	402.4
	4	2.0	8.2	20.9	15.8	17.1	64.0
	Total	3.2	382.8	421.9	155.7	91.5	1055.2
2011	1	0.0	167.8	29.2	1.9	8.7	207.6
	2	0.0	44.1	7.7	0.5	2.3	54.6
	3	0.0	371.0	106.2	3.6	1.6	482.4
	4	0.0	178.9	72.3	2.1	16.0	269.2
	Total	0.0	761.7	215.4	8.1	28.5	1013.8
2012	1	0.0	44.6	236.4	82.7	33.2	396.9

	Quarter	Age					Total
		0	1	2	3	4+	
	2	0.0	10.6	80.6	21.5	8.0	120.7
	3	0.0	82.5	59.2	7.6	14.0	163.4
	4	0.0	133.6	95.9	12.4	22.6	264.5
	Total	0.0	271.3	472.1	124.2	77.8	945.5
2013	1	0.0	17.2	13.5	36.5	39.1	106.4
	2	0.0	5.6	5.5	17.8	18.1	47.0
	3	0.0	10.1	1.8	5.9	6.0	23.7
	4	0.0	54.5	9.7	31.8	32.3	128.3
	Total	0.0	87.3	30.5	92.0	95.6	305.4
2014	1	0.0	139.1	1.1	1.8	3.5	145.4
	2	0.0	625.0	3.6	3.5	4.7	636.8
	3	6.7	1021.7	38.5	1.4	2.5	1070.8
	4	599.9	621.1	48.7	2.7	7.3	1279.8
	Total	606.7	2406.9	91.9	9.4	18.0	3132.9
2015	1	0.0	153.7	96.3	16.4	3.5	270.0
	2	0.0	81.5	44.0	6.4	1.3	133.2
	3	5.7	1213.2	55.6	5.7	2.9	1282.9
	4	0.2	529.0	62.6	9.2	11.4	612.4
	Total	5.9	1977.4	258.5	37.7	19.1	2298.5
2016	1	0.0	5.9	55.1	11.9	11.1	83.2
	2	0.0	34.6	43.8	7.9	7.3	93.6
	3	75.6	508.2	85.8	3.8	5.3	678.8
	4	0.7	35.7	76.9	26.5	13.6	153.3
	Total	76.3	584.4	261.6	50.1	37.3	1008.9

Table 10.2.2. Division 3.a sprat. Quarterly mean weight-at-age (g) in the landings for the years 2004–2016 (from Danish, Swedish, and Norwegian samples). The equivalent data for 1996–2003 can be found in ICES CM 2007 /ACFM: 11.

		Age				
Year	Quarter	0	1	2	3	4+
2004	1		4.9	11.5	13.4	14.0
	2		5.1	9.6	12.5	14.7
	3		11.5	14.2	15.5	16.7
	4	3.9	11.8	15.5	16.0	17.1
Weighted mean		3.9	7.8	12.8	13.8	14.5
2005	1		2.9	11.1	12.7	14.6
	2		4.5	9.7	12.1	13.3
	3	7.7	11.2	13.6	14.4	22.6
	4	7.5	13.2	15.9	17.4	18.1
Weighted mean		7.7	6.4	12.3	13.6	19.4
2006	1		5.2	10.9	14.3	15.1
	2		5.3	10.0	13.0	15.3
	3		12.0	16.7	19.6	20.4
	4	6.0	15.7	17.4	19.6	21.0
Weighted mean		6.0	5.7	12.4	15.3	16.1
2007	1		3.6	9.3	12.9	13.4
	2		5.2	9.9	12.9	15.2
	3		11.8	13.0	15.0	15.2
	4	8.7	12.4	15.4	19.6	20.4
Weighted mean		8.7	11.5	12.7	14.4	15.5
2008	1		5.8	11.8	15.3	18.3
	2		6.2	11.8	15.4	18.1
	3	3.6	5.1	11.2	14.0	14.5
	4	3.5	7.0	9.5	11.0	12.0
Weighted mean		3.5	6.8	11.3	14.8	17.5
2009	1		3.8	7.8	8.2	9.9
	2		4.1	7.7	10.0	11.8
	3		11.7	13.7	13.9	13.4
	4	5.7	11.8	14.6	15.8	15.1
Weighted mean		5.7	6.4	9.3	10.2	11.6
2010	1		5.0	10.2	13.2	15.8
	2		5.3	10.0	13.0	15.3
	3	6.6	10.3	11.3	13.0	14.8
	4	6.6	11.9	13.9	16.0	18.4
Weighted mean		6.6	6.7	10.8	13.4	15.7
2011	1		6.7	13.6	17.7	21.2
	2		6.9	13.1	17.0	20.0
	3		9.4	10.7	11.1	15.7
	4		13.0	16.0	13.0	19.1

		Age				
Year	Quarter	0	1	2	3	4+
Weighted mean			9.5	13.0	13.5	19.6
2012	1		3.6	9.4	11.9	16.1
	2		4.6	8.8	11.4	13.4
	3	5.8	10.0	14.3	16.5	18.8
	4	5.2	10.4	14.0	16.3	17.8
Weighted mean		5.5	9.0	10.9	12.5	16.8
2013	1		6.2	11.6	15.2	18.1
	2		6.3	12.0	15.5	18.3
	3		7.8	11.1	12.8	14.5
	4		8.2	11.0	12.7	13.9
Weighted mean			7.6	11.4	14.2	16.5
2014	1		2.5	5.0	6.5	7.7
	2		2.0	10.3	14.4	16.0
	3	5.7	8.9	12.9	16.4	16.8
	4	2.1	8.0	13.7	16.1	16.1
Weighted mean		2.1	6.5	13.1	13.7	14.6
2015	1		4.9	10.1	11.2	12.6
	2		5.2	9.8	12.7	15.0
	3	6.3	7.7	10.3	14.9	15.2
	4	6.6	10.4	13.5	16.5	20.2
Weighted mean		6.3	8.1	10.9	13.3	17.7
2016	1		5.4	10.9	14.7	18.1
	2		5.9	11.1	14.4	16.9
	3	6.7	9.8	12.1	15.1	17.9
	4	6.7	12.3	15.9	18.5	20.5
Weighted mean		6.7	9.7	12.8	16.7	18.7

Table 10.2.3 Division 3.a sprat. Sampling commercial landings for biological samples in 2016.

Country	Quarter	Landings	No.	No.	No.	Samples
		(tonnes)	samples	meas.	aged	per 1000 t
Denmark	1	300	2	168	50	7
	2	669	2	203	99	3
	3	4 487	19	1 734	294	4
	4	1 281	3	222	100	2
	Total	6 737	26	2 327	543	4
Norway	1	6				
	2	3				
	3	30				
	4	306				
	Total	346				
Sweden	1	446	7	228	228	16
	2					
	3	177				
	4	483	6	510	504	12
	Total	1 106	13	738	732	12
Denmark		6 737	26	2 327	543	4
Norway		346				
Sweden		1 106	13	738	732	12
	Total	8 189	39	3 065	1 275	5
Country	Quarter	Landings	No.	No.	No.	Samples
		(tonnes)	samples	meas.	aged	per 1000 t
Denmark	1	1 075	7	557	50	7
	2	532				
	3	6 501	30	2 913	649	5
	4	3 548	11	902	312	3
	Total	11 656	48	4 372	1 011	4
Norway	1	116				
	2					
	3	2				
	4	180	2	66	66	11
	Total	298	2	66	66	7
Sweden	1	366	1	14	14	3
	2	87				
	3	27				
	4	841	15	1 108	1 105	18
	Total	1 321	16	1 122	1 119	12
Denmark		11 656	48	4 372	1 011	4
Norway		298	2	66	66	7
Sweden		1 321	16	1 122	1 119	12
	Total	13 276	66	5 560	2 196	5

Table 10.2.4. Sprat in Division 3.a. Species composition in Danish sprat fishery in tonnes and percentage of the total catch in the North Sea. Data is reported for 1998–2016.

	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			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	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		29	8	1	154	18 036
Tonnes	2016	7 001	2 140	0	335	1	19	3	0	78	9 579
Percent	1998	56 %	21 %	1 %	3 %	0 %	0 %	0 %	0 %	18 %	100 %
Percent	1999	51 %	26 %	0 %	3 %	1 %	0 %	0 %	10 %	9 %	100 %
Percent	2000	49 %	31 %	0 %	4 %	1 %	0 %	0 %	0 %	14 %	100 %
Percent	2001	55 %	25 %	0 %	4 %	0 %	0 %	0 %	13 %	4 %	100 %
Percent	2002	40 %	45 %	0 %	4 %	0 %	0 %	0 %	2 %	8 %	100 %
Percent	2003	57 %	35 %	2 %	2 %	0 %	0 %	0 %	0 %	4 %	100 %
Percent	2004	62 %	22 %	0 %	5 %	0 %	0 %	0 %	1 %	10 %	100 %
Percent	2005	75 %	15 %	1 %	2 %	0 %	0 %	0 %	2 %	4 %	100 %
Percent	2006	65 %	27 %	2 %	3 %	0 %	0 %	0 %	0 %	2 %	100 %
Percent	2007	72 %	21 %	0 %	2 %	0 %	0 %	0 %	0 %	5 %	100 %
Percent	2008	64 %	26 %	0 %	4 %	0 %	0 %	0 %	6 %	1 %	100 %
Percent	2009	59 %	37 %	0 %	2 %	0 %	0 %	0 %	1 %	1 %	100 %
Percent	2010	52 %	39 %	0 %	3 %	0 %	0 %	0 %	2 %	3 %	100 %
Percent	2011	64 %	33 %	0 %	1 %	0 %	0 %	0 %	2 %	1 %	100 %
Percent	2012	49 %	47 %	0 %	1 %	0 %	0 %	0 %	0 %	2 %	100 %
Percent	2013	38 %	59 %	0 %	2 %	0 %	0 %	0 %	0 %	1 %	100 %
Percent	2014	77 %	17 %	0 %	2 %	0 %	0 %	0 %	0 %	4 %	100 %
Percent	2015	63 %	32 %	0 %	3 %	0 %	0 %	0 %	0 %	1 %	100 %
Percent	2016	73 %	22 %	0 %	3 %	0 %	0 %	0 %	0 %	1 %	100 %

Table 10.3.1. Division 3.a sprat. HERAS indices of sprat per age group 2000–2016. * These figures should be uploaded from FishFrame.

	ABUNDANCE (MILLION)					BIOMASS (1000 T)				
	Age									
Year	0	1	2	3+	Sum	0	1	2	3+	Sum
2000										2.0
2001										8.0
2002										10.0
2003	*	*	*	*	983.0	*	*	*	*	13.0
2004	*	*	*	*	1 090.0	*	*	*	*	15.0
2005	*	*	*	*	5 060.0	*	*	*	*	59.8
2006	86.0	61.3	1 451.9	653.0	2 252.2	0.3	0.6	21.2	11.5	33.6
2007	0.0	5 611.9	323.9	382.9	6 318.7	0.0	47.9	3.8	6.5	58.2
2008	0.0	23.0	457.8	291.2	772.0	0.0	0.2	6.3	5.8	12.3
2009	0.0	169.5	432.4	1 631.9	2 233.8	0.0	1.8	6.5	28.3	36.6
2010	0.0	836.1	343.8	376.3	1 556.2	0.0	7.3	4.9	6.4	18.6
2011	0.0	45.4	546.9	981.9	1 574.2	0.0	0.5	9.1	17.8	27.5
2012	0.3	123.9	290.1	1 488.0	1 902.3	0.0	1.2	5.0	31.4	37.6
2013	1.4	14.5	68.8	448.6	533.3	0.0	0.2	1.2	9.6	10.9
2014	29.6	614.5	109.8	159.4	913.3	0.1	4.8	1.8	3.4	10.1
2015	0.3	840.8	202.0	342.6	1 385.8	0.0	9.6	2.7	6.2	18.5
2016	0	5.4	671.2	280	956.5	0.0	0	8.7	4.8	13.5

	ABUNDANCE (MILLION)					BIOMASS (1000 T)				
	Age					Age				
Year	0	1	2	3+	Sum	0	1	2	3+	Sum
2000										2.0
2001										8.0
2002										10.0
2003	*	*	*	*	983.0	*	*	*	*	13.0
2004	*	*	*	*	1 090.0	*	*	*	*	15.0
2005	*	*	*	*	5 060.0	*	*	*	*	59.8
2006	86.0	61.3	1 451.9	653.0	2 252.2	0.3	0.6	21.2	11.5	33.6
2007	0.0	5 611.9	323.9	382.9	6 318.7	0.0	47.9	3.8	6.5	58.2
2008	0.0	23.0	457.8	291.2	772.0	0.0	0.2	6.3	5.8	12.3
2009	0.0	169.5	432.4	1 631.9	2 233.8	0.0	1.8	6.5	28.3	36.6
2010	0.0	836.1	343.8	376.3	1 556.2	0.0	7.3	4.9	6.4	18.6
2011	0.0	45.4	546.9	981.9	1 574.2	0.0	0.5	9.1	17.8	27.5
2012	0.3	123.9	290.1	1 488.0	1 902.3	0.0	1.2	5.0	31.4	37.6
2013	1.4	14.5	68.8	448.6	533.3	0.0	0.2	1.2	9.6	10.9
2014	29.6	614.5	109.8	159.4	913.3	0.1	4.8	1.8	3.4	10.1
2015	0.3	840.8	202.0	342.6	1 385.8	0.0	9.6	2.7	6.2	18.5

Table 10.3.2. Division 3.a sprat. IBTSQ1 (February) indices of sprat per age group 1984–2017.

			Age Group					
Year	No Rect	No hauls	1	2	3	4	5+	Total
1984	15	38	5 675.45	868.88	205.10	79.08	63.57	6 892.08
1985	14	32	2 157.76	2 347.02	392.78	139.74	51.24	5 088.54
1986	16	41	628.64	1 979.24	2 034.98	144.19	37.53	4 824.58
1987	16	50	2 735.92	2 845.93	3 003.22	2 582.24	156.64	11 323.95
1988	14	38	914.47	5 262.55	1 485.07	2 088.05	453.13	10 203.26
1989	16	43	413.94	911.28	988.95	554.53	135.79	3 004.48
1990	16	44	481.02	223.89	64.93	61.11	45.69	876.65
1991	17	40	492.50	726.82	698.11	128.36	375.44	2 421.23
1992	18	46	5 993.64	598.71	263.97	202.90	76.04	7 135.25
1993	18	46	1 589.92	4 168.61	907.43	199.32	239.64	7 104.92
1994	18	48	1 788.86	715.84	1 050.87	312.65	70.11	3 938.32
1995	18	48	2 204.07	1 769.53	35.19	44.96	4.23	4 057.98
1996	17	49	199.30	5 515.42	692.78	111.98	173.75	6 693.23
1997	18	46	232.65	391.23	1 239.13	139.14	134.51	2 136.67
1998	17	44	72.25	1 585.22	619.76	1 617.71	521.52	4 416.46
1999	17	46	4 534.96	355.24	249.86	44.25	313.52	5 497.83
2000	17	45	292.32	737.80	59.69	51.79	23.21	1 164.80
2001	17	45	6 539.48	1 144.34	676.71	92.37	45.87	8 498.77
2002	17	45	1 180.52	1 035.71	89.96	58.85	12.93	2 377.96
2003	17	46	461.66	1 247.15	1 171.77	382.08	122.99	3 385.65
2004	17	46	402.87	49.00	156.62	86.57	27.48	722.54
2005	17	50	3 314.17	1 563.16	470.84	837.09	538.37	6 723.63
2006	17	45	1 323.59	11 855.76	1 753.92	299.05	159.23	15 391.55
2007	17	46	774.11	306.63	250.81	42.08	13.74	1 387.37
2008	17	46	150.60	981.90	132.46	228.32	107.60	1 600.87
2009	17	46	2 686.72	124.46	259.15	29.60	37.43	3 137.36
2010	17	44	218.66	618.49	151.69	354.14	157.65	1 500.62
2011	17	43	135.55	2 887.27	1 472.91	721.10	839.95	6 056.77
2012	17	46	209.49	1 531.55	651.53	346.72	128.08	2 867.37
2013	17	46	301.26	237.34	596.45	484.86	319.28	1 939.18
2014	18	44	518.18	229.09	308.53	1 340.84	364.72	2 761.36
2015	18	47	957.73	206.94	21.87	8.74	83.51	1 278.79
2016	18	47	4208.38	2216.26	416.80	117.81	141.296	7100.55
2017*	18	49	1100.98	755.14	584.08	203.95	53.486	2697.64

*** Preliminary**

Table 10.3.3. Division 3.a sprat. IBTS Q3 indices of sprat per age group 1991–2016. * No survey

Year	Age Group						Total
	0	1	2	3	4	5+	
1991	36.70	493.72	319.35	19.42	113.08	12.08	994.34
1992	7.52	1 731.96	383.25	178.80	60.99	24.38	2 386.90
1993	0.67	309.01	1 719.96	260.70	50.68	6.10	2 347.11
1994	103.31	9 945.22	95.21	73.75	7.06	0.10	10 224.65
1995	0.00	13 295.42	648.80	90.34	90.73	18.04	14 143.33
1996	0.00	130.75	1 582.10	271.89	62.76	56.22	2 103.72
1997	534.19	437.18	31.67	63.33	6.64	4.77	1 077.79
1998	39.71	62.82	90.15	30.15	53.02	4.78	280.63
1999	2.61	8 082.65	282.95	85.84	66.95	56.13	8 577.11
2000	*	*	*	*	*	*	*
2001	0.27	8 501.66	657.70	434.57	19.85	4.50	9 618.55
2002	0.00	3 568.48	763.63	135.47	71.97	6.96	4 546.51
2003	1 133.30	444.80	1 200.60	495.57	98.30	33.36	3 405.92
2004	191.03	7 388.17	645.61	706.08	167.96	54.27	9 153.11
2005	169.27	12 817.78	1 357.63	183.51	68.87	23.95	14 620.99
2006	0.61	849.82	4 639.73	1 839.29	184.31	115.51	7 629.27
2007	49.05	10 899.96	474.27	666.30	175.11	12.98	12 277.67
2008	480.49	809.37	2 779.77	463.18	663.33	129.31	5 325.46
2009	85.17	3 258.75	370.34	337.84	102.80	57.85	4 212.74
2010	14.49	2 335.44	890.51	500.90	268.70	167.77	4 177.81
2011	1.43	1 413.12	1 159.32	484.34	177.13	131.55	3 366.88
2012	10.41	832.37	3 324.18	2 217.86	657.44	281.26	7 323.52
2013	5.06	356.27	967.29	2 192.62	1 130.27	457.09	5 108.60
2014	4.06	30 111.50	831.07	503.50	249.93	184.78	31 884.84
2015	0.58	16064.67	2110.62	415.73	218.26	163.57	18 973.43
2016	1.33	5034.65	4626.81	1243.44	182.87	116.40	11205.49

Table 10.8.1. Biomass indices for each assessment year derived from the three surveys and combined biomass index.

Assessment year	IBTSQ1	IBTSQ3	HERAS	Biomass index
1984	0.812			0.812
1985	1.785			1.785
1986	1.510			1.510
1987	1.293			1.293
1988	1.057			1.057
1989	0.799			0.799
1990	1.347			1.347
1991	1.018	0.149		0.583
1992	0.830	0.421		0.626
1993	0.608	0.400		0.504
1994	0.585	0.889		0.737
1995	1.563	1.476		1.520
1996	0.270	0.376		0.323
1997	1.924	0.134		1.029
1998	0.691	0.060		0.375
1999	1.219	1.059		1.139
2000	1.081	0.000	0.088	0.390
2001	1.128	1.256	0.353	0.912
2002	1.028	0.703	0.441	0.724
2003	0.963	0.471	0.574	0.670
2004	0.690	1.290	0.662	0.881
2005	0.990	1.968	2.640	1.866
2006	0.746	1.523	1.481	1.250
2007	1.110	1.739	2.569	1.806
2008	0.714	0.645	0.543	0.634
2009	0.959	0.592	1.616	1.055
2010	1.282	0.554	0.821	0.886
2011	0.752	0.422	1.212	0.795
2012	1.146	1.294	1.660	1.366
2013	0.467	0.757	0.481	0.568
2014	0.916	3.448	0.446	1.603
2015	1.034	1.852	0.817	1.234
2016	0.949	1.519	0.596	1.021

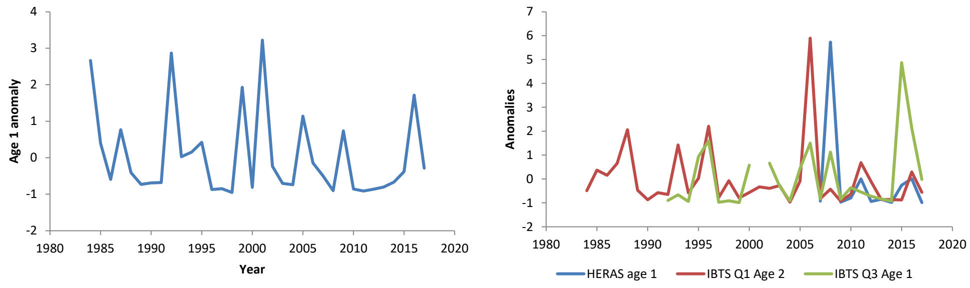


Figure 10.7.1. Division 3.a sprat. Survey index anomalies for surveys used for ages 1 (left) and 2 (right) winter ringers.

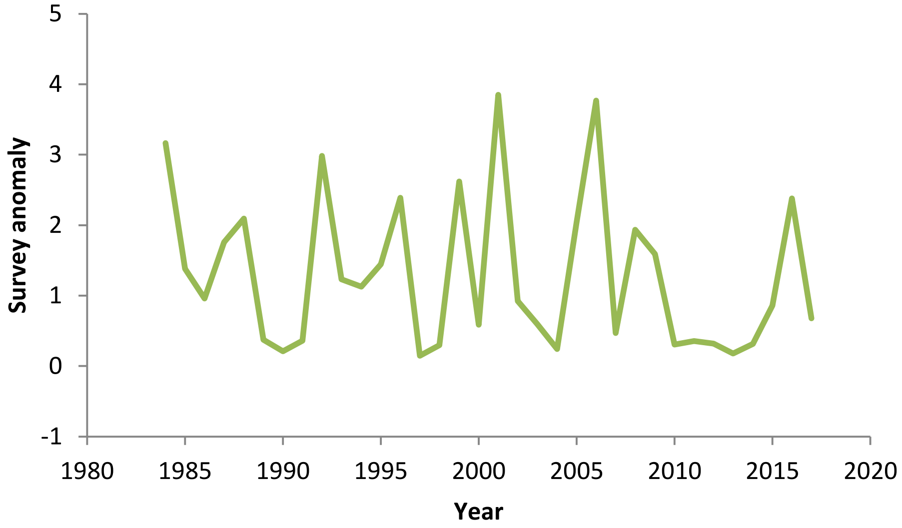


Figure 10.7.2. Division 3.a sprat. Survey index anomalies for total index.

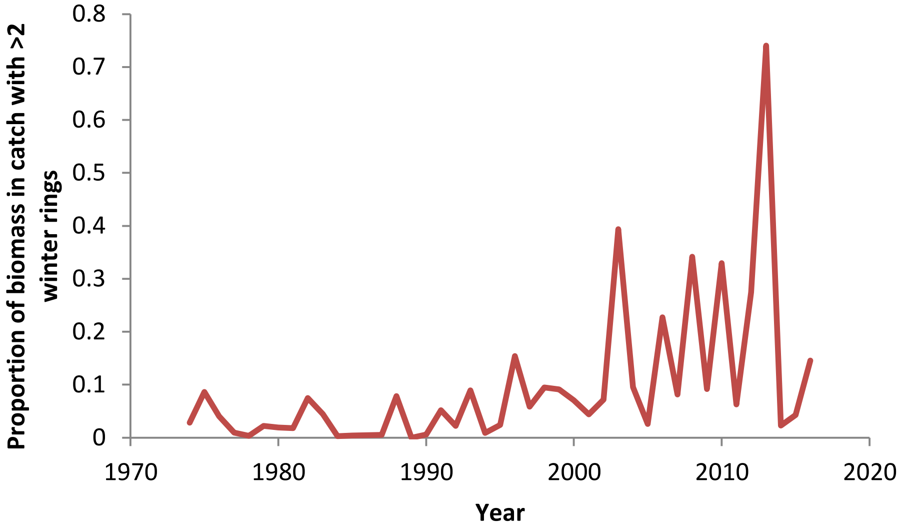


Figure 10.7.3. Division 3.a sprat. The proportion of all commercial catches (in biomass) consisting of fish with more than 2 winter rings.

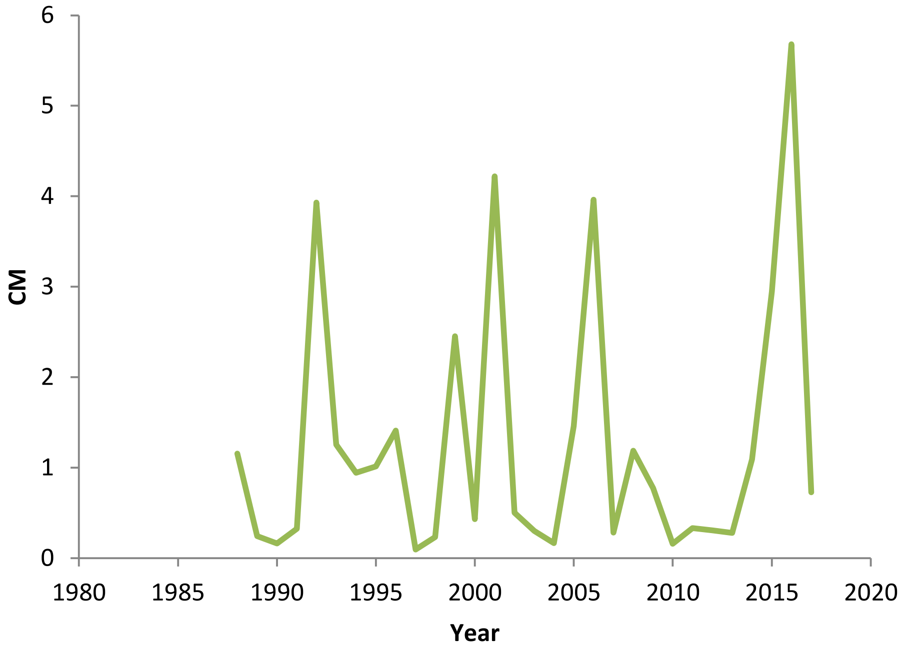


Figure 10.7.4. Division 3.a sprat. Catch multiplier estimated.

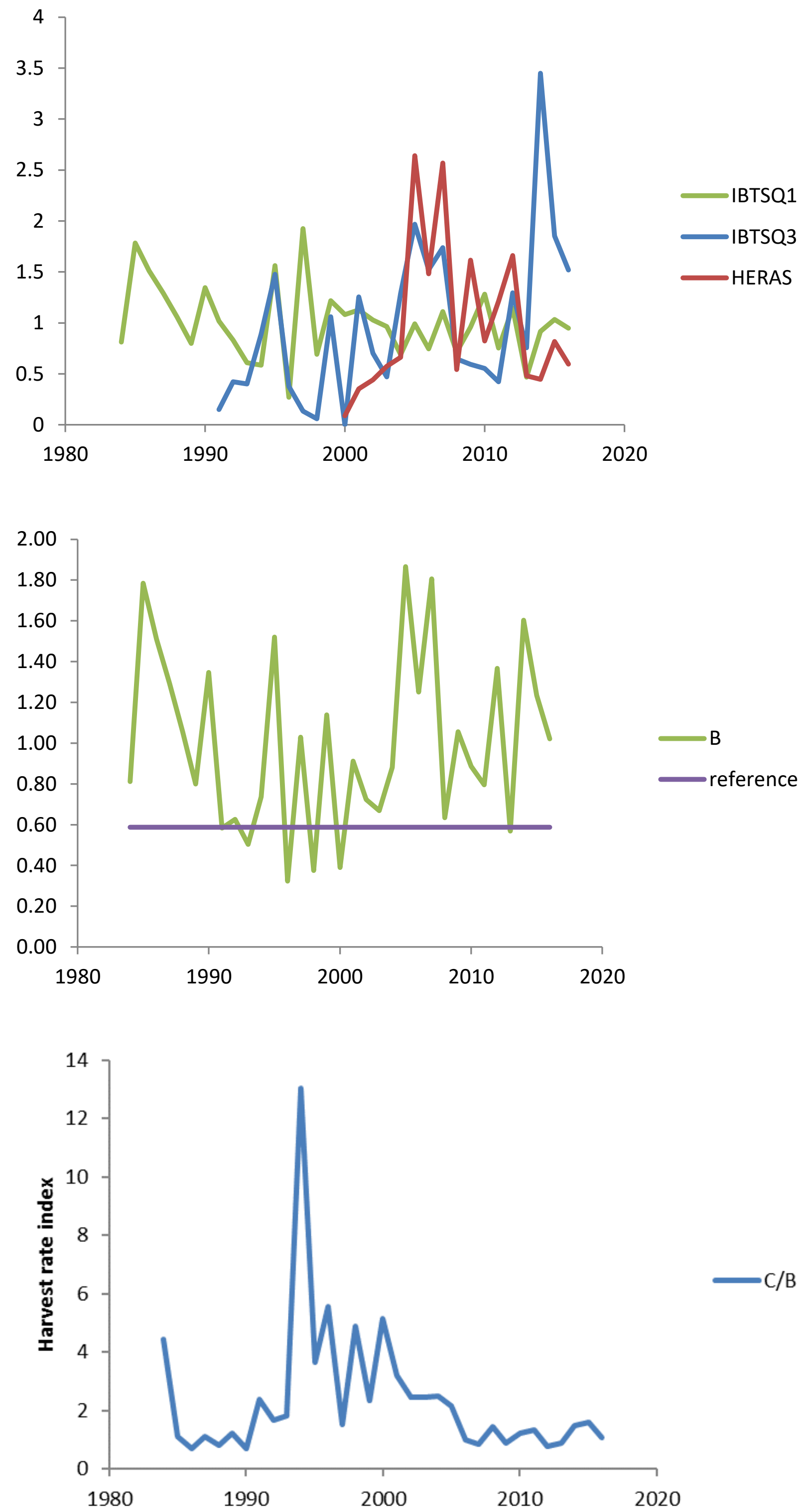


Figure 10.8.1. Division 3.a sprat. Status relative to reference point. Development in individual surveys (top), combined index (middle) and harvest rate index (C/B).

Audit of Sprat in Division 3a

Date: March 21, 2017
Auditor: Piera Carpi

General

- There is no analytical assessment for this stock and advice is given on the basis of a catch multiplier derived from survey data.
- This stock is in ICES data category 3.2.
- The latest index indicates a decrease in the stock. Exploitation rate cannot however, be quantified.
- Discarding is known to occur but cannot be quantified.
- Reference points have been proposed, but the procedure has not been validated, so they have not been used for advice.
- Benchmarked in 2013.

For single stock summary sheet advice:

The assessment relies on 3 surveys, providing estimates of age 1 (one index) and age 2 (3 indices) fish. An overall survey anomaly is calculated and is combined with the relative proportions of age 1 and 2 in recent catches and the previous TAC to derive a new advice. An uncertainty cap is applied such that the newly advised TAC does not deviate from the previous TAC by more than 20%.

1) **Assessment type: SALY**
2) **Assessment**: na
3) **Forecast**: na
4) **Assessment model**: A catch multiplier based on commercial catch data (proportion of age classes) and 4 survey indices; 1 for the most recent cohort and 3 for the previous cohort.
5) **Data issues:** all data available for review
6) **Consistency**: consistent with last year
7) **Stock status**: based on survey data, the stock abundance index in 2017 is lower than the average of the four preceding years. The index is estimated to have decreased by more than 20% and thus the uncertainty cap was applied. No precautionary buffer is applied. No reference points have been estimated for this stock.
8) **Management Plan**: no management plan has been developed for this stock

General comments

The WG report sections and stock annex were clear and concise. The Excel sheet used for the calculation of the survey anomaly would benefit from the inclusion of comments, but on the overall is clear.

Technical comments

Update section number.

Table 9.3.1. seems repeated twice.

Table 9.2.3 “Division 3.a sprat. Sampling commercial landings for biological samples in 2016.” There are two tables one below the other but it is not clear which are the differences between the two.

Conclusions

The assessment has been conducted in line with the stock annex description.

11 Sprat in the North Sea

11.1 The Fishery

11.1.1 ACOM advice applicable to 2016 and 2017

There have never been any explicit management objectives for this stock. Last year, the advised TAC for July 2016 to June 2017 was set to 125 541 t. The 2017 herring bycatch quota is 11 375 t.

11.1.2 Catches in 2016

Catch statistics for 1996–2016 for sprat in the North Sea by area and country are presented in Table 11.1.1. Catch data prior to 1996 are considered unreliable (see Stock Annex). As in previous years, the small catches of sprat from the fjords of western Norway are not included in the catch tables for the North Sea (Table 11.1.1–11.1.2). The WG estimate of total catches for the North Sea in 2016 were 240 673 t (total official catches mounted to 299 193 t). This is a 15% decrease compared to 2015, and 59% above the average for the time series. The Danish catches represent 82% of the total catches.

The spatial distribution of landings was similar to 2015 (Figure 11.1.1). As in previous years, only 14% of the catches were landed in the first and second quarter of 2016 (Table 11.1.2).

11.1.3 Regulations and their effects

The Norwegian vessels are not allowed to fish in the Norwegian zone until the quota in the EU-zone has been taken. They are not allowed to fish in the second quarter or July in the EU and the Norwegian zone. There is also a maximum vessel quota of 550 t when fishing in the EU-zone. A herring by-catch of up to 10% in biomass is allowed in Norwegian sprat catches.

Most sprat catches are taken in an industrial fishery where catches are limited by herring by-catch quantities. By-catches of herring are practically unavoidable except in years with high sprat abundance or low herring recruitment. By-catch is especially considered to be a problem in area 4.c. This led to the introduction of a closed area (sprat box) to ensure that sprat catches were not taken close to the Danish west coast where there large bycatches were expected.

ICES evaluated the effectiveness of the sprat box in 2017 (ICES, 2017). The evaluation concluded that fishing inside the sprat box would be expected to reduce unwanted catches of herring (by weight) and that other management measures are sufficient to control herring bycatch.

11.1.4 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 the last years, the share of the total Norwegian catches taken by trawl has increased a lot (2016: 93% taken by trawl).

11.2 Biological composition of the catch

Only data on by-catch from the Danish fishery were available to the Working Group (Table 11.2.1). The Danish sprat fishery was conducted with a 5.3% by-catch of herring in 2016. The total amount of herring caught as by-catch in the sprat fishery has mostly been less than 10% except in 2012 (11%) and 2008 (11%). In 2013–2014, it was 8%, and in 2015 it was the lowest ever observed (< 2%).

The estimated quarterly landings at age in numbers for the period 1974–2016 are presented in Table 11.2.2. In 2016, one-year old sprat contributed 73% of the total landings, which is similar to 2015 (65%), 2013 (70%) and 2014 (73%) and above the average contribution (61% since 1996, range: 27–94%). 2-year olds contributed 19% in 2016 compared with 20%, 5% and 24% of the total landings in 2013, 2014 and 2015. 0-year olds contributed 7% of the total landings, which is similar to the 9% and 7% in 2015 and 2013, but below the 2014 value of 20%.

Denmark and Norway provided age data of commercial landings in 2016 (Table 11.2.4). Quarters 1, 3 and 4 were covered. The sample data were used to raise the landings data from the North Sea. The landings by the Netherlands, Sweden, UK-England, UK-Scotland, Germany and Belgium were minor and unsampled. The sampling level (no. samples per 2000 t landed) in 2012–2013 (2.2), 2014 (1.8) and 2015 (1.5) was greatly improved compared to 2007–2011 (0.8 samples for 2007–2010, and 1.2 for 2011) because of the newly implemented sampling programme for collecting haul based samples from the Danish sprat fishery. In 2016, however, the level was at 0.8 again. In 2016, 4.c had 1.7 samples per 2000 t, whereas 4.b had 0.8. 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 (almost) by Norway, but due to the lack of sampling by other nations, the total sampling level was below 1 sample per 2000 tonnes.

The number of samples, both length and age-length samples, is shown in Table 11.2.5 and Figure 11.2.1. These are the samples used for the assessment.

11.3 Fishery Independent Information

11.3.1.1.1 IBTS Q1 (February) and Q3

Table 11.3.1 gives the time series of IBTS indices by age. IBTS Q1 data from 1974–2015 were updated in 2016. The index for IBTS Q1 1-year olds in 2017 was the highest in the time series, 160% higher than the average. There has been a steady increase in the IBTS time series since 1990. IBTS Q3 survey indices were also used in the assessment. These indices from 1991–2015 were also updated in 2016.

11.3.2 Acoustic Survey (HERAS)

Total abundance in 2016 was estimated by WGIPS (ICES, 2017)(see section 1.4.2) to be 124 588 million individuals and the biomass 1 118 000 tonnes (Table 11.3.2). This is a more than doubling in terms of abundance and a 57% increase in terms of biomass when compared to last year and a 41% increase in terms of abundance and a 54% increase in terms of biomass when compared to 2014 (ICES, 2017).

Figure 11.3.1 compares the three survey indices for 1-year-olds, and Figures 11.3.2–5 show external and internal consistency of the survey indices.

11.4 Mean weights-at-age and maturity-at-age

Mean weights-at-age in catches and maturity are given in Tables 11.2.3 and 11.4.1. The mean-weight-at-age of the 1+ -year-olds has shown a gradual increase since 2010 (Table 11.2.3 and Figure 11.4.1).

Proportion mature fish was derived from the first quarter IBTS, following the benchmark procedure. Annual varying maturity ogives were used after 1994 (Table 11.6.1). More details about the maturity staging are given in Section 4.5.3.2 in the WKSPRAT report (ICES, 2013). Proportion mature for age-1 in the 2017 IBTS Q1 (0.33) is above the 2013-2016 values (0.21-0.47) as well as the long-term average (1995:2016: 0.40).

11.5 Recruitment

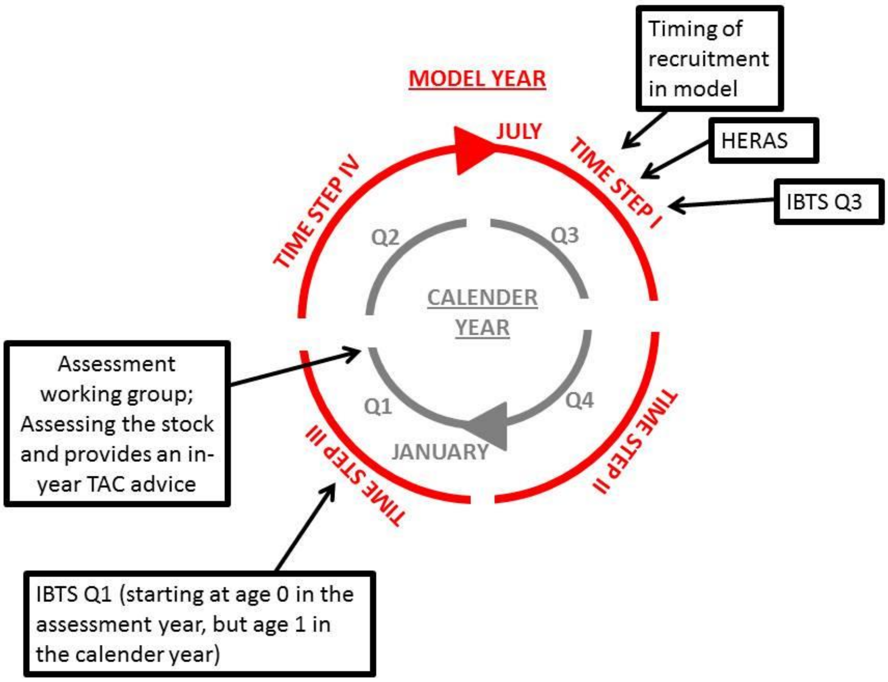
The IBTS Q1 (February) 1-group index (Table 11.3.1) is used as a recruitment index for this stock. The incoming 1-group in 2017 (2016 year class) was estimated to be the highest observed (1984-2016).

11.6 Stock Assessment

The stock assessment was benchmarked in February 2013 (ICES, 2013).

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



11.6.1 Input data

11.6.1.1 Catch data

Information on catch data is provided in Tables 11.1.1–2 and in Figures 11.1.13 and 11.6.1. Sampling effort is presented in Table 11.2.5 and Figure 11.2.1.

The age distribution of quarterly catches of less than 5000 tonnes was generally very poorly estimated. As these catches are too small to have any major effect on the stock, they were removed from the likelihood estimation to avoid problems caused by the low sampling level.

The number caught by year, age group and quarter estimated along with the mean weight at age (Tables 11.2.2–3, Figure 11.4.1). In the end, catches are raised to match the total ICES landings in 2016 as the official catches in some cases include bycatch of e.g. herring.

As the model describes the development in the stock based on years from 1 July to 30 June, an assumption is required on the catches taken in the second half of the assessment year (i.e. January to June 2017). As stated in the Stock Annex, the catch taken in this period is estimated from the average fraction of total catches taken in January to June over the past three years. In this case, this average was 19%, corresponding to an assumed catch of 50 418 t from January to June 2016. This exceeded the agreed TAC for this period, which was only 33 830 t, and hence the 33 830 t was used as the catch in the first half of 2017.

11.6.1.2 Weight at age

The mean weights at age observed in the catch are given in Table 11.2.3 by quarter. It is assumed that the mean weights in the stock are the same as in the catch. The time series of mean weight in the catch and in the stock is shown in Figure 11.4.1.

11.6.1.3 Surveys

Three surveys were included (Tables 11.3.1–3), 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 this age group was excluded from runs. Internal consistency in survey data and external consistency between surveys are presented in Figures 11.3.1–5.

11.6.1.4 Natural mortality

Natural mortalities are derived from the 2015 key run of the multispecies model described in the WGSAM reports (ICES, 2014a; ICES, 2016) similar to the 2015 assessment. Variable mortality is applied up till 2013, and after this the average mortality for 2011–2013 is used. Natural mortalities used in the model are given in Table 11.6.2.

11.6.1.5 Proportion mature

Proportion mature fish was derived from the first quarter IBTS. Annual varying maturity ogives were used after 1994 (Table 11.6.1). More details about the maturity staging are given in Section 4.5.3.2 in the WKSPRAT report (ICES, 2013). The 2017 value for 1-year-olds of 0.57 is above the long-term average of 0.40 (1995-2016).

11.6.2 Stock assessment model

The assessment was made using SMS (Lewy and Vinther, 2004) with quarterly time steps. 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 GOV (IBTS) or HERAS in Q3 and this age group was excluded from runs. External consistency between IBTS Q1, IBTS Q3 and HERAS is shown in Figure 11.3.2.

The model converged and fitted the catches of the main ages caught in the main quarters (the periods with most samples) reasonably (ages 1–2, seasons 1 and 2, Table 11.6.2). The IBTS Q1 had a lower CV as did the HERAS survey, whereas the CV of IBTS Q3 was somewhat higher (Table 11.6.2). The CV of survey observations are in general medium. There were no obvious patterns in the residuals, apart from a series of strong negative residuals of the youngest age in IBTS Q1 in the years 1974 to 1982 (Figures 11.6.2–3). Presumably, this was caused by the lower catchability of this age group to gears different from the GOV, which was used as the primary gear from 1983 onwards. Therefore, the IBTS Q1 for this age group was excluded for the period 1974–1982. Common CVs were estimated for the groups: 0 to 3-year olds in IBTS Q1 and 2 and 3-year olds in HERAS. For all other age groups age specific CVs were estimated.

The final outputs detailing trends in mean F, SSB and recruitment are given in Figures 11.6.4–7 and Tables 11.6.3–4. From these figures it is apparent that recent high catch levels have occurred simultaneously with extremely high SSBs and recruitment.

11.7 Reference points

A B_{lim} of 90 000 t (Figure 11.7.1) and B_{pa} of 142 000 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 0.28.

11.8 State of the stock

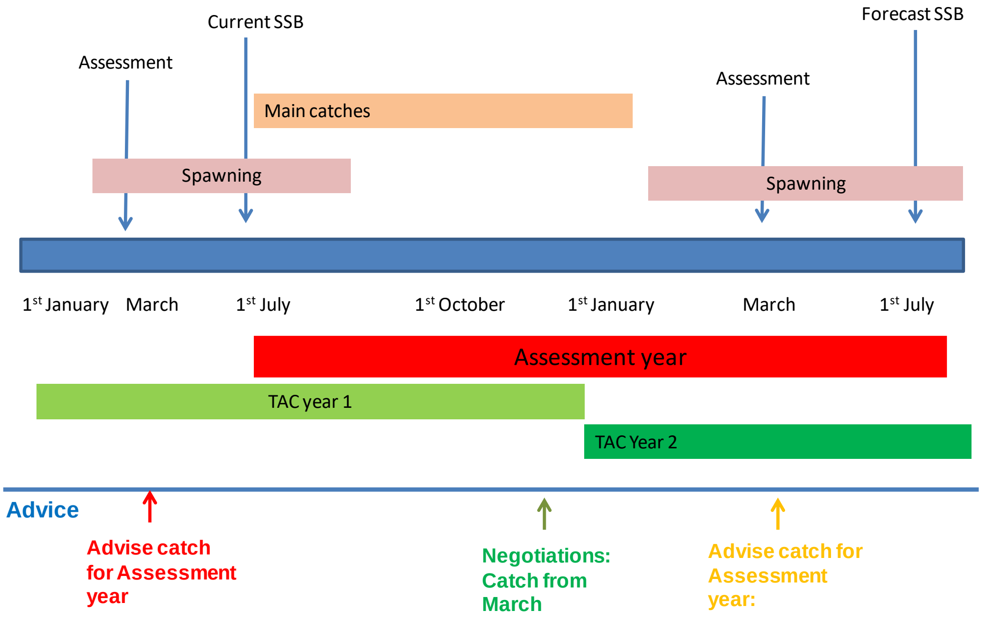
The sprat stock appears to be abundant judged both by surveys individually and by the assessment performed. The stock appears to have been well above B_{pa} since 2008 and has exhibited two years of extremely high recruitment in 2014 and 2016. The current SSB is more than twice the B_{pa}, the highest since 1976. Fishing mortality has been below the long term average (0.4–0.9) in recent years but show increased in 2015 and 2016 to levels above 1.5.

A stock summary from the assessment output can be found in Table 11.6.4 and Figure 11.6.7.

11.9 Short-term projections

The sprat stock forecast is used to evaluate the escapement strategy used for short-lived species like North Sea sprat. Management strategy evaluations for this stock were made in autumn 2013 and presented at the WKMSYREF2 meeting in January 2014 (ICES, 2014b). 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}). In 2014 a value of 0.7 was proposed as an optimal F_{cap} value (according to F_{MSY} criteria), which is a revision of the 2013 value equal to 1.2. This means, that the fishing mortality (F_{bar}(1–2)) derived from the $B_{escapement}$ strategy, should not exceed 0.7.

Since the catch projections are now based on an assessment year which runs from 1 July to 30 June each year rather than the traditional TAC years of 1 January to 31 December the following figure (see below) illustrates the timing of steps in the process in relation to the spawning and fisheries of North Sea sprat.



SSB in 2017 is expected to be above the long term average and well above B_{pa}. Using the input and assumptions detailed above, the projection for an F = 0 is an SSB in July 2017 of 409 000 t (Table 11.9.2). The F_{MSY} approach prescribes the use of an F value of 0.7 (F_{cap}, see explanation above) and results in a TAC advice of 170 387 t (July 2017–June 2018), which is anticipated to result in an SSB of 330 562 t in July 2018, well above B_{pa}.

11.10 Quality of the assessment

The data used within the assessment, the assessment methods and settings were carefully scrutinized during the 2013 benchmark (ICES, 2013). A complete overview of the choices made during the benchmark can be found in the WKSPRAT report (ICES, 2013) and these are also described in the North Sea Sprat Stock Annex. The 2017 assessment was classified as an update assessment and was carried out following these procedures and settings.

The assessment shows high CVs for the catches but lower CVs for surveys. This may be due to low sampling effort in several years in spite of substantial catches taken. The CVs of F, SSB and recruitment are in general low (see Table 11.6.2 and Figure 11.6.4). The model converged and fitted the catches of the main ages caught in the main quarters (the periods with most samples) reasonably well (ages 1–2, season 2, Table 11.6.2). The CV of survey observations are in general lower (Table 11.6.2).

11.11 Management Considerations

A management plan needs to be developed. Sprat is an important forage fish, thus also multispecies considerations should be made.

The sprat stock in the North Sea is dominated by young fish. The stock size is mostly driven by the recruiting year class. Thus, the fishery in a given year will be dependent on that year's incoming year class.

In the forecast table for North Sea herring, industrial fisheries are allocated a bycatch of 11 375 t of juvenile herring in 2017. It is important to continue monitoring bycatch of juvenile herring to ensure compliance with this allocation. Management of this stock should consider management advice given for herring in Subarea 27.4, Div. 27.7.d, and Div. 27.3.a.

11.11.1 Stock units

North Sea sprat is considered an independent stock. This is discussed in WKSPRAT report (ICES, 2013). In addition, there are several peripheral areas of the North Sea where there may be populations of sprats that behave as separate stocks from the main North Sea stock. Local depletion of sprat in such areas is an issue of ecological concern.

There is a necessity to determine whether the sprat in the North Sea (Subarea 27.4) constitute a stock or whether they encompass one or both of the adjoining populations of sprat (i.e. 27.3.a or 27.7d (English Channel)). This is vital for establishing the correct assessment/stock units in the area.

11.12 Ecosystem Considerations

Sprat is an important prey species in the North Sea ecosystem. Many of the plankton-feeding fish, including sprat, have recruited strongly in 2016 (e.g. sandeel, Norway pout). This is in contrast to a previous period of poor recruitment. The implications of the environmental change for sprat and the influence of the sprat fishery on other fish species and sea birds are at present unknown.

In the North Sea, the key predators consuming sprats are included in the stock assessment, using SMS estimates of sprat consumption for each predatory fish stock, and estimates for seabirds. Impacts of changes in zooplankton communities and consequent changes in food densities for sprats are not included in the assessment, but it may be useful to explore the possibility of including this, or a similar proxy bottom-up driver, in future assessments.

The retreat of *C. finmarchicus* and its ecosystem implications is probably the most intensely studied case of bottom up effects on fish stocks. Further details on the linkages between sprat and zooplankton in the North Sea are given in section 1.3.2 in the WKSPRAT report (ICES, 2013).

11.13 Changes in the environment

Temperatures in this area have been increasing over the last few decades. This may have implications for sprat, although the magnitude or direction of such changes has not been quantified. Further details can be found in Section 1.8.

Table 11.1.1. North Sea sprat. Landings (' 000 t) 1996–2016. See HAWG 2006 (ICES, 2006) for earlier data. Catch in fjords 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. The 27.4.b catches for 2000–2007 divided by 27.4.bW and 27.4.bE can be found in HAWG 2008 (ICES, 2008).

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
		Division 4a																			
Denmark	0.3			0.7		0.1	1.1		*		*	0.8	*	*					*	*	0.1
Norway														*		*					
Sweden						0.1															
UK (Scotland)																0.5					
Germany																				*	*
Netherlands																				*	
Total	0.3			0.7		0.2	1.1		*		*	0.8	*	*		0.5			*	*	0.1
		Division 4b																			
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
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
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
UK(Scotland)				1.4								0.1		2.5	1.1	1.9	0.7				
UK(Engl.&Wales)														*							
Germany																3.3	0.5	0.6	1.5	3.1	5.4
Netherlands																1.1	2.7	0.4	2.4	1.2	1.0
Faroe Islands																					4.711
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
		Division 4c																			
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
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
Sweden														0.6	0.6	0.2	0.4	1.3		1.2	0.4
UK(Scotland)													0.2			0.4					*

UK(Engl.&Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5	*	*	*	*
Germany																*	*	1.0		0.6	0.2
Netherlands				0.2												4.2	1.0	0.7	*	1.2	0.8
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
		Total North Sea																			
Denmark	80.7	98.8	131.1	164.3	191.1	157.1	142.0	175.2	192.7	206.0	103.4	76.8	59.6	123.8	129.3	111.0	68.9	60.2	123.5	268.4	196.4
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
Sweden	0.5		1.7	2.1		1.5				*				0.9	1.2	1.2	2.2	1.4	3.9	6.8	12.1
UK(Scotland)				1.4								0.1	0.2	2.5	1.1	2.8	0.7				*
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	*	*	*	*
Germany																3.3	0.5	1.6	1.5	3.7	5.6
Netherlands				0.2												5.3	3.7	1.1	2.4	2.4	1.8
Faroe Islands																					4.7
Belgium																*		*	*	*	*
France																				*	
Total	136.6	103.4	164.3	188.4	195.9	170.2	143.6	176.5	194.3	207.7	113.7	83.8	61.1	133.1	143.5	133.6	85.6	65.9	140.4	290.4	240.7

*** < 50 t**

Table 11.1.2. North Sea sprat. Catches (tonnes) by quarter. Catches in fjords of Western Norway excluded. Data for 1996–1999 in HAWG 2007 (ICES, 2007). The 27.4.b catches for 2000–2007 divided by 27.4.bW and 27.4.bE can be found in HAWG 2008 (ICES, 2008).

Year	Quarter			Area		Total
		27.4.aW	27.4.aE	27.4.b	27.4.c	
2000	1			18 126	28 063	46 189
	2			1 722	45	1 767
	3			131 306	1 216	132 522
	4			12 680	2 718	15 398
	Total			163 834	32 042	195 876
2001	1	115		40 903	9 716	50 734
	2			1 071		1 071
	3			44 174	481	44 655
	4	79		65 102	8 538	73 719
	Total	194		151 249	18 735	170 177
2002	1	1 136		2 182	2 790	6 108
	2			435	93	528
	3			70 504	647	71 151
	4			52 942	12 911	65 853
	Total	1 136		126 063	16 441	143 640
2003	1			11 458	7 727	19 185
	2			625	26	652
	3			56 207	165	56 372
	4			84 629	15 651	100 280
	Total			152 919	23 570	176 489
2004	1			827	1 831	2 657
	2	7		260	16	283

Year	Quarter			Area		Total
		27.4.aW	27.4.aE	27.4.b	27.4.c	
2009	1			36	1 268	1 304
	2			2 526	1	2 527
	3		22	41 513		41 535
	4			78 373	9 336	87 709
	Total		22	122 448	10 604	133 075
2010	1			10 976	17 072	28 048
	2			3 235	3	3 238
	3			14 220		14 220
	4			62 006	35 973	97 979
	Total			90 437	53 048	143 485
2011	1			3 747	21 039	24 786
	2			2 067	3	2 070
	3			22 309	451	22 761
	4	8		70 256	13 759	84 023
	Total	8		98 380	35 252	133 640
2012	1			81	1 649	1 730
	2			2 924	0	2 924
	3			26 779	307	27 086
	4			47 765	6 060	53 825
	Total			77 549	8 016	85 565
2013	1			1 281	3 158	4 438
	2			32	0	32

	3			54 161	496	54 657
	4			120 685	15 937	136 622
	Total	7		175 932	18 280	194 219
2005	1			11 538	2 457	13 995
	2			2 515	123	2 638
	3			107 530		107 530
	4			82 474	1 033	83 507
	Total			204 057	3 613	207 670
2006	1	25	22	13 713	33 534	47 294
	2			190	8	198
	3			40 051	8	40 059
	4	2		26 579	77	26 658
	Total	27	22	80 533	33 627	114 209
2007	1			582	247	829
	2			241	3	244
	3			16 603		16 603
	4	769		41 850	23 531	66 150
	Total	769		59 276	23 781	83 826
2008	1			2 872	43	2 915
	2			52	*	52
	3			21 787		21 787
	4			27 994	8 334	36 329
	Total			52 706	8 377	61 083

	3			25 577	720	26 297
	4			18 892	16 276	35 167
	Total			45 781	20 154	65 934
2014	1			59	125	184
	2			11 631	3	11 635
	3	1		88 457	1 428	89 885
	4	7		37 851	822	38 681
	Total	8		137 999	2 378	140 384
2015	1		*	14 816	16 972	31 788
	2			16 843	107	16 949
	3			124 512	335	124 847
	4	25		88 395	28 375	116 795
	Total	25	*	244 566	45 789	290 380
2016	1	68		18 487	5 969	24 503
	2			8 927	51	8 978
	3	*		158 522	111	158 633
	4	2		34 070	14 466	48 537
	Total	70		220 007	20 596	240 673

*** < 0.5 t**

Table 11.2.1. North Sea sprat. Species composition in Danish sprat fishery in tonnes and percentage of the total catch in the North Sea.

	Year	Sprat	Herring	Horse mack.	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
Tonnes	1998	129 315	11 817	573	673	6	220	11	2 174	1 187	145 978
Tonnes	1999	157 003	7 256	413	1 088	62	321	7	4 972	635	171 757
Tonnes	2000	188 463	11 662	3 239	2 107	66	766	4	423	1 911	208 641
Tonnes	2001	136 443	13 953	67	1 700	223	312	4	17 020	1 141	170 862
Tonnes	2002	140 568	16 644	2 078	2 537	27	715	0	4 102	801	167 471
Tonnes	2003	172 456	10 244	718	1 106	15	799	11	5 357	3 504	194 210
Tonnes	2004	179 944	10 144	474	334	0	4 351	3	3 836	1 821	200 906
Tonnes	2005	201 331	21 035	2 477	545	4	1 009	16	6 859	974	234 251
Tonnes	2006	103 236	8 983	577	343	25	905	4	5 384	576	120 033
Tonnes	2007	74 734	6 596	168	900	6	126	18	6	253	82 807
Tonnes	2008	61 093	7 928	26	380	10	367	0	23	1 735	71 563
Tonnes	2009	112 721	7 222	44	307	3	116	1	1 526	407	122 345
Tonnes	2010	112 395	4 410	11	119	2	18	0	1 236	577	118 769
Tonnes	2011	109 376	8 073	35	191	0	127	0	1 881	345	120 026
Tonnes	2012	67 263	8 573	2	354	0	246	0	93	411	76 943
Tonnes	2013	55 792	5 176	47	445	0	277	2	1	369	62 109
Tonnes	2014	123 180	11 402	0	897	0	70	16	16	1 700	137 280
Tonnes	2015	265 356	4 568	5	1 809	0	527	0	147	3 311	275 723
Tonnes	2016	192 718	11 107	18	4 223	0	439	0	46	2 093	210 643
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

Table 11.2.2. North Sea sprat. Catch in numbers by age (1000's) by quarter and year. (Calendar year)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4	Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1974	Q1	0	6 272 325	790 696	65 338	20 351	1981	Q1	0	677 820	3 301 518	430 692	11 111
	Q2	0	2 218 063	155 263	9 816	4 030		Q2	0	1 239 390	565 592	50 254	11 901
	Q3	0	10 213 374	2 393 120	129 570	7 976		Q3	67 791	7 418 262	1 137 037	59 229	1 917
	Q4	13 084	13 048 044	956 771	52 691	4 158		Q4	0	2 372 758	3 498 461	210 015	23 252
1975	Q1	0	696 195	12 003 206	986 590	25 782	1982	Q1	0	80 850	3 604 533	261 247	8 880
	Q2	0	1 018 123	2 352 752	104 940	4 880		Q2	0	5 846	236 614	21 504	749
	Q3	0	12 918 925	10 736 964	105 391	4 416		Q3	17 113	4 804 566	233 451	3 497	93
	Q4	250 758	14 464 471	5 675 423	295 597	573		Q4	216 721	4 586 482	1 622 144	79 138	19 452
1976	Q1	0	1 107 469	4 640 901	3 154 501	79 988	1983	Q1	0	943 231	222 085	261 541	3 379
	Q2	0	602 808	1 252 379	892 969	25 288		Q2	0	93 992	21 770	35 670	362
	Q3	145 908	34 455 928	1 034 996	62 802	1 684		Q3	293 277	2 325 072	1 196 283	182 646	5 793
	Q4	2 390 988	24 218 227	2 268 791	119 117	10 861		Q4	47 818	1 288 560	622 989	97 960	3 056
1977	Q1	0	958 492	6 582 627	220 068	7 237	1984	Q1	0	137 804	214 705	7 388	0
	Q2	0	336 631	1 911 499	63 715	1 980		Q2	0	68 285	57 546	1 988	0
	Q3	270 260	2 418 648	7 958 073	64 857	1 849		Q3	15 178	2 818 749	238 816	4 770	0
	Q4	714 507	3 795 711	5 165 711	89 508	3 399		Q4	32 969	2 823 642	264 259	7 577	0
1978	Q1	0	1 997 665	1 870 443	2 946 432	50 032	1985	Q1	0	397 395	600 767	10 446	1 033
	Q2	0	944 317	558 836	753 894	12 357		Q2	0	19 013	28 744	500	49
	Q3	19 318	24 762 016	283 043	41 466	2 684		Q3	0	543 759	822 033	14 293	1 414
	Q4	610 307	11 474 429	1 671 693	165 459	10 743		Q4	0	675 670	1 021 452	17 760	1 757
1979	Q1	0	2 824 973	5 296 327	1 403 127	26 486	1986	Q1	0	51 567	131 324	91 756	9 075
	Q2	0	999 681	1 569 671	338 916	6 951		Q2	0	10 271	26 157	18 276	1 807
	Q3	0	26 410 475	604 986	0	114 364		Q3	0	54 333	138 367	96 677	9 562
	Q4	107 972	10 821 695	2 774 083	65 919	217		Q4	0	136 735	348 218	243 300	24 063
1980	Q1	0	834 905	6 082 389	328 697	26 923	1987	Q1	0	523 038	7 571	2 938	0
	Q2	0	176 315	1 569 213	133 865	7 878		Q2	0	449 629	7 721	3 504	0
	Q3	0	1 553 793	13 828 835	1 179 699	69 428		Q3	0	845 988	59 876	994	0
	Q4	0	1 535 249	13 663 793	1 165 620	68 599		Q4	52 643	1 866 082	257 169	1 730	0

Table 11.2.2. North Sea sprat. Catch in numbers by age (1000's) by quarter and year. (Calendar year) (continued)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1989	Q1	0	1 822 864	688 151	35 173	0
	Q2	0	38 434	14 712	1 195	0
	Q3	12 416	1 349 973	3 441 515	971	0
	Q4	674	48 312	75 260	53	0
1990	Q1	0	500 283	243 280	48 737	14 638
	Q2	0	34 285	23 249	6 770	2 271
	Q3	0	2 107 664	1 548 789	449 802	167 844
	Q4	0	1 674 087	1 230 181	357 271	133 316
1991	Q1	0	50 269	3 312	689	103
	Q2	0	32 873	3 114	450	69
	Q3	39 075	1 582 926	1 968 851	33 462	844
	Q4	1 358 716	2 738 086	585 720	12 904	370
1992	Q1	0	8 192	3 674	123	8
	Q2	0	415 567	186 393	6 232	390
	Q3	17 469	8 903 703	1 139 117	143 169	14 295
	Q4	178 160	1 120 582	138 127	17 884	1 902
1993	Q1	0	2 330 690	1 439 234	194 770	8 536
	Q2	0	788 283	382 178	53 291	2 798
	Q3	0	2 861 064	4 943 973	194 177	24 607
	Q4	2 048 272	4 728 377	1 288 186	35 809	2 506
1994	Q1	0	2 327 734	2 074 998	320 669	33 962
	Q2	0	2 427 321	1 081 474	157 150	7 661
	Q3	0	29 911 167	550 021	27 189	375
	Q4	1 891 731	5 127 983	1 436 318	133 383	5 555
1995	Q1	0	421 834	1 895 084	608 541	16 521
	Q2	0	530 161	358 121	116 385	4 436
	Q3	208 386	19 738 855	3 119 870	499 613	3 712
	Q4	731 010	7 327 987	3 289 073	669 519	13 910

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1996	Q1	0	5 784 702	1 613 377	375 365	21 893
	Q2	0	356 707	106 061	25 043	1 625
	Q3	107 253	127 719	381 423	137 974	27 334
	Q4	880 333	660 293	2 178 394	774 114	181 774
1997	Q1	0	1 530 663	515 776	60 268	7 729
	Q2	0	264 007	89 901	14 984	1 470
	Q3	44 531	1 640 137	521 235	74 525	27 396
	Q4	107 553	3 494 688	1 265 240	200 795	85 539
1998	Q1	0	674 134	508 613	70 038	13 829
	Q2	0	83 006	58 156	6 706	1 092
	Q3	620 081	3 588 086	1 619 886	172 387	4 584
	Q4	1 015 745	3 531 232	1 518 689	410 014	0
1999	Q1	0	1 038 772	2 189 060	159 850	33 261
	Q2	0	134 048	226 782	18 915	4 103
	Q3	211 127	13 970 676	458 334	88 243	686
	Q4	85 617	1 934 117	362 667	21 842	111
2000	Q1	0	2 068 324	2 972 728	652 986	240 495
	Q2	0	55 868	110 058	37 736	21 766
	Q3	1 671	9 463 341	1 526 772	84 078	5 227
	Q4	2 432	722 669	421 757	38 132	2 148
2001	Q1	0	756 085	2 938 300	1 259 571	168 402
	Q2	0	10 921	35 795	12 415	1 222
	Q3	330 710	2 999 048	731 582	61 006	0
	Q4	731 508	4 466 857	1 535 060	134 942	0
2002	Q1	0	323 605	70 070	13 307	791
	Q2	0	23 206	5 025	954	57
	Q3	72 234	6 240 286	393 859	40 131	3 446
	Q4	480 139	4 192 059	902 086	193 376	10 170

Table 11.2.2. North Sea sprat. Catch in numbers by age (1000's) by quarter and year. (Calendar year) (continued)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
2003	Q1	0	1 595 254	1 150 283	106 446	3 660
	Q2	0	67 395	38 384	3 408	121
	Q3	0	3 773 602	536 016	39 557	13 331
	Q4	411 438	7 597 795	1 040 850	47 583	30 233
2004	Q1	0	132 197	22 821	1 347	76
	Q2	0	29 872	5 157	304	17
	Q3	330 650	3 616 036	790 575	46 831	3 599
	Q4	21 362 903	4 845 166	372 609	33 761	1 849
2005	Q1	0	3 214 471	218 695	9 249	305
	Q2	0	690 733	41 135	1 703	54
	Q3	0	12 371 678	222 757	34 807	1 169
	Q4	905 687	7 636 106	193 874	15 025	595
2006	Q1	0	675 765	5 164 658	136 240	5 908
	Q2	0	11 341	59 145	1 469	65
	Q3	0	2 354 139	1 164 248	196 933	3 705
	Q4	0	1 589 716	922 747	98 174	2 439
2007	Q1	0	188 409	112 126	21 465	1 057
	Q2	0	12 611	7 505	1 437	71
	Q3	0	791 996	370 110	83 329	3 360
	Q4	570 769	3 607 022	1 587 098	207 134	16 190
2008	Q1	0	275 013	212 650	8 983	1 280
	Q2	0	4 661	3 355	217	36
	Q3	11 226	374 967	1 350 863	273 722	23 195
	Q4	471 069	1 457 841	1 154 410	243 032	40 973
2009	Q1	0	274 316	32 208	1 962	129
	Q2	0	302 545	35 522	2 163	143
	Q3	0	4 428 777	185 438	18 651	853
	Q4	221 908	7 851 426	562 588	93 691	4 255

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
2010	Q1	0	43 328	3 230 747	475 426	71 299
	Q2	0	6 548	342 686	39 999	8 396
	Q3	12 808	1 429 681	433 709	7 880	1 438
	Q4	344 087	3 395 699	3 034 682	825 848	970 833
2011	Q1	0	190 971	1 981 930	704 501	91 150
	Q2	0	90 971	174 916	55 063	6 773
	Q3	2 669	1 410 307	959 871	206 730	28 765
	Q4	366 915	4 094 960	2 652 433	752 025	214 962
2012	Q1	0	101 747	41 459	5 929	697
	Q2	0	191 599	78 071	11 165	1 313
	Q3	16 927	2 207 305	609 219	68 208	16 287
	Q4	111 565	3 503 253	1 603 395	239 132	17 808
2013	Q1	0	118 913	500 345	54 490	4 178
	Q2	0	902	3 798	474	40
	Q3	25 538	2 263 365	330 826	58 469	9 576
	Q4	401 216	2 382 055	507 642	154 932	59 316
2014	Q1	0	7 600	516	66	64
	Q2	0	1 497 692	101 690	13 015	12 598
	Q3	2 123 129	8 292 983	608 778	56 122	50 202
	Q4	1 523 128	3 754 357	323 800	73 041	22 923
2015	Q1	0	1 717 525	2 543 853	166 889	20 547
	Q2	0	2 567 356	88 759	6 639	191
	Q3	1 438 591	10 735 961	2 741 865	119 542	25 685
	Q4	1 050 588	11 640 158	1 642 206	67 751	18 170
2016	Q1	0	610 437	2 118 690	774 125	63 407
	Q2	0	221 736	738 227	293 408	30 599
	Q3	4 536 520	12 446 796	4 494 690	404 708	30 846
	Q4	4 217 143	1 622 423	1 250 761	192 295	34 616

Table 11.2.3. North Sea sprat. Mean weight at age (kg) in catches by quarter and year. (Calendar year)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1974	Q1		0.005953	0.012854	0.017806	0.024999
	Q2		0.005546	0.011308	0.014707	0.023244
	Q3	0.007115	0.00886	0.013422	0.023148	0.026301
	Q4	0.005724	0.008422	0.013785	0.020402	0.025486
1975	Q1		0.003458	0.007102	0.012549	0.019671
	Q2		0.006092	0.009241	0.011088	0.017475
	Q3	0.007115	0.008472	0.013583	0.017937	0.020004
	Q4	0.005928	0.01052	0.016703	0.020838	0.020437
1976	Q1		0.003506	0.009773	0.014807	0.018884
	Q2		0.006176	0.009881	0.013213	0.015831
	Q3	0.003265	0.006809	0.012884	0.014423	0.018191
	Q4	0.003526	0.008306	0.015142	0.01901	0.018466
1977	Q1		0.003634	0.006314	0.010283	0.012952
	Q2		0.003901	0.006241	0.008346	0.009999
	Q3	0.006456	0.008326	0.012426	0.018034	0.016847
	Q4	0.00668	0.010536	0.014313	0.019706	0.016364
1978	Q1		0.003021	0.008346	0.012507	0.016517
	Q2		0.004944	0.00791	0.010578	0.012674
	Q3	0.004891	0.005969	0.011498	0.013582	0.019515
	Q4	0.004693	0.010137	0.016293	0.020106	0.022087
1979	Q1		0.002196	0.007216	0.010489	0.0146
	Q2		0.004063	0.0065	0.008692	0.010414
	Q3	0.007115	0.005577	0.006793	0.01647	0.007835
	Q4	0.003639	0.009961	0.014813	0.018366	0.009894
1980	Q1		0.002197	0.007293	0.0124	0.016323
	Q2		0.004919	0.007869	0.010523	0.012608
	Q3	0.007115	0.005985	0.007818	0.009816	0.011043
	Q4	0.005142	0.005796	0.00785	0.009713	0.010668
1981	Q1		0.003085	0.007593	0.01248	0.016103
	Q2		0.004735	0.00558	0.007625	0.009494
	Q3	0.006912	0.009281	0.012042	0.014347	0.017009
	Q4	0.005142	0.011266	0.014743	0.019207	0.023807
1982	Q1		0.003701	0.008436	0.015486	0.019244
	Q2		0.005507	0.008811	0.011782	0.014116
	Q3	0.006901	0.007327	0.010603	0.01652	0.020027
	Q4	0.008773	0.011151	0.014464	0.021113	0.023851
1983	Q1		0.009546	0.015997	0.021841	0.026272
	Q2		0.009789	0.015661	0.020942	0.025091
	Q3	0.008423	0.01177	0.015375	0.019306	0.021718
	Q4	0.007938	0.012843	0.017098	0.02121	0.018108
1984	Q1		0.00478	0.011143	0.015442	0.018733
	Q2		0.006728	0.010765	0.014394	0.016496
	Q3	0.007528	0.010519	0.013741	0.017255	0.018007

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
	Q4	0.004948	0.012412	0.017589	0.016068	0.018127

Table 11.2.3. (cont.) North Sea sprat. Mean weight at age (kg) in catches by quarter and year. (Calendar year)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1985	Q1		0.009292	0.013534	0.019686	0.019686
	Q2		0.009292	0.013534	0.019686	0.019686
	Q3	0.007115	0.009292	0.013534	0.019686	0.019686
	Q4	0.005142	0.009292	0.013534	0.019686	0.019686
1986	Q1		0.007258	0.00988	0.016584	0.016584
	Q2		0.007258	0.00988	0.016584	0.016584
	Q3	0.007115	0.007258	0.00988	0.016584	0.016584
	Q4	0.005142	0.007258	0.00988	0.016584	0.016584
1987	Q1		0.008761	0.014681	0.020044	0.018733
	Q2		0.008828	0.014124	0.018887	0.016496
	Q3	0.007115	0.009206	0.012646	0.014801	0.018007
	Q4	0.005799	0.009296	0.011176	0.016135	0.018127
1988	Q1		0.008337	0.013971	0.019075	0.018733
	Q2		0.008689	0.013901	0.018588	0.016496
	Q3	0.007115	0.011925	0.014068	0.018104	0.018007
	Q4	0.005142	0.010985	0.014878	0.01841	0.018127
1989	Q1		0.006577	0.011021	0.015047	0.018733
	Q2		0.006786	0.010856	0.014517	0.016496
	Q3	0.005501	0.008423	0.009751	0.018461	0.018007
	Q4	0.004559	0.007692	0.010418	0.012891	0.018127
1990	Q1		0.007415	0.012427	0.016966	0.020408
	Q2		0.007703	0.012323	0.016479	0.019744
	Q3	0.007115	0.008992	0.011747	0.014751	0.016593
	Q4	0.005142	0.008833	0.011964	0.014804	0.016259
1991	Q1		0.004562	0.01082	0.013801	0.017319
	Q2		0.004792	0.007666	0.010251	0.012283
	Q3	0.012675	0.014371	0.015385	0.017269	0.018943
	Q4	0.003714	0.011909	0.016946	0.018066	0.020771
1992	Q1		0.004471	0.007493	0.01023	0.012305
	Q2		0.004563	0.0073	0.009761	0.011695
	Q3	0.008282	0.009893	0.012284	0.014353	0.017807
	Q4	0.006681	0.011437	0.014612	0.016164	0.017393
1993	Q1		0.003364	0.009103	0.01351	0.017633
	Q2		0.004338	0.00694	0.00928	0.011119
	Q3	0.007115	0.010853	0.012203	0.012474	0.017853
	Q4	0.007566	0.010649	0.01347	0.016441	0.017654
1994	Q1		0.002718	0.008346	0.011369	0.015351
	Q2		0.004369	0.00699	0.009347	0.011199
	Q3	0.007115	0.006338	0.00847	0.009733	0.014094
	Q4	0.008741	0.010274	0.012483	0.015304	0.017145
1995	Q1		0.003318	0.008251	0.010122	0.01495

	Q2		0.00486	0.007775	0.010397	0.012457
	Q3	0.002779	0.008008	0.010971	0.011702	0.018007
	Q4	0.005092	0.009736	0.013118	0.015428	0.017

Table 11.2.3. (cont.) North Sea sprat. Mean weight at age (kg) in catches by quarter and year. (Calendar year)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
1996	Q1		0.007444	0.011167	0.012889	0.015444
	Q2		0.007088	0.011339	0.015163	0.018168
	Q3	0.007422	0.01037	0.013546	0.01701	0.019135
	Q4	0.006186	0.010456	0.014605	0.016411	0.019345
1997	Q1		0.005604	0.009392	0.012823	0.015424
	Q2		0.005932	0.009491	0.012691	0.015206
	Q3	0.00831	0.011611	0.015168	0.019046	0.021426
	Q4	0.003464	0.011389	0.015643	0.018844	0.021859
1998	Q1		0.008832	0.014801	0.020208	0.024307
	Q2		0.009043	0.014468	0.019346	0.02318
	Q3	0.005643	0.013941	0.016117	0.017338	0.020284
	Q4	0.00664	0.012016	0.015042	0.01823	0.020252
1999	Q1		0.00429	0.007466	0.010226	0.011339
	Q2		0.004558	0.007292	0.009751	0.011683
	Q3	0.007115	0.009725	0.011621	0.011735	0.013638
	Q4	0.003709	0.010175	0.012755	0.015839	0.013712
2000	Q1		0.003544	0.008627	0.010862	0.011541
	Q2		0.004901	0.007841	0.010486	0.012563
	Q3	0.00881	0.011903	0.014222	0.015713	0.015745
	Q4	0.009355	0.011973	0.014618	0.015758	0.015849
2001	Q1		0.004397	0.009765	0.012648	0.01482
	Q2		0.005723	0.009157	0.012244	0.014671
	Q3	0.007475	0.010445	0.013644	0.017133	0.018007
	Q4	0.004884	0.010751	0.01332	0.017189	0.018127
2002	Q1		0.011187	0.018747	0.025596	0.030787
	Q2		0.009937	0.015899	0.02126	0.025473
	Q3	0.007149	0.010414	0.013722	0.015286	0.016072
	Q4	0.006408	0.011521	0.013412	0.014268	0.015723
2003	Q1		0.004402	0.008511	0.010406	0.011861
	Q2		0.004816	0.007705	0.010304	0.012345
	Q3	0.007115	0.012657	0.0145	0.018719	0.019314
	Q4	0.006866	0.010895	0.014017	0.014721	0.015256
2004	Q1		0.009729	0.016304	0.02226	0.026775
	Q2		0.007607	0.01217	0.016274	0.019499
	Q3	0.008663	0.011171	0.01366	0.014211	0.016819
	Q4	0.004143	0.009141	0.011321	0.014193	0.019042
2005	Q1		0.00339	0.006821	0.007912	0.013494
	Q2		0.00346	0.005535	0.007402	0.008869
	Q3	0.007115	0.00849	0.011568	0.011601	0.017268
	Q4	0.006467	0.010009	0.010948	0.011499	0.017912

2006	Q1		0.00575	0.007732	0.009738	0.010753
	Q2		0.004722	0.007555	0.010103	0.012104
	Q3	0.007115	0.010445	0.011785	0.013184	0.011648
	Q4	0.005142	0.008982	0.012166	0.015054	0.016534

Table 11.2.3. (cont.) North Sea sprat. Mean weight at age (kg) in catches by quarter and year. (Calendar year)

Year	Quarter	Age-0	Age-1	Age-2	Age-3	Age-4
2007	Q1		0.00918	0.015384	0.021004	0.025265
	Q2		0.008414	0.013461	0.018	0.021567
	Q3	0.007115	0.012442	0.013618	0.014343	0.015153
	Q4	0.006192	0.010095	0.012729	0.014914	0.015657
2008	Q1		0.004643	0.007403	0.010125	0.014564
	Q2		0.004723	0.007557	0.010105	0.012107
	Q3	0.008433	0.009856	0.011086	0.012731	0.012988
	Q4	0.005292	0.009311	0.013152	0.01425	0.020143
2009	Q1		0.00858	0.014378	0.01963	0.023612
	Q2		0.007288	0.01166	0.015592	0.018682
	Q3	0.007115	0.00908	0.011801	0.013906	0.017654
	Q4	0.004639	0.009536	0.013137	0.016431	0.018342
2010	Q1		0.00435	0.007669	0.010253	0.013326
	Q2		0.004845	0.007751	0.010365	0.012419
	Q3	0.006815	0.007898	0.009344	0.013557	0.015594
	Q4	0.004482	0.009103	0.01114	0.01314	0.017319
2011	Q1		0.005373	0.007357	0.009542	0.013151
	Q2		0.0045	0.0072	0.009628	0.011535
	Q3	0.005165	0.008287	0.010046	0.013455	0.015423
	Q4	0.004396	0.008888	0.011448	0.014137	0.017203
2012	Q1		0.009602	0.01609	0.021968	0.026424
	Q2		0.008008	0.012811	0.017131	0.020526
	Q3	0.008531	0.008494	0.010352	0.013519	0.016777
	Q4	0.007249	0.008677	0.011985	0.015054	0.017578
2013	Q1		0.003871	0.006698	0.010697	0.013658
	Q2		0.004323	0.006916	0.009248	0.01108
	Q3	0.006135	0.009579	0.012025	0.014621	0.018215
	Q4	0.004394	0.009908	0.012666	0.014675	0.018061
2014	Q1		0.014844	0.024875	0.033962	0.040851
	Q2		0.008588	0.013739	0.018372	0.022013
	Q3	0.008594	0.008508	0.010178	0.015429	0.019534
	Q4	0.00726	0.007699	0.011341	0.012554	0.018182
2015	Q1		0.005386	0.008096	0.011567	0.01174
	Q2		0.006376	0.009917	0.010257	0.010932
	Q3	0.0076	0.008189	0.010428	0.014615	0.016492
	Q4	0.006967	0.008173	0.010089	0.01389	0.015219
2016	Q1		0.003272	0.007363	0.010361	0.014306
	Q2		0.004588	0.007404	0.009878	0.011818
	Q3	0.004023	0.007643	0.011135	0.014085	0.018923
	Q4	0.004932	0.006941	0.011449	0.01357	0.015575

Table 11.2.4. North Sea sprat. Sampling for biological parameters in 2016. This table only shows age-length samples, and therefore the number of samples may differ from Table 11.2.5.

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
Denmark	1	19.56	12	1 235	395
	2	8.98			
	3	125.07	67	5 952	1 158
	4	42.77	22	2 818	948
	Total	196.38	101	10 005	2 501
Norway	1	4.94	5	450	228
	2	0.00			
	3	15.21	3	216	124
	4				
	Total	20.15	8	666	352
All countries	1	24.52	17	1 685	623
	2	8.98			
	3	158.63	70	6 168	1 282
	4	48.54	22	2 818	948
Total North Sea		240.67	109	10 671	2 853

Table 11.2.5. North Sea 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 in the assessment. (Calendar year)

Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1991	10	0	5	31
1992	2	4	38	20
1993	16	2	15	29
1994	13	1	21	29
1995	11	2	16	29
1996	13	2	1	8
1997	4	1	2	16
1998	2	1	16	14
1999	5	1	22	8
2000	14	0	21	8
2001	13	1	2	6
2002	2	0	9	32
2003	11	4	11	26
2004	3	1	12	21
2005	10	4	22	40
2006	29	0	10	1
2007	3	0	5	30
2008	9	3	9	6
2009	2	1	13	29
2010	14	1	19	21
2011	13	2	23	52
2012	3	1	33	86
2013	9	0	31	23
2014	0	1	99	14
2015	13	11	135	25
2016	16	0	71	22

Table 11.3.1. North Sea sprat. Abundance indices by age from IBTS Q1 (Feb) from 1972–2017 as calculated by the stratified method (see Stock Annex, WKSPRAT ICES, 2013). Data from 1974–2014 were updated in 2015.

Year	Age1	Age2	Age3	Age4+	Total
1972	467.25	531.95	53.80	6.81	1 059.81
1973	255.91	206.75	26.07	0.16	488.90
1974	1 178.64	2 008.10	257.81	76.02	3 520.56
1975	96.65	1 567.44	747.15	22.84	2 434.08
1976	863.93	433.09	192.26	3.09	1 492.38
1977	141.86	2 559.19	230.25	19.74	2 951.04
1978	987.54	486.59	227.12	6.96	1 708.21
1979	429.51	212.18	150.98	5.49	798.15
1980	336.85	849.58	31.61	2.85	1 220.89
1981	624.72	817.55	144.51	9.31	1 596.08
1982	119.84	311.95	80.45	3.69	515.94
1983	143.00	453.27	127.60	7.89	731.75
1984	233.76	329.00	39.61	6.49	608.86
1985	376.10	195.48	26.76	4.16	602.49
1986	44.19	73.54	22.01	1.48	141.21
1987	542.24	66.28	19.14	2.16	629.82
1988	98.61	884.07	61.80	6.99	1 051.46
1989	2 314.22	476.29	271.85	7.12	3 069.48
1990	234.94	451.98	102.16	30.28	819.37
1991	676.78	93.38	23.33	2.75	796.24
1992	1 060.78	297.69	43.25	7.77	1 409.48
1993	1 066.83	568.53	118.42	6.41	1 760.19
1994	2 428.36	938.16	92.16	4.10	3 462.77
1995	1 224.89	1 036.40	87.33	3.28	2 351.90
1996	186.13	383.53	146.84	19.03	735.53
1997	591.86	411.96	179.54	17.77	1 201.13
1998	1 171.05	1 456.51	305.91	19.13	2 952.60
1999	2 534.53	562.10	80.35	5.27	3 182.25
2000	1 058.01	860.09	278.32	45.18	2 241.61
2001	883.06	1 057.04	185.54	17.90	2 143.53
2002	896.13	642.52	69.76	8.26	1 616.66
2003	1 818.25	344.39	33.60	2.68	2 198.92
2004	1 593.78	495.63	78.23	5.03	2 172.67
2005	3 059.03	269.39	36.47	0.87	3 365.77
2006	426.01	1 174.00	93.78	5.08	1 698.86
2007	1 053.59	1 341.38	275.18	11.19	2 681.33
2008	1 427.99	766.97	96.68	6.85	2 298.49
2009	3 140.10	451.31	25.53	2.77	3 619.72
2010	2 101.85	1 736.00	156.14	25.48	4 019.48
2011	646.57	966.59	734.01	132.34	2 479.50
2012	2 481.94	1 995.87	429.47	30.58	4 937.86
2013	709.56	1 303.67	453.65	59.46	2 526.34

2014	2 963.62	1 029.25	230.15	29.67	4 252.70
2015	3 218.27	2 912.03	479.29	32.44	6 642.03
2016	858.26	1 433.74	413.41	29.86	2 735.26
2017*	3 588.26	1 279.67	121.12	22.75	5 011.80

* Preliminary

Table 11.3.2. North Sea sprat. Time-series of sprat abundance and biomass (ICES areas 4.a-c) as obtained from summer North Sea acoustic survey. The surveyed area has increased over the years. Only figures from 2004 and onwards are broadly comparable. In 2003, information on sprat abundance is available from one nation only. The model use data from 2003 and onward.

Abundance (million)						Biomass (1000 tonnes)				
Year/Age	0	1	2	3+	sum	0	1	2	3+	sum
2000	0	11,569	6,407	180	18,156	0	100	92	3	196
2001	0	12,639	1,812	110	14,561	0	97	24	2	122
2002	0	15,769	3,687	207	19,664	0	167	55	4	226
2003*	0	25,294	3,983	338	29,615	0	198	61	6	266
2004*	17,401	28,940	5,312	367	52,019	19	267	73	6	366
2005*	0	69,798	2,526	350	72,674	0	475	33	6	513
2006*	0	21,862	19,916	760	42,537	0	159	265	12	436
2007	0	37,250	5,513	1,869	44,631	0	258	66	29	353
2008	0	17,165	7,410	549	25,125	0	161	101	9	271
2009	0	47,520	16,488	1,183	65,191	0	346	189	21	556
2010	1,991	19,492	13,743	798	36,023	22	163	177	14	376
2011	0	26,536	13,660	2,430	42,625	0	212	188	44	444
2012	7,807	21,912	12,541	3,205	45,466	27	177	150	55	409
2013	454	9,332	6,273	1,600	17,660	2	71	74	25	172
2014	5,828	58,405	20,164	3,823	88,219	9	429	228	62	728
2015	198	26,241	22,474	9,799	58,711	0	239	312	161	712
2016	24,792	58,599	33,318	7,880	124,588	24	500	453	141	1118

***re-calculated using FishFrame**

Table 11.3.3. North Sea sprat. Abundance indices by age from IBTS Q3 from 1991–2016 as calculated by the stratified method (see Stock Annex, WKSPRAT ICES, 2013). Data from 1991–2014 updated in 2015.

Year	Age0	Age1	Age2	Age3	Age4+	Total
1991	0.00	196.33	78.74	32.50	0.45	308.02
1992	20.36	2 430.01	2 024.16	120.25	21.31	4 616.09
1993	7.46	1 423.79	1 540.57	317.35	13.41	3 302.58
1994	3.49	2 441.07	333.21	80.24	7.05	2 865.05
1995	0.00	729.86	2 067.47	1 064.51	12.82	3 874.66
1996	1.51	310.54	734.58	315.55	44.04	1 406.23
1997	15.70	4 527.79	1 278.58	237.42	28.24	6 087.72
1998	193.63	2 020.65	1 122.15	146.22	4.82	3 487.46
1999	1 754.76	7 982.21	918.38	61.66	0.12	10 717.12
2000	27.96	2 535.90	1 561.27	42.31	3.29	4 170.73
2001	51.83	2 310.04	1 495.48	116.37	0.75	3 974.47
2002	103.68	4 248.45	1 153.75	112.07	11.60	5 629.54
2003	11.07	1 619.47	303.27	13.41	0.54	1 947.76
2004	4 279.64	3 061.32	840.65	106.76	2.16	8 290.54
2005	0.64	8 273.86	438.34	64.28	25.89	8 803.00
2006	0.05	1 446.66	1 913.58	85.74	2.41	3 448.43
2007	42.73	1 435.51	1 122.14	223.09	4.55	2 828.01
2008	95.18	1 806.34	977.72	123.95	2.89	3 006.09
2009	496.67	9 424.91	2 186.34	262.98	8.74	12 379.64
2010	19.32	3 967.83	3 076.58	179.98	3.67	7 247.38
2011	3.44	10 660.13	3 788.89	1 052.66	63.67	15 568.79
2012	0.06	2 761.31	2 896.50	416.86	31.88	6 106.61
2013	0.04	3 508.33	3 143.59	359.82	46.85	7 058.64
2014	870.06	10 316.05	1 741.91	72.06	1.12	13 001.20
2015	27.60	9 352.37	4 951.39	409.77	0.57	14 741.69
2016	270.35	2 789.74	905.31	193.51	7.95	4 166.87

Table 11.4.1. North Sea sprat. Maturity at age input (from IBTS Q1). (Calendar year)

Year	Age0	Age1	Age2	Age3+
1974	0	0.41134	0.85845	0.94476
1975	0	0.41134	0.85845	0.94476
1976	0	0.41134	0.85845	0.94476
1977	0	0.41134	0.85845	0.94476
1978	0	0.41134	0.85845	0.94476
1979	0	0.41134	0.85845	0.94476
1980	0	0.41134	0.85845	0.94476
1981	0	0.41134	0.85845	0.94476
1982	0	0.41134	0.85845	0.94476
1983	0	0.41134	0.85845	0.94476
1984	0	0.41134	0.85845	0.94476
1985	0	0.41134	0.85845	0.94476
1986	0	0.41134	0.85845	0.94476
1987	0	0.41134	0.85845	0.94476
1988	0	0.41134	0.85845	0.94476
1989	0	0.41134	0.85845	0.94476
1990	0	0.41134	0.85845	0.94476
1991	0	0.41134	0.85845	0.94476
1992	0	0.41134	0.85845	0.94476
1993	0	0.41134	0.85845	0.94476
1994	0	0.41134	0.85845	0.94476
1995	0	0.092549	0.768707	0.874724
1996	0	0.419683	0.739067	0.924385
1997	0	0.661775	0.851568	0.937538
1998	0	0.55938	0.912602	0.979343
1999	0	0.350288	0.880373	0.974545
2000	0	0.427791	0.911569	0.959348
2001	0	0.364679	0.871836	1
2002	0	0.195968	0.730718	0.774047
2003	0	0.519543	0.883941	0.977179
2004	0	0.166232	0.647305	0.842359
2005	0	0.48079	1	1
2006	0	0.283235	0.854179	0.942823
2007	0	0.248309	0.78757	0.896822
2008	0	0.615987	0.922063	0.985663
2009	0	0.52327	0.917751	0.98815
2010	0	0.376405	0.844943	0.948755
2011	0	0.617188	0.978968	1
2012	0	0.517681	0.954882	1
2013	0	0.211287	0.806729	0.980479
2014	0	0.465547	0.867485	0.808139
2015	0	0.331436	0.916164	0.968765
2016	0	0.322358	0.899375	0.966529
2017	0	0.569550	0.952461	0.958593

Table 11.6.1. North Sea sprat. Natural mortality input (years refer to the model year). From multi-species SMS (WKSAM: ICES, 2015) 2015 key run (years and age refer to the model year. For example 2012 refers to the model year July 2012 to June 2013, and S1-S4 refers to the model seasons).

Year	Season	Age 0	Age 1	Age 2	Age 3
1974	S1	0.463	0.375	0.288	0.122
	S2	0.289	0.247	0.209	0.149
	S3	0.314	0.165	0.129	0.129
	S4	0.394	0.334	0.199	0.199
1975	S1	0.509	0.478	0.349	0.169
	S2	0.484	0.306	0.273	0.221
	S3	0.27	0.17	0.154	0.154
	S4	0.346	0.295	0.243	0.243
1976	S1	0.387	0.342	0.282	0.203
	S2	0.532	0.31	0.283	0.241
	S3	0.313	0.206	0.183	0.183
	S4	0.398	0.261	0.258	0.258
1977	S1	0.359	0.333	0.293	0.226
	S2	0.616	0.33	0.309	0.26
	S3	0.398	0.221	0.2	0.2
	S4	0.405	0.304	0.301	0.301
1978	S1	0.31	0.289	0.251	0.201
	S2	0.488	0.277	0.259	0.227
	S3	0.285	0.183	0.167	0.167
	S4	0.326	0.252	0.249	0.249
1979	S1	0.377	0.342	0.286	0.2
	S2	0.461	0.268	0.247	0.208
	S3	0.352	0.186	0.167	0.167
	S4	0.437	0.267	0.263	0.263
1980	S1	0.6	0.592	0.438	0.242
	S2	0.666	0.497	0.415	0.303
	S3	0.422	0.286	0.26	0.26
	S4	0.437	0.315	0.311	0.311
1981	S1	0.583	0.54	0.479	0.21
	S2	0.656	0.419	0.385	0.228
	S3	0.325	0.218	0.192	0.192
	S4	0.362	0.297	0.237	0.237
1982	S1	0.648	0.571	0.502	0.227
	S2	0.662	0.457	0.417	0.257
	S3	0.335	0.232	0.195	0.195
	S4	0.355	0.303	0.247	0.247
1983	S1	0.658	0.545	0.423	0.187
	S2	0.603	0.371	0.309	0.188
	S3	0.276	0.182	0.139	0.139
	S4	0.304	0.237	0.205	0.205
1984	S1	0.717	0.583	0.395	0.203
	S2	0.756	0.489	0.381	0.259

	S3	0.358	0.234	0.203	0.203
	S4	0.334	0.289	0.252	0.252
1985	S1	0.754	0.73	0.438	0.202
	S2	0.707	0.491	0.34	0.218
	S3	0.367	0.188	0.163	0.163
	S4	0.358	0.234	0.231	0.231
1986	S1	0.548	0.523	0.395	0.196
	S2	0.865	0.573	0.441	0.226
	S3	0.357	0.206	0.183	0.183
	S4	0.326	0.287	0.241	0.241
1987	S1	0.709	0.6	0.537	0.231
	S2	1.06	0.7	0.634	0.294
	S3	0.445	0.28	0.239	0.239
	S4	0.385	0.346	0.297	0.297
1988	S1	0.609	0.559	0.429	0.204
	S2	0.909	0.585	0.459	0.232
	S3	0.405	0.195	0.169	0.169
	S4	0.363	0.308	0.277	0.277
1989	S1	0.627	0.572	0.416	0.243
	S2	0.961	0.604	0.493	0.307
	S3	0.415	0.272	0.239	0.239
	S4	0.364	0.295	0.291	0.291
1990	S1	0.6	0.502	0.406	0.211
	S2	0.837	0.544	0.449	0.241
	S3	0.336	0.217	0.186	0.186
	S4	0.317	0.285	0.252	0.252
1991	S1	0.595	0.541	0.393	0.204
	S2	0.787	0.543	0.404	0.225
	S3	0.297	0.197	0.168	0.168
	S4	0.296	0.249	0.222	0.222
1992	S1	0.526	0.423	0.309	0.176
	S2	0.711	0.46	0.344	0.203
	S3	0.281	0.178	0.152	0.152
	S4	0.282	0.246	0.221	0.221
1993	S1	0.41	0.373	0.281	0.169
	S2	0.618	0.408	0.318	0.202
	S3	0.251	0.18	0.149	0.149
	S4	0.254	0.22	0.203	0.203
1994	S1	0.371	0.328	0.254	0.169
	S2	0.528	0.33	0.261	0.181
	S3	0.22	0.157	0.138	0.138
	S4	0.231	0.201	0.186	0.186
1995	S1	0.494	0.444	0.313	0.182
	S2	0.667	0.394	0.314	0.212
	S3	0.281	0.201	0.17	0.17
	S4	0.291	0.247	0.231	0.231

1996	S1	0.401	0.347	0.285	0.168
	S2	0.476	0.328	0.246	0.179
	S3	0.182	0.146	0.13	0.13
	S4	0.196	0.16	0.148	0.148
1997	S1	0.447	0.353	0.244	0.156
	S2	0.624	0.387	0.281	0.191
	S3	0.233	0.164	0.142	0.142
	S4	0.222	0.19	0.188	0.188
1998	S1	0.376	0.349	0.249	0.165
	S2	0.617	0.361	0.268	0.182
	S3	0.25	0.161	0.13	0.13
	S4	0.265	0.225	0.222	0.222
1999	S1	0.421	0.322	0.243	0.152
	S2	0.594	0.303	0.232	0.143
	S3	0.219	0.141	0.118	0.118
	S4	0.227	0.189	0.187	0.187
2000	S1	0.439	0.351	0.264	0.167
	S2	0.619	0.359	0.28	0.186
	S3	0.265	0.173	0.149	0.149
	S4	0.257	0.221	0.219	0.219
2001	S1	0.397	0.353	0.271	0.179
	S2	0.619	0.363	0.286	0.196
	S3	0.254	0.179	0.156	0.156
	S4	0.243	0.21	0.208	0.208
2002	S1	0.472	0.376	0.292	0.205
	S2	0.606	0.394	0.317	0.23
	S3	0.26	0.216	0.175	0.175
	S4	0.288	0.257	0.254	0.254
2003	S1	0.411	0.387	0.292	0.212
	S2	0.64	0.324	0.288	0.214
	S3	0.25	0.202	0.156	0.156
	S4	0.3	0.27	0.259	0.259
2004	S1	0.403	0.298	0.23	0.175
	S2	0.63	0.306	0.243	0.187
	S3	0.208	0.158	0.122	0.122
	S4	0.249	0.223	0.213	0.213
2005	S1	0.468	0.334	0.249	0.166
	S2	0.527	0.305	0.205	0.149
	S3	0.189	0.146	0.107	0.107
	S4	0.243	0.205	0.203	0.203
2006	S1	0.43	0.38	0.209	0.16
	S2	0.58	0.378	0.22	0.171
	S3	0.199	0.153	0.116	0.116
	S4	0.242	0.203	0.201	0.201
2007	S1	0.431	0.367	0.217	0.155
	S2	0.557	0.352	0.217	0.159

	S3	0.209	0.142	0.11	0.11
	S4	0.234	0.193	0.191	0.191
2008	S1	0.437	0.267	0.216	0.141
	S2	0.66	0.282	0.161	0.157
	S3	0.18	0.135	0.108	0.108
	S4	0.203	0.176	0.174	0.174
2009	S1	0.506	0.263	0.21	0.128
	S2	0.64	0.265	0.142	0.138
	S3	0.158	0.118	0.1	0.1
	S4	0.172	0.142	0.14	0.14
2010	S1	0.513	0.319	0.225	0.128
	S2	0.787	0.364	0.159	0.156
	S3	0.226	0.139	0.116	0.116
	S4	0.239	0.178	0.177	0.177
2011	S1	0.632	0.45	0.321	0.156
	S2	0.941	0.529	0.2	0.197
	S3	0.257	0.192	0.144	0.144
	S4	0.31	0.252	0.249	0.249
2012	S1	0.623	0.478	0.175	0.173
	S2	0.819	0.505	0.201	0.198
	S3	0.22	0.175	0.133	0.133
	S4	0.282	0.218	0.216	0.216
2013	S1	0.417	0.373	0.129	0.128
	S2	0.59	0.401	0.152	0.148
	S3	0.234	0.168	0.131	0.131
	S4	0.277	0.216	0.214	0.214
2014*	S1	0.557	0.434	0.208	0.152
	S2	0.783	0.478	0.184	0.181
	S3	0.237	0.178	0.136	0.136
	S4	0.29	0.229	0.227	0.227
2015*	S1	0.557	0.434	0.208	0.152
	S2	0.783	0.478	0.184	0.181
	S3	0.237	0.178	0.136	0.136
	S4	0.29	0.229	0.227	0.227
2016*	S1	0.557	0.434	0.208	0.152
	S2	0.783	0.478	0.184	0.181
	S3	0.237	0.178	0.136	0.136
	S4	0.29	0.229	0.227	0.227

***Average of 2011–2013**

Table 11.6.2. North Sea sprat. Assessment diagnostics.

objective function (negative log likelihood): 486.505

Number of parameters: 145

Maximum gradient: 7.39189e-005

Akaike information criterion (AIC): 1263.01

Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
688	284	43	0	1015

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
503.0	-16.6	1.1	0.0	0.0	0.00	488

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.73	-0.06	0.03	0.00

contribution by fleet:

IBTS Q1 total: -15.846 mean: -0.097

IBTS Q3 total: 14.989 mean: 0.192

Acoustic total: -15.761 mean: -0.375

F, season effect:

----

age: 0

1974-1995: 0.023 0.117 0.495 0.250

1996-2016: 0.060 0.648 0.464 0.250

age: 1

1974-1995: 0.708 0.830 0.618 0.250

1996-2016: 2.211 4.818 0.537 0.250

age: 2

1974-1995: 0.777 1.242 0.573 0.250

1996-2016: 2.398 10.575 0.551 0.250

age: 3

1974-1995: 0.657 1.761 0.752 0.250

1996-2016: 2.297 13.474 0.603 0.250

F, age effect:

	0	1	2	3
1974-1995:	0.023	0.248	0.435	0.435
1996-2016:	0.007	0.053	0.069	0.069

Exploitation pattern (scaled to mean F=1)

		0	1	2	3
1974-1995	season 1:	0.001	0.192	0.369	0.312
	season 2:	0.003	0.225	0.589	0.836
	season 3:	0.012	0.167	0.272	0.357
	season 4:	0.006	0.068	0.119	0.119
1996-2016	season 1:	0.001	0.173	0.242	0.232
	season 2:	0.006	0.377	1.066	1.358
	season 3:	0.004	0.042	0.056	0.061
	season 4:	0.002	0.020	0.025	0.025

sqrt(catch variance) ~ CV:

----

	season			
age	1	2	3	4
0	1.414	1.414	1.414	1.414
1	0.922	0.834	1.414	0.825
2	1.165	1.327	1.414	1.414

3 1.165 1.327 1.414 1.414

Survey catchability:

----

	age 0	age 1	age 2	age 3
IBTS Q1	0.245	1.076	2.310	2.310
IBTS Q3		1.189	3.832	3.832
Acoustic		0.913	2.067	2.724

sqrt(Survey variance) ~ CV:

----

	age 0	age 1	age 2	age 3
IBTS Q1	0.55	0.55	0.55	0.55
IBTS Q3		0.76	0.58	0.90
Acoustic		0.45	0.40	0.40

Recruit-SSB		alfa	beta	recruit s2	recruit s
Sprat	Hockey stick -break.:	1908.895	9.000e+004	0.388	0.623

Table 11.6.3. North Sea Sprat. Assessment output: Stock numbers (thousands). Age 0 at start of 2nd half-year, age 1+ at start of 1st half-year (years and age refer to the model year. For example 2012 refers to the model year July 2012 to June 2013).

Year/Age	Age 0	Age 1	Age 2	Age 3+
1974	262510000	109210000	7086030	397153
1975	464346000	59746000	19611100	952082
1976	203949000	88624900	4249160	406984
1977	241138000	39039500	14547800	403671
1978	238897000	39322000	4160810	557987
1979	209357000	56310900	4969860	197220
1980	266791000	39928800	8033810	313029
1981	101735000	30911600	3007920	313148
1982	66726200	14346000	2679210	121898
1983	78036900	8920800	1915660	280792
1984	43363600	12062800	898004	97526
1985	27582300	4895740	1343970	82354
1986	155965000	3025000	386899	66668
1987	132118000	18917200	413753	58409
1988	254286000	9775460	2308080	64387
1989	101162000	25674400	1532900	412933
1990	156140000	9470670	4247330	444215
1991	226834000	19146700	720145	119877
1992	226956000	31225700	2786920	109465
1993	230836000	36879900	5101940	365730
1994	113401000	47948900	3624230	196416
1995	69753500	28755500	9038410	424679
1996	105336000	11945900	3127710	486895
1997	123965000	29748700	2950460	622593
1998	154051000	26751100	6757770	620295
1999	127824000	33457300	3834100	444427
2000	106715000	29347100	8079010	677787
2001	92742600	21711800	5111950	791388
2002	130813000	20075600	2906530	282626
2003	101285000	25160500	2127180	113414
2004	224474000	20156100	3818170	162753
2005	85900700	49229600	2235150	110826
2006	99945200	20374800	9821680	258901
2007	81246400	23078300	3095560	805355
2008	160299000	19079200	3155790	203923
2009	130731000	35929300	4050830	358055
2010	183720000	29522600	9580380	716453
2011	175595000	31123000	6814800	1800940
2012	174584000	20420100	4462870	1045910
2013	394947000	24693400	3039900	769880
2014	482586000	86106400	6162080	1183920

2015	318148000	73955800	15635800	1406630
2016	758505000	48460400	10243600	1764740
2017	0	115205000	5151230	641853

Table 11.6.4. North Sea Sprat. Assessment output: Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), landings weight (Yield) and average fishing mortality. All estimates are for July – June. For example 2012 refers to the model year 2012/2013.

Year	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F ages 1–2
1974	262510	2930380	488267	379747	0.923
1975	464346	4077470	453307	637282	2.097
1976	203949	1329040	300816	557359	1.09
1977	241138	2070610	295490	318769	1.679
1978	238897	1458560	144967	378632	1.69
1979	209357	1832450	160342	368667	1.388
1980	266791	2193970	155229	300239	1.37
1981	101735	1030450	153243	203897	1.431
1982	66726	595989	69546	123379	0.701
1983	78037	791014	73745	85168	1.456
1984	43364	463698	64246	85617	0.953
1985	27582	260530	35816	40922	1.345
1986	155965	1131120	13361	15687	0.609
1987	132118	1115700	76959	37551	0.287
1988	254286	1950380	76889	95972	0.312
1989	101162	795155	108970	51943	0.093
1990	156140	1247580	84464	67386	1.878
1991	226834	3164560	124660	114872	0.677
1992	226956	2223840	157920	148236	0.777
1993	230836	2101460	222521	209193	1.751
1994	113401	1139500	53414	313687	1.01
1995	69754	528638	174739	387626	1.43
1996	105336	950305	126213	84573	0.682
1997	123965	1422300	245851	104797	0.668
1998	154051	1361480	237048	172063	1.412
1999	127824	1280210	184794	215412	0.779
2000	106715	1414750	238017	195170	1.1
2001	92743	998763	106325	131538	1.524
2002	130813	1188440	148001	157248	1.674
2003	101285	1069610	74879	159515	1.201

Year	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F ages 1–2
2004	224474	2223590	162745	207779	2.013
2005	85901	1053300	141703	232048	1.047
2006	99945	1039840	147210	74648	1.306
2007	81246	915180	226532	85080	1.564
2008	160299	1577060	133145	63623	1.148
2009	130731	1304660	167976	162714	0.881
2010	183720	1585370	241244	126077	0.78
2011	175595	1258480	223133	119083	0.862
2012	174584	1719620	88135	86196	0.904
2013	394947	2705370	150993	81268	0.408
2014	482586	4960920	422068	192679	0.665
2015	318148	3207670	370463	286086	1.115
2016	758505	3558230	246168	252743	1.57
2017			409055		
arith. mean	188030	1656447	179894	188655	1.122
geo. Mean	153915				

Table 11.9.1. North Sea Sprat. Input to forecast (years and age refer to the model year. For example 2016 refers to the model year July 2016 to June 2017, and Q1-Q4 refers to the model quarters).

Age	Age 0	Age 1	Age 2	Age 3
Stock numbers(2017)	166622.8	115205	5151.23	641.853
Exploitation pattern Q1	0.000636	0.189203	0.264493	0.253301
Exploitation pattern Q2	0.006841	0.412178	1.166254	1.485936
Exploitation pattern Q3	0.004901	0.045967	0.060766	0.066526
Exploitation pattern Q4	0.001496	0.012121	0.015624	0.015624
Weight in the stock Q1	6.736667	8.11	10.58333	15.36
Weight in the catch Q1	6.736667	8.11	10.58333	15.36
Weight in the catch Q2	6.386667	7.6	10.94333	13.85333
Weight in the catch Q3	4.666667	8.8	12.66	15.37333
Weight in the catch Q4	5.633333	8.443333	10.55	12.69
Proportion mature(2017)	0	0.373645	0.922884	0.977871
Proportion mature(2018)	0	0.44483	0.906147	0.96448
Natural mortality Q1	0.557	0.434	0.208	0.152
Natural mortality Q2	0.783	0.478	0.184	0.181
Natural mortality Q3	0.237	0.178	0.136	0.136
Natural mortality Q4	0.29	0.229	0.227	0.227

Table 11.9.2. Sprat North Sea. Short-term predictions options table. Basis: Fsq = F (July 2016–June 2017) = 1.524; Yield (2016) = 253; Recruitment (2016) = 759; Recruitment (2017) = geometric mean (GM 1996–2016) = 167 billion; SSB (2017) = 409.

Rationale	Wanted catch* (July 2016–June 2017)	Basis	F (July 2016–June 2017)	SSB* (July 2017)	% SSB change**	% TAC change***
MSY approach	170	Fcap	0.7	331	-19%	-33%
Zero catch	0	F = 0	0	429	4.9%	-100%
Other options	28	F2016–2017 × 0.07	0.1	412	0.8%	-89%
	54	F2016–2017 × 0.13	0.2	397	-3%	-79%
	80	F2016–2017 × 0.20	0.3	382	-7%	-69%
	104	F2016–2017 × 0.26	0.4	368	-10%	-59%
	127	F2016–2017 × 0.33	0.5	355	-13%	-50%
	149	F2016–2017 × 0.39	0.6	342	-16%	-41%
	170	F2016–2017 × 0.46	0.7	331	-19%	-33%
	191	F2016–2017 × 0.52	0.8	319	-22%	-25%
	569	F2016–2017 × 1.64 (Bescapement)	4.03	142	-65%	125%

*Weights in thousand tonnes.

**SSB in July 2016

*** Advised TAC in July 2017 relative to advised TAC in July 2016

Figure 11.1.1. North Sea sprat and 3.a sprat. Sprat catches in the North Sea and Div. 3.a (in tonnes) for each year 2001–2017 by statistical rectangle.

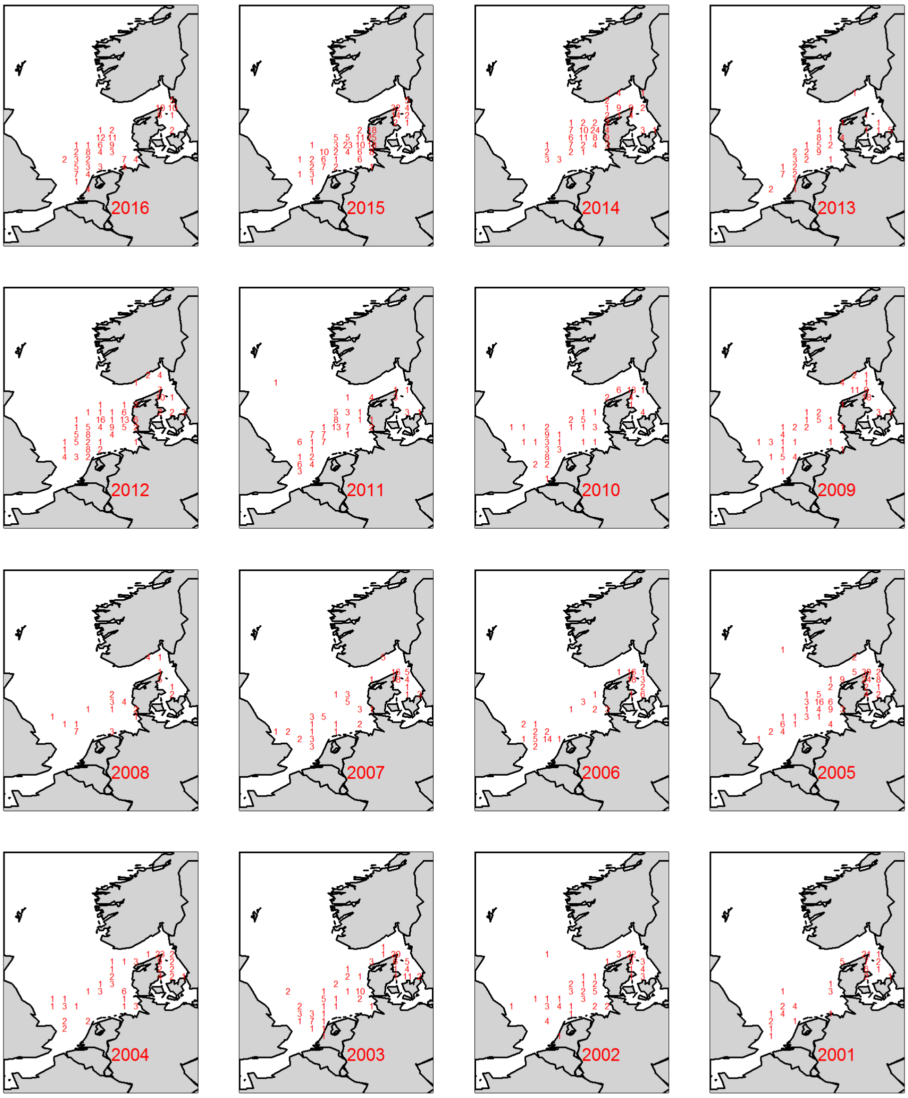


Figure 11.2.1. North Sea sprat and 3.a sprat. Number of samples taken in the North Sea and Div. 3.a for each year 2001–2017 by statistical rectangle.

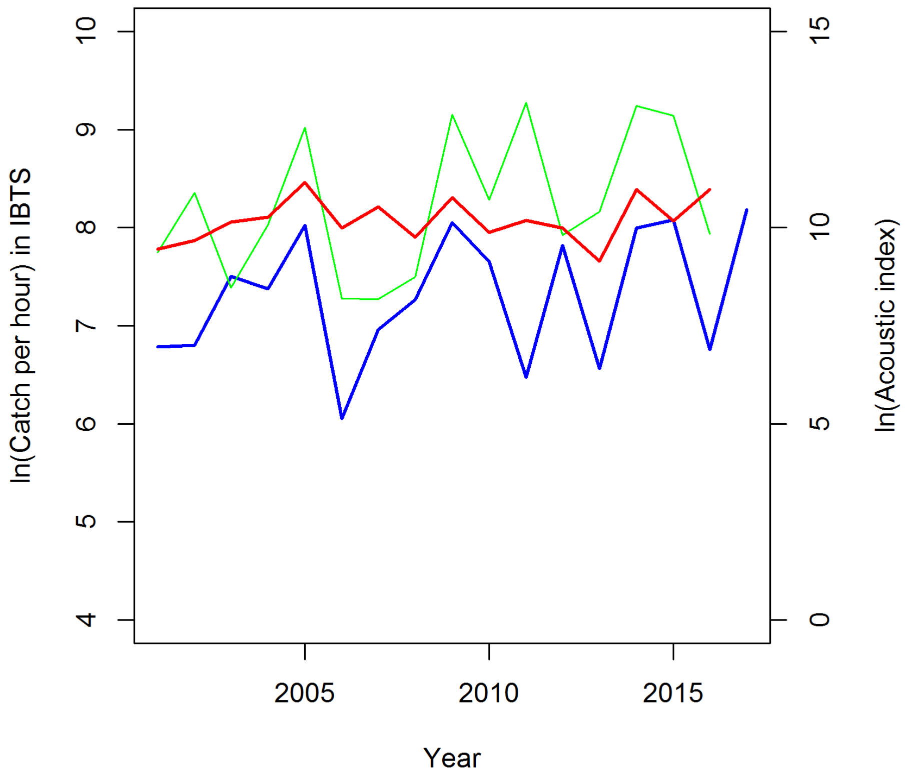


Figure 11.3.1. North Sea sprat. Mean IBTS catch rate of 1-year olds in quarters 1 (blue) and 3 (green) and in HERAS (red).

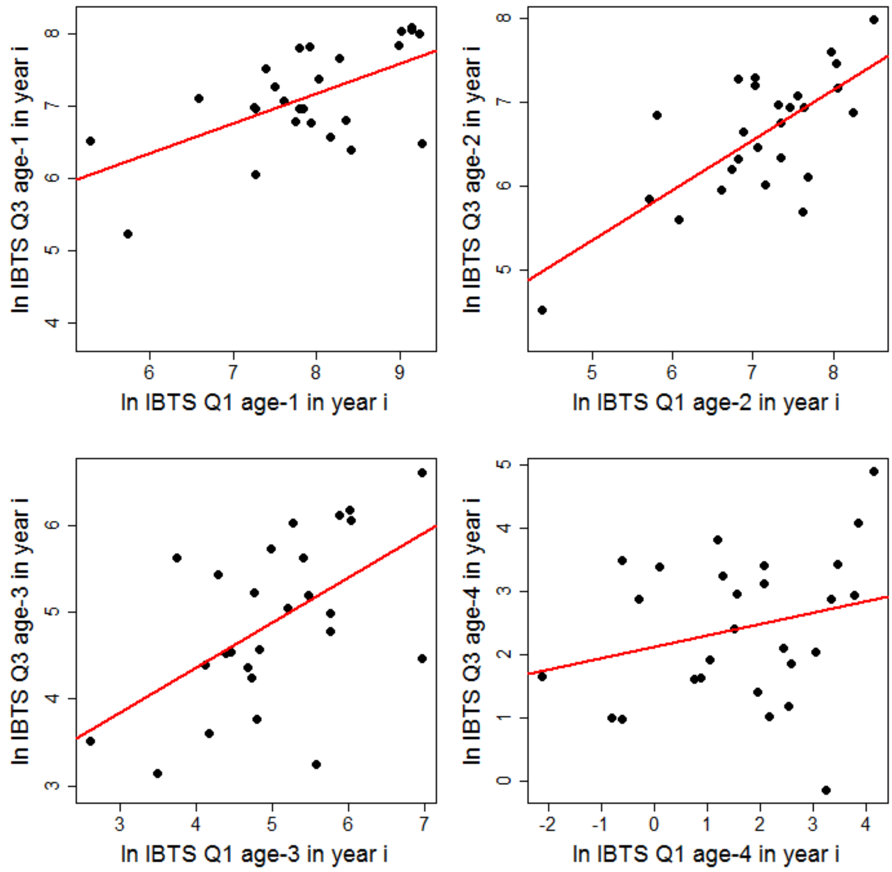


Figure 11.3.2a. North Sea sprat. External consistency between the IBTS Q1 and Q3 surveys. Red dnumber inside the graphs are R^2. (Quarter (Q) and age refer to the calendar year)

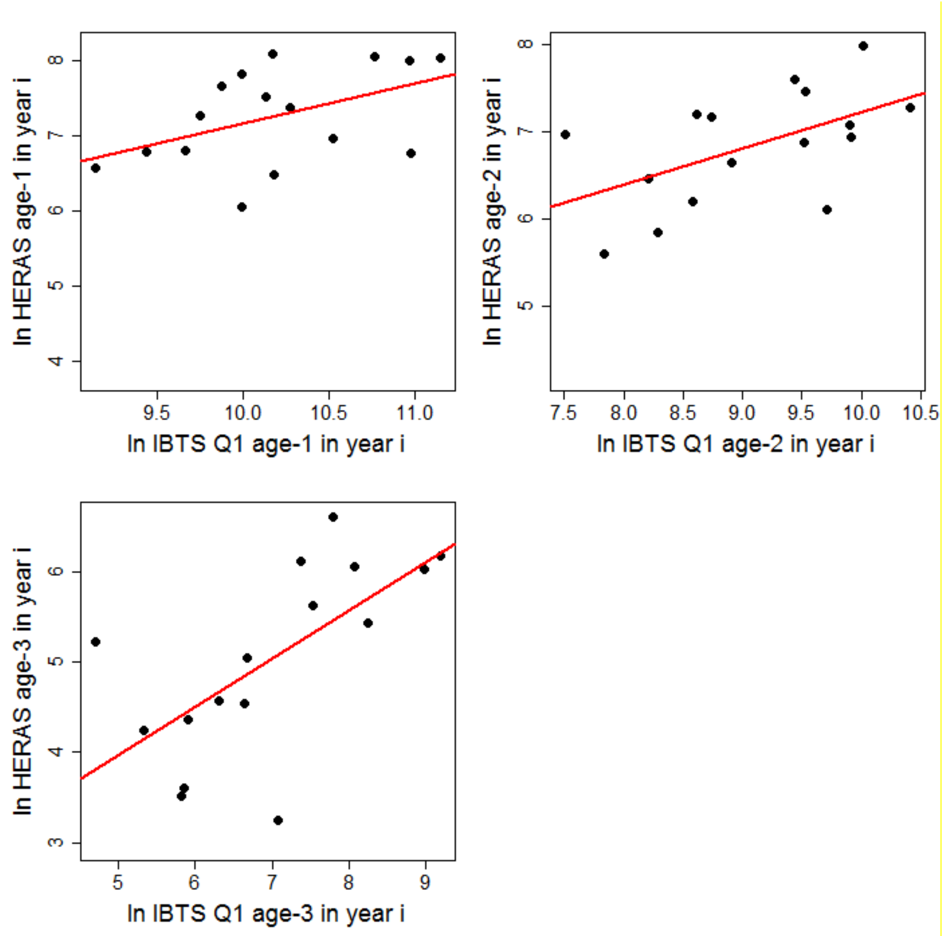


Figure 11.3.2b. North Sea sprat. External consistency between the IBTS Q1 and HERAS. Red number inside the graphs are R2. (Quarter (Q) and age refer to the calendar year)

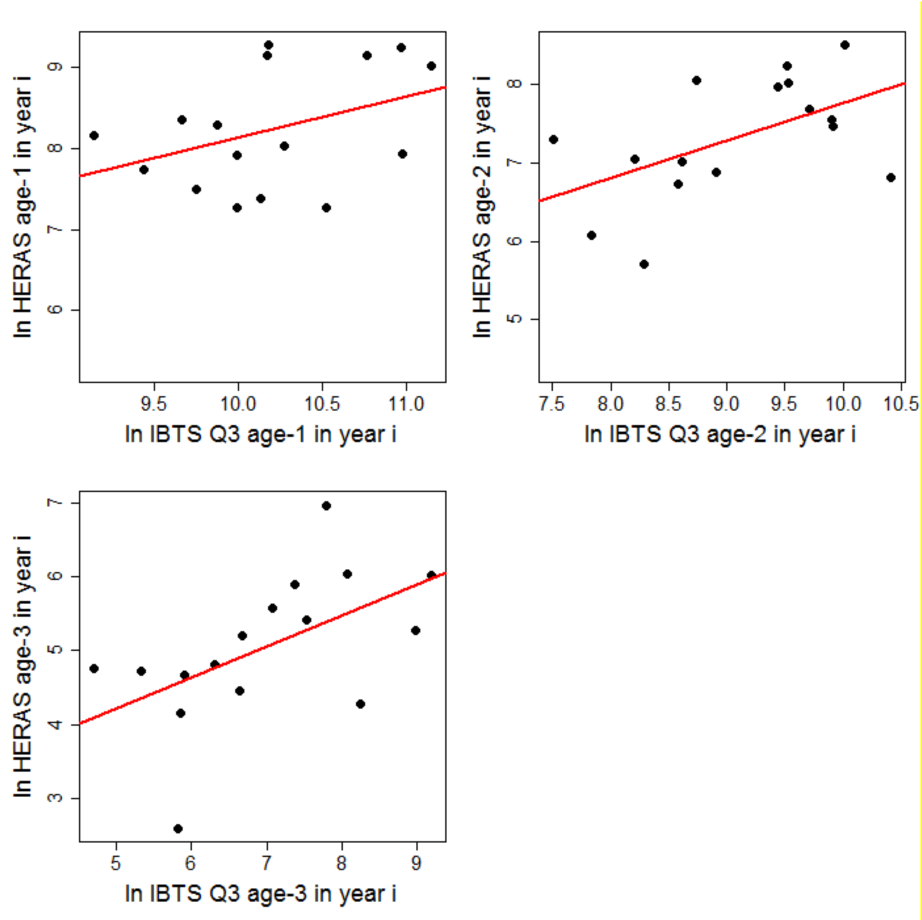


Figure 11.3.2c. North Sea sprat. External consistency between the IBTS Q3 and HERAS. Red number inside the graphs are R^2. (Quarter (Q) and age refer to the calendar year)

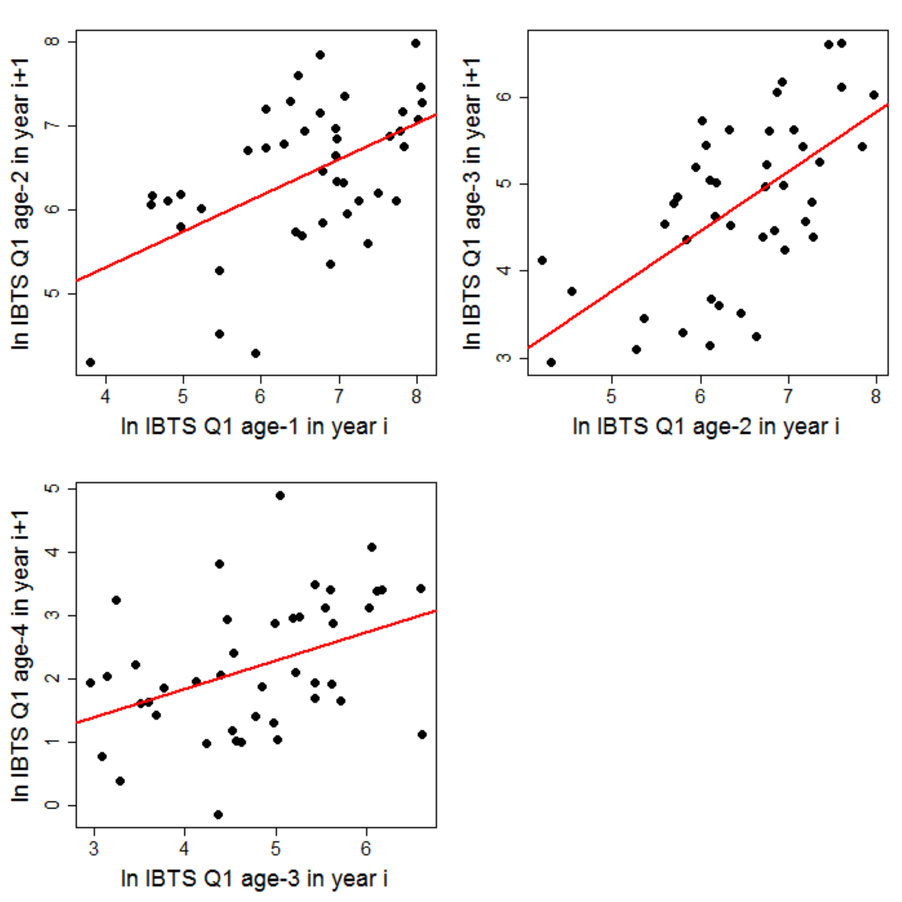


Figure 11.3.3. North Sea sprat. Internal consistency in the IBTS Q1 survey. Red number inside the graphs are R^2. (Quarter (Q) and age refer to the calendar year)

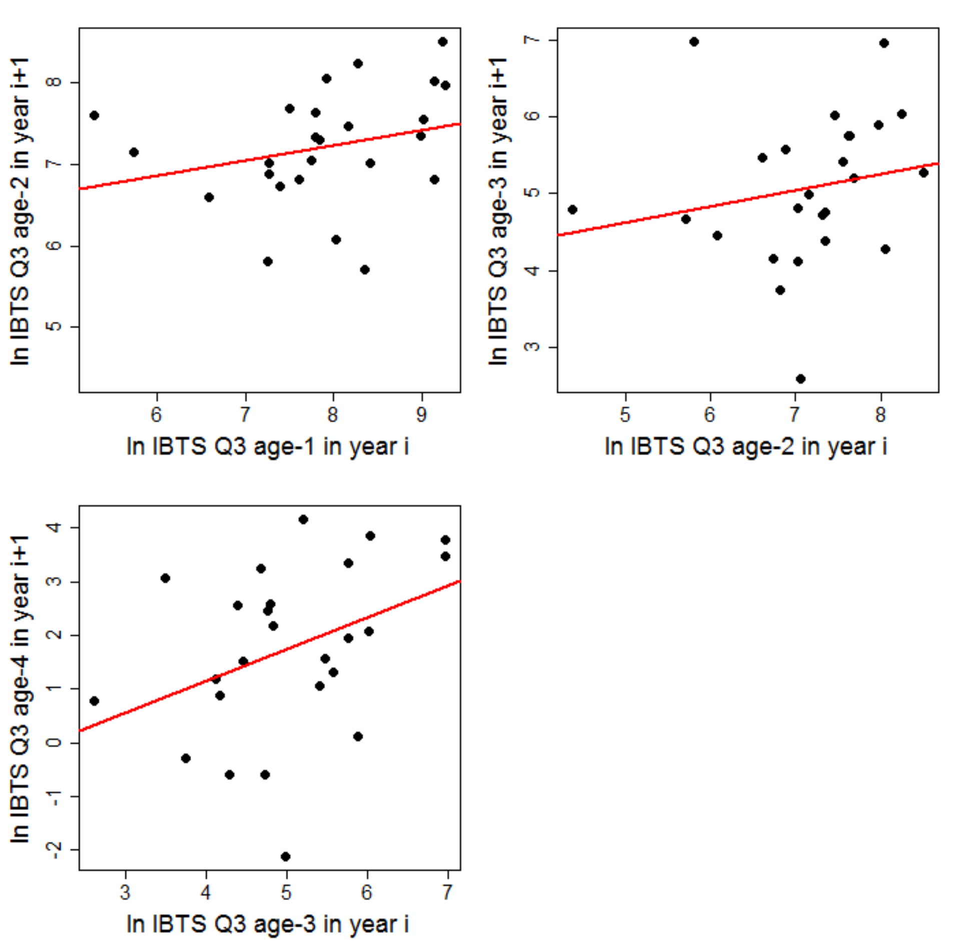


Figure 11.3.4. North Sea sprat. Internal consistency in the IBTS Q3 survey. Red number inside the graphs are R^2. (Quarter (Q) and age refer to the calendar year)

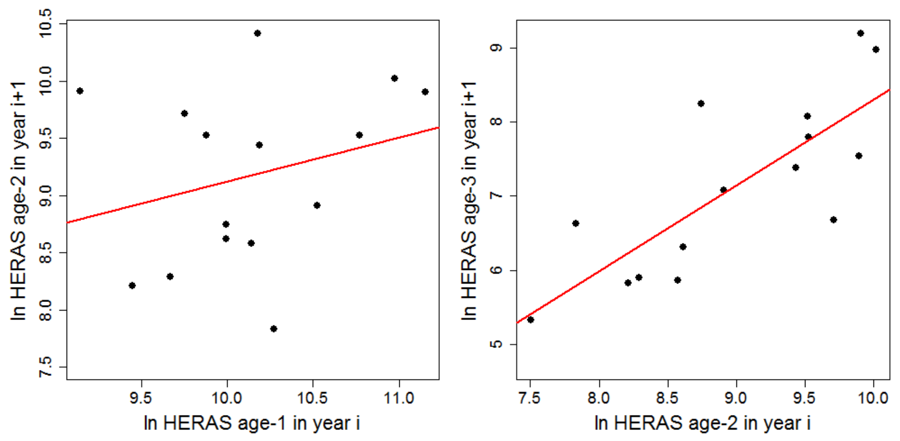


Figure 11.3.5. North Sea sprat. Internal consistency in the HERAS (acoustic) survey. Red number inside the graphs are R^2. (Quarter (Q) and age refer to the calendar year)

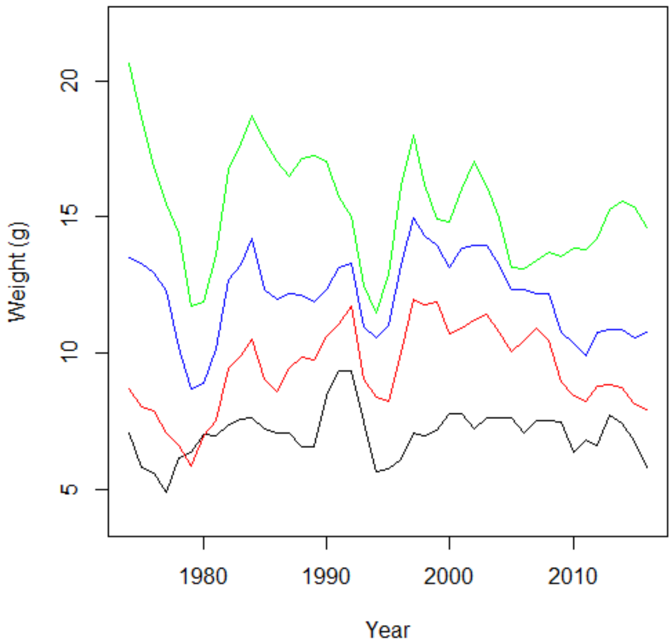


Figure 11.4.1. North Sea sprat. Three year running mean weight at age in the catches in quarter 4 (Calendar year) for age 0 (black), age 1 (red), age 2 (blue) and age 3+ (green).

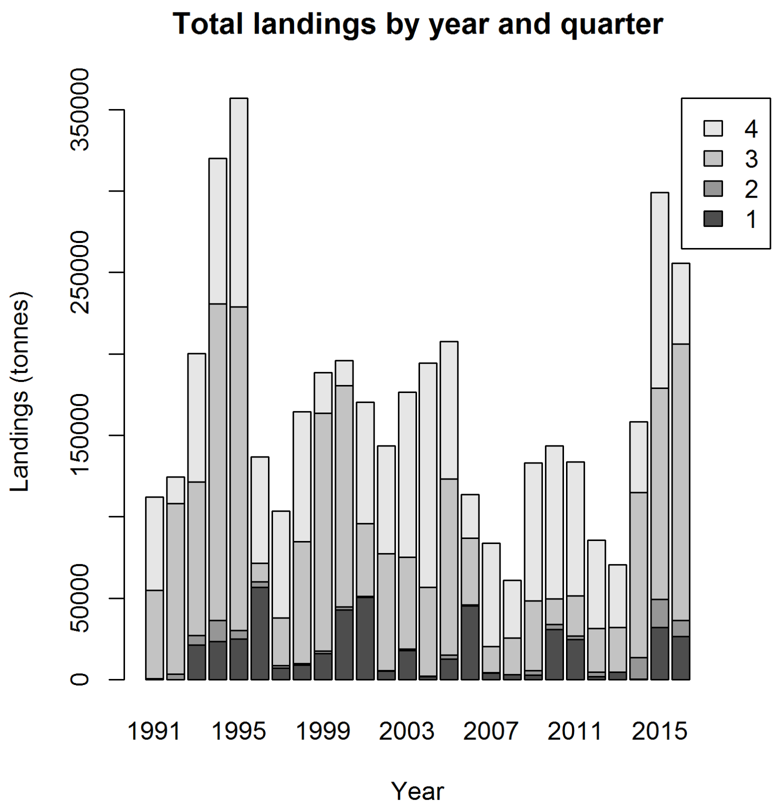


Figure 11.6.1. North Sea sprat. Quarterly distribution of Danish catches (Calendar year).

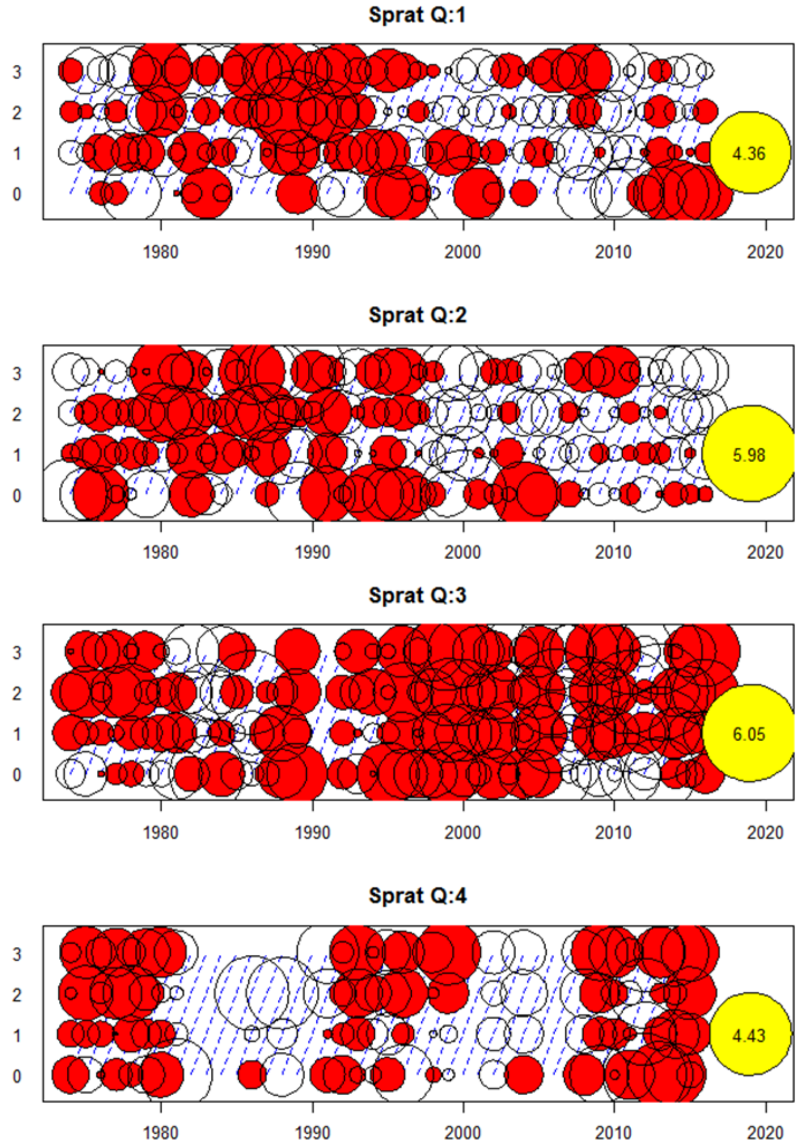


Figure 11.6.2. North Sea sprat. Catch residuals by age. (Model year)

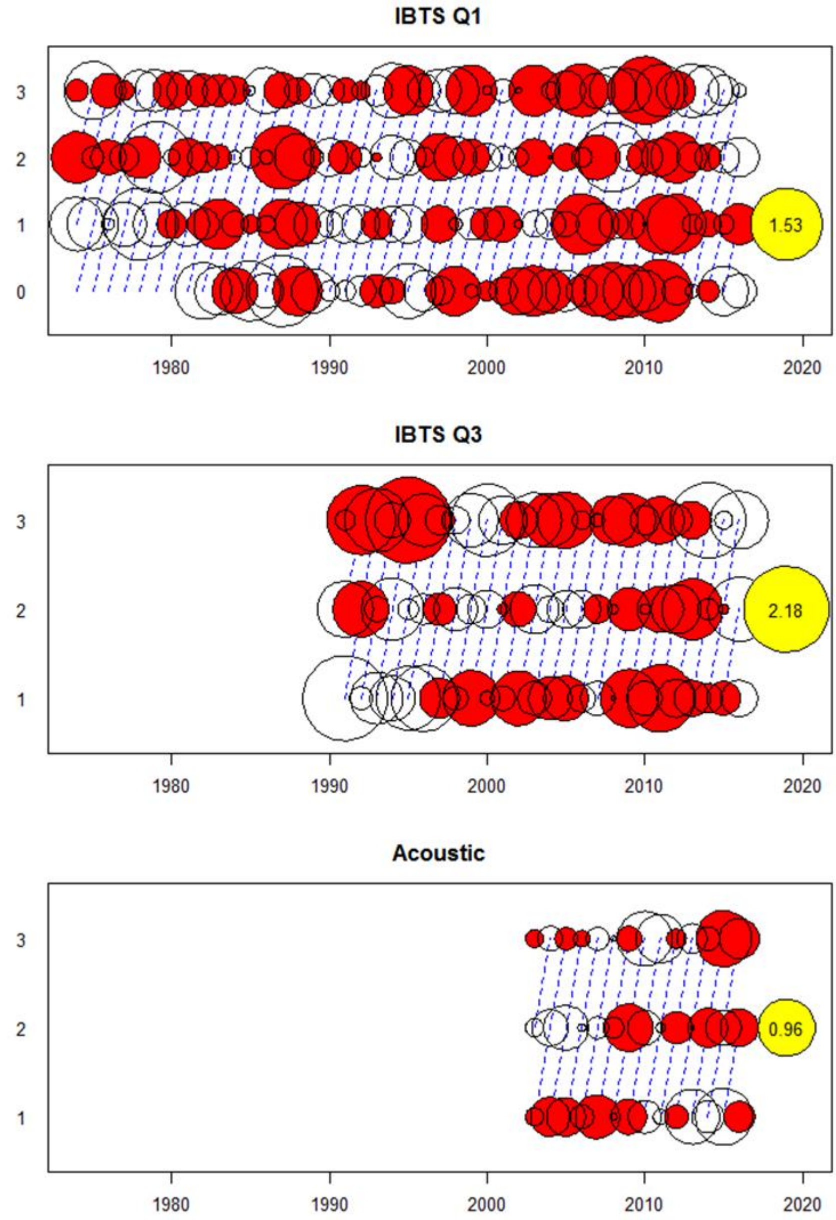


Figure 11.6.3. North Sea sprat. Survey residuals by age. (Model year)

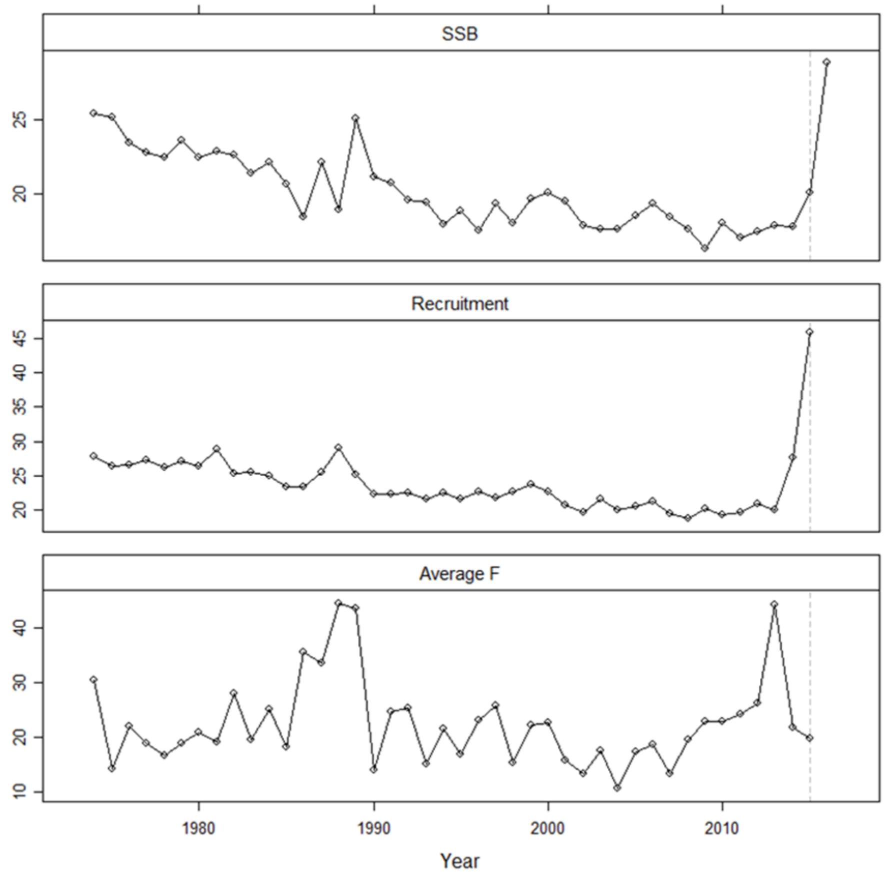


Figure 11.6.4. North Sea sprat. Coefficients of variance (Model year)

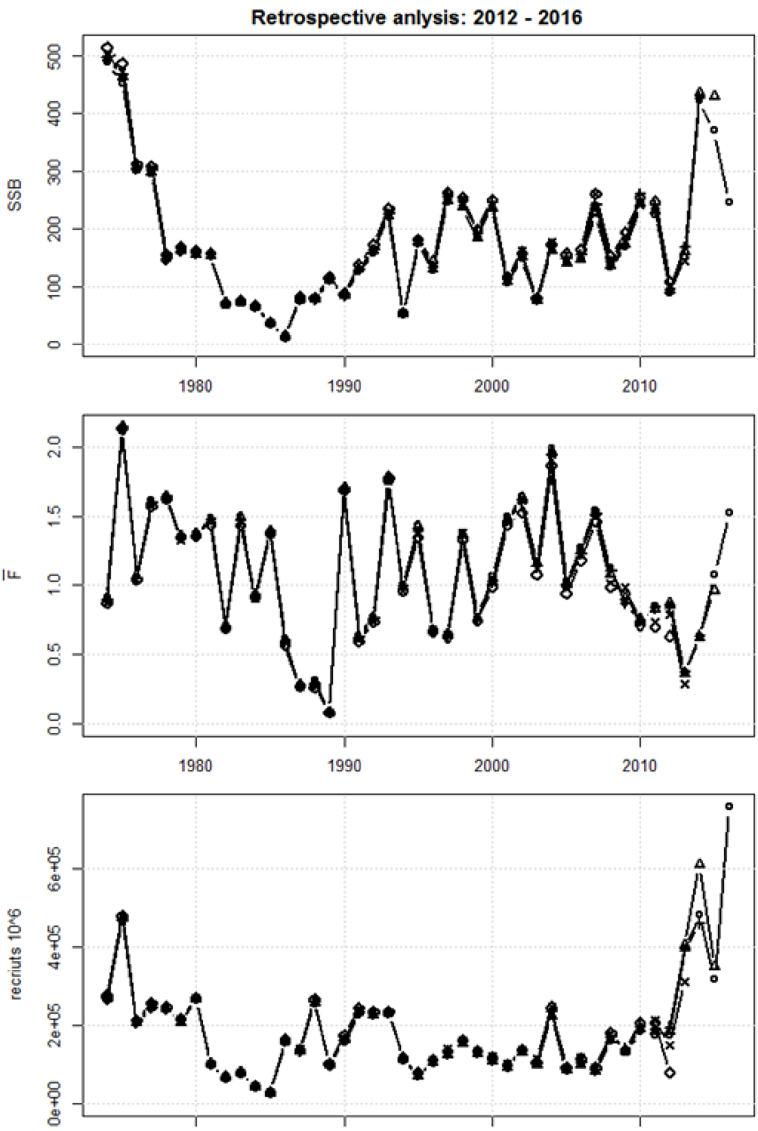


Figure 11.6.5. North Sea sprat. Retrospective analysis (Model year)

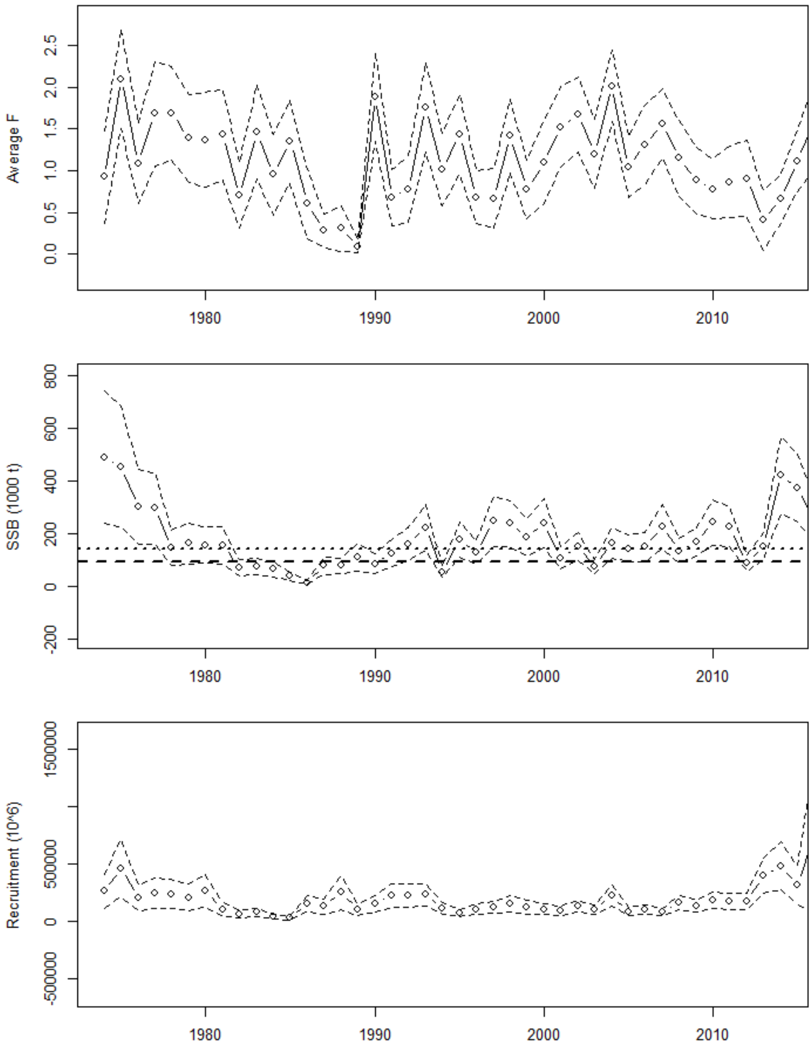


Figure 11.6.6. North Sea sprat. Temporal development in Mean F, SSB and recruitment. Hatched lines are 95% confidence intervals (Model year).

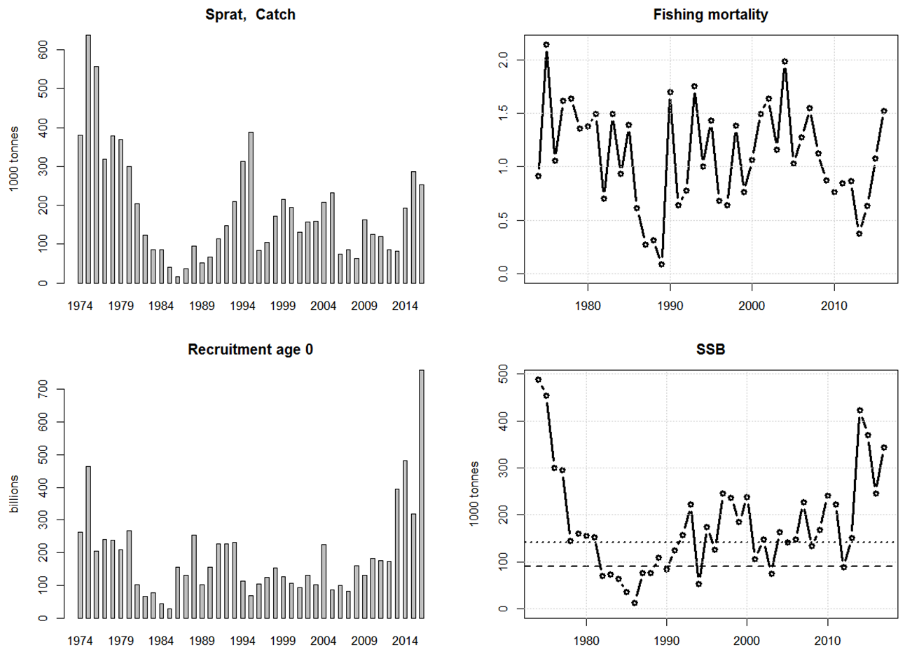


Figure 11.6.7. North Sea sprat. Assessment summary (years and age refer to the model year. For example 2012 refers to the model year July 2012 to June 2013).

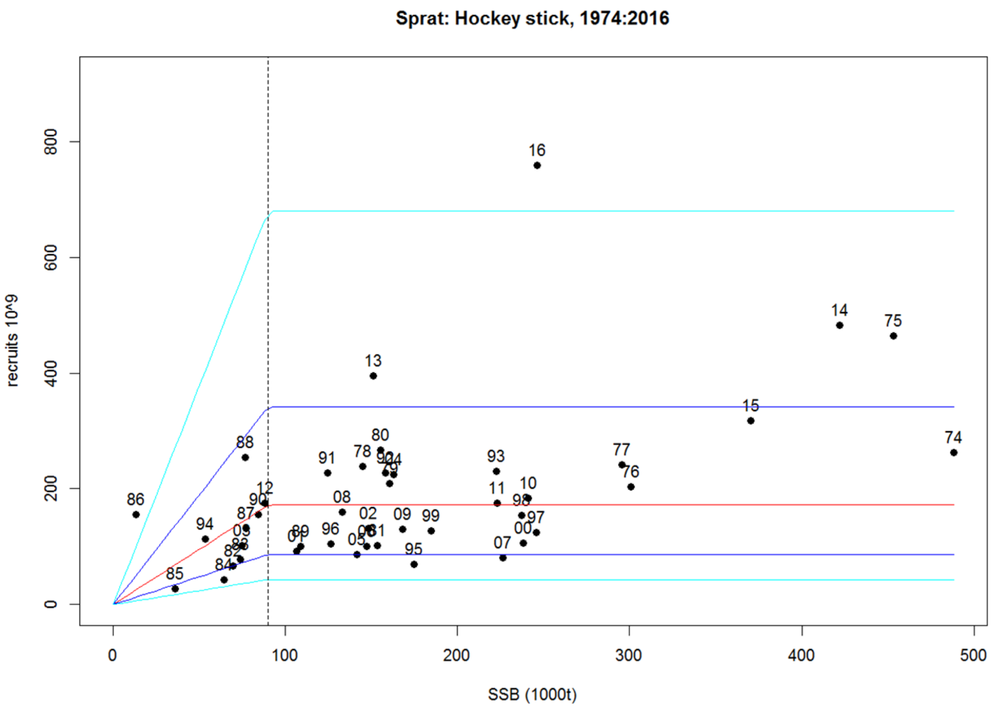


Figure 11.7.1. North Sea sprat. Stock-recruitment relationship (years and age refer to the model year. For example 2012 refers to the model year July 2012 to June 2013).

11.14 Audit of spr.27.4 (Sprat in the North Sea)

Date: 22/3/2017

Auditor: Martin Pastoors

Checklist for audit process

General

- *Has the EG answered those TORs relevant to providing advice?*

Yes, the assessment and advice for North Sea sprat have been carried out according to the TORs.

- *Is the assessment according to the stock annex description?*

Yes, carried out 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?*

Management Strategy evaluations have been performed in 2014 and showed the need for an F-cap combined with the escapement strategy. However, no management plan has been developed. The fishing mortalities observed for this stock are largely well in excess of the F-cap, while the stocks seems to be doing rather well. This requires a re-evaluation of the appropriateness of the current F-cap.

- *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?*

Not really, may be with the exception of the F-cap discussion above.

- *Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?*

No reason for changing the basis of the advice.

12 Sprat in the English channel (subareas 7de)

The stock structure of sprat populations in this Region is not clear. HAWG advocates that the limit of this stock are not clear and further investigations and further work is required to solve the problem.

12.1 The Fishery

12.1.1 ICES advice applicable for 2017 and 2018

The TAC for the English Channel (7.d and e) for 2017 was set equal to 4120 tonnes.

12.1.2 Landings

The total sprat landings are provided in table xx and in figures .

Divisions 7.d–e (English Channel)

Total landings from the international sprat fishery are available since 1950 (see Figure 12.2.5). Sprat landings prior to 1985 in 7.d–e were extracted from official catch statistics dataset (STATLANT27, Historical Nominal Catches 1950–2010, Official Nominal Catches 2006–2013), from 1985 onwards they are 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 late 1970s and 1980s from the English Channel. However, the identity of the catches was not confirmed by the Danish data managers raising the question of whether those reported catches were the result of species misreporting (i.e. herring misreported as sprat). Therefore, ICES cannot verify the quality of catch data prior to 1988.

The fishery starts in August and runs into the following year into February and sometimes March. Most of the catch is taken in 7.e, in particular in the Lyme Bay area. In the last decade catch from UK covered about 99% of landed sprat, however in 2015 and 2016 this percentage diminished, with Netherlands, Denmark, and for the first time in the whole times series, Germany, contributing to about 11% of the reported landings.

The UK has a history of taking the quota, but sprat is found by sonar search and sometimes the shoals are found too far offshore for sensible economic exploitation, skippers then go back to other trawling activity. This offshore/near shore shift may be related to environmental changes such as temperature and/or salinity.

12.1.3 Fleets

In the English Channel the primary gear used for sprat is midwater trawl. Within that gear type three vessels under 15 m have actively target sprat and have been responsible for the majority of landings (since 2003 they took on average 96% of the total landings). In the most recent year only two of the vessels have been targeting sprat. Sprat is also caught by driftnet, fixed nets, lines and pots and most of the landings are sold for human consumption.

12.1.4 Regulations and their effects

There is a TAC for sprat for 7.d–e, English Channel. Up to now the TAC has never been limiting for the sprat landing in the area.

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

There is no information on catches in number or weight in the catch for sprat in this ecoregion.

12.3 Fishery-independent information

PELTIC Acoustic Survey

An autumn Pelagic survey of the Celtic Sea (PELTIC) provided autumn biomass estimates for sprat from 2013–2015 (ICES, 2015). Basic survey design was comparable with the FSP survey although the coverage by PELTIC was extended further offshore and further west, including the waters north of the Cornish Peninsula (Figure 10.3.6, ICES 2015/SSGIEOM:05).

The survey estimates for 2013–2014 were similar, while a decrease in biomass of about 23% was observed in 2015 and a strong drop in biomass of 85 % in was recorded for 2016 (Table 12.3.3) for the Western English Channel. In 2012, both estimates (2011, and 2012) were re-computed using a new more robust Target Strength (TS) published for herring (Saunders *et al*., 2012), which has brought down the estimates but still shows a healthy population. The revised 2011 sprat biomass estimate is 33 861 tonnes and the estimate for 2012 is 27 971 tonnes.

FSP Acoustic Survey off the western English Channel

In October 2011 and 2012, two Fisheries Science Partnership (FSP) surveys were conducted covering the Lyme bay area where the main sprat population was thought to be concentrated during the onset of the fishing season (September–October). See description of the survey in the Stock Annex.

The estimated sprat biomasses were similar in both years. In 2012, both estimates (2011, and 2012) were re-computed using a new more robust Target Strength (TS) published for herring (Saunders *et al.*, 2012), which has brought down the estimates but still shows a healthy population. The revised 2011 sprat biomass estimate is 33 861 tonnes and the estimate for 2012 is 27 971 tonnes.

Biological data

Biological information from trawl catches carried out during the FSP acoustic survey where sampling information was available, suggested that most (73.1% by number) of the sprat were mature (spent), with 26.9% immature, and that the sex ratio slightly favoured females (59:41). Four age classes were identified: 0, 1, 2 and 3, contributing 1.5%, 8.9%, 70.1% and 19.4% to the population by number, respectively. Low numbers of the 0 and 1 age groups may be the result of gear selectivity. The observed low numbers of sprat age 4 and older could be the result of exploitation as the fishery targets the larger fish for human consumption. However, just three of the trawl hauls contained good samples of sprat, so it is equally possible that the age 4+ sprat were undersampled because of their different geographic distribution or behavior.

IBTS Q1 in the Eastern English Channel

Starting in 2006, the French in quarter 1 started to carry out additional tows in the Eastern English Channel as part of the standard IBTS survey. This proved successful and starting in 2007 the RV 'Thalassa' carried out 8 GOV trawls and 20 MIK stations.

During the IBTSWG in 2009, Roundfish Area 10 was created to cover these new stations fished by France and the Netherlands.

Data are stored in DATRAS database and available for the period 2007 to 2012.

12.4 Mean weight-at-age and maturity at age

No data on mean weight at age or maturity at age in the catch are available.

12.5 Recruitment

The various ground fish and acoustic surveys may provide an index of sprat recruitment in this ecoregion. However further work is required.

12.6 Stock Assessment

Sprat in the English Channel (Division 7.d–e)

An analytical assessment was carried out for sprat in the English Channel at WKSPRAT 2013 and requires further development prior to its acceptance.

12.6.1 Data exploration

Landings Per Unit of Effort

A data exploration for English Channel sprat was carried out in 2013 at the benchmark workshop WKSPRAT. An lpue time-series for English Channel sprat based on midwater trawlers data was constructed and updated in 2015 (Table and Figure 10.6.1). The lpue was based on data from a minimum of two < 15 m vessels that target sprat in the area for the whole time series until 2014; in 2015 only one vessel contributes to the LPUE which was therefore considered less reliable for providing advice and not used for this purpose. The vessels used in the index account for on average 95% of total landings for the area. The index includes searching time and time at sea with zero returns which are appropriate given sprat shoaling behavior. The sprat fishing season runs from August to March the following year. The lpue was computed from August to March the following year for consistency with the fishing season that starts when sprat appears on the grounds. If there were no landings in August or March, the effort in those months was excluded from the computation. An annual lpue was calculated as well, and was used for comparison with the acoustic survey.

Vessels considered for lpue calculations have been making use of standard sonar technology to locate the fish throughout the period of analysis and no other major technical advances need to be factored out. Concerns were expressed about using lpue as an index of abundance for sprat. However, the lpue series presented has been used as an indication of the stock development over the years, due to the long time series.

Sprat landings and effort data are available by ICES rectangle for the entire English Channel and for vessels operating a variety of gears both demersal and pelagic. The current lpue index uses data from a minimum of two vessels that target sprat. If an lpue index of abundance was to be derived based on landings from the entire English Channel and from the entire pelagic fleet effort should be standardized. Generalized linear models (GLMs; Nelder and Wedderburn, 1972) are frequently used to standardise catch and effort data. Results for English Channel sprat lpue index was presented this year.

Biomass Index

A pelagic survey was undertaken in Autumn in the western English Channel and Eastern Celtic Sea to acoustically asses the biomass of the small pelagic fish community within this area (divisions 7.e–g). This survey, conducted from the RV Cefas Endeavour, is divided into three geographically separated strata: the western English Channel, the Isles of Scilly and the Bristol Channel (Figure 12.6.2).

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.

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 two years, large schools in the Bristol Channel appeared to consist mainly of juvenile sprat, whereas those in the English Channel also included larger size classes. For more details on the survey design please refer to ICES 2015/SSGIEOM:05.

The biomass index from the PELTIC acoustic survey was used to provide advice on sprat in Division 7.d–e. The index was also used to provide an indication of the current harvest rate. The lpue information, on the other hand, were used to give a general indication of the stock development over time, but were not considered robust enough to base the advice on, due to the marked reduction in the number of fishing vessels operating in the area and to the general drawback of using catch per unit effort indicators for schooling species.

12.7 State of the Stock

Sprat in the English Channel (Division 7.d–e)

The lpue index presented (Table 12.6.1) shows an increasing trend since 2009 and then decreased in the last two years, however the number of vessels contributing to this index has decreased and is considered less informative for management and is no longer the basis for the advice. A short time-series of biomass estimates from the PELTIC survey was presented (Table 12.3.3): despite being a short time series, the acoustic survey covers a wider area (although it only focuses on the 7.e) compared to the one covered by the fishery, and it is considered more reliable for schooling species than a catch per unit effort index. The acoustic estimates for 2015-2016 show a strong drop in biomass in the most recent years compared to the previous ones.

CATCH ADVICE

Catch advice for 2018 is based on the acoustic estimates. Discards occur but are believed to be negligible, therefore the advice is for catch. The advice is based on category 3.2 (WKLIFE 2012) according to the data and analyses available. Those are four acoustic surveys (2013 and 2016) carried out in area 7.e which includes the area where the fishery takes place and a time-series of lpue (1988–2016). Data presented in 2017 showed a decrease in biomass for both the indices in 2015 and a strong drop in 2016 for the acoustic time series, while the lpue remained stable. ICES advice is for no more than 2354 tonnes.

12.8 Short term projections

No projections are presented for this stock.

12.9 Reference Points

No precautionary reference points are defined for sprat populations in this region due to uncertainty in stock definition.

An attempt was made to estimate reference points for this stock following ICES guidelines. Since no length frequency distribution are available for this stock, and since for category 3 short lived species a Biomass reference point ($B_{escapement}$) is required, the only possible option of the two available was to use SPiCT. Despite converging, the confidence intervals around the estimated variables from SPiCT were huge, indicating that the data are not informative and the results not reliable. A proposal to estimate a biomass reference point based on the acoustic biomass time series was made (see sprat in division 3a), but the group did not feel comfortable considering the length of the time series (4 years only), the fact that the survey most likely covers only part of the distribution of the stock (until new evidences will tell otherwise), and that no uncertainty around the estimation are provided. Quality of the Assessment

12.10Management Considerations

Sprat in the English Channel (Division 7.d–e)

Sprat is a short-lived species with large inter-annual fluctuations in stock biomass. The natural inter-annual variability in stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

The sprat has mainly been fished together with herring. The human consumption fishery only takes a minor proportion of the total catch. Within the current management regime, where there is a by-catch ceiling limitation of herring as well as by-catch percentage limits, the sprat fishery is controlled by these factors. Most management areas in this ecoregion do not have a quota for sprat. However, there is a quota in 7.d–e, English Channel, which has not been fully utilized.

Sprat annual landings from 7.d–e over the past 20 years have been 2926 tonnes on average. The 2015 annual landings of 3003 t constitute 16% of the 2015 acoustic estimate of sprat biomass when considering the Lyme Bay area only (23 451 t), while it is 6% when considering the entire surveyed area, estimated to be 60 011 t. However, the estimate for 2016 shows a different picture, with the total biomass estimated for the English Channel area equal to 9362 tonnes, with Lyme bay constituting about 80% of it and equal to 7625 tonnes. This brings the harvest rate equal to really high values: about 44% when considering the whole area, and 44% when considering Lyme Bay only.

The high LPUE values in the last few years suggested that a large component of the stock was available to the fishery in Lyme Bay, and as a consequence the exploitation rate increased. This perception is confirmed from the survey, that despite the low biomass estimated for this year, still sees the bulk of the sprat coming from Lyme bay. The drop in the last two years of the acoustic index, and the decreasing in the lpue index, could in part be due to the availability of sprat in the area, confirming the need to identify the boundaries for this stock, which are still unclear.

The harvest rate is indeed giving some worrying signs. However this perception is strongly dependent from an index that most likely covers only a part of the whole stock distribution. This problem is foreseen to be solved in the near future, with the extension of the survey to the eastern Channel.

12.11 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. A description of the Greater North Sea Ecoregion is given in ICES (2016).

Table 12.1.1 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2016 7.d–e.

Country	Denmark	France	Netherlands	Germany	UK - Eng+Wales+N.Irl.	UK - Scotland	Total
1985	0	14	0	0	3 771	0	3 785
1986	15	0	0	0	1 163	0	1 178
1987	250	23	0	0	2 441	0	2 714
1988	2 529	2	1	0	2 944	0	5 476
1989	2 092	10	0	0	1 520	0	3 622
1990	608	79	0	0	1 562	0	2 249
1991	0	0	0	0	2 567	0	2 567
1992	5 389	35	0	0	1 791	0	7 215
1993	0	3	0	0	1 798	0	1 801
1994	3 572	1	0	0	3 176	40	6 789
1995	2 084	0	0	0	1 516	0	3 600
1996	0	2	0	0	1 789	0	1 791
1997	1 245	1	0	0	1 621	0	2 867
1998	3 741	0	0	0	1 973	0	5 714
1999	3 064	0	1	0	3 558	0	6 623
2000	0	1	1	0	1 693	0	1 695
2001	0	0	0	0	1 349	0	1 349
2002	0	0	0	0	1 196	0	1 196
2003	0	2	72	0	1 368	0	1 442
2004	0	6	0	0	0 836	0	0 842
2005	0	0	0	0	1 635	0	1 635
2006	0	7	0	0	1 969	0	1 976
2007	0	0	0	0	2 706	0	2 706
2008	0	0	0	0	3 367	0	3 367
2009	0	2	0	0	2 773	0	2 775
2010	0	2	0	0	4 408	0	4 410
2011	0	1	37	0	3 138	0	3 176
2012	6	2	8	0	4 458	0	4 474
2013	0	0	0	0	3 793	0	3 793
2014	45	0	275	0	3 358	0	3 678
2015	0	1	346	0	2 657	0	3 003
2016	185	7	231	49	2 867	0	3 339

Table 12.3.1. Sprat in 7.d–e. Annual sprat biomass in ICES Subdivision 7.e (Source: Cefas annual pelagic acoustic survey).

Survey	Area	Season	2011	2012	2013	2014	2015	2016
Partial	Lyme Bay*	Oct	33,861	24,246	69,865	62,946	23,451	7,625
FSP	Lyme Bay**	Oct	33,861	27,971				
PELTIC	W Eng Ch	May	85,358					
PELTIC	W Eng Ch	Oct			75,546	77,800	60,011	9,362

Table 12.6.1. Sprat in 7.d–e. Landings per unit effort (lpue) for 3 vessels that target sprat. For 2015 and 2016, the year refers to the start of the season 1 August year (y) to 31 March in year (y+1). In 2017 both a seasonal and an annual LPUE have been estimated (the year refers to the 1st of January to 31st of December).

Year	HAWG 2015	HAWG 2016	HAWG 2017 (seasonal)	HAWG 2017 (annual)
1988	283	283	352	624
1989	668	682	737	395
1990	429	429	432	569
1991	528	528	529	481
1992	422	422	450	560
1993	630	630	661	850
1994	742	747	812	612
1995	599	599	673	899
1996	803	803	856	927
1997	868	868	842	601
1998	736	736	636	971
1999	970	970	922	844
2000	631	683	865	732
2001	508	521	749	944
2002	598	644	933	622
2003	352	375	591	841
2004	588	588	875	1108
2005	1 050	1 050	1118	1388
2006	992	992	1203	1059
2007	1 050	1 050	1125	945
2008	1 029	1 029	1000	890
2009	773	773	837	1388
2010	1 527	1 527	1546	1288
2011	1 042	1 042	1154	1709
2012	1 904	1 904	1786	1870
2013	1 933	1 933	1832	2225
2014	2 413	2 405	2407	1683
2015		2 221	1481	1765
2016*			1939	624

***The estimate in 2016 for the seasonal LPUE is provisional.**

Table 12.11.1. Sprat in 7.d–e. Catch/survey biomass ratio estimates from acoustic survey in 7.e.

Survey	Area	Season	2011	2012	2013	2014	2015	2016
Partial	Lyme Bay*	Oct	9%	18%	5%	6%	25%	44%
PELTIC	W Eng Ch	May	4%					
FSP	Lyme Bay	Oct	9%	16%				
PELTIC	W Eng Ch	Oct			5%	5%	5%	36%

* ICES rectangles 29E6, 30E6

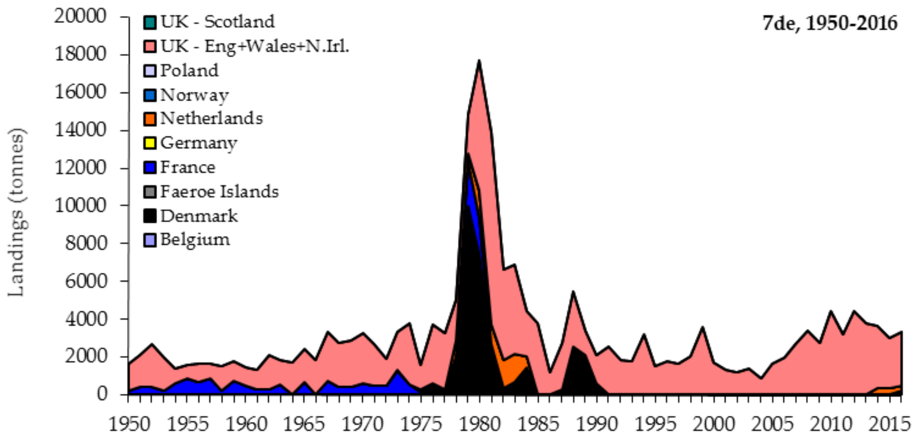


Figure 12.2.5. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2016 ICES Subdivisions 7.d–e.

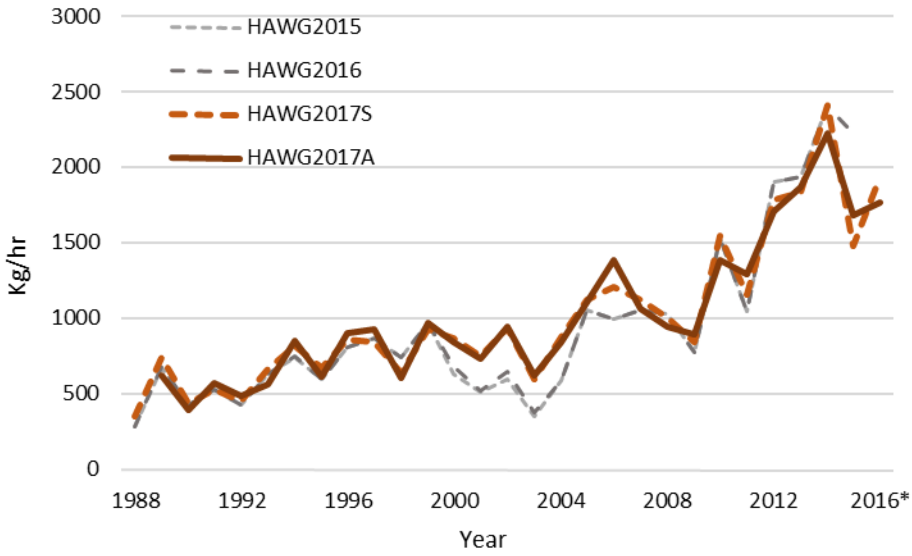


Figure 12.6.1. Sprat in 7.d–e. Lpue (kg/hr). Comparison between the series presented in 2015-2016 and the updated series in 2017 (HAWG 2017A=Annual, HAWG 2017S = seasonal). Note that the 2016 seasonal lpue is provisional because the season runs from 1 August to 31 March the following year.

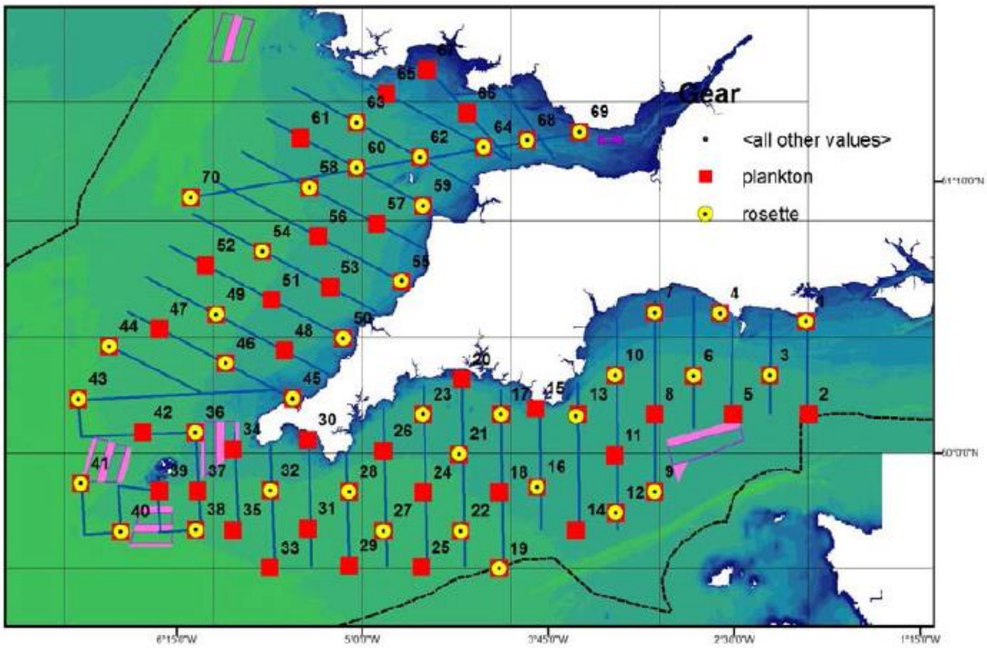


Figure 12.6.2. Sprat in 7.d–e. Survey design with acoustic transects (blue lines), zooplankton stations (red squares) and oceanographic stations (yellow circles).

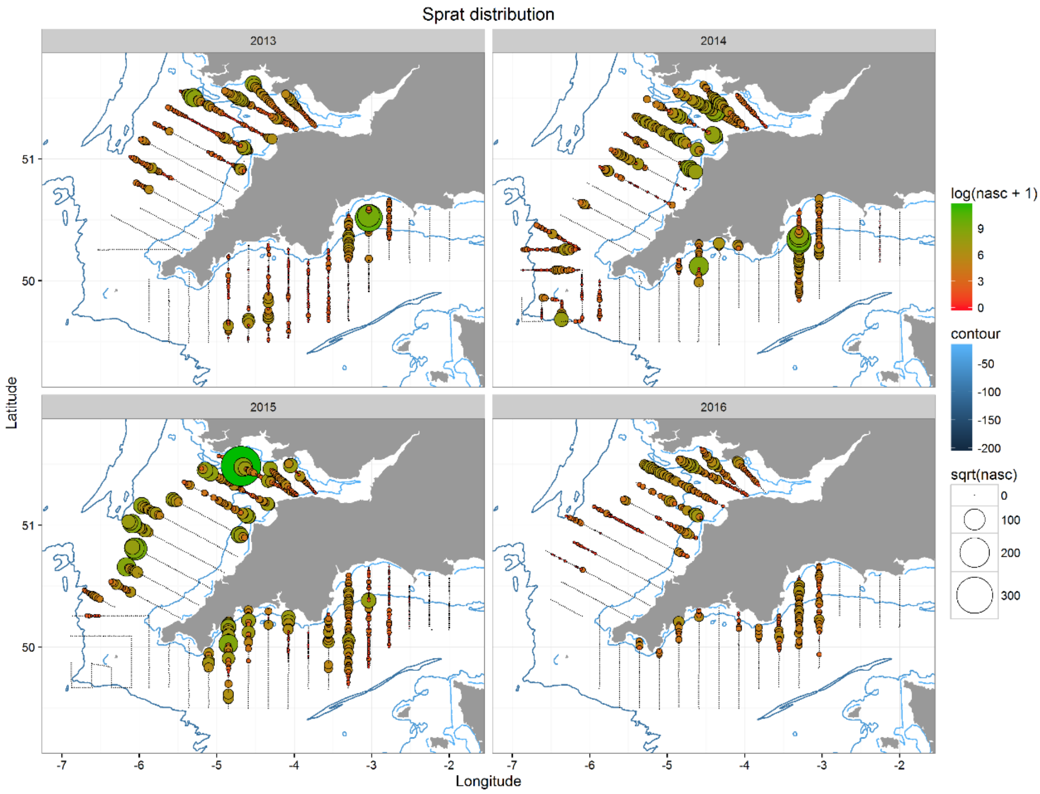


Figure 12.11.1. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October.

12.12 Audit of (Sprat in 7.d and 7.e)

Date: 20th March 2017

Auditor: Richard Nash

General

The English Channel sprat stock is primarily defined as sprat living in and caught in Lyme Bay (south coast of the Great Britain). The geographical limits of the unit stock are unknown and as such the dynamics of the fishery may reflect a small portion of a much large or widespread stock.

In regard to the general ToRs related to the advice, the report mentions the North Sea Ecoregion overview and the group contributed to the fisheries overview for this region. The development of this specific fishery is given in the stock annex and the report. It should be noted that the acoustic survey in this area actually straddles part of the Greater North Sea Ecoregion and the Celtic Seas Ecoregion and reflects the fact that this 'stock' is on the boundary between two Ecoregions.

The Stock Annex does not provide a succinct description of the assessment process (input etc) and refers to the LPUE index. However, the use of the LPUE index and the acoustic index was the agreed input data for the HAWG after the Benchmark (ICES 2013). This procedure was used up until the 2016 Working Group when it was decided to only use the acoustic index. This procedure with only the one index value was used again in 2017.

For single stock summary sheet advice:

The assessment consists of determining the abundance trends in the population of sprat that reside in a part of the English Channel, namely Lyme Bay. There are no age or length data for the catches in this area. The catch options are based on the previous years catch and the perceived change in stock abundance based on the acoustic survey. The estimation of reference points was attempted but this could not be finalized due to a lack of data.

1) **Assessment type:** update
2) **Assessment:** trends
3) **Forecast:** not presented
4) **Assessment model:** No model was used.
5) **Data issues:** In 2015 the LPUE index was not used due to the small number of vessels used (2 vessels). The same argument was used in 2016. The acoustic survey data which were available did not cover the whole area where English Channel sprat were caught. A subset of the acoustic data which corresponded with the location of the majority of the catches (Lyme Bay) were used for the development of the stock.
6) **Consistency:** The methodology used was consistent with last year, one additional year of the acoustic data were available.

7) **Stock status**: The survey index indicated a reduction in the sprat available for the fishery in the area of Lyme Bay. Even though not used, the LPUE also suggested a reduction in the availability of fish. The acoustic survey suggested a substantial decline in abundance. The absolute changes in stock abundance are not available from the acoustic survey.

8) **Management Plan**: There is no management plan for sprat in this area.

General comments

This was a well documented and well ordered section which was easy to follow and interpret.

Technical comments

There are no errors in the draft report. The 'assessment' follows the procedure last year. There is a need to update the stock annex to reflect the current assessment procedure.

Conclusions

The assessment has been performed correctly. There is little else that can be done with the assessment and projections at present until the stock can be defined and an adequate coverage of the distribution to provide a full evaluation of 'stock' abundance is undertaken. There appear to be plans to implement an extended acoustic survey for the majority of the English Channel area which will alleviate the problem of limited acoustic coverage of the area.

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 (6aN); in Donegal Bay (6aS); 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 solve the problem.

13.1 The Fishery

13.1.1 ICES advice applicable for 2017 and 2018

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 2017. 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.

Division 7.a

The main historic fishery was by Irish boats, in the 1970s, in the western Irish Sea. This was an industrial fishery and landings were high throughout the 1970s, peaking at over 8000 t in 1978 (figures 13.2.2–3). The fishery came to an end in 1979, due to the closure of the fish meal factory in the area. It is not known what proportion of the catch was made up of juvenile herring, though the fishing grounds were in the known herring nursery areas. In the late 1990s and early 2000s, UK vessels landed up to 500 t per year. In recent years a trial fishery for sprat was carried out by the vessels that fish herring in the area. This was carried out to investigate the feasibility of a clean commercially viable sprat fishery. The results of the trials were inconclusive and plans to conduct further experiments are under discussion.

Irish Landings from 1950–1994 may be from 7.aN or 7.aS. Very high catches in 7.aS were reported in 2012 (Table 13.1.3) with a decrease in 2013 and only 16 t reported in 2014. In 2015 the catches raised again to over 3500 t and dropped again to less than 1000 t in 2016. Despite the high catches registered in some years, those figures should be interpreted with caution because they may be over-estimated. No landings from 7.aN were reported in 2013 (Table 13.1.2), however there have been reported landings of 522 t in 2014, 771 t in 2015 and 150 t in 2016. With the exception of the last two years, recent Irish landings are mainly from 7.aS, predominantly from Waterford Harbour.

Divisions 7.b–c (West of Ireland)

Sporadic fisheries have taken place, mainly in Galway Bay and the Mouth of the Shannon. The highest recorded landings were in 1980 and 1981 during the winter of 1980/1981, when over 5000 t were landed by Irish boats (Table 13.1.4, Figure 13.2.4). This fishery took place in Galway Bay in the winter of 1980/1981 (Department of Fisheries and Forestry, 1982). Since the early 1990s landings fluctuated from very low levels to no more than 700 t per year in 2000. Zero catches were reported for 2016. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Divisions 7.g–k (Celtic Sea)

Sprat landings in the Celtic Sea from 1985 onwards are WG estimates. In the Celtic Sea, Ireland has dominated landings. Patterns of Irish landings in divisions 7.g and 7.j are similar, though the 7.j landings have been higher. Landings for 7.g and 7.j were aggregated in this report. Landings have increased from low levels in the early 1990s, with catches fluctuating between 0 t in 1993 and just under 4200 t in 2005 (Table 13.1.7). The average catches in the last 10 years were equal to 2548 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 09 (Sprat in subarea 7de).

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 three vessels under 15 m have actively target sprat and have been responsible for the majority of landings (since 2003 they took on average 96% of the total landings). In the most recent year only two of the vessels have been targeting sprat. Sprat is also caught by driftnet, fixed nets, lines and pots and most of the landings are sold for human consumption.

In Ireland, larger sprats are sold for human consumption whilst smaller ones for fish meal. Other countries mainly land catches for industrial purposes.

13.1.4 Regulations and their effects

There is a TAC for sprat for 7.d–e, English Channel. No other TACs or quotas for sprat exist in this ecoregion. Most sprat catches are taken in small-mesh fisheries for either human consumption or reduction to fish meal and oil. It is not clear whether bycatches of herring in sprat fisheries in Irish and Scottish waters are subtracted from quota.

13.1.5 Changes in fishing technology and fishing patterns

There is insufficient information available.

13.2 Biological Composition of the Catch

13.2.1 Catches in number and weight-at-age

There is no information on catches in number or weight in the catch for sprat in this ecoregion.

13.2.2 Biological sampling from the Scottish Fishery (6a)

Between 1985 and 2002 the fishery was relatively well sampled and length and age data exists for this period with some gaps. Unfortunately, the data is not available electronically at the present time.

Sampling of sprat in 6.a came to an end in 2003 and no information on biological composition of catches exists in the period 2003–2011. Sampling was resumed in 2012. A total of 8 landings were sampled in 2012 and a further 5 landings in 2013. It is anticipated that this sampling will continue in the future.

13.3 Fishery-independent information

Celtic Sea Acoustic Survey

The Irish Celtic Sea Herring Acoustic Survey was used to calculate sprat biomass. Biomass estimates for Celtic Sea Sprat for the period November 1991 to October 2014 are shown in Figure 13.3.1 and Table 13.3.1. However, the survey results prior to 2002 are not comparable with the latter surveys because different survey designs were applied.

Since 2004 the survey has taken place each October in the Celtic Sea. Due to the lack of reliable 36 kHz data in 2010, no sprat abundance is available for this year.

It can be seen that there are large inter-annual variations in sprat abundance. Large sprat schools were notably missing in 2006, and so no biomass could be calculated. The utility of this survey as an index of sprat abundance should be considered carefully (Fallon *et al*., 2012). Sprat is the second most abundant species observed from survey data. Sprat biomass over the time series up to 2009 is highly variable, more so than could be accounted for by 'normal' inter survey variability (Figure 13.3.1**)**. Biomass in

2015 is really high, while the value for 2016 dropped down again. This is in part due to the behaviour of sprats in the Celtic Sea which are often seen in the highest numbers after the survey has ended in November/December and again in spring during spawning. The survey is placed to coincide with peak herring abundance and is temporally mismatched with what would be considered sprat peak abundance.

Scottish Acoustic Surveys

A Clyde herring and sprat acoustic survey was carried out in June/July 1985–1990 and then discontinued (Figure 13.3.2 for coverage). Biomass estimates from all years as well as lengths and ages from some years are available from this survey but not presented here.

In 2012 this survey was reinstated as an October/November survey but results from the first survey are not available at the moment. Age and length distribution from this survey are in Figure 13.3.3. In 2013 the survey was cancelled due to technical problems. It is anticipated the survey will continue in the future.

Scottish IBTS surveys

The Scottish West Coast IBTS has been carried out in Q1 since 1981 to the present and in Q4 from 1991 onwards (Figure 13.3.2). Although the survey is a ground fish bottom trawl survey it does catch sprat throughout the survey area. The survey provides numbers at length per haul and aggregated age-length keys on a sub area basis. In the period 1981 to 2012 a total of 1434 hauls were completed and approximately half of these caught sprat. Not updated in the last three year (2013 to 2016).

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.

PELTIC Acoustic Survey

Please refer to section 09 (Sprat in subarea 7de).

FSP Acoustic Survey off the western English Channel

Please refer to section 09 (Sprat in subarea 7de).

IBTS Q1 in the Eastern English Channel

Please refer to section 09 (Sprat in subarea 7de).

13.4 Mean weight-at-age and maturity at age

No data on mean weight at age or maturity at age in the catch are available.

13.5 Recruitment

The various ground fish and acoustic surveys may provide an index of sprat recruitment in this ecoregion. However further work is required.

13.6 Stock Assessment

An analytical assessment was carried out for sprat in the English Channel at WKSPRAT 2013 and requires further development prior to its acceptance. Currently, the only assessment carried out in the Celtic ecoregion is for sprat in 7de and it is based on a survey index of biomass (Please refer to section 09 - Sprat in subarea 7de).

13.7 State of the Stock

Sprat in the English Channel (Division 7.d–e)

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 09 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 stock.

13.11 Management Considerations

Sprat is a short-lived species with large inter-annual fluctuations in stock biomass. The natural inter-annual variability in stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

The sprat has mainly been fished together with herring. The human consumption fishery only takes a minor proportion of the total catch. Within the current management regime, where there is a by-catch ceiling limitation of herring as well as by-catch percentage limits, the sprat fishery is controlled by these factors. Most management areas in this ecoregion do not have a quota for sprat. However, there is a quota in 7.d–e, English Channel, which has not been fully utilized.

13.12 Ecosystem Considerations

In the North Sea Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem, for both fish and seabirds. At present, there are no data available on the total amount of sprat, and in general of other pelagic species, taken by seabirds in the Celtic Seas Ecoregion.

The Celtic Seas Ecoregion is a feeding ground for several species of large baleen whales (O'Donnell *et al.*, 2004–2009). These whales feed primarily on sprat and herring from September to February.

Table 13.1.1 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2016, subarea 6a. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length. (tonnes)

Country	Denmark	Faeroe Islands	Ireland	Norway	UK - Eng+Wales+N.Irl.	UK - Scotland	Total
1985	0	0	51	557	0	2946	3554
1986	0	0	348	0	2	520	870
1987	269	0	0	0	0	582	851
1988	364	0	150	0	0	3 864	4 378
1989	0	0	147	0	0	1 146	1 293
1990	0	0	800	0	0	813	1 613
1991	0	0	151	0	0	1 526	1 677
1992	28	0	360	0	0	1 555	1 943
1993	22	0	2 350	0	0	2 230	4 602
1994	0	0	39	0	0	1 491	1 530
1995	241	0	0	0	0	4 124	4 365
1996	0	0	269	0	0	2 350	2 619
1997	0	0	1 596	0	0	5 313	6 909
1998	40	0	94	0	0	3 467	3 601
1999	0	0	2 533	0	310	8 161	11 004
2000	0	0	3 447	0	0	4 238	7 685
2001	0	0	4	0	98	1 294	1 396
2002	0	0	1 333	0	0	2 657	3 990
2003	887	0	1 060	0	0	2 593	4 540
2004	0	0	97	0	0	1 416	1 513
2005	0	252	1 134	0	13	0	1 399
2006	0	0	601	0	0	0	601
2007	0	0	333	0	0	14	347
2008	0	0	892	0	0	0	892
2009	0	0	104	0	0	70	174
2010	0	0	332	0	0	537	869
2011	0	0	468	0	248	507	1 223
2012	0	0	113	0	0	1 688	1 801
2013	0	0	487	0	0	968	1 455
2014	0	0	3	0	0	1 540	1 543
2015	0	0	1305	0	0	1 060	2 365
2016	0	0	431	0	0	2 177	2 608

Table 13.1.2 Sprat in the Celtic Seas Ecoregion. Irish landings of sprat, 1985–2016 from subarea 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 - Scot-land	Total
1985	668	0	20	0	688
1986	1 152	1	6	0	1 159
1987	41	0	0	0	41
1988	0	0	4	6	10
1989	0	0	1	0	1
1990	0	0	0	0	0
1991	0	0	3	0	3
1992	0	0	0	0	0
1993	0	0	0	0	0
1994	0	0	0	0	0
1995	0	0	30	0	30
1996	0	0	0	0	0
1997	0	0	2	0	2
1998	0	0	3	0	3
1999	0	0	146	0	146
2000	0	0	371	0	371
2001	0	0	269	3	272
2002	0	0	306	0	306
2003	0	0	592	0	592
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	771	0	0	0	771
2016	150	0	0	0	150

Table 13.1.3 Sprat in the Celtic Seas Ecoregion. Irish landings of sprat, 1985–2016 from subarea 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	1 696
2012	6 948
2013	3 082
2014	16
2015	3659
2016	935

Table 13.1.4. Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2016, from subarea 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	4
2012	23
2013	237
2014	0
2015	250
2016	0

Table 13.1.5 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2016, from subarea 7.d–e. (tonnes)

Country	Denmark	France	Nether-lands	Germany	UK - Eng+Wales+N.Irl.	UK - Scot-land	Total
1985	0	14	0	0	3 771	0	3 785
1986	15	0	0	0	1 163	0	1 178
1987	250	23	0	0	2 441	0	2 714
1988	2 529	2	1	0	2 944	0	5 476
1989	2 092	10	0	0	1 520	0	3 622
1990	608	79	0	0	1 562	0	2 249
1991	0	0	0	0	2 567	0	2 567
1992	5 389	35	0	0	1 791	0	7 215
1993	0	3	0	0	1 798	0	1 801
1994	3 572	1	0	0	3 176	40	6 789
1995	2 084	0	0	0	1 516	0	3 600
1996	0	2	0	0	1 789	0	1 791
1997	1 245	1	0	0	1 621	0	2 867
1998	3 741	0	0	0	1 973	0	5 714
1999	3 064	0	1	0	3 558	0	6 623
2000	0	1	1	0	1 693	0	1 695
2001	0	0	0	0	1 349	0	1 349
2002	0	0	0	0	1 196	0	1 196
2003	0	2	72	0	1 368	0	1 442
2004	0	6	0	0	0 836	0	0 842
2005	0	0	0	0	1 635	0	1 635
2006	0	7	0	0	1 969	0	1 976
2007	0	0	0	0	2 706	0	2 706
2008	0	0	0	0	3 367	0	3 367
2009	0	2	0	0	2 773	0	2 775
2010	0	2	0	0	4 408	0	4 410
2011	0	1	37	0	3 138	0	3 176
2012	6	2	8	0	4 458	0	4 474
2013	0	0	0	0	3 793	0	3 793
2014	45	0	275	0	3 358	0	3 678
2015	0	1	346	0	2 657	0	3 003
2016	185	7	231	49	2 867	0	3 339

Table 13.1.6 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2016, subarea 7.f. (tonnes)

Country	Netherlands	UK - Eng+Wales+N.Irl.	Total
1985	273	0	273
1986	0	0	0
1987	0	0	0
1988	0	0	0
1989	0	0	0
1990	0	0	0
1991	0	1	1
1992	0	0	0
1993	0	0	0
1994	0	2	2
1995	0	0	0
1996	0	0	0
1997	0	0	0
1998	0	51	51
1999	0	0	0
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	2	2
2008	0	0	0
2009	0	1	1
2010	0	7	7
2011	0	1	1
2012	0	2	2
2013	0	2	2
2014	0	1	1
2015	0	0	0
2016	0	1	1

Table 13.1.7 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2016, subarea 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	2 642	0	0	0	2 642
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	3 189	0	0	0	3 189

Table 13.1.8 Sprat in the Celtic Seas Ecoregion. Landings of sprat, 1985–2016. Total Landings, divisions 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	Den-mark	Faeroe Is-lands	France	Ireland	Isle of Man	Nether-lands	Norway		Spain	UK - England & Wales	UK - Scotland	Un. Sov. Soc. Rep.	Total
1985	0	0	14	3 964	0	273	557	0	0	3 791	2 946	0	11 545
1986	553	0	0	4 532	1	0	0	0	0	1 173	520	0	6 779
1987	519	0	24	2 230	0	0	0	0	0	2 441	582	0	5 796
1988	2 893	0	2	853	0	2	0	0	0	2 948	3 870	0	10 568
1989	2 092	0	10	1 163	0	0	0	0	0	1 521	1 146	0	5 932
1990	608	0	79	1 325	0	0	0	0	0	1 562	813	0	4 387
1991	0	0	0	205	0	0	0	0	0	2 571	1 526	0	4 302
1992	5 417	0	35	508	0	0	0	0	0	1 791	1 555	0	9 306
1993	22	0	3	2 353	0	0	0	0	0	1 798	2 230	0	6 406
1994	3 572	0	1	232	0	0	0	0	0	3 178	1 531	0	8 514
1995	2 575	0	0	799	0	0	0	0	0	1 546	4 124	0	9 044
1996	0	0	2	4 214	0	0	0	0	0	1 789	2 350	0	8 355
1997	1 245	0	1	2 085	0	0	0	0	0	1 629	5 313	0	10 273
1998	3 781	0	0	1 578	0	0	0	0	0	2 027	3 467	0	10 853
1999	3 064	0	0	5 826	0	1	0	0	0	4 014	8 161	0	21 066
2000	0	0	1	6 032	0	1	0	0	0	2 064	4 238	0	12 336
2001	0	0	0	455	0	0	0	0	0	1 716	1 297	0	3 468
2002	0	0	0	1 729	0	0	0	0	0	1 502	2 657	0	5 888
2003	887	0	2	4 948	0	72	0	0	0	1 960	2 593	0	10 462
2004	0	0	6	4 096	0	0	0	0	0	970	1 416	0	6 488
2005	0	252	0	5 928	0	0	0	0	0	2 239	0	0	8 419
2006	0	0	7	1 523	0	0	0	0	0	2 532	0	0	4 062
2007	0	0	0	3 745	0	0	0	0	1	2 708	14	0	6 468
2008	0	0	0	2 353	0	0	0	0	0	3 369	0	0	5 722
2009	0	0	2	3 773	0	0	0	0	0	2 774	70	0	6 619
2010	0	0	2	3 200	0	0	0	0	0	4 415	537	0	8 154
2011	0	0	1	3 935	0	37	0	0	0	3 399	507.3	0	7 879
2012	6	0	2	9 726	0	8	0	0	0	4 460	1 688	0	15 890
2013	0	0	0	5 453	0	0	0	0	0	3 795	968	0	10 217
2014	45	0	0	2 852	0	275	0	0	0	3 359	1 540	0	8 070
2015	0	0	1	9 307	0	346	0	0	0	2 657	1 060	0	13 371
2016	185	0	7	4 705	0	231	0	49	0	2 868	2 177	0	10 221

Table 13.3.1. Sprat in the Celtic Seas Ecoregion. Sprat biomass by year in the Celtic Sea (Source: MI Celtic Sea Herring Acoustic Survey, ICES, 2016).

Year	Biomass (t)
Nov/Dec-91	36 880
Jan-92	15 420
Jan-92	5 150
Nov-92	27 320
Jan-93	18 420
Nov-93	95 870
Jan-94	8 035
Nov-95	75 440
2002	20 600
2003	1 395
2004	14 675
2005	29 019
2008	5 493
2009	16 229
2011	31 593
2012	35 100
2013	44 685
2014	33 728
2015	83 779
2016	28 016

Table 13.3.2. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Subdivision 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				

Figure 13.1. Sprat in the Celtic Seas Ecoregion. Map showing areas mentioned in the text.

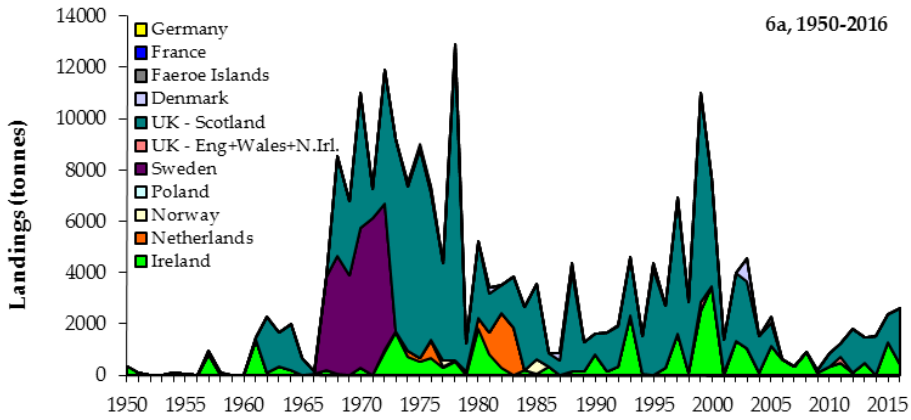


Figure 13.2.1. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2016 ICES Subdivision 6.a.

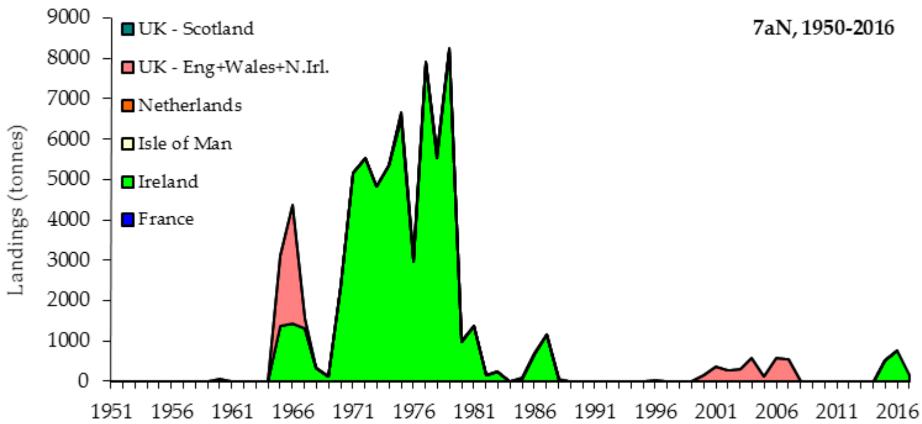


Figure 13.2.2. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2016 ICES Subdivision 7.aN. Note: Irish landings from 1973–1995 may be from 7.aN or 7.aS.

Figure 13.2.3. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2016 ICES Subdivision 7.aS.

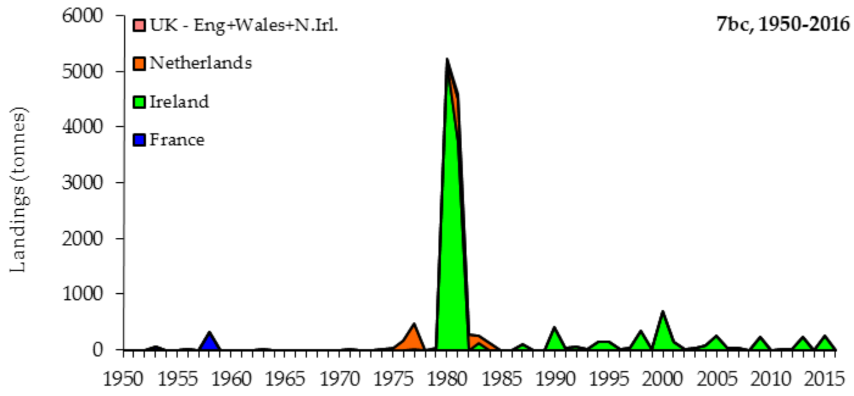


Figure 13.2.4. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2016 ICES Subdivisions 7.b–c.

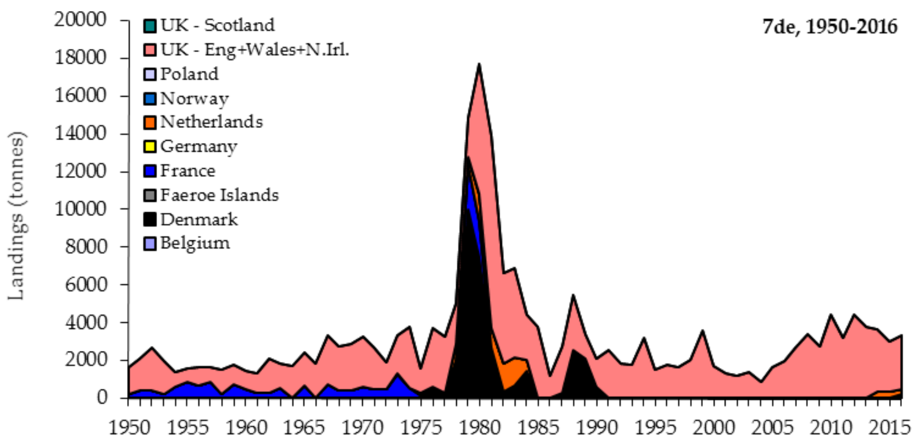


Figure 13.2.5. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2016 ICES Subdivisions 7.d–e.

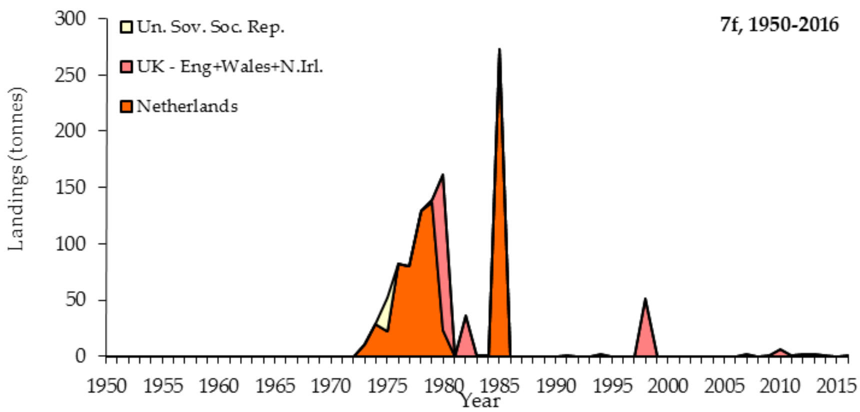


Figure 13.2.6. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2016 ICES Subdivision 7.f.

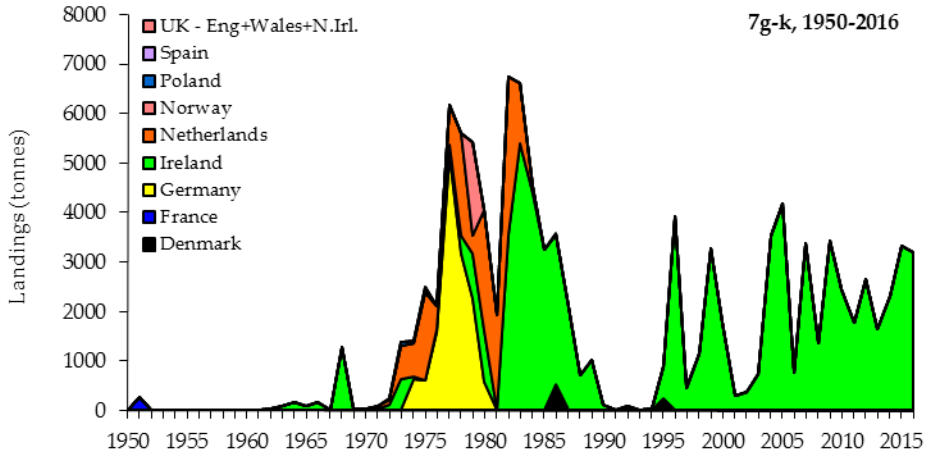


Figure 13.2.7. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2016 ICES Subdivisions 7.g–k.

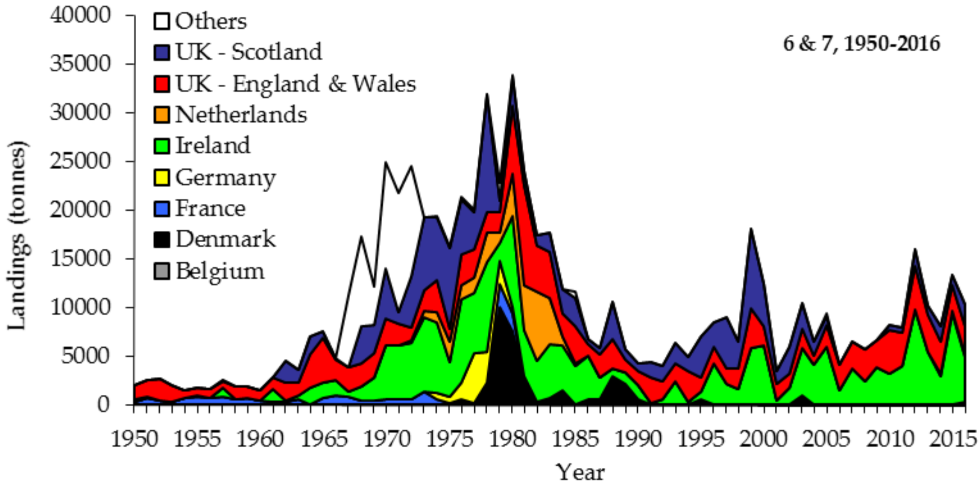


Figure 13.2.8. Sprat in the Celtic Seas Ecoregion. Landings of sprat 1950–2016 ICES divisions 6 and 7 (Celtic Seas Ecoregion).

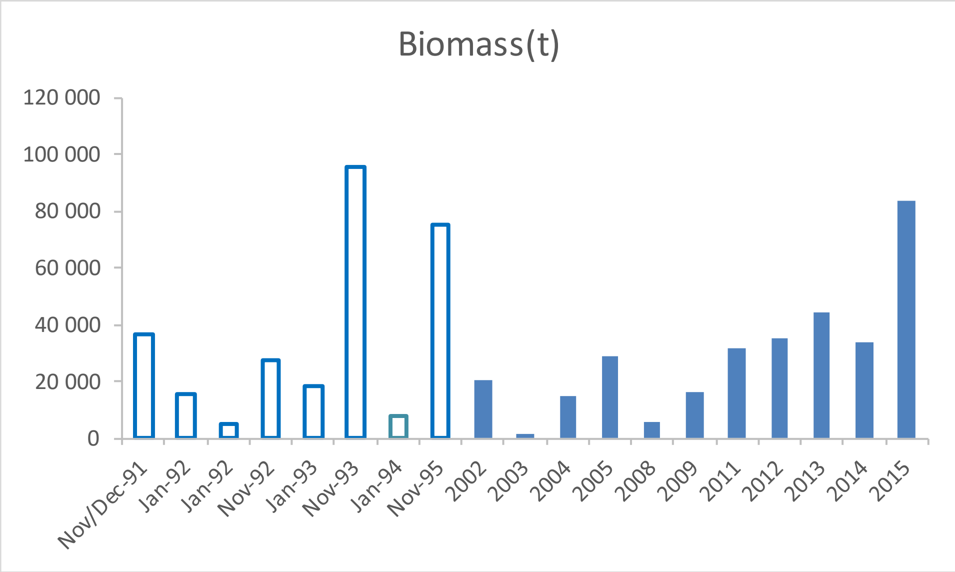


Figure 13.3.1. Sprat in the Celtic Seas Ecoregion. Estimated sprat biomass in the Celtic Sea. (Source: MI Celtic Sea Herring Acoustic Survey). Solid bars correspond to the period where the surveys are considered consistent.

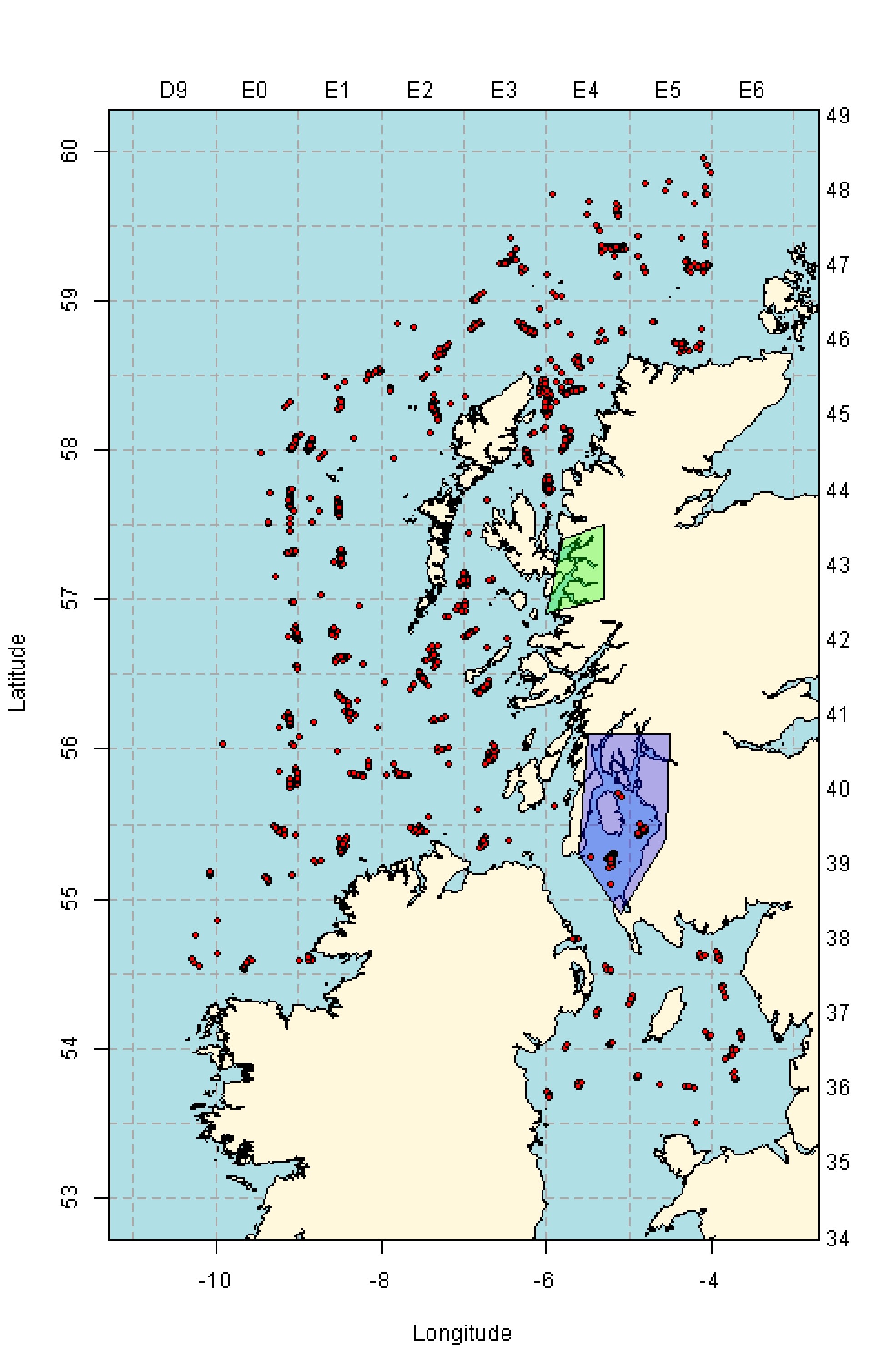


Figure 13.3.2: Extent of Scottish surveys that may provide information about sprat in 6.a. In purple is the extent of the Clyde Herring and Sprat Acoustic Surveys carried out in July between 1985 and 1989 and again in October 2012. In green is the extent of the Sea Lochs Surveys carried out annually in Q1 and Q4 between 2001 and 2005. Red markers indicate all hauls from the Q1 and Q4 Scottish West Coast IBTS between 1985 and 2012.

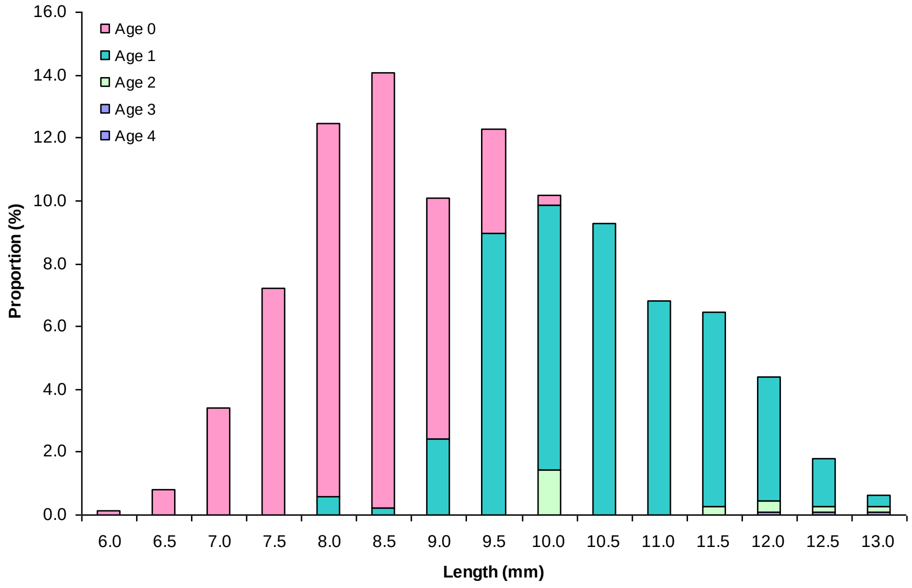


Figure 13.3.3. Length and age of sprat caught in the October 2012 Clyde Herring and Sprat Acoustic Survey. Data from six hauls were combined giving equal weight to the age and length distribution in each haul. 1442 sprat were measured and 182 were aged.

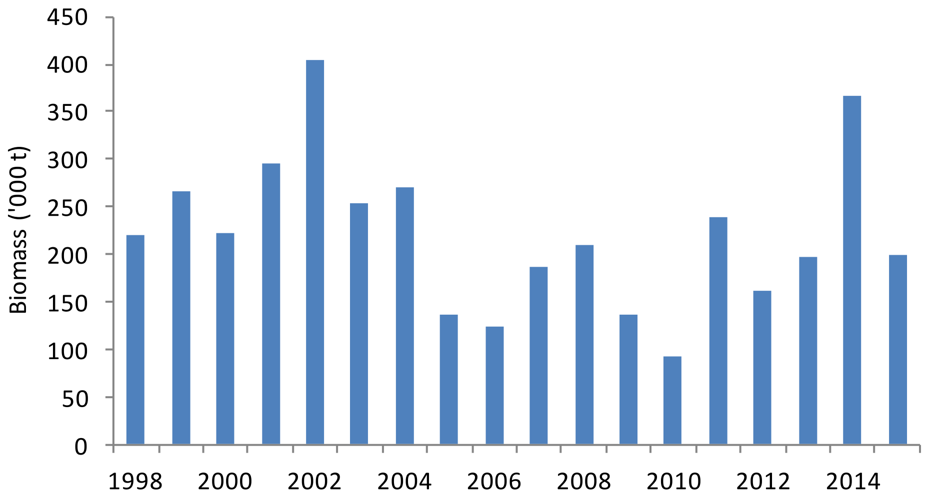


Figure 13.3.4. Sprat in the Celtic Seas Ecoregion. Annual sprat biomass in ICES Subdivision 7.aN.

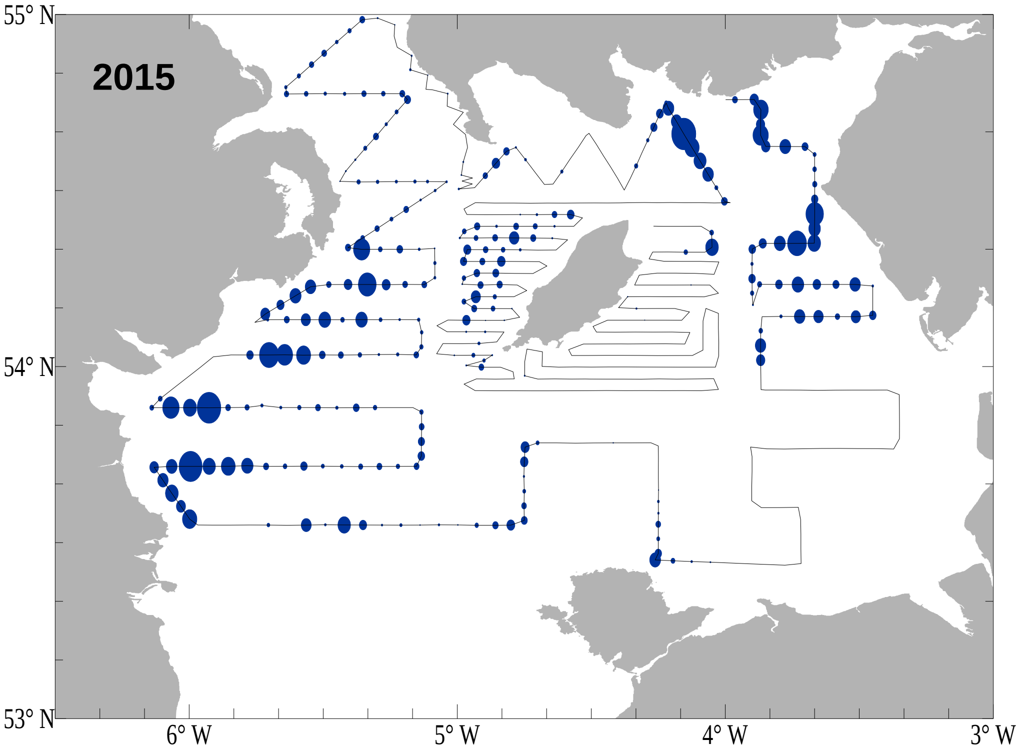


Figure 13.3.5. Sprat in the Celtic Seas Ecoregion. Sprat acoustic densities in ICES Subdivision 7.aN. Size of elipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval) for the UK (NI). September 2015 acoustic survey (AC(7.aN)) . Maximum density was 470 t n.mile^{-2}.

13.13 Audit of Sprat in subareas 6 and 7

Date: 22 March 2017

Auditor: Steven Mackinson

General

The Celtic Sea sprat stock cover divisions 6 and 7, with the exception of 7de. There is no TAC for this stock complex. Data on landings from fisheries around the area were checked since the units were previously reported incorrectly. Edits were made to the report Section 12 to make this clear.

For single stock summary sheet advice:

1) **Assessment type:** NON
2) **Assessment:** not applicable
3) **Forecast:** not applicable
4) **Assessment model:**
5) **Data issues:**
6) **Consistency:**
7) **Stock status**:
8) **Management Plan**:
9) General comments

Technical comments

Conclusions

There is no assessment

14 References

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ICES. 2013. Report of the Benchmark Workshop on Sprat Stocks (WKSPRAT), 11–15 February 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:48. 220 pp

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Annex 1 List of Participants

HAWG 2017, 14–22 March 2017, ICES HQ

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Annex 02 Recommendations

All recommendations have been uploaded to the ICES Recommendation database.

Recommendation	For follow up by:
1. HAWG recommends that SSGIEOM creates the new WGSINS (Working Group for Surveys of Ichthyoplankton in the North Sea and adjacent ecoregions) which will provide a location for planning the IHLS and new MIK type surveys for recruitment of the Downs component of the North Sea herring stock. This WG will also bring all the coordinators and survey personnel for the MIK and IHLS surveys together.	WGEGGS2, IBTSWG, WGIPS
2.a Molecular genetic work, as being conducted for 6a herring, should be extended to the Irish-Celtic Sea area. The work could be achieved on the back of the existing 6a studies, being coordinated by the PAC, with only modest increased costs.	Delegates of ICES, Pelagic Advisory Council, DG-MARE
2b. HAWG recommends the establishment of a new study group to conduct management strategy evaluation of western herring stocks	ACOM, SCICOM-SSGSUE
3. HAWG recommends to add screening and agree on methodology to record Ichtyophonus as a standard procedure in market and survey sampling	IBTSWG, WGIPS, PGDATA, WGBIOP, WKCATCH, WGPDMO
4. HAWG recommends that SSGIEOM creates the new WGSINS (Working Group for Surveys of Ichthyoplankton in the North Sea and adjacent ecoregions)	SSGIEOM
5. WGIPS to evaluate age 6 in the HERAS survey in the NSAS area.	WGIPS
6. WKMSYREF5 to evaluate biomass reference points methodology for short lived data limited stocks	WKMSYREF5
7. HAWG requests updated M-s from a North Sea key-run from WGSAM by the 15th of November. An explanation on the major changes compared to the previous key-run is requested.	WGSAM

Backgrounds for the recommendations

1) Some years ago WGNAPES and WGIPS were merged to create a large planning group for pelagic surveys. Over time WGIPS has developed into a group focussing on tasks and issues mainly related to acoustic surveys. As a consequence, at the WGIPS meeting in 2017, a recommendation was put forward that the International Herring Larvae Surveys (IHLS) should be transferred to a more dedicated Working Group that deals with ichthyoplankton survey planning and also delivers the necessary indices for assessment purposes. The reason for this recommendation is that IHLS, targeting early stages of North Sea herring larvae only and is using fundamentally different methodologies compared to the acoustic surveys dealt with by WGIPS. A possible solution is to replace WGEGGS2 with a new Working Group coordinating ichthyoplankton surveys in the North Sea. Proposed as Working Group for Surveys of Ichthyoplankton in the North Sea and adjacent areas (WGSINS). This new WG will take in the MIK and MIKeyM sampling in the 1st Quarter (IBTS), the new proposed MIK type survey in the spring of each year and the IHLS. This WG will have the remit (ToRs) which would allow other ichthyoplankton surveys in the North Sea and adjacent areas to be

added. It is important though that the MIK-coordinator is a member of both the new WG and the IBTSWG to ensure a close cooperation for the coordination and executing of the MIK-sampling during the 1st Quarter IBTS. Planning and presentation of the results of the MIK-sampling will remain in the IBTSWG reports. Matters concerning ichthyoplankton sampling and processing in the MIK survey would be dealt with at the WGSINS.

2) These recommendations arise from the recent benchmark of Irish Sea herring in WKIRISH.

WKIRISH did not reach consensus on the final formulation of the Irish Sea herring assessment. Upon recommendation of the ACOM Leadership, the matter was forwarded to a sub-group of HAWG for further consideration. Though the sub-group did not reach consensus it agreed on a process for moving forward. This process entails further work to ensure that any potential bias in the Irish Sea herring assessment does not lead to inappropriate management advice. The discussion centres on how the assessemnt may not be reliable as an estimator of stock size in the Irish Sea, due to contamination with fish from other stocks known to be present at that time in Manx waters It was recognised by the sub-group that mixing is a problem for herring surveys around the Isle of Man, the fisheries independent data are probably no more contaminated than the fisheries dependent data.

3) Ichtyophonus: *Ichthyophonus hofer*i is a parasite found in fish. It has a low host-specifity, 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 & 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 (Mel-lergaard and Spanggaard 1997), and in 2008-2010 for Icelandic summer-spawning her-ring (Óskarsson and Pálsson 2011). A time series of the Norwegian data on Ichthyophonus was prepared for HAWG2017, and the occurrence is usually below 1%, except for the beginning of the 1990ies. In the Norwegian part of IBTSQ1, however, high occurrences were again observed (Figure 1.3.5.1). This led to a recommendation for all countries to screen herring for Ichthyophonus during the IBTS surveys (both Q1 and Q3) and HERAS, as well as for the commercial sampling.

4) HAWG recommends that SSGIEOM creates the new WGSINS (Working Group for Surveys of Ichthyoplankton in the North Sea and adjacent ecoregions) which will provide a location for planning the IHLS and new MIK type surveys for recruitment of the Downs component of the North Sea herring stock. This WG will also bring all the coordinators and survey personnel for the MIK and IHLS surveys together.

5) diagnostics of the survey show observations consistently larger than expected based on population dynamics. A check is requested to validate the information on age 6

6) reference point methodology is usually available for longer lived data limited stocks. These methods rely on a certain degree of stationarity in the stock which is not appropriate for short lived species. In addition, there is high autocorrelation in the data which needs to be accounted for to estimate reference points. This is currently lacking from the methods.

Annex 03: ToRs for next meeting

HAWG – Herring Assessment Working Group for the Area South of 62ºN

2017/x/ACOMxx The **Herring Assessment Working Group for the Area South of 62ºN** (HAWG), chaired by Susan Lusseau, UK, and Valerio Bartolino, Sweden, will meet at ICES Headquarters: 12-20 March 2018 to:

a) compile the catch data of North Sea and Western Baltic herring on 12–14 March;

b) address generic ToRs for Regional and Species Working Groups 14-20 March for all other stocks assessed by HAWG.

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

Material and data relevant for the meeting must be available to the group no later than 14 days prior to the starting date.

HAWG will report by XX April 2018 for the attention of ACOM.

Annex 4: List of Stock Annexes

The table below provides an overview of the HAWG stock annexes. Stock Annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year*, *ecoregion*, *species*, and *acronym* of the relevant ICES expert group.

Stock ID	Stock name	Last updated	Link
her.27.3a47d	Herring (*Clupea harengus*) in Subarea 4 and divisions 3.a and 7.d, autumn spawners (North Sea, Skagerrak and Kattegat, eastern English Channel)	March 2017	her-47d3
her.27.6a7bc	Herring (*Clupea harengus*) in divisions 6.a and 7.b–c (West of Scotland, West of Ireland)	February 2015	her-67bc
her.27.20–24	Herring (*Clupea harengus*) in subdivisions 20–24, spring spawners (Skagerrak, Kattegat, and western Baltic)	2016	her-3a22
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)	February 2015	her-irls
her.27.nirs	Herring (*Clupea harengus*) in Division 7.a North of 52°30′N (Irish Sea)	June 2017	her-nirs
san.sa.1r	Sandeel (*Ammodytes* spp.) in divisions 4.b and 4.c, Sandeel Area 1r (central and southern North Sea, Dogger Bank)	November 2016	san-ns1
san.sa.2r	Sandeel (*Ammodytes* spp.) in divisions 4.b and 4.c, Sandeel Area 2r (central and	November 2016	san-ns2

Stock ID	Stock name	Last updated	Link
	southern North Sea)		
san.sa.3r	Sandeel (*Ammodytes* spp.) in divisions 3.a, 4.a, and 4.b, Sandeel Area 3r (Skagerrak and Kattegat, northern and central North Sea)	November 2016	san-ns3
san.sa.4r	Sandeel (*Ammodytes* spp.) in divisions 4.a and 4.b, Sandeel Area 4 (northern and central North Sea)	November 2016	san-ns4
san.sa.5r	Sandeel (*Ammodytes* spp.) in Division 4.a, Sandeel Area 5r (northern North Sea, Viking and Bergen banks)	November 2016	san-ns5
san.sa.6r	Sandeel (*Ammodytes* spp.) in Subdivision 21, Sandeel Area 6 (Kattegat)	November 2016	san-ns6
san.sa.7r	Sandeel (*Ammodytes* spp.) in Division 4.a, Sandeel Area 7r (northern North Sea, Shetland)	November 2016	san-ns7
spr.27.3a	Sprat (*Sprattus sprattus*) in Division 3.a (Skagerrak and Kattegat)	February 2013	spr-kask
spr.27.4	Sprat (*Sprattus sprattus*) in Subarea 4 (North Sea)	February 2013	spr-nsea
spr.27.7de	Sprat (*Sprattus sprattus*) in divisions 7.de (English Channel)	February 2013	spr-eche
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)	February 2013	spr-celt

Annex 05 Benchmarks

1) Celtic Sea Herring

Stock	**Celtic Sea Herring**	
Stock coordinator	Name: Afra Egan	Email: afra.egan@marine.ie
Stock assessor	Name: Mike O'Malley	Email: michael.omalley@marine.ie
Data contact	Name: Graham Johnston	Email: graham.johnston@marine.ie

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	Responsible expert from WG	External expertise needed at benchmark type of expertise / proposed names
(New) data to be Considered and/or quantified					
Tuning series	Observed shift in distribution of herring from 2014 onwards and hence different availability to survey methodology	Consider alternative ways to derive an index post 2014. Need an assessment formulation that can deal with alternating states of nature e.g. pre and post 2014	Yes, from Irish Marine Institute	Mike O'Malley	Expertise in review and evaluating utility of herring surveys in light of changing fish behaviour Mike Power or Gary Melvin (Canada)
Discards					
Biological Parameters	Could there be other factors explaining mortality of herring?	What has been the development in body condition of herring	Length and weight data from commercial fisheries and surveys.	Mike O'Malley	
Fisheries & ecosystem issues and data					

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	Responsible expert from WG	External expertise needed at benchmark type of expertise / proposed names
Assessment method	Can assessment model cope with observed shift in distribution of herring from 2014 onwards. Shifts in selection apparent in catch at age	Model change in catchability in the survey. Compare age compositions in catch and survey time series. Blocking for separate separability periods or varying selection	Yes, from Irish Marine Institute	Mike O'Malley	Expertise in reviewing the ASAP model Tim Miller, Chris Legault (USA),
Biological Reference Points	Possibly may need updating	Possibly may need updating	None	Mike O'Malley	
Other					

2) North Sea Autumn Spawners

Stock	North Sea Autumn Spawners (her-47d3)	
Stock coordinator	Name: Norbert Rohlf	Email: Norbert.Rohlf@thuenen.de
Stock assessor	Name: Niels Hintzen	Email: niels.hintzen@wur.nl
Data contact	Name:	Email:

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Fisheries data	1.: Reconstruction of discards of the entire fleet is required 2. catch data by fleet, as far back as possible (NR) 3. catch data by spawner type (RN, HM, NH, SL,NR, investigate what is available, not to be used as quantitative data in assessment) 4. Define time of fishery per year, get cumulative distribution by week for all years, two strata to separate out Downs (RN, SL, JSE, VB, NR, NH) 4.a Get start of eggs in Rugen factory / vessels (CRS, MP) for start of spawning 4.b start of spawning from larvae data (NR) 5. Consider mixing of WBSS herring in the North Sea (See issue-list WBSS, modelling split, RN)	1. Request discard time-series raised to fleet by all nations fishing for NSAS 2. prepare catch-at-age matrix by fleet 3. estimate spawner type per age and year 4. Logbook analyses by country and week 5.	1. Data requested from all nations fishing for NSAS 2. Data already available back to 1992 3. Data not available yet 4. Data available by nations 5.	Henrik Mosegaard (DNK)

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Tuning series Discards Biological Parameters	1: As the Downs component varies in size, the IBTS0 (MIK) should include this component or it should be corrected for in the assessment (NH) 2: temporal coverage of the southern north sea IHLS needs to be re-evaluated (NH) 3: The use of other age-classes of the IBTS survey needs to be investigated, including appropriate modelling the IBTS index series (CB) 4. Best-practice in predicting natural mortality for years where no multi-species assessment is available needs to be investigated (already available) 5. Consider effect of decreased growth in herring during the past decades (MP)	1a. investigate potential to have a dedicated recruitment survey on the Downs component 1b. Utilise 0-group herring otoliths from Q3 IBTS to distinguish spawning stocks and estimate contribution of autumn and winter spawners to recruitment 2. investigate the need to survey 3 weeks at the Downs component 3. prepare IBTS indices for all age-classes available from DATRAS, statistical modelling of IBTS data 4. Recommendation to WGSAM 5. Evaluate impact on l@age and w@age	1.1.1.1 1a. NA 1b. Samples requested from Q3 IBTS participants and analyses and data requested from DTU (and Thuenen?) 2. Data already available 3. Data already available 4. NA 5. Data already available	Matthias Kloppmann (Ger), Richard Nash (Nor), Cindy van Damme (NL, recruitment survey?), Henrik Mosegaard (DNK) Anna Rindorf,

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Assessment method	1. The use of the SCAI indices in the stock assessment need to be evaluated (update assessment model)(NH) 2. Modify the assessment methodology to separate autumn from winter spawners (age 0)(NH) 3. Modify the assessment to allow fleet-wise selection to be estimated (NH) 4. Timing of fishery in relation to autumn-winter (BB) 5. Predict within year B-fleet bycatch (CRS)	1. Embed the state-space-model currently used to generate the SCAI index in the assessment model 2. Differentiate between autumn and winter spawner at age 0 in the assessment model to fit the IBTS0 index appropriately 3. Modify the assessment model to allow for multiple commercial fleets	1. Already available 2. Need to be developed from scratch 3. Already available	Anders Nielsen (DNK)
Biological Reference Points	1. Investigate reference points under benchmarked assessment outcomes and in relation to the management plan (MP, NH) 2. Evaluate effect of 3-yearly updates on M (SM, BB)	1. Calculate new reference points based on assessment results, following ICES protocol	1. Methods are available	ICES professional secretaries (e.g. Arni Magnusson, David Miller)

3) Western Baltic Spring Spawners

Stock	Western Baltic Spring Spawners (her-3a22)	
Stock coordinator	Name:	Email:
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Data contact	Name:	Email:

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Fisheries data	1. Reconstruction of discards of the entire fleet is required (no good data available, description only) 2. Consider mixing of WBSS herring in the North Sea (split workshop used as input)(HM) 3. Mixing of WBSS and Central Baltic herring (CBH) in catches (TG,VB) 4. Borrowing biological samples among fleets/countries/quarters/areas in IIIa; need for more sound and transparent routines (preparatory work to get data combined + length distributions)(KBH,VB)	1. Request discard time-series raised to fleet by all nations fishing for WBSS 2. Scrutinize data from the 'transfer area' 3. The mixing in catches and its variability in time is unknown, but it is expected to change as a function of variable distributions of the two stocks as well as variability in the spatial and temporal distribution of the fisheries. 3a.apply the separation function to all the countries with catches in SD24? Can it be extended to account for mixing also in SD25? 4a. improve sampling design, ie proportional between sampling and landing 4b. explore spatial-temporal patterns of biological parameters	1. Data requested from all nations fishing for WBSS 2. Include NOR in the datamining 3. Tomas Gröhsler?? 4. biological samples from all coutries	Tomas Gröhsler (GER), Valerio Bartolino (SWE), Cecilie Kvamme (NOR), Richard Nash (NOR), Lotte Worsøe Clausen (DNK)

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Tuning series Discards Biological Parameters	1. Status of N20 environmental relation and possibly a new index (PP) 2. Survey indices (acoustic (HERAS) and IBTS) are not split into stock components (CB,VB) 3. Spatial coverage of stock component sampling (new descriptive information with genetics) (DB,HM) 4. WBSS stock components are more than just Rügen; what dimensions do the other components have in the overall stock? (see 3) 5. Age and size at age (ageing comparison, descriptive purposes) (JC, HM) 6. Constant natural mortalities are currently used (only use simple scaling) 7. Constant maturity ogives are currently used/Fecundity (JT,FV,VB) 8. Get index of MIK for IIIa (winter spawning component, small larvae contribution)(MK)	1. Evaluate if the N20 can contain all our knowledge of larvae in the area (recent research; larval drift models, other components, etc.) 2. Split of survey dataseries based on a modelled split 3. Pick up on analysis done in WKWATSUP 4a. Investigative model of growth and maturity of components 4b. Precision of stock separation methodologies (including also the CBH issue) 4c. Migration and mixing (modelling spatio-temporal resolution) 5. Revision of the precision of ageing and the sampling for age structures 6. Revision of natural mortalities 7. Revision of maturity ogives; probability of spawning: We need a time series for an annual varying maturity ogives to have an effect.	1. Old data (litt); recent research on spawning components. Data should be available and supplied by survey groups (IBTSWG and WGIPS, MuPED). Drift models of herring larvae 2. Data available – model needed 3. Data available 4. Data available; WKSTOCKID (2017) will provide precision of methods; Clausen et al., 2015 as off-set on migration discussion 5. Age-calibration prior to WKPELA (recommendation to WGBIOP 2017) 6. Check with Stefan N 7. given its limits IBTS.Q1?	Dorte Bekkevold, Bastian Huwer, Asbjørn Christiensen (DNK) Henrik Mosegaard (DNK) Casper Berg (DNK) Anna Rindorf (DNK) Mathias Kloppmann (GER)

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Assessment method	1. Investigate the impact on the assessment results given the outcomes of the input data analyses as proposed under Tuning Series and Biological data (VB, AN) 2. Can the components of WBSS be considered in the assessment model? (no model available) 3. Analysis of any retrospective bias (VB, AN,HM) 4. Forecast methodology (bycatch in B-fleet in advice year) (VB,HM) 5. Multifleet assessment model (NH)	1. 2. Can migration and mixing be dealt with in forecasting on the stock (components); Linked stock-approach? 3. 4. Should we explore stochastic forecasting? 5. multifleet assessment model?	1. 2. 3. 4.	Anders Nielsen/Christoffer Moesgaard (SNK) Morten Vinther (DNK)
Biological Reference Points	1. Investigate reference points under benchmarked assessment outcomes and in relation to the management plan (VB, NH) 2. High sensitivity to SR model selection and inclusion of new observations in the time series influence Fmsy for WBSS (VB, NH).	1. Calculate new reference points based on assessment results, following ICES protocol 2. Further scrutinising of Fmsy is needed for WBSS, together with an evaluation for a long term management plan for the stock.	1. Methods are available 2.	ICES professional secretaries (e.g. Arni Magnusson, David Miller)

Annex 06 Working Documents

1. Working Document to the ICES Herring Assessment Working Group, March 2017.

The raising of catch data from the 2016 her-6a7bc monitoring fishery in 6aN.

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**Scottish Pelagic Fishermen's Association (SPFA)

Purpose

This documents sets out the process used to generate the catch matrix for 6aN herring from commercial catches taken during the 2016 monitoring fishery.

Introduction

During the ICES benchmark workshop on herring west of the British Isles (WKWEST, ICES 2015a), the previous separate stock assessments for 6aN herring and 6aS/7bc herring were merged into one combined assessment. The outcome from the first assessment on this combined stock was that ICES advised a zero TAC for 2016 and recommended that a stock recovery plan be developed (ICES 2016a).

In its 2015 autumn plenary, the Scientific, Technical and Economic Committee for Fisheries (STECF) recommended that it would be beneficial to maintain an uninterrupted time series of fishery-dependent catch data. In response to the subsequent special request (to ICES) by the European Commission, ICES provided advice on the size and remits of a scientific monitoring fishery for herring in ICES divisions 6.a, 7.b, and 7.c (ICES 2016b).

Specifically it advised that the number of samples to be collected in a monitoring fishery in 6a/7bc was 46 and that these samples could be obtained through a catch of 4 840 t [6aN – 29 samples for 3 480 t; 6aS,7bc – 17 samples for 1 360 t]. Furthermore, the data should be collected in a way that (i) satisfies standard length, age, and reproductive monitoring purposes by EU Member States for ICES, and (ii) ensures that sufficient spawning-specific samples are available for morphometric and genetic analyses for stock splitting purposes as agreed by the Pelagic Advisory Council monitoring scheme 2016 (Pelagic Advisory Council, 2016).

Subsequent to ICES advice EU Council regulation (EU 2016/0203) made provision for a scientific monitoring TAC of 4 170 t in 6aN and 1 630 t in 6aS/7bc.

Implementation of the monitoring fishery resulted in the 6aN TAC being split equally between 5 large pelagic vessels and the 6aS TAC being split between numerous small inshore vessels. An industry/science collaborative scientific survey program was implemented in tandem with the monitoring fishery to coordinate the collection of information for studies facilitating the return to individual assessments of the two stocks in the future (morphometric and genetic sampling for stock splitting, acoustic surveys on spawning aggregations for estimating relative size of each stock component). A discard derogation was granted to the vessels during the period of the scientific survey work to account for any by-catch of other species and herring catches that could not be landed in marketable condition. This particularly being the case for the 3 Scottish refrigerated-sea-water (RSW) vessels due to logistical constraints.

Biological data was collected onboard from commercial hauls taken in the monitoring fishery (either during or immediately after the scientific survey period) and were used to generate a catch-at-age-matrix for 6aN herring. A few of the landings taken outside the survey period when vessels were fishing their allocated quota were sampled at the market through the national market sampling programmes run by Marine Scotland Science and Marine Institute, Ireland.

The scientific survey

Utilising ICES advice on the monitoring fishery (ICES 2016b), four areas were selected for surveying in 6aN (Figure 1), the limits of which were defined by the geographic distribution of known active herring spawning areas and records of commercial catches (ICES, 2016b). Areas 2-4 are considered to be active spawning areas and Area 1 a pre-spawning aggregation area that contains an unknown mixture of stocks of Western and potentially North Sea herring, where a large proportion of catches has been taken in recent years (ICES 2016b).

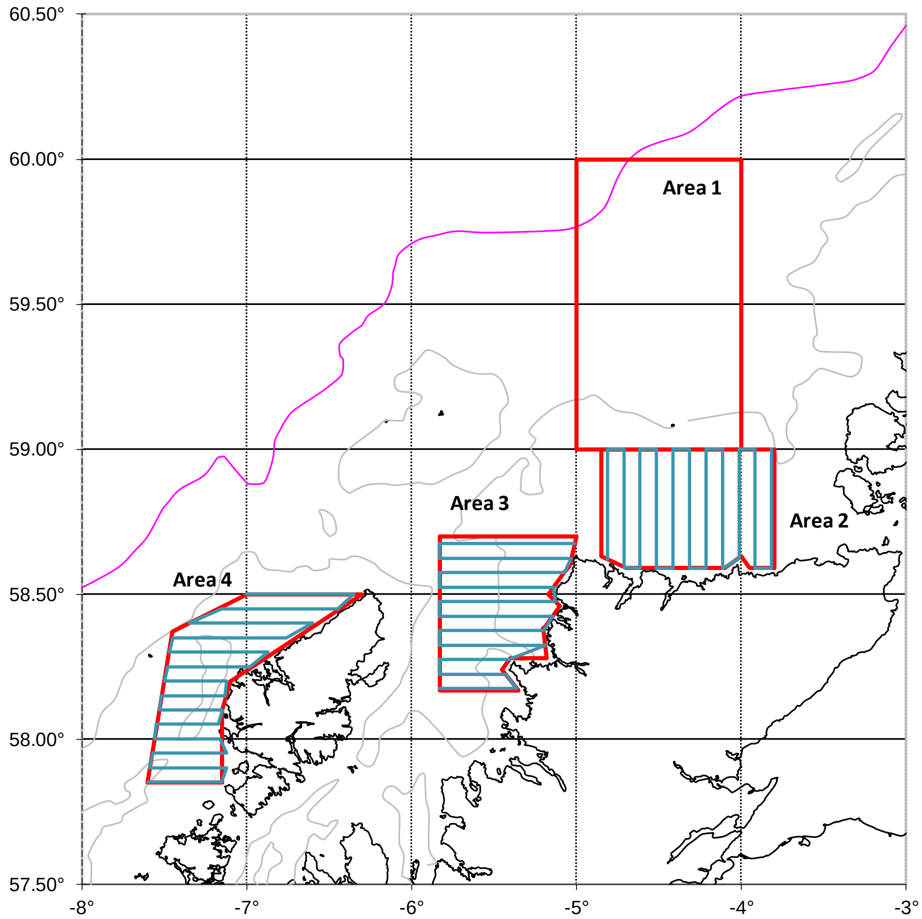

Figure 1. Limits of survey areas used in the 6aN surveys. Area 1- North pre-spawning mixing area, Area 2 - East of Cape Wrath, Area 3 – West of Cape Wrath, Area 4 – Outer Hebrides.

During the scientific survey work a total of 68.4 t of non-target species was caught of which 16.3 t was discarded along with 49.3 t of herring; 3.5 t during acoustic surveys in area 3 and 4 and the remainder (45.8 t) during sampling for morphometric and genetic stock separation studies (Table 1).

Catch-at-age data sources

Commercial catches caught either during or after the scientific survey work carried out in Q3 were sampled and the data used to generate the catch matrix for 6.aN (Table 2). The small non-retained herring catches taken by the 3 Scottish vessels, either during the acoustic surveys in area 3 and 4, or sampled for morphometric and genetic studies during the dedicated survey are not considered representative of commercial fishing activity and as such are not comparable with commercial catch data used in previous years assessments.

No commercially viable aggregations were encountered in area 4 during the survey period and none of the vessels returned to this area for commercial fishing.

Most commercial catches taken by vessels participating in the monitoring fishery apart from one were sampled. The missed catch sampling was from one trip that happened to take a substantial catch in area 1 (849 t; Table 6) during a trip were no biological sampler was on board.

Smaller amounts of herring landings were reported outside of the areas specified in the advice and outside of quarter 3 (Annex 1). These catches were not sampled and the majority of them were not taken through the monitoring fishery agreement, but were “banked” from the 2015 fishery and used to offset bycatch of herring in the horse mackerel fishery. Catches by Ireland in Q4 were sampled by the Marine Institute, Ireland and have been used to collate the catch matrix. They were raised to total catch for the Irish fleet in Q4 in area 6aN by the Marine Institute and were allocated to unsampled quarter 4 catches reported by other nations (Table 4).

Data collation/raising

Samples collected during the monitoring fishery were used to produce a raised estimate of catch numbers-at-age (CANUM) and mean weight-at-age in the catch (WECA) for 6aN to be used in the ICES stock assessment of herring in 6a,7b-c. Estimates of mean length-at-age was also calculated. The decision not to include the biological data from samples of the discarded catch of RSW vessels resulted in a reduction of samples available for use in the raising process for 6aN herring from 39 to 22.

Detailed information on catches from the vessels involved in the monitoring fishery were made available from the vessels and the respective national databases. Information on catches taken outside of the 2016 monitoring fishery were obtained through the ICES official data call as total catches by ICES statistical rectangle by quarter.

Exploratory diagnostics were performed on these samples as a quality control measure to identify any outlying values in the biological data recorded for further investigation or exclusion. None of the length frequencies (Figure 2) of the samples appeared to be truncated or show any signs of grading although the low numbers of fish measured in Scottish samples 02 and 04 result in a plateauing distribution. Overall there was a high level of variability between the proportion of catch numbers-at-age amongst samples although there is a trend of the highest proportion of catches being two year olds with smaller observable peaks of 6 and 7 year olds in several of the samples (Figures 3a and 3b).

Where there was a length category without an age associated, the age for that length category was interpolated using the age-length key for the aggregated samples used in the first step of raising (Table 3). This lead to one fish in area 2 being given an interpolated age of 1 based on its length, which was the only fish in any of the samples of this age.

The raising procedure followed established raising methods. Samples were raised from the highest resolution of landings information available moving towards annual aggregation.

Once the data had been scrutinised the raising was done in a series of steps:

1. The input samples were collated as shown in Table 3 for raising to the catch of each commercial landed trip for each of the refrigerated-sea-water (RSW) vessels and to the reported catches from each area surveyed for each of the freezer trawlers (FT) as follows;

i) A regression analysis was applied to the sampled fish which were both measured and weighed; this produced a regression equation giving an estimated mean weight for each length (L-W relationship).

ii) Onshore otolith reading of samples of herring from 0.5 cm length classes was used to develop an age-length key for the sample.

iii) The total weight of the sample was calculated as the sum product of the numbers at length and the mean weight at length for each length class as estimated using the regression equation.

iv) A raising factor for the proportion of the total landed weight sampled was calculated.

v) The numbers landed (X 000's) for each length class were calculated as the product of the numbers in the sample at each length and the raising factor.

vi) The weight landed at each length class was calculated as the product of mean weight at length and number landed (X 000's) at length.

vii) The age length key was raised to the total numbers (X 000's) at each length class using the proportion at each age of the total aged at each length.

viii) The total catch in numbers (X 000's) at age is calculated as the sum of the catch in numbers across all length classes at each age.

2. The outputs raised to each trip/area/quarter combination in step 1 were combined and raised to total catches within each survey area within each quarter (Table 4). Unsampled reported landings taken in the same area and quarter were given the same composition using the following method (Table 5). The area definition was extended to include adjacent rectangles for this purpose.

i) Calculate 'fill-ins' for mean weights-at-age by catch category

$$\overline{Wt_{c,a,fleet} = \frac{\sum_{\iota=1}^{nfleets}(N_{c,a,\iota} \times Wt_{c,a,\iota})}{\sum_{\iota=1}^{nfleets} N_{c,a,\iota}}}$$

ii) Calculate 'fill-ins' for mean lengths-at-age by catch category

$$\overline{L_{c,a,fleet} = \frac{\sum_{\iota=1}^{nfleets}(N_{c,a,\iota} \times L_{c,a,\iota})}{\sum_{\iota=1}^{nfleets} N_{c,a,\iota}}}$$

iii) Calculate age compositions

$$N_{c,a,fleet} = \sum_{i=1}^{nfleets} N_{c,a,i} \times \frac{Tonnes_{cfleet}}{\sum_{i=1}^{nfleets} Tonnes_{c,i}}$$

3. The raised catches for each area and quarter from step 2 (Table 5) were combined by quarter and raised to the total catch in that quarter following the method outlined under step 2 (Table 6). Given that the sample from area 1 was from a very small catch (23 kg) and the mean weights-at-age seen in this sample (Figure 4) were markedly below those observed for areas 2, 3 and 6aN-other it would be more appropriate to raise the significant unsampled catch reported from area 1 with the composition of all Q3 catch (Table 7).
4. Finally, the catch matrix from all sampled quarters were combined (as in step 2; Table 7) and the resulting composition applied to unsampled catches from quarters 1 and 2 (Table 8).

Results

In the total raised catches for 6aN the proportion of herring of age 2 wr is very high (33% of the total number in the catch, Table 9) and there are very few herring above the age of 7 wr (5%). The proportion of catch number-at-age by area (Figure 5) showed a similar pattern in areas 2 and 3, with the highest proportion of catches being age 2. There was a more or less equal split of the remaining proportion between ages 3-7 and <10% of ages 8-9+. The proportion of catch numbers-at-age in the catches of areas 1 and 6a-other were more variable, with 60% in area 1 being age 2 wr and a peak of age 4 fish in area 6a-other.

The mean weights-at-age for 6aN were very similar to those seen in the 2015 catches excluding a deviation at age 1. There is some uncertainty surrounding this value given that it is based on a single interpolated age. There is also a decrease in the weight at age 9+ wr. This is not unexpected though, as the plus group mean weight will vary with the age composition making up the plus group in a given year. This decrease in weight as well as the low numbers of older fish is consistent with the Malin shelf acoustic survey observations of both fewer and lighter age 9+ fish (WGIPS ICES, 2017).

There was a high consistency in mean weights-at-age (Table 5; Figure 4) in the catches of areas 2 and 3 despite there only being one sample for area 3 (120 fish). Mean weights in area 6a-other loosely tracked areas 2 and 3. In area 1 however they were as much as 30% lower for some ages, the difference being less pronounced for the older ages. This regional difference is expected as as areas 2 and 3 are spawning areas which were fished at spawning time. Area 1 in comparison is a pre-spawning aggregation area and fish were sampled here prior to moving onto the spawning grounds and before gonads were fully developed.

Mean weights-at-age for the large unsampled catch taken in area 1 were deduced from individual fish weights collected as part of the German vessels own quality control procedures using the weight-length relationship and the age at length key from the monitoring fishery samples (Table 10). These were compared to the mean weights-at-age in the small catch sampled from area 1 (Figure 4). These deduced weights-at-age were higher for all ages than those from the available area 1 sample. This is expected as the deduced weights were from catch taken app. 4 weeks later and gonad development would have progressed.

Conclusion

In total 39 trawl samples were collected in the monitoring fishery and associated surveys in 6.aN in 2016. Due to the nature of the surveys and the logistics involved, especially for the RSW vessels, 17 of these samples were not deemed to be representative of "normal" commercial fishing and were excluded from the catch estimation process. A total of 22 samples were available for raising catch falling short of the requirement for 29 samples that was recommended in the special request advice. This shortfall should be taken into consideration in the planning for the sampling of the 2017 monitoring fishery to ensure 100% sampling of commercial hauls.

The remaining 17 samples are being utilised in scientific studies aiding the overall goal of developing a more robust biological basis for assessing the stocks.

The catch raising was carried out following well established practices as documented here and the resulting catch-matrix was made available to the combined assessment for herring in 6.a and 7.b-c.

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ICES 2017. Interim Report of the Working Group of International Pelagic Surveys (WGIPS), 16-20 January 2017, Reykjavik, Iceland. ICES CM 2017\SSGIEOM:15. 572 pp.

Geffen, A. J., Nash, R. D. M., and Dickey-Collas, M. 2011. Characterization of herring populations west of the British Isles: an investigation of mixing based on otolith microchemistry. ICES Journal of Marine Science, 68: 1447–1458.

Table 1. By-catch by species and vessel nationality in the 6.aN monitoring fishery (quantities marked with * were discarded).

Catch (t)	MAC	HOM	WHG	HER	HAD	SPR	TOTAL
GER	16.4	30.9	2.1	-	-	-	49.4
UK-Eng	2.7	-	-	-	-	-	2.7
UK-Sco	7.8*	4.6*	0.3*	49.3*	0.4*	3.5*	65.6*
Total	26.9	35.5	2.1	49.3	0.4	3.5	117.7

Table 2. Number of commercial catch samples collected during the 6.aN monitoring fishery by quarter, area and vessel nationality.

Period	Country	Area 1	Area 2	Area 3	Area 4	6a Other
Q3	UK-Scot	-	7	-	-	-
Q3	Germany	1	4	1	-	1
Q3	UK-Eng	-	5	-	-	-
Q4	Ireland	-	-	-	-	3
Total		1	16	1	0	4

Table 3. Composition of samples as grouped for the first step of raising.

Type	Raising sample	Proportion of catch at age (%)								No. Samples	No. Ages	No. Lengths
		2	3	4	5	6	7	8	9+			
RSW	UKSco	36	15	10	12	9	13	3	3	3	172	310
RSW	UKSco	30	17	7	10	10	20	7	0	1	30	30
RSW	UKSco	38	10	11	10	11	13	3	3	1	96	234
RSW	UKSco	13	18	16	16	25	7	2	2	1	55	55
RSW	UKSco	44	11	11	4	9	13	0	7	1	45	198
FT	GER area	39	18	13	13	8	5	3	2	1	120	215
FT	GER area	25	19	18	10	17	6	3	2	4	404	967
FT	GER area	46	24	7	1	12	3	1	4	1	67	180
FT	GER 6a	26	22	36	3	6	6	1	0	1	62	157
FT	UKEng	36	13	12	10	8	12	4	5	5	405	1070
	Total	-	-	-	-	-	-	-	-	19	1456	3416

Table 4. Catch quantities used in raising in Step 2.

Raising to: area-quarter	Sampled Landings (t)	Unsampled landings (t)	Total landings raised to (t)
Area 1 – Q3	0.023	0.195	2.183
Area 2 – Q3	3336.883	-	3336.883
Area 3 – Q3	3.169	19.941	23.11
Area 4 – Q3	-	-	-
6aN other – Q3	9.009	96.513	105.520

6aN other– Q4	63.196	82.265	145.461
Total	3412.490	198.914	3494.755

Table 5. Area specific catch-at-age, mean weight-at-age and mean length-at-age for monitoring fishery advice areas by quarter (after step 2).

AGE	1	2	3	4	5	6	7	8	9+
Area 1 – Q3									
CANUM	0	1	0	0	0	0	0	0	0
Mean	-	0.115	0.134	0.176	0.153	0.183	0.210	0.215	0.248
Mean	-	23.90	25.20	27.80	26.50	28.10	29.70	30.00	31.50
Area 2 – Q3									
CANUM	1	5778	2200	2188	1930	1990	2296	546	323
Mean	0.097	0.145	0.181	0.204	0.222	0.231	0.238	0.251	0.257
Mean	23.00	25.00	27.00	28.00	29.00	30.00	30.00	30.00	31.00
Area 3 – Q3									
CANUM	0	44	20	11	14	11	16	4	2
Mean	-	0.143	0.171	0.207	0.221	0.232	0.241	0.252	0.264
Mean	-	25.00	26.00	28.00	29.00	29.00	30.00	30.00	31.00
6aN other – Q3									
6aN other – Q4									

Table 6. Catch quantities used in raising in Step 3.

RAISING TO: QUARTER	SAMPLED LANDINGS (T)	UNSAMPLED LANDINGS (T)	TOTAL LANDINGS RAISED TO (T)
Q3	3465.733	847.905	4313.638
Q4	145.461	-	145.461
Total	3611.194	847.905	4459.099

Table 7. Total catch-at-age, mean weight-at-age and mean length-at-age for 6aN in quarters 3 and 4 (after step 3).

AGE (WR)	1	2	3	4	5	6	7	8	9+
Quarter 3									
CANUM	2	7436	2901	2958	2450	2539	2931	697	407
Mean weight	0.097	0.145	0.181	0.204	0.222	0.231	0.237	0.251	0.257
Mean length	22.50	25.20	27.20	28.40	29.20	29.50	29.80	30.40	30.90
Quarter 4									

CANUM	9	255	253	60	184	125	41	0	0
Mean weight	0.101	0.122	0.151	0.169	0.180	0.186	0.200	-	-
Mean length	22.90	24.50	26.50	27.60	28.20	28.60	29.30	-	-

Table 8. Catch quantities used in raising in Step 4.

Raising to: Year	Sampled Landings (t)	Unsampled landings (t)	Total landings raised to (t)
2016	4459.099	264.891	4723.990

Table 9. Total catch numbers-at-age (CANUM), mean weight-at-age (WECA) and mean length-at-age for 6aN herring in 2015 and 2016.

Age (wr)	1	2	3	4	5	6	7	8	9+
2016									
CANUM (000's)	12	8148	3341	3197	2791	2821	3148	739	431
Proportion at age	0%	33%	14%	13%	11%	11%	13%	3%	2%
Mean weight (kg)	0.100	0.144	0.178	0.204	0.219	0.229	0.237	0.251	0.257
Mean length (cm)	22.79	25.22	27.11	28.37	29.17	29.47	29.80	30.38	30.94
2015									
Mean weight (kg)	0.077	0.143	0.180	0.206	0.214	0.231	0.239	0.245	0.269

Table 10. Mean weights for the unsampled catch in survey area 1 in quarter 3 during the monitoring fishery deduced from individual fish weights taken in the routine quality control procedures.

Age (wr)	1	2	3	4	5	6		8	9+
Mean weight	-	0.139	0.162	0.189	0.194	0.211	0.214	0.232	0.285

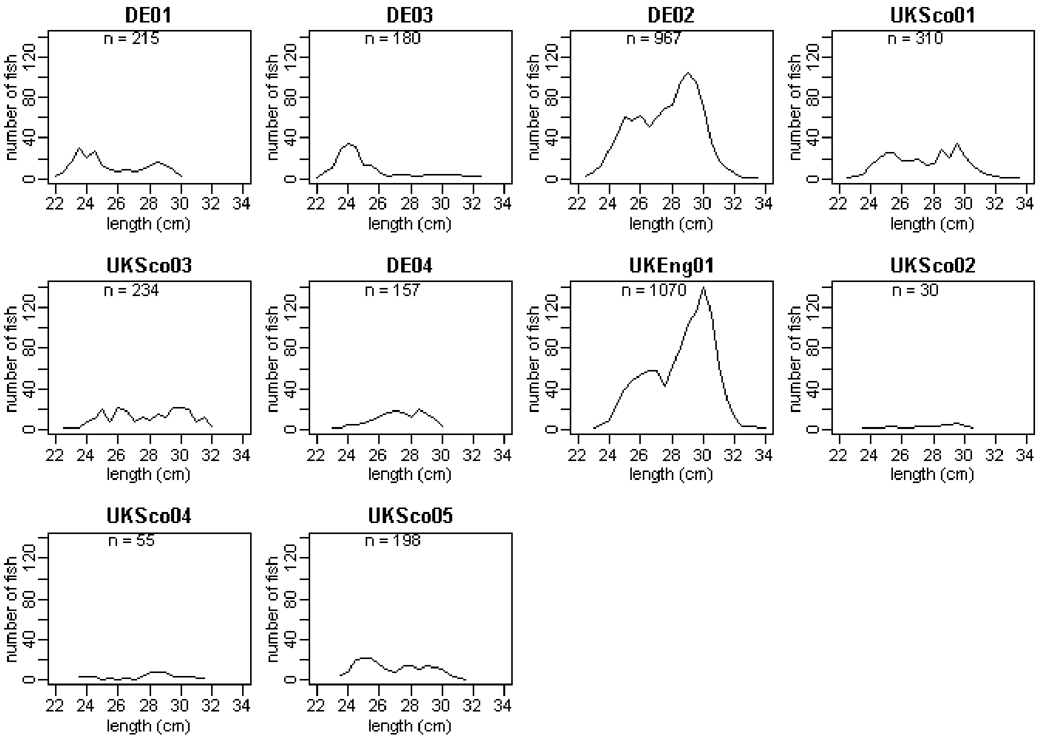

Figure 2. Length frequencies of input samples for first step of raising (Table 3).

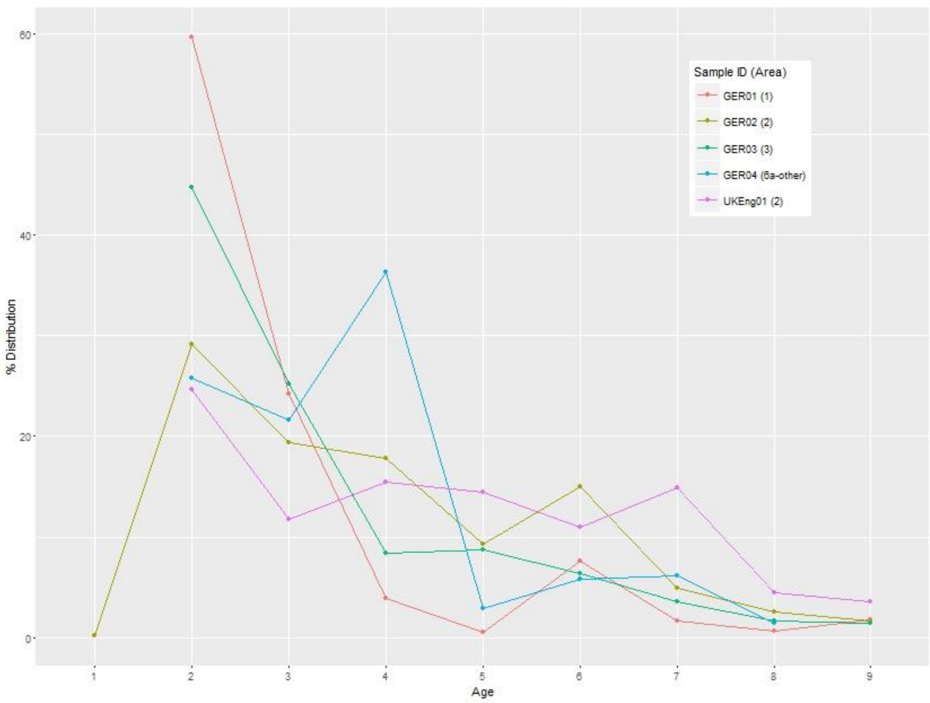

Figure 3a. Proportion of catch numbers-at-age for samples collected from FT aggregated to vessel and area.

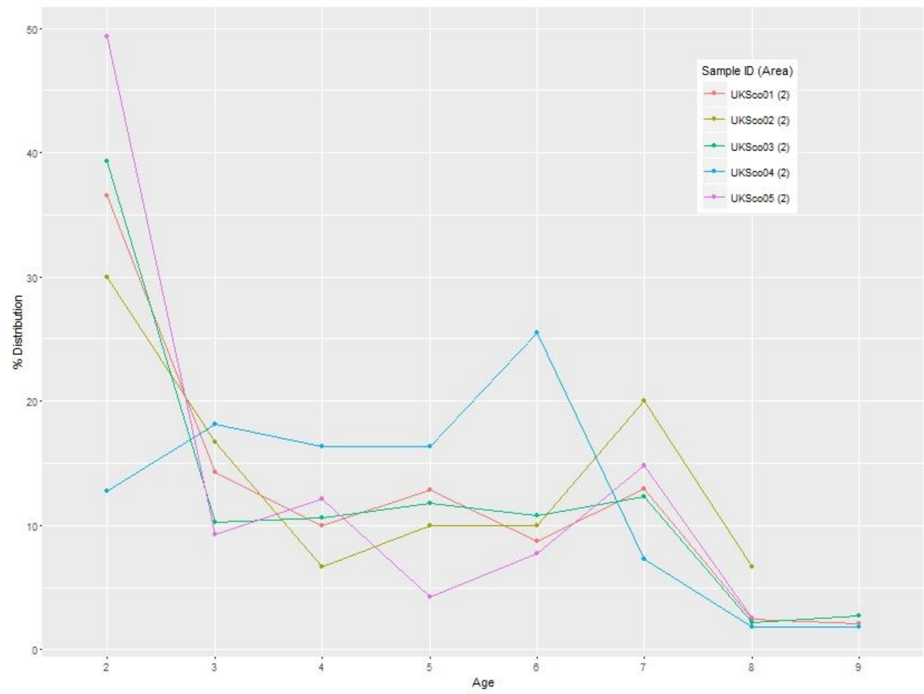

Figure 3b. Proportion of catch numbers-at-age for samples collected from RSW vessels aggregated to trip – all UKSco samples were taken in area 2 (Figure 1).

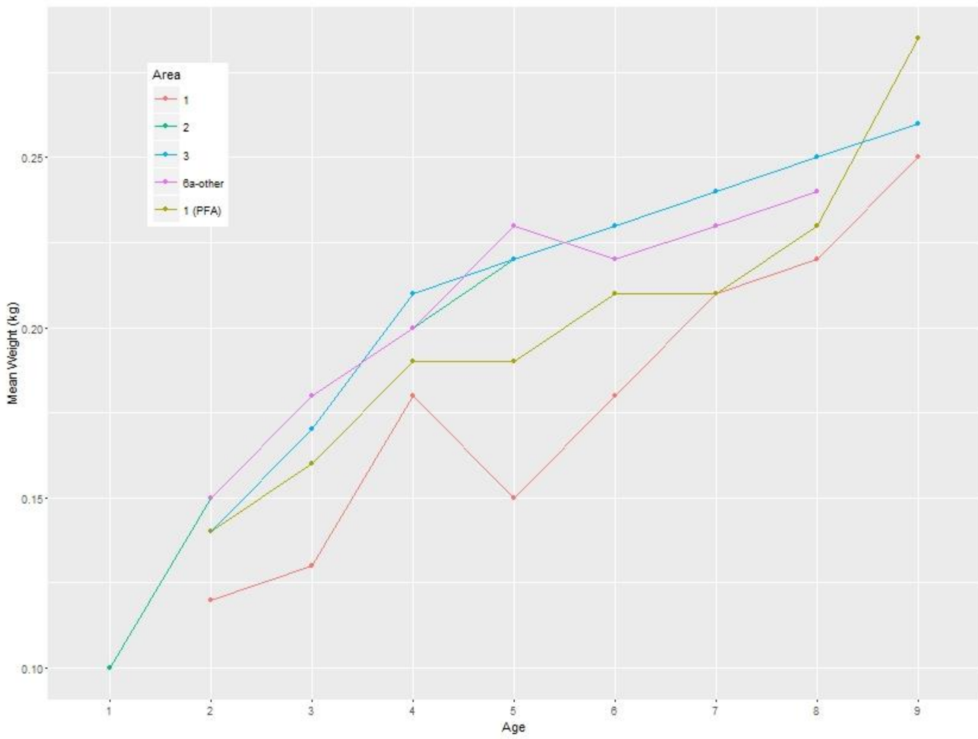

Figure 4. Mean weights-at-age by areas stipulated in advice (Figure 1; Table 5).

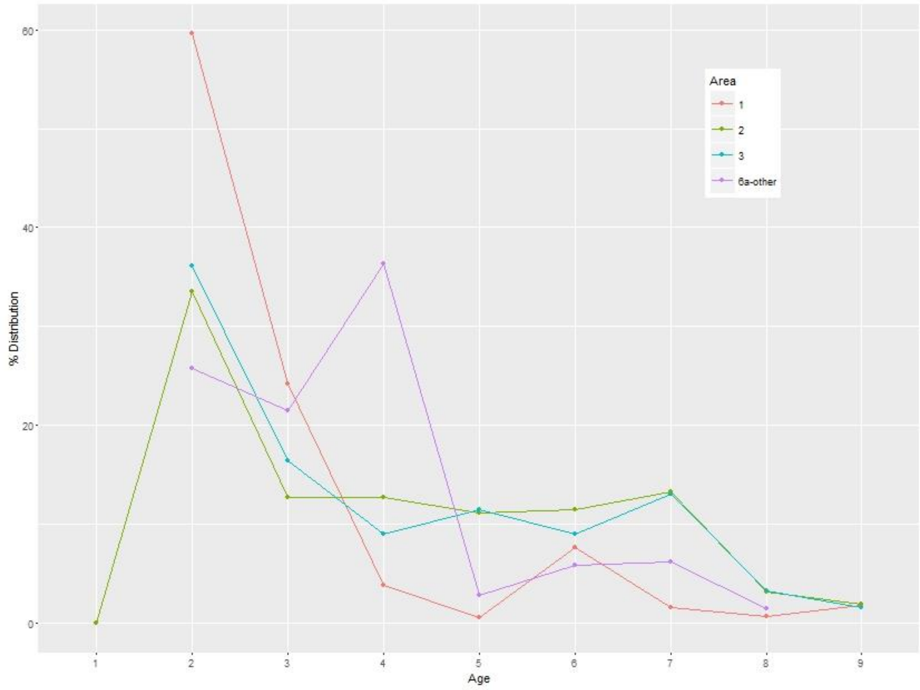

Figure 5. Proportion of catch numbers-at-age by areas stipulated in advice (Figure 1).

Annex 1. Herring in 6.a (North). Catch and sampling effort by nations participating in the fishery in 2016.

AREA: 6.A(N)						
Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Denmark	0.00	23.30	0	0	0	0.00
Germany	1009.11	1028.19	7	1519	653	98.14
Ireland	513.20	568.69	3	808	230	90.24
Netherlands	0.00	299.75	0	0	0	0.00
UK(England)	830.56	830.92	5	1070	405	99.96
UK(Scotland)	2398.28	2423.35	7	827	398	98.97
Period Total	4751.15	5174.20	22	3416	1686	91.82

SUM OF OFFICIAL CATCHES:	**5174.20**
MISREPORTED CATCH:	**-450.00**
WORKING GROUP CATCH:	**4724.20**

QUARTER 1						
Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Denmark	0.00	20.16	0	0	0	0.00
Germany	0.00	19.08	0	0	0	0.00
Ireland	0.00	55.22	0	0	0	0.00
Netherlands	0.00	145.19	0	0	0	0.00
UK(England)	0.00	0.36	0	0	0	0.00
UK(Scotland)	0.00	19.34	0	0	0	0.00
Period Total	0.00	259.35	0	0	0	0.00

SUM OF OFFICIAL CATCHES:	**259.35**
MISREPORTED CATCH:	**0.00**
WORKING GROUP CATCH:	**259.35**

QUARTER 2						
Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Netherlands	0.00	5.55	0	0	0	0.00
Period Total	0.00	5.55	0	0	0	0.00

SUM OF OFFICIAL CATCHES:	**5.55**
MISREPORTED CATCH:	**0.00**
WORKING GROUP CATCH:	**5.55**

Annex 1 (con't). Herring in 6.a (North). Catch and sampling effort by nations participating in the fishery in 2016.

QUARTER 3						
Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Germany	1009.11	1009.11	7	1519	653	100.00
Ireland	0.00	0.27	0	0	0	0.00
Netherlands	0.00	75.62	0	0	0	0.00
UK(England & Wales)	830.56	830.56	5	1070	405	100.00
UK(Scotland)	2398.28	2398.28	7	827	398	100.00
Period Total	2077.95	4313.83	19	4208	1456	48.17

Sum of Official Catches:	4313.83
Unallocated Catch:	0.00
Working Group Catch:	4313.83

QUARTER 4						
Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Denmark	0.00	3.14	0	0	0	0.00
Ireland	513.20	513.20	3	808	230	100.00
Netherlands	0.00	73.39	0	0	0	0.00
UK(Scotland)	0.00	5.73	0	0	0	0.00
Period Total	513.20	595.46	3	808	230	86.19

SUM OF OFFICIAL CATCHES:	**595.46**
MISREPORTED CATCH:	**-450.00**
WORKING GROUP CATCH:	**145.46**

2. Working Document 02

German Herring Fisheries & Stock Assessment in the Western Baltic in 2016

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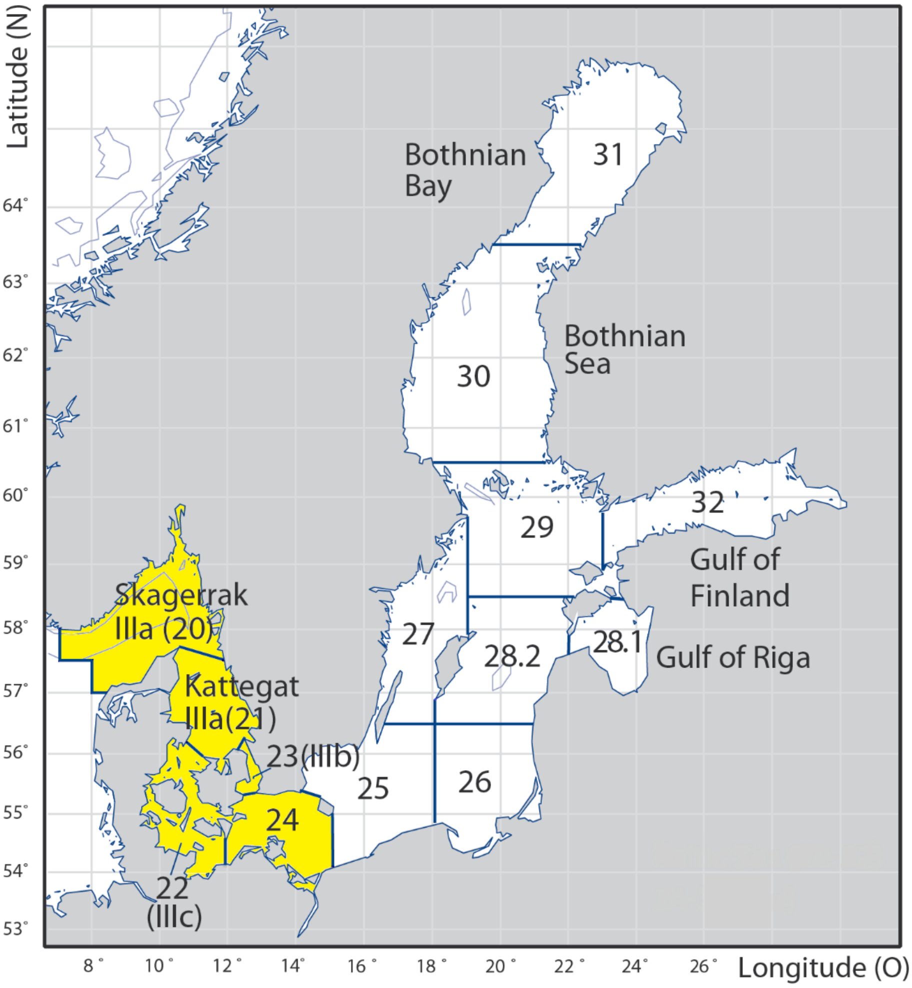
Germany



Section

1 German herring fisheries in 2016

1.1 Fisheries

In 2016 the total German herring landings from the Western Baltic Sea in Subdivisions (SD) 22 and 24 amounted to 14,427 t, which represents an increase of 9 % compared to the landings in 2015 (13,289 t). This increase was caused by an increase of the TAC/quota (German quota for SDs 22 and 24 in 2016: 14,496 t + quota-transfer of 195 t). The fishing activities in one of the main fishing areas, the Greifswald Bay (SD 24) could start earlier than in March due to mild winter conditions in January/February. The German fishery stopped their activities in April due to low quality conditions of herring (e.g. small in size).

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

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	0.097 -0.097	191.698	9,708.984 -209.649	**9,900.779** **-209.746**	**68.0** **-1.4**
II		29.239	2,277.631 -40.250	**2,306.870** **-40.250**	**15.9** **-0.3**
III		0.870	0.425	**1.295**	**0.0**
IV	124.705	23.972	2,193.778	**2,342.455**	**16.1**
TOTAL	**124.802** **-0.097**	**245.779** **0.000**	**14,180.818** **-249.899**	**14,551.399** **-249.996**	**100.0** **-1.7**

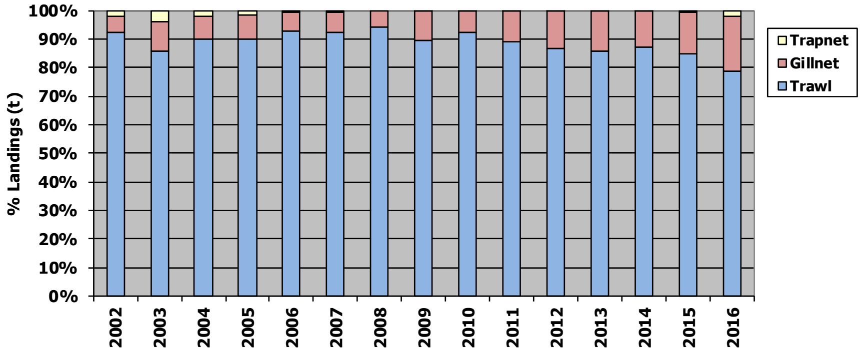
Source: Federal Centre for Agriculture and Food (BLE). Since 2008 the obligation to report via logbooks changed to vessels >8 m (until 2007 for vessels >10 m)

Landings = Total landings
-Landings = Fraction landed abroad

Just as in former years the main fishing season was during the first and second quarter. About 84 % of the herring in 2016 was caught between January and April (2015: 84 %; 2014: 85 %, 2013: 93 %; 2012: 88 %). As in last years, the main fishing area was located in Subdivision 24 (2016: 97 %; 2015: 96 %, 2014: 93 %; 2013: 95 %, 2012: 88 %). The overall fishing pattern during the last years was rather stable in the Baltic area of Subdivisions 22 and 24. Until 2000, the dominant part of herring was caught in the passive fishery by gillnets and trapnets around the Island of Rügen. Since 2001, the activities in the trawl fishery have increased. They reached the highest contribution in 2007 of 67 %, fluctuated in 2008-2014 around 58-64 % (2008: 61 %; 2009: 59 %, 2010: 58 %, 2011: 58 %, 2012: 61 %, 2013: 64 %; 2014: 61 regain the record level of 67 % in 2015 and now was close to the record level (2016: 66 %). The trawl fishery was mostly carried out in Subdivision 24 (2016: 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 2002-2016 in Subdivisions 22 and 24. %),

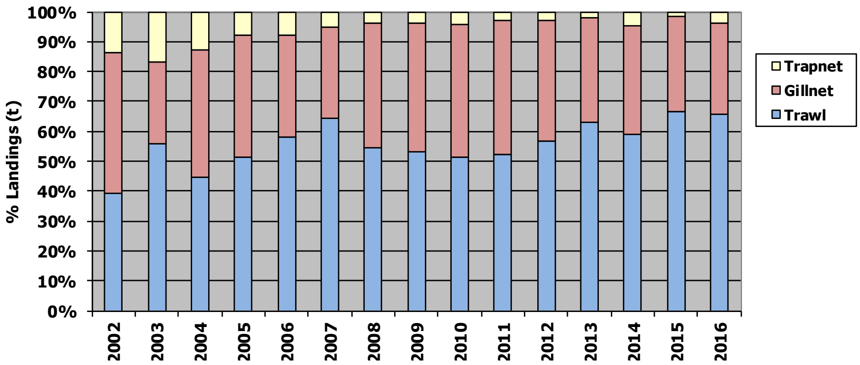
SD 22 (t)	Trawl	Gillnet	Trapnet	Total	SD 22 (%)	Trawl	Gillnet	Trapnet
2002	3,871.716	253.710	78.838	4,204.264	2002	92.1%	6.0%	1.9%
2003	3,147.054	382.678	150.007	3,679.739	2003	85.5%	10.4%	4.1%
2004	2,282.844	196.963	55.674	2,535.481	2004	90.0%	7.8%	2.2%
2005	1,700.627	162.795	29.312	1,892.734	2005	89.9%	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%

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%

SUBDIVISION 24



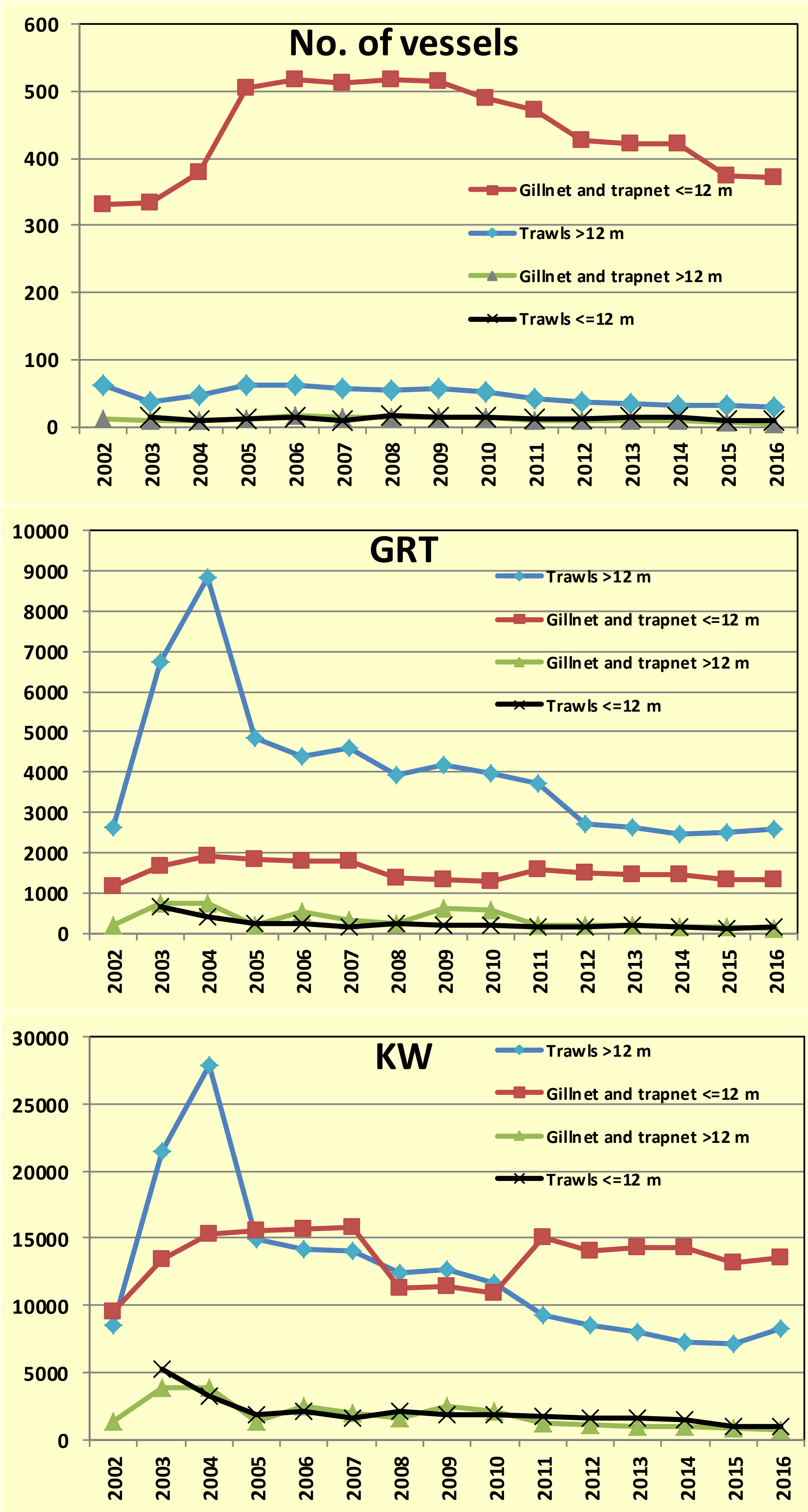
1.2 Fishing fleet

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 2009 until 2016 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
2009	Fixed gears	<=12	515	1,344	11,382
	(gillnet and trapnet)	>12	14	602	2,443
	Trawls	<=12	13	205	1,849
		>12	56	4,172	12,623
	TOTAL		**598**	**6,323**	**28,297**
2010	Fixed gears	<=12	491	1,280	10,884
	(gillnet and trapnet)	>12	13	551	2,121
	Trawls	<=12	14	193	1,830
		>12	53	3,988	11,708
	TOTAL		**571**	**6,012**	**26,543**
2011	Fixed gears	<=12	473	1,566	15,020
	(gillnet and trapnet)	>12	10	185	1,215
	Trawls	<=12	12	171	1,666
		>12	43	3,710	9,325
	TOTAL		**538**	**5,632**	**27,226**
2012	Fixed gears	<=12	426	1,485	14,105
	(gillnet and trapnet)	>12	9	184	1,125
	Trawls	<=12	12	170	1,573
		>12	38	2,712	8,480
	TOTAL		**485**	**4,551**	**25,283**
2013	Fixed gears	<=12	421	1,459	14,289
	(gillnet and trapnet)	>12	9	186	1,005
	Trawls	<=12	14	173	1,557
		>12	35	2,638	7,960
	TOTAL		**479**	**4,456**	**24,811**
2014	Fixed gears	<=12	421	1,443	14,351
	(gillnet and trapnet)	>12	8	149	970
	Trawls	<=12	13	170	1,502
		>12	31	2,469	7,205
	TOTAL		**473**	**4,231**	**24,028**
2015	Fixed gears	<=12	375	1,341	13,163
	(gillnet and trapnet)	>12	7	133	802
	Trawls	<=12	9	122	991
		>12	31	2,503	7,148
	TOTAL		**422**	**4,099**	**22,104**
2016	Fixed gears	<=12	371	1,341	13,532
	(gillnet and trapnet)	>12	5	103	699
	Trawls	<=12	8	137	997
		>12	30	2,599	8,205
	TOTAL		**414**	**4,180**	**23,433**


No. of vessels
600
500
400
300
200
100
0
Gillnet and trapnet <=12 m
Trawls >12 m
Gillnet and trapnet >12 m
Trawls <=12 m
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
GRT
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m
KW
30000
25000
20000
15000
10000
5000
0
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m

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 2016, are given below:

SD 24/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
January	1	61.4	3.1	0.0	0.0	64.6	95.2	4.8	0.0	0.0
	2									
	3									
	Mean	61.4	3.1	0.0	0.0	64.6	95.2	4.8	0.0	0.0
February	1	62.8	0.6	0.0	0.0	63.4	99.1	0.9	0.0	0.0
	2	58.1	0.0	0.0	0.0	58.1	100.0	0.0	0.0	0.0
	3									
	Mean	60.5	0.3	0.0	0.0	60.8	99.5	0.5	0.0	0.0
March	1	54.3	0.1	0.0	0.0	54.4	99.9	0.1	0.0	0.0
	2	54.0	0.8	0.0	0.0	54.8	98.6	1.4	0.0	0.0
	3									
	Mean	54.2	0.4	0.0	0.0	54.6	99.2	0.8	0.0	0.0
Q I	Mean	58.7	1.3	0.0	0.0	60.0	98.0	2.0	0.0	0.0

SD 24/Quarter II		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
April	1	74.1	0.5	0.0	0.0	74.6	99.3	0.7	0.0	0.0
	2									
	3									
	Mean	74.1	0.5	0.0	0.0	74.6	99.3	0.7	0.0	0.0
May	1									
	2									
	3									
	Mean									
June	1									
	2									
	3									
	Mean									
Q II	Mean	74.1	0.5	0.0	0.0	74.6	99.3	0.7	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	60.0	0.0	0.0	0.0	60.0	100.0	0.0	0.0	0.0
	2	59.9	0.0	0.0	0.0	59.9	100.0	0.0	0.0	0.0
	3									
	Mean	60.0	0.0	0.0	0.0	60.0	100.0	0.0	0.0	0.0
Decemb.	1	60.2	0.3	0.0	0.0	60.4	99.5	0.5	0.0	0.0
	2	49.8	0.0	0.0	0.0	49.8	100.0	0.0	0.0	0.0
	3									
	Mean	55.0	0.1	0.0	0.0	55.1	99.8	0.2	0.0	0.0
Q IV	Mean	57.5	0.1	0.0	0.0	57.5	99.9	0.1	0.0	0.0

The officially reported total trawl landings of herring in Subdivision 24 (see 2.1) in combination with the detected mean species composition in the samples (see above) results in the following differences:

Subdiv.	Quarter	Trawl landings (t)	Mean Contribution of Herring (%)	Total Herring corrected (t)	Difference (t)
24	I	**6,353**	98.0	6,226	-127
	II	**806**	99.3	800	-6
	IV	**2,142**	99.9	2,140	-2

The officially reported trawl landings in Subdivision 22 and 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 9494 t – 135 t -> 1 % difference).

1.4 Logbook registered discards/BMS landings

No logbook registered discards or BMS landings (both new catch categories since 2015) of herring have been reported in the German herring fisheries in 2016 (no BMS landing have been reported in 2015 and no discards have been reported before 2016).

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 2011-2016 (Oeberst et al., 2013, WD Oeberst et al., 2014, WD Oeberst et al., 2015; WD Oeberst et al., 2016; WD Oeberst et al., 2017). SF (slightly modified by commercial samples) was employed in the years 2005-2011 to identify the fraction of Central Baltic Herring in German commercial herring landings from SD 22 and 24 (WD Gröhsler et al., 2013). 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. The application of the present SF to commercial catch data in 2016, lead to similar results compared to 2005-2015. German gillnet catches in SD 22 and 24, mostly sampled at the spawning ground, consist of almost 100 % WBSSH. The amount of CBH in trapnet and trawl landings reached 4 % in numbers and 2 % in biomass, respectively. As in the years before it was decided not to exclude CBH when compiling the assessment input data.

1.6 References

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2 Stock assessment data in 2016

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	0.097	0	0	0	no landings	-	-	-
	Q 2	no landings	-	-	-	no landings	-	-	-
	Q 3	no landings	-	-	-	no landings	-	-	-
	Q 4	124.705	0	0	0	no landings	-	-	-
	Total	124.802	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	**0.097**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
	Q 2	**0.000**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
	Q 3	**0.000**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
	Q 4	**124.705**	**0**	**0**	**0**	**0.000**	**0**	**0**	**0**
	Total	**124.802**	**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	175.816	0	0	0	6,353.312	5	2,668	634
	Q 2	17.215	0	0	0	805.674	2	641	181
	Q 3	0.000	-	-	-	0.000	-	-	-
	Q 4	0.094	0	0	0	2,142.378	4	1,971	469
	Total	193.125	0	0	0	9,301.364	11	5,280	1,284
GILLNET	Q 1	15.576	2	805	133	2,914.877	12	4,056	710
	Q 2	11.965	1	421	67	1,347.787	3	1,152	205
	Q 3	0.791	0	0	0	0.425	0	0	0
	Q 4	19.729	1	428	80	51.400	1	346	62
	Total	48.061	4	1,654	280	4,314.489	16	5,554	977
TRAPNET	Q 1	0.306	2	1,040	157	440.795	2	949	216
	Q 2	0.059	1	833	99	124.170	2	1,066	201
	Q 3	0.079	0	0	0	0.000	-	-	-
	Q 4	4.149	0	0	0	0.000	-	-	-
	Total	4.593	3	1,873	256	564.965	4	2,015	417
TOTAL	Q 1	**191.698**	**4**	**1,845**	**290**	**9,708.984**	**19**	**7,673**	**1,560**
	Q 2	**29.239**	**2**	**1,254**	**166**	**2,277.631**	**7**	**2,859**	**587**
	Q 3	**0.870**	**0**	**0**	**0**	**0.425**	**0**	**0**	**0**
	Q 4	**23.972**	**1**	**428**	**80**	**2,193.778**	**5**	**2,317**	**531**
	Total	**245.779**	**7**	**3,527**	**536**	**14,180.818**	**31**	**12,849**	**2,678**

Gear	Quarter	TOTAL (DIV. IIIa & SUBDIV. 22+24)			
		Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	6,529.225	5	2,668	634
	Q 2	822.889	2	641	181
	Q 3	no landings	0	0	0
	Q 4	2,267.177	4	1,971	469
	Total	9,619.291	11	5,280	1,284
GILLNET	Q 1	2,930.453	14	4,861	843
	Q 2	1,359.752	4	1,573	272
	Q 3	1.216	0	0	0
	Q 4	71.129	2	774	142
	Total	4,362.550	20	7,208	1,257
TRAPNET	Q 1	441.101	4	1,989	373
	Q 2	124.229	3	1,899	300
	Q 3	0.079	0	0	0
	Q 4	4.149	0	0	0
	Total	569.558	7	3,888	673
TOTAL	Q 1	9,900.779	23	9,518	1,850
	Q 2	2,306.870	9	4,113	753
	Q 3	1.295	0	0	0
	Q 4	2,342.455	6	2,745	611
	Total	14,551.399	38	16,376	3,214

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				0.158				0.158
	1					0.023	0.001		0.000	0.831	0.042		0.388	0.854	0.043		0.388
	2					0.040	0.006		0.000	1.454	0.264		3.031	1.494	0.270		3.031
	3					0.587	0.071		0.000	21.228	3.303		10.131	21.815	3.373		10.132
	4					0.452	0.074		0.000	16.325	3.452		2.628	16.777	3.526		2.628
	5					0.296	0.020		0.000	10.688	0.943		1.371	10.984	0.963		1.371
	6					0.113	0.010		0.000	4.090	0.454		0.380	4.203	0.464		0.380
	7					0.054	0.006		0.000	1.945	0.303		0.167	1.999	0.309		0.167
	8+					0.050	0.005		0.000	1.801	0.234		0.116	1.851	0.239		0.116
	Sum					1.615	0.192		0.001	58.363	8.996		18.370	59.978	9.188		18.371
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0																
	1																
	2								0.017								0.017
	3					0.002	0.0003	0.000	0.049	0.047	0.088	0.000	0.068	0.049	0.088	0.000	0.116
	4					0.008	0.008	0.001	0.033	0.606	0.640	0.000	0.060	0.614	0.648	0.001	0.093
	5					0.028	0.022	0.001	0.014	3.565	1.900	0.001	0.110	3.593	1.923	0.002	0.124
	6					0.028	0.010	0.001	0.005	5.722	1.361	0.000	0.038	5.750	1.371	0.001	0.044
	7					0.017	0.013	0.001	0.009	3.384	2.296	0.001	0.005	3.401	2.309	0.002	0.014
	8+					0.012	0.020	0.001	0.009	2.195	1.841	0.001	0.005	2.206	1.861	0.002	0.014
	Sum					0.094	0.073	0.005	0.136	15.519	8.126	0.003	0.287	15.612	8.199	0.007	0.423
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0																
	1																
	2						0.0000	0.000	0.0011		0.053				0.053	0.000	0.0011
	3					0.0006	0.0002	0.000	0.0149	1.523	0.661			1.524	0.662	0.000	0.0149
	4					0.0010	0.0004	0.001	0.0293	1.196	0.620			1.197	0.620	0.001	0.0293
	5					0.0008	0.0000	0.000	0.0033	0.749	0.179			0.750	0.179	0.000	0.0033
	6					0.0002	0.0001	0.000	0.0035	0.420	0.055			0.420	0.055	0.000	0.0035
	7					0.0003	0.0000	0.000	0.0001	0.201	0.028			0.201	0.028	0.000	0.0001
	8+					0.0001				0.117	0.023			0.117	0.023		
	Sum					0.0030	0.001	0.001	0.0522	4.206	1.619			4.209	1.620	0.001	0.0522
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								0.000				0.158				0.158
	1					0.023	0.001		0.0000	0.831	0.042		0.388	0.854	0.043		0.388
	2					0.0402	0.006	0.000	0.0183	1.454	0.317		3.031	1.494	0.323	0.000	3.049
	3					0.590	0.071	0.000	0.0642	22.798	4.052	0.000	10.199	23.388	4.123	0.000	10.263
	4					0.461	0.083	0.001	0.0625	18.127	4.712	0.000	2.688	18.588	4.795	0.001	2.750
	5					0.325	0.043	0.002	0.0177	15.002	3.022	0.001	1.481	15.326	3.065	0.002	1.499
	6					0.141	0.019	0.001	0.0089	10.232	1.870	0.000	0.418	10.373	1.889	0.001	0.427
	7					0.071	0.019	0.001	0.0088	5.530	2.627	0.001	0.173	5.601	2.646	0.002	0.181
	8+					0.062	0.025	0.001	0.0085	4.113	2.098	0.001	0.121	4.175	2.123	0.002	0.130
	Sum					1.712	0.266	0.006	0.1889	78.087	18.741	0.003	18.657	79.799	19.007	0.008	18.846

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	3	24	Gillnet	2
Trawl	2	24	Trawl	2					
Trawl	4	24	Trawl	4					
Gillnet	3	22	Gillnet	2					
Trapn	3	22	Trapn	2					
Trapn	4	22	Trapn	2					

2.3 Mean weight (grammes) in the catch

		SUBDIVISION 20				SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
TRAWL	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0								14.0				14.0				14.0
	1					13.7	13.0		44.6	13.7	13.0		44.6	13.7	13.0		44.6
	2					40.2	39.4		86.1	40.2	39.4		86.1	40.2	39.4		86.1
	3					87.4	77.5		118.3	87.4	77.5		118.3	87.4	77.5		118.3
	4					104.5	90.7		133.4	104.5	90.7		133.4	104.5	90.7		133.4
	5					129.3	109.5		152.5	129.3	109.5		152.5	129.3	109.5		152.5
	6					165.6	114.2		145.3	165.6	114.2		145.3	165.6	114.2		145.3
	7					172.7	128.3		178.9	172.7	128.3		178.9	172.7	128.3		178.9
	8+					181.5	135.1		158.3	181.5	135.1		158.3	181.5	135.1		158.3
	Sum					108.9	89.6		116.6	108.9	89.6		116.6	108.9	89.6		116.6
GILLNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0																
	1																
	2								136.0								136.0
	3					131.8	103.3	103.3	140.6	119.8	97.2	97.2	160.7	120.2	97.3	100.0	152.3
	4					145.4	146.8	146.8	145.6	159.6	145.8	145.8	175.6	159.4	145.8	146.5	165.0
	5					156.8	154.3	154.3	155.3	175.3	151.2	151.2	185.5	175.1	151.2	153.4	182.0
	6					169.6	160.9	160.9	151.8	188.7	168.0	168.0	189.6	188.6	167.9	163.8	184.9
	7					182.0	172.5	172.5	141.5	197.7	175.9	175.9	229.0	197.6	175.9	174.1	175.1
	8+					177.1	176.5	176.5	170.5	200.2	177.2	177.2	201.8	200.1	177.2	176.7	182.5
	Sum					166.1	163.2	163.2	145.2	187.8	165.9	165.9	179.3	187.7	165.8	164.1	168.3
TRAPNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0																
	1																
	2						40.7	40.7	40.7		48.5				48.5	40.7	40.7
	3					72.9	64.0	64.0	64.0	82.2	65.7			82.2	65.7	64.0	64.0
	4					94.6	83.0	83.0	83.0	98.2	77.3			98.2	77.3	83.0	83.0
	5					110.6	101.0	101.0	101.0	121.8	94.9			121.8	94.9	101.0	101.0
	6					123.4	106.9	106.9	106.9	134.5	126.2			134.5	126.2	106.9	106.9
	7					143.6	136.0	136.0	136.0	156.6	112.0			156.6	112.0	136.0	136.0
	8+					168.5				162.4	139.9			162.4	139.9		
	Sum					103.3	79.5	79.5	79.5	104.8	76.7			104.8	76.7	79.5	79.5
TOTAL	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0								14.0				14.0				14.0
	1					13.7	13.0		44.6	13.7	13.0		44.6	13.7	13.0		44.6
	2					40.2	39.4	40.7	130.1	40.2	41.0		86.1	40.2	40.9	40.7	86.3
	3					87.5	77.6	67.0	122.7	87.1	76.0	97.2	118.6	87.1	76.0	69.5	118.7
	4					105.2	96.4	114.9	116.2	105.9	96.4	145.8	134.3	105.9	96.4	119.6	133.9
	5					131.7	133.1	152.2	145.2	139.9	134.8	151.2	154.9	139.7	134.8	151.9	154.8
	6					166.4	137.4	155.8	134.1	177.2	153.7	168.0	149.3	177.1	153.5	160.4	149.0
	7					174.8	157.7	172.4	141.5	187.4	169.8	175.9	180.5	187.2	169.7	174.0	178.6
	8+					180.6	168.1	176.5	170.4	190.9	172.1	177.2	160.2	190.8	172.0	176.7	160.9
	Sum					112.0	109.8	149.0	126.9	124.3	121.5	165.9	117.6	124.1	121.4	154.1	117.7

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	3	24	Gillnet	2
Trawl	2	24	Trawl	2					
Gillnet	3	22	Gillnet	2					
Trapn	4	22	Trapn	2					
Trapn	3	22	Trapn	2					
Trapn	4	22	Trapn	2					

The overall slight drop of mean weights in Quarter 4 in the age groups 6 and 8 are caused by some significant contribution of CBH (see Section 1.5) in trawl samples of SD 24. However, the contribution of age 6 and 8 to the overall abundance estimate of herring is less than 0.5 % (see Section 2.2).

2.4 Mean length (cm) in the catch

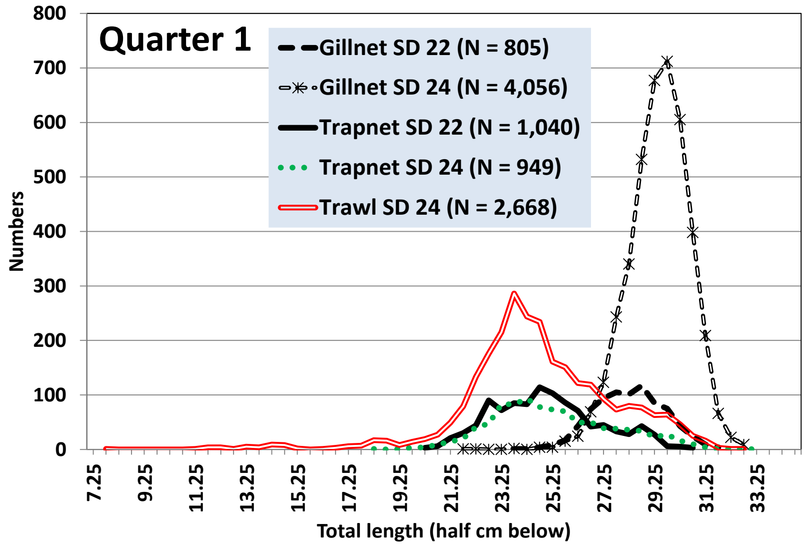
		SUBDIVISION 20				SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0								13.2				13.2				13.2
	1					13.5	13.3		19.0	13.5	13.3		19.0	13.5	13.3		19.0
	2					18.7	18.4		22.8	18.7	18.4		22.8	18.7	18.4		22.8
	3					23.4	22.5		24.9	23.4	22.5		24.9	23.4	22.5		24.9
	4					24.6	23.7		25.6	24.6	23.7		25.6	24.6	23.7		25.6
	5					26.3	25.1		26.9	26.3	25.1		26.9	26.3	25.1		26.9
	6					28.6	25.5		26.4	28.6	25.5		26.4	28.6	25.5		26.4
	7					29.1	26.7		28.5	29.1	26.7		28.5	29.1	26.7		28.5
	8+					29.5	27.3		27.3	29.5	27.3		27.3	29.5	27.3		27.3
	Sum					24.7	23.5		24.7	24.7	23.5		24.7	24.7	23.5		24.7
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0																
	1																
	2								25.9								25.9
	3					25.8	24.5	24.5	26.2	25.2	23.8	23.8	27.1	25.2	23.8	24.1	26.7
	4					26.7	27.0	27.0	26.6	27.6	27.0	27.0	28.2	27.6	27.0	27.0	27.6
	5					27.5	27.6	27.6	27.3	28.6	27.4	27.4	28.7	28.6	27.4	27.5	28.5
	6					28.5	28.1	28.1	27.2	29.5	28.6	28.6	29.1	29.5	28.6	28.3	28.8
	7					29.5	29.1	29.1	26.2	30.0	29.1	29.1	31.0	30.0	29.1	29.1	28.0
	8+					29.1	29.3	29.3	28.5	30.2	29.2	29.2	29.7	30.2	29.2	29.3	29.0
	Sum					28.3	28.3	28.3	26.5	29.4	28.4	28.4	28.3	29.4	28.4	28.3	27.7
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0																
	1																
	2						18.5	18.5	18.5		20.0				20.0	18.5	18.5
	3					22.6	21.4	21.4	21.4	23.4	22.1			23.4	22.1	21.4	21.4
	4					24.5	23.2	23.2	23.2	24.8	23.3			24.8	23.2	23.2	23.2
	5					25.6	24.6	24.6	24.6	26.8	24.9			26.8	24.9	24.6	24.6
	6					26.6	25.2	25.2	25.2	27.9	27.7			27.9	27.7	25.2	25.2
	7					27.8	27.8	27.8	27.8	29.5	26.4			29.5	26.4	27.8	27.8
	8+					29.4				29.9	28.9			29.9	28.9		
	Sum					25.0	22.8	22.8	22.8	25.3	23.1			25.3	23.1	22.8	22.8
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								13.2				13.2				13.2
	1					13.5	13.3		19.0	13.5	13.3		19.0	13.5	13.3		19.0
	2					18.7	18.4	18.5	25.4	18.7	18.7		22.8	18.7	18.7	18.5	22.8
	3					23.4	22.5	21.6	25.0	23.4	22.5	23.8	24.9	23.4	22.5	21.8	24.9
	4					24.6	24.0	25.1	25.0	24.7	24.1	27.0	25.6	24.7	24.1	25.4	25.6
	5					26.4	26.3	27.4	26.8	26.9	26.5	27.4	27.1	26.9	26.5	27.4	27.1
	6					28.6	27.0	27.8	26.4	29.1	27.8	28.6	26.6	29.1	27.8	28.1	26.6
	7					29.2	28.3	29.1	26.2	29.7	28.8	29.1	28.6	29.7	28.8	29.1	28.5
	8+					29.4	28.8	29.3	28.5	29.9	29.0	29.2	27.4	29.9	29.0	29.3	27.5
	Sum					24.9	24.8	27.4	25.5	25.7	25.6	28.4	24.7	25.7	25.6	27.7	24.7

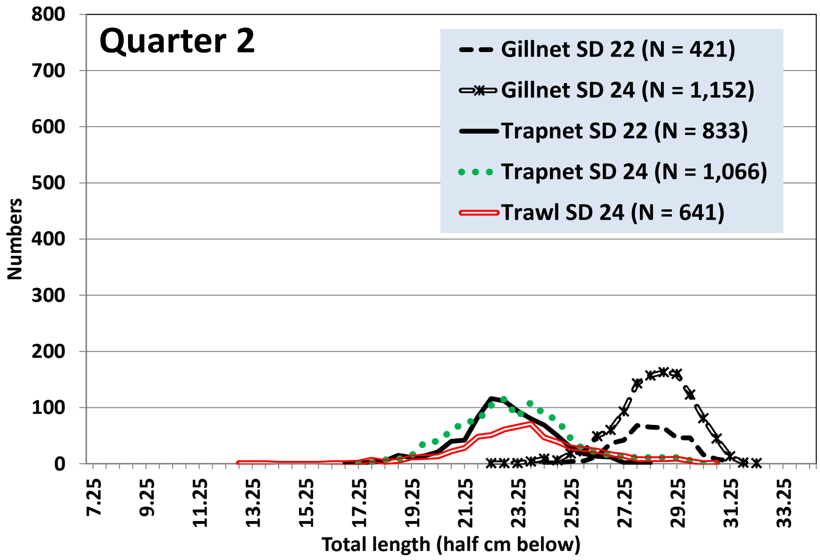
REPLACEMENT OF MISSING SAMPLES:

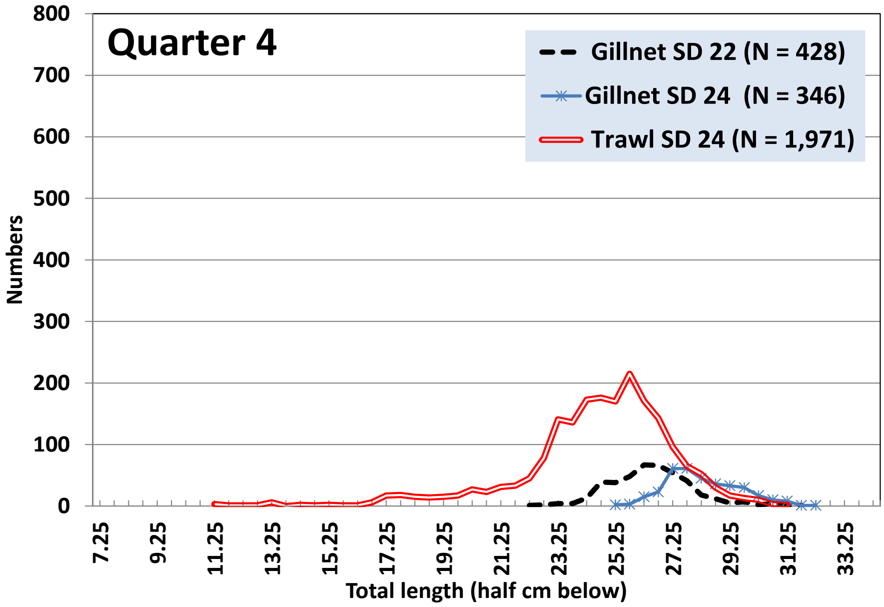
SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	1	24	Trawl	1	Gillnet	3	24	Gillnet	2
Trawl	2	24	Trawl	2					
Gillnet	3	22	Gillnet	2					
Trapn	4	22	Trapn	2					
Trapn	3	22	Trapn	2					
Trapn	4	22	Trapn	2					

The overall slight drop of mean length in Quarter 4 in the age groups 6 and 8 are caused by some significant contribution of CBH (see Section 1.5) in trawl samples of SD 24. However, the contribution of age 6 and 8 to the overall abundance estimate of herring is less than 0.5 % (see Section 2.2).

2.5 Sampled length distributions by Subdivision, quarter and type of gear







Annex 07 Minority Opinion within HAWG on the latest benchmark of 7aN herring

This statement does not reflect the opinion of HAWG but of one member only.

Maurice Clarke (Ireland).

HAWG was asked to consider an assessment formulation from WKIRISH with catchability q =1 on the SSB index. There was not consensus on the choice of this formulation. A majority supported it, but a minority did not support it and there were those who did not express a preference. As I was one of those in the minority, I wish to enter a statement.

The disagreement concerns whether the SSB index can be considered a reliable absolute estimator of stock size of the the 7aN stock, due to contamination with fish from the Celtic Sea herring stock (Divisions 7aS,7g,7j). There is published information on mixing in this area, though this was not considered in detail during HAWG.

There are inadequacies in the text in Section 1.9.3 as follows:

The WKIRISH3 "*reviewers decided to leave the decision on a way forward to HAWG*". That request came, instead, from the ACOM Leadership. The reviewers requested that HAWG draft the TOR for an inter-benchmark to decide on the matter.

Paragraph 3 referring to the literature suggests a level of detailed consideration that was not given at the HAWG.

In "*restricting the survey area to close to the spawning grounds to minimise any contamination from pre-recruits and individuals which may not belong to the Irish Sea stock"* does not constitute an adequate method to exclude contamination, given published studies showing non Irish Sea herring close to the Isle of Man

"*Irish Sea herring advice is based on the benchmarked stock*" is misleading. The benchmark (WKIRISH) reviewers were not in agreement on the assessment, with q=1 on the biomass index, being put forward by the HAWG.

No new benchmarks have been planned for these stocks.