ICES WGBFAS REPORT 2017

ICES ADVISORY COMMITTEE

ICES CM 2017/ACOM:11

REF. ACOM

Report of the Baltic Fisheries Assessment Working Group (WGBFAS)

19–26 April 2017

Copenhagen, Denmark

ICES CIEM

International Council for the Exploration of the Sea

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Recommended format for purposes of citation:

ICES. 2017. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 19-26 April 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:11. 810 pp.

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Executive Summary

The ICES Baltic Fisheries Assessment Working Group (WGBFAS) met 19-26 April 2017 (Chair: Tomas Gröhsler, Germany and Co-chair: Michele Casini, Sweden), with 41 participants and 9 countries represented. The objective of WGBFAS was to assess the status of the following stocks:

- Sole in Division 3.a, SDs 20–24
- Cod in Kattegat, Cod in SDs 22–24, Cod in SDs 25–32
- Herring in SDs 25–27, 28.2, 29 and 32, Herring in SD 28.1 (Gulf of Riga), Herring in SDs 30-31 (Gulf of Bothnia)
- Sprat in SDs 22–32
- Plaice in SDs 21–23, Plaice in SDs 24–25
- Flounder in SDs 22–23; in SDs 24–25; in SDs 26+28 and SDs 27+29–32, Brill in SDs 22–32, Dab in SDs 22–32 and Turbot in SDs 22–32

WGBFAS also identified the data needed for next year's data call with some suggestions for improvements in the data call, and stock-specific research needs.

The report contains an introduction with the summary of other WGs relevant for the WGBFAS, the methods used, and ecosystem considerations. The results of the analytical stock assessment or survey trends for the species listed above are then presented with all the stocks with the same species in the same sections. The report ends with references, recommendations, links to Stock Annexes and list of Working Documents.

The principle analytical models used for the stock assessments were XSA and SAM.

For most flatfishes and cod in SDs 25–32 (data limited stocks), CPUE trends from bottom trawl surveys were used in the assessment (except plaice in SDs 24–25 for which relative SSB from SAM was used). For the data limited stocks, reference points based on length-based indicators were estimated (except cod in SDs 25-32 for which relative reference points were estimated using the SPiCT model).

For cod in SDs 25–32, intersessional work was planned to hopefully allow returning to an analytical stock assessment in the near future.

Ecosystem changes have been analytically considered in the following stock assessments: Herring in SD 25–27, 28.2, 29 and 32, and Sprat in SD 22–32, in form of cod predation mortality.

1 Introduction

1.1 List of participants

Name	Country
Amosova, Victoria	Russia
Artemenkov, Dmitriy	Russia
Berg, Casper	Denmark, part time
Bergenius, Mikaea	Sweden
Boje, Jesper	Denmark
Casini, Michele (co-chair)	Sweden
Degel, Henrik	Denmark
Eero, Margit	Denmark
Grygiel, Wlodzimierz	Poland, part time
Gröhsler, Tomas (chair)	Germany
Hjelm, Joakim	Sweden, part time
Holmgren, Noél	Sweden, part-time
Hommik, Kristiina	Estonia
Horbowy, Jan	Poland
Jonusas, Stanislovas	EC observer, part time
Jounela, Pekka	Finland
Kaljuste, Olavi	Estonia
Karpushevskiyi, Igor	Russia
Kornilovs, Georgs	Latvia
Krumme, Uwe	Germany
Luzenczyk, Anna	Poland
Lövgren, Johan	Sweden
Mildenberger, Tobias	Denmark
Mirny, Zuzanna	Poland, part time
Neuenfeldt, Stefan	Denmark, part time
Nielsen, Anders	Denmark, part time
Norrström, Niclas	Sweden, part time
Pekcan-Hekim, Zeynep	Sweden
Pönni, Jukka	Finland
Plikshs, Maris	Latvia
Öhman, Kristin	Sweden
Orio, Alessandro	Sweden, part time
Raid, Tiit	Estoni
Raitaniemi, Jari	Finland
Schade, Franziska	Germany, part time
Statkus, Romas	Lithuania
Stoetera, Sven	Germany
Storr-Paulsen, Marie	Denmark
Strehlow, Harry	Germany, part time
Ustups, Didzis	Latvia, part time
Vinther, Morten	Denmark, part time

Contact details for each participant are given in Annex 1.

1.2 Terms of reference

2016/2/ACOM11 The **Baltic Fisheries Assessment Working Group** (WGBFAS), chaired by Tomas Gröhsler, Germany and co-chaired Michele Casini, Sweden will meet at ICES Headquarters, 19–26 April 2017 to:

a) Address generic ToRs for Regional and Species Working Groups

b) Review the main result from WGIAB, WGSAM, SGSPATIAL with main focus on the biological processes and interactions of key species in the Baltic Sea;

c) Review progress of the intersessional work agreed in 2016 to improve the assessment of the Baltic cod stocks; and update as appropriate

d) Advise on how the results of the intersessional work can be applied in the assessment of the Baltic Sea cod stocks.

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

1. 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;
2. Propose appropriate MSY proxies for each of the stocks listed below by using methods provided in the ICES Technical Guidelines (i.e. peer reviewed methods 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
bll-2232	Brill (Scophthalmus rhombus) in subdivisions 22–32 (Baltic Sea)	WGBFAS	3.2
cod-kat	Cod (Gadus morhua) in Subdivision 3.a.21 (Kattegat)	WGBFAS	3.2
cod-2532	Cod (Gadus morhua) in subdivisions 25–32, eastern Baltic stock (eastern Baltic Sea)	WGBFAS	3.2
dab-2232	Dab (Limanda limanda) in subdivisions 22–32 (Baltic Sea)	WGBFAS	3.2
fle-2223	Flounder (Platichtys flesus) in subdivisions 22 and 23 (Belt Seas and the Sound)	WGBFAS	3.2
fle-2425	Flounder (Platichtys flesus) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic)	WGBFAS	3.2
fle-2628	Flounder (Platichtys flesus) in subdivisions 26 and 28 (east of Gotland and Gulf of Gdansk)	WGBFAS	3.2
fle-2732	Flounder (Platichtys flesus) in subdivisions 27 and 29–32 (northern central and northern Baltic Sea)	WGBFAS	3.2
ple-2432	Plaice (Pleuronectes platessa) in subdivisions 24–32 (Baltic Sea, excluding the Sound and Belt Seas)	WGBFAS	3.2
tur-2232	Turbot (Scophthalmus maximus) in subdivisions 22–32 (Baltic Sea)	WGBFAS	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 15 March 2017 according to the Data Call 2017.

WGBFAS will report by 3 May 2017 for the attention of ACOM.

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.

1.2.1 Prepare the data calls for the next year update assessment and for the planned data evaluation workshops.

Data call 2018

A subgroup comprising WGBFAS stock coordinators and ICES discussed issues that emerged during the latest 2017 assessment group data call of ICES. The data call text was reviewed and suggestions for improvement were compiled. Besides various details regarding changes, clarifications and improvements in the data call text and tables, participants agreed that the deadline for data submission should be approx. 4 weeks prior to the start of the assessment group (not only 2 weeks). ICES will produce a revised version and circulate it well in advance of the next WGBFAS. .

1.2.2 Identify research needs of relevance for the expert group

General

The WG recognizes that the core lies in understanding the productivity of marine ecosystems. Ecosystems productivity will change in response to many factors, including human pressures, and the impacts of climate change on marine ecosystems, and it is the roll of WGBFAS to handle these science needs with scientific and innovative solutions. Furthermore, there is a widespread agreement about the need to move towards an ecosystem approach to fisheries management that takes into account species interactions which require that the quantity and quality of data used in fish stock assessment have increased to be used in the new advanced stock assessment methods. The variable ecological situation in the Baltic Sea and urgent need for ecological understanding to support the assessment, the ecosystem working groups in ICES provide regular updates on selected environmental and lower trophic level indicators, including those related to fish recruitment, and regional descriptions of ecosystem changes (ICES WGIAB 2012, 2014). However, recent ICES initiatives to bring together ecosystem and stock assessment scientists in seeking solutions to the Eastern Baltic cod assessment and management revealed that there is lack of up-to-date ecosystem process understanding, essential for stock assessment and management advice. This could possibly also affect other stocks but currently there is also a challenge related to mismatch between what is available from science and what is needed for stock assessment and management advice.

Below is list of the most important parameters for a reliable stock assessment, which are all are dependent on up-to-date ecosystem process understanding:

- *Reliable recruitment estimates*

  Important for the development of the stock and for the forecast,

- *Reliable growth estimates*

  Important for stock development and health of the stock,

- *Accurate age determination*

  Vital for age base stock assessment models,

  Needed to accurately determine growth,

- *Catchability in the fishery*

  Shift in catchability will affect our perception of the stock development,

- *Quality assured survey indices*

Will affect our perception of the stock,

- *Ecosystem dependent estimates of natural mortality*

  Will affect our perception of the stock,

- *Accurate discard information*

  Accurate catch numbers and weight are central for stock assessment and are also important for the evaluation of the landing obligation,

- *Spatial distribution and migration between management areas*

  Integrated ecosystem knowledge is important to determine ecosystem advice,

- *Nutritional condition development*

  Important indicator of the ecosystem health and also possibly for information of infections,

- *Development of alternative stock assessment models that can include new information*

  The present variable ecological situation in the Baltic Sea and the need to integrate ecosystem factors in traditional assessment models demands alternative models,

Stock specific research needs

1) Sole in 3.a

See issue list

2) Cod in Kattegat

The issues identified at WKBALT (2017) that could explain the unallocated removals estimated; inflow of recruits from the North Sea and their return migration when they become mature is needed to be analyzed in order to determine unallocated removals. This could be explored by analyzing historical samples to determine stock origin. This will need to be dome in steps, starting with; determine stock origin for 1+ individuals 10 years (200 individuals per year) back in time. These can then be analyzed with the newly developed SAM-model that can handle migration rates (Winther 2017). The second step is to gather genetic samples from the whole size range of cod, in order to split the different cohorts. The second step allows using other models than newly developed SAM-model including the traditional SAM and SS3. Alternative stock assessment models are also something that needs to be developed.

WKBALT (2017) also highlighted the need to explore additional mortality factors like seal predation.

1) Plaice in 21–23

none

2) Plaice in 24–32

none

3) Flounder in 26+28

none

4) Flounder in 27+29–32

none

5) Flounder in 24–25

none

6) Flounder in 22–23

none

7) Plaice in 21–23

none

8) Turbot in 22-32

none

9) Brill in 22-32

none

10) Dab in 22-32

none

11) Herring in 25–27, 28.2, 29 and 32

see issue list

12) Herring in 28.1 (GoR)

see issue list

13) Herring in 30 and 31

none

14) Sprat in 22–32

see issue list

15) Cod in 22–24

see issue list

16) Cod in 25–32

There is work in progress that focuses on reliable growth estimates and accurate age determination. Another on-going task is alternative stock assessment models. But see issue list.

1.2.3 Benchmark process

1.2.3.1 Assess the progress on the benchmark preparation of herring in subdivisions 25–27, 28.2, 29 and 32 and Gulf of Riga herring (subdivision 28.1)

During last year's WGBFAS a benchmark was proposed for the **Central Baltic Herring**. A preliminary issue list was subsequently submitted to ICES in February 2017. Since then and up to the WGBFAS meeting this year, the urgency of, and data availability for, solving these issues have been investigated. It was concluded that many of the suggested issues, such as mortality, age reading quality, recruitment and assessment method are not urgent. These issues should however, be pursued intersessionally for the coming years, to determine if these in fact require consideration. Some issues, such as, the misreporting of herring and sprat which again appears to be a problem in some nations with the large incoming year classes of herring and sprat, can potentially be urgent to resolve. Similarly urgent could be the issue of mixing of Central and Western Baltic herring. However, the WGBFAS meeting concluded that we do not presently have sufficient data to investigate the impact of these two issues on the perception of the Central Baltic Herring stock. One issue the WGBFAS meeting considered potentially important is the inclusion of the BIAS index including the subdivision 32. The new index is currently being produced by the WGBIFS members and its inclusion in the assessment will be investigated during the autumn 2017. If the influence of the new index will have a large impact on our perception of the stock, we will call for an interim benchmark dealing with this particular issue. If the impact is low, we will prepare ICES for a review in conjunction with the update assessment 2018. The future plan however, is that the issues on the issue list will be progressively worked on for the next coming years.

During last year's WGBFAS a benchmark was proposed also for the Gulf of Riga Herring. A preliminary issue list was subsequently submitted to ICES in February 2017. The main identified issues were inspection of the tuning fleets, recruitment estimates, mixing with the Central Baltic herring and age reading. It is considered that the trapnet tuning fleet could be significantly affected by the market conditions and management decisions and it should be investigated how this could be taken into account. Till 2011 the recruitment in intermediate year was predicted in RCT3 using environmental factors which were assumed to influence the reproduction success of the Gulf of Riga herring. However, due to worsening of the relationship between recruitment and used environmental factors the recruitment in intermediate year was assumed to be equal with the geometric mean in previous years. It is planned to investigate previously used relationships and to present results during the next WGBFAS meeting. Concerning age reading during this year there will results from otolith exchange exercise performed for the Baltic herring. Age reading is also important part of discriminating between Central Baltic herring and Gulf of Riga herring and it will be solved with the help of bilateral age reading exercises between Latvia and Estonia. It was also concluded that it will not be possible to conclude this work till the proposed time of the benchmark meeting and it was proposed to postpone it. It was also pointed out that several experts are involved in data preparation for both stocks and both stocks have several common issues therefore it would be desirable that the benchmarking of both stocks is made together.

1.2.3.2 Consider and propose stocks to be benchmarked

Since the last **sole (Division 3a and subdivisions 22-24)** benchmark in 2015 a number of issues that can improve the present assessment have been recognized. At DTU Aqua, Denmark, a project focusing on these issues have been initiated and is running in 2017 and 2018. The work packages in the project are:

- Abundance and distribution of juveniles; identification of nursery grounds and evaluation of their importance for recruitment to the stock.
- Growth and recruitment; improvement of ageing by means of otolith calibration between readers and otolith structure to validate age.
- Stock structure - genetics; genotyping spawning fish in order to identify stock structure in the entire stock assessment area SD 20-24 and also to evaluate main migration patterns.

- Survey coverage – design; analysis of appropriate survey coverage with respect to the stock distribution. In 2016 survey area was already extended into Skagerrak and the Belts and this scheme will be evaluated.
- Improvement of biological data sampling - reference fleet; sampling from the fishery is difficult due to small and scattered landings; since 2016 agreements with specific fishermen were initiated to improve biological sampling.
- Selectivity in various gears – SELTRA; introduction of new selective devices in fishing gears have caused selectivity to change substantially. In order to quantify this change experimental sole fishery will be conducted with the most used devices.
- Improvement of assessment; the effect of revising a number of input data and assumptions in the assessment due to the above mentioned work packages will be evaluated with respect to estimation of the stock and fishing pressure.

The outcome of the project is likely available for a benchmark of the sole stock in early 2019.

1.2.4 Review progress of the intersessional work agreed in 2016 to improve the assessment of the Baltic cod stocks; and update as appropriate

Biology

WGBFAS 2016 suggested a scientific workshop to be held prior to WGBFAS 2017, to discuss the biology of eastern Baltic cod. This is to facilitate communication between researchers and WGBFAS and ensure the transfer of new scientific results into stock assessment work. This suggestion was followed and a workshop on Biological Input to Eastern Baltic Cod Assessment (WKBEBCA) took place 1-2 March, 2017 in Gothenburg, Sweden. The workshop was well attended, and involved scientists working on cod biology, but normally not participating in stock assessment work. Thus, the workshop is considered to have been successful in bringing together available expertise on the issues and make progress in understanding the biological changes in the stock. In short, the workshop identified drivers for potential changes in growth and natural mortality that allows constructing the timeline for likely change. However the magnitude of potential reduction in growth and increase in natural mortality within the entire life-span of the fish was not possible to quantify. Different hypothesis can be made, which can unlikely be verified until the tagging data (from TABACOD project) becomes available (ICES WKBEBCA 2017).

Survey indices

At WGBFAS 2017, two alternative approaches for modelling survey indices were presented, that both allow treating the entire survey time series as one, i.e. without separating it to two periods as it is done with the standard indices calculated in DATRAS. Also, the alternative approaches allow estimating CV in survey indices that is a useful input to some assessment models (e.g. SS3).

Production model (SPICT)

WGBFAS 2016 recommended to further develop MSY Proxy methods that would allow estimating stock status in relation to potential Fmsy reference points in situations where temporal changes in life history parameters (such as growth and natural mortality) have taken place, as is the case for Eastern Baltic cod. At WGBFAS 2017, a modified version of SPICT model was presented that allows taking into account a change in productivity over time, estimated within the model (see section 2.1.6 for details). Compared to age/length based models, SPICT has the advantage that growth and natural mortality do not need to be separated but are modelled together as productivity. WGBFAS 2017 considered SPICT to be applicable for defining the stock status of EB cod in relation to reference points (F/FMSY and B/BMSY). Moreover, WGBFAS saw potential in this method to be used directly as a basis for providing catch advice corresponding to MSY. This led to a recommendation of an inter-benchmark before WGBFAS 2018 (see section 1.2.5).

Age/length based approaches (SS3)

An age/length based stock assessment model using Stock Synthesis(SS3) framework has been set up for EB cod allowing for changes in natural mortality, growth and selectivity in later years. The model fits reasonably well to the data and can produce historical dynamics of the stock similar to former age-based assessments.

A specific issue that was focused on during the discussions at WGBFAS 2017 was that the age/length based stock assessment models (incl. SS3) need to separate between growth and natural mortality, which both are suspected to have changed over time, but by unknown magnitudes. The growth, natural mortality and selectivity are confounded in the model, and cannot be independently estimated without any additional information available on any of these. The SS3 model currently available is solving this by including an age-length-key to inform growth, which is based on traditional age readings from different countries. WGBFAS 2017 considered this approach not appropriate to determine growth, given that traditional age readings have been concluded to be unreliable for later years, which is one of the main reasons that the former age-based assessment has been abandoned since 2015. Further, it was pointed out that the assumption on the magnitude of change in growth is crucial for the assessment output in terms of mortality, as the same length distribution can be obtained by a combination of faster growth and higher mortality, or by slower growth and lower mortality.

During WGBFAS 2017, possible future steps were discussed. The group supported continued work on age/length based models (such as SS3). It is recognized that validated growth information will not be available until ca 2019-2020, i.e after the ongoing tagging project (TABACOD) is completed. Nevertheless, the group supported continued parallel efforts towards setting up a reasonable assumption on the magnitude of change in growth, which can then be verified and improved when the tagging data becomes available. As next steps with age/length based methods, WGBFAS 2017 recommends focusing on the input data issues, which include:

i) The method for calculating survey indices (based on the two approaches presented to WGBFAS 2017, described above).

ii) Age-length-key or some other form of input to inform the model about the assumed magnitude of change in growth. Suggested approaches to derive justifiable assumptions include looking into the magnitude of change in potential drivers for growth, and by which magnitude have these affected the growth in former times (i.e. before 2006), when age readings are considered to be of a more reasonable quality. This could possibly be combined with some age-reading information to construct an ALK that would reflect the magnitude of growth change expected, based on the magnitude of change in drivers.

iii) Natural mortality of young cod, where the values formerly derived from SMS model should be evaluated and updated.

1.2.5 Advice on how the results of the intersessional work can be applied in the assessment of the Baltic Sea cod stocks

WGBFAS 2017 recommends an inter-benchmark to take place before WGBFAS 2018 to address the following two issues:

i) The method for estimating modelled survey indices, as an alternative to the present indices calculated from DATRAS. Two possible approaches for modelling survey indices were presented to WGBFAS 2017. One of the advantages of the modelled survey indices is that one longer time series can be used, instead of separating the indices in different time periods, as is currently done with DATRAS indices. Survey indices are important input to any stock assessment approach. Thus, identifying the best available approach for producing survey indices is relevant both for present stock assessment approach (DLS), for production model (SPICT) as well as for any age/length based models expected to be adopted in future.

ii) Evaluate whether the production model (SPICT) developed for EB cod and presented at WGBFAS 2017 in relation to MSY Proxy reference points, can also be used directly to provide catch advice corresponding to MSY. WGBFAS considers this to be a considerable improvement compared to the present DLS approach, using only 5 years of survey data. Adopting SPICT model as a basis for advice is seen as an intermediate step, until an age/length based approach is ready to be used. This implies that at the same time intersessional work on age/length based methods and related input data (see 1.2.4) should continue.

1.2.6 Estimate MSY proxy reference points for the category 3 and 4 stocks in need of new advice in 2017

For each of the stocks listed below methods provided in the ICES Technical Guidelines (i.e. peer reviewed methods that were developed by WKLIFE V, WKLIFE VI, and WKProxy) were used to provide MSY proxy reference points:

Stock Code	Stock name description	EG	Data Category	Details are given in stock report section
bll-2232	Brill (Scophthalmus rhombus) in subdivisions 22–32 (Baltic Sea)	WGBFAS	3.2	8
cod-kat	Cod (Gadus morhua) in Subdivision 3.a.21 (Kattegat)	WGBFAS	3.2	2
cod-2532	Cod (Gadus morhua) in subdivisions 25–32, eastern Baltic stock (eastern Baltic Sea)	WGBFAS	3.2	2
dab-2232	Dab (Limanda limanda) in subdivisions 22–32 (Baltic Sea)	WGBFAS	3.2	8
fle-2223	Flounder (Platichtys flesus) in subdivisions 22 and 23 (Belt Seas and the Sound)	WGBFAS	3.2	3
fle-2425	Flounder (Platichtys flesus) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic)	WGBFAS	3.2	3
fle-2628	Flounder (Platichtys flesus) in subdivisions 26 and 28 (east of Gotland and Gulf of Gdansk)	WGBFAS	3.2	3
fle-2732	Flounder (Platichtys flesus) in subdivisions 27 and 29–32 (northern central and northern Baltic Sea)	WGBFAS	3.2	3
ple-2432	Plaice (Pleuronectes platessa) in subdivisions 24–32 (Baltic Sea, excluding the Sound and Belt Seas)	WGBFAS	3.2	5
tur-2232	Turbot (Scophthalmus maximus) in subdivisions 22–32 (Baltic Sea)	WGBFAS	3.2	8

1.3 Working Groups response to recommendations from other ICES groups

ID	EG	Year	Recommendation	Status
48	WGBIFS	2016	WGBIFS recommends that, the BIAS-dataset, including the valid data from 2015, can be used in the assessment of the herring and sprat stocks in the Baltic Sea with the restriction that the following years are excluded from the index series: 1993, 1995 and 1997.	considered at the WGBFAS meeting in 2016
49	WGBIFS	2016	WGBIFS recommends that the current BIAS index series can be used in the assessment of the Bothnian Sea herring with the restriction that the year 1999 is excluded from the dataset. The abundance indices for age groups 0 and 1 should be handled with caution.	considered at the WGBFAS meeting in 2016
50	WGBIFS	2016	WGBIFS recommends that, the BASS-dataset with the valid data of 2015 can be used in the assessment of the sprat stock in the Baltic Sea.	considered at the WGBFAS meeting in 2016
87	WKDEICE	2016	2. Establish a back–to–back meeting with WGBFAS in 2017	not established in 2017
109	PGDATA	2016	PGDATA suggest that WGBFAS is testing the data questionnaire of "major changes in design and estimation" presently in Figure 4.3 in this report. The report has to be filled out by every data provider (institute / country) providing data for a given stock	communicated to all WGBFAS members
261	WKFICON	2016	2. According to the results presented during the WKFICON workshop and the discussions carried out, participants recommend that body condition indicators must be included in stock assessments. In order to progress in this issue, the new WGFICON working group will invite to the first meeting the responsible scientists of the different organisms to which this recommendation is addressed (i.a. WGBFAS)	communicated to all WGBFAS members

1.4 Reviews of groups or work important for WGBFAS

1.4.1 Meeting of the Chairs of Assessment Expert Groups (WGCHAIRS)

WGBFAS 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:

Data call: ICES sends out one data call on all ICES assessment or related working groups. As last year ICES members are requested to either upload the catch/landings data in InterCatch or send it to the ICES secretariat for registration purposes. For the second time BMS and logbook registered discard data are requested in 2017 (relevant for cod stocks in the Baltic). ICES presented guidelines on handling of late data submission.

Benchmarks: In 2015 a new benchmark process was suggested, which however received substantial criticisms at the ASC in 2016. ACOM agreed to use the North Sea demersal and herring stocks as test cases and requested the ACOM leadership to liaison with the chairs of WGNSSK and HAWG to set up scoping workshops back to back with the expert group meetings in 2017.

Rounding: New rules to round numbers were presented.

MSY approach for category 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 WGBFAS for two cod stocks and 8 flatfish stocks.

Guidelines: ACOM has agreed to develop and publish technical guidelines for the advisory process. Completed technical guidelines were released in December 2016, other guidelines to be released in 2017.

Conflict of interest: In order to deal with conflict of interest (COI) situations at ICES in the future, Bureau has developed a policy document on COI, including an outline for a process to be considered prior to and when COI situations arise.

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

1.4.2 Baltic International fish survey Working Group (WGBIFS)

The presentation of WGBIFS 2017 was composed from three parts focused on the outcomes from:

a) Baltic acoustic-trawl surveys (BIAS, BASS) in 2016,
b) BITS surveys in 2016-Q4 and 2017-Q1,
c) hydrological monitoring in the Polish part of the southern Baltic (2016-Q4 and 2017-Q1).

The Baltic International Acoustic Survey (BIAS) vs. plan in September-October 2016, regarding the area coverage with acoustic-trawl monitoring was completed in 96% however, some „white” areas in the ICES SDs 29-S and 32-E are indicated. The above-mentioned survey was realised by all countries located on the coasts of the Baltic Sea. The geographical distribution of herring, sprat and cod from age groups 1-8+ and separately YOY abundance in the Baltic, calculated per the ICES rectangles in given the ICES subdivision based on one by one the BIAS surveys in 2015 and 2016 was demonstrated in consecutive graphs. In September-October 2016, the highest concentrations of herring (age 1+) were detected in the ICES SDs 29-E and 32 (middle part) and next in the western and northern parts of the Åland Sea as well in the Bothnian Sea. During the same survey, the geographical distribution of YOY-herring abundance in the Baltic was limited mainly to the eastern part of the Gulf of Finland, western part of the ICES SD 29 and the Arkona Basin as well the southern part of the Kattegat. Sprat (age 1+) dense shoals were more widely distributed than herring. The centre of high concentrations of adult sprat, in comparison with the BIAS-2015, was slightly shifted from the central part of the Baltic Proper to the Estonian, Latvian and Finnish coasts. Considerable YOY-sprat abundance was recorded in the Arkona Basin and next in the southern part of the ICES SD 29. Cod (age 1+) was concentrated mostly in the ICES SD 24-W, nearby the Bornholm and Öland Island. The BIAS-dataset, including the valid data from 2016 can be used in the assessment of the CBH (herring) and sprat stocks in the Baltic Sea with the restriction that the years 1993, 1995 and 1997 (when the monitored area coverage was poor) are excluded from the index series. The current BIAS index series can be used in assessment of the Bothnian Sea herring with the restriction that the year 1999 is excluded from the dataset. The abundance indices for age groups 0 and 1 should be handled with caution.

The Baltic Acoustic Spring Survey (BASS) vs. plan in May 2016, regarding the area coverage with acoustic-trawl monitoring was completed in 47% and broad „white" areas in the ICES SDs 24, 25 and in parts of the ICES SDs 26 and 28 were omitted from this inspection. The above-mentioned inspection was realised during the Latvian-Polish, Estonian-Polish and Lithuanian surveys. The BASS-dataset can be used in the assessment of the sprat stock in the Baltic Sea with restriction that the year 2016 is excluded from the dataset.

The realization of valid ground trawl hauls vs. planned during the Baltic International Trawl Survey BITS-Q4/2016 and the BITS-Q1/2017 was on the level of 94 and 99% (by numbers), respectively and was considered by the WGBIFS-2017 as appropriate tuning series data for the assessment of Baltic and Kattegat cod and flatfish stocks. The set of maps, inserted to the presentation reflects the geographical distribution of cod, flounder, plaice, turbot, dab and brill near seabed, during spring and autumn BITS surveys in 2016. For such visualisation the CPUE (in numbers per 1h of trawling - for all age groups, in unit of the standard TV-3 trawl) parameter was applied.

Moreover, the WGBIFS-2017 respond to a set of inquiries, sent by the WGBFAS was also presented. The responses were focused on the evaluation of quantity and quality of the fish research surveys indices.

The recent measurements (Nov. 2016, Feb.-March 2017) of the water temperature, salinity and oxygen content in the seabed zone of the Polish marine waters indicate on an improvement of hydrological conditions of the southern Baltic however, more locally than expected.

1.4.3 Workshop on Spatial Analyses for the Baltic Sea 2 (WKSPAT IAL)

The ICES Workshop on Spatial Analyses for the Baltic Sea 2 (WKSPATIAL2) in 2016 aimed to: 1) continue investigating the cod stomach contents from the EU tender with particular emphasis on the spatial-temporal changes, the relation to prey availability and environmental condition, and the link to cod growth/condition; 2) start investigating the relation between cod food intake and condition/growth, 3) continue investigating the spatial dynamics in quantitative and qualitative feeding of sprat and herring and identify their dietary overlap, and 4) investigate and identify possibilities for spatially-explicit multispecies models for fish species including the new stomach contents information. We calculated prey-type specific cod consumption rates and estimated trends in feeding levels for different lengths of cod, using the stomach database standardized in WKSPATIAL. Applying a simple bioenergetics growth model, we found that nowadays many small pre-spawning cod within the reach of The BITS survey have feeding levels that imply severe growth inhibition that is then carried through life despite favourable feeding conditions for larger cod. The cod stomach data standardized in WKSPATIAL were also used in Gadget multispecies assessment model. The model estimates fit well to the stomach data starting from late 1980s. The model detected a switch between the proportions of herring and sprat in the modelled diet of cod at the time of the regime shift in Baltic (late 1980s). Before the regime shift herring comprised a larger proportion in the cod diet than sprat did, while after the regime shift it became opposite. Analyses of the relation between clupeid fish diet and prey availability showed that on average, the relatively richest food resource for herring and sprat, was observed in the Baltic Proper and the poorest in the eastern Gulf of Finland. The spatial dynamics in the taxonomic composition of herring and sprat stomachs broadly resembled that of the availability of prey. While the stomach fullness of sprat was relatively stable across the areas, that of herring was the highest in the eastern Gulf of Finland and the Irbe Strait area.

1.4.4 Working group of Integrated Assessment (WGIAB)

WGIAB is currently in the first year of a new three year ToR cycle. The groups' main activities are to develop a trait-based approach of understanding ecosystem function and to explore the social-ecological system. During the meeting a new conceptual model of the interrelationships between ecosystem and society was produced. Additionally the group evaluated the probability of occurrence and magnitude of the effect of pressures occurring in the Baltic Sea. The top 5 pressures were: Input of nutrients, increased temperature, decreased salinity, input of hazardous substances, and the input and spread of non-indigenous species.

1.4.5 Workshop on Developing Integrated Advice for Baltic Sea ecosystem-based fisheries management (WKDEICE)

The WKDEICE 2016 meeting addressed 5 topics focusing on the EBC in subdivisions 25-32, namely: developing a strategy for integrating environmental and economic information in fish stock advice, conducting an integrated environmental assessment, conducting a socio-economic assessment, conducting short-term projections informed by environmental and economic conditions, and communicating the approach and the results. A central point of the meeting was to design a concept of operationalized integrated ecosystem assessment including short-term predictions to be used in advice on the Baltic Sea fish stocks. The model is only a proof of concept due to the lack of reliable assessments of the EBC since 2013. The harvest control rules of the conceptual model vary the fishing mortality of the stock set by fisheries advice by applying a multiplier that depends on the environmental conditions. The group is also working on modifying the existing advice document format. A full suggestion for a modified advice sheet will be delivered after the next WKDEICE workshop planned to take place 19-21 June, 2017 at the National Fisheries Research Institute in Gdynia, Poland.

1.4.6 Working Group on Multispecies Assessment Methods (WGSAM)

During the Working Group on Multispecies Assessment Methods (WGSAM), a Key Run of the Baltic Sea Ecopath with Ecosim model was presented and reviewed in detail by 4 WGSAM experts, and approved by the group following implementation of changes agreed in plenary at the meeting and verified by the 4 experts in January 2017.

1.4.7 Working Group on the History of Fish and Fisheries (WGHIST)

During the 2016 meeting of the Working Group on the History of Fish and Fisheries (WGHIST) , discussions were raised about how historical data, and in particular the resources and knowledge that WGHIST members share, can be used to better understand fish species/stock dynamics and contribute to management or advisory issues, both inside and outside ICES. However, even though the importance of these data is undeniable, is still very challenging to include them in quantitative stock assessment or other type of fishery management. Willingness to explore different methods to use WGHIST data in understanding stocks dynamic was expressed among WGHIST members, yet WGHIST needs help in understanding how to use the data/information available, as well as creative assistance and collaboration from modellers that have experienced working with data-limited cases. Because of this need for experts to cooperate, a proposal put forth at the 2016 meeting to organize a workshop between interested WGHIST scientists and stock assessment experts and modellers from others ICES WGs. Therefore, WGHIST carried out some preliminary steps to proceed with the organization of the workshop in 2017. From here, the next steps will be to identify stock assessment scientists and modellers who are interested in joining in the workshop, and finally organizing it. This activity seems particularly promising and would hopefully help in discover new ways in which historical data can be used to understand stocks dynamics and contribute to management issues.

1.4.8 Working Group on Data Needs for Assessments and Advice (PGDATA)

The main output of the meeting was a an evaluation of the 2017 ICES EG data call, were the PROXY data call on length data from data limited stocks was included. The audit included redefinition of some variables, mainly concerning the landing obligation and clarification of the text. The process was thought to be very useful as the data provider has not earlier been involved in the process of committing on the data call but merely been trying to compile with the data call text. It was however thought that involvement of PGDATA earlier in the process starts January, could even further improve the process as the data call deadline prevented the wanted thoroughness. Further, the meting focused on finalizes the ToRs for the workshop on BIOPTIM and establish the work process and preparation for the workshop. The BIOPTIM aims to look at ways in which biological parameters obtained from sampling commercial catches can be optimized so that the time and money spent on sampling can be effectively justified in terms of providing quality information to end users. The aim is to develop an R tool-box which can be used by national labs to quantify the effects of different sampling intensities and sampling designs, and support discussions on the advantages and disadvantages of different sampling strategies in terms of time and cost savings involved. As part of the improvement of the data quality on biological parameters (mainly otoliths) PGDATA and WGBIOP developed a roadmap for implementing the SmartDots software developed by ILVO to replace WebGR as the regional/European system for otolith age reading and possible maturity classification. Further development of SmartDot in spring 2017 will make it possible for SmartDots to be integrated in a web platform provided by ICES. PGDATA 2017 also finalised the guideline for the data preparation workshops which included taking the feedback from the 2016 benchmark data evaluation meeting for the Irish Sea (WKIRISH2) and Kattegat cod (WKBALT) into account and to streamline the benchmark process even further by updating the issue list template that are normally populate by the assessment working groups. To increase the data quality and the communication between the expert groups and the data providers

PGDATA suggested a further development and maintenance of the Data Quality Assurance Repository. The idea is to structure all the work done on data quality and best practices in the different technical workshops and thereby avoid that scientist from national institutes or from other working groups has to read through all the reports to find the relevant guidelines.

1.5 Methods used by the Working Group

1.5.1 Analysis of catch-at-age data

Full analytical assessment of fish stock with following short term forecasts was done for the following stocks in the Baltic:

- Cod in the subdivisions 22—24
- Sole in Division 3.a + SDs 22—24
- Plaice in subdivisions 21—23
- Herring in the subdivisions 25—29 and 32, excluding Gulf of Riga
- Herring in the Gulf of Riga (Subdivision 28.1)
- Herring in Subdivisions 30 and 31
- Sprat in the subdivisions 22—32.

No analytical assessment but a trend-based assessment was carried out for the following stocks:

- Cod in the Kattegat
- Cod in subdivisions 25–32
- Plaice in subdivisions 24–32
- Flounder in subdivisions 22–23,
- Flounder in subdivisions 24–25,
- Flounder in subdivisions 26 and 28,
- Flounder in subdivisions 27, 29–32,
- Brill in subdivisions 22–32,
- Dab22–32 in subdivisions
- Turbot in subdivisions 22–32.

The main tools for the assessment of the state of stocks and catch-at-age was the stochastic state-space model (SAM) (Nielsen, ICES 2008) and VPA tuned using the (Extended Survival Analysis) XSA method (Darby and Flatman, 1994).

SAM was used for assessment of cod in Kattegat, cod in SDs 22-24, plaice in SDs 21–23, herring in SD's 30 and 31 and sole in Division 3.a+ SDs 22–24. The model allows estimation of possible bias (positive or negative) in the data on removals from the stock in specific years. Settings of the model were used as specified in Stock Annex. Details on model configuration, including all input data and the results can be viewed at www.stockassessment.org.

The results of analyses are presented in corresponding sections of stocks.

1.5.2 Assessment Software

Overview of used versions of software:

SOFTWARE	PURPOSE	VERSION
MSVPA	Outout for further assessment	
XSA	Historical assessment	VPA95
RETVPA	Retrospective analysis	
RCT3	Recruitment estimates	
MFDP	Short-term prediction	
SAM	Historical and exploratory assessment	

1.5.3 Methods applied in subsequent assessments

Assessment classifications:

STOCK	CLASSIFICATION IN 2016	ASSESSMENT IN 2017
Cod in Kattegat	Trend based	Bench mark, Trend based
Cod in SD 22–24	Update	Update
Cod in SD 25–32	Trend based	Trend based
Sole in SDs 20–24	Update	Update
Flounder in SD 22–23	Trend based	Trend based
Flounder in SD 24–25	Trend based	Trend based
Flounder in SD 26–28	Trend based	Trend based
Flounder in SD 27–32	Trend based	Trend based
Plaice SD 21–23	Update	Update
Plaice SD 24–32	Trend based	Trend based
Dab SD 22–32	Trend based	Trend based
Brill SD 22–32	Trend based	Trend based
Turbot SD 22–32	Trend based	Trend based
Herring in SD 25–27, 28.2, 29 &32	Update	Update
Herring in GOR (SD 28.1)	Update	Update
Herring in SD's 30 and 31 (Gulf of Bothnia)	Update	Benchmark, Update
Sprat in SD 22–32	Update	Update

1.6 Stock annex

A table containing links to the stock annexes covered by WGBFAS is found in Annex 4 of this report.

1.7 Ecosystem considerations

The WGBFAS recognizes the importance of considering ecosystem variability and trends in the stock assessments, and to assess the effects of fishing activities on the ecosystem as a whole. To this end, we have used the reports of the Study Group/Working Group on Spatial Analyses for the Baltic Sea (SGSPATIAL/WKSPATIAL), the Working Group on Integrated Assessments of the Baltic Sea (WGIAB), the Working Group on Multi-species Assessment Methods (WGSAM), as well as peer-reviewed publications and other analyses presented at WGBFAS as input to the sections below. We list the details of how ecosystem variability has been accounted for and in which stock assessments. We also propose measures and further development of methods to account for ecosystem variability and fisheries-induced ecosystem effects in stock assessments.

1.7.1 Abiotic factors

The ecosystem changes in the Baltic Sea are synthesized by the ICES WGIAB (2008 and subsequent reports) in Integrated Ecosystem Assessments (IEA) conducted for seven sub-regions of the Baltic Sea: i) the Sound (ÖS), ii) the Central Baltic Sea (CBS), encompassing the three deep basins, Bornholm Basin, Gdansk Deep and Gotland Basin; iii) the Gulf of Riga (GoR), iv) the Gulf of Finland (GoF), v) the Bothnian Sea (BoS), vi) the Bothnian Bay (BOB) and a coastal site in the southwestern Baltic Sea (COAST). The updated IEA (ICES WGIAB, 2015) corroborated the correlation between temperature and salinity, and included 2014 values for the abiotic factors being tracked.

The main drivers of the observed ecosystem changes vary somewhat between sub-regions, but they all include the increasing temperature and decreasing salinity (Figure 1.7.1). These are influenced by large-scale atmospheric processes illustrated by the Baltic Sea Index (BSI), a regional calibration of the North Atlantic Oscillation index (NAO) (Lehmann *et al.*, 2002). The change from a generally negative to a positive index for both BSI and NAO in the late eighties was associated with more frequent westerly winds, warmer winter and eventually a warmer climate over the area (Figure 1.7.1). Further, the absence of major inflow events has been hypothesized to be related to the high NAO period (Hänninen *et al*., 2000). An indication of this is that only two major inflows to the Baltic Sea have been recorded during the high BSI-period since the late 1980s. Contrary to what occurred in surface waters, salinity in deeper waters has increased after the early 1990s to levels as high as in 1960s–1970s (Figure 1.7.1).

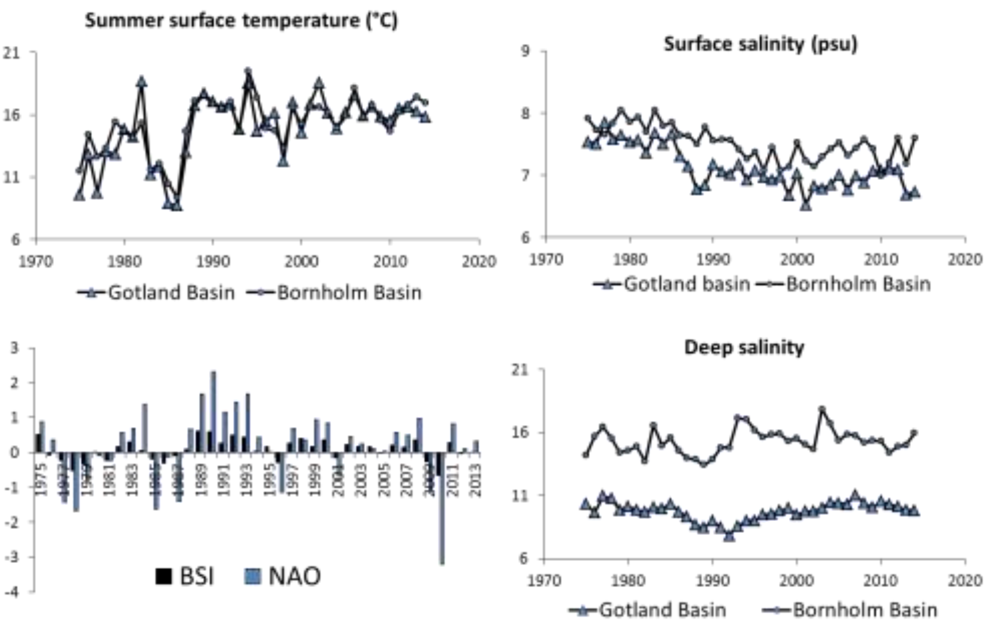


Figure 1.7.1. Time-series in summer surface temperature and surface salinity (top panels), BSI (Baltic Sea Index) and NAO (North Atlantic Oscillation index) and deep salinity (lower panel) in the Gotland Basin and Bornholm Basin.

In addition to temperature and salinity, fishing pressure was identified as an important driver for CBS and BoS. For the highly eutrophicated GoF, also nutrient loads were found to be an important driver. Trends in nutrient concentration and loading vary between the sub-regions; the concentrations of DIN and DIP decreases in ÖS and CBS, whereas in GoR and GoF DIP concentration is increasing because of internal loading. In contrast, in BoS and BoB DIN concentration is increasing, and in BoB and COAST the total DIP loading from run-off is also increasing. Although the long-term decrease in salinity is apparent in all sub-regions, the recent trends in salinity differ. In GoR, as in the CBS, salinity has increased since 2003, whereas in COAST salinity is continuing to decrease due to the increased freshwater input from runoff.

The suggested driving forces of the observed regime shift in all sub-regions, decreasing salinity and increasing temperature, are both consequences of climate change. However, it must be underlined that the population changes observed in several trophic levels (fish and plankton) in many areas are also the result of top-down regulation and trophic cascades (Casini *et al.*, 2008, 2009), emphasizing the role of fishing pressure on ecosystem changes.

Moreover, the reversal of abiotic factors back to the values as observed in the 1970s–1980s did not produce a parallel reversal of the biotic conditions, this likely confirming that currently the Baltic Sea is strongly controlled by other mechanisms, as for ex. trophic interactions (Casini *et al.*, 2009, 2010; Möllmann *et al.*, 2009)

A particular feature of the Baltic Sea since the mid-1990s has been a drastic increase in the extent of anoxic and hypoxic areas, likely due to lack of strong water inflows from the North Sea and potentially increased biological oxygen consumption on seafloor (Figure 1.7.2).

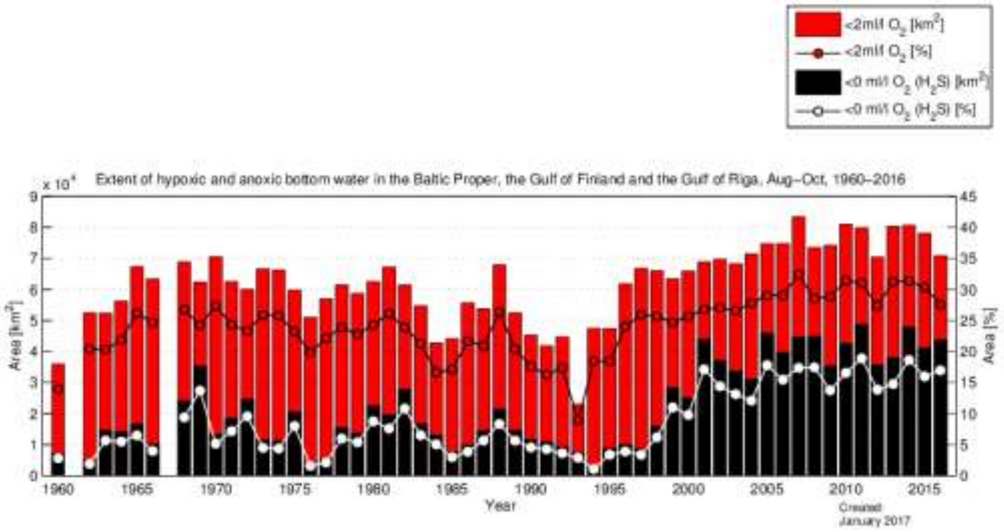


Figure 1.7.2. Time-series of anoxic and hypoxic seabed in the entire Baltic Proper. From the Swedish Meteorological and Hydrological Institute (SMHI) annual report.

The underlying processes leading to a certain stock status and furnishes an easy-to-understand way to communicate the results to the stakeholders and managers (Working Document 6 in the WGBFAS 2010 report). The approach has recently been further developed to provide a visually effective way to track changes in the performance of drivers of fish stock dynamics (Eero *et al.*, 2012). In a changing environment, the status of individual fish populations and consequently the fishing possibilities can change rapidly, not always for reasons directly related to fisheries. In order to take the ecosystem context into account in the management process and achieve consensus concerning fishing possibilities among stakeholders, it is important that the status of various drivers influencing fish stocks, and their relative impacts are broadly understood.

An overview of the dynamics of the eastern Baltic cod, sprat and central Baltic herring SSB and recruitment together with the dynamics of drivers influencing the dynamics of biomass and recruitment is presented in Figure 1.7.3.

Environmental conditions for Eastern Baltic cod recruitment of year-classes 2010–2011 were assessed by the ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (ICES WGIAB, 2013). This assessment was made based on an indicator of the limiting abiotic conditions for cod egg survival, the reproductive volume, found to be the most encompassing indicator of the significant indicators of environmental conditions of cod recruitment (as assessed by models on SSB-recruitment residuals; WGIAB, 2013). The reference value of reproductive volume distinguishing positive from negative environmental influence on cod recruitment (Figure 1.7.4) was derived using the quantitative relationship between recruitment residuals and reproductive volume (WGIAB, 2013).

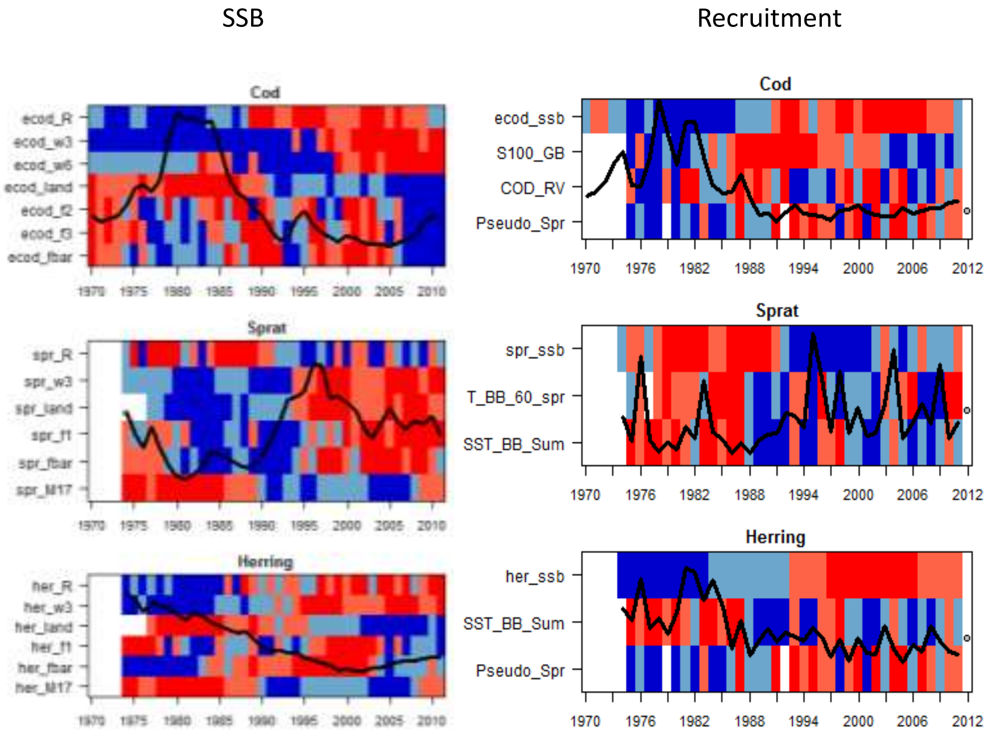


Figure 1.7.3. Temporal changes in indicators influencing the SSB and recruitment of the eastern Baltic cod, sprat and central Baltic herring. The colours refer to quartiles of the values observed in the time series, high values are marked with blue and low values with red colours, except for mortality where the colours are inversed. The lines show the trends in SSB and Recruitment of the stocks, the dost for recruitment in the final years show the values used in short-term forecast (R-recuitment; w-weight at age; land-landings, f-fishing mortality at age; M-natural mortality (average of ages 1–7); S100_GB- salinity at 100 m depth in Gotland Basin; COD_RV- cod reproductive volume, Pseudo_Spr-abundance of Pseudocalanus in spring; T-BB-60_spr- temperature at 60 m depth in spring in Bornholm Basin; SST_BB_Sum- Sea surface temperature in summer in Bornholm Basin).

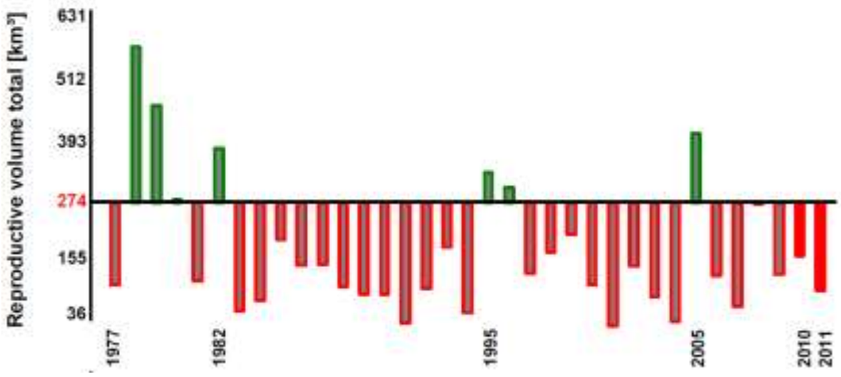


Figure 1.7.4. Time series of reproductive volume for Eastern Baltic cod (summed across the three deep basins in the Baltic Sea), assembled by WGIAB 2013. Relationships between each variable and residuals from cod recruitment (back shifted) vs. cod SSB were derived during WGIAB 2013, using linear models of first or second-order polynomials for year-classes 1977–2009. Bars indicate the values relative to the reference value of each variable (derived from the fitted relationships on cod recruitment residuals, as the point where there is no environmental effect on recruitment); green bars indicate beneficial environmental conditions and red bars poor conditions for cod egg survival. This shows the poor conditions for cod recruitment for the year-classes 2010–2011 (corresponding to recruitment of age 2 in 2012–2013).

1.7.2 Biotic factors

1.7.2.1 Changes in Spatial distributions

Fish distribution has changed considerably during the past decades. The Eastern Baltic cod, in parallel with the decrease in its stock size, contracted its distribution to the southern areas since the mid-1980s. The sprat stock on the other hand, increased mostly in the northern areas of the Baltic Proper (Figure 1.7.5), which has been interpreted as a spatial predation release effect (Casini *et al.*, 2011). As a consequence of the spatial relocation of the sprat stock to more northern areas, the growth of sprat decreased mostly in these areas (Figure 1.7.6), indicating a spatial density-dependent effect (Casini *et al.*, 2011). These results show the importance of spatial analyses to deepen the knowledge on Baltic resources. The current low spatial overlap between predator (cod) and prey (sprat), at least in some seasons, implies changes in the strength of the predator-prey relationship from the 1970s–1980s. Moreover, the reallocation of the sprat population in the northern Baltic proper implies a spatial differentiation in the strength of intra-specific and inter-specific competition among clupeids.

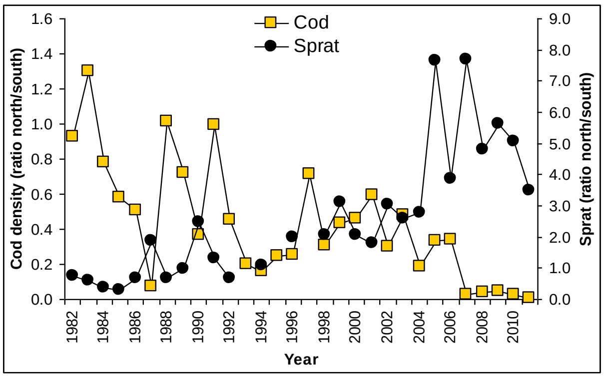


Figure 1.7.5. Ratio between sprat stock in northern Baltic Proper (SDs 27–29) and southern areas (SDs 25–26) as calculated by acoustic surveys, and ratio between cod stock in the northern Baltic Proper (SDs 27–28) and southern areas (SDs 25–26) from bottom trawl surveys. Modified from Casini *et al.* (2011).

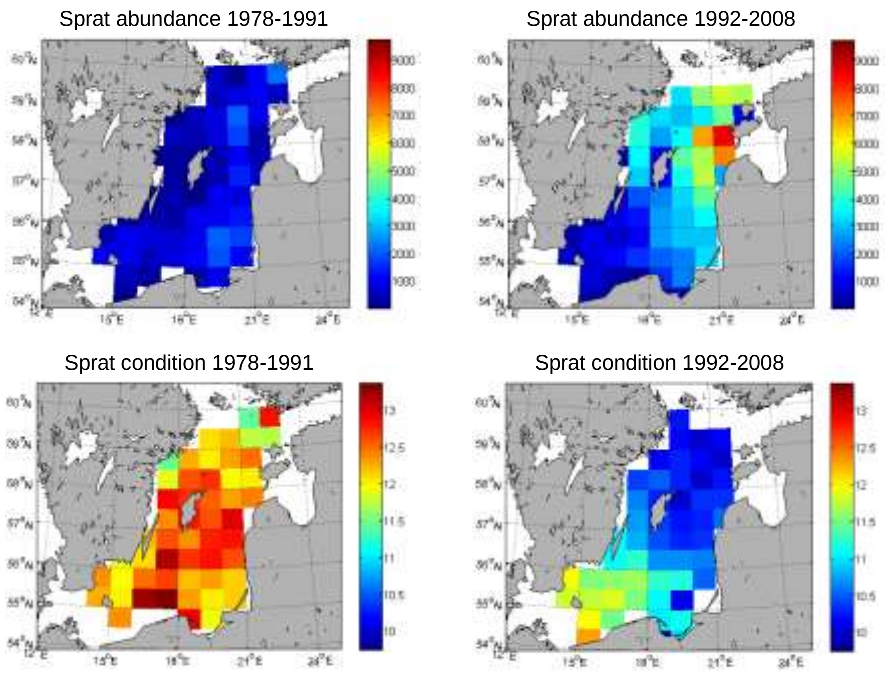


Figure 1.7.6. Spatial patterns in mean sprat abundance and clupeid condition in 1984–1991 and 1992–2008, from autumn acoustic survey. Only years with at least 10 individuals per rectangle were used in the condition calculation. From Casini *et al.* (2011).

1.7.2.2 SGSPATIAL and WKSPATIAL work on the link between cod feeding and growth/condition

The work of ICES SGSPATIAL 2014 and WKSPATIAL 2015,2016 (ICES, 2016) was focused on finalizing the stomach database from the data collated during the EU stomach tender running between 2012–2014 (Huwer *et al.*, 2014). Preliminary analyses of the data showed a decrease in the consumption rate and food intake of Eastern Baltic cod since the early 1990s (Figure 1.7.7). The proportion in weight of benthic vs. pelagic prey in the stomachs also decreased during the same time period, potentially due to increase in hypoxic areas. This indicates a decrease in feeding success and a change in the feeding habits of cod during the past 20 years, which could suggest a decrease in growth and explain the simultaneous decrease in cod condition.

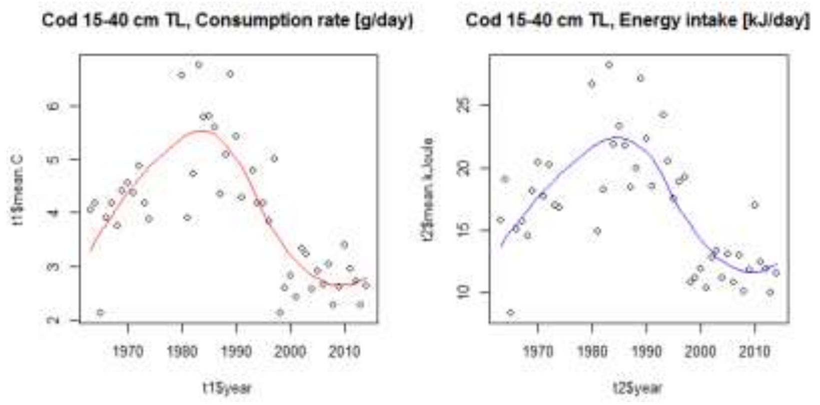


Figure 1.7.7. Temporal changes in consumption rate and energy intake for cod 15-40 cm (WKSPATIAL 2016).

1.7.2.3 Baltic cod body condition is related to hypoxic areas, density dependence and food limitation

Investigating the factors regulating fish condition is crucial in ecology and the management of exploited fish populations. The body condition of cod (*Gadus morhua*) in the Baltic Sea has dramatically decreased during the past two decades, with large implications for the fishery relying on this resource. We characterized the changes in the Baltic cod condition during the past 40 year. Moreover, we statistically investigated the potential drivers of the Baltic cod condition during the past 40 years using newly compiled fishery-independent biological data and hydrological observations (Casini *et al*., 2016).

The results showed that cod condition increased between mid-1970s to early 1990s, followed by a drop until the late 2010s. After that the condition stabilized at low levels. The same pattern was observed for all the ICES Subdivisions and all the length classes investigated (Figures 1.7.8).

The statistical analyses evidenced a combination of different factors operating before and after the ecological regime shift that occurred in the Baltic Sea in the early 1990s. The changes in cod condition related to feeding opportunities, driven either by density-dependence or food limitation, along the whole period investigated and to the fivefold increase in the extent of hypoxic areas in the most recent 20 years (Figures 1.7.9-1.7.10). Hypoxic areas can act on cod condition through different mechanisms related directly to species physiology, or indirectly to behaviour and trophic interactions (Figure 1.7.11). Our analyses found statistical evidence for an effect of the hypoxia-induced habitat compression on cod condition possibly operating via crowding and density-dependent processes (Casini *et al*., 2016). These results furnish novel insights into the population dynamics of Baltic Sea cod that can aid the management of this currently threatened population.

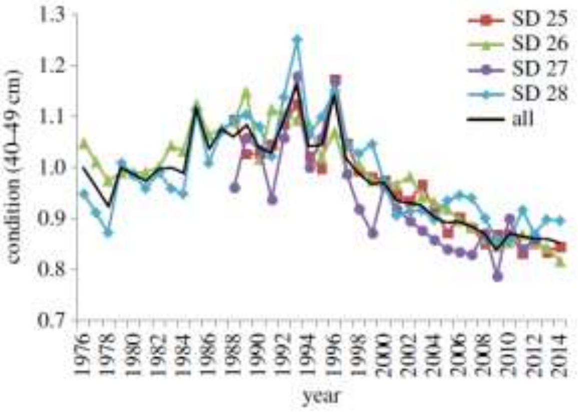


Figure 1.7.8. Temporal developments of mean cod condition in the different Subdivisions (SDs) of the Central Baltic Sea for cod 40-49 cm. The black thick line is the average between the SDs. From Casini et al. 2016.

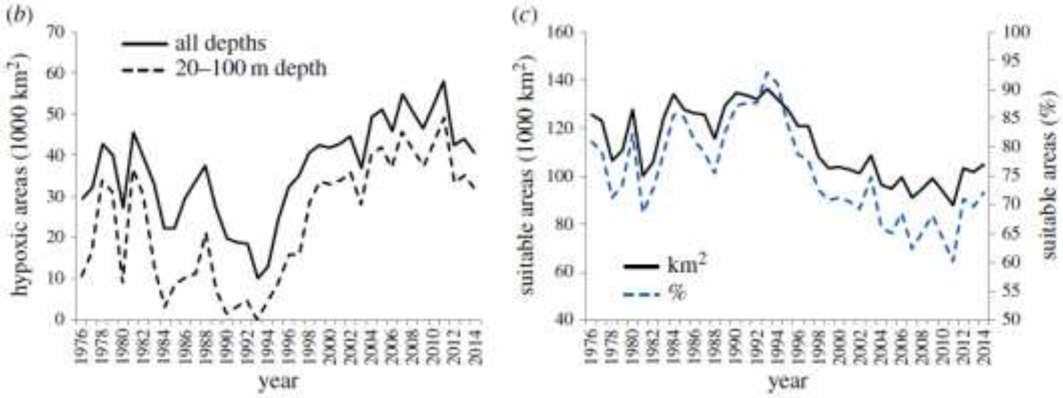


Figure 1.7.9. (b) time series of total hypoxic areas (all depths), and hypoxic areas between 20-100m depth, the latter used as predictors to explain cod condition in the GAMs; c) time series of suitable areas for cod (> 1 ml/l oxygen concentration) between 20-100m depth, in absolute values and in percentage. The time-series refer to the Central Baltic Sea (SDs 25-28). From Casini et al. 2016.

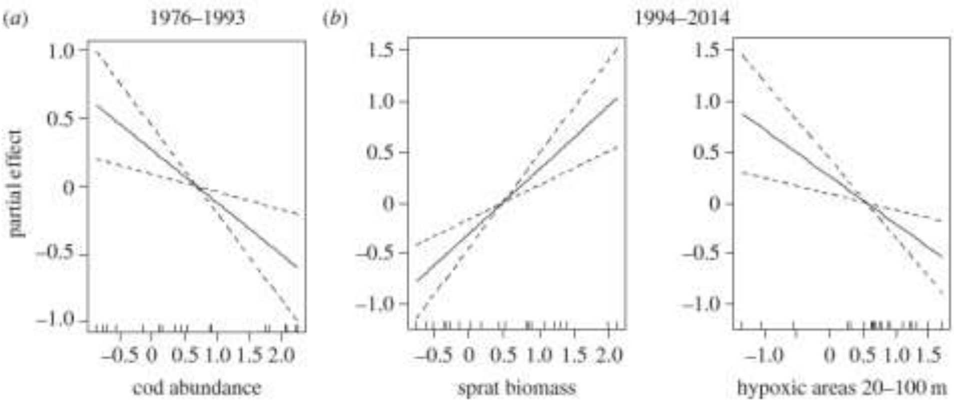


Figure 1.7.10. Results of the GAM (final model) for the two separated time periods (1976-1993 and 1994-2014). The partial effects of each predictor on cod condition are shown. From Casini et al. 2016.

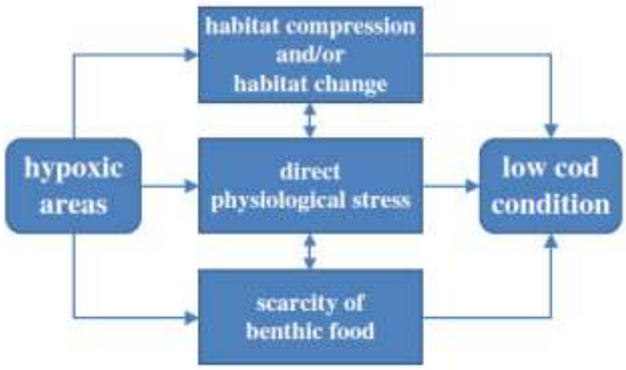


Figure 1.7.11. Schematic representation of the mechanisms potentially explaining the negative relationship between hypoxic areas and cod condition. From Casini et al. 2016.

1.7.2.4 Condition factor and feeding conditions in the Gotland Basin

The present available biological and fishery industry information reveal several changes in the structure and the biology of the cod stock in the Baltic. (i) Mean weight at age of cod decreasing since 2005. The decrease started earlier in the elder ages than the younger ones. (ii) There are observations from fishery that cod body condition in recent years has decreased. (iii) The deoxygenation and extension of hypoxic areas of Baltic Sea basins are increasing. This is to a large extent related to change of periodicity of major Baltic inflows. (iv) Cod stock in the Gotland basin remains very low although temporary increases were observed.

Based on these stock and ecosystem changes we tried to identify the main abiotic and biotic drivers that have led to the change in body condition of cod. As a test area we selected the Gotland basin, in which environmental and cod stock biological data have been collected since 1974. The results show that the temporal decrease in cod condition is mainly related to the extension of hypoxic area and oxygen saturation in water layers above the halocline. Extension of hypoxic area is also associated with change of cod diet. Since 1990's the share of benthic invertebrates and fishes has decreased significantly. The dominant species in the cod diet were clupeid fishes. Significant relation was found with herring abundance only, which has a more demersal distribution than sprat.

Fisheries industry indicated that cod body condition were quite sufficient in coastal areas (depths below 30m) to compare with the deeper parts of the basin. We assume that this due to an expansion of invasive round goby in the coastal areas that total abundance since 2005 till 2013 has increased almost 100 times. Round goby is very easily accessible food item for cod in areas where the distribution is overlapping.

The main conclusions from the analyses are (i) The decrease of condition factor is determined by regime changes in the Eastern Baltic that depends from water exchange with North Sea; (ii) Main factors affecting condition factor from these analyses is hypoxia area and oxygen content; (iii) Although the sprat abundance is increasing the utilization of sprat may be insufficient due to prey and predator distribution (overlap) differences in time and space in the Gotland Basin; (iv) There were no stock density effects revealed on cod growth and condition.

1.7.2.5 Analyses of cod stomachs, biological and hydrological components

This paper is a study of occurring in recent years (1999–2013) changes in cod physiological parameters of different size groups, which are related to food and maturation rates, and, to a certain extent, to an attempt to identify possible causes, factors and interactions that have formed the current environmental uncertainties and risks when assessing abundance, biomass of Eastern Baltic cod and prospects of this fishery type. The results of our research in the ICES SD 26 confirm trends in growth and early maturation of the Eastern cod stock. Thus, at the present time the size composition of the cod stock is characterized by the dominance of small-sized fish, and the average length of 50% matured females decreased to 32 cm, males - up to 21 cm.

Energy and plastic resources of liver provide generative processes. According to our data, hepatosomatic indices (HPI) of all size groups of cod fell by 2013 in comparison with the beginning of the 2000's. Statistically significant HPI correlations between all parameters are found only in component 2, which characterizes the inter-annual variability of this index with a tendency to reduce its values. This fact is also proved by our analysis of cod energy level dynamics while studying the liver fat (% fat content in chemical composition – Figure 1.7.12).

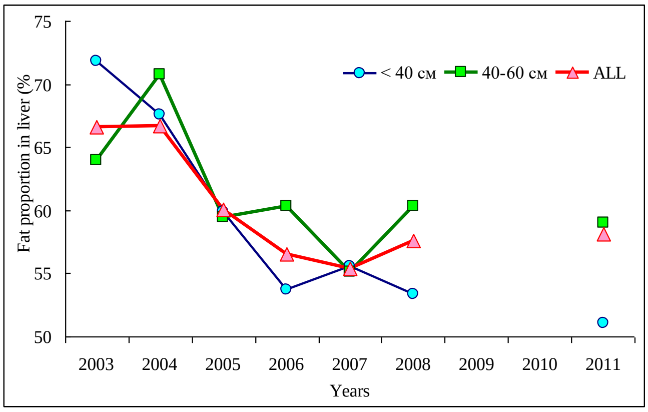


Figure 1.7.12. Fat proportion in liver of different cod size groups (in %) based on chemical analysis (data obtained by L.I. Perova and M.L. Vinokur, technological direction of AtlantNIRO: Reports on the research work "Investigation of nutrition and biological value of commercial and non-commercial fishes of the Atlantic Ocean and the Baltic Sea based on the catches for the period of 2003–2011").

Taking into account the decrease of liver energy resources of all cod size groups in recent years, increasing of the fed state degree by sprat and reducing of the feeding rate by crustaceans, it can be assumed that abundance of *Saduria entomon* and *Mysis mixta*, especially during the fish fattening, i.e., in the autumn-winter season, is the main biotic driver that influence the physiological state of all cod size groups.

Changes in living conditions cause an adaptive response of cod, the biological essence of which is to preserve the species in the new environment. Based on the data presented, taking into account the results of the work showed that a size decrease of different species in aquatic systems is a universal or very general ecological response to warming, it can be concluded that the current increase in water temperature in the Baltic Sea, along with the expansion of waters with oxygen deficiency (in particular, through the influence of the latter factor in the narrowing of cod prey items spectrum) are the main abiotic drivers determining the structural changes in the population of Eastern Baltic cod in recent years.

1.7.3 Ecosystem and multispecies models

During the last year, two papers have been published and one has been accepted for publication regarding Nash Equilibrium, a new management target to level off conflicts between interacting species. The Nash Equilibirum (NE) is defined as the multispecies state of fishing mortalities at which none of the species' yields can increase by changing the fishing effort. This is an optimum defined in general terms by John Nash (Nash, 1951), but not until now proposed as a management target in line with the MSY and ecosystem-based framework of the EU's common fishery policy (CFP).

A management strategy evaluation of NE was performed by Farcas and Rossberg (2016) comparing 9 other management options, including single-species MSY plans to achieve MSY from multiple (9-38) in silico stocks. Most plans outperformed (long-term yields) single-species management plans with pressure targets that were set without considering multispecies interactions. Nash equilibrium plans produced total yields comparable to plans aiming to maximize total harvested biomass, and were more robust to structural instability. They were concerned that implementation of the CFP, without "the systematic conservatism" of a NE, is in particular sensitive to structural instability. Expected yields are therefore comparably low, predicting the transition to MSY will lower rather than raise total long-term yields.

Norrström, Casini & Holmgren (2017) independently suggests NE as the multispecies MSY reference point. They analysed the NE for the cod, the herring and the sprat in the Baltic Sea main basin using an age-structured model capturing the ecological interactions between the species supported by ICES data. The study was also presented at WGSAM (ICES, 2017). Since the publication, an update has been made introducing density-dependent effects of herring and sprat on clupeid growth. The effect on the NE was higher yields on cod and herring, and lower yields on sprat (Table 1.7.1). This raised the BMSY for herring above Bpa, which was already achieved for cod and sprat.

Table 1.7.1. Nash equilibrium reference points for herring and sprat according to Norrström et al. (2017), denoted P in the table. Updated values including density-dependence of clupeid growth is denoted U. For the update, also the FMSY ranges are shown. ICES current single-species MSY, MSY ranges, Blim and Bpa are shown for comparison. Yield and biomasses in thousand tonnes.

	FMSY			Ranges		BMSY				MSY	
	P	U	ICES	U	ICES	P	U	Blim	Bpa	P	U
Cod	0.47	0.45		.32-.63		211	295	63	89	76	102
Herring	0.3	0.27	0.22	.17-.43	.16-.28	460	733	430	600	115	167
Sprat	0.54	0.59	0.26	.45-.73	.19-.27	794	663	400	560	402	371

Nash equilibrium has now also been calculated for the North Sea by Thorpe, Jennings and Dolder (in press). They included 21 interacting species and took into account the existing mixed fisheries putting constraints on the set of Fs defining the NE. F-ranges for the NE were calculated, and the risk of stock collapse was analyzed across the range. The greatest collective long-term benefits from mixed multispecies fisheries will be achieved when F-PGY is close to or below FMSY as defined at the Nash equilibrium.

1.7.4 Ecosystem considerations in the stock assessments

The WGBFAS recognises the importance of the changes in the ecosystem for the development of the Kattegat and Baltic Sea fish stocks, and has therefore when possible accounted for these in the stock assessments.

The changes in cod predation pressure on clupeids are accounted for in the assessments of herring in SD 25–27, 28.2, 29 and 32 and sprat SD 22-32 stocks by using SMS estimates of natural mortality up to 2012 (WKBALT 2013), and extrapolated using Eastern Baltic cod SSB index the year after.

The results of the spatial distribution analysis are included in the advice sheet for sprat. Recommendations include directing fishing efforts targeting sprat to areas where the abundance of sprat is high and the abundance of cod is low.

1.7.5 Conclusions and recommendations

As shown above, there are important ecosystem changes that need to be considered in the assessments. WGBFAS has accounted for the impact of climatic factors as well as of other species, from both lower and higher trophic levels, on the assessed stocks. However, WGBFAS wishes to further advance this matter during future work. To this end, WGBFAS needs input from the following working groups:

1) **WGIAB**: within the current stock assessment framework, ecosystem considerations necessarily are simplified to include interactions between two or at most three species, and/or one or at most two environmental variables. WGBFAS therefore highly appreciates the work done by the WGIAB to develop methods for integrated assessments of the ecosystem state and development. WGBFAS suggests WGIAB to update annually the time-series of abiotic and biotic conditions acknowledged affecting the stocks dealt by WGBFAS.

2) **WKSPATIAL**: due to the large changes in the distribution of several Baltic Sea stocks, WKSPATIAL is suggested to continue carrying out analyses elucidating the reasons and the effects of these changes. WKSPATIAL is also suggested to quantify the spatial overlaps between predator and prey and between competing species, for multispecies purposes. Moreover, to continue the work on understanding the link between food availability, stomach contents and growth/condition of cod is of paramount importance.

3) **WGSAM**: continue to develop multispecies models for the Baltic Sea region and to benchmark models for different use in the assessment.

4) **WKDEICE**: continue to develop strategies for integrating environmental and economic information in fish stock advice.

1.8 Stock Overviews

In WGBFAS, a total of 3 cod stocks, 1 sole stock, 3 herring stocks, 1 sprat stock and 10 flatfish stocks, are considered. In 2017 analytical assessments were carried out for, cod in SD 22–24, herring in SD 25–29, 32 (excl. GoR), herring in GoR, herring in SD 30-31, sole in SD 20-24 and sprat in SD 22–32, plaice in 21–23. Spawning stock trends are given for cod in Kattegat and plaice in 24–32. Survey trends are given for cod in 25–32, brill in 22–32, turbot in 22–32 and the four flounder stocks. Results of the assessments are presented in the subsequent sections of the WG report.

1.8.1 Cod in Kattegat

The reported catches of cod in Kattegat have declined from more than 15 000 tonnes in the 1970ies, 10 000 tonnes in the late 1990ies. In 2016, reported landings were 299 t. The SSB has been at the historically lowest level since the late 1990s. However later years the SSB has increased to higher levels and are now in to order of the one in the late 1990.The present level of fishing mortality is uncertain due to significant unallocated removals, which are considered to be both due to fisheries and biological issues. The recruitment of 2011 was the highest in the time series (1997–2016), whereas the recruitment in 2016 was the lowest in the time series.

1.8.2 Cod in subdivisions 22–24 (Western Baltic cod)

The cod stock in the Western Baltic has historically been much smaller than the neighbouring Eastern Baltic stock, from which it is biologically distinct. It appears to be a highly productive stock, which has sustained a very high level of fishing mortality for many years. In SD 24 there is a mixing between the eastern and western Baltic cod stock, which is taken in account in the present assessment. Recreational fishery is for this stock a rather large and increasing proportion of the total catch and amounted for close to 27% in 2016. Recruitment is rather variable and the stock is highly dependent upon the strength of incoming year-classes, the 2015 year class was estimated to be very low, however the 2016 class is presently estimated to be very large. The 2016 spawning stock biomass was estimated around 13 000 t (which is below B_{lim}, 27 400 t). However, with the large incoming 2016 year class and the predicted low F in 2017, due to a large reduction in TAC in 2017, it is estimated that the stock will increase to close to 28 000 t. in 2018.

1.8.3 Cod in subdivisions 25–32 (Eastern Baltic cod)

The Eastern Baltic cod Stock is biologically distinct from the adjacent Western Baltic (subdivisions 22–24) stock although there is mixing of the two stocks in SD 24 that is taken into account in present assessment. The biomass increased in the end of the 1970s to the historically highest level during 1982–1983 and thereafter declined to the lowest level on record in 2004 and 2005. In the late 2000s the stock was estimated to have increased and fishing pressure declined. The average condition of cod (weight at length) has been decreasing since the 1990s to present historic low level. At the same time, size at first maturity is declined from ca 35cm to 20cm. The decline in condition is likely caused by many factors such as a general decrease in food availability (benthos, pelagic fish and other food items), density dependence of cod, increased parasites induced by seals, increased anoxic areas etc. Abundance of larger (> 40cm) cod has drastically declined since 2013. Last stronger year classes occurred in 2011-2012 keeping relatively high abundance of smaller cod for some years. In latest surveys, both small and larger cod were at low levels. Analytical assessment is presently not available, and assessment is based on survey trends.

1.8.4 Sole in Subdivisions 20–24

The landings of sole in SD20–24 fluctuated between 200 and 500 t annually prior to the mid-1980s. Landings increased to a maximum of 1400 t in 1993 and have since then decreased to around 300 t in 2014 – 2016, the lowest level since 1983. Sole has mainly been caught in a mixed fishery as a valuable by-catch; the trawl fishery for Nephrops and a gillnet fishery for cod and plaice. During 2002–2004 the fishery was increasingly limited by quota restrictions, increasing the incentive for misreporting. After 2005 the fishery has been less restricted, however, the effort regulations on kw-days that was put in force in 2009 might potentially have restricted the effort on sole although the precise vessel behaviour in relation to the many regulation is poorly known. The closed area in Kattegat to protect spawning cod might also restrict trawl fisheries for sole. Spawning stock biomass peaked at about 4000 t in 1992–1994 and also in 2005. Since then the SSB have decreased and have been between $B_{pa}/B_{trigger}$ (2600 t) and B_{lim} (1850 t) in the past decade. Fishing mortality has decreased continuously since the mid-1990s and is recently well below F_{pa} (0.23). Despite at recent low fishing mortality the stock has not recovered to levels above the trigger biomass (MSY Btrigger) This might be due to low recruitment since 2004 with a historic low in 2012. This changed biological regime with lower productivity is therefore used as basis for the recently defined MSY reference points.

1.8.5 Plaice in 21–23

Plaice is caught all year round, mainly from winter to spring. In Subdivision 22 plaice are mostly taken in mixed fisheries together with cod. In Subdivision 21 plaice is almost exclusively a bycatch in the combined *Nephrops*–sole fishery. Information on discard in 2014 indicates that discard in weight was close to 50% of the total catch but in 2015 the discard rate has decreased. The SSB in the plaice stock has increased since 2009 and is in 2016 estimated to have increased 4 fold in the time series (starting in 1999). At the same time the relative trend in F has decreased in is estimated to be in a low level present. Discard information is considered reliable since 2001.

1.8.6 Plaice in 24–32

Plaice is mainly caught in the area of Arkona and Bornholm basin (subdivisions 24 and 25). ICES Subdivision 24 is the main fishing area with Denmark and Germany being the main fishing countries. Subdivision 25 is the second most important fishing area. Denmark, Sweden and Poland are the main fishing countries there. Minor catches occur in the rest of the Eastern Baltic. The stock size indicator from surveys has increased steadily since the early 2000s about five fold since the start of the survey time series in 2001. The average stock size indicator in the last two years (2015–2016) is 25% higher than the abundance indices in the three previous years (2012–2014). In 2014 discard data was for the first time included in the advice of the stock. Discard was estimated to be relatively high for this stock – close to 45% in 2014 and about 35% in 2015. Discards in 2016 were exceptional high (~67%) and mostly fished by Danish trawler in Q4 in SD25.

1.8.7 Flounder in the Baltic

In January 2014 the flounder stocks in the Baltic were benchmarked. As a result four different stocks of flounder were identified (WKBALFLAT, ICES 2014). Flounder (*Platichthys flesus*) is the most widely distributed among all flatfish species in the Baltic Sea.

1.8.8 Flounder in 22–23

The stock size indicator from surveys has increased steadily since 2005 about four fold. The average stock size indicator (biomass-index) in the last two years (2015–2016) is 10% higher than the biomass-indices in the three previous years (2012–2014).ICES Subdivision 22 is the main fishing area for this stock with Denmark and Germany being the main fishing countries. Subdivision 23 is only of minor importance (around 10% of the total landings of the stock). Discards of flounder are known to be high with ratios around 30–50% of the total catch of vessels using active gears. Passive fishing gears have lower discards, varying between 10 to 20% of the total catch. Depending on market-prices and quota of target-species (e.g. cod), discards vary between quarter and years. The discarded fraction can cover all length-classes and rise up to 100% of a catch.

1.8.9 Flounder in 24–25

This stock is the largest flounder stock in the Baltic. The biomass index from surveys has been increasing over the time series. The average stock size indicator (biomass-index) in the last two years (2015–2016) is 63% higher than the biomass-indices in the three previous years (2012–2014).

Landings in SD 25 are substantially higher than in SD 24. The main fishing nations in SD 24 are Poland and Germany and in SD 25 – Poland and Denmark. The majority of landing is taken by Poland.

The discard ratio in both subdivisions varies between countries, gear types, and quarters. Discarding practices are controlled by factors such as market price and cod catches. Despite the high variability in discard ratios, discard estimates since 2014 have been used in the advice because discards reporting has improved.

1.8.10 Flounder in 26 and 28

Flounder is taken as by-catch in demersal fisheries and, to a minor extent, in a directed fishery. The main countries landing flounder from subdivisions 26 and 28 are Latvia, Russia, Poland and Lithuania. Flounder landings in both subdivisions are dominated by active gears, taking in average 80% of total landings. Discards are considered to be substantial and determined by cod fishery and market capacity.

The stock size indicator from surveys has been decreasing. The average stock size indicator in the last two years (2015–2016) is 34% lower than the abundance indices in the three previous years (2012–2014).

1.8.11 Flounder in 27, 29–32

Flounder is taken both as bycatch in demersal fisheries and in a directed fishery. Landings mainly originate from passive gears such as gillnets. Discard patterns are unknown. In Estonia, discards are not allowed. Flounder in the northern Baltic Sea is also caught to a great extent in recreational fishery; estimates from surveys collated by ICES (2014d) suggest recreational landings of around 30% of the total landings.

The ICES BITS survey do not cover the Northern Baltic area and the survey conducted are local surveys close to the coast. The indices are very variable between years and no clear trend is evident.

1.8.12 Dab in 22–32

Dab (*Limanda limanda*) is distributed mainly in the western part of the Baltic Sea. The eastern border of its occurrence is not clearly identified. There are indications of three dab populations in the Baltic Sea: one in the Belt Sea (subdivisions 22 and 24W), one in the Sound (Subdivision 23), and one in the Arkona and Bornholm basins (subdivisions 24E and 25). Nursery grounds of the latter are located in shallow coastal areas and spawning only takes place in the western Arkona basin. The main dab landings are taken by Denmark (subdivisions 22 and 24) and Germany (mainly in Subdivision 22). The landings of dab are mostly bycatches of the directed cod fishery. Discard are substantial for this stock and estimated to be close to 50%.

The stock size indicator from surveys has increased steadily since 2001 nearly three-fold. The survey index varied around 106 kg $hour^{-1}$ between 2010 and 2016 in SD 22–24.

1.8.13 Brill in 22–32

Brill is distributed mainly in the western part of the Baltic Sea and Brill fishery is dominated by Denmark in SD 22 (95% of the catches in 1985–2016). Yearly landings within the Baltic Sea have varied between 27 and 105 tonnes during the last ten years. The eastern border of its occurrence is not clearly described. Additional information have been available based on the international coordinated Baltic International Trawl Survey (BITS) since 2001 where standard gear were applied and common survey design were used. The stock size indicator from surveys was the highest in 2011 and varied around 1.1 individuals hour^{-1} larger or equal to 20 cm between 2012 and 2016 in SD 22–24.

1.8.14 Turbot in 22–32

Turbot is a coastal species commonly occurring from Skagerrak up to the Sea of Åland. Turbot spawns in shallow waters (10–40 m, 10–15 m in central Baltic) and the metamorphosing postlarvae migrate close to shore to shallow water (down to one meter depth). Turbot fishery is concentrated on the westerly parts of the Baltic Sea (SD 22–26) and mean annual landings are around 200 tonnes since 2013. Biological and fishery data of turbot were available from all national fisheries. For turbot the genetic data show no structure within the Baltic Sea (Nielsen *et al.*, 2004, Florin and Höglund, 2007), although the former discovered a difference between Baltic Sea and Kattegat with a hybrid zone in SD 22.

Spatial distributions of turbot during BITS suggest that the turbot stock SD 22–32 is probably related with turbot in SD 21.

The stock size indicator from surveys varied around 2.90 individuals/hour larger or equal to 20 cm in the last five year in SD 22–28.

1.8.15 Herring in subdivisions 25–29 & 32 excl. Gulf of Riga (Central Baltic herring)

Is one of the largest herring stock assessed by the WG and it comprises a number of spawning components. This stock complex experienced a high biomass level in the early 1970s but has declined since then. The proportion of the various spawning components has varied in both landings and in stock. The southern components, in which individuals are growing to a relatively larger size, has declined and during the last years the more northerly components, in which individuals reach a maximum size of only about 18–20 cm, are dominating in the landings. The latest stronger year-classes were the 2002, 2007, 2011 and 2014 year-class, respectively. The 2014 year class is estimated to be the highest of the whole time series. The spawning stock size has shown an increasing trend, with minor fluctuations, since the beginning of the 2000´s. The present SSB estimate for 2016 is above the long-term average (1974–2016). The amount of reported landings taken within the small meshed industrial fisheries may be uncertain as it is mostly caught in mixed fisheries together with sprat. F is in 2017 estimated to 0.20 and is thereby below F_{MSY} (0.22).

1.8.16 Gulf of Riga herring

The stock is classified to have a full reproduction capacity. The spawning stock biomass of the Gulf of Riga herring has been rather stable at the level of 40 000–60 000 t in the 1970s and 1980s. The SSB started to increase in the late 1980s, reaching the record high level of 120 000 t in 1994. Since then the SSB has been the range of 71 000–124 000 t. The year class abundance of this stock is significantly influenced by hydro- meteorological conditions (by the severity of winter, in particular). Mild winters in the second half of 1990s have supported the formation of series of rich year-classes and increase of SSB. Due to low and only occasional presence of sprat in the Gulf, there is no mixed pelagic fishery in the Gulf of Riga.

1.8.17 Herring in subdivisions 30 and 31

The spawning stock of Gulf of Bothnia herring was at relatively low level of 200 000 t in the beginning of the 1980s, from which it started to increase and peaked in 1994. A new increasing development started in the first half of the 2000s. Although recruitment has been on average much higher during the high biomass period, favourable environmental conditions have contributed to the production of abundant year classes. The most abundant year classes have hatched in very warm summers like 2002, 2006, 2011, or 2014. In the biomass estimates from the acoustic surveys in 2007–2016, there is no trend in SSB, Z at age or change in the age distribution of the stock. This suggests that the recent exploitation has not impacted the state of the stock. SSB in 2016 is estimated to have decreased from its highest peak in 2014, but it is still regarded to be clearly above the MSYBtrigger like it has been since the end of the 1980s.

1.8.18 Sprat in subdivisions 22–32

The spawning stock biomass of sprat has been low in the first half of 1980s, when cod biomass was high. At the beginning of 1990s the stock started to increase rapidly and in 1996–1997 it reached the maximum observed SSB of 1.9 million t. The stock size increased due to the combination of strong recruitments and declining natural mortality (effect of quickly decreasing cod biomass). The increase in stock size was followed by large increase in catches, which reached record high level of over half million t. in 1997. High catches in following years led to stock decline and fluctuations of SSB at the level of about 1 million t. since the beginning of 2000s. Spawning stock biomass for over 30 years was higher than precautionary levels, while F in recent years usually fluctuated between F_{pa} and F_{lim} Due to strong year-class of 2014, the stock has increased in recent years. During recent two decades the stock distribution has been changing with tendency to increase density in north-eastern Baltic.

1.9 Recommendations

See Annex 2.

2 Cod in the Baltic Sea

2.1 Cod in Subdivisions 25-32

2.1.1 The fishery

The complete description of eastern Baltic fisheries development is presented in the Stock Annex.

2.1.1.1 Landings

From 2015 there is a landing obligation for cod in the Baltic Sea. Thus there is no minimum landing size, but a minimum conservation reference size (MCRS) of 35 cm is in force, which is a change from earlier years minimum landings size (MLS) of 38 cm. Cod below MCRS cannot be sold for human consumption and has to be landed as a separate fraction of the catch. The landed cod below MCRS is here referred to as 'BMS landings' (BMS=Below Minimum Size). National landings of cod from the eastern Baltic management area (Subdivisions 25–32) by year are given in Table 2.1.1 as provided by the Working Group members. Landings by country, fleet and subdivision in 2016 are shown in Table 2.1.2. The total provided landings in SD 25-32 in 2016 summed up to 29 313 t, whereof 99% were above MCRS and only 316 t were BMS landings. It is however not clear exactly how large the BMS landings were in total since countries have chosen different approaches in the data submission. BMS landings were provided by Latvia, Lithuania and Sweden. Poland and Denmark included BMS landings in the discard estimate in the data submission and provided separate information on the "official" BMS landings (not included in the 316 t mentioned above), indicating very small amounts of BMS (<1% of the landings). Remaining countries did not provide information on BMS landings. Germany used a knife-edge approach for catch estimation and all fish below 35 cm were submitted as discards. The total landings in the management area in 2016 declined by 8 030 t compared to 2015. The available TAC for eastern Baltic cod has not been taken since 2009. In 2016, 70% of the TAC was caught, BMS landings and discards included (Fig.2.1.1)

Part of the landings of Eastern Baltic cod stock are taken in SD 24, i.e. the management area of Western Baltic cod (Fig. 2.1.2). The total landings in SD 24 are divided between the two stocks using stock identification information derived from otolith shape analyses combined with genetics (ICES WKBALTCOD 2015). Approximately 10-15 % of total landings of Eastern Baltic stock are estimated to be taken in SD 24 in later years (Fig.2.1.2; Table 2.1.3).

2.1.1.2 Unallocated landings

For 2016, similar to 2010–2015, information on unreported landings was not available and the Working Group was not in a position to quantify them. Unallocated landings have been a significant problem during 1993–1996 and 2000–2007 when the unreported landings have been 35–40%. More detailed information of unreported landings is given in Stock Annex. Misreporting significantly declined in 2008–2009 and amounted to 6–7%. The decrease of unreported landings in recent years obviously is related to a decreasing fishing fleet due to EU vessel scrapping program and improvement of fishing control. Since the TAC has not been taken since 2009, misreporting is considered a minor problem in recent years.

2.1.1.3 Discards

In addition to landings above MCRS and BMS landings, discard estimates were also submitted from most countries. Even though there is a landing obligation in the Baltic Sea from 2015, discards were still estimated from on-board sampling by most countries (Denmark, Finland, Germany, Latvia, Poland and Sweden). It should also be noted that the German discard amount was estimated with a knife-edge approach, meaning that all catch above 35 cm was submitted as landings and all catch below 35 cm as discards regardless of the fate of the catch, and that a few other countries discard estimates also include small amounts of BMS landings (at most 6% of the total discard amount reported by the country, according to additional information submitted on BMS landings). The total discards in 2016, in subdivision 25-32, were estimated to 3 620 t, which constituted 11% of the total catch in weight and 20% in numbers; 11 million individuals. 97% of discards in numbers was caught by active gears (Table 2.1.4). This was a decrease from 2015, when the discard rate was 14% of total catch in weight and 24% in numbers (Table 2.1.5). Since the reported BMS landings (landings of cod below 35 cm) were very small, only 1% of total catch and 1.1% of the total landings in weight, they did not have a significant impact on the discard rate in 2016. As no adjustments for misreporting in landings were made, no adjustments of the discards were made.

The most abundant length class discarded in 2016 was length class 30-34 cm (55% in numbers) followed by length classes 35-37 cm and 25-29 cm 4 (21% and 15%, respectively). Table 2.1.6 gives a comparison between landed and discarded numbers by length class for the year 2016.

The annual estimations of discards (and thus also the variation in discard figures from year to year) must be taken with caution because of the general low sampling intensity, of particularly passive gears, and thus large uncertainties in the estimates.

Discards included, the total catch in subdivision 25-32 was 32 933 t.

The total discards in tons estimated for SD 24 were divided between eastern and western Baltic cod using the same stock splitting information as for landings, which resulted in 293 tons of estimated discards of eastern Baltic stock in SD 24 in 2016 (Table 2.1.3). This results in discard rate of 10 % in weight, for the entire eastern Baltic stock, including both the SDs 25-32 and the fraction of the stock in SD24.

2.1.1.4 Effort and CPUE data

No data on commercial CPUEs was presented at WGBFAS. The effort data from EU STECF (2016) shows a decline in kw-days both for trawls and gill-nets in the central Baltic Sea in 2012-2015.

2.1.2 Biological information for catch

2.1.2.1 Catch in numbers of the stock

Catch numbers at length of the fraction of the Eastern Baltic cod stock distributed in SD 24 were derived by upscaling the numbers at length estimated for SD 25 by the fraction of catch originating from SD 24, separately for landings and discards. The catch numbers for SDs 25-32 were derived from compilation of biological information submitted to Intercatch.

2.1.2.2 Length composition of catch

The most abundant length class in the total catch 2016 was 38-44 cm (45% in numbers), followed by 35-37 cm (21%) and 30-34 cm (15%) (Table 2.1.6). Table 2.1.7 shows the total catch in numbers by length class, quarter, sub-division and gear. Table 2.1.8 gives the estimated mean weight per length class and gear in the landings and discards 2016.

Due to issues with age reading of eastern Baltic cod (ICES WKBALTCOD 2015) information on age structure of catches is not available.

2.1.2.3 Quality of biological information from catch

Due to issues with age determination of eastern Baltic cod, only numbers and mean weight at length were requested from commercial catches for the data year 2016. All countries biological data was estimated nationally before being uploaded and further processed in InterCatch. Numbers and mean weight at length were provided for 68% of the total landings (>MCRS) in weight and 61% of the estimated discards. This was a decrease from 2015, when 90% of the landings and 69% of the discards were covered with sample data. Length distributions for discards should be considered more uncertain than length distributions for landings due to a lower sampling coverage, especially for passive gears that are poorly sampled in many strata. The BMS landings (<MCRS) were in most cases not sampled for length and were assumed to have the same length structure as the discards in the extrapolation procedure. However, since the reported BMS landings were very low (1% of total catch in weight) this was of minor importance for the overall length structure. As in previous years since 2013, the input data for SDs 25-32 were prepared solely using InterCatch. The use of only one reporting format (in this case InterCatch) provides a more transparent way to record how the input data for assessment have been calculated. However, due to the large methodological differences in the data reporting and preparation, some inconsistencies could be expected between the data compiled in 2013–2016 and the data compiled in previous years.

2.1.3 Fishery independent information on stock status

The main source of fishery independent information on the stock is the Baltic International Trawl survey (BITS) conducted in Q1 and Q4 that is used for stock assessment. The following sections summarize the available biological information on stock status.

Stock distribution

Data from BITS surveys do not indicate notable changes in cod distribution in most recent surveys (Fig. 2.1.3). The highest cpue values are generally recorded in SD 25, followed by SD 26. Relatively high cpue values are recorded also in SD 24 that is a mixing area for eastern and western Baltic cod; in the easternmost areas of SD 24 most of the cod are of eastern origin. The cpue values further north-east (SD 27-28) are generally very low indicating that the bulk of the stock is concentrated in southern Baltic Sea, i.e. in SDs (24)25-26. However, in 2017 Q1 survey, relatively high cpue values were recorded in SD 28 compared to the former surveys. Time series of cpue by SDs and size-groups of cod shows that highest concentrations of smaller individuals (<35cm) are found in SD 25. For larger cod (>35cm) the cpue in SDs 24-26 is relatively similar. It should be noted that survey coverage in SD 26 is relatively poor in later years, with few stations in areas where relatively high abundances of cod have been found in some available surveys (e.g. 2016 Q4; Fig. 2.1.3).

Nutritional condition

Nutritional condition (Fulton K) of eastern Baltic cod has substantially declined since the 1990s in all SDs 24-28 (Fig. 2.1.4). The proportion of cod with very low condition (Fulton K <0.8) in samples from Q1 surveys has been increasing from below 5% in the 1990s and early 2000s to close to 20% in 2013-2014, for cod at 40-60cm in length. In more recent surveys since 2015 Q1, the condition has improved and the proportion of cod at low condition has declined to around 10%. Also, average condition is showing some improvement in these later surveys in Q1. In Q4 survey, no change in condition is apparent in latest years. For smaller cod (25-40cm), the improvement in condition in Q1 is less clear, while the condition appears further deteriorated in Q4 (Fig. 2.1.5).

Growth and natural mortality

It is hypothesized that growth of EB cod has reduced since the 1990s, due to reduced size at maturation, poor condition of cod, hypoxia, and parasite infestation, however clear evidences are not available (ICES WKBEBCA 2017). For smaller (<30 cm cod), counts of daily rings on otoliths suggest stable growth rate from 2001 to 2013 (ICES WKBEBCA 2017). Natural mortality of cod is hypothesized to have increased due to reduced size at maturation, poor condition, seal predation, cannibalism and parasite infestation. However, similar to growth, the magnitude of change is not quantified (ICES WKBEBCA 2017).

Maturity

Size at first maturation has substantially declined in the period from the 1990s to 2000s (Fig. 2.1.6). The L50 (50% percent mature and contributing to spawning) has been estimated at around 35-40cm in the early 1990s and has declined to 20cm since late 2000s to 2015 (males and females combined). Being mature is defined as having entered the maturity stage 62 (based on DATRAS scale). In Q1 surveys from 2016-2017 L50 is estimated to have remained at around 20cm. The effect of this change on reproductive capacity of the stock is unknown.

Recruitment

Larval abundances from ichthyoplankton surveys suggest that stronger year-classes occurred in 2011 and 2012 (Köster et al. 2016), which are also visible in length frequency data from Q1 BITS survey at around 20cm in 2013 and 2014 (Fig. 2.1.7). These strong year-classes have sustained the stock until 2016. No strong year classes are apparent in the data for later years. The CPUE of <25cm cod has been variable over time, the most recent values from 2016 and 2017 surveys are around the average since the 1990s (Fig. 2.1.8).

Adult biomass and size distribution

Relative abundance of cod follows similar trends in Q1 and Q4 surveys (Fig. 2.1.8). The combined data for Q1 and Q4 (Q1 is combined with Q4 data the year before) show that since 2013, biomass of cod >40 cm has substantially declined from the relatively high levels recorded in 2009-2012 (Fig. 2.1.9). The 2016 estimate shows a slight increase in the biomass of these larger cod compared to 2013-2015, but declined again to close to the lowest level in the time series in 2017.

The indices for cod at 30-40cm were relatively stable and high until 2016 but dropped substantially in 2017. For cod <30cm in length, the values in 2013-2014 have been at a highest level in the time series since 2003 (due to the strong year-classes from 2011 and 2012). In 2015-2017 the abundance and biomass of <30cm cod has remarkably declined.

2.1.4 Assessment

No analytical assessment for the stock is presently available, mainly due to uncertainties in age information, and presumed changes in growth and natural mortality, which have not been quantified. The challenges for analytical assessment for this stock are described in Eero et al. (2015).

2.1.4.1 Stock trends from BITS survey

The assessment is based on trends in BITS survey index. An index of SSB was produced using the combined time-series of BITS Q1 and Q4 surveys.

CPUE (No./h) per length-class by quarter and SD was derived from the DATRAS database. CPUE in weight (Kg/h) was estimated by Quarter and SD and year using length-weight relationships based on individual fish data from the DATRAS database. Mean CPUE (Kg/h) for Q1 and Q4 for the whole stock were thereafter obtained as a weighted average over SDs, by using area size of SDs as weightings. The CPUEs (Kg/h) from Q1 and Q4 were combined as a geometric mean (Q1 raw and Q4 shifted 1 year ahead) to produce an index of SSB from 2003 to 2017 (Fig. 2.1.10). The index used for assessment is based on cod >= 30 cm. The index based on SD 25-28 is considered to represent the relative dynamics of the entire EB cod stock (i.e. representing the relative dynamics of EB cod also in SD 24).

After a steep increase between 2005 and 2010, the SSB index (for cod >30 cm) abruptly decreased between 2012 and 2013, and remained relatively stable for 2013-2015 with an average of 140 Kg/h. In 2016, cpue increased to around 180 Kg/h, but declined sharply to 96 Kg/h in 2017. Until 2016, the stock has been sustained by larger year-classes from 2011-2012. These year-classes increased the cpue of relatively larger (40-45 cm) cod in 2016, resulting in increased biomass index. In 2016 Q4 and 20017 Q1 these strong year-classes from 2011 and 2012 had apparently disappeared from the stock or diminished to very low numbers, while no stronger year-classes have appeared since. Thus, the reduction in biomass index in 2017 is due to low recruitment in later years, in combination with mortality.

The average CPUE of the last two years (2016-2017) was 4% lower than the average CPUE of the previous three years (2013-2015).

2.1.4.2 Harvest rate

Time-series of harvest rates between 2003 and 2016 were created as ratio between total catches for the stock (including landings and discards and the proportion of EB cod catch taken in SD 24) and the biomass index for >=30cm cod (Fig. 2.1.9). The harvest rate was highest in 2004, followed by a substantial reduction. Between 2009-2011, the harvest rate was stable at the lowest level in the time series since 2003. Thereafter, harvest rate increased by more than 30% from 2011 to 2015. Due to increased biomass in 2016 (combination of Q4 in 2015 and Q1 in 2016), the harvest rate in 2016 shows a decline from previous level. Harvest rate estimates by size-groups (catch of given length groups divided by biomass index of the same length-group) show that larger cod >40cm in length is exposed to a higher fishing pressure compared to the average of > 30cm cod used in the final assessment. The 2016 value for harvest rate declined for all size groups (Fig. 2.1.9).

2.1.5 Short term forecast and management options

No short-term forecast was performed for the stock.

2.1.6 Reference points

There are no reference points defined for Eastern Baltic cod, in terms of absolute values.

Three approaches, recommended by ICES, were considered at WGBFAS 2017 for estimating MSY Proxy reference points for Eastern Baltic cod:

i) Length based indicators (LBI)

ii) Mean-length Z, Gedamke Hoenig

iii) SPICT model

The LBI and Mean-length Z methods (i and ii) were concluded not to be applicable for this stock, due to likely changes in growth and natural mortality, which are not quantified. Thus, the parameters used in these approaches (Linf, K, M/K) are not known and different conclusions in terms of stock status can be obtained by making different assumptions (see the chapter 2.1.6.1 for details).

SPICT model has the advantage that it is not dependent on being able to quantify growth or natural mortality separately, and this model was considered useful for defining the stock status of Eastern Baltic cod. SPICT provides relative estimates for stock status (F/FMSY and B/BMSY), which are estimated with reasonably low uncertainty for EB cod. The absolute estimates separately for F, B, FMSY and BMSY are associated with much larger uncertainties than the relative values F/FMSY and B/BMSY, therefore the absolute values should not be used. Further explanations and description of the SPICT model are provided in chapter 2.1.6.2 and Annex 2.1.

2.1.6.1 LBI and Mean-length Z approach

This section describes the background for why the LBI and Mean-length Z approaches are not applicable for Eastern Baltic cod for defining the stock status.

Length data

Length frequency data for catches of EB cod are available from Intercatch from 2000 onwards, shown in Fig. 2.1.11. Lc is calculated from these data. In LBI analyses Lc is defined as length at 50% mode; in mean-length Z approach, Lc is the first fully selected length.

Size at maturity

Size at first maturation was estimated from Q1 BITS survey, for females and males combined. The fish which had reached the stage "maturing" (scale 62 in DATRAS) were considered as mature. Size at first maturation (L50) of EB cod has reduced from ca 35 cm in 2000 to ca 20 cm at present.

Von Bertalanffy growth parameters

Growth parameters for Eastern Baltic cod have always been poorly estimated, as has been pointed out already years ago, in a study summarizing growth studies from before the 1990s (Bagge et al. 1994). The problem that was identified was that the differences in mean length of successive age-groups were almost constant, and thus not fitting the von Bertalanffy growth model. This was suggested to possibly be due to age-reading errors. The same issue is apparent in a more recent data, using BITS survey information for 1997-2006 (Fig. 2.1.12), where the age groups seem to grow at a constant rate, in the range where data are available, not fitting the vBL growth model.

Furthermore, age reading data since 2007 is considered to be of reduced quality (ICES WKBALCOD 2015), while it is hypothesized that EB cod growth (possibly both K and Linf) has reduced in later years. The possible drivers for reduced growth include reduced nutritional condition, maturation at a smaller size, direct effects of hypoxia etc (ICES WKBEBCA 2017). These variables have similar trends over time and, if influencing growth, suggest a reduced growth from the 1990s to late 2000s, and stable low level since around 2011 (Fig. 2.1.13).

The potential change in growth parameters has until now not been possible to quantify. Thus, the current levels of K and Linf are unknown, which limits the use of the indicators that require these parameters to be known or assume equilibrium status with stable growth.

Natural mortality

Natural mortality has historically been used as constant at 0.2. However, several changes in cod biology and in the ecosystem suggest that natural mortality has increased in later years. The potential drivers include reduced size at maturation, low nutritional condition, and increased seal abundance possibly increasing mortality both via predation and parasite infestation (ICES WKBEBCA 2016). The trends in these potential drivers are relatively similar suggesting an increased M since the early 2000s, with some drivers levelling off in the late 2000s (Fig. 2.1.14). The magnitude of change in M has not been quantified.

LBI

The length based indicators suggested by ICES to measure conservation status of large individuals are measured relative to Linf, and include i) maximum length of the largest 5% (Lmax5%) ; ii) 95 th percentile (L95%) and iii) Pmega. For EB cod, the indicators i) and ii) can be used to describe the developments in respective indicators over time, but not to define conservation status, as the value for Linf is not known. Calculation of Pmega requires knowledge of Linf as well as M/K which are not available for EB cod presently. Thus, this indicator cannot be calculated. The Lmax5% indicator has declined from around 65 cm in early 2000s to 52 cm in 2015. L95 has a similar trend, being presently around 50cm (Fig. 2.1.15a)

In relation to conservation of immature fish, both Lc (length at first catch, 50% of the mode) and L25 (25^{th} percentile of length distribution) are considerably above Lmat (size at first maturation). This is largely because Lmat has substantially declined over time, while Lc and L25 are relatively stable, showing a minor decline. Thus, fishery is not exploiting immature individuals (Fig. 2.1.15). The indicators L25 and L75 (75th percentile of length distribution) (Fig. 2.1.15b) demonstrate a very narrow length range in catches of EB cod, with only 5cm interval between these two indicators.

The length based indicator for MSY (Lmean/LF=M) is using Linf and additionally M/K ratio that is often assumed to be 1.5. This ratio would apply K at 0.13 when assuming natural mortality at 0.2, as has been assumed for EB cod in former times. This is in line with the growth parameters estimated for EB cod historically. Thus, in former times, using the value 1.5 for EB cod could be reasonable. In recent decade, natural mortality is considered to have increased and growth likely declined (ICES WKBEBCA 2017). Thus, the M/K is likely considerably higher for EB cod in present situation than 1.5, though the value cannot be quantified. Different scenarios were explored, with realistic combinations of M/K and Linf values. The results demonstrated that depending on the scenario applied, different conclusion can be obtained concerning Lmean relative to LF=M that defines the reference point for MSY. The scenarios assuming a high Linf and low M/K indicated an overexploited status in recent years, while in scenarios with lower Linf and a higher M/K , LF=M was lower than Lmean, suggesting good status in recent years.

In conclusion, this approach is not applicable for defining the status of EB cod in relations to MSY, as the values for Linf and M/K are not known, and different assumption can lead to contrasting conclusions. Additionally, it is questionable whether the concept of LF=M is applicable for EB cod in present situation, given the non-equilibrium status and presumably large changes in cod biology in recent decade (ICES WKBEBCA 2017).

Mean Length estimate of Z

The Gedamke-Hoenig method to estimate total mortality Z from length frequency data uses as well von Bertalanffy growth parameters. In exploratory analyses, growth parameters were chosen for the years 2000-2005 so that it would result in a similar level of Z as estimated from former analytical stock assessments for Eastern Baltic cod for that period. For the more recent period (2011-2015), different sets of growth parameters were applied to demonstrate the sensitivity of the obtained mortality estimate to assumptions on growth. Assuming that growth has not changed compared to the first period, this would apply a slight increase in Z from 1.1 to 1.2 in later period. Opposite, if growth is assumed to have reduced, considerably lower values of Z could be obtained. The next step would be an assumption on natural mortality that likely has increased in later years, but by unknown magnitude. Thus, the level and change in fishing mortality compared to previous period, obtained from this approach is entirely dependent on assumptions on changes in growth and natural mortality. Consequently, the YPR reference points were not calculated as these would as well depend on assumptions on growth and mortality.

In conclusion, this approach is not considered applicable for Eastern Baltic cod in present situation given the likely changes in growth and natural mortality, which have so far not been quantified.

2.1.6.2 SPICT model

SPICT stands for a stochastic surplus production model in continuous time (Pedersen and Berg, 2016). SPICT does not need to separate between growth and natural mortality of the fish, which is a strong advantage in situations where these cannot be separated, like is presently the case for Eastern Baltic cod. A specific version of SPICT was applied for Eastern Baltic cod, to allow taking into account a potential change in surplus production over time. The time period with a separate productivity “regime” was estimated in the model, based on maximum likelihood value, thus not making explicit assumption on when the productivity change should take place and by which level. The new productivity regime was estimated in SPICT to start from 2010 (giving the best likelihood value). This is in line with the trends in major drivers considered to affect productivity changes (in terms of growth and natural mortality), which were levelling off in the late 2000s (Fig. 2.1.13, 2.1.14).

SPICT operates internally with absolute values, but produces output, including the uncertainties also in relative terms (F/FMSY and B/BMSY), because the relative estimates are considerably more certain compared to the absolute ones. This is because the same parameters are included in both numerator and denominator of the relative values, which reduces the uncertainty in the relative estimates. The absolute catch corresponding to MSY is also reasonably well estimated, as the product of F*B is considerably better estimated than the F and B individually, because these estimates are strongly negatively correlated. Therefore, the absolute values for F, B, FMSY and BMSY are not recommended to be used. The relative values for F/FMSY and B/BMSY are reasonably well estimated in the model for Eastern Baltic cod and can be used to define the stock status relative to the reference points. The technical specifics of the SPICT model for Eastern Baltic cod and the model outputs are given in Annex 2.1.

2.1.7 Quality of the assessment

The presumable decrease in growth has possibly affected the catchability of the BITS surveys. Survey coverage in SD 26 is relatively poor in later years, with few stations in areas where relatively high abundance of cod have been found in some years, which could affect the time-series.

2.1.8 Comparison with previous assessment

The assessment is based on survey index following the same approach as in last year. Thus, the perception of the stock status for earlier years has not changed. New data points are added to survey series, and respective trends are described in section 2.1.4.

2.1.9 Management considerations

BMS landings in 2016 were very low and discarding still occurs, with estimated discard rate at 10% for the Eastern Baltic stock.

The present distribution pattern of cod, sprat and herring (cod mainly concentrated in Subdivision 25 and 26, and clupeids in the more northern Subdivisions), implies that an increase in F on cod, not necessarily will result in increasing the Baltic clupeid stock sizes. Conversely, a decrease in F on cod will not necessarily result in a decrease of the Baltic clupeid stock size if it will not be accompanied by a cod expansion to northern areas. A reduction of clupeid F in Subdivision 25 can possibly improve growth and condition of cod as well as reduce cannibalism. However, as the relative contribution of different factors to poor condition of cod is not fully understood, the effect of reduced clupeid F on cod condition and growth is unclear.

Table 2.1.1 Cod SDs 25-32. Total landings (tons) by country.

Year	Denmark	Estonia	Finland	German Dem.Rep.**	Germany Fed. Rep.	Latvia	Lithuania	Poland	Russia	Sweden	USSR	Faroe Islands^	Norway	Unallocated***	Total
1965	35313		23	10680	15713			41498		21705	22420				147352
1966	37070		26	10589	12831			56007		22525	38270				177318
1967	39105		27	21027	12941			56003		23363	42980				195446
1968	44109		70	24478	16833			63245		24008	43610				216353
1969	44061		58	25979	17432			60749		22301	41580				212160
1970	42392		70	18099	19444			68440		17756	32250				198451
1971	46831		53	10977	16248			54151		15670	20910				164840
1972	34072		76	4055	3203			57093		15194	30140				143833
1973	35455		95	6034	14973			49790		16734	20083				143164
1974	32028		160	2517	11831			48650		14498	38131				147815
1975	39043		298	8700	11968			69318		16033	49289				194649
1976	47412		287	3970	13733			70466		18388	49047				203303
1977	44400		310	7519	19120			47702		16061	29680				164792
1978	30266		1437	2260	4270			64113		14463	37200				154009
1979	34350		2938	1403	9777			79754		20593	75034	3850			227699
1980	49704		5962	1826	11750			123486		29291	124350	1250			347619
1981	68521		5681	1277	7021			120901		37730	87746	2765			331642
1982	71151		8126	753	13800			92541		38475	86906	4300			316052
1983	84406		8927	1424	15894			76474		46710	92248	6065			332148
1984	90089		9358	1793	30483			93429		59685	100761	6354			391952
1985	83527		7224	1215	26275			63260		49565	78127	5890			315083
1986	81521		5633	181	19520			43236		45723	52148	4596			252558
1987	68881		3007	218	14560			32667		42978	39203	5567			207081
1988	60436		2904	2	14078			33351		48964	28137	6915			194787
1989	57240		2254	3	12844			36855		50740	14722	4520			179178
1990	47394		1731		4691			32028		50683	13461	3558			153546
1991	39792	1810	1711		6564	2627	1865	25748	3299	36490		2611			122517
1992	18025	1368	485		2793	1250	1266	13314	1793	13995		593			54882
1993	8000	70	225		1042	1333	605	8909	892	10099		558		18978	50711
1994	9901	952	594		3056	2831	1887	14335	1257	21264		779		44000	100856
1995	16895	1049	1729		5496	6638	4513	25000	1612	24723		777	293	18993	107718
1996	17549	1338	3089		7340	8709	5524	34855	3306	30669		706	289	10815	124189
1997	9776	1414	1536		5215	6187	4601	31396	2803	25072		600			88600
1998	7818	1188	1026		1270	7765	4176	25155	4599	14431					67428
1999	12170	1052	1456		2215	6889	4371	25920	5202	13720					72995
2000	9715	604	1648		1508	6196	5165	21194	4231	15910				23118	89289
2001	9580	765	1526		2159	6252	3137	21346	5032	17854				23677	91328
2002	7831	37	1526		1445	4796	3137	15106	3793	12507				17562	67740
2003	7655	591	1092		1354	3493	2767	15374	3707	11297				22147	69476
2004	7394	1192	859		2659	4835	2041	14582	3410	12043				19563	68578

2005	7270	833	278		2339	3513	2988	11669	3411	7740			14991	55032
2006	9766	616	427		2025	3980	3200	14290	3719	9672			17836	65532
2007	7280	877	615		1529	3996	2486	8599	3383	9660			12418	50843
2008	7374	841	670		2341	3990	2835	8721	3888	8901			2673	42235
2009	8295	623			3665	4588	2789	10625	4482	10182			3189	48439
2010	10739	796	826		3908	5001	3140	11433	4264	10169				50277
2011	10842	1180	958		3054	4916	3017	11348	5022	10031				50368
2012	12102	686	1405		2432	4269	2261	14007	3954	10109				51225
2013	6052	249	399		541	2441	1744	11760	2870	5299				31355
2014	6035	166	350		676	1999	1088	11026	3444	4125				28908
2015	9652	189	388		1477	2586	1974	12937	3512	4628				37343
2016	6756	2	57		918	2717	1698	9583	3392	4189				29313

*** Provisional data.**

**** Includes landings from October to December 1990 of Fed.Rep.Germany.**

***** Working group estimates. No information available for years prior to 1993.**

^ Landings for 1997 were not officially reported – estimated by ICES.

Table 2.1.2. Cod in SD 25-32. Total landings (tons) by fleet, country and subdivision in 2016. BMS landings are included.

Subdivision		25	26	27	28	29	30	31	32	Total 25–32
Fleet	Country									
Active	Denmark	4320	2057	33	0	0				6410
	Estonia	0	0		0	0			0	0
	Finland	0					0		0	0
	Germany	879	39							918
	Latvia	343	1994		66					2404
	Lithuania	3	1380							1383
	Poland	3091	3848	0	0	0				6939
	Russia		3024							3024
	Sweden	2768	854	1	0			0		3623
Total Active gears		11405	13198	33	66	0	0	0	0	24702
Passive	Denmark	293	47	5	0	0				345
	Estonia				1	0			1	2
	Finland					57	0	0	0	57
	Latvia	124	153		36					313
	Lithuania		315							315
	Poland	2409	235	0	0	0				2644
	Russia		368							368
	Sweden	452		23	2	88	1	0		566
Total Passive gears		3278	1118	28	39	145	1	0	1	4610
Total all gears		14683	14316	61	105	145	1	0	1	29313

Table 2.1.3. Eastern Baltic cod stock in Subdivisions 25–32 and Subdivision 24. History of ICES estimates of landings, discards, and catch by area. Weights in tonnes.

	Eastern Baltic cod stock in Subdivisions 25-32				Eastern Baltic cod stock in Subdivision 24			Eastern Baltic cod stock in Subdivisions 24 and 25-32
Year	Unallocated*	Discards	Landings	Catch	Landings	Discards	Catch	Total catch
1965			147352	147352				
1966		8735	177318	186053				
1967		11733	195446	207179				
1968		9700	216353	226053				
1969		10654	212160	222814				
1970		7625	198451	206076				
1971		5426	164840	170266				
1972		8490	143833	152323				
1973		7491	143164	150655				
1974		7933	147815	155748				
1975		9576	194649	204225				
1976		4341	203303	207644				
1977		2978	164792	167770				
1978		9875	154009	163884				
1979		14576	227699	242275				
1980		8544	347619	356163				
1981		6185	331642	337827				
1982		11548	316052	327600				
1983		10998	332148	343146				
1984		8521	391952	400473				
1985		8199	315083	323282				
1986		3848	252558	256406				
1987		9340	207081	216421				
1988		7253	194787	202040				
1989		3462	179178	182640				
1990		4187	153546	157733				
1991		2741	122517	125258				
1992		1904	54882	56786				
1993	18978	1558	50711	52269				
1994	44000	1956	100856	102812	1784	166	1950	104762
1995	18993	1872	107718	109590	4041	541	4582	114172
1996	10815	1443	124189	125632	10210	1087	11297	136929
1997**		3462	88600	92062	6615	629	7244	99306
1998		2299	67428	69727	4588	630	5218	74945
1999		1838	72995	74833	6338	588	6926	81759
2000	23118	6019	89289	95308	6694	1153	7847	103155
2001	23677	2891	91328	94219	7261	383	7644	101863
2002	17562	1462	67740	69202	4566	548	5114	74316
2003	22147	2024	69477	71501	6569	854	7423	78924

2004	19563	1201	68578	69779	4925	184	5109	74888
2005	14991	1670	55032	56702	5191	1808	6999	63701
2006	17836	4644	65531	70175	6279	142	6421	76596
2007	12418	4146	50843	54989	7876	856	8733	63722
2008	2673	3746	42234	45980	8934	768	9702	55682
2009	3189	3328	48438	51766	8456	474	8930	60696
2010		3543	50276	53819	6479	559	7037	60856
2011		3850	50368	54218	7487	521	8009	62227
2012		6795	51225	58020	8419	564	8982	67002
2013		5020	31355	36375	5226	1331	6557	42932
2014		9627	28909	38536	5439	1268	6707	45243
2015		6328	37342	43670	5047	912	5959	49629
2016		3620	29313	32933	4430	293	4723	37656

***ICES estimates. No information available for years prior to 1993.**

****For 1997 landings were not officially reported – estimated by ICES**

Table 2.1.4. Cod in SD 25-32. Discard (in numbers ('000)) by gear type and year.

YEAR	PASSIVE GEAR	ACTIVE GEAR	GRAND TOTAL
1996	2037	5318	7355
1997	2255	15325	17580
1998	12772	9565	22337
1999	865	21314	22179
2000	14471	8822	23293
2001	1920	9008	10929
2002	1283	5841	7125
2003	3933	4315	8248
2004	1349	2324	3673
2005	799	4396	5195
2006	2786	9937	12722
2007	496	10562	11058
2008	2452	6275	8728
2009	1244	7538	8782
2010	1595	7482	9078
2011	584	9367	9950
2012	268	18367	18635
2013	1132	12688	13820
2014	1836	26027	27864
2015	2386	15964	18350
2016	296	10889	11185

Table 2.1.5. Cod in SD 25-32. Landings, discards and discard rate of cod in subdivision 25-32, BMS landings are included since 2015.

Year	Landings (t)	Discards (t)	Discard rate (% of catch)
2000	52304	1452	3%
2001	53771	1813	3%
2002	39081	2880	7%
2003	43990	3665	8%
2004	41599	1690	4%
2005	34214	2573	7%
2006	41331	5466	12%
2007	34163	4594	12%
2008	36742	2540	6%
2009	38181	4561	11%
2010	47337	4140	8%
2011	47352	6405	12%
2012	49027	8222	14%
2013	29770	6930	19%
2014	28908	9627	25%
2015	37342	6328	14%
2016	29313	3620	11%

Table 2.1.6. Cod in SD 25-32. Landings (>MCRS), BMS landings (<MCRS) and discards in numbers ('000) by length class in 2016, from subdivision 25-32.

Length class (cm)	Landings (Human consumption)	BMS landings	Discards	Total
<20	3			3
20-24	21	13	203	237
25-29	208	107	1707	2022
30-34	1534	532	6184	8250
35-37	9506	251	2339	12096
38-44	24757	50	664	25471
45-49	6129	2	67	6199
>=50	2235	1	20	2256
Total	44393	955	11185	56533

Table 2.1.7. Cod in SD 25-32.Numbers ('000) by length class, quarter, gear and SD in total catch in SD 25-32, in 2016.

			Length class (cm)								
Quarter	Gear	Subdivision	<20	20-24	25-29	30-34	35-37	38-44	45-49	>=50	Total
1	Active	25		12	209	1607	2406	3725	467	159	8586
		26		17	100	723	1163	3643	963	364	6973
		27		0	1	10	17	32	6	2	67
		28		0	0	0	0	0	0	0	0
		29		0	0	0	0	0	0	0	0
	Passive	25	0	17	23	83	279	538	98	46	1085
		26	0	7	11	24	51	134	50	20	298
		27	0	0	0	1	5	9	2	1	18
		28	0	0	0	0	2	4	1	0	7
		29	0	0	1	2	9	18	3	2	35
		32	0	0	0	0	0	0	0	0	0
Total Q1			0	54	345	2451	3932	8102	1589	595	17069
2	Active	25		78	826	2214	2876	3942	943	273	11151
		26		37	211	1226	1745	4449	756	338	8762
		27		0	0	0	0	0	0	0	0
		28		0	1	8	13	29	5	3	59
		29		0	0	0	0	0	0	0	0
		32		0	0	0	0	0	0	0	0
	Passive	25	0	5	16	36	107	1068	357	91	1680
		26	0	3	10	23	23	260	111	28	459
		27	0	0	1	1	1	11	4	1	19
		28	0	0	0	0	0	4	1	0	6
		29	0	0	1	2	6	59	20	5	93
		30	0	0	0	0	0	0	0	0	0
		31	0	0	0	0	0	0	0	0	0
		32		0	0	0	0	0	0	0	1
Total Q2			0	125	1065	3511	4771	9822	2198	739	22232
3	Active	25		7	71	403	774	880	193	74	2402
		26	3	5	85	261	243	732	215	146	1690
		27		0	0	0	0	0	0	0	0
		28		0	1	5	11	25	8	6	56
		29		0	0	0	0	0	0	0	0
		30		0	0	0	0	0	0	0	0
		31		0	0	0	0	0	0	0	0
		32				0	0	0	0	0	0
	Passive	25	0	1	4	13	13	136	183	92	442
		26	0	1	5	11	7	134	72	30	261
		27	0	0	0	0	0	1	1	0	2
		28	0	0	0	1	1	7	10	5	24
		29	0	0	1	1	1	13	17	9	43
		30	0	0	0	0	0	0	0	0	0
		31		0	0	0	0	0	0	0	0
		32		0	0	0	0	0	0	0	0
Total Q3			3	15	168	695	1049	1928	699	363	4919
4	Active	25		32	311	907	1211	1456	375	141	4433
		26		8	124	632	1064	3547	743	276	6394
		27		0	0	0	0	1	0	0	1
		28		0	0	0	0	0	0	0	0
		29		0	0	0	0	0	0	0	0
		31			0	0	0	0	0	0	0
		32				0	0	0	0	0	0
	Passive	25	0	2	2	23	45	432	431	94	1028
		26	0	1	6	29	21	175	155	46	433
		27	0	0	0	0	0	1	1	0	2
		28	0	0	0	0	0	4	4	1	8
		29	0	0	0	1	2	4	4	1	13
		30	0	0	0	0	0	0	0	0	1
		31		0	0	0	0	0	0		0
		32		0	0	0	0	0	0	0	0
Total Q4			0	42	444	1593	2343	5619	1713	559	12314
Total 2016			3	237	2022	8250	12096	25471	6199	2256	56533

Table 2.1.8. Cod in SD 25-32.Mean weight (g) by length class and catch category for cod in subdivision 25-32, in 2016.

Gear	Length class	Landings (human consumption)	BMS landings	Discards	Total catch
Active	<20	43			43
	20-24	115	108	115	114
	25-29	234	199	195	199
	30-34	349	310	313	319
	35-37	443	398	391	432
	38-44	614	496	494	610
	45-49	912	670	715	910
	>=50	1412	1093	1097	1410
Passive	<20	48	73	80	65
	20-24	97	114	109	109
	25-29	220	206	181	192
	30-34	367	330	320	342
	35-37	479	444	450	475
	38-44	725	548	682	725
	45-49	974	723	925	973
	>=50	1425	1036	1269	1423

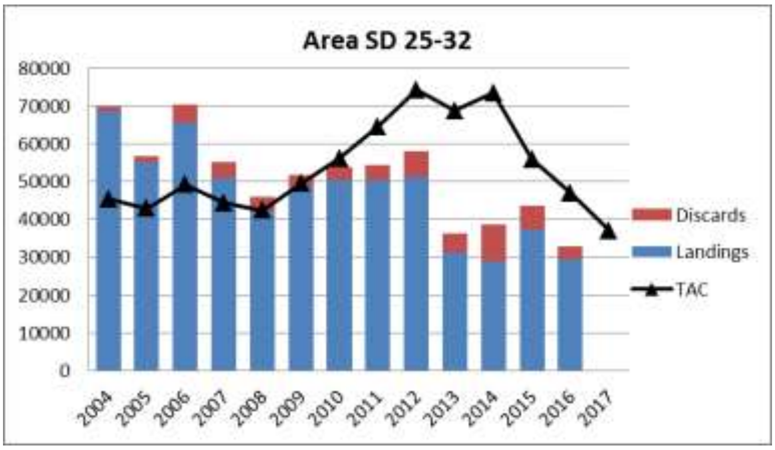


Figure 2.1.1 Cod in SD 25-32. Landings (incl. unallocated for historical period), discards and TAC for management area of SD 25-32.

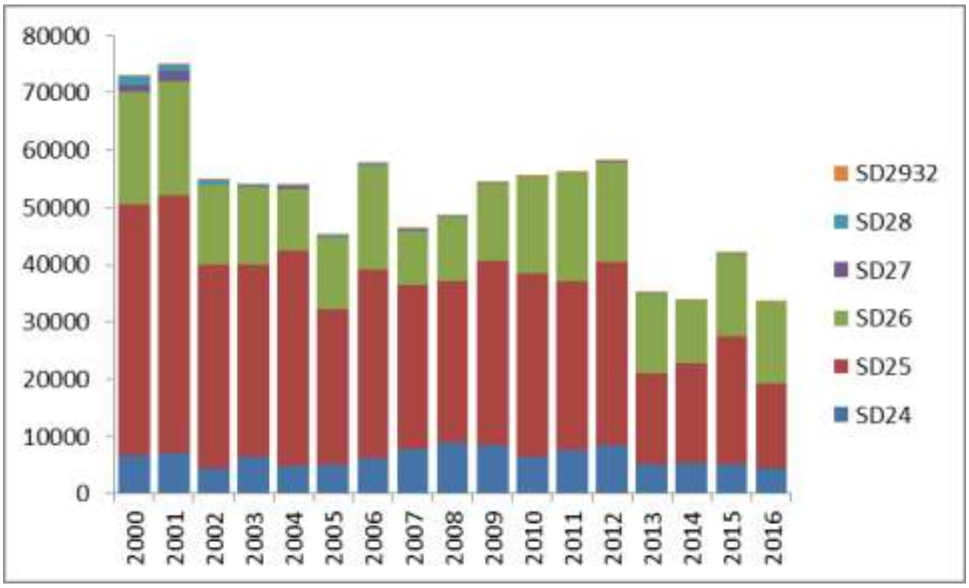


Figure 2.1.2 Cod in SD 25-32. Landings of eastern Baltic cod stock by SD, including the fraction of landings taken in SD 24.

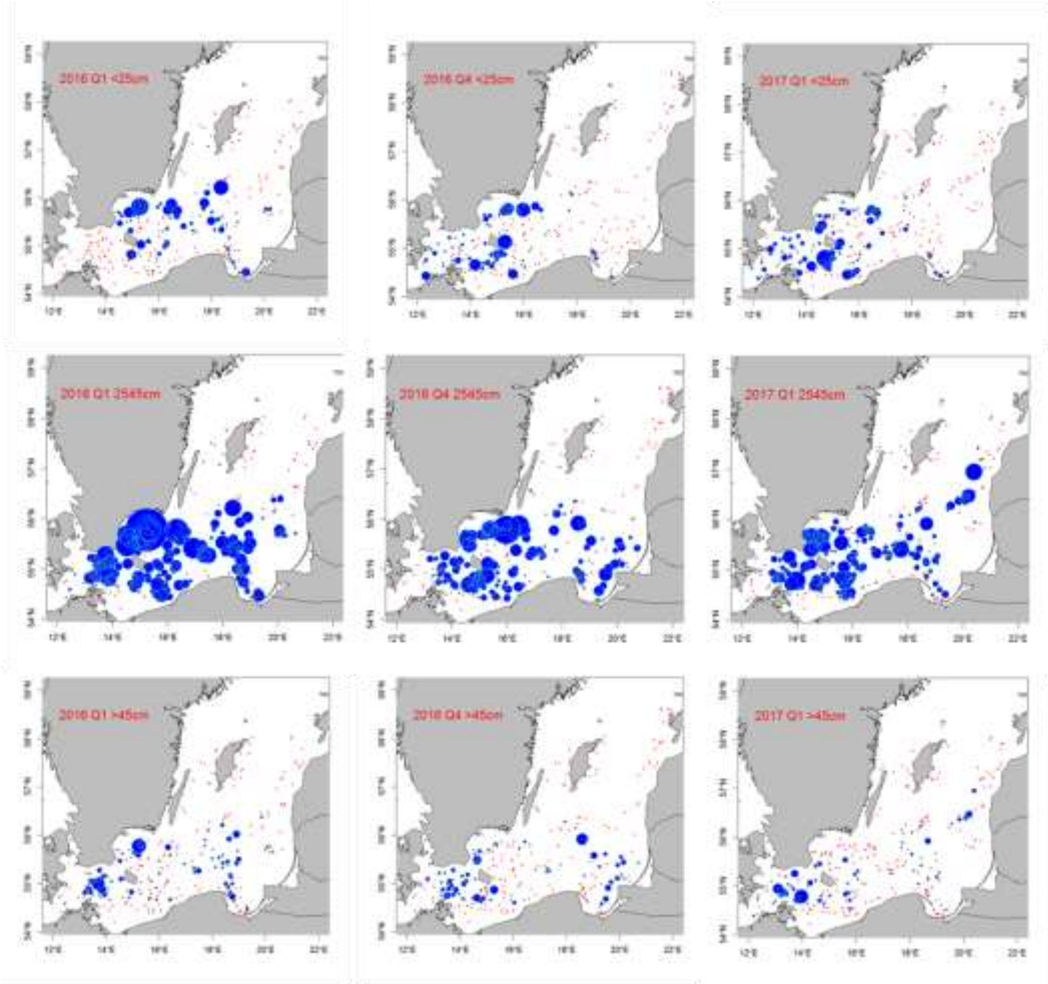


Figure 2.1.3. Cod in SD 25-32. Distribution of cod from BITS surveys in Q1 and Q4 in 2016 and Q1 in 2017, by 3 size-groups (<25cm, 25-45cm and >45cm cod). The scale is comparable between surveys within a size group, but not between size-groups.

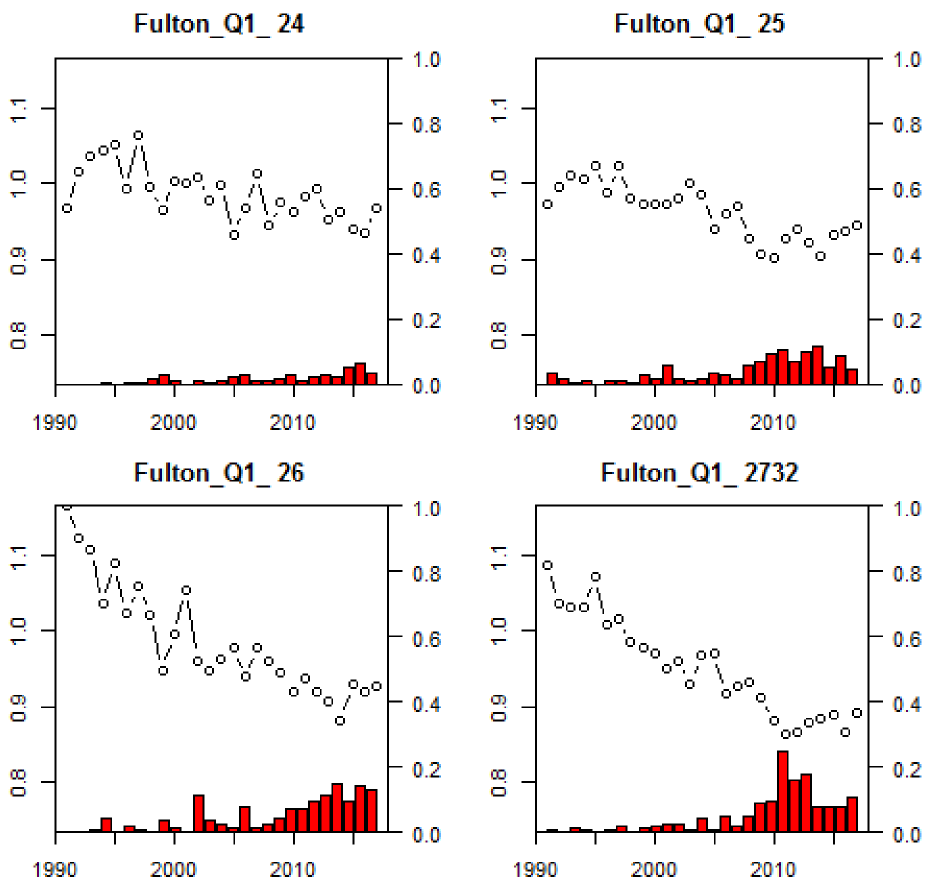


Figure 2.1.4. Cod in SD 25-32. Condition (Fulton K) of cod at 40-60cm in length in Q1 BITS survey, by SDs. The lines show mean values for Fulton K, the bars show the proportion of cod at Fulton K <0.8.

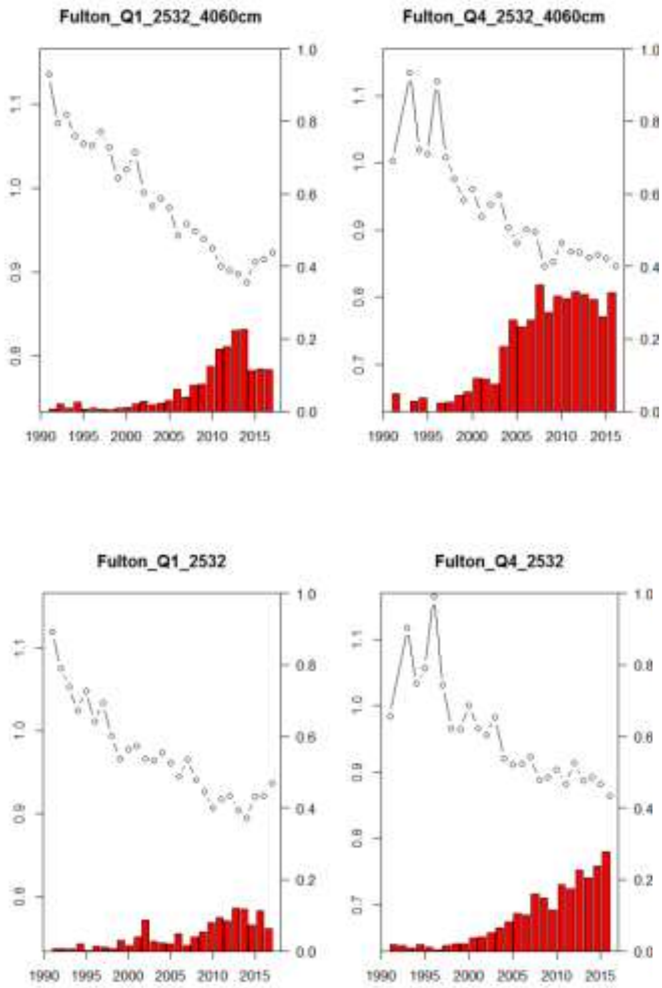


Figure 2.1.5. Cod in SD 25-32. Mean condition (Fulton K) (shown as lines) of cod at 40-60cm (upper panels) and 25-40cm (lower panels) in length, in Q1 and Q4. The bars show the proportion of cod at Fulton K <0.8.

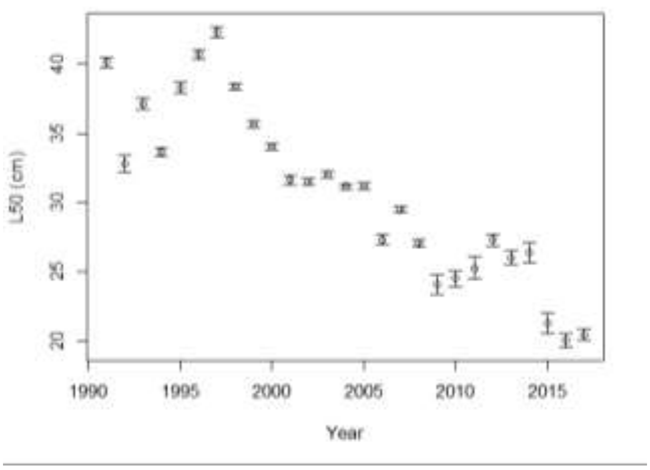


Figure 2.1.6. Cod in SD 25-32. Size at first maturation (L50), for females and males combined, estimated from BITS Q1 survey.

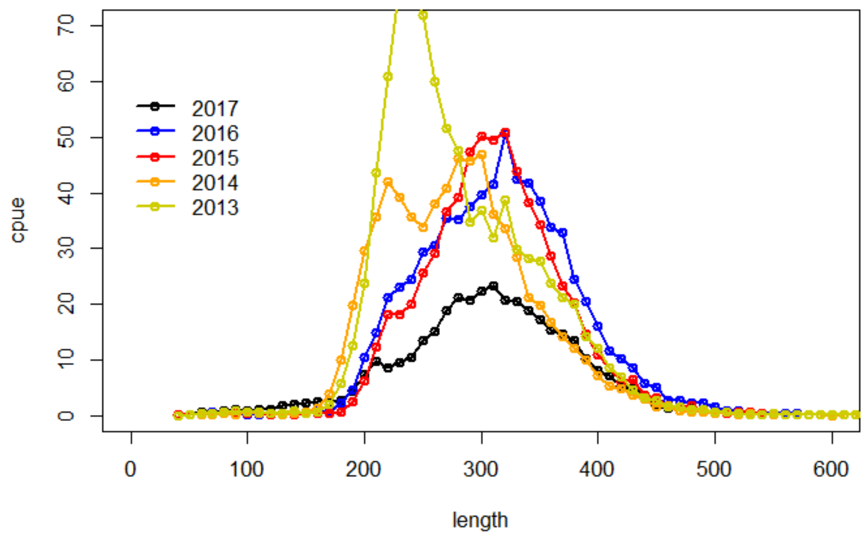


Figure 2.1.7. Cod in SD 25-32. Length distribution of cod in BITS Q1 surveys in 2013-2017, following the stronger year-classes from 2011-2012 (visible first at around 20 cm in length in 2013 and 2014 surveys, respectively).

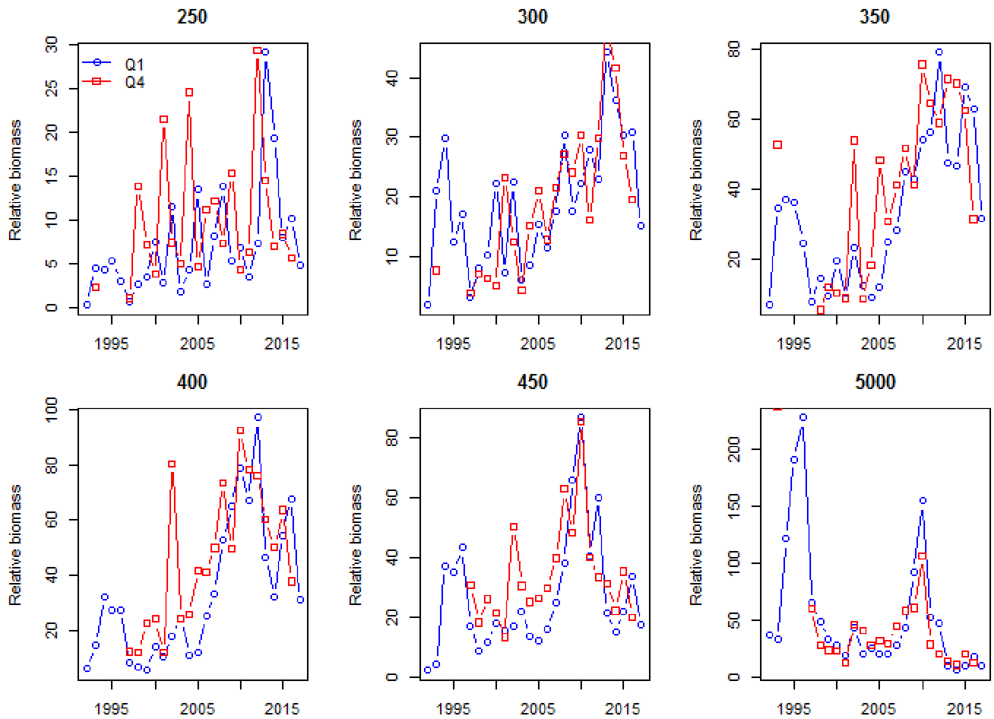


Figure 2.1.8. Cod in SD 25-32. CPUE of cod by size-groups (<250, 250-300, 300-350, 350-400, 400-450 and >450mm) in Q1 and Q4.

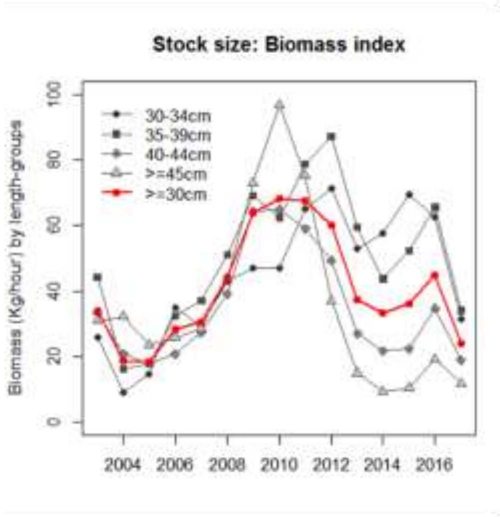


Figure 2.1.9. Cod in SD 25-32. Relative biomass for cod by length groups, for Q1 and Q4 combined (left panel). Exploitation rate (catch divided by combined survey index for Q1 and Q4) by length groups, compared to the average exploitation rate for the stock (total catch divided by survey index for >=30cm cod; red line).

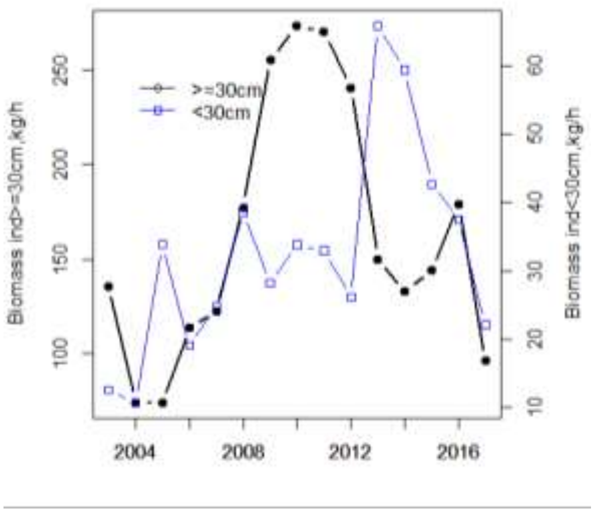


Fig. 2.1.10. Cod in SD 25-32. Relative biomass index of >=30 cm and <30cm cod, estimated from Q1 and Q4 BITS surveys combined.

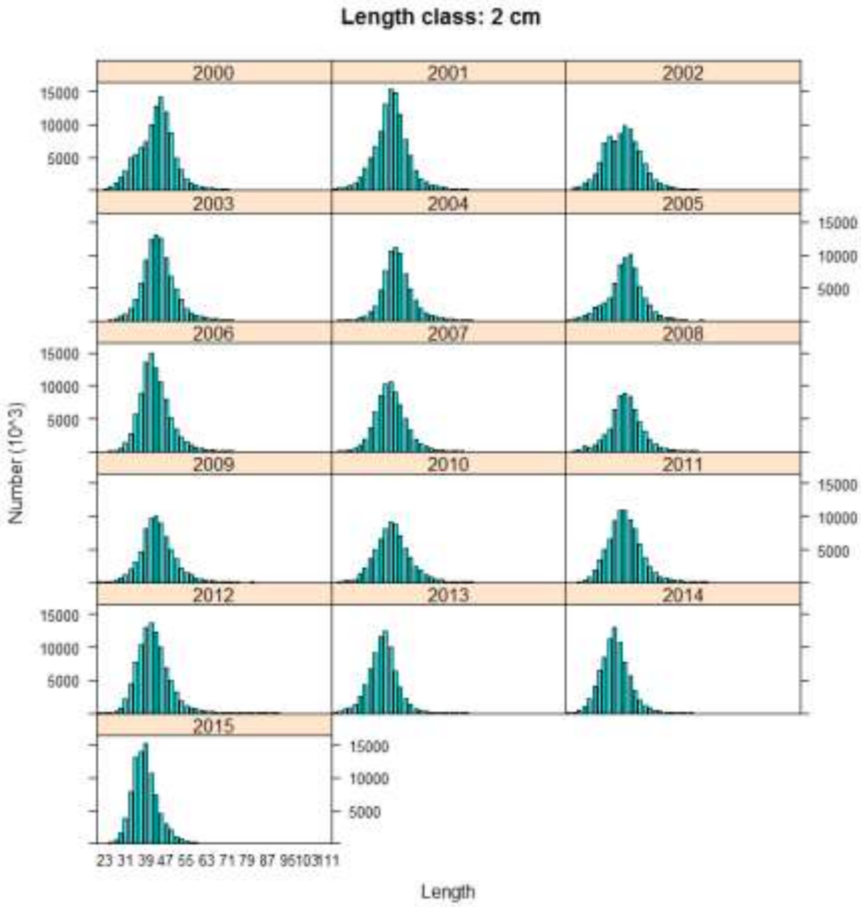


Figure 2.1.11. Cod in SD 25-32. Length distribution of catches.

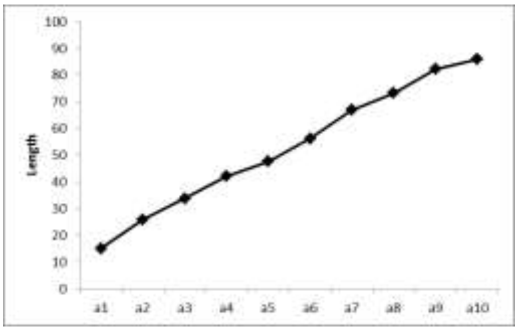


Figure 2.1.12. Cod in SD 25-32. Mean length at age of cod, estimated based on BITS Q1 survey data, combined for years 1997-2006.

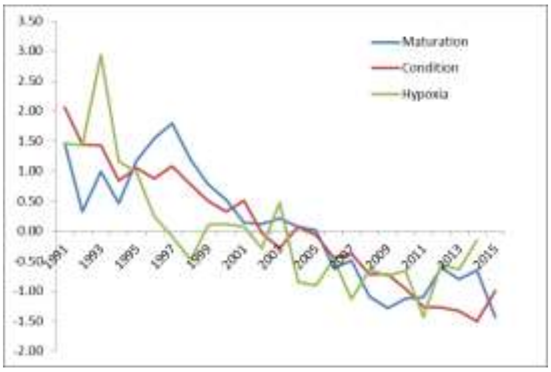


Figure 2.1.13. Cod in SD 25-32. Standardized trends in size at first maturation, nutritional condition (average for 40-60cm fish) (estimated from BITS Q1 data) and the extent of hypoxic areas in the Baltic Sea (from Casini et al. 2016).

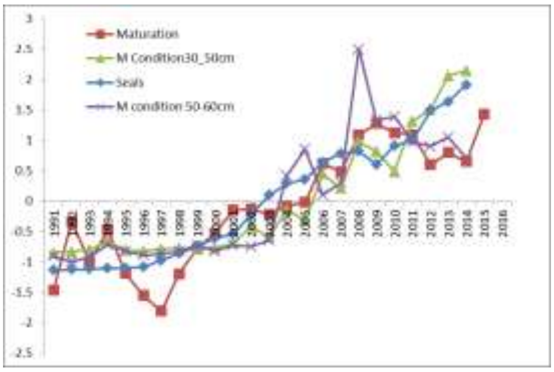


Figure 2.1.14. Cod in SD 25-32.Standardized trends in size at first maturation (from Q1 BITS), estimated M due to low condition for 30-50 and 50-60 cm cod (from Casini et al. 2016) and abundance of seals in the Baltic Sea (HELCOM estimates).

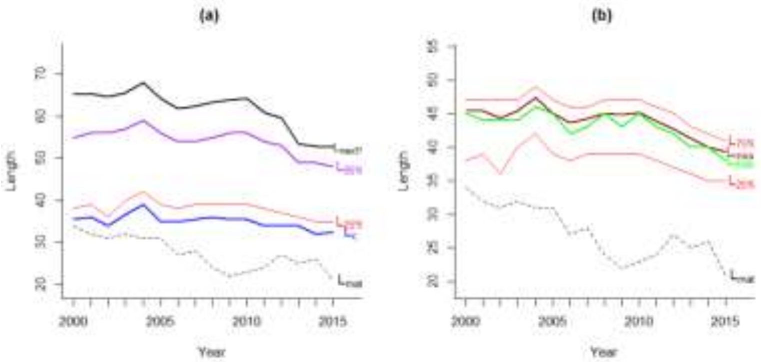


Figure 2.1.15. Cod in SD 25-32. Length based indicators for EB cod.

2.2 Cod in Kattegat

2.2.1 The fishery

2.2.1.1 Recent changes in fisheries regulations

TAC is mainly regulating the fishing in Kattegat since the effort limitation was stopped in 2016. The effort system was introduced in the first cod recovery plan (EC No. 423/2004). Effort was limited by allowed number of fishing days for individual fishing vessels. In 2009, following the introduction of the new cod management plan (EC No. 1342/2008) for North Sea (incl. Kattegat), a new effort system was introduced. In this system each Member State was given kWdays for different gear groups. It is then the MS responsibility to distribute the kWdays among fishing vessels. MS could apply for derogation from the kWdays system if the catches in a certain part of the fleet was shown to consist of less than 1.5% cod (article 11(2)(b)) or avoid cuts (or part of cuts) if they introduce highly selective gear and cod avoidance plans (article 13). Sweden has used this derogation from the kWday system for the part of the fishery using sorting grids. This fishery constituted since 2010 more than half of the Swedish effort. Denmark introduced in 2010 a cod recovery plan covering their entire Kattegat fishery. As a part of this plan, since 2011 it is mandatory in Danish fisheries to use a SELTRA trawl with at least 180 mm panel.

In 2009, as a part of the attempts to rebuild of the cod stock in Kattegat, Denmark and Sweden, introduced protected areas on historically important spawning grounds in South East Kattegat. The protected zone consists of three different areas in which the fisheries are either completely forbidden or limited to certain selective gears (Swedish grid and Danish SELTRA 300 trawl) during all or different periods of the year. Since 2012 the cod quota in Kattegat was considered to be a by-catch-quota where the landings of cod should constitute of 50 % of the total landings.

The main fishery mortality for Kattegat cod is as bycatch in the *Nephrops* fishery. The decrease in minimal landings size in *Nephrops* enforced in 2015 (from 40 mm carapace to 32mm carapace) might have an effect on the exploitation pattern for *Nephrops* (new areas exploited, new temporal trends in the fishery pattern) etc. These potential changes will most certainly affect the Kattegat cod stock development. Additionally, the termination of the effort system may also affect the fishery mortality for Kattegat cod. The effect of these changes on cod mortality is however hard to foresee.

2.2.1.2 Trends in landings

Agreed TACs and reported landings have been significantly reduced since 2000 to the present historical low level. The reported landings of cod in the Kattegat in 2016 were 299 tons, higher levels as last year (Table 2.2.1)

2.2.1.3 Discards

Both Sweden and Denmark implemented the TAC regulation through a ration-period system until 2007. The ration sizes were reduced substantially since 2000—2001 and the rations in the Kattegat were lower than those in adjacent areas, giving incentives for misreporting of catches by area (Hovgård, 2006), which could potentially have biased landings statistics for these years.

Discard estimates were available from Sweden for 1997—2016 and from Denmark for 2000—2016.The estimated discard numbers by age and total discards in tons are presented in Table 2.2.2. The sampling levels are shown in Table 2.2.3.

In 2016, the estimated discards formed about 43 percent of the catch weight and the proportion of discards in catch has decreased the last year compared to the previous years (Figure 2.2.1). In numbers, the available data indicates that close to 72 % of the cod caught in the Kattegat is discarded. Discarding has in previous years mostly affected ages 1-2 but in 2015 and 2016 it also included both age 3 and 4+. The inclusion of 3 and 4-year-old classes in the discard could be related to the poor recruitment in the last three years. The increasing number of older fish in the Kattegat and poor recruitment can be observed in the age structure of the survey catches (Table 2.2.2; Figure 2.2.2, Figure 2.2.4).

2.2.1.4 Unallocated removals

Unreported catches have historically been considered to be an issue for this stock, estimated as part of unallocated removals within the assessment model. Last benchmark (WKBALT 2017) concluded the catch data to be of reasonable quality from 2011 onwards. Major issues identified at WKBALT (2017) that could explain the unallocated removals estimated in the model include inflow of recruits from the North Sea cod and their return migration when they become mature, as well as possibly increased natural mortality due to seal predation.

2.2.2 Biological information

2.2.2.1 Catch in numbers

Historical total landings in numbers by age and year are given in Table 2.2.6.

2.2.2.2 Maturity at age

The historical time series of visual based maturity estimations used in the assessment are presented in Table 2.2.9. The estimates are based on IBTS 1st quarter survey. Due to low number of cod in the survey, the maturities in recent years are based on a running mean of 3 years.

2.2.2.3 Natural mortality

A constant natural mortality of 0.2 was assumed for all ages for the entire time series.

2.2.2.4 Quality of catch and biological information

Both Danish and Swedish sampling data were available from the commercial fishery in 2016. Danish and Swedish commercial sample sizes are shown in Table 2.2.3. and table 2.2.4. Landings were allocated to age groups using the Danish and Swedish age information as shown in Table 2.2.5. The catch numbers followed the same procedure as the landings and catch in numbers by age is presented in Table 2.2.6)

Mean weight at age in the landings in 2016, presented in Table 2.2.7, and was provided by Sweden and Denmark. Historical weight at age in the landings is given in Table 2.2.7 for all years included in the assessment.

Mean weight at age in the stock is based on the IBTS 1st quarter survey for age-groups 1—3. Due to low number of cod in the survey, the weights in the stock in recent years are based on a running mean of 3 years. The weight of ages 4—6+ were set equal to the mean weights in the landings. The historical time series of mean weight at age in the stock is given in Table 2.2.8.

2.2.3 Fishery independent information

The CPUE-values used were from IBTS 1st and 3rd quarter surveys ,from the BITS surveys in the 1st quarter (Danish R/V Havfisken) and from the Cod survey 4th Quarter. The internal consistency of surveys (numbers at age plotted against numbers at age+1 of the same cohort in the following year) are shown in Figure 2.2.3a–d. The survey indices available for the Working Group are presented in Table 2.2.10.

The tuning series available for assessment:

FLEET	DETAILS
BITS-1Q	Danish survey, 1st quarter, R/V Havfisken (age 1-5) (1997-2017)
IBTS-3Q	International Bottom Trawl Survey, 3rd quarter, Kattegat (age 1-6) (1997-2016)
IBTS-1Q	International Bottom Trawl Survey, 1st quarter, Kattegat; (Ages 1-6) (1997-2017)
CODS-4Q	Cod survey, 4th Quarter, Kattegat, (ages 1-6). (2008-2016)

2.2.4 Assessment

2.2.4.1 Future plans after benchmark in 2017

The issues identified at WKBALT (2017) that could explain the unallocated removals estimated in SAM include inflow of recruits from the North Sea and their return migration when they become mature. WKBALT 2017 suggested intersessional work to be continued looking into possibilities to take migration more explicitly into account in the SAM model, to be able to separate fishing mortality from migration. A modified version of SAM model was presented at WGBFAS 2017, incorporating proportions of juvenile North Sea and Kattegat cod, estimated in the model, and assuming return migration to take place when the fish become mature (WD by Vinther, M. WGBFAS 2017).

WGBFAS concluded that data on the proportions of juvenile cod in the Kattegat originating from North Sea are needed, to be incorporated in the model, or used to validate the values estimated in the model. The first step would be to analyze historical samples to determine stock origin for individuals at age 1, for the latest 10 years (200 individuals per year). These data could then be included in the new version on SAM model, to account for the North Sea component in the Kattegat. The time line for this work to be completed is considered to be 2 years.

A longer term step would be to gather genetic samples from the whole size range of cod, and also analyse the samples back in time that would be needed in order to split the different cohorts between North Sea and Kattegat cod, to assess the developments in Kattegat stock alone. This could be done using the traditional SAM or possibly other models (e.g SS3).

2.2.4.2 State-space model (SAM)

A stochastic state-space model (SAM) (Nielsen, 2008, 2009) was used for assessment of cod in the Kattegat link to the model. The model allows estimation of possible bias (positive or negative) in the data on removals from the stock in specific years. Settings of the model were used as specified in the Stock Annex. Two runs was performed

Catch (landings and discards) from 1997—2016 with estimating total removals from 2003—2015 within the model based on survey information. (SPALY _Scaling)

Catch (landings and discards) from 1997—2016 without estimating total. (SPALY _)

Unallocated removals were estimated separately for the years 2003—2016, but common for all age-groups within a year. The scaling factors estimated for 2005—2016 were significant for all the years in the SAM run with landings and total removals estimated. For the SAM run with discard and total removals estimated all years(except for 2003) significant. The total removals were estimated several fold higher than reported landings, and are not explainable by the estimated discard data only (Figure 2.2.12).

Estimates of recruitment, SSB and mortality (Z-0.2) with confidence intervals from the two runs with total removals estimated are presented in Figure 2.2.7—2.2.9 and Tables 2.2.11—2.2.12. All information about the residuals and results from the two SAM runs Fig 2.2.11; 2.2.13; 2.2.14; 2.215-2.2.15.

2.2.4.3 Conclusions on recruitment trends

The absolute values of recruitment estimated from the assessment analyses are considered uncertain, mainly due to mixing with North Sea cod and possibly also uncertain natural mortality estimates. Additionally, discards are associated with uncertainties; at least for part of the time series. The year classes of 2015 and 2016 are the lowest in the times serie Fig 2.2.6.This can be contrasted to the biggest year class in the time series from 2011.

2.2.4.4 Conclusions on trends in SSB and fishing mortality

The assessment is indicative of trends only and shows that spawning-stock biomass (SSB) has strongly increased since 2009 from a historical low level, from 2015 the SSB has levelled out and decreased 2016. The mortality has shown a decreasing trend since 2008, followed by a slight increase 2016. However, the exact level of fishing mortality can still not be reliably estimated. The runs that estimated total removals show estimated mortality (Z-0.2) in the interval of 0,293 to 0,62. In contrast the run without estimating total removals in the interval of 0.056 to 0.165. However, the overall perception is that the total mortality has gone down since 2008 (Table 2.2.11—2.2.12, Fig 2.2.8).

2.2.5 Short term forecast and management options

No short term forecast was produced in this year's assessment

2.2.6 Reference points

Two different methods have been used to explore proxies for MSY reference points.

One of the main issues with the assessment of cod in the Kattegat is the inflow on young cod from the North Sea and return migration when they become mature. This implies that the basis for calculation of the proxies for reference points are constructed from life history and stock dynamics data, originating from possibly two stocks. The issue with unallocated removals (migration, possibly unallocated natural mortality) that bias the current SAM assessment are not solved by applying a production model (SPICT). If the problem with stock mixing is resolved, the SPiCT as well as an age based analytical assessment could likely be used for determining reference points for cod in the Kattegat.

Another problem is the large change in size distribution the last couple of years, which is especially a problem in the LBI- analysis. Hence, this makes it highly questionable to use these two methods as a basis for proxies for new reference points.

The sections below describe the analyses conducted.

2.2.6.1 LBI

To use the LBI Application (https://scott.shinyapps.io/LBIndicator_shiny/) you need: 1) a length frequency distribution (table 3) 2) weight at length data, (table 3) and 3) estimates of the life history parameters including L_{inf} and L_{mat}. The length and weight distribution used was based on the WECA and CANUM from the 3 last years (2014-2016). To determine L_{inf} and L_{mat}, age, length and maturity data was used for the time period 1997-2017 (survey). The calculated L_{inf} gave was unrealistically high (1498 mm). Hence, L_{inf} from Fishbase was used as a proxy. L_{inf} was calculated as the average for all data in the near vicinity (North sea and the Baltic) of Kattegat (36 references) and the average value was 1140 mm. the survey data suggested that L_{mat} should be 275 mm, which is rather low. Based on the references in Fishbase suggest that L_{mat} should be 390 mm (13 references) and was used in the analysis. The results are presented below and indicate that the stock is below MSY 2014 and 2015 but above MSY in 2016 (table 2).

Table 1 Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
Lmax5%	Mean length of largest 5%	Linf	Lmax5% / Linf	> 0.8	Conservation (large individuals)
L95%	95th percentile		L95% / Linf		
Pmega	Proportion of individuals above Lopt + 10%	0.3–0.4	Pmega	> 0.3	
L25%	25th percentile of length distribution	Lmat	L25% / Lmat	> 1	Conservation (immatures)
Lc	Length at first catch (length at 50% of mode)	Lmat	Lc/Lmat	> 1	
Lmean	Mean length of individuals > Lc	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	Lmean/Lopt	≈ 1	Optimal yield
Lmaxy	Length class with maximum biomass in catch	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	Lmaxy / Lopt	≈1	
Lmean	Mean length of individuals > Lc	LF=M = (0.75Lc+0.25Linf)	Lmean / LF=M	≥ 1	MSY

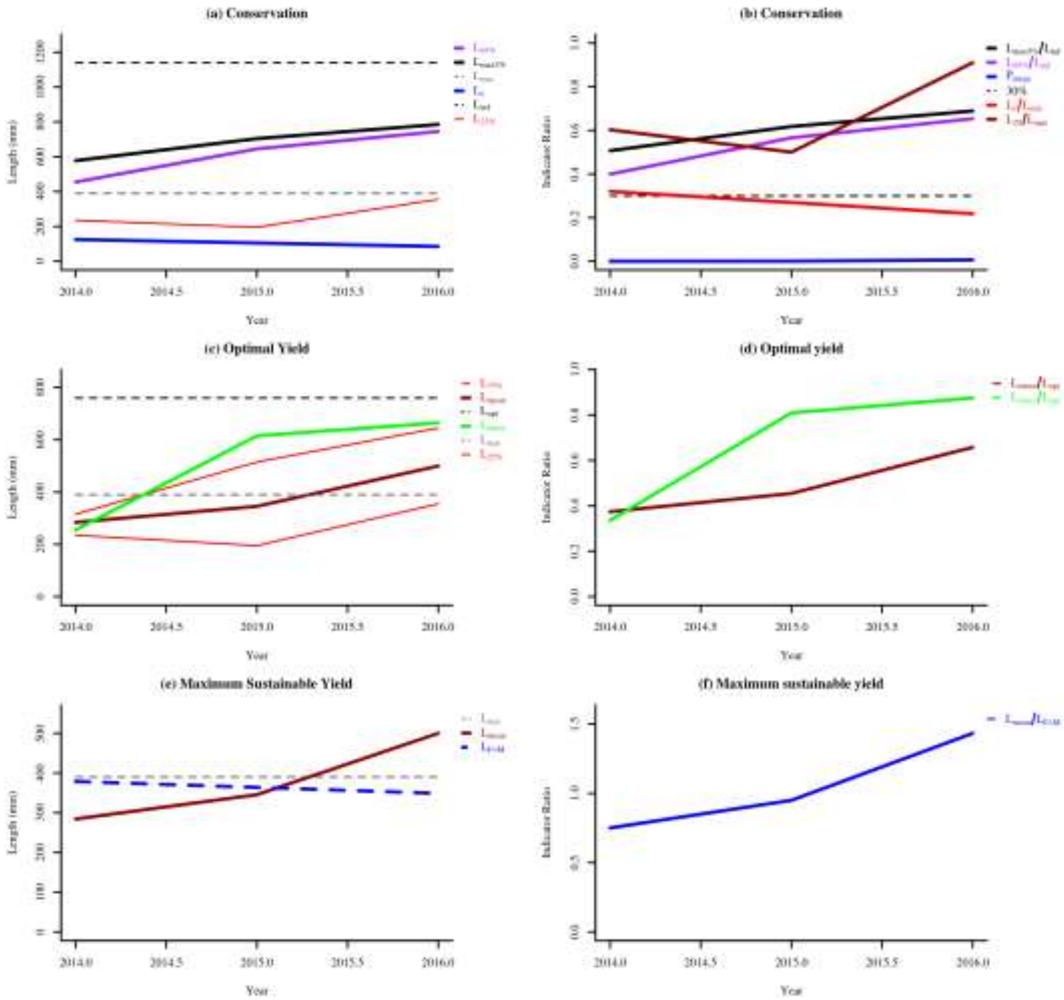


Table 2. Indicator status for the most recent three years

	Conservation				Optimizing Yield	Lmean	MSY
Year	Lc / Lmat	L25% / Lmat	Lmax 5 / Linf	Pmega	Lmean / Lopt	mm	Lmean / LF = M
2014	0.32	0.60	0.51	0.00	0.37	304	0.75
2015	0.27	0.50	0.62	0.00	0.45	381	0.95
2016	0.22	0.91	0.69	0.01	0.66	568	1.43

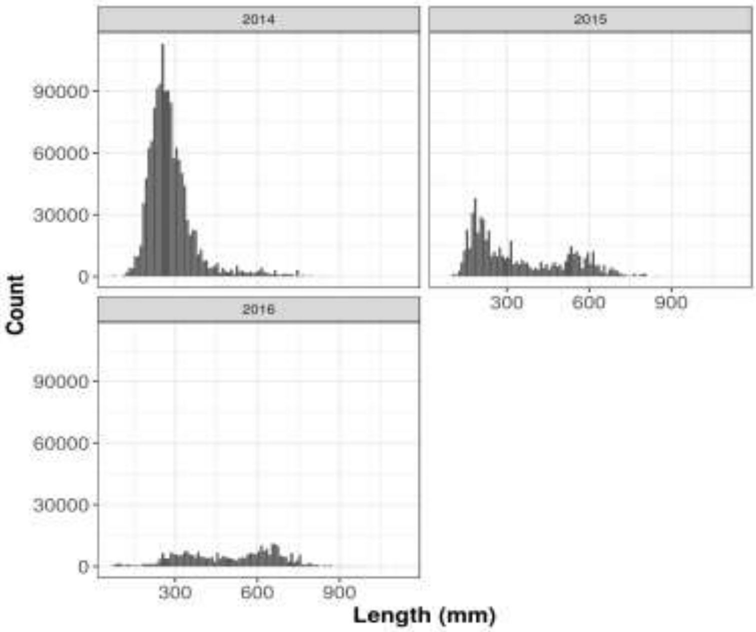


Figure 2. Binned length frequency distributions

2.2.6.2 SPiCT

Survey data

The fraction of the population in terms of age/size used to represent biomass trends should correspond to the fraction represented in commercial catches. At first step, survey indices in numbers at age as used in the SAM assessment were converted to biomass at age, using mean weight at age in the stock. Catch numbers at age were converted to biomass at age, using mean weight in the stock from age 2 onwards; and mean weight in discards for age 1. Next, relative age structure in survey biomass was compared to that in commercial catch (Fig. 1). Based on this comparison, cod survey seems to cover relatively older cod compared to catches, and the time series is relatively short. BITS (Havfisken) Q1 is considered only useful for the assessment up to age 3. Therefore, the time series of relative biomasses from IBTS Q1 and Q3 that both have longer time series and include most ages were chosen to be included in the SPICT analyses (Fig. 3). The time series started from 1997. All runs used IBTS Q1 and Q3 series of survey biomass.

Catch data

Two versions of catch data were used: i) catches in tons were set equal to reported landings in tons plus estimated discards from observer programs; ii) catch was increased for years 2005-2010, where substantial missing removals have been estimated, and it is known that there have been issues with the quality of catch data in this period. Since 2011, WKBALT considered the quality of catch data to be of reasonable quality. The two catch time series are shown in Fig. 2.

Effort

A run was made that included trend in fishing impact (estimated from VMS, cod distribution and gear selectivity data) (WKBALT 2017), for 2007-2015, as a measure of effort.

Results

Figures 4-6 present SPICT model results from 3 runs:

1) Catches set equal to reported landings and estimated discards from observed program

2) Catches increased for 2005-2010, to account for possible underestimation of catch for these years

3) Same as Run 2, but including additionally time series of relative effort.

The diagnostics reveals some issues with all three models (Fig 4b-6b), least for Run 1#.

All three runs estimate F/FMSY below one for recent years, suggesting low fishing pressure. Biomass is mostly estimated to be below BMSY, however, the estimates have a high uncertainty, and the result therefore less conclusive.

The analyses are conducted for the Kattegat area, where the issue of inflow of North Sea cod into the Kattegat and return migration is not taken into account, which may bias the results.

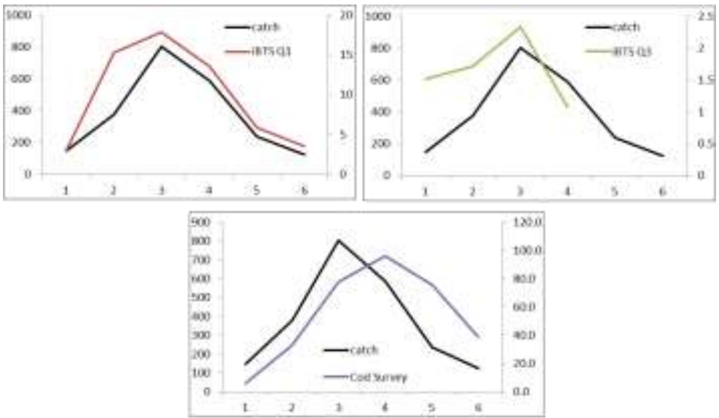


Fig. 1. Biomass at age in commercial catch compared to surveys.

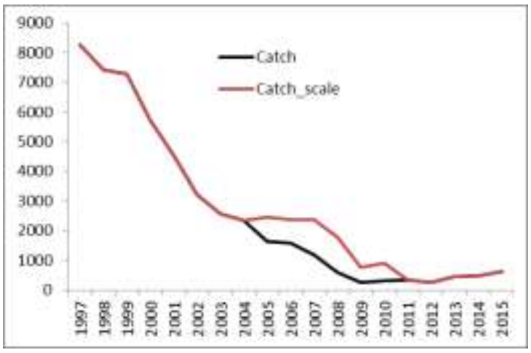


Fig. 2. Catch of Kattegat cod (landings plus discards) as reported (black line), compared to when the catches are increased in 2005-2010, to account for possible missing catch.

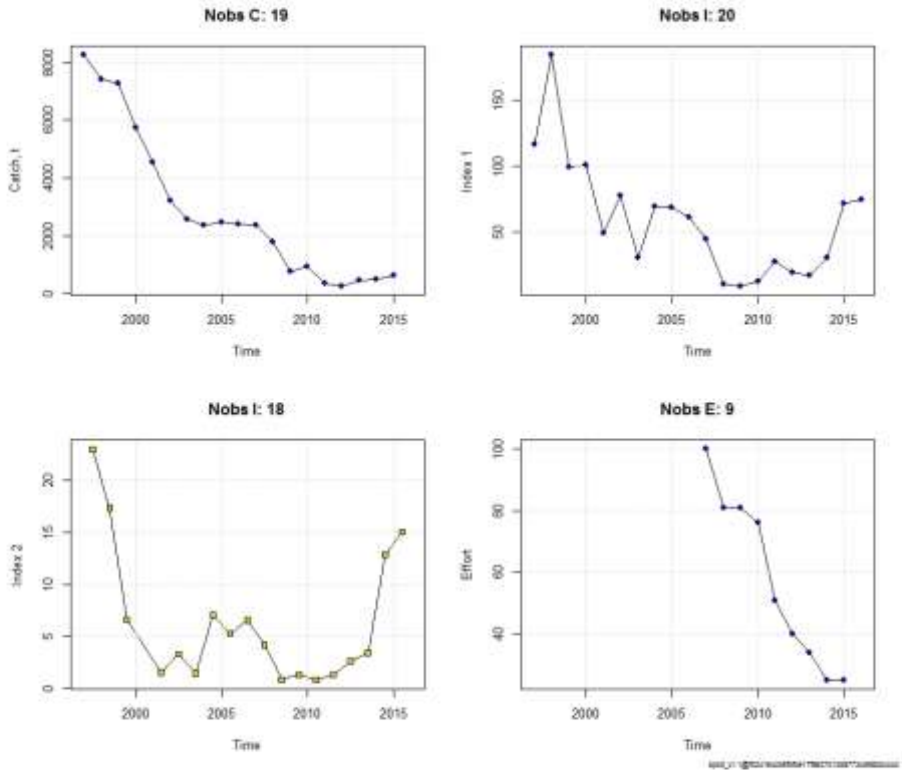


Fig. 3. Input data used in SPICT (shown for Run 3#).

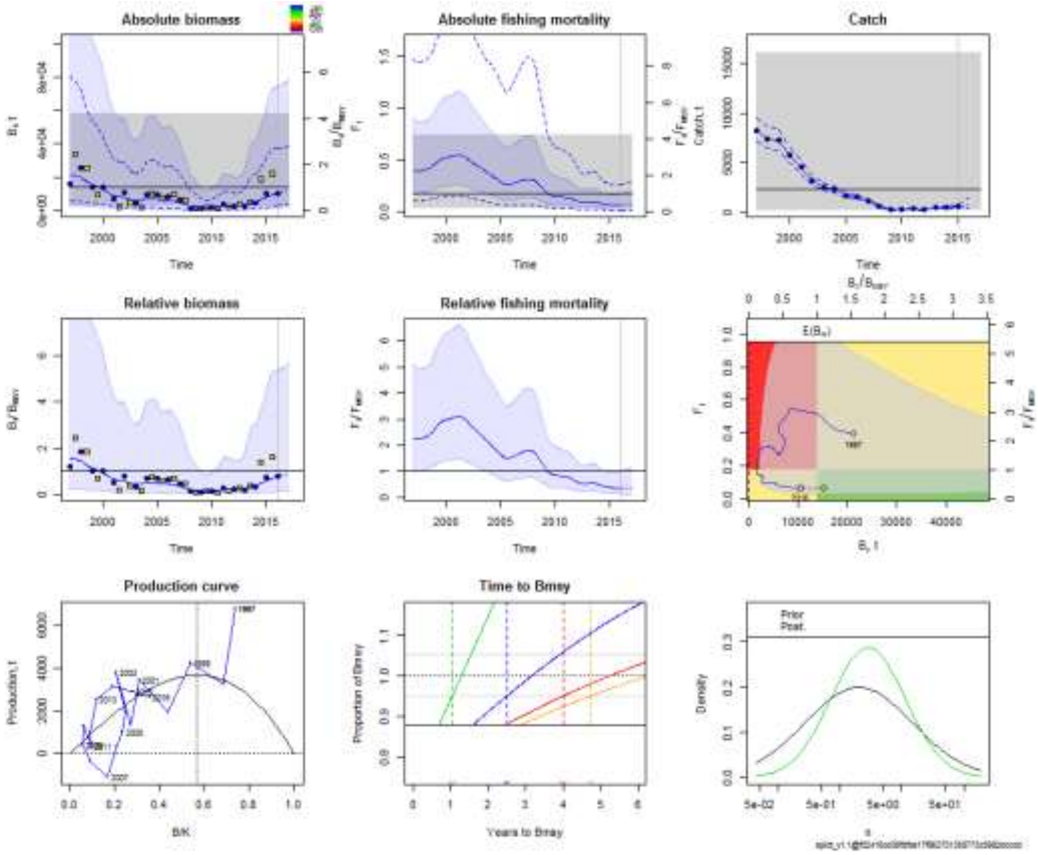


Fig. 4a. Output from SPICT using reported catch (Run 1#).

2.2.7 Quality of the assessment

Indices from for different surveys that provide information on cod in the Kattegat were used in the assessment. All available survey indices are relatively noisy, however contain information that is to a certain extent consistent between years in single surveys and agrees on the same level with the estimates from other surveys. In 2003—2016, the survey data indicates significantly higher total removals from the stock than can be explained by the reported catch data.

WKBALT 2017 concluded that the unallocated removals can largely be explained by mixing with North Sea cod and potentially increased natural mortality. Also, uncertainties in catch numbers at least for some years in the time series likely contribute to this mis-match.

Therefore, current level of fishing mortality cannot be reliably estimated and are in the range of 0,62-0,056 in the SPALY runs. The highest estimate of the amount of unallocated removals was found in the year 2014 (Fig 2.2.12).

The exact estimates of SSB are considered uncertain, however all available information consistently indicates that SSB is has increased from low levels and in 2016 are in the vicinity of 5271 to 6140 t.

2.2.8 Comparison with previous assessment

The input data were updated from the time series used in last year's assessment, besides the changes made to input data at WKBALT 2017 (revised discard time series and excluding BITS Q4 survey). The assessment was performed using state-space assessment model (SAM) as in last year. The results from this year's assessment can be found in table 2.2.11 and 2.2.12.

2.2.9 Management considerations

It should be taken into consideration that:

The year class of 2015 is the lowest observed in the time series. The recruitment in the last 3 years has been very low.

Table 2.2.1 Cod in the Kattegat. Landings (in tonnes) 1971-2015.

YEAR	KATTEGAT			TOTAL	
	Denmark	Sweden	Germany1		
1971	11748	3962	22	15732	
1972	13451	3957	34	17442	
1973	14913	3850	74	18837	
1974	17043	4717	120	21880	
1975	11749	3642	94	15485	
1976	12986	3242	47	16275	
1977	16668	3400	51	20119	
1978	10293	2893	204	13390	
1979	11045	3763	22	14830	
1980	9265	4206	38	13509	
1981	10693	4380	284	15337	
1982	9320	3087	58	12465	
1983	9149	3625	54	12828	
1984	7590	4091	205	11886	
1985	9052	3640	14	12706	
1986	6930	2054	112	9096	
1987	9396	2006	89	11491	
1988	4054	1359	114	5527	
1989	7056	1483	51	8590	
1990	4715	1186	35	5936	
1991	4664	2006	104	6834	
1992	3406	2771	94	6271	
1993	4464	2549	157	7170	
1994	3968	2836	98	7802	2
1995	3789	2704	71	8164	3
1996	4028	2334	64	6126	4
1997	6099	3303	58	9460	5
1998	4207	2509	38	6835	
1999	4029	2540	39	6608	
2000	3285	1568	45	4897	
2001	2752	1191	16	3960	
2002	1726	744	3	2470	
2003	1441	603 7	1	2045	
2004	827	575	1	1403	
2005	608	336	10	1070	6
2006	540	315	21	876	
2007	390	247	7	645	
2008	296	152	1	449	
2009	134	62	0.3	197	
2010	117	38	0.3	155	
2011	102	42	1.4	145	
2012	63	31	0.0	94	
2013	60	32	0.0	92	
2014	75	32	0.0	108	
2015	68	38	0.0	106	
2016	185	114	0.0	299	

1 Landings statistics incompletely split on the Kattegat and Skagerrak

2 Including 900 t reported in Skagerrak.

3 Including 1.600 t misreported by area.

4 Excluding 300 t taken in Sub-divisions 22–24.

5 Including 1.700t reported in Sub-division 23.

6 Including 116 t reported as pollack7 the catch reported to the EU exceeds the catch reported to the WG (shown in the table) by 40%

Table 2.2.2 Cod in Kattegat. Estimates of discard in numbers (in thousands) by ages and total weight in tonnes. The estimation of total discards is not entirely consistent between the years.

DENMARK						
Year	a1	a2	a3	a4	a5	a6
1997						
1998						
1999						
2000	880	1634	22	3	0	0
2001	1365	386	3	0	0	0
2002	2509	1226	290	0	0	0
2003	114	876	40	0	0	0
2004	2562	352	58	0	0	0
2005	616	1285	0	0	0	0
2006	614	752	203	0	0	0
2007	135	1098	259	20	0	0
2008	20	99	57	4	1	0
2009	210	41	2	0	0	0
2010	367	224	14	0	0	0
2011	559	354	22	0	0	0
2012	707	161	10	0	0	0
2013	517	322	8	3	0	0
2014	431	621	22	4	2	0
2015	120	86	82	19	7	0
2016	9	40	17	33	13	4
SWEDEN						
Year	a1	a2	a3	a4	a5	a6
1997	567	678	212	13	0	0.0
1998	684	641	157	8	0	0.0
1999	579	663	177	10	0	0.0
2000	922	876	153	19	2	0.0
2001	745	720	142	17	2	0.0
2002	667	419	93	12	1	0.0
2003	514	715	49	3	1	0.2
2004	982	583	533	2	2	0.3
2005	237	464	6	5	0	0.0
2006	784	448	182	7	3	0.3
2007	534	278	32	12	0	0.1
2008	148	48	10	0.1	0	0.0
2009	179	14	0.1	0.1	0	0.0
2010	63	58	0	0	0	0
2011	71	51	9	0	0	0
2012	180	54	5	0	0	0
2013	550	190	21	1	2	0
2014	79	174	20	1	2	0
2015	119	57	58	24	4	4

2016	7	43	11	5	3	1	
DK and SWE discard numbers combined							Total discard in
Year	a1	a2	a3	a4	a5	a6	tons
1997	1398	2102	478	26	0.4	0.1	881
1998	1369	1454	284	23	0.3	0.0	664
1999	1158	1964	314	18	0.5	0.0	764
2000	1802	2510	175	22	1.9	0.0	992
2001	2110	1105	146	17	1.7	0.0	823
2002	3176	1645	383	12	1.3	0.0	577
2003	628	1591	89	3	0.9	0.2	750
2004	3544	934	591	2	2.1	0.3	1063
2005	853	1749	6	5	0.0	0.0	575
2006	1398	1200	386	7	2.6	0.3	849
2007	668	1377	291	32	0.5	0.1	577
2008	168	147	67	4	1	0	165
2009	389	55	2	0	0	0	77
2010	430	282	14	0	0	0	167
2011	631	405	31	0	0	0	216
2012	887	215	15	0	0	0	142
2013	1067	512	29	4	2	0	351
2014	510	795	42	5	4	0	339
2015	239	143	140	43	11	4	401
2016	16	83	28	38	16	5	222

Table 2.2.3 Cod in the Kattegat. Numbers of discard samples by years and countries.

Country /Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Denmark				52	68	43	30	47	33	22	10
Sweden	45	50	55	63	40	63	38	26	48	66	72
Total	45	50	55	115	108	106	68	73	81	88	82

Country /Year	2008	2009	2010	2011	2012	2013	2014	2015	2016
Denmark	24	38	34	43	48	58	55	46	37
Sweden	50	49	58	48	41	44	39	40	40
Total	74	87	92	91	89	102	94	86	77

Table 2.2.4 a Cod in the Kattegat. Sampling level of Danish landings, 2016.

	N. of size distributions	N. of cod	N. of cod	N. of cod
Quarter	sampled	aged	weighed	measured
1	6	79	79	79
2	8	78	78	78
3	5	57	57	57
4	4	90	90	90
Total	23	304	304	304

Table 2.2.4 b Cod in the Kattegat. Sampling level of Swedish landings, 2016.

	N. OF SIZE DISTRIBUTIONS	N. OF COD	N. OF COD	N. OF COD
Quarter	sampled	aged	weighed	measured
1	20	411	411	411
2	17	270	270	270
3	15	257	257	257
4	17	365	365	365
Total	69	1303	1303	1303

Table 2.2.5. Cod in the Kattegat. Landings numbers and mean weight at age by quarter and country for 2016

Sub-div 21

Year	2016 Quarter	1				
Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1						
2	0.81009	1203	0.5801	728.4	1.39	1004.96
3	2.649421	1323.106	2.4135	1264.3	5.06	1295.07
4	7.707155	2906.639	5.172	1827.2	12.88	2473.16
5	0.356902	5219.535	5.7785	2443.5	6.14	2604.98
6	0.475267	3242.097	1.2082	3629.1	1.68	3519.84
7	0.24	3689.00	0.4054	4676.8	0.64	4310.37
8			0.0767	5809.5	0.08	5809.50
9			0.01	4240.00	0.01	4240.00
10						
SOP (t)	28.74			33.32	64.49	
Landings (t)	28.56			30.97	59.53	

Sub-div 21

Year	2016 Quarter	3				
Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1						
2			1.0057	751.6	1.01	751.60
3	1.61124	2296.54	0.6787	1884.9	2.29	2174.54
4	3.604535	2663.924	2.9321	2571	6.54	2622.24
5	1.131036	2591.68	3.7788	2669.8	4.91	2651.80
6	0.199067	3551	1.1683	3463.7	1.37	3476.41
7			0.2854	5070	0.29	5070.00
8			0.0168	8143.2	0.02	8143.20
9						
10						
SOP (t)	16.23			25.16	42.10	
Landings (t)	16.70			24.40	41.10	

Sub-div 21

Year	2016 Quarter	2				
Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1						
2			0.1573	894.6	0.16	894.60
3	1.173824	1480.938	0.8192	1327.8	1.99	1417.99
4	6.974087	2707.137	2.9314	2084.4	9.91	2522.85
5	1.368926	4542.518	3.3119	2858	4.68	3350.64
6	0.76845	3719.788	1.1059	3919.5	1.87	3837.62
7			0.6456	5303	0.65	5303.00
8			0.2327	5402.7	0.23	5402.70
9			0.02	5194.80	0.02	5194.80
10			0.01	4949.10	0.01	4949.10
SOP (t)	26.84			24.56	54.26	
Landings (t)	29.00			25.00	54.00	

Sub-div 21

Year	2016 Quarter	4				
Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1						
2	7.53869	1432.868	1.8313	1227.5	9.37	1392.73
3	26.72072	2978.35	3.3885	1561.8	30.11	2818.93
4	2.890909	3737.352	3.2628	2171.2	6.15	2906.95
5	0.815697	5750	4.8435	2929.2	5.66	3335.78
6			1.8693	3654.2	1.87	3654.20
7			0.244	5634.7	0.24	5634.70
8			0.1693	3506.1	0.17	3506.10
9			0.01	19024.20	0.01	19024.20
10						
SOP (t)	105.88			37.02	142.90	
Landings (t)	108.40			35.00	143.40	

Sub-div 21

Year	2016 Quarter	all				
Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1						
2	8.34878	1432.868	3.5744	1227.5	11.92	1371.30
3	32.15521	2978.35	7.2999	1884.9	39.46	2776.04
4	21.17669	3737.352	14.2983	2571	35.47	3267.25
5	3.672561	5750	17.7127	2929.2	21.39	3413.63
6	1.442784	3719.788	5.3517	3919.5	6.79	3877.09
7	0.24	3689.00	1.5804	5634.7	1.82	5379.04
8			0.4955	8143.2	0.50	8143.20
9			0.03	5194.80	0.03	5194.80
10			0.02	19024.20	0.02	19024.20
SOP (t)	207.99			136.67	355.40	
Landings (t)	185.00			113.00	298.00	

Table 2.2.6 Cod in the Kattegat. Catches (Landings +Discards) in numbers (in thousands) by year and age. In the assessment the plus-group is defined as 6+.

	Age					
Year	1	2	3	4	5	6
1997	1456	2540	5137	891	222	88
1998	1499	3587	1595	1908	283	76
1999	1201	3859	3972	455	409	77
2000	1819	3942	2346	1027	125	103
2001	2166	2012	2034	703	187	45
2002	3190	2161	1062	391	85	40
2003	628	2441	650	184	65	16
2004	3547	1077	1195	206	65	39
2005	854	2169	121	167	21	12
2006	1406	1305	796	36	33	9
2007	668	1446	383	190	16	26
2008	175	191	136	40	33	7
2009	400	92	30	22	9	4
2010	433	361	33	8	4	2
2011	631	445	84	6	2	1
2012	889	231	30	13	2	0
2013	1068	533	49	12	3	1
2014	510	804	66	20	6	0
2015	239	144	167	56	15	6
2016	16	95	68	75	38	13

Table 2.2.7 Cod in the Kattegat. Weight at age (kg) in the landings by year and age.In the assessment the plus-group is defined as 6+.

	Age							
Year	1	2	3	4	5	6	7	8+
1971	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1972	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1973	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1974	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1975	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1976	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1977	0.699	0.880	1.069	1.673	2.518	3.553	5.340	6.635
1978	0.699	0.880	1.170	1.690	2.860	4.120	5.180	6.900
1979	0.708	0.868	1.086	1.890	2.215	3.382	7.314	6.101
1980	0.691	0.893	0.951	1.440	2.478	3.157	3.526	6.903
1981	0.604	0.799	1.123	1.432	2.076	3.532	4.420	4.644
1982	0.600	0.784	1.233	1.391	2.078	2.911	3.698	6.480
1983	0.595	0.752	1.129	1.943	3.348	3.141	5.301	6.325
1984	0.711	0.745	1.133	1.687	2.798	3.022	5.273	7.442
1985	0.606	0.839	0.986	1.614	2.575	4.090	6.847	7.133
1986	0.671	0.705	1.253	1.955	2.956	4.038	7.100	7.290
1987	0.483	0.716	1.118	1.972	2.868	4.200	5.185	8.288
1988	0.541	0.784	1.099	1.792	2.880	4.283	5.852	7.073
1989	0.621	0.921	1.269	2.296	3.856	5.733	5.166	6.527
1990	0.618	0.973	1.584	2.323	3.288	5.383	6.412	10.337
1991	0.578	0.861	1.533	2.986	4.548	4.179	9.127	12.055
1992	0.610	0.707	1.291	2.662	4.048	5.888	7.067	7.895
1993	0.567	0.862	1.583	2.321	4.970	7.566	9.391	8.705
1994	0.549	0.783	1.276	2.652	3.526	7.279	9.793	10.130
1995	0.598	0.799	1.121	1.947	2.404	3.537	9.973	10.708
1996	0.469	0.669	1.088	1.771	2.638	3.773	4.677	7.871
1997	0.450	0.621	0.959	1.950	2.806	3.877	5.756	7.213
1998	0.623	0.697	0.853	1.680	2.497	4.317	6.669	8.948
1999	0.496	0.624	0.911	1.616	2.588	4.665	5.376	8.040
2000	0.487	0.611	0.868	1.332	2.779	3.944	5.069	9.020
2001	0.466	0.646	0.901	1.585	2.597	4.693	7.117	7.691
2002	0.546	0.711	1.120	2.052	3.539	4.814	6.915	7.833
2003	0.550	0.700	1.370	2.460	3.750	5.920	7.840	10.890
2004	0.570	0.700	1.010	1.630	2.700	3.920	6.180	9.420
2005	0.428	0.854	1.623	2.343	3.584	5.442	6.439	8.307
2006	0.480	0.880	1.519	3.130	3.995	4.222	5.264	6.713
2007	0.48	0.802	1.482	2.275	3.344	3.829	1.802	7.897
2008	0.574	1.075	1.837	3.210	4.097	4.437	5.552	5.827
2009	0.717	0.976	1.493	2.651	4.069	4.693	4.870	5.792
2010	0.412	0.879	1.910	3.081	4.038	3.592	4.252	6.404
2011	0.444	0.915	1.498	2.695	3.372	4.997	4.059	7.569
2012	0.545	1.191	1.769	3.174	4.004	5.224	4.305	6.921
2013	0.488	0.888	1.702	2.545	3.726	3.310	5.100	NA
2014	0.434	1.007	1.907	2.523	3.938	5.431	NA	NA
2015	0.434	1.343	1.879	2.597	3.726	3.777	NA	NA
2016	0.434	1.267	2.472	2.534	2.793	3.665	NA	NA

Table 2.2.8 Cod in the Kattegat. Weight at age (kg) in the stock by year and age. In the assessment the plus-group is defined as 6+.

	Age							
Year	1	2	3	4	5	6	7	8+
1971	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1972	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1973	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1974	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1975	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1976	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1977	0.059	0.355	0.919	1.673	2.518	3.553	5.34	6.635
1978	0.059	0.355	1.006	1.69	2.86	4.12	5.18	6.9
1979	0.059	0.35	0.934	1.89	2.215	3.382	7.314	6.101
1980	0.058	0.361	0.817	1.44	2.478	3.157	3.526	6.903
1981	0.051	0.323	0.965	1.432	2.076	3.532	4.42	4.644
1982	0.05	0.317	1.06	1.391	2.078	2.911	3.698	6.48
1983	0.05	0.304	0.971	1.943	3.348	3.141	5.301	6.325
1984	0.06	0.301	0.974	1.687	2.798	3.022	5.273	7.442
1985	0.051	0.339	0.848	1.614	2.575	4.09	6.847	7.133
1986	0.056	0.285	1.077	1.955	2.956	4.038	7.1	7.29
1987	0.041	0.289	0.961	1.972	2.868	4.2	5.185	8.288
1988	0.045	0.317	0.945	1.792	2.88	4.283	5.852	7.073
1989	0.052	0.372	1.091	2.296	3.856	5.733	5.166	6.527
1990	0.052	0.393	1.362	2.323	3.288	5.383	6.412	10.337
1991	0.06	0.415	1.799	2.986	4.548	4.179	9.127	12.055
1992	0.052	0.34	1.191	2.662	4.048	5.888	7.067	7.895
1993	0.056	0.353	1.086	2.321	4.97	7.566	9.391	8.705
1994	0.035	0.269	1.225	2.652	3.526	7.279	9.793	10.13
1995	0.032	0.148	1.31	1.947	2.404	3.537	9.973	10.708
1996	0.027	0.22	0.496	1.771	2.638	3.773	4.677	7.871
1997	0.034	0.179	0.743	1.95	2.806	3.877	5.756	7.213
1998	0.049	0.213	0.442	1.68	2.497	4.317	6.669	8.948
1999	0.046	0.207	0.625	1.616	2.588	4.665	5.376	8.04
2000	0.046	0.176	0.624	1.332	2.779	3.944	5.069	9.02
2001	0.065	0.269	0.72	1.585	2.597	4.693	7.117	7.691
2002	0.045	0.29	1.334	2.052	3.539	4.814	6.915	7.833
2003	0.066	0.224	1.054	2.46	3.75	5.923	7.835	10.891
2004	0.052	0.407	1.007	1.63	2.7	3.916	6.181	9.423
2005	0.058	0.349	1.187	2.343	3.584	5.442	6.439	8.307
2006	0.064	0.280	1.083	3.130	3.995	4.222	5.264	6.713
2007	0.058	0.289	1.060	2.275	3.344	3.829	1.802	7.897
2008	0.045	0.335	1.010	3.210	4.097	4.437	5.552	5.827
2009	0.053	0.300	1.069	2.651	4.069	4.693	4.870	5.792
2010	0.052	0.285	1.171	3.081	4.038	3.592	4.252	6.404
2011	0.051	0.269	0.905	2.695	3.372	4.997	4.059	7.569
2012	0.044	0.251	0.923	3.174	4.004	5.224	4.305	6.921
2013	0.041	0.255	1.043	2.545	3.726	3.310	5.1	NA
2014	0.049	0.285	1.050	2.541	3.869	5.431	NA	NA
2015	0.055	0.311	1.036	2.023	3.385	2.873	NA	NA
2016	0.045	0.338	1.041	2.448	2.72	3.665	NA	NA

Table 2.2.9 Cod in the Kattegat. Proportion mature at age (combined sex). In the assessment the plus-group is defined as 6+

	Age							
Year	1	2	3	4	5	6	7	8+
1971	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1972	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1973	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1974	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1975	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1976	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1977	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1978	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1979	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1980	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1981	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1982	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1983	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1984	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1985	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1986	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1987	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1988	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1989	0.02	0.37	0.78	0.97	1.00	1.00	1.00	1.00
1990	0.02	0.61	0.62	0.99	0.93	1.00	1.00	1.00
1991	0.02	0.62	0.64	0.88	1.00	1.00	1.00	1.00
1992	0.07	0.51	0.99	1.00	1.00	1.00	1.00	1.00
1993	0.03	0.49	0.73	0.95	0.87	1.00	1.00	1.00
1994	0.01	0.60	0.96	1.00	1.00	1.00	1.00	1.00
1995	0.00	0.12	0.97	1.00	1.00	1.00	1.00	1.00
1996	0.00	0.29	0.57	0.95	1.00	1.00	1.00	1.00
1997	0.00	0.19	0.90	1.00	1.00	1.00	1.00	1.00
1998	0.00	0.38	0.65	1.00	1.00	1.00	1.00	1.00
1999	0.02	0.58	0.87	1.00	1.00	1.00	1.00	1.00
2000	0.02	0.42	0.92	1.00	1.00	1.00	1.00	1.00
2001	0.02	0.44	0.91	1.00	1.00	1.00	1.00	1.00
2002	0.00	0.57	0.92	0.99	1.00	1.00	1.00	1.00
2003	0.00	0.54	1.00	1.00	1.00	1.00	1.00	1.00
2004	0.00	0.74	0.86	1.00	1.00	1.00	1.00	1.00
2005	0.01	0.53	0.83	0.92	1.00	1.00	1.00	1.00
2006	0.00	0.59	0.81	1.00	1.00	1.00	1.00	1.00
2007	0.00	0.60	0.89	0.93	1.00	1.00	1.00	1.00
2008	0.00	0.35	1.00	1.00	1.00	1.00	1.00	1.00
2009	0.00	0.54	0.90	0.95	1.00	1.00	1.00	1.00
2010	0.00	0.48	0.94	1.00	1.00	1.00	1.00	1.00
2011	0.00	0.60	0.90	1.00	1.00	1.00	1.00	1.00
2012	0.00	0.49	0.87	0.92	1.00	1.00	1.00	1.00
2013	0.00	0.37	0.46	0.91	1.00	1.00	1.00	1.00
2014	0.00	0.37	0.59	0.83	1.00	1.00	1.00	1.00
2015	0.00	0.51	0.57	0.83	1.00	1.00	1.00	1.00
2016	0.00	0.59	0.72	0.82	1.00	1.00	1.00	1.00

Table 2.2.10 Cod in the Kattegat. Tuning data (from trawl surveys) available for assessment.

Tuning Data; Cod in the Kattegat (part of Division IIIa)_30/03/11
104
Havfisken_SD21_Q1
1997 2017
1 1 0 0.25
1 3

1	104.5521	24.10579	16.37002
1	-9	-9	-9
1	464.8633	25.74058	8.849065
1	97.61678	44.32915	5.524313
1	25.78994	30.09901	11.12194
1	98.273	16.65293	3.154041
1	8.341221	47.24216	5.778205
1	175.0556	11.18347	5.333215
1	83.14981	86.67933	2.545501
1	122.1756	39.54309	10.57858
1	28.87485	46.52737	8.608119
1	13.09734	6.648041	1.012895
1	16.21239	0.908864	0
1	38.50059	21.42233	1.388748
1	46.24852	15.00446	14.26268
1	86.61548	10.8254	1.844459
1	212.3437	51.34188	10.25782
1	98.78039	781.8792	12.40911
1	37.3475	17.53	15.1715
1	2.06	8.22	3.59
1	115.11	3.41	3.63

IBTSQ1_1-6
1997 2017
1 1 0 0.25
1 6

1	174.47	54.179	108.874	6.336	1.379	1.052
1	199.37	470.649	47.071	24.617	2.672	1.321
1	237.68	167.799	62.984	2.257	3.114	0.583
1	74.85	233.688	47.39	14.025	1.313	1.16
1	47.05	46.059	24.373	5.276	1.692	0.748
1	93.05	20.843	15.715	14.689	3.273	1.066
1	2.34	52.554	3.58	2.626	1.713	0.375
1	91.02	14.122	32.847	6.007	2.051	2.649
1	19.99	86.948	5.061	10.697	1.2	0.388
1	67.31	21.883	27.47	2.661	2.247	0.987
1	41.61	41.937	7.399	7.523	0.766	0.828
1	8.392	2.409	2.224	0.858	0.583	0.417
1	25.383	0.925	0.442	2.042	0	0.333
1	14.636	22.46	0.242	0.333	0.529	0.542
1	43.727	24.426	17.362	0.6	0.177	0.125
1	46.955	9.528	2.019	4.056	0	0.083
1	31.394	14.16	3.62	0.88	1.41	0.27
1	3.45	30.82	9.95	3.21	0.47	0.21
1	18.334	10.184	27.36	9.498	4.189	2.151
1	0.522	14.551	4.311	18.679	5.759	3
1	23.69	0.8	0.93	1.92	6.2	15.4

continued

Table 2.2.10 Cod in the Kattegat. Tuning data (from trawl surveys) available for assessment.

IBTS_Q3						
1997 2016						
1 1 0.75 0.83						
1 4						
1	141.86	32.69	14.63	0.78		
1	141.92	38.42	1.57	0.92		
1	85.73	6.18	1.64	0.2		
1	-9	-9	-9	-9		
1	6.03	2.11	0.46	0.12		
1	46.53	1.51	0.26	0.19		
1	1.7	4.5	0.13	0.05		
1	67.12	2.28	2.43	0.08		
1	12.17	10.94	0.08	0.26		
1	25.69	4.2	2.94	0.17		
1	5.33	4.22	1.15	0.62		
1	1.94	0.47	0.07	0.15		
1	19.49	0.13	0	0.08		
1	2.5	1.28	0	0.08		
1	8.348	1.59	0.45	0		
1	8.29	1.25	0.05	0.583		
1	9.95	6.78	1.08	0.05		
1	3.646	9.836	7.433	0.812		
1	4.71	2.12	7.361	3.229		
1	0.376	0.654	1.63	2.17		
CODS_Q4						
2008	2016					
1	1	0.83	0.92			
1	6					
1	52.8	17.8	11.3	7.3	4.3	2.3
1	166.3	8.2	2.1	2	2.2	1
1	113.2	64.3	2.4	0.4	0.5	0.1
1	91.1	54	24.4	5.1	0.8	0.2
1	-9	-9	-9	-9	-9	-9
1	207.9	209.5	63.1	30.4	5.4	0.8
1	144.5	277.3	231.7	93.6	41.3	17.7
1	92.6	126.7	125.2	105.6	68.9	38.7
1	57.5	37.1	48.9	48.7	42.9	43.3

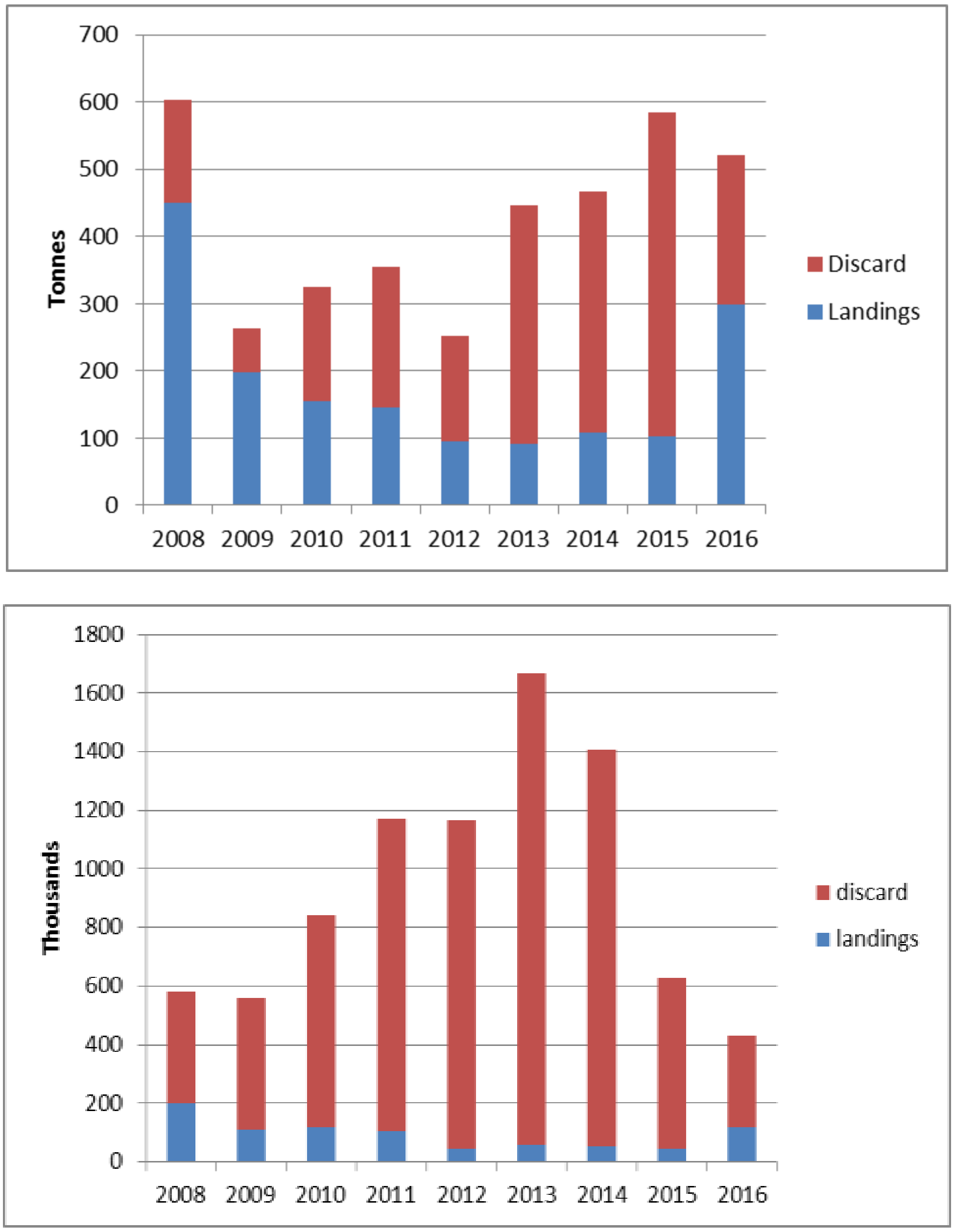


Figure. 2.2.1. Cod in the Kattegat. Estimates of discards (Denmark and Sweden combined) compared to reported landings, both in tons (upper panel) and in numbers (lower panel).

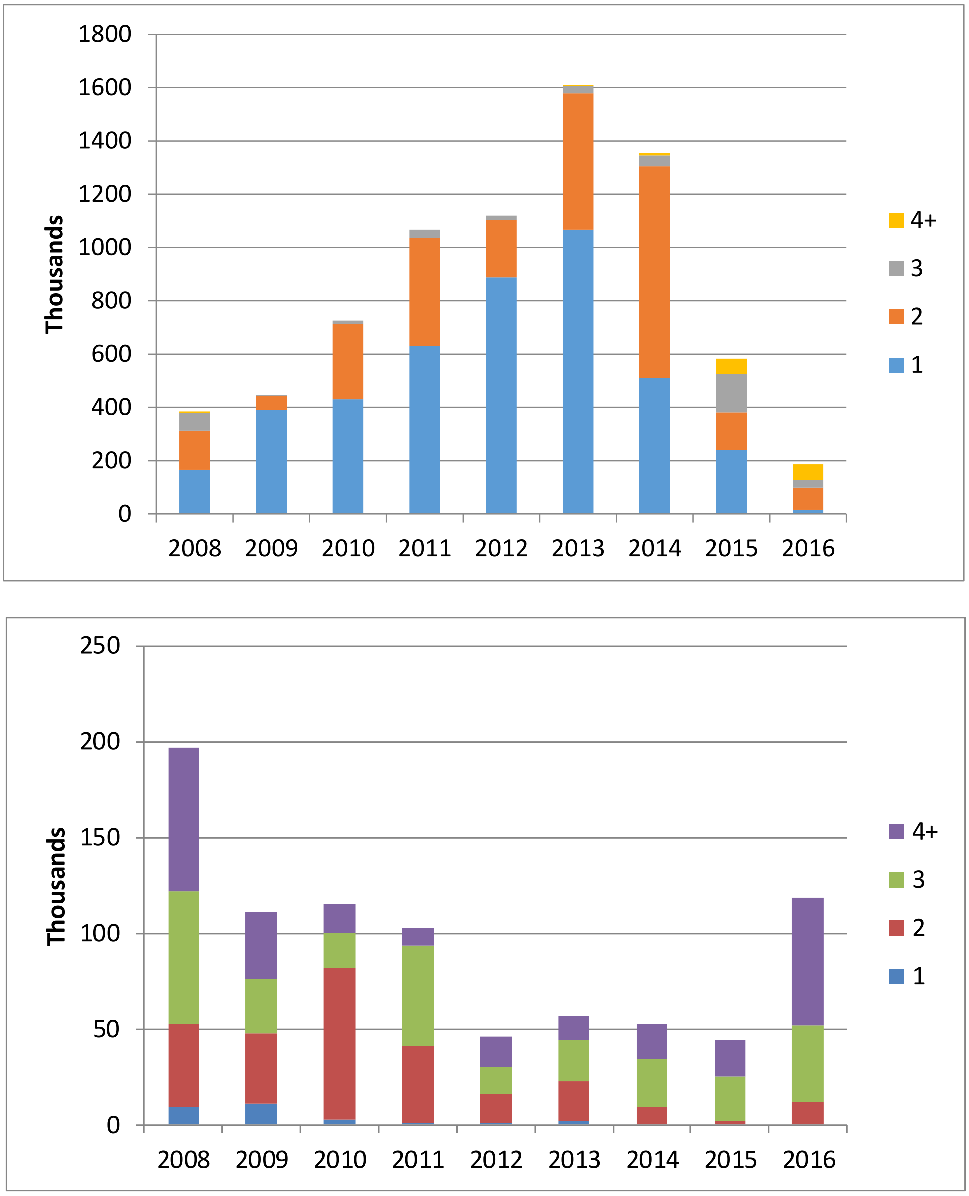
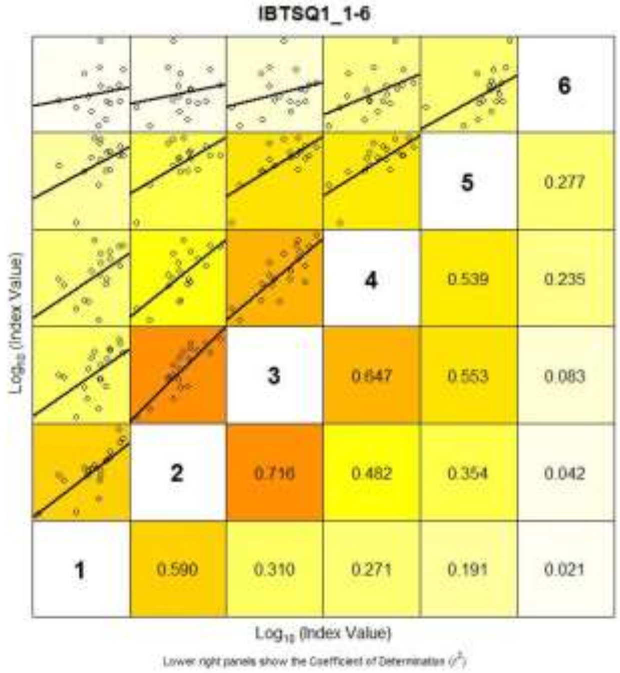
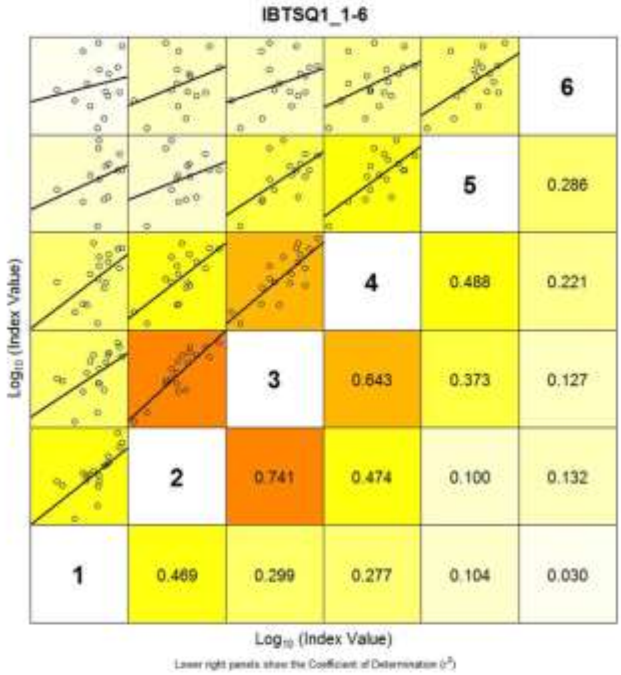


Figure. 2.2.2. Cod in the Kattegat. Estimates of discards age in numbers by upper panel. Landings in numbers by age, lower panel (Sweden and Denmark combined).

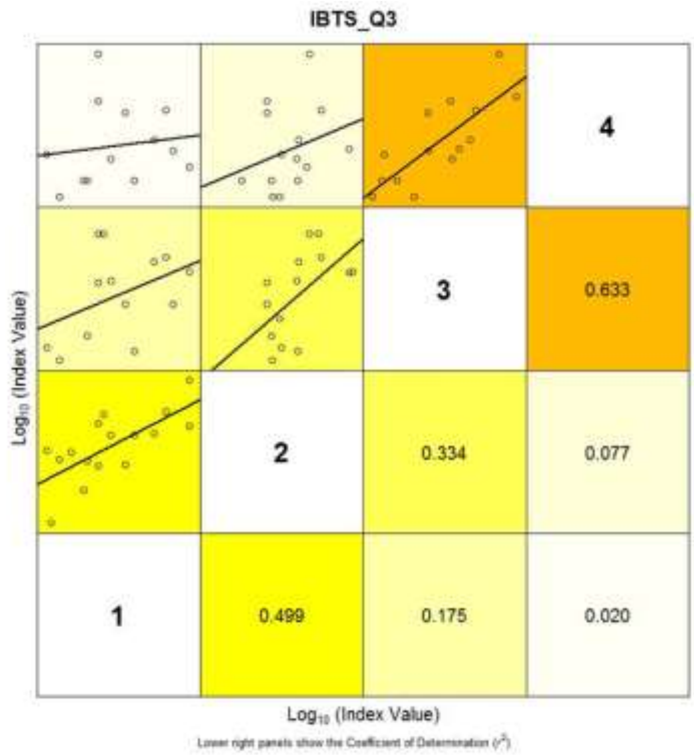


2016

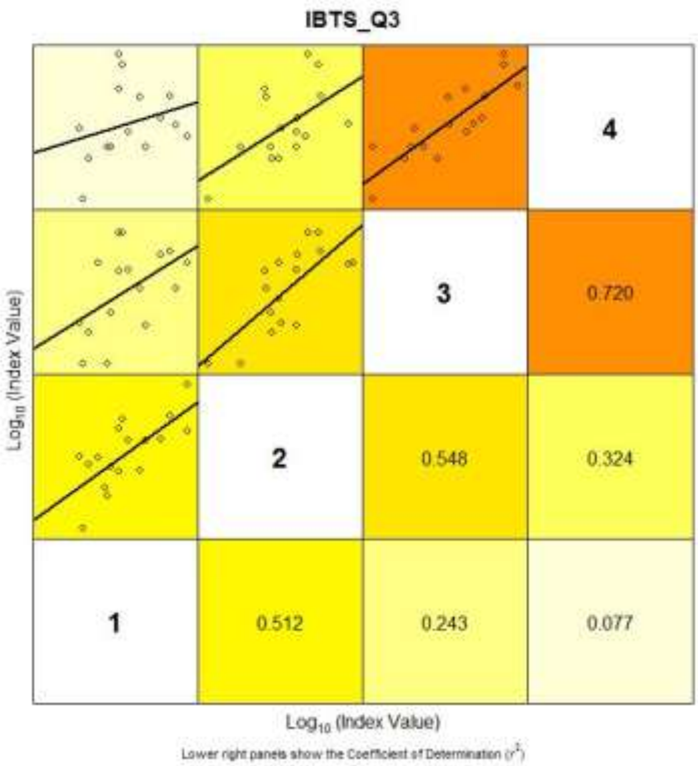


2015

Figure 2.2.3a.Cod in Kattegat. IBTS 1st quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2000-2016. Upper 2016 and lower 2015.

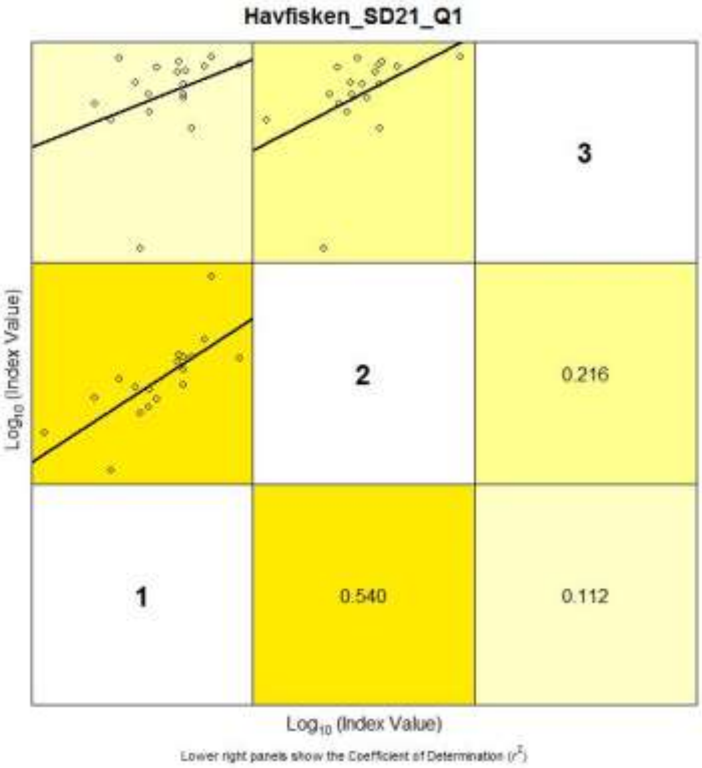


2015

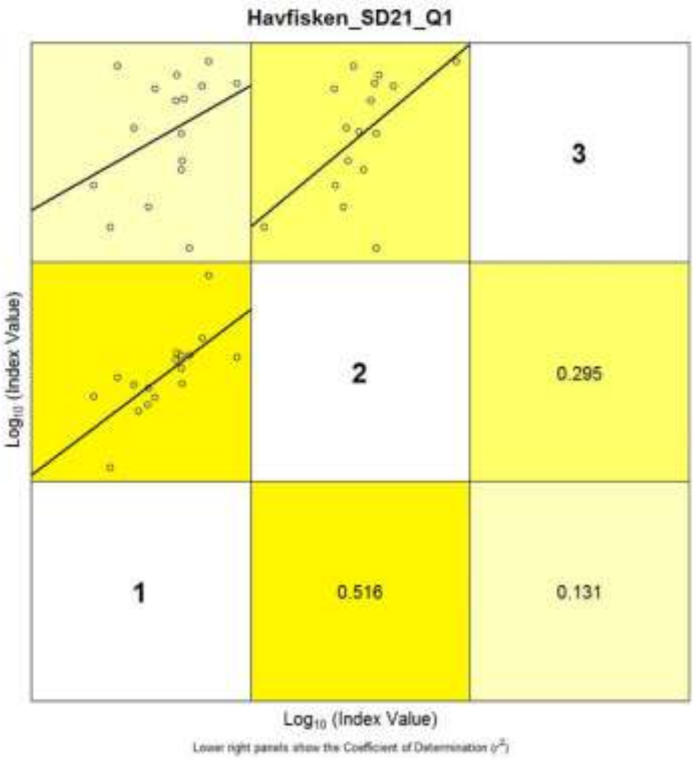


2016

Figure 2.2.3 b. Cod in Kattegat. IBTS 3rd quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2000-2015. Individual points are given by year-class. Upper plot 2015 and lower 2016.

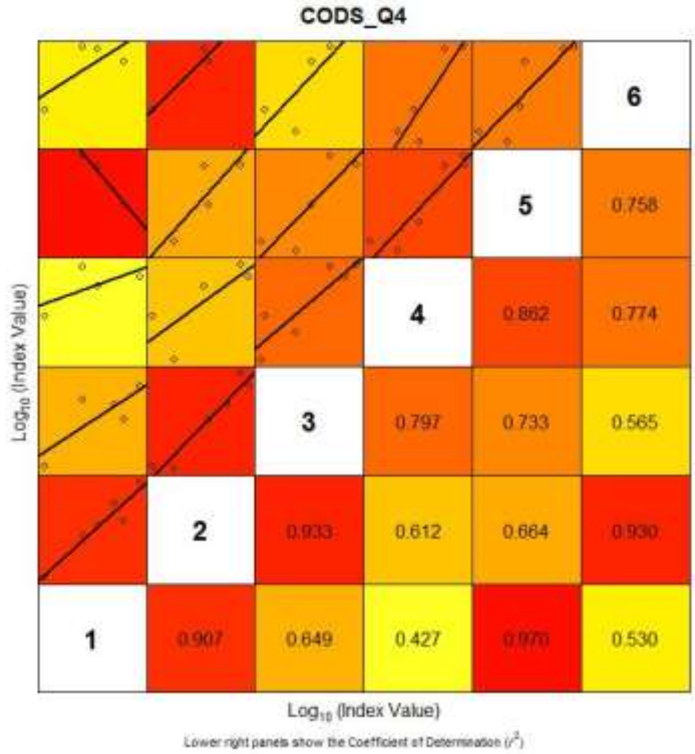


2016

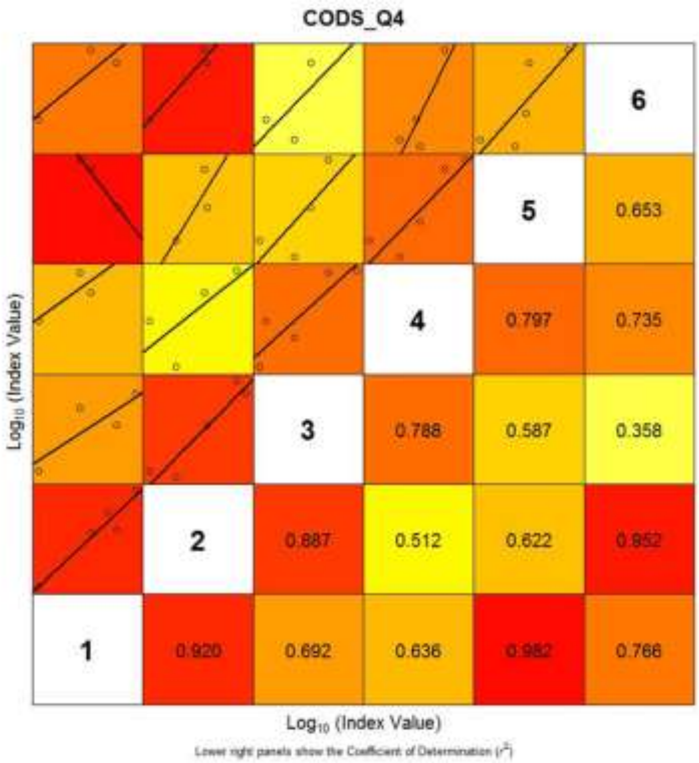


2015

Figure 2.2.3c. Cod in Kattegat. Havfisken 1st quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2000-2016.. Upper plot 2016, lower 2015.



2016



2015

Figure 2.2.3d .Cod in Kattegat. Cod survey quarter 4survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2008-2015. Individual points are given by year-class. Red dots highlight the information from the latest year. Upper plot 2016, lower plot 2015.

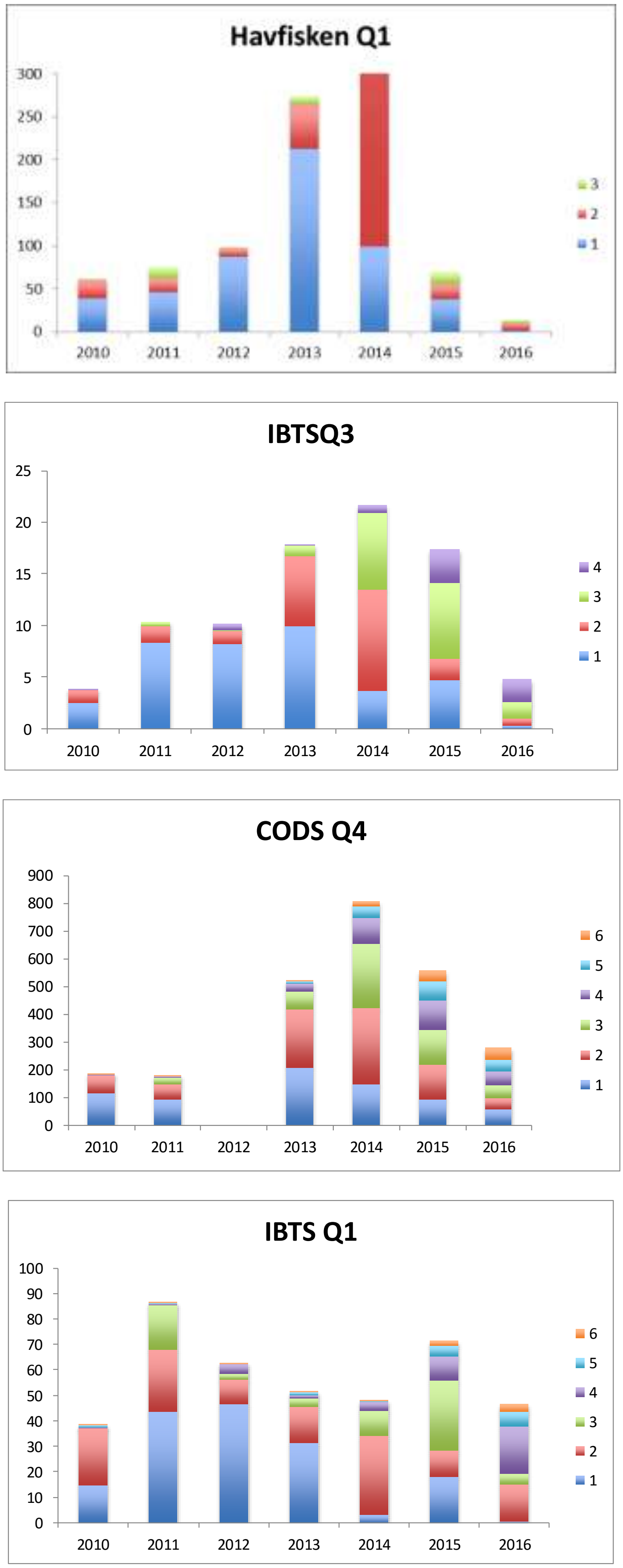


Figure.2.2.4. Cod in the Kattegat. Age structure of the four surveys used as stock indices in Kattegat 2010-2016.

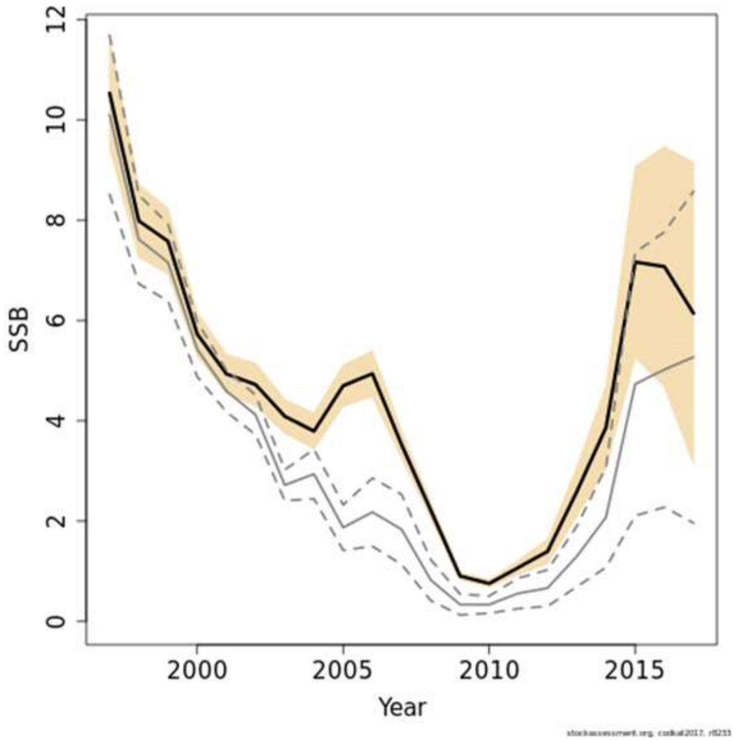


Fig 2.2.7 Cod in the Kattegat. SSB. SAM run without scaling (grey lines) and Sam run with scaling.(black line with brown 95 % confidence interval).

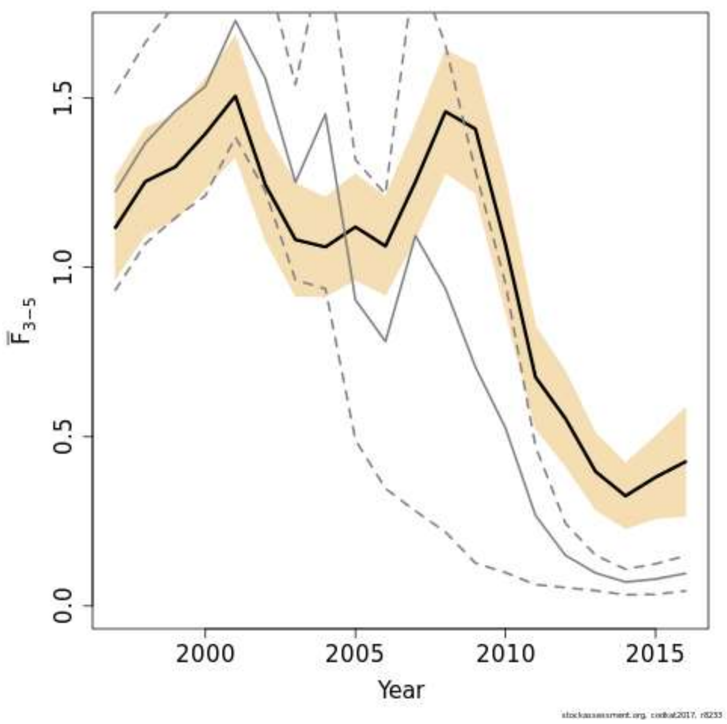


Fig 2.2.8 Cod in the Kattegat. Unallocated mortality (Z-0.2) SAM run without scaling (grey lines) and Sam run with scaling (black line with brown 95 % confidence interval).

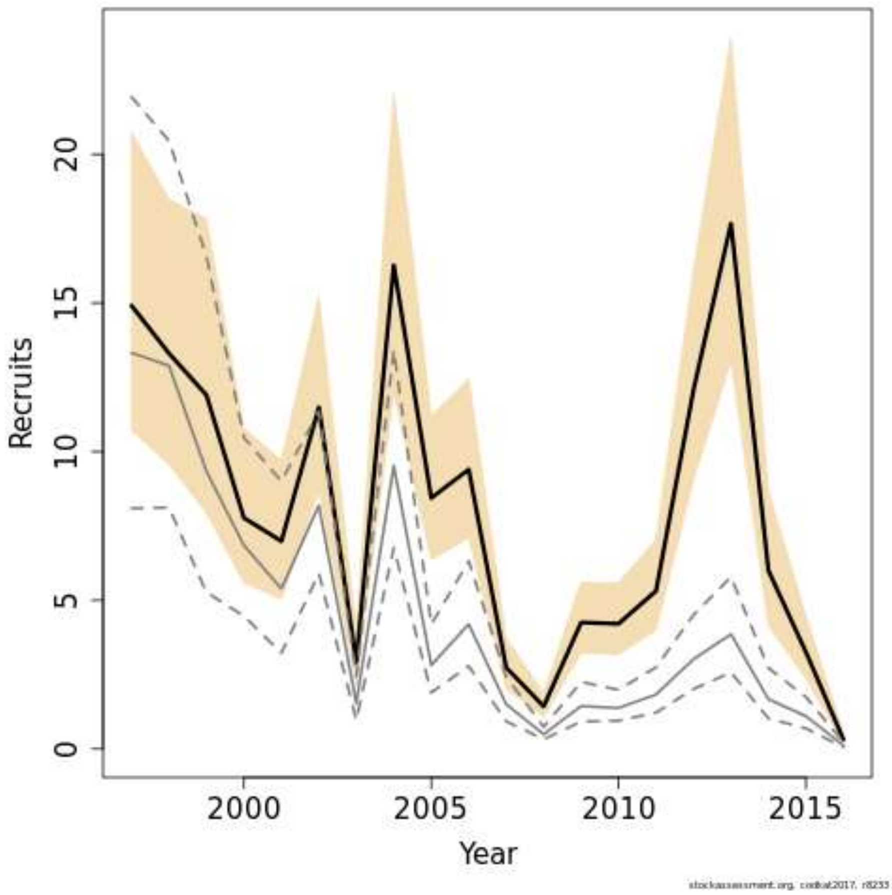


Fig 2.2.9 Cod in the Kattegat. Recruitment. SAM run without scaling (grey lines) and Sam run with scaling.(black line with brown 95 % confidence interval).

Year	Catch multiplier
2003	1,4
2004	1,1
2005	2,8
2006	2,7
2007	2,0
2008	3,5
2009	4,1
2010	3,4
2011	3,5
2012	5,8
2013	6,2
2014	6,8
2015	6,4
2016	6,0

Fig 2.10 Cod in the Kattegat. Catch multiplier. The scaling factor by year from the SAM run with scaling.

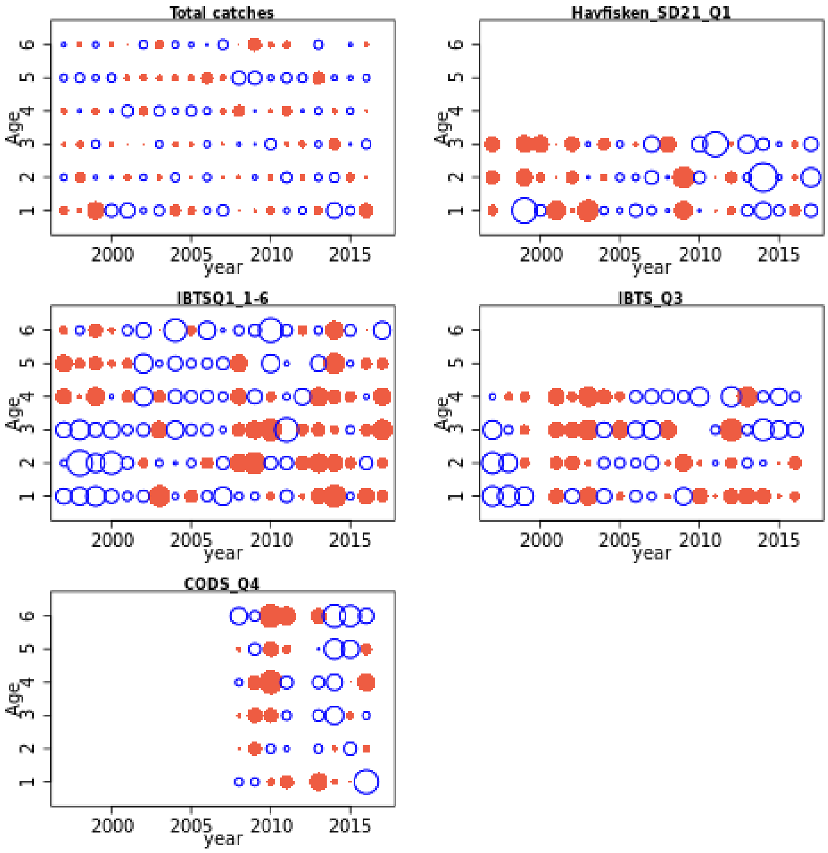
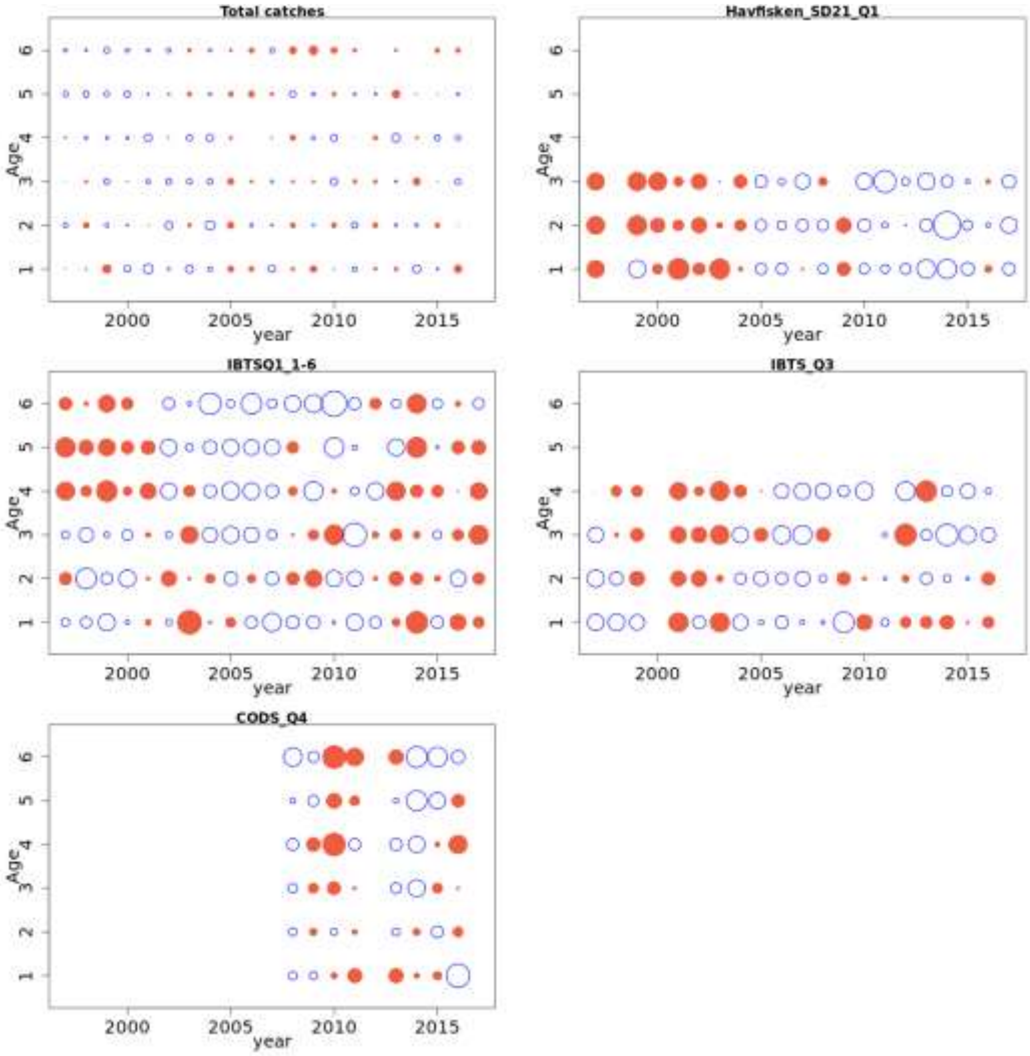


Fig 2.2.11a Cod in the Kattegat. Residuals. SPALY with scaling. The figures show normalized residuals for the current run. Blue circles indicate positive residuals (larger than predicted) and filled red circles indicate negative residuals (lower than predicted).



b)

Fig 2.2.11b Cod in the Kattegat. SPALY without scaling .The figures show normalized residuals for the current run. Blue circles indicate positive residuals (larger than predicted) and filled red circles indicate negative residuals (lower than predicted).

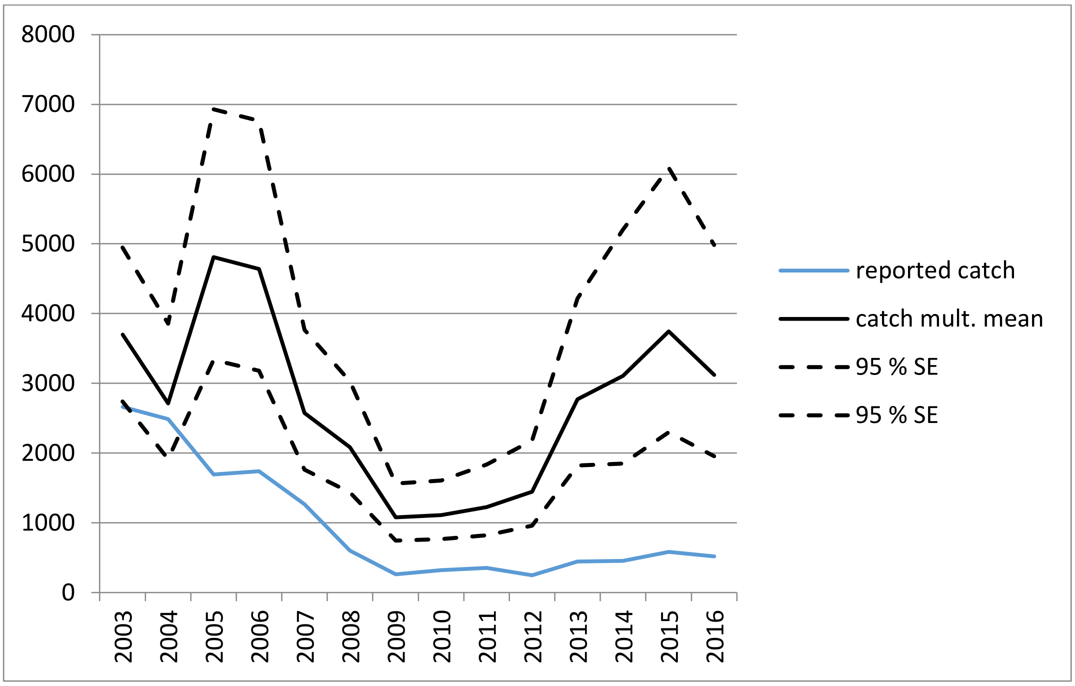
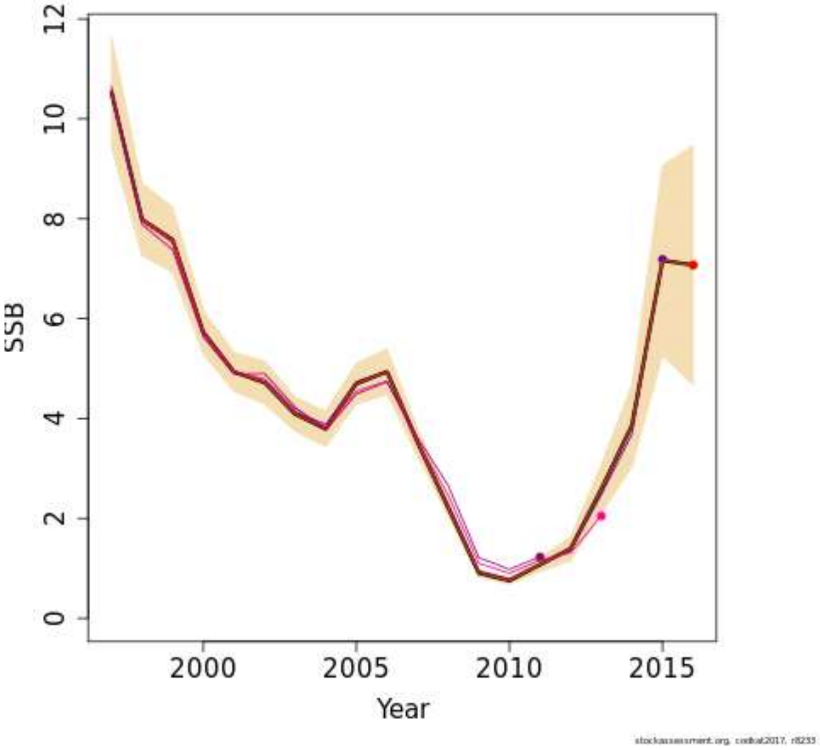
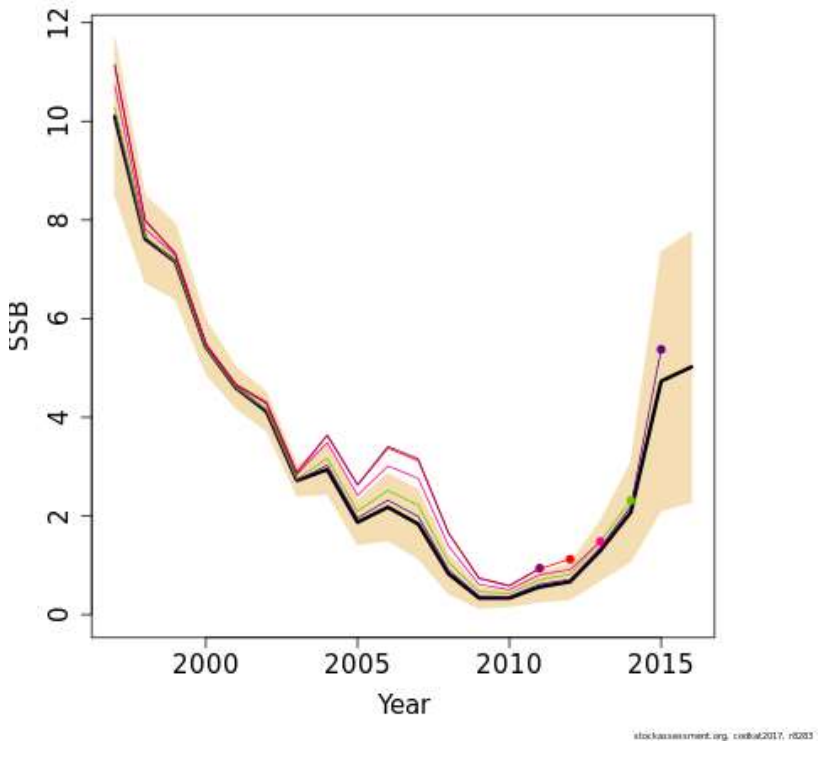


Fig 2.2.12 Cod in the Kattegat. Reported catch and the catch achieved by using the multiplier, mean and upper an lower 95 % estimates.

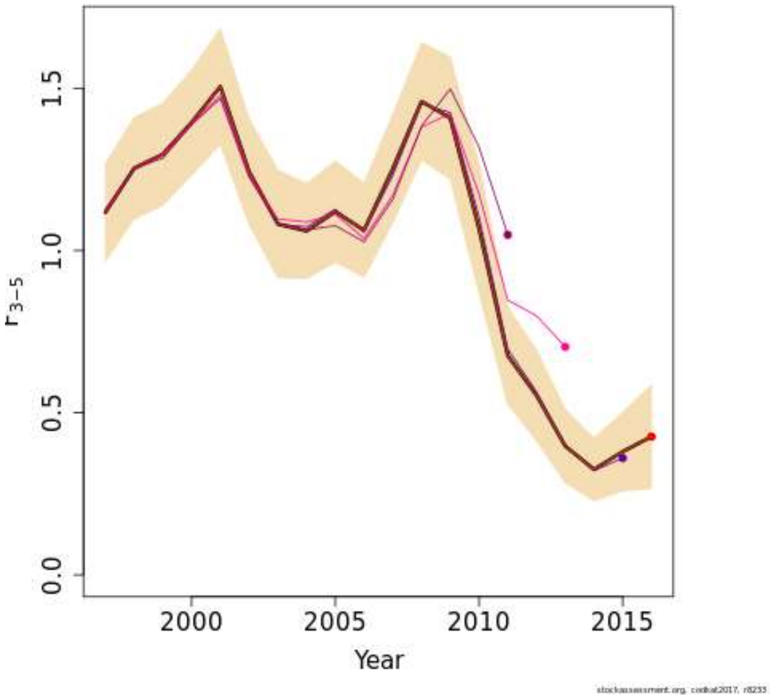


a)

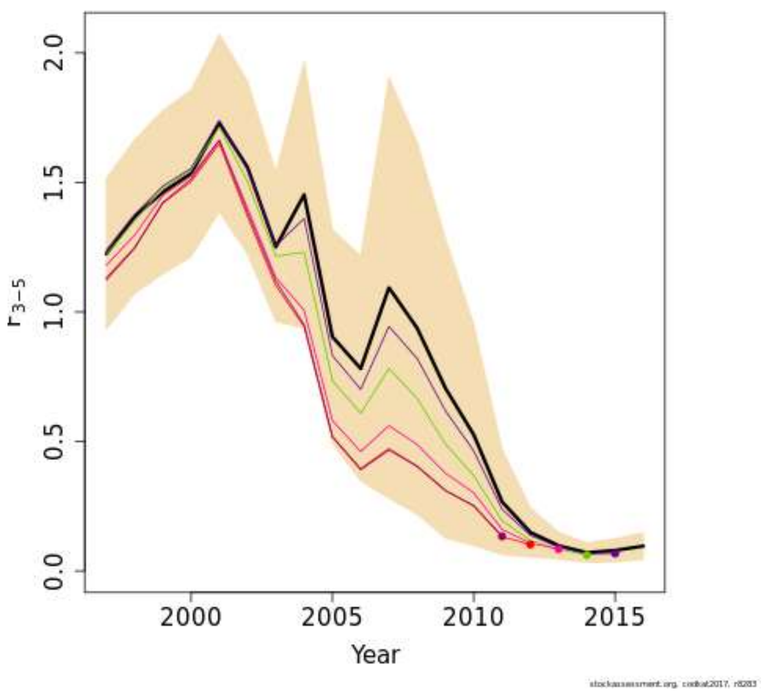


b)

Fig 2.2.13 Cod in the Kattegat. Retrospective SSB. a) SPALY with scaling b) SPALY without scaling

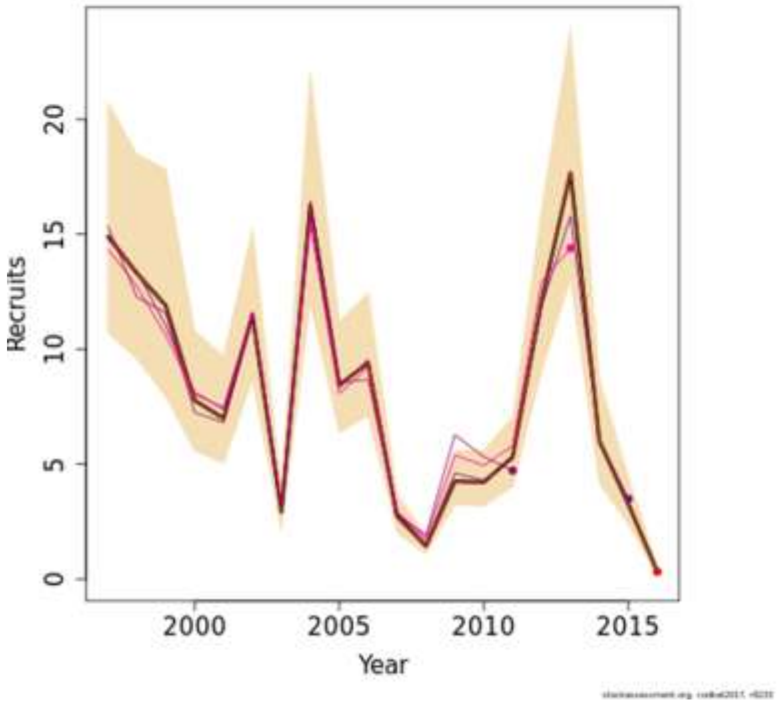


a)

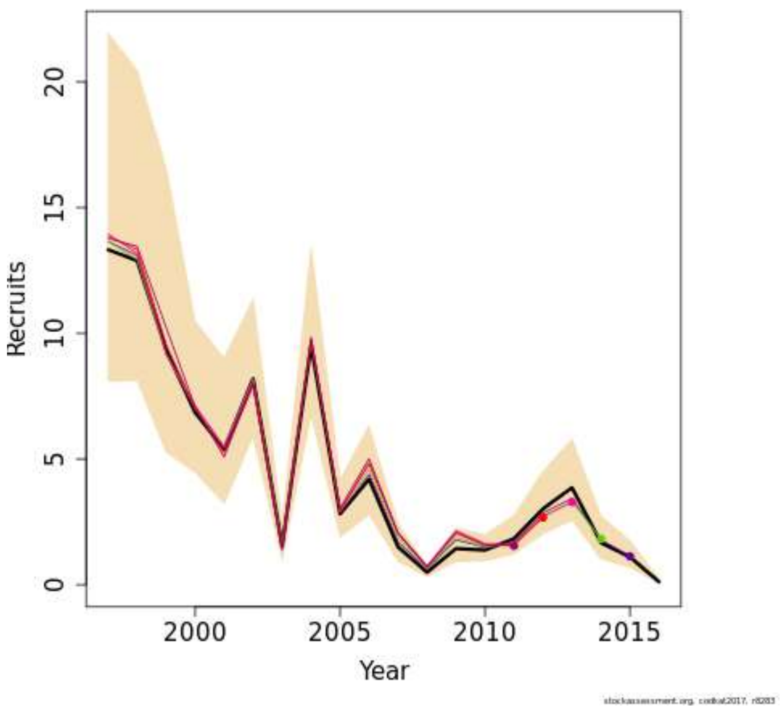


b)

Fig 2.2.14 Cod in the Kattegat. Retrospective Z. a) SPALY with scaling b) SPALY without scaling.



a)



b)

Fig 2.2.15 Cod in the Kattegat. Retrospective Recuitment. a) SPALYwith scaling b) SPALY without scaling.

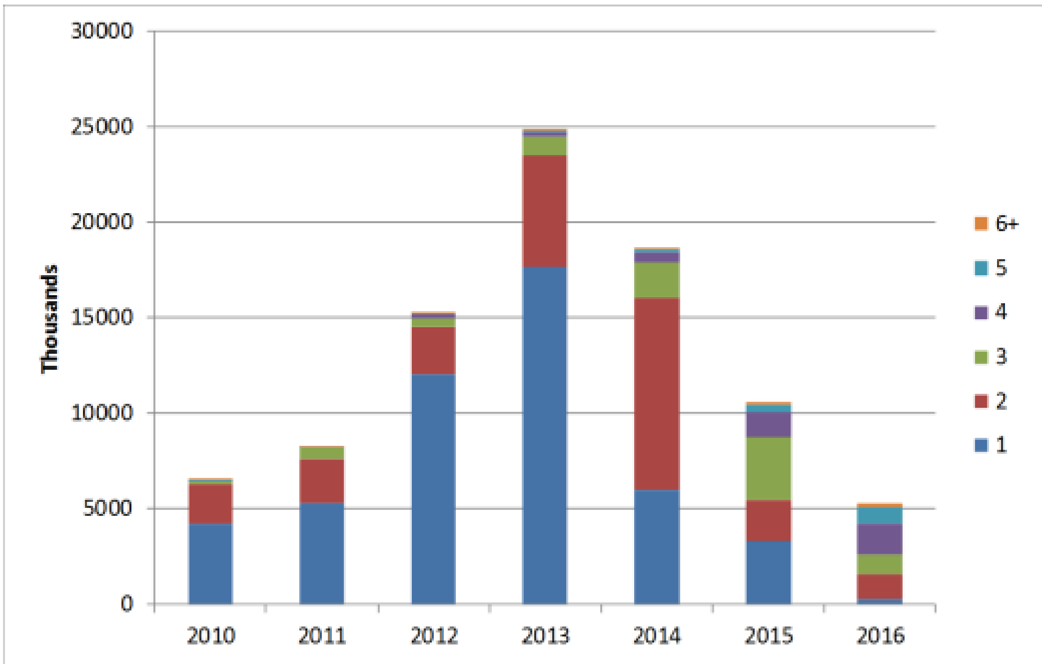


Figure. 2.2.17. Cod in the Kattegat. Estimates of stock numbers by age and year 2010-2016- Estimates from SAM output with scaling.

2.3 Western Baltic cod (update assessment)

4) Assessment type: Update assessment
5) Assessment: Analytical
6) Forecast: SAM
7) Assessment model: SAM
8) Stock status: SSB < B_{lim} in 2017. F (3–5) is in 2016 estimated to be 0.93.
9) Management plan. A new multi annual Baltic management plan has been implemented in 2016

2.3.1 The Fishery

Commercial catches are mainly taken by trawlers and gillnetters; and to a small degree by Danish Seines on the transitional area between subdivisions 22 and 24 (eastern Mecklenburg Bight/Darss sill). There is a trawling ban in place in subdivision (SD) 23 (the Sound) since 1932, but a small area in the north of SD 23 is open for trawlers in January and since 2016 the first 2 weeks of February; however, gillnetters are taking the major part of the commercial cod catches in SD 23. In SD 22 and 24 the main part of the catches are taken by trawlers. The major part of western Baltic cod stock landings is taken in SD 22 (Figure 2.3.1). Overall catches are predominantly Danish, German and Swedish, with smaller amounts from Poland and occasionally reported by other Baltic coastal states, mainly from SD 24. Time series of total cod landings by SD in the management area of SD 22–24 are given in Table 2.3.1; and landings by passive and active gear in 2016 are given in Table 2.3.2 (both include eastern Baltic cod landings in SD 24).

In 2016 decision makers decided to change the spawning closure in the western Baltic (SD22-24) from 4 weeks April in 2015 to 6 weeks covering the period from 15th of February to 31st of March which is more in correspondence with the peak spawning time. Since 01.01.2015, the EU landing obligation is in place, obliging the fisheries to land the entire catch of cod. There is a “minimum conservation reference size” of ≥ 35 cm, i.e. cod below this size cannot be sold for human consumption but has to be landed whole. This regulation replaced the minimum landing size of 38 cm valid until the end of 2014. For information on historical regulations, see Stock Annex.

2.3.1.1 Landings

In 2016, the reported commercial landings of the Western Baltic (WB) cod stock were estimated at 6.4 thousand tonnes, 68% of the commercial catches in 2016 were taken in SD 22-23 (Table 2.3.1, Table 2.3.2). The landings of cod in SD 22 and SD 23 by EU sorting categories are shown in Figure 2.3.2.

A comparison of the cod landings by EU size sorting category in SD 22 by countries showed that larger sized cod (particularly cod of the 4–7 kg segment) consistently contribute to the Danish landings while the German landings from SD 22 are mainly composed of cod < 4 kg (commercial size sorting groups 5-3). Size sorting composition of the landings in SD 23 was relatively similar between Denmark and Sweden –and similar to the landings of Germany in SD 22 (Figure 2.3.2).Hence, the remarkable proportion of large-sized cod almost exclusively comes from Danish landings in SD 22. The landings by commercial sorting, year and area can be seen in Figure 2.3.4.

As the western and eastern cod stock is mixing in SD 24, a splitting factor (based on genetics and otolith shape analysis) was applied to the commercial cod landings in SD 24 to include only those fish belonging to the WB cod stock. To do this, a weighted average of the proportions of WB cod in SD 24 in the two sub-areas (Area 1 and Area

2 in Figure 2.3.5 for separation between the stocks) was applied. The weightings for each year represented relative proportions of commercial Danish and German cod landings (main part of fisheries in SD 24) taken in Areas 1 and 2.

In 2016, 3 352 kg of BMS cod (below minimum conservation reference size) or 0.078% of the total landings in SD 22-23 were landed. In SD 24, 30 922 kg of BMS landings were reported. As the amount of cod landed below the minimum conservation reference size was much lower than the amounts registered in the at-sea observer programs, discard estimates from the at-sea observer programs and BMS landings were summed in the total discard estimates. It is legal to discard damaged cod if it is registered in the logbook, however, no logbook registered discards were reported for SD 22–24 in 2016.

2.3.1.2 Discards

All relevant countries uploaded their data to InterCatch. Discard data from at-sea observer programs for 2016 were available from Germany, Sweden, Denmark and Poland for SD 22–24. Denmark does not sample and report discards of passive gears, assuming zero discards. Discards of the passive gear of Denmark were raised using mainly discard ratios from Germany and Sweden (Table 2.3.4).

The overall discard rate in SD 22 and SD 23 was below 1%. The very low discard rates could be due to the combined effect of the reduction of the minimum landing size from 38 cm to 35 cm, very weak recruitment in 2015 and 2014 and the landing obligation.

For cod in SD 24, the discard rate was estimated to be 6.2%. This is due to the larger amount of smaller cod in the area (Figure 2.3.4 compared to Figure 2.3.2). Catches of long-liners was very low in 2016.

The discard weights at age for 2016 were included in the catch-at-age weights (see section 2.3.2.3).

2.3.1.3 Recreational catch

At the benchmark 2013 (WKBALT 2013), recreational catches were included in the assessment, which was confirmed and updated in the 2015 benchmark (WKBALTCOD 2015). Currently the recreational catch included in the assessment represents German data only, the amount varying between 1500–3200 t in the years 2005–2016. The earlier years are extrapolated based on the estimates for the recent period (WKBALT 2013). German recreational catches are mainly taken by private and charter boats and to a small degree by land-based fishing methods. The amount in 2016 is estimated to be 2316 t.

Since 2009, an investigation of the Danish recreational fishery was initiated (Sparrevohn and Storr-Paulsen 2010). Danish and Swedish recreational data are currently not included in the assessment, but efforts to incorporate these data are ongoing. A preliminary estimate from the Danish recreational fishery in 2016 is 970 t a 22% decrease compared to 2015. No recreational data was available from Sweden for 2016. The amount of German recreational catch included in the assessment compared to commercial landings and discards is shown in Figure 2.3.3 and Table 2.3.6.

All German recreational cod catch in SD 22–24 is assumed to be WB cod (WKBALTCOD, 2015).

2.3.1.4 Unallocated removals

German recreational fisheries data are included in the assessment. Danish and Swedish recreational fisheries data are not yet included but are under preparation (see above).

Another potential source of unallocated removals is the passive gear fishing fleet without the obligation to keep a daily logbook or where official sale notes are not available (e.g. vessels < 8 m and German part-time fishers). However, reliable estimates of the potentially unallocated removals are not available for this fleet segment.

In 2015, Germany included for the first time cod discard estimates from the German pelagic trawl fishery for herring in SD24 (PTB_SPF; mainly from the ICES rectangles 37G3 and 38G3, in Q1, Q2, Q4). In 2016, this estimate amounted to approximately 35 t.

2.3.1.5 Total catch

Total catches in the management area of western Baltic (SD 22–24), including commercial landings, discards and German recreational catches of western Baltic cod stock, and landings and discards of eastern Baltic cod in SD 24 are shown in Table 2.3.6.

2.3.1.6 Data quality

Denmark, Germany, Sweden, and Poland provided quarterly landings, LANUM and WELA by gear type (active, gillnets set, longline set) and Subdivision (Table 2.3.7). Finland provided landings only.

In 2015 a landing obligation was introduced in the Baltic and therefore the observer trips conducted by the national institutes have changed from observing a mandatory behaviour towards observing an illegal act. This could have an influence on the fishers′ behaviour and give more biased estimates. However, both Denmark and Germany has been able to conduct observer trips on board commercial vessels in 2016.

Denmark and Sweden sample landings via harbour-sampling and sample discard via at-sea sampling. Germany samples catches (i.e. both landings and discards) via at-sea observers and purchased samples from commercial vessels. The German catch sampling program samples length distributions of catches and uses a knife-edge approach to separate the catch into landings and discards (i.e. presently 35 cm). Poland has an at-sea observer program (where both discards and landings are sampled) and a harbour sampling for landings. Sampling levels of commercial catch in 2016 are given in Table 2.3.3.

All data were successfully uploaded to and processed in InterCatch. There was no national filling of empty strata prior to upload to InterCatch so that bias due to undocumented national extrapolations could be reduced. The list of unsampled strata and their allocated sampled strata in 2016 (i.e. the allocation overview) applied in InterCatch is given in Table 2.3.4 for landings and discards. However, the Danish port sampling scheme (where commercial size sorting categories are sampled) result in national raising of passive and active gear landings strata with the same data sets. Both Denmark and Sweden are sampling boxes as the secondary sampling unit. In Denmark this is presently done under the assumption that the age and length distribution within a box does not depend on the gear that caught the fish. Information on the number of boxes per size sorting category and strata would be very important to assess the quality of the data submitted to the assessment. However, presently size sorting category data cannot be hold within InterCatch. If these data were to be assessed in the future, the data would have to be provided outside InterCatch, e.g. in the RDB which can contain this information.

The different sampling units (number of boxes vs number of trips) render between-country comparisons difficult. However, differences in sampling intensity between countries are obvious. While Denmark has 44% of the TAC, they contributed only 8%

of the length measurements and 14% of age readings (Table 2.3.4). Possible effects of the differences between national sampling levels on data quality of the international data set have not been assessed.

The reported numbers at age in SD 22 peaked at age 3 for Germany and at age 4-5 for Denmark, which was in line with the differences in size sorting categories between countries (Figure 2.3.2).

Sampling levels in German recreational fisheries are shown in Tables 2.3.8 and 2.3.9.

2.3.2 Biological data

2.3.2.1 Proportion of WB cod in SD 22-24

Time series of estimated proportions of eastern and western Baltic cod within SD 24 are available from 1996 onwards from otolith shape analyses, using genetically validated baselines (WKBALTCOD 2015). Systematic differences in the proportion of mixing were found by sub-areas within SD 24, with a higher proportion of eastern Baltic cod closer to SD 25. Thus, the proportions of eastern and western cod in SD 24 were estimated separately for 2 sub-areas, marked as Area 1 (Darss sill and entrance of SD 23) and Area 2 (Arkona basin, Rönnebank, Oderbank) in Figure 2.3.5.

In 2016, 58% of cod in SD 24 was found to be WB cod in Area 1 and 24% in Area 2 based on the otolith shape of 708 cod (Table 2.3.10). The split is conducted on the cod otoliths sampled from the Danish trawl fisheries in SD 24. Samples for otolith shape analysis were collected during all four quarters. The spilt is weighted with landings from both Germany and Denmark based on landings by ICES square in SD 24.

Germany analyzed the mixing proportions using >11 000 otoliths from the quarter 4 BITS surveys conducted annually between 1992 and 2016 in SD 24. A genetically validated baseline from 2015/16 was used to assign otoliths shapes. The mixing proportions were similar to Danish estimates from commercial trawl samples in recent years while in the early 1990s the proportion of EB cod in the German estimates was very high while it was very low in Danish estimates. The German time series is being extended backwards to the late 1970s using historical otoliths. Possibilities to merge the German and Danish data sets and the incorporation of additional otoliths from Sweden and Poland will be explored for a future benchmark.

2.3.2.2 Catch in numbers

Time series of commercial landings, discards, recreational catch and total catch at age are shown in tables 2.3.11, 2.3.12, 2.3.13 and 2.3.14, respectively. Given the aging issues with EB cod that have a major contribution in SD 24, age composition information is only used from SD 22–23 (WKBALTCOD, 2015). Commercial catch at age for the entire western cod stock (i.e. including western Baltic cod in SD 24) were obtained by upscaling the catch at age in SD 22 by the catch of WB cod taken in SD 24 compared to SD 22. Catch at age in SD 23 were subsequently added, to obtain the catch at age of WB cod stock for SD 22–24.

The major part of commercial landings in 2016 was age-group 3. However, it was not as abundant as in the last year where the relatively large 2012 year class was present as age 3. The share of age 1 cod in terms of numbers is less than 2%, due to the very low 2015 year class (Figure 2.3.6). The main part of estimated discards for the western Baltic cod stock is age-groups 1 and 2 in numbers (Figure 2.3.6 and 2.3.7).

2.3.2.3 Mean weight at age

Mean weight at age in commercial landings, discards and in total catch is shown in tables 2.3.15, 2.3.16 and 2.3.17, respectively. This is based on data from SD 22–23. The mean weight at age in total catch is estimated as a weighted average of mean weights at age in commercial landings, discards and recreational catch, weighted by the respective catch numbers.

Weight-at-age in the stock for ages 1–3 is obtained from BITS 1st quarter survey data for SD 22–23. Weights at ages 4–7 in the stock were set equal to the annual mean weights in the catch (Table 2.3.18).

2.3.2.4 Maturity ogive

The maturity ogive estimations are based on data from BITS 1st quarter surveys in SD 22–23 (Table 2.3.19) and represent spawning probability (see Stock Annex and WKBALT 2013 for details). A moving average over 3 years is applied.

Spawning stock biomass is calculated at the start of the year, i.e. the proportion of fishing and natural mortality before spawning is assumed to be zero for all years and ages.

2.3.2.5 Natural mortality

Natural mortality at age 0 was assumed to be 0.8. The natural mortality values for cod at age 1 incorporate predation mortalities derived from an earlier MSVPA key run. These predation mortalities have not been updated since 1997; and presently the value 0.242 is applied for age 1. A constant value of 0.2 is used for older ages in the entire time series (Table 2.3.20).

2.3.3 Fishery independent information

In the western Baltic area two vessels are contributing to the survey used in the assessment, the German "Solea" and the Danish "Havfisken". Both vessels are part of the international coordinated BITS (Baltic international trawl survey). In 2016 the old Danish vessel Havfisken was replaced by a new Havfisken. A calibration study was conducted in connection to the survey and a working document #9 on calibration has been provided on the subject in last years´ report.

BITS Q1 and Q4

The tuning series used in the assessment are BITS Q1 and BITS Q4 surveys. The years and age-groups included in the assessment are shown in the table below and the time series of CPUE indices in Table 2.3.21. The CPUE by age from all tuning series are shown in Figure 2.3.11. Survey indices are calculated using a model-based approach and the area included in the indices is SD 22–23 and the western part of SD 24 (longitude 12° to 13°). Presently the area covering the eastern part of the SD24 is not included in the index.

FLEET	YEAR RANGE	AGE RANGE
BITS, Q4, SD22–24W (13 degrees)	2001–2016	age 0–4
BITS, Q1, SD22–24W (13 degrees)	2001–2017	age 1–4

Internal consistency of all tuning series is presented in Figure 2.3.8 and the time series in Figure 2.3.9.

2.3.3.1 Recruitment estimates

The moderately strong 2012 year class can be followed in the survey as age 3 in 2016 and age 4 in 2016. The 2015 year class was very low and among the lowest in the time series. In contrast to 2015, a very strong year class (age 0) was detected in the Q4 BITS 2016 and in both the German and Danish pound net in SD 22. The strong 2016 year class was confirmed in Q1 BITS 2017 as age 1 cod (Figure 2.3.10, 2.3.10).

2.3.4 Assessment

A stochastic state-space model (SAM) is used for assessment of cod in the western Baltic Sea.

The configuration of the model used in the assessment is specified in the Stock Annex.

Exploratory runs leaving out one tuning series at a time were conducted (Figure 2.3.12), which indicated relatively consistent influence of both surveys on the assessment results and that BITS Q4 has the highest impact on the 2017 estimation of SSB and F.

Several exploratory runs were conducted as the assessment showed a large downscaling of SSB in 2016. One exploratory run was conducted with a fixed stock weight to test the effect of an annual updated stock weight; however; this had a relatively small effect on SSB the final year. Further, different retrospective options were conducted where only one time series at a time was used for the retrospective going 2 years back (BITS Q1, BITS Q4 or CANUM). This exercise indicated that it was the new updated data from 2016 that downscaled the SSB. The reason for this could be due to an inconsistency between survey data and commercial catch data. A relatively large part (1/3) of the total catch is from SD 24 where only a limited area is used from the survey index. However, from the survey plots (Figure 2.3.11) it can be seen that a large part of the medium-sized cod (between 25 and 45 cm) are caught in the area that is presently not included in the survey. The reason for excluding this part of the survey at the benchmark was due to lack of a split in the survey data. An exploratory run was conducted during this meeting including the whole survey area from SD 24 and with some assumptions on the split of data based on German otolith shape analyses (see section 2.2.2.1). The retrospective pattern on SSB improved, suggesting that a more thorough analysis on how to include the whole survey area would be beneficial.

The summaries for SSB, Recruitment and F from the final run are shown in Figure 2.3.14 and Table 2.3.22. Stock number and fishing mortalities are presented in tables 2.3.23 and 2.3.24, respectively. The residuals of the final run are presented in Figure 2.3.15. The standard deviation of the different estimates used in the model is shown in Figure 2.3.16.

The retrospective analysis (Figure 2.3.17) indicates systematic overestimation of SSB, especially in the last year. For F, the retrospective pattern is also large but does not seem to be biased. The reason for the bias is elaborated on earlier in this section.

The input data and settings are visible in www.stockassessment.org, the stock is "WBcod_2017".

2.3.5 Short-term forecast and management options

The short term forecast is based on the SAM short term forecast module.

From the assessment model the final estimates with a full dataset of fishing mortality and stock numbers is used, and their estimation variances and co-variances. These quantities are then simulated forward in time for a number of specified scenarios. The uncertainties are propagated forward in time, and the process variation (as estimated from the historic period) is added. These uncertainties are propagated all the way through the calculations.

The simulation is carried out at logarithmic scale, and medians are used as main summary statistic on the untransformed scale.

The input data for short-term forecast are shown in Table 2.3.26. Last year a TAC (catch) constraint was used in the intermediate year. This was derived from the splitting factor (0.58) applied to the TAC (5597 t) and recreational catches added (1754 t). This gives a total catch of 5090 t in 2017 and an F at 0.37.

The recreational catch in the intermediate year was derived by using a 3 year mean in catch 2014-2016 (2654 t) where the assumed reduction in catch due to the introduced bag limitation of a maximum of 5 cod per angler per day has been introduced in 2017. The bag limitation of 5 cod per angler per day has been estimated to reduce the catch by approximately 900 t (Strehlow 2016, unpublished data).

As in last years´ advice calculations have been conducted on how the stock advice can be transformed into an area management advice. The assumption for this calculation is that the relative catch distribution between subdivisions is stable. The total commercial catch of WB cod stock commercial catch have on average in the most recent three years been quite stable between subdivisions 22–23 and Subdivision 24, amounting to 69% and 31%, respectively,. Further, in the most recent three years, the overall ratio EB cod / WB cod in the commercial catch in Subdivision 24 has been 2.30. This means that every time 1 WB cod is caught in SD 24, 2.30 eastern Baltic cod is caught at the same time. The advice based on the management plan indicates that the total catch (excluding the recreational fishery at 1754 t) can be 3541 t for the western Baltic cod stock in 2018. From these 31% will be caught in SD 24 (if the distribution is similar as in the former year), making a catch of west Baltic cod at 1098 t. To this value the eastern Baltic cod fraction can be applied (2.30) giving a catch of eastern Baltic cod of 2525 t. This would altogether give a total catch in the western Baltic management area of 6066 t in 2108.

2.3.6 Reference points

In 2016 a Baltic multiannual management plan has been introduced with F ranges (0.15-0.26 and 0.26-0.45) depending on the SSB in the intermediate year compared to the MSY B-trigger level.

Biomass reference points B_{lim}= 27.4kt and B_{pa} at 38.4kt (WKBALT COD 2015). B_{pa} is considered to correspond to B_{MSY} trigger.

F_{lim} and F_{pa} were estimated using EqSim with the same settings and dataset as used for the F_{MSY} calculation, however, calculated without trigger and F_{cv}=0, F_{phi}=0. This estimation gave a F_{lim} at 1.01 and an F_{pa} at 0.74.

2.3.7 Quality of assessment

The uncertainty on the catch matrix is relativity high in this assessment. Normally the catches from age 2–7 are close to 0.2; however, in this assessment the standard deviation from the catches age 2–7 is 0.4 indicting a relatively high uncertainty on catches. The reason for the high uncertainty could be the splitting factor applied in SD 24, recreational catches.

Mixing of the eastern and western Baltic cod stocks is a major issue in SD 24. The stock mixing within SD 24 is variable spatially and possibly between seasons and age-groups of cod. This introduces uncertainty to the stock separation keys presently applied in the assessment. Also, for some years in the time series the stock separation keys are based on extrapolations from other years. Further, the preparation of assessment input data to separate between western and eastern Baltic stock involves a number of additional assumptions which introduces uncertainty to the assessment. However, separating the western Baltic cod (SD 2223 + the component of western Baltic cod in SD 24) within the management area SD 22–24 after WKBALTCOD (2015) removed several sources of uncertainty characterizing the previous years´ assessments (e.g. age reading issues, higher discards in SD 24). Therefore, despite the uncertainties mentioned above, this years´ assessment is considered to provide a relatively reliable perspective of the stock status of the western Baltic cod stock. Furthermore, an age reading calibration has been conducted between Denmark and Germany in 2015 and the agreement is now 94%, which is considered very well.

Recreational fishery catches have been included from Germany and used in the assessment not only as topping up the catches but as an age-based input in the catch and weight matrix. In 2016 German recreational catches for this stock were close to 27% of the total catch and can therefore not be ignored in the assessment. The present lack of the Danish and Swedish recreational fishery adds to uncertainty in the assessment; however, it is the plan to include the Danish and Swedish recreational data at the next benchmark when the data have been verified by on-site studies and include biological data such as length and weight.

Issue list:

The stock has been suggested as a candidate for a next benchmark and a relatively long issue list was compiled and is present at the SharePoint. Among the most important things to look at are:

- Apply the stock split on the survey using German otolith shape data from 1992 to present, and then test if it is possible to include a larger part of the survey area in SD 24.
- Extend and complete the otolith shape analyses of the German surveys in SD24 back to the late 1970s to cover the peak period of Baltic cod (relevant for reference points); and provide more years with genetic validation
- Include Danish and German and preferably Swedish and Polish data on otolith shape to conduct the split on commercial data.
- Include Danish and Swedish recreational data, including biological data
- Reconsider the reference point, especially the breaking point
- Assess the number of boxes per size sorting category and strata from the port samples and compare in detail the age, weight and length distributions with German sampling data.
- Include Swedish data from survey in SD 23 (IBTS).
- Consider German pound net data for an additional cod recruitment index from the commercial fisheries (since 2011)

2.3.8 Comparison with previous assessment

In previous years the assessment was conducted for the area of SD 22–24 that includes a significant fraction of the eastern Baltic cod stock. The last two years, the assessment has been conducted for the western Baltic cod stock only. The assessment this year has downscaled the 2016 SSB by 29% compared to last year. The 2016 recruitment was upscaled slightly, however, still at a historic low level. In last year's assessment for 2017 and 2018 a 10 year resampling from recruits were used as standard in the forecast but in 2017 the recruitment (age 1) has been record high (65578 millions or an increase by 85% of the level used in the forecast).

2.3.9 Management considerations

The management area of SD 22–24 contains a mixture of eastern and western Baltic cod populations, particularly in SD 24. This has been shown by genetic analyses. Thus, part of the catches taken in the management area of SD 22–24 is cod that genetically is eastern Baltic cod but lives in SD 24. Management should consider how to protect the western Baltic cod stock when the two stocks are fished within the same area. This could be done by implementing a sub-TAC.

Table 2.3.1. Cod in management area of SD 22–24. Total landings (tons) of cod in the ICES Sub-divisions 22, 23, 24 (includes eastern Baltic cod landings in SD 24).

Table 2.3.1 Cod in SD 22-24. Total landings (tons) of COD in the ICES Sub-divisions 22, 23, 24.

	Denmark			Finland	German Dem.Rep.[1]	Germany, FRG		Estonia		Lithuania	Latvia	Poland	Sweden			Total				
	22	23	22+24	24	22+24	22	22+24	22	24	24	24	24	22	23	22+24	22	23	24	Unalloc.	Grand total
1965			19457		9705		13350								2182	27867		17007		44874
1966			20500		8393		11448								2110	27864		14587		42451
1967			19181		10007		12884								1996	28875		15193		44068
1968			22593		12360		14815								2113	32911		18970		51881
1969			20602		7519		12717								1413	29082		13169		42251
1970			20085		7996		14589								1289	31363		12596		43959
1971			23715		8007		13482								1419	32119		14504		46623
1972			25645		9665		12313								1277	32808		16092		48900
1973			30595		8374		13733								1655	38237		16120		54357
1974			25782		8459		10393								1937	31326		15245		46571
1975			23481		6042		12912								1932	31867		12500		44367
1976		712	29446		4582		12893								1800	33368	712	15353		49433
1977		1166	27939		3448		11686							550	1516	29510	1716	15079		46305
1978		1177	19168		7085		10852							600	1730	24232	1777	14603		40612
1979		2029	23325		7594		9598							700	1800	26027	2729	16290		45046
1980		2425	23400		5580		6657							1300	2610	22881	3725	15366		41972
1981		1473	22654		11659		11260							900	5700	26340	2373	24933		53646
1982		1638	19138		10615		8060							140	7933	20971	1778	24775		47524
1983		1257	21961		9097		9260							120	6910	24478	1377	22750		48605
1984		1703	21909		8093		11548							228	6014	27058	1931	20506		49495
1985		1076	23024		5378		5523							263	4895	22063	1339	16757		40159
1986		748	16195		2998		2902							227	3622	11975	975	13742		26692
1987		1503	13460		4896		4256							137	4314	12105	1640	14821		28566
1988		1121	13185		4632		4217							155	5849	9680	1276	18203		29159
1989		636	8059		2144		2498							192	4987	5738	828	11950		18516
1990		722	8584		1629		3054							120	3671	5361	842	11577		17780
1991		1431	9383				2879							232	2768	7184	1663	7846		16693
1992		2449	9946				3656							290	1655	9887	2739	5370		17996
1993		1001	8666				4084							274	1675	7296	1275	7129	5528	21228
1994		1073	13831				4023							555	3711	8229	1628	13336	7502	30695
1995		2547	18762	132			9196				15			611	2632	16936	3158	13801		33895
1996		2999	27946	50			12018		50		32			1032	4418	21417	4031	23097	2300	50845
1997		1886	28887	11			9269		6			263		777	2525	21966	2663	18995		43624
1998		2467	19192	13			9722		8		13	623		607	1571	15093	3074	16049		34216
1999		2839	23074	116			13224		10		25	660		682	1525	20409	3521	18225		42155
2000		2451	19876	171			11572		5		84	926		698	2564	18934	3149	16264		38347
2001		2124	17446	191			10579		40		46	646		693	2479	14976	2817	16451		34244
2002		2055	11657	191			7322				71	782		354	1727	11968	2409	9781		24158
2003		1373	13275	59			6775				124	568		551	1899	9573	1925	13127		24624
2004		1927	11386				4651				221	538		393	1727	9091	2320	9430	13	20854
2005		1902	9867	2			7002	72	67		476	1093		720	835	8729	2621	10686	9	22045
2006		1899	9761	242			7516		91		586	801			1855	9979	1914	10858		22751
2007		2169	8975	220			6802		69		273	2371		534	2322	7840	2713	13183		23736
2008		1612	8582	159			5489		134		30	1361		525	2189	5687	2139	12256		20082
2009		567	7871	259			4020		194		23	529		269	1817	3451	839	11259		15549
2010		689	6849	203			4250			9	159	319		490	1151	3925	1179	9016		14120
2011		783	7799	149			4521				24	487		414	2153	5493	1198	9641		16332
2012		733	8381	260			4522		3		11	818		390	1955	4896	1123	11053		17072
2013		580	6566	50			3237				128	708		380	1317	4675	960	7333		12968
2014	2206	795	6804	7		2109	3243				39	854	1	565	1231	4316	1361	7862		13538
2015	2781	738	6623	28		2213	2915				7	755		493	1858	4994	1232	7193		13418
2016	1576	675	4881	29		1617	2390					657	1	448	1550	3193	1123	6313		10629

[1] Includes landings from Oct.-Dec. 1990 of Fed.Rep.Germany.

Table 2.3.2. Cod in management area of SD 22–24. Total landings (t) by Sub-division (includes Eastern Baltic cod in SD 24) sorted by column "22–24".

Year:	2016		Gear:	Active and passive gea
Sub-div.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	1576	675	3305	5555
Germany	1617		773	2390
Sweden	0	448	1550	1998
Poland	0	0	657	657
Finland		0	29	29
Latvia	0	0	0	0
Estonia	0	0	0	0
Lithuania	0	0	0	0
Russia	0	0	0	0
Total	3193	1123	6313	10629

Year:	2016		Gear:	Active gear
Sub-div.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	657	104	2869	3630
Germany	1014	0	395	1408
Sweden	0	6	980	986
Poland	0	0	430	430
Finland	0	0	29	29
Estonia	0	0	0	0
Lithuania	0	0	0	0
Russia	0	0	0	0
Latvia	0	0	0	0
Total	1671	110	4702	6484

Year:	2016		Gear:	Passive gea
Sub-div.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	919	571	436	1925
Germany	603		378	981
Sweden	0	442	570	1012
Poland	0	0	227	227
Latvia	0	0	0	0
Estonia	0	0	0	0
Finland	0	0	0	0
Lithuania	0	0	0	0
Russia	0	0	0	0
Total	1522	1013	1611	4146

Table 2.3.3. Cod in Sub-divisions 22–23. Overview of the number of samples (number of trips or number of boxes), number of length measurements and number of otoliths available per stratum in 2016 (upper, middle and lower table, respectively). Color codes indicate sampling coverage (see legend below).

			Area	Season									
Number of samples			27,3,c,22				27,3,b,23				Total	Country sum	%
Country	Catch Categc	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards *1	Active	15			7					22		
TAC 44%		Gillnets set										45	**237%**
		Longline set											
	Landings *2	Active	8	8	2	2			2	1	23		
		Gillnets set	8	8	2	2			2	1	--		
		Longline set							2		--		
Germany	Discards *1	Active	4	3							7		
TAC 21%		Gillnets set	4								4	70	**368%**
		Longline set											
	Landings *1	Active	7	4	3	3					17		
		Gillnets set	7	28		7					42		
		Longline set											
Sweden	Discards *1	Active											
TAC 16%		Passive					5	6	2	6	19		
	Landings *2	Active										36	**189%**
		Passive					4	5	2	6	17		
Total			45	43	5	19	9	11	8	13	151		

*1: number of trips; *2: number of boxes

			Area	Season									
Number of length measurements			27,3,c,22				27,3,b,23				Total	Country sum	%
Country	Catch Categc	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards	Active	88			26					114		
TAC 44%		Gillnets set										525	**603%**
		Longline set											
	Landings	Active	120	90	43	57			57	44	411		
		Gillnets set	120	90	43	57			57	44	--		
		Longline set							57		--		
Germany	Discards	Active	42	27							69		
TAC 21%		Gillnets set	39								39	4954	**5694%**
		Longline set											
	Landings	Active	1222	732	347	24					2325		
		Gillnets set	1193	764		564					2521		
		Longline set											
Sweden	Discards	Active										872	**1002%**
TAC 16%		Passive					10	23	16	38	87		
	Landings	Active											
		Passive					176	263	82	264	785		
Total			2704	1613	390	671	186	286	212	346	6351		

Number of otoliths age-read											Total	Country sum	%
Country	Catch Categc	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards	Active	25			26					51		
TAC 44%		Gillnets set										462	**531%**
		Longline set											
	Landings	Active	120	90	43	57			57	44	411		
		Gillnets set	120	90	43	57			57	44	--		
		Longline set							57		--		
Germany	Discards	Active	10	26							36		
TAC 21%		Gillnets set	25								25	2031	**2334%**
		Longline set											
	Landings	Active	563	476	347	5					1391		
		Gillnets set	347	127		105					579		
		Longline set											
Sweden	Discards	Active											
TAC 16%		Passive					10	23	16	38	87	717	**824%**
	Landings	Active											
		Passive					176	188	82	184	630		
Total			1090	719	390	193	186	211	212	266	3210		

sampled stratum
extrapolation of landed size sorting samples
not sampled but L or D

Table 2.3.4. Cod 22–23. Unsampled landing and discard strata and allocated sampled strata in 2016.

Unsampled landings strata and allocated sampled strata in 2016.

DE_27.3.c.22_Gillnets set_3_L,DE_27.3.c.22_Gillnets set_2_L,X
DE_27.3.c.22_Gillnets set_3_L,DE_27.3.c.22_Gillnets set_4_L,X
DE_27.3.c.22_Longline set_2_L,DK_27.3.b.23_Longline set_3_L,X
DK_27.3.b.23_Active_1_L,DE_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_1_L,DK_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_2_L,DE_27.3.c.22_Active_1_L,X
DK_27.3.b.23_Active_2_L,DE_27.3.c.22_Active_2_L,X
DK_27.3.b.23_Active_2_L,DK_27.3.c.22_Active_2_L,X
DK_27.3.b.23_Gillnets set_1_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Gillnets set_1_L,SE_27.3.b.23_Passive_1_L,X
DK_27.3.b.23_Gillnets set_2_L,DE_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Gillnets set_2_L,DE_27.3.d.24_Gillnets set_2_L,X
DK_27.3.b.23_Longline set_2_L,DK_27.3.b.23_Longline set_3_L,X
SE_27.3.b.23_Active_2_L,DE_27.3.c.22_Active_2_L,X
SE_27.3.b.23_Active_2_L,DE_27.3.d.24_Active_2_L,X
SE_27.3.b.23_Active_4_L,DE_27.3.c.22_Active_1_L,X
SE_27.3.b.23_Active_4_L,DE_27.3.c.22_Active_2_L,X
SE_27.3.b.23_Active_4_L,DE_27.3.c.22_Active_3_L,X
SE_27.3.b.23_Active_4_L,DE_27.3.c.22_Active_4_L,X
SE_27.3.c.22_Passive_2_L,DE_27.3.c.22_Gillnets set_2_L,X
SE_27.3.c.22_Passive_2_L,DE_27.3.d.24_Gillnets set_2_L,X
SE_27.3.c.22_Passive_2_L,SE_27.3.b.23_Passive_1_L,X
SE_27.3.c.22_Passive_2_L,SE_27.3.b.23_Passive_2_L,X
SE_27.3.c.22_Passive_2_L,SE_27.3.b.23_Passive_3_L,X
SE_27.3.c.22_Passive_2_L,SE_27.3.b.23_Passive_4_L,X

Unsampled discard strata and allocated sampled strata for Western Baltic cod in 2016 (SD22-23).

DE_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_1_Gillnets set_D,X
DE_27.3.c.22_2_Gillnets set_D,SE_27.3.b.23_2_Passive_D,X
DE_27.3.c.22_3_Gillnets set_D,DE_27.3.c.22_1_Gillnets set_D,X
DE_27.3.c.22_3_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X
DE_27.3.c.22_4_Active_D,DE_27.3.c.22_1_Active_D,X
DE_27.3.c.22_4_Active_D,DE_27.3.c.22_2_Active_D,X
DE_27.3.c.22_4_Active_D,DK_27.3.c.22_1_Active_D,X
DE_27.3.c.22_4_Active_D,DK_27.3.c.22_4_Active_D,X
DK_27.3.c.22_2_Active_D,DE_27.3.c.22_1_Active_D,X
DK_27.3.c.22_2_Active_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.c.22_3_Active_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.c.22_3_Active_D,DK_27.3.c.22_4_Active_D,X

Table 2.3.5. Cod 22–23. 2016. Discard (Number * 1000) by quarter and gear type.

Sum of DISCARD	Quarter				Grand Total
Gear type	1	2	3	4	
Passive gears	8	5	14	3	30
Active gears	22	17	0*	10	49
Grand Total	30	22	14	13	79

*, stratum active-quarter3: few samples without discards (trawling with rock-hopper gear)

Table 2.3.6. Western Baltic cod. Catches in the WB management area (SD 22–24) for WB and EB stocks (in tonnes). Recreational catch: German data only.

Year	WB cod stock					EB cod stock					EB+WB cod stock
	Landings	Discards	Recreational catch	% of comm. catch in SD 22-23	% of comm. catch in SD 24	Landings in SD 24	Discards in SD24	Landings in SD 25-32	Discards in SD 25-32	% of catch in SD 24	Catch in SD 22-24
1994	21409	2069	1828	0.46	0.54	1784	166	100856	1956	2	27256
1995	29854	3143	2133	0.66	0.34	4041	541	107718	1872	4	39712
1996	38335	6897	2190	0.68	0.32	10210	1087	124189	1443	8	58719
1997	37009	3994	2280	0.67	0.33	6615	629	88600	3462	7	50526
1998	29628	5577	2372	0.63	0.37	4588	630	67428	2299	7	42795
1999	35817	4390	2243	0.68	0.32	6338	588	72995	1838	8	49376
2000	31653	3794	2386	0.68	0.32	6694	1153	89289	6019	8	45680
2001	26983	2456	2494	0.67	0.33	7261	383	91328	2891	8	39576
2002	19592	1410	2215	0.72	0.28	4566	548	67740	1462	7	28331
2003	18055	3482	2361	0.66	0.34	6569	854	69476	2024	9	31321
2004	15916	2193	2284	0.74	0.26	4925	184	68578	1201	7	25503
2005	16845	3186	2835	0.63	0.37	5191	1808	55032	1670	11	29866
2006	16472	1689	1887	0.74	0.26	6279	142	65532	4644	8	26468
2007	15859	1344	1698	0.66	0.34	7876	855	50843	4146	14	27634
2008	11148	355	1513	0.69	0.31	8934	768	42235	3746	17	22717
2009	7093	341	1921	0.60	0.40	8456	474	48439	3328	15	18285
2010	7641	814	2287	0.67	0.33	6479	557	50276	3543	12	17778
2011	8845	272	1794	0.75	0.25	7487	508	50368	3850	13	18907
2012	8654	349	2657	0.69	0.31	8419	556	51225	6795	13	20634
2013	7742	945	2029	0.70	0.30	5226	1305	31355	5020	15	17248
2014	8099	867	2485	0.67	0.33	5439	1268	28909	9627	15	18158
2015	8372	449	3161	0.71	0.29	5047	912	37342	6328	12	17941
2016	6233	156	2316	0.68	0.32	4430	293	29312	3620	13	13428

Table 2.3.7. Cod in SD 22–23. Numbers at age (LANUM) and mean weight at age (WELA) in commercial landings by Sub-division, quarter and gear in 2016.

Year:		Gear:	Trawl, gillnet and longlines combined			
Year:	2016	Quarter:	1			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	weight [g]	*10-3	weight [g]	*10-3	weights [g]
1						
2	33	751	15	769	48	762
3	404	1517	74	1202	478	1382
4	327	2435	83	1745	409	2139
5	39	3835	18	2900	57	3434
6	16	5177	5	4730	21	4986
7	7	7386	3	5791	10	6589
8	1	8882	0.4	7266	2	8074
9	1	8260	1	4676	2	5572
10						
11						
SOP [t]	1587		317		1904	
Landings (t)	1571		314		1885	

Year:	2016	Quarter:	2			
Sub-div,	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	weight [g]	*10-3	weight [g]	*10-3	weights [g]
1						
2	54	872	15	872	69	872
3	245	1673	34	1202	279	1459
4	104	2427	31	1723	135	2107
5	9	3807	11	2585	20	3252
6	8	4751	2	4089	11	4457
7	3	4062	1	4739	5	4352
8	2	6663	0.1	6549	2	6618
9		2884	0.2	5572	0.2	4676
10						
11						
SOP [t]	676		153		829	
Landings (t)	676		153		829	

Year:	2016	Quarter:	3			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	weight [g]	*10-3	weight [g]	*10-3	weights [g]
1						
2	66	1012	83	974	149	987
3	50	2225	19	1214	69	1719
4	60	3449	28	2008	88	2728
5	6	3856	10	2591	16	3223
6	1	4158	1	3489	3	3712
7			1	3406	1	3406
8	3	9760	0.2	3761	3	8260
9						
10						
11						
SOP [t]	426		191		617	
Landings (t)	426		191		617	

Continued on next page.

continued

Table 2.3.7. Cod in SD 22–23. Numbers at age (LANUM) and mean weight at age (WELA) in commercial landings by Sub-division, quarter and gear in 2016.

Year:	**2016**	**Quarter:**	**4**			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	w eight [g]	*10-3	w eight [g]	*10-3	w eights [g]
1						
2	227	1516	156	1159	383	1278
3	49	2957	73	1389	122	2173
4	35	4065	64	2008	99	2890
5	5	5139	9	2923	14	3661
6	2	4285	3	3707	5	3900
7			0.1	4992	0.1	4992
8			0.001	9200	0.001	9200
9			0.003	8260	0.003	8260
10						
11						
SOP [t]	520		464		984	
Landings (t)	520		464		984	

Year:	**2016**	**Quarter:**	**All**			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers	Mean	Numbers	Mean	Numbers	Mean
	*10-3	w eight [g]	*10-3	w eight [g]	*10-3	w eights [g]
1						
2	380	1019	269	950	649	975
3	748	2046	200	1252	948	1672
4	526	2959	205	1870	731	2431
5	59	3993	48	2730	107	3361
6	27	4719	12	3955	39	4310
7	10	5487	5	4998	16	5212
8	6	8435	1	6837	7	7736
9	1	5572	1	5572	2	5572
10						
11						
SOP [t]	3193		1123		4316	
Landings (t)	3193		1123		4316	

Table 2.3.8. Western Baltic Cod. Overview of the numbers of on-site surveys and interviewed anglers, 2005–2016.

Year	Angling method	Number of on-site surveys	Numbers of interviews
2005	Charter boat angling	93	1114
	Boat angling		200
	Trolling		13
	Shore angling	90	130
	Wading		37
	Total	**183**	**1494**
2006	Charter boat angling	89	1905
	Boat angling		316
	Trolling		4
	Shore angling	79	115
	Wading		46
	Total	**168**	**2386**
2007	Charter boat angling	80	1256
	Boat angling		202
	Trolling		4
	Shore angling	82	353
	Wading		73
	Total	**162**	**1888**
2008	Charter boat angling	81	786
	Boat angling		128
	Trolling		6
	Shore angling	48	89
	Wading		43
	Total	**129**	**1052**
2009	Charter boat angling	204	1690
	Boat angling		346
	Trolling		29
	Shore angling	49	172
	Wading		51
	Total	**253**	**2288**
2010	Charter boat angling	233	1730
	Boat angling		366
	Trolling		40
	Shore angling	57	173
	Wading		50
	Total	**290**	**2359**
2011	Charter boat angling	283	2181
	Boat angling		411
	Trolling		7
	Shore angling	58	166
	Wading		51
	Total	**341**	**2816**
2012	Charter boat angling	258	1465
	Boat angling		358
	Trolling		24
	Shore angling	58	111
	Wading		25
	Total	**316**	**1983**
2013	Charter boat angling	240	1116
	Boat angling, Trolling		287
	Shore angling, Wading	84	184
	Total	**324**	**1587**

Continued

Table 2.3.8. Western Baltic Cod. Overview of the numbers of on-site surveys and interviewed anglers, 2005–2016.

Year	Angling method	Number of on-site surveys	Numbers of interviews
2014	Charter boat angling	231	1143
	Boat angling, Trolling		217
	Shore angling, Wading	84	175
	Total	**315**	**1535**
2015	Charter boat angling	236	1072
	Boat angling, Trolling		231
	Shore angling, Wading	87	166
	Total	**323**	**1469**
2016	Charter boat angling	252	1195
	Boat angling, Trolling		244
	Shore angling, Wading	77	165
	Total	**329**	**1604**

Table 2.3.9. Western Baltic cod. Overview of the number of samples and length measurements of cod from recreational fishing events (charter vessels trips & shore fishing), boat and trolling self-measurements, as well as charter vessel sampling, 2005–2016.

Year	Sample Type	Number of Samples	Harvest n	Release n
2005	Boat, charter boat angling	13	435	
	Shore angling	4	1026	
	Total	**17**	**1461**	
2006	Boat, charter boat angling	5	352	
	Shore angling	1	10	
	Total	**6**	**362**	
2007	Charter boat angling	1	18	8
	Shore angling	5	498	
	Total	**6**	**516**	**8**
2008	Boat, charter boat angling, trolling	24	275	7
	Shore angling	8	345	26
	Total	**32**	**620**	**33**
2009	Boat, charter boat angling, trolling	84	1351	885
	Shore angling	3	3	10
	Total	**87**	**1354**	**895**
2010	Charter vessel sampling – survey agent	74	2567	1604
	Shore fishing – self-measurement	13	1067	31
	Total	**87**	**3634**	**1635**
2011	Boat, charter boat angling, trolling	65	4089	1089
	Shore angling	15	584	13
	Total	**80**	**4673**	**1102**
2012	Boat, charter boat angling, trolling	32	1546	533
	Shore angling			
	Total	**32**	**1546**	**533**
2013	Boat, charter boat angling, trolling	47	2257	1345
	Shore angling			
	Total	**47**	**2257**	**1345**
2014	Boat, charter boat angling, trolling	42	3318	1104
	Boat angling – self-measurement	3	403	
	Total	**45**	**3721**	**1104**
2015	Boat, charter boat angling, trolling	42	2853	949
	Total	**42**	**2853**	**949**
2016	Boat, charter boat angling, trolling	53	2521	398
	Total	**53**	**2521**	**398**

Table 2.3.10. Western Baltic cod. Percentage of western cod in Area 1 (W: western part of SD 24, 12- 13 degrees longitude) and Area 2 (E: eastern part of SD 24, from 13 -15 degrees longitude); and weighted average of those percentages applied to extract the WB cod landings in SD 24.

year	Area 1 _ W	Area 2 E	Procent west cod in ladnings for SD 24
1994	90	85	87
1995	80	65	71
1996	66	49	56
1997	69	60	65
1998	72	71	71
1999	72	60	65
2000	71	49	59
2001	65	48	56
2002	63	45	53
2003	62	43	50
2004	61	40	48
2005	59	48	51
2006	58	34	42
2007	57	34	40
2008	46	20	27
2009	51	21	25
2010	55	21	28
2011	51	15	22
2012	52	19	24
2013	53	23	29
2014	51	25	31
2015	50	23	30
2016	58	24	30

Table 2.3.11. Western Baltic cod. Landings (in numbers (000)) by year and age.

age	a1	a2	a3	a4	a5	a6	a7+
1994	861	4813	14354	2167	78	18	15
1995	713	11353	4891	5607	1204	130	3
1996	95	23493	17313	717	2059	107	2
1997	1828	1996	28790	2559	322	324	77
1998	2412	18594	2129	5720	654	105	76
1999	658	23476	12518	1597	1214	244	92
2000	809	6454	20432	3065	126	244	47
2001	1409	10463	6630	4812	793	46	89
2002	437	8189	8295	1581	878	258	17
2003	649	10155	4551	1310	231	192	66
2004	65	1510	8780	1909	337	122	83
2005	267	8381	1666	2982	342	91	50
2006	259	1549	10879	513	570	77	15
2007	58	3311	2617	3638	411	219	33
2008	20	601	2599	946	871	257	128
2009	177	444	1497	981	506	184	81
2010	185	3320	1022	609	429	133	54
2011	72	864	3439	1285	288	81	41
2012	113	1307	1270	1929	525	60	14
2013	287	600	1729	806	738	313	68
2014	42	2662	1079	821	139	145	24
2015	172	940	3012	376	226	34	61
2016	1	889	1398	1046	142	56	35

Table 2.3.12. Western Baltic cod. Discard (in numbers (000)) by year and age.

age	a1	a2	a3	a4	a5	a6	a7+
1994	3680	1787	758	10	0	0	0
1995	3690	5106	313	30	0	0	0
1996	22714	2418	10	0	0	0	0
1997	15255	0	0	0	0	0	0
1998	17009	2709	121	0	0	0	0
1999	2670	9026	303	0	0	0	0
2000	2719	4456	2523	0	0	0	0
2001	1987	4475	306	49	0	0	0
2002	1526	2266	219	16	0	0	0
2003	1067	7605	415	13	0	0	0
2004	2244	866	2375	0	0	0	0
2005	945	7455	43	0	0	0	0
2006	873	2637	764	43	2	0	0
2007	281	2502	511	40	5	0	0
2008	76	574	204	4	0	0	0
2009	191	484	179	12	0	0	0
2010	218	915	475	303	7	0	0
2011	6	151	105	256	77	1	0
2012	30	268	204	231	42	0	0
2013	37	705	469	701	170	5	0
2014	691	1649	50	8	0	0	0
2015	229	862	315	24	0	0	0
2016	44	307	54	1	0	0	0

Table 2.3.13. Western Baltic cod. German recreational catch (in numbers (000)) by year and age.

age	a1	a2	a3	a4	a5	a6	a7+
1994	464	801	726	86	14	2	1
1995	448	1219	608	233	34	3	1
1996	265	1371	683	158	32	3	1
1997	715	713	900	142	24	4	1
1998	490	1251	540	225	29	3	1
1999	213	1336	639	168	31	4	1
2000	463	1075	775	168	27	3	1
2001	370	1168	530	280	31	2	1
2002	472	1236	613	94	61	11	1
2003	220	1324	662	148	19	7	1
2004	623	970	822	88	23	3	2
2005	96	2169	406	324	9	1	1
2006	82	445	1232	57	30	1	1
2007	9	753	681	262	55	3	2
2008	1	327	870	147	50	1	0
2009	235	1482	484	225	42	14	4
2010	213	1693	235	142	41	9	19
2011	149	517	1178	27	8	0	1
2012	336	1083	399	550	22	3	1
2013	942	758	657	51	30	0	0
2014	279	2041	511	171	9	2	0
2015	146	1067	1393	134	33	2	1
2016	67	799	824	246	52	6	2

Table 2.3.14. Western Baltic cod. Catch in numbers ('000) at age (incl. Landing, discards, recreational catch).

age	a1	a2	a3	a4	a5	a6	a7+
1994	5005	7401	15838	2263	92	20	16
1995	4851	17678	5812	5870	1237	133	4
1996	23074	27282	18006	875	2090	111	3
1997	17798	2709	29690	2701	345	328	78
1998	19911	22553	2790	5946	683	108	77
1999	3541	33839	13461	1765	1246	248	93
2000	3992	11984	23730	3233	153	247	49
2001	3766	16106	7467	5140	824	48	90
2002	2436	11691	9128	1692	939	269	18
2003	1937	19085	5628	1471	250	198	67
2004	2932	3346	11977	1997	361	125	85
2005	1307	18005	2115	3305	351	92	50
2006	1214	4631	12876	612	602	78	15
2007	348	6566	3808	3939	472	222	35
2008	98	1502	3674	1098	921	258	128
2009	603	2410	2160	1218	549	198	85
2010	617	5928	1732	1054	477	142	72
2011	226	1533	4722	1568	373	82	42
2012	478	2658	1874	2709	589	63	15
2013	1266	2063	2855	1558	938	318	69
2014	1012	6351	1640	999	148	147	24
2015	547	2870	4719	534	259	35	63
2016	112	1995	2277	1293	194	62	37

Table 2.3.15. Western Baltic cod. Mean weight at age in commercial landings.

age	a1	a2	a3	a4	a5	a6	a7+
1994	0.445	0.834	1.367	2.378	4.491	6.436	5.659
1995	0.398	0.792	1.215	2.112	3.643	6.064	11.622
1996	0.442	0.685	1.086	2.091	2.879	5.544	8.372
1997	0.503	0.753	0.993	1.685	2.195	4.043	6.407
1998	0.524	0.737	1.155	1.915	2.960	3.940	6.444
1999	0.528	0.666	1.133	1.405	3.141	3.920	4.978
2000	0.509	0.707	0.957	1.655	3.479	5.174	7.302
2001	0.519	0.688	1.082	1.756	3.181	5.090	7.026
2002	0.512	0.716	1.124	1.701	3.386	4.079	6.586
2003	0.593	0.810	1.092	2.002	3.679	5.162	7.224
2004	0.517	0.776	1.008	1.487	3.376	4.179	6.131
2005	0.599	0.738	1.270	2.207	3.362	4.875	6.868
2006	0.217	0.625	1.086	2.485	3.674	4.205	5.730
2007	0.412	0.862	1.186	2.093	3.185	4.747	6.421
2008	0.437	0.906	1.347	2.187	3.234	4.352	6.955
2009	0.768	0.702	1.158	1.794	3.120	4.979	4.985
2010	0.807	0.944	1.111	1.805	2.924	3.384	4.306
2011	0.955	1.212	1.292	1.382	1.905	2.551	2.117
2012	0.902	0.976	1.189	2.000	2.610	2.506	3.504
2013	0.832	1.035	1.288	1.843	2.517	3.301	3.534
2014	0.859	0.988	1.467	2.793	3.857	5.577	5.453
2015	0.625	0.807	1.585	2.601	4.759	4.507	6.926
2016	0.000	1.027	1.239	2.488	3.273	4.947	6.309

Table. 2.3.16. Western Baltic cod. Mean weight at age in discards.

age	a1	a2	a3	a4	a5
1994-2014	0.082	0.262	0.391	0.531	0.469
2015	0.082	0.155	0.333	0.363	0.352
2016	0.082	0.297	0.371	0.487	0.962

Table 2.3.17. Western Baltic cod. Mean weight at age in catch (combined for commercial landings, discards, recreational catch).

age	a1	a2	a3	a4	a5	a6	a7+
1994	0.309	0.711	1.314	2.369	4.322	6.189	5.582
1995	0.287	0.669	1.162	2.086	3.620	6.009	9.181
1996	0.262	0.660	1.088	2.033	2.872	5.494	6.699
1997	0.297	0.754	0.996	1.697	2.226	4.041	6.372
1998	0.296	0.699	1.171	1.901	2.950	3.938	6.408
1999	0.313	0.595	1.123	1.454	3.120	3.918	4.970
2000	0.325	0.597	0.919	1.676	3.338	5.158	7.220
2001	0.369	0.611	1.082	1.763	3.181	5.057	6.995
2002	0.332	0.654	1.113	1.702	3.343	4.097	6.527
2003	0.384	0.641	1.073	1.981	3.654	5.136	7.178
2004	0.301	0.680	0.927	1.504	3.375	4.195	6.093
2005	0.334	0.598	1.256	2.165	3.377	4.874	6.833
2006	0.260	0.500	1.053	2.298	3.621	4.215	5.700
2007	0.293	0.674	1.044	2.029	3.030	4.736	6.331
2008	0.303	0.672	1.226	2.105	3.191	4.354	6.952
2009	0.405	0.454	1.144	1.816	3.081	4.852	4.977
2010	0.410	0.814	1.006	1.514	2.865	3.450	4.625
2011	0.484	0.974	1.228	1.239	1.618	2.542	2.177
2012	0.538	0.830	1.139	1.868	2.450	2.558	3.538
2013	0.634	0.704	1.133	1.220	2.134	3.258	3.536
2014	0.294	0.749	1.350	2.590	3.750	5.547	5.453
2015	0.355	0.635	1.443	2.458	4.433	4.448	6.900
2016	0.363	0.827	1.219	2.377	3.120	4.836	6.281

Table 2.3.18. Western Baltic cod. Mean weight (kg) at age in stock.

age	a0	a1	a2	a3	a4	a5	a6	a7+
1994	0.005	0.063	0.301	0.874	2.369	4.322	6.189	5.582
1995	0.005	0.063	0.301	0.874	2.086	3.620	6.009	9.181
1996	0.005	0.057	0.259	0.990	2.033	2.872	5.494	6.699
1997	0.005	0.050	0.327	0.896	1.697	2.226	4.041	6.372
1998	0.005	0.081	0.316	0.735	1.901	2.950	3.938	6.408
1999	0.005	0.042	0.285	0.801	1.454	3.120	3.918	4.970
2000	0.005	0.059	0.234	0.801	1.676	3.338	5.158	7.220
2001	0.005	0.043	0.388	0.895	1.763	3.181	5.057	6.995
2002	0.005	0.043	0.433	1.117	1.702	3.343	4.097	6.527
2003	0.005	0.054	0.321	1.032	1.981	3.654	5.136	7.178
2004	0.005	0.067	0.536	0.870	1.504	3.375	4.195	6.093
2005	0.005	0.051	0.350	1.038	2.165	3.377	4.874	6.833
2006	0.005	0.043	0.310	0.795	2.298	3.621	4.215	5.700
2007	0.005	0.073	0.411	0.908	2.029	3.030	4.736	6.331
2008	0.005	0.043	0.465	1.019	2.105	3.191	4.354	6.952
2009	0.005	0.051	0.559	1.327	1.816	3.081	4.852	4.977
2010	0.005	0.066	0.369	1.082	1.514	2.865	3.450	4.625
2011	0.005	0.045	0.360	0.767	1.239	1.618	2.542	2.177
2012	0.005	0.050	0.301	0.882	1.868	2.450	2.558	3.538
2013	0.005	0.049	0.391	0.866	1.220	2.134	3.258	3.536
2014	0.005	0.039	0.345	0.965	2.590	3.750	5.547	5.453
2015	0.005	0.055	0.409	0.924	2.458	4.433	4.448	6.900
2016	0.005	0.047	0.341	0.690	2.377	3.120	4.836	6.281

Table 2.3.19. Western Baltic cod. Proportion mature at age (spawning probability).

age	a1	a2	a3	a4	a5	a6	a7+
1994	0.03	0.35	0.74	0.78	1.00	1.00	1.00
1995	0.03	0.35	0.74	0.78	1.00	1.00	1.00
1996	0.03	0.35	0.74	0.78	1.00	1.00	1.00
1997	0.03	0.35	0.74	0.78	1.00	1.00	1.00
1998	0.03	0.35	0.74	0.78	1.00	1.00	1.00
1999	0.03	0.35	0.74	0.78	1.00	1.00	1.00
2000	0.04	0.52	0.83	0.81	1.00	1.00	1.00
2001	0.01	0.49	0.82	0.92	1.00	1.00	1.00
2002	0.01	0.40	0.79	0.82	1.00	1.00	1.00
2003	0.02	0.39	0.72	0.77	1.00	1.00	1.00
2004	0.02	0.46	0.77	0.79	1.00	1.00	1.00
2005	0.02	0.53	0.79	0.92	1.00	1.00	1.00
2006	0.01	0.70	0.88	0.98	1.00	1.00	1.00
2007	0.02	0.79	0.91	0.98	1.00	1.00	1.00
2008	0.03	0.81	0.87	0.95	1.00	1.00	1.00
2009	0.03	0.70	0.85	0.88	1.00	1.00	1.00
2010	0.17	0.69	0.80	0.84	1.00	1.00	1.00
2011	0.14	0.67	0.86	0.88	1.00	1.00	1.00
2012	0.19	0.67	0.81	0.89	1.00	1.00	1.00
2013	0.10	0.67	0.86	0.88	1.00	1.00	1.00
2014	0.08	0.67	0.81	0.89	1.00	1.00	1.00
2015	0.05	0.65	0.83	0.89	1.00	1.00	1.00
2016	0.08	0.71	0.85	0.83	1.00	1.00	1.00

Table 2.3.20. Western Baltic cod. Natural mortality at age.

age	a0	a1	a2	a3	a4	a5	a6	a7+
1994	0.8	0.266	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.8	0.286	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.8	0.286	0.2	0.2	0.2	0.2	0.2	0.2
1997-2016	0.8	0.242	0.2	0.2	0.2	0.2	0.2	0.2

Table 2.3.21. Western Baltic cod. Tuning fleets BITS Q4 and Q1.

BITS Q4	a0	a1	a2	a3	a4
2001	15858	798	349	41	88
2002	1994	1897	263	82	14
2003	19618	1235	739	33	45
2004	6556	11010	914	123	32
2005	5328	2499	1572	49	72
2006	2875	3631	316	314	80
2007	614	380	166	80	297
2008	24712	53	56	38	80
2009	3266	2363	61	49	25
2010	12132	853	522	14	13
2011	4304	1658	123	87	8
2012	19564	1648	391	45	58
2013	9085	3901	189	42	24
2014	7350	1631	750	74	63
2015	371	894	311	111	55
2016	62809	360	70	14	111

contiuned

Table 2.3.21. Western Baltic cod. Tuning fleets BITS Q4 and Q1.

BITS Q1	a1	a2	a3	a4
2001	5116	3866	836	396
2002	11877	2269	1294	81
2003	923	3279	364	110
2004	10478	1188	1650	41
2005	7332	25298	995	469
2006	10961	4691	5850	93
2007	2039	7590	1757	958
2008	99	792	872	216
2009	7525	609	661	198
2010	2741	8157	279	104
2011	10514	5677	10606	34
2012	1904	2703	1245	726
2013	7101	2379	1805	158
2014	4375	3820	494	142
2015	2866	4247	1469	100
2016	102	1224	726	375
2017	13786	581	989	140

Table 2.3.22. Western Baltic cod. Estimated recruitment (millions), total stock biomass (TBS), spawning stock biomass (SSB) (tonnes), and average fishing mortality for ages 3 to 5 (F35).

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F35	Low	High
1994	64602	86267	427966	49613	35380	69571	31729	21640	46523	1.184	0.97	1.444
1995	90219	28633	160123	50413	39270	64717	29822	22700	39178	1.246	1.043	1.487
1996	27889	85193	395268	53210	40844	69319	33124	25350	43281	1.19	1.01	1.403
1997	85050	111911	515318	52313	38873	70399	34475	24877	47777	1.19	1.012	1.4
1998	114005	40538	184241	52365	40482	67736	26930	20809	34851	1.209	1.03	1.419
1999	37235	39698	171603	53370	40338	70612	31445	24061	41095	1.296	1.104	1.521
2000	37647	27560	111734	47715	35939	63349	36279	26822	49071	1.294	1.108	1.51
2001	24077	45040	160284	38292	30682	47790	29057	23065	36605	1.314	1.115	1.548
2002	40135	15108	62630	32112	25726	40085	22494	17824	28388	1.268	1.079	1.491
2003	14241	70085	252342	28311	22743	35242	17361	14070	21422	1.181	1.011	1.38
2004	67711	27465	96117	30915	24531	38960	19205	14870	24803	1.123	0.957	1.318
2005	23225	24631	87224	38832	30412	49584	26635	21129	33576	1.047	0.886	1.239
2006	22948	8417	29483	35882	27795	46323	30853	23773	40043	0.951	0.775	1.167
2007	6920	3430	16305	33827	26794	42705	31008	24387	39426	0.964	0.806	1.152
2008	3298	30444	122558	23412	18944	28933	21314	17172	26453	0.992	0.839	1.173
2009	27695	13308	46812	17429	14351	21168	14098	11491	17297	1.003	0.848	1.187
2010	11015	19205	72917	17389	13827	21868	13100	10501	16343	0.996	0.841	1.18
2011	15891	14252	50380	16463	12597	21516	13212	9999	17457	0.971	0.818	1.153
2012	11509	35265	131313	18787	14787	23868	15205	11826	19551	0.964	0.809	1.149
2013	30333	20226	73666	15559	12610	19197	12087	9694	15072	1.056	0.852	1.308
2014	16543	12035	46092	19716	15829	24558	15387	12390	19109	0.99	0.8	1.224
2015	10098	2542	14529	20910	16297	26830	16828	13063	21679	0.948	0.729	1.233
2016	2600	38307	548312	16895	12232	23337	13479	9689	18752	0.93	0.668	1.294
2017	65408	15580	272653				12932	7448	20492			
Avr.	**35429**	**33964**	**168745**	**33206**	**25708**	**42942**	**22836**	**17444**	**29927**	**1.10**	**0.92**	**1.32**

Table 2.3.23. Western Baltic cod. Estimated stock numbers (SAM).

Year\Age	0	1	2	3	4	5	6	7+
1994	192144	64602	18162	31195	4498	218	24	20
1995	67711	90219	45252	8266	8761	1335	60	8
1996	183506	27889	67508	21049	1907	2414	274	10
1997	240145	85050	13308	33962	4782	563	545	80
1998	86422	114005	56162	5755	8182	1228	153	148
1999	82537	37235	78747	23766	1514	1963	305	87
2000	55492	37647	25059	33223	5391	307	412	82
2001	84965	24077	26450	9822	6981	1373	67	111
2002	30761	40135	17445	11119	2043	1542	342	35
2003	132986	14241	32533	7372	2296	505	349	91
2004	51380	67711	10778	16300	1986	558	142	115
2005	46351	23225	54014	5221	4707	550	128	65
2006	15753	22948	15880	25362	1763	1340	143	41
2007	7479	6920	15722	8023	7377	745	417	55
2008	61084	3298	5176	6966	2565	1830	263	154
2009	24959	27695	3893	3618	2130	812	406	116
2010	37421	11015	22137	2875	1424	621	202	123
2011	26796	15891	7842	12613	1456	500	135	73
2012	68050	11509	11138	4361	4564	672	135	44
2013	38600	30333	7790	5863	1537	1384	221	59
2014	23553	16543	21043	3858	1806	342	306	57
2015	6078	10098	10850	10409	1243	490	80	99
2016	144929	2600	6782	4863	3477	380	124	53
2017	144929	65408	1997	4155	1684	1169	107	50

Table 2.3.24. Western Baltic cod. Estimated fishing mortalities by age from SAM.

Year\Age	1	2	3	4	5+
1994	0.107	0.585	1.168	1.103	1.28
1995	0.111	0.612	1.233	1.164	1.34
1996	0.111	0.605	1.208	1.119	1.244
1997	0.11	0.607	1.213	1.13	1.229
1998	0.11	0.619	1.234	1.157	1.235
1999	0.113	0.655	1.32	1.248	1.32
2000	0.111	0.661	1.331	1.245	1.306
2001	0.11	0.668	1.354	1.266	1.321
2002	0.103	0.637	1.299	1.224	1.282
2003	0.093	0.579	1.189	1.139	1.214
2004	0.084	0.527	1.097	1.081	1.19
2005	0.076	0.483	1.003	1.004	1.135
2006	0.069	0.439	0.909	0.907	1.038
2007	0.067	0.432	0.904	0.922	1.065
2008	0.064	0.42	0.899	0.948	1.129
2009	0.062	0.409	0.884	0.961	1.165
2010	0.059	0.392	0.858	0.956	1.175
2011	0.057	0.376	0.833	0.935	1.146
2012	0.057	0.377	0.835	0.933	1.124
2013	0.06	0.406	0.91	1.023	1.233
2014	0.059	0.392	0.868	0.956	1.145
2015	0.058	0.383	0.842	0.911	1.092
2016	0.057	0.379	0.831	0.89	1.068

Table 2.3.25. Western Baltic Cod. Input to short-term forecast.

2017									
Age	N	M	Mat	PF	PM	SWt*	Sel	CWt	LWt
1	65408	0.242	0.07	0	0	0.05	0.06	0.34	0.74
2		0.2	0.68	0	0	0.36	0.38	0.74	0.94
3		0.2	0.83	0	0	0.86	0.84	1.34	1.43
4		0.2	0.87	0	0	2.47	0.91	2.47	2.63
5		0.2	1.00	0	0	3.77	1.09	3.77	3.96
6		0.2	1.00	0	0	4.94	1.09	4.94	5.01
7		0.2	1.00	0	0	6.21	1.09	6.21	6.23
2018									
Age	N	M	Mat	PF	PM	SWt*	Sel	CWt	LWt
1	14206	0.242	0.07	0	0	0.05	0.06	0.34	0.74
2		0.2	0.68	0	0	0.36	0.38	0.74	0.94
3		0.2	0.83	0	0	0.86	0.84	1.34	1.43
4		0.2	0.87	0	0	2.47	0.91	2.47	2.63
5		0.2	1.00	0	0	3.77	1.09	3.77	3.96
6		0.2	1.00	0	0	4.94	1.09	4.94	5.01
7		0.2	1.00	0	0	6.21	1.09	6.21	6.23
2019									
Age	N	M	Mat	PF	PM	SWt*	Sel	CWt	LWt
1	14499	0.242	0.07	0	0	0.05	0.06	0.34	0.74
2		0.2	0.68	0	0	0.36	0.38	0.74	0.94
3		0.2	0.83	0	0	0.86	0.84	1.34	1.43
4		0.2	0.87	0	0	2.47	0.91	2.47	2.63
5		0.2	1.00	0	0	3.77	1.09	3.77	3.96
6		0.2	1.00	0	0	4.94	1.09	4.94	5.01
7		0.2	1.00	0	0	6.21	1.09	6.21	6.23

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); * updated numbers in September 2016 because of a typo.

Sel = Exploitation pattern

CWt = Weight in catch (Kg)

LWt = Weight in commercial landings (Kg)

Natural mortality (M): Constant

Weight in the landing, catch (LWt, CWt): average of 2014-2016

Weight in the stock (SWt): average of 2014-2016

Exploitation pattern (Sel.): average of 2015

Table 2.3.26. Western Baltic Cod. Output of short-term forecast.

Basis	Total catch (2018)*	Commercial catch, assuming recreational catch of 1754 tonnes	Wanted catch** (2018)	Unwanted catch** (2018)	F_{total} (2018)	F_{wanted} (2018)	$F_{unwanted}$ (2018)	SSB (2019)	% SSB change **	% Advice change ***
ICES advice basis										
MSY approach: F_{MSY} $F = F_{MSY} \times (SSB_{2018}/ \text{MSY } B_{trigger})$ EU multi annual management plan	5295	3541	3454	87	0.19	0.12	0.003	48929	76	286
F = MAP^ $F_{MSY\ lower}$ $F = \text{MSY } F_{lower(AR)} \times (SSB_{2018}/ \text{MSY } B_{trigger})$	3130	1376	1342	34	0.11	0.05	0.001	51190	84	50
Other options										
F_{MSY}	7154	5400	5268	132	0.26	0.19	0.005	46848	69	489
Zero commercial catch	1754	0	0	0	0.06^^	0	0	52747	90	-100
F_{pa}	17569	15815	15428	387	0.74	0.65	0.016	35931	29	1625
F_{lim}	22078	20324	19827	497	1.01	0.91	0.023	31076	12	2116
SSB (2019) = B_{lim}	25804	24050	23462	588	1.27	1.15	0.029	27399	-1	2523
SSB (2019) = B_{pa}	15195	13441	13112	329	0.62	0.54	0.013	38399	38	1366
SSB (2019) = MSY $B_{trigger}$	15195	13441	13112	329	0.62	0.54	0.013	38399	38	1366
F = F_{2017}	9792	8038	7841	197	0.37	0.30	0.007	43779	58	777

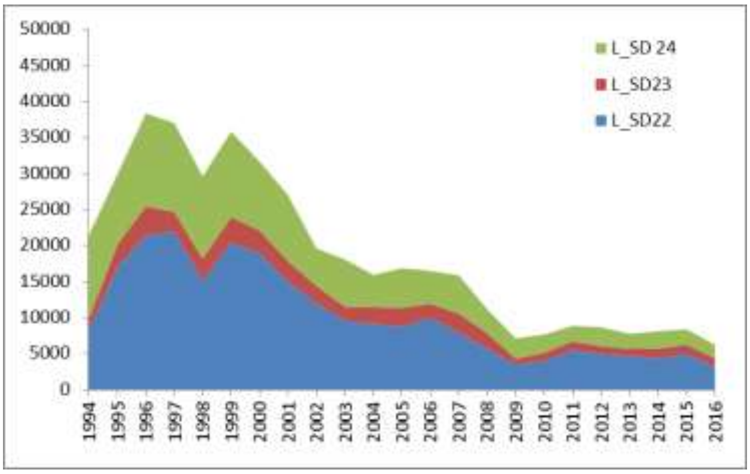


Figure 2.3.1. **Western Baltic cod. Landings by SD (tonnes).**

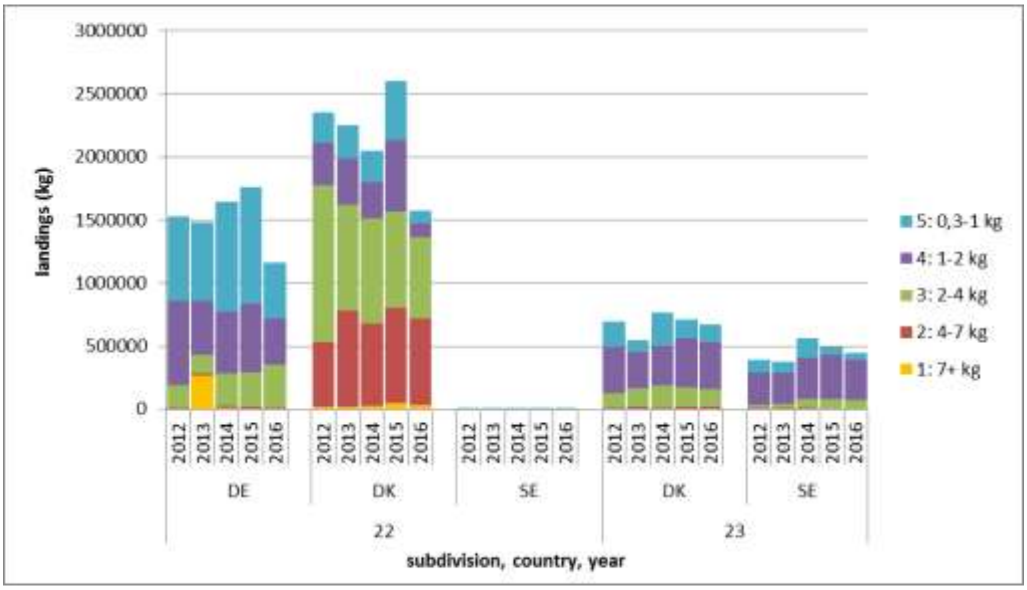


Figure 2.3.2. **Western Baltic cod stock. Landings of cod by commercial size sorting categories in SD22 and SD23 by country (DE: Germany; DK: Denmark; SE: Sweden) and year (2002–2016).**

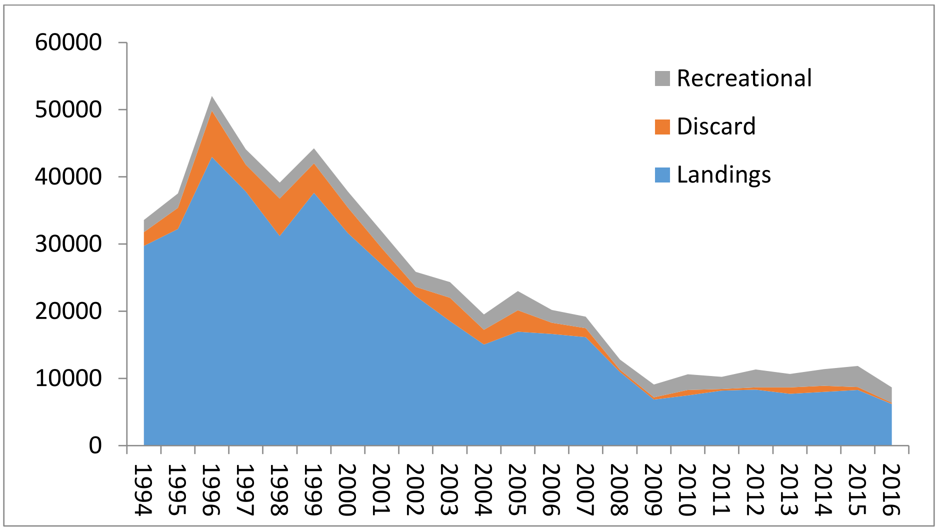


Figure 2.3.3. Western Baltic cod. Commercial landings, discard and recreational catch (tonnes).

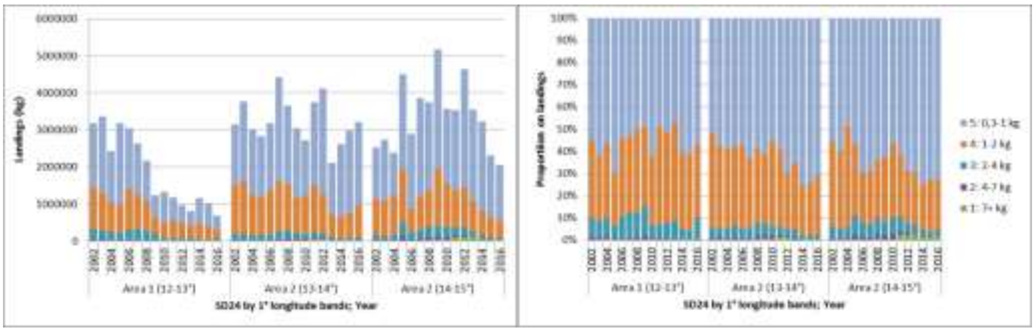


Figure 2.3.4. Western Baltic cod. Landings of cod by commercial size sorting categories in SD24 by 1° longitude bands and year (2002–2016). Data from DK, GER, SWE, POL. Left panel: Absolute values; right panel: relative values.

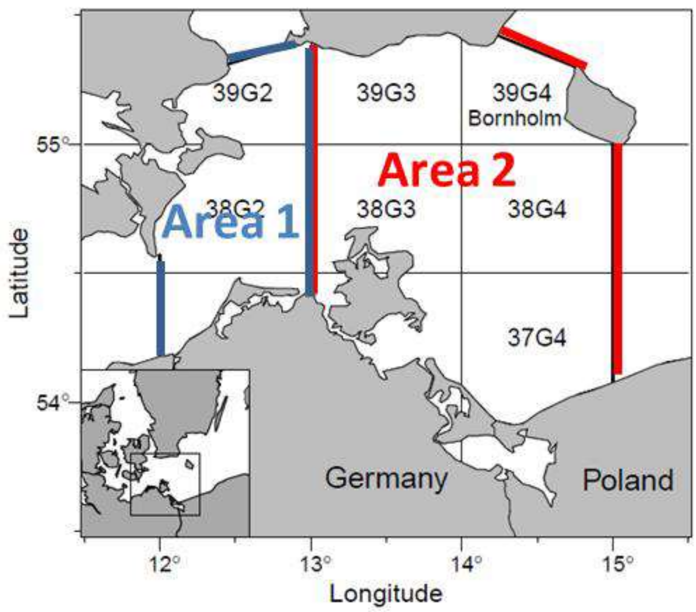


Figure 2.3.5. Western Baltic cod. Subareas (Area 1 and Area 2 within SD 24) for which different keys for splitting between eastern and western Baltic cod catches in SD 24 were applied.

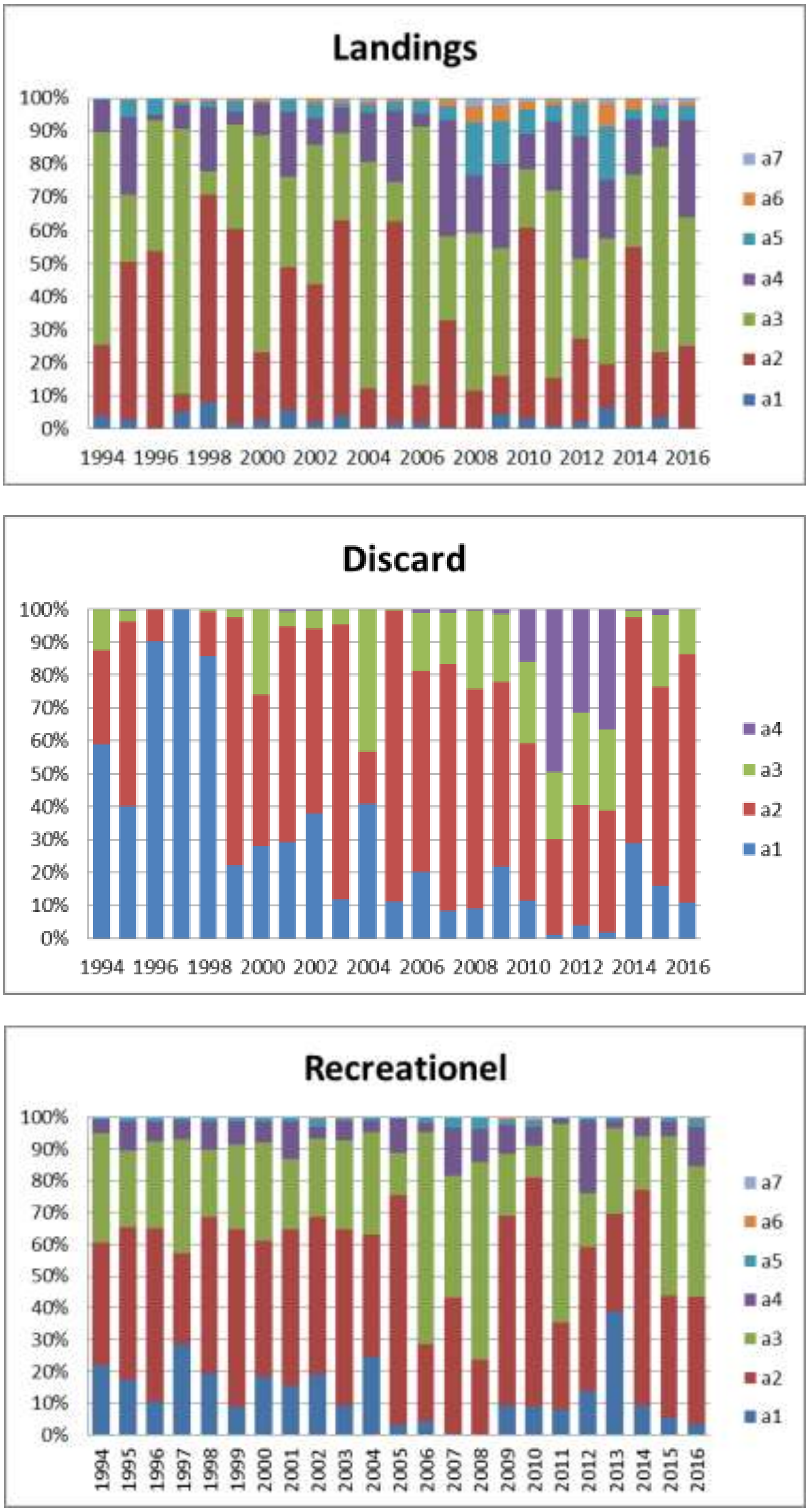


Figure 2.3.6. Western Baltic cod. Number at age distribution of cod in commercial landings, discards and recreational catch (relative proportions).

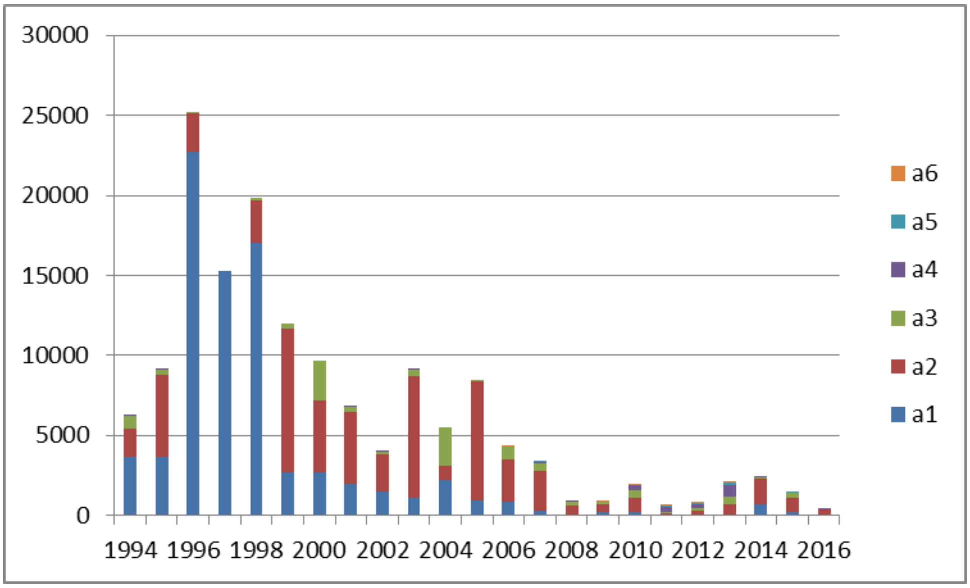


Figure 2.3.7. Western Baltic cod. Commercial discards in numbers by age (absolute values).

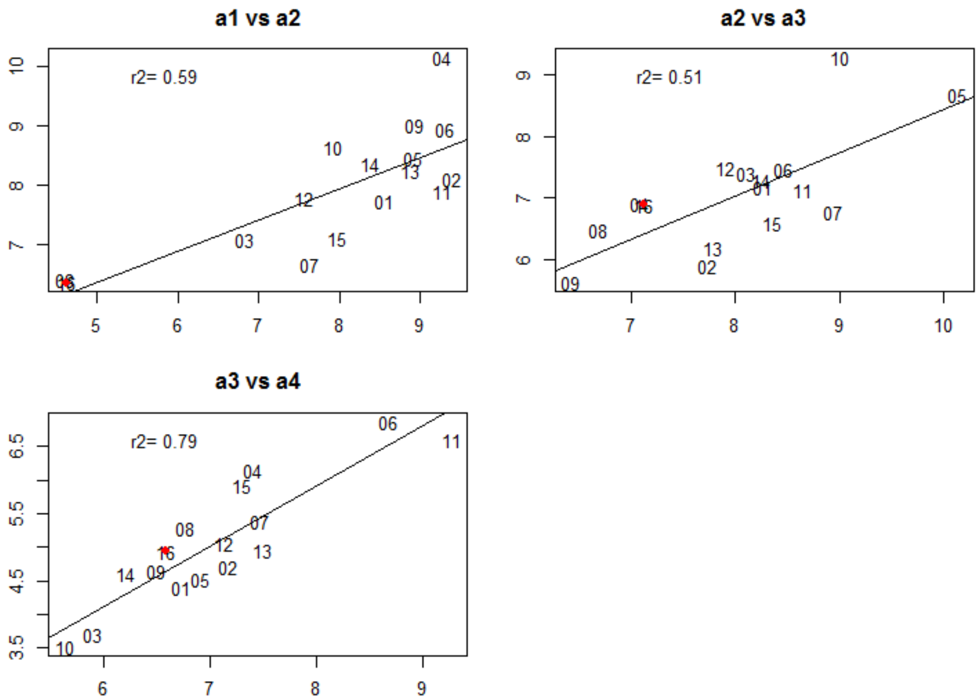


Figure 2.3.8. Western Baltic cod. CPUE at age *i* vs numbers at age *i* +1 in the following year, in BITS Q1 survey. Red dots highlight the information from the latest year.

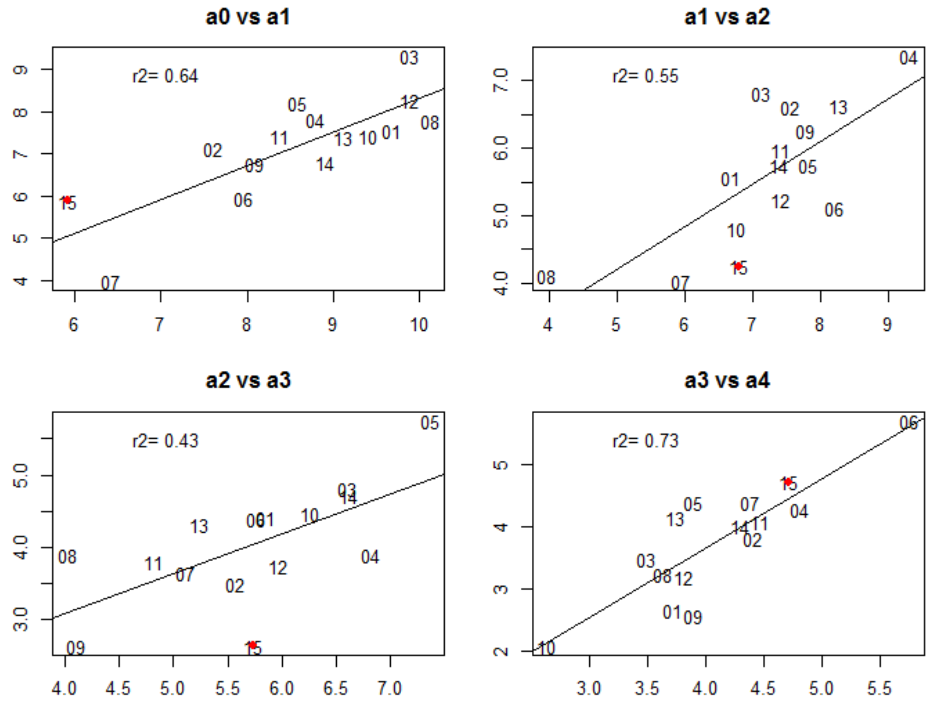


Figure 2.3.9. Western Baltic cod. CPUE at age *i* vs numbers at age *i* +1 in the following year, in BITS Q4 survey. Red dots highlight the information from the latest year.

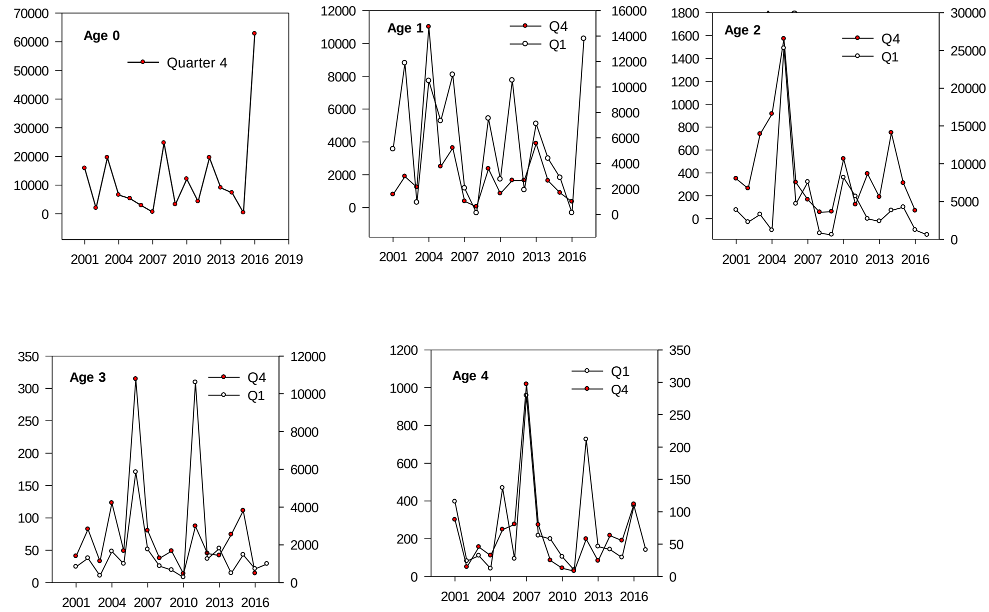


Figure 2.3.10. Western Baltic cod. Time series of BITS Q1 and BITS Q4 in numbers by age groups.

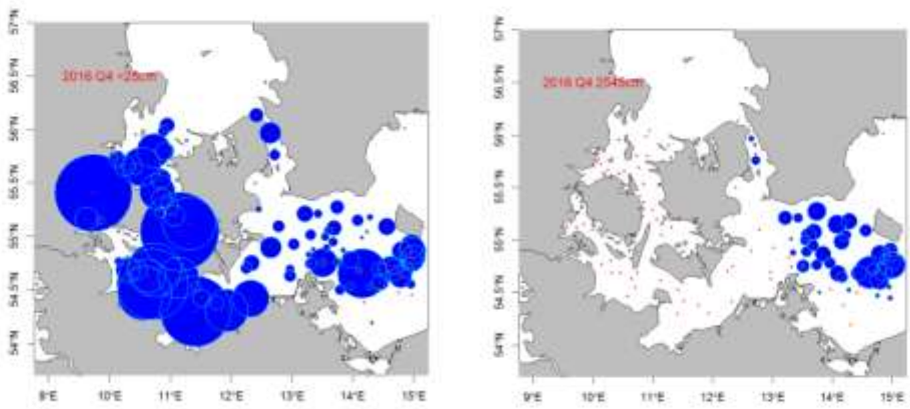


Figure 2.3.11. Western Baltic cod. Distribution of cod<25 cm from BITS Q4 2016 (left) and cod 25-45 cm (right).

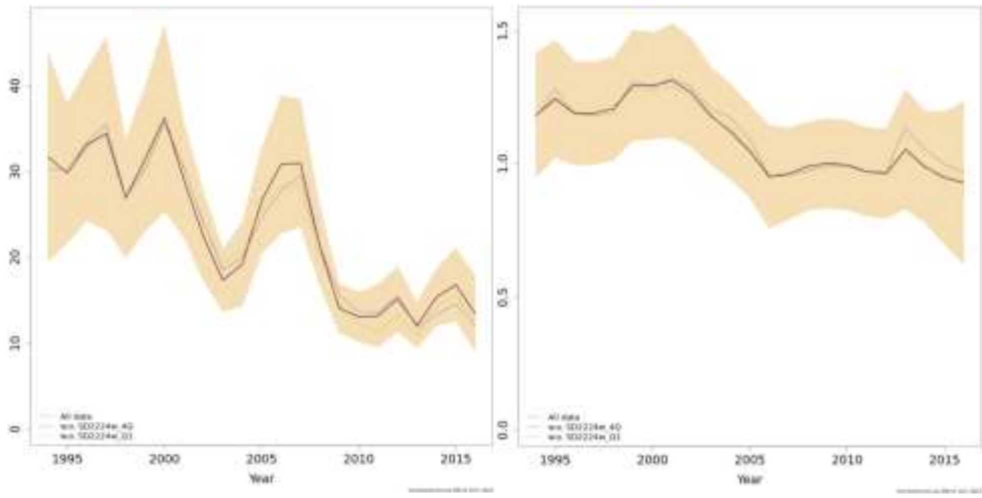


Figure 2.3.12. Western Baltic cod. The SSB and F from exploratory runs leaving out one tuning series at a time.

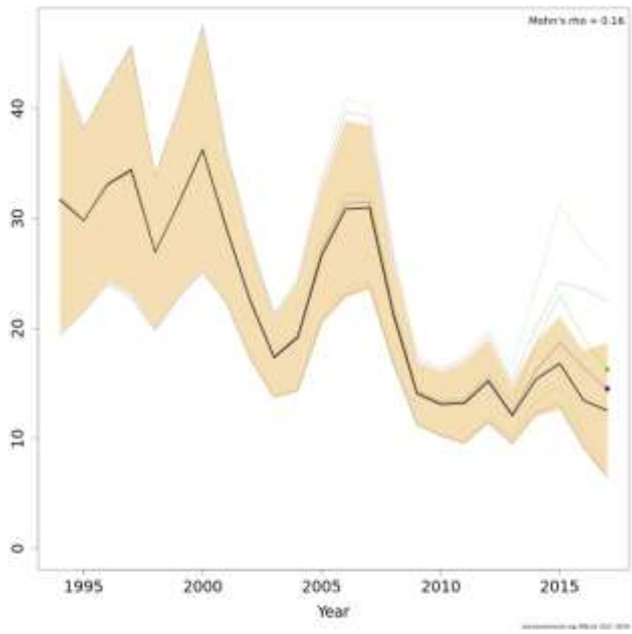


Figure 2.3.13. Western Baltic cod. The retro SSB from exploratory runs excluding the catch data of the last 2 years.

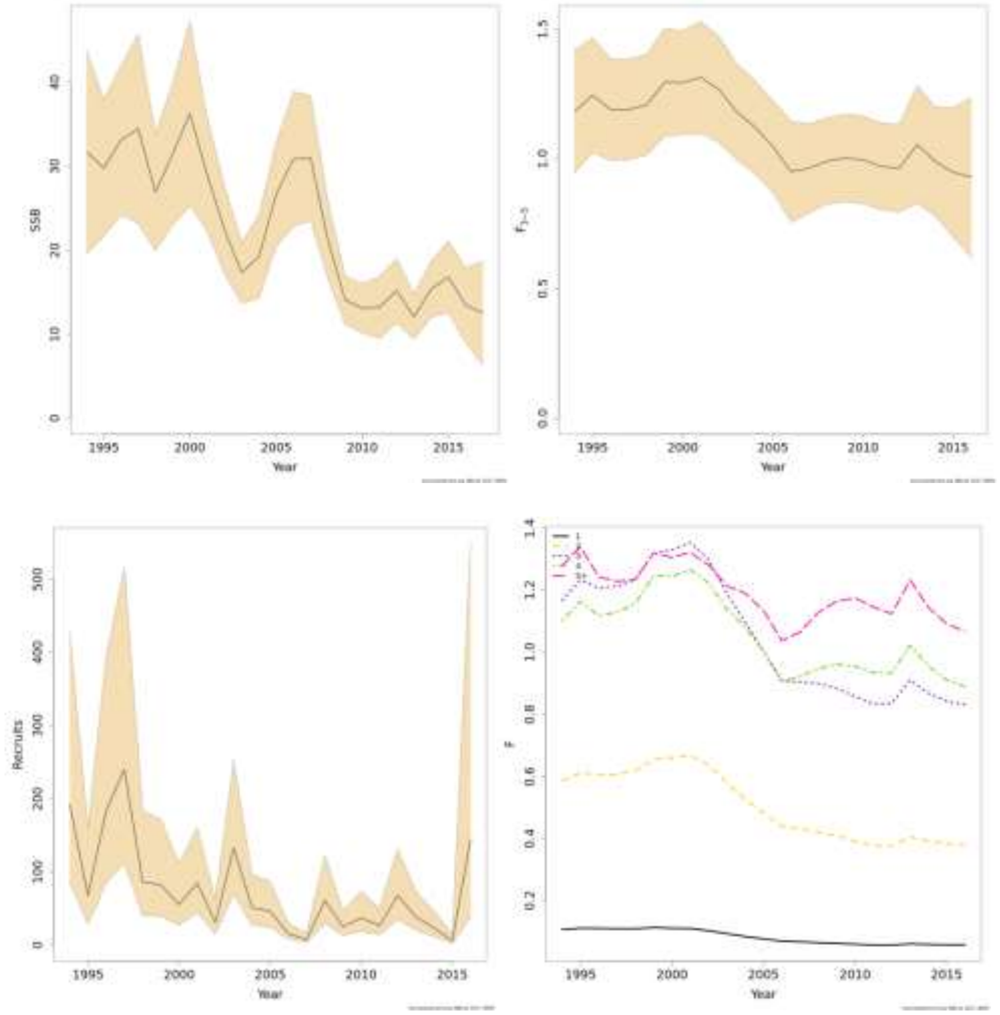


Figure 2.3.14. Western Baltic cod. SSB (upper left), F (3–5) (upper right) and stock numbers at age 0 (lower left) and F by age groups (lower right) from the final assessment.

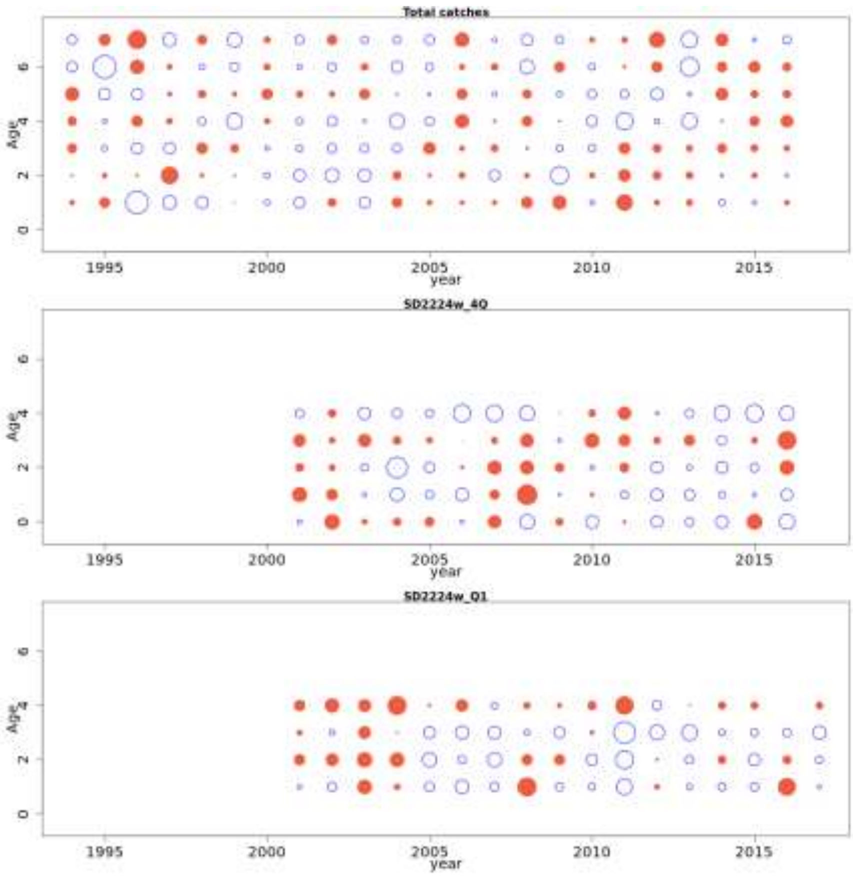


Figure 2.3.15. Western Baltic cod. Standardized residuals from the final SAM run where open circles are positive and filled circles are negative residuals.

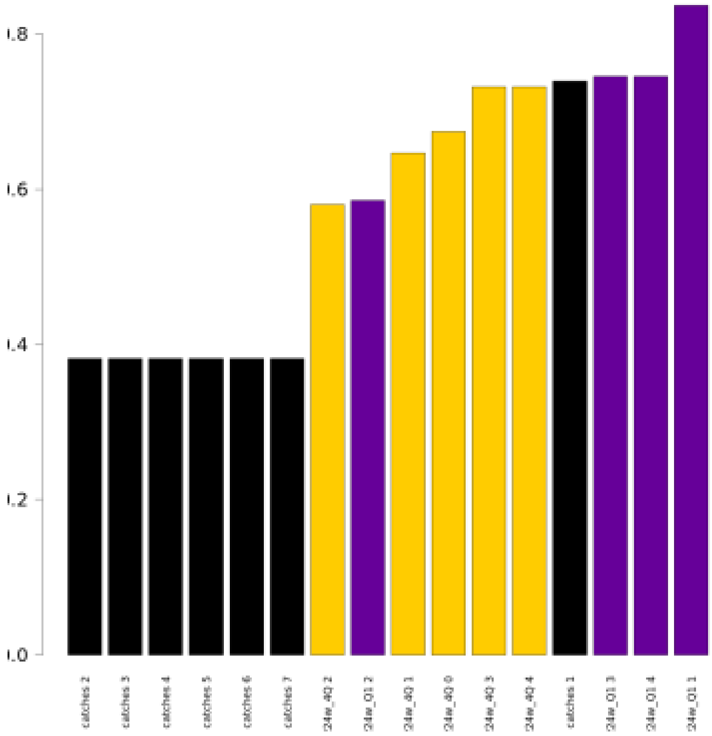


Figure 2.3.16. **Western Baltic cod. SD of log observations from catch data and surveys by age, Y scale is from 0.0 to 0.8.**

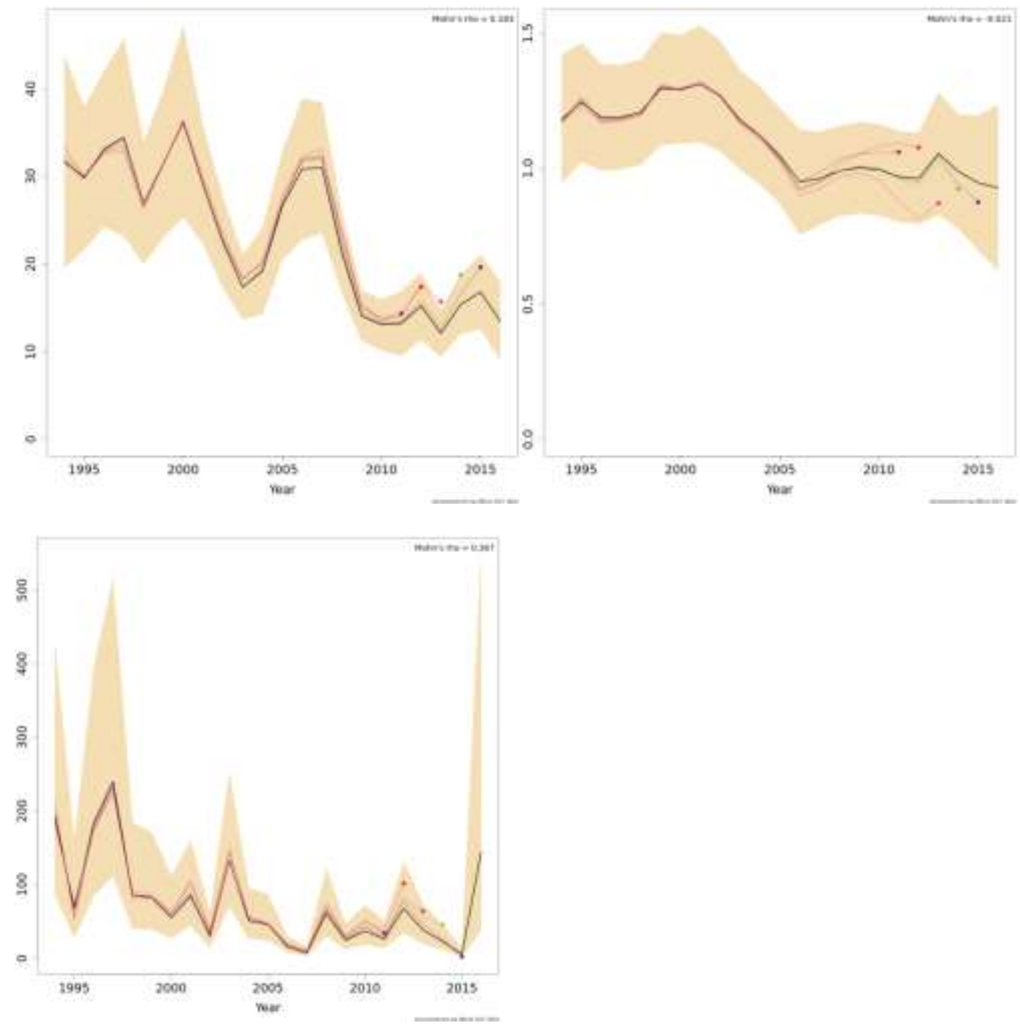


Figure 2.3.17. Western Baltic cod. Retrospective analyses of SSB, F(3–5) and recruitment (age 0).

3 Flounder in the Baltic

3.1 Introduction

3.1.1 WKBALFLAT – Benchmark

In January 2014 the flounder stocks in the Baltic were benchmarked. As a result four different stocks of flounder were identified - fle(WKBALFLAT 2014). Flounder (Platichthys flesus) is the most widely distributed among all flatfish species in the Baltic Sea.

There are significant disparities between two sympatric flounder populations in the Baltic Sea, the pelagic and the demersal spawners. They differ in their spawning habitat, egg characteristics (Nissling *et al.*, 2002; Nissling and Dahlman, 2010) and genetics (Florin and Höglund, 2008; Hemmer-Hansen *et al.*, 2007a), although they utilize the same feeding grounds in summer - autumn (Nissling and Dahlman, 2010).

Demersal spawners produce small and heavy eggs which develop at the bottom of shallow banks and coastal areas in the northern part of the Baltic Proper. They were established as a one stock/assessment unit comprised of SDs 27, and 29-32, but they also inhabit SD28 (Nissling and Dahlman, 2010).

Pelagic spawners are distributed in the southern and the deeper eastern part of the Baltic Sea and spawn at 70–130 m depth. The activation of their spermatozoa and fertilisation occurs at an average of 10–13 psu, whereas an average salinity required to obtain neutral egg buoyancy is 13.9–26.1 psu (Nissling *et al.*, 2002).

There are also differences within the pelagic spawners, which led to the designation of three stocks/assessment units at the DCW KBALFLAT: SD 22 and 23; SD 24 and 25; SD 26 and 28 (ICES, 2014). There is evidence of a differentiation between SD 22 and 23 from SD 24 and 25 based on egg buoyancy (Nissling *et al.*, 2002), length at maturity, and to some extent genetics (Hemmer-Hansen *et al.*, 2007b). Even though there is no physical connection between SD 22 and SD23, flounder in these areas are assumed to be connected through the western part of SD 24.

Flounder in SD 24 and 25 are also different from flounder in SD 26 and 28 based on separate spawning areas, and tagging data indicate no dispersal between these areas (Cieglewicz, 1963; Otterlind, 1967; Vitinsh, 1976). Trends in survey cpue are inconclusive and the extent of exchange of early life stages between the areas is unknown. Therefore, the distinction between these two stocks should be further examined, e.g. whether a more consistent assessment with lower uncertainty would be obtained in merging these two units. For the time being, it was decided to assume two separate stocks.

The migrations between the mature flounder stocks are limited. Details can be found in Appendix 7.

3.1.2 Discard

During WKBALFLAT the quality of the estimations of discards were questioned. The main problem was very high flounder discards variability, which exceed the landings or sometimes are even 100% of the catch. Within InterCatch, it is not possible to raise discard data properly, when discard data are available for particular stratum and there is no landing of flounder assigned, then the discard is estimated as zero (see introduction section on IC for further comments).

Because the discard ratio in both subdivisions is significantly different between countries, fleets, vessels and even individual hauls of the same vessel and trip, a common discard ratio cannot be applied. Discarding practices are, in fact, controlled by factors such as market price and cod catches.

According the call for data submission for ICES WGBFAS, new method for estimated the discards was recommended and should be applied to all flounder stocks, here the main issue was that the discard should be raised by total landings or effort and not by the landings of flounders:

$$\text{Discard Rate}_{\text{Time,SD,fleet segment,Species}} = \frac{\sum \text{Weight of discard}_{\text{Trip,Haul,Time,SD,Fleet segment,Species}}}{\sum \text{Weight of landing}_{\text{Trip,Haul,Time,SD,Fleet segment}}}$$

$$\text{Discard (ton)}_{\text{Time,SD,Fleet segment,Species}} = \text{Landings (ton)}_{\text{Time,SD,fleet segment}} \times \text{Discard Rate}_{\text{Time,SD,fleet segment,Species}}$$

WKBALFLAT recommended, that the quantitative assessment cannot be provided until discards recalculation by using better approach, which avoid the underestimation of discards.

3.1.3 Tuning fleet

Since 2001 the Baltic International Trawl Survey (BITS) has been carried out using a new (stratified random) design and a new standard gear (TV3). BITS surveys are performed twice a year, in 1^{st} and 4^{th} quarter.

For the northern Baltic Sea flounder the surveys used were four national gillnet surveys since the BITS survey was deemed inappropriate for this stock (not covering shallow areas, not covering Northern Baltic Sea). From Estonia two surveys were available and from Sweden 2 surveys were available as well.

3.1.4 Effort

Time series from 2009/2016 was available from ICES WGBFAS data call where countries submitted flatfish effort data by fishing fleet and subdivision. Effort data was asked to report as days at sea. However, different calculation methods were used by countries. Some countries reported all of fishing days when flounder were landed, some countries reported number of fishing days were significant amount of flounder were landed, while some countries reported fishing days for whole demersal fleet. It was discussed than in the future more specific description about methodology should be given.

Standardisation and weighting factor was applied for submitted effort data to calculate a common effort index for whole population. First, every country data were standardised using proportion for given year from the national average. Standardised effort data were weighted by demersal fish landings for every country and year and final effort for whole population was calculated summing all countries efforts.

3.1.5 Biological data

Because of the major age determination problems in flounder, WGBFAS decided in 2006 that age data from whole otoliths shall not be used for assessment (ICES, 2006; see also Gardmark, *et al.*, 2007; ICES, 2007a).

3.1.6 Survival rate

Survival rate for the discarded flounder is unknown. However, the relatively wide range of survival rates was obtained from several studies conducted in the Baltic Sea (see WKBALFLAT 2014, WD 2.1). During WKBALFLAT the precautionary level of survival rate was assumed as 50% in I and IV quarter and 10% in II and III quarter (ICES, 2014b).

3.1.7 Reference points

The stock status was evaluated by calculating length based indicators applying the LBI method developed by WKLIFE V (ICES, 2015). Commercial landings were used to estimate length distribution and average weight by length groups. Biological parameters: Linf and Lmat were calculated using survey data from DATRAS. For estimating Linf data from Q1 and Q4 were taken unsorted by sex. In the case of Lmat data were derived from only from Q1 and females, as distinguishing between mature and immature fish were possible only for this time of the year.

3.2 Flounder in subdivisions 22 and 23 (Belts and Sound)

3.2.1 The fishery

The landing data of flounder in the Western Baltic (fle.27.2223) according to ICES subdivisions and countries are presented in Table 3.2.1. The trend and the amount of the landings of this flatfish are shown in Figure 3.2.1.

Flounder is mainly caught in the area of Belt Sea (SD 22) with Denmark and Germany being the main fishing countries. The Sound (SD 23) is of minor importance for the contribution to the total landings (Table 3.2.2). Denmark and Sweden are the main fishing countries there.

Flounder are caught mostly by trawlers and gillnetters. The minimum landing size is 23 cm. Active gears provide most of the landings in SD 22 (ca. 70%), whereas landings from passive gears are low. However, in SD 23, passive gears provide around 85% of total flounder landings (for Swedish fleet 98–100%) in this area. Flounder is caught as a bycatch-species in cod targeting fisheries (i.e. mostly trawlers) and in a mixed flatfish fishery (i.e. mostly gillnetters).

3.2.2 Landings

The highest total landings of flounder in subdivisions 22 and 23 were observed at the end of the seventies (3790 t in 1978). Landings decreased in the period between 1989 and 1993. Since 1993 the landings increased again and reached a moderate temporal maximum in 2000 (2597 t). After 2000 the landings decreased to 866 t in 2006. Landings slightly increased since 2006 and vary between 1400 and 1000 tonnes since then. Landings in 2016 were about 1153 tonnes.

3.2.2.1 Unallocated removals

Unallocated removals might take place but are considered minor and are not reported from the respective countries. Recreational fishery on flounder might take place with unknown removals, but is also considered to be of minor influence.

3.2.2.2 Discards

Discards of flounder are known to be high with ratios around 20–50% of the total catch of vessels using active gears (e.g. trawling). Passive fishing gears have lower discards, varying between 10 to 20% of the total catch. Depending on market prices and quota of target species (e.g. cod), discards vary between quarters and years. The discarded fraction can cover all length-classes and rise up to 100% of a catch.

The available data on discards are incomplete for all subdivisions. In 2016, discard-data from the passive-gear segment of the commercial fisheries is considered limited and therefore not sampled by Denmark. The quality of the discard data increased in recent years, as more estimation was given by the national data submitters. In strata not having landings assigned, no discard-information was given.

Subdivision 22 (the Belt) shows a very good sampling coverage that allows reasonable discard estimations at least for the last four years. Subdivision 23 (Sound) is sampled less; only a few biological samples are available. However, discard estimations provided by national data submitters are given in many strata.

Sampling intensity has increased steadily in the last years; therefore less discard ratio were borrowed. Table 3.2.3 gives an overview of total landings and the estimated discard weights and empty strata. Before 2006, sampling intensity was too low to give a reasonable estimation, especially in the passive segment, where almost no data are available. The discard in 2016 is estimated to be around 495 tonnes, which would result in a discard ratio of 30% of the total catch.

3.2.2.3 Effort and CPUE Data

The CPUE was calculated as standardized fishing effort for both, the demersal active and passive fleet. National fleet effort (days at sea) per SD is transformed into a standard catch (effort per stratum and country divided by average effort per country over the period 2009–2016). Standard catches were weighted by the mean of cod landings by country and fleet.

Fishing effort in subdivisions 22 and 23 decreased from 2004 to 2010 with 50% and has remained stable since then. No significant change in effort was found in the time-period 2009 to 2016 for active gears (Figure 3.2.3). Passive gears show a slight, but continuous decrease since 2012.

3.2.3 Biological composition of the catch

Length-distributions from commercial fisheries sampling are available from Germany, Denmark and Sweden in the time-period from 2000 onwards. However, the available length-sampling do not cover all strata in the given period of 2000 to 2016.

These gaps in sampling (e.g. non-sampled length-distribution in quarter for a given fishing gear by a country) were filled by the stock-coordinator by borrowing/extrapolating from similar strata. The resulting length-distributions were tested for their internal consistency.

Age-data are considered to be applicable only when the ageing was conducted using new method (i.e. breaking and burning of otoliths) as recommended by ICES WKARFLO (2007; 2008) and ICES WKFLABA (2010).

From commercial fisheries samples, age information for catch numbers ate age (CANUM) and mean weights in the catch (WECA) are available from Germany (2009 onwards) and Denmark (2012 onwards). CANUM and WECA per length are available from 2014 to the recent year and used to calculate MSY proxy reference points.

In years where only numbers-at-length are available (but no age-data), preliminary analyses applying statistical slicing method using the von-Bertalanffy growth-equation have been conducted (see Section 3). Further development and validation of this approach, for example comparison with real age reading data for later years, is encouraged.

The calculated age-based CANUM for the period 2000 onwards were only used for exploratory analyses during the benchmark in 2014 and 2015, due to issues with sampling-coverage and data-quality before 2009. Further, the age distributions derived from slicing methods should be verified against real age readings for years when these are available.

3.2.3.1 Catch in numbers

The catch in numbers per length for the three most recent years is given in Figure 3.2.4.. Almost no flounder above 35 cm are caught (Figure 3.2.4).

3.2.3.2 Mean weights-at-age

Mean weight per length class was almost only available from German sampling-program (commercial fisheries, Figure 3.2.5). Germany has no fishery in SD 23, therefore, no weight-information were available. Calculated weights from SD 22 were assumed to be the same as SD 23. It is however unlikely, that mean-weights are similar, since the fishing pattern and timing is different between the subdivisions. SD 23 shows almost no active fisheries, almost 90% of the catches come from passive gears. Passive gears often catch larger fishes and have a lower discard-rate. Recent years show a decrease in the average weight for almost all age classes.

3.2.3.3 Maturity-at-age

The maturity ogive was taken from the BIT survey. Both quarters from the period 2000 to 2016 were combined and an average maturity-at-age was calculated:

Age	1	2	3	4	5	6	7	8	9	10
Maturity	0.12	0.56	0.81	0.95	0.94	0.94	0.88	0.88	0.90	1.00

The benchmark in 2015 (ICES 2015) additionally recommended that sex-ratios should be available at least in a pilot study to determine whether it has an influence on the assessment or both sexes can be combined in future assessments.

3.2.3.4 Natural mortality

No further information or studies on natural mortality are available. The average natural mortality for all age classes is set at 0.2 as a default.

3.2.4 Fishery independent information

The "Baltic International Trawl Survey (BITS)" is covering the area of the flounder stock in SD 22–23. The survey is conducted twice a year (1st and 4th quarter) by the member states having a fishery in this area. Survey-design and gear is standardized. Due to a change in trawling gear in 2000, only first and fourth quarter BITS since 2001 are considered. Effort and biomass-index are calculated from the catches. The BITS-Index is calculated as:

Average number of flounder >= 20 cm weighted by the area of each depth stratum which all together covers the area covered by the stock. These are multiplied with the average weight of the length-class (Figure 3.2.6).

In 2012, one haul in the Q4 survey was excluded from the calculations in SD 23 as it was clearly an outlier, providing values ten times higher than in all other years in this area.

3.2.5 Assessment

The flounder stock in SD 22–23 is categorized as a data-limited-stock (DLS). Especially data from the beginning of the time-period (2000–2006) is considered as very poor with a low sampling-coverage in time and space. More than half of the strata (landings and discards) from that period were filled with borrowed data (extrapolated length-distributions and mean weights per length-class). Any analytical assessment using this data-matrix can only be used as an exploratory assessment, but not for reasonable advice.

Following the instructions of the ICES DLS Guidance Report (2012), the stock is assessed as

"Category 3: Stocks for which survey-based assessments indicate trends"

This category includes stocks for which survey indices (or other indicators of stock size such as reliable fishery-dependent indices; e.g. lpue, cpue, and mean length in the catch) are available that provide reliable indications of trends in stock metrics such as mortality, recruitment, and biomass.

Stock-trends are suggested to be estimated using the weighted index from BITS-Survey (i.e. a relative index, calculated from standardized methods and gears).

Both 1st and 4th quarter surveys are aggregated into one index value for a given year (using geometric mean between quarters). For advice, the relative change in the average index in the last two years is compared to the average of the three years before.

Additionally, trends in commercial landings and standardized effort have to be taken into account. Length based indicators are used to assess the stock status in terms of over-exploitation of immatures and/or large individuals following the guidelines provided by WKLIFE V (2015). The 3 year average (204-2016) absolute value of $L_{F=M}$ was used as a F_{MSY} Proxy.

Survey trends have increased steadily since the early 2000s. The average stock size indicator (kg/hour) in the last two years (2015–2016) is 10% higher than the biomass index in the three previous years (2012–2014; Figure 3.2.7). This would imply a catch advice of no more than 4030 tonnes in 2018 (i.e. the advised catch of 2016 x index factor).

3.2.6 Reference points

The stock status was evaluated by calculating length based indicators applying the LBI method developed by WKLIFE V (2015). CANUM and WECA of commercial catches from 2014-2016 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

L_{inf}: average of 2002-2016, both quarter and sexes → L_{inf} = 33.2 cm

L_{mat}: average of 2002-2016, quarter 1, only females → L_{mat} = 23 cm

The results were compared to standard length-based reference values to estimate the status of the stock (Table 3.2.4).

The results of LBI (Table 3.2.5) show that stock status of fle.27.2223 is above possible reference points (Table 2). Lmax5% is well above the lower limit of 0.80 (i.e. 1.19 in 2016), some truncation in the length distribution in the catches might take place. Over proportional amounts of mega spawners occur, as Pmega is larger than 75% of the catch. This might very well be an artefact produced by a relative small Linf, which would also explain the overfishing of immatures (Lc/Lmat) Catch is close to the theoretical length of Lopt and Lmean is stable over time and close to 1, indicating fishing close to the optimal yieldExploitation consistent with FMSY proxy (LF=M).

Table 3.2.1. Fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings (tonnes) by country and subdivision.

Year/SD	Denmark		Germ. Dem. Rep.	Germany, FRG	Sweden	
	22	23	22	22	22	23
1970						
1971						
1972						
1973	1,983		181	349		
1974	2,097		165	304		
1975	1,992		163	469		
1976	2,038		174	392		
1977	1,974		555	393		
1978	2,965		348	477		
1979	2,451		189	259		
1980	2,185		138	212		
1981	1,964		271	351		
1982	1,563	104	263	248		
1983	1,714	115	280	418		
1984	1,733	85	349	371		
1985	1,561	130	236	199		
1986	1,525	65	127	125		
1987	1,208	122	71	114		
1988	1,162	125	92	133		
1989	1,321	83	126	122		
1990	941		52	183		
1991	925			246		
1992	713	185		227		
1993	649	194		235		26
1994	882	181		44		84
1995	859	231		286		58
1996	1,041	227		189	2	58
1997	1,356			655		42
1998	1,372			411		61
1999	1,473			510		37
2000	1896			660		41
2001	2030			458		52
2002	1,490			317		42
2003	1063			241		33
2004	952			315		31
2005	725	184		94		38
2006	620	182		34		30
2007	585	233		406		26
2008	554	199		627		47
2009	505	113		521		37
2010	557	91		376		29
2011	441	78		497	0.2	28
2012	530	98		569		22
2013	639	83		713		19
2014	513	68		589	0	23
2015	361	73		679	0	16.5
2016	436	63		641	0	14.4

Table 3.2.2. Fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings (tonnes) by subdivision.

Year	Total by SD		Total
	22	23	SD 22-23
1970			
1971			
1972			
1973	2,513		2,513
1974	2,566		2,566
1975	2,624		2,624
1976	2,604		2,604
1977	2,922		2,922
1978	3,790		3,790
1979	2,899		2,899
1980	2,535		2,535
1981	2,586		2,586
1982	2,074	104	2,178
1983	2,412	115	2,527
1984	2,453	85	2,538
1985	1,996	130	2,126
1986	1,777	65	1,842
1987	1,393	122	1,515
1988	1,387	125	1,512
1989	1,569	83	1,652
1990	1,176		1,176
1991	1,171		1,171
1992	940	185	1,125
1993	884	220	1,104
1994	926	265	1,191
1995	1,145	289	1,434
1996	1,232	285	1,517
1997	2,011	42	2,053
1998	1,783	61	1,844
1999	1,983	37	2,020
2000	2,556	41	2,597
2001	2,488	52	2,540
2002	1,807	42	1,849
2003	1,304	33	1,337
2004	1,267	31	1,298
2005	819	222	1,041
2006	654	212	866
2007	991	259	1,250
2008	1,181	246	1,427
2009	1,026	150	1,176
2010	933	120	1,053
2011	938	106	1,044
2012	1099	120	1,219
2013	1352	102	1,454
2014	1103	91	1,193
2015	1040	90	1,130
2016	1076	77	1,153

Table 3.2.3. Fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Overview of sampling intensity and discard estimations (no additional survival rate is added to this calculation).

Year	landings	estimates discard	ratio	total strata*	Unsampled strata
2006	1452	532	0.27	29	20
2007	1287	629	0.33	28	19
2008	1421	447	0.24	29	14
2009	1172	1027	0.47	29	15
2010	1051	536	0.34	31	16
2011	1040	534	0.34	31	7
2012	1220	563	0.32	29	12
2013	1453	502	0.26	26	13
2014	1193	540	0.31	26	11
2015	1130	314	0.22	28	14
2016	1153	495	0.30	28	10

Table 3.2.4 Fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
Lmax5%	Mean length of largest 5%	Linf	Lmax5% / Linf	> 0.8	Conservation (large individuals)
L95%	95th percentile		L95% / Linf		
Pmega	Proportion of individuals above Lopt + 10%	0.3–0.4	Pmega	> 0.3	
L25%	25th percentile of length distribution	Lmat	L25% / Lmat	> 1	Conservation (immatures)
Lc	Length at first catch (length at 50% of mode)	Lmat	Lc/Lmat	> 1	
Lmean	Mean length of individuals > Lc	$Lopt = \frac{3}{3+M/k} \times L_{inf}$	Lmean/Lopt	≈ 1	Optimal yield
Lmaxy	Length class with maximum biomass in catch	$Lopt = \frac{3}{3+M/k} \times L_{inf}$	Lmaxy / Lopt	≈1	
Lmean	Mean length of individuals > Lc	LF=M = (0.75Lc+0.25Linf)	Lmean / LF=M	≥ 1	MSY

Table 3.2.5 Fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Indicator status for the most recent three years.

	Conservation				Optimizing Yield	MSY
Year	Lc / Lmat	L25% / Lmat	Lmax 5 / Linf	Pmega	Lmean / Lopt	Lmean / LF = M
2014	0.54	1.13	1.2	0.87	1.33	1.67
2015	0.54	1.17	1.19	0.9	1.33	1.66
2016	0.46	1.22	1.21	0.95	1.38	1.89

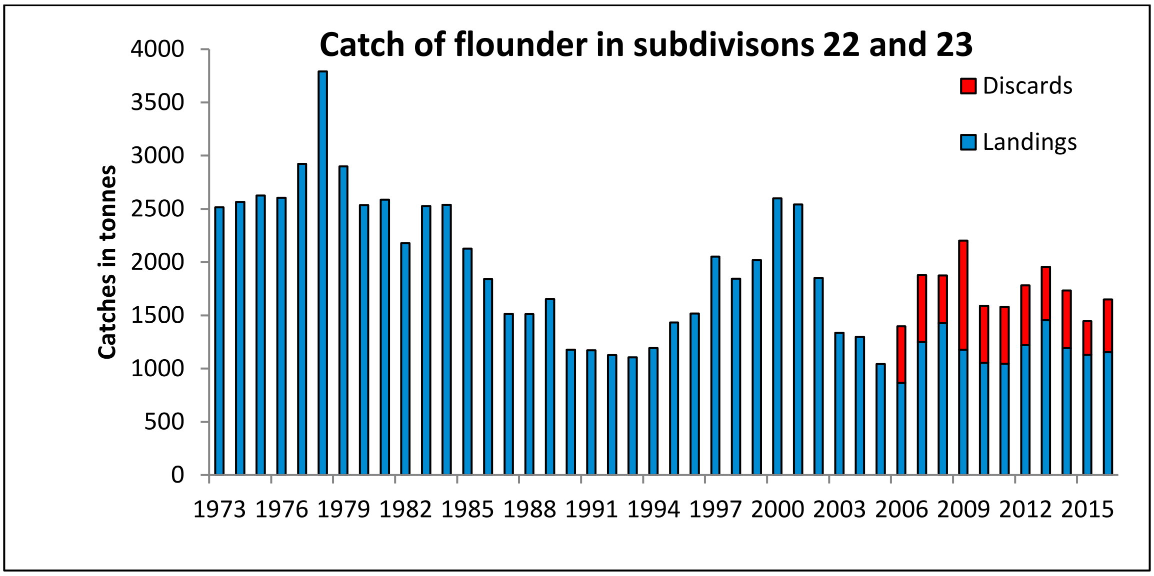


Figure 3.2.1. **Fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings of flounder in tonnes for subdivisions SD 22–23 (Western Baltic Sea). ICES discard estimates are included from 2006 onwards**

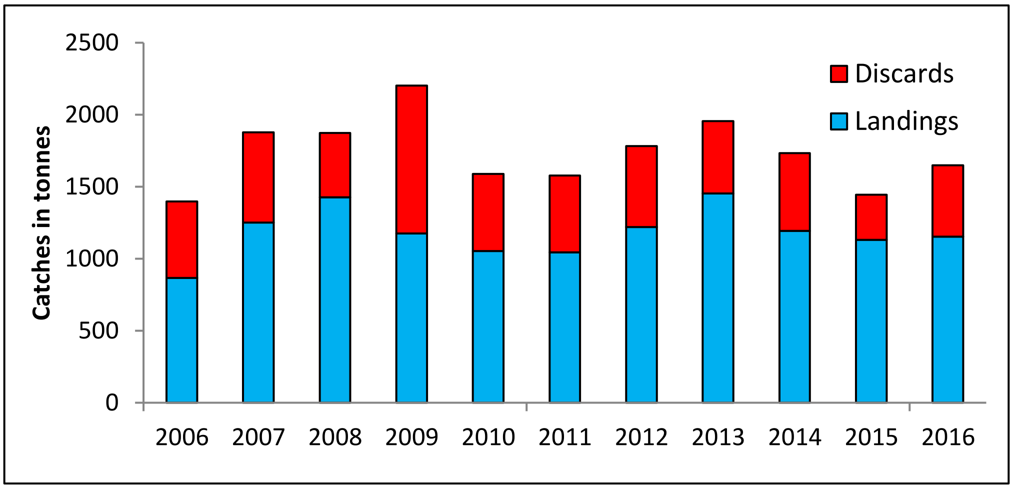


Figure 3.2.2. **Fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings and calculated discards (in tonnes) of flounder for subdivisions SD 22–23 (Western Baltic Sea).**

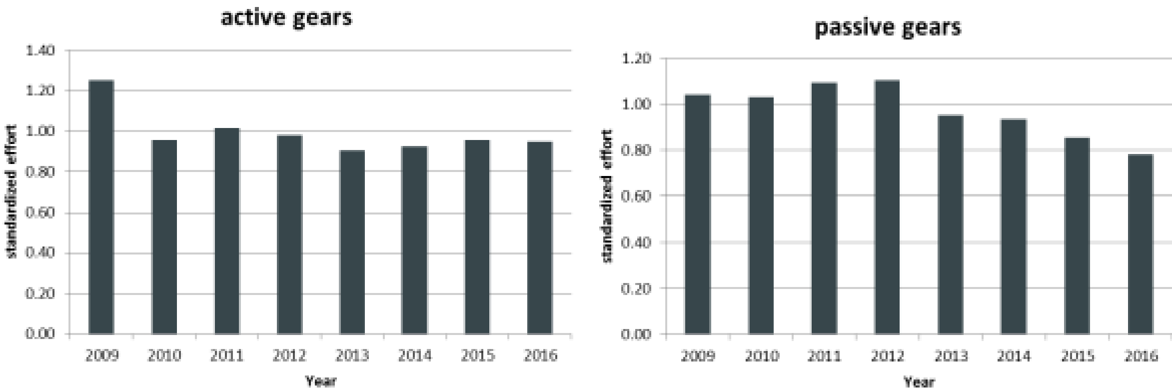


Figure 3.2.3. Fle.27.2223. Standardized effort for active and passive fleet in Subdivision 22 and 23 (Belts and Sound). Standard catches (effort per strata and country divided by average effort per country) were weighed by national cod landings.

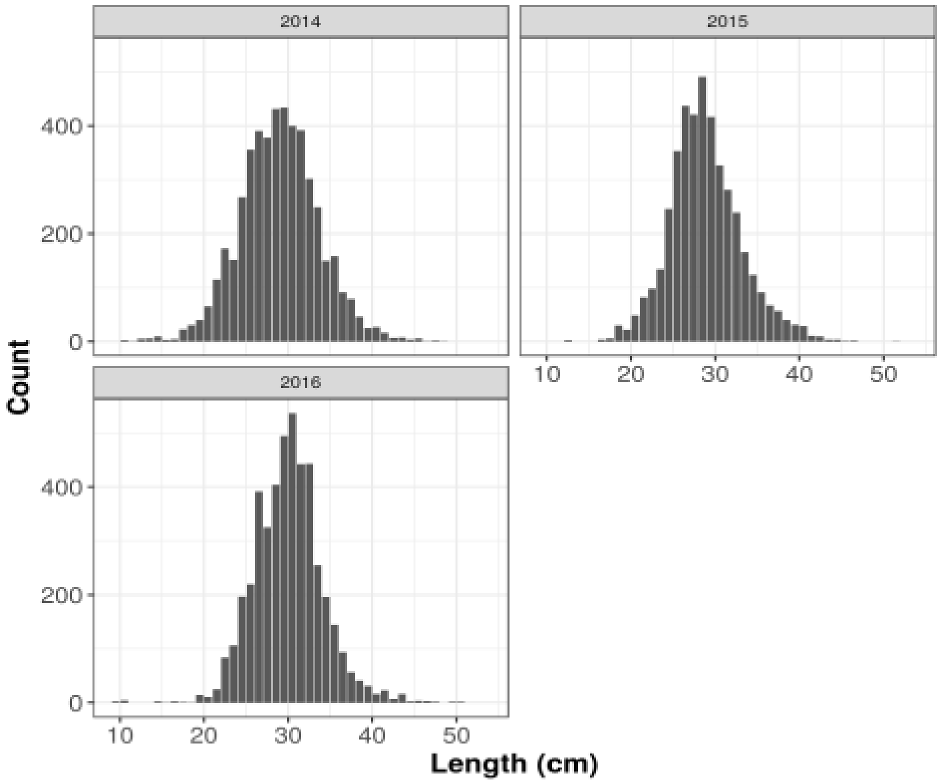


Figure 3.2.4. Fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Catch in numbers per length class in Subdivision 22 and 23 (Belts and Sound). All countries and fleets were combined.

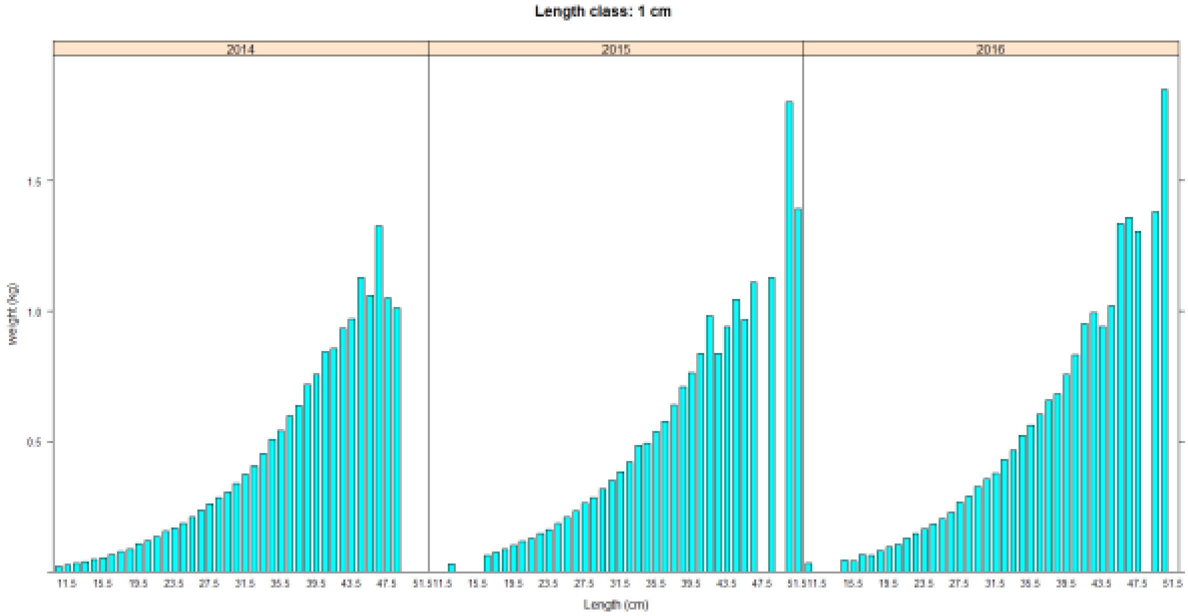


Figure 3.2.5. Fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Average weight-at-length for all length classes in subdivisions 22 and 23 (Belts and Sound) in the recent three years. All countries and fleets were combined.

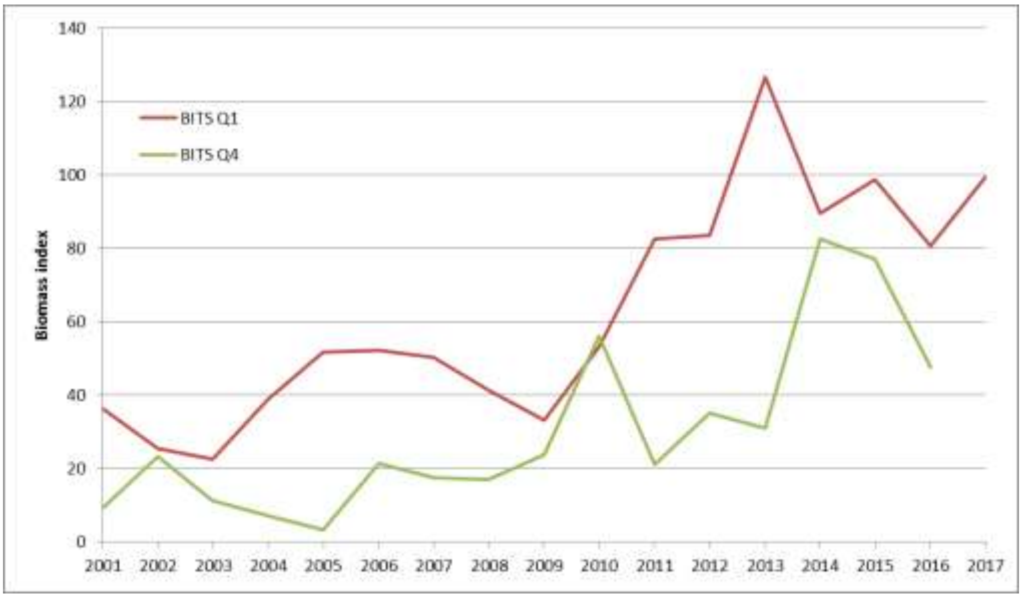


Figure 3.2.6. Fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Survey-biomass-index (BITS) for Q1 and Q4 from 2002 to 2016. 2017 values (for Q1) are preliminary

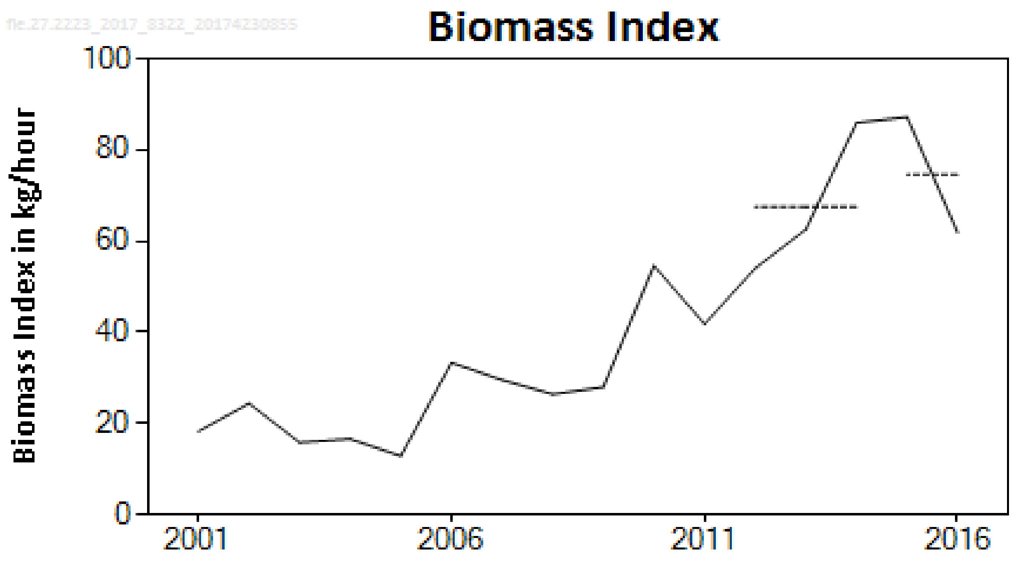


Figure 3.2.7. Fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Survey-biomass-index (BITS). Dashed lines indicate the average values used for advice (i.e. avg. of the last two years and the avg. of the three years before).

3.3 Flounder in subdivisions 24 and 25

ICES SD 24 and 25 were defined as a new assessment unit for flounder at a Benchmark Workshop on Baltic Flatfish Stocks (WKBALFLAT; ICES 2014) in 2014.

There are significant disparities between two sympatric flounder populations in the Baltic Sea, demersal and pelagic-spawning (the group to which flounder in SDs 24–25 belong). There are also differences within the pelagic-spawning flounder, which led to the designation of three stocks/assessment units at the WKBALFLAT (ICES 2014): SD 22 and 23; SD 24 and 25; SD 26 and 28.

3.3.1 The Fishery

3.3.1.1 Landings

Landings from SD 25 are substantially higher than in SD 24 (Figure 4.3.1). The main fishing nations in SD 24 are Poland and Germany and in SD 25 – Poland and Denmark. The majority of landings in both SD's is taken by Poland (Figure 4.3.2, Table 4.3.1a).

Flounder landings in both SD's are dominated by active gears, taking around 80% of total landings in 2016 (Figure 4.3.3).

In 2016 landings were 14 637 tonnes (3 020 tonnes and 11 617 tonnes for SD 24 and SD 25, respectively). Since 2014 the discard has been estimated according to the new methodology suggested during WKBALFLAT (ICES 2014). The total catch for flounder in subdivisions 24–25 reached 19 779 tonnes in 2016 (Figure 4.3.4).

3.3.1.2 Discards

During WKBALFLAT (ICES 2014) the quality of the estimated discards was questioned and new method for discards estimation was recommended:

$$\text{Discard Rate}_{\text{Time,SD,fleet segment,Species}} = \frac{\sum \text{Weight of discard}_{\text{Trip,Haul,Time,SD,Fleet segment,Species}}}{\sum \text{Weight of landing}_{\text{Trip,Haul,Time,SD,Fleet segment}}}$$

$$\text{Discard (ton)}_{\text{Time,SD,Fleet segment,Species}} = \text{Landings (ton)}_{\text{Time,SD,fleet segment}} \times \text{Discard Rate}_{\text{Time,SD,fleet segment,Species}}$$

Not every stratum has discards estimates, in that case discard rate was borrowed from other strata according to allocation scheme considering differences in discard patterns between subdivisions, countries, gear types and quarters (Table 4.3.2). Then the discard rate was raised by demersal fish landings. Such discard estimations have been performed since 2014. The highest discards in subdivisions 24 and 25 can be assigned to Denmark and Sweden (only in 2014). Germany and Poland have the moderate discards, although the discard rate for Poland is relatively low (Table 4.3.1b; Figure 4.3.5).

The discard rate for 2016 is 0.26 with discard equal to 5 143 tonnes.

3.3.1.3 Effort and CPUE data

Effort data back to 2009 is available for all countries. As countries have not used the same approach, the effort was standardized within each country and weighted by the national demersal fish landings from SD 24–25. The effort in 2016 is one of the lowest over the time series (Figure 4.3.6).

3.3.2 Biological information

3.3.2.1 Age composition

Because of the major age determination problems in the case of flounder, age-data are considered to be applicable only when the ageing was conducted using recommended methods (slicing and staining or breaking and burning techniques) established by WKARFLO (ICES 2007; ICES 2008) and WKFLABA (ICES 2010). Age readings achieved by using the new methodology are available for survey (Table 4.3.3) and for commercial data (Table 4.3.4).

The mean weight at age remains relatively stable over the years. (Figure 4.3.7).

In 2016 the most abundant age group was 5, whereas in 2015 age 4 (Figure 4.3.8).

3.3.2.2 Quality of catch and biological data

The number of sampled fish in SD 24 is slightly higher than in SD 25, even though the landings in SD 25 are much higher (Figure 4.3.9). Most of the samples in SD 24 are analyzed by Germany and in SD 25 by Poland.

Although the discard ratio in both subdivisions varies between countries, gear types, and quarters and additionally discarding practices are controlled by factors such as market price and cod catches, the quality of the catch is improving, as discard reporting is increasing. Sampling coverage of discards differs between years and subdivisions and has improved in 2016 (Figure 4.3.10). Flounder discard in SD 24 and SD 25 is sampled mainly by Germany, Sweden and Denmark.

3.3.3 Fishery independent information

Since 2001 the Baltic International Trawl Survey (BITS) has been carried out using a new (stratified random) design and a new standard gear (TV3). BITS surveys are conducted twice a year, in 1st and 4th quarter. BITS surveys in SD 24 are performed by Germany and since 2016 also by Poland and in SD 25 by Poland, Denmark and Sweden. Number of stations is higher in SD 25 compared to SD 24 (Table 4.3.5).

3.3.4 Assessment

The flounder stock in SD 24–25 belongs to category 3.2.0.: Stocks for which survey-based assessments indicate trends (ICES DLS approach, ICES 2012).

Stock trend is estimated using the Biomass Index from BITS-Q1 and BITS-Q4 surveys. The index is calculated by length-classes for the fish bigger or equal to 20 cm, and covers the period from 2001 onwards.

Both BITS-Q1 and BITS-Q4 surveys (Figure 4.3.11) are aggregated into one annual index value for a given year (using geometric mean between quarters). The Biomass-Index is calculated for each year. The advice is based on a comparison of the average from two most recent index values with the three preceding values (Figure 4.3.12). The advice index for this year is 1.63.

Stock trends from Baltic International Trawl Survey (BITS) for SD 24 and 25 have been increasing during the last 10 years, even though the landings are also increasing (Figure 4.3.1 and 4.3.6).

3.3.5 Reference points

The stock status was evaluated by calculating length based indicators applying the LBI method developed by WKLIFE V (ICES, 2015). Commercial landings from InterCatch from 2014-2016 were used to estimate CANUM and WECA (Figure 4.3.4.13). Whereas the biological parameters: L_{inf} and L_{mat} were calculated using survey data from DATRAS. For estimating L_{inf} data from 2012-2017 (as the recommended ageing technique was implemented by all of the countries since 2012 onwards) from Q1 and Q4 were taken. In the case of L_{mat} data were derived from 2001-2017, only from Q1, as distinguishing between mature and immature fish were possible only for this time of the year. Three versions of biological parameters were calculated for F, M and both (Table 4.3.6), as the difference in size of the fish depending on the sex was observed.

Four different runs for estimating LBI (Table 4.3.7) were provided to check the sensitivity of the method (Tables 4.3.8a-d).

Average $L_{F=M}$ for 2014 – 2016 is equal to 20.9 cm and L_{mean} - 27.0 cm. The results from all runs were giving similar results in terms of $F_{MSY\ proxy}$ (L_{mean} / $L_{F=M}$) indicator, which was used for stock status assessment. According to this indicator the fishing pressure for this stock for the last three years were at the safe level. The most optimistic values of LBI were provided when biological parameters for males were used, as males are reaching maturity at the smaller size and are characterized by a lower growth rate. The run using L_{inf} calculated from both sexes and L_{mat} from females was chosen for all flounder stocks (Table 4.3.8a).

Table 4.3.1a. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Total landings (tonnes) 1973–2016 by Subdivision and country.

Year	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
	SD 24	SD 25	SD24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24–25
1973			386									3144									1580			502	5612
1974			2578									2139									1635			470	6822
1975			1678									1876									1871			400	5825
1976			482									2459									1549			400	4890
1977			389									3808									2071			416	6684
1978			415									2573									996			346	4330
1979			405									2512									1230			315	4462
1980			286									2776									1613			62	4737
1981			548									2596									1151			51	4346
1982			257									3203									2484			55	5999
1983			450									3573									1828			180	6031
1984			306									2720									2471			45	5542
1985			649									3257									2063			40	6009
1986			1558									2848									3030			51	7487
1987			1007									2107									2530			43	5687
1988			990									2986									1728			58	5762
1989			1062									3618									1896			56	6632
1990			1389									1632									1617			120	4758
1991			1497									1814									2008			55	5374
1992			975									1972									1877			129	4953
1993			635									1230									3276			90	5231

Year	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
	SD 24	SD 25	SD24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24–25
1994			1016									4262									3177			38	8493
1995			2110			8						2825									7437			214	12594
1996			2306						1			1322									6069			819	10517
1997			2452			15			1			1982									3877			370	8697
1998			2393			10			2			1729			2						4215			236	8587
1999			1206			8						1825									4015			111	7165
2000	825	923	1748				14	4	18	1809	171	1979							605	3765	4370	49	123	172	8288
2001	1026	1976	3002				9	68	77	1468	299	1766							531	4962	5493	30	95	125	10464
2002	995	1877	2872				5	34	39	1910	154	2064							1288	6577	7865	30	111	141	12982
2003	750	1052	1802				2	7	8	1165	389	1553							758	5087	5845	45	106	152	9360
2004	1114	1753	2866							1307	275	1582	1	6	7				1177	5633	6810	19	86	105	11370
2005	853	1445	2298				1	2	3	881	43	924	2		2				2194	7192	9386	26	58	84	12696
2006	513	1518	2031				2	3	5	973	7	979		11	11				1782	5959	7741	23	61	84	10852
2007	620	623	1243				2	8	10	1455	215	1670	8	7	15		11	11	3016	5840	8856	27	59	86	11891
2008	422	313	736							1601	238	1840		74	74		4	4	2094	5569	7663	29	66	95	10410
2009	325	199	524				41		41	1175	29	1204		155	155		31	31	2378	5802	8180	27	65	92	10227
2010	333	368	701		16	16	13	2	16	953	31	983		31	31		19	19	1833	7665	9498	21	64	85	11348
2011	310	226	536		20	20	3	2	5	1529	147	1676		39	39		15	15	1567	6666	8233	26	60	86	10610
2012	290	250	540		19	19	20	17	36	904	151	1055		8	8		24	24	1331	7325	8657	23	67	90	10430
2013	572	1889	2460		10	10	1	9	10	771	332	1103	4	76	80		54	54	2104	8118	10222	35	344	379	14318
2014	349	1324	1673		83	83		0	0	751	212	963	3	288	291		74	74	1537	9821	11358	22	146	168	14610
2015	169	1614	1783		39	39	1	4	4	635	181	815	2	6	8		7	7	1122	7247	8370	24	40	64	11090
2016	135	84	219	0	0	0	2	0	2	630	246	876	0	81	81	0	9	9	2238	11157	13395	16	41	56	14637

Table 4.3.1b. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Estimated discards (tonnes) 2014–2016 by Subdivision and country.

Year	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
	SD 24	SD 25	SD24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24	SD 25	SD 24–25	SD 24–25
2014	1402	2450	3852	0	0	0	0	0	0	171	15	185	2	35	37	0	7	7	29	128	157	187	1117	1303	5542
2015	1186	3900	5086	0	0	0	0	0	0	199	35	234	0	0	0	0	1	1	80	307	387	98	157	255	5965
2016	664	2880	3544	0	0	0	2	0	2	298	63	360	0	8	8	0	0	0	235	390	625	386	216	602	5143

Table 4.3.2. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Discard allocation scheme for2016

24		2016				
fleet	quarter	Denmark	Germany	Poland	Sweden	Finland
Active	1			PL_A_1_25	DK_A_1_25	PL_A_1_25
	2			DE_A_2_25	DK_A_2_25	
	3	DK_A_3_25	DE_A_3_25	DK_A_3_25	SE_A_3_25	
	4			DE_A_4_24	SE_A_4_25	DE_A_4_24
Passive	1	SE_P_1_24		DE_P_1_24		
	2	SE_P_2_24		PL_P_2_25		
	3	SE_P_3_24		DE_P_3_24		
	4	SE_P_4_24		PL_P_4_25		

25		2016						
fleet	quarter	Denmark	Germany	Poland	Sweden	Finland	Latvia	Lithuania
Active	1				DE_A_1_25	PL_A_1_25	PL_A_1_25	PL_A_1_25
	2			DE_A_2_25	DE_A_2_25		DE_A_2_25	
	3			DK_A_3_25				
	4			DE_A_4_24			DE_A_4_24	
Passive	1	SE_P_1_25		LV_P_1_25				
	2	SE_P_2_25						
	3	SE_P_3_25		SE_P_3_25				
	4	SE_P_4_25					PL_P_4_25	

Table 4.3.3. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Available survey age data determined with a new method.

Country	SD 24	SD 25
Denmark		since 2012
Germany	since 2009	
Poland		2000–2002 only 1st quarter 2004–2010 only 1st quarter since 2011 1st and 4th quarter
Sweden		since 2007

Table 4.3.4. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Available commercial age data determined with a new method.

Country	SD 24	SD 25
Denmark	since 2012	
Germany	since 2008	since 2008
Latvia		2010
Poland	2000–2010 only 1st quarter since 2011 1st and 4th quarter	2000–2010 only 1st quarter since 2011 1st and 4th quarter
Sweden		since 2009

Table 4.3.5. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Number of BITS-stations in SD 24 and SD 25.

	SD 24		SD 25	
	Q1	Q4	Q1	Q4
2001	66	40	96	52
2002	55	46	57	75
2003	48	46	97	61
2004	50	47	112	63
2005	43	46	113	81
2006	43	44	95	72
2007	45	41	88	81
2008	35	47	97	62
2009	45	53	104	81
2010	50	31	80	77
2011	44	50	105	77
2012	52	47	102	74
2013	54	38	102	75
2014	52	49	97	73
2015	50	38	97	73
2016	53	47	85	81
2017	46		102	
average	49	44	96	72

Table 4.3.6. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Biological parameters (L_{inf} and L_{mat}) calculated for Females, Males and both sexes.

	Females	Males	Both
Linf [mm]	348	287	330
Lmat [mm]	200	138	160

Table 4.3.7. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Description of the selected LBI

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
Lmax5%	Mean length of largest 5%	Linf	Lmax5% / Linf	> 0.8	Conservation (large individuals)
L95%	95th percentile		L95% / Linf		
Pmega	Proportion of individuals above Lopt + 10%	0.3–0.4	Pmega	> 0.3	
L25%	25th percentile of length distribution	Lmat	L25% / Lmat	> 1	Conservation (immatures)
Lc	Length at first catch (length at 50% of mode)	Lmat	Lc/Lmat	> 1	
Lmean	Mean length of individuals > Lc	Lopt = $\frac{3}{3+M/k} \times \mathbf{L_{inf}}$	Lmean/Lopt	≈ 1	Optimal yield
Lmaxy	Length class with maximum biomass in catch	Lopt = $\frac{3}{3+M/k} \times \mathbf{L_{inf}}$	Lmaxy / Lopt	≈1	
Lmean	Mean length of individuals > Lc	LF=M = (0.75Lc+0.25Linf)	Lmean / LF=M	≥ 1	MSY

Table 4.3.8a. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West).Indicator status for the most recent three years. L_{inf} calculated using both sexes and L_{mat} using females only. L_{inf} = 33.0 cm and L_{mat} = 20.0 cm. Final run.

	Conservation				Optimizing Yield	MSY
Year	Lc / Lmat	L25% / Lmat	Lmax 5 / Linf	Pmega	Lmean / Lopt	Lmean / LF = M
2014	0.72	1.2	1.06	0.73	1.21	1.39
2015	0.68	1.2	1.06	0.75	1.22	1.46
2016	1.12	1.25	1.06	0.77	1.25	1.09

Table 4.3.8b. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West).Indicator status for the most recent three years. L_{inf} and L_{mat} calculated using both sexes. . L_{inf} = 33.0 cm and L_{mat} = 16.0 cm.

	Conservation				Optimizing Yield	MSY
Year	Lc / Lmat	L25% / Lmat	Lmax 5 / Linf	Pmega	Lmean / Lopt	Lmean / LF = M
2014	0.91	1.5	1.06	0.73	1.21	1.39
2015	0.84	1.5	1.06	0.75	1.22	1.46
2016	1.41	1.56	1.06	0.77	1.25	1.09

Table 4.3.8c. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Indicator status for the most recent three years. L_{inf} and L_{mat} calculated using females only. L_{inf} = 34.8 cm and L_{mat} = 20.0 cm.

	Conservation				Optimizing Yield	MSY
Year	Lc / Lmat	L25% / Lmat	Lmax 5 / Linf	Pmega	Lmean / Lopt	Lmean / LF = M
2014	0.72	1.2	0.99	0.6	1.14	1.35
2015	0.68	1.2	1	0.63	1.15	1.43
2016	1.12	1.25	1	0.63	1.18	1.07

Table 4.3.8d. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West).Indicator status for the most recent three years. L_{inf} and L_{mat} calculated using males only. L_{inf} = 28.7 cm and L_{mat} = 13.9 cm

	Conservation				Optimizing Yield	MSY
Year	Lc / Lmat	L25% / Lmat	Lmax 5 / Linf	Pmega	Lmean / Lopt	Lmean / LF = M
2014	1.04	1.71	1.2	0.96	1.37	1.47
2015	0.96	1.71	1.21	0.97	1.39	1.55
2016	1.61	1.79	1.21	0.98	1.42	1.14

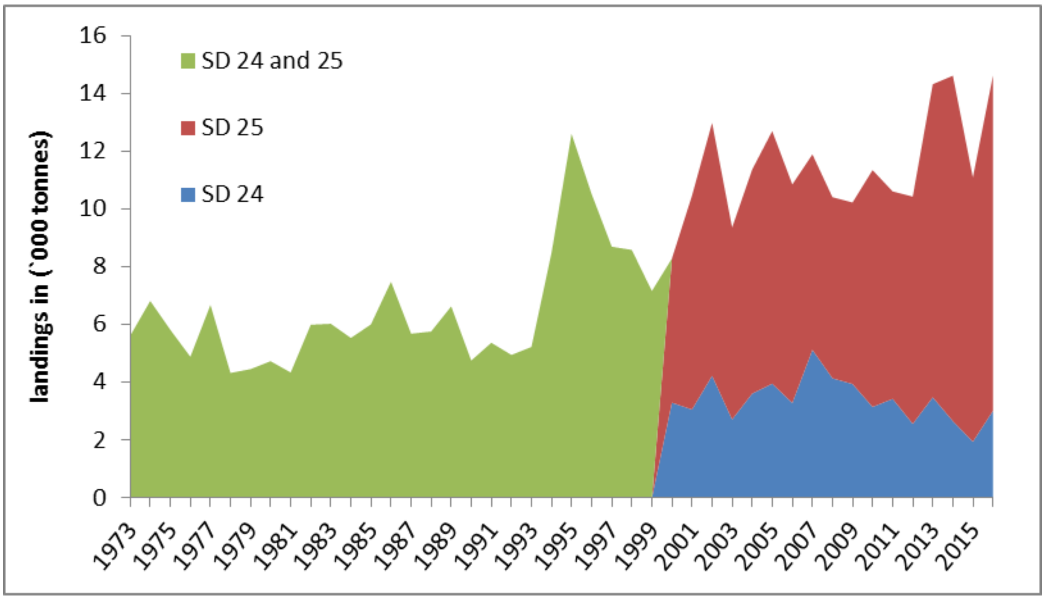


Figure 4.3.1. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Landings in thousand tonnes.

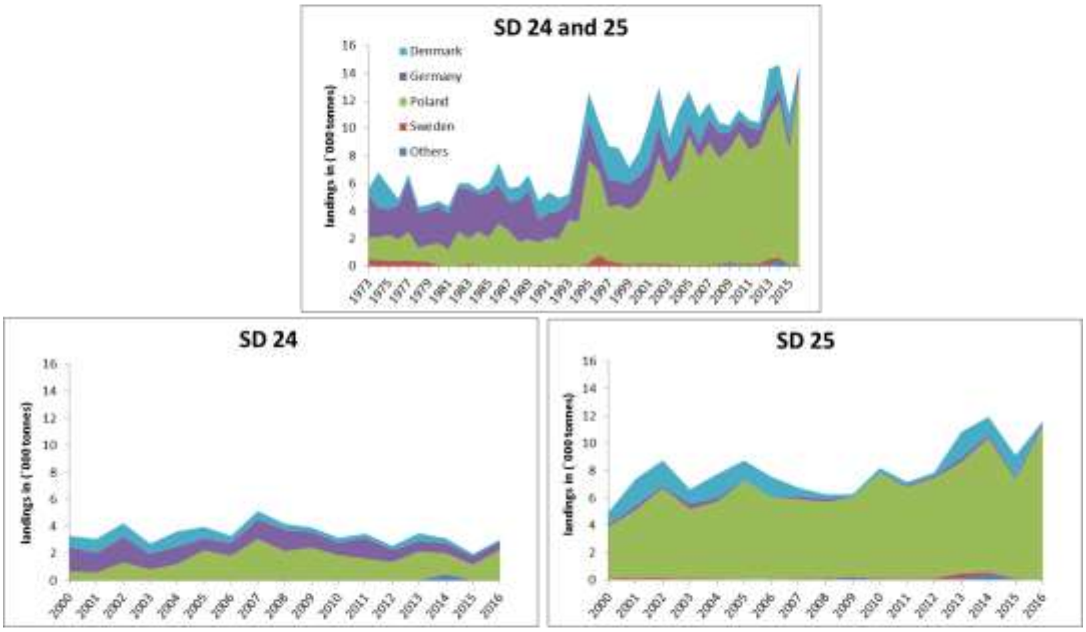


Figure 4.3.2. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Landings by country in thousand tonnes (for merged SD 24–25 – upper plot and separately for SD 24 and SD 25 – lower plots).

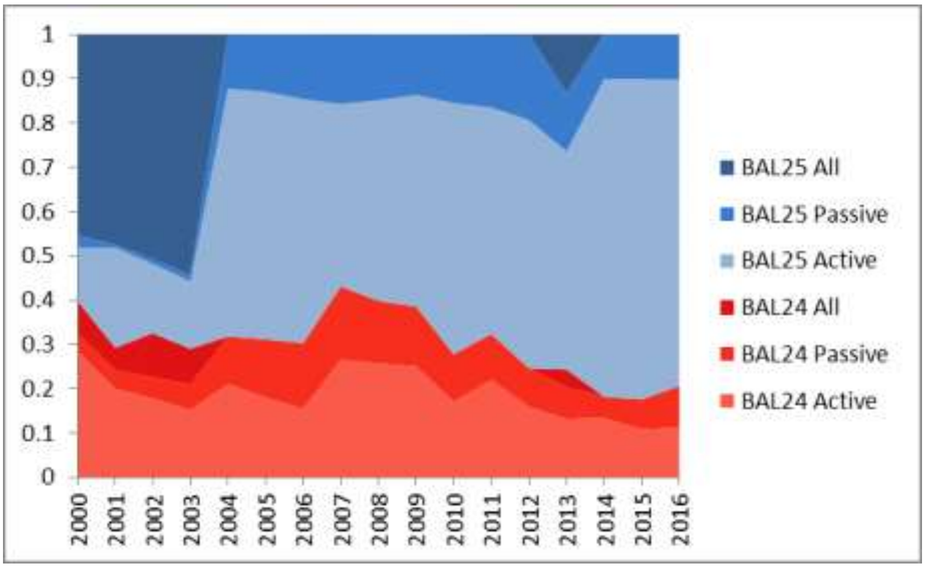


Figure 4.3.3. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Landings by fleet type in thousand tonnes (SD 24 - reddish colors, SD 25 – bluish).

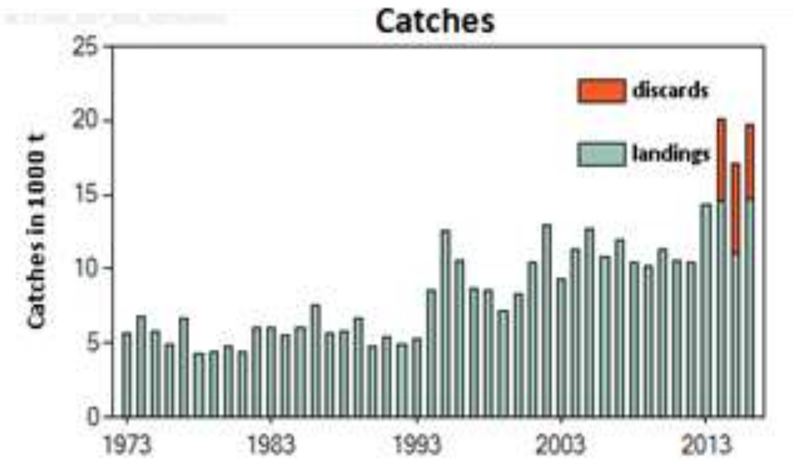


Figure 4.3.4. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Landings in thousand tonnes (discards available since 2014).

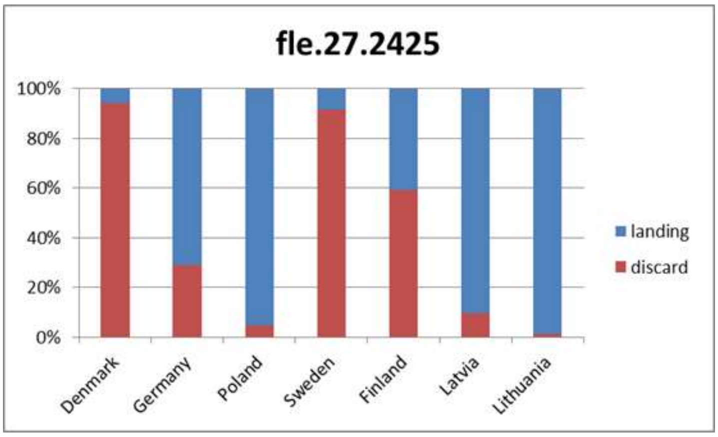


Figure 4.3.5. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West).Discard and landing proportion in 2016 catches in countries.

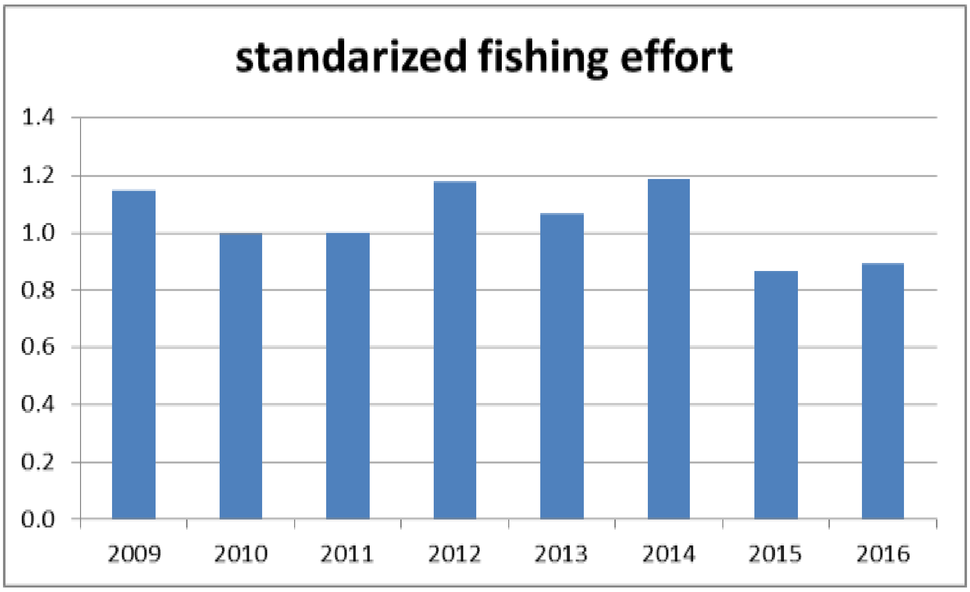


Figure 4.3.6. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Standardized fishing effort (days at sea standardized within each country and weighted by the national demersal fish landings from SD 24–25).

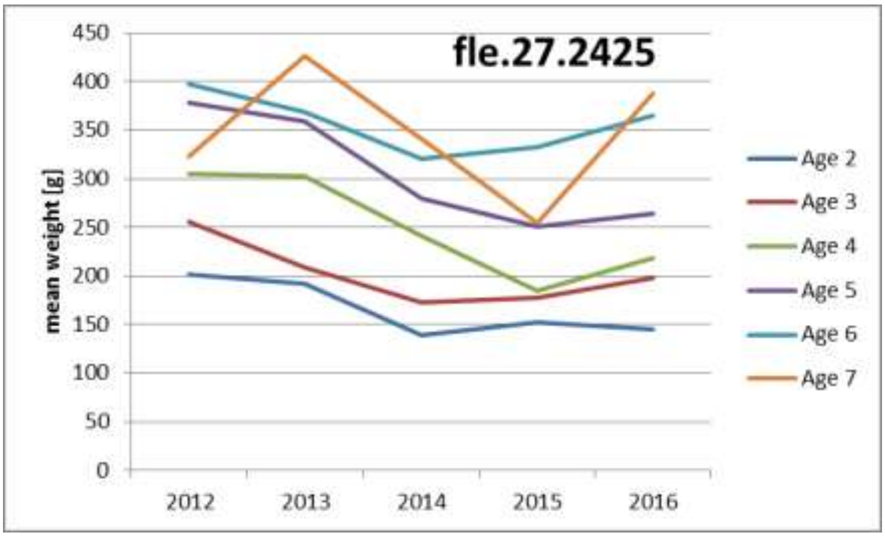


Figure 4.3.7. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Mean weight at age in grams.

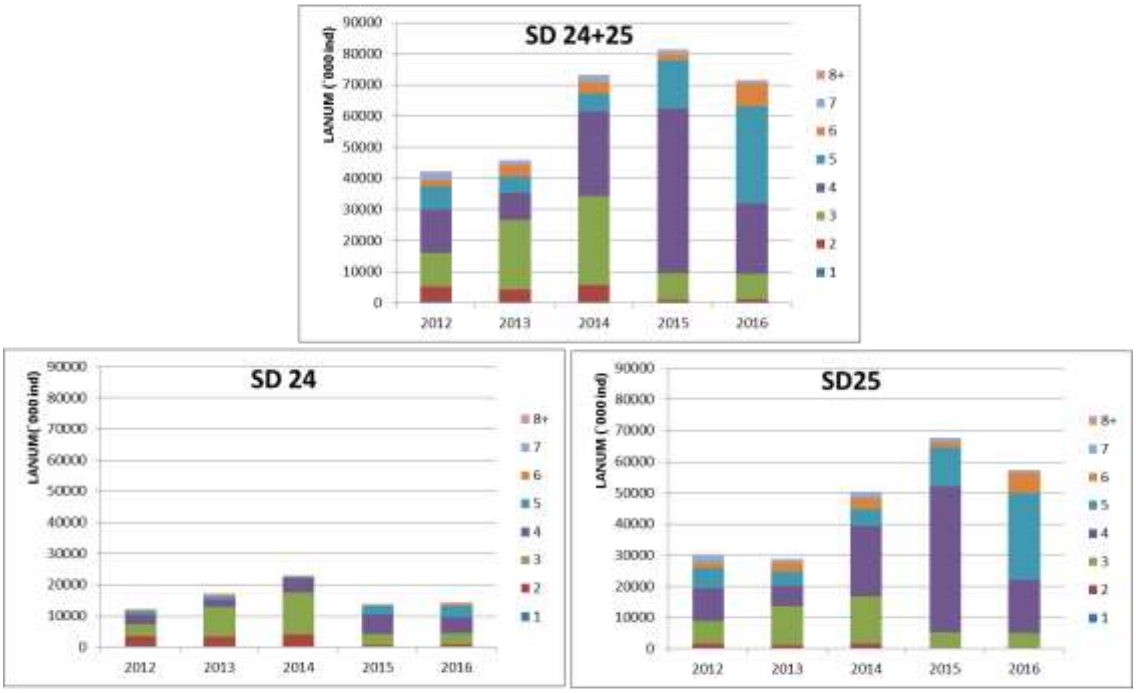
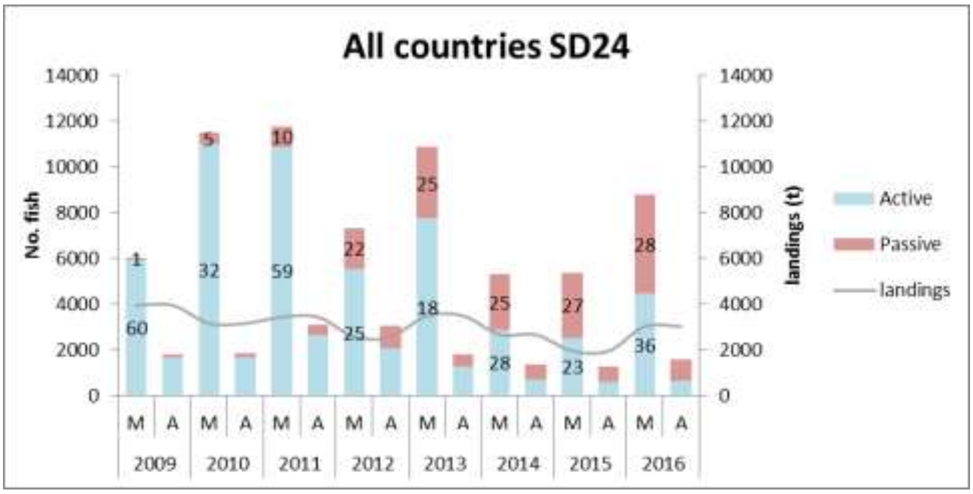


Figure 4.3.8. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Landings at age in numbers (thousands individuals).



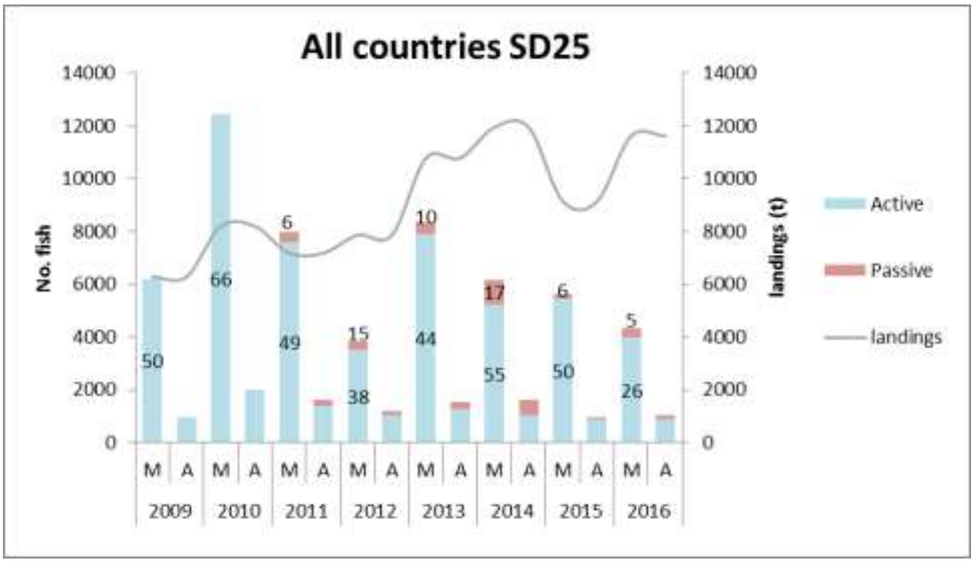


Figure 4.3.9. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). The coverage of sampled landing in subdivisions 24 and 25 (first column of each year presents number of measured fish, second – number of aged fish; numbers on the columns are number of samples of: passive fleet - upper value and active fleet – lower value; the additional axis shows landing values – gray line).

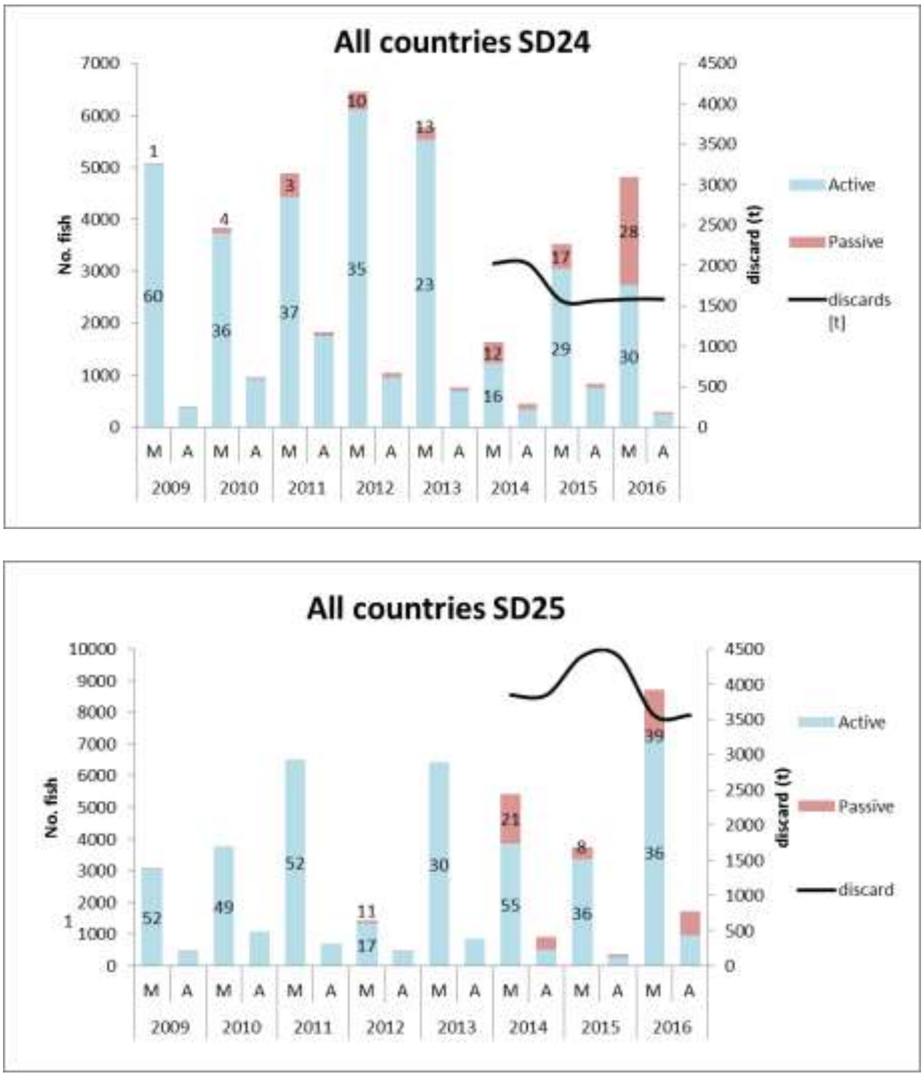


Figure 4.3.10. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). The coverage of sampled discards in subdivisions 24 and 25 (first column of each year presents number of measured fish, second – number of aged fish; numbers on the columns are number of samples of: passive fleet - upper value and active fleet – lower value; the additional axis shows discard values – black line).

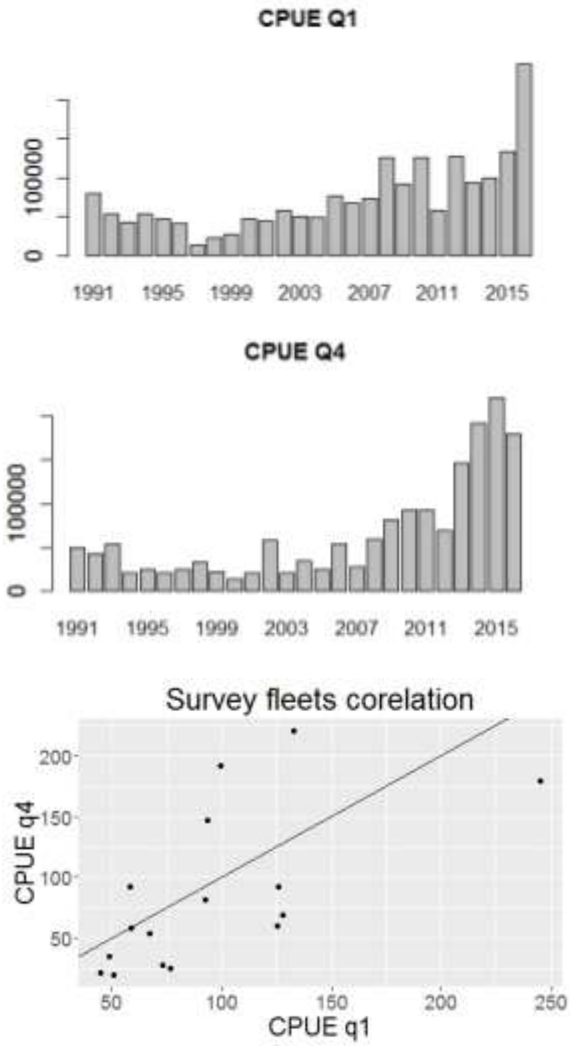


Figure 4.3.11. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Stock trends from Baltic International Trawl Survey (BITS) for SD 24 and 25.

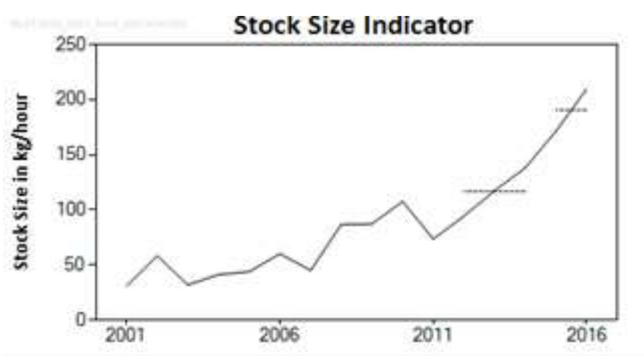


Figure 4.3.12. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Biomass index (black line indicates geometric mean of the biomass index from the first and fourth quarter).

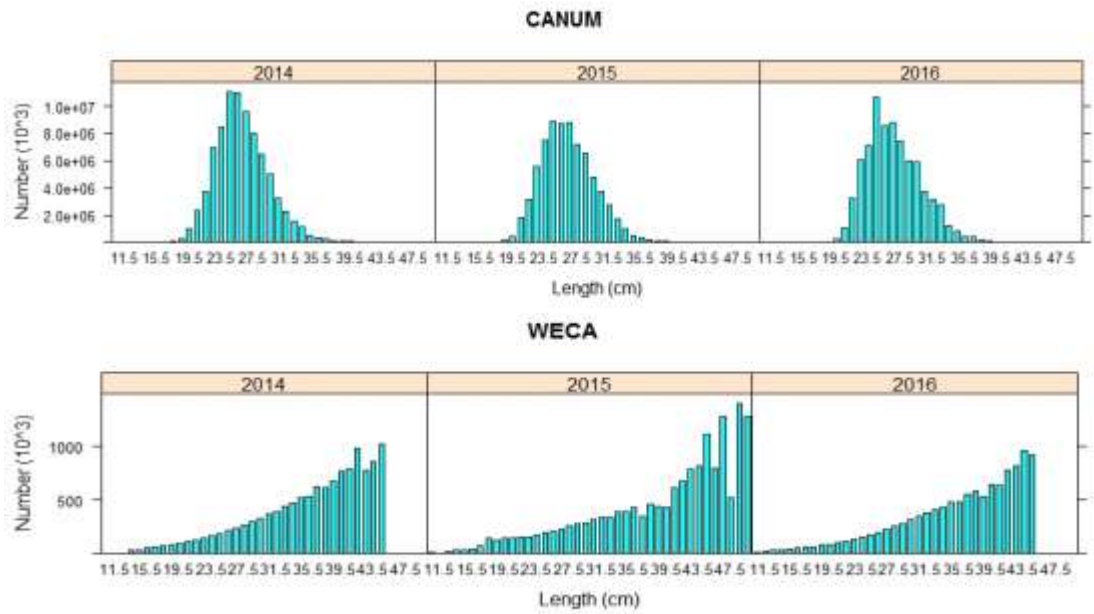


Figure 4.3.13. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic – West). Catch number (CANUM) and weight in catch (WECA) per length classes

3.4 Flounder in subdivisions 26–28 (Eastern Gotland and Gulf of Gdansk)

3.4.1 Fishery

The main fishing countries in Subdivision 26 are Latvia, Poland, Russia and Lithuania (Table 3.4.1). In the previous years the Polish fishery was mainly a gillnet fishery targeting flounder along the coast whereas the Latvian, Russian and Lithuanian landings were mainly in a bottom trawl mix-fishery.

3.4.1.1 Landings

Landings by countries and subdivisions are presented in Table 3.4.1.

The total landings in SD 26 and 28 combined decreased from 4443 tonnes in 2016 to 4252 tonnes in 2016 (Figure 3.4.1., 3.4.2.). The highest landings were recorded in Latvia (1843 tonnes), Russia (1133 tonnes) and Poland (912 tonnes). The major part of the landings was realised with active fishing gears (3411 tonnes).

Major part of the landings was taken in Subdivision 26 (58.9%) and in trawl fishery (80.2%). The total landings in Subdivision 28 amounted to about 1748 tonnes in 2016 a remarkable higher than long term average. The landings in Subdivision 28 started to increase from 2011 and last three years are more than 1000 tones. The Latvian landings were 1683 tonnes (increased 5 to 10 times comparing to 10 years ago). Latvian landings were mainly taken by the trawl fishery.

Due to unfavourable cod fishing conditions and market limitation for sprat, in some countries (Latvia, Russia) specialized flounder fishery was performed in the last years.

3.4.1.2 Unallocated removals

There is no information about unallocated removals for this stock.

3.4.1.3 Discards

The first discard estimates were calculated in WKBALFLAT in InterCatch data base in 2014. It was found that raising procedure in InterCatch for such by-cach species as flounder gives underestimated and imprecise discard estimates. Therefore WK decided that discard raising should be performed outside of InterCatch.

Discard data of flounder from 2015 according to ICES Data Call were submitted in InterCatch. Discards rates from Latvia, Lithuania, Poland and Sweden were reported in InterCatch. In Russia and Estonia discarding of flounder is forbidden and therefore 0 discard was applied for those countries.

Estimated discard ratio varied significantly by countries, fleets and quarters. The highest discards (by weight) were observed in Poland (118 t) and Lithuania (10 t) (Table 3.4.2). Significant decrease of discard was observed in Latvia where major part of flounder was landed. Weighted average of flounder discard in subdivisions 26 and 28 in 2016 was estimated 4.3% what is significantly lower than estimate for 2015 (17%).

3.4.1.4 Effort and CPUE data

Time series from 2009–2016 were available from ICES WGBFAS data call where countries were asked to submit flatfish effort data by fishing fleet and subdivision. It should be mentioned that different calculation methods were used by countries to estimate a fishing effort. Some countries reported all of fishing days when flounder were landed; some countries reported number of fishing days were significant amount of flounder were landed, while some countries reported fishing days for whole demersal fleet.

Standardisation and weighting factor were applied for submitted effort data to calculate a common effort index for the stock. First, every countries data were standardised using proportion for given year from the national average. Standardised effort data were weighted by cod and flounder landings for every country and year and final effort for stock was calculated summing all countries efforts.

According to new effort estimates a decreasing trend of effort was observed in previous years with some increase in the last year (Figure 3.4.3). In general, fishing effort is fluctuated without any trend. A decrease in effort over the last two years was observed in Russia; Latvia and Poland, while in Lithuania, effort in last two years was significantly higher than average (Figure 3.4.4).

The highest landings per unit effort in 2016 were registered in Latvia, Russia and Estonia (Figure 3.4.5) which indicated a target flounder fishery in those countries. Flounder landings per day at sea in Sweden, Poland, Lithuania, Finland were less than 100 kg which indicated that flounder is typically bycatch in the fishery.

3.4.2 Biological information

3.4.2.1 Catch in numbers

In total, 4002 otoliths were collected from the catch (3174 from landings and 828 from discards, Table 3.4.3) . Otoliths from Estonia, Latvia, Lithuania, Poland and Russia covering landings, while otoliths from discards were available from Latvia, Poland and Lithuania.

3.4.2.2 Mean weights-at-age

Mean weights at age is presented in Section 3.4.5.1 and was used for MSY proxy calculations.

3.4.3 Fishery independent information

Catch per unit of effort (kg per hour) from the BITS Survey in 1st and 4th quarters was used to calculate an index representing flounder abundance by weight, as the stock is defined as a Data limited stock by ICES. Data were compiled from the ICES DATRAS output format "*CPUE_per_length_per_haul*" where the data base provides CPUE by length in numbers. Weight at length was estimated as an average weight at length for data from 1991–2013, separately for 1st and 4th quarter and subdivisions 26+28. Next, to such data weight-length relationships of the form w=aL^b were fitted, were: a = 0.0154 and b = 2.91 for 1st quarter and a = 0.0158 and b = 2.90 for 4th quarter. Next, biomass for fish longer than 20 cm were summed to get total biomass index by quarters. All fish with length < 20 cm were excluded from the calculations, as . flounder nurseries are located in shallow coastal areas and are not covered in BITS surveys. For the final index the geometric mean of 1st and 4th quarter indices was used.

3.4.4 Assessment

No analytical assessment can be presented for this stock. Therefore, detailed management options cannot be presented. ICES is in the process of compiling existing data and testing assessment models.

The ICES framework for category 3 stocks was applied. The Baltic International Trawl Survey (BITS – Q1+Q4) was used as the index of stock development. The assessment is based on a comparison of the two latest index values (index A) with the three preceding values (index B).

The stock shows a decreasing trend from the beginning of the century although the estimated indices in last three years are on stable level (Figure 3.4.6, Table 3.4.4). The stock abundance is estimated to have decreased by 34% between 2012–2014 (average of the three years) and 2015–2016 (average of the two years). This implies a decrease in landings by at least 20% in relation to catch in 2016. The precautionary buffer was applied in 2014 and was therefore not applied again.

Discard estimation from 2016 was accepted in the working group and therefore catch advice for 2018 was produced.

3.4.5 Reference points

The MSY proxy reference points were evaluated by calculating length based indicators applying the LBI method developed by WKLIFE V (2015).

3.4.5.1 Input data

The following input parameters were used for the calculations

- Length distribution of flounder from commercial catch
- Average weight by length groups from commercial catch
- Lmat- flounder length when 50% of flounder female are mature – data from DATRAS
- Linf- asymptotic length of flounder – data from DATRAS
- M/K ratio – 1.5

All calculations were performed in https://scott.shinyapps.io/LBIndicator_shiny/

Length distribution from commercial catch was used from 2011- 2016 (Figure 3.4.7). Latian data only were used in calculation due to longest available time series. In the plenary Latvian and Polish data were presented and no significant difference was found between the countries. The modal length groups in flounder commercial catches are from 24 – 30 cm. There is small variation in length distribution by years.

The same data (2011-2016) were used to calculated mean weight by length groups from commercial fishery (Figure 3.4.8). Average weight in 2014 was lower than in other years.

Combined L_{mat} for flounder in subdivisions 26 and 28 was calculates using DATRAS data from 2011-2016. Lmat was estimated 19.5 cm (Figure 3.4.9) and was used in MSY proxy calculations.

L_{inf} was calculated using DATRAS data from BITS survey Qurarter 1 and 4 from subdivisions 26 and 28, both sex combined, including all countries. L_{inf} was estimated using Bertalanffy growth function - 28.87 cm (Figure 3.4.10) while observed flounder in commercial landings in 2011-2014 were up to 44 cm. Age data quality was discussed in the plenary and exploratory comparison of available age data was performed (Figure 3.4.11). The slowest growth rate was observed in Latvian and Swedish data – what is representing mainly data from Subdvision 28. Poland, Denmark and Lithuanian data build another cluster- are representing flounder mainly form Subdivision 26. Russian data shows the highest growth rate and is significantly different from other countries. Differences in age data influencing quality of L_{inf} estimation, what is variable depending of data (country) used in calculation (L_{inf} up to 89cm).

3.4.5.2 Output data

The results of LBI show that stock status is above all possible reference points (Table 3.4.5, Table 3.4.6, Figure 3.4.12). $L_{max5\%}$ is well above the lower limit of 0.80 (i.e. 1.21 in 2016), what indicate high proportion of large individuals in the catches. Conservation of immature fish in on good and stable level (1.21-1.26 by years). MSY proxy indicate that fishing pressure is on sustainable level in all three reported years (1.07 to 1.15). Lmean from the last three years was estimated 27.52 cm.

Table 3.4.1. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Total ICES landings (tonnes) by Subdivision and country.

Country	1996			1997			1998			1999			2000		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark			0	10		10			0			0	8	0	9
Finland			0			0			0			0	0		0
Germany	10	9	19	12	4	16	2		2			0			0
Poland	2 556		2 556	1 730		1 730	1 370		1 370	1 435		1 435	721		721
Sweden	48	31	79	31	370	401	18	117	135	47		47	0	27	28
Estonia		44	44		101	101		146	146		92	92		65	65
Latvia	74	215	289	78	284	362	88	274	362	140	365	505	113	302	415
Lithuania	316		316	554		554	737		737	547		547	575		575
Russia	740		740	1 001		1 001	1 188		1 188	964		964	1 236	0	1 236
Total	3 744	299	4 043	3 416	759	4 175	3 403	537	3 940	3 133	457	3 590	2 654	395	3 049

Country	2001			2002			2003			2004			2005		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	1	14	15	42	0	42	1		1	1		1	0		0
Finland			0	0		0	0		0			0	0		0
Germany			0			0			0			0			0
Poland	548		548	626		626	648		648	1 955		1 955	1 743		1 743
Sweden	3	179	182	4	48	52		17	17		18	18	0	124	124
Estonia		100	100		91	91		122	122		89	89		133	133
Latvia	201	412	613	221	375	596	281	392	673	169	600	769	383	1 333	1 716
Lithuania	1 127		1 127	1 077		1 077	1 066		1 066	834		834	949		949
Russia	1 355		1 355	1 314		1 314	1 402		1 402	1 277		1 277	1 393		1 393
Total	3 235	706	3 941	3 284	514	3 798	3 399	531	3 929	4 236	707	4 943	4 468	1 590	6 058

Country	2006			2007			2008			2009			2010		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	4		4	2		2			0			0	0		0
Finland	0	0	0	1	0	2			0			0			0
Germany			0			0			0			0			0
Poland	1 675		1 675	1 829		1 829	1 451		1 451	1 472		1 472	1 727		1 727
Sweden	1	20	22	1	18	20	0	18	19	0	17	17	0	15	15
Estonia		83	83		92	92		91	91		77	77	0	93	93
Latvia	317	838	1 155	166	877	1 043	203	374	577	52	312	364	25	225	250
Lithuania	355		355	268		268	601	27	629	472	27	499	407	55	462
Russia	1 231		1 231	2 650		2 650	1 960		1 960	969		969	1 030		1 030
Total	3 583	941	4 524	4 917	987	5 905	4 216	512	4 727	2 964	433	3 398	3 189	388	3 577

Country	2011			2012			2013			2014			2015		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	1		1	0		0	22		22	0,87	0	1	0	0	0
Finland	1		1	10		10	8		8	0,46	0	0	0	0	0
Germany			0			0	0		0			0			
Poland	1 437		1 437	1 501		1 501	1 578	3	1 581	1210	0	1 210	981	0	981
Sweden	1	20	20	2	13	14	21	24	45	0,27	0	0	0	17	18
Estonia	15	74	89	11	70	81	24	52	76	25,5	53,8	79	2	53	55
Latvia	114	166	280	378	244	622	780	619	1 399	299	1279	1 578	281	1 744	2 025
Lithuania	418	0	418	640	12	651	947	1	949	698	0	698	258	0	258
Russia	1 139		1 139	1 079		1 079	1 010		1 010	1047	0	1 047	1 106	0	1 106
Total	3 127	260	3 387	3 620	339	3 959	4 391	698	5 089	3 281	1 333	4 614	2 628	1 815	4 443

Country	2016		
	SD 26	SD 28	Total
Denmark	0	0	0
Finland			0
Germany	1	0	1
Poland	912	0	912
Sweden	3	14	16
Estonia	0	52	52
Latvia	161	1683	1 843
Lithuania	295	0	295
Russia	1133	0	1 133
Total	2503	1748	4 252

Table 3.4.2. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Estimated discard rate by countries for flounder in the Baltic Sea, subdivisions 26 and 28 in 2016.

	Landings	Discards	Discard ratio
Estonia	51,7	0,0	0,00
Germany	0,9	0,3	0,24
Latvia	1843,3	9,7	0,01
Lithuania	294,8	61,8	0,17
Poland	911,6	117,7	0,11
Russia	1132,8	0,0	0,00
Sweden	16,4	1,5	0,08
Total	4251,5	190,9	0,04

Table 3.4.3. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Number of collected otoliths from flounder catch in Subdivisions 26 and 28.

Country	Discards	Landings	Total
Estonia		196	196
Latvia	179	488	667
Lithuania	477	904	1381
Poland	172	340	512
Russia		1246	1246
Total	828	3174	4002

Table 3.4.4. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch per unit of effort (kg per hour) from BIT Survey in 1st and 4th Quarters, Subdivision 26 and 28.

Biomass index (kg hour−1)			
Year	1st quarter	4th quarter	Combined index
1991	124.2		124.2
1992	51.1		51.1
1993	91.3	48.4	66.5
1994	13.5		13.5
1995	59.6		59.6
1996	105.3		105.3
1997	25.7	52.8	36.8
1998	96.4	67.9	80.9
1999	102.3	73.7	86.8
2000	197.9	65.2	113.6
2001	278.9	404.1	335.8
2002	238.2	316.5	274.6
2003	159.9	143.3	151.4
2004	145.6	366.0	230.9
2005	128.5	307.0	198.6
2006	103.8	150.2	124.8
2007	238.7	223.2	230.8
2008	330.1	198.8	256.2
2009	160.9	145.1	152.8
2010	242.2	196.4	218.1
2011	230.4	209.9	219.9
2012	211.7	134.2	168.5
2013	132.7	175.8	152.8
2014	82.7	63.5	72.5
2015	97.3	72.4	83.9
2016	132.6	55.1	85.5

Table 3.4.5. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
Lmax5%	Mean length of largest 5%	Linf	Lmax5% / Linf	> 0.8	Conservation (large individuals)
L95%	95th percentile		L95% / Linf		
Pmega	Proportion of individuals above Lopt + 10%	0.3–0.4	Pmega	> 0.3	
L25%	25th percentile of length distribution	Lmat	L25% / Lmat	> 1	Conservation (immatures)
Lc	Length at first catch (length at 50% of mode)	Lmat	Lc/Lmat	> 1	
Lmean	Mean length of individuals > Lc	Lopt = $\frac{3}{3+M/k} \times L_{inf}$	Lmean/Lopt	≈ 1	Optimal yield
Lmaxy	Length class with maximum biomass in catch	Lopt = $\frac{3}{3+M/k} \times L_{inf}$	Lmaxy / Lopt	≈1	
Lmean	Mean length of individuals > Lc	LF=M = (0.75Lc+0.25Linf)	Lmean / LF=M	≥ 1	MSY

Table 3.4.6. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Length based indicator of flounder in subdivisions 26 and 28 status for the most recent three years

	Conservation				Optimizing Yield	MSY		
Year	Lc / Lmat	L25% / Lmat	Lmax 5 / Linf	Pmega	Lmean / Lopt	Lmean / LF = M	Lmean	LF=M
Ref	>1	>1	>0.8	>0.3	~1 (>0.9)	>1	cm	cm
2014	1.21	1.23	1.10	0.96	1.40	1.09	27.04	24.84
2015	1.21	1.28	1.25	0.98	1.47	1.14	28.22	24.84
2016	1.10	1.23	1.23	0.97	1.42	1.17	27.31	23.34

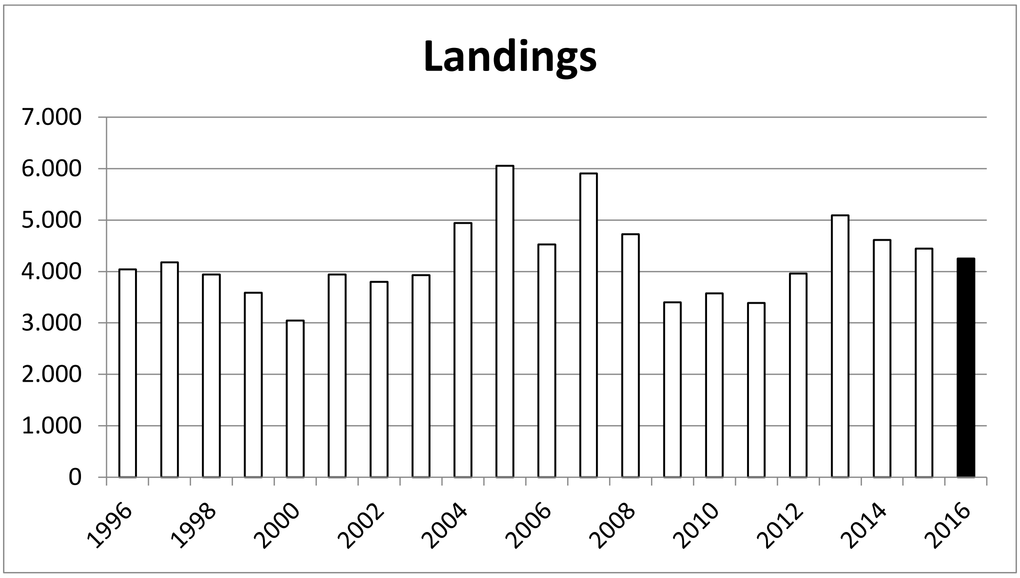


Figure 3.4.1. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder in subdivisions 26 and 28.

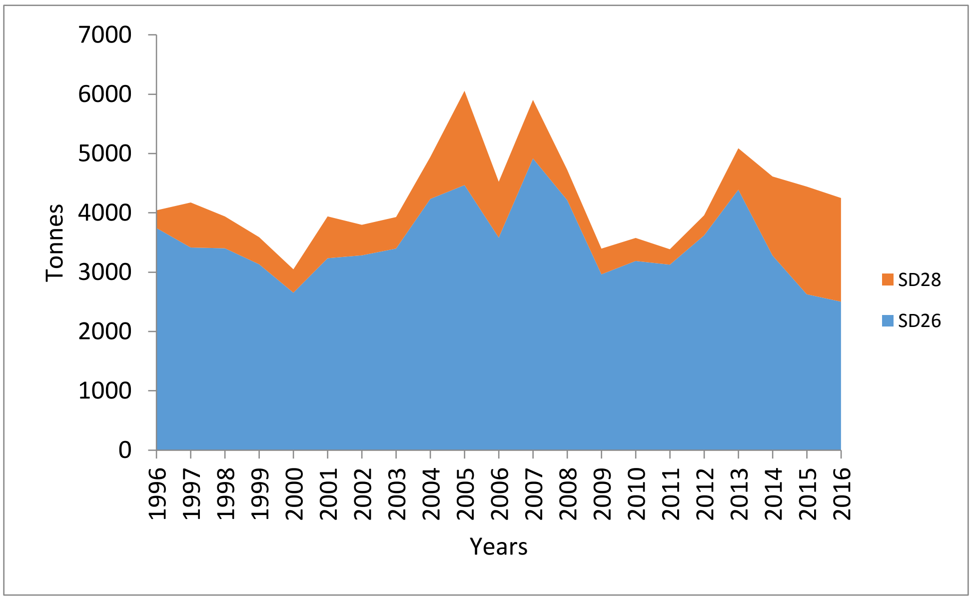


Figure 3.4.2. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder by subdivisions.

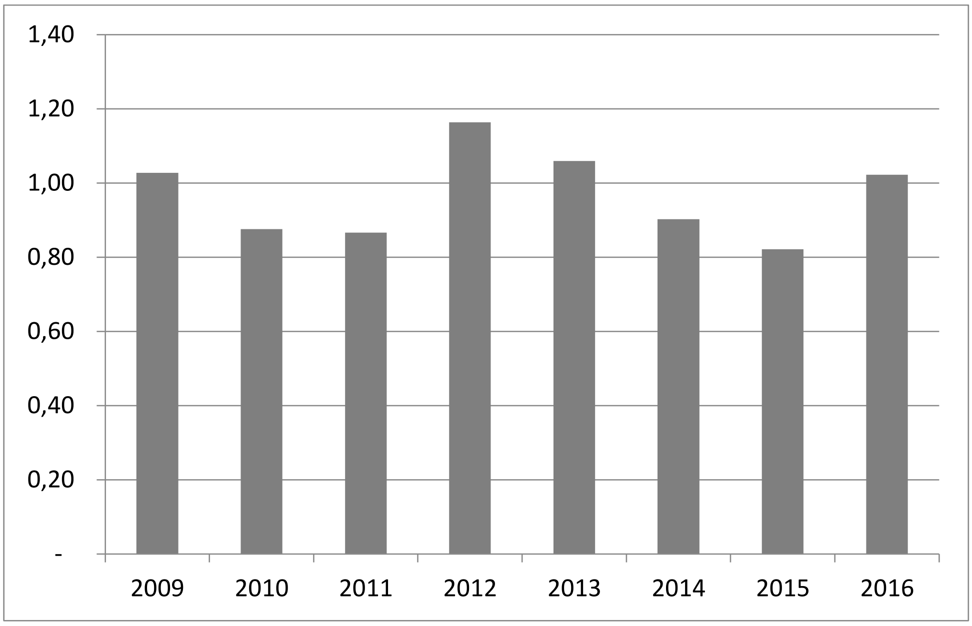


Figure 3.4.3. **Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Effort datta (days at sea) of flounder in subdivisons 26 and 28 (days at sea).**

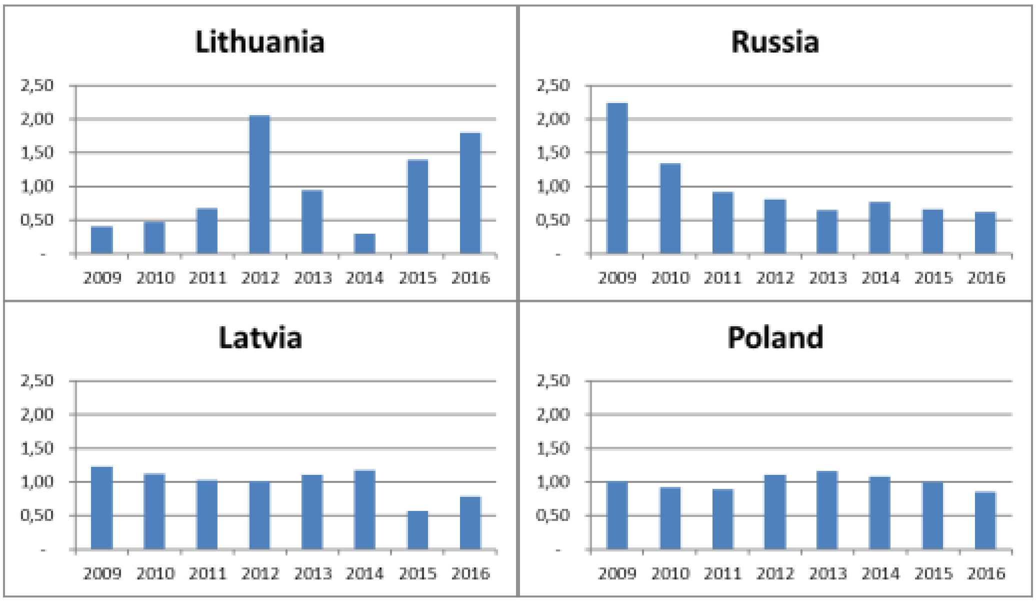


Figure 3.4.4. **Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Effort data of flounder in subdivisions 26 and 28 by main fishing countries (days at sea).**

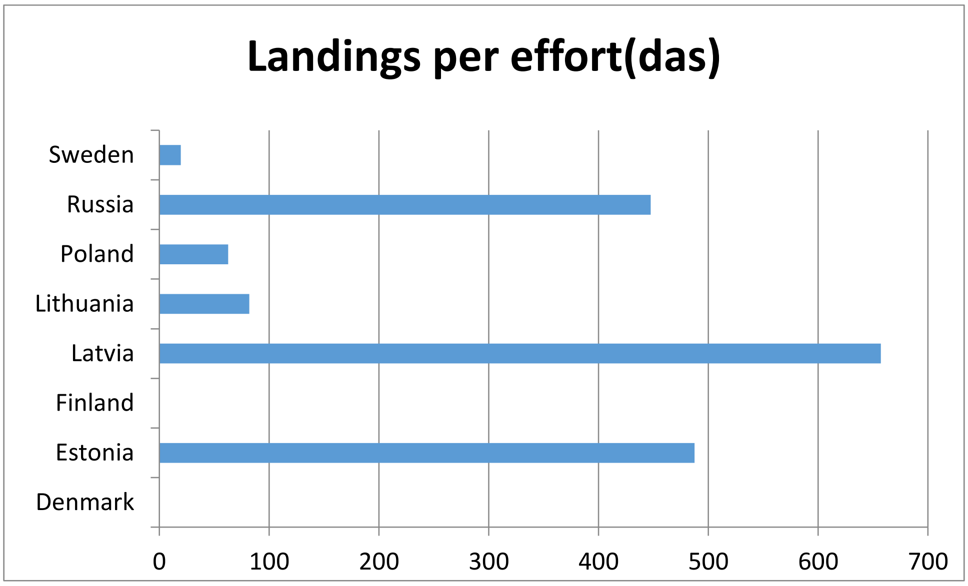


Figure 3.4.5. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Landings of flounder per days at sea by country in subdivisions 26 and 28.

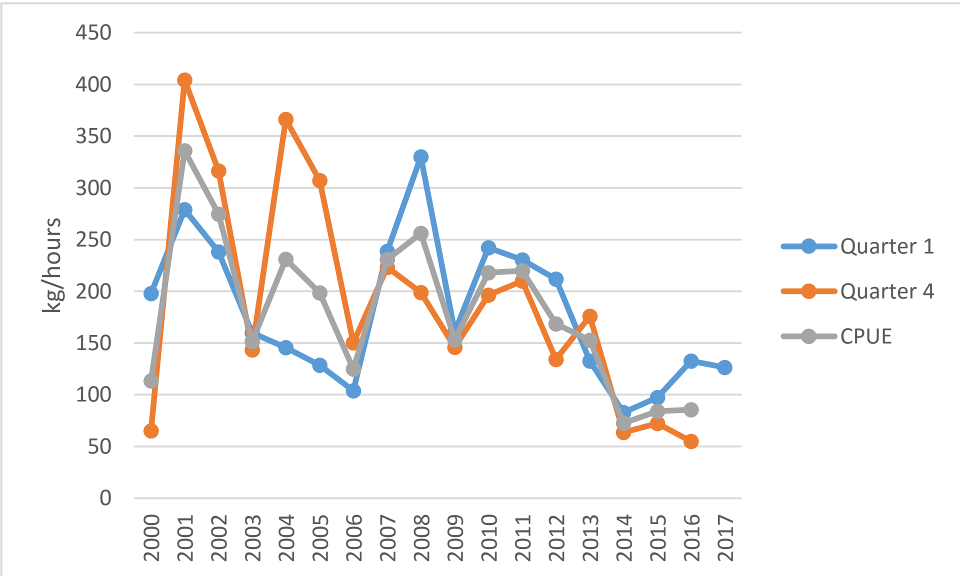


Figure 3.4.6. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch per unit of effort (kg per hour) from BIT Survey in 1st and 4th Quarters, subdivisions 26 and 28.

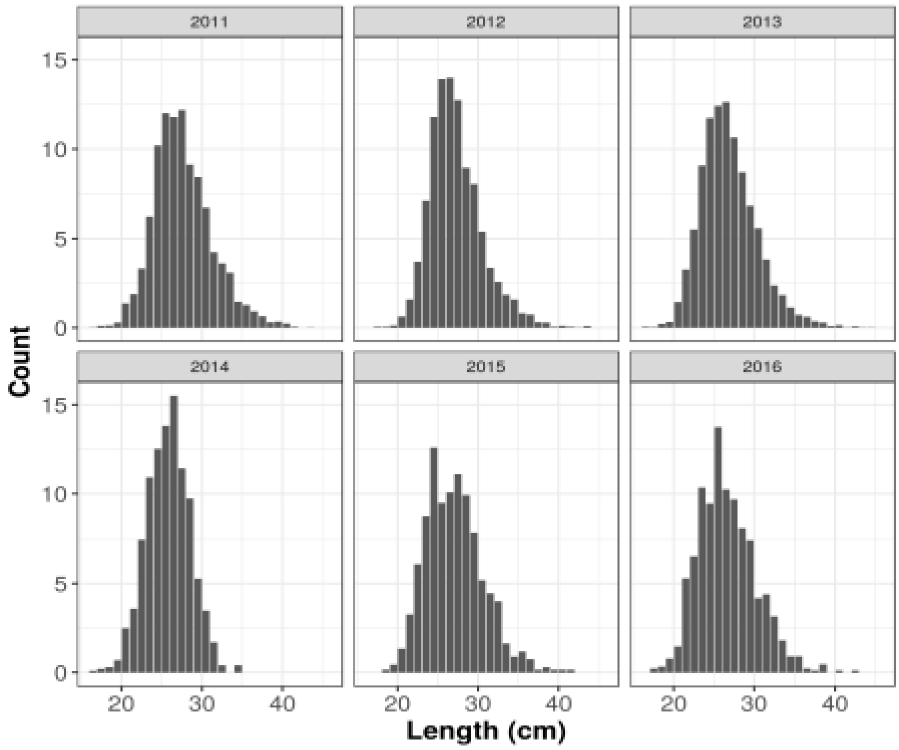


Figure 3.4.7. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Length distribution of flounder in Subdivisions 26 and 28 from commercial catch.

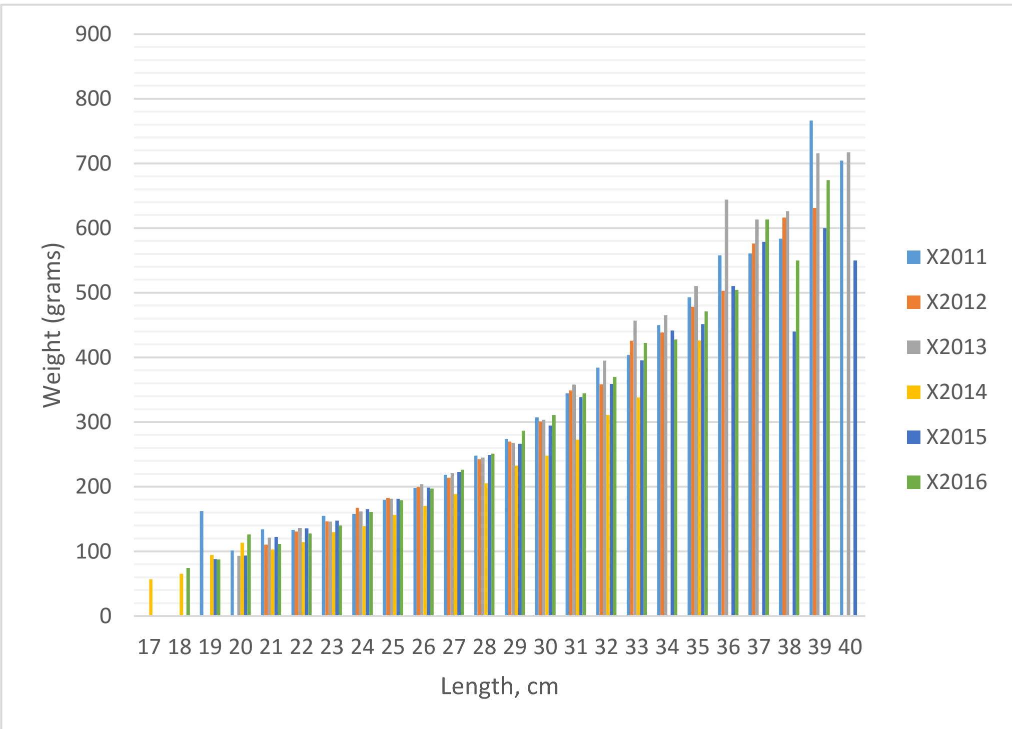


Figure 3.4.8. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Mean weights (in grams) at length of flounder in subdivisions 26 and 28.

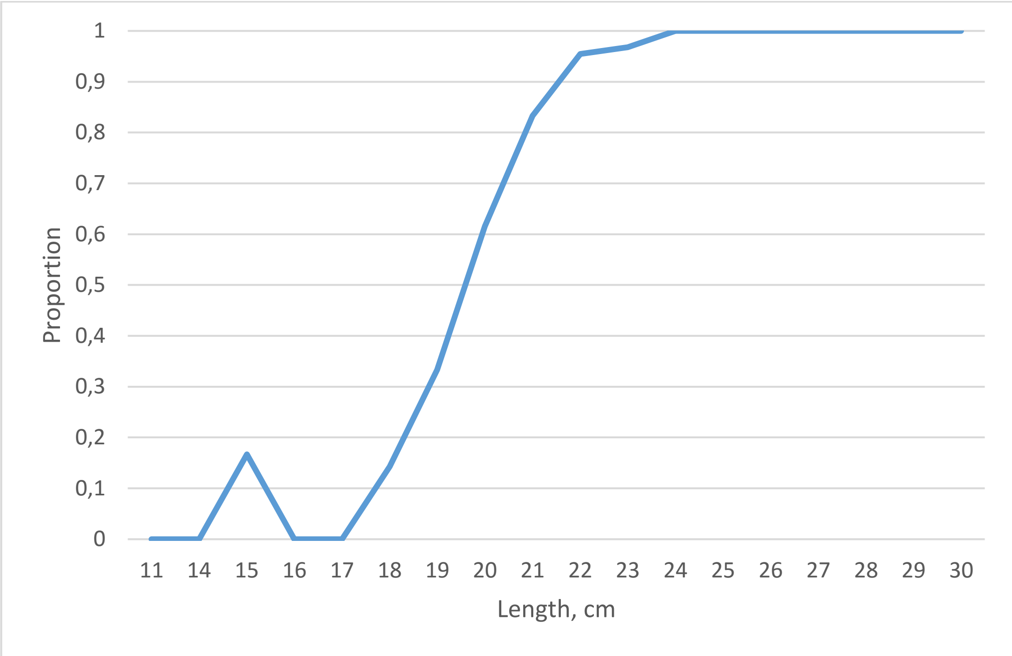


Figure 3.4.9. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Proportion of mature flounder female by length, ICES subdivisions 26 and 28

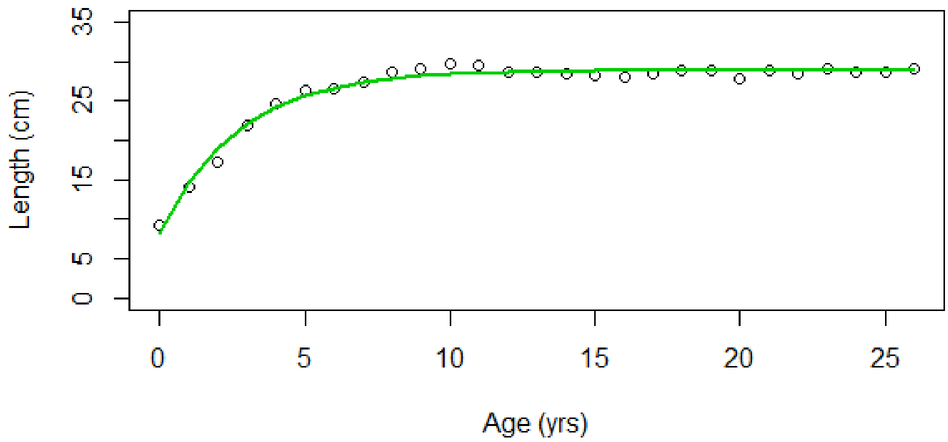


Figure 3.4.10. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Bertalanffy growth function of flounder in subdivisions 26 and 28

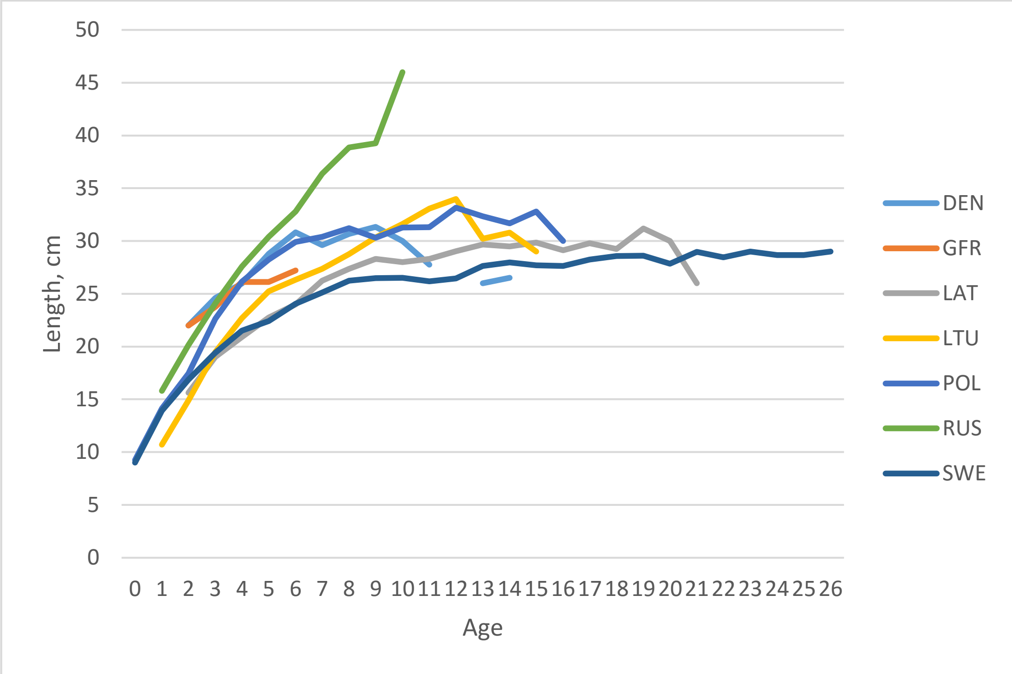


Figure 3.4.11. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Mean length of flounder at age by countries. ICES subdivisions 26 and 28. BITS Q1 and Q4 combined, 2011-2016.

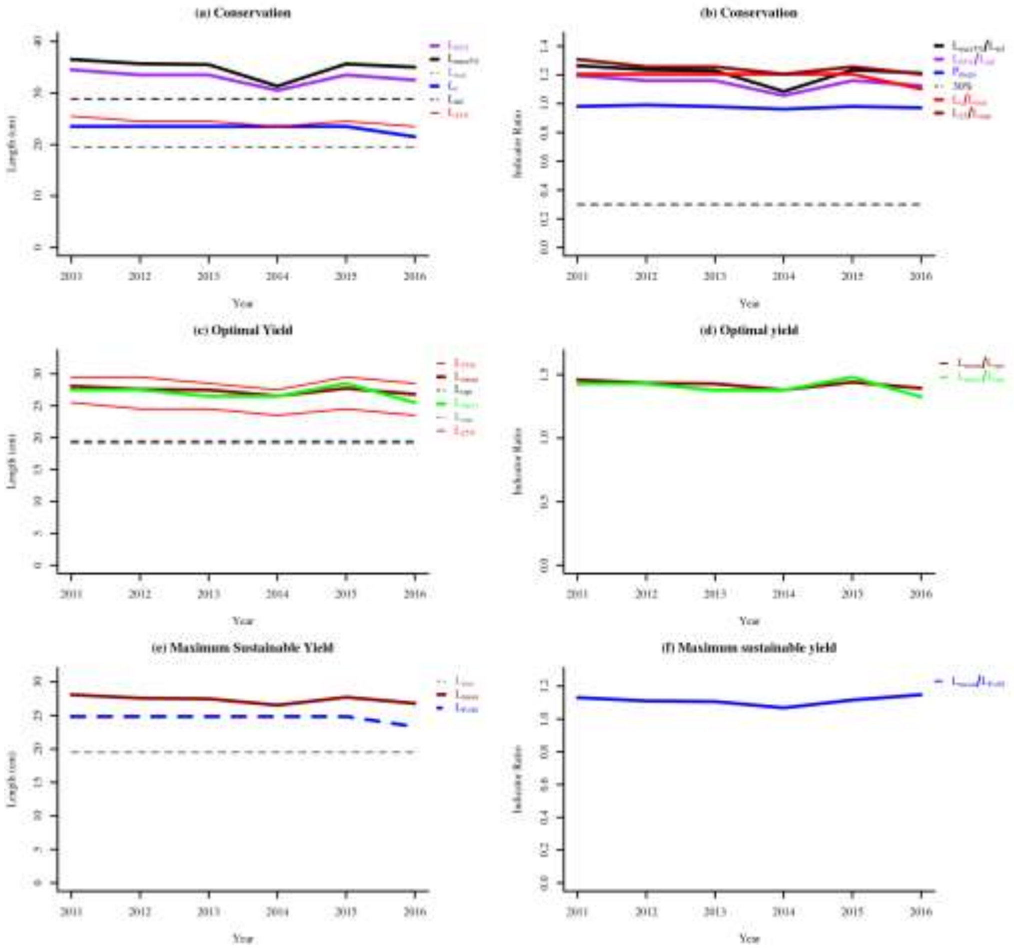


Figure 3.4.12. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Length based indicator of flounder in subdivisions 26 and 28 trends.

3.5 Flounder in Subdivision 27, 29–32 (Northern flounder)

Based on the decision by Benchmark Workshop on Baltic Flatfish Stocks (WKBALFLAT; 26—28 Nov 2013; 27—31 Jan 2014) flounder with demersal eggs inhabiting mainly the Northern Baltic Proper (SD 27, 29—32) is treated as a separate flounder stock. In the rest of the Baltic Sea flounder with pelagic eggs dominate

Flounder with demersal eggs spawn in the shallow water down to salinities of 5—7 psu. This means that, flounder in the SDs 31 and 32 are at the border of its distribution area. Eggs are demersal, small (diameter < 1 mm) and relatively heavy. There are probably local spatially distinctive populations in the different coastal areas, and the migration between these areas is limited. Flounder with demersal eggs inhabit also the Central Baltic Sea; however, it is not possible to separate the landings of the two spawning types and in SD 28 presumably pelagic spawning type dominates. Therefore, SD 28 is not included in this stock.

3.5.1 Fishery

3.5.1.1 Landings

In subdivisions 27 and 29—32 flounder is caught mainly in the SDs 29 and 32. The majority (>85%) of the catches are taken with passive gears, mostly gillnets. Yearly total landings have been around 200 tonnes the last eight years but were above 1000 tonnes in the 1980s (Figure 3.5.1). Estonia is the major fishing nation, standing for more than 80% of the catches followed by Sweden with a share of 15% and the rest is taken by Finland and in some years also Poland (Table 3.5.1).

3.5.1.2 Discards

Discards probably take place, the extent depending on market price, but the amount is unknown. In the major fishing country, Estonia, discard is not allowed. Survival rate of flounder in discards is unknown for passive gears but can probably be high under certain conditions. In Sweden no discard sampling is made for this stock. Swedish discard rate is calculated using estimates from SD 25 and scaled up to total landings of demersal fish species in the fished strata (passive gear per quarter and SD). Swedish discard can be almost up to the same level as landings, in 2016 the total discard is estimated 29.8 tonnes. Estimated discard in Finland is low, scaling up to total landings of demersal fish species landings from the three sampled stratum gives a total amount of discard of 5.1 tonnes in 2015 and 0.6 tonnes in 2016.

3.5.1.3 Recreational fishery

In the northern Baltic Sea the importance of recreational fishery is substantial. Recreational catches are estimated by Estonia and Finland (Table 3.5.2). In Sweden flounder is not distinguished from the rest of flatfishes, which complicates the catch estimates for recreational fishery. Although the species composition is unknown the majority of this is ought to be flounder. Rough calculations have shown that recreational fishery catches for Sweden can be three times higher as commercial landings, same seems to be true for Finland. In Estonia the reported recreational catch is on average equivalent to 20-30% of the commercial landings. Using the estimates from WKBALFLAT (2014) total recreational catches in this area are up to 40% of the commercial landings, however the quality of the estimates is not well known and the data is therefore not included in the advice.

3.5.1.4 Effort

The exploitation status of the stock is unknown, since effort data from the most important fishery, passive gears, is lacking from the dominating fishing nation Estonia (Table 3.5.3). In addition, there is no data on effort for the recreational fishery which could be up to a magnitude of 60% of the commercial landings (calculation made using 2016-year data).

3.5.2 Biological information

Age data are considered to be applicable only when the ageing was conducted using new method (i.e. breaking and burning of otoliths technique) as recommended by ICES WKARFLO (2007; 2008) and ICES WKFLABA (2010).

3.5.2.1 Catch in numbers

Age information from commercial catches is very limited. Catch in numbers-at-age (CANUM) and mean weight-at-age are available from Estonian commercial trap nets between 2011-2016 in SD29 and 32. Age data were not sampled in commercial landings in Finland, for Sweden age data exist only for the years 2009-2010.

Estonia commercial landings length distribution is available only from trap nets and some extent from Danish seine landings. However, most of the fish (~80%) is caught with gillnets and the selectivity of these gears is quite different, gillnets having a narrower selectivity (Figure 3.5.2). In Sweden the minimum legal size for flounder is 21 cm and fisherman use mainly 60-70 mm mesh sizes. For Estonia the situation is more complicated, minimum legal size in SD29-32 is 18 cm and most of the gillnet landings are caught with mesh sizes ≥ 55 mm; however, depending on the year up to 15% of landings with gillnets are caught with nets with smaller mesh size then 55 mm. It was decided that data from Küdema survey (SD29) mesh sizes 50, 60 mm would be representative for the length composition of the commercial fishery. To incorporate the effect of catching fish with gears such as trap nets, Danish seine and smaller mesh size gillnets (<55mm), length data from 38 mm mesh size gillnets were added to the length distribution from mesh sizes 50, 60 mm, according to the rate of the landings that were caught with other gear then gillnets. Corresponding results of catch in numbers by length class and year can be seen in Figure 3.5.3.

3.5.2.2 Mean weights-at-age

Mean weights per age were available only from Estonia commercial trap net landings. The weight per age strongly fluctuate. The high fluctuation of weights per age could be the product of small sample size, especially for older ages. Mean weights per age are also available for survey in SD29. The survey weight data seem to be more stable compared to the commercial data (Figure 3.5.4).

3.5.3 Fishery independent data

Fishery independent data are gathered from four national gillnet surveys since the BITS survey was deemed inappropriate for this stock (not covering shallow areas, not covering Northern Baltic Sea). From Estonia two surveys were available, one in Muuga bay near Tallinn (mesh size 40—60 mm bar length) in SD 32 ongoing since since 1993, and one in Küdema bay in SD 29 since 2000 (mesh size 21.5, 30, 38, 50 and 60 mm bar length). In Muuga the survey is done weekly from May to October while in Küdema six fixed stations are fished during six nights in October/November in depths 14—20 m. Data were restricted to October for the Muuga survey index.

From Sweden two surveys were available using the same gear as in Küdema and the same time of year September/October in two areas in the southern and the northern part of SD 27, Kvädöfjärden (data from 1989) and Muskö (data from 1992) respectively. In Kvädöfjärden six fixed stations are fished during six nights at 15—20 m depth while in Muskö eight fixed stations are fished during six nights at 16—18 m depth.

Cpue in biomass (kg per fishing station and fishing day) was used as biomass index for all four surveys. The arithmetic mean of the two surveys in SD 27 was combined with the biomass indices in 29 and 32. The stock size indicator could be calculated from year 2000 and onwards. For this the indices from these SD-s were combined using the total commercial landings of flounder per SD as a weighting factor (Table 3.5.4).

3.5.4 Assessment

Assessment method of category 3 for stocks for which survey-based assessments indicate trends (ICES DLS approach, ICES, 2012) was used. For providing advice, the average index based on the last two years was compared with the average index from the three preceding years, according to ICES DLS guidelines.

Stock trends are calculated based on national gillnet surveys: two surveys in SD 27, one survey in SD 29 and one survey in SD 32 (Figure 3.5.5). Stock size indicator increased by 174 % based on mean stock index of 2015-2016 compared to 2012-2014 (Figure 3.5.6). This extremely high increase is affected by the four-fold increase in Küdema bay survey biomass index in 2015 (Table 3.5.4). For the past four years' consistent increase in all survey biomasses is evident (except Muuga bay), although in much smaller scale. Probably so high cpue value for Küdema bay in 2015 is not representative, although consistent increase in all survey biomasses (except Muuga bay) is evident for years before 2015. This year's cpue value for the stock was lower than the cpue in 2014, due to that it was deemed that there is no clear way for correcting the 2015 Küdema bay biomass index value.

As was done last year, the sensitivity of the advice to a single extreme years was investigated. New 2015 biomass index value for SD29 was calculated interpolating the increase in the area between two previous years (SD29 survey biomass indicator increased 16% from 2013 to 2014) to 2014 and 2015. As a result, to these changes 174% increase was replaced with a 31% increase. Independent of the remarkable decrease of the index factor in 2015, uncertainty cap of 1.2 was applied, according to ICES advice (ICES, 2012).

3.5.5 Reference points

For MSY proxy reference point calculations two different methods, length-based indicators and length-based spawning potential ratio, were used. Both of the methods need a commercial catch/landings length composition and Beverton-Holt life-history parameters (L_{inf}, M/K, L_{mat}) (Table 3.5.5). The description how commercial catch length composition was calculated can be found in the chapter 3.5.2.1 'Catch in numbers'.

M/K ratio of 1 was chosen over the default value 1.5. Estimate of growth rate for flounder was quite high (0.344 $year^{-1}$) (Figure 3.5.7). There is no estimate of natural mortality for this flounder stock but previous estimates of total mortality are available (ICES, 2014). Estimated total mortality rates are very different for Estonia and Sweden - around 0.2-0.45 in Küdema and 0.68-1.68 in Muskö, respectively. Because most of the fish is caught around Estonian coastal areas it was decided that natural mortality value around 0.3 seems more appropriate and correspondingly M/K value 1 was used in the assessments.

LBI calculations were made using code that was used by WKIND3.3i group. The L_c and L_{mean} calculations differ little bit form the calculations that are presented by WKLIFE V (ref). L_c was calculated using mean lengths of all lengths associated with frequencies falling within 20-80% on the left side of the mean maximum frequency, where the mean maximum was taken from the three largest frequencies around the first mode (ICES 2016d). L_{mean} was calculated using all length classes, to make the estimation of this indicator independent of L_c, which tends to be more variable.

ICES. Based on the LB-indicators flounder in can be concluded? that the stock is not overfished (Table 3.5.6). Length based indicators should be calculated from length data that incorporates discards. In this case actual estimates of discard and corresponding length composition is unknown. However, current length distribution was calculated using survey data and includes also individuals smaller than minimum legal size, lowering the bias of not having estimates of discard.

LB-SPR calculations were made using Shiny App (http://barefootecologist.com.au/lbspr). Current online version of LB-SPR assumes that the selectivity is asymptotic. The assumption of asymptotic selectivity is crucial for this model and when presented data from different kind of selectivity (e.g. dome-shaped) it is likely to achieve biased estimates of F/M and SPR. This is very important notation, considering that flounder is caught mainly with gillnets and for this type of gear dome-shaped selectivity is assumed. The reason why dome-shaped selectivity causes problems is that the method will assume that any large individuals that are missing from the data have been removed by fishing (Hordyk *et al.*, 2015). In the case when large fish are underrepresented in the length sample, LB-SPR method will overestimate F/M and underestimate SPR. The method is also very sensitive to estimates of L_{inf}, especially in cases where the value of M/K ratio is low (Hordyk *et al.*, 2015). Underestimation of L_{inf} value will produce overestimation of F/M ratio and underestimation of SPR. Hordyk *et al*. (2015) found that when L_{inf} parameter was specified to be too low (10-20% lower), the model hit the lower bound of F/M (F/M=0), and returned estimates of SPR of 1. Figure 3.5.8 shows model fit for Northern flounder stock and it can be seen that the fit isn't ideal, especially for year when second small peak can be seen (2009-2011). Year 2009 model fit was poor and this also seen from the F/M and SPR values – F/M ratio is estimated to be 0 and the SPR=1. For the last three years' model fit seems reasonable and corresponding values of F/M and SPR are indicating that the stock is not overfished and there are no problems with the spawning biomass (Figure 3.5.9). Based on these results flounder in subdivisions 27 and 29-32 is not overfished and in a good status (Figure 3.5.10). However, the model assumes asymptotic selectivity and this may not be the case with flounder, this can be seen from the poor model fit for some of the years and doubtful estimates of SPR and F/M for 2009. Taking into account the assumptions of selectivity, and the model sensitivity to L_{inf} in cases of low M/K values, it was decided to not use the LB-SPR model for estimating MSY proxies.

Table 3.5.1. Flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Total landings (tonnes) by Subdivision and country.

YEAR	COUNTRY	SD 27	SD 29	SD 30	SD 31	SD 32	TOTAL
1980	Finland*		27	14	1	11	53
	Sweden	20	32				52
	USSR		334			1 080	1 414
	Total	20	393	14	1	1 091	1 519
1981	Finland*		67	4		7	78
	Sweden	21	34				55
	USSR		445			1 078	1 523
	Total	21	546	4	0	1 085	1 656
1982	Finland*		38	6		6	50
	Sweden	65	3				68
	USSR		615			1 121	1 736
	Total	65	656	6	0	1 127	1 854
1983	Finland*		28	7		3	38
	Sweden	212	9				221
	USSR		497			1 114	1 611
	Total	212	534	7	0	1 117	1 870
1984	Finland*		27	10		6	43
	Sweden	53	2				55
	USSR		286			1 226	1 512
	Total	53	315	10	0	1 232	1 610
1985	Finland*		21	9		7	37
	Sweden	47	2				49
	USSR		265			806	1 071
	Total	47	288	9	0	813	1 157
1986	Finland*		36	11		5	52
	Sweden	60	3				63
	USSR		281			556	837
	Total	60	320	11	0	561	952
1987	Denmark	1					1
	Finland*		37	18		3	58
	Sweden	51	2				53
	USSR		279			397	676
	Total	52	318	18	0	400	788
1988	Finland*		43	21		5	69
	Sweden	68	3				71
	USSR		257			331	588
	Total	68	303	21	0	336	728
1989	Finland*		39	24		6	69
	Sweden	66	3				69
	USSR		214			214	428
	Total	66	256	24	0	220	566
1990	Finland*		35	19		4	58

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	USSR		144			141	285
	Total	0	179	19	0	145	343
1991	Finland*		53	17		5	75
	Sweden	88					88
	Estonia		135			51	186
	Total	88	188	17	0	56	349
1992	Finland*		48	10		5	63
	Sweden	86	3				89
	Estonia		47			46	93
	Total	86	98	10	0	51	245
1993	Finland*		52	26		5	83
	Sweden	83					83
	Estonia		86			55	141
	Total	83	138	26	0	60	307
1994	Denmark	9					9
	Finland*		47	24		8	79
	Sweden	33	10				43
	Estonia		3			4	7
	Total	42	60	24	0	12	138
1995	Denmark		1				1
	Finland*		54	29		6	89
	Sweden	81					81
	Estonia		52			35	87
	Total	81	107	29	0	41	258
1996	Finland*		47	36		9	92
	Sweden	114					114
	Estonia		99			145	244
	Total	114	146	36	0	154	450
1997	Finland*		35	32		13	80
	Sweden	105					105
	Estonia		96			125	221
	Total	105	131	32	0	138	406
1998	Finland*		36	21		14	71
	Sweden	70					70
	Estonia		79			87	166
	Total	70	115	21	0	101	307
1999	Denmark	0	1				1
	Finland*		43	22	2	9	76
	Sweden	15					15
	Estonia		150			164	314
	Total	15	194	22	2	173	406
2000	Denmark	1					1
	Finland*		34	13	0	9	56
	Sweden	73					73
	Estonia**		166			126	292

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Total	74	200	13	0	135	422
2001	Denmark	10					10
	Finland*		28	14	0	7	50
	Sweden	85			3		88
	Estonia**		135			220	355
	Total	100	164	14	3	227	503
2002	Finland*		16	8		11	35
	Sweden	90		5			95
	Estonia**		166			226	392
	Total	90	182	13	0	247	523
2003	Denmark	1					1
	Finland*	0	16	9	0	7	31
	Sweden	57					57
	Estonia****		156			128	284
	Total	57	172	9	0	135	374
2004	Finland*		13	18	0	4	34
	Sweden	45					45
	Estonia**		127			167	294
	Total	45	140	18	0	171	373
2005	Finland*		11	10	0	3	23
	Sweden	47	2	0			49
	Estonia		144			114	258
	Total	47	157	10	0	117	330
2006	Finland*		11	4.166	0	2	17
	Sweden	33					33
	Estonia		165			129	294
	Total	33	176	4	0	131	344
2007	Finland*		6	1	0	2	9
	Sweden	39	0	0	0		39
	Estonia**		110			104	214
	Total	39	116	1	0	107	263
2008	Finland		5	1	0	5	11
	Sweden	49	0	0			49
	Estonia**		103			86	189
	Total	49	108	1	0	89	249
2009	Finland		6	1	0	3	10
	Sweden	41	0	0			41
	Estonia**		109			102	210
	Total	41	115	1	0	105	262
2010	Finland	0	6	1	0	3	10
	Sweden	36	0	0			36
	Estonia**		85			96	180
	Total	36	91	1	0	99	227
2011	Finland	0	5	1	0	2	9
	Sweden	34	0	0	1		35

YEAR	COUNTRY	SD 27	SD 29	SD 30	SD 31	SD 32	TOTAL
	Estonia**	0	94	0	0	83	177
	Total	34	99	1	1	85	221
2012****	Finland		3	0	0	1	5
	Poland***		3				3
	Sweden	36	0		0		36
	Estonia**		79			67	147
	Total	36	85	0	0	69	190
2013	Finland		3	1	0	1	5
	Poland		3				3
	Sweden	31	0				31
	Estonia		123			75	198
	Total	31	129	1	0	77	237
2014	Finland		2	0	0	1	4
	Poland		0				
	Sweden	29	0				29
	Estonia		85			65	150
	Total	29	87	0	0	67	183
2015	Finland		3	0	0	1	4
	Poland		0				0
	Sweden	26	0	0			27
	Estonia		81			64	145
	Total	26	85	0	0	64	176
2016	Finland		2	0	0	1	3
	Poland						0
	Sweden	22	0				22
	Estonia		96			52	148
	Total	22	98	0	0	53	173

*** Finland 1980-2007: Catches of SDs 27&28 are included in SD 29 & catches of SD 31 are included in SD 30**

**** Data Corrected for Estonia 2000-2004, 2007-2012 with figures from Estonian Ministry of Environment, older data includes recreational fishery**

***** Poland 2012 corrected**

Zero values equal to landings under 0.5 tonnes

Table 3.5.2. Flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Recreational fishery catch estimate for Estonia and Finland.

	Estonia		Finland			
	SD32	SD29	SD32	SD29	SD30	SD31
2000			156	187	30	1
2001						
2002			14	78	63	0
2003						
2004			12	64	3	0
2005						
2006			25	48	2	0
2007						
2008			6	27	7	0
2009						
2010			1	9	0	1
2011						
2012	16.6	15.0	13	24	1	0
2013	19.6	16.9				
2014	16.6	15.0	1	9	1	0
2015	28.0	15.7	1	9	1	0
2016	20.0	15.0	1	9	1	0

Table 3.5.3. Flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Fishing effort (days at sea) per country and gear type (passive/active).

	SWE Active	SWE Passive	EE Active	FI Passive
2009	4	3029	46	9030.8
2010	11	2265	22	10067.6
2011	6	2250	3	8290.0
2012	4	2119	14	6120.0
2013	8	2037	77	5510.4
2014	3	2004	56	4466.7
2015	16	2177	50	2814.0

Table 3.5.4. Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Biomass index for the surveys (kg per number of gillnet stations times number of fishing days) Muuga Bay (SD 32), Küdema Bay (SD 29), Muskö (SD 27), and Kvädöfjärden (SD 27) and combined index.

SD	32	29	27			
Survey	Muuga-Q4	Kudema-Q4	Kvädöfjärden-Q41)	Muskö-Q41)	Combined for SD272)	COMBINED3)
	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	kg gear-night-1)
1989			1.05			
1990			1.52			
1991			0.53			
1992			1.75	5.04	3.40	
1993	0.49		1.72	4.98	3.35	
1994	0.20		1.15	1.23	1.19	
1995	0.43		1.08	0.94	1.01	
1996	0.4		0.56	0.17	0.36	
1997	0.47		0.72	0.62	0.67	
1998	0.73		1.14	0.69	0.91	
1999	0.28		0.87	0.2	0.53	
2000	0.25	3.45	1.45	1.09	1.27	2.03
2001	0.65	2.32	1.4	1.11	1.25	1.38
2002	0.17	1.01	1.43	0.56	0.99	0.64
2003	0.3	2.81	0.52	1.1	0.81	1.67
2004	0.47	1.35	0.5	0.87	0.68	0.86
2005	0.39	1.70	0.2	0.53	0.36	1.03
2006	0.42	1.57	0.31	1.02	0.66	1.04
2007	0.1	2.24	0.58	2.51	1.54	1.29
2008	0.11	2.68	1.29	4.44	2.87	1.77
2009	0.36	0.86	0.2	2.2	1.20	0.71
2010	0.14	0.79	0.45	1.04	0.75	0.49
2011	0.24	0.97	0.16	0.5	0.33	0.58
2012	0.13	1.03	0.14	0.48	0.31	0.56
2013	0.13	2.03	0.32	0.95	0.63	1.21
2014	0.09	2.35	0.43	0.98	0.70	1.26
2015	0.07	8.70	0.53	1.32	0.92	4.37
2016	0.11	1.90	0.43	0.76	0.60	1.18

1) Biomass prior to 2009 is estimated from numbers and length distribution

2) Arithmetic mean

3) Weighted mean with the respective SDs landings.

Table 3.5.5. Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Flounder input parameters for LBI and LB-SPR.

Data type	Source	Years/Value	Notes
Length frequency distribution	Küdema survey, mesh sizes 38, 50 & 60 mm	2009-2016	
Mean weight at length			
Linf	Commercial trapnet data SD29+32 (2011-2016)	27.45 cm	combined sex
K		0.344 year-1	
Lmat	2011 survey in Hiiumaa (Q2)	16.8 cm	females only
Lmat95		20.89 cm	
M/K		1	

Table 3.5.6. Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Flounder status for the most recent three years based on the length-based indicators.

	Conservation	Optimaizing Yield	MSY
Year	**Lc/Lmat**	**Lmean/Lopt**	**Lmean/Lf=m**
Ref	**>1**	**~1(>0.9)**	**≥1**
2014	1.10	1.08	1.04
2015	1.13	1.09	1.02
2016	1.16	1.11	1.04

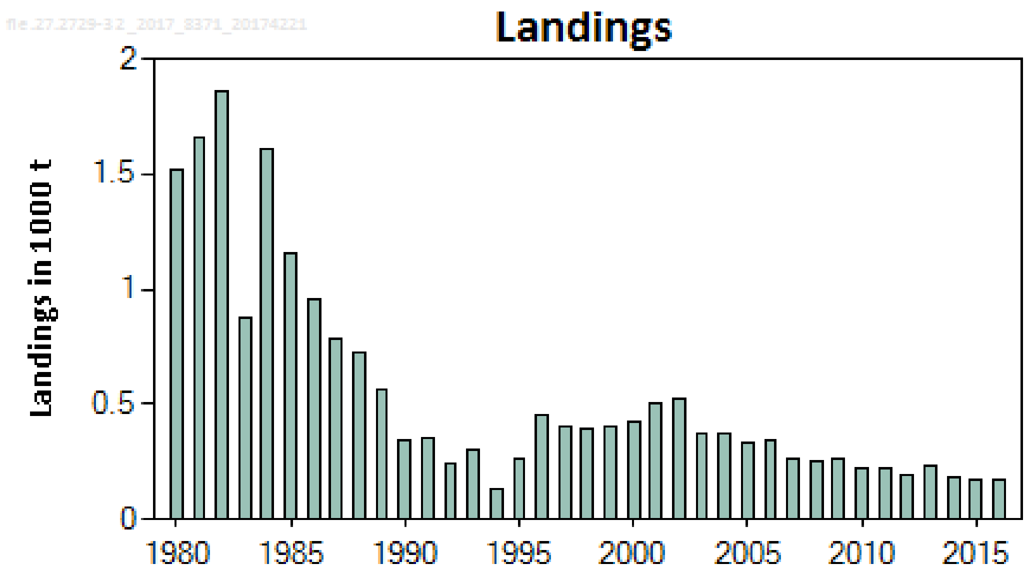


Figure 3.5.1. **Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea).**

Landings (1000 t).

Figure 3.5.2. **Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea).Comparison of commercial trap net length distribution with SD29 survey length distribution (mesh sizes 50 & 60 mm).**

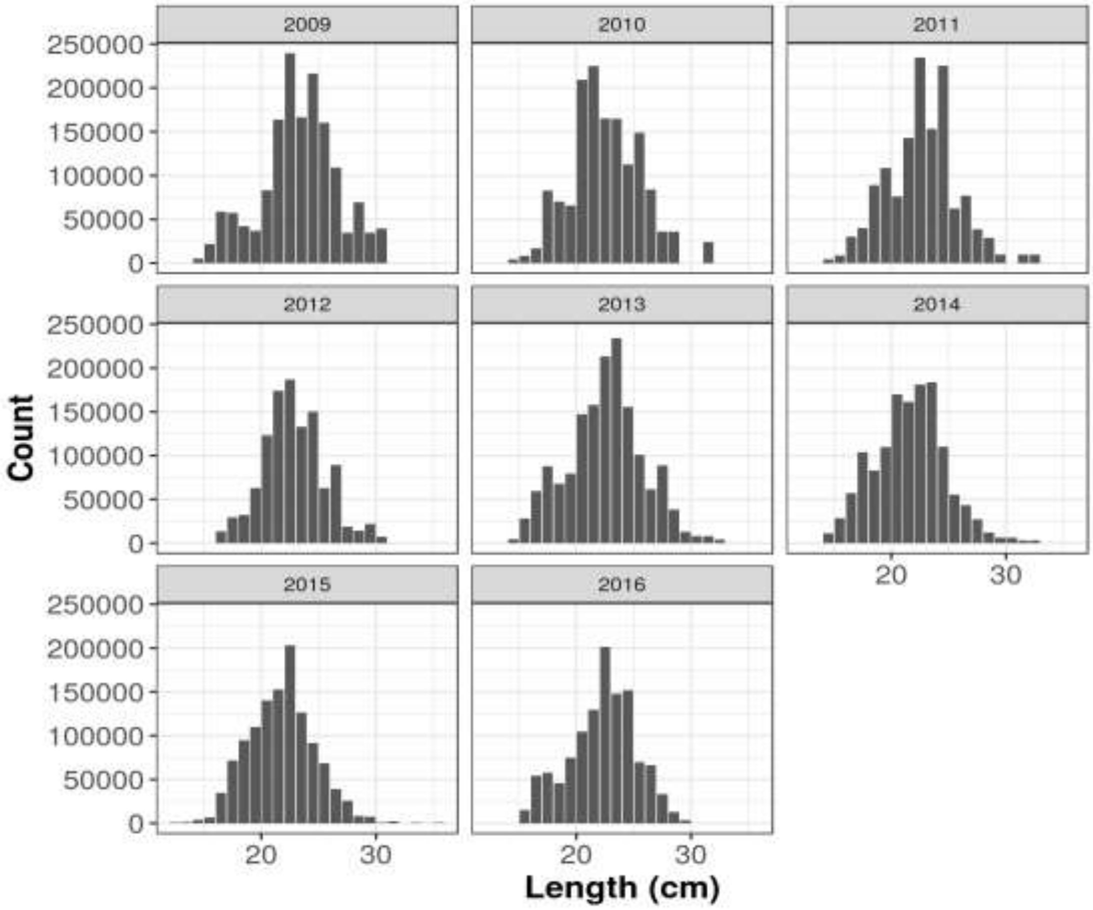


Figure 3.5.3. Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea).Representative catch in numbers by length class for flounder commercial landings in subdivisions 27 and 29-32.

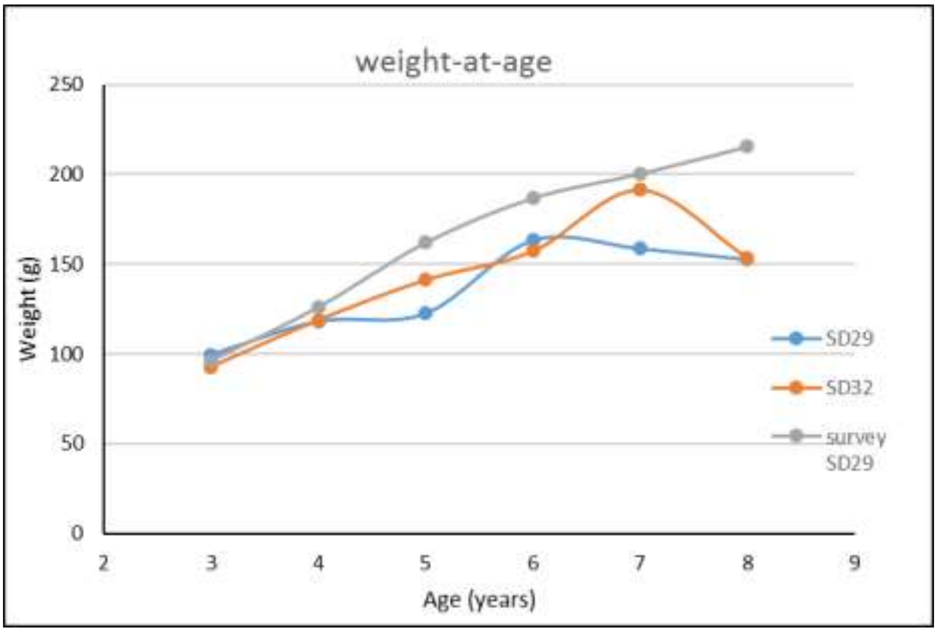


Figure 3.5.4. Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea).Mean weights per age for Estonian commercial trap net landings per Subdivision (Q3+4) and for survey in SD29 (Küdema bay).

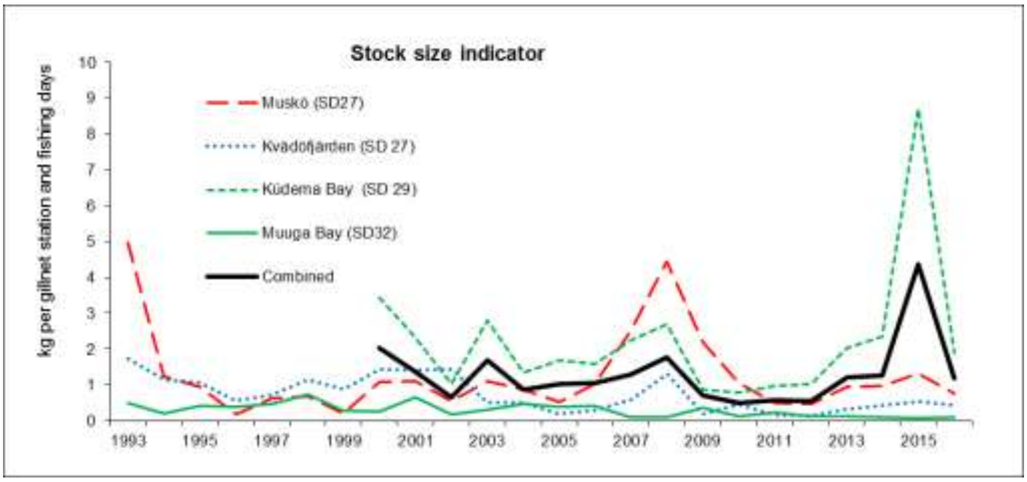


Figure 3.5.5. Flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Biomass indices of Muuga Bay (SD 32) (solid green line), Küdema Bay (SD 29) (dashed green line), Muskö (SD 27) (red dash line), Kvädöfjärden (SD 27) (dotted blue line) surveys and combined index (kg per gillnet station and fishing days).

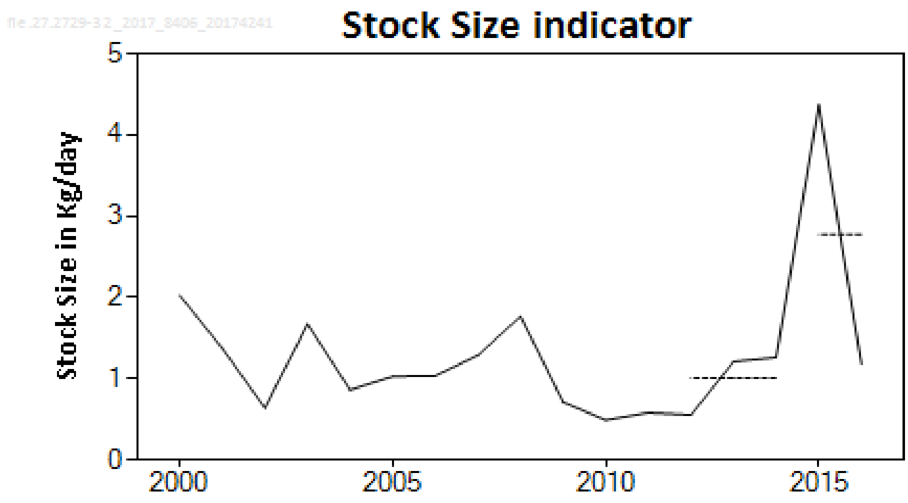


Figure 3.5.6. Flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea) Combined biomass index of four surveys (Muuga Bay (SD 32), Küdema Bay (SD 29), Muskö (SD 27), and Kvädöfjärden (SD 27)) (kg × gillnet fishing station−1). The dashed lines denote the average of the biomass index of periods used for the estimation of the index factor.

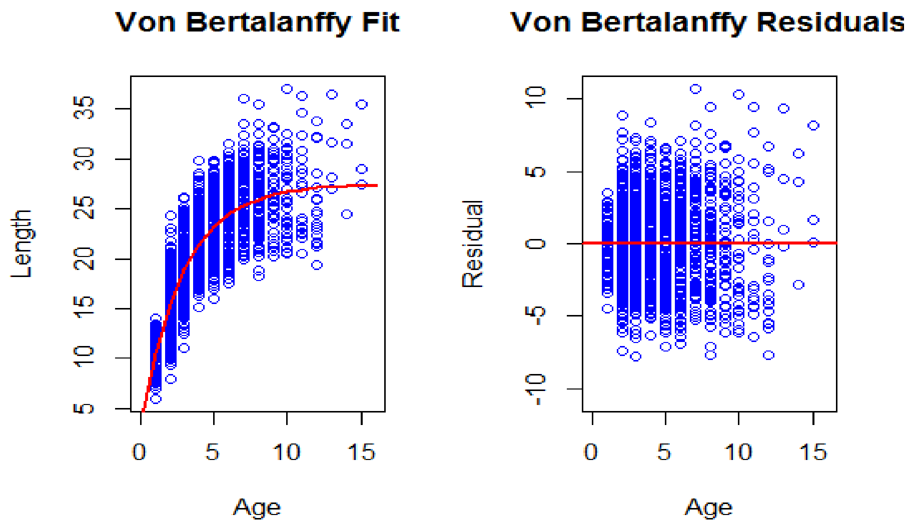


Figure 3.5.7. Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea).Von Bertalanffy growth curve for flounder in subdivision 27 and 29-32 based on data from commercial trap net catches in SDs 29+32 in 2011-2016.

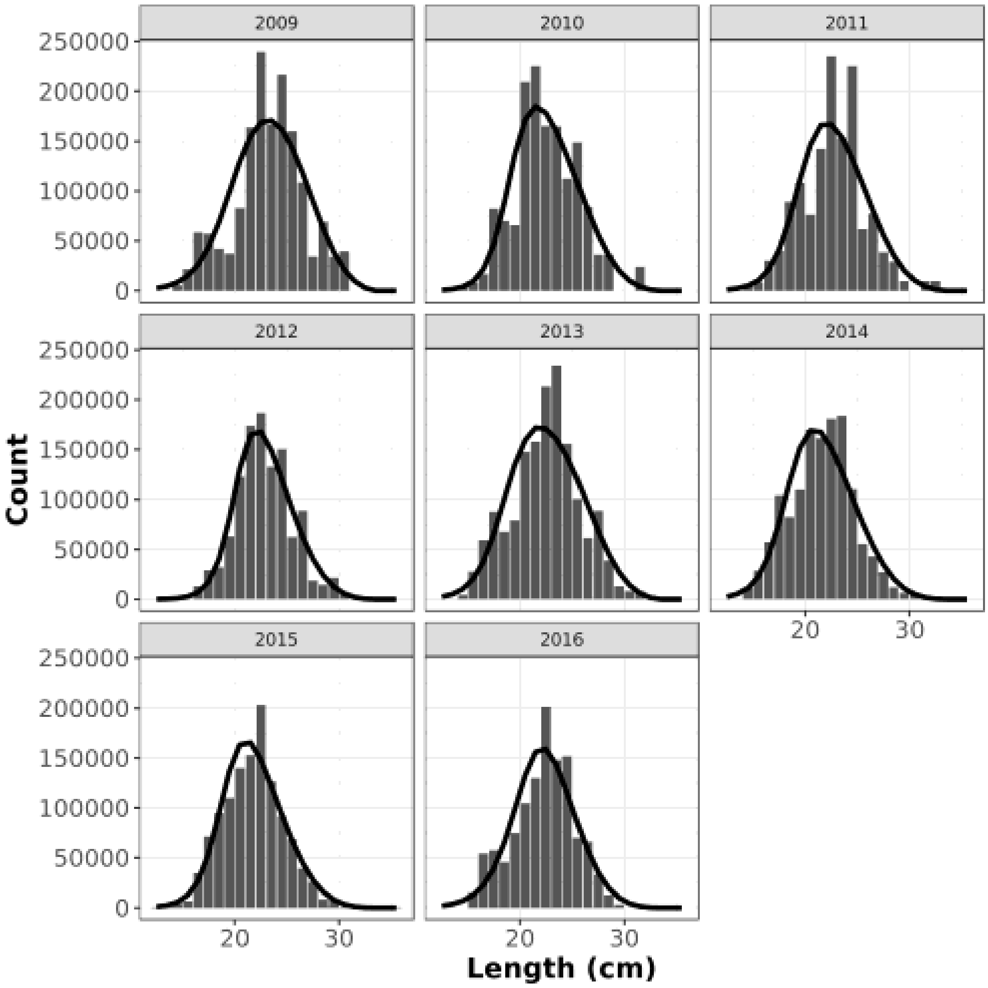


Figure 3.5.8. Flounder in Subdivision 27 and 29-32 length distribution model fit for the LB-SPR model (2009-2016)

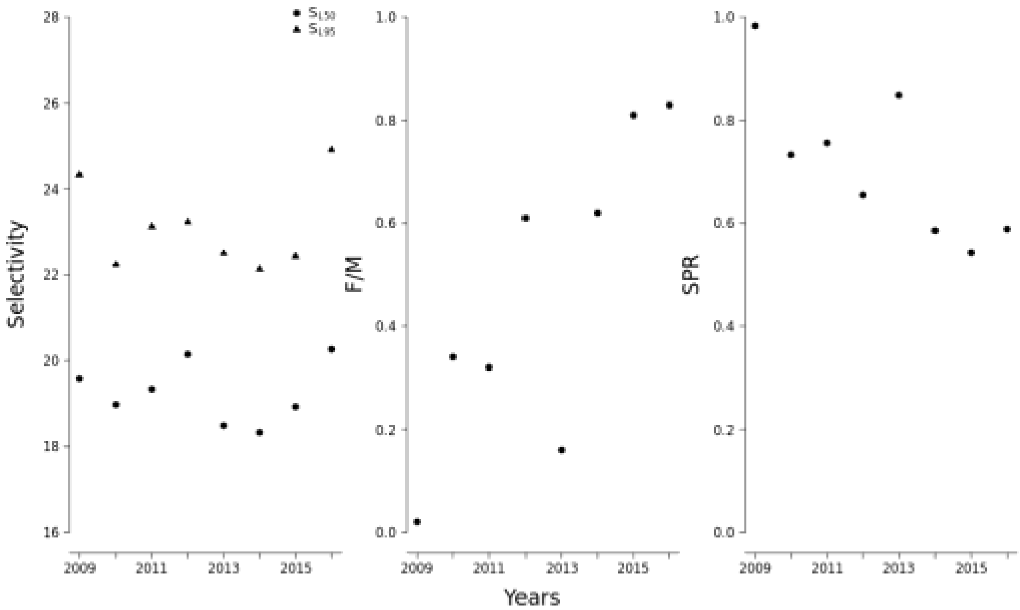


Figure 3.5.9. Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea).LB-SPR results for flounder in SD 27 and 29-32. Left panel shows length at selectivity (S_{L50}, S_{L95}), middle one is ratio between fishing mortality and natural mortality (F/M) and right panel describes spawning potential ratio.

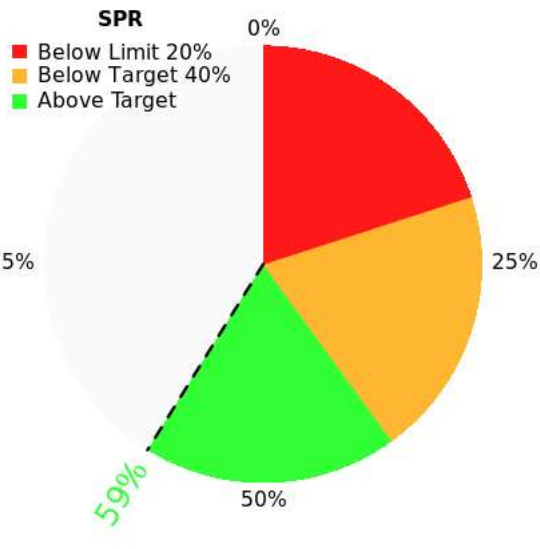


Figure 3.5.10. Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). 2016 spawning potential ratio for flounder in SD 27 and 29-32 in relation to according to the reference point (40% SPR).

4 Herring

4.1 Introduction

4.1.1 Pelagic Stocks in the Baltic: Herring and Sprat

Descriptions of the fisheries for pelagic species and other species are found in Section 1.4 Fisheries Overview.

The distribution by Subdivision of reported landings of herring and sprat in 2016 is given in Table 4.1.1.

In Table 4.1.2 the proportion of herring in landings is given by country, Subdivision and quarter for 2016 together with the proportion of herring in the acoustic survey in the fourth quarter. It is tacitly assumed that the acoustic survey would yield a reasonably good picture of the spatial distribution of the pelagic stocks. Consequently some resemblance with the distribution of landings of the two species could be expected.

Table 4.1.3 shows the total reported landings of herring by quarter for 2016, along with the number of samples, the number of fish measured and the number of fish aged.

4.1.1.1 Mixed pelagic fishery and its impact on herring

Pelagic stocks in the Baltic Proper (subdivisions 25–29, 32) are mainly taken in pelagic trawl fisheries, of which the majority take herring and sprat simultaneously. According to the national data submitters the mixing of pelagic species in the landings are variably taken care of before submitting input data. It is recommended that this issue is explored further.

4.1.2 Fisheries Management

4.1.2.1 Management units

Sprat is managed in the Baltic Sea by two quotas: one EC and one Russian quota.

Herring has in former time been managed by three TAC's:

- SD 22–29S and 32 (excl. Gulf of Riga),
- Gulf of Riga (SD 28.1),
- SD 29N, 30, 31.

The units were changed in 2005 to be:

- SD 22–24,
- SD 25–27, 28.2, 29 and 32 (EC and Russian quotas),
- Gulf of Riga (SD 28.1),
- SD 30, 31.

The historical development of agreed TACs and reported landings for these management units are illustrated in Figure 4.1.1.

Management 2016 and 2017 herring – sprat

The stock status, recommendations from ICES and the TAC decided are presented for the pelagic stocks. The stock status is expressed in relation to the MSY and precautionary reference levels.

Stock	Stock status ACOM 2016 in relation to SSB	Stock status ACOM 2016 in relation to F	ICES Advice for 2017 (Basis) (t)	TAC 2017 (t)
SPRAT				
SD 22–32	Above trigger & Full reproductivity	Below target & Harvested sustainably	314 000 (MSY approach)	*303 593
HERRING				
SD 25–29 & 32 (excl. GOR)	Above trigger & Full reproductivity	Below target & Harvested sustainably	216 227 (MSY approach)	*220 629
SD 28.1 (Gulf of Riga)	Above trigger & Full reproductivity	Above target & Harvested sustainably	23 078 (MSY approach)	31 074
SD 30–31 (Gulf of Bothnia)	Above trigger & Full reproductivity	Above target & Harvested unsustainably	140 998 (MSY approach)	140 998

***EC + Russian quotas**

4.1.3 Catch options by management unit for herring

The herring assessed in SD 25–29 and 32 is also caught in the Gulf of Riga; likewise the Gulf herring assessed in the Gulf of Riga is caught in SD 28 outside the Gulf. These allocations may be based on proportions of landed amounts in the areas.

Proportion of the Western Baltic Spring Spawning Herring (WBSSH) stock (her.27.20-24) caught in SD 22–24.

Year	WBSSH caught in SD 22-24 (1000 tons)*	Total catches of the WBSSH stock (1000 tons)*	% of WBSSH caught in SD 22-24
2000	53.9	109.9	49.0%
2001	63.7	105.8	60.2%
2002	52.7	106.2	49.6%
2003	40.3	78.3	51.5%
2004	41.7	76.8	54.3%
2005	43.7	88.4	49.4%
2006	41.9	90.5	46.3%
2007	40.5	69.0	58.7%
2008	43.1	68.5	62.9%
2009	31.0	67.3	46.1%
2010	17.9	42.2	42.4%
2011	15.8	27.8	57.0%
2012	21.1	38.7	54.5%
2013	25.5	43.8	58.2%
2014	18.3	37.4	48.9%
2015	22.1	37.5	58.9%
2016	25.1	51.3	48.9%
Mean	35.2	67.0	52.8%

***Finnish data not included.**

Proportion of Central Baltic herring (CBH) stock (her.27.25-2932) caught in the Gulf of Riga (SD 28.1).

	CBH caught in Gulf of Riga (SD 28.1) (1000 tons)	Total catches of the CBH stock (SD 25–27, 28.2, 29 & 32) (1000 tons)	% of CBH caught in Gulf of Riga (SD 28.1)
2000	4.6	175.6	2.6%
2001	2.9	148.4	2.0%
2002	3.5	129.2	2.7%
2003	4.3	113.6	3.8%
2004	3.3	93.0	3.5%
2005	2.3	91.6	2.5%
2006	3.2	110.4	2.9%
2007	1.5	116.0	1.3%
2008	6.1	126.2	4.8%
2009	4.9	134.1	3.7%
2010	5.2	136.7	3.8%
2011	5.5	116.8	4.7%
2012	3.8	101.0	3.8%
2013	4.1	101.0	4.1%
2014	4.5	132.7	3.4%
2015	5.0	174.4	2.8%
2016	4.3	192.1	2.2%
Mean	4.1	128.9	3.2%

Proportion of the Gulf of Riga herring (GORH) stock (her.27.28) caught outside the Gulf of Riga in SD 28.2 (only Latvian catches).

Year	GORH caught outside Gulf of Riga in SD 28.2 (1000 tons)	Total stock GORH catches (1000 tons)	% GORH caught outside Gulf of Riga in SD 28.2
2000	1.9	34.7	5.5%
2001	1.2	38.8	3.1%
2002	0.4	39.7	1.0%
2003	0.4	40.8	1.0%
2004	0.2	39.1	0.5%
2005	0.5	32.2	1.6%
2006	0.4	31.2	1.3%
2007	0.1	33.7	0.3%
2008	0.1	31.1	0.3%
2009	0.1	32.6	0.3%
2010	0.4	30.2	1.3%
2011	0.1	29.7	0.3%
2012	0.2	28.1	0.7%
2013	0.3	30.4	1.0%
2014	0.2	26.2	0.8%
2015	0.3	32.8	1.0%
2016	0.3	30.9	1.0%
Mean	0.4	33.1	1.2%

The two tables above are used for the calculation of the fishing quotas in SD 25–27, 28.2, 29 and 32 and in the Gulf of Riga (SD 28.1).

4.1.4 Assessment units for herring stocks

The herring in the Central Baltic Sea is assessed as two units:

- Herring in SD 25–27, 28.2, 29 and 32
- Gulf of Riga herring (SD 28.1)

The herring in the Gulf of Bothnia are assessed as one stock. It includes two subdivisions:

- Herring in SD 30
- Herring in SD 31

The herring in SW Baltic (SD 22–24) is assessed together with the spring spawners in Kattegat and Skagerrak (Division 3.a) within ICES Herring Assessment Working Group for the Area South of 62° N (HAWG).

Table 4.1.1. Pelagic landings ('000 t) and species composition (%) in 2016 by Subdivision and quarter.

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
SD 25	Landings ('000 t)	21.36	36.83	10.51	7.94	**76.64**
	Herring (%)	30.73	35.56	84.79	83.91	**45.97**
	Sprat (%)	69.27	64.44	15.21	16.09	**54.03**
SD 26	Landings ('000 t)	60.99	29.28	9.88	17.48	**117.63**
	Herring (%)	31.39	31.03	69.34	42.58	**36.15**
	Sprat (%)	68.61	68.97	30.66	57.42	**63.85**
SD 27	Landings ('000 t)	12.81	4.63	0.02	1.37	**18.84**
	Herring (%)	51.41	64.16	71.69	79.88	**56.64**
	Sprat (%)	48.59	35.84	28.31	20.12	**43.36**
SD 28*	Landings ('000 t)	71.81	27.53	8.50	24.57	**132.41**
	Herring (%)	49.59	77.31	54.85	51.93	**56.13**
	Sprat (%)	50.41	22.69	45.15	48.07	**43.87**
SD 29	Landings ('000 t)	47.51	14.23	0.73	12.57	**75.04**
	Herring (%)	48.00	83.53	62.19	56.46	**56.30**
	Sprat (%)	52.00	16.47	37.81	43.54	**43.70**
SD 30	Landings ('000 t)	33.07	45.05	13.01	18.09	**109.21**
	Herring (%)	91.87	97.35	99.25	90.08	**94.71**
	Sprat (%)	8.13	2.65	0.75	9.92	**5.29**
SD 31	Landings ('000 t)	0.01	3.34	0.92	0.10	**4.37**
	Herring (%)	100.00	100.00	100.00	100.00	**100.00**
	Sprat (%)	0.00	0.00	0.00	0.00	**0.00**
SD 32	Landings ('000 t)	16.26	4.76	0.76	17.03	**38.81**
	Herring (%)	49.13	81.31	50.19	57.06	**56.58**
	Sprat (%)	50.87	18.69	49.81	42.94	**43.42**
Total	Landings ('000 t)	**267.93**	**167.57**	**45.19**	**100.57**	**581.26**
	Herring (%)	**48.18**	**65.28**	**77.68**	**60.82**	**57.59**
	Sprat (%)	**51.82**	**34.72**	**22.32**	**39.18**	**42.41**

* Gulf of Riga included

Table 4.1.2. Proportion of herring in landings 2016.

COUNTRY	QUARTER	SUB-DIVISION							
		25	26	27	28*	29	30	31	32
DEN	1	0.13	0.13	0.29	0.20	0.18			
	2	0.22			0.51	0.43			
	3								
	4	1.00							
EST*	1			0.00	0.75	0.33			0.38
	2	0.00		0.00	0.98	0.52			0.66
	3				0.54	0.46			0.45
	4				0.43	0.42			0.47
FIN	1	0.05		0.47	0.40	0.71	0.92	1.00	0.47
	2					0.99	0.98	1.00	1.00
	3					0.69	0.99	1.00	0.77
	4					0.66	0.90	1.00	0.52
GER	1	0.43	0.27	0.35	0.30	0.22			
	2	0.32			0.41	0.43			
	3								
	4					0.18			
LAT*	1	0.11	0.11		0.43				
	2	0.23	0.09		0.67				
	3		0.15		0.52				
	4	0.35	0.35		0.48				
LIT	1	0.06	0.36		0.19	0.28			
	2	0.32	0.84	0.41	0.23	0.35			
	3		0.73		0.58				
	4		0.96		0.44				
POL	1	0.27	0.24	0.29	0.08	0.09			
	2	0.36	0.39		0.21				
	3	0.84	0.75		0.05				
	4	0.85	0.61	0.92	0.64	0.29			
RUS	1		0.30						1.00
	2		0.25						1.00
	3		0.68						1.00
	4		0.27						1.00
SWE	1	0.46	0.51	0.59	0.55	0.51	0.97	1.00	
	2	0.60	0.05	0.65	0.55	0.53	0.98	1.00	
	3	0.88		0.72	0.85	1.00	1.00	1.00	
	4	0.81	0.94	0.80	0.82	0.50	1.00	1.00	
Total	1	0.31	0.31	0.51	0.49	0.48	0.93	1.00	0.41
	2	0.36	0.31	0.64	0.74	0.84	0.98	1.00	0.66
	3	0.85	0.69	0.72	0.55	0.62	0.99	1.00	0.45
	4	0.84	0.43	0.80	0.52	0.56	0.91	1.00	0.47
Acoust. Stock**	4	0.65	0.56	0.40	0.21	0.60	1.00		0.62

* Gulf of Riga included

** SD 32 was covered by the acoustic survey only very partially (only the westermost part)

Table 4.1.3. Herring in subdivisions 25–32. Samples of commercial catches by quarter and Subdivision for 2016 available to the Working Group.

Subdivision	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 25	1	6 564	21	1 593	973
	2	13 097	22	1 000	614
	3	8 911	14	765	644
	4	6 664	18	1 700	1 008
	Total	35 236	75	5 058	3 239
Subdivision 26	1	19 145	42	6 680	2 969
	2	9 084	37	7 362	2 268
	3	6 850	13	3 373	507
	4	7 445	19	4 575	1 201
	Total	42 524	111	21 990	6 945
Subdivision 27	1	6 588	7	590	589
	2	2 970	3	151	151
	3	16	1	125	122
	4	1 096	3	402	402
	Total	10 669	14	1 268	1 264
Subdivision 28*	1	34927	34	5400	3423
	2	20544	58	5823	5061
	3	4647	19	2681	1402
	4	12580	29	4128	2658
	Total	72697	140	18032	12544
Subdivision 29	1	22 806	12	1 682	634
	2	11 886	13	2 444	904
	3	457	6	1 109	291
	4	7 098	9	1 760	566
	Total	42 246	40	6 995	2 395
Subdivision 30	1	36 493	13	4 137	223
	2	56 322	30	10 555	582
	3	14 195	17	4 943	409
	4	18 488	22	8 151	280
	Total	125 498	82	27 786	1 494
Subdivision 31	1	15	0	0	0
	2	3 383	14	4142	454
	3	966	7	1915	362
	4	166	4	657	123
	Total	4 531	25	6 714	939
Subdivision 32	1	7 987	25	2 794	1 113
	2	3 868	55	5 789	2 090
	3	382	9	1 744	640
	4	9 720	45	4 202	1 044
	Total	21 957	134	14 529	4 887
Subdivisions 25-32	**1**	**134 525**	**154**	**22 876**	**9 924**
	2	**121 154**	**232**	**37 266**	**12 124**
	3	**36 423**	**86**	**16 655**	**4 377**
	4	**63 257**	**149**	**25 575**	**7 282**
	Total	**355 358**	**621**	**102 372**	**33 707**

* Gulf of Riga included

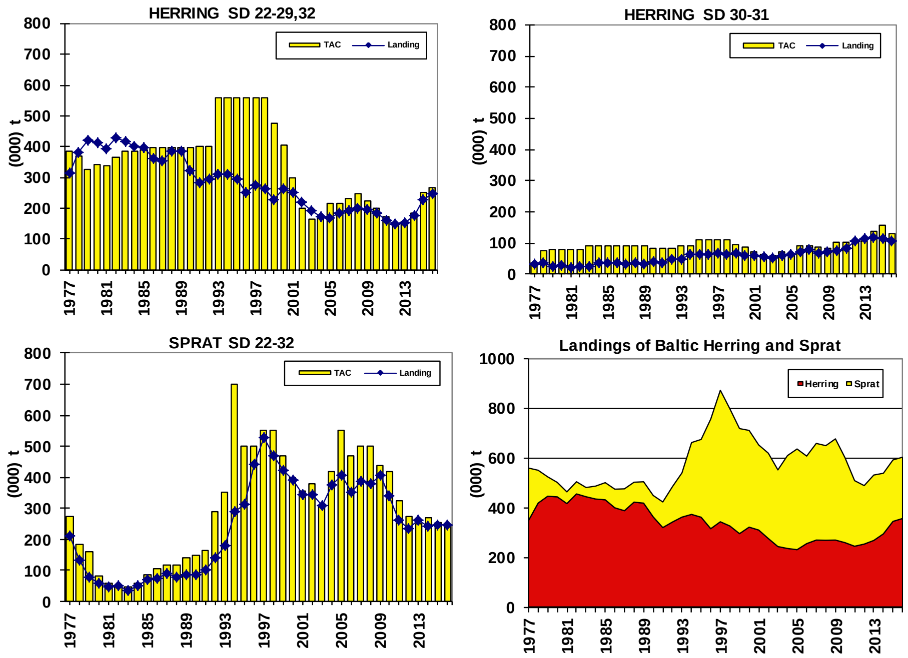


Figure 4.1.1. Reported landings of herring and sprat and agreed TACs in the Baltic Sea. (since 2007 TACs for herring and sprat: EC quota + Russian TAC).

4.2 Herring in subdivisions 25–27, 28.2, 29 and 32

4.2.1 The Fishery

4.2.1.1 Landings

The total reported catches by country, which also include the fraction of the Central Baltic Herring that is caught in the Gulf of Riga (SD 28.1, see Section 4.1.3), are given in Table 4.2.1. Catches in 2016 amounted to 192 056 t, which is 10% higher than last year. Catches increased for Denmark (1118%), Estonia (7%), Germany (49%), Latvia (48%), Lithuania (10%), Poland (5%), Russia (16%), Sweden (11%), but decreased for Finland (-9%). The largest part of the catches in 2016 was taken by Sweden (29%), followed by Poland (21%) and Finland (15%).

Catches by country and Subdivision are presented in tables 4.2.2–4.2.3 (incl. Central Baltic Herring caught in SD 28.1, see Section 4.1.3). The spatial distribution of catches shows that in the last few years most catches were taken in 25, 26 and 29. In 2016 the distribution of catches was as follows: 22% in SD 29, 22% in SD 26 and 18% in SD 25.

4.2.1.2 Discards

There was only one country, Sweden, reporting logbook registered discard of 565 kg in 2016. No discards have been reported earlier years. Discarding at sea is therefore regarded to be negligible.

4.2.1.3 Unallocated removals

A working document was presented in 2013 with a compilation on species measurement error for mixed pelagic species (/ICES CM 2012/ACOM:10: WD 5 Walther *et al.*). The conclusion was that it is hard to make an accurate estimate on the proportion of herring and sprat in the catches from industrial trawl fisheries with small meshed trawls. In area 24–26 misreporting of herring exists and is accounted for by Denmark. Some catches are hard to sample because they are landed in foreign ports.

This was followed up by a questionnaire sent out before the benchmarking WKBALT in 2013 (ICES CM 2013/ACOM:43: WD 5 Krumme, Gröhsler). The result of this questionnaire was that, at the time of the questionnaire, countries that seemingly have problems estimating the proportion of herrings in the catches are dealing with this on a national level with additional sampling and correct the input figures for assessment to assure as high accuracy as possible. The correction by country for this misreporting is however variable from year to year and thus misreporting can in recent years (in the years after the benchmark) be a potential problem and should be investigated further.

4.2.1.4 Effort and CPUE data

Data on commercial effort and CPUE were not used in the assessment.

4.2.2 Biological information

4.2.2.1 Catch in numbers

Most countries provided age composition of their major catches (caught in their waters by quarter and Subdivision). The catches for which age composition was missing represented about 7% of the total catches in 2016. All German catches, which only represent a minor part (2%) of the total catches, were landed in foreign ports and therefore no age composition of catches could be provided from Germany.

The compilation of 2016 national data was done by Subdivision and quarter, but not by fishery (Table 4.2.4). The non-sampled catches were assumed to have the same age composition as those sampled in the same Subdivision and quarter.

Herring of age groups 1–4 constitute in 2016 over 68% of the catches in numbers (Figure 4.2.1) which is 6% less than in 2015. The strong year class of 2014 is now 2 years old and contributes to the fishery with 36% of the catches in numbers. The internal consistency of the catch at age in numbers was checked by plotting catch at age against the catch of the same cohort at age 1 year younger (Figure 4.2.2). Table 4.2.3 gives catches, catch numbers at age and mean weight at age by Subdivision, whereas Table 4.2.4 shows catches by Subdivision and by quarter.

4.2.2.2 Mean weights-at-age

The mean weights-at-age were compiled by Subdivision and quarter for 2016 (Table 4.2.4) and then combined to give the mean weight-at-age for the whole catch. The marked decrease in mean weights at age that started in the early 1980s ceased around the mid-1990s and remains at this low level. When a particular strong year class occurs, like the 2002 and 2007, there may be density dependent effects (Figure 4.2.3). The increased sprat stock size has most likely also contributed to the low herring weight-at-age during the past 25 years. The marked geographical differences in growth patterns are shown in Table 4.2.4. The mean weight is higher in subdivisions 25 and 26 than in the more northern subdivisions. As consequence, the observed variation in average weight (total catches in ton/total numbers) could be due not only to a real decrease in growth, but also on where the larger proportion of herring are caught (Figure 4.2.4). In 2009–2012 there has been a small but steady increase of catches in 25 and 26. This increase stopped in 2013 and catches were decreasing in these SDs. From 2014 the catches in 25 and 26 have increased and decreased every other year with an increase in 2016. Since 2013 catches in 25 have decreased until it stopped in 2016. In SD 26 the catches followed the variations of 25 and 26 combined, since 2011. In SD 29 catches increased between 2011 and 2013, but since 2014 catches have been decreasing. In SD 28 catches have increased since 2014. . The notable decrease in mean weight at age since 2012 is therefore likely explained by the decreased catches in the south and increased catches in the north (with the exception of SD 29) where the herrings are smaller at age. As in the years before, the mean weight in the catch was also used as the mean weight in the stock. There is no survey information in the first quarter available, which could be used to calculate the mean weight in the stock (ICES CM 2013/ACOM:43). The mean weights in the catch from the first quarter could also be a candidate to be taken as mean weight in the stock. However, no corresponding data were available when conducting the benchmark in 2013 (ICES CM 2013/ACOM:43).

4.2.2.3 Maturity at age

The constant maturity ogive used by the WG is based on data between 1974–2011, based on the work of the Study Group on Baltic Herring and Sprat Maturity (ICES, 2002).

Source	Age 1	Age 2	Age 3	Age 4	Age 5+
Mean	0.016	0.67	0.90	0.94	0.97
WG ogive	0	0.70	0.90	1.00	1.00

An attempt to update the maturity ogive was done before the benchmark group (see Section 4.2.2.2 and ICES CM 2013/ACOM:43). The new maturity ogive was however not used due to inconsistencies in some parts of the data, a very high maturity at age 1 with a notable year and country effect. The new maturity ogive was also, apart from inconsistencies mentioned, similar to the old ogive and therefore it was decided to keep the old maturity ogive static between 1974–2013 (Table 4.2.8).

4.2.2.4 Natural mortality

In the benchmarking assessment (ICES CM 2013/ACOM:43) a new data series of M was introduced from the Stochastic Multi-Species model (SMS) covering the years 1974–2011 (ICES CM 2012/SSGSUE:10). In general that the new M values give higher estimates for age 2–8+, except for the values in the early period at the beginning of the time series, which are similar or even lower (age 1) than the previously ones. The new M values were explored during the benchmark process in 2013. The new M values however, resulted in a more optimistic view of the stock status (higher SSB/Recruitment and lower F) (for further background see ICES CM 2013/ACOM:43). For the assessments between 2012 and up to 2014 therefore, final estimates of M in 2014 were chosen as 2011 from the SMS model (ICES CM 2015/ACOM:10). In last year's and this year's assessment it was decided to use M values for 2012–2016 estimated from the regression of M values taken from SMS against cod SSB in 1974–2011 (Figure 4.2.5a). As analytical estimates of cod SSB in recent years are not available due to difficulties with the cod assessment, and index of cod SSB obtained from the BITS surveys, used as the basis for the cod advice, was rescaled to approximate analytical estimates of SSB. The rescaling was based on the relationship between both series in 2003–2011 (Figure 4.2.5b). SSB of cod from last accepted analytical assessment and rescaled BITS index are shown in Figure 4.2.5c. The final values of M are given in Table 4.2.7.

4.2.2.5 Quality of catch and biological information

The level and frequency of herring sampling in subdivisions 25–29 and 32 (excl. GoR) in the Baltic for 2016 is compiled in Table 4.2.2. The overall frequency was 2.5 samples, 333 fishes measured and 148 fishes aged per 1000 tonnes landed. In 2016, sampling was most frequent in SD 32 followed by SD 26 and SD 28. Compared to 2015 the sampling has decreased and sampling could be improved for catches in foreign ports.

Recent investigations indicated a mixing of Central Baltic herring (CBH) and Western Baltic spring spawning herring (WBSSH) in SDs 24–26 (ICES CM 2012/ACOM:10: WD 6 Gröhsler *et al.*; ICES HAWG 2014). Growth curve analyses of both WBSSH and CBH from survey data showed that a significant difference in growth parameters can be used to allocate an individual herring of unknown stock to either WBSSH or CBH based on a Stock Separation Function (SF) with length-at-age as measure (Gröhsler *et al.*, 2013). It is recommended to estimate the degree the mixing of WBSSH and CBH in SD 24–26. For this it is needed that all countries catching herring in this area apply the SF. To verify and improve the quality of assignment of stock identity, novel methods (e.g. genetic) should be additionally applied.

Mixed fisheries are generally not considered a problem in the Baltic Sea. However the catch data are regarded as uncertain for this fishery, particularly from 1992 and onwards due to the mixing of sprat and herring in the catches. Analysis of a questionnaire answered by all Baltic countries during 2012 revealed that misreporting is mainly an issue of the industrial trawl fishery targeting sprat-herring mix in near shore waters, e.g. archipelago area of Sweden or the Kolobrzeg-Darlowo fishing ground off Poland (further details see Annex H3 of WKBALT 2013/ICES CM 2013/ACOM:43). Countries with major proportions of sprat catches used for industrial purposes are Sweden, Poland and Denmark. Countries with major proportions of herring catches used for industrial purposes are Finland and Sweden. At the time of the questionnaire, countries that seemingly have problems estimating the proportion of herrings in the catches were dealing with this on a national level with additional sampling and correct the input figures for assessment to assure as high accuracy as possible. The correction by country for this misreporting is however variable from year to year and there are again indications that misreporting is a problem in some nations (Hentat-Sundberg *et al*. 2014). The lack of appropriate information to account for this in the reporting of official catch figures can thus be a potential problem for the perception of these stocks. The possibility to find a method to correct for this should be investigated further.

The maturity ogive used was investigated before the last benchmarking of the stock (ICES CM 2013/ACOM:43). Data on herring maturity from Denmark, Finland, Poland, Lithuania, Russia and Sweden were provided from 1984–2012. Data provided showed that the maturity at age 1 that was unusually high. It was not possible at this stage to evaluate the maturity at age 1 and to exclude parts of the data. Using the old maturity ogive may result in a slight underestimation of the spawning stock biomass. The conclusion from the group was however to keep the old maturity ogive.

4.2.3 Fishery independent information

As in the last year, the stock abundance estimates from the Baltic International Acoustic October Survey (BIAS) were available to tune the XSA (1991-latest year, ages 1-8+). The tuning index covers the area of SD 25–27, 28.2 and 29. All available data covering the southern and northern part of SD 29 are used within the compilation. As in previous years, the estimates for the years 1993, 1995 and 1997 were excluded due to an incomplete coverage of the standard survey area. Year 2011 of the index was updated in 2016 by the WGBIFS working group. The new estimates of numbers at age differed by no more than 0.3% compared to the 2011 estimates as of last year, however, and the updated estimates were therefore used since the 2016 assessment (using data from 1974 to 2015). The final BIAS index for ages 1–8+ is given in Table 4.2.11.

The consistency of the survey data at age was checked by plotting survey numbers at each given age against the numbers of the same year class at age 1 (Figure 4.2.6). Including the 2016 data did not have major impacts on the strength of the internal consistency compared to last year.

4.2.4 Assessment

4.2.4.1 Recruitment estimates

The data series of 0 group herring from the acoustic surveys in subdivisions 25–27, 28.2 and 29 (including southern and northern data) in 1991–2016 was used in a RCT3 analysis to estimate the year class 2016 at age 1 for 2017. The RCT3 input and result are presented in tables 4.2.17 and 4.2.18. The estimate of the year class 2016 (Age 1 in 2016: 18 192 mill.) is below the estimated average recruitment of the time series (1974–2016).

4.2.4.2 Exploration of SAM

During the benchmark assessment in 2013 (ICES CM 2013/ACOM:43) the state-space assessment model SAM was explored as an alternative method to assess the central Baltic herring stock. This year’s final but still preliminary configuration of SAM is given in Table 4.2.16. The assessment run and the software internal code are available at https:/www.stockassessment.org, CHB2017. Results of SAM compared to XSA are presented in figure 4.2.11. In general SAM produces lower estimates of SSB and recruitment (age 1), whereas it shows higher fishing mortality (F3–6). The retrospective pattern of SAM in the last two years is different to the XSA output showing a tendency to slightly underestimate fishing mortality and overestimate spawning stock biomass (Figure 4.2.12).

4.2.4.3 XSA

The assessment performed this year is an update XSA assessment.

The XSA settings were established in the benchmark assessment performed in 2013 and were decided to be i.e. catchability dependent on stock size at age < 2 and independent of age > = 6, but with the application of a weak shrinkage (S.E. = 1.5).

As the last update of the natural mortalities provided by WGSAM 2012 only cover data for the years 1974–2011, it was in 2016 decided to use estimates of M for 2012–2016 based on the regression of M against the Eastern Baltic cod SSB (see Section 4.2.2.4 on natural mortality above).

The input data for catch at age analysis are found in tables 4.2.5–4.2.11, containing catches in numbers at age, mean weights at age in the catch and in the stock, tuning fleet and natural mortality by age and year, proportion of F and M before spawning time and proportion mature fish by age. As in previous years the mean weight in the stock was taken as the mean weight in the catch.

The diagnostics of the final XSA run which converged after 67 iterations, are shown in Table 4.2.12. Including the latest acoustic estimates for 2016 led to slightly improved regression statistics compared to last year's results. Fishing mortalities and stock number are given in Table 4.2.13 and Table 4.2.14, respectively. The summary is presented in Table 4.2.15.

The development of herring biomass as estimated by the acoustic surveys and by XSA is illustrated in Figure 4.2.7. The 2016 acoustic SSB and total biomass show a steep decrease, whereas the XSA estimates showed a small decrease the last year. The acoustic estimates have been highly variable over the time series.

A retrospective analysis for the whole time series is given in Figure 4.2.8. In recent years, there has been a tendency to slightly overestimate fishing mortality. Spawning stock biomass has consistently been underestimated.

The log catchability residuals some year effects with variable positive and negative residuals. Like last year, this was apparent especially for ages 2, 3 and 5, where negative trends were apparent in the beginning of the time series (Figure 4.2.9). Residuals were however overall small and therefore considered acceptable. The variance ratio between the internal (within fleet) and external standard (among fleet) errors were within the acceptable range (< 3 and > 0.3).

The abundance by age group of the tuning fleet was plotted against the estimated stock numbers (Figure 4.2.10). The regression analyses gave R (squared) values in the range 0.4–0.8. which is about the same as last year's estimates, even if the last year's tuning fleet estimates were then adjusted to the start of the year.

4.2.4.4 Historical stock trend

A slow but steady increase of SSB was observed since 2001 (Figure 4.2.13). The SSB in 2016 is estimated to be slightly over the long-term mean. Since the assessment in 2011 the SSB has been revised upwards each year probably caused by underestimation of incoming strong year classes. The general trend in the stock development has not changed however. The historical decrease in SSB is believed to be partly caused by a shift in fishing area from SD 25 and 26 to SD 28.2 and 29 where the average mean weight is lower. Holmgren *et al.* 2012 showed that with the current growth rate and continuous low cod abundance, the herring stock will not reach equilibrium state until 2030. During the last three years the catches in SD 25 and 26 has increased slightly, where the mean weight at age are higher and this can influence the estimation of SSB. In numbers the metrics shows a spawning stock that varies around 25–30 billion fish in the period 1982–1996. The stock starts to decrease in 1997, to reach a value of 18 billion fish in 2003 which is the lowest value of the time series. In 2004 the spawning stock numbers starts to increase to 2011 after which the stock declined again for two years, after which it increased again. The spawning stock numbers in 2016 increased steeply since 2015 and were the highest of the time series (Figure 4.2.14).

A major cause for decreasing trends in stock development is the drastic decrease in mean weight (size) at age during the period of assessment (Figure 4.2.3). One of the reasons is that slow-growing herring, emanating from the north-eastern parts of the Baltic, have been dominating the catches over the recent years. These fish are also caught - outside the spawning time - in other parts of the Baltic, thereby decreasing the overall mean weights. However, mean weight decreased in all the areas of the Baltic Sea, likely indicating a real change in growth rate. Simultaneously, a decrease in body condition for herring was also observed, which was attributed to a decreased salinity (Möllmann *et al*., 2003; Rönkkönen *et al*., 2004; Casini *et al.*, 2010) and increased competition with large sprat stock (Cardinale and Arrhenius, 2000; Casini *et al.*, 2006; Casini *et al*., 2010), both factors decreasing the availability of the main prey of herring, the copepod *Pseudocalanus* spp.

Fishing mortality more than doubled over the assessment period, but showed a declining trend starting in 2002. After two years with record low F in 2012 and 2013 (F = 0.11 and 0.10 respectively) it has increased to 0.20 in 2016 (Figure 4.2.13). The large proportion of slow-growing herring may have contributed to the increase in fishing mortality in the 1990s and early 2000, as a given catch in tonnes of these small and slow-growing herring will contain many more individuals and thus cause a higher fishing mortality.

Recruitment-at-age 1 was high in the beginning of the 1980s, but being on a low level for some years afterwards (Figure 4.2.13). Since the mid-1980s recruitment has varied between 8 and 27 billion, without a clear trend. The 2014 year class is however, estimated to be more than 200 percent higher than the last strong 2007 year class, and is the greatest year class in the time series (27 746 million). Recruitment-at-age 1 in 2016 was lower than in 2015, but slightly greater than the average recruitment of the time series.

4.2.5 Short-term forecast and management options

The input data of the short-term prediction are presented in Table 4.2.19. The mean weights at age in the prediction, for both catch and stock, were the average of 2014–2016. Density dependent effects of strong year classes have shown decreasing mean weights. This was the case for the year class 2002 and it was considered to apply for this effect for the 8+ group. However an investigation of growth of strong year's classes showed that this is not necessarily an effect that is consistent for the oldest year classes. Therefore it was decided not include any decreasing of the mean weight in the 8+ group when calculating the average of 2014–2016.

The estimate of recruitment of age 1 for 2017 was taken from the RCT3 analysis (tables 4.2.17–4.2.18), whereas recruits in 2018 and 2019 were the GM for 1988–2015 , 16 115 million.). The natural mortalities were assumed as the average of 2014–2016. The exploitation pattern was taken as the average over 2013–2016. The TAC constraint of 224

989 t (EU quota of 191 129 t + EU/Russian quota of 29 500 t + CBH caught in GOR 4 580 t (mean 2011–2015) – GoR herring caught in the Central Baltic area 220 t) was used in the predictions in the intermediate year 2017 since the total TAC in 2016 was almost fully exploited. This resulted in a fishing mortality of 0.19 (Table 4.2.20), which lies below the present estimated F in 2016 of 0.20. The SSB is expected to increase to 1341 625 t in 2017.

4.2.6 Reference points

During the Joint ICES-MYFISH Workshop to consider the basis for F_{MSY} ranges for all stocks in 2014 (WKMSYREF3/ICES CM 2014/ACOM:64) the F_{MSY} reference points were revised. The new estimate of F_{MSY} is 0.22. The F_{MSY} ranges were in 2016 adopted as part of the multiannual plan for the stocks of cod, herring and sprat in the Baltic Sea ((EU) 2016/1139). Further ranges of F_{MSY} are provided in the text table below.

Stock	MSY Flower	FMSY	MSY Fupper with AR	MSY Btrigger (1000 t)	MSY Fupper with no AR
Herring in subdivisions 25–27, 28.2, 29 and 32	0.16	0.22	0.28	600	0.22

AR = Advice rule

4.2.7 Quality of assessment

The assessment has been benchmarked in 2013 (ICES CM 2013/ACOM:43).

The assessment is based on catch data and on an international acoustic survey (BIAS), where the early period of the years 1982–1990 were excluded from the data series in 2013 (ICES CM 2013/ACOM:43). The acoustic index for the years 1991–2013 is consistently based on area-corrected estimates and is considered an important step forward in the quality of the assessment. The natural mortality was provided from multi-species models for the years 1974–2011, and from a regression of M against the Eastern Baltic cod SSB in 2012–2016.

Recruitment data are derived from a 0-group acoustic index, which were revised in 2013 (ICES CM 2013/SSGESST:08) and since then includes area corrected values. Catches of central Baltic spring-spawning herring taken in the Gulf of Riga are included in the assessment.

ICES has been stating for several years that the pelagic fisheries take a mixture of herring and sprat and this causes uncertainties in catch levels. The extent to which species misreporting has occurred is however not well known". Analysis of a questionnaire answered by all Baltic countries during 2012 revealed that misreporting is mainly an issue of the industrial trawl fishery targeting sprat-herring mix in nearshore waters (ICES CM 2013/ACOM:43: WD 5 Krumme, Gröhsler). Countries with major proportions of sprat catches used for industrial purposes are Sweden, Poland and Denmark. Countries with major proportions of herring catches used for industrial purposes are Finland and Sweden. The official catch figures of both sprat and herring are modified by Poland and Denmark, but not currently in Sweden. A worst case scenario using the permitted margin of tolerance of 10% in the logbooks of the quantities by species on board (EU 1224/2009) revealed that sprat catches may be underestimated by 5% and that herring catches may be underestimated by 4%. It is was concluded at the time after the questionnaire that that species misreporting could be regarded of minor importance. However, as Sweden is not currently correcting for this misreporting it can in recent years (in the years after the benchmark) be a potential problem for our perception of these stocks.

Different growth rates within the distribution area of herring may influences the actual level of SSB estimates. However the rather stable distributions of the catches within the different SDs during the last year's and the possibility to track the last strong year classes such as 2002, 2007, 2011 and 2014 in the catch at age data, suggest presently no major changes in the distribution of the different stock components.

4.2.8 Comparison with previous assessment

Compared to last year, the present assessment resulted in 2% higher SSB estimates for 2014. $F_{(3\text{–}6)}$ in 2014 was estimated to be 8% lower compared to last year's assessment and recruitment-at-age 1 in 2014 (year class 2013) was estimated to be 2% higher in this year's assessment.

Category	Parameter	Assessment 2016	Assessment 2017	Diff. (+/–) %
Data input	Maturity ogives	age 1 - 0%, age 2 and 3 - 70% age 4 and older 100%	age 1 - 0%, age 2 and 3 - 70% age 4 and older 100%	No
	Natural mortality	M in 1974-2011 estimated in SMS, M2012- M2015 estimated from regression of M against cod SSB	M in 1974-2011 estimated in SMS, M2012- M2016 estimated from regression of M against cod SSB	No
XSA input	Catchability dependent on year class strength	Age < 2	Age < 2	No
	Catchability independent on age	Age > = 6	Age > = 6	No
	SE of the F shrinkage mean	1.5	1.5	No
	Time weighting	Tricubic, 20 years	Tricubic, 20 years	No
	Tuning data	International acoustic autumn	International acoustic autumn	No
XSA results	SSB 2014 (1000 t) TSB 2014 (1000 t) F(3–5) 2014 Recruitment (age 1) in 2014 (billions)	1013 1459 0.18 27.7	1050 1742 0.18 61.1	+4% 19% 0% 121%

4.2.9 Management considerations

The stock shows a total Biomass and SSB that is in line with the levels of the end of 1980s. The SSB has been steadily increasing since 2001. Fishing mortality (F3–6; 0.20) is below the adopted F_{MSY} of 0.22 (ICES CM 2015/ACOM:64). It can be noted that several year classes above the long term mean have contributed to the stock in the last 10 years (2007, 2008, 2011, 2012 and 2014). The fluctuations of the eastern cod stock and sprat stock (see also WKREFBAS 2008/ICES CM 2008/ACOM:28) should be taken into account in herring management. Currently the cod stock is concentrated in SD 25 and 26 and shows bad growth conditions probably due to lack of food. This may be related to low abundance of herring in this area (WGBIFS 2016). WGBFAS is performing short-term forecasts using the latest cod predation mortality estimates (SMS, ICES CM 2012/SSGSUE:10; Section 4.2.2.4 on natural mortality), in this way taking in account the predation by the cod stock.

Table 4.2.1 Herring in SD 25–29, 32 (excl. GoR). Catches by country (1000 t) (incl. central Baltic herring caught in GoR, see Section 4.1.3).

Year	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia**	Sweden	Total
1977	11.9		33.7	0.0			57.2	112.8	48.7	264.3
1978	13.9		38.3	0.1			61.3	113.9	55.4	282.9
1979	19.4		40.4	0.0			70.4	101.0	71.3	302.5
1980	10.6		44.0	0.0			58.3	103.0	72.5	288.4
1981	14.1		42.5	1.0			51.2	93.4	72.9	275.1
1982	15.3		47.5	1.3			63.0	86.4	83.8	297.3
1983	10.5		59.1	1.0			67.1	69.1	78.6	285.4
1984	6.5		54.1	0.0			65.8	89.8	56.9	273.1
1985	7.6		54.2	0.0			72.8	95.2	42.5	272.3
1986	3.9		49.4	0.0			67.8	98.8	29.7	249.6
1987	4.2		50.4	0.0			55.5	100.9	25.4	236.4
1988	10.8		58.1	0.0			57.2	106.0	33.4	265.5
1989	7.3		50.0	0.0			51.8	105.0	55.4	269.5
1990	4.6		26.9	0.0			52.3	101.3	44.2	229.3
1991	6.8	27.0	18.1	0.0	20.7	6.5	47.1	31.9	36.5	194.6
1992	8.1	22.3	30.0	0.0	12.5	4.6	39.2	29.5	43.0	189.2
1993	8.9	25.4	32.3	0.0	9.6	3.0	41.1	21.6	66.4	208.3
1994	11.3	26.3	38.2	3.7	9.8	4.9	46.1	16.7	61.6	218.6
1995	11.4	30.7	31.4	0.0	9.3	3.6	38.7	17.0	47.2	189.3
1996	12.1	35.9	31.5	0.0	11.6	4.2	30.7	14.6	25.9	166.7
1997	9.4	42.6	23.7	0.0	10.1	3.3	26.2	12.5	44.1	172.0
1998	13.9	34.0	24.8	0.0	10.0	2.4	19.3	10.5	71.0	185.9
1999	6.2	35.4	17.9	0.0	8.3	1.3	18.1	12.7	48.9	148.7
2000	15.8	30.1	23.3	0.0	6.7	1.1	23.1	14.8	60.2	175.1
2001	15.8	27.4	26.1	0.0	5.2	1.6	28.4	15.8	29.8	150.2
2002	4.6	21.0	25.7	0.3	3.9	1.5	28.5	14.2	29.4	129.1
2003	5.3	13.3	14.7	3.9	3.1	2.1	26.3	13.4	31.8	113.8
2004	0.2	10.9	14.5	4.3	2.7	1.8	22.8	6.5	29.3	93.0
2005	3.1	10.8	6.4	3.7	2.0	0.7	18.5	7.0	39.4	91.6
2006	0.1	13.4	9.6	3.2	3.0	1.2	16.8	7.6	55.3	110.4
2007	1.4	14.0	13.9	1.7	3.2	3.5	19.8	8.8	49.9	116.0
2008	1.2	21.6	19.1	3.4	3.5	1.7	13.3	8.6	53.7	126.2
2009	1.5	19.9	23.3	1.3	4.1	3.6	18.4	***11.8	50.2	134.1
2010	5.4	17.9	21.6	2.2	3.9	1.5	25.0	9.1	50.0	136.7
2011	1.8	14.9	19.2	2.7	3.4	2.0	28.0	8.5	36.2	116.8
2012	1.4	****11.4	18.0	0.9	2.6	1.8	25.5	13.0	26.2	101.0
2013	3.4	12.6	18.2	1.4	3.5	1.7	20.6	10.0	29.5	101.0
2014	2.7	15.3	27.9	1.7	4.9	2.1	27.3	15.9	34.9	132.7
2015	0.3	18.8	31.6	2.9	5.7	4.7	39.0	20.9	50.6	174.4
*2016	4.0	20.1	28.9	4.3	8.4	5.2	41.0	24.2	56.0	192.1

*** Preliminary**

**** In 1977–1990 sum of catches for Estonia, Latvia, Lithuania and Russia**

***** Updated in 2011**

****** Updated in 2013 from 8.3 kt to 11.4 kt and included in 2014 assessment (WBAFS 2014).**

Table 4.2.2 Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and Subdivision for 2016 available to the Working Group.

1/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas.	Number of fish aged
Sub-division 25	Denmark	1	164	12	158	100
		2	770	13	86	86
		3	0	0	0	0
		4	49	8	256	208
		Total	982	33	500	394
	Estonia	1				
		2				
		3				
		4				
		Total				
	Finland	1	13	0	0	0
		2				
		3				
		4				
		Total	13	0	0	0
	Germany	1	277	0	0	0
		2	380	0	0	0
		3				
		4				
		Total	657	0	0	0
	Latvia	1	94	0	0	0
		2	166	0	0	0
		3	0	0	0	0
		4	57	0	0	0
		Total	317	0	0	0
	Lithuania	1	35	0	0	0
		2	1 653	0	0	0
		3				
		4				
		Total	1 688	0	0	0
	Poland	1	3 160	4	835	277
		2	7 650	6	620	234
		3	6 349	1	190	71
		4	5 507	3	869	229
		Total	14	2 514	811	
	Sweden	1	2 821	5	600	596
		2	2 478	3	294	294
		3	2 562	13	575	573
		4	1 052	7	575	571
		Total	8 913	28	2 044	2 034
	Total	1	6 564	21	1 593	973
		2	13 097	22	1 000	614
		3	8 911	14	765	644
		4	6 664	18	1 700	1 008
		Total	35 236	75	5 058	3 239

Table 4.2.2 (cont'). **Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and Subdivision for 2016 available to the Working Group.**

2/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas.	Number of fish aged
Sub-division 26	Denmark	1	142	1	3	3
		2	0	0	0	0
		3	0	0	0	0
		4	0	0	0	0
		Total	142	1	3	3
	Finland	1				
		2				
		3				
		4				
		Total				
	Germany	1	880	0	0	0
		2				
		3				
		4				
		Total	880	0	0	0
	Latvia	1	102	1	200	100
		2	43	2	400	200
		3	32	0	0	0
		4	187	1	200	100
		Total	364	4	800	400
	Lithuania	1	560	4	1252	925
		2	94	2	423	368
		3	12	0	0	0
		4	20	2	557	301
		Total	685	8	2 232	1 594
	Poland	1	5 435	17	1 842	690
		2	4 782	10	1 843	496
		3	2 896	2	409	156
		4	4 265	6	1 228	392
		Total	17 378	35	5 322	1 734
	Russia	1	5958	16	3 285	1 153
		2	4165	23	4 696	1 204
		3	3909	11	2 964	351
		4	2622	10	2 590	408
		Total	16 655	60	13 535	3 116
	Sweden	1	6069	3	98	98
		2	0.85	0	0	0
		3				
		4	350	0	0	0
		Total	6 420	3	98	98
	Total	1	19 145	42	6 680	2 969
		2	9 084	37	7 362	2 268
		3	6 850	13	3 373	507
		4	7 445	19	4 575	1 201
		Total	42 524	111	21 990	6 945

Table 4.2.2 (cont'). Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and Subdivision for 2016 available to the Working Group.

3/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Sub-division 27	Denmark	1	724	1	73	73
		2	0	0	0	0
		3	0	0	0	0
		4	0	0	0	0
		Total	724	1	73	73
	Finland	1	171	0	0	0
		2				
		3				
		4				
		Total	171	0	0	0
	Germany	1	5	0	0	0
		2				
		3				
		4				
		Total	5	0	0	0
	Latvia	1				
		2				
		3				
		4				
		Total				
	Lithuania	1				
		2	38	0	0	0
		3				
		4				
		Total	38	0	0	0
	Poland	1	125	0	0	0
		2				
		3				
		4	36	0	0	0
		Total	161	0	0	0
	Sweden	1	5 562	6	517	516
		2	2 932	3	151	151
		3	16	1	125	122
		4	1 060	3	402	402
		Total	9 569	13	1 195	1 191
	Total	1	6 588	7	590	589
		2	2 970	3	151	151
		3	16	1	125	122
		4	1 096	3	402	402
		Total	10 669	14	1 268	1 264

Table 4.2.2 (cont'). Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and Subdivision for 2016 available to the Working Group.

4/6

Sub-division 28.2 (includes landings of Central Baltic Herring from Gulf of Riga)	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
	Denmark	1	646	1	29	29
		2	287	0	0	0
		3	0	0	0	0
		4	0	0	0	0
		Total	934	1	29	29
	Estonia	1	1595	7	465	464
		2	3041	4	273	273
		3	16	0	0	0
		4	995	12	728	722
		Total	5 647	23	1 466	1 459
	Finland	1	443	0	0	0
		2				
		3				
		4				
		Total	443	0	0	0
	Germany	1	1 598	0	0	0
		2	366	0	0	0
		3				
		4				
		Total	1 964	0	0	0
	Latvia	1	1 529	11	3248	1279
		2	1 540	30	3367	3016
		3	1 190	8	1500	860
		4	3 422	11	2650	1195
		Total	7 681	60	10 765	6 350
	Lithuania	1	692	0	0	0
		2	131	0	0	0
		3	104	0	0	0
		4	1 338	0	0	0
		Total	2 264	0	0	0
	Poland	1	67	0	0	0
		2	69	4	32	31
		3	12	0	0	0
		4	543	0	0	0
		Total	691	4	32	31
	Russia	1				
		2				
		3				
		4				
		Total				
	Sweden	1	14 669	4	558	553
		2	1 610	2	501	496
		3	938	1	250	249
		4	2 581	4	550	542
		Total	19 798	11	1 859	1 840
	Total	1	21 241	23	4 300	2 325
		2	7 044	40	4 173	3 816
		3	2 259	9	1 750	1 109
		4	8 879	27	3 928	2 459
		Total	39 422	99	14 151	9 709

Table 4.2.2 (cont'). Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and Subdivision for 2016 available to the Working Group.

5/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Sub-division 29	Denmark	1	1181	1	3	3
		2	77	0	0	0
		3	0	0	0	0
		4	0	0	0	0
		Total	1 258	1	3	3
	Estonia	1	1 366	2	171	169
		2	653	7	600	598
		3	101	3	159	159
		4	871	5	441	440
		Total	2 991	17	1 371	1 366
	Finland	1	10 550	4	1 253	208
		2	9 516	6	1 844	306
		3	344	3	950	132
		4	4 839	4	1 319	126
		Total	25 250	17	5 366	772
	Germany	1	612	0	0	0
		2	139	0	0	0
		3				
		4	83	0	0	0
		Total	834	0	0	0
	Latvia	1				
		2				
		3				
		4				
		Total				
	Lithuania	1	437.748	0	0	0
		2	70	0	0	0
		3				
		4				
		Total	508	0	0	0
	Poland	1	40	0	0	0
		2				
		3				
		4	54	0	0	0
		Total	94	0	0	0
	Sweden	1	8 619	5	255	254
		2	1 430	0	0	0
		3	12	0	0	0
		4	1 251	0	0	0
		Total	11 312	5	255	254

Table 4.2.2 (cont'). **Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and Subdivision for 2016 available to the Working Group.**

6/6

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Sub-division 32	Denmark	1				
		2				
		3				
		4				
		Total				
	Estonia	1	3 238	9	851	851
		2	1 746	18	1 746	1 746
		3	308	5	500	500
		4	6 167	7	618	618
		Total	11 459	39	3 715	3 715
	Finland	1	2 583	5	937	184
		2	15	5	1 513	162
		3	8	3	944	90
		4	368	3	962	124
		Total	2 975	16	4 356	560
	Latvia	1				
		2				
		3				
		4				
		Total				
	Russia	1	2166	11	1 006	78
		2	2107	32	2 530	182
		3	66	1	300	50
		4	3 185	33	2 647	242
		Total	7 524	77	6 483	552
	Sweden	1				
		2				
		3				
		4				
		Total				
	Total	1	7 987	25	2 794	1 113
		2	3 868	55	5 789	2 090
		3	382	9	1 744	640
		4	9 720	43	4 227	984
		Total	21 957	132	14 554	4 827
SD 25-32 (excl. 28.1 & 30-31)	**Total**	**Quarter**	**Catches in tons**	**Number of samples**	**Number of fish meas.**	**Number of fish aged**
		1	**84 331**	**130**	**17 639**	**8 603**
		2	**47 949**	**170**	**20 919**	**9 843**
		3	**18 875**	**52**	**8 866**	**3 313**
		4	**40 901**	**119**	**16 592**	**6 620**
		Total	**192 056**	**471**	**64 016**	**28 379**

Table 4.2.3. Herring in SD 25–29, 32 (excl. GoR). Catch by country and SD and mean weight by SD in 2016.

Catch (1000 t) by country and SD							
Country	Total	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
Denmark	4.040	0.982	0.142	0.724	0.934	1.258	0.000
Estonia	20.097	0.000	0.000	0.000	5.647	2.991	11.459
Finland	28.852	0.013	0.000	0.171	0.443	25.250	2.975
Germany	4.340	0.657	0.880	0.005	1.964	0.834	0.000
Latvia*	8.362	0.317	0.364	0.000	7.681	0.000	0.000
Lithuania	5.184	1.688	0.685	0.038	2.264	0.508	0.000
Poland	40.990	22.666	17.378	0.161	0.691	0.094	0.000
Russia	24.179	0.000	16.655	0.000	0.000	0.000	7.524
Sweden	56.011	8.913	6.420	9.569	19.798	11.312	0.000
Total	192.056	35.236	42.524	10.669	39.422	42.246	21.957
*Catches in SD 28.2 include 1 617.2 t of CBH taken in GoR (SD 28.1)							

Catch in numbers (thousands)							
AGE	Total	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	321745	14	10000	0	405	282232	29095
1	602141	16560	40594	7467	11886	431034	94598
2	3014945	56091	182644	226946	151621	1430460	967183
3	934748	116087	154848	43608	70994	231759	317452
4	1188734	173179	202847	86142	220359	358168	148039
5	838456	137152	155153	87660	228314	177631	52546
6	331740	39739	63368	15720	141634	55305	15974
7	465961	79382	75134	31634	192597	78948	8267
8	410810	92582	76042	17898	111736	102986	9567
9	132567	27806	35654	2354	56823	8038	1892
10+	85625	23137	28438	768	27715	4214	1353
Total N	8327471	761727	1024722	520198	1214083	3160774	1645966
CATON	192.056	35.236	42.524	10.669	39.422	42.246	21.957
Mean weight (g)							
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
0	6.2	13.9	11.8	0.0	5.7	6.0	5.7
1	8.6	22.9	18.4	8.9	7.5	7.3	8.1
2	12.3	31.8	30.6	12.2	15.5	9.7	11.2
3	25.5	48.0	43.4	20.0	26.6	15.9	16.2
4	29.3	41.5	40.4	25.8	30.4	21.4	19.6
5	33.9	47.3	43.1	28.4	32.2	23.8	21.7
6	37.4	50.0	44.8	28.3	37.3	26.4	24.5
7	40.7	51.9	47.7	32.2	40.0	29.6	25.0
8	44.5	54.2	52.8	36.0	40.6	36.4	32.9
9	48.8	56.0	59.7	48.0	41.6	30.6	31.4
10+	56.6	52.0	67.9	41.8	50.7	46.0	56.9

CATON is given in 1000 tonnes

Table 4.2.4. Herring in SD 25–29, 32 (excl. GoR). Catch in number at age per SD and quarter in 2016. Catch in numbers (millions) (CATON in 1000 t).

1/2

QUARTER: 1							
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	235.394	4.512	18.757	6.523	9.154	161.695	34.753
2	1917.419	4.920	74.120	171.279	99.281	1185.314	382.505
3	383.575	19.394	73.923	24.276	30.503	120.655	114.824
4	533.564	28.877	97.916	48.163	95.689	189.958	72.960
5	435.791	24.433	95.521	50.321	117.347	118.690	29.479
6	171.062	11.287	31.971	8.423	85.951	22.767	10.664
7	251.646	15.339	35.947	18.876	127.148	48.226	6.109
8	182.868	20.112	37.824	12.699	73.996	31.264	6.972
9	56.921	7.238	15.898	2.246	27.974	2.662	0.903
10+	26.221	4.108	10.784	0.562	9.781	0.986	0.000
Total N	4194.460	140.221	492.661	343.367	676.824	1882.217	659.169
CATON	84.331	6.564	19.145	6.588	21.241	22.806	7.987
QUARTER: 2							
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	132.587	1.397	5.536	0.000	0.709	121.220	3.726
2	367.541	17.873	59.701	41.928	11.313	78.891	157.836
3	304.218	33.469	35.998	13.381	11.289	93.012	117.069
4	355.199	57.917	35.955	26.762	42.054	145.255	47.257
5	219.133	50.832	21.118	30.331	56.404	50.208	10.241
6	88.159	18.689	10.728	6.245	20.274	28.814	3.410
7	119.184	36.314	12.161	11.597	30.782	27.126	1.205
8	138.269	37.776	10.936	4.460	19.376	65.126	0.595
9	42.290	10.993	5.967	0.000	20.915	4.078	0.337
10+	37.978	13.574	7.137	0.000	14.301	2.823	0.143
Total N	1804.559	278.833	205.235	134.704	227.417	616.553	341.818
CATON	47.949	13.097	9.084	2.970	7.044	11.886	3.868
QUARTER: 3							
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	26.129	4.474	10.053	0.016	0.124	9.030	2.433
2	79.862	16.107	23.305	0.218	10.458	11.094	18.680
3	64.034	36.292	16.455	0.068	6.221	1.312	3.687
4	110.183	52.524	35.079	0.172	19.970	1.711	0.727
5	68.525	36.812	16.158	0.094	14.713	0.638	0.111
6	18.959	2.854	9.975	0.021	6.015	0.071	0.023
7	28.293	8.045	15.751	0.026	4.305	0.157	0.009
8	42.165	21.827	16.274	0.016	3.790	0.225	0.033
9	19.654	6.990	10.689	0.005	1.885	0.085	0.000
10+	13.772	4.795	7.566	0.000	1.411	0.000	0.000
Total N	471.578	190.719	161.304	0.635	68.893	24.324	25.703
CATON	18.875	8.911	6.850	0.016	2.259	0.457	0.382
QUARTER: 4							
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	208.031	6.178	6.249	0.929	1.900	139.089	53.686
2	650.122	17.190	25.517	13.521	30.569	155.161	408.163
3	182.921	26.933	28.473	5.883	22.980	16.780	81.871
4	189.787	33.862	33.897	11.044	62.646	21.244	27.095
5	115.007	25.075	22.356	6.915	39.850	8.095	12.716
6	53.559	6.908	10.694	1.032	29.394	3.653	1.878
7	66.838	19.684	11.275	1.135	30.362	3.439	0.944

8	47.508	12.867	11.009	0.723	14.573	6.371	1.966
9	13.702	2.584	3.101	0.103	6.049	1.213	0.652
10+	7.653	0.660	2.951	0.206	2.222	0.404	1.210
Total N	471.578	190.719	161.304	0.635	68.893	24.324	25.703
CATON	40.901	6.664	7.445	1.096	8.879	7.098	9.720

Table 4.2.4 (cont'). **Herring in SD 25–29, 32 (excl. GoR).** **Mean weight at age per SD and quarter in 2016. Mean weight (g).** **2/2**

QUARTER:	1						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	NA	NA	NA	NA	NA	NA	NA
1	5.6	9.1	11.1	7.4	4.7	5.1	4.2
2	9.8	34.6	25.9	11.5	11.8	8.8	8.4
3	23.4	52.8	42.4	18.5	24.9	14.9	15.9
4	26.8	43.5	38.6	25.0	29.0	20.2	20.2
5	31.6	48.4	41.8	28.6	31.4	24.0	21.4
6	35.7	51.0	39.7	29.0	36.4	27.3	24.8
7	37.8	46.6	43.3	33.5	39.9	28.4	26.0
8	41.3	50.7	48.2	36.4	39.9	33.8	33.6
9	46.7	49.3	53.6	49.2	44.4	27.2	26.4
10+	54.1	57.4	59.6	39.0	49.9	30.6	NA
QUARTER:	2						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	14.0	NA	14.0	NA	NA	NA	NA
1	5.6	15.5	19.2	NA	13.0	4.9	3.5
2	14.6	31.3	33.7	12.7	18.4	10.9	7.5
3	22.7	49.9	45.1	20.9	23.4	16.4	13.3
4	27.7	40.8	45.4	25.6	25.9	22.7	16.5
5	32.6	45.7	48.9	26.7	28.3	23.4	19.7
6	34.7	46.5	50.0	26.1	33.0	25.9	23.4
7	40.9	53.7	50.5	30.2	34.2	32.4	22.9
8	43.5	54.0	56.7	33.8	34.7	38.7	24.3
9	45.9	57.7	66.6	NA	36.4	34.2	31.9
10+	55.3	51.6	71.6	NA	51.2	52.5	46.9
QUARTER:	3						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	5.4	NA	8.9	NA	NA	5.4	5.7
1	20.5	28.2	25.5	17.0	25.0	13.9	10.3
2	23.3	33.6	26.6	17.6	23.5	16.7	14.0
3	39.3	46.4	33.4	21.3	29.7	20.9	18.9
4	39.0	42.5	39.1	26.8	31.9	22.0	23.6
5	45.1	51.6	41.8	34.6	33.7	20.8	29.6
6	45.2	60.1	46.9	31.2	35.7	32.0	25.7
7	47.7	49.3	49.5	41.4	38.4	35.6	20.7
8	55.2	56.6	56.5	39.0	42.9	40.5	24.2
9	58.0	58.9	60.7	44.0	40.4	26.3	NA
10+	61.9	45.1	74.2	0.0	52.9	NA	NA
QUARTER:	4						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	6.2	13.9	11.8	0.0	5.7	6.0	5.7
1	12.5	30.7	27.8	19.2	17.3	11.5	10.8
2	17.1	29.7	40.7	19.1	23.5	15.8	15.0
3	29.8	44.5	49.8	24.1	29.6	20.4	20.5
4	33.7	39.4	41.5	29.8	35.0	23.1	23.4
5	38.1	43.1	44.3	33.8	39.5	24.4	23.9
6	44.5	53.5	53.1	35.5	43.2	25.1	24.6
7	48.7	54.0	56.2	31.5	46.6	25.5	21.6
8	50.1	55.7	59.5	41.6	51.3	25.7	33.4
9	53.0	59.2	74.4	20.0	46.9	26.2	38.0
10+	61.6	76.0	73.3	49.5	49.2	37.8	58.1

Table 4.2.5. Herring in SD 25–29, 32 (excl. GoR). XSA input: Catch in numbers (thousands). CANUM: Catch in numbers (Total International Catch) (Total) (Thousands)

CANUM: Catch in numbers (Total International Catch) (Total) (Thousands)									
Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+	SOPCOF %
1974	2436300	1553800	1090600	1347900	483100	343500	619000	285100	99.5
1975	1861800	1229200	1405600	829900	870700	364000	274800	546800	100.2
1976	2093100	1114800	1034000	907300	476800	558500	246500	494400	100.0
1977	1258500	1825900	773600	608300	621700	365300	284000	545400	99.9
1978	1044000	1298700	1575100	436800	355100	370700	186800	478300	100.0
1979	405300	1195500	873200	1159500	338900	278700	281200	478500	100.0
1980	1037000	907100	977400	524600	654900	182500	204400	550500	100.0
1981	1325500	1523500	680000	615000	343600	436300	146600	527500	100.2
1982	867000	2277000	810100	334200	312000	188100	250500	420700	99.6
1983	744300	1698700	1875700	625300	233100	245700	162500	433400	100.3
1984	822000	1177900	1282900	1145700	374300	165500	166300	421100	100.0
1985	1237800	2124100	1076100	867300	707200	240300	131000	346900	99.9
1986	552824	1733617	1601914	838843	614707	320221	114772	208901	100.4
1987	920000	726000	1445000	1237000	607000	461000	238000	194000	100.1
1988	474000	2091300	746300	1009600	849400	354300	254200	210100	100.1
1989	792900	540600	1988300	580000	840700	695100	266500	336600	99.9
1990	643300	1194800	585500	1245900	419400	541100	370500	306000	100.4
1991	372900	1571700	1286100	512700	807700	278400	265900	238200	100.1
1992	1112600	1139400	1696900	702900	324100	422300	157700	218600	100.7
1993	826300	1852600	1503000	1473400	615700	274000	197500	140100	99.8
1994	486870	1138560	1559930	1068900	1057400	495520	213790	282450	100.5
1995	820500	960200	1742700	1555400	645700	440400	205200	212100	100.5
1996	985800	1441300	1095900	1216600	798100	492000	301100	223800	99.3
1997	549200	1350300	1738700	1173900	904800	492600	244200	186100	99.9
1998	1873286	947360	1810804	1781642	813071	481770	211361	186102	100.1
1999	628815	1660328	949293	1307772	950155	340256	185943	119952	102.9
2000	1842170	940000	1682170	818970	864530	567220	191280	185030	99.9
2001	1052466	1930067	605055	1010660	375834	391122	303247	199646	99.4
2002	1034640	1012975	1339851	456838	522442	179710	169851	230139	98.6
2003	1347364	782607	687478	686673	261252	226812	89925	202367	101.1
2004	656630	1242941	673629	568055	384598	162350	119700	129883	100.0
2005	326272	753498	1187077	557148	378447	219723	82530	159318	101.2
2006	808387	505592	754016	1104978	409059	264865	154493	147666	100.8
2007	457582	920291	630258	703185	823805	268661	135977	112019	101.2
2008	789388	735511	968418	461494	485798	711012	165897	215625	99.4
2009	653043	1395081	745935	855049	302486	340499	486075	239340	100.0
2010	546352	645269	1357314	661735	630229	283763	283721	362390	101.0
2011	293118	568892	770797	1130531	415505	312765	128881	235287	101.0
2012	333355	317009	416640	517743	642002	234424	160708	208441	100.0
2013	470327	655679	260040	410703	467439	403588	172879	224139	100.0
2014	470062	902642	1003705	385671	488077	409753	285297	250759	100.0
2015	1415576	745130	1264634	1252762	378036	384811	369954	473420	100.0
2016	602141	3014945	934748	1188734	838456	331740	465961	629002	

Table 4.2.6. Herring in SD 25–29, 32 (excl. GoR). XSA input: Mean weight in the Catch and in the Stock (Kilograms).

WECA (= WEST): Mean weight in Catch (Total International Catch) (Total) (Kilograms)								
Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.0300	0.0350	0.0430	0.0460	0.0710	0.0790	0.0830	0.0750
1975	0.0300	0.0340	0.0520	0.0520	0.0540	0.0790	0.0780	0.0790
1976	0.0230	0.0380	0.0400	0.0600	0.0580	0.0570	0.0800	0.0810
1977	0.0290	0.0310	0.0500	0.0580	0.0690	0.0610	0.0720	0.0910
1978	0.0270	0.0440	0.0430	0.0560	0.0620	0.0730	0.0730	0.0810
1979	0.0240	0.0420	0.0590	0.0530	0.0660	0.0720	0.0770	0.0860
1980	0.0240	0.0370	0.0540	0.0680	0.0630	0.0770	0.0800	0.0940
1981	0.0260	0.0350	0.0530	0.0700	0.0790	0.0770	0.0860	0.1000
1982	0.0220	0.0390	0.0530	0.0650	0.0750	0.0840	0.0800	0.1010
1983	0.0180	0.0310	0.0560	0.0590	0.0770	0.0870	0.0910	0.1030
1984	0.0160	0.0300	0.0460	0.0650	0.0670	0.0820	0.0890	0.1010
1985	0.0160	0.0230	0.0420	0.0580	0.0670	0.0750	0.0850	0.1020
1986	0.0180	0.0250	0.0330	0.0510	0.0630	0.0690	0.0790	0.0990
1987	0.0150	0.0330	0.0380	0.0450	0.0590	0.0640	0.0710	0.0920
1988	0.0200	0.0260	0.0470	0.0510	0.0530	0.0650	0.0710	0.0900
1989	0.0230	0.0360	0.0370	0.0520	0.0570	0.0590	0.0670	0.0820
1990	0.0180	0.0310	0.0420	0.0390	0.0600	0.0620	0.0640	0.0770
1991	0.0230	0.0240	0.0350	0.0490	0.0410	0.0600	0.0560	0.0690
1992	0.0130	0.0230	0.0310	0.0420	0.0570	0.0500	0.0670	0.0710
1993	0.0130	0.0210	0.0320	0.0350	0.0440	0.0510	0.0500	0.0660
1994	0.0160	0.0210	0.0280	0.0380	0.0420	0.0520	0.0610	0.0640
1995	0.0110	0.0210	0.0240	0.0320	0.0410	0.0420	0.0490	0.0540
1996	0.0110	0.0170	0.0240	0.0280	0.0330	0.0370	0.0400	0.0510
1997	0.0110	0.0170	0.0220	0.0260	0.0300	0.0350	0.0400	0.0440
1998	0.0100	0.0180	0.0210	0.0280	0.0330	0.0370	0.0410	0.0460
1999	0.0130	0.0160	0.0220	0.0250	0.0290	0.0360	0.0390	0.0540
2000	0.0130	0.0230	0.0260	0.0280	0.0310	0.0360	0.0410	0.0460
2001	0.0140	0.0190	0.0290	0.0300	0.0340	0.0370	0.0440	0.0470
2002	0.0133	0.0216	0.0271	0.0330	0.0366	0.0392	0.0438	0.0454
2003	0.0094	0.0242	0.0298	0.0355	0.0388	0.0446	0.0501	0.0549
2004	0.0086	0.0143	0.0265	0.0304	0.0389	0.0418	0.0474	0.0540
2005	0.0122	0.0152	0.0193	0.0292	0.0356	0.0434	0.0481	0.0561
2006	0.0120	0.0234	0.0237	0.0263	0.0339	0.0435	0.0486	0.0553
2007	0.0123	0.0215	0.0254	0.0300	0.0330	0.0427	0.0497	0.0603
2008	0.0133	0.0222	0.0257	0.0302	0.0370	0.0335	0.0439	0.0498
2009	0.0112	0.0199	0.0268	0.0295	0.0354	0.0418	0.0357	0.0464
2010	0.0120	0.0183	0.0258	0.0322	0.0332	0.0385	0.0450	0.0450
2011	0.0125	0.0215	0.0246	0.0317	0.0375	0.039	0.0474	0.0475
2012	0.0142	0.0291	0.0268	0.0329	0.0417	0.0458	0.0511	0.0597
2013	0.0120	0.0210	0.0351	0.0324	0.0386	0.0480	0.0505	0.0566
2014	0.0118	0.0201	0.0294	0.0390	0.0350	0.0446	0.0492	0.0553
2015	0.0071	0.0217	0.0272	0.0331	0.0399	0.0403	0.0471	0.0512
2016	0.0086	0.0123	0.0256	0.0293	0.0339	0.0374	0.0407	0.047

Table 4.2.7. Herring in SD 25–29, 32 (excl. GoR). XSA input: Natural mortality.

NATMOR: Natural Mortality (Total International Catch) (Total)								
Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.3167	0.2941	0.2553	0.2280	0.2185	0.2265	0.2138	0.2046
1975	0.3392	0.3140	0.2799	0.2463	0.2296	0.2406	0.2228	0.2065
1976	0.3096	0.2862	0.2614	0.2424	0.2293	0.2347	0.2234	0.2072
1977	0.3322	0.3001	0.2681	0.2462	0.2377	0.2462	0.2321	0.2127
1978	0.4203	0.2903	0.2903	0.2513	0.2482	0.2382	0.2199	0.2199
1979	0.4685	0.2739	0.2376	0.2463	0.2463	0.2291	0.2184	0.2148
1980	0.4969	0.4011	0.3281	0.2384	0.2860	0.2220	0.2111	0.2072
1981	0.4612	0.4013	0.3459	0.3020	0.2663	0.2850	0.2135	0.2065
1982	0.5024	0.4168	0.3529	0.3155	0.2662	0.2380	0.2466	0.2078
1983	0.4725	0.4300	0.3636	0.3337	0.2631	0.2334	0.2210	0.2162
1984	0.3962	0.3720	0.3459	0.2882	0.2882	0.2263	0.2155	0.2098
1985	0.3621	0.3405	0.3148	0.2808	0.2491	0.2364	0.2283	0.2042
1986	0.3327	0.3160	0.2994	0.2662	0.2575	0.2399	0.2230	0.2069
1987	0.3176	0.2838	0.2755	0.2755	0.2491	0.2264	0.2183	0.2119
1988	0.3084	0.2980	0.2709	0.2635	0.2635	0.2301	0.2252	0.2136
1989	0.2917	0.2777	0.2777	0.2657	0.2525	0.2381	0.2197	0.2140
1990	0.2622	0.2551	0.2482	0.2518	0.2377	0.2354	0.2284	0.2295
1991	0.2433	0.2387	0.2316	0.2239	0.2288	0.2186	0.2219	0.2176
1992	0.2432	0.2387	0.2291	0.2244	0.2143	0.2201	0.2096	0.2088
1993	0.2488	0.2481	0.2422	0.2398	0.2316	0.2224	0.2224	0.2127
1994	0.2510	0.2499	0.2457	0.2428	0.2404	0.2329	0.2273	0.2318
1995	0.2516	0.2508	0.2473	0.2445	0.2445	0.2445	0.2359	0.2273
1996	0.2464	0.2457	0.2457	0.2445	0.2431	0.2405	0.2389	0.2315
1997	0.2556	0.2556	0.2543	0.2522	0.2496	0.2496	0.2496	0.2496
1998	0.2611	0.2596	0.2596	0.2570	0.2542	0.2496	0.2496	0.2364
1999	0.2713	0.2713	0.2699	0.2641	0.2641	0.2585	0.2585	0.2554
2000	0.2685	0.2672	0.2624	0.2624	0.2585	0.2585	0.2528	0.2492
2001	0.2626	0.2613	0.2590	0.2590	0.2521	0.2491	0.2454	0.2454
2002	0.2710	0.2710	0.2639	0.2597	0.2597	0.2499	0.2499	0.2437
2003	0.2422	0.2411	0.2389	0.2323	0.2352	0.2323	0.2288	0.2260
2004	0.2436	0.2436	0.2369	0.2369	0.2331	0.2272	0.2239	0.2239
2005	0.2495	0.2495	0.2469	0.2432	0.2348	0.2269	0.2269	0.2168
2006	0.2585	0.2505	0.2505	0.2505	0.2505	0.2342	0.2342	0.2231
2007	0.2630	0.2540	0.2540	0.2540	0.2495	0.2361	0.2361	0.2141
2008	0.2705	0.2687	0.2625	0.2625	0.2584	0.2584	0.2499	0.2437
2009	0.2962	0.2892	0.2892	0.2851	0.2793	0.2695	0.2793	0.2635
2010	0.3191	0.3117	0.3069	0.3069	0.3010	0.2964	0.2807	0.2886
2011	0.3346	0.3306	0.3279	0.3279	0.3249	0.3202	0.3036	0.3120
*2012	0.2985	0.2782	0.2644	0.2525	0.2453	0.2368	0.2296	0.2230
*2013	0.2877	0.2696	0.2574	0.2468	0.2403	0.2327	0.2264	0.2205
*2014	0.2857	0.2680	0.2560	0.2457	0.2394	0.2320	0.2258	0.2200
*2015	0.2870	0.2691	0.2569	0.2464	0.2400	0.2325	0.2262	0.2203
*2016	0.2910	0.2723	0.2595	0.2485	0.2418	0.2340	0.2274	0.2213

1971–2011 based on latest MSVPA/SMS-data provided by WGSAM 2012

*** 2012–2015 based on the regression of M against Eastern Baltic cod SSB**

Table 4.2.8. **Herring in SD 25–29, 32 (excl. GoR). XSA input: Proportion mature at year start.**

MATPROP: Proportion of Mature at Year Start (Total international Catch) (Total)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2016	0.0	0.7	0.9	1.0	1.0	1.0	1.0	1.0

Table 4.2.9. **Herring in SD 25–29, 32 (excl. GoR). XSA input: Proportion of M before spawning.**

MPROP: Proportion of M before Spawning (Total International Catch) (Total)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2016	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table 4.2.10. **Herring in SD 25–29, 32 (excl. GoR). XSA input: Proportion of F before spawning.**

FPROP: Proportion of F before Spawning (Total international Catch) (Total)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2016	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35

Table 4.2.11. **Herring in SD 25–29, 32 (excl. GoR). XSA input: Tuning Fleet/International Acoustic Survey.**

Fleet: International Acoustic Survey (Catch: Millions)

Year	Fish. Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	1	6943	20002	11964	4148	9643	2511	2280	2453
1992	1	7417	9156	13178	7156	4108	2274	1540	1167
***1993**	1	-11	-11	-11	-11	-11	-11	-11	-11
1994	1	3924	11881	20304	11527	5653	2099	941	829
***1995**	1	-11	-11	-11	-11	-11	-11	-11	-11
1996	1	3985	13762	9989	7361	4533	2359	1179	777
***1997**	1	-11	-11	-11	-11	-11	-11	-11	-11
1998	1	4285	2171	6617	6521	2584	1524	791	430
1999	1	1754	4742	3194	4251	3680	1428	833	630
2000	1	10151	2560	9874	4838	5200	3234	3007	2061
2001	1	4029	8194	3286	4661	1567	1238	861	464
2002	1	2687	4242	6508	2842	2326	870	741	455
2003	1	16704	9116	10643	6690	2320	1778	755	1156
2004	1	4914	13229	6789	4672	2500	1132	604	680
2005	1	1920	8251	15345	7123	4356	2541	1096	1129
2006	1	7317	8060	12700	21121	7336	3068	1701	1212
2007	1	5401	6587	2975	4191	7093	1697	883	807
2008	1	6842	6822	7589	3613	4927	3563	877	807
2009	1	6409	12141	6820	5551	2059	2969	2089	614
2010	1	3829	8279	12048	5006	3543	1685	1902	1600
****2011**	1	2339	5668	10993	12669	5525	3257	1448	2242
2012	1	14948	3630	7545	9345	9200	2685	2262	2082
2013	1	6896	9160	3855	6934	7127	7272	2154	3489
2014	1	5086	10114	15409	5916	7370	6664	4933	3653
2015	1	36179	9812	15273	15549	5486	4873	3648	4362
2016	1	6816	27756	7191	7275	4046	2032	1492	1471

*not used due to incomplete coverage

**Data for 2011 include small revisions (WGBFAS 2015)

Table 4.2.12. Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run:

Diagnostics. 1/3

FLR XSA Diagnostics 2017-04-12 11:41:17
CPUE data from indices

```
Catch data for 43 years 1974 to 2016. Ages 1 to 8.
fleet                                        first   last   first   last   alpha
beta
                                               age    age    year   year
1 BIAS SD 25-27&28.2&29S+N (April 2016)          1      7    1991   2016     0.8
0.9
```

Time series weights :
Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :
Catchability independent of size for ages > 1
Catchability independent of age for ages > 5

Terminal population estimation :
Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.
S.E. of the mean to which the estimates are shrunk = 1.5
Minimum standard error for population
estimates derived from each fleet = 0.3
prior weighting not applied

Regression weights

age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
all	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.037	0.033	0.036	0.043	0.035	0.016	0.026	0.033	0.027	0.037
2	0.091	0.082	0.081	0.050	0.065	0.055	0.044	0.069	0.073	0.083
3	0.154	0.138	0.121	0.117	0.089	0.069	0.063	0.095	0.142	0.135
4	0.167	0.172	0.189	0.167	0.152	0.088	0.095	0.134	0.176	0.207
5	0.189	0.177	0.175	0.230	0.171	0.133	0.113	0.166	0.199	0.181
6	0.233	0.264	0.194	0.274	0.193	0.150	0.122	0.143	0.201	0.283
7	0.178	0.232	0.315	0.268	0.215	0.156	0.164	0.123	0.193	0.416
8	0.178	0.232	0.315	0.268	0.215	0.156	0.164	0.123	0.193	0.416

XSA population number (Thousand)

year	1	2	3	4	5	6	7	8
2007	14457857	12058001	5019922	5197059	5411159	1453181	937402	767759
2008	28194423	10713162	8542761	3338823	3411997	3489136	908833	1172537
2009	21372087	20822757	7545801	5721162	2163247	2208120	2069775	1008461
2010	15382382	15329962	14386121	5005258	3560514	1373031	1388903	1757202
2011	9954930	10714179	10672468	9419990	3114890	2092885	776158	1403919
2012	24392292	6876028	7215842	7034579	5826914	1897615	1252949	1616495
2013	21540883	17558878	4873867	5124730	4968876	3963789	1281888	1653047
2014	16964240	15482325	12663091	3499546	3607047	3464586	2763017	2417407
2015	61114865	12127025	10897362	8814742	2372607	2385457	2365995	3009771
2016	19584250	43882753	8495548	7229440	5725380	1517875	1537219	2053937

Estimated population abundance at 1st Jan 2017

year	1	2	3	4	5	6	7	8
2017	0	13891168	30390309	5668843	4545850	3722488	899831	803864

Table 4.2.12 (cont'). Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run: Diagnostics. 2/3

```
Fleet:  BIAS SD 25-27&28.2&29S+N (April 2017)
 Log catchability residuals.
```

	year								
age	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.18	0.091	NA	-0.129	NA	-0.154	NA	-0.038	-0.07
2	0.803	0.243	NA	0.422	NA	0.365	NA	-0.72	-0.254
3	0.629	0.322	NA	0.905	NA	0.157	NA	-0.131	-0.323
4	0.062	0.273	NA	0.685	NA	0.203	NA	-0.111	-0.238
5	0.991	0.372	NA	0.252	NA	0.269	NA	-0.507	-0.152
6	0.372	0.138	NA	0.107	NA	0.176	NA	-0.095	-0.594
7	0.366	0.361	NA	-0.018	NA	-0.141	NA	-0.103	-0.07

age	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.334	0.119	-0.034	0.31	0.054	-0.104	0.14	0.085	-0.259
2	-0.34	0.264	-0.148	0.62	0.197	0.178	0.56	-0.175	-0.017
3	0.569	-0.134	0.051	0.674	0.212	0.208	0.475	-0.54	-0.141
4	0.45	0.179	-0.07	0.254	-0.004	0.405	0.652	-0.505	-0.199
5	0.582	-0.177	0.025	0.083	-0.414	0.258	0.794	-0.111	-0.017
6	0.403	-0.148	-0.216	0.31	-0.189	-0.006	0.363	-0.2	-0.289
7	0.621	-0.209	-0.021	0.124	-0.269	0.179	-0.009	-0.462	-0.381

age	2009	2010	2011	2012	2013	2014	2015	2016
1	-0.089	-0.093	-0.022	0.212	-0.062	-0.038	-0.003	0.003
2	-0.089	-0.172	-0.164	-0.21	-0.236	0.009	0.227	-0.009
3	-0.115	-0.181	0.021	-0.028	-0.316	0.141	0.323	-0.186
4	-0.274	-0.244	0.057	-0.068	-0.046	0.208	0.287	-0.247
5	-0.417	-0.308	0.24	0.03	-0.087	0.312	0.464	-0.735
6	-0.064	-0.065	0.124	-0.074	0.159	0.224	0.334	-0.018
7	-0.24	0.026	0.31	0.168	0.101	0.126	0.039	-0.233

```
 Regression statistics
 Ages with q dependent on year class strength
[1] "0.680963082893183" "10.5850675178679"
```

Table 4.2.12 (cont'). Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run: Diagnostics. 3/3

```
Terminal year survivor and F summaries:
 ,Age 1 Year class =2015
source
                                      scaledWts survivors yrcls
BIAS SD 25-27&28.2&29S+N (April 2017)     0.712  13953433  2015
fshk                                      0.030  18452307  2015
nshk                                      0.259  13283281  2015

 ,Age 2 Year class =2014
source
                                      scaledWts survivors yrcls
BIAS SD 25-27&28.2&29S+N (April 2017)     0.958  30108330  2014
fshk                                      0.042  41190120  2014

 ,Age 3 Year class =2013
source
                                      scaledWts survivors yrcls
BIAS SD 25-27&28.2&29S+N (April 2017)     0.955   4706249  2013
fshk                                      0.045   8476248  2013

 ,Age 4 Year class =2012
source
                                      scaledWts survivors yrcls
BIAS SD 25-27&28.2&29S+N (April 2017)      0.95   3552126  2012
fshk                                       0.05   7546380  2012
 ,Age 5 Year class =2011
source
                                      scaledWts survivors yrcls
BIAS SD 25-27&28.2&29S+N (April 2017)     0.916   1784054  2011
fshk                                      0.084   4347902  2011
,Age 6 Year class =2010
source
                                      scaledWts survivors yrcls
BIAS SD 25-27&28.2&29S+N (April 2017)      0.95    883638  2010
fshk                                       0.05   1667041  2010
,Age 7 Year class =2009
source
                                      scaledWts survivors yrcls
BIAS SD 25-27&28.2&29S+N (April 2017)     0.943    636678  2009
fshk                                      0.057   1643586  2009
```

Table 4.2.13. Herring in SD 25–29, 32 (excl. GoR). Fishing Mortality (F) at age.

Terminal Fs derived using XSA (With F shrinkage)

	age							
year	1	2	3	4	5	6	7	8
1974	0.1715	0.127	0.1707	0.2264	0.1685	0.1724	0.19	0.19
1975	0.1809	0.1385	0.1782	0.201	0.231	0.1911	0.2088	0.2088
1976	0.0973	0.1771	0.1823	0.1785	0.177	0.2361	0.1982	0.1982
1977	0.1175	0.1288	0.1953	0.1644	0.1867	0.2084	0.1875	0.1875
1978	0.0856	0.1932	0.1736	0.1719	0.1434	0.1687	0.1621	0.1621
1979	0.0407	0.1564	0.2065	0.2015	0.2065	0.1668	0.1926	0.1926
1980	0.0737	0.1549	0.2071	0.1922	0.1798	0.1697	0.1814	0.1814
1981	0.055	0.1936	0.2014	0.2211	0.1968	0.1918	0.2043	0.2043
1982	0.0391	0.1633	0.1811	0.1656	0.1825	0.1663	0.1724	0.1724
1983	0.0435	0.1328	0.2432	0.2434	0.1837	0.2262	0.2189	0.2189
1984	0.0346	0.1136	0.1721	0.2652	0.255	0.2019	0.242	0.242
1985	0.067	0.141	0.1684	0.1908	0.2813	0.2776	0.2514	0.2514
1986	0.0583	0.1465	0.1712	0.2121	0.2169	0.2081	0.2135	0.2135
1987	0.0527	0.1135	0.1945	0.2134	0.25	0.2632	0.2436	0.2436
1988	0.0605	0.1832	0.178	0.2187	0.2406	0.2366	0.2333	0.2333
1989	0.0667	0.1003	0.2942	0.2206	0.3058	0.3369	0.2896	0.2896
1990	0.0392	0.1469	0.1609	0.3275	0.2608	0.3479	0.3142	0.3142
1991	0.0291	0.1342	0.2449	0.2151	0.3848	0.2857	0.2971	0.2971
1992	0.0726	0.122	0.2181	0.2113	0.2093	0.3669	0.264	0.264
1993	0.0583	0.1748	0.2455	0.3114	0.2997	0.2809	0.2993	0.2993
1994	0.0356	0.1122	0.2306	0.2906	0.4055	0.4381	0.381	0.381
1995	0.0474	0.0962	0.2654	0.401	0.301	0.3084	0.3394	0.3394
1996	0.0685	0.1159	0.1599	0.3165	0.3901	0.4171	0.3776	0.3776
1997	0.0641	0.1333	0.2112	0.2721	0.4378	0.4728	0.3978	0.3978
1998	0.1459	0.1599	0.2843	0.3727	0.3272	0.4706	0.4049	0.4049
1999	0.0862	0.2005	0.2567	0.369	0.3747	0.2349	0.3553	0.3553
2000	0.1377	0.1937	0.3477	0.3997	0.4831	0.4345	0.2134	0.2134
2001	0.108	0.2252	0.1972	0.392	0.3449	0.4497	0.4689	0.4689
2002	0.1116	0.1547	0.2588	0.2399	0.3879	0.2918	0.3805	0.3805
2003	0.0698	0.1225	0.1584	0.2157	0.2213	0.3053	0.2426	0.2426
2004	0.0538	0.0888	0.1537	0.1983	0.1865	0.2157	0.2701	0.2701
2005	0.0402	0.0846	0.1203	0.192	0.2046	0.1595	0.1667	0.1667
2006	0.0572	0.0851	0.1205	0.1657	0.2218	0.2242	0.1662	0.1662
2007	0.0368	0.0906	0.1538	0.1668	0.1893	0.2332	0.1782	0.1782
2008	0.0326	0.0818	0.1384	0.1715	0.1768	0.2638	0.2317	0.2317
2009	0.0361	0.0806	0.1213	0.1892	0.1753	0.1941	0.3148	0.3148
2010	0.0426	0.0504	0.1165	0.1674	0.2304	0.274	0.268	0.268
2011	0.0354	0.0647	0.0889	0.1524	0.1707	0.1928	0.2148	0.2148
2012	0.0161	0.0548	0.0685	0.0875	0.1335	0.1502	0.1557	0.1557
2013	0.0258	0.044	0.063	0.0955	0.1126	0.1219	0.1642	0.1642
2014	0.0328	0.0695	0.095	0.1337	0.1662	0.143	0.1232	0.1232
2015	0.0273	0.0734	0.1424	0.1761	0.1989	0.2006	0.193	0.193
2016	0.0365	0.0825	0.1346	0.2070	0.1814	0.2829	0.4162	0.4162

Table 4.2.14. Herring in SD 25–29, 32 (excl. GoR). Stock number at age (Number*10-4).**

	Age							
Year	1	2	3	4	5	6	7	8
1974	18115116	15090240	7894563	7457598	3475679	2429218	3981080	1823955
1975	13329768	11118249	9903958	5155888	4734500	2360383	1630142	3224484
1976	26360651	7923963	7071490	6263968	3296554	2986957	1532887	3056824
1977	13400270	17548954	4985626	4537540	4111862	2195905	1865450	3561517
1978	15702005	8546700	11427796	3136614	3009450	2689920	1393694	3550826
1979	12856079	9467735	5270030	7186147	2054400	2034328	1790701	3030461
1980	18714285	7726481	6156850	3380125	4592172	1306267	1369262	3669222
1981	31191975	10577161	4431259	3605204	2197507	2882290	882883	3159314
1982	29099041	18614846	5834346	2563482	2136658	1382986	1789169	2986630
1983	22131126	16932742	10421371	3420429	1584438	1364173	923076	2447055
1984	29453591	13209781	9644831	5680717	1920738	1013535	861566	2168001
1985	22882573	19144223	8128239	5745371	3266384	1115738	660478	1736914
1986	11529532	14898326	11827898	5013706	3585093	1921770	667325	1207325
1987	21003876	7798401	9381517	7388388	3107627	2230764	1227844	994460
1988	9414139	14503679	5241594	5863325	4531389	1886485	1367149	1122673
1989	14219555	6509562	8964301	3345965	3620155	2737177	1182931	1483232
1990	19057155	9936609	4460634	5060139	2057402	2071352	1540151	1261730
1991	14679230	14097501	6647550	2963037	2835240	1249734	1155878	1027704
1992	17932210	11178861	9709033	4127789	1910238	1535010	754765	1039536
1993	16521728	13075699	7793828	6207859	2669787	1250596	853459	600841
1994	15800551	12152939	8566264	4785794	3577332	1569469	756057	989594
1995	20081061	11863735	8460839	5320565	2807409	1875262	802335	821919
1996	16842346	14890634	8385063	5067118	2790098	1627074	1078788	793974
1997	10049377	12292605	10372131	5589225	2891438	1481220	843006	635526
1998	15724393	7299445	8331725	6512062	3308502	1454112	719232	626375
1999	8724032	10466969	4798462	4836383	3469421	1849838	707671	451799
2000	16372756	6102046	6530177	2833960	2567846	1831539	1129460	1084779
2001	11726445	10906647	3848795	3547699	1461620	1223204	915884	595775
2002	11224354	8095251	6704980	2439026	1850296	804598	608171	815450
2003	22562502	7656348	5288962	3975537	1479972	968279	468083	1046244
2004	14162085	16515599	5322347	3554950	2540068	937522	565623	609393
2005	9381523	10518926	11844537	3601323	2300504	1669636	602065	1156111
2006	16534868	7021986	7531119	8203958	2330495	1482549	1134543	1078439
2007	14457857	12058001	5019922	5197059	5411159	1453181	937402	767759
2008	28194423	10713162	8542761	3338823	3411997	3489136	908833	1172537
2009	21372087	20822757	7545801	5721162	2163247	2208120	2069775	1008461
2010	15382382	15329962	14386121	5005258	3560514	1373031	1388903	1757202
2011	9954930	10714179	10672468	9419990	3114890	2092885	776158	1403919
2012	24392292	6876028	7215842	7034579	5826914	1897615	1252949	1616495
2013	21540883	17558878	4873867	5124730	4968876	3963789	1281888	1653047
2014	16964240	15482325	12663091	3499546	3607047	3464586	2763017	2417407
2015	61114865	12127025	10897362	8814742	2372607	2385457	2365995	3009771
2016	19584250	43882753	8495548	7229440	5725380	1517875	1537219	2053937

Table 4.2.15. Herring in SD 25–29, 32 (excl. GoR). Output from XSA: Stock Summary.

Summary (without SOP correction)

Year	RECRUITS Age 1	TOTALBIO	TOTSPBIO	FBAR 3- 6
1974	18115116	2660035	1683342	0.18
1975	13329768	2385044	1577408	0.20
1976	26360651	2297794	1368886	0.19
1977	13400270	2321163	1521998	0.19
1978	15702005	2239361	1441824	0.16
1979	12856079	2078554	1410091	0.20
1980	18714285	2141678	1359022	0.19
1981	31191975	2455812	1288491	0.20
1982	29099041	2563208	1434355	0.17
1983	22131126	2285409	1408071	0.22
1984	29453591	2187907	1321236	0.22
1985	22882573	2016890	1270356	0.23
1986	11529532	1756716	1205417	0.20
1987	21003876	1766167	1150388	0.23
1988	9414139	1671656	1154698	0.22
1989	14219555	1635787	1017851	0.29
1990	19057155	1483346	875410	0.27
1991	14679230	1380685	788409	0.28
1992	17932210	1274590	809946	0.25
1993	16521728	1219629	762903	0.28
1994	15800551	1271050	773069	0.34
1995	20081061	1120911	679845	0.32
1996	16842346	1017447	626540	0.32
1997	10049377	893293	588136	0.35
1998	15724393	867222	540088	0.36
1999	8724032	726563	459795	0.31
2000	16372756	844075	470975	0.42
2001	11726445	752696	427121	0.35
2002	11224354	749255	446227	0.29
2003	22562502	877612	517700	0.23
2004	14162085	804794	525969	0.19
2005	9381523	856278	593317	0.17
2006	16534868	1015256	659796	0.18
2007	14457857	1054000	689864	0.19
2008	28194423	1274620	703641	0.19
2009	21372087	1314304	808877	0.17
2010	15382382	1310104	868744	0.20
2011	9954930	1217855	863526	0.15
2012	24392292	1461709	923727	0.11
2013	21540883	1504699	1001657	0.10
2014	16964240	1570540	1103797	0.13
2015	61114865	1741588	1050468	0.18
2016	19584250	1547450	1036926	0.20

Table 4.2.16. Herring in SD 25–29, 32 (excl. GoR). Configuration settings of SAM.

Min Age (should not be modified unless data is modified accordingly)
1
Max Age (should not be modified unless data is modified accordingly)
8
Max Age considered a plus group (0=No, 1=Yes)
1
The following matrix describes the coupling
of fishing mortality STATES
Rows represent fleets.
Columns represent ages.

1	2	3	4	5	6	7	7
0	0	0	0	0	0	0	0

Use correlated random walks for the fishing mortalities
(0 = independent, **1 = correlation estimated**)
1
Coupling of catchability PARAMETERS

0	0	0	0	0	0	0	0
1	2	3	4	5	6	7	8

Coupling of power law model EXPONENTS (if used)

0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0

Coupling of fishing mortality RW VARIANCES

1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0

Coupling of log N RW VARIANCES

1	2	2	2	2	2	2	2

Coupling of OBSERVATION VARIANCES

1	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3

Stock recruitment model code (**0=RW**, 1=Ricker, 3=BH, ... more in time)
0
Years in which catch data are to be scaled by an estimated parameter
0
first the number of years
Then the actual years
Them the model config lines years cols ages
Define Fbar range
3 6

Table 4.2.17. Herring in SD 25–29, 32 (excl. GoR). Input for RCT3 analysis.

Yearclass	VPA Age 1 (thousands	Acoustic (SD 25-29S+N) Age 0 (thousands
1991	17932	13733
1992	16522	1608
1993	15801	
1994	20081	6122
1995	16842	
1996	10049	336
1997	15724	
1998	8724	508
1999	16373	2591
2000	11726	1319
2001	11224	2123
2002	22563	16046
2003	14162	9067
2004	9382	1587
2005	16535	5568
2006	14458	1990
2007	28194	12197
2008	21372	8673
2009	15382	3366
2010	9955	1178
2011	24392	10098
2012	21541	11141
2013	16964	3068
2014	61115	35061
2015	-11	7662
2016	-11	2940

Table 4.2.18. Herring in SD 25–29, 32 (excl. GoR). Output from RCT3 analysis.

Analysis by RCT3 ver3.1 of data from file : rect3in.txt
Herring 25-29, 32 (excl. GOR). RCT3 input data.
Data for 1 surveys over 26 years: 1991 - 2016
Regression type = C
Tapered time weighting applied
power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E. for any survey taken as .20
Minimum of 3 points used for regression
Forecast/Hindcast variance correction used.

Yearclass 2010

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS	.38	6.50	.22	.735	16	7.07	9.21	.268	.613
					VPA	Mean =	9.63	.338	.387

Yearclass 2011

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS	.39	6.44	.21	.763	17	9.22	10.03	.253	.656
					VPA	Mean =	9.61	.349	.344

Yearclass = 2012

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS	.41	6.30	.20	.787	18	9.32	10.09	.244	.692
					VPA	Mean =	9.65	.365	.308

Yearclass = 2013

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS	.41	6.29	.19	.806	19	8.03	9.55	.217	.737
					VPA	Mean =	9.69	.364	.263

Yearclass = 2014

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS	.42	6.21	.19	.795	20	10.46	10.58	.253	.654
					VPA	Mean =	9.70	.349	.346

Yearclass = 2015

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS	.52	5.36	.24	.830	21	8.94	10.02	.273	.771
					VPA	Mean =	9.83	.501	.229

Yearclass = 2016

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS	.53	5.29	.23	.840	21	7.99	9.51	.274	.775
					VPA	Mean =	9.85	.509	.225

Year Class	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2010	11757	9.37	.21	.21	.98	9956	9.21
2011	19618	9.88	.20	.20	.97	24393	10.10
2012	21031	9.95	.20	.20	.99	21541	9.98
2013	14572	9.59	.19	.06	.11	16965	9.74
2014	28982	10.27	.20	.41	4.08	61115	11.02
2015	21417	9.97	.24	.08	.11		
2016	14587	9.59	.24	.14	.34		

Table 4.2.19. Herring in SD 25–29, 32 (excl. GoR). Input data for short-term predictions.

MFPD VERSION 1A RUN: V2 TIME AND DATE: 16:36, 4/24/2017 FBAR ARE RANGE: 3-6

2016

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	14587000	0.2879	0	0.35	0.3	0.0092	0.0365	0.0092
2	14114825	0.2698	0.7	0.35	0.3	0.0180	0.0851	0.0180
3	30775576	0.2575	0.9	0.35	0.3	0.0274	0.1404	0.0274
4	5728434	0.2469	1	0.35	0.3	0.0338	0.1950	0.0338
5	4584411	0.2404	1	0.35	0.3	0.0363	0.2062	0.0363
6	3749824	0.2328	1	0.35	0.3	0.0408	0.2364	0.0408
7	905210	0.2265	1	0.35	0.3	0.0457	0.2764	0.0457
8	807651	0.2205	1	0.35	0.3	0.0512	0.2764	0.0512

2017

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	16114962	0.2879	0	0.35	0.3	0.0092	0.0365	0.0092
2		0.2698	0.7	0.35	0.3	0.0180	0.0851	0.0180
3		0.2575	0.9	0.35	0.3	0.0274	0.1404	0.0274
4		0.2469	1	0.35	0.3	0.0338	0.1950	0.0338
5		0.2404	1	0.35	0.3	0.0363	0.2062	0.0363
6		0.2328	1	0.35	0.3	0.0408	0.2364	0.0408
7		0.2265	1	0.35	0.3	0.0457	0.2764	0.0457
8		0.2205	1	0.35	0.3	0.0512	0.2764	0.0512

2018

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	16114962	0.2879	0	0.35	0.3	0.0092	0.0365	0.0092
2		0.2698	0.7	0.35	0.3	0.0180	0.0851	0.0180
3		0.2575	0.9	0.35	0.3	0.0274	0.1404	0.0274
4		0.2469	1	0.35	0.3	0.0338	0.1950	0.0338
5		0.2404	1	0.35	0.3	0.0363	0.2062	0.0363
6		0.2328	1	0.35	0.3	0.0408	0.2364	0.0408
7		0.2265	1	0.35	0.3	0.0457	0.2764	0.0457
8		0.2205	1	0.35	0.3	0.0512	0.2764	0.0512

Input units are thousands and kg - output in tonnes

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)

N2016 AGE 1:	OUTPUT FORM RCT3 ANALYSIS (TABLE 4.2.17)
N2016 Age 2–8+:	Output from VPA (Table 4.2.14)
N2017/2018 Age 1:	Geometric Mean from VPA-Output of age 1 (Table 4.2.15) for the years 1988–2015
Natural Mortality (M):	Average of 2014–2016
Weight in the Catch/Stock (CWt/SWt):	Average of 2014–2016
Expoitation pattern (Sel):	Average of 2014–2016

Table 4.2.20. Herring in SD 25–29, 32 (excl. GoR). Output from short-term predictions with management option table for *'TAC constraint' in 2017.

MFDP VERSION 1A RUN: V2 HERRING CBD PREDICTION TIME AND DATE: 16:36, 4/24/2017 FBAR AGE RANGE: 3-6

2017						
Biomass	SSB	FMult	FBar	Landings		
1826915	1341625	0.9996	0.1944	224989		
2018					2019	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
1721339	1383265	0	0	0	1793175	1448388
.	1374124	0.1	0.0195	26011	1766934	1414553
.	1365047	0.2	0.0389	51537	1741190	1381608
.	1356033	0.3	0.0584	76587	1715933	1349528
.	1347084	0.4	0.0778	101172	1691154	1318287
.	1338197	0.5	0.0973	125300	1666842	1287864
.	1329373	0.6	0.1167	148981	1642987	1258234
.	1320611	0.7	0.1362	172224	1619581	1229376
.	1311910	0.8	0.1556	195038	1596614	1201268
.	1303271	0.9	0.1751	217431	1574077	1173890
.	1294692	1	0.1945	239413	1551962	1147220
.	1286174	1.1	0.214	260991	1530260	1121240
.	1277715	1.2	0.2334	282173	1508962	1095930
.	1269316	1.3	0.2529	302968	1488061	1071272
.	1260976	1.4	0.2723	323382	1467548	1047248
.	1252694	1.5	0.2918	343425	1447415	1023839
.	1244471	1.6	0.3112	363103	1427655	1001030
.	1236305	1.7	0.3307	382424	1408259	978803
.	1228196	1.8	0.3501	401394	1389222	957143
.	1220144	1.9	0.3696	420021	1370535	936033
.	1212149	2	0.389	438311	1352192	915460

TAC constraint in 2017	
EU	191 129
+EU/Russia	29 500
+CBH in GOR	4580
–GORH	220
Total	224 989
Mean catches in 2011–2015	

Table 4.2.20 (cont'). **Herring in SD 25–29, 32 (excl. GoR). Output from short-term predictions with management option table for *'TAC constraint' in 2017.**

Basis	Total catch (2018)	Ftotal (2018)	SSB (2019)	% SSB change *	% Advice change **	% TAC change ***
ICES advice basis						
EU MAP : FMSY	267745	0.22	1113149	0.867285	24%	21%
Other options						
F = 0	0	0	1448388	1.0470792	-100%	-100%
Fpa	457890	0.4102	893608	0.7425145	112%	108%
Flim	553453	0.5203	789549	0.6808629	156%	151%
SSB (2019) = Blim	924535	1.098	429915	0.449796	328%	319%
SSB (2019) = Bpa	739660	0.7731	599790	0.56308	242%	235%
SSB (2019) = MSY Btrigger	739660	0.7731	599790	0.56308	242%	235%
F = F2017	239413	0.1945	1147220	0.8860949	11%	9%
F = MAP FMSY lower	200236	0.1601	1194895	0.9121935	-7%	-9%
F = MAP FMSY lower differing by 0.01	211757	0.1701	1180807	0.9045079	-2%	-4%
F = MAP FMSY lower differing by 0.02	223170	0.1801	1166908	0.8969033	3%	1%
F = MAP FMSY lower differing by 0.03	234473	0.1901	1153196	0.8893801	8%	6%
F = MAP FMSY lower differing by 0.04	245670	0.2001	1139667	0.8819368	14%	11%
F = MAP FMSY lower differing by 0.05	256760	0.2101	1126319	0.8745718	19%	16%
F = MAP FMSY lower differing by 0.07	278626	0.2301	1100155	0.8600753	29%	26%
F = MAP FMSY lower differing by 0.08	289405	0.2401	1087334	0.8529414	34%	31%
F = MAP FMSY lower differing by 0.09	300081	0.2501	1074684	0.8458828	39%	36%
F = MAP FMSY lower differing by 0.10	310657	0.2601	1062202	0.8388989	44%	41%
F = MAP FMSY lower differing by 0.11	321133	0.2701	1049886	0.8319883	49%	46%
F = MAP FMSY upper	331510	0.2801	1037734	0.8251511	53%	50%
* SSB 2019 relative to SSB 2018.						
** Wanted catch in 2018 relative to Advice in 2017 (216 227 t).						
*** Wanted catch in 2018 relative to TAC in 2017 (225 989 t).						

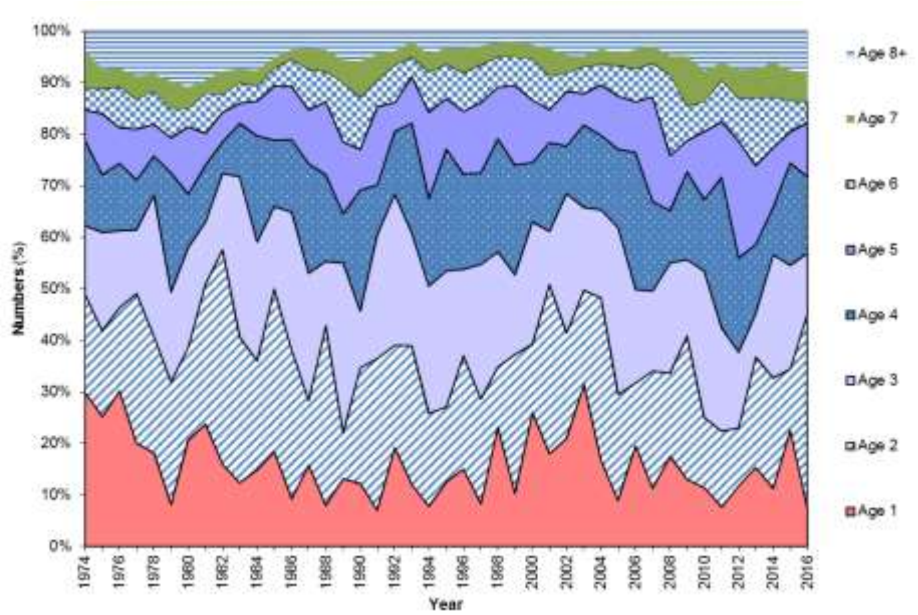


Figure 4.2.1. **Herring in SD 25–29, 32 (excl. GoR). Proportions of age groups (numbers) in total catch (CANUM).**

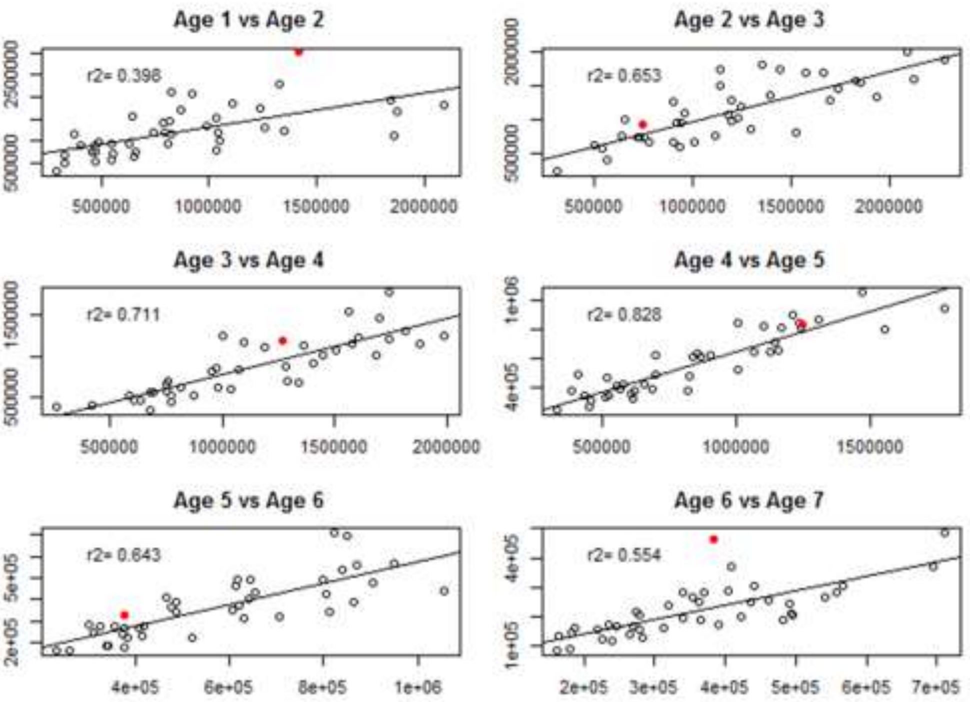


Figure 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Catch in numbers (thousands) at age vs. numbers at age +1 of the same cohort in the following year in the period 1974–2016

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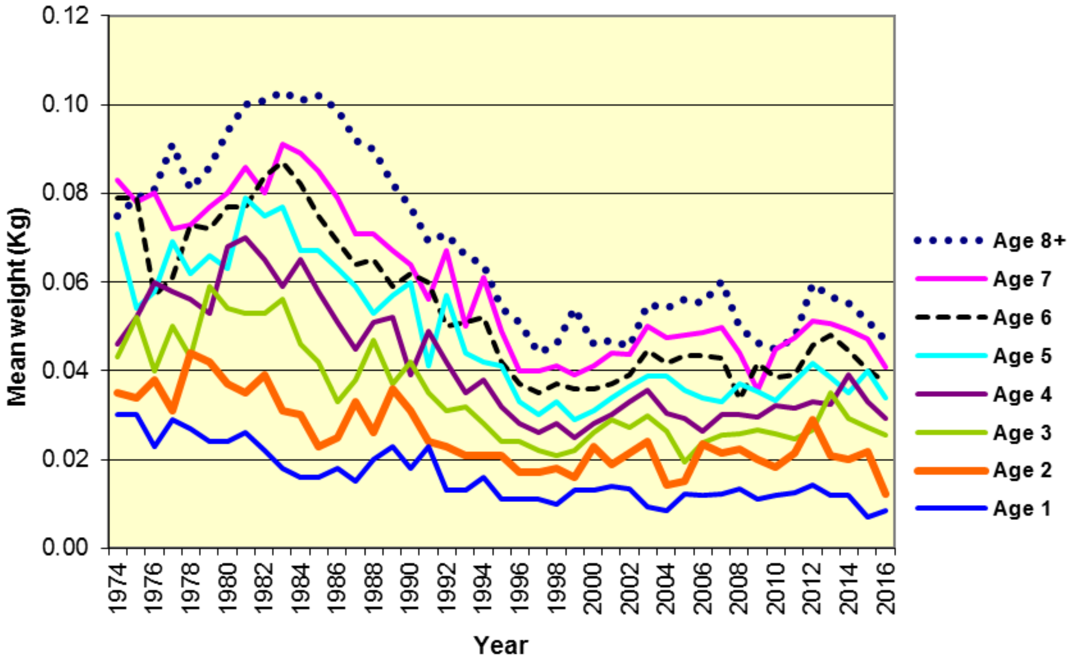


Figure 4.2.3. Herring in SD 25–29, 32 (excl. GoR). Trends in the mean weights at age (kg) in the catch (WECA).

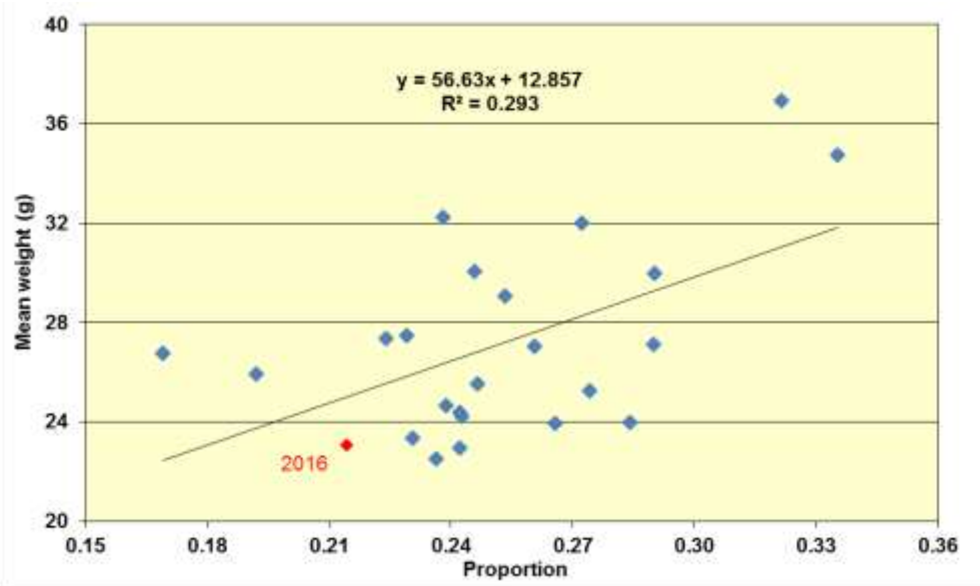


Figure 4.2.4. Herring in SD 25–29, 32 (excl. GoR).Average individual weight in catches vs. the proportion of catches taken in SD 25 and 26 (1993–2016).

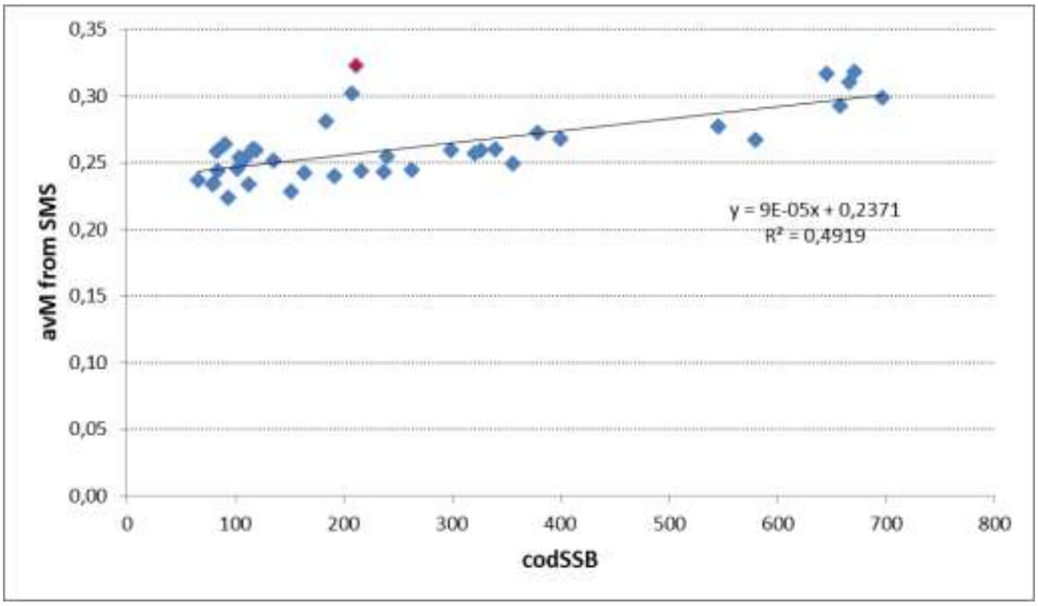


Figure 4.2.5a. Herring in SD 25–29, 32 (excl. GoR). The dependence of average M for herring on cod SSB.

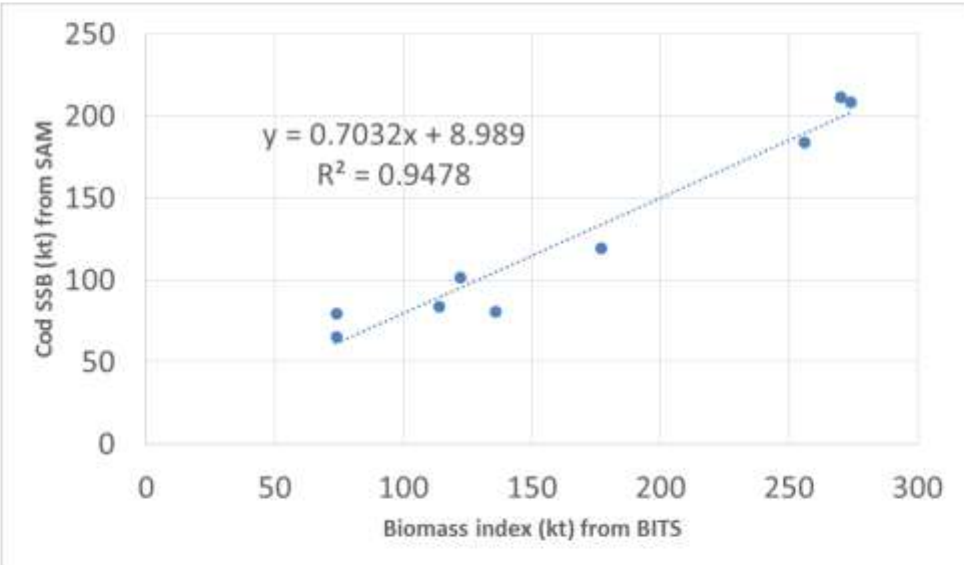


Figure 4.2.5b. Herring in SD 25–29, 32 (excl. GoR). The relationship between cod SSB and biomass index from BITS (years 2003–2011).

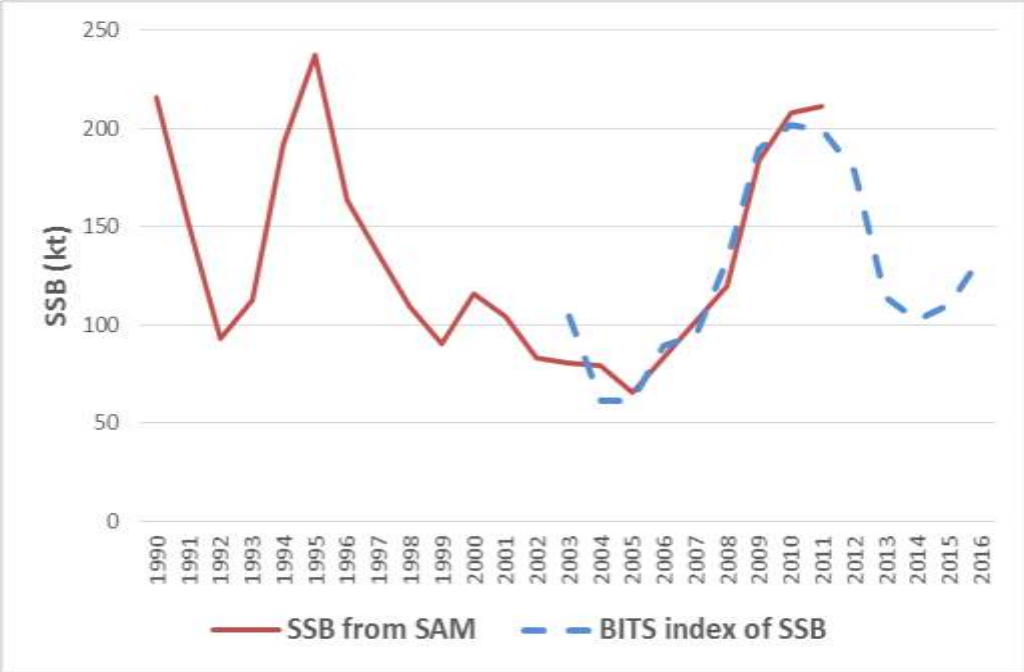


Figure 4.2.5c. **Herring in SD 25–29, 32 (excl. GoR). The biomass index from BITS rescaled to level of cod SSB from last accepted assessment (2012).**

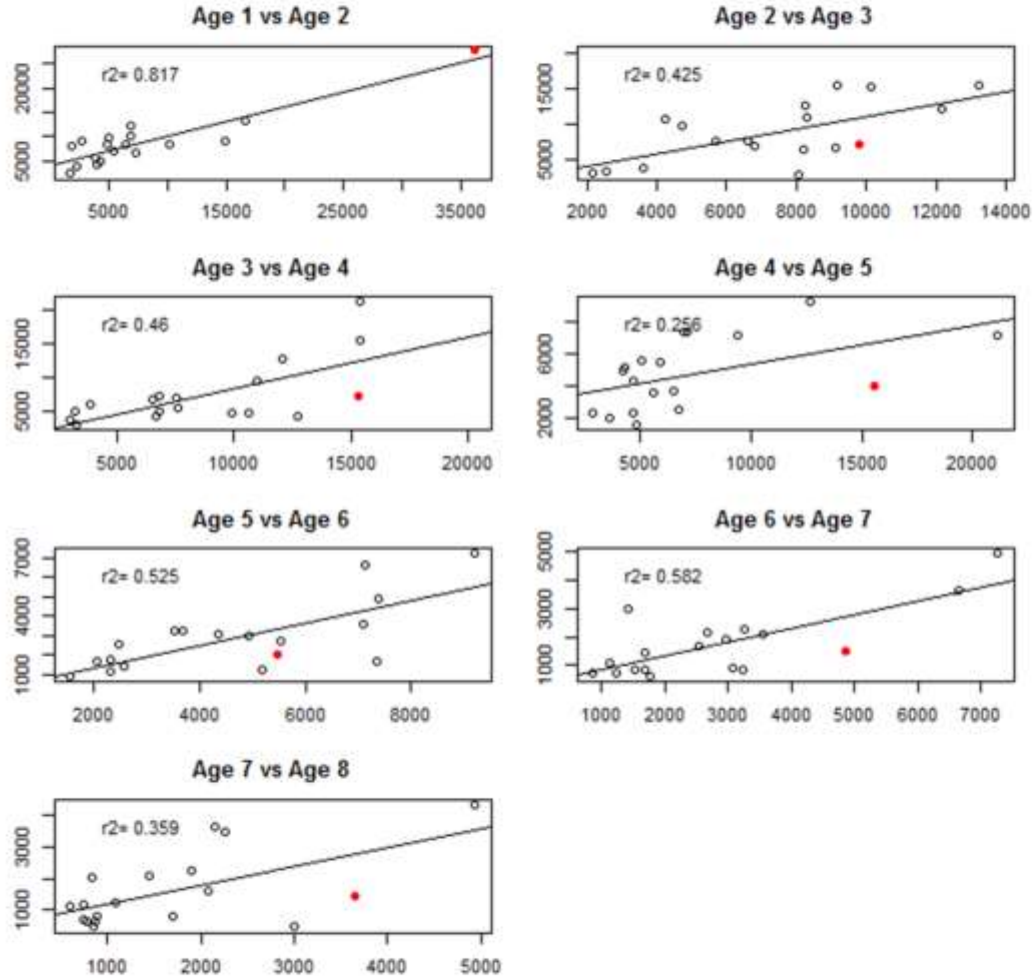


Figure 4.2.6. Herring in SD 25–29, 32 (excl. GoR). Acoustic survey numbers at age vs. numbers at age +1 of the same cohort in the following year in the period 1991–2016 (STANDARD INDEX). Years 1993, 1995, and 1997 were excluded.

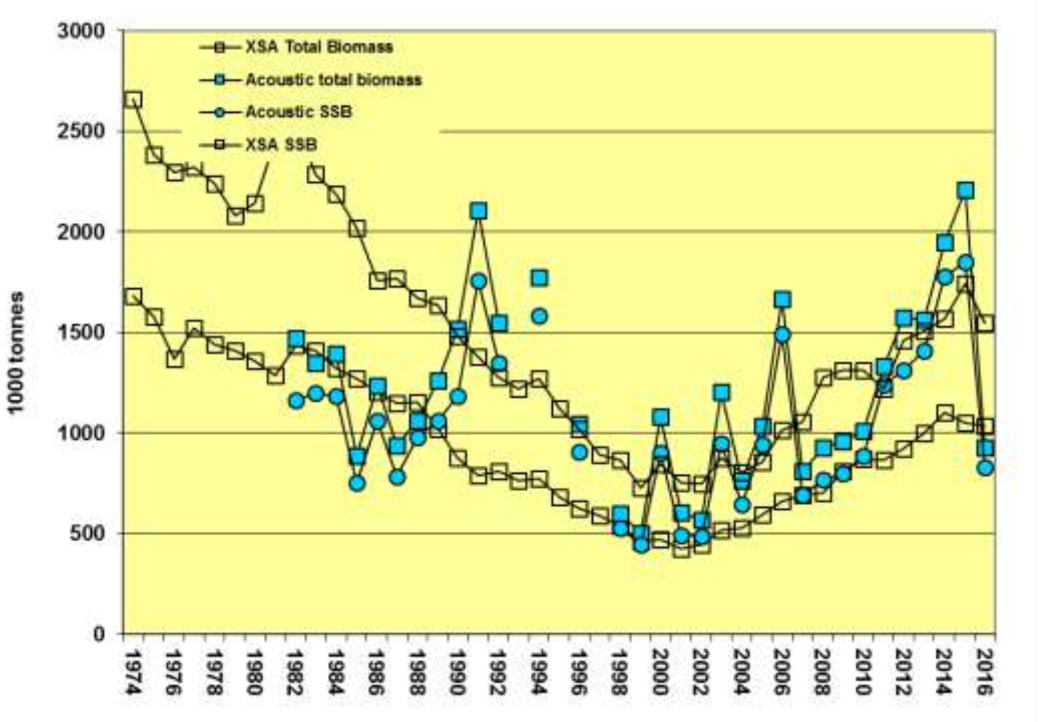


Figure 4.2.7. **Herring in SD 25–29, 32 (excl. GoR). Estimates of biomass and SSB from acoustic surveys (BIAS) and from XSA.**

Acoustic biomasses = Acoustic abundance x WECA;

Acoustic SSB = Acoustic abundance x WECA x MATPROP

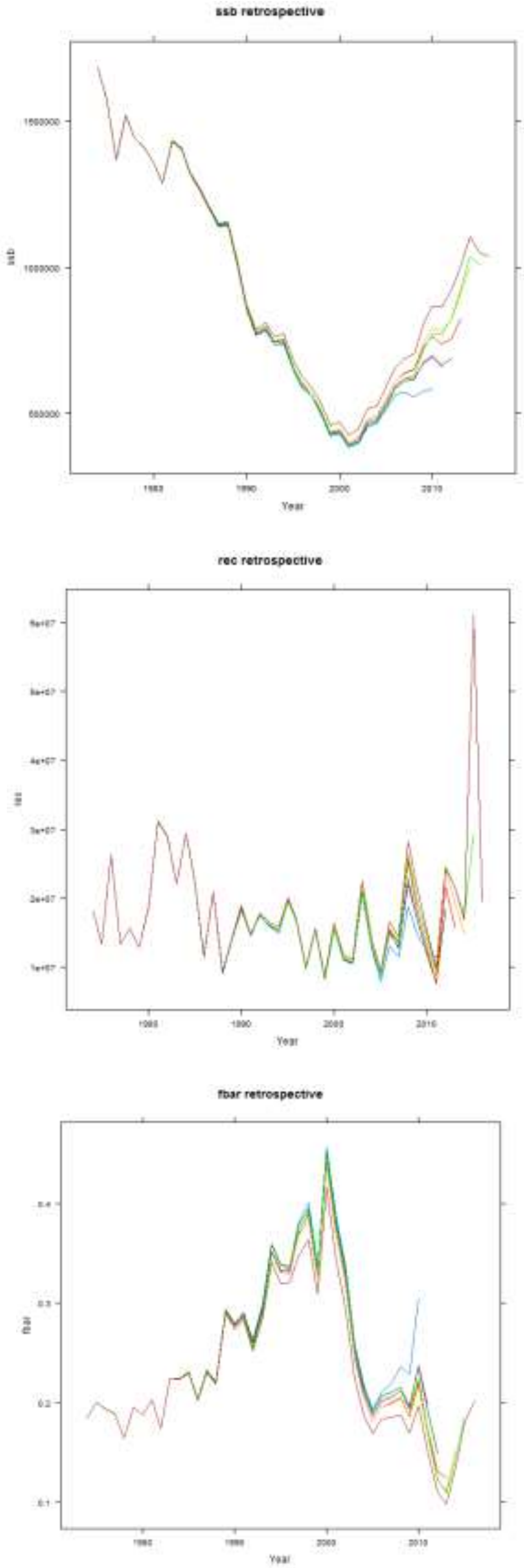
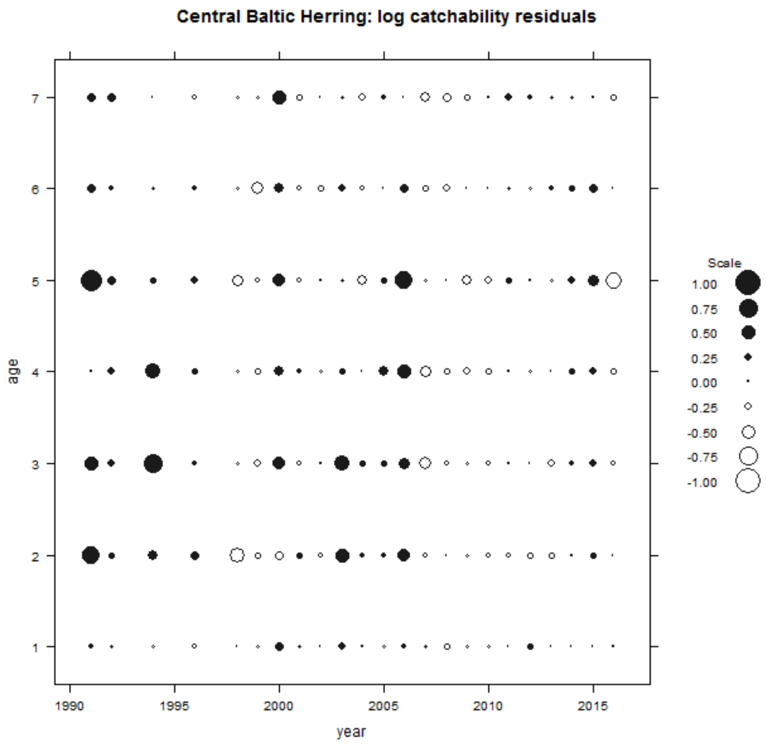


Figure 4.2.8. Herring in SD 25–29, 32 (excl. GoR). Retrospective Analysis.



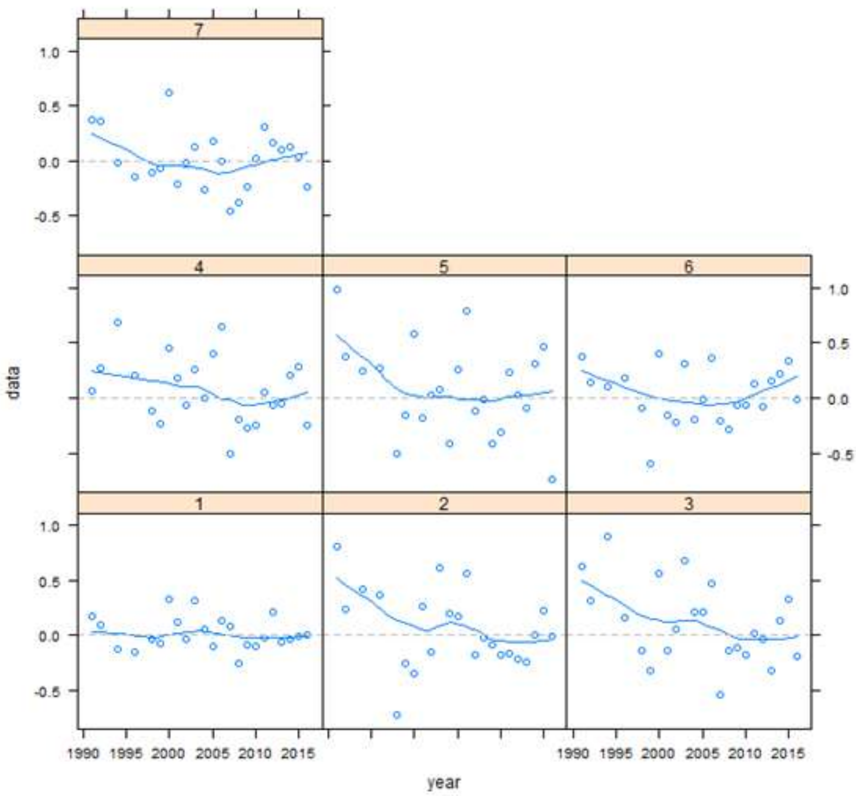


Figure 4.2.9. Herring in SD 25–29, 32 (excl. GoR). International Acoustic Survey (Ages 1–7): Log Catchability residuals. Standardized log catchability residuals (top figure). Observed (circles) vs predicted (line) numbers (bottom figure).

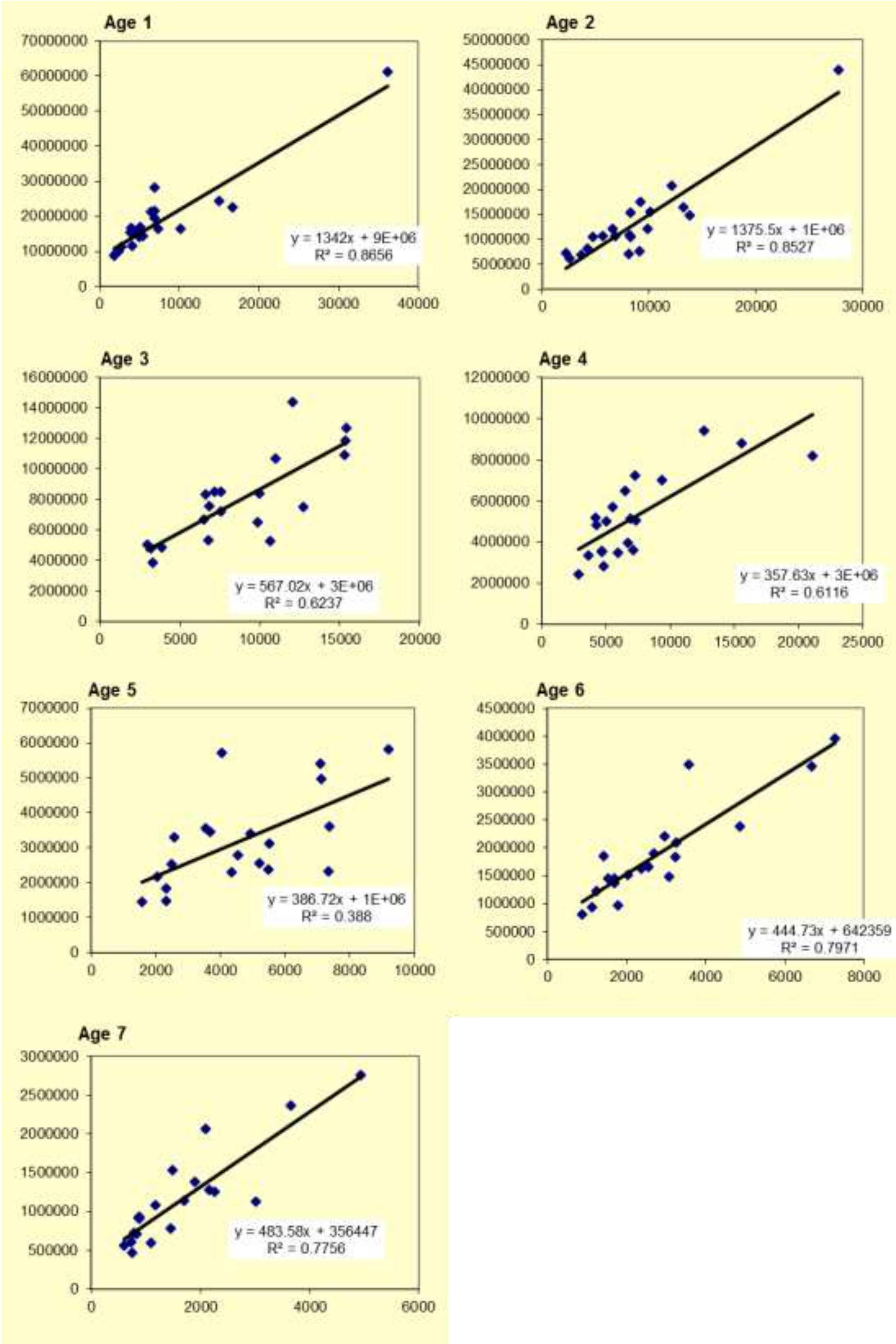


Figure 4.2.10. Herring in SD 25–29, 32 (excl. GoR). Regression of XSA population vs. acoustic survey population numbers. x-axis = Acoustic estimates; y-axis = XSA.

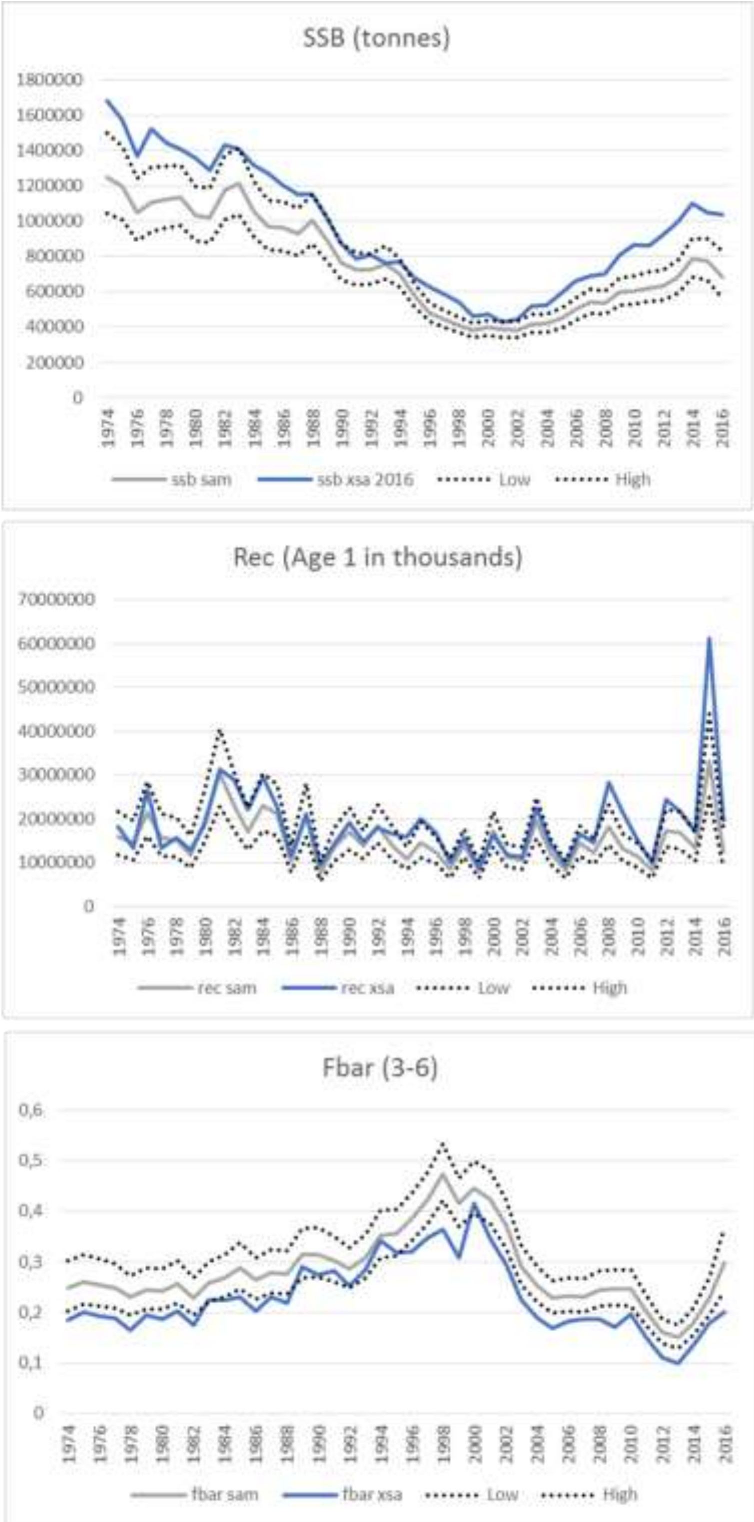


Figure 4.2.11. Herring in SD 25–29, 32 (excl. GoR). Comparison of fishing mortality (F_{3-6}), spawning stock biomass (SSB) and recruitment (age 1) from XSA and SAM (dotted line represents the 95% confidence intervals of the SAM results).

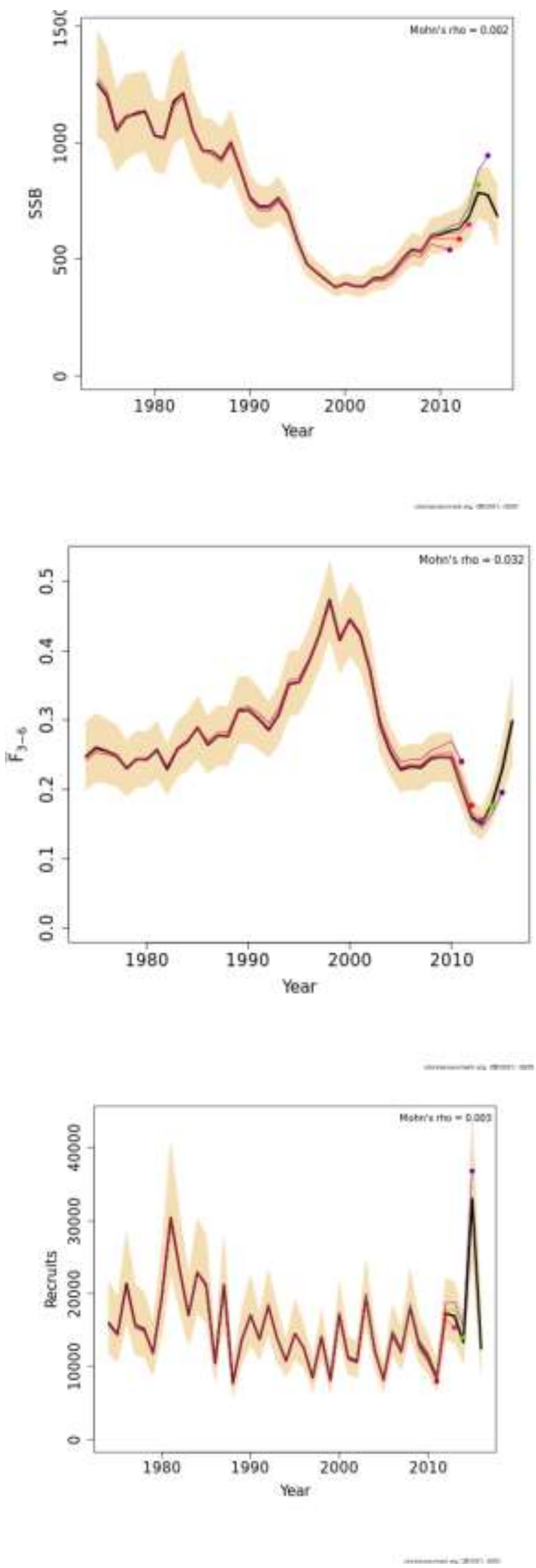


Figure 4.2.12. Herring in SD 25–29, 32 (excl. GoR). Retrospective of SAM.

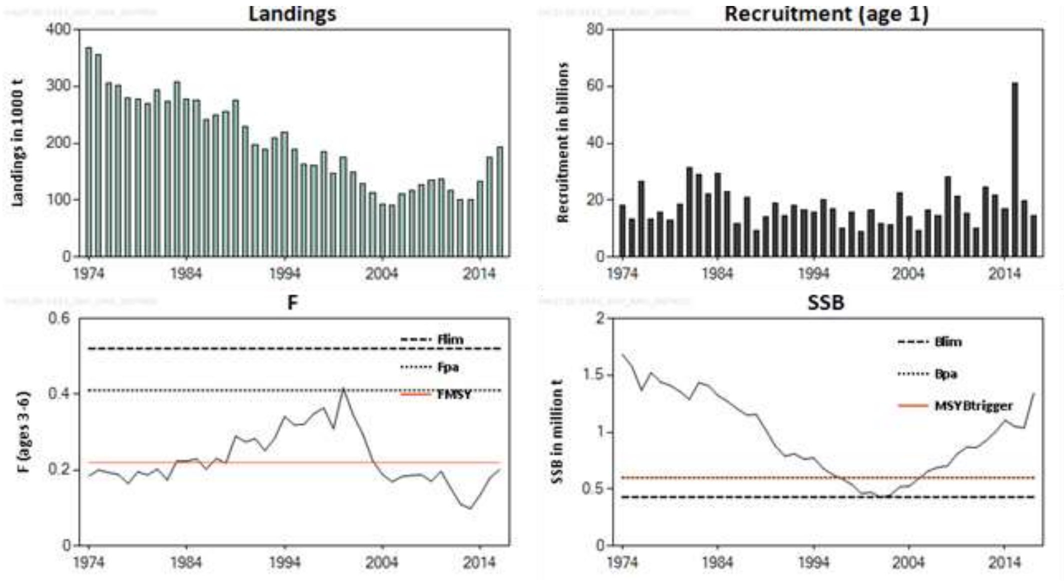


Figure 4.2.13. Herring in SD 25–29, 32 (excl. GoR). Summary sheet plots: Catches, fishing mortality, recruitment (age 1) and SSB. (Recruitment in 2016 from RCT3 & SSB in 2016 predicted)

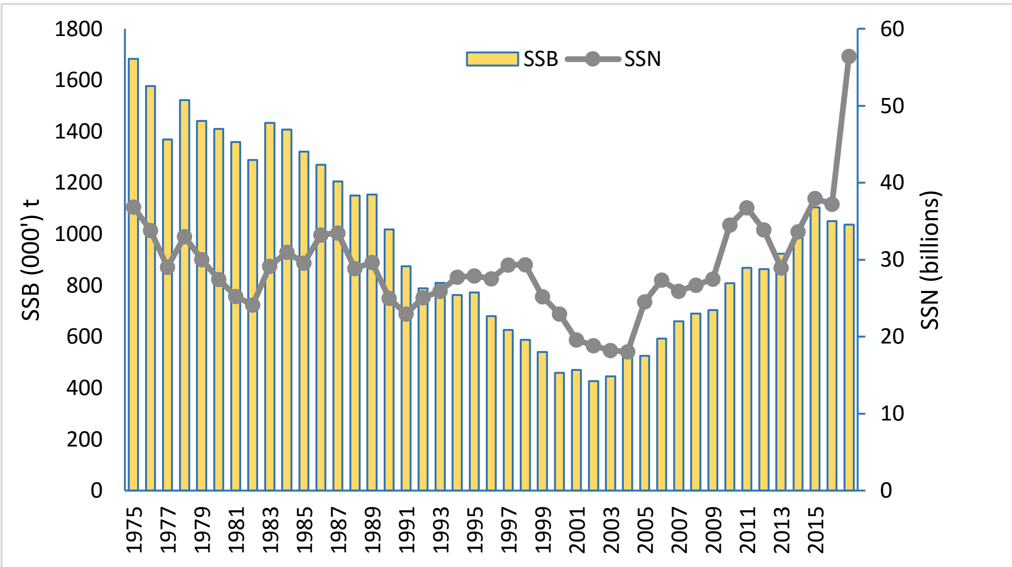


Figure 4.2.14. Herring in SD 25–29, 32 (excl. GoR). SSB (000' t) and Spawning Stock in Numbers (SSN) (billions).

4.3 Gulf of Riga herring (Subdivision 28.1) (update assessment)

Gulf of Riga herring is a separate population of Baltic herring (Clupea harengus membras) that is met in the Gulf of Riga (ICES Subdivision 28.1). It is a slow-growing herring with one of the smallest length and weight at age in the Baltic and thus differs considerably from the neighbouring herring stock in the Baltic Proper (Subdivisions 25–28.2, 29 and 32) (ICES, 2001; Kornilovs, 1994). The differences in otolith structure serve as a basis for discrimination of Baltic herring populations (ICES, 2005, Ojaveer et al. 1981, Raid et al. 2005). When fishes are aged they are also assigned their population belonging, The stock does not migrate into the Baltic Proper; only minor part of the older herring leaves the gulf after spawning season in summer –autumn period but afterwards returns to the gulf. There is evidence, that the migrating fishes mainly stay close to the Irbe Strait region in Subdivision 28.2 and do not perform longer trips. The extent of this migration depends on the stock size and the feeding conditions in the Gulf of Riga. In 1970s and 1980s when the stock was on a low level the amount of migrating fishes was considered negligible. In the beginning of 1990s when the stock size increased also the number of migrating fishes increased and the catches of Gulf of Riga herring outside the Gulf of Riga in Subdivision 28.2 were taken into account in the assessments.

4.3.1 The Fishery

Herring fishery in the Gulf of Riga is performed by Estonia and Latvia, using both trawls and trap-nets. Herring catches in the Gulf of Riga include the local Gulf herring and the open-sea herring, entering the Gulf of Riga for spawning. Discrimination between the two stocks is based on the different otolith structure due to different feeding conditions and growth of herring in the Gulf of Riga and the Baltic Proper (ICES, 2005). The Latvian fleet also takes gulf herring outside the Gulf of Riga in Subdivision 28.2. In 2016 these catches were 289 t, while the average catches in the last five years were 237 t. These catches are included in the total Gulf herring landings (Table 4.3.1b) and CATON (Table 4.3.4).

4.3.1.1 Catch trends in the area and in the stock

The catches have shown a sharp increase in the 1990s after being at a record low level during the 1980s. After the considerable decrease of catches in 1998 as a result of the decline in market conditions, the total catches of herring in the Gulf of Riga have gradually increased till 44 694 t in 2003. In 2005 the total herring landings decreased to 33 915 t and since then have been rather stable following the changes of TAC which is usually almost fully utilised. In 2015 the catches considerably increased to 37 503 t being the highest in the last 11 years. In 2016 the total catches of herring in the Gulf of Riga were 34 892 t (Table 4.3.1a).

The landings of the Gulf of Riga herring stock showed similar pattern as the total caches of herring in the Gulf of Riga. They were the highest in the beginning of 2000s and then gradually decreased. In 2015 and 2016 the catches of the Gulf of Riga herring stock were 32 851 t and 30 865 t respectively.

The landings of open-sea herring in the Gulf of Riga were 4 315 t in 2016 (Table 4.3.1b). The average catch of open-sea herring in the last five years was 4 344 t.

The trap-net catches of Gulf herring were 10 342 t in 2016 being 1 038 t higher than in 2015. The fishing effort in trap-net fishery remained the same as in 2015. The trap-net catches comprised 29.6% of the total catches of herring in 2016.

4.3.1.2 Unallocated landings

According to the information (interviews) on the level of misreporting in the commercial fishery, since 1993 till 2010 unallocated landings were added to the official landings. In the recent years it was stated that the level of misreporting is gradually decreasing due to scrapping of the fishing vessels. Thus since in Latvia the trawl fishing fleet has decreased almost three times, it is considered that the fishing capacities now are more or less balanced with the fishing possibilities and no unallocated landings were assumed in 2011–2016. The level of misreporting in Estonian herring fishery has been low in 1995–2016 and therefore the official catch figures were used in the assessment.

4.3.1.3 Discards

The discards of herring in the Gulf of Riga are assumed very rare and have not been recorded by observers working on the fishing vessels.

4.3.1.4 Effort and CPUE data

The number of trap-nets used in herring fishery increased up to 2001 and slightly decreased since then, however in 2005 the decrease was more substantial especially in the Estonian coastal fishery. In 2016 the number of trap-nets remained as the same level as in the previous year (Table 4.3.8). Until the beginning of 2000 the trawl fishery has been permanently performed by 70 Latvian and 5–10 Estonian vessels with 150–300 HP engines. A considerable increase (more than 270%) in trawl catches of gulf herring was observed in Estonia in 2002–2003 and remained the same in 2004 but was substantially reduced in 2005–2015. In Latvia the number of trawl fleet vessels is gradually decreasing due to scrapping and there were 24 active vessels in 2016. A number of protection measures have been implemented by the authorities in management of the Gulf of Riga herring fishery. The maximum number and engine power of trawl vessels operating in the Gulf of Riga are limited. Additionally, the summer ban (from mid- June to September) in the Estonian part of the gulf and the 30-day ban for trawl fishery during the main spawning migrations of herring (April–May) in both Latvia and Estonia are implemented in the Gulf of Riga. No historical time-series of CPUE data are available.

4.3.2 Biological information

4.3.2.1 Catch in numbers

The quarterly catches of Gulf herring from Estonian and Latvian trawl and trap-net fishery were compiled to get the annual catch in numbers (Table 4.3.3, Figure 4.3.1). The available catch at age data are for ages 1–8+. In XSA ages 1–8+ and in tuning fleets ages 1–8 are used.

4.3.2.2 Mean weight-at-age

The annual mean weights by age groups used for assessment were compiled from quarterly data on the trap-net and trawl fishery of Estonia and Latvia (Table 4.3.6, Figure 4.3.3.). The mean weights-at-age in the stock were assumed to be equal to the mean weights in catches because it was not possible to obtain the historical mean weight-at-age at the spawning time. Besides since the gears used in the herring fishery are not selective the weight in the catch should correspond to the weight in the stock.

A decreasing trend in mean weight-at-age of Gulf of Riga herring was observed since the mid–1980s. Since 1998 the mean weight-at-age has started to increase and in 2000 was at the level of the beginning of the 1990s, but was still considerably lower than in the 1980s. Since 2000 the mean weight-at-age was fluctuating without clear trend and probably depended on feeding conditions in the specific year. Thus the most unfavourable feeding conditions in 2003 resulted in a decrease of mean weight-at-age for most of the age groups. Particularly low weight was recorded for 1-year-old herring (abundant year-class of 2002), that was the lowest on record. In 2009 the mean weight-at-age decreased in the most of the age groups in comparison with the previous year and stayed low also in 2010. In 2011-2013 the feeding conditions in the Gulf of Riga were favourable for herring and the mean weight-at-age increased in all age groups while the average Fulton's condition factor of herring in autumn of 2011 was the highest in the last 20 years (Putnis et al., 2011). In 2016 the mean weight-at age decreased in age groups 4+ in comparison with the previous year (Figure 4.3.3.).

4.3.2.3 Maturity at age

As no special surveys on herring maturity are performed in the Gulf of Riga it was decided to use the same maturity ogives as in previous years (Table 4.3.5).

4.3.2.4 Natural mortality

Since the cod stock has remained at a low level in the Gulf of Riga, the natural mortality was taken to be the same as that used in the previous years - 0.2 (Table 4.3.7). Constant natural mortality M=0.20 is used for all the years except for the period 1979–1983 when a value of M=0.25 is used due to presence of cod in the Gulf of Riga.

4.3.2.5 Quality of catch and biological data

The sampling of biological data from commercial trawl and trap-net catches was performed by Estonia and Latvia on monthly basis (from trap-nets on weekly basis). The sampling intensity of both countries is described in Table 4.3.2. The check of consistency of catch-at-age data is shown in Figure 4.3.2. In 2016 the sample number per 1000 t was as follows: in Estonia 2.6 samples and in Latvia 2.9 samples.

4.3.3 Fishery independent information

Two tuning fleets were available: from trap-net fishery (1996-present) and from joint Estonian-Latvian hydro-acoustic survey in the Gulf of Riga which has been carried out in the end of July-beginning of August since 1999. The tuning data are given in Tables 4.3.8-4.3.9. The check of internal consistency of tuning data is shown in Figures 4.3.4 and 4.3.5.

In trap-net fleet (Figure 4.3.4) the correlation was high and in 2016 was similar to the previous year. In acoustic fleet the correlation did not changed much in comparison with the previous year. In some age groups it slightly improved while in other it became slightly worse (Figure 4.3.5.).

4.3.4 Assessment

4.3.4.1 Recruitment estimates

The historical dynamics of the recruitment (age 1) reveal a trend rather similar to that of the spawning stock biomass. The recruitment fluctuated between 500–3000 millions in the 1970s and 1980s mainly having the values at the lower end. In the 1990s the reproduction of Gulf of Riga herring improved and recruitment had values above long-term average in most of the years (Table 4.3.13). In 2000s three record high year classes appeared reaching values over 6000 millions at age 1 in the beginning of the year.

Till 2011 the values of mean water temperature of 0–20 m water layer and the biomass of Eurytemora affinis in May (factors which significantly influence the year class strength of Gulf herring, ICES 1995/J:10) were regressed to the 1-group from the XSA using the RCT3 program. It was considered that year-class strength of the Gulf of Riga herring was strongly influenced by the severity of winter, which determines the water temperature, and abundance of zooplankton in spring. The higher water temperature in spring favours a longer spawning period and more even distribution of herring spawning activity. After mild winters the abundance of zooplankton is higher thus ensuring better conditions for the feeding of herring larvae. However, it was found in the previous years that RCT3 poorly predicts the rich year classes. In 2011 the analysis of factors determining year-class strength was performed and a paper at ICES Annual science conference in Gdansk was presented (Putnis et al., 2011). Two additional significant relationships were found for the herring year-class strength. It was shown that since 2000 the year-class strength strongly depend on the feeding conditions during the feeding season of the adult (1+) herring. The feeding conditions were characterised as the average Fulton's condition factor for ages 2–5. In 2012 RCT3 analysis was done for the prediction of recruitment using the biomass of Eurytemora affinis in May and average Fulton's condition factor. However, this estimate was not accepted due to high variation ratio. In 2012 it was decided to use for the short-term forecast geometric mean of year classes over the period from 1989 corresponding to period of improved reproduction conditions and prevalence of mild winters. The corresponding estimate for this year short-term forecast is 3003.880 millions of age group 1 in the beginning of 2017, which is the geometric mean value for 1989–2014 year-classes. The same value for recruitment was used also for year-classes 2018 and 2019.

4.3.4.2 Assessment (update)

The assessment was performed with the same settings in XSA as in the previous year and in accordance with the stock annex. The tuning used in the assessment were the effort in the commercial trap-nets directed at the Gulf herring in the Estonian and Latvian trap-net fishery and the corresponding abundance of Gulf herring in trap-net catches and the data from the hydro-acoustic survey (Tables 4.3.8 and 4.3.9). The catchability was assumed to be independent of stock size for all ages, and the catchability independent of age for age >=5 was selected. The default level of shrinkage (SE=0.5) was used in terminal population estimation. The diagnostics from XSA is presented in Table 4.3.10 and the XSA results are shown in Tables 4.3.11-4.3.13. In general the diagnostics were similar to the last year, but they slightly improved for the acoustic fleet. Log catcability residuals for both fleets are shown in Figure 4.3.6. For acoustic fleet some year effect is seen in 2010–2011. The retrospective analysis is shown in Figure 4.3.7. In comparison with assessment of the previous year this year assessment produced higher SSB estimate (+9.7%) and lower fishing mortality estimate (-11.0%). The recruitment estimate of 2014 year class was 2.9% higher than obtained in 2015 (Table 4.3.11).

4.3.4.3 Historical stock trends

The resulting estimates of the main stock parameters (Table 4.3.13, Figure 4.3.8) show that the spawning stock biomass of the Gulf of Riga herring has been rather stable at the level of 40 000–50 000 t in the 1970s and 1980s. The SSB started to increase in the late 1980s, reaching the record high level of 124 292 t in 1994. The increase of SSB was connected with the regime shift which started in 1989 and manifested itself as a row of mild winters that was very favourable for the reproduction of Gulf of Riga herring.

After mild winters the abundance of zooplankton in spring is usually higher thus ensuring better feeding conditions for herring larvae and evidently higher survival of them. Beginning with 1989, most of the year-classes were abundant or above the long-term average and only in few years when the winters were severe (1996, 2003, 2006, 2010, 2013) the recruitment was poor. Afterwards due to rather high fishing mortality SSB decreased and was fluctuating at the level below 100 000 t. In 2005–2006 SSB decreased to the level of 70 000 t that is below the long-term mean, but the SSB has increased since then. The estimate for 2016 is 86 654 t and it has decreased in comparison with previous year. The mean fishing mortality in age groups 3–7 has been rather high in 1970s and 1980s fluctuating between 0.35 and 0.71. It has decreased below 0.4 in 1989 and stayed on this level till 1996. Afterwards the fishing mortality increased to levels above 0.4 that is regarded as Fpa. Since 2010 the fishing mortality has decreased below 0.4 and in 2013-2014 even below 0.3 but has significantly increased in 2015 and 2016 being respectively 0.38 and 0.40. It is connected with rather high fishing mortality in older age groups 5-7.

4.3.5 Short-term forecast and management options

The input data and summary of short-time forecast with management options are presented in the Tables 4.3.14 and 4.3.15. For prediction the mean weights-at-age were taken to be equal to the average of the last three years 2014–2016. The exploitation pattern has been taken equal to the average of 2014–2016 and is not scaled to the last year. Since the cod abundance is still at a very low level in the eastern Baltic and absent in the Gulf of Riga, the natural mortality was assumed to remain at the level of 0.2. The abundance of 1 year age group in 2017–2019 (year-classes of 2016, 2017, 2018) were taken to be equal to the geometric mean of year classes over the period 1989–2014. Taking into account that the herring TAC for the Gulf of Riga is usually almost utilised the catch constraint of 26 723 t for the intermediate year was used. The value was obtained from herring TAC in the Gulf of Riga in 2017 minus average catch of central Baltic herring in the Gulf of Riga in 2011-2015. The SSB in 2017 would be 88.6 thousand t (according to the 2016 prediction 82.1 thousand t). In 2018-2019 SSB will slightly increase and will be around 90 thousand t. The catch corresponding to FMSY (0.32) would be 24.9 thousand t in 2018. In 2017 the catches will be dominated by year-classes of 2012 and 2015, both 24%, and in 2018 the year classes of 2015 and 2016 will be the most abundant, respectively 22% and 25%. The SSB in 2018 will be dominated by year classes of 2015 and 2016, both 30%, and in 2019 will be dominated by the younger age groups of 2 and 3 year-old herring (Figure 4.3.9). The share of younger age groups (1-3) in the yield of 2017-2018 will increase, 49% and 59% respectively. The yield-per-recruit summary is presented in Table 4.3.16.

4.3.6 Reference points

The biological reference points were estimated using the PA software (CEFAS, Lowestoft, UK). The results are presented in the Figures 4.3.10. The following values of reference points were obtained. The values in brackets were found in 2016 analysis:

- F0.1=0.25 (0.24)
- Flow=0.05 (0.05)
- Fmed=0.31 (0.30)
- Fhigh=0.72 (0.68)
- Floss =0.30 (0.30)

The Blim value was obtained estimating the stock-recruitment relationship and the knowledge about fisheries and stock development of the Gulf of Riga herring. It was considered that Gulf of Riga herring belongs to the stocks with no evidence that recruitment has been impaired or that a relation exists between stock and recruitment for which Blim=Bloss is applied. The corresponding value is Blim=40 800 t. The Bpa value was obtained from the following equation: Bpa = Blim × exp(σ × 1.645) = Blimx1.4 = 57 100 t.

Flim was then derived from Blim in the following way. R/SSB was calculated at Blim , and the slope of the replacement line at Blim, and then it was inverted to give SSB/R. This SSB/R was used to derive Flim from the curve of SSB/R against F. The obtained value Flim=0.88. The Fpa value was obtained from the equation Flim=Fpa/1.4 and was Fpa=0.63.

Instead of MBAL estimate of 50,000 t used previously the Btrigger value of 60 000 t selected at the Workshop on Multi-annual Management of Pelagic Fish Stocks in the Baltic (ICES, 2009) was used.

4.3.7 Quality of assessment

The catches are estimated on the basis of the national official landing statistics of Latvia and Estonia. The stock is well sampled and the number of measured and aged fish has been historically high (Table 4.3.2.). Since 1993 the total landings of Latvia were increased according to information on misreporting. There was no information on unallocated catches of herring since 2011. Due to scrapping of fishing vessels the fishing fleet in the Gulf of Riga has been considerably reduced and the fishing capacity could be in balance with the fishing possibilities. The number of trap-nets directed at the Gulf herring in the Estonian and Latvian trap-net fishery and the corresponding abundance of Gulf herring in trap-net catches are used for tuning VPA. These data could be very sensitive to changes in market demand and could be affected by fishery regulation. Therefore, the joint Estonian-Latvian hydro-acoustic surveys were started in 1999 to obtain the additional tuning data, which were implemented for the first time in 2004 assessment.

4.3.8 Comparison with the previous assessment

The comparison between main input parameters for assessment and the results of XSA and predictions from 2016 and 2017 are presented in the text table below.

Comparison of XSA settings from assessments performed in 2016 and 2017

Category	Parameter	Assessment 2016	Assessment 2017	Diff.
XSA Setting	Catchability dependent on stock	Independent for all ages	Independent for all ages	No
	Catchability independent of age	>=5	>=5	No
	Survivor estimates shrinkage towards mean F of	Final 5 years, 3 oldest ages	Final 5 years, 3 oldest ages	No
	S.E. of the mean for shrinkage	0.5	0.5	No
Tuning fleet	Trap-nets	1996-2015	1996-2016	No
	Acoustic survey	1999-2015	1999-2016	No

Comparison of SSB and F estimates from assessments performed in 2016 and 2017

Assessment year	Tuning fleet	SSB (2015) (t)	FBAR3-7 (2015)
2016 (update)	Trap-nets+acoustics	93,762	0.4239
2017 (update)	Trap-nets+acoustics	102,850	0.3774
Diff. (+/-)%		+9.7	-11.0%

Comparison of prediction results performed in 2016 and 2017 Parameter	Prediction 2016	Prediction 2017	Actual yield 2016 (t)	Diff. (+/-)%
Yield 2016 (t)	30,515		30,865	+1.1
SSB 2017 (t)	82,052	88,633		+8.0
Yield 2017 (t)	23,078	26,723		+15.8

4.3.9 Management considerations

There are no explicit management objectives for this stock. The International Baltic Sea Fisheries Commission (IBSFC) started to treat Gulf of Riga herring as a separate management unit in 2004 and a separate TAC for the Gulf of Riga was established. Since then the TAC is divided into catch quotas of Estonia and Latvia. Thus the danger of overshooting the ICES advice for the Gulf of Riga herring, that was present when this stock was managed together with herring stock in the Central Baltic, has been reduced. It should be taken into account that some amount of herring from Sub-divisions 25–27, 28.2, 29, 32 is taken in the Gulf of Riga (Subdivision 28.1) and some amount of Gulf of Riga herring is taken in Subdivision 28.2. This is taken into account when setting TAC for the Gulf of Riga herring and herring in Sub-divisions 25–27, 28.2, 29, 32.

4.3.1a Total catches of herring in the Gulf of Riga by nation.

(official landings + unallocated landings '000 t).

Year	Estonia	Latvia	Unallocated landings	Total
1991	7.420	13.481	-	20.901
1992	9.742	14.204	-	23.946
1993	9.537	13.554	3.446	26.537
1994	9.636	14.05	3.512	27.198
1995	16.008	17.016	3.401	36.425
1996	11.788	17.362	3.473	32.623
1997	15.819	21.116	4.223	41.158
1998	11.313	16.125	3.225	30.663
1999	10.245	20.511	3.077	33.833
2000	12.514	21.624	3.244	37.382
2001	14.311	22.775	3.416	40.502
2002	16.962	22.441	3.366	42.769
2003	19.647	21.78	3.267	44.694
2004	18.218	20.903	3.136	42.257
2005	11.213	19.741	2.961	33.915
2006	11.924	19.186	2.878	33.988
2007	12.764	19.425	2.914	35.103
2008	15.877	19.290	1.929	37.096
2009	17.167	18.323	1.832	37.322
2010	15.422	17.751	1.775	34.948
2011	14.721	20.203	-	35.024
2012	13.789	17.944	-	31.733
2013	11.898	18.462	-	30.360
2014	10.561	20.065	-	30.626
2015	16.501	21.002	-	37.503
2016	15.814	19.078	-	34.892

Table 4.3.1b Herring caught in the Gulf of Riga and

Gulf of Riga herring catches in the Central Baltic ('000 t) .

Year	Catches in the Gulf of Riga			Gulf of Riga herring catches	
	Gulf of Riga herring	Central Baltic herring	Total	In the Central Baltic	Total
1977	24.2	2.4	26.6	-	24.2
1978	16.7	6.3	23	-	16.7
1979	17.1	4.7	21.8	-	17.1
1980	15.0	5.7	20.7	-	15
1981	16.8	5.9	22.7	-	16.8
1982	12.8	4.7	17.5	-	12.8
1983	15.5	4.8	20.3	-	15.5
1984	15.8	3.8	19.6	-	15.8
1985	15.6	4.6	20.2	-	15.6
1986	16.9	1.3	18.2	-	16.9
1987	12.9	4.8	17.7	-	12.9
1988	16.8	3.0	19.8	-	16.8
1989	16.8	5.9	22.7	-	16.8
1990	14.8	6.0	20.8	-	14.8
1991	14.8	6.1	20.9	-	14.8
1992	20.5	3.5	23.9	1.3	21.8
1993	22.2	4.3	26.5	1.2	23.4
1994	22.2	5.0	27.2	2.1	24.3
1995	30.3	6.1	36.4	2.4	32.7
1996	28.2	4.4	32.6	4.3	32.5
1997	36.9	4.3	41.2	2.9	39.8
1998	26.6	4.1	30.7	2.8	29.4
1999	29.5	4.3	33.8	1.9	31.4
2000	32.8	4.6	37.4	1.9	34.7
2001	37.6	2.9	40.5	1.2	38.8
2002	39.2	3.5	42.8	0.4	39.7
2003	40.4	4.3	44.7	0.4	40.8
2004	38.9	3.3	42.3	0.2	39.1
2005	31.7	2.3	33.9	0.5	32.2
2006	30.8	3.2	34.0	0.4	31.2
2007	33.6	1.5	35.1	0.1	33.7
2008	31.0	6.1	37.1	0.1	31.1
2009	32.4	4.9	37.3	0.1	32.6
2010	29.7	5.2	34.9	0.4	30.2
2011	29.6	5.5	35.0	0.1	29.7
2012	27.9	3.8	31.7	0.2	28.1
2013	26.3	4.1	30.4	0.3	26.6
2014	26.1	4.5	30.6	0.2	26.3
2015	32.5	5.0	37.5	0.3	32.8
2016	30.6	4.3	34.9	0.3	30.9

Table 4.3.2. Sampling of herring landings in the Gulf of Riga in 2016.

Country	Quarter	Landings	Samples	Measured	Aged
Estonia	I	6938	11	1100	1098
	II	8512	18	1650	1245
	III	48	10	293	293
	IV	316	2	199	199
	Total	15814	41	3242	2835
Latvia	I	7433	9	2848	1079
	II	5728	29	3167	2916
	III	2353	7	1300	760
	IV	3564	10	2250	995
	Total	19078	55	9565	5750
Total	I	14371	20	3948	2177
	II	14240	47	4817	4161
	III	2401	17	1593	1053
	IV	3880	12	2449	1194
Grand total	Total	34892	96	12807	8585

Table 4.3.3 Gulf of Riga herring. Catch in numbers 1977-2016 in thousands.

Year	1	2	3	4	5	6	7	8+
1977	69500	885100	141400	109700	35300	15700	16000	600
1978	112000	97300	403900	39200	35900	9300	3200	5700
1979	76700	176500	103800	342500	22100	19300	6800	5500
1980	101000	125900	99600	55400	133100	10500	8600	2500
1981	62500	172500	112000	83000	51400	71700	7400	3500
1982	80000	96000	116900	68800	43000	29900	24500	3300
1983	49700	225300	138300	77700	38900	23300	15500	9600
1984	44000	152100	255100	96300	56700	32500	14700	11900
1985	23200	283900	203900	121700	31800	23700	8000	6100
1986	9200	106700	246900	110600	66500	19600	8000	5800
1987	70000	49000	110000	205000	75000	32000	5000	2000
1988	6000	197700	112700	112400	144600	38700	27800	5900
1989	61100	47400	492700	143000	76300	53900	6500	5400
1990	88100	83100	67100	263500	66800	27600	14600	4100
1991	119500	234000	94500	40800	180500	40500	35400	40800
1992	150300	339100	369300	91300	33200	157400	19000	47600
1993	192200	381400	298100	224400	66800	19000	78800	26900
1994	164230	288440	368870	263500	192700	46080	9410	56150
1995	232400	316900	363000	426900	277200	170900	39300	51500
1996	428800	450100	281400	247600	291000	183800	105600	57000
1997	204200	930700	559700	345400	242800	186700	90600	61100
1998	239360	282060	505410	274890	172470	114020	90230	67650
1999	361890	446500	157050	316480	157200	83650	60670	81050
2000	259030	552300	359430	123730	258070	83980	35120	53370
2001	819480	461570	378160	261040	81170	120980	56040	70710
2002	304160	1182680	360540	202120	118950	36310	48060	44940
2003	596730	396180	922840	231180	107440	70510	19990	58640
2004	166760	1342020	306210	505770	129160	64390	33200	62270
2005	383307	197546	873585	171434	186054	50952	27898	28826
2006	787870	600120	113610	467380	100900	70420	16470	20010
2007	305070	1145970	441270	83890	303940	59690	33710	24170
2008	599430	340150	707460	166050	21870	112520	11600	26250
2009	284970	787100	206390	505640	109220	20860	101490	29430
2010	469190	407890	515480	109990	275720	55630	7760	75000
2011	94610	346460	325910	398850	86030	168030	35030	44130
2012	458920	123970	276010	196090	245430	39330	90650	33980
2013	435220	596630	95600	143650	86850	128500	21350	57920
2014	76960	553760	443440	68530	115750	62060	80660	58830
2015	277380	141080	575230	394950	68160	82500	63190	117450
2016	467310	287890	110350	427240	291430	43770	50850	94760

Table 4.3.4 **Gulf of Riga herring. Catch in tons. (CATON).**

Year	Catch
1977	24,186
1978	16,728
1979	17,142
1980	14,998
1981	16,769
1982	12,777
1983	15,541
1984	15,843
1985	15,575
1986	16,927
1987	12,884
1988	16,791
1989	16,783
1990	14,931
1991	14,791
1992	20,000
1993	22,200
1994	24,300
1995	32,656
1996	32,584
1997	39,843
1998	29,443
1999	31,403
2000	34,069
2001	38,785
2002	39,701
2003	40,803
2004	39,115
2005	32,225
2006	31,232
2007	33,742
2008	31,139
2009	33,376
2010	30,174
2011	29,443
2012	28,115
2013	26,511
2014	26,253
2015	32,535
2016	30,865

Table 4.3.5 **Gulf of Riga herring. Proportion of mature at year start in 1977-2016.**

Period	1	2	3	4	5	6	7	8+
1977-2016	0	0.93	0.98	0.98	1	1	1	1

Table 4.3.6 Gulf of Riga herring. Weights in catch and stock in 1977-2016, kg.

Year	Age 1	2	3	4	5	6	7	8+
1977	0.0132	0.0160	0.0227	0.0269	0.0295	0.0312	0.0294	0.0508
1978	0.0098	0.0177	0.0219	0.0273	0.0311	0.0304	0.0381	0.0504
1979	0.0122	0.0162	0.0234	0.0276	0.0298	0.0340	0.0368	0.036
1980	0.0145	0.0201	0.0241	0.0321	0.0393	0.0456	0.0533	0.0711
1981	0.0121	0.0216	0.0288	0.0334	0.0390	0.0439	0.0499	0.0595
1982	0.0141	0.0214	0.0287	0.0357	0.0372	0.0451	0.0503	0.06837
1983	0.0138	0.0193	0.0276	0.0379	0.0416	0.0509	0.0610	0.0913
1984	0.0100	0.0150	0.0215	0.0281	0.0343	0.0391	0.0491	0.0559
1985	0.0129	0.0172	0.0208	0.0278	0.0358	0.0487	0.0531	0.0665
1986	0.0126	0.0198	0.0256	0.0314	0.0402	0.0462	0.0639	0.0709
1987	0.0101	0.0154	0.0197	0.0263	0.0303	0.0379	0.0431	0.0905
1988	0.0117	0.0186	0.0210	0.0273	0.0368	0.0434	0.0586	0.075
1989	0.0120	0.0148	0.0166	0.0196	0.0230	0.0315	0.0382	0.0364
1990	0.0146	0.0178	0.0198	0.0269	0.0306	0.0331	0.0522	0.0554
1991	0.0119	0.0154	0.0178	0.0199	0.0214	0.0225	0.0269	0.0336
1992	0.0112	0.0136	0.0177	0.0215	0.0236	0.0250	0.0264	0.0359
1993	0.0125	0.0136	0.0161	0.0201	0.0247	0.0263	0.0275	0.0352
1994	0.0112	0.0146	0.0162	0.0188	0.0215	0.0252	0.0263	0.03
1995	0.0104	0.0136	0.0164	0.0179	0.0209	0.0229	0.0263	0.0291
1996	0.0105	0.0125	0.0157	0.0177	0.0189	0.0215	0.0235	0.028
1997	0.0097	0.0124	0.0149	0.0178	0.0191	0.0196	0.0212	0.0242
1998	0.0101	0.0133	0.0169	0.0182	0.0203	0.0213	0.0225	0.024
1999	0.0131	0.0155	0.0189	0.0221	0.0231	0.0245	0.0265	0.0289
2000	0.0125	0.0165	0.0201	0.0229	0.0254	0.0264	0.0282	0.0296
2001	0.0102	0.0160	0.0205	0.0230	0.0245	0.0277	0.0283	0.0307
2002	0.0100	0.0153	0.0193	0.0236	0.0250	0.0271	0.0280	0.0309
2003	0.0075	0.0153	0.0199	0.0223	0.0248	0.0263	0.0268	0.0276
2004	0.0086	0.0101	0.0165	0.0210	0.0242	0.0268	0.0271	0.0331
2005	0.0120	0.0142	0.0159	0.0204	0.0244	0.0260	0.0298	0.0308
2006	0.0086	0.0132	0.0178	0.0191	0.0228	0.0266	0.0275	0.0296
2007	0.0089	0.0117	0.0154	0.0202	0.0196	0.0237	0.0271	0.0278
2008	0.0098	0.0148	0.0173	0.0204	0.0238	0.0233	0.0286	0.0327
2009	0.0092	0.0140	0.0176	0.0191	0.0218	0.0207	0.0244	0.0294
2010	0.0091	0.0138	0.0169	0.0194	0.0209	0.0237	0.0231	0.026
2011	0.0118	0.0153	0.0184	0.0211	0.023	0.0255	0.0262	0.0324
2012	0.0094	0.0159	0.0203	0.0232	0.0258	0.0277	0.0299	0.0334
2013	0.0097	0.0146	0.0197	0.0227	0.0257	0.0282	0.0295	0.0319
2014	0.0098	0.0138	0.0176	0.0216	0.0236	0.0253	0.0271	0.0302
2015	0.0089	0.0150	0.0182	0.0211	0.0230	0.0252	0.0272	0.0295
2016	0.0086	0.0152	0.0181	0.0204	0.0223	0.0239	0.0260	0.0283

Table 4.3.7 Gulf of Riga herring. Natural mortality.

Year	Age 1	2	3	4	5	6	7	8	9+
1977-1978	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
1979	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1980	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1981	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1982	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1983	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1984-2016	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Table 4.3.8 Gulf of Riga herring. Tuning fleet: trap-nets (effort number of trap-nets).

Year	Effort	Age2	Age3	Age4	Age5	Age6	Age7	Age8*
1996	94.0	84.40	87.40	88.80	95.60	67.90	33.40	8.70
1997	101.0	115.50	115.70	85.10	68.20	46.70	18.80	12.40
1998	70.0	65.38	122.80	65.70	36.40	20.80	20.20	6.60
1999	78.0	34.56	21.36	101.42	51.14	25.81	18.47	18.49
2000	84.0	91.12	89.00	27.79	114.19	31.05	5.96	5.12
2001	100.0	124.13	149.34	118.20	37.23	59.59	27.53	10.40
2002	90.0	207.06	107.78	61.26	39.47	8.93	12.12	6.11
2003	86.0	77.79	265.91	72.98	23.36	25.15	3.17	6.07
2004	68.0	109.49	79.51	114.20	29.77	15.85	7.43	1.68
2005	51.0	23.01	162.65	31.30	51.30	13.68	6.04	4.31
2006	49.0	81.76	27.33	101.11	34.88	23.22	6.76	3.77
2007	57.0	126.63	108.24	24.53	91.65	16.98	9.91	2.59
2008	50.0	64.97	179.19	48.29	7.15	37.46	1.92	6.85
2009	60.0	159.17	45.13	165.51	40.41	7.13	35.53	4.37
2010	45.0	44.1	98.18	21.26	67.95	15.61	2.1	13.44
2011	45.0	40.8	62.4	96.73	15.04	44.65	7.68	3.3
2012	43.0	19.42	49.24	47.99	54.99	7.76	21.69	3.78
2013	45.0	107.13	26.36	37.23	26.01	35.77	4.71	11.23
2014	45.0	148.61	119.84	17.15	22.46	8.66	15.28	1.82
2015	43.0	15.96	128.17	76.97	9.93	11.83	8.64	19.22
2016	43.0	50.18	25.23	117.5	92.86	10.77	12.14	6.08

Table 4.3.9 Gulf of Riga herring. Tuning fleet: Hydroacoustic survey.

Year	Effort	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8*
1999	1	5292	4363	1343	1165	457	319	208	61
2000	1	4486	4012	1791	609	682	336	151	147
2001	1	7567	2004	1447	767	206	296	58	66
2002	1	3998	5994	1068	526	221	87	165	34
2003	1	12441	1621	2251	411	263	269	46	137
2004	1	3177	10694	675	1352	218	195	84	25
2005	1	8190	1564	4532	337	691	92	75	62
2006	1	12082	1986	213	937	112	223	36	33
2007	1	1478	3662	1265	143	968	116	103	24
2008	1	9231	2109	4398	816	134	353	16	23
2009	1	6422	4703	870	1713	284	28	223	10
2010	1	5353	2432	1813	256	618	111	13	50
2011	1	3162	5289	2503	2949	597	865	163	58
2012	1	5957	758	1537	774	1035	374	308	134
2013	1	9435	5552	592	1240	479	827	187	318
2014	1	1109	3832	2237	276	570	443	466	46
2015	1	3221	539	1899	1110	255	346	181	197
2016	1	4542	1081	504	1375	690	152	113	40

* Age 8 is true age group

Table 4.3.10 Gulf of Riga herring. XSA diagnostics. 1/4

```
Lowestoft VPA Version 3.1
 10/04/2017  10:17
 Extended Survivors Analysis
 Herring Gulf of Riga
 CPUE data from file c:\dati\vpa\herg\fleet1.txt
 Catch data for 40 years. 1977 to 2016. Ages 1 to 8
 Fleet        First  Last  First  Last  Alpha   Beta
              Year   year  age    age
 Trap-nets    1996   2016   2      7    0.330   0.580
 Acoustics        1999   2016   1      7    0.550   0.600

 Time series weights :
    Tapered time weighting applied
    Power = 3 over 20 years
 Catchability analysis:
    Catchability independent of stock size for all ages
    Catchability independent of age for ages >=5
 Terminal population estimation:
    Survivor estimates shrunk towards the mean F
    of the final 5 years or the 3 oldest ages.
    S.E. of the mean to which the estimates are shrunk =0.500
    Minimum standard error for population estimates derived from each
    fleet =0.300
    Prior weighting not applied
 Tuning converged after   32 iterations

 Regression weights
  0.751, 0.820, 0.877, 0.921, 0.954, 0.976, 0.990, 0.997, 1.000, 1.000

 Fishing mortalities
 Age  2007   2008   2009   2010   2011   2012   2013   2014   2015   2016
  1   0.186  0.131  0.116  0.206  0.101  0.110  0.096  0.097  0.154 0.158
  2   0.298  0.325  0.246  0.253  0.231  0.186  0.204  0.170  0.258 0.237
  3   0.480  0.304  0.324  0.261  0.330  0.291  0.214  0.230  0.268 0.331
  4   0.595  0.333  0.361  0.296  0.331  0.339  0.242  0.235  0.330 0.327
  5   0.435  0.300  0.375  0.351  0.399  0.350  0.246  0.314  0.388 0.435
  6   0.949  0.283  0.510  0.339  0.376  0.320  0.312  0.279  0.388 0.466
  7   0.420  0.471  0.439  0.368  0.372  0.358  0.288  0.329  0.512 0.441

XSA population numbers (Thousands)
                                 AGE
 YEAR     1        2        3        4        5        6        7
 2007  1.99E+06 4.91E+06 1.28E+06 2.07E+05 9.52E+05 1.08E+05  1.09E+05
 2008  5.39E+06 1.35E+06 2.98E+06 6.47E+05 9.33E+04 5.04E+05  3.41E+04
 2009  2.76E+06 3.87E+06 8.01E+05 1.80E+06 3.80E+05 5.66E+04  3.11E+05
 2010  2.79E+06 2.02E+06 2.48E+06 4.74E+05 1.03E+06 2.14E+05  2.78E+04
 2011  1.09E+06 1.86E+06 1.28E+06 1.56E+06 2.89E+05 5.93E+05  1.25E+05
 2012  4.87E+06 8.06E+05 1.21E+06 7.54E+05 9.19E+05 1.59E+05  3.33E+05
 2013  5.26E+06 3.57E+06 5.47E+05 7.38E+05 4.40E+05 5.30E+05  9.43E+04
 2014  9.22E+05 3.91E+06 2.39E+06 3.62E+05 4.74E+05 2.81E+05  3.18E+05
 2015  2.15E+06 6.85E+05 2.70E+06 1.55E+06 2.34E+05 2.84E+05  1.74E+05
 2016  3.54E+06 1.51E+06 4.33E+05 1.69E+06 9.13E+05 1.30E+05  1.58E+05

Estimated population abundance at 1st Jan 2017
0.00E+00, 2.48E+06, 9.75E+05, 2.55E+05, 9.99E+05, 4.84E+05, 6.68E+04,

Taper weighted geometric mean of the VPA populations:
2.80E+06, 1.98E+06, 1.28E+06, 8.19E+05, 4.26E+05, 2.14E+05, 1.16E+05,

Standard error of the weighted Log(VPA populations) :
0.6606, 0.6879, 0.7159, 0.6710, 0.6864, 0.6861, 0.8063,1
```

continued

Table 4.3.10 Gulf of Riga herring. XSA diagnostics. 2/4

Log catchability residuals.

Fleet : Trap-nets

Age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	No data for this fleet at this age									
2	-0.56	0.35	-1.03	-0.10	0.07	-0.01	-0.04	-0.64	0.14	0.24
3	-0.48	-0.22	-0.99	-0.28	0.18	0.02	0.24	0.17	-0.03	0.31
4	-0.31	-0.24	-0.16	-0.42	0.28	-0.08	0.10	0.26	0.00	-0.08
5	-0.39	-0.18	-0.12	0.42	0.25	-0.09	-0.53	0.09	0.46	0.77
6	-0.49	-0.54	0.13	-0.07	0.38	-0.26	0.16	0.03	0.42	0.44
7	-0.65	-0.28	-0.11	-0.67	0.32	-0.30	-0.52	-0.01	0.10	0.44

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	No data for this fleet at this age									
2	-0.29	0.48	0.10	-0.23	-0.24	-0.12	0.06	0.28	-0.12	0.22
3	0.35	0.06	-0.18	-0.27	-0.03	-0.18	-0.10	-0.05	-0.04	0.19
4	0.55	0.10	0.14	-0.32	0.02	0.09	-0.23	-0.29	-0.16	0.18
5	0.14	-0.02	0.16	-0.04	-0.26	-0.09	-0.20	-0.39	-0.42	0.47
6	0.86	-0.06	0.39	0.05	0.10	-0.31	-0.04	-0.84	-0.44	0.28
7	0.08	-0.25	0.26	0.10	-0.10	-0.01	-0.35	-0.37	-0.21	0.20

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	2	3	4	5	6	7
Mean Log q	-14.0960	-13.4615	-13.2723	-13.1410	-13.1410	-13.1410
S.E(Log q)	0.2756	0.2014	0.2388	0.3518	0.4320	0.2707

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	1.05	-0.363	14.08	0.85	20	0.30	-14.10
3	1.08	-0.891	13.41	0.92	20	0.22	-13.46
4	1.00	-0.034	13.27	0.89	20	0.25	-13.27
5	0.93	0.499	13.13	0.82	20	0.34	-13.14
6	1.35	-1.432	13.40	0.63	20	0.56	-13.11
7	1.00	-0.037	13.20	0.90	20	0.28	-13.19

Fleet: Acoustics

Age	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0.10	0.01	-0.28	0.07	0.04	0.66	0.45	0.05	-0.78
2	0.58	0.54	-0.12	0.22	-0.12	0.58	0.72	-0.25	-0.46
3	0.67	0.32	0.24	-0.07	0.02	-0.30	0.39	-0.58	0.03
4	0.10	0.56	0.24	-0.02	-0.24	0.45	-0.21	-0.50	-0.15
5	-0.07	0.16	0.10	-0.41	-0.14	-0.16	0.52	-0.64	0.05
6	0.53	0.25	0.12	-0.02	0.51	0.28	-0.22	0.10	0.40
7	0.18	0.52	-0.80	0.27	0.14	0.24	0.07	-0.50	-0.03

Age	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.02	0.32	0.18	0.53	-0.33	0.05	-0.35	-0.10	-0.25
2	0.29	0.00	-0.01	0.84	-0.29	0.22	-0.26	-0.43	-0.54
3	0.33	0.03	-0.40	0.62	0.17	-0.03	-0.17	-0.43	0.11
4	0.29	0.03	-0.57	0.70	0.09	0.53	-0.26	-0.27	-0.15
5	0.31	-0.29	-0.53	0.74	0.10	0.01	0.14	0.09	-0.25
6	-0.41	-0.63	-0.68	0.38	0.82	0.41	0.40	0.20	0.21
7	-0.71	-0.30	-0.77	0.26	-0.09	0.63	0.35	0.11	-0.30

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	1	2	3	4	5	6	7
Mean Log q	-6.1999	-6.4531	-6.5575	-6.6646	-6.5735	-6.5735	-6.5735
S.E(Log q)	0.3688	0.4415	0.3392	0.3889	0.3731	0.4689	0.4367

Regression statistics:

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	1.08	-0.426	5.51	0.74	18	0.41	-6.20
2	0.96	0.207	6.78	0.73	18	0.44	-6.45
3	0.98	0.161	6.73	0.82	18	0.35	-6.56
4	0.90	0.648	7.39	0.79	18	0.36	-6.66
5	1.20	-1.010	5.31	0.72	18	0.45	-6.57
6	0.87	0.760	7.22	0.77	18	0.40	-6.45
7	0.81	1.513	7.58	0.87	18	0.33	-6.64

continued

Table 4.3.10 Gulf of Riga herring. XSA diagnostics. 3/4

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Terminal year survivor and F summaries :
Age 1 Catchability constant w.r.t. time and dependent on age

 Year class = 2015

 Fleet            Estimated    Int    Ext    Var    N  Scaled   Estimated
                  Survivors    s.e    s.e    Ratio     Weights     F
 Trap-nets              1.000    0.000  0.000   0.00   0   0.000    0.000
 Acoustics            1922198    0.384  0.000   0.00   1   0.592    0.199
 F shrinkage mean  3571813     0.50                      0.408    0.112

 Weighted prediction:
 Survivors,        Int     Ext    N    Var       F
 at end of year,   s.e     s.e         Ratio
   2475333         0.31    0.40   2    1.296   0.158
Age 2  Catchability constant w.r.t. time and dependent on age
Year class = 2014
Fleet             Estimated   Int   Ext   Var    N    Scaled  Estimated
                  Survivors   s.e   s.e   Ratio       Weights    F
Trap-nets              1216874   0.300  0.000  0.00  1     0.416    0.194
Acoustics               725024   0.295  0.217  0.74  2     0.395    0.307
F shrinkage mean   1109315   0.50                       0.190    0.211
Weighted prediction :
Survivors        Int      Ext    N    Var      F
at end of year   s.e      s.e         Ratio
    974609       0.20     0.16   4    0.825   0.237

Age 3  Catchability constant w.r.t. time and dependent on age
Year class = 2013
Fleet           Estimated    Int    Ext   Var   N  Scaled  Estimated
                Survivors    s.e    s.e   Ratio    Weights    F
Trap-nets             268700     0.214   0.156 0.73  2  0.472    0.316
Acoustics             220239     0.229   0.175 0.76  3  0.394    0.374
F shrinkage mean 324494     0.50                  0.134    0.268
Weighted prediction:
Survivors       Int      Ext    N    Var      F
at end of year  s.e      s.e         Ratio
    254784      0.15     0.10   6    0.692   0.331

Age 4  Catchability constant w.r.t. time and dependent on age
Year class = 2012
Fleet             Estimated   Int    Ext    Var   N  Scaled  Estimated
                  Survivors   s.e    s.e    Ratio    Weights    F
Trap-nets              1141496   0.176  0.090  0.51  3   0.519   0.292
Acoustics               803726   0.202  0.102  0.50  4   0.373   0.393
F shrinkage mean    1116774   0.50                    0.108   0.297
Weighted prediction :
Survivors        Int    Ext    N    Var      F
at end of year   s.e    s.e         Ratio
    999078       0.13   0.08   8    0.639   0.327

Age 5  Catchability constant w.r.t. time and dependent on age
Year class = 2011
Fleet           Estimated    Int    Ext   Var   N  Scaled  Estimated
                Survivors    s.e    s.e   Ratio    Weights    F
Trap-nets           526139      0.163  0.146 0.90  4   0.502   0.406
Acoustics             397339      0.186  0.076 0.41  5   0.383   0.509
F shrinkage mean 647323      0.50                    0.115   0.342
Weighted prediction :
Survivors        Int      Ext    N     Var      F
at end of year   s.e      s.e          Ratio
    483912       0.12     0.09   10    0.721   0.435
```

continued

Table 4.3.10 Gulf of Riga herring. XSA diagnostics. 4/4

```
Age 6 Catchability constant w.r.t. time and age (fixed at the value for age)5
Year class = 2010
Fleet            Estimated    Int     Ext    Var   N   Scaled   Estimated
                 Survivors    s.e     s.e    Ratio     Weights    F
Trap-nets               58140       0.158   0.121  0.77  5    0.491    0.520
Acoustics               70088       0.179   0.109  0.61  6    0.382    0.448
F shrinkage mean  98797       0.50                    0.127    0.337
Weighted prediction:
Survivors,         Int      Ext    N    Var      F
at end of year     s.e      s.e         Ratio
     66798         0.12     0.09   12   o.722   0.466

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age 5
Year class = 2009
Fleet               Estimated    Int    Ext    Var   N Scaled  Estimated
                    Survivors    s.e    s.e    Ratio   weights    F
Trap-nets                  75017      0.153  0.114  0.75  6  0.538    0.478
Acoustics                  94657      0.181  0.130  0.72  7  0.342    0.396
F shrinkage mean      90229      0.50                 0.119    0.412
Weighted prediction:
Survivors        Int      Ext    N    Var      F
at end of year   s.e      s.e         Ratio
     83040       0.12     0.08   14   0.668   0.441
```

Table 4.3.11 Gulf of Riga herring. XSA output: Fishing mortality at age.

Run title : Herring Gulf of Riga
At At 10/04/2017 10:17
Terminal Fs derived using XSA (With F shrinkage)

YEAR	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
AGE										
1	0.0849	0.1222	0.0932	0.1088	0.0812	0.0552	0.046	0.0243	0.0187	0.0091
2	0.4228	0.1644	0.2963	0.2304	0.2904	0.1824	0.2296	0.1988	0.2153	0.1118
3	0.6604	0.3472	0.2727	0.2875	0.351	0.347	0.4624	0.4555	0.4464	0.2947
4	0.618	0.3809	0.5812	0.2419	0.4407	0.403	0.437	0.7187	0.4098	0.4665
5	0.6456	0.4184	0.3965	0.4997	0.3946	0.4595	0.4468	0.6948	0.552	0.4126
6	0.8246	0.3452	0.4304	0.3523	0.5949	0.4485	0.5205	0.8899	0.718	0.8089
7	0.7027	0.384	0.474	0.3678	0.4815	0.4411	0.4727	0.7755	0.5646	0.5674
+gp	0.7027	0.384	0.474	0.3678	0.4815	0.4411	0.4727	0.7755	0.5646	0.5674
FBAR 3- 7	0.6903	0.3751	0.431	0.3498	0.4526	0.4198	0.4679	0.7069	0.5382	0.51

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE										
1	0.0199	0.0119	0.0538	0.0272	0.0366	0.0394	0.0678	0.0679	0.0772	0.1076
2	0.0615	0.0719	0.1228	0.0963	0.0935	0.1382	0.133	0.1377	0.1809	0.2106
3	0.1613	0.1962	0.2574	0.2561	0.1513	0.2095	0.1734	0.184	0.2573	0.2421
4	0.427	0.2465	0.4093	0.2129	0.2444	0.2141	0.1899	0.2286	0.3364	0.2803
5	0.678	0.6141	0.2637	0.3404	0.2213	0.3218	0.24	0.2476	0.4006	0.4048
6	0.3569	0.945	0.4879	0.1431	0.3571	0.3063	0.3083	0.2595	0.3629	0.5091
7	0.4911	0.6071	0.3896	0.2333	0.2758	0.2823	0.2473	0.2465	0.369	0.4008
+gp	0.4911	0.6071	0.3896	0.2333	0.2758	0.2823	0.2473	0.2465	0.369	0.4008
FBAR 3- 7	0.4229	0.5218	0.3616	0.2372	0.25	0.2668	0.2318	0.2332	0.3452	0.3674

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
AGE										
1	0.1544	0.1005	0.1492	0.115	0.1615	0.1609	0.0994	0.2004	0.1449	0.1355
2	0.3583	0.3309	0.2757	0.3566	0.3082	0.3697	0.3253	0.3383	0.3872	0.354
3	0.4402	0.3365	0.3102	0.3741	0.4437	0.4222	0.5555	0.4509	0.3857	0.4037
4	0.5289	0.4031	0.3653	0.4308	0.5149	0.4534	0.53	0.6877	0.4937	0.3676
5	0.4902	0.5536	0.4259	0.5783	0.5646	0.4697	0.466	0.6481	0.5878	0.6141
6	0.496	0.4508	0.5764	0.4253	0.5948	0.5354	0.5692	0.57	0.5786	0.4618
7	0.5103	0.4766	0.4623	0.5105	0.5656	0.5014	0.6466	0.5817	0.5219	0.3702
+gp	0.5103	0.4766	0.4623	0.5105	0.5656	0.5014	0.6466	0.5817	0.5219	0.3702
FBAR 3- 7	0.4931	0.4441	0.428	0.4638	0.5367	0.4764	0.5535	0.5877	0.5135	0.4435

YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	FBAR
AGE											
1	0.1855	0.1311	0.1162	0.2059	0.101	0.1099	0.0959	0.0968	0.1539	0.1577	0.1361
2	0.2982	0.3251	0.2464	0.2532	0.2309	0.1864	0.204	0.1701	0.2583	0.2369	0.2217
3	0.4804	0.3038	0.3239	0.2612	0.3302	0.2914	0.2145	0.23	0.2681	0.3307	0.2763
4	0.5952	0.3333	0.3613	0.296	0.3314	0.339	0.2421	0.235	0.3303	0.3271	0.2975
5	0.4352	0.2997	0.3745	0.3514	0.3992	0.35	0.2463	0.3142	0.3884	0.435	0.3792
6	0.9487	0.2831	0.5104	0.339	0.376	0.3201	0.3119	0.2794	0.3877	0.4656	0.3776
7	0.4203	0.4709	0.4389	0.3685	0.3716	0.3577	0.2879	0.3294	0.5123	0.4409	0.4275
+gp	0.4203	0.4709	0.4389	0.3685	0.3716	0.3577	0.2879	0.3294	0.5123	0.4409	
FBAR 3- 7	0.5759	0.3382	0.4018	0.3232	0.3617	0.3317	0.2606	0.2776	0.3774	0.3998	

Table 4.3.12 Gulf of Riga Herring. XSA output: Stock numbers at age (start of year).

Run title: Herring Gulf of Riga
At 10/04/2017 10:17
Terminal Fs derived using XSA (With F shrinkage)

YEAR	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
AGE											
1	94322	107648	97694	111033	90840	168886	125357	202679	138693	111954	392355
2	283694	70935	78000	69315	77559	65231	124468	93242	161958	111453	90828
3	32331	152182	49273	45171	42872	45180	42330	77053	62578	106912	81595
4	26299	13676	88049	29214	26389	23505	24870	20762	40004	32785	65192
5	8202	11605	7650	38347	17862	13227	12234	12512	8285	21740	16834
6	3090	3521	6253	4007	18119	9375	6507	6095	5113	3906	11782
7	3503	1109	2041	3167	2194	7784	4663	3011	2049	2042	1424
+gp	130	1960	1631	911	1025	1036	2852	2403	1546	1464	564
TOTAL	451569	362636	330591	301165	276861	334224	343281	417757	420225	392255	660574

YEAR	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
AGE											
1	56019	128941	363475	367764	429878	323995	276662	345568	464623	157728	276611
2	314900	45322	100039	289616	290287	338355	247874	211651	261899	341602	110660
3	69930	239929	32818	74386	215945	206984	242511	176843	144611	173698	195467
4	56851	47056	151856	20797	52351	143385	142491	165174	111941	92935	91568
5	34825	36375	25587	100487	13336	34601	97089	92819	96606	69246	44836
6	6996	15428	22878	14905	65939	7914	22284	62054	50912	52763	34724
7	6751	2226	7755	16233	8538	39744	4760	14075	35341	25052	26306
+gp	1416	1835	2166	18593	21255	13489	28242	18302	18918	16725	19535
TOTAL	547689	517113	706573	902782	1097529	1108467	1061913	1086486	1184852	929750	799707

YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE											
1	288547	263537	607175	226183	697117	101490	314097	686923	199132	539304	276442
2	204812	203497	192328	422963	157662	516756	68004	222478	491116	135431	387306
3	65079	127285	116635	115700	239279	93234	301653	37802	127848	298400	80104
4	114303	39072	71689	61275	62104	112403	48627	167927	20670	64745	180296
5	50097	64947	20794	35074	31879	29928	46264	24301	95197	9332	37984
6	21103	26792	29823	9680	17953	16379	12816	21043	10766	50439	5662
7	18113	9709	14336	13470	4640	8319	7584	5883	10857	3413	31115
+gp	23973	14605	17891	12471	13444	18191	7756	7092	7718	7655	8939
TOTAL	786026	749443	1070671	896817	1224078	896702	806803	1173450	963303	1108720	1007848

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	GMST	AMST
AGE										
1	278640	108843	487116	526068	92167	214909	353980	0	224739	276987
2	201512	185677	80552	357292	391327	68496	150854	247533	172531	210463
3	247839	128077	120671	54733	238541	270285	43314	97461	104975	129039
4	47439	156270	75371	73822	36162	155177	169242	25478	58533	73666
5	102849	28887	91854	43965	47443	23406	91311	99908	31212	41450
6	21385	59257	15867	52996	28137	28369	12996	48391	15382	21965
7	2782	12475	33312	9432	31762	17421	15762	6680	7352	11499
+gp	26943	15596	12389	25423	23002	32054	29110	23640		
TOTAL	929388	695082	917131	1143731	888540	810118	866570	549091		

Table 4.3.13 Gulf of Riga Herring. XSA output: Summary.

Run title	:	Herring Gulf of Riga				
At	10/04/2017	10:17				
Terminal	Fs	derived	using	XSA	(With	shrinkage)
	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 7
1977	943217	76734	54522	24186	0.4436	0.6903
1978	1076477	66256	49356	16728	0.3389	0.3751
1979	976935	66130	46738	17142	0.3668	0.431
1980	1110326	69530	46712	14998	0.3211	0.3498
1981	908405	65531	47221	16769	0.3551	0.4526
1982	1688857	72903	42757	12777	0.2988	0.4198
1983	1253569	76280	50855	15541	0.3056	0.4679
1984	2026790	66151	39911	15843	0.397	0.7069
1985	1386925	77457	51928	15575	0.2999	0.5382
1986	1119540	86724	64257	16927	0.2634	0.51
1987	3923554	97525	51491	12884	0.2502	0.4229
1988	560194	116201	96597	16791	0.1738	0.5218
1989	1289408	85976	63207	16783	0.2655	0.3616
1990	3634747	138871	77184	14931	0.1934	0.2372
1991	3677640	141216	87044	14791	0.1699	0.25
1992	4298780	166620	105792	20000	0.189	0.2668
1993	3239948	174966	120259	22200	0.1846	0.2318
1994	2766616	169465	124292	24300	0.1955	0.2332
1995	3455683	165929	115882	32656	0.2818	0.3452
1996	4646234	166847	104926	32584	0.3105	0.3674
1997	1577283	133008	102635	39843	0.3882	0.4931
1998	2766111	119460	81016	29443	0.3634	0.4441
1999	2885468	135577	83071	31403	0.378	0.428
2000	2635367	131681	82832	34069	0.4113	0.4638
2001	6071746	156008	78487	38785	0.4942	0.5367
2002	2261831	142934	99910	39701	0.3974	0.4764
2003	6971167	155454	85469	40803	0.4774	0.5535
2004	1014905	119817	91299	39115	0.4284	0.5877
2005	3140972	123480	72436	32225	0.4449	0.5135
2006	6869235	142101	69867	31232	0.447	0.4435
2007	1991318	125345	89840	33742	0.3756	0.5759
2008	5393038	155308	88206	31137	0.353	0.3382
2009	2764422	147827	103986	32554	0.3131	0.4018
2010	2786400	138464	97869	30174	0.3083	0.3232
2011	1088428	127867	98851	29639	0.2998	0.3617
2012	4871163	142770	84268	28115	0.3336	0.3317
2013	5260676	167870	101167	26511	0.2621	0.2606
2014	921667	146699	119556	26253	0.2196	0.2776
2015	2149088	138063	102850	32851	0.3194	0.3774
2016	3539800	131542	86654	30865	0.3562	0.3998
Arith. Mean	2773598	123215	81530	25822	0.3244	0.4192
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 4.3.14 Gulf of Riga Herring. Short-term forecast input.

MFDP version 1a
Run: HerGoR17_01
Time and date: 20:07 10.04.2017
Fbar age range: 3-7

2017

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	3003880	0.2	0	0.2	0.3	0.0091	0.136133	0.0091
2	2475330	0.2	0.93	0.2	0.3	0.0147	0.2218	0.0147
3	974610	0.2	0.98	0.2	0.3	0.0180	0.2763	0.0180
4	254780	0.2	0.98	0.2	0.3	0.0210	0.2975	0.0210
5	999080	0.2	1	0.2	0.3	0.0230	0.3792	0.0230
6	483910	0.2	1	0.2	0.3	0.0248	0.3776	0.0248
7	66800	0.2	1	0.2	0.3	0.0268	0.4275	0.0268
8	236400	0.2	1	0.2	0.3	0.0293	0.4275	0.0293

2018

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	3003880	0.2	0	0.2	0.3	0.0091	0.1361	0.0091
2		0.2	0.93	0.2	0.3	0.0147	0.2218	0.0147
3		0.2	0.98	0.2	0.3	0.0180	0.2763	0.0180
4		0.2	0.98	0.2	0.3	0.0210	0.2975	0.0210
5		0.2	1	0.2	0.3	0.0230	0.3792	0.0230
6		0.2	1	0.2	0.3	0.0248	0.3776	0.0248
7		0.2	1	0.2	0.3	0.0268	0.4275	0.0268
8		0.2	1	0.2	0.3	0.0293	0.4275	0.0293

2019

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	3003880	0.2	0	0.2	0.3	0.0091	0.1361	0.0091
2		0.2	0.93	0.2	0.3	0.0147	0.2218	0.0147
3		0.2	0.98	0.2	0.3	0.0180	0.2763	0.0180
4		0.2	0.98	0.2	0.3	0.0210	0.2975	0.0210
5		0.2	1	0.2	0.3	0.0230	0.3792	0.0230
6		0.2	1	0.2	0.3	0.0248	0.3776	0.0248
7		0.2	1	0.2	0.3	0.0268	0.4275	0.0268
8		0.2	1	0.2	0.3	0.0293	0.4275	0.0293

Input units are thousands and kg - output in tonnes

Table 4.3.15 Gulf of Riga Herring. Short-term prediction results.

MFDP version 1a
Run: HerGoR17_01
Herring Gulf of Riga
Time and date: 20:07 10.04.217
Fbar age range: 3-7 Not scaled, Catch constraints

2017						
Biomass	SSB	FMult	FBar	Landings		
130178	88633	0.9614	0.338	26723		
2018					2019	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
131163	94898	0	0	0	161052	122422
	94332	0.1	0.0352	3091	157740	118639
	93770	0.2	0.0703	6096	154521	114985
	93211	0.3	0.1055	9017	151392	111456
	92656	0.4	0.1406	11857	148350	108048
	92104	0.5	0.1758	14617	145393	104755
	91555	0.6	0.211	17302	142517	101574
	91010	0.7	0.2461	19912	139721	98500
	90469	0.8	0.2813	22451	137001	95529
	89931	0.9	0.3164	24919	134356	92658
	89396	1	0.3516	27321	131784	89883
	88864	1.1	0.3868	29657	129281	87201
	88336	1.2	0.4219	31929	126847	84607
	87812	1.3	0.4571	34140	124479	82100
	87290	1.4	0.4922	36292	122174	79675
	86772	1.5	0.5274	38385	119932	77330
	86257	1.6	0.5626	40423	117750	75062
	85745	1.7	0.5977	42405	115626	72867
	85237	1.8	0.6329	44336	113559	70745
	84731	1.9	0.6681	46214	111547	68691
	84229	2	0.7032	48044	109588	66704

Input units are thousands and kg - output in tonnes

Table 4.3.16 Gulf of Riga herring. Yield-per-recruit input.

MFYPR version 2a
Run: HerGoR17_ypr_01
HerringGulfofRiga,ANON,COMBSEX,PLUSGROUP
Time and date: 10:33 20.04.2017
Fbar age range: 3-7

Age	M	Mat	PF	PM	SWt	Sel	CWt
1	0.2	0	0.2	0.3	0.009	0.136	0.009
2	0.2	0.93	0.2	0.3	0.015	0.222	0.015
3	0.2	0.98	0.2	0.3	0.018	0.276	0.018
4	0.2	0.98	0.2	0.3	0.021	0.297	0.021
5	0.2	1	0.2	0.3	0.023	0.379	0.023
6	0.2	1	0.2	0.3	0.025	0.378	0.025
7	0.2	1	0.2	0.3	0.027	0.428	0.027
8	0.2	1	0.2	0.3	0.029	0.428	0.029

Weights in kilograms

Table 4.3.17 Gulf of Riga herring Yield-per-recruit results.

MFYPR version 2a
Run: HerGoR17_ypr_01
Time and date: 10:33 20.04.2017
Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJ	SSBJan	SpwnNosS	SSBSpwn
0	0	0	0	5.5167	0.1121	4.435	0.1017	4.1767	0.0958
0.1	0.0352	0.1275	0.0028	4.8819	0.0948	3.8021	0.0844	3.5568	0.0789
0.2	0.0703	0.2192	0.0046	4.4253	0.0826	3.3474	0.0722	3.1116	0.0671
0.3	0.1055	0.2891	0.0059	4.0784	0.0735	3.0023	0.0632	2.7739	0.0583
0.4	0.1406	0.3444	0.0068	3.804	0.0665	2.7296	0.0562	2.5072	0.0516
0.5	0.1758	0.3895	0.0075	3.5802	0.0609	2.5074	0.0506	2.2902	0.0462
0.6	0.211	0.4273	0.008	3.3933	0.0563	2.3222	0.0461	2.1093	0.0418
0.7	0.2461	0.4595	0.0084	3.2342	0.0525	2.1646	0.0423	1.9557	0.0381
0.8	0.2813	0.4874	0.0087	3.0967	0.0492	2.0287	0.0391	1.8233	0.035
0.9	0.3164	0.5118	0.009	2.9764	0.0464	1.9098	0.0363	1.7076	0.0324
1	0.3516	0.5334	0.0092	2.8699	0.044	1.8046	0.0339	1.6054	0.0301
1.1	0.3868	0.5528	0.0093	2.7747	0.0419	1.7109	0.0318	1.5145	0.028
1.2	0.4219	0.5702	0.0095	2.6891	0.04	1.6266	0.0299	1.4328	0.0263
1.3	0.4571	0.5861	0.0096	2.6115	0.0383	1.5503	0.0282	1.3589	0.0247
1.4	0.4922	0.6005	0.0097	2.5408	0.0368	1.4808	0.0267	1.2917	0.0232
1.5	0.5274	0.6138	0.0097	2.476	0.0354	1.4172	0.0254	1.2304	0.022
1.6	0.5626	0.626	0.0098	2.4163	0.0341	1.3587	0.0241	1.174	0.0208
1.7	0.5977	0.6374	0.0098	2.3612	0.033	1.3047	0.023	1.122	0.0197
1.8	0.6329	0.6479	0.0099	2.31	0.0319	1.2546	0.022	1.0739	0.0188
1.9	0.6681	0.6577	0.0099	2.2624	0.031	1.208	0.021	1.0293	0.0179
2	0.7032	0.6669	0.0099	2.2179	0.0301	1.1646	0.0202	0.9877	0.017

Reference	F multiplie	Absolute F
Fbar(3-7)	1	0.3516
FMax	2.5907	0.9109
F0.1	0.7005	0.2463
F35%SPR	0.8546	0.3005

Weights in kilograms

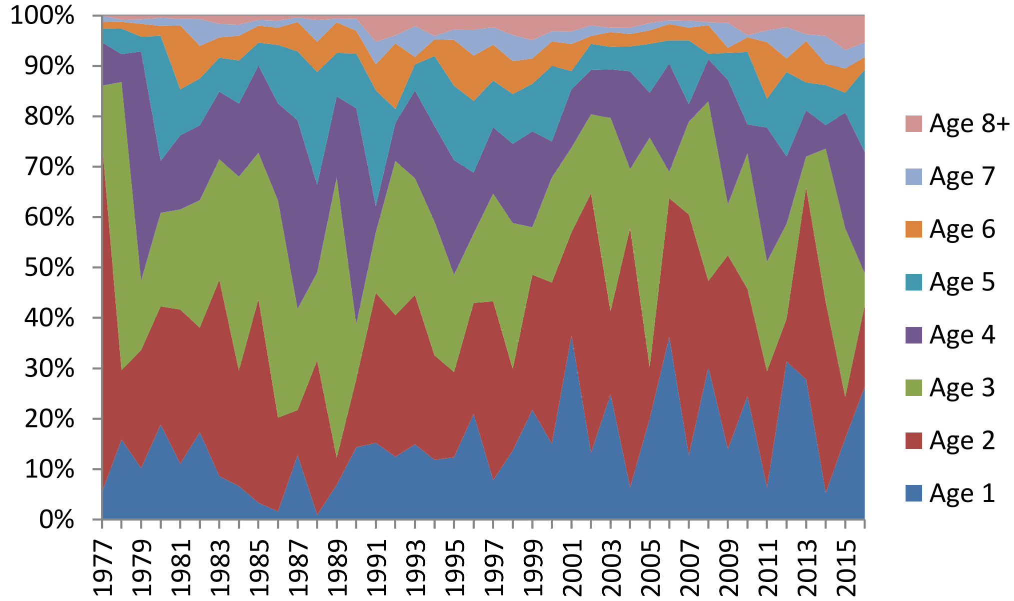
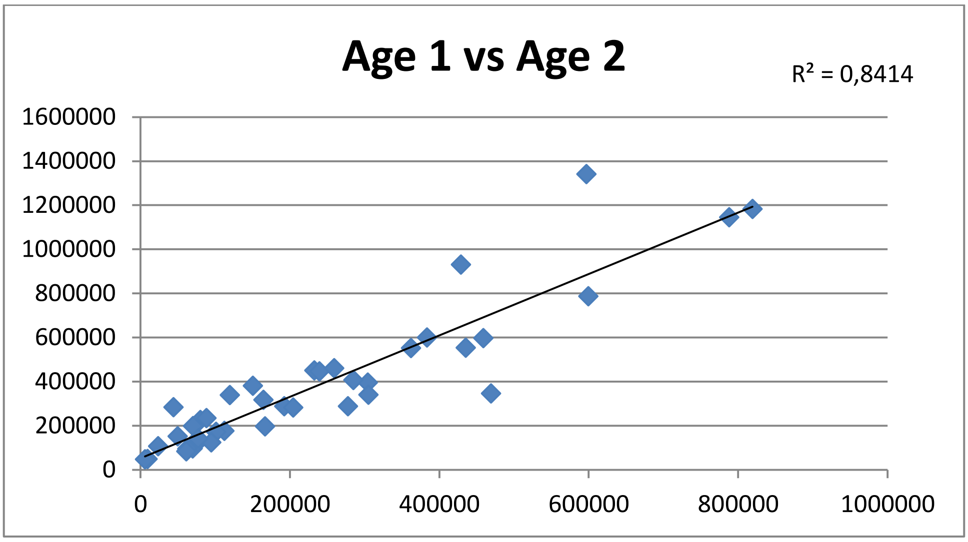
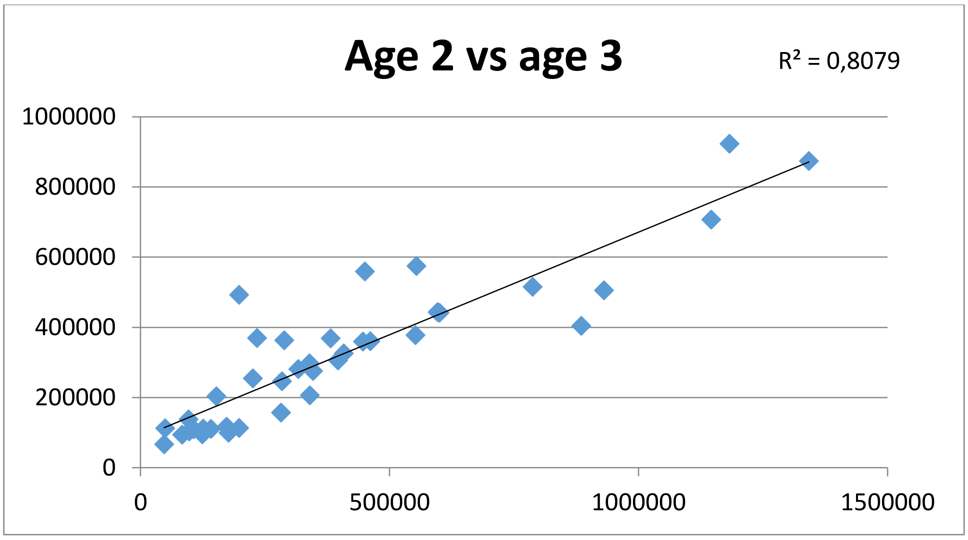


Figure 4.3.1 **Gulf of Riga herring. Relative catch at age in numbers in 1977-2016.**





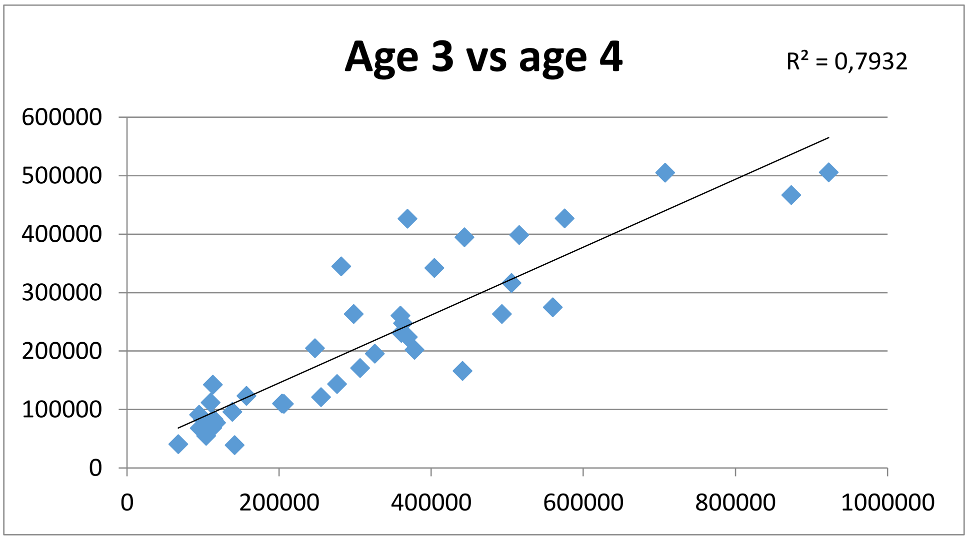
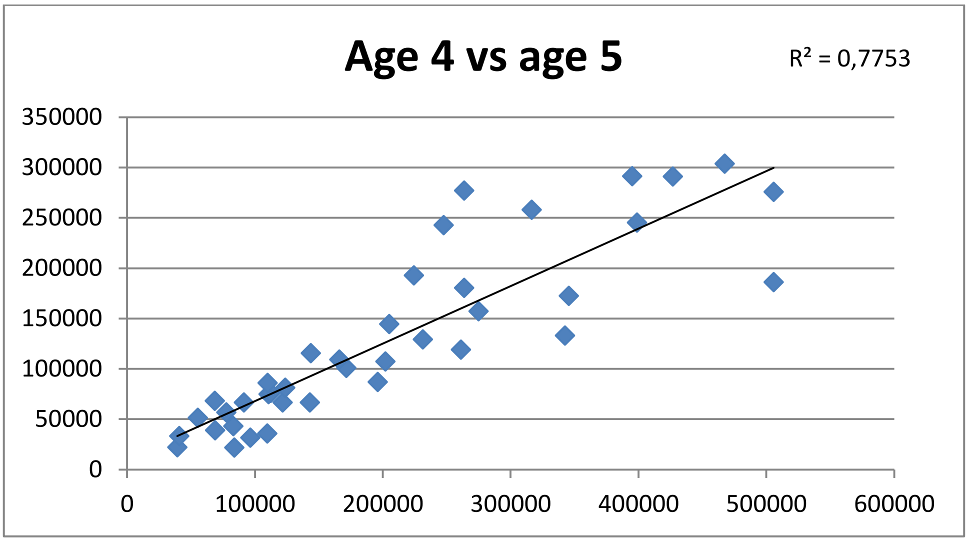
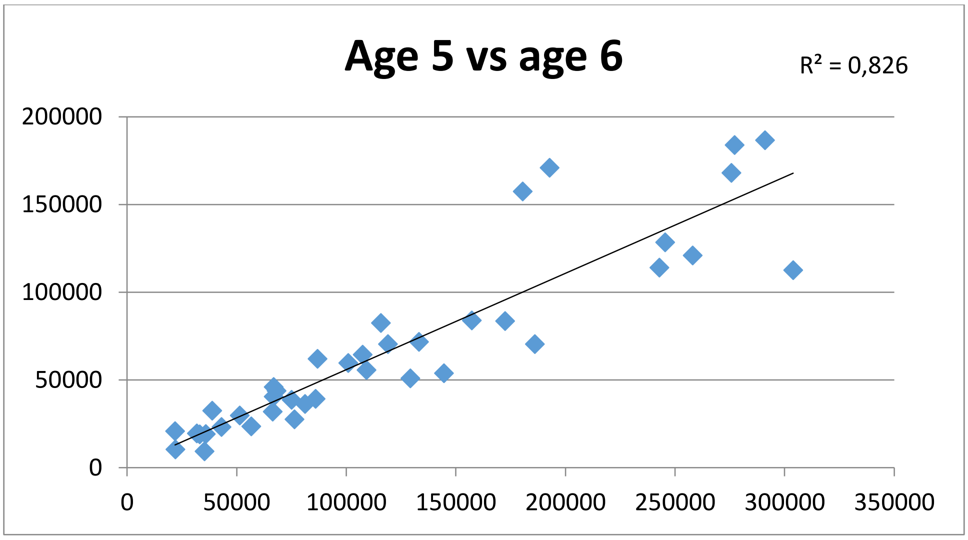


Figure 4.3.2 1/2 **Gulf of Riga herring. Check for consistency in catch-at-age data.**





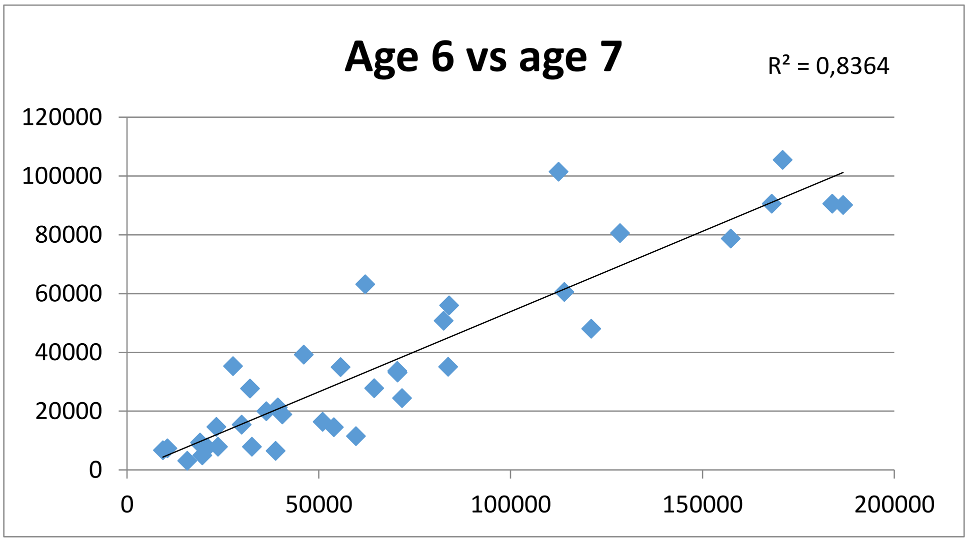


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Figure 4.3.2 2/2 **Gulf of Riga herring. Check for consistency in catch-at-age data.**

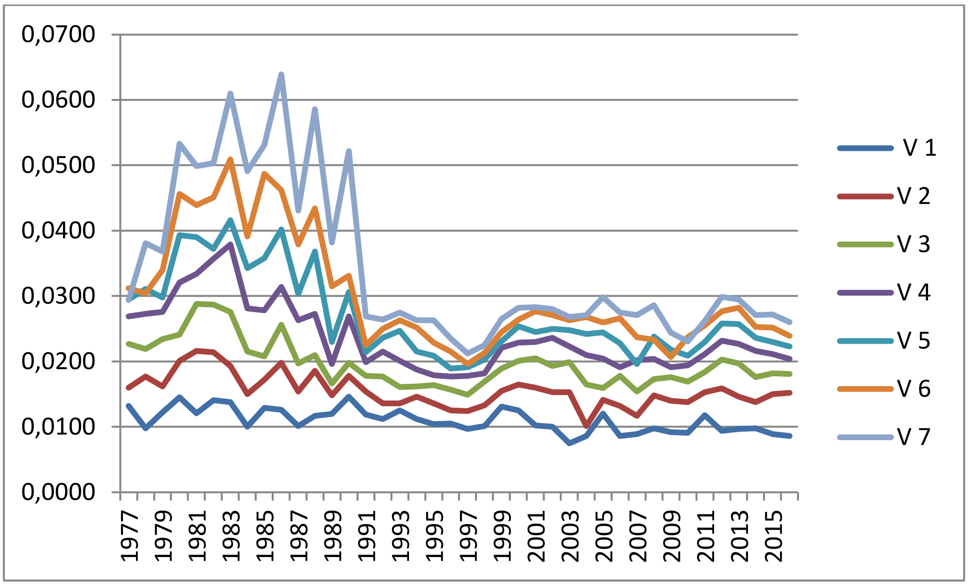


Figure 4.3.3 **Gulf of Riga herring. Mean weight at age in the catches.**

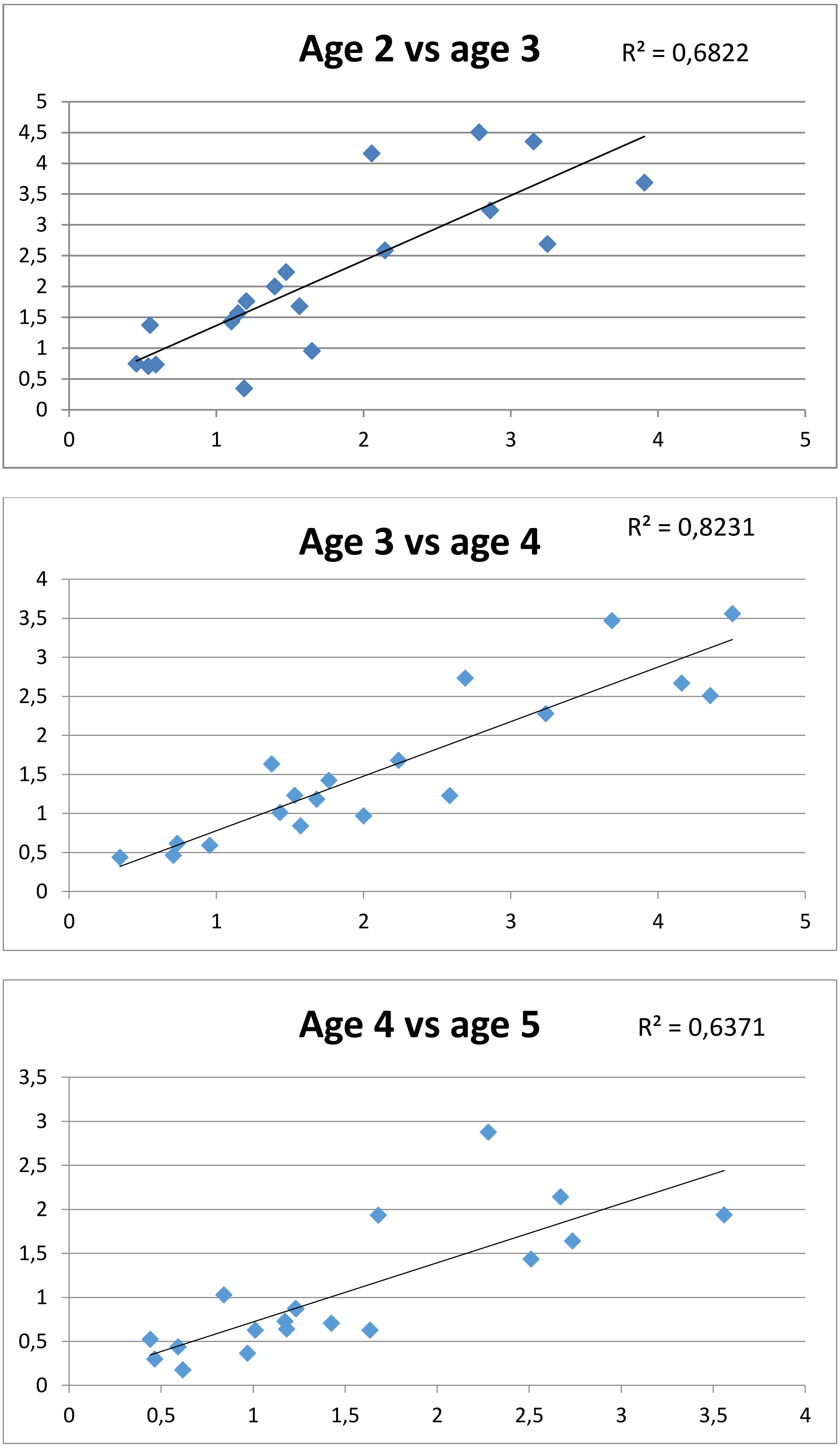
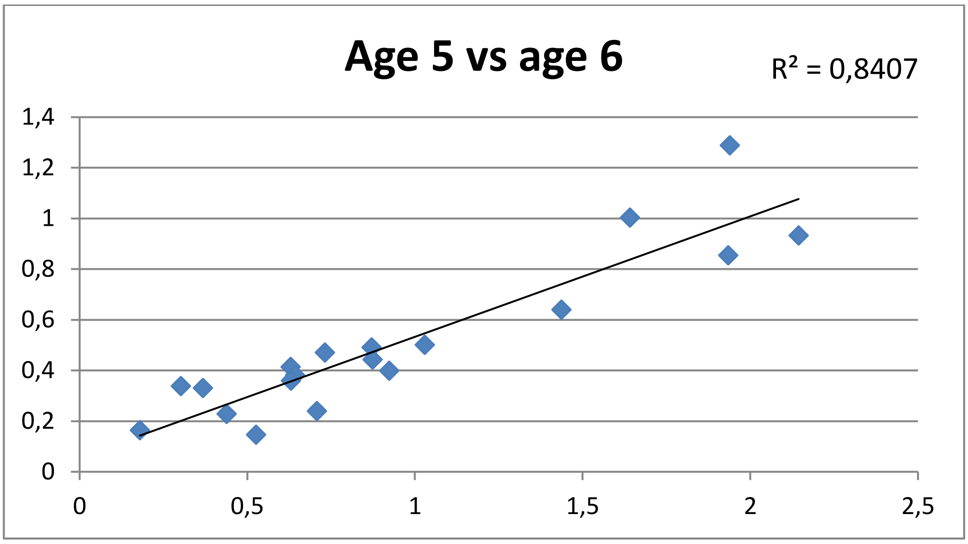


Figure 4.3.4 Gulf of Riga herring. Check for consistency of trap-net fleet (log indices) data. ½



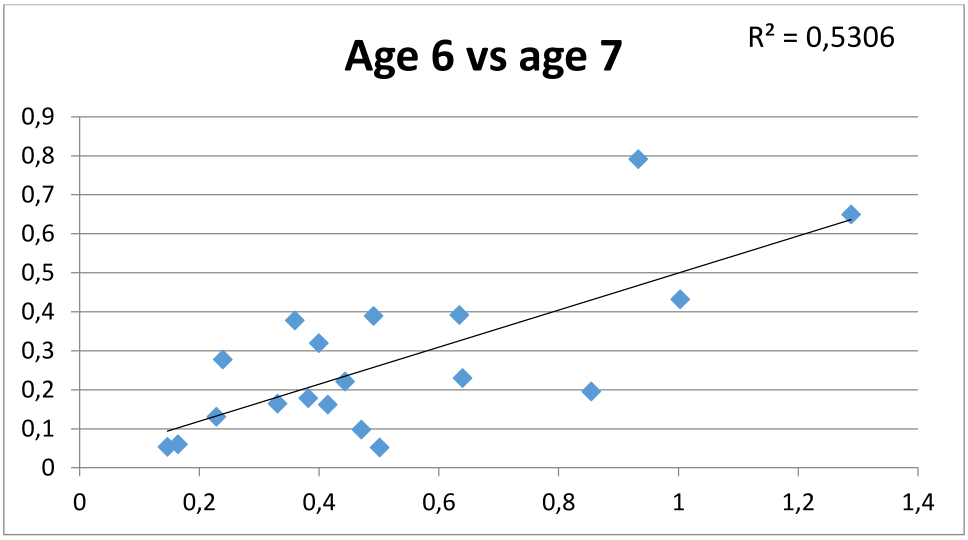


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Figure 4.3.4 2/2 **Gulf of Riga herring. Check for consistency of trap-net fleet (log indices) data.**

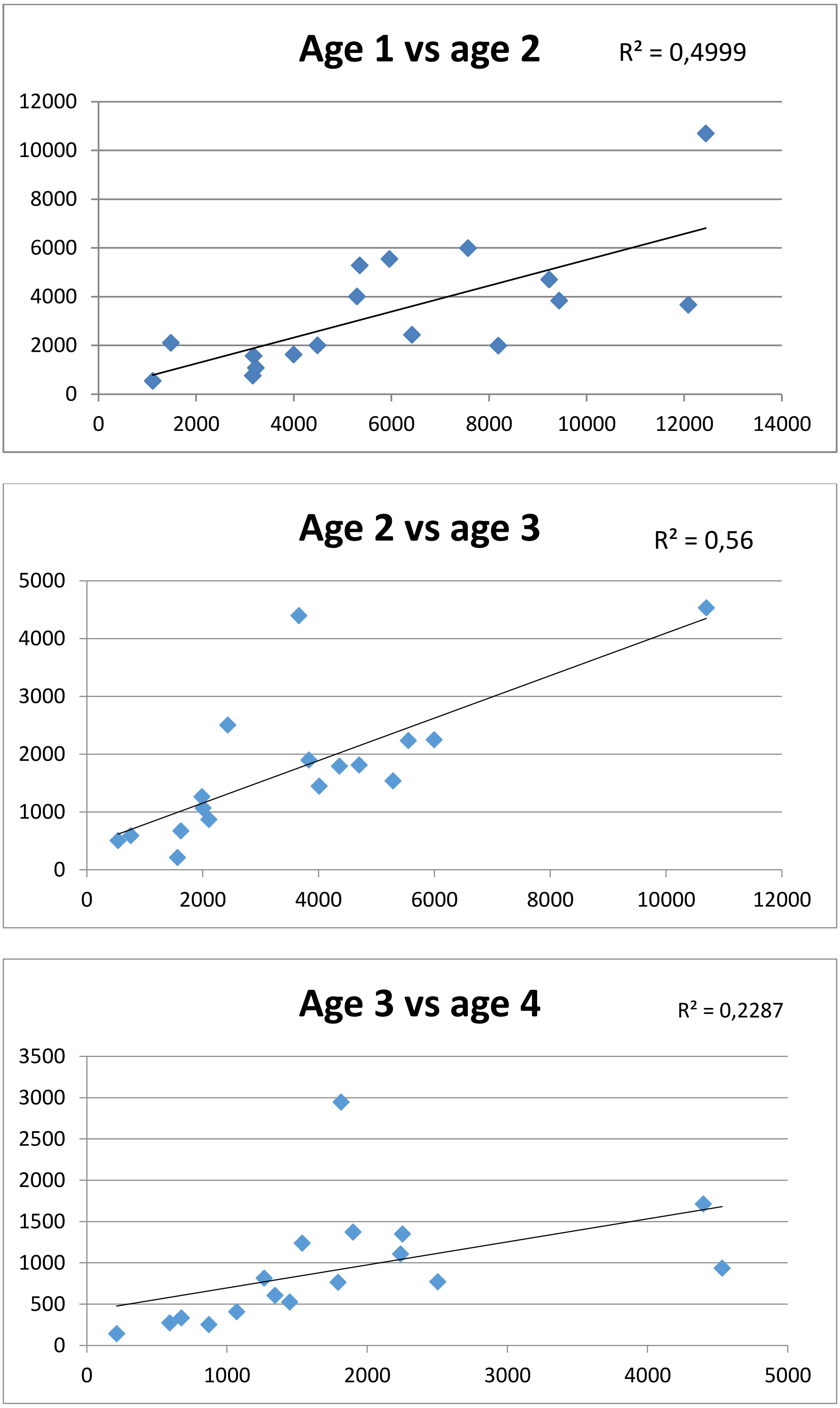
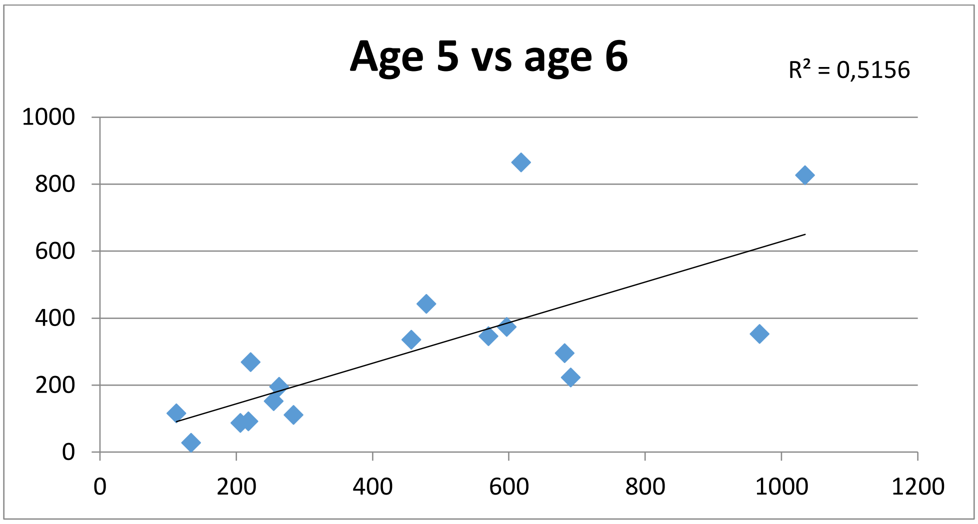
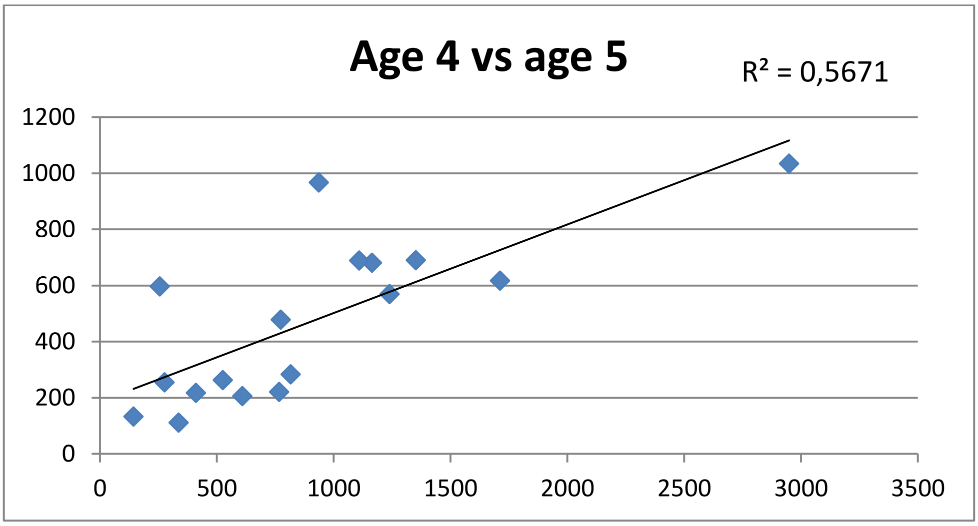


Figure 4.3.5 1/2 **Gulf of Riga herring. Check for consistency of acoustic fleet data.**





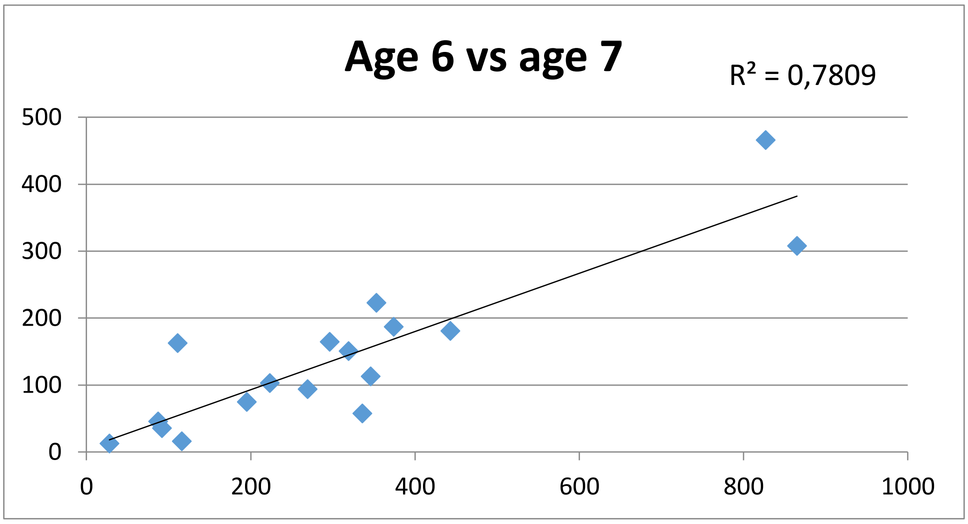


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Figure 4.3.5 2/2 **Gulf of Riga herring. Check for consistency of acoustic fleet data.**

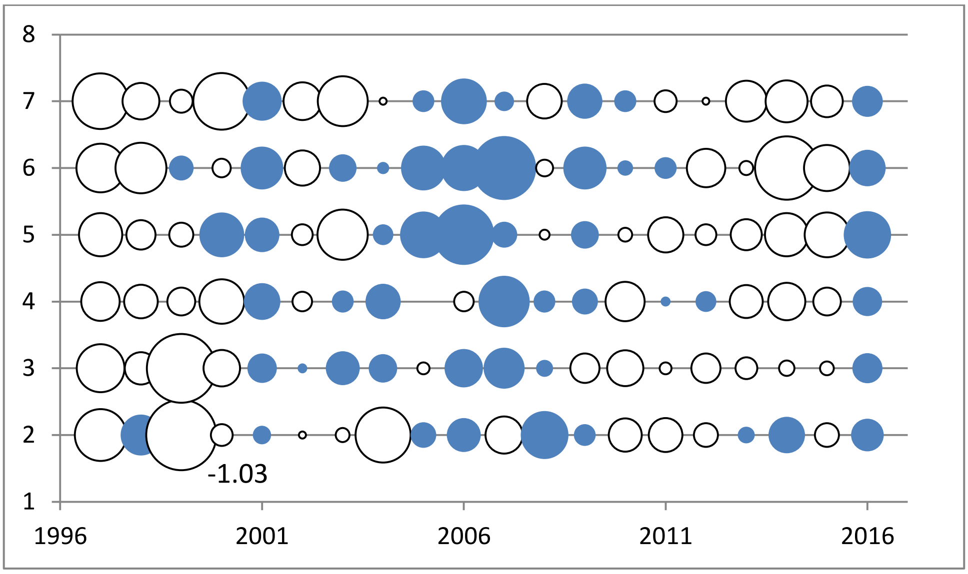


Figure 4.3.6a Gulf of Riga herring. Log catchability residuals of trap-net fleet.

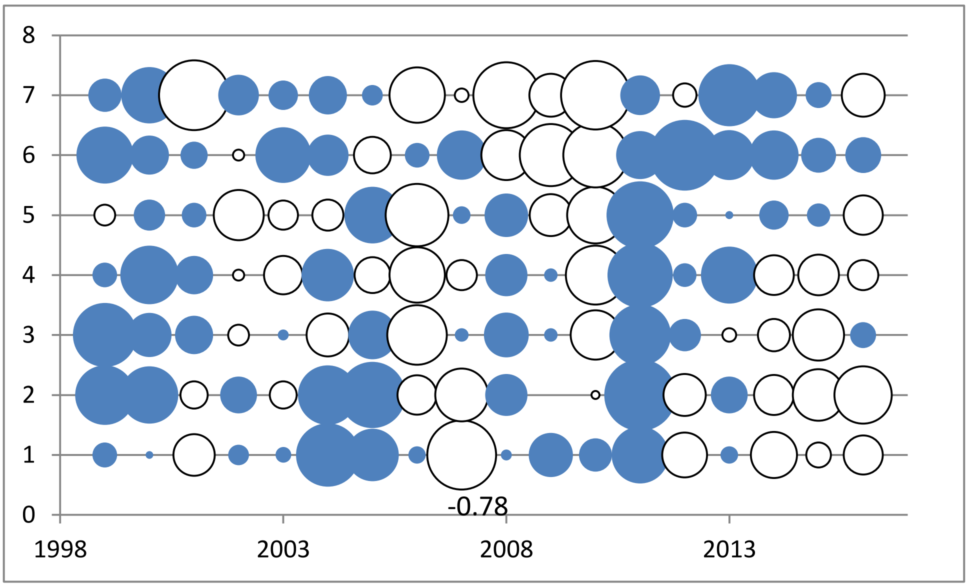
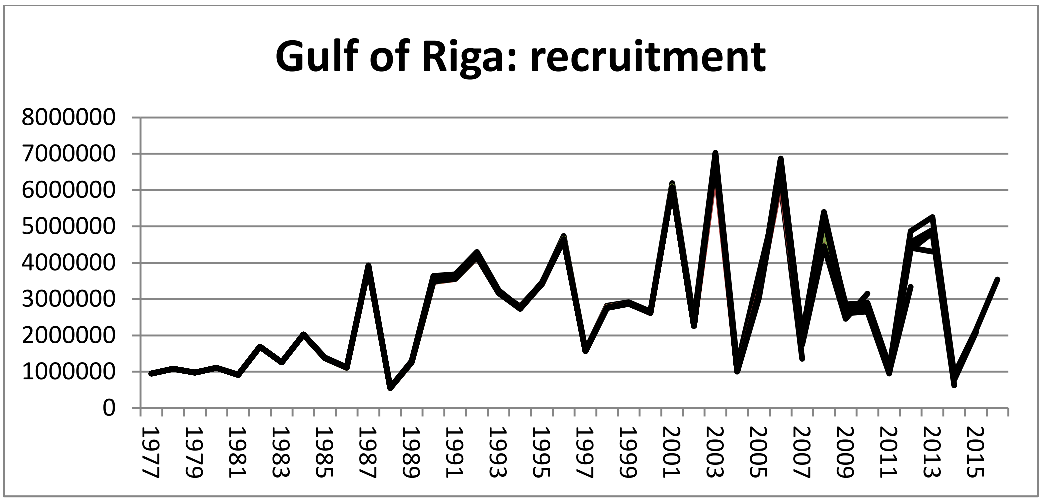
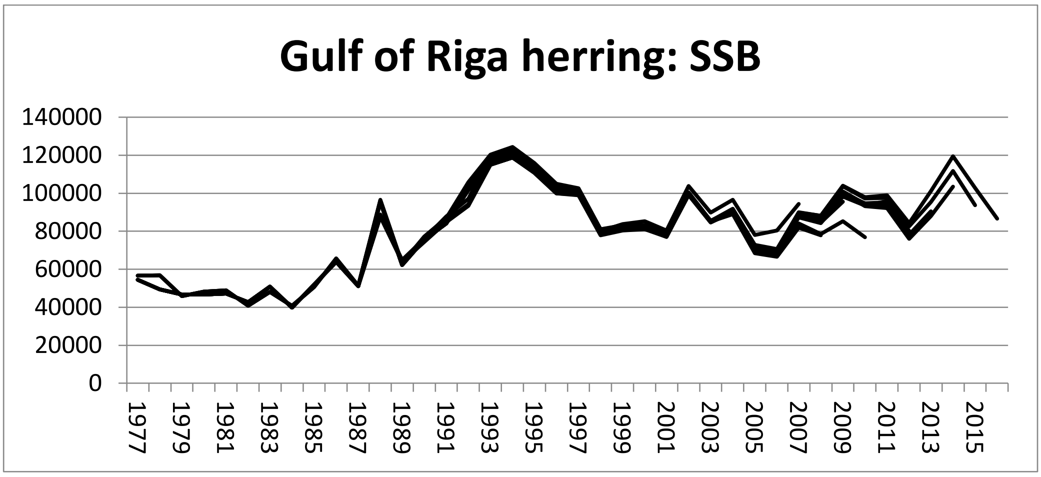


Figure 4.3.6b Gulf of Riga herring. Log catchability residuals of acoustic fleet.





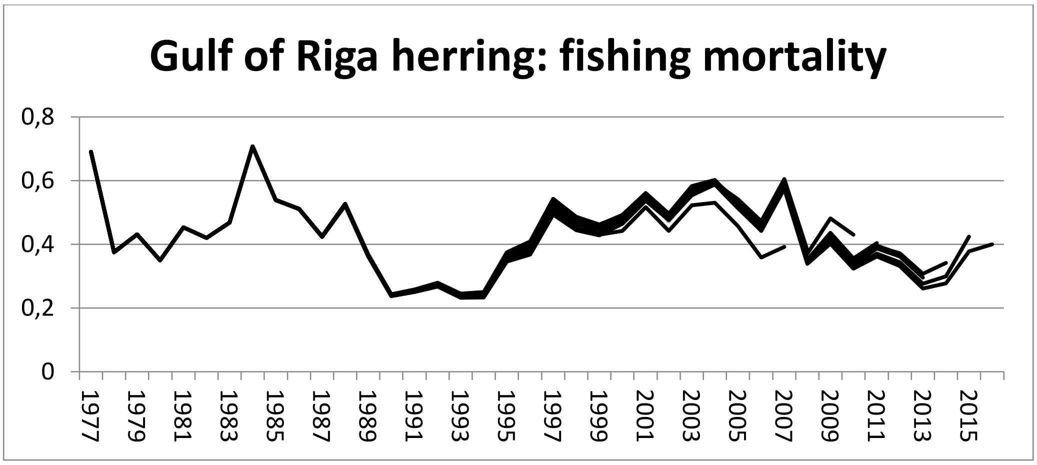


Figure 4.3.7 **Gulf of Riga herring. Retrospective analysis.**

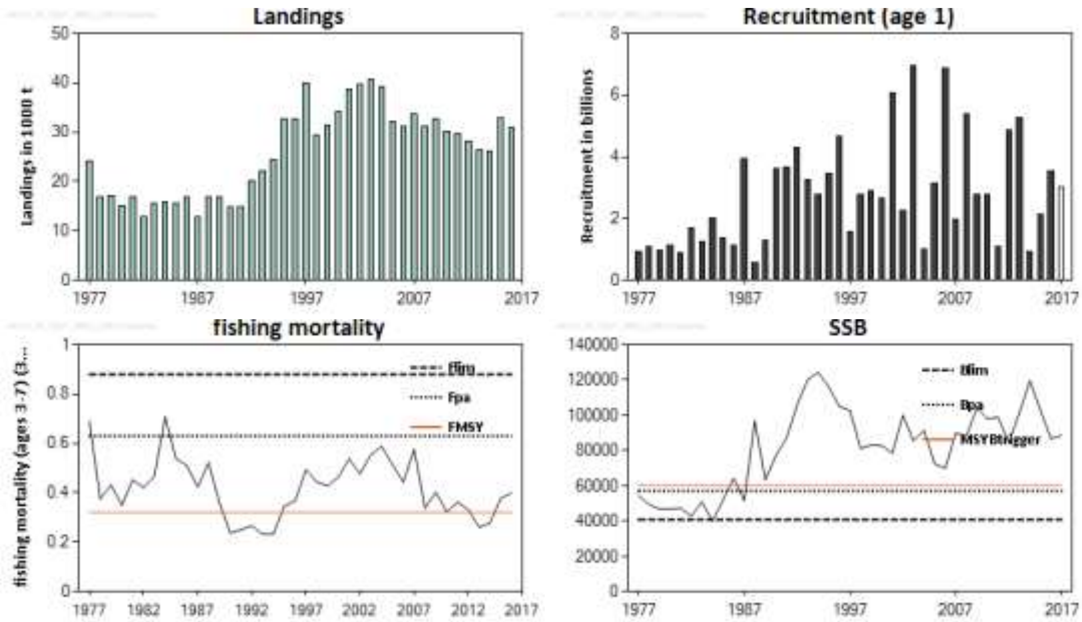


Figure 4.3.7 **Gulf of Riga herring. Stock summary.**

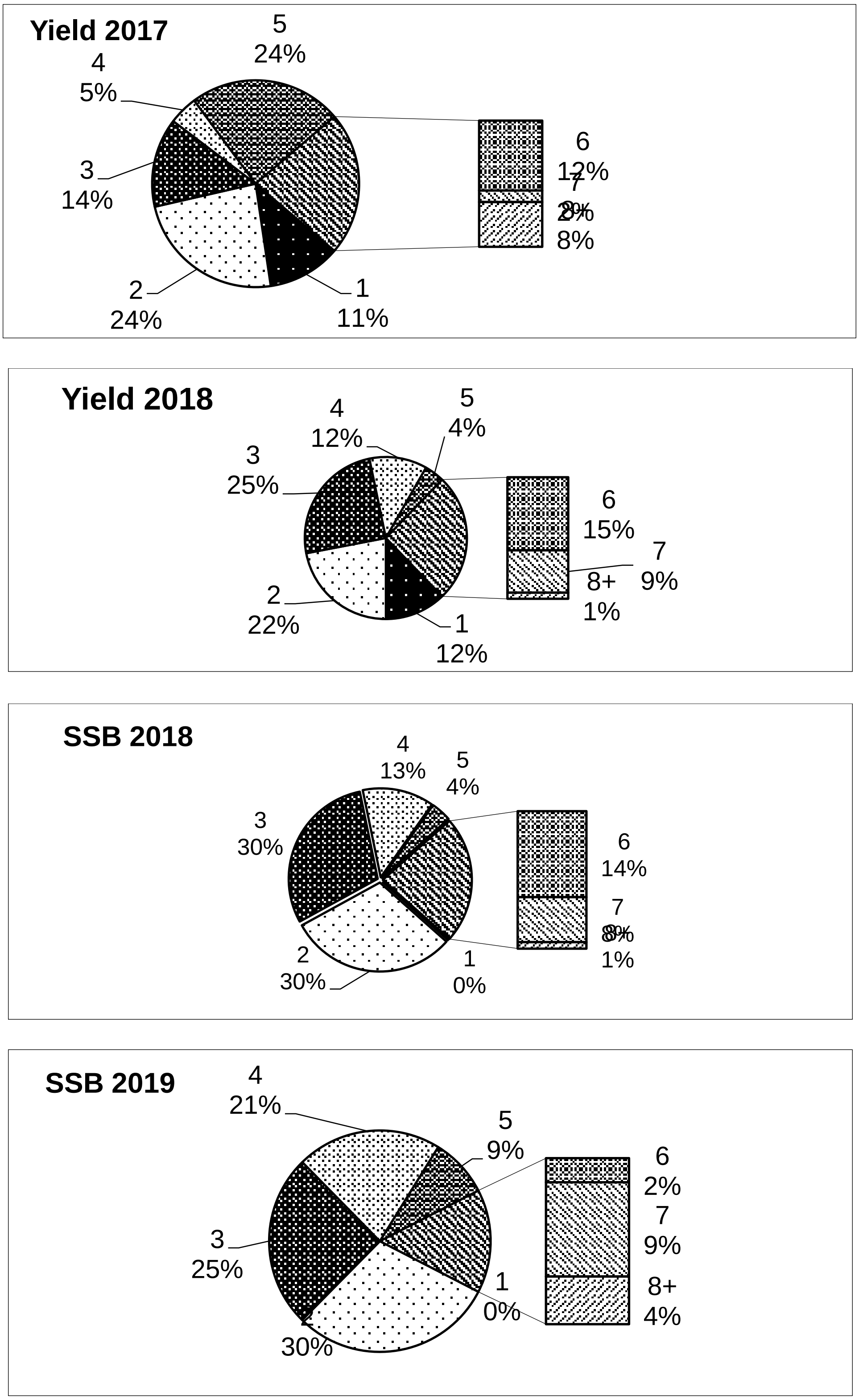


Figure 4.3.9 **Gulf of Riga herring. Short-term forecast for 2017-2019.**

Yield and SSB at age 1-8+under the status quo fishing mortality.

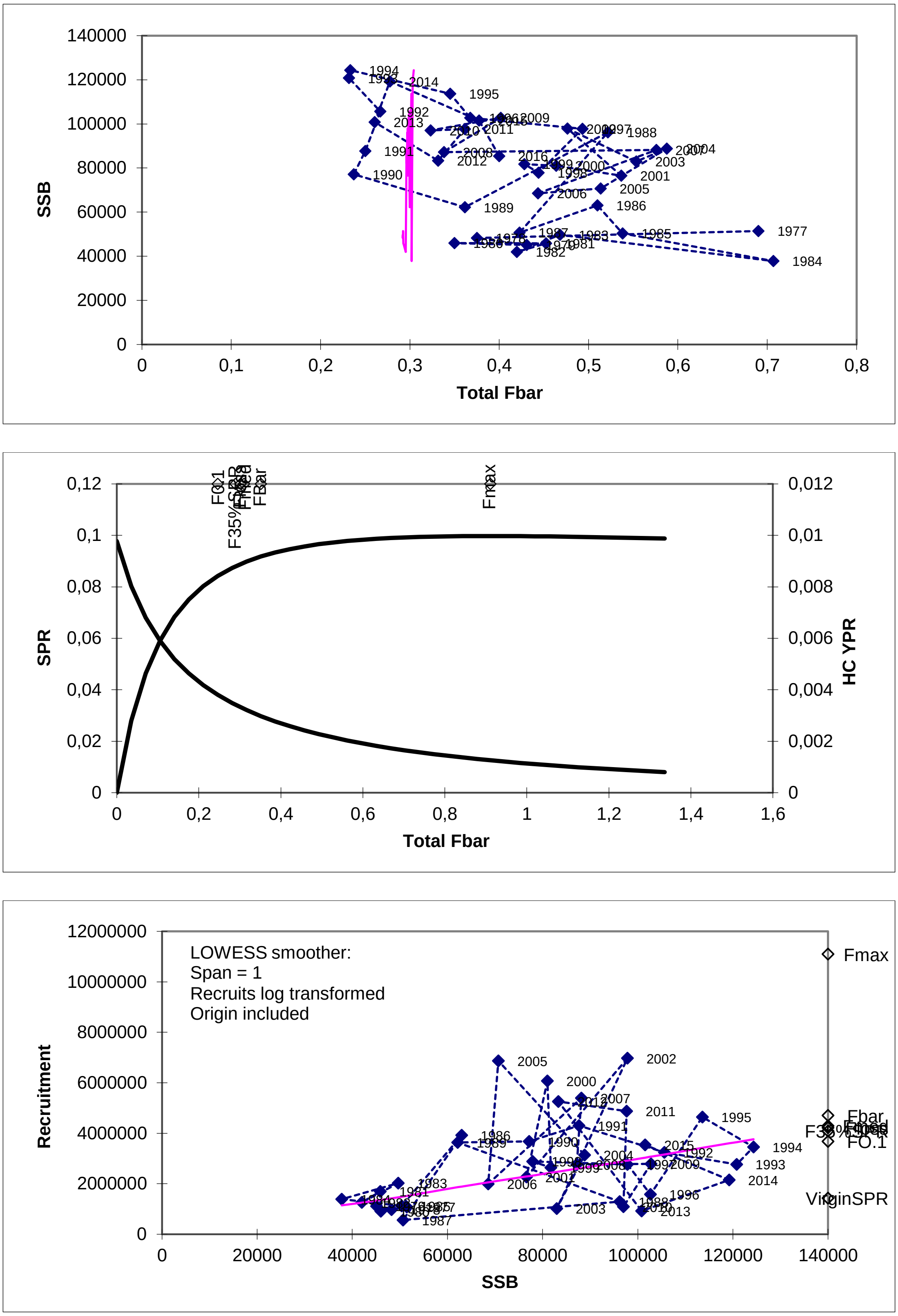
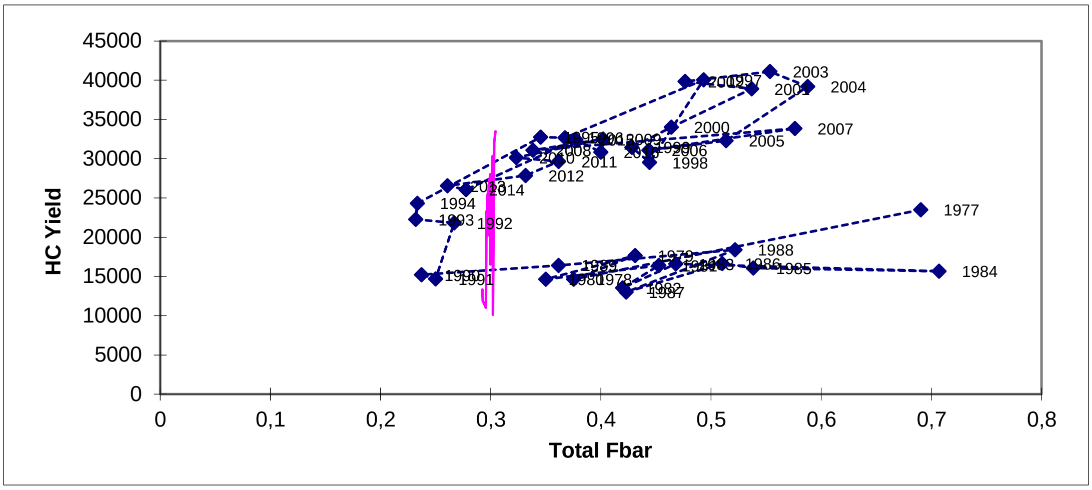
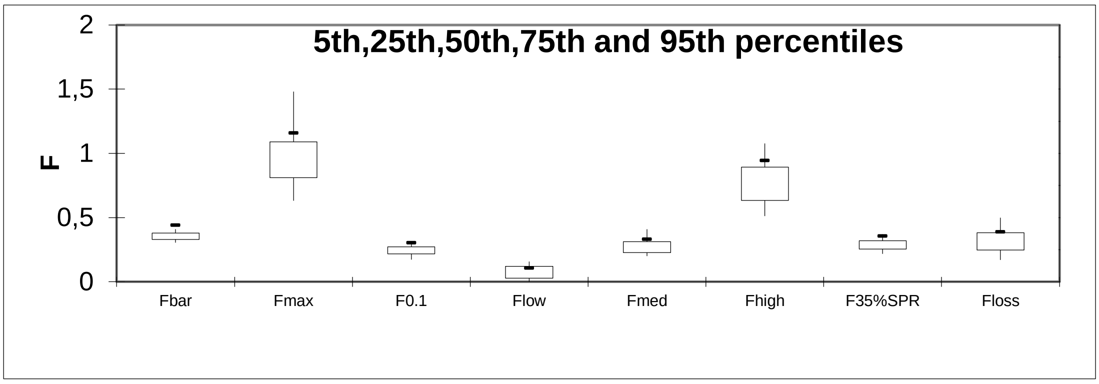


Figure 4.3.10 Gulf of Riga herring. PA plots and reference points. 1/2





Reference point	Deterministic	Median	75th percentile	95th percentile	Hist SSB < ref pt %	
MedianRecruits	2699895	2700739	2775622	2965666		
MBAL	60000				25.00	
Bloss	37805					
SSB90%R90%Surv	84677	85529	94946	101946	52.50	
SPR%ofVirgin	30.47	30.35	32.15	35.44		
VirginSPR	0.10	0.10	0.11	0.13		
SPRloss	0.03	0.03	0.04	0.05		
	Deterministic	Median	25th percentile	5th percentile	Hist F > ref pt %	
FBar	0.35	0.35	0.33	0.31	70.00	
Fmax	0.91	0.93	0.81	0.63	0.00	
F0.1	0.25	0.24	0.22	0.17	92.50	
Flow	0.05	0.09	0.03	0.00	100.00	
Fmed	0.31	0.27	0.23	0.20	82.50	
Fhigh	0.72	0.76	0.63	0.51	0.00	
F35%SPR	0.29	0.29	0.26	0.22	82.50	
Floss	0.30	0.31	0.25	0.17	82.50	

continued

Figure 4.3.10 2/2 Gulf of Riga herring. PA plots and reference points.

4.4 Herring in Subdivisions 30 and 31 (Gulf of Bothnia)

4.4.1 The Fishery

The three main fleets operating in Baltic herring fisheries in the Gulf of Bothnia are:

Pelagic trawling (single and pair trawling)

Demersal trawling

Trapnet fisheries (spawning fishery)

In the Finnish trawl fishery, the same trawls are often used in the pelagic trawling near the surface and in deeper mid-water. In 2016, 96% of the Finnish landings came from trawl fishery, 3% with trapnets, and 0.1% with gill-nets. In 2016, 97% of the Swedish catches came from trawls: 83% from pelagic trawls and 14% from demersal trawls, 3% were caught from gill-nets and <1% with other passive gears.

4.4.1.1 Landings

The total catch in Gulf of Bothnia increased by 15087 tonnes (13%) from 2015 to 130 029 tonnes in 2016 (Figure 4.4.1), of which 83% (107 803 tonnes) was Finnish catch and 17% (22 226 tonnes) was Swedish catch (Table 4.4.1). The Finnish catch increased by 7% (7018 tonnes) and the Swedish catch increased by 57% (8068 tonnes) compared to 2015.

4.4.1.2 Unallocated removals

No unallocated removals were reported.

4.4.1.3 Discards

Discarding rates in the Finnish fisheries are negligible (estimated to be few tonnes annually) and have therefore not been taken into account in assessments. Sweden is catching herring primarily for human consumption, and the preferred fish size is about 16 cm while smaller sized fish are presumably discarded. Another reason for discarding is connected with the catch amounts related to the market's demand. In gillnet and trapnet fisheries, all the fish damaged by seal (grey or ringed) predation are typically discarded. In autumn, herring is also sometimes appearing as unwanted bycatch in the vendace and whitefish fisheries. Most of the discards are reported in the herring fishery with nets. In Sweden, the interviews of fishermen indicated that they estimated the discard rate to be about 10% for the entire year.

Based on the Swedish official statistics and informal interviews 6–12% of Swedish herring catches taken from SD 30 have been discarded in the recent years. This constitutes up to 1% of the total herring catches in SD 30 and discards are therefore regarded as negligible, and not used in the assessment.

4.4.1.4 Effort and CPUE data

One commercial tuning series is used in the assessment, a trapnet cpue time series 1990–2006 from Bothnian Sea. In the trapnet fisheries the number of trapnets set is used as effort. Throughout the 1980s the number of trap nets decreased drastically, in 1991 the number of trapnets was only a fifth of the number in 1980, but since then their number remained more or less stable.

The trapnet-tuning fleet was renewed in 2013 according to recommendations from WKPELA 2012 (see also IBP her-30 report). It comprised of unbroken time series of catch and effort combined from three areas in Finnish coast of Bothnian Sea (rectangles

23, 42 and 47) (Figure 4.4.2). In 2015, however, the area 23 did not have a qualified trapnet fishery anymore, i.e. catch and effort were 0. The time series was further shortened from 1990–2014 to 1990–2006 because of declining trend in effort (Figure 4.4.3).

4.4.2 Biological information

4.4.2.1 Catch in numbers

During WKBALT meeting several different plus-groups (9+ to 15+) in the age-matrices of the assessment input data were examined and finally the age group 10+ was chosen to be used in the final assessment instead of the 9+, which has been previously used for both stocks (Figure 4.4.4). The data of Finnish catches at age from the Bothnian Sea were available and have been used to apply to the Swedish catches as well except in years 1987, 1989–1991, 1993 and 2000–2015. These years in the Swedish catches were mostly allocated according to Swedish catch sampling. In 2015 Swedish unsampled catches were allocated in InterCatch according to the Finnish sampling from respective fisheries (Table 4.4.2). Finnish and Swedish sampling of the catches are shown in Table 4.4.3. The time–series that previously started from 1973 in SD 30 was shortened to start from 1980 to be compatible with the time–series for SD 31 due to the unavailable Finnish catch data before 1980 and Swedish data even for years before 2010. The most common age class in numbers in the 2016 catches and largest in biomass was the age-group 2, which derives from the record-high 2014 year-class. The total catch in numbers is shown in Table 4.4.4.

4.4.2.2 Mean weight at age

Mean weight at age in the catches (Table 4.4.5) was assumed similar to the mean weight in the stock. The average weight at age decreased for all ages since about 1990 (Figure 4.4.5), but stabilized in the beginning of the 2000. The weights have been stable for age-groups 1 and 2, decreased in age-groups 3 to 8 and increased in age-groups 9 and 10+ in year 2016.

4.4.2.3 Maturity at age

Constant maturity ogives have been used for period 1980–1982. Since 1983 the proportions mature at age have been annually updated from the samples taken before spawning time. Updated maturity ogives for 1980–2016 are shown in Table 4.4.6 and Figure 4.4.6. There is generally high variability in maturity ogives among years, which causes some noise in assessments. The annual variation in age-group 2 is usually quite large. The sensitivity of the variability in maturity ogives from year to year was evaluated in the benchmark assessment in 2012 and it was concluded that there were no grounds for discontinue to update the maturity ogives annually (ICES 2012).

4.4.2.4 Natural mortality

Natural mortality rate 0.15 has been used for all the age groups in all years in the stock assessment runs; respectively the proportion of natural mortality before spawning has been assumed to be 0.33 and fishing mortality before spawning 0.15 for all the years and ages.

Although the predation of seals, cormorants and cod on herring do not seem to have had a major impact on the total stock estimates (see stock annex for details), the development of the populations of these predators should be followed and their impact re-analysed at latest when the increase of the predators or the development of herring stock dynamics implicate possible effects. Particularly the effects of seals need special attention.

4.4.2.5 Quality of catch and biological information

From Finnish commercial catches, 91 length-samples and 70 age-samples were taken in 2016, and 16 length-samples and 10 age-samples from the Swedish fisheries. In total in 2015, 34 500 herring were length-measured from commercial catches and 2433 aged from commercial catches and 3741 from acoustic survey (Table 4.4.3).

4.4.3 Fishery independent information

A joint Swedish – Finnish hydroacoustic survey has been annually conducted in late September – early October in the Bothnian Sea from 2007 until 2010 with Swedish RV Argos. In 2011 and 2012 the surveys were performed with Danish RV Dana and since 2013 with Finnish RV Aranda. This survey is coordinated by ICES within the frame of the Baltic International Acoustic Surveys (BIAS). The survey covers most of the stock area, excluding only the shallow areas mainly along the Finnish coast. The survey generally tracked all age groups well, with the exception of the 2012 survey (Figure 4.4.4). The survey is providing yearly estimates of abundance and biomass (Figure 4.4.7). In the 2017 benchmark the age-group 1 was included in the survey-index because it was concluded that it had similar consistency within the age-matrix as other age groups (ICES 2017).

In 2012 the survey was not performed according to standard coverage (60 nmi per 1000 nmi^2 = statistical rectangle), but only half of it and with half the number of con- trol trawl hauls (normally 2 per rectangle) due to the withdrawal of the Swedish half of the total funds to the survey.. In 2015 a part of the Bothnian Sea was not covered due to breakdown of the research vessel, but the acoustic index was accepted by WGBIFS to be used in assessment (ICES 2016). In 2016 the survey coverage was good. Acoustic surveys have shown to be essential for the assessment of this stock, and therefore they should be continued with the required effort-level.

The biological samples for ages from the surveys in 2007–2016 have been annually used for 3^{rd} and/or 4^{th} quarter ALK's for length distributions from commercial sampling and mean weights at age in the input data.

4.4.4 Assessment

4.4.4.1 SAM

The state space assessment model (SAM) (ICES WGMG report 2009) was used in the update assessment. This stock was benchmarked at The Benchmark Workshop on Baltic Stocks (WKBALT) 2017 7–10 February 2017, and this is an update assessment of the work conducted there.

The stock assessment for her.27.3031 can be viewed at https://www.stockassessment.org (username:guest, password:guest), under the stock name: GoB-Her_2017_config1.

The spawning stock size peaked in mid 90's and in 2015. The update assessment shows a decreased SSB in 2016 (Figure 4.4.8-10). The average F has in general been increasing since 2010 and shows a peak in 2016 (0.225). The recruitment has shown an increasing trend from 1980 to 2016, with a peak in 2015. The normalised residuals are high in 2016 in all age groups for the acoustic survey fleet (Figure 4.4.11.). This is caused by extremely high abundance of age group 1 in 2015 and extremely low abundance for all ages in 2016 (Figure 4.4.4 and 4.4.7). Consistencies of the different ages within hydroacoustic abundances, trapnet cpue and catch data are presented in Figures 4.4.12 - 4.4.14. In the hydroacoustic internal consistency plot all values in 2016 are below the line indicating that the survey has down scaled all age groups compared to last year's survey. However, for the internal consistency of the commercial catches the same down scaling is not evident. In order to test the sensitivity of the model results to different survey indices, model runs excluding one survey at a time (leave-one-out runs) were conducted (Figure 4.4.15). When excluding the trapnet tuning series and only keeping in the acoustic survey, the patterns of estimated SSB and F_{bar} are different and are somewhat outside the model uncertainty estimates of a "complete" model that uses both survey data sets. When excluding the hydroacoustics there is a 200 000 t difference especially in the period after 2006. The acoustic survey is still relatively short and samples a younger part of the population compared to the size selective trap net fishery which could add to the differences in the patterns. Excluding either survey indices does not have much impact on recruitment with the exception of 2015. The retrospective analysis shows an overestimated SSB for the last three years (Mohn's rho=0.042), whereas for fishing mortality shows underestimation during the last 3 years (Mohn's rho= 0.049). Retrospective analysis for recruits are highly unstable during the final years (Mohn's rho=0.455) (Figure 4.4.16.). The acoustic survey data based abundance index was highest in year 2015 and lowest in year 2016 in the time series. This caused major uncertainty in recruitment estimates for the year 2016. In order to reduce the uncertainty an additional model was fitted with lower error. However, since it didn't differ from the update assessment model it was decided to go ahead with the update assessment using the initial (benchmarked) model and keep the improved model for future checks.

4.4.4.2 Recruitment estimates

According to the acoustic survey results, the recruitment (age 0) in year 2013 was 8.5 times higher than in years 2007–2012 average survey estimates. As in many other Baltic pelagic stocks the yearclass 2014 was huge (22.8 times higher) and in year 2015 still 9.1 times higher compared to the mean value for 2007–2012.

According to the estimates from SAM, recruitment of herring in the Gulf of Bothnia in 2002 was 17% higher than any other year class previously observed (Figure 4.4.10.). The year class 2013 was 13% larger than 2002 year class and the year class of 2014 97% lager. The 2014 yc was an exceptionally abundant year class in the Baltic Sea area also for other pelagic stocks. The recruitment estimates since 2002 have been over the average recruitment estimated over the period after the Baltic Sea regime shift in the late 1980s, having high year classes in most years after 2002. It should be noted however, that the confidence intervals, particularly around the more recent years, are very large.

4.4.4.3 Historical trends

The herring spawning stock biomass increased rapidly since 1981 (Table 4.4.7.). It peaked in 1994, decreased until 2002, and thereafter increased again to a record high level in 2014. The large uncertainty around the SSB estimate has reduced after the model was revised in the benchmark. During the current period of high recruitment, the spawning stock biomass is between three to four times larger than it was in the low recruitment period before the late 1980s.

4.4.5 Short-term forecast and management options

The short term forecast is based on the SAM short term forecast module and the settings for the short term forecast are as follows:

The mean weights at age were assumed to be equal to the average of the mean weights at age across the years 2014–2016. Natural mortality was set to 0.15 and we used the average fishing mortality rate in 2014–2016 scaled to the last year. Recruitment in 2017 and 2018 were estimated based on resampling from the sampled distribution in 1980–2016. The proportion of total annual natural mortality before spawning was assumed to be 33% and proportion of F before spawning 15% of the annual fishing mortality. The summary of the short-term forecast with different management options are presented in the Table 4.4.8.

The short term forecast showed that fishing mortality at MSY (F_{MSY} = 0.21), the herring catches in the Gulf of Bothnia would be 95.6 thousand tonnes in 2018 with a decrease of SSB by -17%.

Details on the forecast scenarios and results can also be viewed https://www.stock-assessment.org (login:guest, password:guest), choose stock **sam-tmb-gulf-bot-her-an-2.**

4.4.6 Reference points

Reference points for the GoB herring stock were calculated in WKBALT (2017) with upper and lower ranges. The proposed summary table of the Gulf of Bothnia stock reference points is:

Stock	
Reference point	Value
FP.05 (5% risk to Blim) with MSY Btrigger	0.21
FP.05 (5% risk to Blim) without MSY Btrigger	0.180
FMSY	0.21
FMSY lower	0.151
FMSY upper	0.21
Fpa	0.23
Flim	0.29
FMSY upper precautionary	0.20
FMSY range with MSY Btrigger	0.15-0.21
FMSY range without MSY Btrigger	0.15-0.18
MSY Btrigger	283180 t
Bpa	283180 t
Blim	202272 t

4.4.7 Quality of the assessment

The tuning is based on acoustic surveys in the Bothnian Sea since 2007 and commercial trapnet data from the Bothnian Sea herring stock assessments from the years 1990–2006. Trapnet data from later years have not been included in the assessment, because the effort decreased a lot in later years and they are regarded too unreliable. Presently the time series is too short in the acoustic survey data to be used alone (WKBALT 2017).

The results from especially the acoustic survey of 2016 give a very uncertain figure of the stock status, as the estimate of stock numbers decreased a lot for all age-groups compared to the previous year and this large drop is not reflected in the commercial catch data.

Several concerns regarding the trapnet tuning index have been raised in the working group. In short, it is uncertain whether the trapnet index is still representative of the stock in SD 30 & 31; the stock levels estimated by the model are very sensitive to small changes in the model used to produce the tuning index. The acoustic tuning index is showing high variation in the ages in recent years. The survey time series is still relatively short. It is anticipated that extending the acoustic survey time-series will improve the quality of the assessment.

4.4.8 Management considerations

This stock is the resource basis for the herring TAC set for Management Unit III including subdivisions 30 and 31. The current assessment unit in the two subdivisions was previously assessed as two herring stocks, which were merged at the benchmark workshop in 2017 (ICES 2017).

Table 4.4.1. Herring in GOB (SD's 30 and 31). Landings by country (t).

Year	Finland	Sweden	Total
1980	27657	2152	29809
1981	19616	1910	21526
1982	24099	2400	26499
1983	23115	3093	26208
1984	31550	2995	34545
1985	32830	2602	35432
1986	32742	2837	35579
1987	30403	2225	32628
1988	32979	3439	36418
1989	29458	3628	33086
1990	36418	2762	39180
1991	30019	3400	33419
1992	42510	4100	46610
1993	45352	3962	49314
1994	59055	2931	61986
1995	62704	2843	65547
1996	59452	1851	61303
1997	67727	2081	69808
1998	59473	3001	62474
1999	64392	2110	66502
2000	57365	1487	58852
2001	55742	2064	57806
2002	49847	4122	53969
2003	49787	3857	53644
2004	56067	5356	61423
2005	60222	2 689	62 911
2006	69646	1 672	71 318
2007	75108	3 570	78 678
2008	64065	3 849	67 914
2009	67047	4 201	71 248
2010	70658	1 932	72 590
2011	78348	3 502	81 850
2012	99454	6 553	106 007
2013	103421	10 975	114 396
2014	102416	12 950	115 366
2015	100784	14 158	114 942
2016	107803	22 226	130 029

Table 4.4.2. Herring in SD's 30 and 31. Allocation of Swedish unsampled landings.

Swedish non-sampled landings and discards					Allocated accord. to Finnish sampling				
SD	Q	Gear	Category	Tonnes	SD	Q	Gear	Category	Tonnes
30	1	Bottom Trawl	L	1059305	30	1	Pelagic trawl	L	30377
31	3	Bottom Trawl	L	42304	31	3	Pelagic trawl	L	894
31	4	Bottom Trawl	D	1	31	4	Pelagic trawl	L	89
31	4	Bottom Trawl	L	68787	31	4	Pelagic trawl	L	89
30	1	Gillnet	L	5631	30	1	Gillnet	L	1
30	2	Gillnet	D	873	30	2	Gillnet	L	126
31	3	Gillnet	D	2	31	3	Gillnet	L	3
30	3	Gillnet	D	111	30	3	Gillnet	L	18
30	4	Gillnet	D	5	30	4	Gillnet	L	3
30	4	Gillnet	L	30995	30	4	Gillnet	L	3
31	4	Gillnet	L	436	31	4	Gillnet	L	5
31	2	Passive gears	L	8093	31	2	Trapnet	L	237
30	2	Passive gears	L	960	30	2	Trapnet	L	3353
31	3	Passive gears	L	625	31	3	Trapnet	L	23
31	4	Passive gears	L	547	31	4	Trapnet	L	2
30	1	Pelagic trawl	L	5049230	30	1	Pelagic trawl	L	30377
30	2	Pelagic trawl	L	11104200	30	2	Pelagic trawl	L	40372
30	3	Pelagic trawl	L	780000	30	3	Pelagic trawl	L	12835

Table 6.3 Herring in SD's 30 and 31. Landings and sampling by country in 2016.

30		Quarter	Landings in tons	Number of length samples	Number of fish measured	Number of age samples	Number of fish aged
30	Finland	1	30379	13	4137	13	223
		2	43851	25	7226	16	375
		3	12908	13	3144	10	209
		4	16294	19	5935	17	280
		Total	103432	70	20442	56	1087
	Sweden	1	6114	0	0	0	0
		2	12471	5	3329	3	207
		3	1287	4	1799	3	200
		4	2194	3	2216	0	0
		Total	22066	12	7344	6	407
31	Finland	1	15	0	0	0	0
		2	3340	12	3285	7	259
		3	920	5	1550	5	175
		4	96	4	657	2	123
		Total	4371	21	5492	14	557
	Sweden	1	0	0	0	0	0
		2	44	2	857	2	195
		3	46	2	365	2	187
		4	70	0	0	0	0
		Total	159	4	1222	4	382
30 + 31	Finland	1	30394	13	4137	13	223
		2	47190	37	10511	23	634
		3	13828	18	4694	15	384
		4	16390	23	6592	19	403
		Total	107803	91	25934	70	1644
	Sweden	1	6114	0	0	0	
		2	12515	7	4186	5	402
		3	1333	6	2164	5	387
		4	2264	3	2216	0	
		Total	22226	16	8566	10	789
	Finland + Sweden	1	36508	13	4137	13	223
		2	59705	49	13796	28	1036
		3	15161	23	6244	20	771
		4	18654	27	7249	19	403
		Total	**130028**	**107**	**34500**	**80**	**2433**

Table 4.4.4. Herring in SD's 30 and 31. Catch in Numbers (thousands)

	1	2	3	4	5	6	7	8	9	10+
1980	124930	112920	61920	66620	262270	90230	96830	57120	21975	40745
1981	27570	124000	59130	48010	57110	136920	54220	40650	22597	30533
1982	26810	107840	270020	60380	49410	73080	114910	32730	32040	29280
1983	102120	191340	104320	178520	23900	32000	48610	86810	21824	34186
1984	142210	291180	209560	109520	132580	25450	25350	35000	57350	46910
1985	95150	373640	319790	144620	50160	88430	17750	15850	18317	65363
1986	19100	406380	354920	217790	100740	47350	56500	9160	11426	50994
1987	49170	77260	232130	254920	143520	69250	43370	21590	10706	35064
1988	16480	226490	86310	203000	213910	122760	52930	26270	15435	33005
1989	99380	79740	181120	70520	127840	133340	71910	28950	14631	24039
1990	199890	511580	63700	131380	47270	99210	114320	47820	17975	33175
1991	44190	224870	341910	48990	92540	58850	71890	46920	27505	29295
1992	89540	232470	463390	358030	67780	81820	74790	55710	28937	33293
1993	222810	391710	211390	348550	317940	53970	62080	40350	25885	27285
1994	84500	404060	361710	221140	347250	311050	48400	78140	34470	36160
1995	109660	249730	515960	325460	230160	287240	205880	41230	61001	49429
1996	109490	519790	247930	337900	258500	165210	203360	129180	18462	43208
1997	141310	407600	490200	274540	317290	230680	187540	150140	91849	49041
1998	296540	259230	337110	363200	238600	180210	160460	67120	53018	185492
1999	147710	694270	312710	373660	278140	163180	216350	79080	57399	140131
2000	289776	211673	433968	326427	200555	209571	118562	76728	62365	249664
2001	266243	450302	203894	460811	167923	140134	139361	92518	68976	215126
2002	308482	270574	404072	159300	216521	101917	58483	90625	82209	197092
2003	305396	425299	267888	246267	177145	185773	67146	57477	49827	210942
2004	104393	1021965	490316	243896	200519	143971	136323	65848	59707	165796
2005	172165	238898	1189611	337559	182116	161536	87738	95355	76075	163435
2006	176592	292909	132105	1061307	379704	161606	94974	128742	90335	230801
2007	552847	660118	357542	168654	1017283	275806	92438	127731	87818	179484
2008	266434	873384	327757	318645	218789	404664	186749	126807	94630	176538
2009	268319	446210	586402	414737	128103	131399	355613	143488	82792	178957
2010	297532	820306	481726	418950	286816	105453	82757	234997	86170	172487
2011	251376	634214	569108	374424	369070	174016	92440	81609	247597	307835
2012	512943	429102	696213	573553	364869	348220	183169	148802	82567	511352
2013	486237	894795	530634	396023	567340	299623	294588	182312	95551	394846
2014	434458	701891	753506	267860	427997	284267	225170	212795	118943	385511
2015	1378190	913322	725069	450623	325361	247165	222505	150439	112138	288127
2016	821289	1663093	811016	466569	337671	225412	268940	147995	125977	363110

Table 4.4.5. Herring in SD's 30 and 31. Mean weight in catch and in the stock (g).

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10+
1980	8	19	24	33	36	38	41	46	50	57
1981	11	18	27	33	40	42	45	48	55	68
1982	5	15	26	35	39	44	44	51	52	64
1983	5	15	28	36	43	48	49	54	62	68
1984	10	19	30	39	44	52	56	61	60	70
1985	7	16	29	39	45	47	60	60	58	66
1986	8	15	25	33	39	45	48	51	59	62
1987	9	21	28	34	41	46	51	58	60	66
1988	11	18	31	35	41	47	53	61	63	75
1989	10	21	32	41	47	53	57	61	68	74
1990	8	20	32	39	46	51	56	60	69	81
1991	9	20	27	37	42	49	53	55	58	69
1992	12	20	27	31	41	46	51	54	59	67
1993	13	20	27	31	34	46	50	55	60	69
1994	10	20	27	32	35	40	52	57	62	70
1995	7	18	26	29	34	38	44	53	62	77
1996	9	17	25	31	35	39	43	50	58	69
1997	9	15	23	29	34	37	43	48	55	71
1998	8	13	19	26	32	39	44	55	57	68
1999	7	12	20	26	32	40	45	51	58	68
2000	8	13	19	23	28	32	36	41	46	62
2001	8	14	21	25	29	32	39	42	43	55
2002	8	16	24	28	30	34	37	39	47	58
2003	6	15	23	27	30	36	40	40	45	59
2004	5	12	20	25	31	35	40	41	43	56
2005	7	12	18	24	29	30	39	39	42	47
2006	7	13	18	22	27	32	37	40	41	45
2007	6	13	20	22	26	29	34	36	38	49
2008	8	13	19	21	29	28	31	38	41	46
2009	9	16	21	23	30	32	35	38	43	51
2010	9	16	21	26	28	36	34	38	45	50
2011	9	15	22	25	27	29	31	37	38	46
2012	7	15	22	26	30	32	37	40	43	50
2013	10	17	23	25	30	34	37	38	47	52
2014	10	17	24	30	32	37	43	50	47	55
2015	10	16	23	29	31	38	41	45	48	54
2016	11	16	22	27	31	35	37	42	50	59

Table 4.4.6. Herring in SD's 30 and 31. Proportion of mature at age.

	1	2	3	4	5	6	7	8	9	10+
1980	0	0.31	0.92	0.97	1	1	1	1	1	1
1981	0	0.31	0.93	0.97	1	1	1	1	1	1
1982	0	0.29	0.93	0.97	1	1	1	1	1	1
1983	0	0.21	0.92	0.98	1	1	1	1	1	1
1984	0	0.23	0.93	0.97	1	1	1	1	1	1
1985	0	0.2	0.92	0.99	1	1	1	1	1	1
1986	0	0.28	0.91	0.97	1	1	1	1	1	1
1987	0	0.32	0.89	0.97	1	1	1	1	1	1
1988	0	0.1	0.85	0.96	1	1	1	1	1	1
1989	0	0.23	0.97	1	1	1	1	1	1	1
1990	0	0.59	1	1	1	1	1	1	1	1
1991	0	0.59	0.94	1	1	1	1	1	1	1
1992	0	0.5	0.9	1	1	1	1	1	1	1
1993	0	0.44	0.82	0.97	1	1	1	1	1	1
1994	0	0.63	0.97	1	1	1	1	1	1	1
1995	0	0.35	0.91	0.95	1	1	1	1	1	1
1996	0	0.66	1	1	1	1	1	1	1	1
1997	0	0.32	0.84	0.97	1	1	1	1	1	1
1998	0.03	0.33	0.72	0.96	1	1	1	1	1	1
1999	0.01	0.38	0.88	0.99	1	1	1	1	1	1
2000	0.11	0.65	0.93	0.98	1	1	1	1	1	1
2001	0.01	0.61	0.97	0.97	1	1	1	1	1	1
2002	0.03	0.58	0.96	0.97	0.99	0.96	1	1	1	1
2003	0	0.56	0.94	0.97	0.96	1	1	0.89	0.89	1
2004	0.02	0.34	0.91	0.97	1	1	1	1	1	0.96
2005	0.02	0.28	0.86	0.96	0.94	0.97	1	1	1	0.96
2006	0.02	0.37	0.92	0.91	1	0.94	1	1	1	1
2007	0.02	0.56	0.87	1	0.96	1	1	0.9	1	0.97
2008	0	0.5	0.91	1	0.93	1	1	1	1	0.94
2009	0	0.51	0.91	0.95	0.95	0.91	0.97	0.97	1	1
2010	0.05	0.87	1	1	1	1	1	1	1	1
2011	0.01	0.46	1	1	1	1	1	1	1	0.97
2012	0.01	0.75	0.97	0.98	1	1	0.94	1	1	0.99
2013	0.11	0.78	0.98	1	1	1	1	1	1	0.98
2014	0.16	0.71	1	1	1	1	0.94	0.95	1	1
2015	0.13	0.8	0.98	1	1	1	1	1	1	1
2016	0.05	0.72	0.9	1	1	1	1	1	1	0.92

Table 4.4.7. Herring in SD's 30 and 31. SAM output summary table. Historical stock trends of Gulf of Bothnia herring in 1980–2016.

Year	Recruits Age 1 Thousands	Low	High	TSB	Low	High	SSB tonnes	Low	High	Landings tonnes	F_{3-7}	Low	High
1980	3197884	1937289	5278751	234216	163355	335816	181498	121852	270341	29809	0.147	0.101	0.214
1981	1486597	965846	2288118	228662	161387	323981	170076	114691	252206	13700	0.14	0.098	0.199
1982	1998685	1224717	3261768	224583	158267	318685	183322	125394	268010	17847	0.144	0.102	0.203
1983	4506359	2984492	6804264	256017	183062	358047	192144	131539	280671	18501	0.137	0.099	0.19
1984	5700133	3731646	8707019	359691	264850	488493	229349	160271	328201	25629	0.138	0.1	0.19
1985	4551648	3020763	6858368	368060	276864	489295	253470	184145	348893	26120	0.131	0.096	0.177
1986	1408449	923144	2148886	350459	267175	459705	268606	200767	359367	26489	0.125	0.093	0.167
1987	3156581	2081710	4786452	378511	291822	490951	301945	228699	398650	24520	0.118	0.089	0.156
1988	1415509	920673	2176307	389259	299725	505539	300139	226011	398579	27650	0.113	0.086	0.148
1989	6420458	4202205	9809678	444631	345566	572095	337392	257599	441900	28658	0.103	0.079	0.135
1990	7912861	5199744	12041626	519177	406484	663113	379269	293479	490137	31282	0.097	0.074	0.128
1991	3265750	2104061	5068827	519177	407754	661047	409626	319969	524405	26219	0.095	0.073	0.125
1992	4891453	3291915	7268206	591253	471871	740840	457714	360613	580962	39310	0.102	0.08	0.131
1993	7060313	4668554	10677401	636029	515122	785315	448651	357625	562845	40179	0.107	0.084	0.137
1994	3488561	2381497	5110256	649527	530131	795813	536059	433601	662728	56380	0.122	0.098	0.152
1995	4657549	3139644	6909308	596002	488288	727479	483110	391312	596444	61086	0.138	0.112	0.171
1996	3945160	2697889	5769062	569207	468453	691632	474492	386714	582195	56109	0.149	0.121	0.184
1997	3652783	2503099	5330523	543074	446957	659859	429768	348872	529421	65527	0.17	0.137	0.21
1998	6058665	4161891	8819890	515555	422000	629852	398714	320719	495677	56892	0.176	0.142	0.217
1999	2969785	2025161	4355021	491393	401989	600681	395933	319285	490981	62345	0.183	0.148	0.227
2000	5065685	3483681	7366108	434956	356048	531352	356112	287846	440568	56261	0.177	0.144	0.217
2001	4506359	3039368	6681413	430198	353907	522934	342491	278519	421157	54984	0.167	0.136	0.204
2002	6446191	4439623	9359664	443743	365484	538758	340783	277423	418612	50218	0.152	0.124	0.186
2003	9341711	5812376	15014095	461390	378774	562026	336381	274927	411572	49638	0.15	0.122	0.183
2004	2782889	1903567	4068399	478303	395109	579015	346972	285809	421224	55450	0.152	0.125	0.185
2005	3898101	2684325	5660711	484077	402348	582409	379269	312799	459863	57942	0.15	0.123	0.182
2006	4799393	3280020	7022571	488454	407088	586083	382315	315907	462682	68365	0.153	0.126	0.186
2007	8745064	6034479	12673199	514011	427751	617667	390038	322107	472296	75432	0.157	0.129	0.192
2008	5493082	3880599	7775591	505347	418601	610068	380028	312586	462021	65430	0.157	0.128	0.192
2009	6715978	4627003	9748071	573206	472388	695540	424641	347382	519083	68873	0.154	0.125	0.189
2010	6543613	4633949	9240255	598391	491940	727877	491393	401130	601968	72590	0.153	0.124	0.19
2011	5121716	3609862	7266752	596599	490371	725838	467895	381177	574342	81850	0.159	0.128	0.196
2012	8903901	6158846	12872451	658026	539005	803329	530725	430663	654038	100640	0.179	0.144	0.222
2013	7224582	5120589	10193084	709276	580160	867126	570347	462379	703526	114395.6	0.192	0.154	0.24
2014	7968446	5514436	11514527	736011	598403	905262	587129	472598	729416	115366	0.199	0.158	0.25
2015	12188458	8192585	18133289	741181	596038	921668	564672	450233	708199	114941.8	0.212	0.167	0.271
2016	6695860	3572728	12549106	703624	548466	902677	529136	410881	681424	130028.6	0.225	0.172	0.295
Average	5248276	3517675	7854298	497872	399811	621023	385178	305609	486611	55856	0.14927	0.117324	0.190297

Table 4.4.8. Herring in SD's 30 and 31. Short-term forecast with different management options of the Gulf of Bothnia herring.

VARIABLE	FBAR17	FBAR18	FBAR19	SSB19	SSB% CHANGE	C18	C19
MSY lower	0.283	0.151	0.151	462502	-12	70617	70766
MSY	0.283	0.21	0.21	434037	-17	95566	90783
MSY upper	0.283	0.21	0.21	434037	-17	95566	90783
Fpa	0.283	0.23	0.23	425100	-19	103591	96890
Flim	0.283	0.29	0.29	397958	-24	126860	112171
Fsq	0.283	0.283	0.283	401010	-24	124250	110379
Fsq, then 0	0.283	0	0	543176	3	0	0

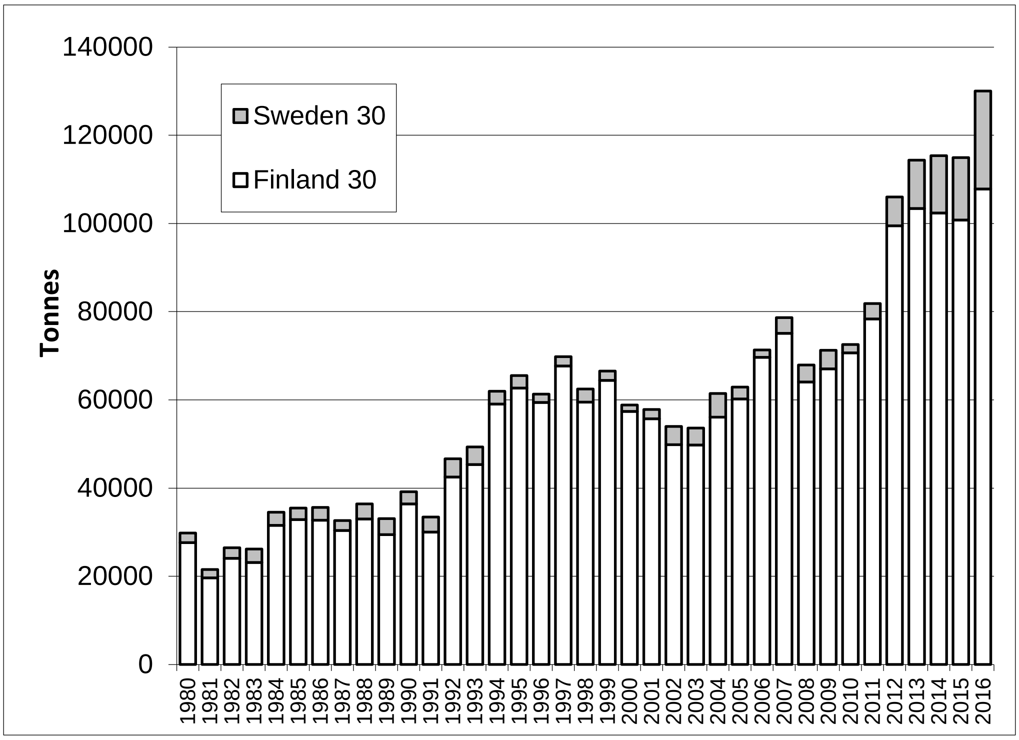


Figure 4.4.1. Herring in SD's 30 and 31. Landings by country.

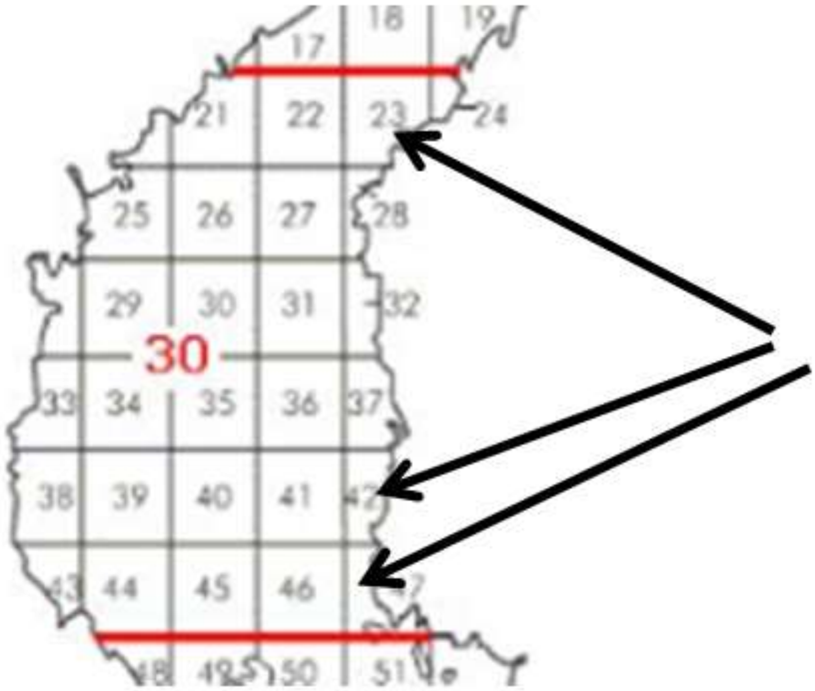


Figure 4.4.2. Herring in SD's 30 and 31. The areas of unbroken time series of catch and effort data for trapnet tuning-series.

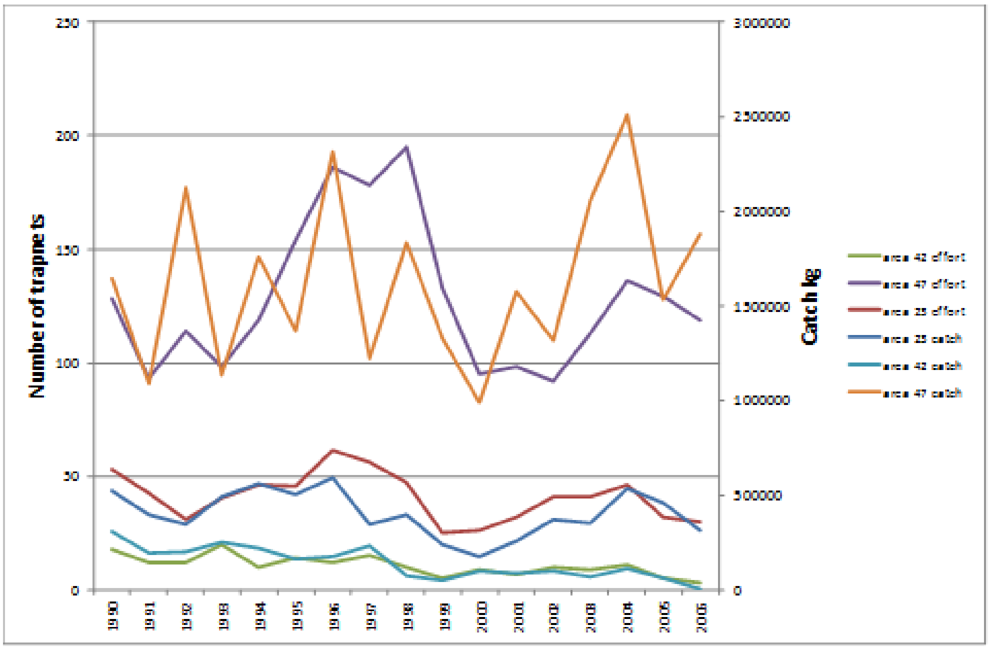


Figure 4.4.3. Herring in SD's 30 and 31. Trapnets catch (kg) and effort (number of traps) in three different areas (see map Figure 4.4.2) used to calculate the trap net tuning index for the spaly assessment.

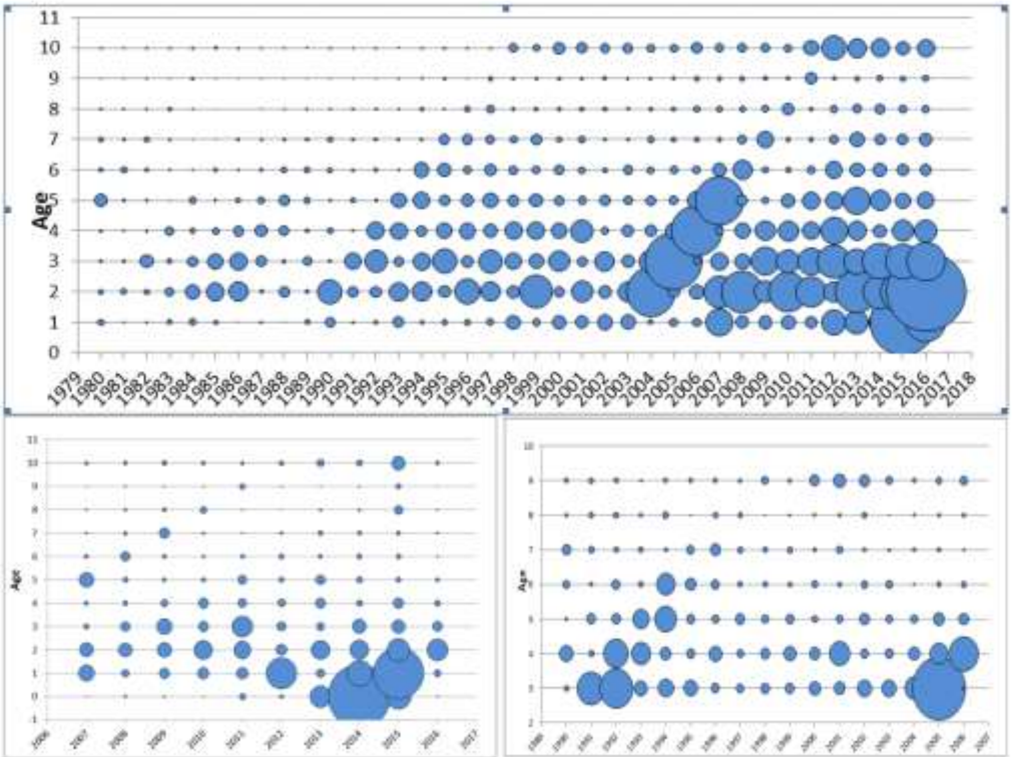


Figure 4.4.4. Herring in SD's 30 and 31. Age composition in commercial catch and CPUE by age in trapnets and acoustic survey.

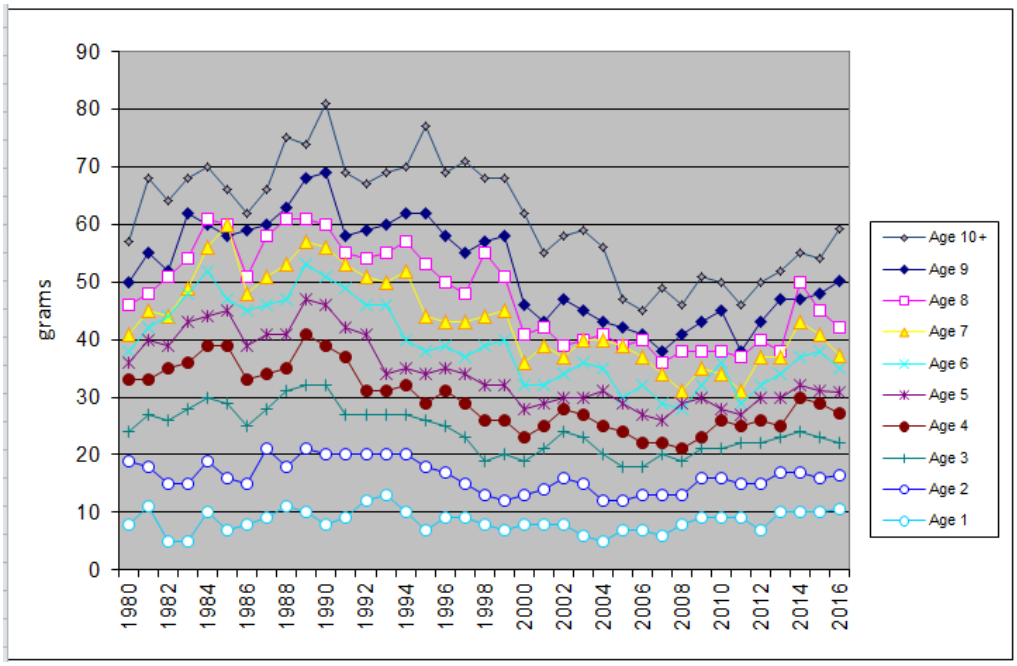


Figure 4.4.5. **Herring in SD's 30 and 31. Weights at age in catches and in stock**

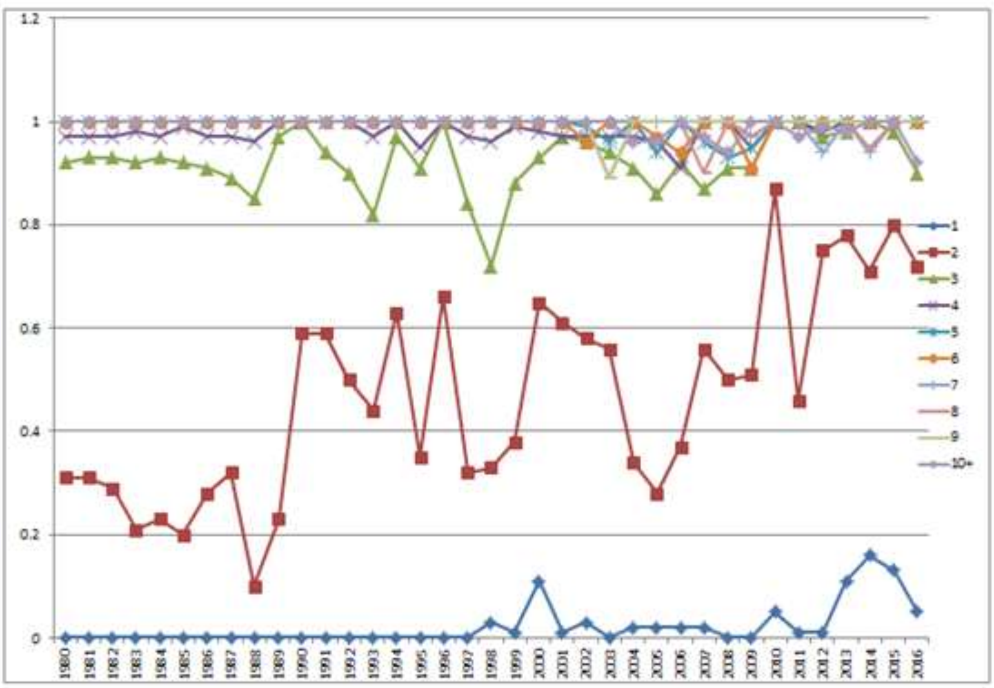


Figure 4.4.6. **Herring in SD's 30 and 31. Maturity ogives.**

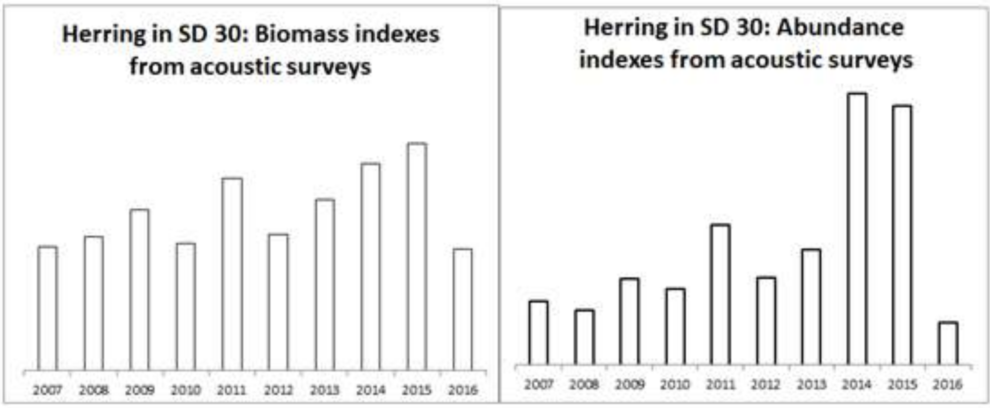
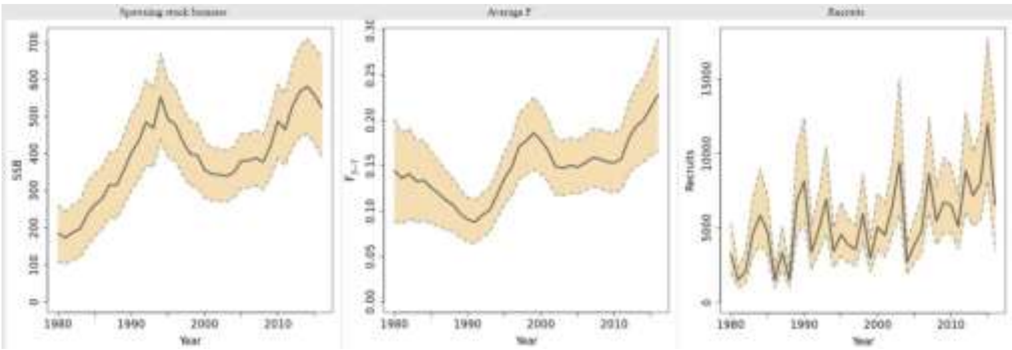


Figure 4.4.7. Herring in SD's 30 and 31. Abundance and biomass indexes from 2007-2016 Bothnian acoustic surveys.



Figures 4.4.8.-10. Herring in SD's 30 and 31. Estimated SSB, F and age 1 recruitment of Gulf of Bothnia herring in 1980 - 2016.

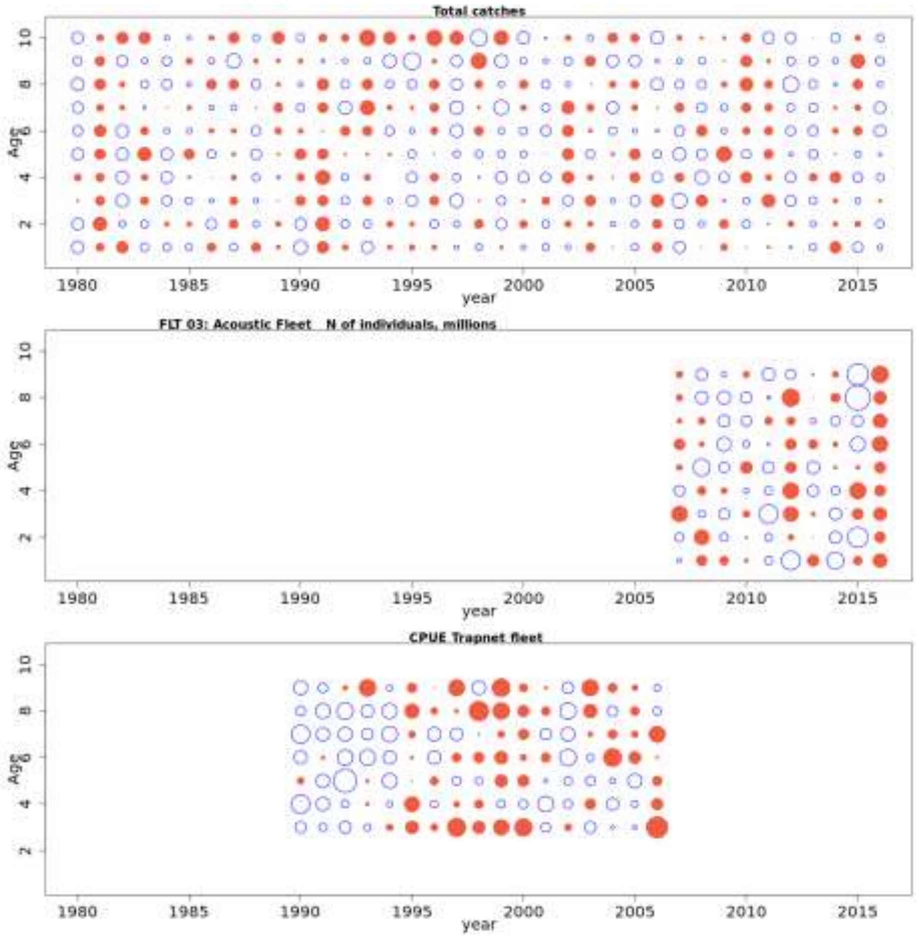


Figure 4.4.11. Herring in SD's 30 and 31. Normalized residuals of three Gulf of Bothnia fleets in 1980 – 2016, catch data (top), acoustic index and CPUE from trapnet data. Red filled circles indicate negative residuals and blue open circles positive residuals.

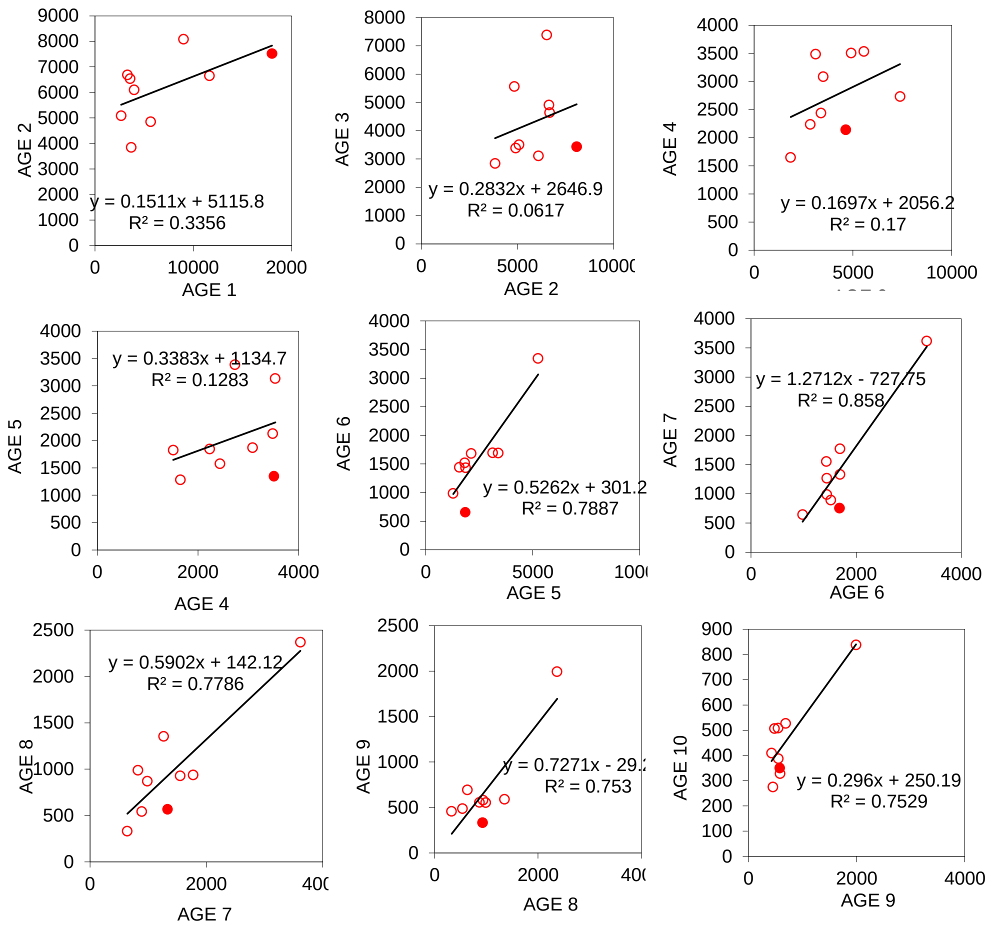


Figure 4.4.12. Herring in SD's 30 and 31. Consistencies of the different ages within Gulf of Bothnia herring hydroacoustic abundance indices. The full dot represents the latest estimates.

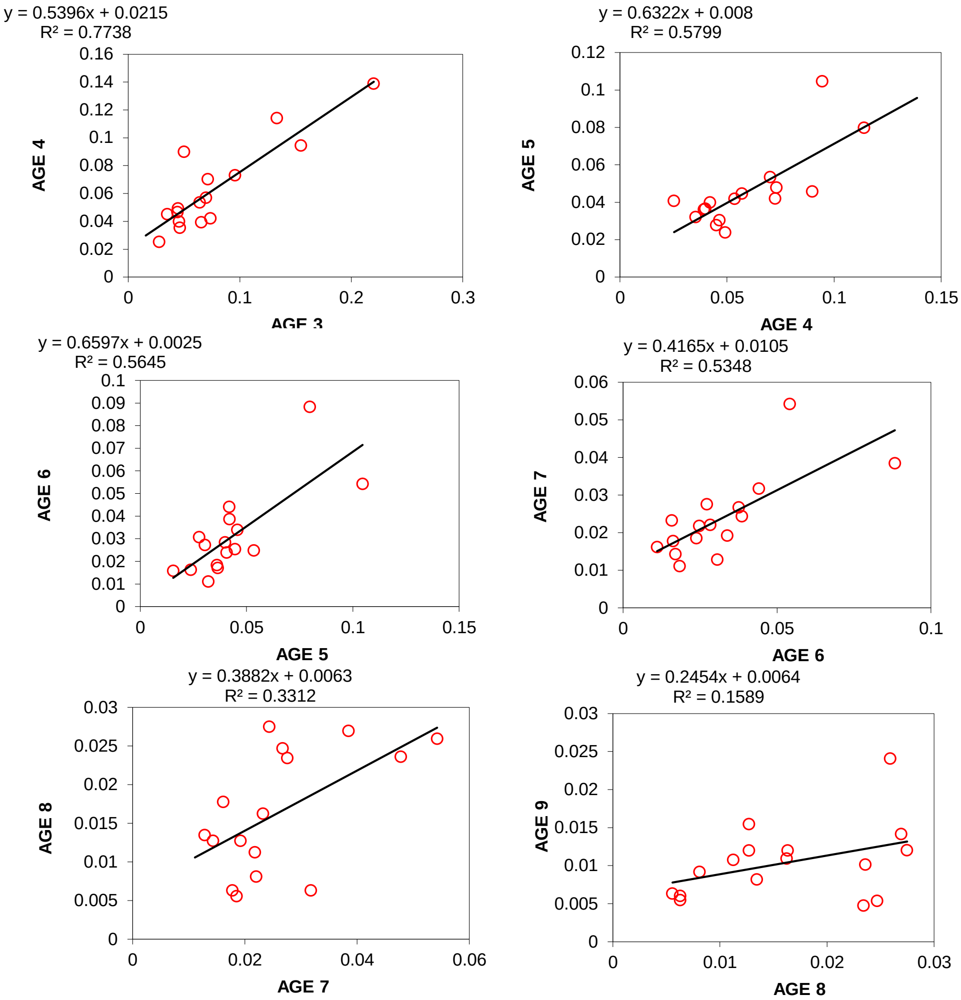


Figure 4.4.13. **Herring in SD's 30 and 31. Consistencies of the different ages within Gulf of Bothnia herring trapnet abundance indices.**

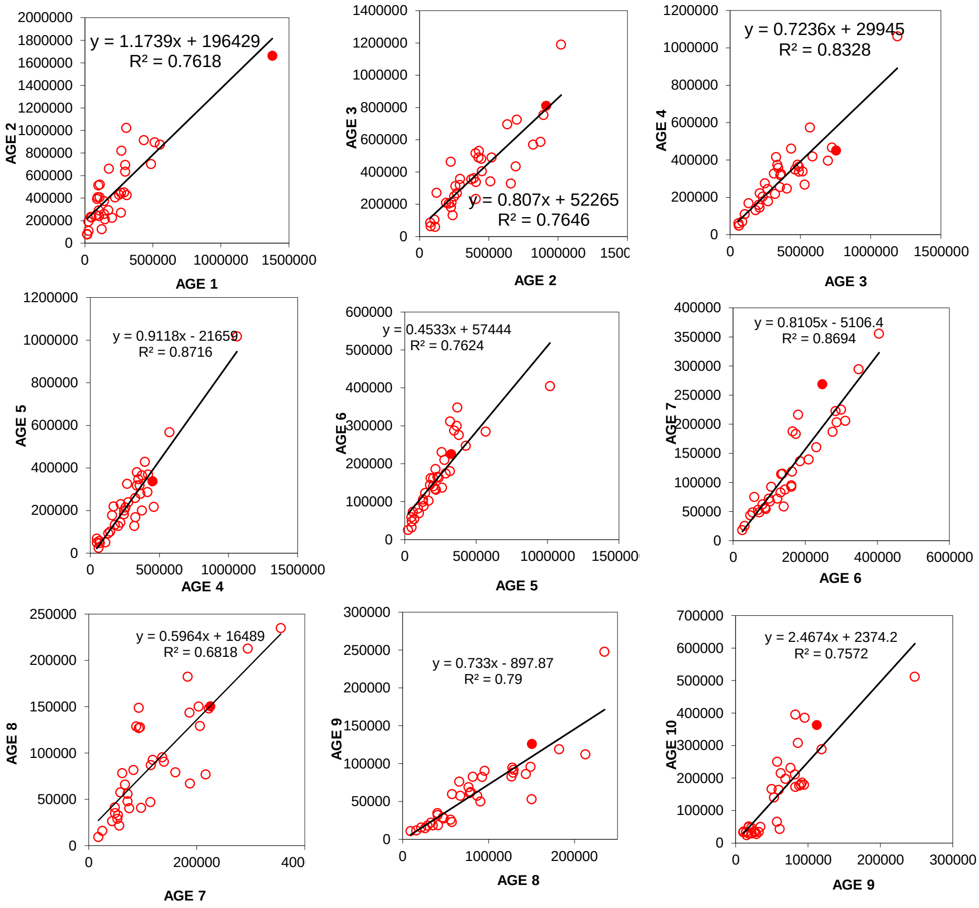


Figure 4.4.14. Herring in SD's 30 and 31Consistencies of the different ages within Gulf of Bothnia herring catch data.

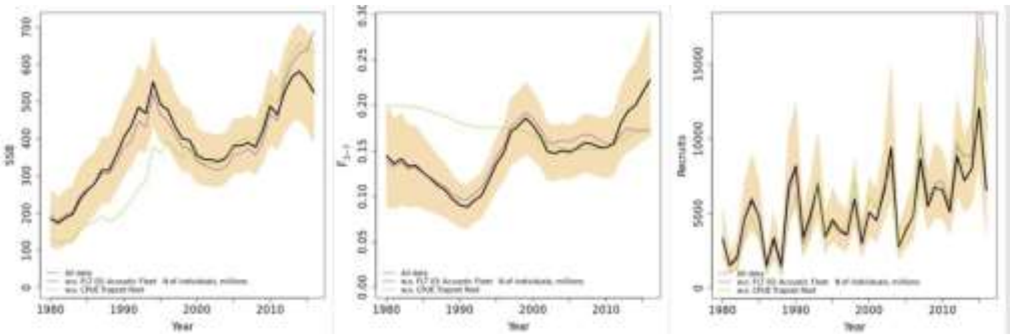


Figure 4.4.15. Herring in SD's 30 and 31. Leave-one-out runs of the Gulf of Bothnia herring stock in 1980 - 2016.

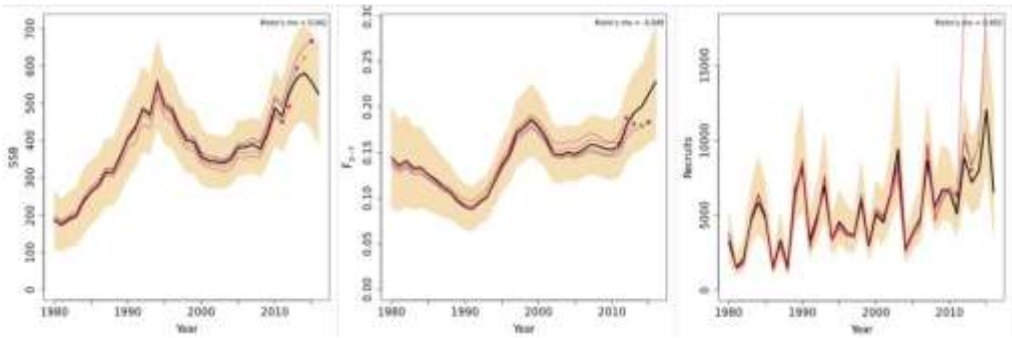


Figure 4.4.16. Herring in SD's 30 and 31. Retrospective analysis of the Gulf of Bothnia herring stock in 1980 - 2016.

5 Plaice

5.1 Introduction

5.1.1 Biology

5.1.1.1 Assessment units for plaice stocks

The plaice stocks within inner Danish waters and the Baltic consists of two stocks. One stock (PLE27.21–23) is defined by the Sub-division 27.21 (=Kattegat), Sub-division 27.23 (= the Sound) and Sub-division 27.22 (=Belt area and western part of the Baltic Sea). The other stock (PLE27.24–32) is defined by the area east of Bornholm in the Baltic Sea. Each stock is manages based on individual assessments. PLE27.21–23 is category 1 stock and PLE27.24–32 is a category 3 stock.

5.2 Plaice in subdivisions 27.21-23 (Kattegat, the Sound and Western Baltic)

This stock id is a result of the recommendation made by the benchmark workshop WKPLE in February 2015 (ICES 2015) and later by the Stock Identification Method Working Group (SIMWG) in June 2015, which confirmed the revised stock structure for the plaice stocks in the North Sea, Skagerrak, Kattegat and the Baltic Sea recommendation made by ICES WKPESTO (2012). Plaice in Skagerrak is now included in the North Sea stock. Kattegat and Subdivision 22 and 23 are merged into one stock and Subdivision 24–32 is regarded as one separate stock. The stock was as a consequence of the benchmark in February 2015 upgraded to category 1 (full analytical age based assessment).

The SAM State Based model was used for the assessment.

5.2.1 The fishery

5.2.1.1 Technical conservation measures

Minimum Landing Size in SD 27.21 is 27 cm.

Minimum Landing Size in SD 27.22 and SD 27.23 is 25 cm.

The closed season for spawning females in SD 7.22 and 27.23 from 15/1 to 30/4, which was introduced in the mid-sixties has been given up from the beginning of 2017.

In the Sund (SD 23) trawling is only allowed in the northern-most part and as this area was also included in zone to protect spawning cod in Kattegat trawling is forbidden in February and March were the cod is on spawning migration.

In SD 22 the BACOMA exit window is implemented. This is a square mesh window inserted in the top panel of the cod-end. The mesh size in the exit panel was increased to from 110 to 120 mm in 2010.

In Kattegat the plaice fishery is very much connected to the cod fishery and as part of the Danish cod recovery plan introduced in 2011 it is mandatory in Danish fisheries to use a SELTRA trawl with 180 mm panel during the first three quarters of a year. In 2009, as a part of the attempts to rebuild of the cod stock in Kattegat, Denmark and Sweden, introduced protected areas on historically important spawning grounds in South East Kattegat. The protected zone consists of three different areas in which the fisheries are either completely forbidden or limited to certain selective gears (Swedish grid and Danish SELTRA 300 trawl) during all or different periods of the year.

From 1st of January 2017 landings obligations are introduced in SD 22 and 23. This will have implications for the catches in 2017 as well as the management and catch opportunities in 2017. For the implications for the management please see below.

5.2.1.2 Landings

The annual landings are available since 1970 (SD 22) and 1972 (SD 21) and are given by Sub-Division and country separately in Table 5.2.1. The landings by subdivision are plotted in figure 5.2.1 and by country in figure 5.2.2 The landing by country and the TAC for each subdivision is given in figure 5.2.2x1 and figure 5.2.2x2. Discard and landings (2016) by gear type and quarter is given in table 5.2.3 and figure 5.2.3.

5.2.1.3 Unallocated removals

No significant misreporting is believed to take place.

5.2.1.4 Discards

Discard data are only available back to 2002 but the discard amount is extrapolated three years backwards to 1999 by the average discards from 2002–2004. SAM can handle if minor gaps exist the data series but cannot handle long periods of missing data. As discard information are only available back to 2002, the discard time series is extended three years back to 1999 in order to provide a time series sufficiently long for the assessment. The discard estimates are processed in InterCatch and consistent throughout the whole time series (2002–2016). Historical landings and discards by country is given in Figure 5.2.6.

Discard and landings in 2016 in tons by gear type, country and quarter is given in table 5.2.4.

5.2.1.5 Effort and cpue data

Effort data from Sweden and Denmark only is available in InterCatch back to 2013. Data from Germany is available from 2002 and on although the units are not consistent throughout the series.

5.2.2 Biological information

5.2.2.1 Age composition

Since 2004, Denmark and Sweden have put a significant amount of effort into increasing the quality of age reading for plaice in Kattegat through a series of workshops and otolith exchanges between age readers. During the WGBFAS in 2015 it was demonstrated that significant inconsistencies between readers particularly from Denmark and circulation of otoliths between the three countries were initiated. The results of the exercise were available in March 2016 and confirm the inconsistency particularly between the reading methods applied (reading of whole and sliced otoliths). No solution to solve the quality issues was provided in the report and it is not possible to introduce actions to overcome the quality issue for the time being.

Catch at age were raised using ICES InterCatch database.

Relative age distributions in the discard and landing by year are presented on figures 5.2.4 and 5.2.5.

5.2.2.2 Mean weight at age

Weight at age in catch is presented in Table 5.2.6 and in figure 5.2.7. Mean weight in stock is obtained from Combined 1 quarter surveys but is used as an average from 2002–2016. Weight in stock is shown in figure 5.2.8.

5.2.2.3 Natural mortality

Natural mortality is assumed constant for all years and is set at 0.1 for all ages except age 1, which is set to 0.2.

5.2.2.4 Maturity-at-age

The annual maturity ogives was revised for the ICES WKPLE in 2015 and is based on the average from 2002–2016 from information from the Combined 1q survey Figure 5.2.9.

5.2.2.5 Quality of catch and biological data

The sampling of the commercial catches is relatively god except for Sub-division 23 where no sampling is made by either Sweden or Denmark (Table 5.2.2). This has to be seen in the light of the relative limited catches from that area (3.2% of total catch).

It is acknowledged that the variability of growth as well as inconsistency in age readings are important sources of uncertainty in the catch matrix.

The internal consistency of the catch matrix is rather good for age 3, 4 and 5 and less good for other ages. The plots are shown in figure 5.2.19.

5.2.3 Fishery independent information

Only scientific tuning fleets are used. Data from two tuning series are used. These two series are constructed by the combination of 1st quarter NS-IBTS and the 1st quarter BITS and the combination of 3rd quarter NS-IBTS and 4th quarter BITS. The surveys are combined using the GAM approach (Berg *et al.* 2013) considering the uneven distributions of the two surveys.

Very few plaice aged 0 (4th quarter) are caught during the surveys and these are removed from the analysis.

Index time series at age for Combined 1st and Combined 3rd and 4th quarter are given in Figure 5.2.10–11.

The “Leave one-out analysis” shows that both combined survey are given significant weight (Figure. 5.2.15). The retrospective analysis is quite robust considering the short time series (Figure. 5.2.13). Some year effect can be seen in the residuals in the late years (2017, 1st quarter) but otherwise without any expressed pattern (Figure 5.2.16).

The internal consistency for combined 1st quarter survey and 3rd +4th quarter combined survey are given in figure 5.2.17 and figure 5.2.18 respectively and both are acceptable despite the age interpretation problems in the stock.

5.2.4 Assessment

The stock was as a result of the WKPLE in February 2015 upgraded to Category 1 (Full annual age based analytical assessment). The State based Assessment Model (SAM) is used. The assessment is an update of the benchmark assessment (WKPLE) and the settings are according to the stock annex (PLE 27.21-23).

5.2.4.1 Recruitment estimates

The recruitment in 2016 is estimated to around 35 mill. This is at the same level as estimated for 2015 and can be considered as a stable recruitment in the whole time series (1999–2016). The historic trend is given in Figure 5.2.12c and Table 5.2.7.

5.2.4.2 SAM

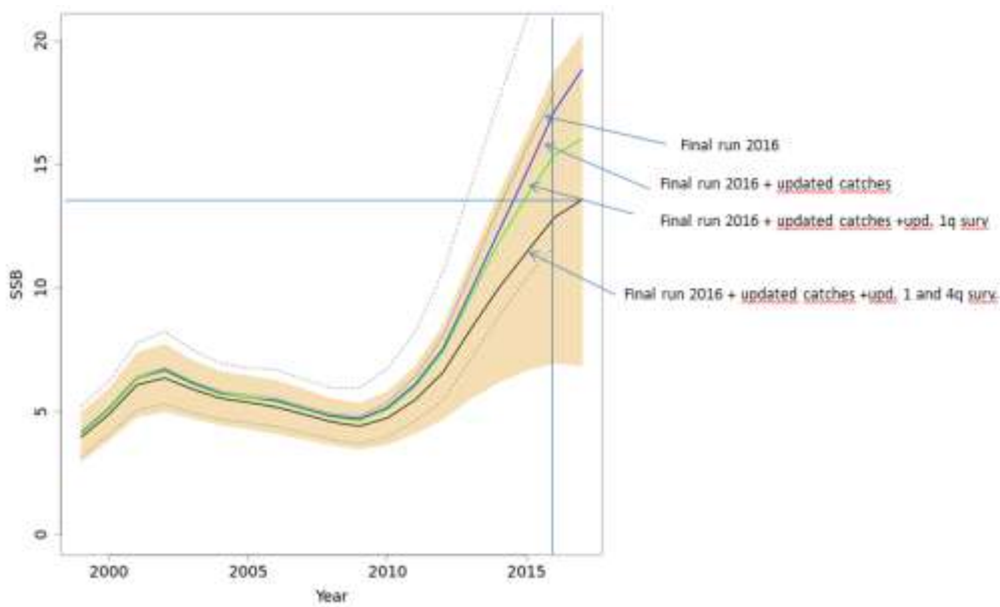
The final run in SAM is named: PLE21_23_WGBFAS_2017_final_run. The assessment available at "stockassessment.org" and is visible for everybody.

The input data are given in the table 5.2.6a to table 5.2.6i.

F and M before spawning are both set to 0.

5.2.4.3 Historical stock trends

The stock is in a very good condition. The result shows (Figure 5.2.12abc and tab. 5.2.7) an increase in SSB from estimated 11340 tons in 2015 to 12759 tons in 2016 and estimated to 13487tons in 2017. This is actually a decrease of 25 % compared to last year assessment. It was verified that the drop was not a consequence of the change in survey calibration procedure compared to last year and not because of the update of the maturity ogive (re-running final 2017 assessment with the calibration procedure used last year and last year maturity ogive) but instead was caused by accumulative consequence of decreased index values for all age groups (except age1 in 4q) in both survey series and the added year in the catch matrix. This was demonstrated by successive adding of the surveys and the updated catch matrix to the 2016 final assessment. The estimated SSB for each of the described steps is shown in the text figure below where it can be seen that the sum of all three changes lead to an assessment result comparable to the final 2017 assessment.



Text figure showing the transforming of the SSB graph to something comparable to the 2017 assessment by successively adding the 2017 data to the final assessment of 2016.

The F in 2016 has increased compared to last year from 0.18 to 0.28 after showing constantly decreasing in the whole period. This is the case for all age groups (Table. 5.2.8

and Figure 5.2.14). The recruitment is regarded as constant but with significant variation. The recruitment in 2016 is estimated to 30 mill.

5.2.5 Short-term forecast and management options

The short term forecast was made according to the stock annex using the SAM assessment software. The recruitment in 2017 is estimated by SAM based on the 1 quarter 2017 survey. The recruitment is regarded as stable in the whole time series (Figure 5.2.12c) and the recruitment for 2018 and on is estimated by sampling the whole time series.

5.2.6 Reference points

All reference points were available and unchanged compared to last year.

5.2.7 Quality of assessment

The assessment suffers from a relative short time-series (1999–2016) and the confidence limits are in general quite large. Technically the assessment performs quite well even though some patterns are shown in residuals for catch matrix and tuning series.

5.2.8 Comparison with previous assessment

The assessment in 2017 does not change the conception of the stock from last year assessment.

5.2.9 Manageme issues

The management areas for plaice in the Baltic Sea (i.e. Subdivision (SD) 21 and SDs 22−32) are different from the stock areas (i.e. SDs 21−23 and 24−32). The following shows an option for calculating TAC by management area based on the catch distribution observed in 2016. The catch ratio between SD 21 and SDs 22−23 in 2016 was used to calculate a split of the advised catches for 2018, and a similar calculation was done for the landings only. The advised catch for the stock in SDs 24−32 (Section 5.3.16) was added to the calculated catch for SDs 22−23 to obtain plaice catches by management area that would be consistent with the ICES advice for the two stocks. This results in catches of no more than 2237 tonnes in SD 21 and 6272 tonnes in SDs 22−32. The corresponding wanted catches would be no more than 1467 tonnes in SD 21 and 4106 tonnes in SDs 22−32.

Basis		Catch 2016	Landings 2016	ICES stock advice 2018 (catch)	ICES stock advice 2018 (corresponding wanted catch)
Stock area based	SDs 21–23	4521	3020	5405	4005
	SDs 24–32	1580	521	3104	1568
Total advised catch and corresponding wanted catch, 2018 (SDs 21–32)				8509	5573
Management area based	SD 21	1871	1106		
	SDs 22–23	2650	1914		
	SDs 22–32	4230	2435		

	calculation	results
Share of SDs 21–23 2016 catch in SD 21	1871 t / 4521 t t (catch 2016 SD 21 / catch 2016 SDs 21–23)	0.414
Catch 2018 for SD 21	5405 t × 0.414 (ICES stock advice 2018 (catch) for SDs 21–23 × share)	2237
Catch 2018 for SDs 22–32	8509 t – 2237 t (total advised catch 2018 SDs 21–32 – catch SD 21)	6272
Share of SDs 21–23 2016 landings in SD 21	1106 t / 3020 t (landings 2016 SD 21 / landings 2016 SDs 21–23)	0.366
Wanted catch 2018 for SD 21	4005 t × 0.366 (ICES stock advice 2018 (wanted catch) for SDs 21–23 × share)	1467
Wanted catch 2018 for SDs 22–32	5573 t – 1467 t (wanted catch 2018 SDs 21–32 − wanted catch SD 21)	4106

Table 8.2 1. Plaice in SD 27.21–23. Official landings (t) by sub-Division and country. 1970–2016.

Year/SD	21-Denmark	21-Germany	21-Sweden	22-Denmark	22-Germany	22-Sweden	23-Sweden	23-Denmark
	21	21	21	22	22	22	23	23
1970				3,757	202			
1971				3,435	160			
1972	15,504	77	348	2,726	154			
1973	10,021	48	231	2,399	165			
1974	11,401	52	255	3,440	202			
1975	10,158	39	296	2,814	313			
1976	9,487	32	177	3,328	313			
1977	11,611	32	300	3,452	353			
1978	12,685	100	312	3,848	379			
1979	9,721	38	333	3,554	205			
1980	5,582	40	313	2,216	89			
1981	3,803	42	256	1,193	80			
1982	2,717	19	238	716	45			
1983	3,280	36	334	901	42			
1984	3,252	31	388	803	30			
1985	2,979	4	403	648	94			
1986	2,470	2	202	570	59			
1987	2,846	3	307	414	18			
1988	1,820	0	210	234	10			
1989	1,609	0	135	167	7			
1990	1,830	2	202	236	9			
1991	1,737	19	265	328	15			
1992	2,068	101	208	316	11			
1993	1,294	0	175	171	16		2	
1994	1,547	0	227	355	1		6	
1995	1,254	0	133	601	75		12	64
1996	2,337	0	205	859	43	1	13	81
1997	2,198	25	255	902	51		13	
1998	1,786	10	185	642	213		13	
1999	1,510	20	161	1,456	244	1	13	
2000	1,644	10	184	1,932	140		26	
2001	2,069		260	1,627	58		39	
2002	1,806	26	198	1,759	46		42	
2003	2,037	6	253	1024	35	0	26	
2004	1,395	77	137	911	60		35	
2005	1,104	47	100	908	51		35	145
2006	1,355	20	175	600	46		39	166
2007	1,198	10	172	894	63		69	193
2008	866	6	136	750	92	0	45	116
2009	570	5	84	633	194	0	42	139
2010	428	3	66	748	221	0	17	57
2011	328	0	40	851	310		11	46
2012	196	0	30	1189	365	7	12	54
2013	232	0	60	1253	319	0	76	14
2014	343	1	68	1097	320	0	45	57
2015	807	0	87	1103	560	0	103	26
2016	984	1	121	1108	680	0	107	20

Table 5.2.2. Plaice in SD 27.21–23. Sampling effort 2016 by country, gear type and area.

Row Labels	CATON (T)	length sanples	No length mesures	No of age samples	No of age readings
27.3.a.21					
Active					
Discards					
Denmark	611	37	2690	37	631
Germany	1	0	0	0	0
Sweden	130	28	1901	28	636
Landings					
Denmark	790	7	2648	7	506
Germany	1	0	0	0	0
Sweden	107	0	0	0	0
Passive					
Discards					
Denmark	22	0	0	0	0
Sweden	1	0	0	0	0
Landings					
Denmark	193	7	2648	7	506
Sweden	14	0	0	0	0
MIS_MIS_0_0_0_HC					
Discards					
Germany	0	0	0	0	0
Landings					
Germany	0	0	0	0	0
27.3.b.23					
Active					
Discards					
Denmark	6	0	0	0	0
Sweden	1	0	0	0	0
Landings					
Denmark	9	2	297	2	95
Sweden	1	0	0	0	0
Passive					
Discards					
Denmark	11	0	0	0	0
Sweden	1	0	0	0	0
Landings					
Denmark	98	2	297	2	95
Sweden	18	0	0	0	0
27.3.c.22					
Active					
Discards					
Denmark	471	23	2400	23	293
Germany	110	14	651	14	324
Landings					
Denmark	728	14	3712	14	878
Germany	540	14	2031	14	824
Passive					
Discards					
Denmark	102	0	0	0	0
Germany	33	5	191	5	19
Landings					
Denmark	380	14	3712	14	878
Germany	140	24	1175	24	437
Sweden	0	0	0	0	0
Grand Total	4521	191	24353	191	6122

Table 5.2.3. Plaice in SD 27.21–23. Landings (tons) and discard (tons) in 2016 by Subdivision, catch category, and quarter.

Sum of CATON (Tons)	Column Labels					
Row Labels	1	2	3	4	Grand Total	
27.3.a.21	267	444	573	587	1871	
Discards	146	232	298	90	765	
Active	142	230	285	86	743	
Passive	4	2	12	4	23	
MIS_MIS_000_HC					0	0
Landings	121	213	275	497	1106	
Active	105	141	184	467	898	
Passive	15	72	91	30	208	
MIS_MIS_000_HC					0	0
27.3.b.23	10	38	64	33	145	
Discards	4	3	7	4	18	
Active	2	2	0	1	7	
Passive	1	1	6	3	12	
Landings	7	35	57	29	127	
Active	2	1	0	7	10	
Passive	5	33	57	22	117	
27.3.c.22	968	532	209	796	2505	
Discards	439	116	49	113	717	
Active	423	97	3	59	582	
Passive	16	19	46	54	135	
Landings	529	416	160	683	1788	
Active	438	272	51	506	1268	
Passive	91	144	108	176	520	
Grand Total	1245	1015	846	1415	4521	

Table 5.2.4. Plaice in SD 27.21–23. Landings (kg) and discard (kg) in 2016 by Subdivision, catch category, country and quarter.

Sum of CATON (Tons)	Column Labels				
Row Labels	1	2	3	4	Grand Total
Denmark	928	723	740	1031	3422
27.3.a.21	198	379	517	523	1617
Discards	107	184	271	71	633
Active	102	183	259	68	611
Passive	4	2	12	3	22
Landings	91	195	246	451	984
Active	76	128	160	426	790
Passive	15	66	87	25	193
27.3.b.23	9	33	53	29	124
Discards	4	3	7	4	17
Active	2	2	0	1	6
Passive	1	1	6	3	11
Landings	6	30	46	25	107
Active	2	1	0	6	9
Passive	4	29	46	20	98
27.3.c.22	721	312	169	480	1681
Discards	410	47	37	79	573
Active	402	33	0	37	471
Passive	8	14	37	43	102
Landings	310	265	133	400	1108
Active	263	158	46	261	728
Passive	47	107	87	139	380
Germany	247	222	39	316	825
27.3.a.21		2		0	2
Discards		1		0	1
Active		1		0	1
MIS_MIS_0_0_0_HC				0	0
Landings		1		0	1
Active		1		0	1
MIS_MIS_0_0_0_HC				0	0
27.3.c.22	247	221	39	316	823
Discards	29	69	12	34	144
Active	21	64	3	22	110
Passive	8	5	9	12	33
Landings	219	152	27	282	680
Active	175	114	6	245	540
Passive	44	37	22	37	140
Sweden	70	69	67	68	274
27.3.a.21	69	64	56	64	252
Discards	39	46	27	19	131
Active	39	46	27	18	130

Sum of CATON (Tons)	Column Labels				
Row Labels	1	2	3	4	Grand Total
Passive	0	0	0	1	1
Landings	29	17	29	45	121
Active	29	12	25	41	107
Passive	0	6	4	4	14
27.3.b.23	1	5	11	4	21
Discards	0	1	0	1	2
Active		1		0	1
Passive	0	0	0	0	1
Landings	1	4	11	4	20
Active		0		1	1
Passive	1	4	11	2	18
27.3.c.22		0			0
Landings		0			0
Passive		0			0
Grand Total	1245	1015	846	1415	4521

Table 8.2 6a. Plaice in SD 27.21–23. Landing fraction.

	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10	
1999	0.00	0.24	0.30	0.59	0.80	0.55	0.64	0.89	0.98	0.99	# IC. Discard component is average of 2002-20006
2000	0.14	0.23	0.48	0.49	0.78	0.85	0.81	0.94	0.97	0.97	# IC. Discard component is average of 2002-20006
2001	0.02	0.44	0.51	0.41	0.64	0.83	0.85	0.93	0.99	0.98	# IC. Discard component is average of 2002-20006
2002	0.09	0.09	0.38	0.34	0.47	0.42	0.62	1.00	0.78	0.91	#IC
2003	0.06	0.24	0.50	0.67	0.74	0.67	0.59	1.00	1.00	1.00	#IC
2004	0.05	0.29	0.52	0.67	0.75	0.92	1.00	0.99	1.00	1.00	#IC
2005	0.12	0.34	0.76	0.82	0.73	0.72	0.75	0.49	0.38	0.68	#IC
2006	0.00	0.18	0.37	0.56	0.90	0.77	0.79	0.96	1.00	1.00	#IC
2007	0.02	0.37	0.44	0.68	0.80	0.67	0.55	0.57	0.78	0.98	#IC
2008	0.00	0.07	0.53	0.78	0.87	0.95	0.97	0.88	0.93	0.98	#IC
2009	0.07	0.15	0.35	0.61	0.53	0.32	0.37	0.15	1.00	0.37	#IC
2010	0.08	0.14	0.45	0.63	0.71	0.91	0.97	0.97	0.98	0.99	#IC
2011	0.07	0.15	0.28	0.42	0.56	0.55	0.73	0.73	0.86	0.98	#IC
2012	0.02	0.23	0.46	0.63	0.82	0.96	0.99	0.93	1.00	0.83	#IC
2013	0.01	0.16	0.47	0.59	0.57	0.85	0.88	0.82	1.00	0.87	#IC
2014	0.00	0.20	0.42	0.42	0.49	0.55	0.56	0.54	0.68	0.83	#IC
2015	0.00	0.20	0.50	0.58	0.74	0.85	0.93	0.88	0.84	0.82	#IC
2016	0.02	0.23	0.49	0.61	0.62	0.73	0.86	0.94	0.90	1.00	#IC

Table 8.2 6b. Plaice in SD 27.21–23. Maturity ogive

	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10
Mean (2002-2016)	0.20	0.51	0.69	0.84	0.93	0.96	0.97	0.98	0.98	0.99

Table 8.2 6c. Plaice in SD 27.21–23. Landing mean weight (kg)

Year	1	2	3	4	5	6	7	8	9	10+
1999	0.081	0.159	0.196	0.280	0.356	0.313	0.368	0.806	0.563	1.263
2000	0.101	0.156	0.220	0.258	0.324	0.416	0.515	0.631	0.994	1.199
2001	0.084	0.184	0.215	0.248	0.311	0.371	0.432	0.578	0.843	1.172
2002	0.097	0.117	0.182	0.202	0.252	0.357	0.390	0.424	0.458	0.559
2003	0.092	0.157	0.216	0.261	0.258	0.355	0.331	0.498	0.548	0.746
2004	0.097	0.161	0.222	0.300	0.305	0.355	0.426	0.613	0.478	1.195
2005	0.104	0.180	0.248	0.293	0.319	0.340	0.397	0.570	0.881	1.432
2006	0.061	0.133	0.205	0.255	0.358	0.287	0.306	0.447	0.530	0.884
2007	0.047	0.143	0.195	0.276	0.429	0.467	0.569	0.661	0.540	0.794
2008	0.102	0.142	0.210	0.299	0.375	0.439	0.489	0.502	0.455	0.520
2009	0.096	0.137	0.189	0.268	0.306	0.280	0.322	0.267	0.644	0.556
2010	0.105	0.158	0.240	0.259	0.325	0.396	0.403	0.374	0.381	0.419
2011	0.077	0.141	0.239	0.280	0.284	0.311	0.425	0.411	0.430	0.437
2012	0.074	0.169	0.286	0.366	0.384	0.452	0.423	0.478	0.564	0.553
2013	0.076	0.138	0.259	0.366	0.446	0.511	0.540	0.503	0.647	0.804
2014	0.087	0.159	0.229	0.305	0.373	0.388	0.471	0.556	1.117	0.727
2015	0.077	0.135	0.223	0.256	0.332	0.410	0.521	0.715	0.689	0.768
2016	0.074	0.150	0.218	0.280	0.338	0.404	0.498	0.498	0.701	0.648

Table 8.2 6d. Plaice in SD 27.21–23. Natural maturity

	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10
All years	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table 8.2 6e. Plaice in SD 27.21–23. Discard mean weight (kg)

Year	1	2	3	4	5	6	7	8	9	10+
1999	0.081	0.120	0.156	0.208	0.288	0.242	0.289	0.436	0.622	1.154
2000	0.081	0.120	0.156	0.208	0.288	0.242	0.289	0.436	0.622	1.154
2001	0.081	0.120	0.156	0.208	0.288	0.242	0.289	0.436	0.622	1.154
2002	0.082	0.104	0.124	0.171	0.193	0.353	0.321	0.519	0.189	0.913
2003	0.081	0.120	0.149	0.165	0.138	0.110	0.136	0.436	0.622	1.154
2004	0.089	0.127	0.175	0.297	0.249	0.159	0.294	0.168	0.622	1.154
2005	0.091	0.141	0.177	0.224	0.300	0.394	0.535	0.724	1.054	1.394
2006	0.061	0.110	0.154	0.183	0.561	0.192	0.159	0.331	0.622	1.154
2007	0.044	0.088	0.132	0.176	0.323	0.437	0.636	0.824	1.052	1.732
2008	0.102	0.136	0.157	0.287	0.365	0.388	0.111	0.104	0.126	0.132
2009	0.086	0.118	0.139	0.194	0.168	0.139	0.148	0.161	0.622	0.210
2010	0.095	0.121	0.130	0.159	0.187	0.353	0.513	0.452	0.955	0.185
2011	0.066	0.113	0.206	0.233	0.213	0.167	0.276	0.274	0.333	0.217
2012	0.070	0.131	0.244	0.320	0.298	0.183	0.181	0.643	0.178	0.586
2013	0.074	0.106	0.206	0.332	0.390	0.207	0.295	0.242	0.411	0.789
2014	0.087	0.130	0.171	0.279	0.339	0.335	0.424	0.405	1.140	0.465
2015	0.077	0.100	0.144	0.160	0.212	0.235	0.321	0.200	0.130	0.321
2016	0.070	0.107	0.140	0.175	0.275	0.376	0.281	0.182	0.246	0.305

Table 5.2.6f. Plaice in SD 27.21–23. Total catches (CANUM).

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1999	1377659	7286520	7123406	6540780	2427443	355338	167828	60681	39013	89466
2000	1610659	7179902	9714540	5232865	2256294	1057577	316913	112681	24920	39940
2001	1405659	9931207	10245755	4543348	1356553	940961	409406	92047	50314	48320
2002	4435651	8578400	20441469	12680459	1269575	292505	129360	58473	8181	5161
2003	946442	12394512	4692894	6070359	3079534	399508	101550	31089	8697	4837
2004	1015923	2702712	6024522	3791879	2375641	916596	171059	3396	1358	2795
2005	774005	7254148	3086708	2166619	991902	776303	330360	56681	3068	16163
2006	321609	4580833	9969825	2896298	1208044	867801	611949	105917	13137	11880
2007	267054	3636564	7725502	3650027	1054350	522184	97803	83092	26152	22273
2008	2147170	7356643	4817249	2517528	973474	379320	154559	41156	67899	105171
2009	681346	5923506	4454970	2925220	1266692	463083	66854	146568	516	10243
2010	1007663	6382103	4475417	1781851	574649	207700	128380	106640	74233	35767
2011	2681908	6570857	5962611	1686722	679439	490565	257862	141363	74256	70418
2012	990000	3978884	4597271	2014708	477022	150657	106988	70967	56634	67134
2013	1778988	5835653	4700512	2424381	785435	203019	81130	34499	30040	32541
2014	446667	3373311	5047504	4184430	1521451	530256	116942	40482	5390	19456
2015	268363	3195165	4417121	3785213	2402626	747101	352195	61537	15351	5859
2016	1258096	4309152	6803758	3340644	2161240	1063172	294669	152507	56218	54383

Table 5.2.6g. Plaice in SD 27.21–23. Mean weight (kg) in in stock by age.

MEAN(1999-2016)	**0.021**	**0.070**	**0.147**	**0.240**	**0.291**	**0.303**	**0.324**	**0.386**	**0.543**	**0.466**

Table 5.2.6h. Plaice in SD 27.21–23. Mean weight (kg) in catch by age.

YEAR	1	2	3	4	5	6	7	8	9	10+
1999	0.081	0.159	0.196	0.280	0.356	0.313	0.368	0.806	0.563	1.263
2000	0.101	0.156	0.220	0.258	0.324	0.416	0.515	0.631	0.994	1.199
2001	0.084	0.184	0.215	0.248	0.311	0.371	0.432	0.578	0.843	1.172
2002	0.097	0.117	0.182	0.202	0.252	0.357	0.390	0.424	0.458	0.559
2003	0.092	0.157	0.216	0.261	0.258	0.355	0.331	0.498	0.548	0.746
2004	0.097	0.161	0.222	0.300	0.305	0.355	0.426	0.613	0.478	1.195
2005	0.104	0.180	0.248	0.293	0.319	0.340	0.397	0.570	0.881	1.432
2006	0.061	0.133	0.205	0.255	0.358	0.287	0.306	0.447	0.530	0.884
2007	0.047	0.143	0.195	0.276	0.429	0.467	0.569	0.661	0.540	0.794
2008	0.102	0.142	0.210	0.299	0.375	0.439	0.489	0.502	0.455	0.520
2009	0.096	0.137	0.189	0.268	0.306	0.280	0.322	0.267	0.644	0.556
2010	0.105	0.158	0.240	0.259	0.325	0.396	0.403	0.374	0.381	0.419
2011	0.077	0.141	0.239	0.280	0.284	0.311	0.425	0.411	0.430	0.437
2012	0.074	0.169	0.286	0.366	0.384	0.452	0.423	0.478	0.564	0.553
2013	0.076	0.138	0.259	0.366	0.446	0.511	0.540	0.503	0.647	0.804
2014	0.087	0.159	0.229	0.305	0.373	0.388	0.471	0.556	1.117	0.727
2015	0.077	0.135	0.223	0.256	0.332	0.410	0.521	0.715	0.689	0.768
2016	0.074	0.150	0.218	0.280	0.338	0.404	0.498	0.498	0.701	0.648

Table 5.2.6i. Plaice in SD 27.21–23. Survey indices NS-IBTS and BITS combined.

1st quater

	Age 1	age2	age3	age4	age5
1999	1130.456	9500.666	3635.928	916.0208	470.48
2000	3147.665	23627.94	9246.97	1523.0505	423.8616
2001	997.4851	13981.7	11961.14	2835.7172	413.4765
2002	1624.571	4129.795	9777.229	4693.0871	960.0951
2003	1565.265	16979.69	6754.134	6600.7918	3205.186
2004	977.2483	5833.365	9990.684	4592.8493	2751.08
2005	1034.141	13227.08	10157	5131.9729	1677.714
2006	271.5767	7805.922	14111.21	5857.3413	2875.201
2007	941.4152	7082.286	11014.46	8999.8458	2180.456
2008	1574.44	6128.324	6972.158	3337.7584	1037.082
2009	893.1924	4841.14	7078.944	3547.6889	1200.69
2010	3647.509	9312.203	12146	6637.0434	2175.196
2011	1619.55	14553.5	13050.65	6479.2924	2563.098
2012	2712.754	13514.53	13750.42	5479.7616	1311.405
2013	430.1549	7075.577	20569.03	9927.1026	4851.114
2014	213.7153	9005.576	13252.34	12791.594	5870.35
2015	2090.077	16670.48	12583.52	9515.0907	8208.858
2016	669.0108	15031.64	29132.14	11992.608	7784.093
2017	338.8323	13067.3	4917.9	5724.787	3274.173

3rd and 4th quarter

	Age 1	age2	age3	age4	age5
1999	27112.12	16164.57	2582.745	285.0961	341.3786
2000	13557.39	19548.2	6172.434	111.3898	92.5919
2001	4907.608	12355.58	4810.576	1301.9682	112.8812
2002	10038.46	5094.993	4829.468	3295.1416	668.3598
2003	4196.029	12273.73	2951.049	2299.4312	1157.798
2004	7568.736	6861.374	9737.716	3152.9767	1738.325
2005	8031.728	9924.539	2579.312	1391.357	355.4813
2006	6589.536	8657.213	6726.094	1696.3551	831.3893
2007	5825.279	9419.933	3132.249	2026.1452	536.257
2008	2811.739	9658.714	6849.426	2726.0113	724.2899
2009	5341.861	9371.214	8571.293	1622.0119	315.8967
2010	5646.867	7413.529	4501.954	3300.1006	992.4021
2011	14268.91	13574.91	7284.579	2437.9372	516.3411
2012	10088.22	12649.16	8977.759	4737.7378	1056.898
2013	5347.143	9382.919	8577.974	3963.2027	1820.244
2014	14053.91	11208.61	6963.356	3030.7174	2578.514
2015	8127.236	15402.9	10327.74	7657.7174	4044.191
2016	12836.3	13289.73	9724.151	4446.243	2336.215

Table 5.2.7. Plaice in SD 27.21–23. SAM Final run. Estimated recruitment, total stock biomass (TBS in tonnes), spawning stock biomass (SSB in tonnes), and average fishing mortality for ages 3 to 5 (F35).

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F35	Low	High
1999	52523	40223	68583	6241	4968	7840	3892	3015	5024	0.946	0.735	1.217
2000	45615	35483	58642	7882	6419	9680	4769	3844	5916	0.996	0.814	1.219
2001	29319	22320	38513	9123	7416	11222	5935	4786	7360	0.938	0.774	1.137
2002	33456	26040	42985	9085	7399	11155	6239	5025	7747	0.863	0.708	1.053
2003	25413	19678	32818	8243	6819	9964	5805	4749	7094	0.783	0.632	0.971
2004	29261	22775	37593	7733	6421	9313	5444	4476	6622	0.755	0.604	0.944
2005	24563	19199	31426	7470	6173	9041	5283	4322	6459	0.754	0.600	0.946
2006	22494	17565	28806	7167	5872	8749	5094	4131	6282	0.789	0.635	0.980
2007	22880	17869	29295	6741	5526	8223	4809	3901	5927	0.782	0.622	0.983
2008	23742	18487	30491	6365	5234	7741	4504	3665	5537	0.757	0.596	0.962
2009	28653	22485	36511	6265	5142	7634	4330	3505	5349	0.684	0.516	0.906
2010	35172	27591	44835	6864	5572	8455	4652	3699	5850	0.610	0.429	0.869
2011	39066	30440	50135	7986	6381	9994	5378	4184	6913	0.556	0.357	0.867
2012	35277	27581	45121	9370	7242	12123	6475	4834	8673	0.383	0.210	0.700
2013	30424	23581	39254	11282	8347	15250	8218	5842	11560	0.311	0.164	0.592
2014	30977	23603	40655	12956	9218	18209	9883	6730	14514	0.270	0.145	0.503
2015	29882	21956	40668	14380	9896	20896	11340	7446	17271	0.260	0.146	0.462
2016	30031	20511	43971	15783	10452	23833	12759	8031	20272	0.283	0.164	0.487
2017							13487	8192	22205			

Table 5.2.8. Plaice in SD 27.21–23. Estimated fishing mortality (F) at age.

Year\Age	1	2	3	4	5+
1999	0.044	0.355	0.770	1.154	0.912
2000	0.046	0.368	0.788	1.206	0.995
2001	0.047	0.367	0.734	1.104	0.975
2002	0.049	0.379	0.710	0.991	0.890
2003	0.044	0.347	0.651	0.891	0.806
2004	0.040	0.321	0.623	0.866	0.775
2005	0.037	0.306	0.612	0.870	0.779
2006	0.036	0.309	0.638	0.918	0.811
2007	0.037	0.313	0.649	0.923	0.774
2008	0.041	0.332	0.650	0.901	0.720
2009	0.040	0.320	0.609	0.814	0.627
2010	0.039	0.305	0.570	0.732	0.528
2011	0.039	0.292	0.529	0.669	0.471
2012	0.031	0.221	0.383	0.457	0.310
2013	0.028	0.194	0.325	0.370	0.239
2014	0.024	0.169	0.286	0.322	0.203
2015	0.023	0.163	0.278	0.309	0.192
2016	0.026	0.185	0.311	0.336	0.201

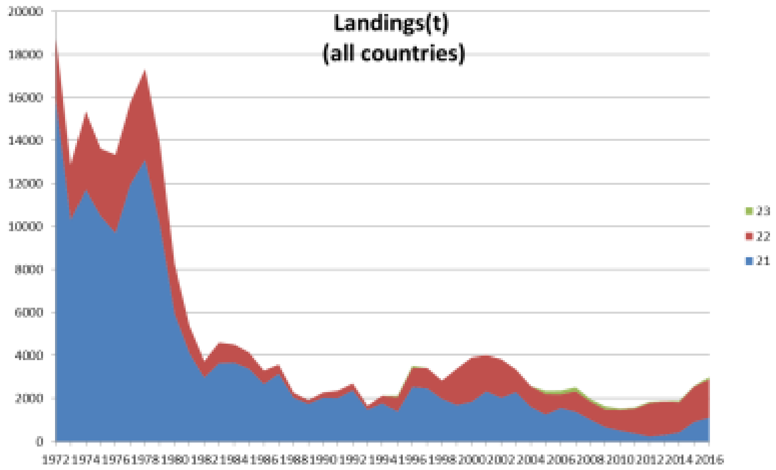


Figure 5.2.1. **Plaice in SD 27.21–23. Landings by subdivision by year.**

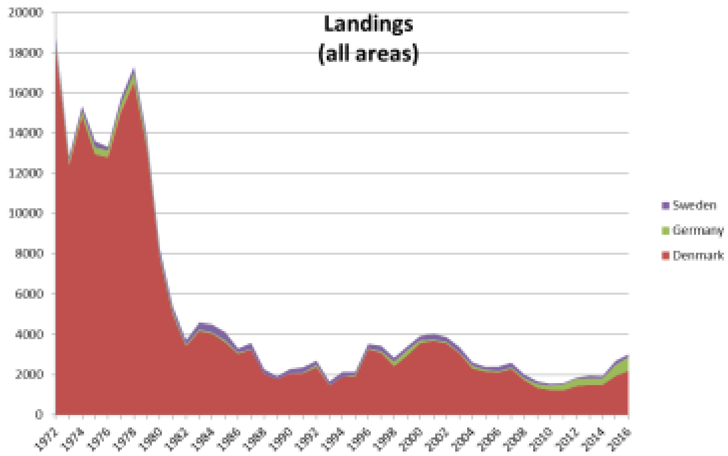


Figure 5.2.2. **Plaice in SD 27.21–23. Landings (t) by country by year.**

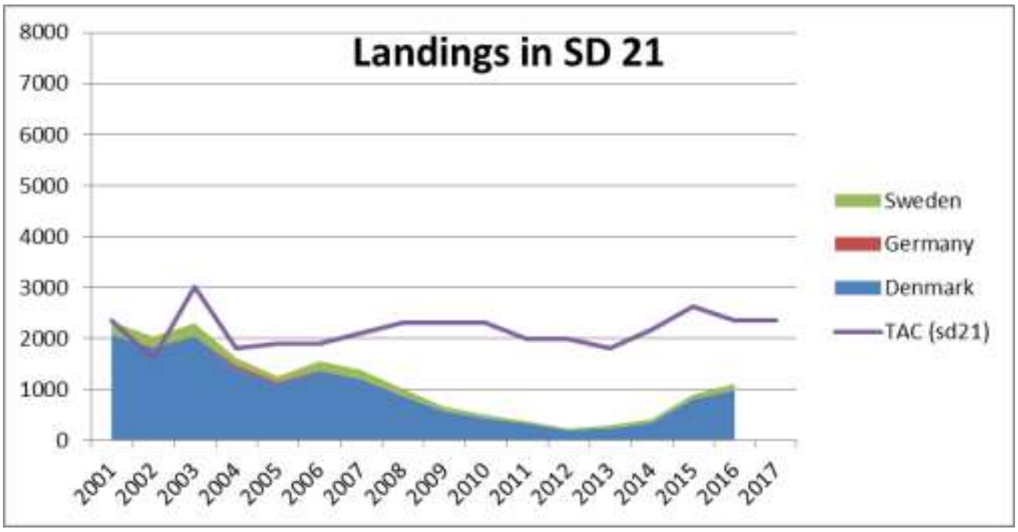


Figure 5.2.x1. Plaice in SD 27.21–23. Landings (t) in SD 27.21 by country by year. TAC is plotted as well.

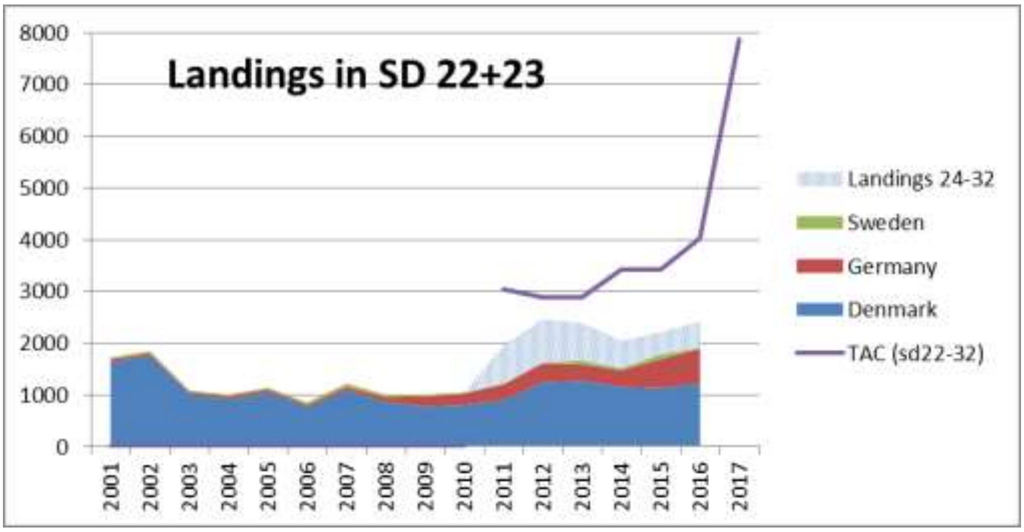


Figure 5.2.x2. Plaice in SD 27.21–23. Landings (t) in SD 27.22+23 by country by year. TAC is plotted as well.

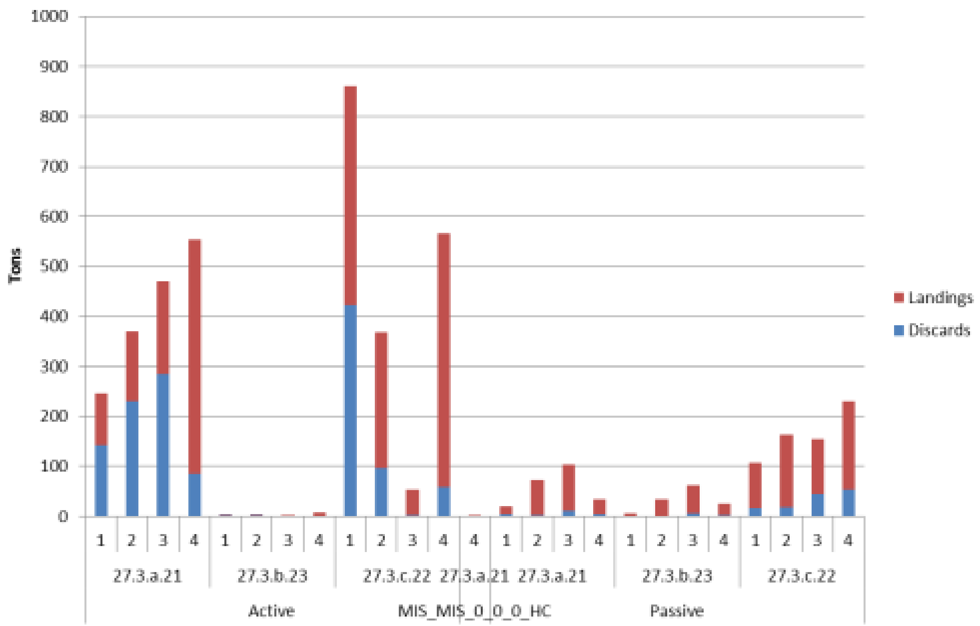


Figure 5.2.3. **Plaice in SD 27.21–23. Catches (t) in 2016 by gear type, area, quarter and catch category.**

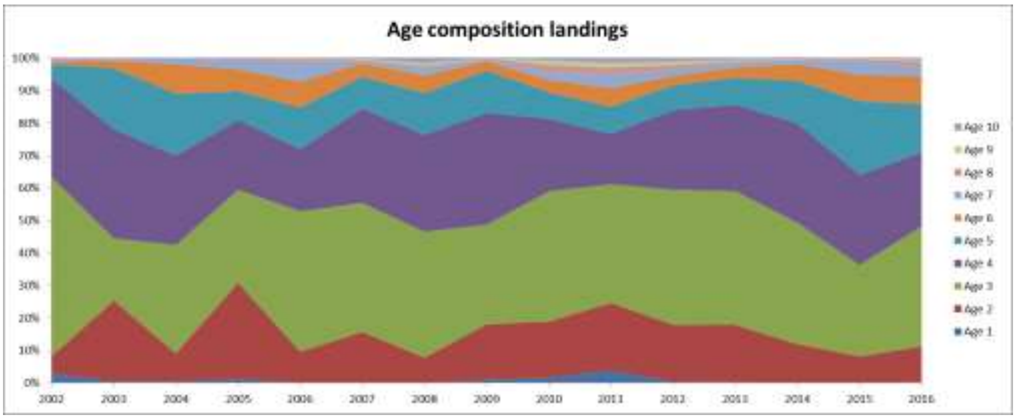


Figure 5.2.4. **Plaice in SD 27.21–23. Age composition for landings from 2002 to 2016.**

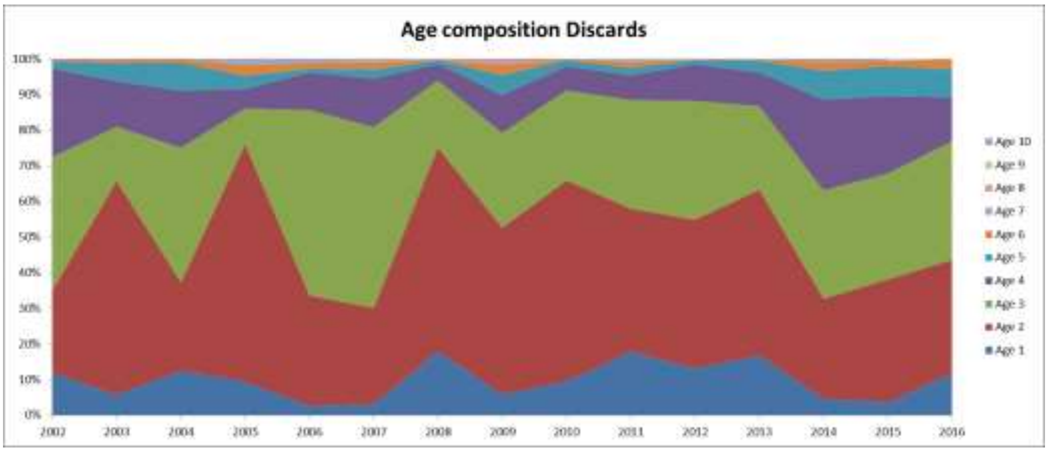


Figure 5.2.5. Plaice in SD 27.21–23. Age composition for discards from 2002 to 2016.

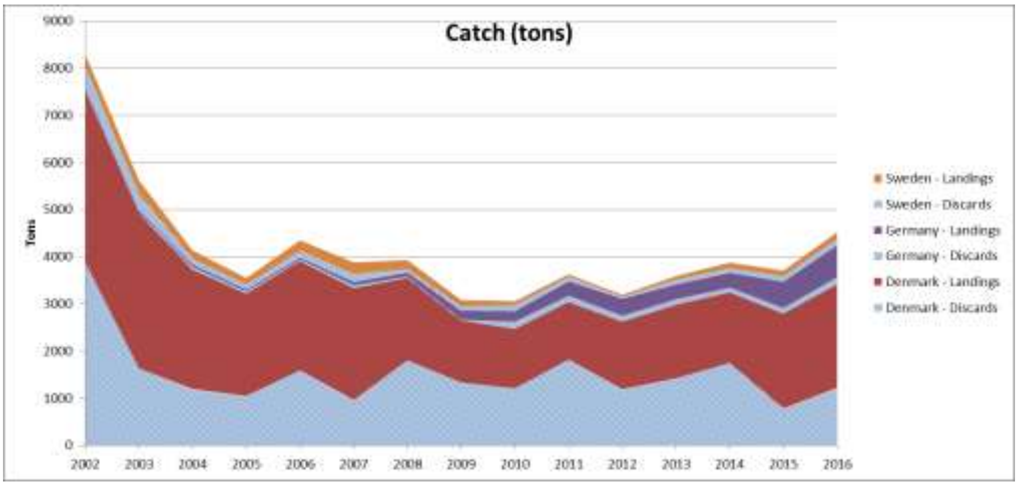


Figure 5.2.6. Plaice in SD 27.21–23. Catches (t) split into catch category and country by year. Discard indicated with similar pattern but belonging to landing right above.

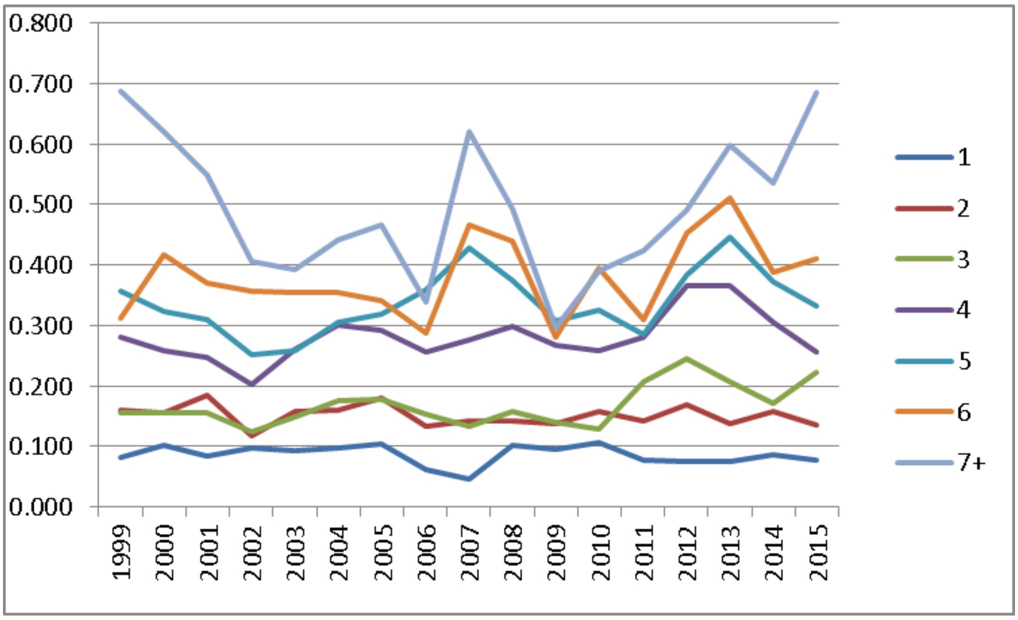


Figure 5.2.7. **Plaice in SD 27.21–23. Mean weight (kg) at age in catch.**

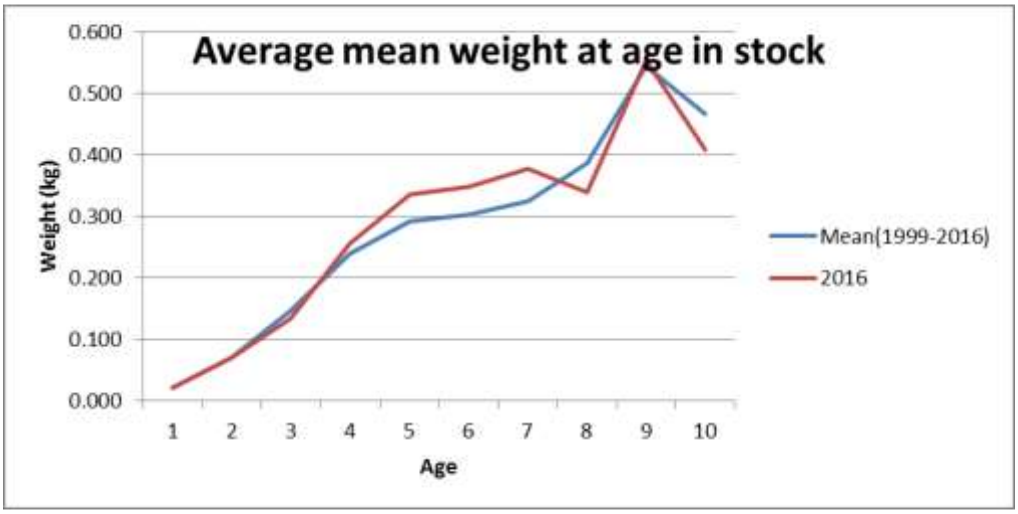


Figure 5.2.8. **Plaice in SD 27.21–23. Mean weight (kg) at age in stock.**

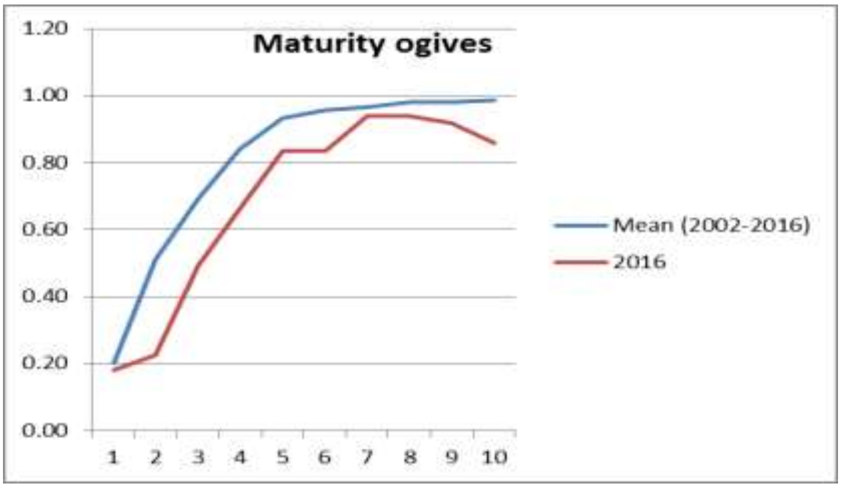


Figure 5.2.9. Plaice in SD 27.21–23. Maturity ogive based on 2016 first quarter combined surveys compared with the mean of the series from 2002–2016.

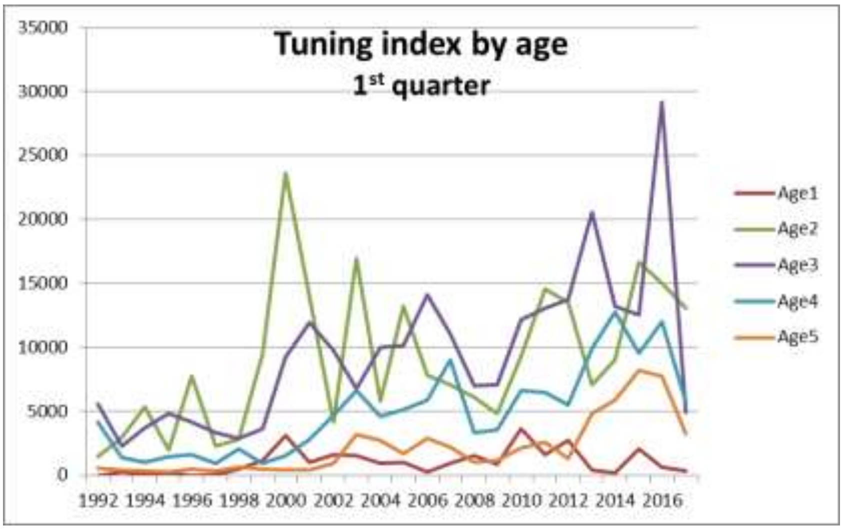


Figure 5.2.10. Plaice in SD 27.21–23. Index by age for 1st quarter surveys.

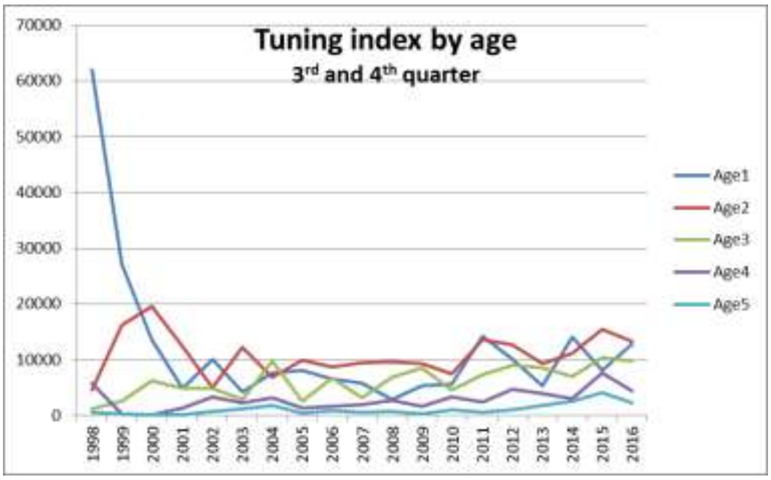


Figure 5.2.11. **Plaice in SD 27.21–23. Index by age for 3rd and 4th quarter surveys.**

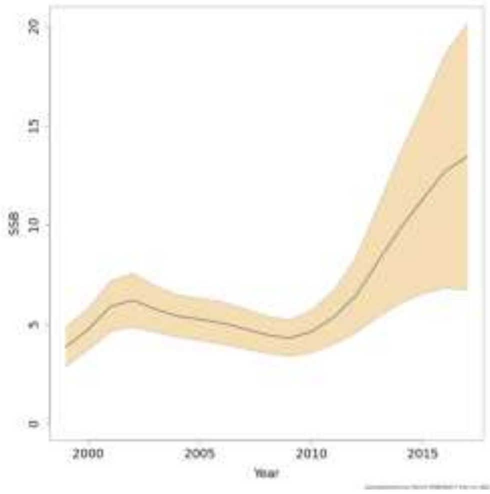


Figure 5.2.12a. **Plaice in SD 27.21–23. SSB (1000 tons) estimates from SAM output.**

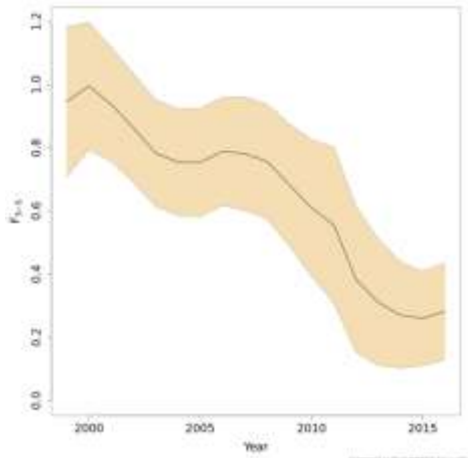


Figure 5.2.12b. **Plaice in SD 27.21–23. F(3-5) estimates from SAM output.**

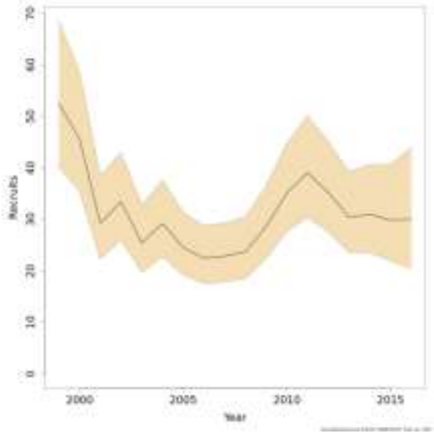


Figure 5.2.12c. Plaice in SD 27.21–23. Recruitment (numbers) estimates from SAM output.

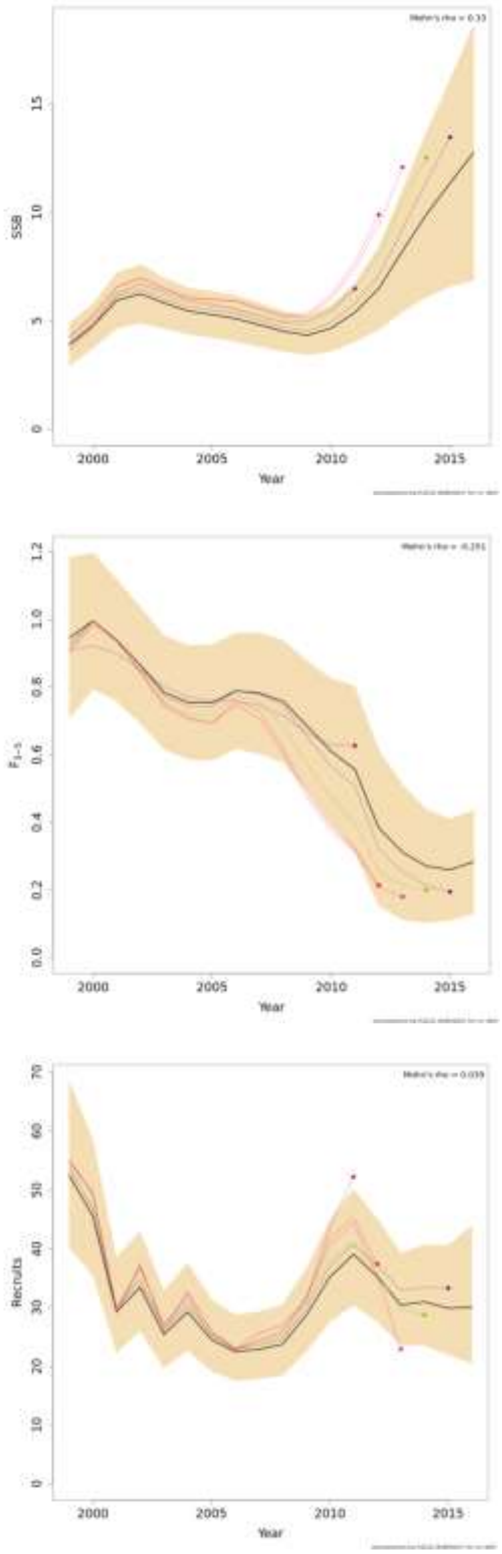


Figure 5.2.13. Plaice in SD 27.21–23. The results of the retrospective analysis showing the SSB (1000 t), the F(3–5) and the recruitment (numbers).

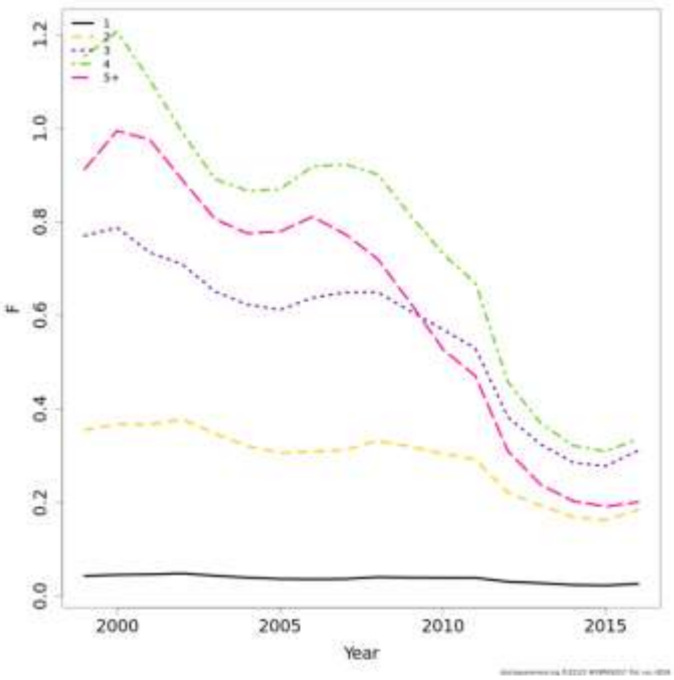


Figure 5.2.14. Plaice in SD 27.21–23. Estimated F by age group.

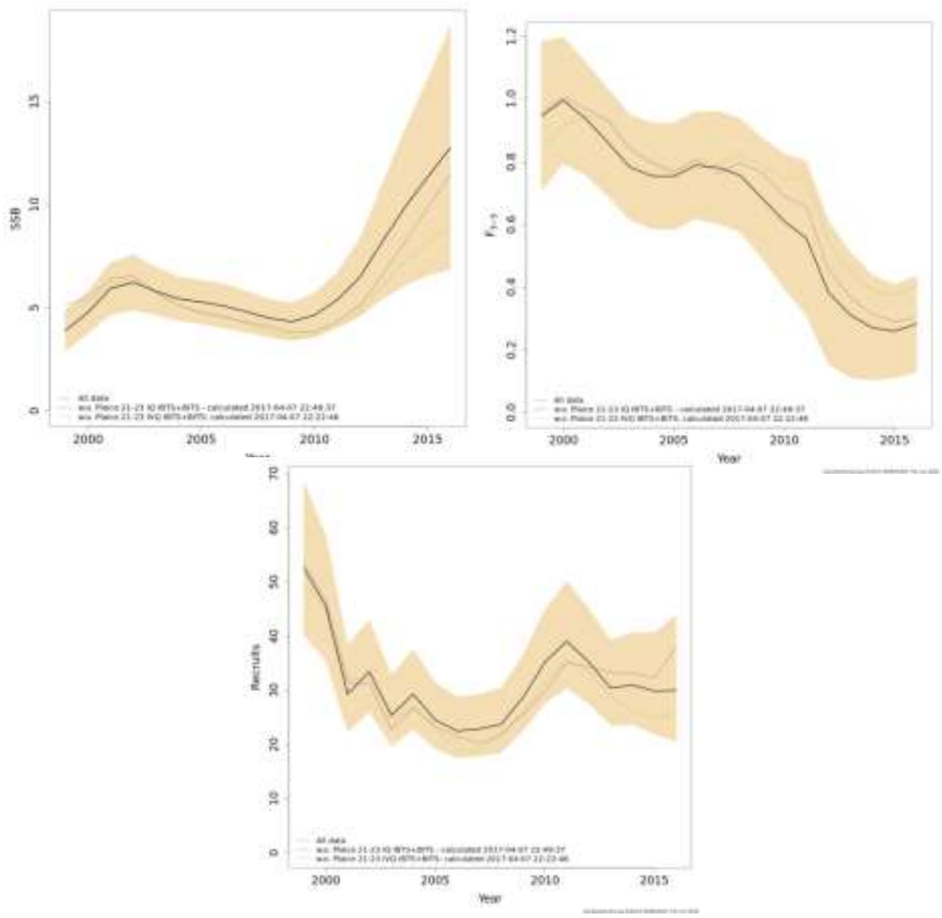


Figure 5.2.15. Plaice in SD 27.21–23. Results of leave out analysis for SSB (1000t), F and R(numbers).

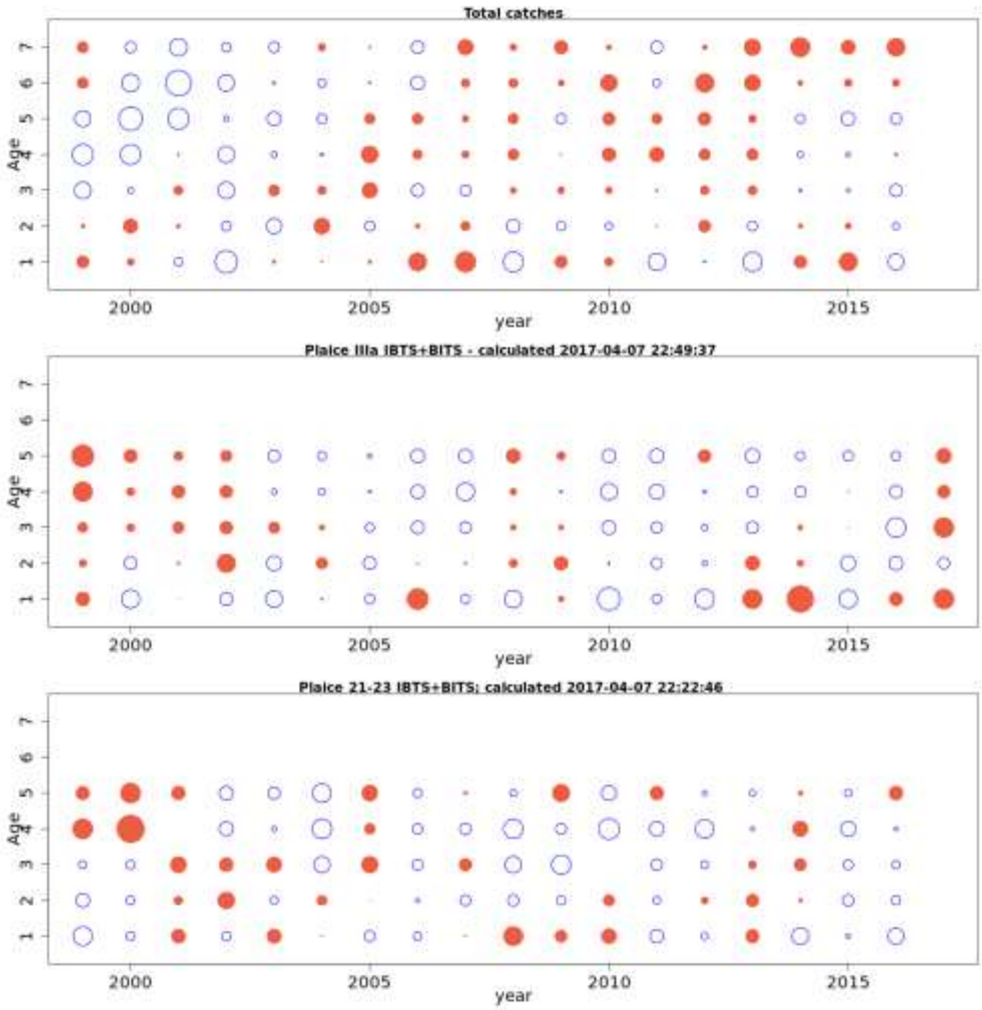


Figure 5.2.16. Plaice in SD 27.21–23. Residuals for catch matrix 1st and 3rd + 4th quarter surveys.

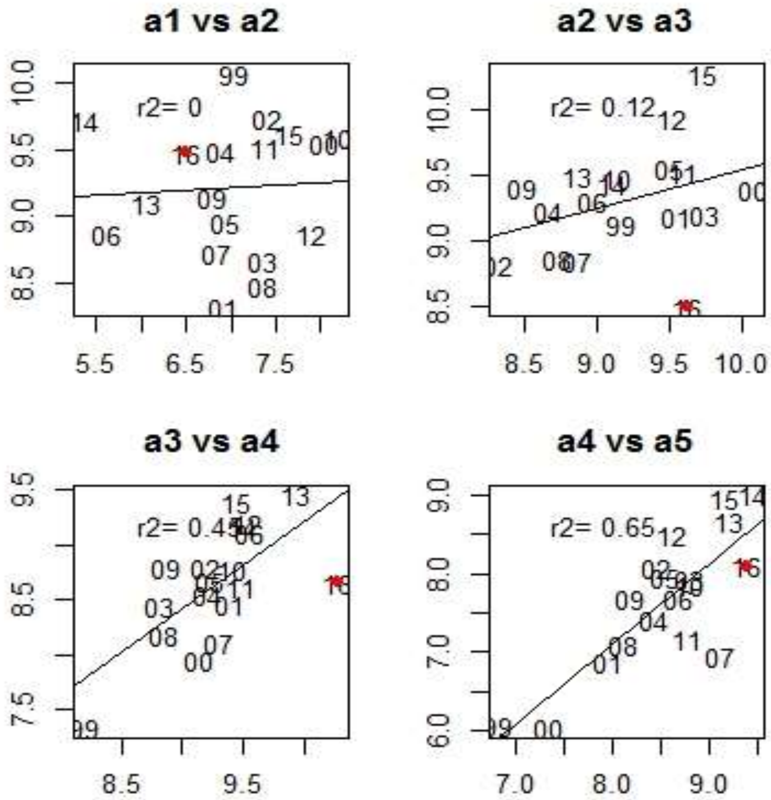


Figure 5.2.17. Plaice in SD 27.21–23. Internal consistency for 1st quarter combined survey.

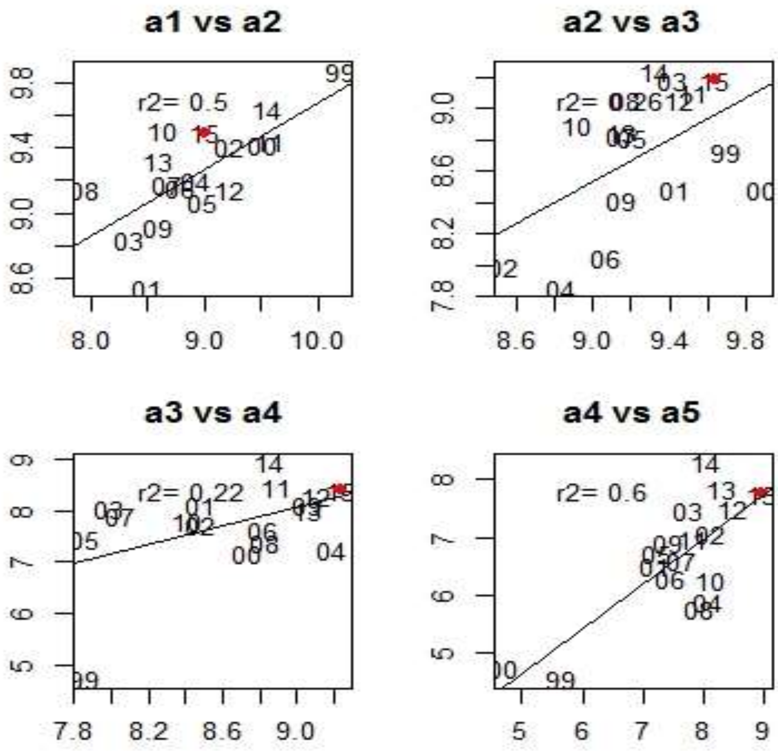


Figure 5.2.18. Plaice in SD 27.21–23. Internal consistency for 3rd and 4th quarter combined survey.

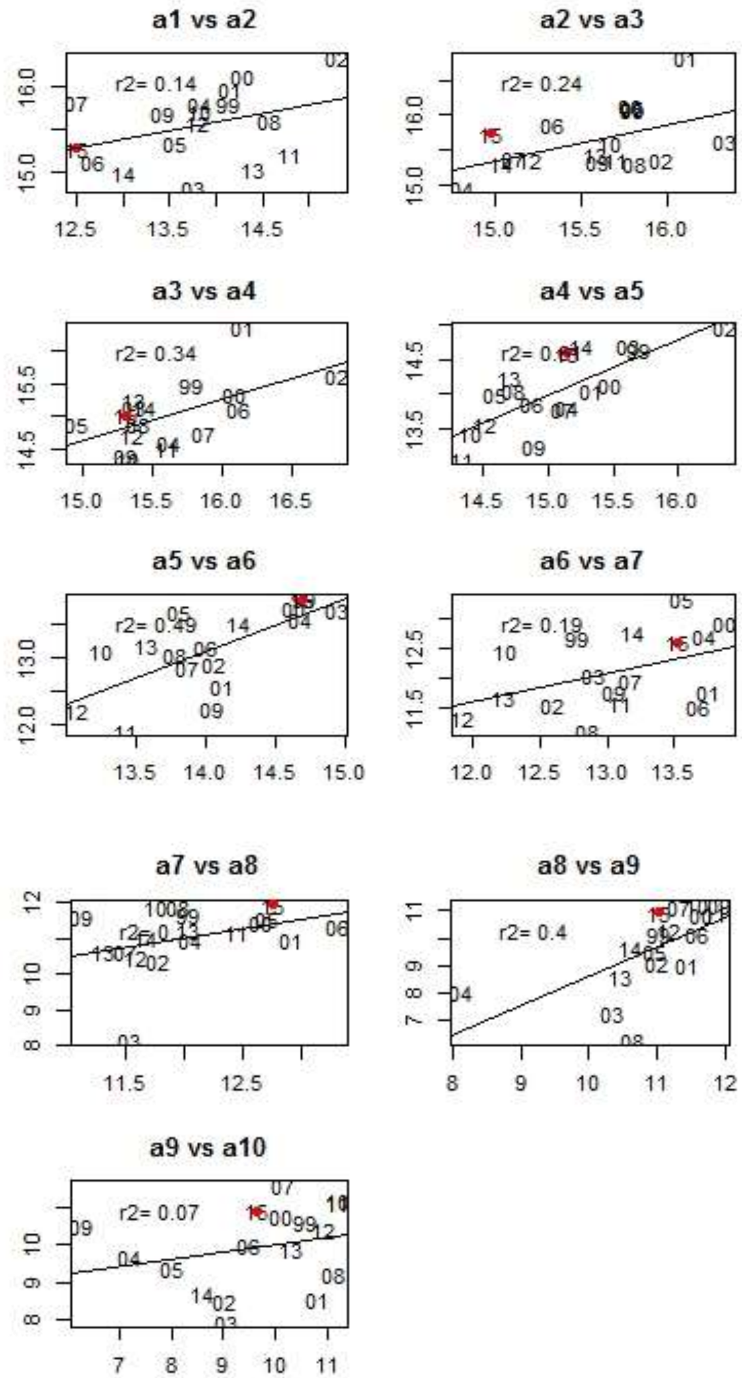


Figure 5.2.19. Plaice in SD 27.21–23. Internal consistency for catch matrix. Red dot indicates latest year value.

5.3 Plaice in subdivisions 24–32

5.3.1 The Fishery

There are no management objectives for the stock. The management areas do not match the assessment areas. The TAC for the combined stock ple.27.22-32 in 2016 was increased to 4034 tons and again in 2017 to 7862 tons. The latest increase is related to the change in assessment of the ple.27.21-23 stock, which is now assessed via an analytical assessment and therefore the TAC is given based on F_{MSY}.

5.3.1.1 Technical Conservation Measures

Plaice is mainly caught in the area of Arkona and Bornholm basin (SD 24 and SD 25). ICES Subdivision 24 is the main fishing area with Denmark and Germany being the main fishing countries. Subdivision 25 is the second most important fishing area. Denmark, Sweden and Poland are the main fishing countries there. Minor catches occur in Gdansk basin (SD 26). Marginal catches of plaice in other SD are found occasionally in some years, but were usually lower than 1 ton/year.

Plaice are caught by trawlers and gillnetters mostly. The minimum landing size is 25 cm in 2016, active gears provide most of the landings in SD 24 (ca. 85%) and SD 25 (ca. 75%), whereas landings from passive gears are low. However, in SD 26, passive gears provided 67% of total plaice landings in 2016.

5.3.1.2 Landings

The catch landings data of plaice in the Eastern Baltic (ple.27.24-32) according to ICES subdivisions and countries are presented in Tables 5.3.1 and 5.3.2. Only Denmark, Sweden, Poland, Germany and Finland (traded quota from Sweden) have a TAC for landing plaice. The trend and the amount of the landings of this flatfish per country are shown in Figure 5.3.1.

The highest total landings of plaice in SD’s 24 to 32 were observed at the end of the seventies (4530 t in 1979) and the lowest around the period between 1990 and 1994 (80 t in 1993). Since 1995 the landings increased again and reached a moderate temporal maximum in 2003 (1281 t) and again in 2009 (1226 t). After 2009 the landings are decreasing to 748t in 2011, slightly increased in 2012 to around 848 tons and decreased to 427 tons in 2015. Landings in 2016 were 521 tons.

5.3.1.3 Unallocated removals

Unallocated removals might take place but are considered minor and are not reported from the respective countries. Recreational fishery on plaice might take place with unknown removals, but is also considered to be of minor influence.

5.3.1.4 Discards

Discard in the commercial fisheries can be high and seems to vary greatly between countries. For example the trawl-fishery targeting cod in SD 26 may even have a 100% discard rate of plaice throughout the year. Only a few occasional landings from trawl-fisheries took place in SD 26. Countries without a TAC for plaice are assumed to have 100% discard.

However, the available data on discards are incomplete for all subdivisions. National discard estimations were missing in some strata, where countries have a cod-targeting trawl-fishery which may have some bycatch of plaice.

Sampling coverage, esp. in the passive-gear segment is low, especially on discard in SD 25 and SD 26, where often only Danish data were available. The discard in 2016 is exceptional high and estimated to be around 1050 tons, which would result in a discard ratio of 67% of the total catch. This is mainly driven by discarding of the Danish trawling fleet in the 4th quarter (~830 tons) in SD25.

5.3.1.5 Effort and CPUE data

The CPUE was calculated as standardized fishing effort for both, the demersal active and passive fleet. National fleet effort (days at sea) per SD is transformed into a standard catch (effort per stratum and country divided by average effort per country over the period 2009–2016). Standard catches were weighted by the mean of cod landings by country and fleet.

Fishing effort in subdivisions 24 and 25 decreased from 2004 to 2010 with 50% (see Figure 4.2.4 from STECF-report 2015) and remains stable since then. The standardized effort for active and passive gears show a slight, but continuous decrease since 2012 (Figure 5.3.2).

5.3.2 Biological composition of the catch

5.3.2.1 Age composition

Age class 3 is most abundant in the landing fraction of plaice. In the discard fraction, age class 2-3 is most abundant. Almost no plaice above age class 5 are found in the discards.

5.3.2.2 Mean weight-at-age

Recent years show a decrease in the average weight for almost all age classes (Figure 5.3.4). Age class 1 did not appear in the sampled catches after 2012. The age classes above 7 are usually not very well sampled, causing some fluctuations in the average weight. Passive gears often catch larger fishes and have a lower discard-rate.

5.3.2.3 Natural mortality

No further information or studies on natural mortality are available. The average natural mortality for age classes 1 and 2 are is set at 0.2, age classes 3+ are set at 0.1 as a default.

5.3.2.4 Maturity-at-age

The maturity ogive was taken from the BIT survey from SD22 and SD24 (since they are more reliable and consistent than SD24+, see WKPLE 2015 report). Both quarters from the period 2002 to 2017 (2017, preliminary 1st quarter only) were combined and an average maturity-at-age was calculated:

Age	1	2	3	4	5	6	7	8	9	10
Maturity	0.18	0.51	0.70	0.85	0.94	0.97	0.97	0.99	0.98	0.99

5.3.3 Fishery independent information

The "Baltic International Trawl Survey (BITS)" is covering the area of the plaice stock in SD24–32. The survey is conducted twice a year (1st and 4th quarter) by the memberstates having a fishery in this area. Survey-design and gear is standardized. Due to a change in trawling gear in 2000, only first and fourth quarter BITS since 2001 are considered. The CPUE is calculated from the catches. The BITS-Index is calculated as:

Average number of plaice > = 20 cm weighted by the area of each depth stratum which all together covers the area covered by the stock. (Figure 5.3.5).

The internal consistency plots of the surveys (Figure 5.3.6.a and 5.3.6.b) indicate a good consistency between the age classes. Younger fish in Q1 show low consistency following the cohorts because the trend some cases is defined by one outlying measuring point. The medium and older aged fish show better consistency.

The internal consistency in the commercial catches are also quite good (Figure 5.3.7). Only the medium aged fishes show a lesser consistency.

5.3.4 Assessment

The stock was as a result of the WKPLE in February 2015 upgraded to Category 3.2.0 (DLS; exploratory assessment with SSB trends). The State based Assessment Model (SAM) is used. The assessment is an update of the benchmark assessment (ICES WKPLE) and the setting is according to the stock annex (ple.27.24-32).

The final run in SAM is named: ple.27.24-32_WGBFAS2017

5.3.4.1 Exploration of SAM

The stock is in a very good condition. The result shows (Figures 5.3.8a-c and Table 5.3.3) an increase in SSB from < 3000 tons in 2010 to 5700 tons in 2016 and estimated to 8215 tons in 2017. The increase is probably resulting out of the high amount of discard and the respective higher total catch in 2016. The F in 2016 is approximately the same as last year (0.57) and has been constantly decreasing in the whole period. This is the case for all age groups except the older age groups (7, 8, 9+), which seem to have a slight increase (Figure. 5.3.9). The recruitment is regarded as constantly increasing but with significant variation. The recruitment in 2016 is estimated to 34 mill. which is the highest value since 2002.

The normalized residuals show some year effects for the commercial catches in the last three years (Figure. 5.3.10). The retrospective analysis is less robust even when considering the short time series. Only the last 3 years are within the confidence intervals. The F has been estimated to be within the confident intervals (Figure. 5.3.11). Final assessment

This stock was benchmarked in 2015 (ICES WKPLE) and the basis of the advice was changed. The advice is now made based on relative SSB trends and F estimated by SAM.

Usually the factor for the catch advice is calculated as average SSB of 2 most resent years (2015–2016) divided with SSB average of the preceding three years (2012–2014) - this estimate gives an increase of 25%. Uncertainty cap is applied as the calculated trend exceeds the limit of 20% changes.

F_{SQ} is estimated to 0.60 over the period of 2010 to 2016. No F_{MSY} is available for the stock

However, a decreasing trend in total landings (and catch) appeared in the last three years. Advice will then be given based on the advised catch of the last year (2015). Advised catches for 2017 is 2587 tons based on the total catch and average discard ratio of the last three years (2014-2016) to account for the exceptional high discard in 2016.

Since the difference between the advised (2157 tons in 2015) and the taken catch (647 tons in 2015) is very high and increasing with each year, it should be considered to give an advice based on the taken catch instead of advised catch of the previous year.

5.3.4.2 Historical stock trends

Before the benchmark in 2015, trends in the stock were evaluated by survey-indices only. The survey indices are shown in Figure 5.3.5. See section 5.3.1 under "Description of the fishery" for historical trend details.

5.3.5 Recruitment estimates

The recruitment in 2016 is estimated to around 34 mills. This is an increase since 2013 and can be considered as a stable recruitment in the whole time series (2002–2016). The historic trend is given in Figure 5.3.8 and Table 5.3.3.

5.3.6 Short-term forecast and management options

No short term forecast is given for the stock.

5.3.7 Reference points

5.3.7.1 Length based indicators (LBI)

The stock status was evaluated by calculating length based indicators applying the LBI method developed by WKLIFE V (2015). CANUM and WECA of commercial catches from 2014-2016 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

- L_{inf}: average of 2002-2016, both quarter and sexes → L_{inf} = 45.813 cm
- L_{mat}: average of 2002-2016, quarter 1, only females → L_{mat} = 21 cm

The output (relative descriptive values) was compared to reference values (Table 5.3.5) to estimate the status of the stock in respect to length based Indicators. Table 5.3.6 states all results in a traffic light system, where the values of the respective year and indicator are colored depending on whether they are below or above the relative reference point.

The results of LBI show that stock status of ple.27.24-32 is above possible reference points (Table 5.3.6). $L_{max5\%}$ is close to the lower limit of 0.80 (i.e. 0.78 in 2016), some truncation in the length distribution in the catches might take place. A lack of mega spawners occurs, as P_{mega} is less than 30% of the catch and indicates a truncated length distribution in the catch. Catch is close to the theoretical length of L_{opt} and L_{mean} is stable over time and close to 1, indicating fishing close to the optimal yieldExploitation (Figure 5.3.12) consistent with F_{MSY} proxy ($L_{F=M}$).

5.3.7.2 Surplus production model (SPiCT)

The stochastic production model in continuous time (SPiCT) was applied to the plaice stock ple.27.24-32. Input data were commercial catch (landings and discards) from 2002 to 2016 and the BITS biomass index Q1 and Q4.

The results of the assessment are stating a good status of the stock, below or above the respective reference points. The results are however uncertain with large confidence intervals (Figure 5.3.13, Table 5.3.7).Due to the high uncertainty in the assessment outputs the reference points were not considered for the management of plaice. The high variance might be attributed to inconsistency between catch and index time series and missing contrast in the catch time series, which also is only covering 15 years.

Despite the high variance, the model states a good stock condition in recent years and well within F_{MSY} and B_{MSY}. Following the ICES approach, a proxy for MSY $B_{trigger}$ can be calculated as 0.5 x B_{MSY}.

5.3.8 Quality of assessment

The stock is categorized as a Category 3.2 Data Limited Stock (DLS). Stock Trend analysis was made based on the results of the SAM assessment run. SSB was used as biomass index for estimating the stock trend. The calculated trend was used for calculating the catch in 2017. Even though the SAM assessment is premature, the assessment shows surprisingly robustness despite the relative short time series available. This is expressed in the retrospective analysis which looks acceptable (Figure 5.3.11), although the SSB shows a consistent overestimation. The F looks good, while the recruitment is poorly estimated. The F by age group is shown in Figure 5.3.9. The final summary plots (F_{bar}, Spawning Stock Biomass (SSB) and recruitment) for the SAM run are shown in Figure 5.3.8.a-c. The summary output from the SAM is shown in table 5.3.4, the final numbers used for the advice are given in Table 5.3.4.

5.3.9 Comparison with previous assessment

Compared to the first year of giving a catch advice in 2015 (before that, landings advice was given based on survey trends), no major changes were found. Both, the trend of the stock and the respective catch advice are similar to 2015 and 2016. The estimated F (0.87) is similar to 2015 (0.89), the recruitment estimates (2.88) increased compared to the previous assessment (2.14). The relative SSB also increased (1.43 in 2015 to 1.77 in 2016. For 2017, a SSB of 2.53 is estimated). Data quality is improving annually and with increased sampling by the member states. Commercial effort data were changed backwards to 2009. Now a standardized effort per fleet can be given which increases the quality of the advice (Figure 5.3.2).

5.3.10 Management considerations

To improve the exploratory assessment and hence the quality of the advice, more discard estimations are required by national data submitters. Additionally, more flexible tools need to be developed for InterCatch, allowing the allocation of discards also to strata with no landings attached (discard only) and extrapolation across years (to allow reasonable borrowing in years without sufficient estimations). Data handling, such as allocation and hole-filling should take place in the database to allow comprehension of the methods used.

The sampling of biological data needs further enhancement, esp. in SD 25, where the number of age readings and length measurements is in no relation to the landings. The discarded fraction needs a better sampling coverage. Although all landing countries are obliged to submit biological data, not all available information was uploaded by every country. To improve the quality of the assessment, this is however mandatory.

To improve the exploratory SAM, natural mortality values should be verified, the index values of BITS should be verified as well to minimize residuals.

Table 5.3.1. Ple.27.24-32. Plaice in the Baltic Sea. Total landings (tons) by ICES Sub-division and country.

YEAR/SD	DENMARK			GERM. DEM. REP*	GERMANY, FRG		POLAND		SWEDEN**						FINLAND		
	24(+25)	25	26+27	24	24(+25)	25	25(+24)	26	24	25	26	27	28	29	24	25	26
1970	494				16				149								
1971	314				2				107								
1972	290				2				78								
1973	203			44	1		174	30	75								
1974	126			10	2		114	86	60								
1975	184			67	1		158	142	45								
1976	178			82	3		164	76	44								
1977	221			36	2		265	26	41								
1978	681			1198	3		633	290	32								
1979	2027			1604	7		555	224	113								
1980	1652			303	5		383	53	113								
1981	937			52	31		239	27	118								
1982	393			25	6		43	64	40	6		7	1				
1983	297			12	14		64	12	133	20		24	2				
1984	166			2	8		106		23	3		4	1				
1985	771			593	40		119	49	25	4		5	1				
1986	1019			372	7		171	59	48	7		9	1				
1987	794			142	16		188	5	68	10		12	1				
1988	323			16	1		9	1	49	7		9	1				
1989	149			5			10		34	5		6	1				
1990	100			1	1		6		50								
1991	112				9		2	1	5	2		2					
1992	74				4		6		3	1		1					
1993	66				6		4		4								
1994	159						43	4	4	7							
1995	343				91		233	2	13	10	1						
1996	263				77		183	5	28	23	10	1					
1997	201				56		308	3	7	8		1					
1998	278				41		101	14	6	17		1					
1999	183				46		145	1	5	10							
2000	161				37		408	3	9	12							
2001	173				43		549	3	9	13							
2002***	153	159	0		137	7	429	3	10	15							
2003	326	299	2		68	25	480	10	16	51		0	0				
2004	167	239			50	13	292	8	6	37							
2005	164	241			90	17	511	11	16	28		0	0				
2006	82	632			173	11	52	3	17	41			0				
2007	408	490	0		151	12			41	61		0	0				
2008	450	339			150	10	29	0	45	69			0				

Year/SD	Denmark			Germ. Dem. Rep*	Germany, FRG		Poland		Sweden**						Finland		
	24(+25)	25	26+27	24	24(+25)	25	25(+24)	26	24	25	26	27	28	29	24	25	26
2009	581	359	0		96	21	42	0	43	79		0					
2010	345	295	1		66	13	93	8	22	61	1	0					
2011	291	233			109	6	37	1	33	36	0	0			1	0	0
2012	477	148	0		86	4	62	2	23	43	1	0			2	1	0
2013	382	196	0		46	1	45	5	29	33	0	0			1		
2014	231	118	0		57	<1	80	7	21	19	<1	<1	0	0	<1		
2015	145	69	0		44	1	140	5	12	12	0	0	0	0	0		
2016	187	60	1		93	2	151	3	15	10	<1	<1	0	0	0	0	0

***From October to December 1990 landings from Fed. Rep. of Germany are included.**

****For the years 1970–1981 and 1990 the Swedish landings of subdivisions 25–28 are included in Subdivision 24.**

*****From 2002 and onwards Danish and German, FRG landings in SW Baltic were separated into subdivisions 24 and 25.**

Table 5.3.2. Ple.27.24-32. Landings (tons) and discard (tons) in 2016 by Subdivision, catch category, country and quarter.

Area	Country	CatchCategory	1	2	3	4	total
27.3.d.24	Denmark	Landings	18.49	62.72	46.24	59.09	186.53
		Discards	0.88	34.60	29.42	16.87	81.76
	Germany	Landings	4.90	16.80	20.42	51.17	93.29
		Discards	0.49	3.80	11.19	4.81	20.29
	Poland	Landings	1.22	7.74	23.53	16.97	49.46
		Discards	0.43	3.50	10.97	3.34	18.24
	Sweden	Landings	0.10	3.15	3.35	7.91	14.50
		Discards	0.13	3.84	2.59	1.97	8.53
27.3.d.25	Denmark	Landings	15.65	0.58	1.43	42.64	60.31
		Discards	19.09	209.23	2.62	606.65	837.59
	Germany	Landings	1.16	0.08	0.29	0.05	1.57
		Discards	0.53	0.05	0.24	0.02	0.83
	Poland	Landings	39.16	18.21	21.67	22.33	101.37
		Discards	4.08	1.54	11.10	4.37	21.08
	Latvia	Discards	0.60	0.09			0.69
	Sweden	Landings	1.21	1.63	2.83	4.31	9.97
		Discards	2.23	1.91	12.92	47.63	64.69
27.3.d.26	Poland	Landings	0.01	0.70	1.10	1.18	2.98
		Discards	0.15	0.17	0.18	0.22	0.71
	Latvia	Discards	0.32	0.18	0.08	3.51	4.09

Table 5.3.3. Ple.27.24-32. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), and average fishing mortality for ages 2 to 5 (F25).

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F25	Low	High
2002	3980	0.339	2071	7651	2119	1372	3271	1025	0.351	640	1642	0.828
2003	5769	0.491	3279	10148	2326	1601	3380	1047	0.358	740	1481	0.835
2004	8202	0.698	4576	14699	3203	2189	4684	1365	0.467	960	1939	0.748
2005	5735	0.488	3263	10080	3786	2659	5391	1929	0.660	1370	2715	0.659
2006	3007	0.256	1432	6315	3634	2621	5038	2243	0.768	1625	3097	0.639
2007	2294	0.195	940	5598	3167	2305	4351	2138	0.732	1583	2886	0.629
2008	3195	0.272	1554	6568	3101	2287	4205	2038	0.698	1537	2703	0.615
2009	7903	0.673	4383	14250	4059	2967	5552	2292	0.785	1707	3077	0.621
2010	17566	1.496	9284	33234	6274	4215	9338	2811	0.962	2060	3835	0.638
2011	19157	1.631	10146	36170	8693	5679	13308	3972	1.360	2738	5762	0.648
2012	12869	1.096	7035	23541	8659	5947	12606	4534	1.552	3179	6466	0.638
2013	11783	1.003	6582	21093	7366	5262	10310	4085	1.398	2967	5624	0.624
2014	15775	1.343	8618	28875	7728	5447	10963	3916	1.340	2889	5306	0.59
2015	25084	2.136	13011	48360	10052	6752	14964	4655	1.593	3364	6442	0.573
2016	33827	2.881	15956	71712	12979	8132	20714	5770	1.975	3960	8407	0.574
2017								8215		4798	14066	

Table 5.3.4. Ple.27.24-32. Final results from the assessment run which is used for the advice.

Year	Relative recruitment (age 1)	Relative SSB	Landings	Discards	Relative mean F (ages 3–5)
2002	0.339	0.315	915	353	1.26
2003	0.491	0.322	1281	271	1.27
2004	0.698	0.42	1081	214	1.138
2005	0.488	0.593	1081	166	1.003
2006	0.256	0.69	1012	818	0.972
2007	0.195	0.657	1167	491	0.957
2008	0.272	0.627	1102	294	0.936
2009	0.673	0.705	1226	418	0.945
2010	1.496	0.864	903	998	0.971
2011	1.631	1.221	748	1377	0.986
2012	1.096	1.394	848	917	0.971
2013	1.003	1.256	738	781	0.949
2014	1.343	1.204	534	481	0.898
2015	2.136	1.431	427	220	0.872
2016	2.881	1.774	521	1058	0.873
2017		2.526			

Table 5.3.5. Ple.27.24-32. Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
Lmax5%	Mean length of largest 5%	Linf	Lmax5% / Linf	> 0.8	Conservation (large individuals)
L95%	95th percentile		L95% / Linf		
Pmega	Proportion of individuals above Lopt + 10%	0.3–0.4	Pmega	> 0.3	
L25%	25th percentile of length distribution	Lmat	L25% / Lmat	> 1	Conservation (immatures)
Lc	Length at first catch (length at 50% of mode)	Lmat	Lc/Lmat	> 1	
Lmean	Mean length of individuals > Lc	$Lopt = \frac{3}{3+M/k} \times L_{inf}$	Lmean/Lopt	≈ 1	Optimal yield
Lmaxy	Length class with maximum biomass in catch	$Lopt = \frac{3}{3+M/k} \times L_{inf}$	Lmaxy / Lopt	≈1	
Lmean	Mean length of individuals > Lc	LF=M = (0.75Lc+0.25Linf)	Lmean / LF=M	≥ 1	MSY

Table 5.3.6 Ple.27.24-32. Indicator status for the most recent three years

	Conservation				Optimizing Yield	MSY
Year	Lc / Lmat	L25% / Lmat	Lmax 5 / Linf	Pmega	Lmean / Lopt	Lmean / LF = M
2014	1.02	1.12	0.82	0.06	0.88	0.97
2015	0.74	1.02	0.83	0.06	0.83	1.10
2016	0.64	1.07	0.78	0.04	0.84	1.19

Table 5.3.7. Ple.27.24-32. Overview of SPiCT result values on catch and survey data 2002-2016.

	Deterministic reference points (Drp)				
		estimate	cilow	ciupp	log.est
	Bmsyd	819.93	328.85	2044.37	6.71
	Fmsyd	2.24	0.96	5.26	0.81
	MSYd	1837.90	1662.55	2031.75	7.52
Stochastic reference points (Srp)					
		estimate	cilow	ciupp	log.est
	Bmsys	867.48	203.32	3701.24	6.77
	Fmsys	2.15	0.55	8.36	0.76
	MSYs	1865.77	1575.53	2209.49	7.53
States	w	0.95	CI	(inp$msytype:	s)
		estimate	cilow	ciupp	log.est
	B_2016.75	1752.34	768.62	3995.11	7.47
	F_2016.75	1.03	0.41	2.61	0.03
	B_2016.75/Bmsy	2.02	1.03	3.94	0.70
	F_2016.75/Fmsy	0.48	0.23	1.00	-0.73
Predictions	w	0.950	CI	(inp$msytype:	s)
		prediction	cilow	ciupp	log.est
	B_2017.00	1614.09	652.91	3990.26	7.39
	F_2017.00	1.09	0.39	3.05	0.09
	B_2017.00/Bmsy	1.86	1.00	3.46	0.62
	F_2017.00/Fmsy	0.51	0.22	1.18	-0.67
	Catch_2017.00	1635.30	930.41	2874.21	7.40
	E(B_inf)	1370.06	NA	NA	7.22

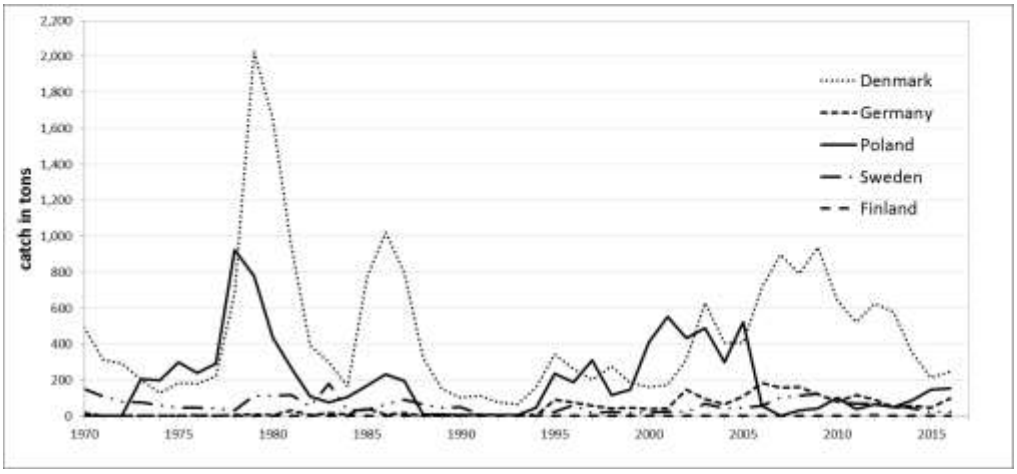


Figure 5.3.1. Ple.27.24-32. Historical landings per country (in tons).

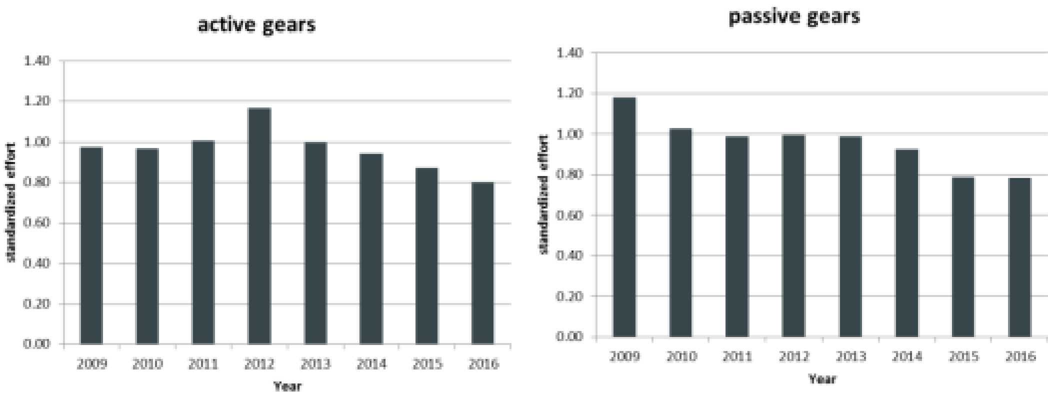


Figure 5.3.2. Ple.27.24-32. Standardized effort for active and passive fleet in Subdivision 24 to 26 (no plaice landings in SD27+). Standard catches (effort per strata and country divided by average effort per country) were weighed by national cod-landings.

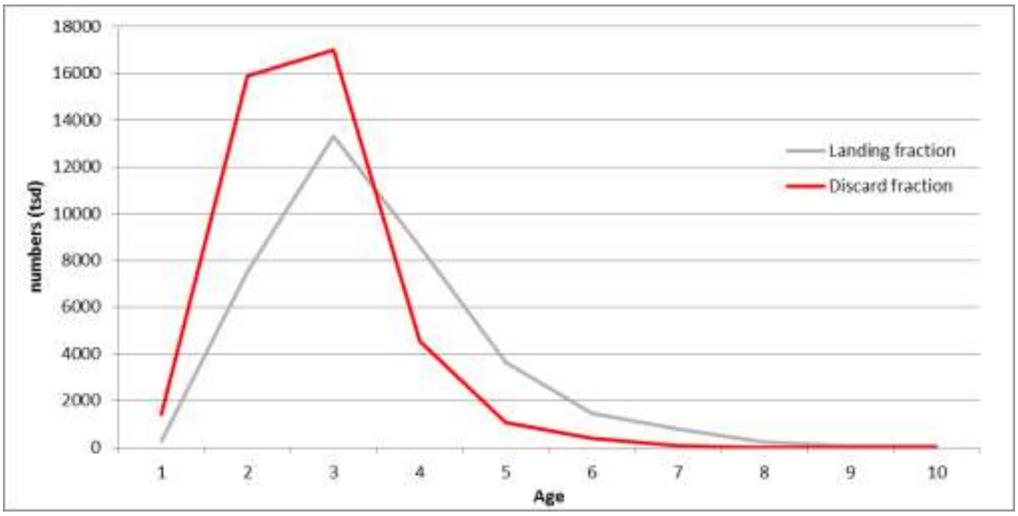


Figure 5.3.3. Ple.27.24-32. Catch in numbers per age class and catch category in Subdivision 24 and 25. All countries and fleets were combined.

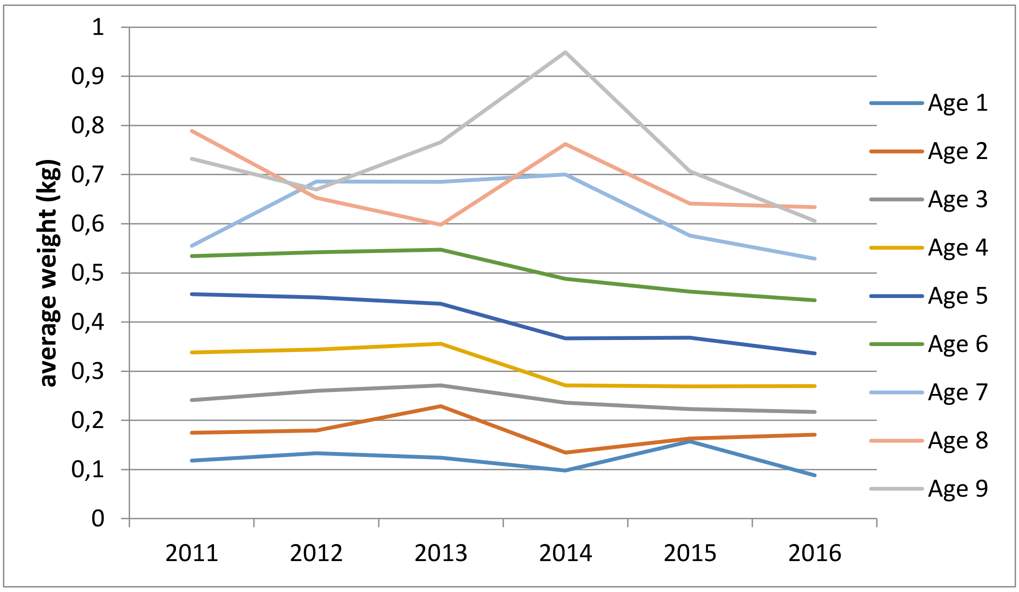


Figure 5.3.4. Ple.27.24-32. Average weight-at-age for the age classes 1 to 10 in Subdivision 24 and 25. All countries and fleets were combined.

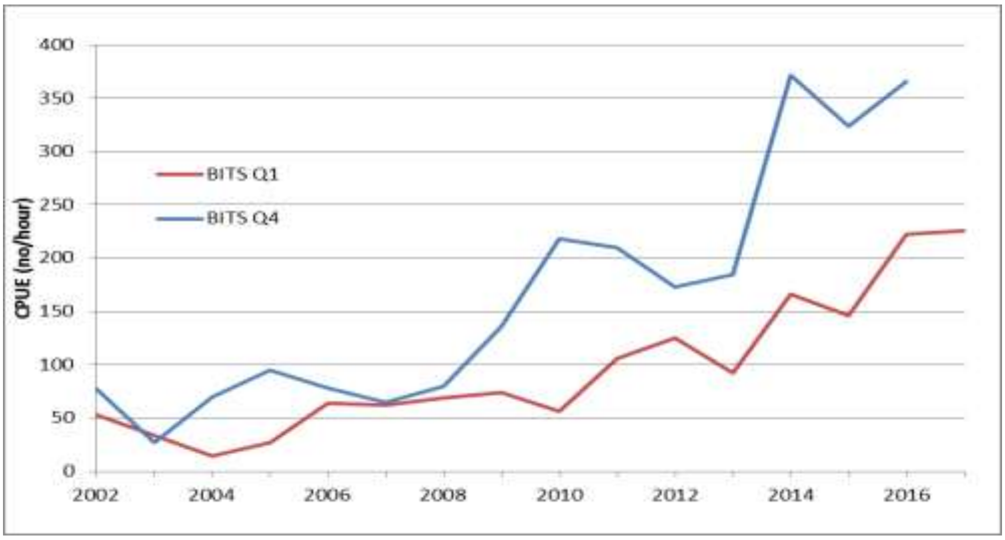


Figure 5.3.5. Ple.27.24-32. Average cpue index from Q1 and Q4 BITS from SD24-SD26 (no plaice catches in SD27+). 2017 data (Q1) are preliminary.

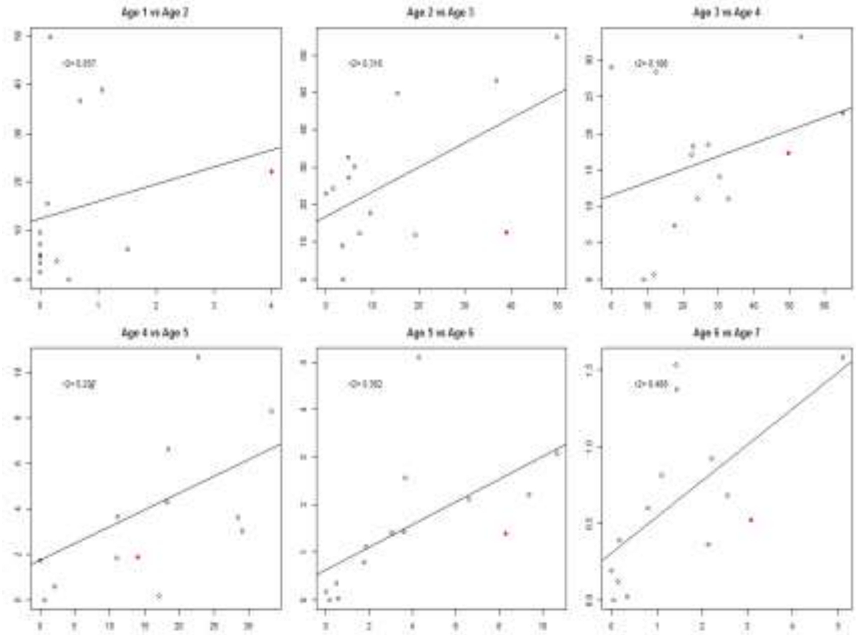


Figure 5.3.6.a. Ple.27.24-32. Internal consistency of age classes 1–7 from Q1 BITS.

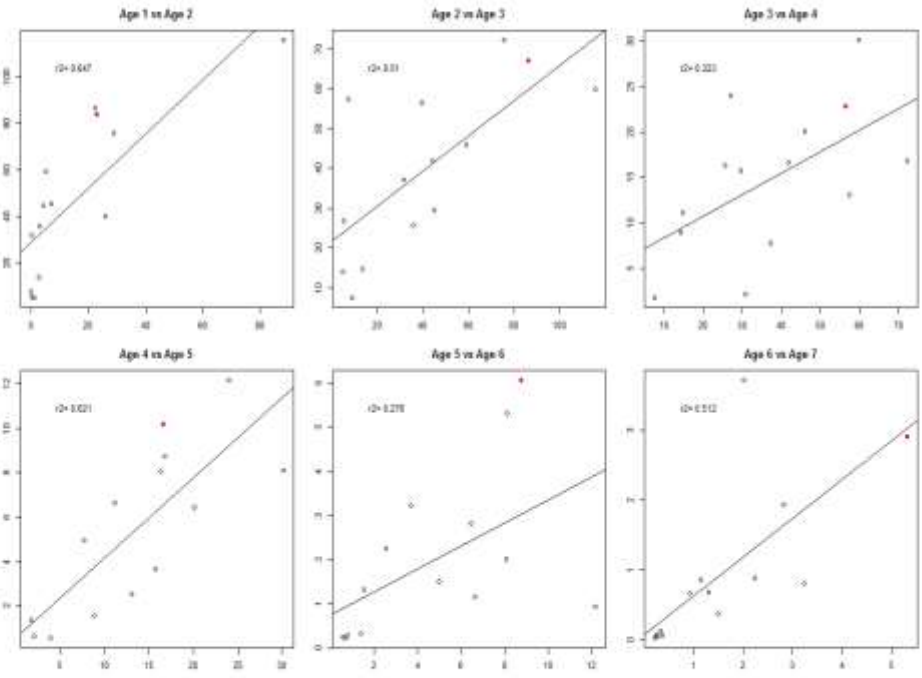


Figure 5.3.6.b. **Ple.27.24-32. Internal consistency of age classes 1–7 from Q4 BITS.**

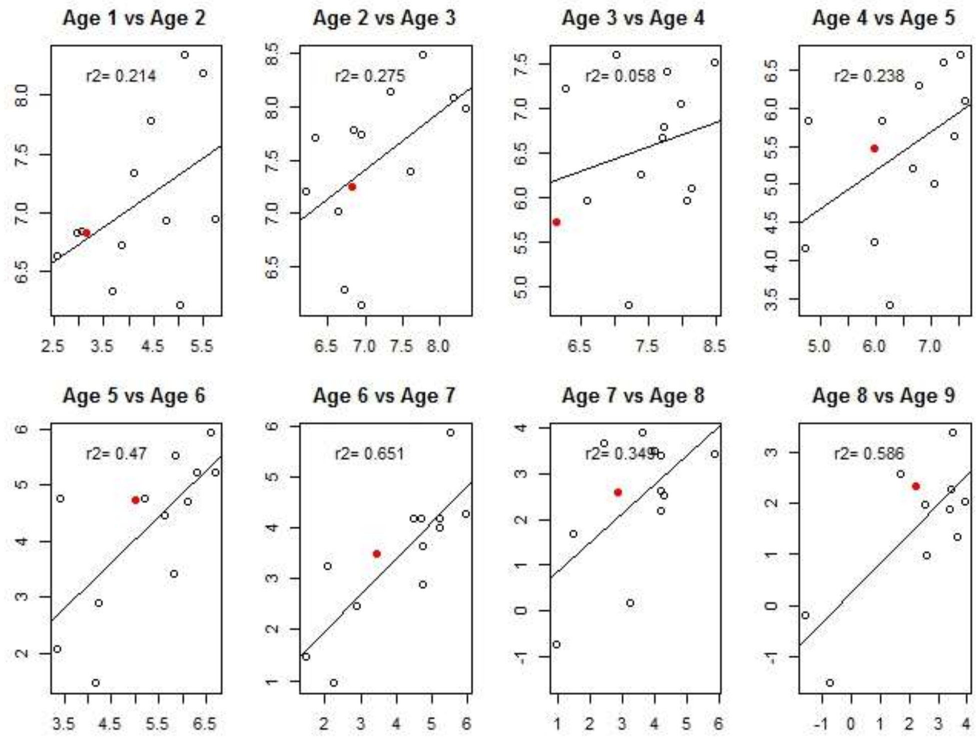


Figure 5.3.7. Ple.27.24-32. Internal consistency of age classes 1–7 from commercial catches. All fleets and countries were combined.

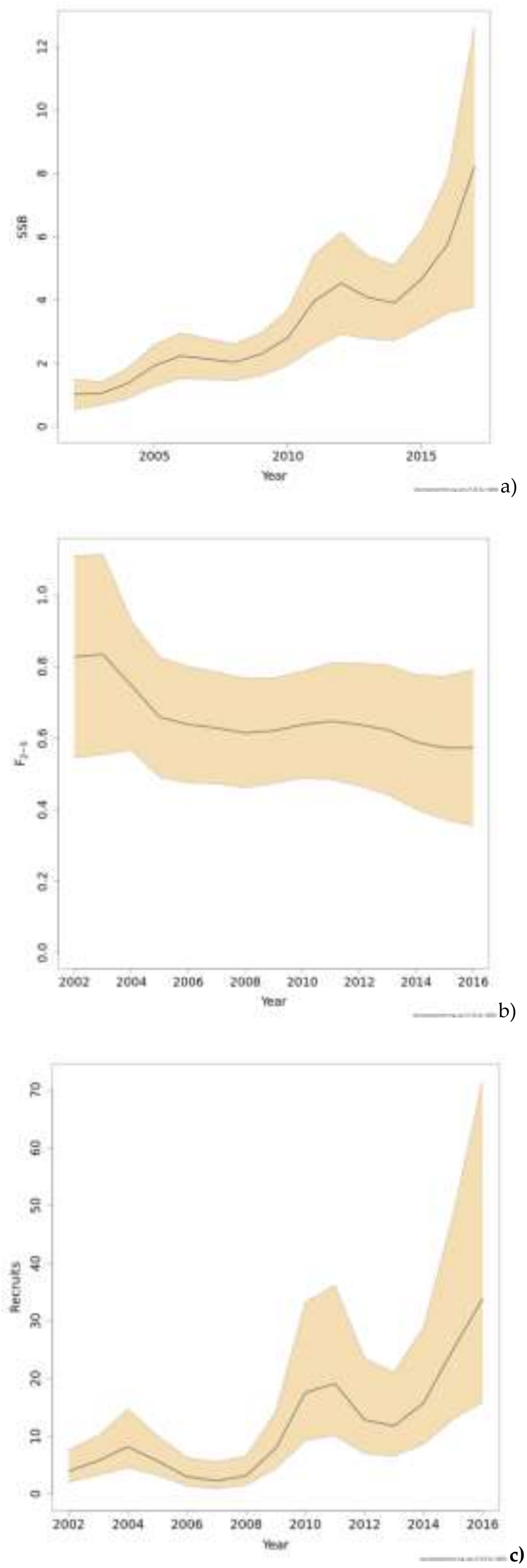


Figure 5.3.8. Ple.27.24-32. Results from the exploratory SAM assessment: a) total SSB, b) F (age2–5,) and c) recruitment.

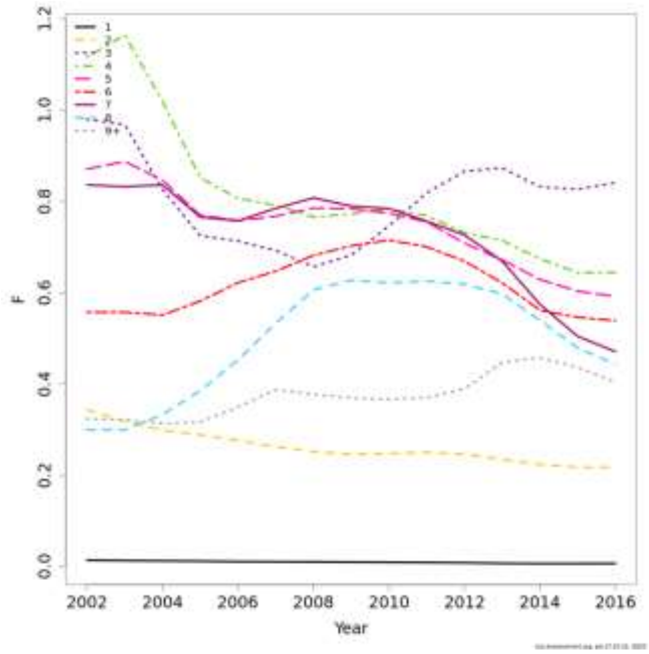


Figure 5.3.9. Ple.27.24-32. Average fishing mortality per age group (age class 9 as a plus-group).

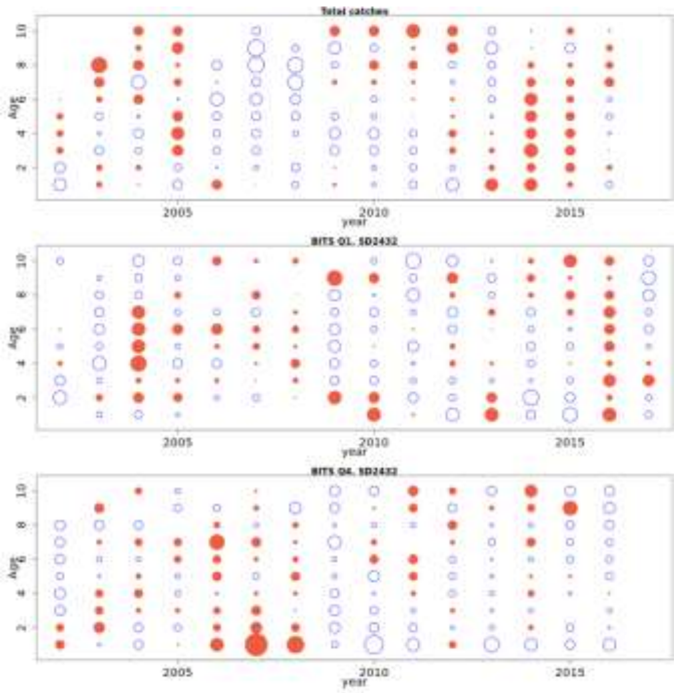


Figure 5.3.10. Ple.27.24-32. Normalized residuals for the current run. Blue circles indicate positive residuals (obs larger than predicted) and filled circles indicate negative residuals.

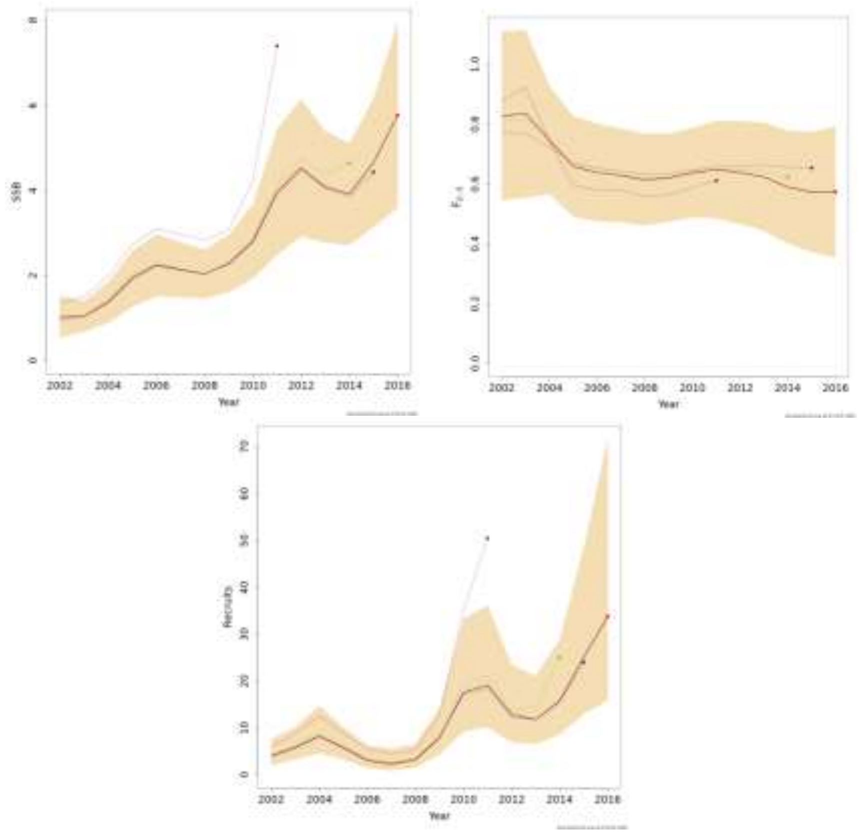


Figure 5.3.11. Ple.27.24-32. The results of the retrospective analysis showing the SSB, the F (3–5) and the recruitment.

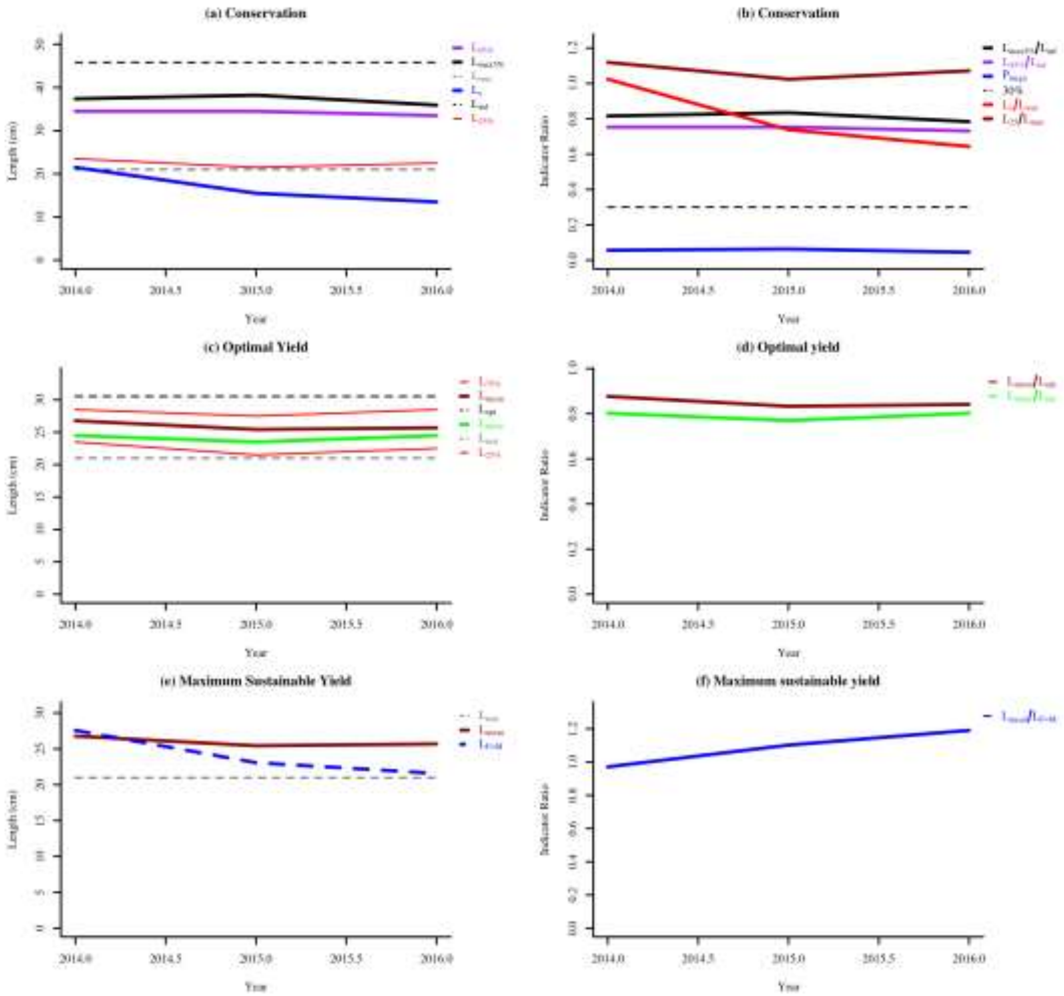


Figure 5.3.12 **Ple.27.24-32 Indicator trends of the Length based Indicator calculations.**

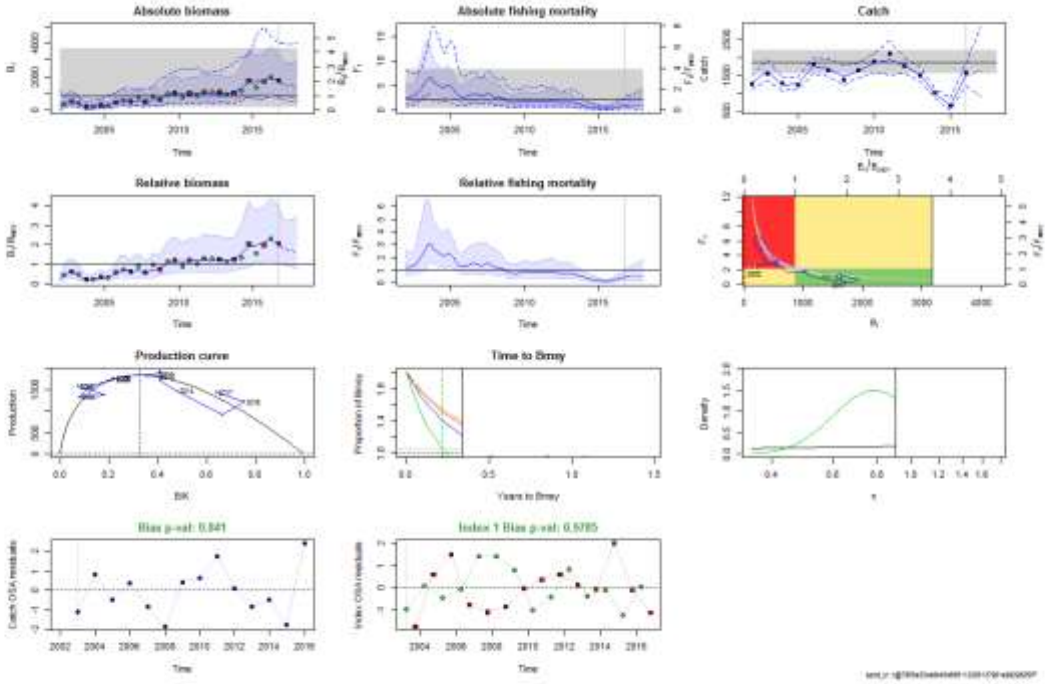


Figure 5.3.13. Ple.27.2432. Overview of the results of the surplus production model (SPiCT) on catch and survey data 2002-2016.

6 Sole in Subdivisions 20–24 (Skagerrak, Kattegat, the Belts and Western Baltic)

6.1 The Fishery

Sole is economically an important species in in the Danish fisheries. For both Kattegat and Skagerrak the major part of the sole catches is taken in the mixed species trawl fishery using mesh sizes 90–105 mm and with gillnets using mesh sizes of 90–120 mm. The landings share of active and passive gears is approx. 60/40. Minimum legal landing size is 24.5 cm.

There is seasonality in sole fishery with both gill net and trawl. The low season for trawl is from May to September (Figure 6.2). The season for gill net fishery for sole is from April to September. During this season, about 80% of the gill net catches are sole. Additional information of the sole fishery can be found in the Stock Annex.

6.1.1 Landings

The officially reported landings by area, gear and country for 2016 are given in Table 6.1. Denmark took 88% of the total catch in 2016. Kattegat has traditionally been the most important area accounting for 63% of the annual catches in average. The proportion of Danish landings from the Skagerrak in 2016 (26%) is below historic average.

Historical catches, including the working group corrections, are given in Table 6.2 and Figure 6.1. The fishery fluctuated between 200 and 500 t annually prior to the mid-1980s and increased to 1400 t in 1993. Since then, landings have decreased with a low in recent years of about 220 t. Figure 6.2 provide the Danish catches cumulated by month since 1998, indicating the main periods of fishery and the 1 quarter of 2017.

6.1.2 Discards

Danish discard sampling at sea is carried out within EU programmes that began in 1995 in both Kattegat and Skagerrak. Results indicate that the amount of sole discarded was very limited in years after 2005 when the fishery was not restricted by quotas (i.e., discard levels are believed to be only a few percent when measured relative to the sole landings). Discards in 2016 amounts to 5% of the catches by weight based on sampling from trawlers(Table 6.3) and average of the recent 5 years are 4% discard by weight (used in advice).

Since the discards are overall estimated to be insignificant and rather constant over the entire time series and in addition incomplete in coverage, these data are not included in present assessment.

6.1.3 Effort and CPUE Data

Presently only private logbook time series from selected Danish trawlers and gillnetters are kept from the past to calibrate to assessment: 1987–2008 and 1994–2007, respectively (Table 6.5).

6.2 Biological composition of the catch

6.2.1 Catch in numbers

Sampling of age structure of the catch was available only for the Danish fishery (Table 6.4). With the continued low landings in 2016 also followed relatively few sampled fish (248 specimens from the fishery). The age structure of the Danish catch was assumed to apply to the total international catch (Table 6.6).

The age composition of the catch has mainly been composed of 3–5-year-olds since the beginning of the 1990s but in recent years older fish have a higher proportion of the catch (Figure 6.6).

6.2.2 Mean weight-at-age

Data for mean weight-at-age in the catches were derived using the same sample allocation as used in the computation of catch-at-age. The mean weight-at-age in the catch is shown in Table 6.7 and Figure 6.7. In general, weight-at-age data are highly variable between years, and this variability is not assumed to be connected to biological events but rather reflect the poor sampling, ageing problems and/or sex differentiated growth.

6.2.3 Maturity at age

Due to insufficient biological information on maturity, the present assessment uses a fixed maturity ogive as in all assessments since 1996 (knife-edge maturity-at-age 3).

6.2.4 Natural mortality

The natural mortality is unknown and was assumed to be 0.1 per year for all ages.

6.2.5 Quality of catch and biological data

Denmark provided statistics on catch sampling for the Kattegat, Skagerrak and the Belts (Table 6.4). Sampling in 2016 remained inadequate especially for Skagerrak where no sampling was achieved and also with respect to gears; gillnetters was no sampled in 2016. The small and scattered catches mainly taken as by-catch prevent proper port sampling with the present sampling intensity. The data scarcity impedes the quality of the assessment (see Section 6.2.1). Initiatives to improve sampling under the present low catch fishery are presently initiated as by means of cooperation with fishermen (reference fleet) which gained more samples in 2016 in comparison to 2015.

6.3 Fishery independent information

Since 2004 a survey conducted cooperatively by DTU Aqua and with Danish fishermen (Jørgensen, 2015, WD#1 WGBFAS 2015) was designed with fixed haul positions chosen by both scientific and fishermen. The survey takes place in November-December and covers part of Skagerrak and entire Kattegat (Figure 6.4). The survey ceased in 2012-13 but resumed in 2014. The survey in 2016 was redesigned to cover more areas in Skagerrak and also in the Belts (Fig. 6.5); 20 stations in Skagerrak (Jammerbugt) and 6 stations in the Belts (northern part of Storebælt). The extended area was not utilized in the survey index calculation, but awaits a longer time series and further evaluation. Catch rates from the additional areas in Skagerrak and the Belts had catch rates lower than the remaining survey area in Kattegat. Based on 69 successful hauls out of 80 planned hauls in 2016, age disaggregated indices from the survey are used for the analytical assessment (Table 6.5). The index is estimated by a GAM model that takes into account spatial diversity of growth and also that the survey coverage have been reduced over time (see stock annex). The aggregated index show a decrease from 2015 to 2016 (Figure 6.3 and Table 6.5).

6.4 Assessment

Since the benchmark in 2010 (WKFLAT) SAM has been used as the assessment model. Final assessment in 2017 is named 'sole20-24' at stockassessment.org.

6.4.1 Model residuals

Model residuals from SAM for the survey and catches are provided in Figure 6.8. Estimated standard deviations of log observations are provided by age group and fleet in Table 6.8.

6.4.2 Fleet sensitivity analysis

In order to examine the effect of the single fleet calibration indices on the F and SSB estimates, SAM runs were conducted with the single fleets left out of the analysis one at a time (Figure 6.9). From the plots it is obvious that the survey has a marked effect on the assessment and deviate in stock and F perception from the catch matrix (e.g. fishery). The catch matrix is most likely reflecting information from the trawlers the as a tuning fleet was left out last year due to severe changes in efficiency (catching less fish per effort). The discrepancy in SSB and F history that appear when leaving out the survey from the assessment is therefore partly expected.

6.4.3 Final stock and fishery estimation

Stock summary (SSB, fishing mortality and recruitment) as estimated from the SAM model is provided in Figure 6.10. The SSB in the past 5 years have varied between 1700 t and 2200 t and is estimated to 2016 t in 2016. This fluctuation is most likely dependant on the variation in mean weights in the landings (Figure 6.7). Fishing mortality has since 2005 decreased continually and is in 2016 estimated to 0.17. Recruitment calculated as age 1 has since 2012 been slightly increasing but still below the average for the recent (Figure 6.10, Table 6.11).

6.4.4 Retrospective analysis

Retrospective pattern (Figure 6.11) of the SSB and F estimates show patterns of bias in especially the last year; fishing mortality is underestimated and SSB is overestimated, although the extent of the over- and underestimation is relatively small. Mohns rho calculated for the three analyses are in the range 0.13-0.17 and thus at acceptable levels.

6.4.5 Historical stock trends

Estimated fishing mortalities, stock numbers and recruitment are provided in Tables 6.9 and 6.10, and the stock summary is given in Table 6.11 and Figure 6.10. SSB was estimated at 2016 t in 2016 t above Blim and below MSY Btrigger.. SSB has been estimated in the range 1800-2400 t in the past nine years with no clear trend.

Fishing mortality has decreased continuously since 2005 until 2015 but increased slightly in 2016 from 0.14 to 0.17.

Recent recruitment (2014–2015 year-classes at age 1) was estimated to improve from the previous years and the 2014 year class is estimated above the geometric mean for the period since 1994 (perceived the present productivity regime) (tables 6.10–6.11).

6.5 Short-term forecast and management options

Input data to short term prediction are provided in Table 6.12.

Discards are not included in the assessment but comprise 5% in weight in 2016 (Table 6.3). The average of the discard in the recent 5 years (4%) is used to "top up" catches to derive landings. Catch options are provided in table 6.12.

In previous two years catch assumptions have been TAC constrained, i.e. that TAC would be fished within the intermediate year. Prior to that F status quo assumptions were made. For a number of years in the recent decade the TAC has not been fully utilized even though TACs were constantly reduced. In 2015 a record low TAC resulted in fully utilization, but in 2016 an increasing TAC (391t) was not caught. TAC increased further in 2017 to 551 t. It is doubtful that this TAC will be fished given the development of reported landings in the first quarter of 2017 (Figure 6.2). Therefore the group have decided that an F status quo option for 2017 is more likely that a TAC constraint option. However, an Fsq option with F in 2018= F2017=0.17 is calculated to result in catches in 2017 of 303 t which is far from the TAC of 551 t. One of the assumed main reasons for the low utilization of the sole TAC in recent years are that the *Nephrops* fishery in which sole is a valuable by-catch has used more effort to target *Nephrops* due to high market prices. Market prices are hard to predict but the group put more trust in a continued regime where *Nephrops* is targeted and that the sole TAC of 551t will therefore not be fully fished.

For 2017 is therefore assumed that fishing mortality will continue at status quo (0.17) corresponding to catches of 303 t. Given this scenario, SSB in the beginning of 2018 is estimated to 2741 t which is above MSY Btrigger. With this assumption the forecast predicts that fishing at F_{MSY} in 2018 will lead to yields of 453 t (Table 6.13). At this level of exploitation, spawning stock biomass is estimated at 2811 t in 2019 (for trends see Figure 6.13). Catch in 2018 and stock composition in 2018 and early 2019, is estimated to be dominated by age 3 and 4 as indicated in Figure 6.14 under the assumed average recruitment and F_{sq} exerted in 2017.

A yield-per-recruit analysis was made with long term averages (15 years) with unscaled exploitation pattern. The yield-per-recruit curve (Figure 6.15) indicates that maximal yield per recruit is poorly estimated at $F_{4\text{-}8}$ around 0.74 and that $F_{0.1}$ is estimated to 0.20.

6.6 Reference points

Reference points were redefined under the interbenchmark, IBPSOLKAT (ICES, 2015) in November 2015 as follows:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY Btrigger	2600 t	Bpa	ICES (2015)
	FMSY	0.23	Equilibrium scenarios stochastic recruitment, short time-series 1992–2014, constrained by Fpa.	ICES (2015)
Precautionary approach	Blim	1850 t	Bloss from 1992 (low productivity regime)	ICES (2015)
	Bpa	2600 t	Blim × e 1.645σ, σ = 0.20	ICES (2015)
	Flim	0.315	Equilibrium scenarios prob(SSB< Blim)< 50% with stochastic recruitment	ICES (2015)
	Fpa	0.23	Flim × e -1.645σ, σ = 0.18	ICES (2015)
Management plan	SSBMGT	Not defined.		
	FMGT	Not defined.		

6.7 Quality of assessment

Sampling from this relatively small and spatially dispersed fishery has for a long time been a challenge and often results in few measured fish per sample. The 2016 sampling was improved from previous years by means of a so-called reference fleet, i.e. agreements with specific fisherman of self-sampling on board the vessel during the fishing trip. The initiative will be further developed over the next years to ensure that all areas, fleets and seasons are properly sampled.

The assessment this year has tendencies of bias in the SSB and F estimation in relation to previous years; SSB is slightly overestimated and F is slightly underestimated. However, this trend is not of a magnitude that leads to questioning the terminal estimates of SSB and F.

6.8 Comparison with previous assessment

This year's assessment is carried out in accordance with the procedure described in the stock annex. However, due to a weak retrospective pattern in estimation of SSB and F, stock and fishery perception has changed somewhat compared to last year: SSB in recent years is lower and F is higher. The stock status in relation to reference points are though unchanged.

6.9 Management considerations

Management of the sole fishery should take into account that particular the trawl fishery is a mixed fishery with cod and Nephrops. With the restricted catch opportunities of cod in SD 21, combined with the intended landing obligation could results in cod being a choke species in the mixed fishery. If the mixed fishery for sole and cod could be un-coupled, management in the Kattegat would be more straightforward and sustainable. Such un-coupling could be achieved by selective gears and area restrictions.

As maturity at age is not determined for the species but set to age 3+, SSB for the stock is uncertain. Present assumption is that maturity is constant over time. Any future adoption of an observed maturity ogive (derived from any survey) might therefore change the perception of the stock history and stock-recruitment relations c. This again will have an impact on the estimates of biomass reference points. Similarly establishment of a weight-at-age in the stock from the survey will have implications on perception of present stock biomass. Work is ongoing to improve the some of the biological parameters for sole in the assessment.

6.10 Issues relevant for a forthcoming benchmark

Since the last benchmark in 2015 a number of issues that can improve the present assessment have been recognized. At DTU Aqua, Denmark, a project focusing on these issues has been initiated and is running in 2017 and 2018. The work packages in the project are:

- Abundance and distribution of juveniles; identification of nursery grounds and evaluation of their importance for recruitment to the stock.
- Growth and recruitment; improvement of ageing by means of otolith calibration between readers and otolith structure to validate age.
- Stock structure - genetics; genotyping spawning fish in order to identify stock structure in the entire stock assessment area SD 20-24 and also to evaluate main migration patterns.
- Survey coverage – design; analysis of appropriate survey coverage with respect to the stock distribution. In 2016 survey area was already extended into Skagerrak and the Belts and this scheme will be evaluated.
- Improvement of biological data sampling - reference fleet; sampling from the fishery is difficult due to small and scattered landings; since 2016 agreements with specific fishermen were initiated to improve biological sampling.
- Selectivity in various gears – SELTRA; introduction of new selective devices in fishing gears have caused selectivity to change substantially. In order to quantify this change experimental sole fishery will be conducted with the most used devices.
- Improvement of assessment; the effect of revising a number of input data and assumptions in the assessment due to the above mentioned work packages will be evaluated with respect to estimation of the stock and fishing pressure.

The outcome of the project is likely available for a benchmark of the sole stock in early 2019.

Table 6.1 Sole 20-24. Landings (t) of sole in 2016 by area, nation, quarter and gear.

Skagerrak (SD20)	Quarter				Gear		Total
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	17	28	9	24	45	33	78
Germany	0	0	0	0	0	0	0
Sweden	1	0	0	0	1	0	1
Norway	1	1	0	0	1	1	2
Total	19	29	9	24	47	34	81
Kattegat (SD21)	**Quarter**				**Gear**		**Total**
Nation	1	2	3	4	Trawl	Gillnet	
DK	36	19	23	84	115	47	162
Germany	0	19	0	16	18	17	35
Sweden	4	3	2	4	7	5	13
Total	40	41	25	105	141	70	210
Belts and Baltic (SD22–24)	**Quarter**				**Gear**		**Total**
Nation	1	2	3	4	Trawl	Gillnet	
DK	13	16	8	19	25	31	56
Germany	0	0	0	0			0
Sweden	0	0	0	0	0	1	1
Total	13	16	8	19	25	31	57

Table 6.2 Sole 20-24. Catches (tons) in the Skagerrak, Kattegat and the Belts 1952–2016. Official statistics and Expert Group corrections. For Sweden there is no information 1962–1974.

Year	Denmark			Sweden	Germany	Belgium	Netherlands	Working Group	Total
	Kattegat	Skagerrak	Belts	Skag+Kat	Kat+Belts	Skagerrak	Skagerrak	Corrections	
1952	156			51	59				266
1953	159			48	42				249
1954	177			43	34				254
1955	152			36	35				223
1956	168			30	57				255
1957	265			29	53				347
1958	226			35	56				317
1959	222			30	44				296
1960	294			24	83				401
1961	339			30	61				430
1962	356				58				414
1963	338				27				365
1964	376				45				421
1965	324				50				374
1966	312				20				332
1967	429				26				455
1968	290				16				306
1969	261				7				268
1970	158	25							183
1971	242	32			9				283
1972	327	31			12				370
1973	260	52			13				325
1974	388	39			9				436
1975	381	55		16	16		9	-9	468
1976	367	34		11	21	2	155	-155	435
1977	400	91		13	8	1	276	-276	513
1978	336	141		9	9		141	-141	495
1979	301	57		8	6	1	84	-84	373
1980	228	73		9	12	2	5	-5	324
1981	199	59		7	16	1			282
1982	147	52		4	8	1	1	-1	212
1983	180	70		11	15		31	-31	276
1984	235	76		13	13		54	-54	337
1985	275	102		19	1	+	132	-132	397
1986	456	158		26	1	2	109	-109	643
1987	564	137		19		2	70	-70	722
1988	540	138		24		4			706
1989	578	217		21	7	1			824
1990	464	128		29		2		427	1050
1991 [1]	746	216		38	+			11	1011
1992	856	372		54				12	1294
1993	1016	355		68	9			-9	1439
1994	890	296		12	4			-4	1198
1995	850	382		65	6			-6	1297
1996	784	203		57	612			-597	1059
1997	560	200		52	2				814
1998	367	145		90	3				605
1999	431	158		45	3				637
2000	399	320	13	34	11			-132 [2]	645
2001 [1]	249	286	21	25				-103 [2]	478
2002 [3]	360	177	18	15	11			281	862
2003 [3]	195	77	17	11	17			301	618
2004 [3]	249	109	40	16	18			392	824
2005 [3]	531	132	118	30	34	Norway		145	990
2006	521	114	107	38	43	9	4		836
2007	366	81	93	45	39	9	0		633
2008	361	102	113	34	35	7	3		655
2009	325	103	145	37	27	4			641
2010	273	61	125	46	26	3	3		538
2011	271	127	65	53	33	3			552
2012	154	140	28	30	0	6	0		358
2013	153	78	33	54	9	6	0		332
2014	141	104	48	36	2	3	0		335
2015	95	66	36	9	7	5	6		224
2016	164	78	56	14	17	2	16		348

Considerable non-reporting assumed for the period 1991–1993. [2]Catches from Skagerrak were reduced by these amounts because of misreporting from the North Sea. The subtracted amount has been added to the North Sea sole catches. Total landings for these years in IIIA has been reduced by the amount of misreporting. [3]Assuming misreporting rates at 50, 100, 100 and 20% in 2002-2005, respectively.

Table 6.3 Sole 20-24. Discard from active gears as obtained from observers.

Age	Discard in weight (kg)														
	Year														
	1999	2000	2001	2002	2003	2004	2005	2006-2009	2010	2011	2012	2013	2014	2015	2016
1	-	7,992	-	-	-	-	-	-	616	140	128	490	3,128	1,156	5,913
2	-	36,918	-	4,312	24,384	-	-	-	3,136	1,767	1,326	2,392	2,492	828	2,761
3	-	119,198	-	-	7,040	-	-	-	2,646	1,105	1,782	1,872	19,126	-	1,800
4	-	4,592	-	4,171	10,366	-	-	-	2,175	972	4,032	954	1,316	1,076	3,408
5	-	-	-	1,962	-	-	-	-	2,499	888	680	510	1,785	981	14
6	-	-	-	-	588	-	-	-	166	480	928	1,232	972	264	315
7	-	-	-	-	158	-	-	-	1,080	714	570	1,030	1,800	-	702
8	-	-	-	-	123	-	-	-	291	545	248	416	1,220	296	-
9	-	-	-	-	-	-	-	-	1,197	306	572	708	232	-	172
10	-	-	-	-	158	-	-	-	117	605	393	224	-	832	1,456
11	-	-	-	-	-	-	-	-	-	-	345			118	-
Total	-	169	-	10	43	-	-	-	14	8	11	10	32	6	17
Landings (	637	645	478	862	618	826	994	706	538	552	359	332	335	224	348
Catches	637	814	478	872	661	826	994	706	552	560	370	342	367	230	365
Discard %	0%	21%	0%	1%	6%	0%	0%	0%	3%	1%	3%	3%	9%	2%	5%

Table 6.4 Sole 20-24. Sampling and ageing in 2016 from Danish fishery.

	Belts			Skagerrak			Kattegat			Total		
Quarter	Official landings	Sampled catch (kg)	Aged	Official landings	Sampled catch	Aged	Official landings	Sampled catch	Aged	Official landings	Sampled catch	Aged
1	13,084	11,876	13	17,956	58	2	39,703	-	-	70,743	11,934	15
2	16,007	-	-	28,081	151	5	30,182	5,057	27	74,270	5,208	32
3	7,832	-	-	8,856	413	2	24,123	5,270	28	40,811	5,683	30
4	18,906	11,640	91	23,771	-	-	96,468	74,857	80	139,145	86,497	171
Total	**55,829**	23,516	104	78,664	622	9	190,476	85,184	135	324,969	109,322	248

Table 6.5 Sole 20-24. Tuning fleets.

```
Fisherman-DTU Aqua survey
2004    2016
1       1       0.8     1
1       9
1 16.96855 55.96557 49.91849 31.40997 21.654053  8.95753   7.338731  4.406735  5.974572
1 12.9165  38.55566 67.76623 36.26695 17.922071  8.103796  2.825377  1.760731  1.408326
1 34.49494 38.78022 28.75144 51.28045 25.700827 13.987184  4.847019  1.59038   5.073859
1 31.81877 33.34679 24.29132 29.50392 30.758811 20.639429 11.842925  7.085257 12.459447

1 10.10062 46.08714 28.33982 15.61443 13.149731 17.57112   7.660865  6.547051  7.49172

1 15.07643 17.49389 28.97174 11.86504 14.733418 14.04448  17.367429  6.486122  7.384532

1 13.77282 16.57213 19.58162 17.88166  7.257644 10.282022  8.609531 12.691073 14.655291

1 14.95544 29.93514 17.91332 17.04403 15.805618 10.058751  9.017387  4.136279 19.496536

1 -1  -1  -1 -1  -1  -1  -1  -1  -1
1 -1  -1  -1 -1  -1  -1  -1  -1  -1
1 22.08253 17.32933 19.17415 14.45406 12.31646  9.540256  4.023012  8.644736  12.266636

1 33.77455 28.74293 16.83042 15.29688  9.64730217.502387  6.471581  4.740233  30.78858

1 14.32513 30.5701  21.59495 11.69164 11.201131 3.292864  6.255114  3.625479  21.290815
Private logbooks Gillnet KC + KS combined
1994    2007
1       1       0.25    0.87
2       9
 7246      1071       8794      7892      2547      1254       268       187        60

 5900       682       3284      6795      4942      1673       936       203       153
24238      4914      19748      8589     10880      6350      2872      1578       948

19939      1303       5568      8787      7036      9251      6658      4775      3280

18984      2685       3309      3816      4869      2632      3033      3443      2270

19917     10704      33215      3187      3507      2700      2176      1978      1633
23645      2336      12192     11953      1815      2285      2461      2222      2315
17755      5721      11108      9181      3953      1463      2717       812      1260
19930     17094      20860      6010      6043      6757      2384      2155      2801
13812      2029      17166     16000      4387      7051      2468       395       691
 5518       547       3854      4483      2289      1391       864       523       226
 9067      2827      11590     13754      5559      1832       485       455       170
 9742      1495       5999     10446      8760      5434      1443       991       287
 7026      1374       2638      2360      3039      1856       920       394       319
Private logbook TR KC+KS combined
1987    2008
1       1       0.75    1
2       6
 712      2756      5140      5562      2667       954
 876      5667      7735      5361      3432      1025
```

933	5097	2253	3761	2825	2126
1174	16408	10277	2753	3874	1545
1809	16085	35139	14745	4452	3878
3136	56849	46507	16304	7177	1545
4035	41739	44475	19945	11105	6685
5276	9498	55455	64125	19324	12725
4969	42026	35885	41231	29359	14705
4294	24861	38831	23489	26033	16360
4027	3927	13138	14220	10668	13279
2464	12543	3357	1117	1041	1736
2142	13031	24798	3690	4268	3927
3342	9566	16153	20370	3215	2692
2268	6292	11562	6052	6953	635
1498	29987	20538	4835	5483	3963
2093	7473	21584	14949	7199	3760
3999	20124	39887	47640	18374	8401
2463	7956	34026	29590	16011	6975
3132	11878	14708	24084	19146	12809
2730	14422	11847	4636	8756	515
1281	4393	2674	2438	2735	2130

Table 6.6 Sole 20-24. Catch in numbers (thousands) by year and age.

YEAR,	1984,	1985,	1986,
AGE			
2,	64,	786,	258,
3,	638,	594,	1255,
4,	240,	190,	671,
5,	117,	55,	210,
6,	31,	60,	33,
7,	33,	16,	36,
8,	40,	8,	33,
+gp,	175,	69,	63,
TOTALNUM,	1338,	1778,	2559,
TONSLAND,	337,	397,	643,
SOPCOF %,	99,	100,	100,

YEAR,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	1994,	1995,	1996,
AGE										
2,	391,	516,	863,	1209,	530,	506,	523,	127,	272,	316,
3,	857,	1035,	613,	1300,	1301,	1178,	1804,	1037,	622,	1015,
4,	1018,	897,	847,	651,	928,	939,	1251,	1451,	1359,	537,
5,	434,	484,	592,	564,	334,	493,	826,	752,	1226,	691,
6,	174,	129,	404,	310,	345,	320,	418,	444,	600,	440,
7,	64,	37,	83,	167,	302,	178,	117,	152,	385,	232,
8,	31,	23,	30,	27,	180,	166,	137,	45,	142,	148,
+gp,	87,	60,	52,	31,	76,	239,	157,	59,	104,	203,
TOTALNUM,	3056,	3181,	3484,	4259,	3996,	4019,	5233,	4067,	4710,	3582,
TONSLAND,	722,	706,	824,	1050,	1011,	1294,	1439,	1198,	1297,	1059,
SOPCOF %,	100,	100,	100,	100,	95,	93,	100,	99,	98,	98,

YEAR,	1997,	1998,	1999,	2000,	2001,	2002,	2003,	2004,	2005,	2006,
AGE										
2,	54,	303,	249,	142,	170,	655,	48,	195,	231,	122,
3,	251,	146,	826,	483,	369,	758,	431,	602,	1015,	400,
4,	440,	212,	150,	771,	360,	285,	480,	814,	1083,	857,
5,	365,	299,	228,	114,	354,	423,	280,	475,	583,	734,
6,	505,	267,	177,	130,	68,	472,	344,	257,	276,	505,
7,	360,	250,	165,	123,	84,	94,	197,	187,	117,	169,
8,	262,	218,	167,	135,	36,	85,	25,	86,	102,	67,
+gp,	263,	292,	233,	306,	205,	464,	210,	171,	91,	116,
TOTALNUM,	2500,	1987,	2195,	2204,	1646,	3236,	2015,	2787,	3498,	2970,
TONSLAND,	814,	605,	638,	646,	476,	862,	619,	824,	990,	836,
SOPCOF %,	100,	100,	100,	100,	99,	100,	100,	99,	98,	98,

YEAR,	2007,	2008,	2009,	2010,	2011,	2012,	2013,	2014,	2015,	2016,
AGE										
2,	293,	313,	554,	230,	138,	26,	48,	13,	37,	110,
3,	420,	330,	683,	591,	558,	157,	226,	66,	81,	273,
4,	384,	354,	445,	458,	613,	284,	286,	178,	95,	190,
5,	583,	297,	285,	211,	246,	160,	194,	109,	109,	175,
6,	299,	489,	139,	132,	65,	111,	137,	199,	89,	82,
7,	135,	240,	92,	67,	28,	36,	62,	105,	81,	38,
8,	81,	179,	29,	83,	14,	54,	23,	68,	18,	50,
+gp,	108,	202,	88,	103,	106,	192,	96,	69,	93,	181,
TOTALNUM,	2303,	2404,	2315,	1875,	1768,	1020,	1072,	807,	603,	1099,
TONSLAND,	633,	656,	640,	541,	507,	358,	332,	331,	215,	348,
SOPCOF %,	97,	102,	98,	101,	100,	100,	109,	100,	100,	101,

Table 6.7 Sole 20-24. Weight at age (kg) in the catch and in the stock.

YEAR,	1984,	1985,	1986,
AGE			
2,	.1830,	.1740,	.1650,
3,	.2130,	.2340,	.2310,
4,	.2570,	.2830,	.2870,
5,	.2940,	.2910,	.2970,
6,	.2970,	.3350,	.4090,
7,	.2800,	.2920,	.2670,
8,	.3210,	.2790,	.2620,
+gp,	.3680,	.3640,	.3830,
SOPCOFAC,	.9930,	.9984,	.9995,

YEAR,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	1994,	1995,	1996,
AGE										
2,	.1600,	.1590,	.1760,	.1800,	.1740,	.2130,	.1780,	.1740,	.1870,	.1760,
3,	.1940,	.1970,	.2210,	.2280,	.2290,	.2520,	.2240,	.2290,	.2000,	.2180,
4,	.2450,	.2350,	.2550,	.2510,	.2750,	.3360,	.2740,	.2800,	.2480,	.2670,
5,	.2740,	.2510,	.2660,	.3080,	.2920,	.4120,	.3280,	.3420,	.2910,	.3070,
6,	.3190,	.3350,	.2710,	.3330,	.3460,	.4300,	.3740,	.3880,	.3510,	.3390,
7,	.3600,	.3480,	.3520,	.4000,	.3090,	.4910,	.4030,	.4450,	.3820,	.4040,
8,	.4170,	.3630,	.3000,	.5470,	.3860,	.5660,	.3880,	.4480,	.4320,	.4570,
+gp,	.3610,	.3520,	.3550,	.5550,	.5030,	.6220,	.4740,	.3940,	.3830,	.6640,
SOPCOFAC,	1.0027,	1.0032,	.9964,	.9970,	.9508,	.9304,	.9980,	.9931,	.9767,	.9826,

YEAR,	1997,	1998,	1999,	2000,	2001,	2002,	2003,	2004,	2005,	2006,
AGE										
2,	.1980,	.1610,	.1620,	.1690,	.1840,	.1720,	.1740,	.2030,	.1920,	.2010,
3,	.2720,	.2190,	.2320,	.2360,	.2420,	.2050,	.2100,	.2370,	.2230,	.2150,
4,	.2960,	.3160,	.3040,	.3040,	.2900,	.2940,	.2460,	.2910,	.3000,	.2630,
5,	.3080,	.3220,	.3680,	.3440,	.3780,	.3730,	.3600,	.3280,	.3240,	.3170,
6,	.3450,	.3500,	.3600,	.3190,	.3460,	.3860,	.3820,	.3710,	.3670,	.3390,
7,	.3590,	.3580,	.3780,	.3640,	.3080,	.2140,	.4310,	.4010,	.3710,	.3210,
8,	.3640,	.3770,	.3970,	.3520,	.3620,	.2920,	.2610,	.3700,	.4210,	.2930,
+gp,	.3610,	.3270,	.3500,	.3280,	.2810,	.2760,	.3820,	.3150,	.3720,	.3440,
SOPCOFAC,	.9983,	1.0006,	1.0041,	1.0004,	.9941,	.9967,	.9971,	.9916,	.9841,	.9794,

YEAR,	2007,	2008,	2009,	2010,	2011,	2012,	2013,	2014,	2015,	2016,
AGE										
2,	.2110,	.2150,	.2110,	.2580,	.2610,	.2850,	.2390,	.2270,	.2210,	.2340,
3,	.2280,	.2460,	.2590,	.2700,	.2710,	.2790,	.2250,	.2830,	.2390,	.2670,
4,	.2950,	.2670,	.3010,	.2830,	.2920,	.3170,	.2760,	.3720,	.2860,	.2680,
5,	.3020,	.2800,	.3190,	.3240,	.2770,	.3750,	.3040,	.4210,	.3910,	.2830,
6,	.3540,	.2900,	.4030,	.3110,	.3580,	.4060,	.3730,	.4430,	.4040,	.3410,
7,	.3390,	.2960,	.4390,	.3690,	.4760,	.4060,	.3050,	.4860,	.3880,	.3300,
8,	.3800,	.3010,	.4390,	.3100,	.2850,	.3500,	.3060,	.4540,	.5010,	.5440,
+gp,	.2440,	.2460,	.2630,	.2630,	.3010,	.4060,	.2870,	.4060,	.4340,	.4390,
SOPCOFAC,	.9654,	1.0209,	.9832,	1.0103,	1.0003,	1.0006,	1.0891,	.9976,	1.0043,	1.0051,

Table 6.8 Sole 20-24. SAM diagnostics. Standard deviation estimates of log observations (Canum).

(Fleet1: fleet2: Survey, fleet3: PL gillnetters, fleet4: PL trawlers).

Index	Fleet number	Age	Catchability	Low	High
1	2	1	7.82759	5.65384	10.83710
2	2	2	14.11242	10.65698	18.68826
3	2	3	16.49827	12.53162	21.72047
4	2	4	18.29001	14.27337	23.43698
5	2	5	18.29001	14.27337	23.43698
6	2	6	18.29001	14.27337	23.43698
7	2	7	18.29001	14.27337	23.43698
8	2	8	18.29001	14.27337	23.43698
9	2	9	18.29001	14.27337	23.43698
10	3	2	0.06680	0.04744	0.09406
11	3	3	0.29269	0.23269	0.36816
12	3	4	0.32308	0.25667	0.40668
13	3	5	0.30739	0.25791	0.36636
14	3	6	0.30739	0.25791	0.36636
15	3	7	0.30739	0.25791	0.36636
16	3	8	0.30739	0.25791	0.36636
17	4	2	1.61358	1.26566	2.05714
18	4	3	2.98517	2.33011	3.82438
19	4	4	2.86726	2.23320	3.68133
20	4	5	2.88566	2.35621	3.53409
21	4	6	2.88566	2.35621	3.53409

Table 6.9 Sole 20-24. Fishing mortality at age (age 6-9 assumed constant).

YEAR\AGE	2	3	4	5	6+
1984	0.085	0.383	0.473	0.402	0.381
1985	0.075	0.301	0.370	0.337	0.295
1986	0.085	0.314	0.410	0.390	0.349
1987	0.099	0.333	0.446	0.450	0.448
1988	0.097	0.312	0.415	0.410	0.403
1989	0.101	0.317	0.426	0.430	0.420
1990	0.095	0.301	0.411	0.417	0.386
1991	0.097	0.305	0.423	0.442	0.488
1992	0.097	0.307	0.426	0.467	0.585
1993	0.096	0.309	0.430	0.483	0.596
1994	0.083	0.267	0.370	0.422	0.465
1995	0.088	0.289	0.388	0.446	0.498
1996	0.083	0.282	0.358	0.407	0.440
1997	0.078	0.256	0.338	0.388	0.430
1998	0.074	0.238	0.318	0.378	0.410
1999	0.068	0.225	0.298	0.350	0.373
2000	0.065	0.214	0.292	0.333	0.363
2001	0.056	0.183	0.243	0.289	0.307
2002	0.062	0.197	0.264	0.323	0.408
2003	0.055	0.170	0.246	0.300	0.379
2004	0.064	0.196	0.290	0.344	0.430
2005	0.072	0.223	0.323	0.369	0.433
2006	0.073	0.229	0.323	0.372	0.372
2007	0.074	0.237	0.325	0.352	0.309
2008	0.082	0.268	0.372	0.374	0.319
2009	0.072	0.254	0.357	0.326	0.195
2010	0.066	0.250	0.352	0.311	0.171
2011	0.051	0.205	0.308	0.252	0.129
2012	0.042	0.162	0.263	0.220	0.141
2013	0.037	0.143	0.242	0.207	0.143
2014	0.032	0.114	0.206	0.186	0.144
2015	0.029	0.103	0.176	0.179	0.121
2016	0.034	0.127	0.212	0.219	0.145

Table 6.10 Sole 20-24. Stock number at age from SAM.

Year\Age	1	2	3	4	5	6	7	8	9+
1984	6103	2563	1654	516	367	128	81	126	484
1985	5236	5823	2342	923	261	222	87	44	344
1986	4893	4599	4873	1708	607	169	142	73	257
1987	4679	4391	3813	3208	1027	373	126	91	222
1988	5949	3835	3820	2694	1830	492	172	73	181
1989	7328	5443	2662	2581	1682	1149	258	98	150
1990	7378	7112	4503	1755	1595	1013	686	134	136
1991	7810	6561	5602	2893	1037	945	672	465	181
1992	6099	7853	5335	3435	1561	585	503	370	400
1993	3756	5993	6774	3569	2075	870	282	262	364
1994	3454	2957	5154	4801	2147	1188	396	136	278
1995	2435	3428	2602	3954	3128	1420	757	259	273
1996	1839	2150	3027	1847	2395	1685	828	416	384
1997	3349	1226	1420	1736	1239	1514	1107	638	559
1998	3596	3639	870	904	966	759	834	683	764
1999	3318	3430	3781	633	718	607	520	510	882
2000	4375	2652	2628	2558	424	495	368	371	961
2001	5499	4025	2201	1918	1565	295	382	202	916
2002	4422	5811	3866	1528	1498	1171	234	284	882
2003	4317	3740	4313	2781	1146	1075	640	120	666
2004	3164	4315	3744	3255	1749	759	585	339	448
2005	2753	2901	4628	3493	2192	965	365	284	331
2006	3199	2506	2299	3489	2241	1441	550	230	409
2007	3318	2714	1979	1597	2162	1078	768	348	489
2008	2409	3156	1904	1396	1069	1385	658	531	587
2009	2237	2291	2626	1254	984	690	865	354	645
2010	2039	2068	2115	1742	750	660	437	659	775
2011	1774	1903	1952	1585	1143	491	445	254	1092
2012	1537	1542	1502	1452	990	814	328	363	1082
2013	1624	1298	1379	1208	1071	720	625	229	947
2014	2392	1310	1051	1003	844	829	476	530	827
2015	2906	2170	1102	880	676	677	569	300	1184
2016	2484	2627	1953	922	751	462	448	391	1285
2017*		2248	2298	1556	675	546	361	351	1312

***Estimated by simple forward projection of 2016 stock**

Table 6.11 Sole 20-24. Stock summary from SAM..

Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), and average fishing mortality for ages 4 to 8 (F48). "Low" and "high" are lower and upper boundary of 95% confidence limits as indicated on plots.

YEAR	RECRUITS	LOW	HIGH	TSB	LOW	HIGH	SSB	LOW	HIGH	F48	LOW	HIGH
1984	6103	3667	10155	1708	1373	2124	873	692	1100	0.404	0.302	0.540
1985	5236	3395	8074	2450	1928	3112	1122	885	1424	0.318	0.238	0.425
1986	4893	3231	7409	3074	2498	3782	2021	1596	2559	0.369	0.288	0.473
1987	4679	2988	7327	3073	2575	3668	2090	1723	2535	0.448	0.351	0.571
1988	5949	3940	8982	3127	2643	3699	2160	1803	2587	0.407	0.319	0.519
1989	7328	4814	11155	3576	3016	4240	2179	1837	2584	0.423	0.334	0.536
1990	7378	4870	11179	4441	3725	5295	2719	2288	3230	0.397	0.315	0.500
1991	7810	4928	12375	4796	4041	5693	3186	2667	3806	0.466	0.376	0.578
1992	6099	3963	9386	6138	5145	7321	4099	3453	4866	0.529	0.424	0.661
1993	3756	2485	5679	5181	4380	6130	3889	3252	4651	0.540	0.426	0.685
1994	3454	2310	5165	4789	4095	5600	4067	3444	4802	0.437	0.347	0.551
1995	2435	1552	3819	4202	3624	4872	3415	2930	3980	0.466	0.370	0.586
1996	1839	1041	3248	3728	3223	4312	3239	2792	3758	0.417	0.337	0.517
1997	3349	2197	5104	3079	2669	3553	2636	2264	3068	0.403	0.326	0.500
1998	3596	2397	5396	2660	2278	3107	1859	1583	2182	0.385	0.308	0.482
1999	3318	2168	5078	3015	2535	3586	2260	1887	2706	0.354	0.283	0.441
2000	4375	2917	6561	2992	2550	3512	2282	1924	2706	0.343	0.274	0.429
2001	5499	3538	8549	3301	2802	3889	2231	1892	2629	0.290	0.227	0.372
2002	4422	2939	6652	3893	3238	4681	2629	2190	3155	0.362	0.285	0.461
2003	4317	2837	6569	3885	3317	4549	2975	2485	3560	0.337	0.255	0.445
2004	3164	2183	4585	4257	3648	4968	3191	2715	3751	0.385	0.299	0.494
2005	2753	1873	4046	4245	3590	5019	3522	2954	4200	0.398	0.313	0.508
2006	3199	2179	4697	3691	3100	4396	2996	2492	3601	0.362	0.285	0.461
2007	3318	2254	4885	3241	2748	3821	2469	2078	2933	0.321	0.247	0.416
2008	2409	1617	3590	2864	2392	3429	2041	1692	2462	0.341	0.259	0.448
2009	2237	1519	3296	2972	2445	3613	2354	1908	2905	0.254	0.190	0.339
2010	2039	1381	3010	2738	2232	3358	2082	1673	2590	0.235	0.175	0.316
2011	1774	1167	2697	2700	2159	3376	2097	1657	2653	0.189	0.139	0.257
2012	1537	950	2485	2812	2215	3570	2280	1777	2927	0.181	0.132	0.249
2013	1624	1009	2615	2178	1704	2784	1770	1370	2287	0.175	0.128	0.240
2014	2392	1559	3670	2641	2092	3334	2200	1719	2816	0.165	0.120	0.226
2015	2906	1770	4770	2592	2040	3293	1938	1498	2508	0.144	0.102	0.202
2016	2484	1359	4540	2663	2046	3466	2016	1527	2662	0.173	0.123	0.244

Table 6.12 Sole 20-24. Input to short term prediction.

2017								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	2392	0.1	0	0	0	0.063	0	0.063
2	2274	0.1	0	0	0	0.209	0.196	0.209
3	2243	0.1	1	0	0	0.252	0.715	0.252
4	1539	0.1	1	0	0	0.308	1.232	0.308
5	679	0.1	1	0	0	0.360	1.212	0.360
6	538	0.1	1	0	0	0.377	0.85	0.377
7	358	0.1	1	0	0	0.405	0.85	0.405
8	347	0.1	1	0	0	0.428	0.85	0.428
9	1294	0.1	1	0	0	0.461	0.85	0.461
2018								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	2392	0.1	0	0	0	0.063	0	0.063
2	1958	0.1	0	0	0	0.209	0.196	0.209
3	2040	0.1	1	0	0	0.252	0.715	0.252
4	1933	0.1	1	0	0	0.308	1.232	0.308
5	1107	0.1	1	0	0	0.360	1.212	0.360
6	412	0.1	1	0	0	0.377	0.85	0.377
7	329	0.1	1	0	0	0.405	0.85	0.405
8	221	0.1	1	0	0	0.428	0.85	0.428
9	1016	0.1	1	0	0	0.461	0.85	0.461
2019								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	2375	0.1	0	0	0	0.063	0	0.063
2	1914	0.1	0	0	0	0.209	0.196	0.209
3	1745	0.1	1	0	0	0.252	0.715	0.252
4	1758	0.1	1	0	0	0.308	1.232	0.308
5	1594	0.1	1	0	0	0.360	1.212	0.360
6	900	0.1	1	0	0	0.377	0.85	0.377
7	371	0.1	1	0	0	0.405	0.85	0.405
8	302	0.1	1	0	0	0.428	0.85	0.428
9	1160	0.1	1	0	0	0.461	0.85	0.461

Input units are thousands and kg

Table 6.13 **Sole 20-24. Basis for forecasts and management options table for short term predictions.**

Basis:

VARIABLE	VALUE	SOURCE	NOTES
F ages 4–8 (2017)	0.17	ICES (2017a)	Fsq (F2017)
SSB (2018)	2741	ICES (2017a)	When fishing at Fsq (0.17) in 2017
Rage1 (2017-2018)	2392	ICES (2017a)	Sampling from recent low recruitment (2012–2016).
Total catch (2017)	303	ICES (2017a)	Assumed landings at F=0.17 plus discards.
Landings (2017)	291	ICES (2017a)	Assessment not including discards, topping up in advice.
Discards (2017)	4%	ICES (2017a)	Mean (2012–2016) discard rate in weight.

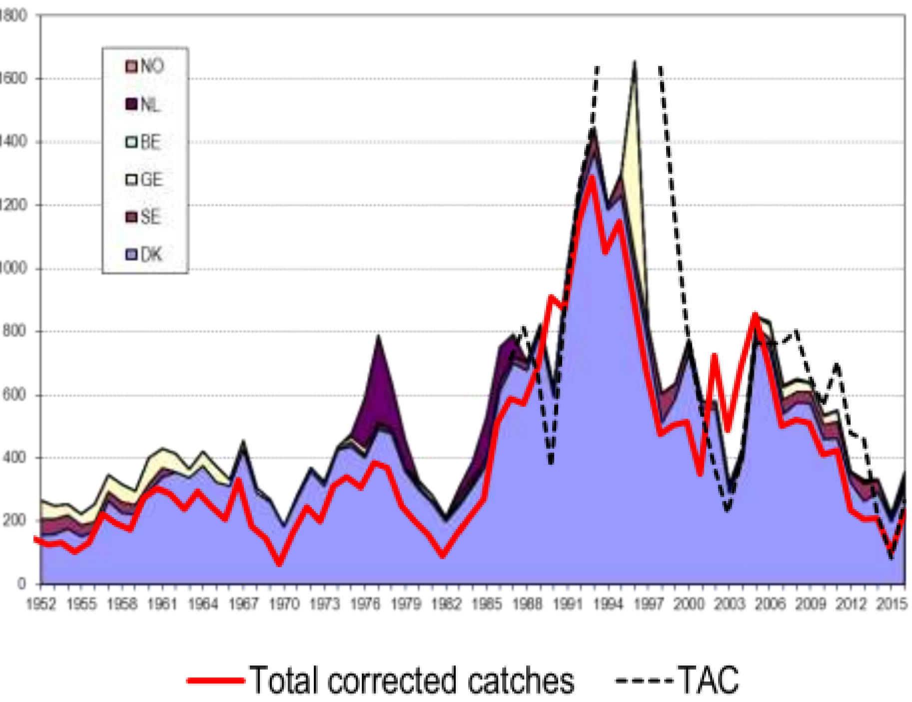
BASIS	TOTAL CATCH (2018)	WANTED CATCH* (2018)	UNWANTED CATCH* (2018)	FWANTED (2018)	SSB (2019)	% SSB CHANGE **	% TAC CHANGE ***
ICES advice basis							
MSY approach: FMSY	453	436	17	0.23	2811	3	-21
Other options							
F = 0	0	0	0	0	3273	19	-100
Fpa	453	436	17	0.23	2811	3	-21
Flim		575		0.32	2668	-3	4
SSB (2019) = Blim	1452	1367	56	0.99	1850	-33	148
SSB (2019) = Bpa	680	640	26	0.36	2600	-5	16
SSB (2019) = MSY Btrigger	680	640	26	0.36	2600	-5	16
F = F2017	382	336	15	0.17	2919	7	-39

*** Total catch is calculated based on wanted catch (fish that would be landed in the absence of the EU landing obligation) and 4% discard rate (in weight).**

**** The "wanted catch" is used to describe fish that would be landed in the absence of the EU landing obligation.**

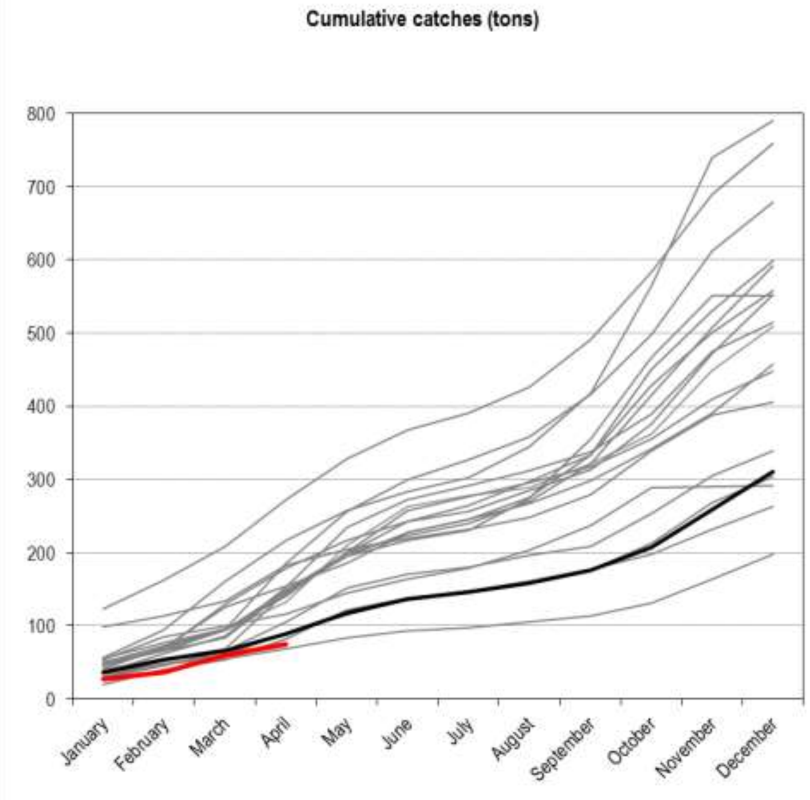
***** SSB 2019 relative to SSB 2018.**

^ Wanted catch 2018 relative to TAC 2017.



1800
1600
1400
1200
1000
800
600
400
200
0
NO
NL
BE
GE
SE
DK
1952 1955 1958 1961 1964 1967 1970 1973 1976 1979 1982 1985 1988 1991 1994 1997 2000 2003 2006 2009 2012 2015
Total corrected catches
TAC

Figure 6.1 Sole 20-24. Landings of sole in Skagerrak and Kattegat (IIIa) by nation since 1952. Bold red line indicate estimated total landings including misreportings as estimated by the WG and dashed black-bold line is TAC.



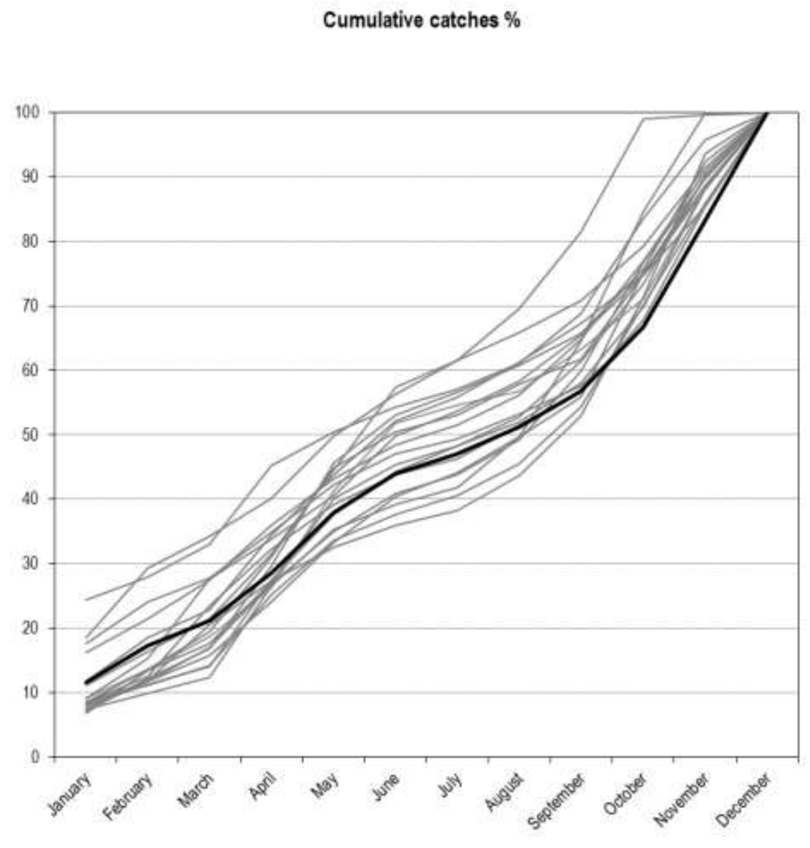


Figure 6.2 Sole 20-24. Cumulative Danish landings of sole by month. Black bold curve is 2016 and red bold curve is 2017.

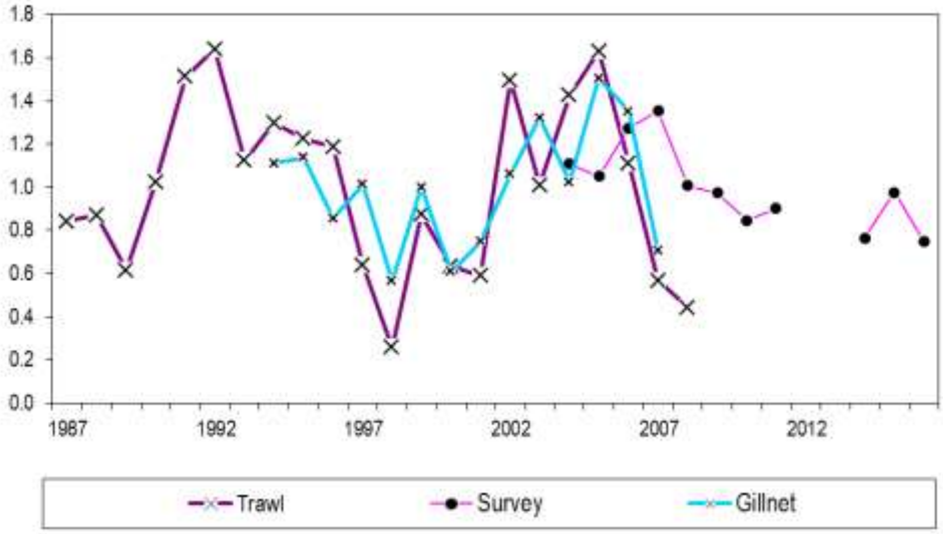


Figure 6.3 **Sole 20-24. Standardised CPUE of sole from private logbooks from trawlers , private logbooks gillnetters and Fisherman/DTU Aqua survey.**

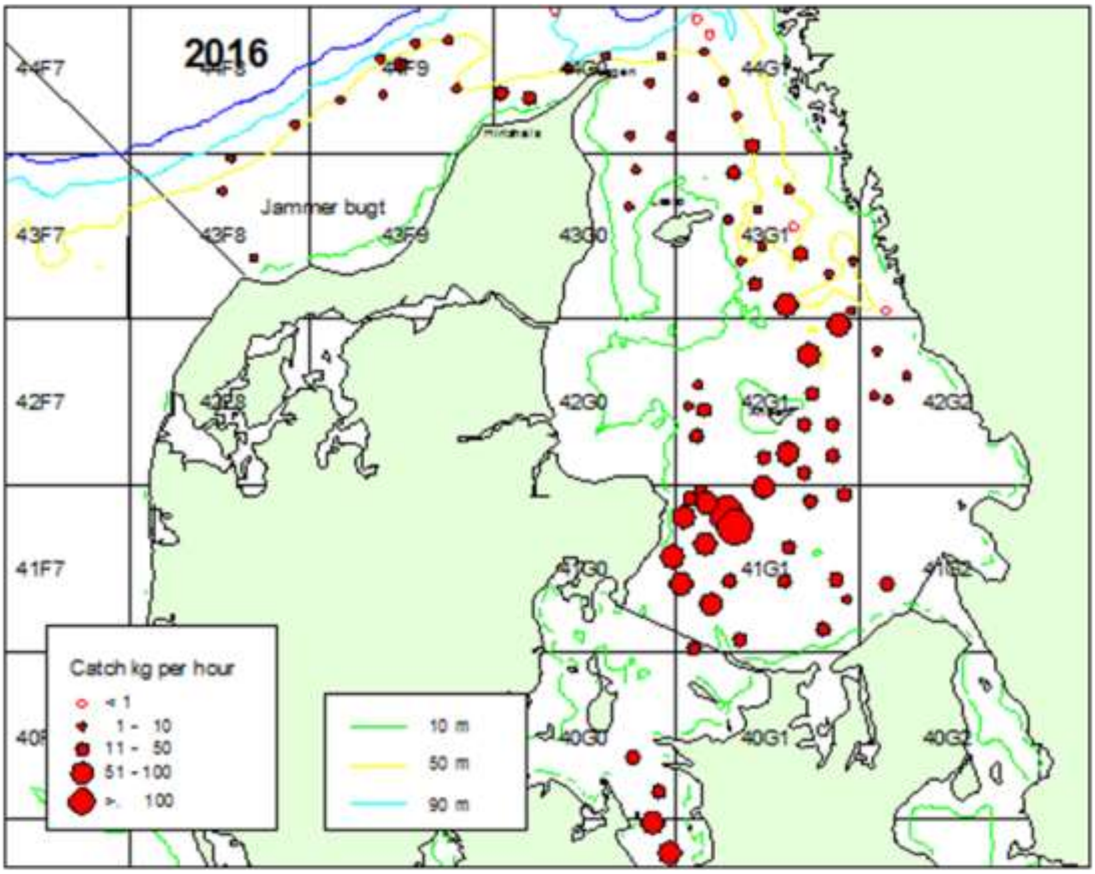


Figure 6.4 **Sole 20-24. Fisherman-DTU Aqua survey. Distribution of stations in 2016.**

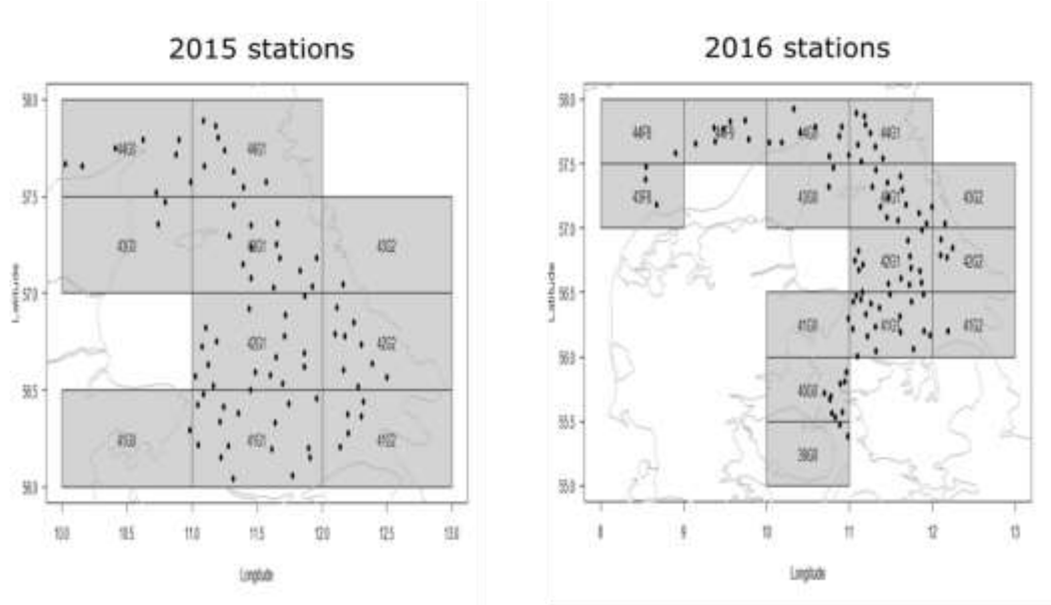


Figure 6.5 Sole 20-24. Map of sole survey station distribution in 2015 and 2016, illustrating the extended survey area in 2016.

Figure 6.6 Sole 20-24. Landing numbers at age.

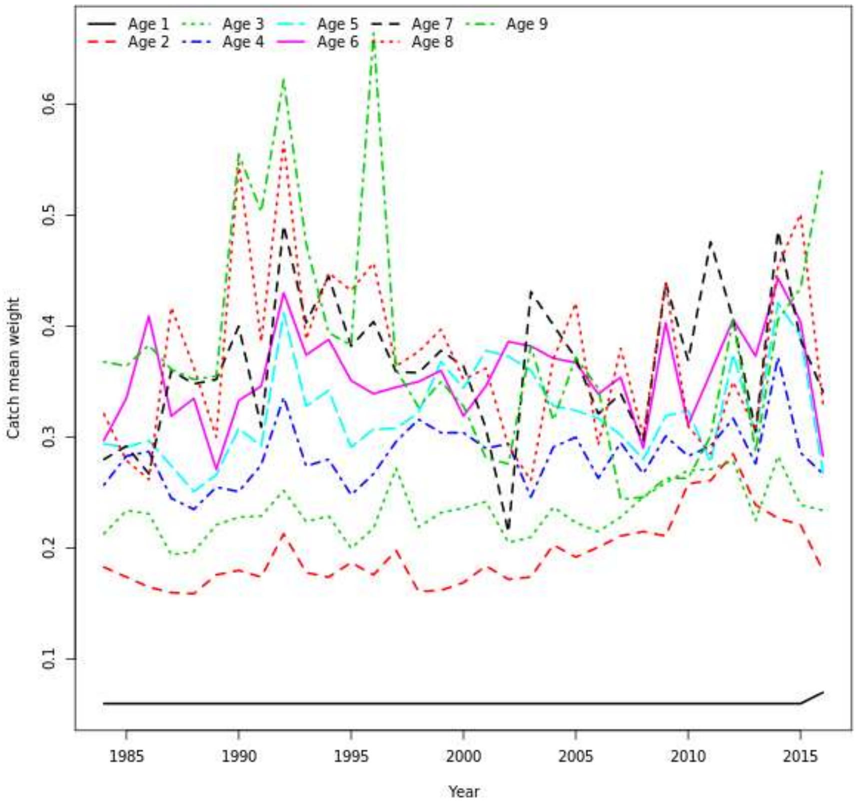


Figure 6.7 **Sole 20-24. Landings weight-at-age.**

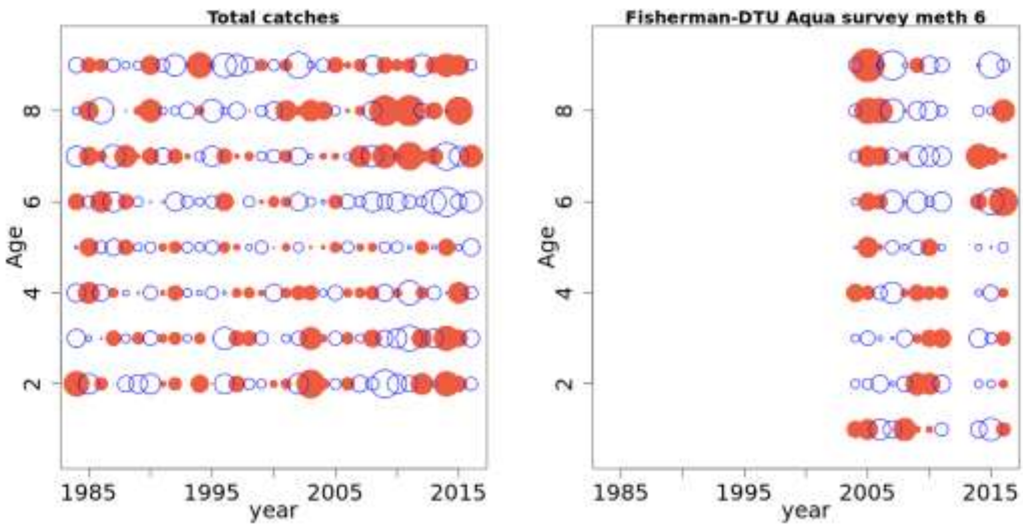


Figure 6.8 **Sole 20-24. Model residuals for survey and landings.**

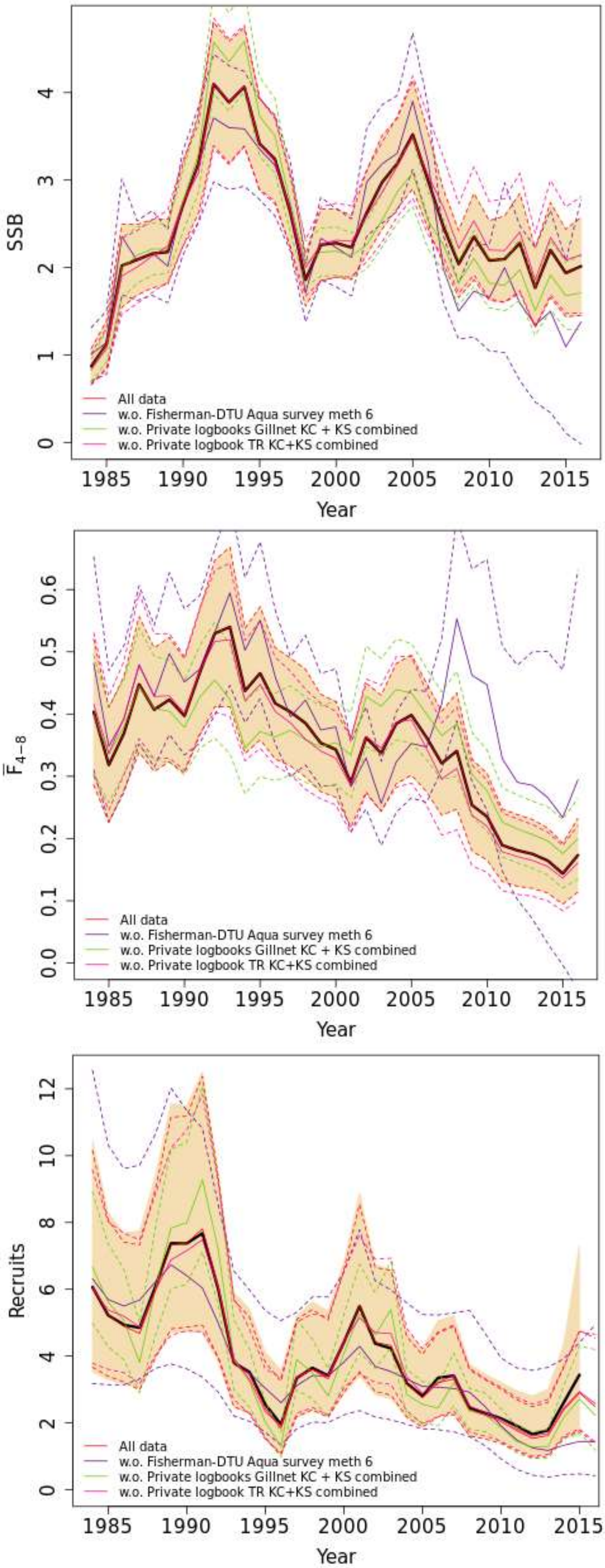


Figure 6.9 **Sole 20-24. Fleet sensitivity. Estimated SSB, fishing mortality and recruitment from runs leaving single fleets out.**

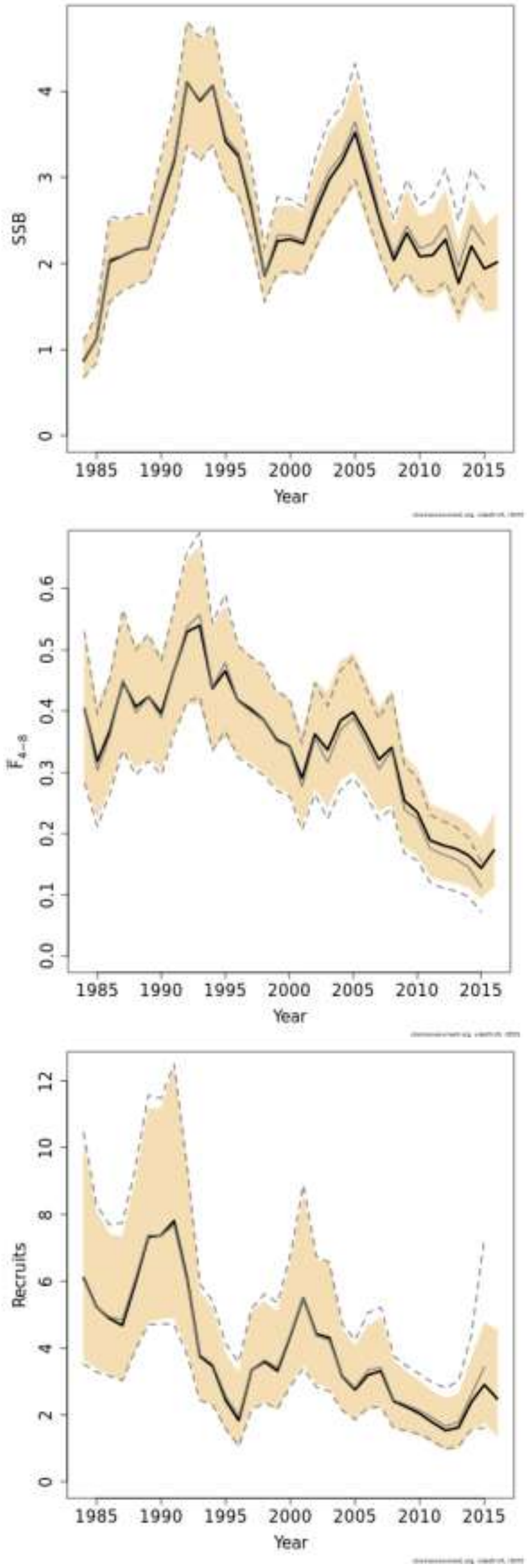


Figure 6.10 Sole 20-24. Stock summary compared to last year's assessment (grey curves and dashed lines, confidence intervals).

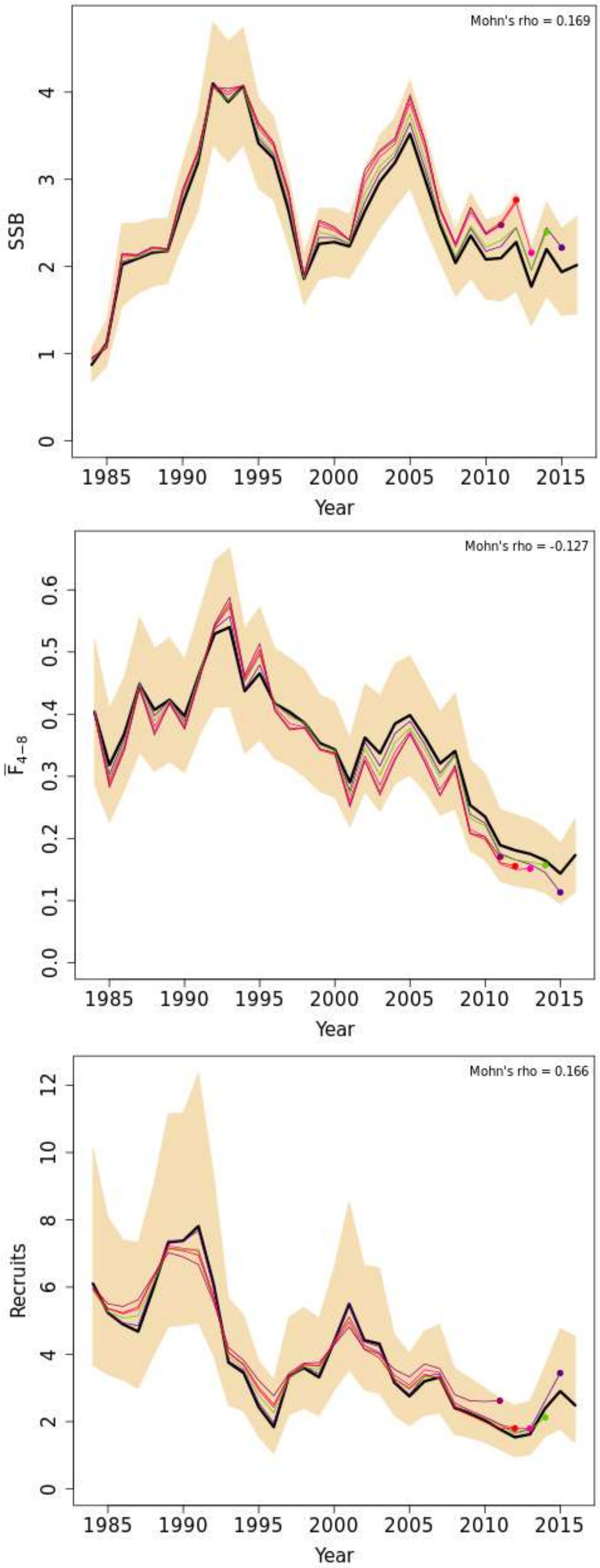


Figure 6.11 Sole 20-24. Retrospective analyses. Upper: SSB and F, lower: R. Confidence limits are provided for the 2016 scenario.

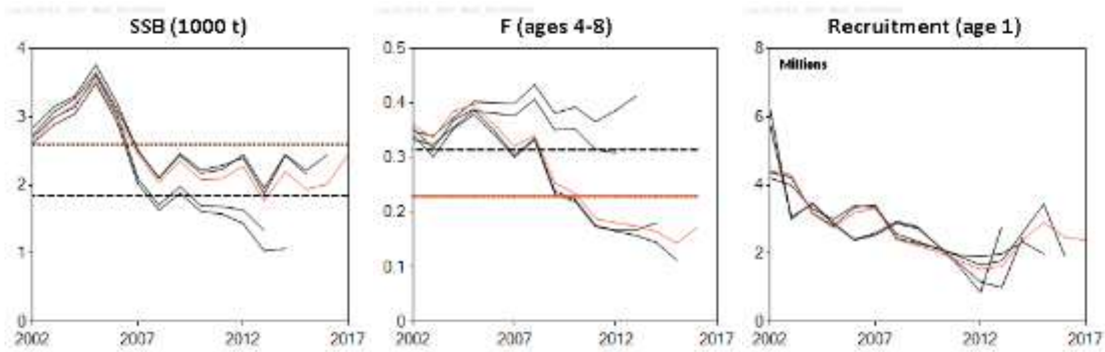


Figure 6.12 Sole 20-24. Historical performance of F, SSB and recruitment. .

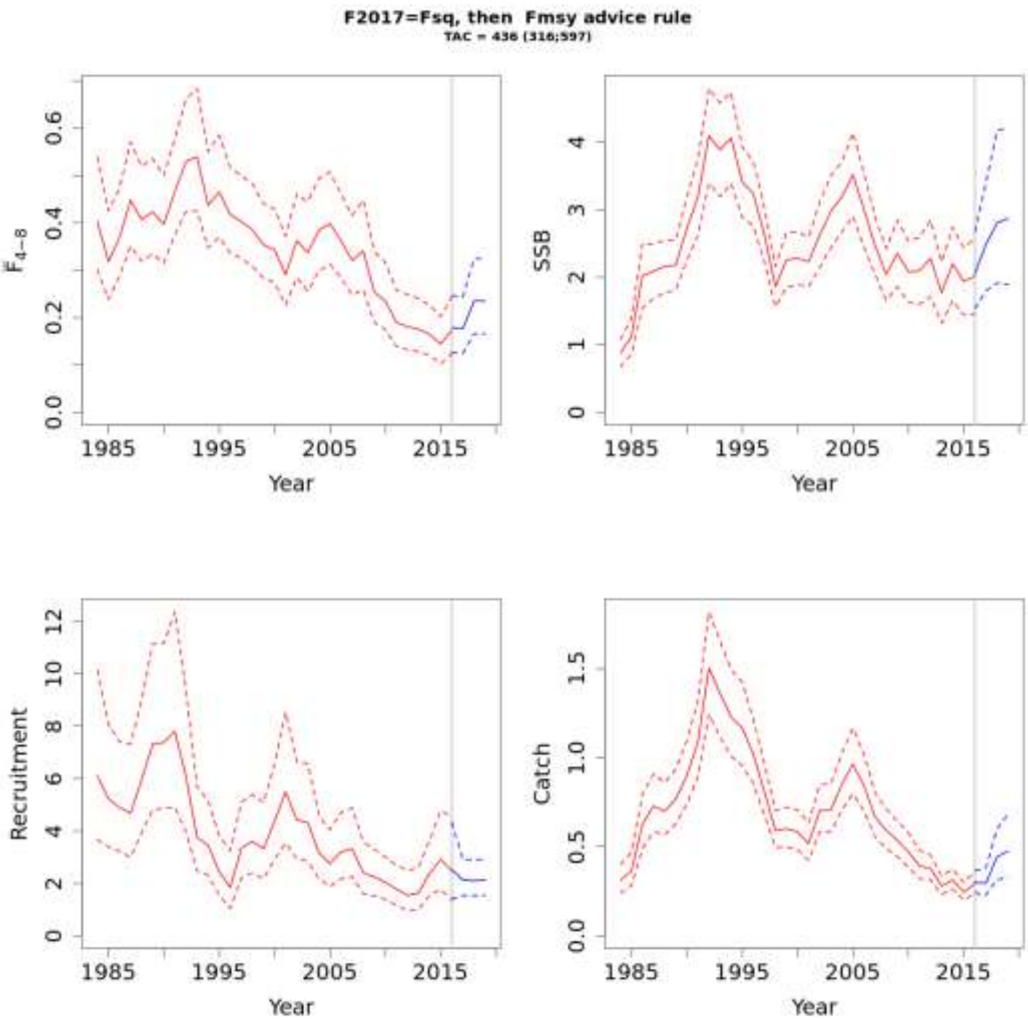


Figure 6.13 Sole 20-24. Illustrative forecasts of F, SSB, recruitment and yield in 2018-19 assuming status quo fishing mortality in 2017 (F=0.17) , recent low recruitment and Fmsy advice rule (F=0.23) for 2018 and 2019.

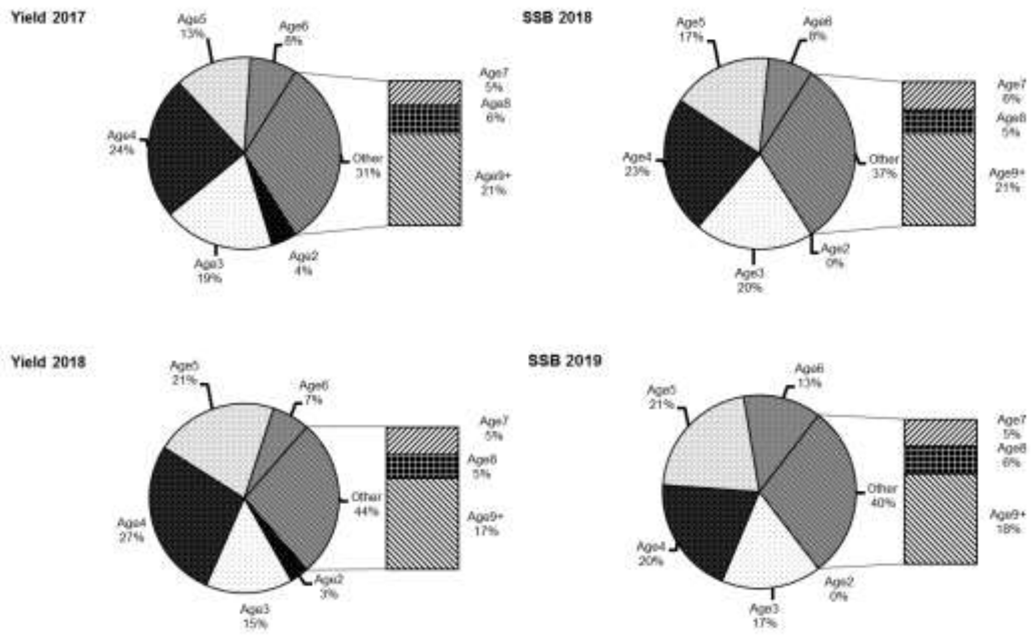


Figure 6.14 Sole 20-24. Short-term forecast for 2017-2019. Yield and SBB at age 2-9+ for status quo assumed fishing mortality in 2017.

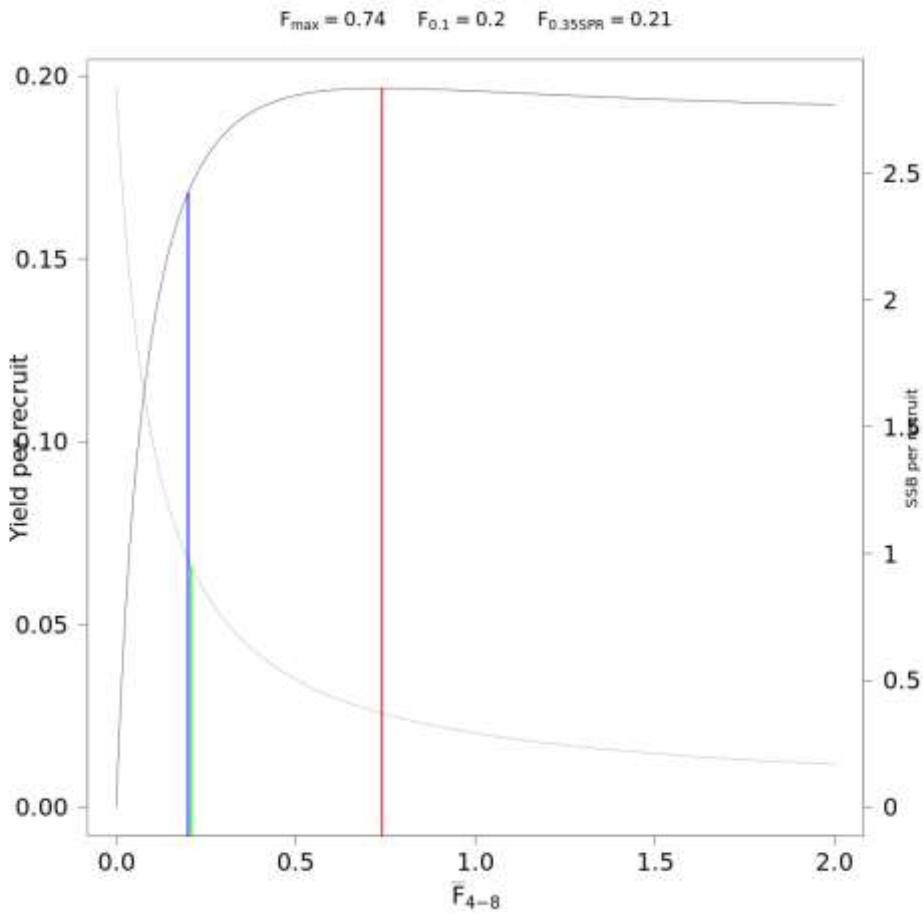


Figure 6.15 **Sole 20-24 Yield per recruit curve and reference point estimates (red=Fmax, green=F35%SPR and blue=F0.1).**

7 Sprat in subdivisions 22–32

As in previous years sprat in the Baltic subdivisions 22–32 was assessed as a single unit. The note on assessments by „assessment units" used up to early 1990s (subdivisions 22–25, subdivisions 26+28, and subdivisions 27, 29–32) is provided in section 7.7.

In 2013 the sprat assessment was benchmarked at WKBALT (2013) and the present assessment of sprat has been conducted following procedure agreed during the benchmark. The major change at benchmark workshop was the change of predation mortality from estimates provided by MSVPA to estimates obtained with SMS model.

In addition, at benchmark the tuning fleet from Age 0 index, in previous assessment constrained to subdivisions 26+28, was extended to cover subdivisions 22–29. In some years minor revisions were made in other tuning fleets data (May and October acoustic surveys).

Following extensive analysis of the XSA options, no reason was found to change previous settings (age 1 with catchability, q, dependent on stock size, q plateau at age 5, shrinkage SE of 0.75).

The SAM model was attempted as an alternative assessment model; it produced slightly lower SSB and higher Fs than the XSA. However, the XSA has been still considered as a main assessment model for sprat stock.

Maturity estimates were obtained from several countries but due to time constraints only simplified approach for their analysis was applied. The results did not suggest the need to change the maturity parameters used so far. However, further analysis of maturity data would be needed by employing statistical methods (e.g. GLM). For such analysis there was not enough time at benchmark workshop.

7.1 The Fishery

7.1.1 Landings

According to the data uploaded to the InterCatch, sprat catches in 2016 were 246510 t, which is 0.3% less than in 2015 and 53% less than the record high value of 529 400 t in 1997. In 2016 the TAC of 202320 t set for EU was utilized in 105%. The largest decrease in catches was observed for Denmark (15%). At the same time the Finnish catches increased by 41% compared to 2015. Russian catches increased by 13%.

The spatial distribution (by subdivision) of sprat catches was similar to previous years. Subdivision 26 dominated the catches with a 30% share in the sprat catch. Other important areas are subdivisions 28, 25 and 29 (24, 17 and 13%, respectively). Landings by country and subdivision are presented in tables 7.1–7.2. Figure 7.0 presents the shares of catches by subdivision in 2001–2016. Table 7.3 contains landings, catch numbers, and weight at age by subdivision and quarter.

7.1.2 Unallocated removals

No information on unallocated catches was presented to the group. It is expected, however, that misreporting of catches occurs, as the estimates of species composition of the clupeid catches are imprecise in some mixed pelagic fisheries.

7.1.3 Discards

According to the EC Common Fisheries Policy (adopted in 2014) in 2015, the landing obligation began to cover small and large pelagic species, industrial fisheries and the main fisheries in the Baltic. Historically, discards in most countries have probably been small because the undersized and lower quality fish can be used for production of fish meal and feeding in animal farms. In fisheries directed for human consumption, however, young fish (0 and 1 age groups) were discarded with higher rates in years when strong year classes recruit to the fishery. Recruitment to the fishery takes place in the 4th (age 0) and 1st (age 1) quarters. The amount of discarding of these age-groups was unknown. In the 2015 data call (L.27/ACB/HSL in 2015) ICES requested landings, discards, biological sample and effort data from 2014 in support of the ICES fisheries advice in 2015. Only Estonia and Germany provided the requested discard data for Baltic sprat. However, these 2 countries reported zero discards years 2012-2014. For year 2015 catches, there were no discard data of Baltic sprat available. Only Finland has uploaded discard data for Baltic sprat in 2016 into the InterCatch – 563 kg from passive gear catches.

7.1.4 Effort and CPUE data

Only Denmark and Lithuania uploaded the fishing effort data for 2014 into the InterCatch in 2015. No new fishing effort data were provided in 2016 and 2017. Russia previously provided the data on fishing effort and cpue for Subdivision 26 in 1995-2010 (Table 7.4). These data indicate increase in cpue in 1995–2006 and stable cpue in 2007–2010. Available effort and cpue data are restricted to only some regions and years, and are not considered representative for the entire stock and therefore were not applied in the assessment.

7.2 Biological information

7.2.1 Age composition

All countries provided age distributions of their major catches (landed in their waters) by quarter and Subdivision (Table 7.5). Catches for which the age composition was missing represented only about 11% of the total. Almost all German catches (96%) were taken outside the German waters but also these were very well sampled, resulting that 87% of German total landings were sampled. The unsampled catches were distributed to ages according to overall age composition in a given Subdivision and quarter using "Allocation scheme" with CATON values as weighting keys in InterCatch. A large part of the sprat catches is taken as part of the fish meal fishery. In some fisheries the catch species composition is not very precise.

The estimated catch at age in numbers is presented in Table 7.3 and 7.6 and the age composition of the catches is shown in Figure 7.1. The consistency of the catch-at-age estimates was checked in bubbles-plot (Figure 7.2). The correlation between catch at a given age and the catch of the same generation 1 year later is high and exceeds 0.9 in most cases.

7.2.2 Mean weight-at-age

Almost all countries presented rather extensive data on weight-at-age in the catch by quarter and subdivision. Mean weights-at-age in the catch were obtained as averages weighted by catch in numbers. The weights-at-age have decreased by about 40% in 1992–1998 (Figure 7.3). In 1999–2005 the weights have fluctuated without a clear trend.

Although, the mean weights-at-age of the year-class 2003 are significantly lower compared to other year-classes in the last decade. Since 2006 the mean weights increased somewhat, but have dropped again in last years. The mean weight of the year-class 2014 is very low; it could be a result of density dependent effect as this year-class was very abundant. Mean weights in the stock were assumed the same as mean weights in the catch (Table 7.7). The consistency of the weight-at-age estimates was explored in 2005 and it was considered satisfactory.

7.2.3 Natural mortality

As in previous years the natural mortalities used varied between years and ages as an effect of cod predation. Up to 2012 WGBFAS meeting the M estimates were based on the MSVPA model and (in years in which the MSVPA estimates were lacking) regression of predation mortality against cod SSB. In the benchmark workshop new estimates of predation mortality (covering 1974–2011) were provided from SMS model (WKMULTBAL, ICES, 2013b). They differ moderately (+/- 20%) from mortalities derived from MSVPA. The M values for 2012–2016 were estimated from the regression of M values taken from SMS against cod SSB in 1974–2011(Figure 7.4.a). However, analytical estimates of cod SSB in recent years are not available due to difficulties with cod assessment. Therefore index of cod SSB obtained from BITS surveys and used as the basis for cod advice was rescaled to approximate analytical estimates of SSB. The rescaling was based on strong relationship between both series in 2003–2011 (Figure 7.4b). SSB of cod from last accepted analytical assessment and rescaled BITS index are shown in Figure 7.4c.

Final estimates of M are given in Table 7.8.

7.2.4 Maturity-at-age

The maturity estimates were kept unchanged from previous years and constant throughout the time series (Table 7.9). In 2002 the WG was provided with rather extensive maturity data by the Study Group on Herring and Sprat Maturity. These data were analysed using GLM approach and year dependent estimates were obtained (ICES, 2002). These estimates at age 1 varied markedly from year to year but the WG felt that it was necessary to continue sampling and perform more extensive analysis of the data. Thus the maturities were averaged over years in 2002 assessment. These maturities were kept the same in the assessments up to 2012.

At benchmark workshop (ICES, 2013a) maturity estimates were obtained from several countries but due to time constraints only simplified approach for their analysis was applied. The results did not suggest the need to change the maturity parameters used so far. Thus, maturities estimated in 2002 are still kept in present assessment.

Proportions of F and M before spawning are shown in tables 7.10–7.11.

7.2.5 Quality of catch and biological data

In all countries around the Baltic Sea fish catch statistics are based on log-book data. In some countries, such as Denmark and Poland, these data are supplemented by data collected in regional Marine Offices. In Denmark, Sweden, Finland, and to a lesser degree in Poland, much of the sprat catch is taken in industrial fisheries where large by-catches of other fish species (mostly herring) may occur. The species composition of these catches is not accurately known, and can create errors in annual sprat catch statistics.

The landings and sampling activity for 2016 by quarter, ICES subdivision, and country is presented in Table 7.5. These data show that generally in 2016 the sampling activity by ICES subdivision exceeded much the levels indicated in the EC regulation No. 1639/2001, i.e. at least 1 sample per 2000 t. of catch, 100 length measurements and 50 age readings per sample. On average number of samples was 4.2 times higher than indicated in the directive, and 741 length measurement and 208 age readings were recorded per 2000 t catch.

7.3 Fishery independent information

Two tuning data sets covering subdivisions 22–29 were available: from Baltic International Acoustic Survey (BIAS) in autumn in 1991–2016 and one covering subdivisions 24–26 and 28 from international Baltic Acoustic Spring Survey (BASS) in May in 2001–2016 (tables 7.12–7.14). The survey data were corrected for area coverage (WGBIFS, ICES, 2017). However, in 2016 the May survey (BASS) only covered ca. 50% of planed areas, **so the 2016 survey estimates from BASS we not used in the assessment**. Such was also recommendation from WGBIFS (ICES, 2017).

The internal consistency of survey at age estimates and consistency between surveys was checked on graphs (figures 7.5a-c). The correlation between CPUE at given age and the CPUE of the same generation 1 year later is high ranging between 0.7–0.9.

7.4 Assessment

7.4.1 XSA

The input data for the catch at age analysis are presented in tables 7.6–7.14. The settings for the parameterisation of XSA were the same as specified in the benchmark assessment (and no change from previous benchmark settings):

1) tricubic time weighting,
2) catchability dependent on year class strength at age 1 (only for this age group the slopes of regressions were significantly different from 1),
3) catchability independent of age for ages 5 and older,
4) the SE of the F shrinkage mean equal 0.75.

Table 7.15 contains the diagnostic of the run. The log q residuals are presented in Figure 7.6. The data are moderately noisy for October fleet (SE of log q = 0.4-0.5). The log q residuals from the May survey are somewhat lower with a SE's range of 0.3–0.45. The residuals from acoustic survey on age 0 (shifted to represent age 1) are rather high at the beginning of the time series but they decline at later years (regression SE about 0.3). The correlations between XSA estimates and survey indices are high (R^2 mostly at level of 0.6–0.8).

In previous assessments the May survey had the highest influence on survivor estimates (ca. 40–55% weight except of age 1) but in present assessment due to exclusion of this survey data from 2016 the survivors estimated by May survey have bigger variance and the October survey gets higher weight (40 – 50%) . The weight of estimates resulting from shrinkage is low (up to 7%) (Figure 7.7a). The survey estimates of survivors are quite consistent at most ages (but worse than in previous assessments) – consistency is somewhat lower at age 3 where estimate based on May survey diverge from estimate using October survey (Figure 7.7b). The estimates based on age 0 acoustic fleet are down-weighted with increasing age.

Retrospective analysis (Figure 7.8) shows quite scattered estimates for F. The average F estimates, *i.e.* F(3–5), are most noisy as they are based on Fs from 3 ages only. In addition, recruitment of sprat is very variable which easily can lead to overestimation of F for weak year classes when they neighbour strong year classes, due to possible misspecification of age readings from these strong generations. The estimates of SSB in most years are relatively consistent. The retrospective analysis shows consistent estimates of recruitment. The Mohn's Rho is -0.01, 0.09, and 0.09 respectively for F, SSB, and recruitment.

The fishing mortalities, stock numbers and summary tables are presented in tables 7.16–7.18. Fish stock summary plots are presented in figures 7.9 and 7.10.

7.4.2 Exploration of SAM

The SAM model was attempted at benchmark workshop as the second assessment model for sprat. Results of SAM parameterised in similar way as XSA are compared with XSA estimates in Figure 7.11a. For 2016 the SAM estimate of SSB and recruitment are lower than the XSA estimate by 8% and 36% while the fishing mortality is higher by 40% than the XSA value. The residuals distributions for SAM model show similar patterns as in case of XSA (Figure 7.11b). The retrospective analysis is somewhat better for SAM than for XSA, especially for fishing mortality (Figure 7.11c). The assessment with SAM is available at the https://www.stockassessment.org (short name of the stock is sprat2016a).

7.4.3 Recruitment estimates

The acoustic estimates on age-0 sprat in subdivisions 22–29 (shifted to represent age 1) and XSA estimates were analysed using the RCT3 program (tables 7.19 and 7.20, Figure 7.12). The R^2 between XSA numbers and acoustic indices are high, generally at range of 0.7–0.8. Estimates are mainly determined by survey (weight of 60–70%). The 2016 year class was estimated 10% below average at 79 billion.

7.4.4 Historical stock trends

In the 1990s the SSB exceeded 1 million t, being record high in 1996–1997 (about 1.9 million t). These values were several times higher than the SSB estimates of 300 000 t in the early 1980s. Since 1997 the SSB has decreased, and after 2000 it has fluctuated mostly in range of 0.9–1.2 million tons. In recent years SSB has declined due to rather low recruitment (among year-classes of 2009–2015 only 2014 is strong) but increased markedly in 2016. The estimate of SSB for 2016 is 1.176 million tons due to strong 2014 year-class. Weight-at-age has decreased since the early 1990s, and has remained low since then. This is likely due to density-dependent effects. Autumn acoustic surveys show that in recent years the stock has been mainly concentrated in subdivisions 27–29 and 32 (Casini *et al.*, 2011, WGBIFS, 2017).

7.5 Short-term forecast and management options

The RCT3 program estimate of the 2016 year class at age 1 was used in the predictions. The 2017 and 2018 year classes were assumed as geometric mean of the recruitment at age 1 in 1991–2016 (period of recruitment fluctuations without clear trend, the 2016 value is well estimated in the assessment). The natural mortalities and mean weights-at-age were assumed as averages of 2014–2016 values. The fishing pattern was smoothed as the average F at age in 2014–2016 scaled to the final year value (decline in F in 2013-2016). Input data for catch prediction are presented in Table 7.21.

The catch projection with status quo F produces catch of 261 Kt in 2017, which is lower than TAC of 304 Kt (261 Kt for EU and 42.6 Kt for Russia). Thus, the TAC constraint option for catch projection was run (Table 7.22) and is recommended to be used for advice. In Figure 7.13 the sensitivity of the projection to the assumed strength (GM) of the 2017 and 2018 year classes and the estimate of 2016 year class is presented. The assumed level (GM) of the 2017 year class contributes in 9% to the predicted catch in 2018 and with assumed level of the 2018 year class contributes in 37% to SSB in 2019.

7.6 Reference points

Up to 2012 the PA software (CEFAS, Lowestoft) was used to estimate biological reference points. The estimated $\mathbf{F}_{med}$ (used by ACFM as a basis for $\mathbf{F}_{pa}$= 0.4, value estimated in middle of 1990s) changed substantially from year to year assessment and in 2012 was estimated at unrealistically low level of 0.14.

Presently suggested BRPs were estimated at benchmark using the methodology shortly described below. Three stock-recruitment models were fitted to the entire time series data: Beverton and Holt (B&H), Ricker, and hockey-stick models. They all showed similar fits to the available range of data, explaining only about 11% of the recruitment variance. The B_{lim} was estimated as the biomass that produces half of maximal (from the model) recruitment (410 000 t; close to average of outcomes from different recruitment models) and $B_{MSYtrigger}$=B_{pa} at 574 000 t (B_{pa} = B_{lim} *1.4).

The method of equilibrium yield and biomass (Horbowy and Luzenczyk, 2012) was used to estimate the F_{MSY} reference points. The uncertainty included in the estimating procedure was from assessment errors in SSB and R, which are then used to estimate the S-R relationship. In addition, uncertainty was imposed on weight, natural mortality, selection and maturity-at-age. The CV was assumed at 0.2 for SSB, R and maturity, and it was estimated using data from most recent ten years for weight, selection and M. 1000 replications were performed to determine the distribution of the MSY parameters. The F_{MSY} was estimated at 0.29 (median from stochastic simulations, SD=0.11) and B_{MSY} at 617 thousand t (SD=161).

The biological reference points derived based on the replacement lines depend on the natural mortality, weight at age, and maturity data used. In recent years the natural mortalities increased markedly but the weights at age were still low. The changes in M and weights may have very large impact on estimate of the MSY reference points.

During the workshop on BRP (ICES-MYFISH Workshop to consider the basis for FMSY ranges for all stocks (WKMSYREF3, ICES, 2014)) the F_{MSY} reference points were revised and ranges for them estimated. The new estimate of F_{MSY} is 0.26, while ranges are provided in the text table below.

Stock	MSY Flower	FMSY	MSY Fupper with AR	MSY Btrigger (thousand t)	MSY Fupper with no AR
Sprat in subdivisions 22–32 (Baltic Sea) a)	0.19	0.26	0.27	570	0.21

7.7 Quality of assessment

In the mixed fishery for herring and sprat the reported quantities landed by each species are (could be) imprecise. These uncertainties could influence the estimates of absolute stock size and fishing mortality. The retrospective plots show quite large deviations of estimates for certain years. In case of fishing mortality the deviations are to some extent caused by F_{bar} based on three values only (F at age 3–5), that is sensitive to bias in F-at-age, occurring especially for weak year classes neighbouring a strong year class.

The predicted SSB for the year following the prediction year is very sensitive to the assumed (GM) year class strength. The assumed year classes contribute usually in 40–55% to the predicted SSB, this year it is less (37%) as strong 2014 year still markedly contributes to biomass and catches.

The sprat in subdivisions 22–32, now being assessed as one unit, was previously considered to be composed of three stock components: sprat in subdivisions 22–25, 26+28, and 27+29–32. An analysis of the impact of merging components on stock assessment was performed during benchmark workshop (2013) and recently within Inspire project (BONUS financial support) . It showed that sum of biomass of separately assessed components is similar to biomass estimated for the whole stock (section xx). The analysis of the effects of merging components on prediction and sprat management is in progress within Inspire project and it is expected to be finished by next WG meeting.

The inputs to the assessments are catch-at-age data and age-structured stock estimates from the acoustic surveys. The survey estimates of stock numbers are internally consistent and the same applies to catch at age numbers. Survey are also consistent between themselves.

7.8 Comparison with previous assessment

The comparison between the results of 2015 and 2016 assessments is presented in the text table below. The XSA settings were the same in both years.

CATEGORY	PARAMETER	ASSESSMENT 2016	ASSESSMENT 2017	DIFF. (+/-) %
Data input	Maturity ogives	age 1 - 17%, age 2 - 93%	age 1 - 17%, age 2 - 93%	No
	Natural mortality	M in 1974-2011 estimated in SMS, M2012-2015 estimated from regression of M against cod SSB	M in 1974-2011 estimated in SMS, M2012- M2016 estimated from regression of M against cod SSB	No
XSA input	Catchability dependent on year class strength	Age<2	Age<2	No
	Catchability independent on age	Age >=5	Age >=5	No
	SE of the F shrinkage mean	0.75	0.75	No
	Time weighting	Tricubic, 20 years	Tricubic, 20 years	No
	Tuning data	International acoustic autumn International Acoustic May	International acoustic autumn International Acoustic May, (2016 data excluded from May survey)	Yes
		Acoustic on age 0 (subdiv. 22-29)	Acoustic on age 0 (subdiv. 22-29)	No
XSA results	SSB 2015 (million t)	0.89	0.85	-5%
	TSB 2015 (million t)	1.68	1.76	5%
	F(3-5) 2015	0.27	0.31	18%
	Recruitment (age 1) in 2015 (billions)	159	196	23%

7.9 Management considerations

There is a EU multiannual plan for sprat in the Baltic Sea (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R1139&from=EN). In the plan Fmsy ranges are defined as 0.19 - 0.26 and 0.26-0.27.

As in previous years, sprat in Baltic subdivisions 22–32 was assessed as a single unit, and this procedure shows relatively good assessment quality.

The spawning stock biomass has been low in the first half of 1980s. In the beginning of 1990s the stock started to increase rapidly and in 1996–1997 it reached the maximum observed spawning stock biomass of 1.9 million tonnes. The stock size increased due to the combination of strong recruitments and decline in natural mortality (effect of low cod biomass). Next stock declined, since 2002 the spawning biomass has been fluctuating at range of 0.9–1.2 million t., and declined again below the average in recent years. After 2000 fishing mortality increased and in recent years fluctuated usually between F_{pa} and F_{lim}. Among the year classes 2009–2016 only one (2014) was strong, which contributed to previous stock decline.

In 2018–2019 the stock is predicted to stay at recent levels if it is exploited at F_{MSY}.

The marked part of the sprat catches is taken in a mixed sprat-herring fishery, and the species composition of these catches is imprecise in some fishing areas /periods.

Table 7.1 Sprat landings in Subdivisions 22-32 (thousand tonnes).

Year	Denmark	Finland	German Dem. Rep.	Germany Fed. Rep.	Poland	Sweden	USSR	Total
1977	7.2	6.7	17.2	0.8	38.8	0.4	109.7	180.8
1978	10.8	6.1	13.7	0.8	24.7	0.8	75.5	132.4
1979	5.5	7.1	4.0	0.7	12.4	2.2	45.1	77.1
1980	4.7	6.2	0.1	0.5	12.7	2.8	31.4	58.1
1981	8.4	6.0	0.1	0.6	8.9	1.6	23.9	49.3
1982	6.7	4.5	1.0	0.6	14.2	2.8	18.9	48.7
1983	6.2	3.4	2.7	0.6	7.1	3.6	13.7	37.3
1984	3.2	2.4	2.8	0.7	9.3	8.4	25.9	52.5
1985	4.1	3.0	2.0	0.9	18.5	7.1	34.0	69.5
1986	6.0	3.2	2.5	0.5	23.7	3.5	36.5	75.8
1987	2.6	2.8	1.3	1.1	32.0	3.5	44.9	88.2
1988	2.0	3.0	1.2	0.3	22.2	7.3	44.2	80.3
1989	5.2	2.8	1.2	0.6	18.6	3.5	54.0	85.8
1990	0.8	2.7	0.5	0.8	13.3	7.5	60.0	85.6
1991	10.0	1.6		0.7	22.5	8.7	59.7*	103.2

Year	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden	Total
1992	24.3	4.1	1.8	0.6	17.4	3.3	28.3	8.1	54.2	142.1
1993	18.4	5.8	1.7	0.6	12.6	3.3	31.8	11.2	92.7	178.1
1994	60.6	9.6	1.9	0.3	20.1	2.3	41.2	17.6	135.2	288.8
1995	64.1	13.1	5.2	0.2	24.4	2.9	44.2	14.8	143.7	312.6
1996	109.1	21.1	17.4	0.2	34.2	10.2	72.4	18.2	158.2	441.0
1997	137.4	38.9	24.4	0.4	49.3	4.8	99.9	22.4	151.9	529.4
1998	91.8	32.3	25.7	4.6	44.9	4.5	55.1	20.9	191.1	470.8
1999	90.2	33.2	18.9	0.2	42.8	2.3	66.3	31.5	137.3	422.6
2000	51.5	39.4	20.2	0.0	46.2	1.7	79.2	30.4	120.6	389.1
2001	39.7	37.5	15.4	0.8	42.8	3.0	85.8	32.0	85.4	342.2
2002	42.0	41.3	17.2	1.0	47.5	2.8	81.2	32.9	77.3	343.2
2003	32.0	29.2	9.0	18.0	41.7	2.2	84.1	28.7	63.4	308.3
2004	44.3	30.2	16.6	28.5	52.4	1.6	96.7	25.1	78.3	373.7
2005	46.5	49.8	17.9	29.0	64.7	8.6	71.4	29.7	87.8	405.2
2006	42.1	46.8	19.0	30.8	54.6	7.5	54.3	28.2	68.7	352.1
2007	37.6	51.0	24.6	30.8	60.5	20.3	58.7	24.8	80.7	388.9
2008	45.9	48.6	24.3	30.4	57.2	18.7	53.3	21.0	81.1	380.5
2009	59.7	47.3	23.1	26.3	49.5	18.8	81.9	25.2	75.3	407.1
2010	43.6	47.9	24.4	17.8	45.9	9.2	56.7	25.6	70.4	341.5
2011	31.4	35.0	15.8	11.4	33.4	9.9	55.3	19.5	56.2	267.9
2012	11.4	27.7	9.0	11.3	30.7	11.3	62.1	25.0	46.5	235.0
2013	25.6	29.8	11.1	10.3	33.3	10.4	79.7	22.6	49.7	272.4
2014	26.6	28.5	11.7	10.2	30.8	9.6	56.9	23.4	46.0	243.8
2015	22.5	24.0	12.0	10.3	30.5	11.0	62.2	30.7	44.1	247.2
2016	19.1	23.7	16.9	10.9	28.1	11.6	59.3	34.6	42.4	246.5

* Sum of landings by Estonia, Latvia, Lithuania, and Russia.

Table 7.2 Sprat landings in the Baltic Sea by country and Subdivision (thousand tonnes). 1/3

Year 2001

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	**39.7**	-	-	39.7	-	-	-	-	-	-	-
Estonia	**37.5**	-	-	-	-	-	6.3	16.1	-	-	15.1
Finland	**15.4**	-	-	-	-	-	-	4.5	3.2	0.001	7.6
Germany	**0.8**	0.02	0.8	-	-	-	-	-	-	-	-
Latvia	**42.8**	-	-	1.1	7	-	34.7	-	-	-	-
Lithuania	**3**	-	-	-	3	-	-	-	-	-	-
Poland	**85.8**	-	0.4	46.3	39.1	-	-	-	-	-	-
Russia	**32**	-	-	-	29.6	-	2.3	-	-	-	-
Sweden	**85.4**	-	1	2.9	4.8	27.8	30.2	18.1	-	-	0.5
Total	**342.2**	**0.02**	**2.1**	**90**	**83.5**	**27.8**	**73.5**	**38.7**	**3.2**	**0.001**	**23.2**

Year 2002

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	**42.0**	4.7	1.0	22.5	7.7	0.7	4.6	0.9	-	-	-
Estonia	**41.3**	-	-	-	-	-	7.7	17.0	-	-	16.6
Finland	**17.2**	-	0.8	2.3	0.004	0.1	0.001	3.7	4.8	-	5.5
Germany	**1.0**	0.03	-	0.1	0.4	0.1	0.1	0.2	-	-	-
Latvia	**47.5**	-	-	1.4	4.5	-	41.7	0.0	-	-	-
Lithuania	**2.8**	-	-	0.0	2.8	-	-	-	-	-	-
Poland	**81.2**	-	0.04	39.7	41.5	-	-	-	-	-	-
Russia	**32.9**	-	-	-	29.9	-	2.9	-	-	-	-
Sweden	**77.3**	-	3.0	13.3	5.6	27.2	19.9	8.3	-	-	-
Total	**343.2**	**4.8**	**4.8**	**79.3**	**92.4**	**28.1**	**76.8**	**30.1**	**4.8**	**0.0**	**22.1**

Year 2003

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	**32.0**	8.2	0.7	10.4	8.9	1.8	1.7	0.3	-	-	-
Estonia	**29.2**	-	-	-	-	-	11.1	11.6	-	-	6.5
Finland	**9.0**	-	0.03	0.4	0.04	0.2	0.1	4.6	1.5	0.001	2.0
Germany	**18.0**	0.2	0.5	0.8	3.0	9.5	2.8	1.1	-	-	-
Latvia	**41.7**	-	-	0.8	7.8	-	33.2	-	-	-	-
Lithuania	**2.2**	-	-	-	2.2	-	-	-	-	-	-
Poland	**84.1**	-	0.03	26.7	57.4	-	-	-	-	-	-
Russia	**28.7**	-	-	0.0	27.2	-	1.4	-	-	-	-
Sweden	**63.4**	-	2.1	5.5	8.6	24.1	19.3	3.8	-	-	-
Total	**308.3**	**8.3**	**3.5**	**44.6**	**115.1**	**35.6**	**69.6**	**21.5**	**1.5**	**0.001**	**8.5**

Year 2004

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	**44.3**	16.0	5.5	16.8	0.5	0.5	3.9	1.1	-	-	-
Estonia	**30.2**	-	-	-	-	-	8.9	10.1	-	-	11.1
Finland	**16.6**	-	0.5	2.5	0.003	0.1	0.03	9.3	3.0	0.003	1.1
Germany	**28.5**	0.8	0.9	1.4	6.0	8.2	6.8	4.4	-	-	-
Latvia	**52.4**	-	-	2.3	7.5	0.2	42.4	0.0	-	-	-
Lithuania	**1.6**	-	-	-	1.6	-	-	-	-	-	-
Poland	**96.7**	-	1.4	33.6	61.6	0.04	0.02	-	-	-	-
Russia	**25.1**	-	-	-	23.9	-	1.2	-	-	-	-
Sweden	**78.3**	-	1.4	9.2	7.6	25.8	22.3	12.0	-	-	-
Total	**373.7**	**16.8**	**9.7**	**65.8**	**108.8**	**34.8**	**85.6**	**36.9**	**3.0**	**0.003**	**12.2**

Year 2005

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	**46.5**	17.6	2.1	11.1	5.4	0.3	10.0	-	-	-	-
Estonia	**49.8**	-	-	-	-	-	7.1	16.6	-	-	26.0
Finland	**17.9**	-	0.1	0.6	0.6	0.1	0.3	9.0	3.2	0.005	4.0
Germany	**29.0**	1.2	0.1	0.4	4.3	10.2	6.8	6.1	-	-	-
Latvia	**64.7**	-	-	1.2	7.3	0.4	55.8	-	-	-	-
Lithuania	**8.6**	-	-	-	8.6	-	-	-	-	-	-
Poland	**71.4**	-	2.0	23.5	45.6	0.2	0.1	-	-	-	-
Russia	**29.7**	-	-	-	29.7	-	-	-	-	-	0.1
Sweden	**87.8**	-	0.7	11.1	10.3	25.1	24.5	16.2	-	-	-
Total	**405.2**	**18.8**	**5.0**	**47.9**	**111.7**	**36.2**	**104.5**	**47.9**	**3.2**	**0.005**	**30.2**

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Table 7.2 Sprat landings in the Baltic Sea by country and Subdivision (thousand tonnes).

Year 2006

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	**42.1**	19.4	1.7	6.9	9.9	0.3	2.6	1.2	-	-	-
Estonia	**46.8**	-	-	0.1	-	0.3	5.5	19.2	-	-	21.6
Finland	**19.0**	-	0.2	0.5	1.1	1.9	2.0	6.8	3.5	0.007	3.0
Germany	**30.8**	1.2	0.01	1.3	8.2	12.0	4.6	3.4	-	-	-
Latvia	**54.6**	-	-	1.1	6.0	-	47.5	-	-	-	-
Lithuania	**7.5**	-	-	-	7.5	-	-	-	-	-	-
Poland	**54.3**	-	0.8	16.7	36.8	-	-	-	-	-	-
Russia	**28.2**	-	-	-	27.9	-	-	-	-	-	0.3
Sweden	**68.7**	0.0	0.7	4.6	25.3	13.7	16.6	7.6	0.0	0.0	0.2
Total	**352.1**	**20.5**	**3.4**	**31.3**	**122.8**	**28.3**	**78.9**	**38.3**	**3.5**	**0.007**	**25.1**

Year 2007

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	**37.6**	9.6	0.7	6.4	17.0	-	3.0	0.8	-	-	-
Estonia	**51.0**	-	-	2.2	0.8	0.1	4.3	15.3	-	-	28.3
Finland	**24.6**	0.0	0.0	1.9	4.2	0.3	2.6	4.5	7.2	0.002	3.8
Germany	**30.8**	0.8	0.46	1.8	12.2	5.8	4.8	4.9	-	-	-
Latvia	**60.5**	-	-	5.1	7.4	1.4	46.5	-	-	-	-
Lithuania	**20.3**	-	-	1.7	11.8	-	3.6	3.2	-	-	-
Poland	**58.7**	-	0.8	21.4	36.4	0.04	0.06	-	-	-	-
Russia	**24.8**	-	-	-	24.8	-	-	-	-	-	-
Sweden	**80.7**	-	1.8	10.0	30.8	11.0	14.9	11.9	0.1	-	0.2
Total	**388.9**	**10.4**	**3.8**	**50.5**	**145.4**	**18.7**	**79.8**	**40.6**	**7.3**	**0.002**	**32.4**

Year 2008

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	**45.9**	5.6	1.0	5.6	4.0	7.1	13.2	0.3	-	-	9.2
Estonia	**48.6**	-	-	0.3	0.0	-	5.3	15.6	-	-	27.3
Finland	**24.3**	-	-	2.1	2.1	0.2	2.3	8.6	5.2	0.0002	3.8
Germany	**30.4**	1.3	0.07	1.8	6.0	4.0	13.7	3.6	-	-	-
Latvia	**57.2**	-	-	2.1	6.3	0.2	48.6	0.005	-	-	-
Lithuania	**18.7**	-	0.01	5.5	6.0	0.7	4.6	1.8	-	-	-
Poland	**53.3**	-	3.9	25.4	23.8	0.02	0.15	-	-	-	-
Russia	**21.0**	-	-	-	21.0	-	-	-	-	-	-
Sweden	**81.1**	-	2.0	13.3	13.2	9.1	27.4	15.4	0.00005	-	0.7
Total	**380.5**	**6.9**	**7.1**	**56.0**	**82.4**	**21.4**	**115.2**	**45.3**	**5.2**	**0.0002**	**41.0**

Year 2009

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	**59.7**	3.8	0.5	0.7	9.7	14.3	0.3	22.1	8.3	-	-	-
Estonia	**47.3**	-	-	-	0.6	-	-	2.5	13.7	-	-	30.5
Finland	**23.1**	-	-	-	0.0	2.7	0.3	2.9	7.7	4.4	0.0001	5.2
Germany	**26.3**	1.4	-	0.24	1.9	3.7	6.2	9.0	4.0	-	-	-
Latvia	**49.5**	-	-	0.0	6.0	5.0	0.5	38.0	0.008	-	-	-
Lithuania	**18.8**	-	-	0.45	3.3	6.4	0.5	7.2	0.9	-	-	-
Poland	**81.9**	-	0.3	2.1	25.4	33.9	6.60	8.40	5.2	-	-	-
Russia	**25.2**	-	-	-	-	25.2	-	-	-	-	-	-
Sweden	**75.3**	-	-	2.4	7.9	13.5	10.5	28.2	12.6	0.0014	-	0.2
Total	**407.1**	**5.2**	**0.9**	**5.9**	**54.8**	**104.6**	**24.9**	**118.3**	**52.3**	**4.4**	**0.0001**	**35.9**

Year 2010

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	**43.6**	8.0	-	0.7	5.2	12.3	2.4	9.6	5.3	-	-	-
Estonia	**47.9**	-	-	-	-	-	-	2.6	16.9	-	-	28.3
Finland	**24.4**	-	-	-	-	1.9	0.3	5.3	6.8	3.3	0.002	6.9
Germany	**17.8**	1.8	-	0.05	1.3	4.7	2.8	4.5	2.7	-	-	-
Latvia	**45.9**	-	-	-	5.2	5.0	-	35.7	-	-	-	-
Lithuania	**9.2**	-	-	-	0.03	4.6	-	4.6	-	-	-	-
Poland	**56.7**	-	0.02	0.1	14.3	32.8	6.1	2.9	0.6	-	-	-
Russia	**25.6**	-	-	-	-	25.6	-	-	-	-	-	-
Sweden	**70.4**	-	-	1.6	5.3	8.8	22.5	19.9	12.2	0.003	-	-
Total	**341.5**	**9.8**	**0.02**	**2.5**	**31.2**	**95.7**	**34.1**	**85.0**	**44.5**	**3.3**	**0.002**	**35.2**

continued 3/3

Table 7.2 Sprat landings in the Baltic Sea by country and Subdivision (thousand tonnes).

Year 2011

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	31.4	7.1		0.426	2.4	4.0	0.13	8.9	8.1			0.3
Estonia	35.0				0.2	0.2	0.04	2.5	11.9			20.2
Finland	15.8					0.6	0.27	1.2	4.5	3.49		5.7
Germany	11.4	1.2		0.061	0.4	2.8	0.01	3.8	3.3			
Latvia	33.4			0.003	2.5	4.2	0.12	26.6				
Lithuania	9.9			0.021	1.8	5.8	0.05	1.7	0.6			
Poland	55.3			0.689	9.5	38.0	0.16	6.0	1.0			
Russia	19.5					19.5						
Sweden	56.2			1.190	5.9	8.9	11.02	15.4	11.9	0.08		1.8
Total	267.9	8.3	0.00	2.4	22.7	83.8	11.8	66.1	41.2	3.6	0.000	28.0

Year 2012

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	11.4	4.73	0.00	0.23	2.5	1.4	0.13	-	2.45	-	-	-
Estonia	27.7	-	-	-	-	-	-	2.19	10.16	-	-	15.3
Finland	9.0	-	-	-	-	-	-	-	2.34	2.45	0.02	4.1
Germany	11.3	0.92		0.06	2.0	2.2	0.09	4.10	1.93	-	-	-
Latvia	30.7	-	-	-	0.1	4.7	-	25.85	0.01	-	-	-
Lithuania	11.3	-	-	-	2.8	6.6	-	2.00	-	-	-	-
Poland	62.1	-	-	3.56	24.3	30.5	0.08	2.55	1.16	-	-	-
Russia	25.0	-	-	-	-	25.0	-	-	-	-	-	-
Sweden	46.5	-	-	0.59	7.7	2.7	5.30	19.31	10.62	0.04	-	0.3
Total	235.0	5.7	0.00	4.4	39.3	73.0	5.6	56.0	28.7	2.5	0.022	19.8

Year 2013

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	25.6	7.10		0.36	3.31	2.2	0.7	3.4	8.4			
Estonia	29.8							1.8	11.7			16.2
Finland	11.1				0.08		0.1	0.2	4.1	2.86		3.7
Germany	10.3	0.59		0.17	1.30	2.6	0.9	1.4	3.4			
Latvia	33.3				0.12	4.2		28.6	0.4			
Lithuania	10.4				1.35	4.6		3.1	1.3			
Poland	79.7			0.96	19.13	53.4	1.6	2.6	2.1			
Russia	22.6					22.6						
Sweden	49.7			0.12	8.25	4.4	10.9	8.8	16.5	0.12		0.5
Total	272.4	7.7	0.00	1.6	33.5	94.0	14.2	50.0	47.9	3.0	0.000	20.5

Year 2014

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	26.6	1.07		1.50	6.52	4.8	0.2	5.7	6.8	0.00	0.00	0.1
Estonia	28.5	0.00		0.00	0.00	0.0	0.0	1.1	9.9	0.00	0.00	17.5
Finland	11.7	0.00		0.00	0.00	0.0	0.2	0.1	2.8	2.80	0.00	5.8
Germany	10.2	0.60		0.04	2.62	2.2	0.6	1.5	2.6	0.00	0.00	0.0
Latvia	30.8	0.00		0.00	0.27	2.9	0.0	27.6	0.0	0.00	0.00	0.0
Lithuania	9.6	0.00		0.00	0.65	3.5	0.0	4.5	0.9	0.00	0.00	0.0
Poland	56.9	0.00		1.49	21.83	31.2	0.2	2.1	0.1	0.00	0.00	0.0
Russia	23.4	0.00		0.00	0.00	23.4	0.0	0.0	0.0	0.00	0.00	0.0
Sweden	46.0	0.00		0.04	8.27	6.4	6.3	11.0	12.8	0.25	0.00	0.9
Total	243.8	1.7	0.00	3.1	40.2	74.5	7.5	53.6	35.9	3.0	0.001	24.3

Year 2015

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	22.5	4.239		0.265	0.077	2.918	2.038	9.562	3.133	0.222	0.000	0.000
Estonia	24.0	0.000		0.000	0.490	0.000	0.205	1.378	6.807	0.000	0.000	15.073
Finland	12.0	0.000		0.000	0.354	0.000	0.482	0.082	4.396	2.027	0.000	4.619
Germany	10.3	0.657		0.071	2.680	0.851	0.294	4.671	1.068	0.000	0.000	0.000
Latvia	30.5	0.000		0.000	0.527	2.716	0.000	27.067	0.182	0.000	0.000	0.000
Lithuania	11.0	0.000		0.000	4.355	0.782	0.000	5.117	0.749	0.000	0.000	0.000
Poland	62.2	0.000		2.715	26.122	33.004	0.001	0.387	0.000	0.000	0.000	0.000
Russia	30.7	0.000		0.000	0.000	30.694	0.000	0.000	0.000	0.000	0.000	0.000
Sweden	44.1	0.000		0.059	5.857	0.957	13.320	11.212	12.544	0.181	0.000	0.000
Total	247.2	4.9	0.00	3.1	40.5	71.9	16.3	59.5	28.9	2.4	0.0003	19.7

Year 2016

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	19.1	2.911		1.199	3.851	0.973	1.775	2.860	5.504	0.000		0.000
Estonia	23.7	0.000		0.000	0.535	0.000	0.104	4.780	4.702	0.000		13.566
Finland	16.9	0.000		0.000	0.274	0.000	0.191	0.677	7.139	5.342		3.284
Germany	10.9	0.394		0.075	1.166	2.378	0.010	4.184	2.698	0.000		0.000
Latvia	28.1	0.000		0.000	1.390	1.789	0.000	24.922	0.000	0.000		0.000
Lithuania	11.6	0.000		0.000	4.063	1.039	0.054	5.126	1.275	0.000		0.000
Poland	59.3	0.000		3.703	24.620	28.475	0.313	1.587	0.560	0.000		0.000
Russia	34.6	0.000		0.000	0.000	34.588	0.000	0.000	0.000	0.000		0.000
Sweden	42.4	0.000		0.032	5.506	5.862	5.719	13.958	10.919	0.435		0.000
Total	246.5	3.3	0.0	5.0	41.4	75.1	8.2	58.1	32.8	5.8	0.0	16.9

Table 7.3 SPRAT in SD 22-32. Catch in numbers and weight at age by quarter and Sub-division in 2016 1/4

Sub-division 22

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	13.5	63.3	76.7	0.0	0.0	4.2	4.2
1	13.5	0.7	2.8	13.3	30.3	3.7	3.6	9.0	9.0
2	168.2	8.5	14.5	68.2	259.5	8.8	8.8	11.2	11.2
3	15.8	0.8	1.2	5.5	23.2	11.8	11.6	12.4	12.4
4	0.3	0.0	0.0	0.0	0.3	12.6	12.6	0.0	0.0
5	0.2	0.0	0.2	0.8	1.2	11.7	11.7	14.5	14.5
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	198.0	10.0	32.1	151.1	391.3				
SOP	1723.0	87.1	261.4	1229.1	3300.6				
Catch	1724.2	87.4	262.0	1232.0	3305.7				

Sub-division 23

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0					0.0				
1					0.0				
2					0.0				
3					0.0				
4					0.0				
5					0.0				
6					0.0				
7					0.0				
8					0.0				
9					0.0				
10					0.0				
Sum	0.0	0.0	0.0	0.0	0.0				
SOP	0.0	0.0	0.0	0.0	0.0				
Catch	0.0	0.0	0.0	0.0	0.0				

Sub-division 24

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.3	0.9	1.2	0.0	0.0	5.8	4.4
1	15.5	13.1	0.0	0.0	28.6	4.6	7.9	0.0	0.0
2	106.6	49.2	12.6	3.4	171.7	11.8	13.8	14.7	15.0
3	55.7	46.4	12.4	3.8	118.4	13.3	15.0	15.8	16.2
4	18.9	16.2	7.6	2.4	45.0	14.3	16.1	16.8	17.1
5	3.1	3.3	2.9	0.8	10.0	15.1	18.9	17.1	17.2
6	0.0	1.1	1.0	0.3	2.4	0.0	19.1	17.6	17.5
7	0.0	0.5	1.1	0.4	2.0	0.0	19.3	18.7	18.8
8	0.0	0.4	0.0	0.0	0.4	0.0	23.2	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	199.8	130.1	37.9	11.9	379.8				
SOP	2387.2	1839.6	598.5	182.2	5007.5				
Catch	2385.9	1842.6	598.4	182.2	5009.0				

Table 7.3 SPRAT in SD 22-32. Catch in numbers and weight at age by quarter and Sub-division in 2016 2/4

Sub-division 25

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.4	35.6	35.9	0.0	0.0	6.2	4.9
1	36.5	23.2	2.5	3.4	65.6	4.0	4.9	10.3	9.4
2	352.4	1157.9	51.3	38.7	1600.4	9.9	8.7	12.0	12.5
3	273.6	689.0	32.8	21.3	1016.7	11.9	10.0	14.3	14.1
4	284.1	361.2	17.2	12.5	675.0	13.7	12.2	15.2	14.8
5	155.3	89.0	7.7	3.8	255.8	14.9	13.4	15.3	14.9
6	63.0	39.1	3.6	1.6	107.2	15.6	13.9	15.8	15.5
7	24.4	22.0	1.5	0.7	48.5	15.6	14.4	16.0	15.5
8	17.2	10.5	1.0	0.9	29.5	14.8	14.0	15.7	13.5
9	4.4	2.8	0.3	0.1	7.6	15.9	16.1	15.5	13.0
10	1.5	0.8	0.1	0.1	2.5	17.6	13.5	12.5	12.0
Sum	1212.4	2395.5	118.4	118.5	3844.8				
SOP	14811.4	23739.0	1594.8	1280.6	41425.8				
Catch	14799.2	23730.8	1598.4	1277.9	41406.2				

Sub-division 26

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	1.1	563.8	564.9	0.0	0.0	3.2	3.5
1	977.1	451.2	8.7	296.7	1733.7	3.3	4.8	6.1	8.1
2	3038.0	1720.1	140.4	349.6	5248.1	7.2	7.7	10.2	10.1
3	882.0	342.1	54.7	71.7	1350.5	9.1	8.9	12.0	13.6
4	450.7	108.1	41.3	34.1	634.1	11.2	11.2	12.6	15.7
5	151.5	34.9	15.1	27.4	228.8	12.2	12.0	12.8	14.7
6	61.7	10.8	7.8	6.0	86.2	13.4	12.0	13.2	15.9
7	41.7	0.7	1.0	2.7	46.2	13.7	13.5	15.0	17.1
8	17.7	2.3	4.3	2.6	26.8	16.0	12.8	13.1	14.9
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	5620.4	2670.0	274.4	1354.5	9919.3				
SOP	41702.1	20251.6	3032.9	9999.5	74986.1				
Catch	41842.9	20194.6	3028.3	10038.5	75104.2				

Sub-division 27

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	5.0	5.0
1	32.3	3.4	0.0	1.0	36.8	2.3	2.9	7.5	7.5
2	650.6	176.1	0.3	15.1	842.1	6.0	5.9	8.8	8.8
3	74.6	16.7	0.2	7.0	98.6	8.6	8.7	9.3	9.3
4	88.9	25.1	0.1	3.9	118.0	10.1	9.3	11.5	11.5
5	43.2	13.3	0.0	1.5	58.0	10.5	9.8	12.0	12.0
6	7.4	2.5	0.0	0.0	9.9	9.7	9.0	0.0	0.0
7	7.4	3.0	0.0	0.2	10.6	11.2	10.5	11.0	11.0
8	7.7	3.0	0.0	0.3	11.0	11.3	10.7	11.5	11.5
9	1.2	0.5	0.0	0.0	1.7	10.0	10.0	0.0	0.0
10	1.2	1.5	0.0	0.2	2.9	12.0	10.3	9.0	9.0
Sum	914.7	245.0	0.7	29.3	1189.7				
SOP	6241.1	1662.7	6.3	276.1	8186.2				
Catch	6226.1	1658.6	6.3	276.1	8167.1				

Table 7.3 SPRAT in SD 22-32. Catch in numbers and weight at age by quarter and Sub-division in 2016 3/4

Sub-division 28

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	4.2	149.3	153.5	0.0	0.0	3.3	3.2
1	141.1	153.7	57.9	215.2	567.9	2.7	3.3	6.9	7.1
2	3829.7	675.5	311.1	927.3	5743.6	6.7	6.2	8.1	8.2
3	354.8	64.2	47.4	89.8	556.3	9.1	8.7	9.0	10.0
4	361.5	57.4	24.6	45.7	489.2	10.1	9.4	9.9	10.9
5	210.0	15.1	13.7	29.0	267.7	10.4	10.6	10.5	11.0
6	24.8	16.9	2.9	14.5	59.1	11.6	9.7	10.5	11.4
7	22.5	2.0	0.8	3.9	29.1	11.4	10.7	10.4	12.6
8	37.7	15.5	3.9	21.3	78.4	11.5	10.2	10.5	11.5
9	4.7	0.0	0.0	0.0	4.7	10.0	0.0	0.0	0.0
10	4.7	0.0	0.0	0.0	4.7	11.5	0.0	0.0	0.0
Sum	4991.5	1000.4	466.4	1496.0	7954.3				
SOP	36182.9	6297.4	3826.1	11784.0	58090.5				
Catch	36201.1	6245.5	3835.9	11811.0	58093.5				

Sub-division 29

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	67.7	0.0	0.0	40.6	108.2	2.2	0.0	0.0	5.3
1	116.6	8.9	2.2	71.8	199.5	2.8	3.3	7.7	7.7
2	2687.3	323.7	13.9	162.1	3187.0	5.3	5.6	7.4	8.5
3	324.0	9.9	3.2	56.5	393.6	8.6	7.6	10.6	11.0
4	285.3	17.0	2.7	53.8	358.8	9.2	9.5	11.3	11.3
5	162.8	18.4	2.9	48.1	232.2	10.1	9.1	11.6	11.7
6	70.2	1.8	2.4	45.3	119.7	11.8	12.1	12.1	11.8
7	91.5	4.6	2.7	43.2	142.0	11.4	10.5	12.1	11.6
8	83.4	1.9	0.0	48.6	133.9	11.7	12.3	0.0	12.1
9	5.7	0.0	0.0	0.0	5.7	8.0	0.0	0.0	0.0
10	2.8	1.4	0.0	0.0	4.2	9.0	11.0	0.0	0.0
Sum	3897.2	387.7	30.0	570.0	4884.9				
SOP	24691.1	2356.1	279.5	5561.5	32888.2				
Catch	24701.7	2342.8	277.9	5474.2	32796.6				

Sub-division 30

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.0	2.2	2.2	0.0	0.0	0.0	3.8
1	7.9	5.1	0.0	1.6	14.6	7.5	7.9	7.3	7.5
2	17.8	8.8	2.1	87.5	116.1	9.4	9.6	10.3	10.3
3	30.1	13.2	2.0	31.4	76.7	11.6	11.3	11.9	12.1
4	31.1	14.6	1.1	18.5	65.2	11.7	11.8	12.8	13.5
5	32.5	14.9	0.6	2.8	50.8	12.0	11.9	13.5	13.6
6	35.2	15.4	0.3	3.3	54.2	12.5	12.1	14.8	14.1
7	36.2	15.4	0.7	3.9	56.1	12.7	12.1	14.5	13.9
8	36.6	16.2	1.1	7.0	60.9	12.6	12.3	15.9	15.3
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	227.2	103.6	7.8	158.3	496.9				
SOP	2688.5	1195.5	97.6	1798.8	5780.5				
Catch	2689.0	1195.4	97.4	1795.2	5777.0				

Table 7.3 SPRAT in SD 22-32. Catch in numbers and weight at age by quarter and Sub-division in 2016 4/4

Sub-division 31

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
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	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	0.0	0.0	0.0	0.0	0.0				
SOP	0.0	0.0	0.0	0.0	0.0				
Catch	0.0	0.0	0.0	0.0	0.0				

Sub-division 32

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.7	44.4	45.1	0.0	0.0	3.0	3.0
1	93.3	5.6	6.7	191.4	297.0	2.7	3.1	6.0	6.4
2	570.3	107.1	37.2	637.6	1352.2	5.1	5.3	7.0	7.3
3	105.2	6.5	2.8	52.8	167.3	9.0	8.0	9.1	9.4
4	124.1	10.0	1.5	26.4	162.0	9.9	8.8	9.9	10.0
5	89.1	7.8	1.7	23.2	121.9	10.4	9.0	10.2	10.1
6	57.7	1.8	0.5	9.4	69.4	10.8	9.3	10.3	11.0
7	60.1	3.1	0.4	8.1	71.7	11.5	9.3	9.8	11.4
8	60.6	4.6	1.0	9.5	75.7	11.7	9.8	9.9	10.7
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	1160.6	146.5	52.6	1002.6	2362.3				
SOP	8287.6	885.3	380.3	7303.2	16856.5				
Catch	8269.0	889.1	379.3	7313.1	16850.4				

Sub-divisions 22-32

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	67.7	0.0	20.1	900.1	987.8	2.2	0.0	4.0	3.6
1	1433.7	665.0	80.9	794.3	2974.0	3.2	4.5	6.9	7.4
2	11420.8	4226.9	583.5	2289.5	18520.7	6.6	7.5	9.1	8.5
3	2115.8	1188.9	156.8	339.8	3801.3	9.5	9.8	11.8	11.4
4	1644.9	609.6	95.9	197.3	2547.8	10.9	11.6	12.6	12.3
5	847.7	196.5	44.8	137.4	1226.4	11.6	12.1	12.6	12.1
6	320.1	89.3	18.4	80.3	508.2	12.7	12.4	13.3	12.1
7	283.9	51.3	8.1	63.0	406.2	12.3	12.7	14.0	12.1
8	260.9	54.3	11.3	90.2	416.6	12.3	11.8	12.4	12.2
9	16.1	3.2	0.3	0.1	19.7	10.9	15.2	15.5	13.0
10	10.4	3.7	0.1	0.2	14.4	11.8	11.3	12.4	10.0
Sum	18421.9	7088.8	1020.3	4892.2	31423.1				
SOP	138714.9	58314.2	10077.5	39415.2	246521.8				
Catch	138839.1	58186.8	10083.7	39400.2	246509.7				

Table 7.4 SPRAT in SD 22-32. Fishing effort and CPUE data.

Year	Russia - Sub-division 26			
	Type of vessels			
	[*)]SRTM (51 m length, 1100 hp)		MRTK (27 m length, 300 hp)	
	Effort [h]	CPUE, [kg/h]	Effort [h]	CPUE, [kg/h]
1995	8907	647	8760	601
1996	12129	620	7810	953
1997	17140	470	10691	746
1998	13469	646	9986	782
1999	13898	869	15967	965
2000	14417	766	13501	1031
2001	12837	937	12912	1282
2002	11789	884	18979	1012
2003	5869	958	14128	1285
2004	2973	895	14751	1394
2005	1696	1323	21908	1115
2006	877	1362	16592	1406
2007			16032	1303
2008			14428	1306
2009			17966	1258
2010			14179	1276

[*)] - vessels withdrawn from exploitation in 2007

Table 7.5 Sprat in Sub-divisions 22-32. Samples of commercial catches by quarter, country and Sub-division for 2016 available to the Working Group. 1/7

Sub-division	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
22	Denmark	1	1,417.3	2	211	58
		2	-	0	0	0
		3	262.0	0	0	0
		4	1,232.0	3	471	143
		Total	2,911.3	5	682	201
	Germany	1	307.0	1	346	104
		2	87.4	0	0	0
		3	-			
		4	-			
		Total	394.4	1	346	104
	Total	1	1,724.2	3	557	162
		2	87.4	0	0	0
		3	262.0	0	0	0
		4	1,232.0	3	471	143
		Total	3,305.6	6	1028	305

Sub-division	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
23+24	Denmark	1	1198.9	1	97	49
		2	-			
		3	-			
		4	0.2	0	0	0
		Total	1,199.1	1	97	49
	Finland	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Germany	1	57.7	5	366	91
		2	14.1	1	54	39
		3	-			
		4	3.6	2	62	16
		Total	75.4	8	482	146
	Latvia	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Lithuania	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Poland	1	1,121.2	2	422	84
		2	1,825.5	11	2061	626
		3	598.4	5	651	150
		4	157.6	1	188	116
		Total	3,702.7	19	3322	976
	Sweden	1	8.1	0	0	0
		2	3.0	0	0	0
		3	-			
		4	20.8	0	0	0
		Total	31.9	0	0	0
	Total	1	2,385.9	8	885	224
		2	1,842.6	12	2115	665
		3	598.4	5	651	150
		4	182.2	3	250	132
		Total	5,009.0	28	3901	1171

continued

Table 7.5 Sprat in Sub-divisions 22-32. Samples of commercial catches by quarter, country and Sub-division for 2016 available to the Working Group. 2/7

Sub-division	Country	Quarter	Landings	Number of	Number of fish	
25			in tons	samples	measured	aged
	Denmark	1	1,083.1	10	1133	423
		2	2,767.5	6	636	216
		3	-			
		4	-			
		Total	3,850.6	16	1769	639
	Estonia	1				
		2	535.0	0	0	0
		3				
		4				
		Total	535.0	0	0	0
	Finland	1	274.0	0	0	0
		2				
		3				
		4				
		Total	274.0	0	0	0
	Germany	1	367.2	2	633	107
		2	799.2	0	0	0
		3				
		4				
		Total	1,166.5	2	633	107
	Latvia	1	786.4	0	0	0
		2	547.7	0	0	0
		3	-			
		4	56.3	0	0	0
		Total	1,390.4	0	0	0
	Lithuania	1	509.3	0	0	0
		2	3,553.9	0	0	0
		3				
		4				
		Total	4,063.3	0	0	0
	Poland	1	8,505.6	25	4837	903
		2	13,895.9	14	3118	464
		3	1,242.6	28	4907	422
		4	976.2	27	4934	559
		Total	24,620.3	94	17796	2348
	Sweden	1	3,273.6	3	459	458
		2	1,631.5	2	445	444
		3	355.8	10	525	520
		4	245.4	3	250	248
		Total	5,506.2	18	1679	1670
	Total	1	14,799.2	40	7062	1891
		2	23,730.8	22	4199	1124
		3	1,598.4	38	5432	942
		4	1,277.9	30	5184	807
		Total	41,406.2	130	21877	4764

continued

Table 7.5 Sprat in Sub-divisions 22-32. Samples of commercial catches by quarter, country and Sub-division for 2016 available to the Working Group. 3/7

Sub-division 26	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	972.8	0	0	0
		2				
		3				
		4				
		Total	972.8	0	0	0
	Estonia	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Finland	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Germany	1	2,378.0	4	1249	210
		2				
		3				
		4				
		Total	2,378.0	4	1249	210
	Latvia	1	842.1	2	419	235
		2	406.2	6	1220	587
		3	186.3	0	0	0
		4	354.1	3	616	286
		Total	1,788.7	11	2255	1108
	Lithuania	1	1,016.9	0	0	0
		2	17.2	0	0	0
		3	4.3	0	0	0
		4	0.8	0	0	0
		Total	1,039.2	0	0	0
	Poland	1	17,231.8	32	6468	1062
		2	7,555.7	10	1753	526
		3	972.0	14	2942	218
		4	2,715.4	19	3147	594
		Total	28,474.9	75	14310	2400
	Russia	1	13,578.2	8	1858	451
		2	12,199.4	19	4007	451
		3	1,865.6	9	1659	301
		4	6,945.2	10	2067	400
		Total	34,588.4	46	9591	1603
	Sweden	1	5,823.1	3	160	158
		2	16.2	0	0	0
		3	-			
		4	23.0	0	0	0
		Total	5,862.3	3	160	158
	Total	1	41,842.9	49	10154	2116
		2	20,194.6	35	6980	1564
		3	3,028.3	23	4601	519
		4	10,038.5	32	5830	1280
		Total	75,104.2	139	27565	5479

continued

Table 7.5 Sprat in Sub-divisions 22-32. Samples of commercial catches by quarter, country and Sub-division for 2016 available to the Working Group. 4/7

Sub-division	Country	Quarter	Landings	Number of	Number of fish	
27			in tons	samples	measured	aged
	Denmark	1	1,775.3	1	118	60
		2				
		3				
		4				
		Total	1,775.3	1	118	60
	Estonia	1	80.1	0	0	0
		2	24.2	0	0	0
		3				
		4				
		Total	104.3	0	0	0
	Finland	1	191.0	0	0	0
		2				
		3				
		4				
		Total	191.0	0	0	0
	Germany	1	10.2	1	327	58
		2				
		3				
		4				
		Total	10.2	1	327	58
	Latvia	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Lithuania	1				
		2	54.2	0	0	0
		3				
		4				
		Total	54.2	0	0	0
	Poland	1	310.0	0	0	0
		2	-			
		3	-			
		4	3.0	0	0	0
		Total	313.0	0	0	0
	Sweden	1	3,859.6	6	475	474
		2	1,580.2	3	500	498
		3	6.3	0	0	0
		4	273.1	2	181	179
		Total	5,719.2	11	1156	1151
	Total	1	6,226.1	8	920	592
		2	1,658.6	3	500	498
		3	6.3	0	0	0
		4	276.1	2	181	179
		Total	8,167.1	13	1601	1269

continued

Table 7.5 Sprat in Sub-divisions 22-32. Samples of commercial catches by quarter, country and Sub-division for 2016 available to the Working Group. 5/7

Sub-division 28	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	2,583.4	0	0	0
		2	276.3	0	0	0
		3				
		4				
		Total	2,859.7	0	0	0
	Estonia	1	2,828.1	15	3461	1350
		2	172.1	2	301	150
		3	55.2	0	0	0
		4	1,724.4	13	2709	1232
		Total	4,779.7	30	6471	2732
	Finland	1	677.0	0	0	0
		2				
		3				
		4				
		Total	677.0	0	0	0
	Germany	1	3,652.0	6	1469	276
		2	531.8	1	310	61
		3				
		4				
		Total	4183.9	7	1779	337
	Latvia	1	10,853.5	7	1445	698
		2	3,254.9	5	977	388
		3	3,324.5	6	1239	534
		4	7,489.3	5	1008	495
		Total	24,922.2	23	4669	2115
	Lithuania	1	2,896.0	0	0	0
		2	428.7	0	0	0
		3	75.0	0	0	0
		4	1,726.4	0	0	0
		Total	5,126.2	0	0	0
	Poland	1	804.0	1	195	76
		2	263.9	5	1192	76
		3	218.5	0	0	0
		4	300.6	0	0	0
		Total	1,587.0	6	1387	152
	Russia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Sweden	1	11,907.1	3	800	799
		2	1,317.8	0	0	0
		3	162.7	0	0	0
		4	570.3	0	0	0
		Total	13,957.8	3	800	799
	Total	1	36,201.1	32	7370	3199
		2	6,245.5	13	2780	675
		3	3,835.9	6	1239	534
		4	11,811.0	18	3717	1727
		Total	58,093.5	69	15106	6135

continued

Table 7.5 Sprat in Sub-divisions 22-32. Samples of commercial catches by quarter, country and Sub-division for 2016 available to the Working Group. 6/7

Sub-division	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
29	Denmark	1	5401.7	1	104	52
		2	102.5	0	0	0
		3				
		4				
		Total	5504.3	1	104	52
	Estonia	1	2789.8	2	490	200
		2	595.4	0	0	0
		3	119.7	3	729	300
		4	1196.8	5	1141	500
		Total	4701.8	10	2360	1000
	Finland	1	4359.0	4	995	0
		2	80.0	4	47	0
		3	158.2	3	829	302
		4	2541.4	4	537	484
		Total	7138.5	15	2408	786
	Germany	1	2140.4	2	644	110
		2	187.9	0	0	0
		3				
		4	370.0	0	0	0
		Total	2698.2	2	644	110
	Latvia	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Lithuania	1	1144.5	0	0	0
		2	130.0	0	0	0
		3				
		4				
		Total	1274.5	0	0	0
	Poland	1	425.0	0	0	0
		2				
		3				
		4	135.0	0	0	0
		Total	560.0	0	0	0
	Sweden	1	8441.3	5	550	539
		2	1247.0	1	270	270
		3				
		4	1231.0	0	0	0
		Total	10919.3	6	820	809
	Total	1	24701.7	14	2783	901
		2	2342.8	5	317	270
		3	277.9	6	1558	602
		4	5474.2	9	1678	984
		Total	32796.6	34	6336	2757

Sub-division	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
30	Denmark	1				
		2				
		3				
		4				
		Total	0.0	0	0	0
	Finland	1	2492.0	13	1035	0
		2	961.0	16	611	0
		3	97.0	10	434	189
		4	1792.0	18	1615	555
		Total	5342.0	57	3695	744
	Sweden	1	197.0	0	0	0
		2	234.4	0	0	0
		3	0.4	0	0	0
		4	3.2	0	0	0
		Total	435.0	0	0	0
	Total	1	2689.0	13	1035	0
		2	1195.4	16	611	0
		3	97.4	10	434	189
		4	1795.2	18	1615	555
		Total	5777.0	57	3695	744

Sub-division	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
31	Finland	1				
		2				
		3				
		4				
		Total	0.0	0	0	0

continued

Table 7.5 Sprat in Sub-divisions 22-32. Samples of commercial catches by quarter, country and Sub-division for 2016 available to the Working Group. 7/7

Sub-division 32	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Estonia	1	5,326.9	9	1746	764
		2	889.0	8	1747	800
		3	376.8	5	1332	500
		4	6,973.5	9	1746	764
		Total	13,566.2	31	6571	2828
	Finland	1	2,942.1	5	1526	0
		2	0.1	1	12	0
		3	2.5	2	607	242
		4	339.6	5	1526	0
		Total	3,284.2	13	3671	242
	Sweden	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Total	1	8,269.0	14	3272	764
		2	889.1	9	1759	800
		3	379.3	7	1939	742
		4	7,313.1	14	3272	764
		Total	16,850.4	44	10242	3070
Sub-divisions 22-32	**Total**	**Quarter**	**Landings in tons**	**Number of samples**	**Number of fish measured**	**Number of fish aged**
		1	**138,839.1**	**181**	**34038**	**9849**
		2	**58,186.8**	**115**	**19261**	**5596**
		3	**10,083.7**	**95**	**15854**	**3678**
		4	**39,400.1**	**129**	**22198**	**6571**
		Total	**246,509.7**	**520**	**91351**	**25694**

Table 7.6 SPRAT in SD 22-32. Catch in Numbers (Thousands) CANUM.

CANUM: Catch in numbers (Total International Catch) (Thousands)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	2615000	6172000	3618000	1940000	1929000	933000	1213000	278000
1975	628000	2032000	5678000	2387000	790000	878000	247000	546000
1976	4682000	818000	2106000	3510000	1040000	350000	548000	422000
1977	2371000	8399000	997000	1907000	1739000	364000	140000	399000
1978	500000	3325000	4936000	480000	817000	683000	73000	189000
1979	1340000	597000	1037000	2291000	188000	150000	335000	125000
1980	369000	1476000	378000	500000	1357000	72000	67000	235000
1981	2303000	920000	405000	94000	88000	527000	13000	99000
1982	363000	2460000	425000	225000	64000	57000	231000	51000
1983	1852000	297000	531000	107000	47000	12000	18000	148000
1984	1005000	2393000	388000	447000	77000	38000	9000	83000
1985	566000	1703000	2521000	447000	271000	30000	19000	65000
1986	495000	1142000	1425000	2099000	340000	188000	16000	50000
1987	779000	394000	1320000	1833000	1805000	227000	149000	73000
1988	78000	2696000	730000	1149000	762000	760000	65000	141000
1989	2102000	290000	1772000	404000	739000	390000	398000	137000
1990	1049000	3171000	346000	952000	188000	316000	112000	200000
1991	1044000	2649000	2439000	407000	569000	106000	160000	152000
1992	1782000	2939000	3040000	1643000	444000	311000	121000	163000
1993	1832000	5685000	3244000	1898000	884000	267000	244000	257000
1994	1079000	8169000	8176000	3525000	2201000	779000	193000	208000
1995	6373000	2341000	6643000	6636000	3366000	1902000	627000	409000
1996	8389000	27675000	4704000	6517000	3323000	1499000	690000	403000
1997	1718000	23182000	23395000	6343000	4108000	1651000	683000	279000
1998	11018000	3803000	17688000	19618000	2659000	1778000	1468000	489000
1999	2082000	19901000	5832000	9972000	8836000	1180000	687000	515000
2000	10535000	2948000	14716000	2870000	4284000	4077000	707000	761000
2001	2776000	11557000	2670000	9252000	1999000	2651000	2264000	523000
2002	6648000	5429000	10781000	3835000	4308000	998000	880000	1340000
2003	9366000	7109000	4805000	5067000	2396000	1903000	833000	1383000
2004	23264000	13094000	5448000	3086000	3246000	1334000	1143000	1364000
2005	2843000	30968000	11254000	2934000	1868000	843000	659000	615000
2006	10851000	3266000	21097000	6832000	1380000	614000	405000	530000
2007	13796000	11968000	3706000	13723000	3855000	623000	301000	539000
2008	6391000	15479000	6684000	2937000	5719000	2255000	299000	362000
2009	21145000	8891000	10181000	3905000	1795000	2837000	1008000	353000
2010	4584000	21493000	5363000	4234000	1239000	881000	994000	511000
2011	8799000	4361000	12720000	2749000	1471000	549000	379000	568000
2012	5218000	5712000	2727000	7041000	1246000	736000	298000	437000
2013	6266000	9569000	4486000	2391000	3849000	682000	310000	317000
2014	4911208	7619008	6498613	2373559	1458602	1402152	352393	371808
2015	17057263	4720316	5121411	3272068	1244627	659072	584565	292838
2016	2973969	18520734	3801288	2547751	1226450	508161	406247	450644

Table 7.7 SPRAT in SD 22-32. Mean weight in the Catch and in the Stock (kg).

WECA (=WEST): Mean weight in Catch (Kilograms)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.0066	0.0105	0.0122	0.0134	0.0139	0.0154	0.0141	0.0143
1975	0.0068	0.0112	0.0124	0.0134	0.0147	0.0143	0.0157	0.0135
1976	0.0069	0.0107	0.0127	0.0135	0.0145	0.0161	0.0147	0.0143
1977	0.0054	0.0110	0.0134	0.0140	0.0144	0.0159	0.0159	0.0158
1978	0.0051	0.0109	0.0125	0.0131	0.0141	0.0152	0.0158	0.0151
1979	0.0055	0.0127	0.0130	0.0137	0.0151	0.0158	0.0156	0.0162
1980	0.0078	0.0113	0.0143	0.0141	0.0143	0.0167	0.0158	0.0160
1981	0.0063	0.0141	0.0161	0.0180	0.0165	0.0159	0.0168	0.0161
1982	0.0088	0.0117	0.0160	0.0162	0.0167	0.0164	0.0163	0.0173
1983	0.0092	0.0145	0.0162	0.0171	0.0169	0.0170	0.0169	0.0168
1984	0.0097	0.0111	0.0146	0.0153	0.0158	0.0163	0.0169	0.0172
1985	0.0091	0.0113	0.0127	0.0140	0.0160	0.0171	0.0171	0.0158
1986	0.0079	0.0121	0.0129	0.0140	0.0148	0.0161	0.0170	0.0167
1987	0.0085	0.0117	0.0133	0.0145	0.0152	0.0164	0.0170	0.0176
1988	0.0056	0.0103	0.0122	0.0142	0.0152	0.0153	0.0166	0.0170
1989	0.0097	0.0136	0.0145	0.0158	0.0169	0.0173	0.0175	0.0181
1990	0.0104	0.0126	0.0149	0.0160	0.0175	0.0177	0.0184	0.0181
1991	0.0090	0.0129	0.0143	0.0158	0.0166	0.0175	0.0169	0.0169
1992	0.0087	0.0121	0.0147	0.0154	0.0173	0.0172	0.0181	0.0184
1993	0.0066	0.0111	0.0138	0.0146	0.0150	0.0162	0.0166	0.0166
1994	0.0080	0.0098	0.0121	0.0140	0.0145	0.0152	0.0155	0.0159
1995	0.0065	0.0106	0.0110	0.0126	0.0137	0.0141	0.0143	0.0145
1996	0.0043	0.0075	0.0103	0.0111	0.0124	0.0128	0.0127	0.0129
1997	0.0067	0.0074	0.0085	0.0101	0.0117	0.0124	0.0125	0.0127
1998	0.0046	0.0076	0.0083	0.0089	0.0104	0.0106	0.0108	0.0118
1999	0.0040	0.0078	0.0092	0.0091	0.0092	0.0106	0.0112	0.0110
2000	0.0062	0.0102	0.0100	0.0108	0.0113	0.0117	0.0128	0.0134
2001	0.0063	0.0093	0.0114	0.0108	0.0116	0.0113	0.0110	0.0118
2002	0.0069	0.0097	0.0102	0.0109	0.0111	0.0111	0.0115	0.0117
2003	0.0050	0.0099	0.0108	0.0109	0.0114	0.0111	0.0107	0.0108
2004	0.0044	0.0076	0.0105	0.0112	0.0111	0.0114	0.0111	0.0113
2005	0.0047	0.0069	0.0081	0.0107	0.0112	0.0116	0.0110	0.0113
2006	0.0049	0.0078	0.0082	0.0089	0.0108	0.0112	0.0111	0.0114
2007	0.0056	0.0077	0.0091	0.0092	0.0094	0.0109	0.0113	0.0110
2008	0.0068	0.0092	0.0098	0.0105	0.0103	0.0102	0.0112	0.0122
2009	0.0050	0.0092	0.0105	0.0109	0.0114	0.0108	0.0110	0.0120
2010	0.0052	0.0080	0.0099	0.0107	0.0110	0.0112	0.0108	0.0114
2011	0.0040	0.0091	0.0096	0.0107	0.0114	0.0114	0.0114	0.0124
2012	0.0059	0.0094	0.0111	0.0112	0.0120	0.0123	0.0123	0.0121
2013	0.0051	0.0096	0.0115	0.0125	0.0126	0.0129	0.0130	0.0125
2014	0.0052	0.0092	0.0107	0.0120	0.0127	0.0127	0.0123	0.0123
2015	0.0042	0.0095	0.0110	0.0117	0.0126	0.0132	0.0125	0.0122
2016	0.0047	0.0071	0.0099	0.0113	0.0118	0.0126	0.0123	0.0122

Table 7.8 SPRAT in SD 22-32. Natural Mortality.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974	0.49	0.49	0.49	0.47	0.46	0.46	0.46	0.46
1975	0.53	0.53	0.53	0.51	0.50	0.50	0.49	0.49
1976	0.47	0.47	0.47	0.46	0.45	0.44	0.44	0.44
1977	0.55	0.55	0.54	0.53	0.52	0.51	0.51	0.51
1978	0.67	0.67	0.66	0.64	0.63	0.62	0.61	0.61
1979	0.78	0.78	0.77	0.75	0.73	0.72	0.71	0.71
1980	0.84	0.84	0.83	0.81	0.79	0.77	0.77	0.77
1981	0.80	0.80	0.80	0.77	0.75	0.74	0.74	0.74
1982	0.82	0.82	0.82	0.79	0.77	0.76	0.75	0.75
1983	0.76	0.76	0.76	0.74	0.72	0.71	0.70	0.70
1984	0.63	0.63	0.63	0.61	0.59	0.58	0.58	0.58
1985	0.54	0.54	0.53	0.52	0.51	0.50	0.50	0.50
1986	0.47	0.47	0.47	0.46	0.45	0.45	0.44	0.44
1987	0.43	0.43	0.43	0.42	0.41	0.40	0.40	0.40
1988	0.43	0.43	0.43	0.42	0.41	0.41	0.41	0.41
1989	0.39	0.39	0.39	0.38	0.38	0.37	0.37	0.37
1990	0.33	0.33	0.33	0.32	0.32	0.32	0.32	0.32
1991	0.28	0.28	0.28	0.28	0.28	0.27	0.27	0.27
1992	0.27	0.27	0.27	0.27	0.26	0.26	0.26	0.26
1993	0.30	0.30	0.30	0.29	0.29	0.29	0.29	0.29
1994	0.30	0.30	0.30	0.29	0.29	0.29	0.29	0.29
1995	0.30	0.30	0.30	0.29	0.29	0.29	0.29	0.29
1996	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
1997	0.30	0.30	0.30	0.30	0.29	0.29	0.29	0.29
1998	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31
1999	0.34	0.34	0.34	0.33	0.33	0.33	0.32	0.32
2000	0.34	0.34	0.34	0.33	0.33	0.33	0.32	0.32
2001	0.33	0.33	0.33	0.32	0.32	0.32	0.31	0.31
2002	0.35	0.35	0.35	0.34	0.33	0.33	0.33	0.33
2003	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
2004	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28
2005	0.30	0.30	0.30	0.30	0.29	0.29	0.29	0.29
2006	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31
2007	0.33	0.33	0.33	0.33	0.32	0.32	0.32	0.32
2008	0.35	0.35	0.35	0.35	0.34	0.34	0.34	0.34
2009	0.37	0.37	0.37	0.37	0.36	0.36	0.35	0.35
2010	0.42	0.42	0.42	0.41	0.40	0.40	0.40	0.40
2011	0.45	0.45	0.45	0.44	0.43	0.43	0.42	0.42
2012	0.36	0.36	0.36	0.35	0.35	0.35	0.34	0.34
2013	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30
2014	0.30	0.30	0.30	0.30	0.29	0.29	0.29	0.29
2015	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.30
2016	0.33	0.33	0.33	0.32	0.32	0.32	0.32	0.32

Table 7.9 SPRAT in SD 22-32. Proportion Mature at Spawning Time.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2014	0.170	0.930	1.0	1.0	1.0	1.0	1.0	1.0

Table 7.10 SPRAT in SD 22-32. Proportion of M before Spawning.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2016	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table 7.11 SPRAT in SD 22-32. Proportion of F before Spawning.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2016	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table 7.12 SPRAT in SD 22-32. Tuning Fleet/

Acoustic Survey in SD 22-29 age 0 shifted to represent age 1..

Fleet 03. Acoustic on age 0 in SD 22-29 shifted to represent age 1

Year	Fish. Effort	Age 1
1992	1	59473
1993	1	48035
1994	1	-11
1995	1	64092
1996	1	-11
1997	1	3842
1998	1	-11
1999	1	1279
2000	1	33320
2001	1	4601
2002	1	12001
2003	1	79551
2004	1	146335
2005	1	3562
2006	1	41863
2007	1	66125
2008	1	17821
2009	1	115698
2010	1	12798
2011	1	41916
2012	1	45186
2013	1	33653
2014	1	24694
2015	1	162715
2016	1	36900

Table 7.13 SPRAT in SD 22-32. Tuning Fleet/

InternationalAcoustic Survey in October (SD 22-29).

Fleet 01. International Acoustic Survey corrected by area surveyed (Catch: Millions)

Year	Fish. Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+	total
1991	1	46488	40299	43681	2743	8924	1851	1957	3117	149060
1992	1	36519	26991	24051	9289	1921	2437	714	560	102482
1993	1	-11	-11	-11	-11	-11	-11	-11	-11	-11
1994	1	12532	44588	43274	17272	11925	5112	1029	1559	137291
1995	1	-11	-11	-11	-11	-11	-11	-11	-11	-11
1996	1	69994	130760	20797	23241	12778	6405	3697	1311	268983
1997	1	-11	-11	-11	-11	-11	-11	-11	-11	-11
1998	1	100615	21975	55422	36291	8056	4735	1623	1011	229728
1999	1	4892	90050	15989	35717	38820	5231	3290	1738	195727
2000	1	58703	5285	49635	5676	13933	15835	1554	2678	153299
2001	1	12047	35687	6927	30237	4028	9606	6370	2407	107309
2002	1	31209	14415	36763	5733	18735	2638	5037	4345	118875
2003	1	99129	32270	24035	23198	8016	13163	4831	8536	213178
2004	1	119497	47027	11638	7929	4876	2450	2389	3552	199358
2005	1	7082	125148	48724	10035	5116	3011	2364	3325	204805
2006	1	36531	11774	103289	32412	7937	4583	2111	2947	201584
2007	1	51888	21665	8175	26102	9800	1067	470	1578	120745
2008	1	28805	45118	20134	5350	18820	5678	1241	1917	127063
2009	1	77343	25333	20840	6547	4667	7023	2011	1376	145140
2010	1	11638	51321	10654	6663	1684	1958	2572	1168	87658
2011	1	20620	11657	43357	9990	6747	2615	1795	2808	99589
2012	1	40516	16525	7935	18413	3494	1733	606	1368	90590
2013	1	19408	20364	11448	5684	11219	1771	759	1274	71927
2014	1	10448	8623	9735	4695	2034	3779	681	774	40768
2015	1	99618	17315	19728	11041	3426	3552	2772	1528	158981
2016	1	20531	80822	24344	9305	3725	1475	1203	1250	142656

Table 7.14 SPRAT in SD 22-32. Tuning Fleet/

InternationalAcoustic Survey in SD 24-28 excl. 27

Fleet 02. International Acoustic Survey in May corrected by area surveyed (Catch: Millions)

Year	Fish. Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2001	1	8,225	35,735	12,971	37,328	5,384	4,635	4,526	600
2002	1	27,412	18,982	36,814	19,045	14,759	2,517	3,670	2,585
2003	1	26,469	16,471	8,423	15,533	5,653	7,170	1,660	3,607
2004	1	136,162	65,566	15,784	11,042	12,655	3,271	7,806	6,321
2005	1	4,359	88,830	23,557	7,258	3,517	2,781	1,830	2,243
2006	1	13,417	7,980	76,703	21,046	5,702	1,970	1,526	1,943
2007	1	51,569	28,713	6,377	36,006	7,481	1,261	533	698
2008	1	9,029	40,270	20,164	5,627	21,188	4,210	757	1,477
2009	1	39,412	26,701	36,255	10,549	6,312	14,106	5,341	964
2010	1	9,387	58,680	15,199	15,963	5,062	1,654	5,566	1,273
2011	1	18,092	6,791	66,160	16,689	10,565	4,077	2,399	3,382
2012	1	22,700	22,080	11,274	35,541	7,515	5,025	1,367	2,158
2013	1	24,877	35,333	18,393	11,358	14,959	3,385	2,164	950
2014	1	10,145	26,907	19,857	7,458	6,098	3,810	1,217	1,058
2015	1	70752	24660	29744	18935	8081	4074	2581	1721
2016	1	-11	-11	-11	-11	-11	-11	-11	-11

Table 7.15 SPRAT in SD 22-32. Output from XSA. 1/6

Lowestoft VPA Version 3.1
13/04/2017 23:07
Extended Survivors Analysis
Sprat 22 32

CPUE data from file d:\SprDat16\Fleet3xsa.txt

Catch data for 43 years. 1974 to 2016. Ages 1 to 8.

Fleet	Firs year	Last year	First age	Last age	Alpha	Beta
FLT01:Intern	1991	2016	1	7	0.75	0.85
FLT02: Intern	2001	2016	1	7	0.35	0.42
FLT03: Latvi	1992	2016	1	1	0	0.01

Time series weights :
Tapered time weighting applied
Power = 3 over 20 years
Catchability analysis :
Catchability dependent on stock size for ages < 2
Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 2
Catchability independent of age for ages >= 5
Terminal population estimation :
Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.
S.E. of the mean to which the estimates are shrunk = .750
Minimum standard error for population
estimates derived from each fleet = .300
Prior weighting not applied

Tuning had not converged after 60 iterations

Total absolute residual between iterations
59 and 60 = .00192

Final year F values

Age	1.00	2.00	3.00	4.00	5.00	6.00	7.00
Iteration 59	0.05	0.18	0.22	0.24	0.21	0.27	0.40
Iteration 60	0.05	0.18	0.22	0.24	0.21	0.27	0.40

continued

Table 7.15 SPRAT in SD 22-32. Output from XSA. 2/6

Regression weights

1	1	1	1	1	1	1	0.997	1	1

Fishing mortalities

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.16	0.112	0.148	0.106	0.194	0.088	0.118	0.108	0.107	0.052
2	0.337	0.319	0.271	0.275	0.18	0.235	0.269	0.232	0.162	0.185
3	0.223	0.378	0.438	0.326	0.342	0.205	0.345	0.336	0.272	0.216
4	0.444	0.326	0.486	0.411	0.362	0.413	0.326	0.351	0.318	0.24
5	0.372	0.395	0.409	0.345	0.314	0.348	0.493	0.383	0.353	0.213
6	0.436	0.456	0.416	0.45	0.323	0.317	0.38	0.376	0.334	0.269
7	0.547	0.453	0.453	0.307	0.46	0.364	0.246	0.388	0.296	0.404

XSA population numbers (Thousands)

	AGE						
YEAR	1	2	3	4	5	6	7
2007	110000	49300	21900	45100	14600	2070	838
2008	71700	67500	25300	12600	20800	7300	973
2009	185000	45100	34600	12200	6400	9970	3290
2010	56200	110000	23800	15400	5190	2970	4590
2011	62400	33200	54900	11300	6780	2470	1270
2012	74500	32700	17700	24900	5060	3220	1160
2013	65900	47400	18000	10000	11500	2510	1650
2014	55700	42800	26500	9320	5320	5180	1270
2015	196000	36900	25100	14000	4870	2700	2650
2016	68500	129000	23100	14000	7500	2530	1430

Estimated population abundance at 1st Jan 2017

0	46800	77300	13400	7990	4410	1410

Taper weighted geometric mean of the VPA populations:

84500	54000	28200	15000	7420	3610	1850

Standard error of the weighted Log(VPA populations) :

0.4941	0.5264	0.4592	0.4647	0.4913	0.5344	0.5645

continued

Table 7.15 SPRAT in SD 22-32. Output from XSA. 3/6

Log catchability residuals.
Fleet : FLT01:International

Age	1991	1992	1993	1994	1995	1996
1	99.99	99.99	99.99	99.99	99.99	99.99
2	99.99	99.99	99.99	99.99	99.99	99.99
3	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99

Age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	99.99	0.04	-0.78	0.25	-0.06	0.48	0.36	-0.15	-0.41	0.19
2	99.99	-0.02	0.51	-1.34	0.17	-0.07	0.72	0.12	0.55	-0.41
3	99.99	0.23	-0.16	0.15	-1.01	0.54	0.67	-0.03	0.33	0.59
4	99.99	-0.14	0.46	-0.65	0.3	-0.61	0.76	0.23	0.51	0.51
5	99.99	0.04	0.58	0.13	-0.44	0.42	0.33	-0.02	0.58	0.94
6	99.99	0.19	0.25	0.41	0.53	-0.22	0.67	-0.09	0.2	1.29
7	99.99	-0.77	0.53	-0.3	0.26	0.57	1.19	-0.43	0.71	0.48

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.1	0.15	-0.15	-0.15	0.17	0.32	-0.04	-0.27	-0.1	-0.06
2	0.01	0.43	0.24	0.09	-0.24	0.1	-0.08	-0.87	-0.08	0.24
3	-0.65	0.25	0.04	-0.31	0.29	-0.45	-0.03	-0.59	0.12	0.39
4	-0.08	-0.47	-0.09	-0.34	0.36	0.16	-0.21	-0.32	0.11	-0.11
5	-0.09	0.24	0.05	-0.78	0.34	-0.06	0.37	-0.67	-0.07	-0.52
6	-0.31	0.14	0.02	0.02	0.41	-0.33	-0.05	-0.03	0.54	-0.32
7	-0.13	0.63	-0.1	-0.26	0.8	-0.33	-0.59	-0.33	0.27	0.15

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	2	3	4	5	6	7
Mean Log q	-0.3005	0.103	0.1549	0.2475	0.2475	0.2475
S.E(Log q)	0.4068	0.4258	0.3537	0.4774	0.4417	0.5119

Regression statistics :
Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.63	2.521	4.57	0.83	19	0.24	-0.68

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	0.74	1.597	3.03	0.79	19	0.28	-0.3
3	0.69	1.756	3.11	0.76	19	0.27	0.1
4	0.88	0.605	1.06	0.7	19	0.32	0.15
5	0.85	0.591	1.14	0.6	19	0.42	0.25
6	1.05	-0.188	-0.79	0.59	19	0.47	0.37
7	1.13	-0.407	-1.35	0.5	19	0.59	0.35

continued

Table 7.15 SPRAT in SD 22-32. Output from XSA. 4/6

Fleet : FLT02: International

Age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	99.99	99.99	99.99	99.99	-0.1	0.63	-0.22	0.27	-0.55	-0.24
2	99.99	99.99	99.99	99.99	0.04	0.08	-0.08	0.36	0.08	-0.87
3	99.99	99.99	99.99	99.99	-0.47	0.33	-0.54	0.1	-0.54	0.14
4	99.99	99.99	99.99	99.99	0.11	0.2	-0.04	0.15	-0.23	-0.29
5	99.99	99.99	99.99	99.99	-0.57	-0.25	-0.46	0.41	-0.32	0.15
6	99.99	99.99	99.99	99.99	-0.67	-0.68	-0.32	-0.27	-0.3	-0.03
7	99.99	99.99	99.99	99.99	-0.54	-0.16	-0.37	0.36	-0.04	-0.25

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.37	-0.4	-0.32	-0.11	0.26	0.19	0.37	-0.08	-0.01	99.99
2	0.12	0.15	0.13	0.04	-0.94	0.24	0.34	0.15	0.18	99.99
3	-1.01	0.06	0.37	-0.15	0.5	-0.22	0.28	-0.04	0.4	99.99
4	-0.19	-0.8	-0.08	0.09	0.44	0.4	0.11	-0.23	0.28	99.99
5	-0.79	-0.09	-0.11	-0.13	0.34	0.27	0.18	0.01	0.37	99.99
6	-0.6	-0.64	0.25	-0.65	0.4	0.31	0.17	-0.44	0.26	99.99
7	-0.51	-0.34	0.4	0.07	0.58	0.04	0.09	-0.17	-0.19	99.99

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	2	3	4	5	6	7
Mean Log q	-0.4059	-0.0076	0.2582	0.3934	0.3934	0.3934
S.E(Log q)	0.4135	0.4277	0.3436	0.3441	0.4418	0.3274

Regression statistics :
Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.69	1.552	4.42	0.73	15	0.33	-1.22

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	0.79	0.974	2.64	0.7	15	0.33	-0.41
3	0.8	0.846	2.05	0.67	15	0.35	-0.01
4	0.99	0.044	-0.16	0.67	15	0.36	0.26
5	1.37	-1.262	-3.8	0.57	15	0.46	0.39
6	1.19	-0.627	-1.9	0.54	15	0.52	0.26
7	0.88	0.779	0.6	0.82	15	0.29	0.37

continued

Table 7.15 SPRAT in SD 22-32. Output from XSA. 5/6

Fleet : FLT03: Latvian/Russi

Age	1991	1992	1993	1994	1995	1996
1	99.99	99.99	99.99	99.99	99.99	99.99
2	No data for this fleet at this age					
3	No data for this fleet at this age					
4	No data for this fleet at this age					
5	No data for this fleet at this age					
6	No data for this fleet at this age					
7	No data for this fleet at this age					

Age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	-0.94	99.99	-1.52	-0.25	-0.64	-0.22	0.07	-0.22	-0.79	0.12
2	No data for this fleet at this age									
3	No data for this fleet at this age									
4	No data for this fleet at this age									
5	No data for this fleet at this age									
6	No data for this fleet at this age									
7	No data for this fleet at this age									

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.07	-0.25	-0.13	-0.19	0.38	0.24	0.2	0.19	0.01	0.21
2	No data for this fleet at this age									
3	No data for this fleet at this age									
4	No data for this fleet at this age									
5	No data for this fleet at this age									
6	No data for this fleet at this age									
7	No data for this fleet at this age									

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.57	2.175	5.34	0.72	19	0.32	-0.83

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 2015

Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
FLT01:Intern	43878	0.3	0	0	1	0.434	0.056
FLT02: Inter	1	0	0	0	0	0	0
FLT03: Latvi	57806	0.337	0	0	1	0.345	0.043
P shrinkage	54032	0.53				0.148	0.046
F shrinkage	19114	0.75				0.073	0.124

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of year	s.e	s.e		Ratio	
46831	0.2	0.17	4	0.832	0.052

Age 2 Catchability constant w.r.t. time and dependent on age

Year class = 2014

Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
FLT01:Intern	79319	0.245	0.162	0.66	2	0.503	0.181
FLT02: Inter	76621	0.372	0	0	1	0.21	0.187
FLT03: Latvi	77895	0.365	0	0	1	0.218	0.184
F shrinkage	64666	0.75				0.069	0.217

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of year	s.e	s.e		Ratio	
77335	0.17	0.06	5	0.362	0.185

continued

Table 7.15 SPRAT in SD 22-32. Output from XSA. 6/6

Age 3 Catchability constant w.r.t. time and dependent on age
Year class = 2013

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:Interna	12874	0.216	0.195	0.9	3	0.485	0.224
FLT02: Interr	13812	0.275	0.132	0.48	2	0.28	0.21
FLT03: Latvia	16159	0.339	0	0	1	0.176	0.182
F shrinkage	9104	0.75				0.058	0.303

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
13392	0.15	0.1	7	0.658	0.216

Age 4 Catchability constant w.r.t. time and dependent on age
Year class = 2012

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:Interna	6724	0.192	0.186	0.97	4	0.526	0.279
FLT02: Interr	10969	0.234	0.076	0.32	3	0.295	0.18
FLT03: Latvia	9730	0.338	0	0	1	0.12	0.201
F shrinkage	5034	0.75				0.058	0.358

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7988	0.14	0.12	9	0.904	0.24

Age 5 Catchability constant w.r.t. time and dependent on age
Year class = 2011

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:Interna	3940	0.187	0.177	0.94	5	0.494	0.235
FLT02: Interr	5425	0.204	0.074	0.37	4	0.362	0.176
FLT03: Latvia	5616	0.341	0	0	1	0.085	0.171
F shrinkage	2241	0.75				0.06	0.383

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4408	0.13	0.11	11	0.858	0.213

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5
Year class = 2010

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:Interna	1222	0.188	0.085	0.45	6	0.477	0.304
FLT02: Interr	1668	0.187	0.123	0.66	5	0.403	0.231
FLT03: Latvia	2056	0.345	0	0	1	0.054	0.191
F shrinkage	1035	0.75				0.066	0.35

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1409	0.13	0.08	13	0.625	0.269

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5
Year class = 2009

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:Interna	664	0.183	0.157	0.86	7	0.472	0.42
FLT02: Interr	675	0.178	0.142	0.8	6	0.404	0.415
FLT03: Latvia	574	0.366	0	0	1	0.046	0.473
F shrinkage	1262	0.75				0.077	0.243

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
697	0.13	0.1	15	0.794	0.404

Table 7.16. SPRAT IN SD 22-32. Output from XSA. Fishing mortality (F) at age.

Run title : Sprat 22 32
At 13/04/2017 23:10
Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1974	1975	1976
AGE			
1	0.069	0.044	0.031
2	0.100	0.096	0.102
3	0.299	0.175	0.190
4	0.395	0.477	0.215
5	0.292	0.387	0.562
6	0.566	0.286	0.407
7	0.426	0.391	0.402
+gp	0.426	0.391	0.402
FBAR 3- 5	**0.33**	**0.35**	**0.32**

YEAR	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
AGE										
1	0.076	0.047	0.067	0.028	0.052	0.016	0.021	0.028	0.019	0.042
2	0.099	0.227	0.126	0.188	0.178	0.137	0.029	0.055	0.089	0.064
3	0.245	0.118	0.179	0.212	0.138	0.226	0.073	0.080	0.113	0.139
4	0.374	0.275	0.125	0.233	0.140	0.201	0.150	0.134	0.187	0.178
5	0.216	0.425	0.283	0.187	0.106	0.249	0.104	0.257	0.166	0.292
6	0.556	0.183	0.212	0.308	0.189	0.168	0.118	0.187	0.220	0.225
7	0.390	0.303	0.213	0.252	0.149	0.213	0.127	0.197	0.194	0.235
+gp	0.390	0.303	0.213	0.252	0.149	0.213	0.127	0.197	0.194	0.235
FBAR 3- 5	**0.28**	**0.27**	**0.20**	**0.21**	**0.13**	**0.23**	**0.11**	**0.16**	**0.16**	**0.20**

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE										
1	0.019	0.029	0.059	0.035	0.078	0.045	0.130	0.069	0.155	0.093
2	0.163	0.058	0.190	0.256	0.112	0.228	0.096	0.240	0.219	0.283
3	0.228	0.215	0.176	0.271	0.361	0.291	0.310	0.136	0.440	0.355
4	0.256	0.327	0.378	0.430	0.439	0.415	0.265	0.383	0.347	0.439
5	0.292	0.465	0.298	0.487	0.364	0.421	0.367	0.346	0.357	0.435
6	0.284	0.497	0.432	0.261	0.456	0.313	0.409	0.478	0.336	0.297
7	0.280	0.435	0.372	0.396	0.442	0.365	0.363	0.489	0.331	0.603
+gp	0.280	0.435	0.372	0.396	0.442	0.365	0.363	0.489	0.331	0.603
FBAR 3- 5	**0.26**	**0.34**	**0.28**	**0.40**	**0.39**	**0.38**	**0.31**	**0.29**	**0.38**	**0.41**

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
AGE										
1	0.034	0.079	0.045	0.130	0.069	0.154	0.093	0.123	0.070	0.172
2	0.255	0.110	0.230	0.095	0.240	0.219	0.282	0.201	0.268	0.120
3	0.268	0.360	0.286	0.312	0.135	0.439	0.354	0.407	0.296	0.336
4	0.425	0.433	0.412	0.258	0.387	0.343	0.438	0.454	0.451	0.336
5	0.488	0.358	0.412	0.364	0.334	0.363	0.428	0.627	0.625	0.452
6	0.255	0.458	0.306	0.397	0.472	0.320	0.304	0.501	0.359	0.487
7	0.393	0.428	0.367	0.352	0.466	0.324	0.557	0.332	0.557	0.328
+gp	0.393	0.428	0.367	0.352	0.466	0.324	0.557	0.332	0.557	0.328
FBAR 3- 5	**0.39**	**0.38**	**0.37**	**0.31**	**0.29**	**0.38**	**0.41**	**0.50**	**0.46**	**0.37**

YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	FBAR **-**
AGE											
1	0.160	0.112	0.148	0.106	0.194	0.088	0.118	0.108	0.107	0.053	0.0892
2	0.337	0.319	0.271	0.276	0.180	0.235	0.269	0.232	0.162	0.185	0.1929
3	0.223	0.378	0.438	0.326	0.343	0.205	0.345	0.336	0.272	0.216	0.2748
4	0.445	0.326	0.486	0.412	0.362	0.413	0.326	0.351	0.318	0.240	0.3031
5	0.372	0.395	0.409	0.345	0.314	0.348	0.493	0.383	0.353	0.213	0.3164
6	0.436	0.456	0.416	0.450	0.323	0.318	0.380	0.376	0.334	0.269	0.3262
7	0.547	0.453	0.454	0.307	0.460	0.364	0.246	0.388	0.296	0.404	0.3625
+gp	0.547	0.453	0.454	0.307	0.460	0.364	0.246	0.388	0.296	0.404	
FBAR 3- 5	**0.35**	**0.37**	**0.44**	**0.36**	**0.34**	**0.32**	**0.39**	**0.36**	**0.31**	**0.22**	

Table 7.17. SPRAT IN SD 22-32. Output from XSA.

Stock number at age (Numbers*10^-6).

Run title : Sprat 22 32
At 13/04/2017 23:10
Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year)

YEAR		1974	1975	1976
AGE				
	1	50439	18933	194491
	2	83208	28853	10662
	3	17887	46144	15424
	4	7517	8126	22805
	5	9600	3164	3030
	6	2718	4528	1304
	7	4401	975	2062
+gp		984	2099	1553
TOTAL		176753	112823	251331

YEAR		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
AGE											
	1	42726	15221	30534	20034	67761	35164	133282	50388	40541	15178
	2	117856	22850	7431	13090	8406	28903	15246	61065	26103	23193
	3	6017	61617	9314	3002	4681	3161	11097	6927	30776	13911
	4	7975	2745	28298	3607	1060	1832	1110	4827	3406	16181
	5	11607	3231	1099	11793	1271	427	680	456	2293	1680
	6	1102	5560	1125	399	4438	540	154	298	195	1167
	7	559	379	2490	443	136	1753	214	67	138	95
+gp		1550	953	899	1491	1002	373	1708	606	465	292
TOTAL		189392	112557	81190	53859	88754	72153	163491	124634	103918	71698

YEAR		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE											
	1	33942	13469	40010	49578	54515	93807	87489	66666	259113	169590
	2	9095	21451	8699	25359	34754	40294	70053	63237	48459	186471
	3	13593	5599	11780	5651	15543	23963	28192	47004	39816	33884
	4	7568	7778	3053	6517	3769	9627	15637	18093	27784	23779
	5	8547	3487	4179	1754	3921	2495	5913	10059	10489	15050
	6	800	4202	1693	2247	1113	2469	1534	3660	5623	4937
	7	594	350	2169	845	1362	757	1631	917	2065	2562
+gp		286	748	737	1497	1286	1013	1704	978	1328	1479
TOTAL		74424	57084	72320	93449	116264	174425	212153	210613	394677	437751

YEAR		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
AGE											
	1	59730	171199	56587	102305	49022	55337	122138	231693	49142	80627
	2	119641	42770	114927	38521	63929	32889	33414	83290	153243	33958
	3	115590	68680	27817	65012	24931	36161	18619	18853	50996	86871
	4	21285	65495	34799	14879	33858	15659	16432	9776	9395	28092
	5	12306	10309	30841	16563	8263	16702	7910	8014	4645	4434
	6	8485	5654	5284	14681	8275	4297	8355	3896	3235	1860
	7	2428	4921	2625	2798	7097	3750	2243	4660	1785	1691
+gp		979	1615	1940	2971	1614	5634	3664	5500	1638	2186
TOTAL		340444	370643	274820	257729	196989	170429	212776	365682	274078	239720

YEAR		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	GMST 74-**	AMST 74-**
AGE														
	1	110130	71665	184869	56163	62368	74515	65855	55731	196213	68547	0	61479	79072
	2	49300	67478	45137	110121	33186	32741	47430	42798	36942	129304	46831	37947	51208
	3	21876	25296	34557	23788	54933	17678	17990	26501	25063	23053	77335	20710	29052
	4	45104	12585	12215	15408	11283	24870	10022	9319	13988	14013	13392	10465	15209
	5	14577	20790	6403	5192	6776	5060	11513	5316	4866	7502	7988	5142	7606
	6	2071	7300	9973	2968	2466	3222	2511	5182	2696	2527	4408	2437	3696
	7	838	973	3294	4588	1268	1161	1654	1268	2652	1430	1409	1178	1854
+gp		1473	1157	1133	2319	1857	1677	1675	1323	1314	1565	1460		
TOTAL		245370	207244	297579	220548	174136	160924	158651	147438	283734	247941	152822		

Table 7.18 Sprat in SD 22-32. Output from XSA. Stock summary.

Table 16 Summary (without SOP correction) **Run title : Sprat 22-32**

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 5
1974	50439	1777	1097	242	0.22	0.33
1975	18933	1288	867	201	0.23	0.35
1976	194491	2077	738	195	0.26	0.32
1977	42726	1937	1257	181	0.14	0.28
1978	15221	1283	866	132	0.15	0.27
1979	30534	859	498	77	0.15	0.20
1980	20034	604	311	58	0.19	0.21
1981	67761	750	268	49	0.18	0.13
1982	35164	779	340	49	0.14	0.23
1983	133282	1692	478	37	0.08	0.11
1984	50388	1365	691	53	0.08	0.16
1985	40541	1152	639	70	0.11	0.16
1986	15178	857	581	76	0.13	0.20
1987	33942	844	466	88	0.19	0.26
1988	13469	611	415	80	0.19	0.23
1989	40010	877	438	86	0.20	0.21
1990	49578	1137	570	86	0.15	0.13
1991	54515	1350	776	103	0.13	0.17
1992	93807	1922	1034	142	0.14	0.20
1993	87489	2141	1359	178	0.13	0.16
1994	66666	2206	1407	289	0.21	0.26
1995	259113	3258	1496	313	0.21	0.33
1996	169590	3042	1910	441	0.23	0.28
1997	59730	2775	1885	529	0.28	0.39
1998	171199	2505	1414	471	0.33	0.38
1999	56587	2086	1424	421	0.30	0.37
2000	102305	2273	1352	389	0.29	0.31
2001	49022	1840	1210	342	0.28	0.29
2002	55337	1583	950	343	0.36	0.38
2003	122138	1568	810	308	0.38	0.41
2004	231693	2207	1045	374	0.36	0.50
2005	49142	1930	1310	405	0.31	0.46
2006	80627	1735	1086	352	0.32	0.37
2007	110130	1796	959	388	0.40	0.35
2008	71665	1802	1029	381	0.37	0.37
2009	184869	2067	953	407	0.43	0.44
2010	56163	1740	1077	342	0.32	0.36
2011	62368	1342	827	268	0.32	0.34
2012	74515	1357	751	231	0.31	0.32
2013	65855	1343	804	272	0.34	0.39
2014	55731	1244	769	244	0.32	0.36
2015	196213	1760	848	247	0.29	0.31
2016	68547	1784	1176	247	0.21	0.22
Arith. Mean	**81551**	**1641**	**935**	**237**	**0.24**	**0.29**
Units	(Millions)	(Thousand tonnes)	(Thousand tonnes)	(Thousand tonnes)		

Table 7.19. Sprat in SD 22-32. Input data for RCT3 analysis.

Year	VPA, age 1	Acoustic Age 0, shifted
1992	93807	59473
1993	87489	48035
1994	66666	-11
1995	259113	64092
1996	169590	-11
1997	59730	3842
1998	171199	-11
1999	56587	1279
2000	102305	33320
2001	49022	4601
2002	55337	12001
2003	122138	79551
2004	231693	146335
2005	49142	3562
2006	80627	41863
2007	110130	66125
2008	71665	17821
2009	184869	115698
2010	56163	12798
2011	62368	41158
2012	74515	45186
2013	65855	33653
2014	55731	24694
2015	196213	162715
2016	68547	36900
2017	-11	30762

Table 7.20. Sprat in SD 22-32. Output from RCT3 analysis.

Sprat 22-32: YFS data from international acoustic survey on age 0

Data for 1 surveys over 26 years: 1991-2016
Regression type=C
Tapered time weighting applied
power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E for any survey taken as 0.2
Minimum of 3 points used for regression
Forecast/Hindcast variance correction used.

Yearclass = 2009

Survey/ Series	I-----------Regression----------I Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	I-----------Prediction---------I Predicted Value	Std Error	WAP Weights
Acoust	0.42	7.23	0.32	0.769	15	9.46	11.17	0.37	0.689
				VPA	Mean	=	11.47	0.551	0.311

Yearclass = 2010

Survey/ Series	I-----------Regression----------I Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	I-----------Prediction---------I Predicted Value	Std Error	WAP Weights
Acoust	0.43	7.08	0.31	0.773	16	10.63	11.64	0.358	0.7
				VPA	Mean	=	11.42	0.547	0.3

Yearclass = 2011

Survey/ Series	I-----------Regression----------I Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	I-----------Prediction---------I Predicted Value	Std Error	WAP Weights
Acoust	0.46	6.74	0.35	0.707	17	10.72	11.63	0.41	0.626
				VPA	Mean	=	11.38	0.531	0.374

Yearclass = 2012

Survey/ Series	I-----------Regression----------I Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	I-----------Prediction---------I Predicted Value	Std Error	WAP Weights
Acoust	0.47	6.57	0.36	0.683	18	10.42	11.45	0.408	0.605
				VPA	Mean	=	11.36	0.506	0.395

Yearclass = 2013

Survey/ Series	I-----------Regression----------I Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	I-----------Prediction---------I Predicted Value	Std Error	WAP Weights
Acoust	0.49	6.29	0.36	0.663	19	10.11	11.25	0.408	0.584
				VPA	Mean	=	11.34	0.484	0.416

Yearclass = 2014

Survey/ Series	I-----------Regression----------I Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	I-----------Prediction---------I Predicted Value	Std Error	WAP Weights
Acoust	0.53	5.87	0.36	0.648	20	12	12.19	0.451	0.521
				VPA	Mean	=	11.3	0.47	0.479

Yearclass = 2015

Survey/ Series	I-----------Regression----------I Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	I-----------Prediction---------I Predicted Value	Std Error	WAP Weights
Acoust	0.54	5.68	0.33	0.721	21	10.52	11.39	0.381	0.644
				VPA	Mean	=	11.36	0.513	0.356

Yearclass = 2016

Survey/ Series	I-----------Regression----------I Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	I-----------Prediction---------I Predicted Value	Std Error	WAP Weights
Acoust	0.57	5.35	0.32	0.721	22	10.33	11.24	0.367	0.644
				VPA	Mean	=	11.34	0.494	0.356

Year (Age 1)	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2005	64507	11.07	0.4	0.42	1.07	49142	10.8
2006	115759	11.66	0.37	0.16	0.19	80628	11.3
2007	124204	11.73	0.37	0.25	0.45	110130	11.61
2008	87084	11.37	0.34	0.05	0.02	71665	11.18
2009	137441	11.83	0.33	0.33	0.99	184869	12.13
2010	77886	11.26	0.31	0.14	0.2	56164	10.94
2011	105914	11.57	0.3	0.1	0.11	62369	11.04
2012	102421	11.54	0.32	0.12	0.13	74515	11.22
2013	90507	11.41	0.32	0.04	0.02	65856	11.1
2014	79654	11.29	0.31	0.04	0.02	55731	10.93
2015	128269	11.76	0.33	0.45	1.87	196213	12.19
2016	87477	11.38	0.31	0.01	0	68547	11.14
2017	**79182**	11.28	0.29	0.05	0.03		

Table 7.21 Sprat in SD 22-32. Input data for short-term prediction.

MFDP version 1a
Run: run17a
Time and date: 23:05 16/04/2017
Fbar age range: 3-5

2017

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	79182	0.31	0.17	0.4	0.4	0.0047	0.0668	0.0047
2	46831	0.31	0.93	0.4	0.4	0.0086	0.1443	0.0086
3	77335	0.31	1	0.4	0.4	0.0105	0.2057	0.0105
4	13392	0.31	1	0.4	0.4	0.0117	0.2268	0.0117
5	7988	0.31	1	0.4	0.4	0.0124	0.2368	0.0124
6	4408	0.30	1	0.4	0.4	0.0128	0.2442	0.0128
7	1409	0.30	1	0.4	0.4	0.0124	0.2713	0.0124
8	1460	0.30	1	0.4	0.4	0.0122	0.2713	0.0122

2018

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	88708	0.31	0.17	0.4	0.4	0.0047	0.0668	0.0047
2		0.31	0.93	0.4	0.4	0.0086	0.1443	0.0086
3		0.31	1	0.4	0.4	0.0105	0.2057	0.0105
4		0.31	1	0.4	0.4	0.0117	0.2268	0.0117
5		0.31	1	0.4	0.4	0.0124	0.2368	0.0124
6		0.30	1	0.4	0.4	0.0128	0.2442	0.0128
7		0.30	1	0.4	0.4	0.0124	0.2713	0.0124
8		0.30	1	0.4	0.4	0.0122	0.2713	0.0122

2019

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	88708	0.31	0.17	0.4	0.4	0.0047	0.0668	0.0047
2		0.31	0.93	0.4	0.4	0.0086	0.1443	0.0086
3		0.31	1	0.4	0.4	0.0105	0.2057	0.0105
4		0.31	1	0.4	0.4	0.0117	0.2268	0.0117
5		0.31	1	0.4	0.4	0.0124	0.2368	0.0124
7		0.30	1	0.4	0.4	0.0124	0.2713	0.0124
8		0.30	1	0.4	0.4	0.0122	0.2713	0.0122

Input units are millions and kg - output in kilotonnes

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} Age 1:	RCT3 estimate (Table 7.20)
N_{2017} Age 2-8+:	Survivors estimates from XSA (Table 7.16)
$N_{2018-2019}$ Age 1:	Geometric mean from XSA-estimates at age 1 for the years 1991-2016
Natural Mortality (M):	average 2014-2016
Weight in the Catch/Stock (CWt/SW	average 2014-2016
Expoitation pattern (Sel):	average 2014-2016 scaled to 2016

Table 7.22a. Sprat in SD 22-32. Output from short-term prediction with management option table for status quo fishery in 2017

MFDP version 1a
Run: run17a
Sprat
Time and date: 23:05 16/04/2017
Fbar age range: 3-5

2017				
Biomass	**SSB**	**FMult**	**FBar**	**Landings**
1936	1307	1.0000	0.2231	261

2018					2019	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
1939	1378	0.0	0.000	0	2215	1616
	1367	0.1	0.022	28	2187	1579
	1356	0.2	0.045	56	2160	1543
	1346	0.3	0.067	83	2133	1508
	1335	0.4	0.089	110	2106	1474
	1325	0.5	0.112	136	2080	1441
	1315	0.6	0.134	162	2055	1409
	1305	0.7	0.156	188	2030	1377
	1295	0.8	0.179	212	2005	1346
	1285	0.9	0.201	237	1981	1317
	1255	1.2	0.268	308	1912	1231
	1245	1.3	0.290	330	1889	1205
	1236	1.4	0.312	353	1867	1178
	1226	1.5	0.335	374	1846	1153
	1217	1.6	0.357	396	1824	1128
	1207	1.7	0.379	417	1804	1104
	1198	1.8	0.402	438	1783	1080
	1189	1.9	0.424	458	1763	1057
	1179	2.0	0.446	478	1743	1035

Input units are millions and kg - output in kilotonnes

Table 7.22b. Sprat in SD 22-32. Output from short-term prediction with management option table for TAC constrained fishery in 2017.

MFDP version 1a
Run: runTAC1
Sprat
Time and date: 16:40 19/04/2017
Fbar age range: 3-5

2017				
Biomass	**SSB**	**FMult**	**FBar**	**Landings**
1936	1289	1.0000	0.2632	304

2018					2019	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
1897	1341	0.0	0.000	0	2182	1587
	1329	0.1	0.026	32	2150	1545
	1317	0.2	0.053	64	2119	1504
	1305	0.3	0.079	95	2088	1464
	1293	0.4	0.105	126	2058	1425
	1281	0.5	0.132	155	2028	1388
	1270	0.6	0.158	184	2000	1351
	1258	0.7	0.184	213	1971	1316
	1247	0.8	0.211	241	1944	1282
	1235	0.9	0.237	268	1917	1249
	1148	1.7	0.447	467	1721	1018
	1138	1.8	0.474	489	1699	992
	1128	1.9	0.500	511	1677	968
	1117	2.0	0.526	533	1655	944

Input units are millions and kg - output in kilotonnes

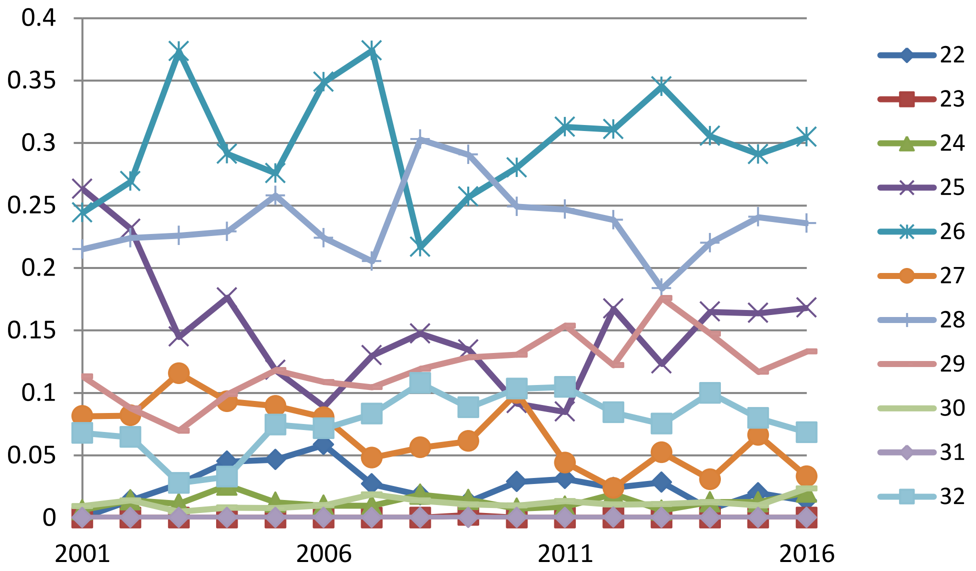


Figure 7.0 Sprat in Subdivisions 22-32. Share of catches by Sub-division in 2001-2015

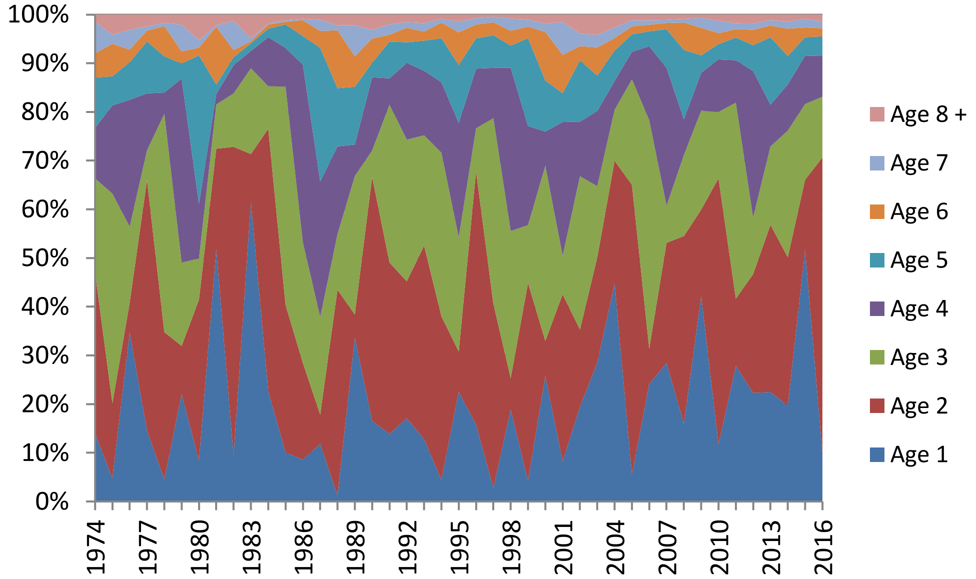


Figure 7.1 Sprat in SD 22-32. Relative catch-at-age in numbers.

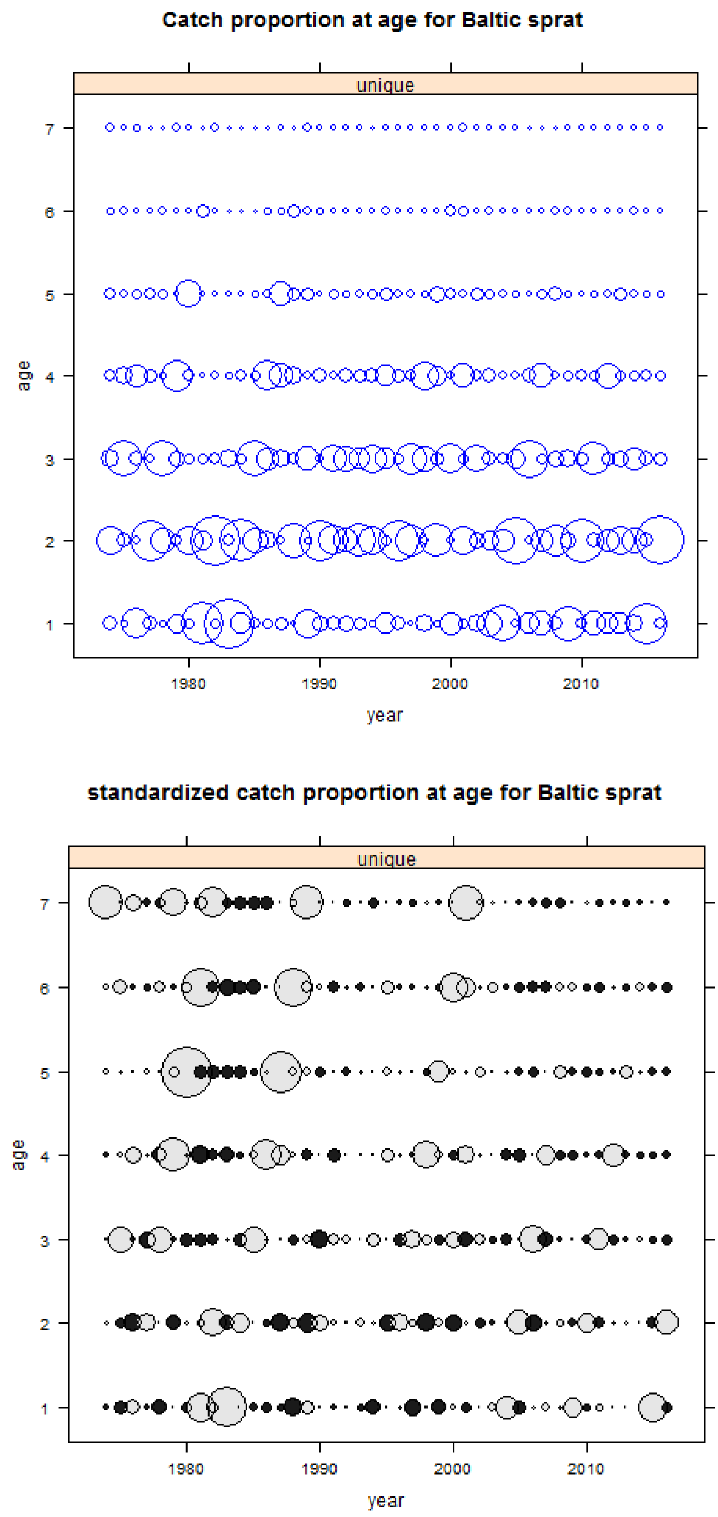
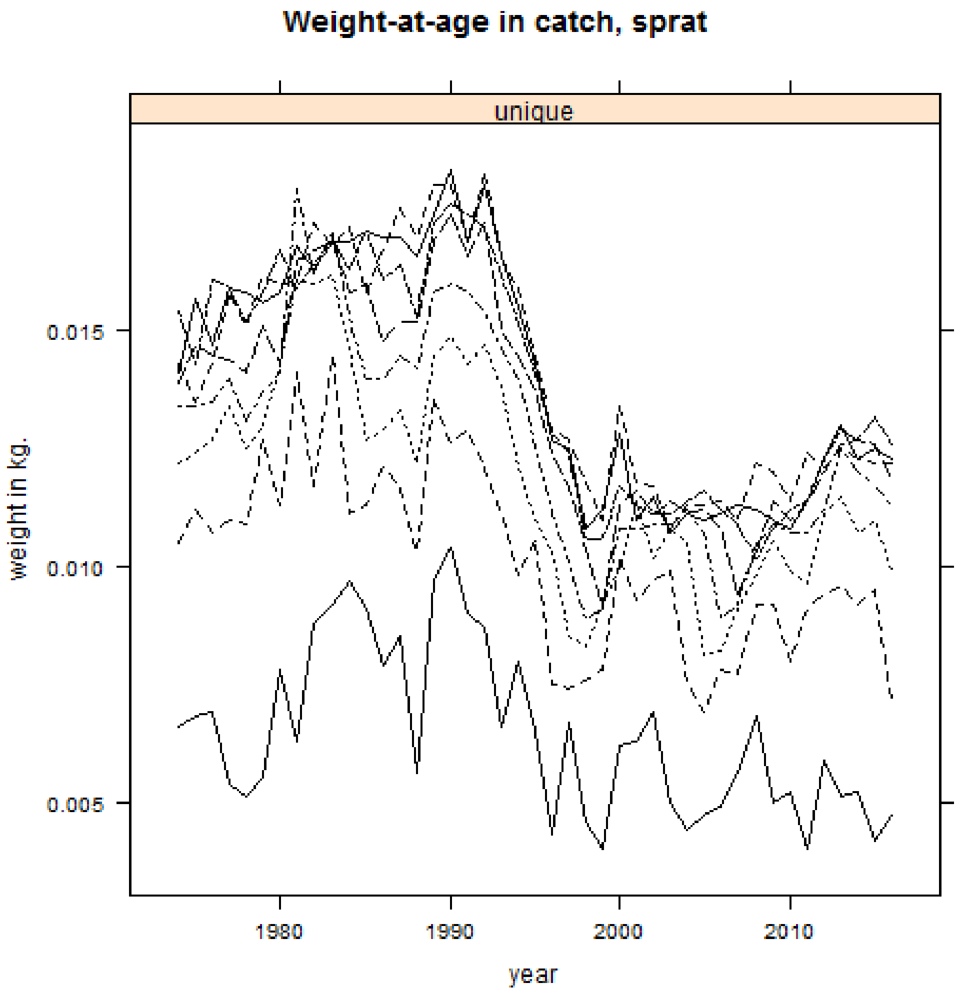


Figure 7.2 Sprat in SD 22–32. CANUM consistency check.



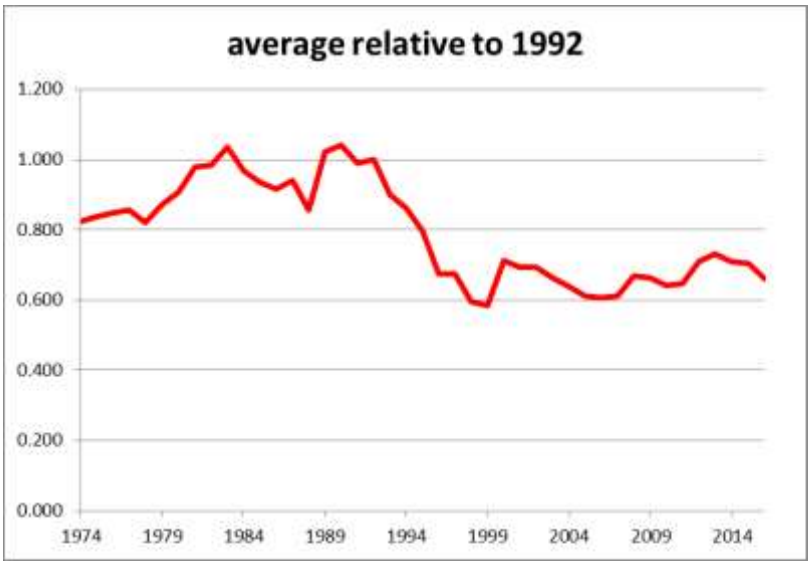


Figure 7.3 Sprat in SD 22–32. Mean weight-at-age in the catches (weight in the stock assumed as in the catches).

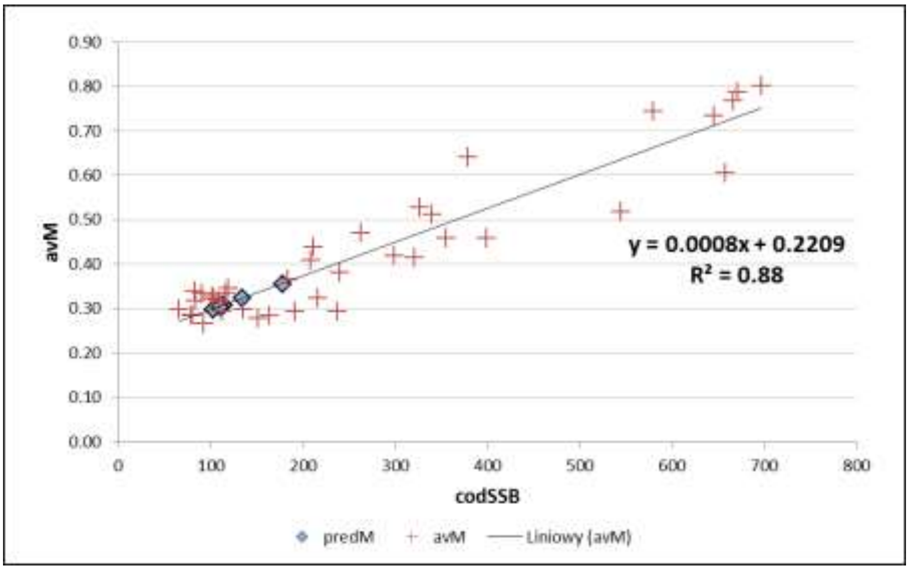


Figure 7.4a Sprat in SD 22–32. The dependence of average M for sprat on cod SSB.

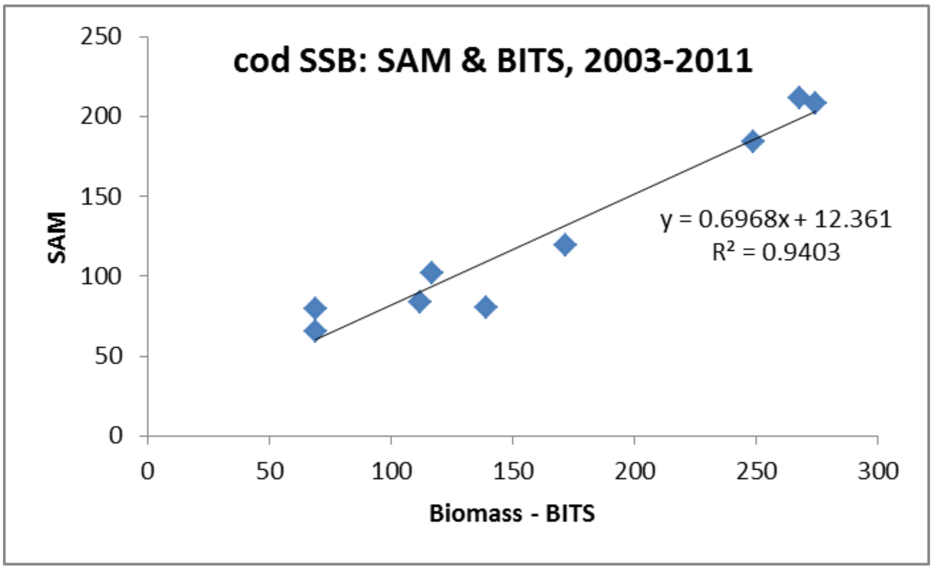


Figure 7.4b Sprat in SD 22–32. The relationship between cod SSB and biomass index from BITS (years 2003–2011).

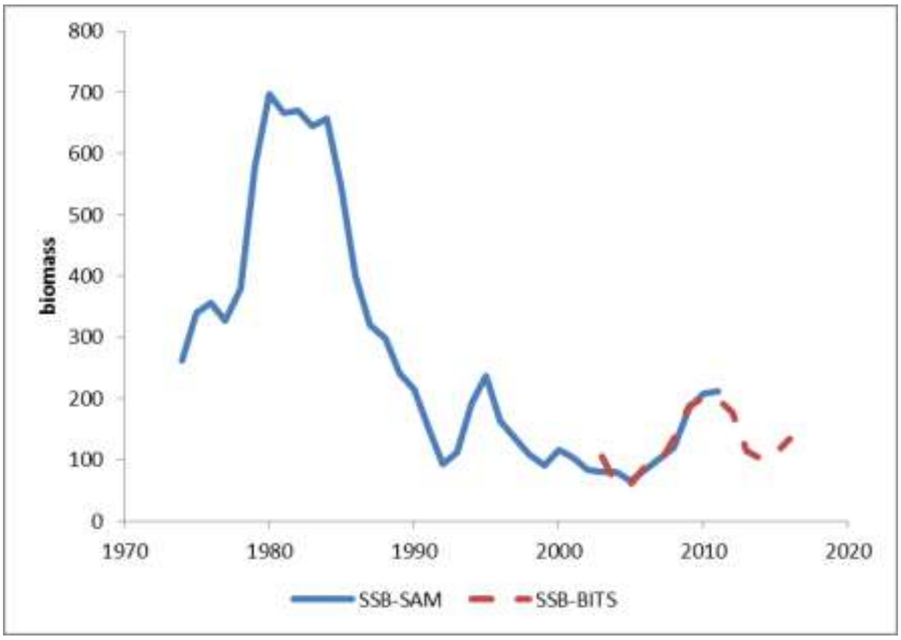


Figure 7.4c Sprat in SD 22–32. The biomass index from BITS rescaled to level of cod SSB and cod SSB from last accepted assessment (2012).

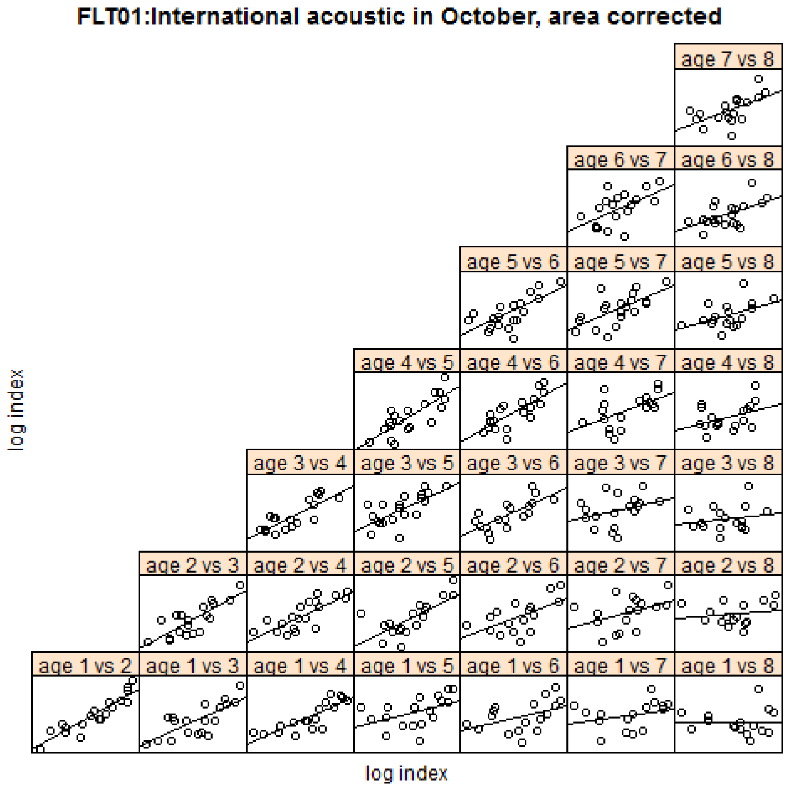


Figure 7.5a Sprat in SD 22–32. Check for consistency in October acoustic survey estimates.

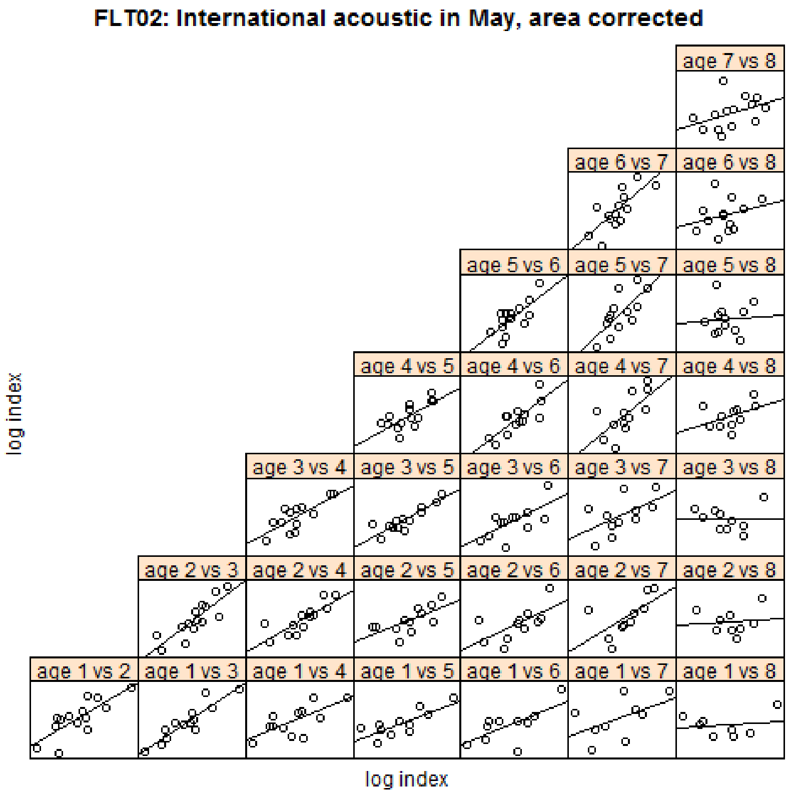


Figure 7.5b Sprat in SD 22–32. Check for consistency in May acoustic survey estimates.

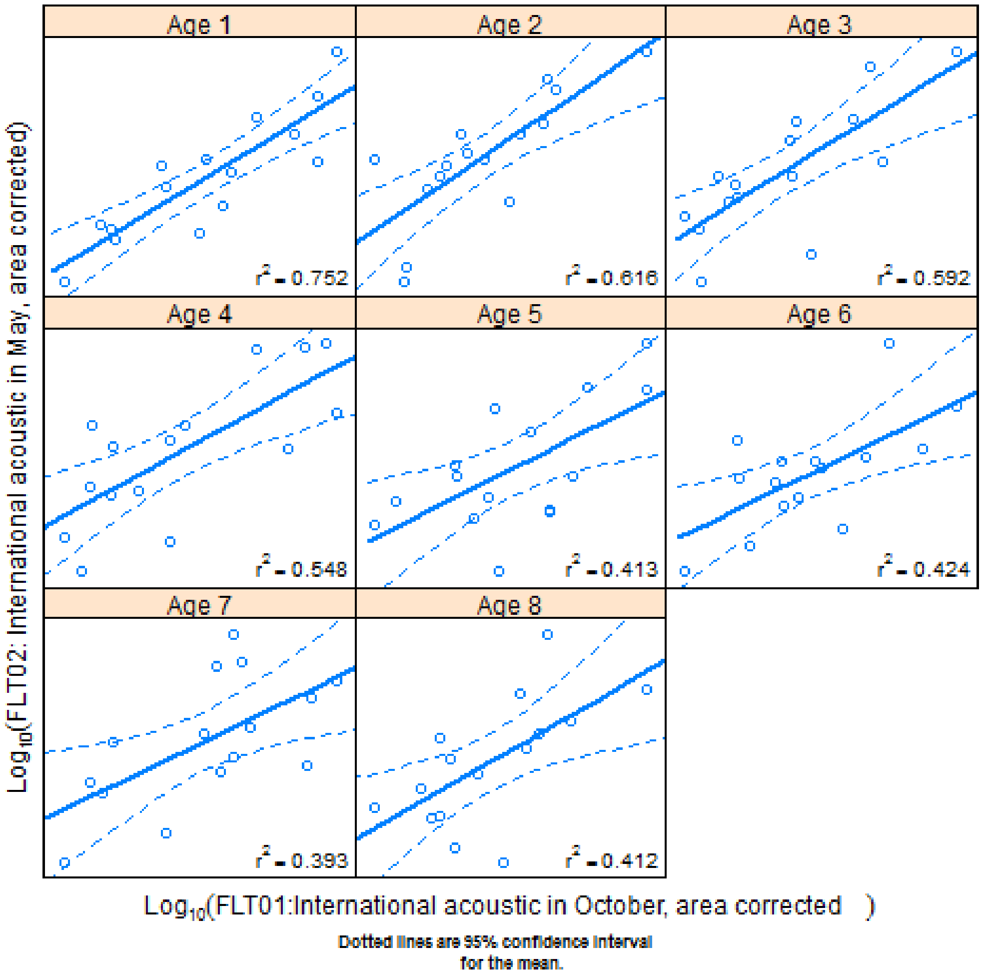


Figure 7.5c Sprat in SD 22–32. Check for consistency between May and October surveys.

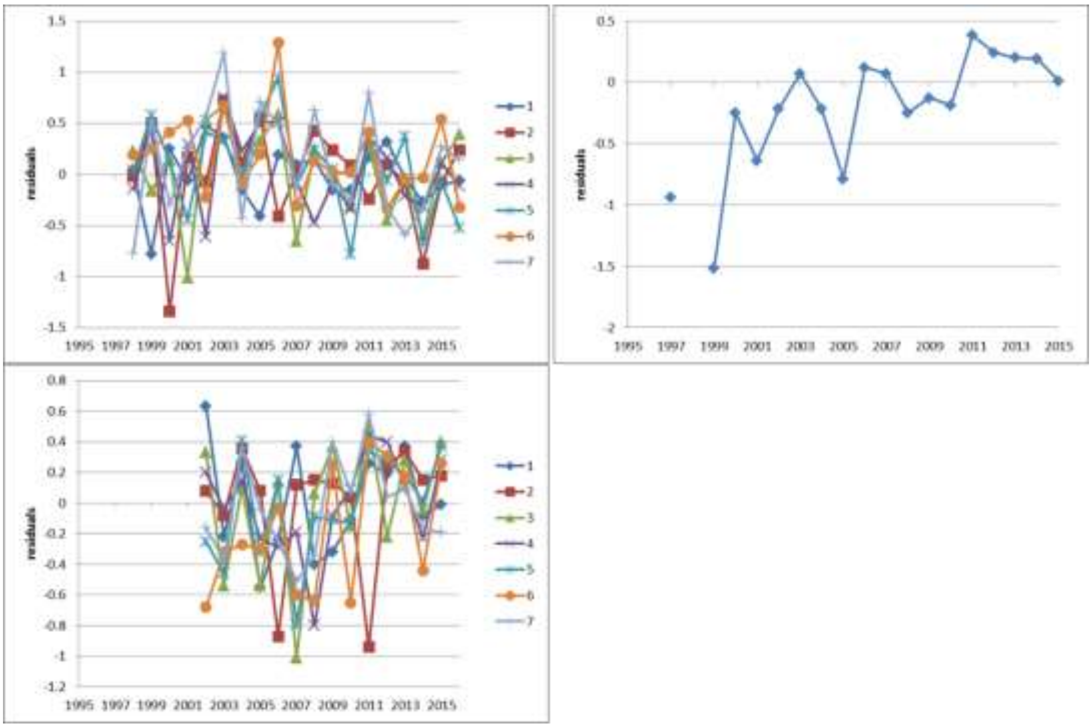


Figure 7.6 Sprat in SD 22–32. Log catchability residuals by fleet.

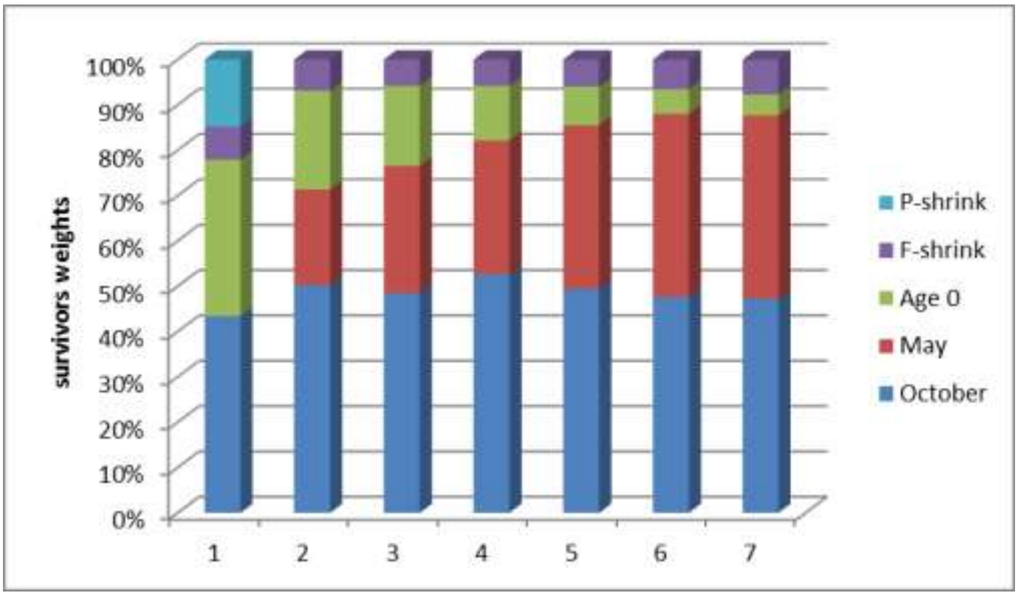


Figure 7.7a Sprat in SD 22–32. Weights of survivors estimates by fleet used to provide final survivors estimates.

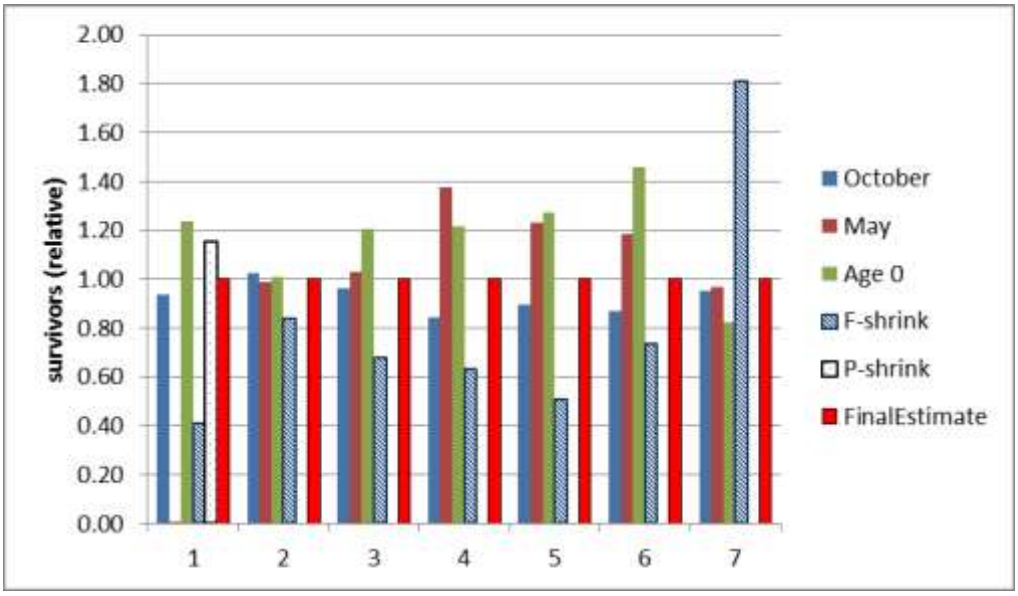


Figure 7.7b Sprat in SD 22–32. Survivors estimates by fleet and age relative to final estimate.

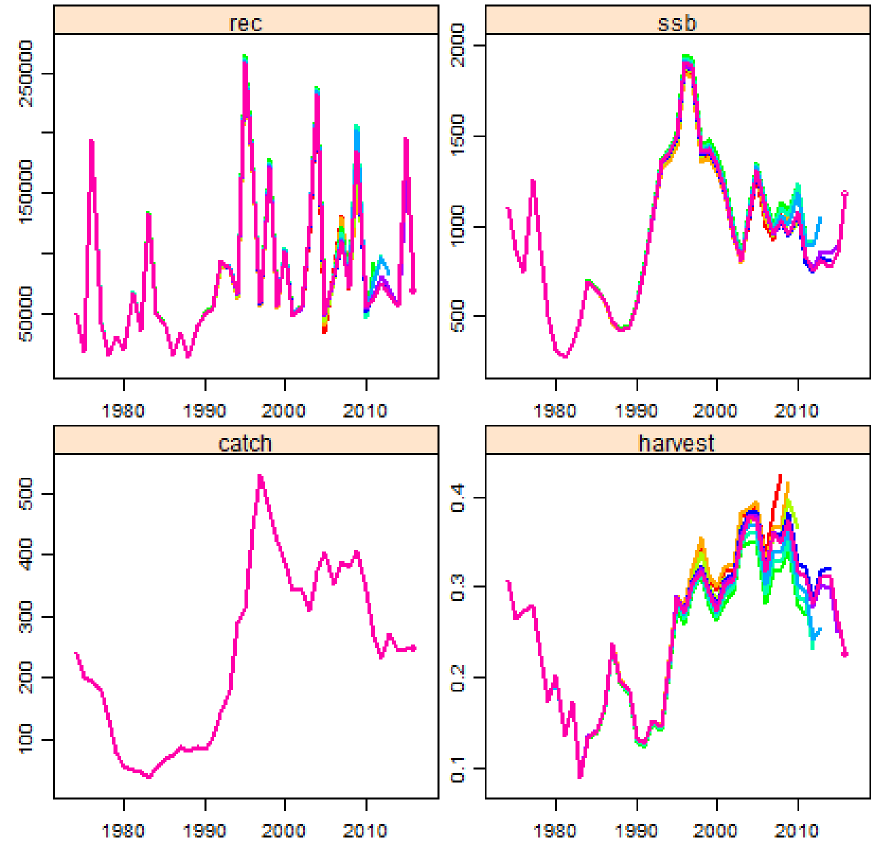


Figure 7.8 Sprat in SD 22–32. Retrospective analysis from XSA.

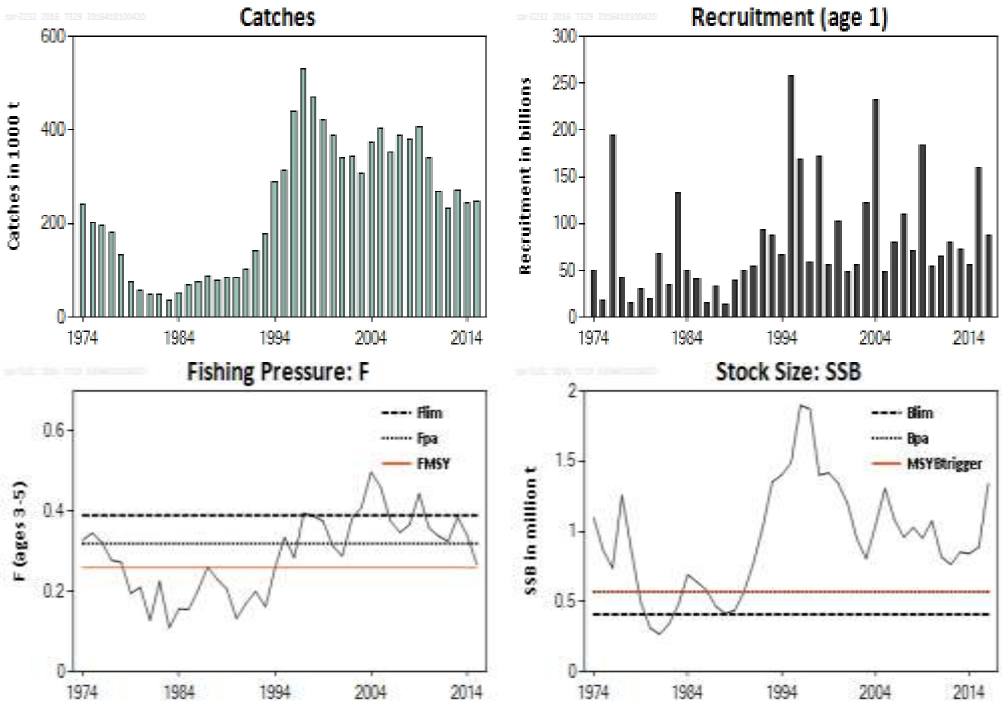


Figure 7.9 Sprat in SD 22–32. Summary sheet plots: landings, fishing mortality, recruitment (age 1) and spawning stock biomass.

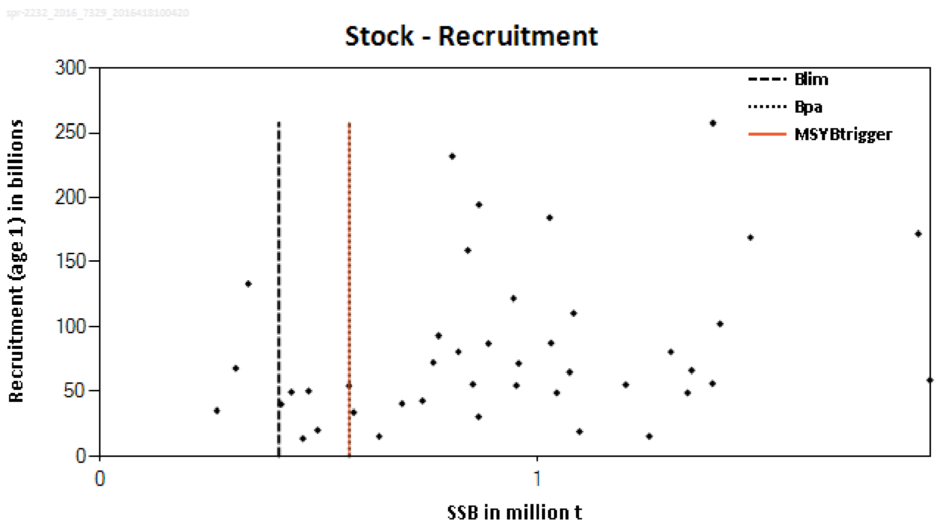


Figure 7.10 Sprat in SD 22–32. Stock recruitment plot (biomass reference lines indicated).

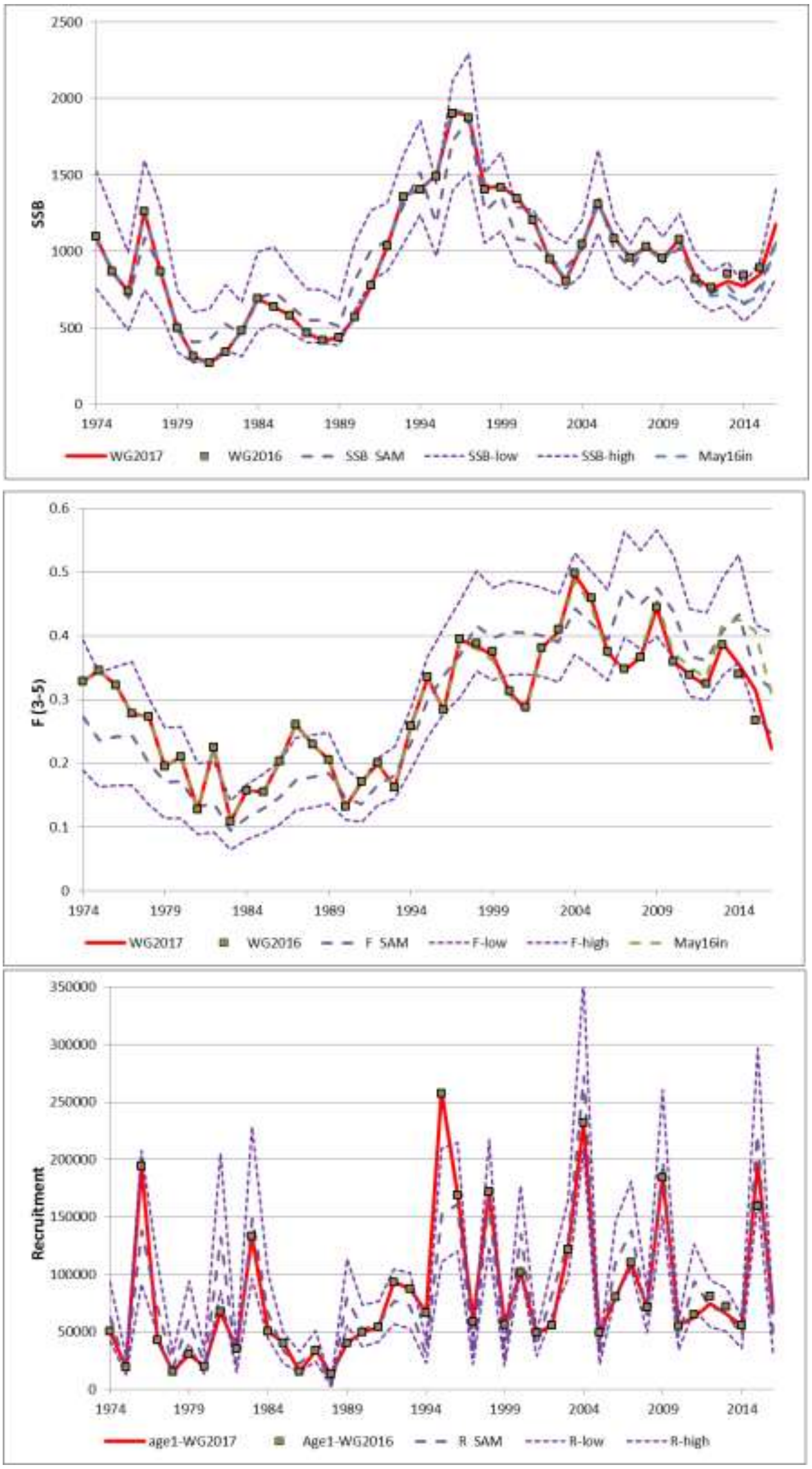


Figure 7.11a Sprat in SD 22–32. Comparison of spawning stock biomass, fishing mortality, and recruitment (age 1) from XSA (present and 2016) with SAM. Uncertainties of SAM estimates are shown (thin, broken lines). In addition, assessment with May survey including 2016 data is shown.

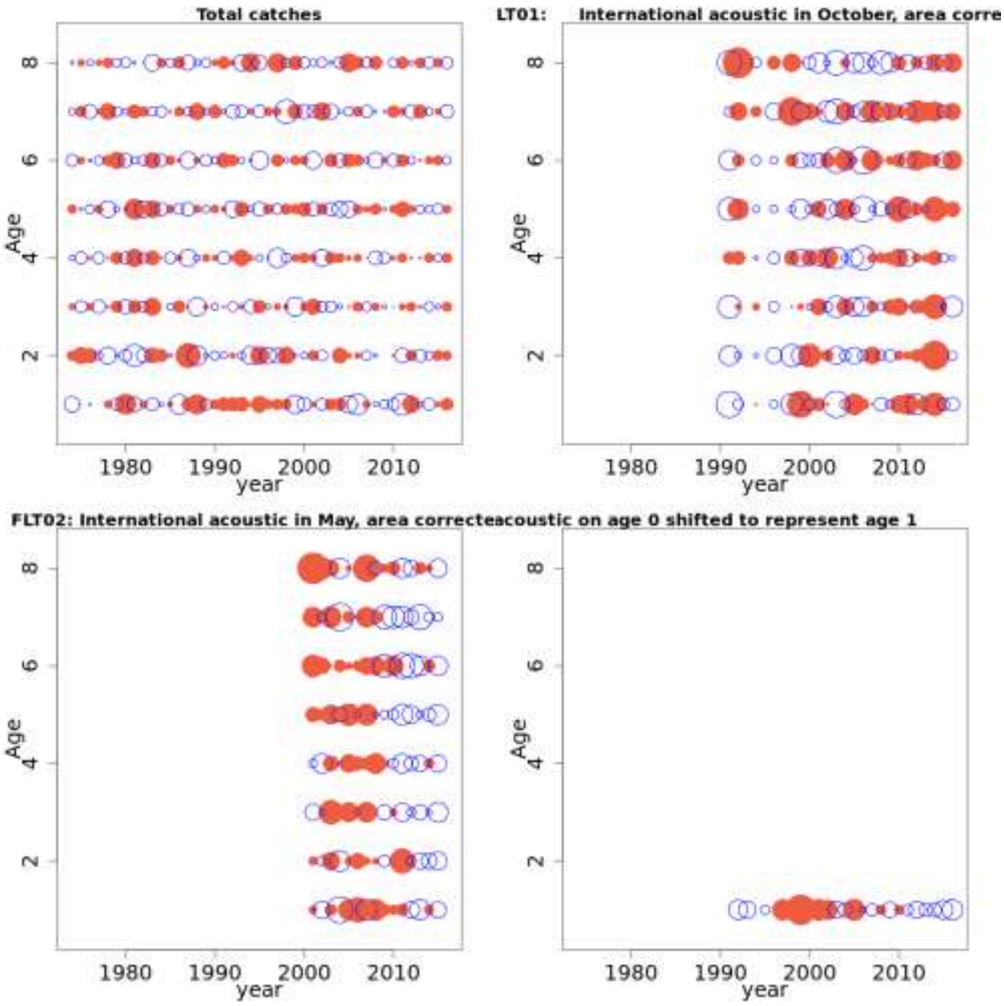


Figure 7.11b Sprat in SD 22–32. Log catchability residuals by fleet from SAM (last year assessment).

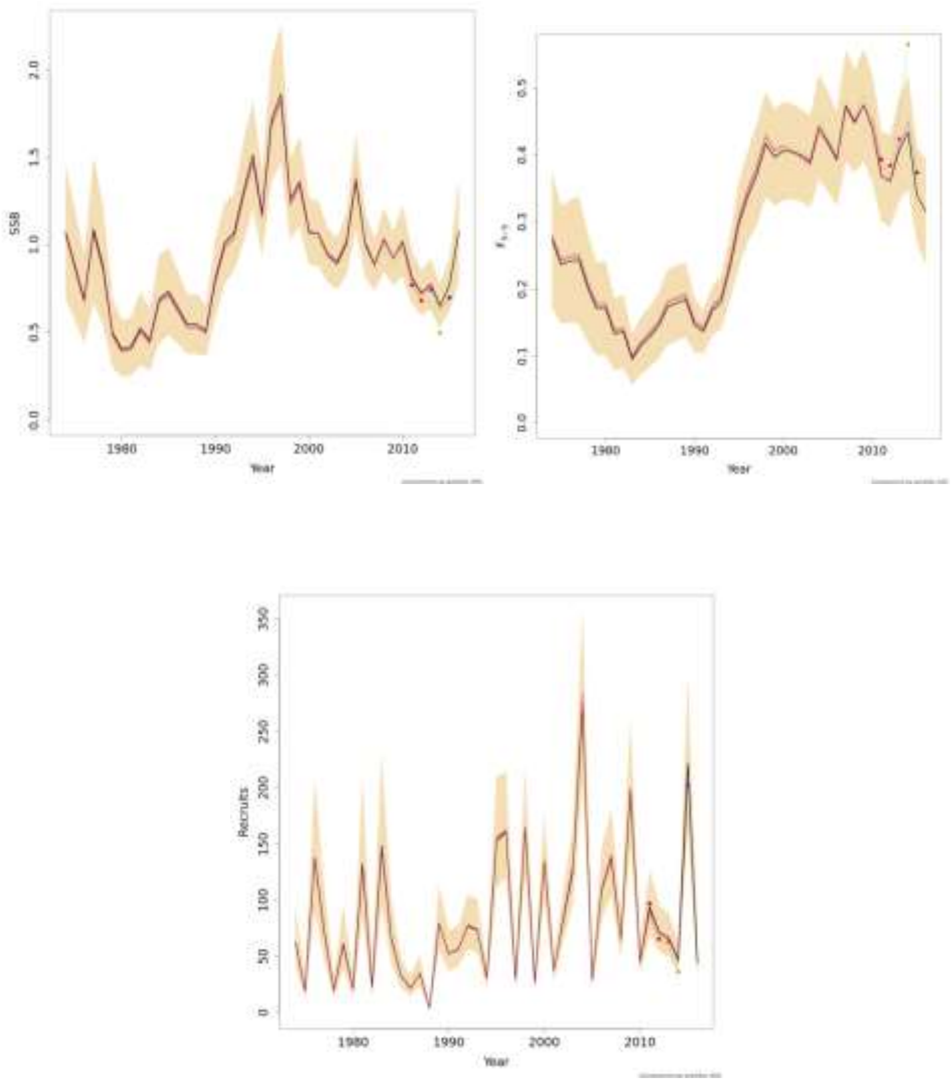


Figure 7.11c. Sprat in SD 22–32. Retrospective analysis from SAM.

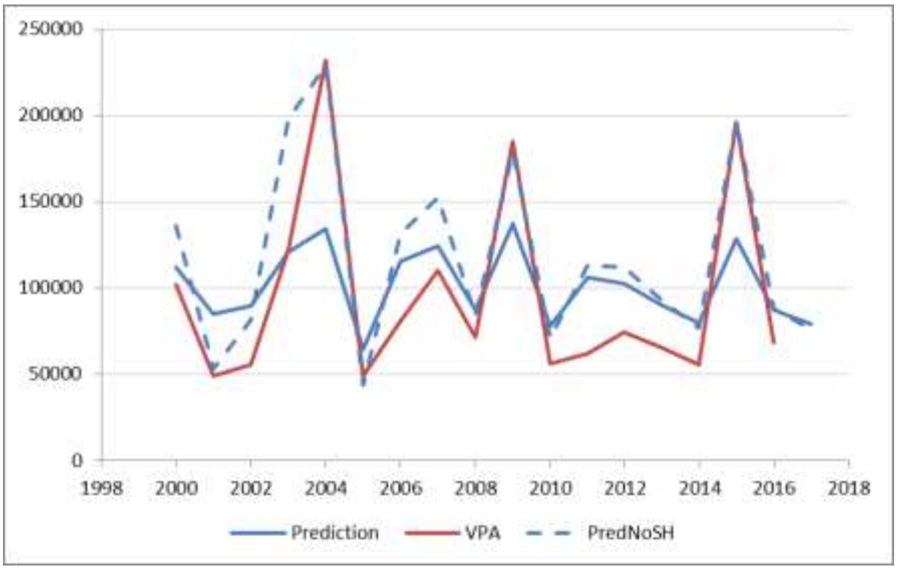


Figure 7.12 Sprat in SD 22–32. Comparison of recruitment estimates from RCT3 and XSA.

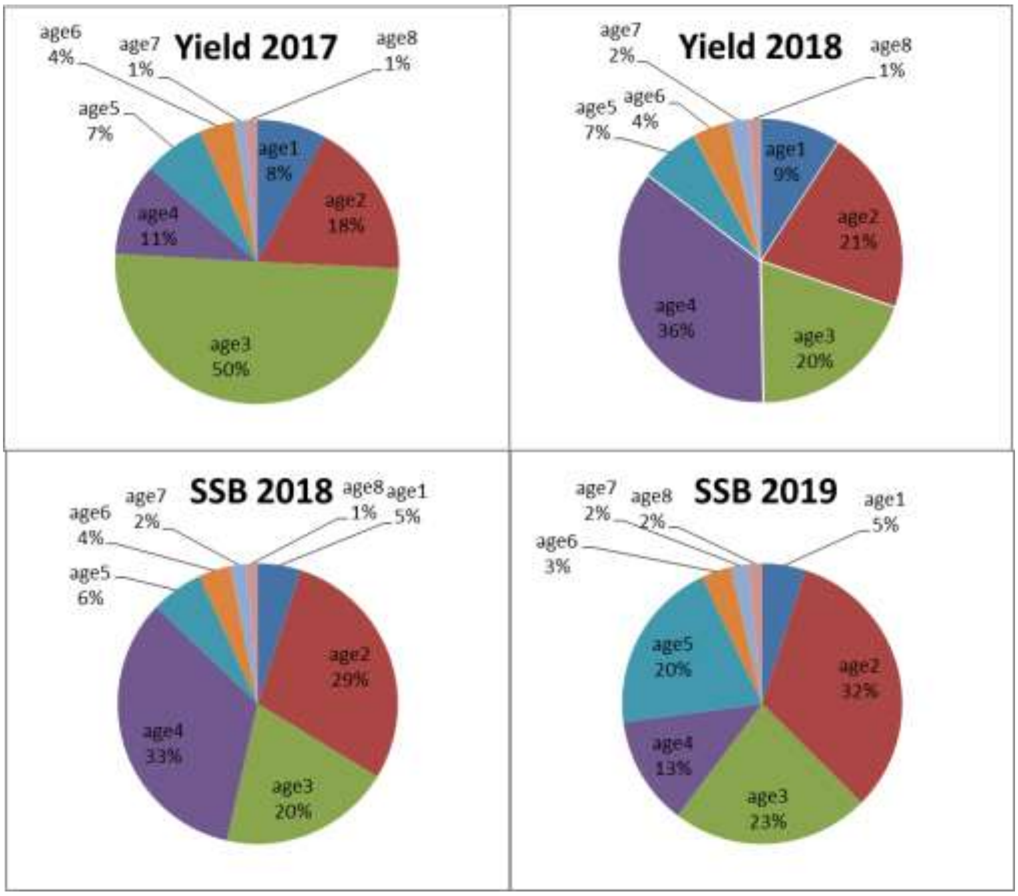


Figure 7.13 Sprat in SD 22–32. Short-term forecast for 2016–2018. Yield and SSB at age 1-8+under the TAC constraint in 2016.

8 Turbot, dab, and brill in the Baltic

8.1 Turbot

8.1.1 Fishery

8.1.1.1 Landings

Turbot were mainly landed in the southern and western parts of the Baltic Proper (ICES subdivisions 22–26). The total landings of turbot increased from 42 t to 1.210 t from 1965 to 1996 followed by a decreased to 525 t in 2000 and a slower decrease until the minimum of 305 t in 2006 and varied between 221 t in 2012 and 394 t in 2009 with slightly negative trend between 2007 and 2016. (Table 8.1.1, Figure 8.1.1). The landings of 2001 and 2012 were slightly corrected based on the evaluation of the reported data and the calculation procedures. A successful turbot gillnet fishery started at the beginning of the 1990s in subdivisions 26 and 28. This development was caused by fishermen having more interest in turbot. Since 1990 in all eastern Baltic countries turbot was sorted out from the flatfish catches due to the better price. For example, the Polish landings of turbot increased from 33 t to 360t from 1999 to 2003. Swedish landings are taken mainly from a gillnet fishery that reached a maximum of 250 t in 1996. Since then landings decreased and have been under 50 t for the last five years. Denmark and Germany are the main fishing countries in the Western Baltic and landed about 148 tons of turbot from subdivisions 22 and 24. Poland, Russia and Sweden are the main fishing countries in the Eastern and landed about 74 tons from subdivisions 25-28 Total landings in 2016 were about 252 tons. Landings are regularly exceeding the advised landings.

Due to the low stock level, fishery targeting turbot was totally closed for some years in the EEZ of Latvia and restrictions were implemented in Lithuania from 1 to 30 July according international regulations.

8.1.1.2 Discard

Estimates of discards were available from all countries from 2012 onwards. The data illustrate the high variability of the relation between landings. The mean proportion of discarded turbot in relation to total catch was 23% for the years 2012 to 2016.

Year	Landings (t)	Discards (t)
2012	221	139
2013	313	25
2014	253	85
2015	233	34
2015	246	100

8.1.2 Biological composition of the catch

Available age data were compared during WKFLABA (2012) meeting. Results using sliced otoliths were remarkable better than using whole otoliths. These two ageing methods showed significantly different results. Applying the new method, the fishing mortality estimate declined by a factor of about two. WKFLABA did not make suggestions for turbot stocks in the Baltic Sea. Genetic information did not show any stock structure while tagging data indicated the existence of small local stocks. Further investigations, especially in the Eastern part of Baltic Sea are recommended.

8.1.3 Fishery independent information

Stock indices (CPUE) were estimated as mean catch in number per hour for turbot with a length of ≥ 20 cm. The CPUE values of the small TV were multiplied with a conversion factor of 1.4 (Figure 8.1.2). Stable index with low fluctuations were observed between 2007 and 2015. The index of 2016 increases compared to the previous year, but is however still on a low level (~3.6 turbot/hour).

8.1.3.1 Catch in numbers

The catch in numbers per length for the three most recent years is given in Figure 8.1.3. Almost no turbot above 35 cm are caught.

8.1.4 Assessment

The advice is base based on the data-limited approach of ICES. The mean abundance index of 2015 and 2016 were 37% higher than the mean of the abundance index from 2012–2014. Therefore, precautionary truncation was applied with a factor of 1.2. Exploitation is consistent with F_{MSY} proxy ($L_{F=M}$) and optimal yield in 2016. MSY $B_{trigger}$ is unknown. Following the ICES guidelines on DLS stocks, the precautionary buffer was not applied, as the length based indicator are stating a good stock status and the effort did not increase (Figure 8.1.4).

8.1.5 Reference points

The stock status was evaluated by calculating length based indicators applying the LBI method developed by WKLIFE V (2015) (Table 8.1.2). CANUM and WECA of commercial catches from 2014-2016 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

- L_{inf}: average of 2002-2016, both quarter and sexes → L_{inf} = 32.67 cm
- L_{mat}: average of 2002-2016, quarter 1, only females → L_{mat} = 22 cm

The results of LBI show that stock status of tur.27.22-32 is slightly above possible reference points (Table 8.1.3). Some truncation in the length distribution in the catches might take place. Over proportional amounts of mega spawners occur, as P_{mega} is larger than 75% of the catch. This might very well be an artefact produced by a relative small L_{inf}, which would also explain the overvfishing of immatures (L_c/L_{mat}) Catch is close to the theoretical length of L_{opt} and L_{mean} is stable over time and close to 1, indicating fishing close to the optimal yieldExploitation consistent with F_{MSY} proxy ($L_{F=M}$).

Table 8.1.1 Turbot in the Baltic Sea. Total landings (tonnes) by ICES Subdivision and country.

Year/SD	Denmark					rm. Dem. Re		Germany, FRG				Poland		Sweden[2]							Latvia		Lithuania	Russia	Finland						Estonia	
	22	23	24(+25	25	26+27	22	24	22	24	25	27	25(+24)	26	22	23	24	25	26	27	28(+29)	26	28	26	26	24	25	29	30	31	32	29	32
1965						3	39																									
1966	16		21			5	53																									
1967	14		20			7	10																									
1968	14		18			3	67																									
1969	13		13			4	57																									
1970	11		13			5	40									2																
1971	11		26			4	86									2																
1972	10		26			3	100									3																
1973	11		30			3	33					58	13			5																
1974	14		40			2	23					34	36			6																
1975	27		48			3	38	15				23	6			7																
1976	29		24				52	11				14	12			7																
1977	32		37				55	9				12	55			8																
1978	33		37			2	27	9				7	3			10																
1979	23		38			3	39	6				29	34			12																
1980	28		38				30	9				12	20			15																
1981	28		62			1	46	8				10	19			7																
1982	31		51			1	27	7				2	17			3	4		4	3												
1983	33		40			3	9	8				5	4			31	41		35	24												
1984	41		45			4	8	12				13	2			3	4		3	2												
1985	56		34			5	22	15				67	15			4	5		4	3												
1986	99		81			6	32	25				32	37			6	8		7	5												
1987	134		93			4	34	30				155	21			8	11		9	6												
1988	117		117			3	28	34				7	10			12	16		14	9												
1989	135		109			7	22	20					11			11	15		13	9												
1990	178		181			4	2	26				24	25			14																
1991	228		137					44	39			73	20			2	12		16													
1992	267		127					55	68			80	55			12	12		21	36				30								
1993	159	29	152					74	56			520	72		2	4	14		13	38				34								
1994	211	18	166					52	57	10		380	30		2	3	18	1	17	44				15								
1995	257	11	94					65	53	4		30	15		2	3	54	9	31	83	34	27	15	20								
1996	207	12	95					36	47	4	1	288	92	1	3	15	100	5	54	104	42	3	72	25								
1997	151		68					60	52	3		290	70		2	6	70	1	53	86	33	14	59	25								
1998	138		80					44	55	1		66	68		2	4	58	1	18	69	12	24	62	96								
1999	106		59					23	48			18	15		2	4	41	3	17	60	20	34	58	48								
2000	97		58					23	54			90	12		2	3	39		16	39	7	9	23	53								
2001	76		53					19	31			121	10		2	5	16		9	29	5	1	18	69								
2002	73		22	4	0			20	32	2		245	65		5	2	15		7	21	2	8	18	50								
2003	48		28	5	0			10	39	1		184	178		1	2	18		3	14	7	2	13	28								
2004	61		27	7				12	27	1		225	96		1	1	8		3	14	3	8	7	15								
2005	57	5	36	12				14	35	1		123	57		1	3	6		5	21	1	6	18	19								
2006	30	5	16	33				19	45	1		87	11		1	2	5	0	4	19	3	3	9	12								
2007	60	5	26	5	0			22	34	0		83	8		0	5	5		2	15	0	1	12	24								
2008	79	5	33	6				24	30	0		95	15		1	7	11		8	17			10	14								
2009	111	6	35	7	0			33	50	1		92	11		1	6	10	0	5	6	0	0	11	8								
2010	102	6	31	4	0			24	35	0		38	1		1	4	16	0	4	8	3	7	9	2								
2011	84	3	24	3	0			26	31	0		66	11	0	0	0	0	0	0	0	3	6	0	5	0	0	0	0	0	0	0	0
2012	43	3	16	1	0			16	27	0	0	55	11	0	0	0	0	0	0	0	5	5	14	15	0	0	0	0	0	0	0	0
2013	66	5	21	1	0			23	40	0	0	61	12	0	1	6	16	0	1	3	5	4	13	20	16	0	0	0	0	0	0	0
2014	84	5	27	1	0			35	30	0	0	25	5	0	1	3	13	0	2	4	2	5	7	6	0		0				0	
2015	84	5	22	1	0			27	19	0	0	41	8	0	0	4	9	0	1	1	0	4	4	3	0	0	0	0	0	0	0	0
2016	68	4	37	3	0			25	23	1		43	13	0	2	5	9	0	1	1	1	5	7	6	0	0	0	0	0	0	0.1	0.1

[1] From October-December 1990 landings of Germany, Fed. Rep. are included

[2] For the years 1970-1981 and 1990 catches of Subdivisions 25-28 are included in Sub-division 24

[3] For the years 1970-1981 and 1990 Swedish catches of Subdivisions 25-28 are included in Subdivision 24

[4] Preliminary data

Danish catches in 2002-2004 in SW Baltic were separated according to Sub-divisions 24 and 25

In 2005 Lithuanian landings are reported for 1995 onwards

Continued

Table 8.1.1 Turbot in the Baltic Sea. Total landings (tonnes) by ICES Subdivision and country.

Year	Total by SD								Total
	22	23	24[3]	25	26	27	28(+29)	30-32	SD 22-32
1965	3	0	39	0	0	0	0		42
1966	21	0	74	0	0	0	0		95
1967	21	0	30	0	0	0	0		51
1968	17	0	85	0	0	0	0		102
1969	17	0	70	0	0	0	0		87
1970	16	0	55	0	0	0	0		71
1971	15	0	114	0	0	0	0		129
1972	13	0	129	0	0	0	0		142
1973	14	0	68	58	13	0	0		153
1974	16	0	69	34	36	0	0		155
1975	45	0	93	23	6	0	0		167
1976	40	0	83	14	12	0	0		149
1977	41	0	100	12	55	0	0		208
1978	44	0	74	7	3	0	0		128
1979	32	0	89	29	34	0	0		184
1980	37	0	83	12	20	0	0		152
1981	37	0	115	10	19	0	0		181
1982	39	0	81	6	17	4	3		150
1983	44	0	80	46	4	35	24		233
1984	57	0	56	17	2	3	2		137
1985	76	0	60	72	15	4	3		230
1986	130	0	119	40	37	7	5		338
1987	168	0	135	166	21	9	6		505
1988	154	0	157	23	10	14	9		367
1989	162	0	142	15	11	13	9		352
1990	208	0	197	24	25	0	0		454
1991	272	0	178	85	20	16	0		571
1992	322	0	207	92	85	21	36		763
1993	233	31	212	534	106	13	38		1167
1994	263	20	226	408	46	17	44		1024
1995	322	13	150	88	93	31	110		807
1996	244	15	157	392	236	55	107		1206
1997	211	2	126	363	188	53	100		1043
1998	182	2	139	125	239	18	93		798
1999	129	2	111	59	144	17	94		556
2000	120	2	115	129	95	16	48		525
2001	95	2	89	137	102	9	30		464
2002	93	5	56	266	135	7	29		591
2003	58	1	69	208	225	3	16		579
2004	73	1	55	241	121	3	22		516
2005	72	5	74	143	94	5	27	0	420
2006	49	6	63	126	35	4	22	0	305
2007	83	5	65	94	44	2	16	0	309
2008	103	6	70	113	39	8	17	0	356
2009	144	7	91	110	31	5	6	0	394
2010	126	7	70	58	15	4	15	0	295
2011	110	3	56	70	19	0	6	0	263
2012	59	3	44	57	44	0	5	0	221
2013	88	5	83	77	50	1	7	0	313
2014	119	5	60	39	19	2	9	0	253
2015	111	5	45	51	15	1	5	0	233
2016	94	6	64	56	28	1	7	0	255

Table 8.1.2 Turbot in the Baltic Sea. Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
Lmax5%	Mean length of largest 5%	Linf	Lmax5% / Linf	> 0.8	Conservation (large individuals)
L95%	95th percentile		L95% / Linf		
Pmega	Proportion of individuals above Lopt + 10%	0.3–0.4	Pmega	> 0.3	
L25%	25th percentile of length distribution	Lmat	L25% / Lmat	> 1	Conservation (immatures)
Lc	Length at first catch (length at 50% of mode)	Lmat	Lc/Lmat	> 1	
Lmean	Mean length of individuals > Lc	$Lopt = \frac{3}{3+M/k} \times L_{inf}$	Lmean/Lopt	≈ 1	Optimal yield
Lmaxy	Length class with maximum biomass in catch	$Lopt = \frac{3}{3+M/k} \times L_{inf}$	Lmaxy / Lopt	≈1	
Lmean	Mean length of individuals > Lc	LF=M = (0.75Lc+0.25Linf)	Lmean / LF=M	≥ 1	MSY

Table 8.1.3 Turbot in the Baltic Sea Indicator status for the most recent three years 2014-2016.

	Conservation				Optimizing Yield	MSY
Year	Lc / Lmat	L25% / Lmat	Lmax 5 / Linf	Pmega	Lmean / Lopt	Lmean / LF = M
2014	0.89	1.16	1.24	0.86	1.34	1.28
2015	0.89	1.16	1.41	0.87	1.39	1.33
2016	0.98	1.02	1.25	0.66	1.26	1.13

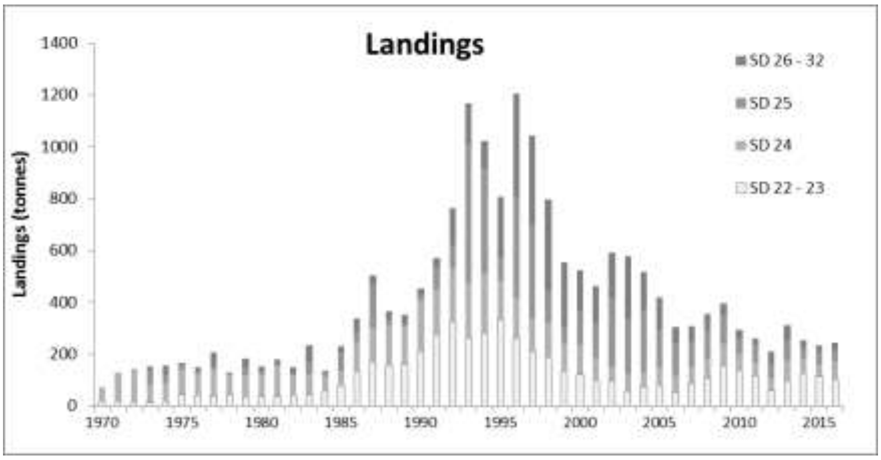


Figure 8.1.1 Turbot in the Baltic Sea. Development of turbot landings [t] from 1970 onwards by ICES subdivision (SD).

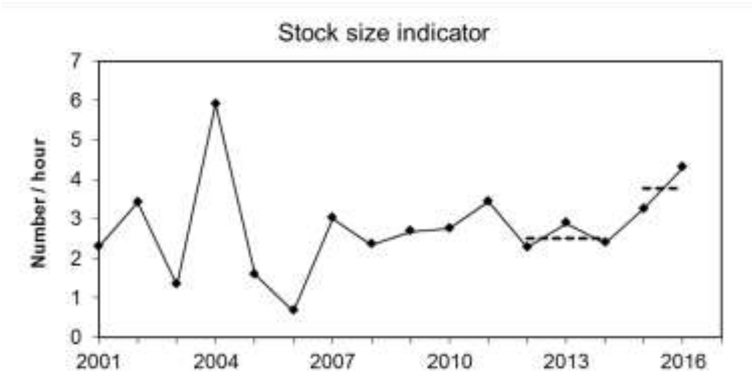


Figure 8.1.2 Turbot in the Baltic Sea. Mean CPUE (no. hr^{-1}) of turbot with L ≥ 20 cm based on arithmetic mean of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–28.

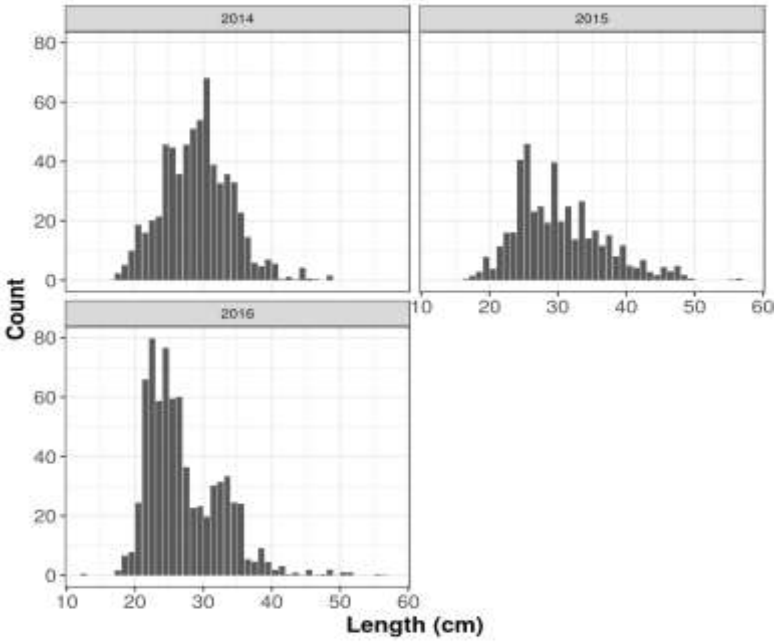


Figure 8.1.3 Turbot in subdivisions 22 to 32. Binned length frequency distributions.

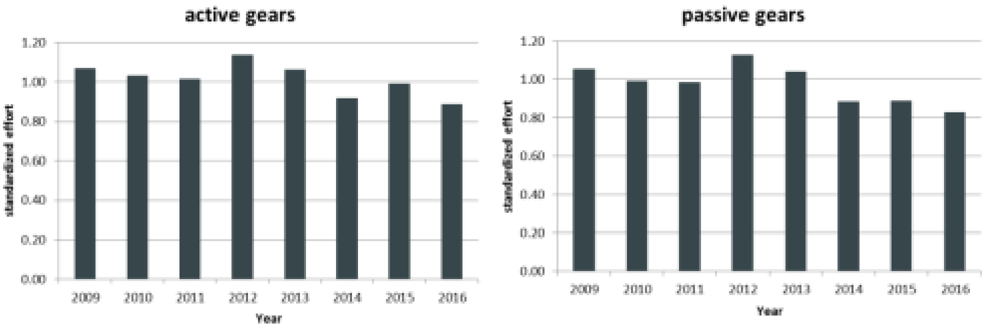


Figure 8.1.4 Turbot in subdivisions 22 to 32. Standardized effort for active and passive fleets in subdivisions 22 to 28 (main distribution range of tur.27.22-32). Standard catches (effort per strata and country divided by average effort per country) were weighted by the mean of cod landings by country.

8.2 Dab

8.2.1 Fishery

8.2.1.1 Landings

Separation of currently used stock unit SD 22–SD 32 was discussed during WKFLABA (2010). Three stock units were proposed which are SD 23, SD 22 & SD 24W and SD 24E & SD 25. Analyses of BITS and IBTS data during WKBALFLAT (2014) suggested a relation of brill in SD 21 and SD 22 and did not support the proposed three stock units. However, WGBALFLAT (2014) agreed that the current used stock definition of SD 22–32 will also be used in the future because additional analyses were not available which support the conclusions based on BITS and IBTS.

Total landings of dab were around 1000 t between 1970 and 1978 and fluctuated around 2000 t between 1979 and 1996 (Table 8.2.1). During the years 1994 to 1996 the total landings of dab were over-reported due to bycatch misreporting in cod fishery. Less than 1000 t were landed in 1997 and from 1999 to 2002. Since 2003 landings have been fluctuated around 1300 t with a maximum of 1894 t in 2004. Landings varied between 1041 t (2010) and 1495 t (2005) without trend between 2005 and 2016.

The largest amount of dab landings are reported by Denmark (subdivisions 22 and 24) and Germany (mainly in Subdivision 22, Figure 8.2.1). The German and Danish landings of dab are mostly bycatches of the directed cod fishery.

8.2.1.2 Discard

Estimates of discards were available from Denmark and Germany in 2012 to 2016.

The data illustrate the high variability of the relation between landings and discards and support the conclusion of the benchmark workshop that the application of the relation between landings and discards of one year in another year results in uncertain estimate.

Year	Landings (t)	Discards (t)
2012	1285	1191
2013	1384	1458
2014	1269	757
2015	1268	1055
2016	1356	1007

8.2.2 Biological composition of the catch

Age samples were realized from 2008 onwards by Germany and Denmark during Baltic International Trawl Survey (BITS) and commercial fishery. This indicates that age data were not available for 2000–2007. The length distributions reported for this period were transferred into age distributions by slicing of the length distributions. Two slicing methods were applied. To assess the quality of the slicing methods data of SD 22 from 2008 to 2012 were used. The length frequencies were sliced by both available methods and the estimated age frequencies were compared with the age frequencies estimated with the standard method described in the BITS manual. Unfortunately, estimated age frequencies based on age data and slicing methods were significantly different.

It was agreed during benchmark that data-limited approach based on landings and indices of BITS will also be used in the next years because the estimation of discards is uncertain and agreement was not possible concerning the method of slicing applied for dab.

It was further agreed during benchmark that the mean weight of dab ≥ 15 cm captured per hour in units of TVL is used instead of the CPUE in number. The limit of 15 cm were chosen because more than 50% of dab > 14 cm of both sexes were maturing during quarter 1 with high fluctuations from year to year. The geometric mean of the new indices of quarter 1 and quarter 4 was used as proxy of the development of the SSB.

8.2.2.1 Catch in numbers

The catch in numbers per length for the three most recent years is given in Figure 8.2.2. Almost no dab above 28 cm are caught.

8.2.3 Fishery independent information

The new stock indices, mean weight of dab ≥ 15 cm captured per hour in units of TVL, were calculated based on the mean catch in number per hour in units of TVL and the mean weight-length relation (Figure 8.2.3). The CPUE values of the small TV were multiplied with a conversion factor of 1.4. Estimates of quarter 1 and quarter 4 BITS were combined by geometric mean.

8.2.4 Assessment

The advice is based on the data-limited approach of ICES. The advice based on landings has been changed to advice based on catch in 2016 based on estimate discards of the respective last three years. The advice for 2018 is also a catch advice. The mean biomass index of 2015 and 2016 were 10% lower than the mean of the mean biomass index from 2012–2014 (Figure 8.2.3). Therefore, precautionary truncation was not applied. The precautionary buffer was also not applied because the length based indicators are stating a good status of the stock. The fishing effort reported by Denmark and Germany in SD 22–24 did also not increased in 2016 (Figure 8.2.4). A precautionary buffer was applied the last time in 2013.

8.2.5 Reference points

The stock status was evaluated by calculating length based indicators applying the LBI method developed by WKLIFE V (2015) (Table 8.2.2). CANUM and WECA of commercial catches from 2014-2016 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

- L_{inf}: average of 2002-2016, both quarter and sexes → L_{inf} = 35.62 cm
- L_{mat}: average of 2002-2016, quarter 1, only females → L_{mat} = 15 cm

The results of LBI show that stock status of dab.27.22-32 is slightly above possible reference points (Table 8.2.3). Some truncation in the length distribution in the catches might take place. P_{mega} is larger than 75% of the catch. Overfishing on immatures is indicated ($L_c/L_{mat} < 1$), but this might very well be an artefact produced by a relative high L_{mat}. Catch is close to the theoretical length of L_{opt} and L_{mean} is stable over time and close to 1, indicating fishing close to the optimal yield. Exploitation consistent with F_{MSY} proxy ($L_{F=M}$).

Table 8.2.1 Dab in the Baltic Sea: total landings (tonnes) of by Subdivision and country.

Year/SD	Denmark				Ger. Dem. Rep.[1]		Germany, FRG				Sweden[2]								Total									Total
	22	23	24(+25)	25-28	22	24	22	24	25	26	22	23	24	25	27	28	29	30	22	23	24[3]	25[5]	26	27	28	29	30	SD 22-30
1970	845		20		11		74												930	0	20	0	0	0	0	0	0	950
1971	911		26		10		64												985	0	26	0	0	0	0	0	0	1,011
1972	1,110		30		9		63						23						1,182	0	53	0	0	0	0	0	0	1,235
1973	1,087		58		18		118						30						1,223	0	88	0	0	0	0	0	0	1,311
1974	1,178		51		18		118						34						1,314	0	85	0	0	0	0	0	0	1,399
1975	1,273		74		20		131						32						1,424	0	106	0	0	0	0	0	0	1,530
1976	1,238		60		17		114						27						1,369	0	87	0	0	0	0	0	0	1,456
1977	889		32		13		89						25						991	0	57	0	0	0	0	0	0	1,048
1978	928		51		19	14	128	4											1,075	0	69	0	0	0	0	0	0	1,144
1979	1,413		50		18	25	123	1					9						1,554	0	85	0	0	0	0	0	0	1,639
1980	1,593		21		15	25	101						3						1,709	0	49	0	0	0	0	0	0	1,758
1981	1,601		32		24	39	164						5						1,789	0	76	0	0	0	0	0	0	1,865
1982	1,863		50		46	38	182	4					6	5	8	6		1	2,091	0	98	5	0	8	6	0	1	2,209
1983	1,920		42		46	28	198						24	20	32	22		2	2,164	0	94	20	0	32	22	0	2	2,334
1984	1,796		65		30	47	175	2					4	3	5	4		1	2,001	0	118	3	0	5	4	0	1	2,132
1985	1,593		58		52	51	187	2					3	3	5	3		1	1,832	0	114	3	0	5	3	0	1	1,958
1986	1,655		85		36	35	185	1					1	1	1	1			1,876	0	122	1	0	1	1	0	0	2,001
1987	1,706		93		14	87	276	4					1	1	1	1			1,996	0	185	1	0	1	1	0	0	2,184
1988	1,846		75		22	91	281	1					1	1	1	1			2,149	0	168	1	0	1	1	0	0	2,320
1989	1,722		48		26	19	218	1					1	1	2	1			1,966	0	69	1	0	2	1	0	0	2,039
1990	1,743		146		14	11	252	1					8						2,009	0	166	0	0	0	0	0	0	2,175
1991	1,731		95				340	5					1						2,071	0	101	0	0	0	0	0	0	2,172
1992	1,406		81				409	6						1	1		4		1,815	0	87	1	0	1	0	4	0	1,908
1993	996		155				556	10				7	1	1			1		1,552	7	166	1	0	0	0	1	0	1,727
1994	1,621		163				1,190	80	45			5	1	1					2,811	5	244	46	0	0	0	0	0	3,106
1995	1,510	47	127	10			1,185	49	3			5	1	5		1			2,695	52	177	18	0	0	1	0	0	2,943
1996	913	37	128				991	134	13	2	3		3	4	1				1,907	37	265	17	2	1	0	0	0	2,229
1997	728		60				413	21	2			5	5	10	3	1			1,141	5	86	12	0	3	1	0	0	1,248
1998	569		89				280	6	2			7	3	3	1				849	7	98	5	0	1	0	0	0	960
1999	664		59				339	4				3	1	1					1,003	3	64	1	0	0	0	0	0	1,071
2000	612		46				212	3				2		1					824	2	49	1	0	0	0	0	0	876
2001	586		72				191	5				4	1	2					777	4	78	2	0	0	0	0	0	861
2002	502		31				173	5				4							675	4	36	0	0	0	0	0	0	715
2003	559		171				494	7	0			1	0						1,053	1	179	0						1,233
2004	953		185				745	10	0			1	1	0					1,698	1	196	0						1,894
2005	752	34	163	16			474	45	9			1	1	0					1,226	35	209	25	0	0	0	0	0	1,495
2006	400	23	112	161			494	24	11			1	2	0		0			894	24	138	172						1,228
2007	860	40	108	7			472	18	0			0	0	0	0	0			1,332	40	126	7						1,504
2008	757	36	86	222			507	33	0			3	0	1	1	2			1,264	39	119	223		1	2			1,648
2009	521	25	97	0			587	32	0			2	0	0	1	3			1,108	27	129	1		1	3			1,268
2010	552	18	51	0			398	17	2			1	0	0					950	19	69	2						1,041
2011	544	20	39	0			647	15	0			1	0	1	0	0			1,192	21	53	1						1,268
2012	481	22	69	0			692	20	0	0	0	1	0	0	0	1	0	0	1,173	23	89	0						1,285
2013	445	18	69	0			834	17	0	0		0	0	1	0	0	1		1,279	18	86	1						1,384
2014	373	11	57	0			801	25	2	0		0	0	0	0	0			1,174	11	82	2						1,269
2015	268	9	21	0	0	0	955	14	0	0	0	0	0	0	1	0	0	0	1,223	9	35	0	0	1	0	0	0	1,268
2016	268	14	21				1,027	23	1	0	0	0	0	0	1	1	0	0	1,295	38	23	1	0	1	1	0	0	1,358

[1] From October-December 1990 landings of Germany, Fed. Rep. are included.

[2] For the years 1970-1981 and 1990 the catches of Sub-divisions 25-28 are included in Sub-division 24.

[3] For the years 1970-1981 and 1990 the Swedish catches of Sub-divisions 25-28 are included in Sub-division 24.

[5] In 1995 Danish landings of Sub-divisions 25-28 are included.

Table 8.2.2 Dab in subdivisions 22 to 32. Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with traffic light system.

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
Lmax5%	Mean length of largest 5%	Linf	Lmax5% / Linf	> 0.8	Conservation (large individuals)
L95%	95th percentile		L95% / Linf		
Pmega	Proportion of individuals above Lopt + 10%	0.3–0.4	Pmega	> 0.3	
L25%	25th percentile of length distribution	Lmat	L25% / Lmat	> 1	Conservation (immatures)
Lc	Length at first catch (length at 50% of mode)	Lmat	Lc/Lmat	> 1	
Lmean	Mean length of individuals > Lc	$Lopt = \frac{3}{3+M/k} \times L_{inf}$	Lmean/Lopt	≈ 1	Optimal yield
Lmaxy	Length class with maximum biomass in catch	$Lopt = \frac{3}{3+M/k} \times L_{inf}$	Lmaxy / Lopt	≈1	
Lmean	Mean length of individuals > Lc	LF=M = (0.75Lc+0.25Linf)	Lmean / LF=M	≥ 1	MSY

Table 8.2.3 Dab in subdivisions 22 to 32. Indicator status for the most recent three years

	Conservation				Optimizing Yield	MSY
Year	Lc / Lmat	L25% / Lmat	Lmax 5 / Linf	Pmega	Lmean / Lopt	Lmean / LF = M
2014	0.83	1.43	0.90	0.25	0.99	1.29
2015	0.57	1.43	0.91	0.23	1.00	1.56
2016	0.57	1.50	0.89	0.31	1.02	1.59

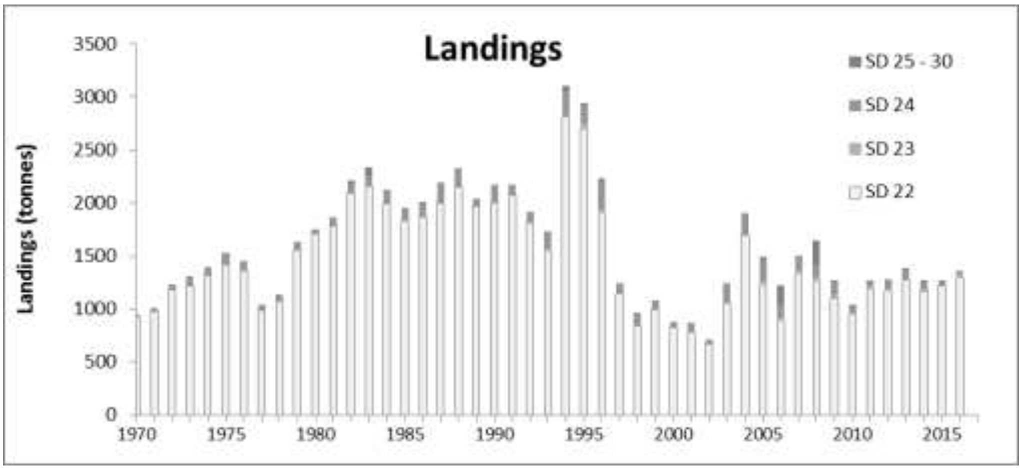


Figure 8.2.1 Dab in subdivisions 22 to 32. Development of dab landings [t] from 1970 onwards by ICES subdivision (SD).

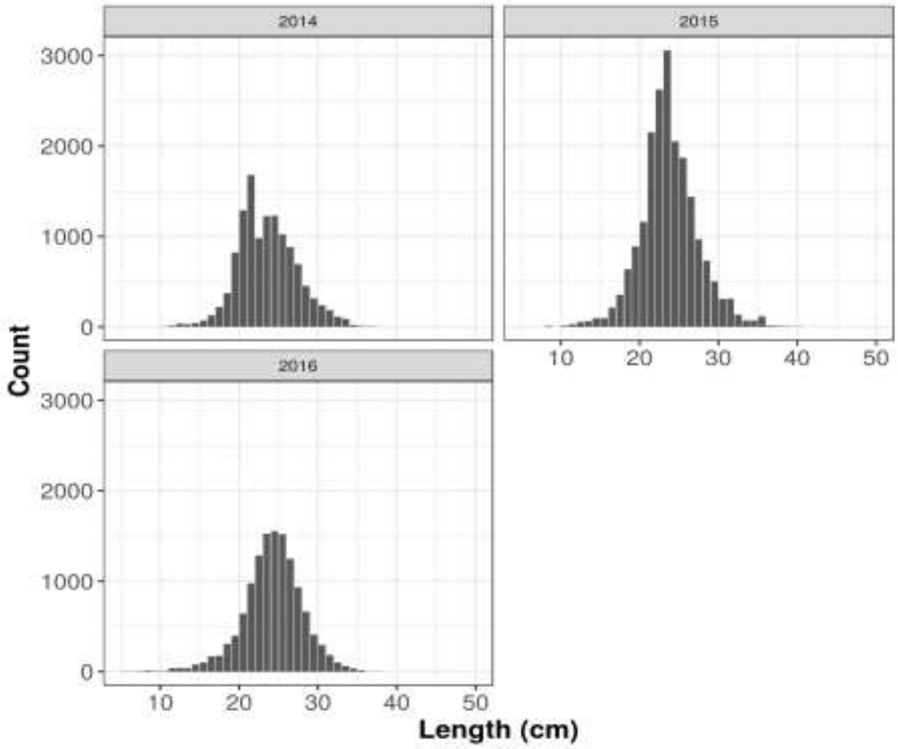


Figure 8.2.2 Dab in subdivisions 22 to 32. Catch in numbers per length for the three most recent years 2014-2016.

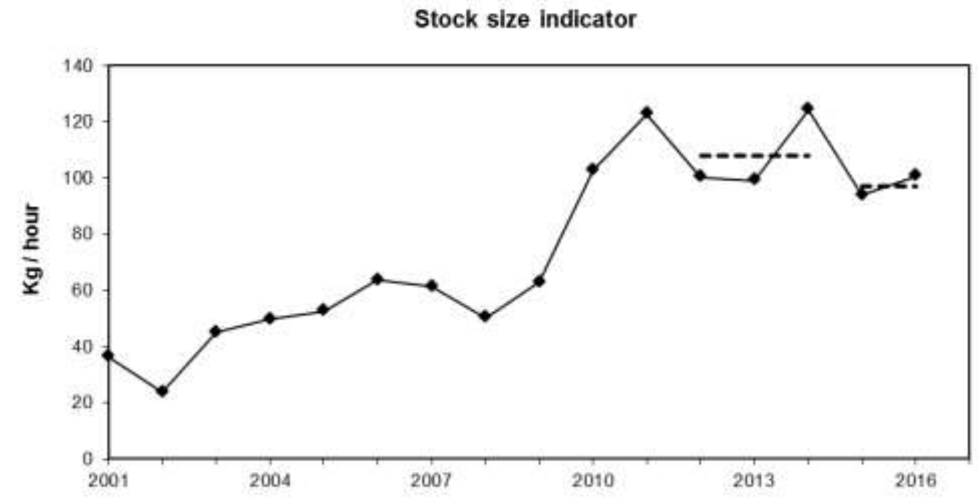


Figure 8.2.3 Dab in subdivisions 22 to 32. Mean biomass (kg hr^{-1}) of dab with L ≥ 15 cm based of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–24.

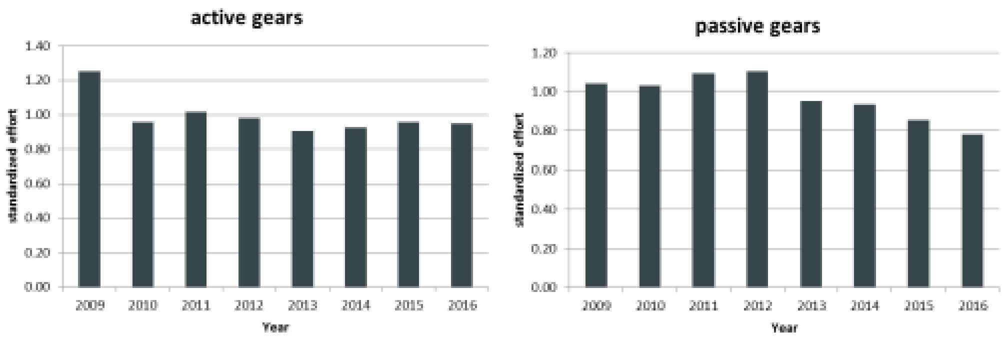


Figure 8.2.4 Dab in subdivisions 22 to 32. Standardized effort for active and passive fleets in subdivisions 22 to 24 (main distribution range of dab.27.22-32). Standard catches (effort per strata and country divided by average effort per country) were weighted by the mean of cod landings by country.

8.3 Brill

8.3.1 Fishery

8.3.1.1 Landings

Total landings of **brill** varied from 1 t to 160 t between 1975 and 2004 (Table 8.3.1, Figure 8.3.1). It can be assumed that the total landings of brill reported for 1994–1996 are overestimated due to species-misreporting in the landings of the directed cod fishery. The landings averaged about 25 t if the years 1994–1996 are excluded. Moderate increase of the landings was observed from 19 t in 2001 to 56 t in 2007 followed by landings of 105 t in the following year. Decreasing trend has been observed since 2009 which is continued with landings of 30 t in 2012, 31 t in 2013 and 28 t in 2014. Slightly increase of landings was reported for 2015 with 40 t and also 2016 with 39 t.

8.3.1.2 Discards

Less than 100 kg of brill was discarded in 2012. The amount of discards increased to 299 kg in 2013 and further increased to 4200 kg in 2014. Discards of brill were not reported in 2015. For 2016, 400 kg discards were reported.

8.3.2 Biological composition of the catch

Stock indices (CPUE) were estimated as arithmetic mean of mean catch in number per hour for brill with a length of ≥ 20 cm of quarter 1 and quarter 4 (arithmetic mean of quarter 1 and 4). The CPUE values of the small TV were multiplied with a conversion factor of 1.4. The CPUE values of brill highly fluctuated from 2004 onwards.

The low CPUE values between 2001 and 2003 correspond with low landings in the same years and the increase of the CPUE values in the following years also correspond with increasing landings.

WKFLABA did not find any data concerning genetic or tagging that could be used to illuminate the stock structure of brill in the Baltic, hence no suggestions for possible assessment units based on biological information were given. Brill is bycatch species of cod fishery and fisheries directed to other flatfish. Slightly decreasing effort (day out of port) were reported by Denmark and Germany in SD 22 and 24 for the latest years.

8.3.3 Fishery independent information

Stock indices (CPUE) were estimated as mean catch in number per hour for brill with a length of ≥ 20 cm (Figure 8.3.2). The CPUE values of the small TV were multiplied with a conversion factor of 1.4. Stable index with low fluctuations were observed between 2007 and 2016.

8.3.4 Assessment

The basis for the advice is the ICES data-limited approach. This approach was already used in 2015 and 2016 and the precautionary buffer was applied. The mean abundance index of 2015 and 2016 was 23% smaller than the mean of the abundance index from 2012–2014. The decrease of the advice was truncated to 80% according to the ICES rule taking into the slightly decreasing fishing effort of Denmark and Germany in SD 22–24 in the last years.

8.3.5 Reference points

The stochastic production model in continuous time (SPiCT) was applied to the Brill stock in subdivisions 22-32. The results of the assessment are very uncertain (Figure 8.3.3) and the retrospective analysis shows a high dependency on single data points (Figure 8.3.4). Due to the high uncertainty in the assessment outputs and the inconsistency in the retrospective analysis the reference points were not considered for the management of Brill. The poor fit might be attributed to the inconsistency between catch and index time series, missing contrast in the catch time series and very low sample size of caught individuals in the BITS surveys. Figure 8.3.5 shows the diagnostics of the assessment. Alternative prior settings, combinations of index times series did not result in a lower uncertainty of the reference points of the SPiCT assessment of Brill.

8.3.6 Management considerations

Brill in ICES Sub-divisions 22-32 is according to survey estimation at the edge of its distributional area, with the centre of gravity being positioned in Kattegat (ICES Subdivision 21, Figure 8.3.6). Survey CPUE (numbers per haul) have to be considered to be very low (<1, and 0 in the Eastern Baltic Sea). Hence, survey data are a weak basis for assessment and potential management reference points, and it might be worthwhile considering to combine Brill in ICES Sub-division 22-32 with Brill in Sub-division 21.

Table 8.3.1 Brill in the Baltic Sea. Total landings (tonnes) by Subdivision and country.

Year	Denmark			Germany, FRG		Sweden		Total			Total
	22	23	24-28	22	24	23	24-28	22	23	24-28	SD 22-28
1970	4							4	0	0	4
1971	3							3	0	0	3
1972	7							7	0	0	7
1973	11		2					11	0	2	13
1974	25		1					25	0	1	26
1975	38		1	1				39	0	1	40
1976	45		1	2				47	0	1	48
1977	60		2	5				65	0	2	67
1978	37			3				40	0	0	40
1979	30							30	0	0	30
1980	26							26	0	0	26
1981	22			1				23	0	0	23
1982	19						17	19	0	17	36
1983	13						42	13	0	42	55
1984	12						3	12	0	3	15
1985	16						1	16	0	1	17
1986	15						3	15	0	3	18
1987	12						3	12	0	3	15
1988	5						1	5	0	1	6
1989	9						1	9	0	1	10
1990							1	0	0	1	1
1991	15							15	0	0	15
1992	28							28	0	0	28
1993	29	5	1					29	5	1	35
1994	57	4	1				1	57	4	2	63
1995	134	12	1			5	8	134	17	9	160
1996	56	6						56	6	0	62
1997	25					1		25	1	0	26
1998	21					1		21	1	0	22
1999	24					1		24	1	0	25
2000	27					1		27	1	0	28
2001	19							19	0	0	19
2002	25		0			1		25	1	0	27
2003	35		1			0		35	0	1	36
2004	39		1			1	0	39	1	1	41
2005	50	9	3			0	0	50	9	3	62
2006	42	9	2	3		0	0	45	9	2	56
2007	50			5		0	0	55	0	0	56
2008	81	9	3	11		1	1	92	10	3	105
2009	70	7	2	11		1	0	82	8	3	92
2010	65	4	1	10		0	0	76	5	1	82
2011	46	5	1	4		1	0	50	6	1	57
2012	24	4	0	2		1	0	26	4	0	31
2013	24	6	0	1	0	1	0	25	7	0	31
2014	19	5	0	2	0	1	0	21	6	0	28
2015	29	7	0	3	0	1	0	32	8	0	40
2016	28	8	0	2	0	1	0	29	9	1	39

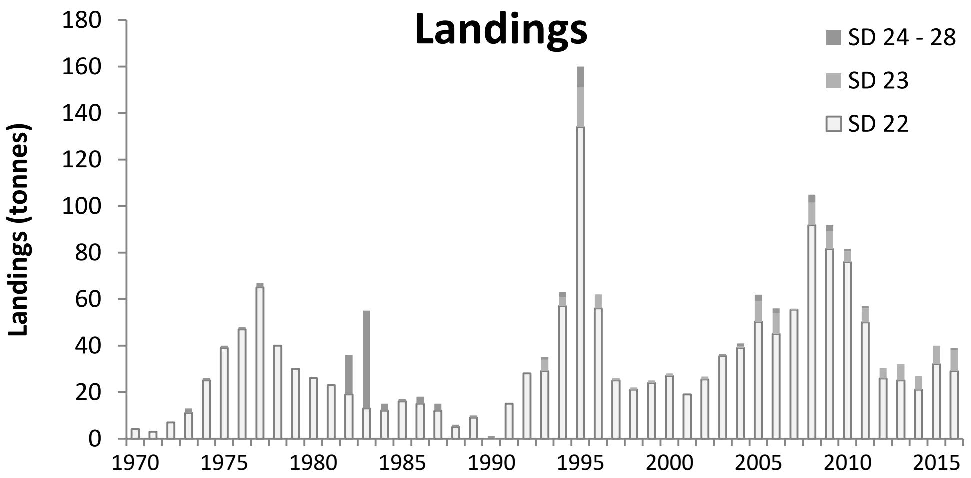


Figure 8.3.1 Brill in the Baltic Sea. Development of brill landings [t] from 1970 onwards by ICES subdivision (SD).

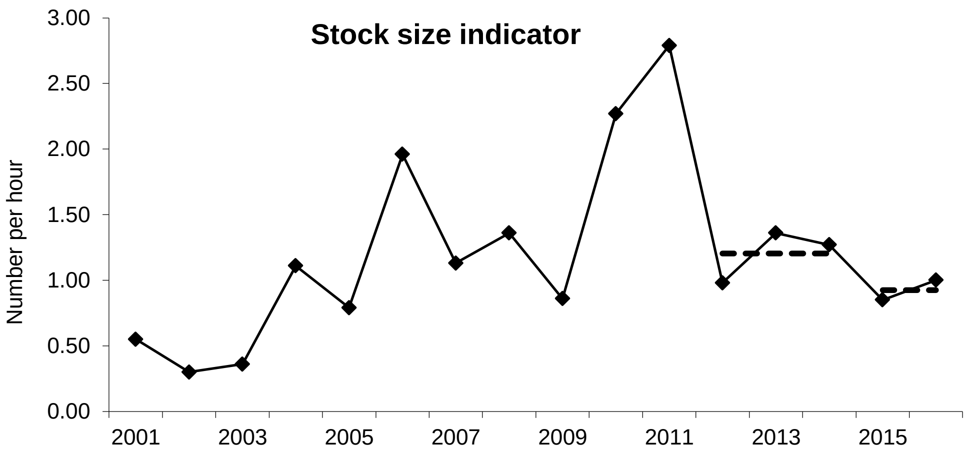


Figure 8.3.2 Brill in the Baltic Sea. Mean CPUE (no. hr^{-1}) of brill with L ≥ 20 cm.

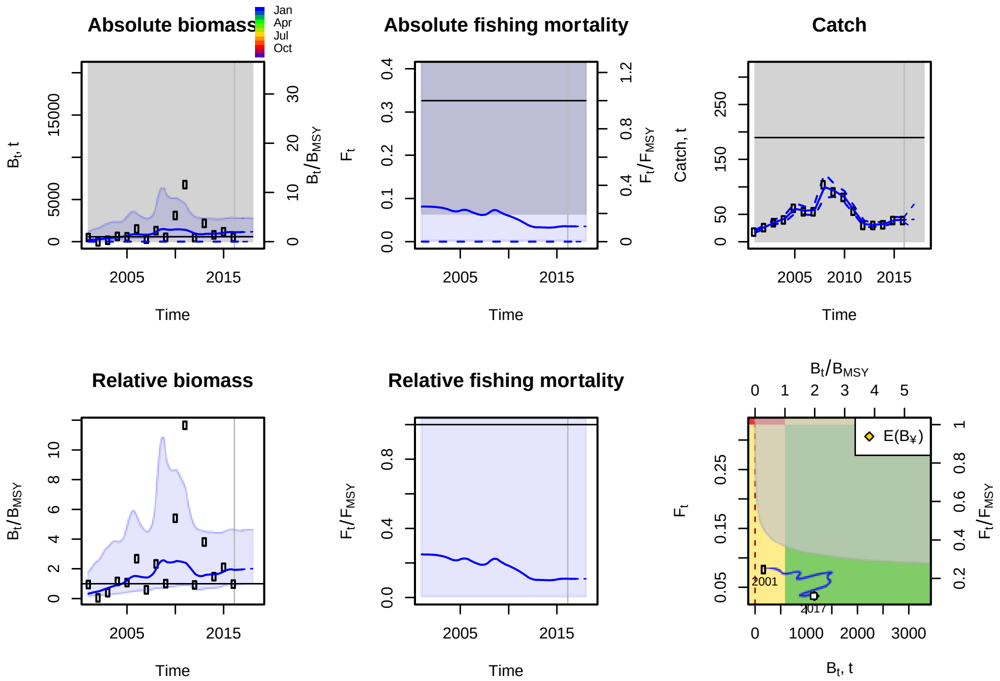


Figure 8.3.3 Brill in the Baltic Sea. Results of SPiCT assessment of Brill in subdivisions 22-32.

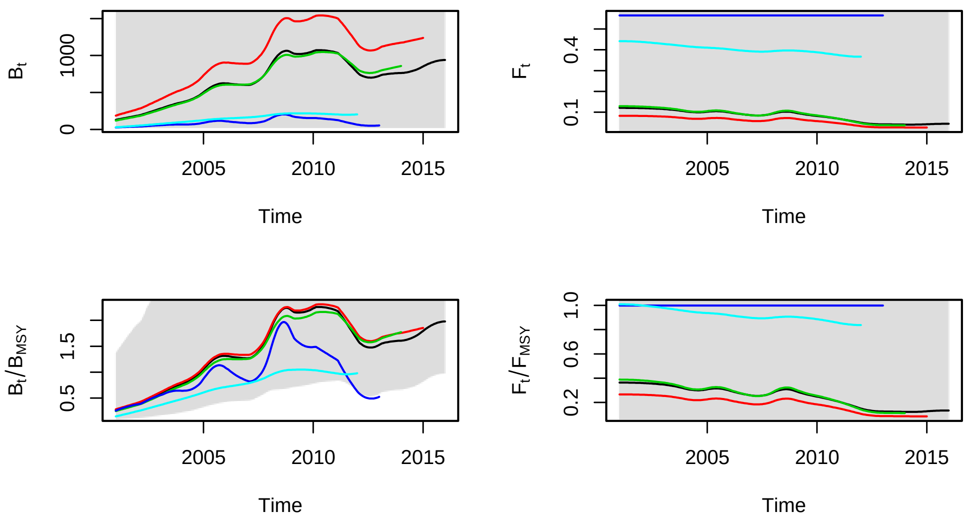


Figure 8.3.4 Brill in the Baltic Sea. Results of retrospective analysis of the SPiCT assessment of Brill in subdivisions 22-32.

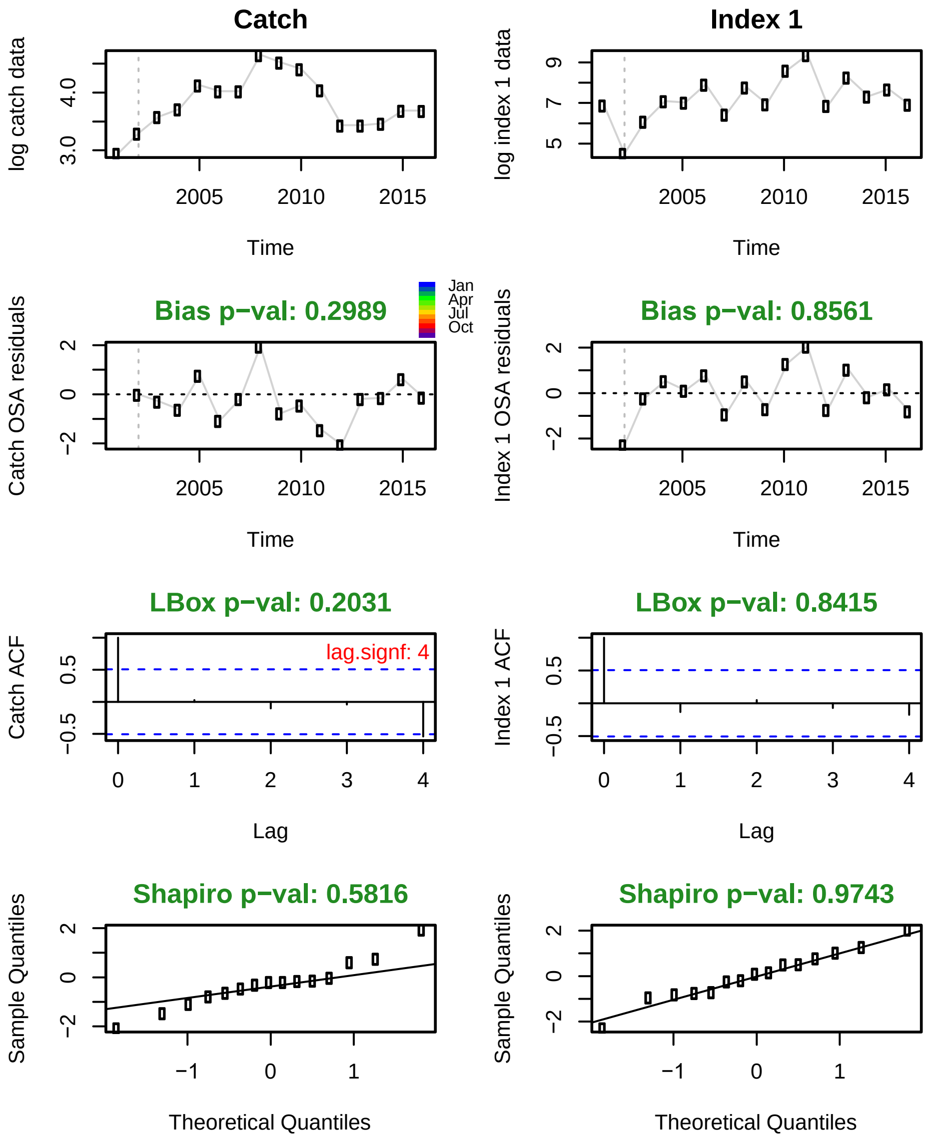


Figure 8.3.5 Brill in the Baltic Sea. Model diagnostics of the SPiCT assessment of Brill in subdivisions 22-32.

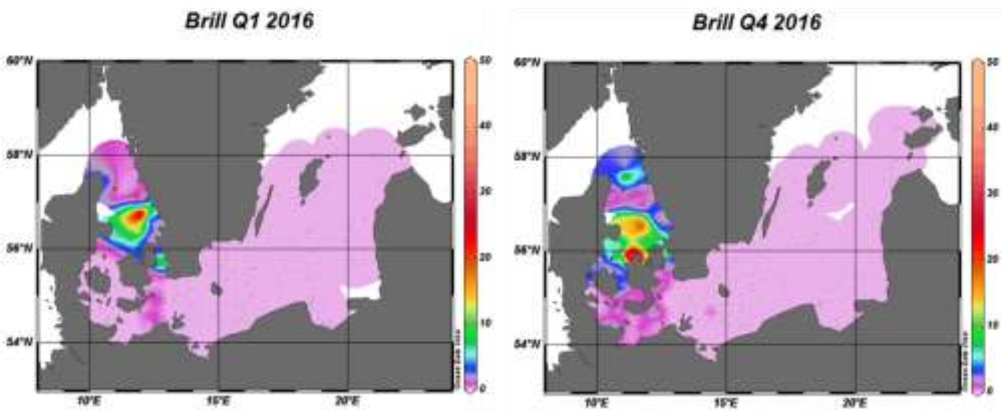


Figure 8.3.6 Brill in the Baltic Sea. Brill distribution in the Baltic Sea, CPUE in numbers per hour indicated in colour bars.

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Annex 1: List of participants

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Annex 2: Recommendations

1. WGBIFS. Estimation of catch selection curve from the BITS survey, to see what size we should base on our stock abundance indices.

Annex 3: ToRs for next meeting

Annex 4: List of Stock Annexes

Name	Title
bll-2232_SA.pdf	Stock Annex: Brill (*Scophthalmus rhombus*) in Subdivisions 22–32 (Baltic Sea)
cod-2224_SA.pdf	Stock Annex: Cod (*Gadus morhua*) in subdivisions 22–24, western Baltic stock (western Baltic Sea)
cod-2532_SA.pdf	Stock Annex: Cod (*Gadus morhua*) in subdivisions 25–32, eastern Baltic stock (eastern Baltic Sea)
cod-kat_SA.pdf	Stock Annex for Cod (*Gadus morhua*) in Division 3.a East (Kattegat)
dab-2232_SA.pdf	Stock Annex: Dab (*Limanda limanda*) in subdivisions 22–32 (Baltic Sea)
fle-2223_SA.pdf	Stock Annex: Flounder (*Platichthys flesus*) in subdivisions 22 and 23 (Belt Seas and the Sound)
fle-2425_SA.pdf	Stock Annex: Flounder (*Platichthys flesus*) in subdivisions 24 and 25 (West of Bornholm and Southwestern central Baltic)
fle-2628_SA.pdf	Stock Annex: Flounder (*Platichthys flesus*) in subdivisions 26 and 28 (east of Gotland and Gulf of Gdansk)
fle-2732_SA.pdf	Stock Annex: Flounder (*Platichthys flesus*) in subdivisions 27 and 29– 32 (northern central and northern Baltic Sea)
her-2532-gor_SA.pdf	Stock Annex: Herring (*Clupea harengus*) in subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea)
her-30_SA.pdf	Stock Annex: Herring (*Clupea harengus*) in Subdivision 30 (Bothnian Sea)
her-31_SA.pdf	Stock Annex: Herring (*Clupea harengus*) in Subdivision 31 (Bothnian Bay)
her-riga_SA.pdf	Stock Annex: Herring (*Clupea harengus*) in Subdivision 28.1 (Gulf of Riga)
ple-2123_SA.pdf	Stock Annex: Plaice (*Pleuronectes platessa*) in subdivisions 21– 23 (Kattegat, Belt Seas, and the Sound)
ple-2432_SA.pdf	Stock Annex: Plaice (*Pleuronectes platessa*) in subdivisions 24–32 (Baltic Sea, excluding the Sound and Belt Seas)
sol-kask_SA.pdf	Stock Annex: Sole (*Solea solea*) in subdivisions 20–24 (Skagerrak and Kattegat, western Baltic Sea)
spr-2232_SA.pdf	Stock Annex: Sprat (*Sprattus sprattus*) in subdivisions 22–32 (Baltic Sea)
tur-2232_SA.pdf	Stock Annex: Turbot (*Scophthalmus maximus*) in subdivisions 22–32 (Baltic Sea)

Annex 5: Appendix of audit reports

Stock Name: Herring in Subdivisions 30 and 31 (Gulf of Bothnia)

General comments:

It is useful to print previous year advice sheet for comparison purposes it will make it easier to find potential errors and or inconsistencies.

Along with the spelling and structure of the text ensure that any values referenced in the text match the values or percentages shown in the tables.

All the values presented in the advice sheet should not be rounded at the WG. All rounded will be done at the ADG.

The check list below is given by section and it results from a compilation of the most frequent errors but by no means is it a complete list.

☐ **ICES stock advice**

☒ Ensure the basis of the advice used is the correct one i.e Management plan; MSY approach; precautionary approach. The same as stated in the basis of advice table and history of advice table.

☐ The advised value of catches should be the same as presented in the catch options table.

The catch option table for Fmsy approach is not similar with the advice in the first line (96100 in table 3 and 114 756 t in the top line.

There is a missing value in catch option table for F

☒ Check the years for which the advice is given.

There is missing a line (I think) in table 7, were the advice for 2018 should be added.

☐ **Stock development over time**

☒ Ensure all units used in the plots are correct (compare with previous year advice sheet).

☒ Ensure all titles of the plots are correct i.e caches; landings, recruitment age (o, 1, 2…); relative index

☒ Recruitment plot: if the intermediate years is an outcome of a model the value should be unshaded.

☐ Ensure the F and SSB reference points (RP) in the plots are the same as in the reference points table. Also, check the respective labels if they correspond with the RP.

☐ Check if the legend of the plots is consistent with what is shown in the plots.

☐ Check that the graphs match the data in table of stock assessment results.

☐ Stock and exploitation status

☐ Compare with the previous year's advice sheet. The years in common should have the same status (symbol).

☐ Check if the labels for the years are correct.

☐ Compare the status table with the F and SSB plots they should show the same information.

☐ Does the stock have a management plan? If yes than the row for the management plan should be filled as well otherwise will read not applicable.

☐ Catch options

Basis of catch options table:

For each of the rows in the table ensure that:

☐ The year is correct,

☐ The value is correct,

☐ The notes are correct and

☐ The sources are correct.

Catch options table:

☐ The forecast should be re-run to ensure all values are correct.

☐ Compare the input data with previous year run (previous year should be in the share point under the data folder)

☐ The wanted catch and SSB values should be given in tonnes (t);

☐ Confirm if the F values for the options F_{lim}; F_{pa}; are correct.

☐ For the options where the value of F will take SSB of the forecast year to be equal to B_{lim}; B_{pa}; $MSY_{Btrigger}$ confirm if the SSB value for the forecast year is equal or close to the reference points.

☐ For the options where a percentage is added or taken (i.e +10%; 15%, etc.) from the current TAC. Ensure that the calculated values are correct.

☒ For all the options given in the table calculate the percentage of change in SSB and TAC.

☐ In the first column (Rationale) ensure the rational of the first line is the correct basis for the advice. All other options should be under "Other options".

Presently this is not the case in the option table

☐ Compare different catch options; higher F should result in lower SSB

There is something wrong with all the values in the option table as they do not fit with the values in the assessment report and the first advice line

☐ Check if SSB change is in line with F.

☐

☐

☐ Basis of the advice

☐ Ensure the basis of the advice is correct and if the same is used in the catch option table and in the ICES stock advice section.

There is something wrong as the basis of the advice value do not correspond to the catch option table

☐ Is there a management plan? If there is one it should be stated if it has been evaluated by ICES and considered precautionary or not and also if it has been sign off by the clients(EU; Norway, Faroe Islands, etc.)

We do not think that the management plan has been evaluated….

☐ Quality of the assessment

It is not possible to produce as 2 stocks has been merge

☐ Are the units in plots correct?

☐ Are the titles in the plots correct including F (age range) recruitment (age).

☐ The red line correspond to the year of assessment (except F which is year of assessment -1)

☐ Each plot should have five lines.

☐ Ensure the reference points lines (in the SSB and F plots) are correct and match with the values in the reference point table and summary plots.

☐ Issues relevant for the advice

☒ Along with the spelling and structure in the text ensure that any values referenced in the text match the values or percentages in the tables within the advice sheet.

☐ Reference points

☒ Ensure all the values, technical basis and sources are correct. If new values were not calculated the table should be the same as previous year.

☐ Basis of the assessment

☐ If there is no change from the previous year the table should be the same.

☐ Ensure there is no typos wrong acronyms for the surveys.

☐ Assessment type- check that the standard text is used.

☐ Information from stakeholders

☒ If no information is available the standard sentence should be "There is no available information"

☐ History of advice, and management

☐ This table should only be updated for the assessment year and forecast year except if there was revision to the previous years.

☒ Ensure that the forecast year "predicted landings or catch corres. to advice" column match the advice given in the ICES stock advice section (usually given in thousand tonnes).

However it does not match the option table

☐ History of catch and landings

Catch distribution by fleet table:

☒ Ensure the legend of the table reflects the year for the data given in the table.

☒ Ensure that the sum of the percentage values in each of the components (landings and discards) amount to 100%

☒ Ensure that the sum of the values for discards and landings are equal to the value in the catch column. However, if only landings or discards components are shown, then total catch should be unknown.

History of commercial landings table:

☒ Ensure that the values for the last row are correct check against the preliminary landings (link to be added)

☐ **Summary of the assessment**

☐ This table is an output from the standard graphs. If there was any errors picked up with any of the plots, then this table should be replaced by a new version once the errors are corrected.

SSB in 2017 do not fit with the table 2 The basis for the catch options

☒ Check if the column names are correct mainly recruitment age and age range for F.

☐ If the stock is category 5 or 6 then it should read “There is no assessment for this stock”

☐ **Sources and references**

☒ Ensure all references are correct.

☒ Ensure all references in the advice sheet are referenced in this section.

Audit of Sole (Solea solea) in subdivisions 20–24 (Skagerrak and Kattegat, western Baltic Sea)

Date: 24.04.2017

Auditor: Tiit Raid

1) **Assessment type:** update assessment . The stock was benchmarked in 2015
2) **Assessment**: analytical (SAM)
3) **Forecast**: presented
4) **Assessment model**: Age-based analytical stochastic assessment (SAM) that uses landings only in the model. SAM – tuned by 3 comm. fleets + 1 survey
   i) Input data: Commercial catches (international landings, ages and length frequencies from catch sampling), one survey index (Fishermen–DTU Aqua 2004–2015), two commercial indices: (private logbook gillnetters (1994–2007), private logbook trawlers (1987–2008)); fixed maturity and fixed natural mortality (0.1) for all age groups. Fisherman-DTU Aqua sole Survey 4th quarter 2004-2016 No survey took place in 2012-2013

Age 1 from the survey is now included in the assessment for forecast purposes (ICES 2015/ACOM:57).

   ii) **5) Data issues:** the data are available in the SharePoint as well described in stock annex. The survey index series, which was interrupted in 2011, has been resumed in 2014 and is used. Discard information has been used to provide advice, but not included in the assessment. Discard information available since 2000, average discard rates 2011–2016 from main fleets are 4%. Discarding increased in 2016 up to 6%.Sufficient biological sampling of landings is difficult to obtain due to the low total landings which are spatially dispersed. This affects the quality of the input data, including the weight-at-age.

5) **Consistency**: The assessments of recent years including the 2017 assessment have been accepted. In general, the results are consistent with the last year's assessment.
6) **Stock status**: Bpa>SSB>Blim, F<Fpa, Flim. R has been is low in recent years, however the year-classes of 2013 and 2014 are estimated above recent average.
7) **Man. Plan**: NA

General comments

The assessment is clear and well documented.

Technical comments

The assessment is performed according to the stock annex. This section is well documented and ordered.

Conclusions

The assessment has been performed correctly. There are no major reasons to deviate from the standard procedure for this stock. The update assessment gives a valid basis for the advice.

Audit of cod in 22-24

Date: 24-4-2017

Auditor: Jesper Boje

General

The report sections were not available on the second last days (not the assessor to blame due to workload) and therefore a proper review of text, tables and figures was not conducted. The general procedure that WGs review themselves is not considered a sound or efficient process.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

8) **Assessment type: update**
9) **Assessment**: analytical
10) **Forecast**: presented – incl in SAM
11) **Assessment model**: – SAM, stock name WBcod_2017 – tuning by 2 surveys
12) **Data issues:** all data available – no changes from last yr
13) **Consistency**: consistent with last yrs assessment; retropattern with overestimation of SSB and underestimation of F
14) **Stock status**: B<<Blim for a while, F around Flim, 2016 yc high but also associated with high uncertainty
15) **Management Plan**: No MAP in place or agreed. Agreed in 2006: SSB above 35 000 t within 10 years and to reduce fishing mortality to 0.27. The main elements in the plan are a 10% annual reduction in F and a 15% constrain on TAC change between years. Plan is **not** evaluated by ICES

General comments

The advice for 2018 is caused by the strong incoming 2016 yc with very high uncertainty. This yc results in increases in SSB in 2018 and 2019. This trend is in contradiction to the strong retrospective pattern where SSB is overestimated.

Technical comments

The assessment is done according to the stock annex.

Conclusions

The assessment and advice has been performed correct.

Annex 6: Benchmark information

Benchmark information per stock

To be filled in by the stock coordinator (send to Scott Large scott.large@ices.dk)

Stock	........sol27.20-24................	
Stock coordinator	Name: Jesper Boje	Email:jbo@aqua.dtu.dk
Stock assessor	Name: do	Email:do
Data contact	Name: do	Email:do

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 bench-mark type of expertise / proposed names
(New) data to be Considered and/or quantified[1]	Additional M - predator relations			
	Prey relations			
	Ecosystem drivers			
	Other ecosystem parameters that may need to be explored?			
Tuning series				
Discards	Implementation of discard into assessment	Due to the scattered fishery and associated scattered sampling, discard series expected to be noisy	Continuation of discard sampling until an appropriate time series is achieved	
Biological Parameters	Abundance and distribution of juveniles	identification of nursery grounds and evaluation of their importance for recruitment to the stock.	Data available from historic Danish coastal surveys	
	Growth and recruitment	improvement of ageing by means of otolith calibration between readers and otolith structure to validate age	A calibration workshop/exchange will be arranged	
	Stock structure - genetics	genotyping spawning fish in order to identify stock structure in the entire stock assessment area SD 20-24 and also to evaluate	Samples will be collected from fishery and survey; analysis conducted by DTU Aqua	

[1] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand.If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

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
		main migration patterns		
	Survey coverage – design	analysis of appropriate survey coverage with respect to the stock distribution. In 2016 survey area was already extended into Skagerrak and the Belts and this scheme will be evaluated	Surcey design changed in 2016 to include the Belts and Skagerrak; evaluation of additional stations conducted annually. When time series appropriate all stations will be included for assessment calibration	
	Improvement of biological data sampling - reference fleet	sampling from the fishery is difficult due to small and scattered landings; since 2016 agreements with specific fishermen were initiated to improve biological sampling	The existing reference fleet will be sought expanded	
	Selectivity in various gears – SELTRA	introduction of new selective devices in fishing gears have caused selectivity to change substantially.	In order to quantify this change experimental sole fishery by DTU Aqua will be conducted with the most used devices.	
Assessment method				
Biological Reference Points				

Annex 7: Working documents

01: Joint fisheries research/fishing industry survey for sole in Skagerrak and Kattegat, November-December 2016. O.A. Jørgensen, Denmark

02: German herring and sprat: Fisheries & Stock assessment data in the Baltic Sea in 2016. Tomas Gröhsler, Germany

03: Assessments of herring stocks in the Central Baltic Herring area and sprat stock in the whole Baltic by former assessment units (AUs). Jan Horbowy, Anna Luzeńczyk, Szymon Smoliński, Poland

04: The method for estimating MSY reference points incorporating density dependence and predation effects. Jan Horbowy, Anna Luzeńczyk, Poland

05: Kattegat cod SAM assessment, including natal homing migration of North Sea cod. Morten Vinther, Denmark

06: Estimating proxy reference points for cod in the Kattegat using SPICT model. Margit Eero, Denmark

07: Eastern Baltic Cod assessment using seasonal data and SPiCT. Casper W. Berg, Denmark

08: Joint Swedish and Danish survey for cod in the Kattegat November-December 2016. O.A. Jørgensen and Marie Storr-Paulsen, Denmark and Katja Ringdahl, Johan Lövgren, Patrik Börjesson and Jonas Hentati Sundberg, Sweden

Working paper 1 ICES WGBFAS April 2017

Joint fisheries research/fishing industry survey for sole in Skagerrak and Kattegat, November-December 2016

by

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Abstract

A survey series targeting sole in Kattegat and Skagerrak was initiated in 2004 in order to establish a time series of catch and effort data independent of the commercial fishery. The number of stations was reduced from 116 to 80 in 2011 but this did not change the overall trends for the most common commercial species. CPUE for sole was stable during 2004-2007 but decreased gradually after then until 2010. In 2011 CPUE increased slightly and was back at the 2009 level. There were no surveys in 2012 and 2013. The surveys were resumed in 2014. The CPUE in kg/hr increased slightly between 2011 and 2014 while the CPUE in numbers/hr decreased to the lowest observed level in the time series. The CUE increased again in 2015 and remained at the 2015 level in 2016.The length distribution had a mode around 24 cm as in previous years but with slightly more large sole than previous. The working paper also includes information on CPUE, biomass and length distribution of cod, plaice and Norway lobster.

Introduction

In 2004 National Institute of Aquatic Resources (DTU Aqua) initiated a survey series targeting sole in Skagerrak and Kattegat in cooperation with The Danish Fishermen's Association. The purpose is to establish a time series of catch and effort data independent of the commercial fishery in order to strengthen the scientific advice on the sole stock in ICES Div. IIIa. However, data on all commercial species are recorded. There were no surveys in 2012 and 2013, but the annual surveys were resumed in 2014.

The survey was originally designed in order to establish fisheries independent CPUE indices by means of fishing at 120 fixed stations where 60 of the positions of the hauls were selected by the skippers on the two vessels participating in the survey, while 60 positions were selected randomly by DTU AQUA.

In 2005 the survey design was changed slightly. The number of stations selected by the fishermen was reduced by 10 from 60 to 50, while the number of stations selected randomly by DTU AQUA was increased by 10. Originally the DTU AQUA stations were placed mainly outside the area where the fishermen have placed their stations. The new stations are primarily placed in the area with the fishermen’s stations and distributed according to the principles used for the other 60 DTU AQUA stations. These 70 randomly distributed stations allow an estimation of the trawlable biomass and abundance for the entire survey area.

In 2011 DTU-Aqua took over a significant proportion of the expenses to the survey from NaturErhvervstyrelsen and the number of planned stations was reduced from 116 to 80 stations.

In 2016 the survey was expanded with 20 stations in Jammerbugt and 6 stations in the northern part of Storebælt. The survey was expanded to test if a better coverage of the fishing grounds would improve the input to the assessment of sole. The expansion will be evaluated after the survey in 2017. The project is a part of an EFMM project: "Forbedring af den biologiske rådgivning om tunger i de indre danske farvande" (Improvement of the biological advice on sole in Danish waters).

In 2016 it was not possible to get permission to conduct the survey in Swedish waters and 10 stations were not covered (St, 40, 89,106, 107, 108, 109, 113, 126, 127,128).

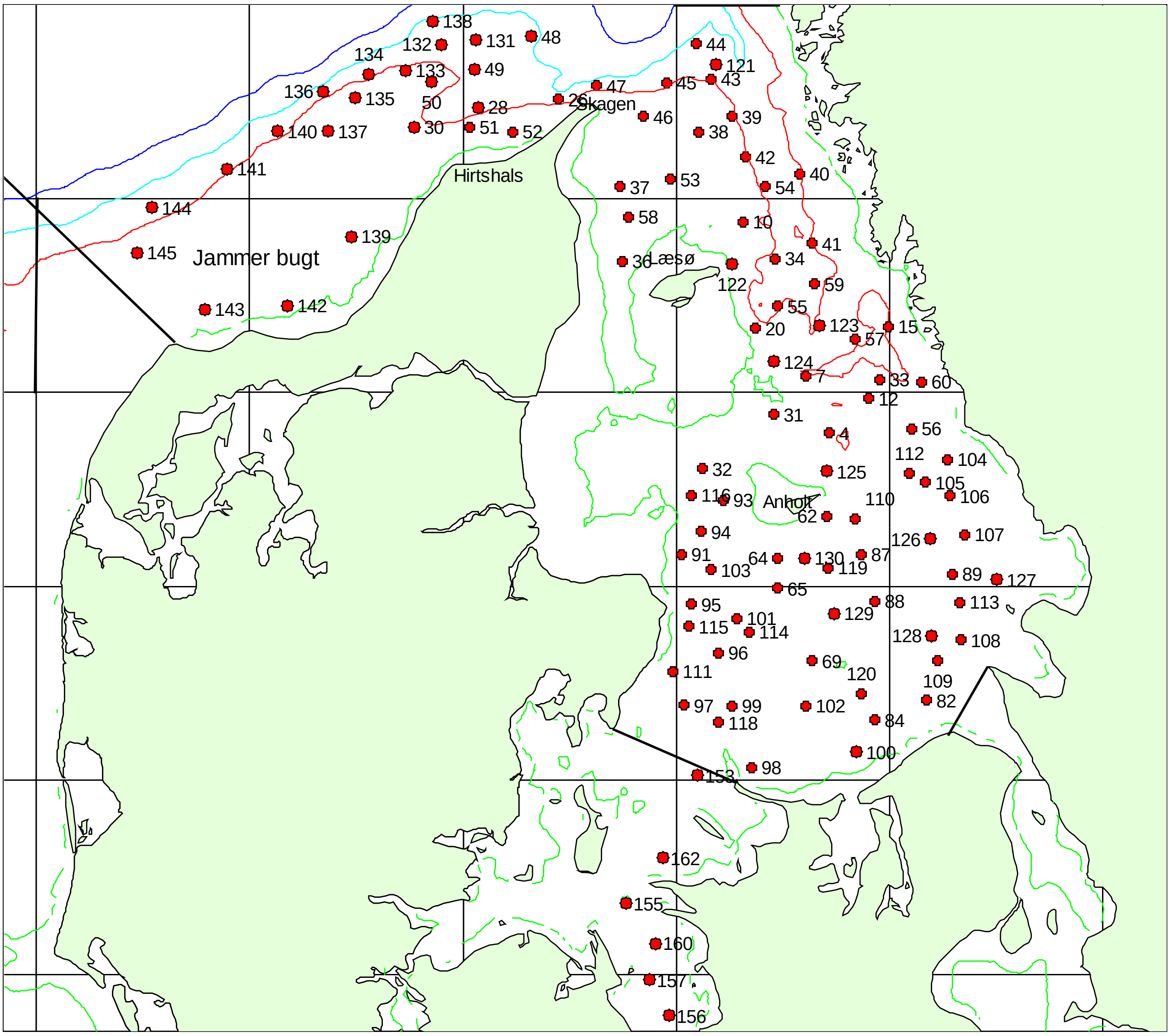


Fig 1. Distribution of stations in 2016.

One commercial trawler and DTUAQUAS "Havfisken" conducted the survey in 2016 without any restrictions in the vessels quota and with dispensation from all by-catch regulations. There was staff from DTU Aqua on board the vessels during the survey.

Materials and Methods

The survey has been conducted by a number of different trawlers thought the time series but they have all been in the same size class. In 2016 the surveys were conducted by:

Vessel	1	2
Engine (hp):	501	457
Tonnage:	105 BRT	48.0 BRT
Length (m):	17.2	17.5

Time

The survey in 2016 was conducted during 13/11 - 12/12, the same time as in previous years.

Survey area

The traditional survey area is restricted by a line 10 mile west of Hirtshals, northwards by the 100 m depth contour line and a line at 58°N, south-eastwards by a line between Gilleleje and Kullen and south-westwards by a line between Gniben og Hassensør on Djursland. Further, the area is restricted by the 10 m depth contour line. In 2016 stations were also placed in Jammerbugt and northern part of Storebælt (Fig.1).

Distribution of hauls

The survey was originally designed in order to establish fisheries independent CPUE indices by means of annual fishing at 120 fixed stations, 60 stations were placed by the fishermen and 60 by DTU-Aqua. In 2010 Stations 30, 48, 49 and 50 in the northern area were excluded from the survey and the total number of stations reduced to 116. In 2011the survey was reduced further to 80 stations, all included in the originally set up. In 2016 further 20 stations were placed in Jammerbugt and 6 stations in the northern part of Storebælt (Fig. 1).

The reduction in stations in 2011has decreased the overall number (and kg) of sole caught per hour, but the trend in the CPUE series has not changed (Fig.2). (It is the trend in the CPUE series, not the actual values that is used in the assessment of sole).

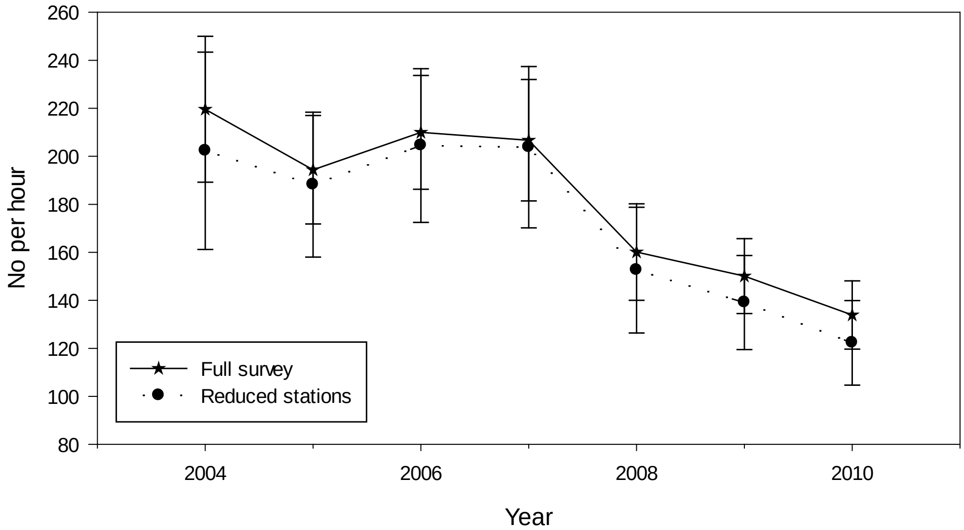


Fig. 2. Catch of Sole in numbers per hour in the “full survey” (116 stations) and the “reduced” survey (80 stations), respectively, with S.E.

The estimated trawlable biomass and abundance is based on the 80 stations. Previously the estimate was based on 70 stations random selected by Aqua. Hence no stations were deeper than 90 m the biomass and abundance has been estimated for depths between 10 and 90 m. The survey area has been stratified in ICES squares and the area between 10 and 90 m has been estimated (Table 4).

There is at least 5 mile between each station in order to spread out the stations (there are a few stations with lesser distance between, but then there is great difference in the depth).

Trawl and trawling procedure

Both vessels used the same trawl (twin trawl + 1 spare trawl) provided by DTU AQUA. The trawls are checked yearly by a net maker. The fishermen provide the otter boards.

Trawl: Twin "Icelandic-sole-trawl" with 140 mm mesh and rockhopper type ground gear with 150 mm rubber discs.
Mesh size in the cod end: 55 mm stretch mesh
Otter boards: 66" "Thyborøn".
Warp: 13 mm.

The otter boards are mounted directly on the tips of the wings without bridles.
Wing spread (otter board spread) is app. 44 m.

Trawl procedure:
Towing time: Traditionally towing time has been 60 min (towing time down to 20 min is accepted). In 2016 towing time was reduced to 30 min on 25% of the traditional stations and towing time was 30 min on all new stations in Jammerbugt and Storebælt.
Towing speed: 2.5 kn. over the seabed.
Hauls start: when the trawl is considered going stable on the bottom.
Haul end: when hauling starts.
Warp length: The depth varies from station to station and so does the warp length. The warp length was recorded at each station in 2004 and this warp length is used at the station in 2005 and onwards.

Each station is fished in the same direction each year if wind and current allows.

Fishing takes place during night time from app. 5 pm to 7 am.

Handling of the catch
After each haul the catch is sorted by species and weighed to nearest 0.1 kg and the number of specimens recorded. Most fish species are measured as total length (TL) to 1.0 cm below. Norway lobster is measured in mm carapace length.

CPUE

CPUE for sole cod, plaice and Norway lobster is estimated as mean catch (kg or numbers) per hour with Standard Error.

Biomass and abundance
The traditional survey area has been stratified in ICES squares (Fig 3, Table 4).
In 2016 5 new stations in Jammerbugt were included in the biomass and abundance estimations.

Biomass and abundance estimates is obtained by applying the swept area method (estimated trawling speed * wing spread * trawling time) using the recorded speed, wing spread and trawling time and the stratum area as weighting factor. The catchability coefficient is assumed to be 1.0.

All catches are standardized to 1 km^2 swept prior to further calculations.

Over all S.E. is estimated using the stratum area as weighting factor. In strata with one haul only STD=biomass (or abundance).

Results

Sole

The reduction in trawling time from 60 min to 30 min does not have a significant effect of the estimation of CPUE:

	30 min		60 min	
	Wight	Number	Weight	Number
Mean	25.1013	163.777	24.8818	150.372
95 Con	19.1621	122.858	7.65329	48.1623
N(hauls)	18		47	

In 2016 69 of the 80 planned stations were successfully covered and sole were caught at 68 of the stations. The catches ranged from 0.1 kg to 145 kg per hour. The greatest catches were generally taken south of Anholt (Fig. 3). The CPUE, biomass and abundance indices have generally been stable during 2004 – 2007 but all indices showed a decline on roughly 25% between 2007 and 2008. The indices declined further during 2009 and 2010 but have been slightly increasing since then.

12 of the 20 planned stations in Jammerbug and 5 stations in Storebælt were conducted successfully.

CPUE.

The CPUE based on the standard stations (including Swedish stations except in 2016) has been increasing slightly but statistically insignificant (95% level) between 2010 and 2016 from 122.3 to 159.2 specimens and 17.4 to 25.9 kg per hour, respectively. (Table 1, Fig. 4 and 5). The CPUE is generally slightly higher if the Swedish stations are excluded, but the trends are the same Fig. 4 and 5.

CPUE in Jammerbugt was in numbers 16.8 (SE 5.9) and 4.8 kg (SE 1.6) n= 12. And in Storebælt CPUE was 250.8 (SE 53.3) specimens and 48.6 kg (SE 7.9), respectively. N=5.

Table 1. CPUE (catch per hour) of sole in number and weight with SE in the traditional survey area. n number of hauls

Year	Number	SE_Number	Weight	SE_Weight	n
2004	202.3	41.1	30.0	5.0	69
2005	188.2	30.2	27.6	3.9	78
2006	204.5	32.0	28.0	3.5	79
2007	203.8	33.6	28.9	4.0	75
2008	152.6	26.2	21.5	3.2	80
2009	139.1	19.6	20.2	2.4	78
2010	122.3	17.6	17.4	2.3	79
2011	140.2	24.5	19.0	2.7	80
2014	121.6	16.3	19.2	2.3	77
2015	166.7	36.4	24.1	4.2	78
2016	159.2	24.5	25.9	3.8	69

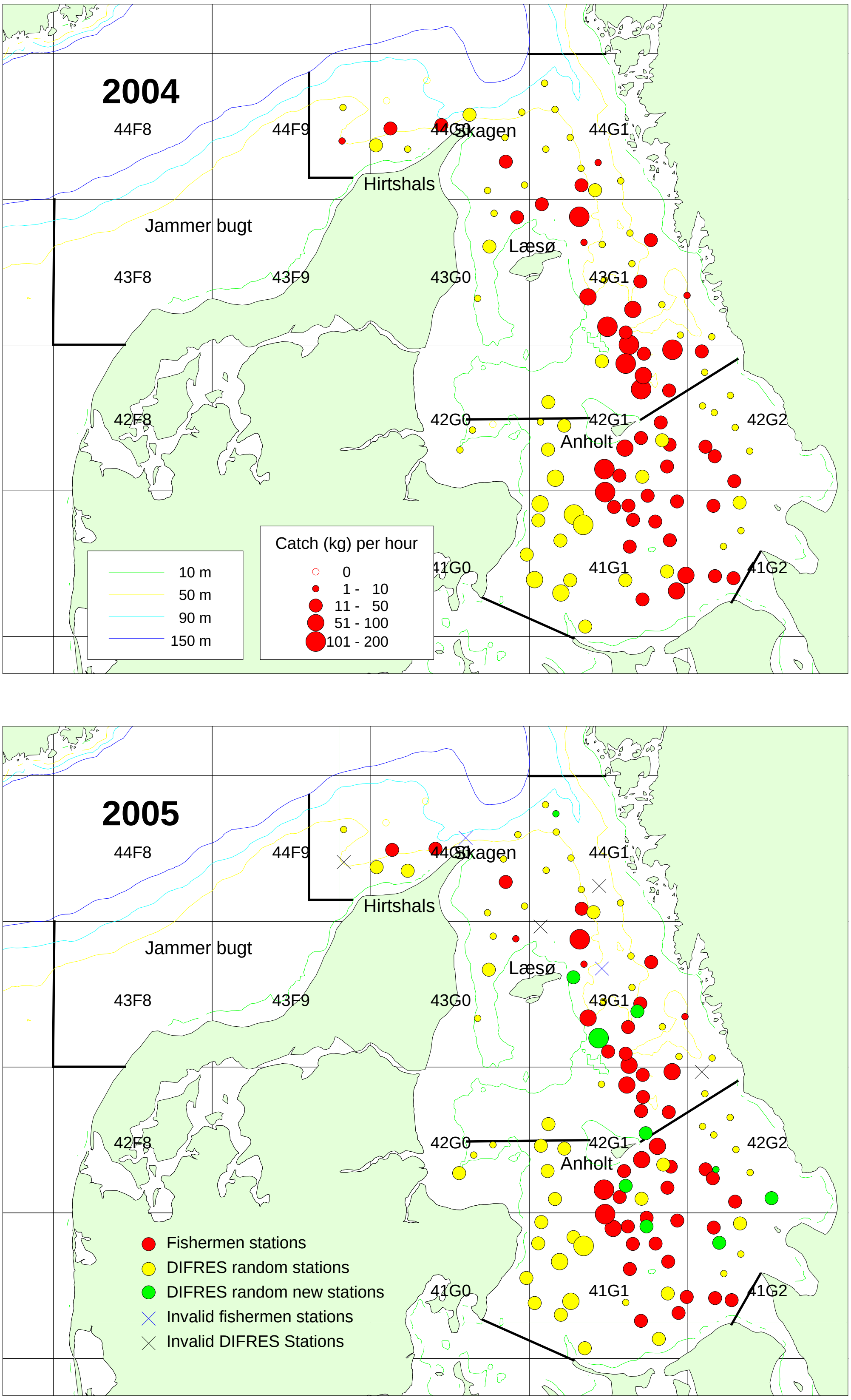


Fig. 3. Catch of sole (kg per hour) in 2004 and 2005. ● DTU AQUA stations ● Fishermen's stations.

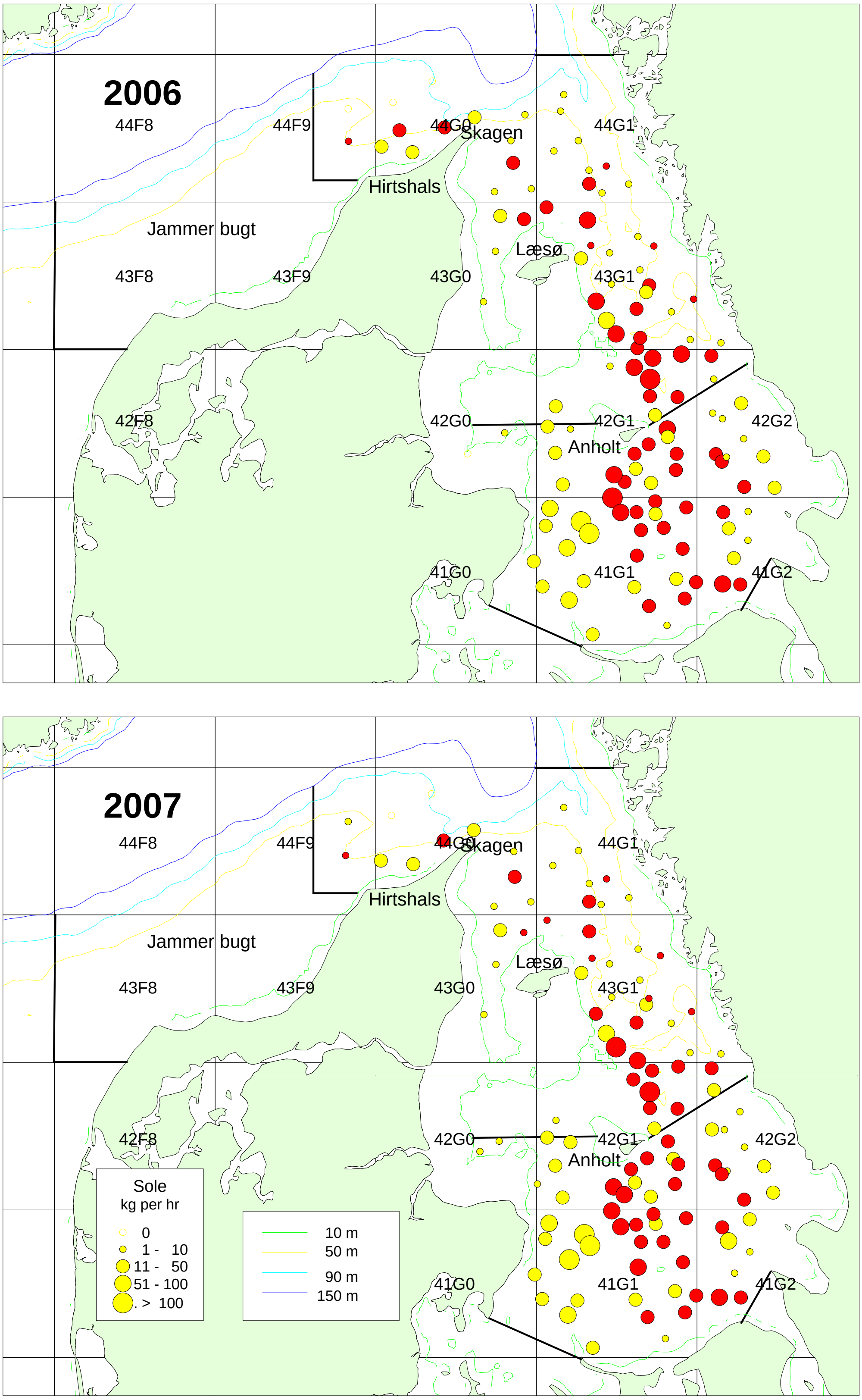


Fig. 3 cont. Catch of sole (kg per hour) 2006 - 2007. ● DTU AQUA stations ● Fishermen's stations.

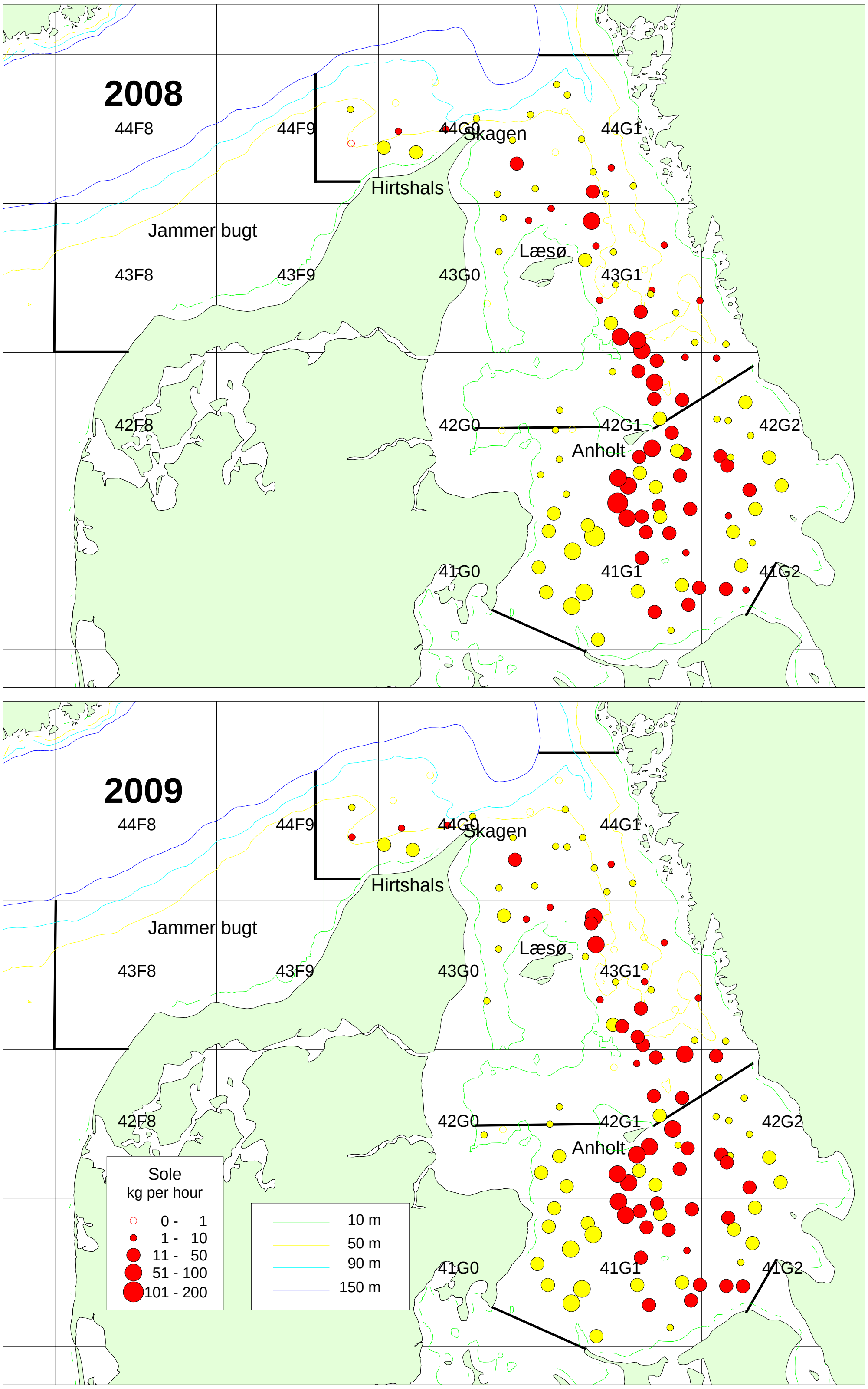
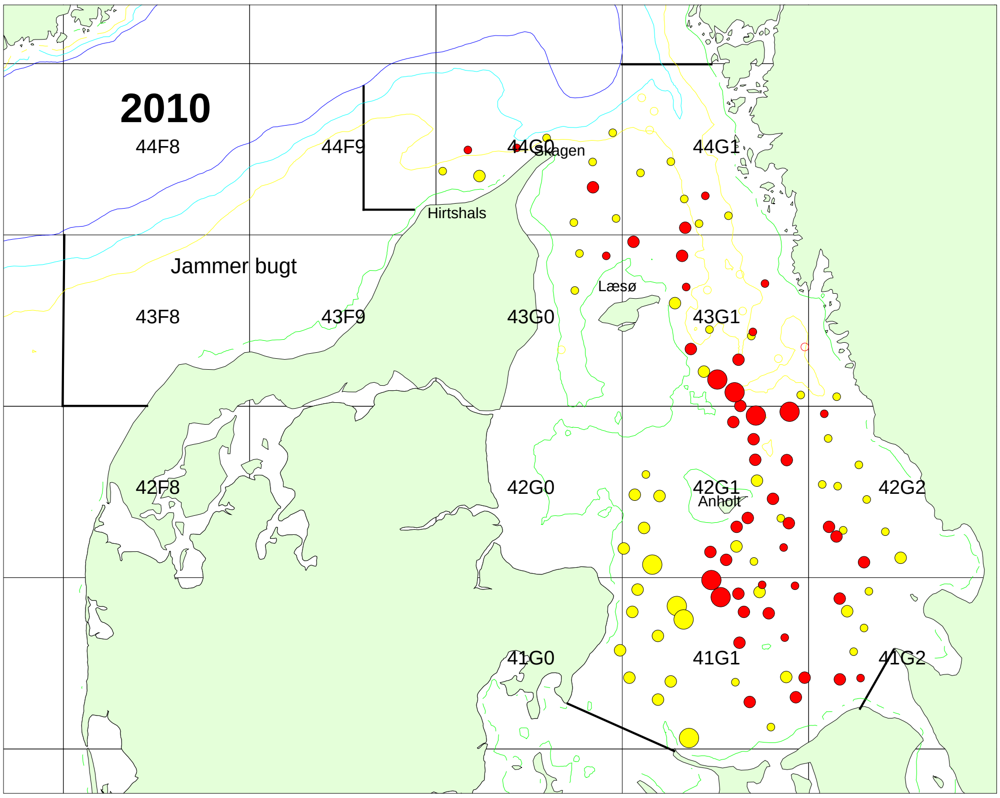


Fig. 3 cont. Catch of sole (kg per hour) 2008 and 2009. ● DTU AQUA stations ● Fishermen's stations.



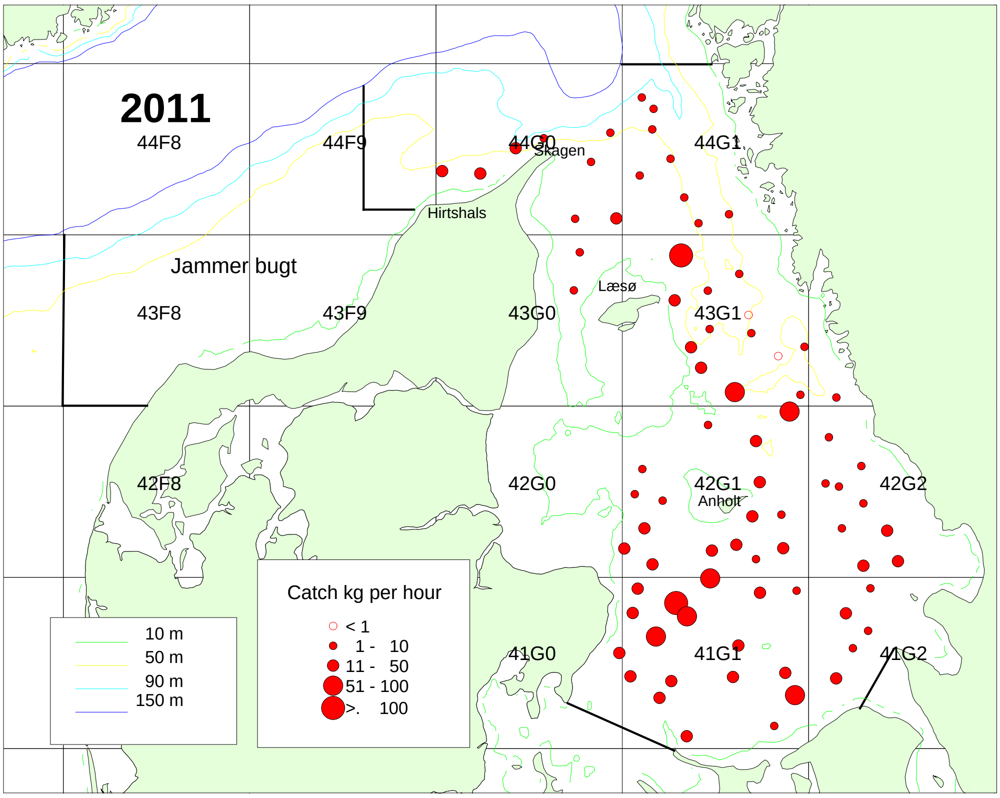


Fig.3 cont. Catch of sole (kg per hour) in 2010 and 2011. 2010 ● DTU AQUA stations ● Fishermen's stations.

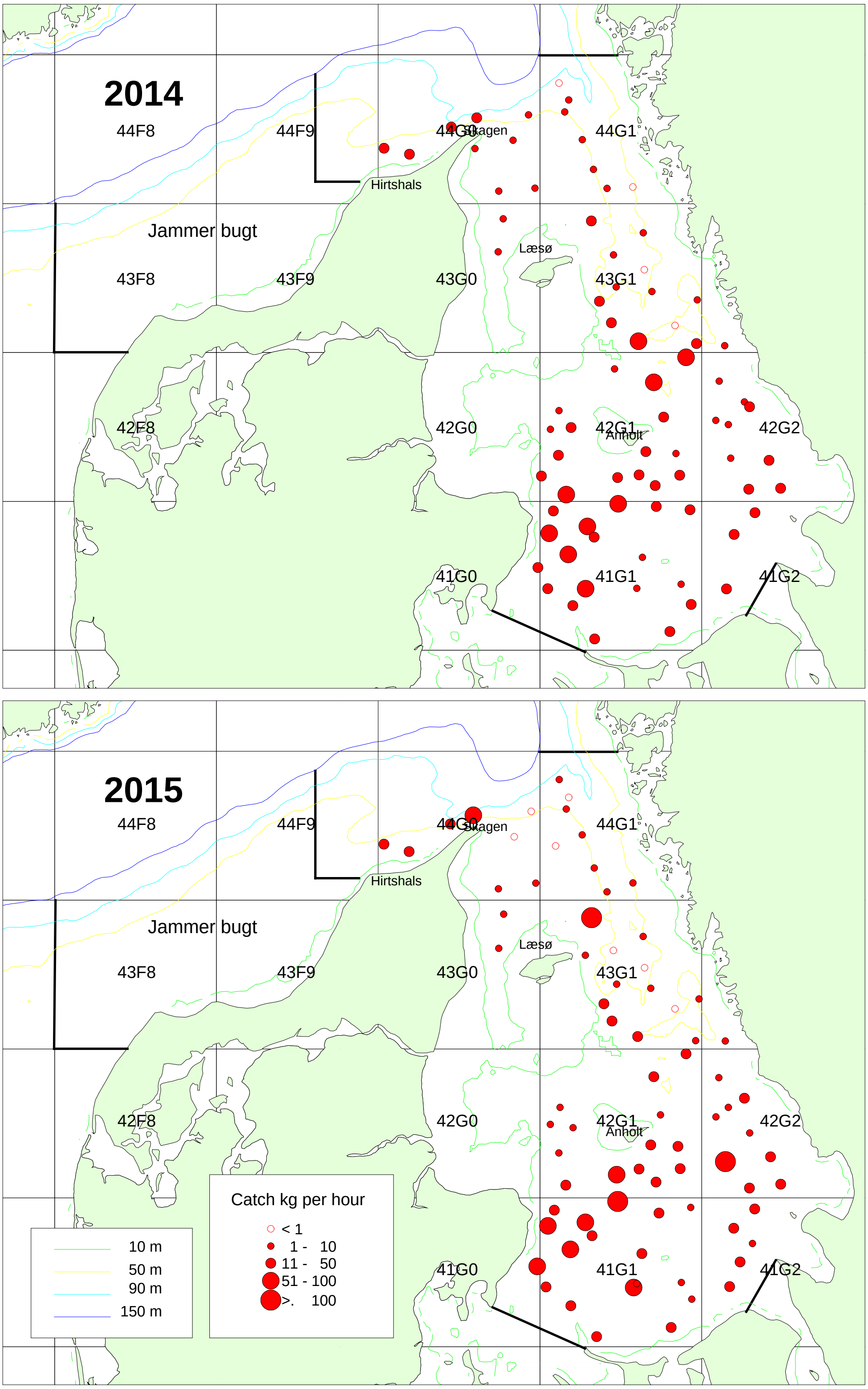


Fig. 3 cont. Catch of sole (kg per hour) in 2014 and 2015.

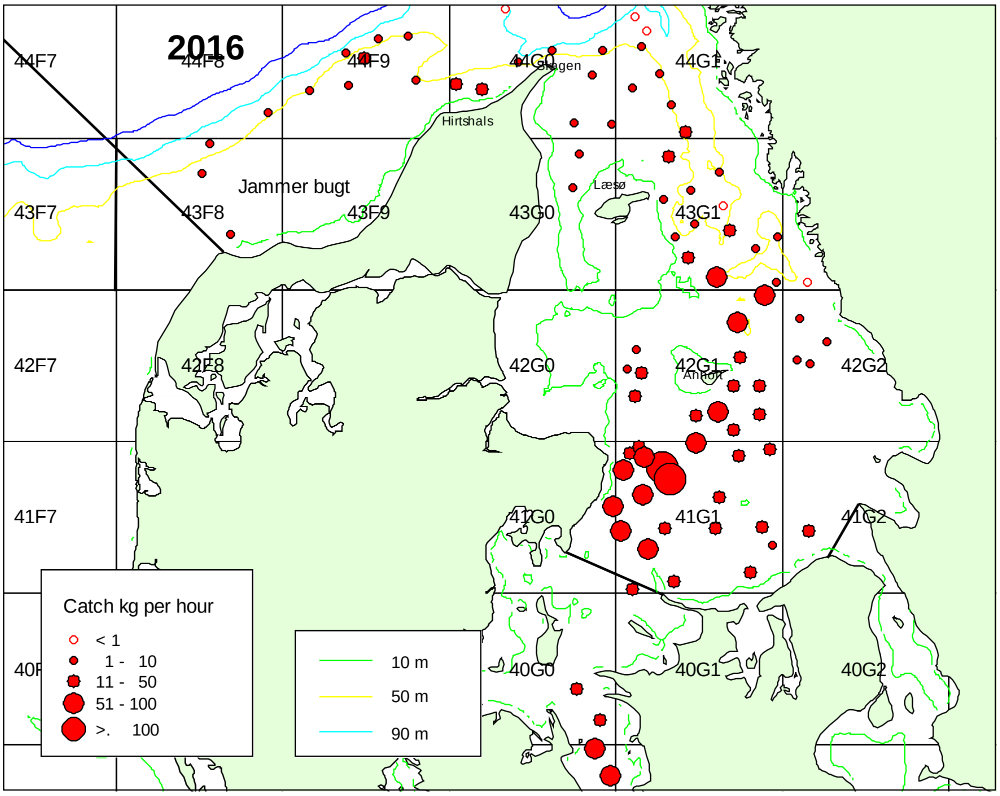


Fig. 3 cont. Catch of sole (kg per hour) in 2016.

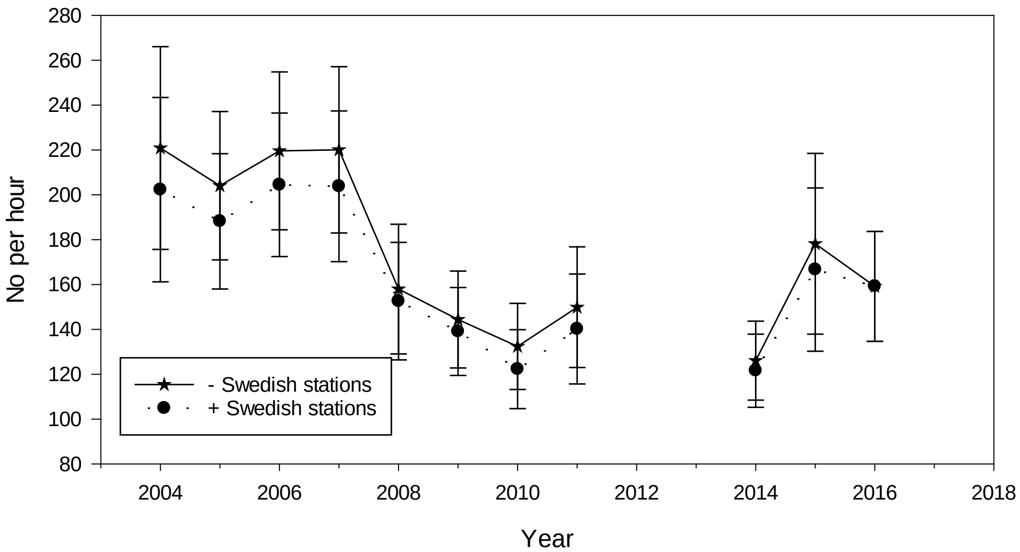


Fig. 4. Catch of sole in number per hour with and without Swedish stations, respectively, with 1* S.E.

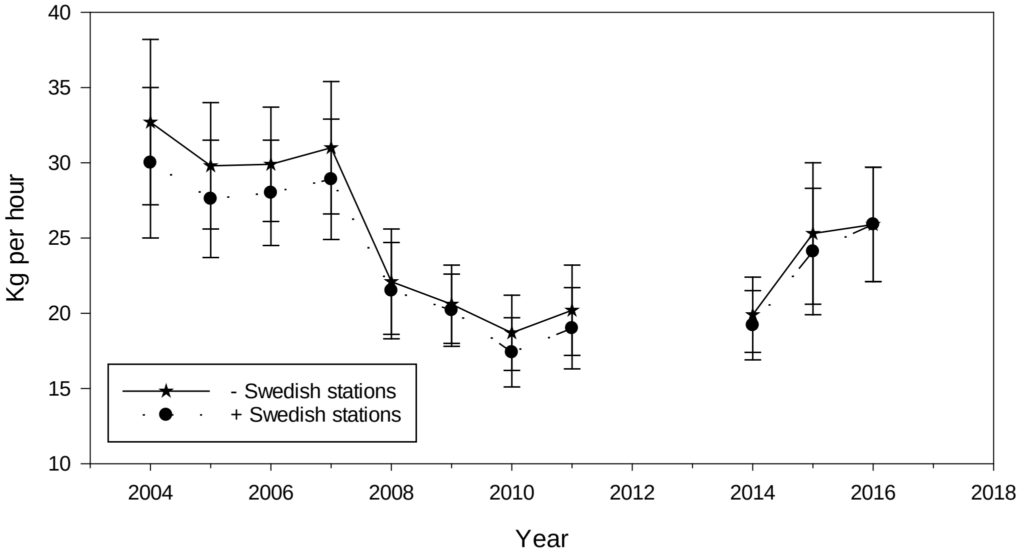


Fig. 5. Catch of sole in kg per hour based with and without Swedish stations with 1* S.E.

Length distribution

In 2016 the length ranged from 7 to 44 cm with a mode at 24 cm while the mode was at 23 cm in 2008-2015 (Fig. 6). In 2016 there were somewhat more fish > 26 cm than seen in 2008-2015. Prior to 2008 the mode was at 22 cm. The length distribution has not changed despite the reduction in stations.

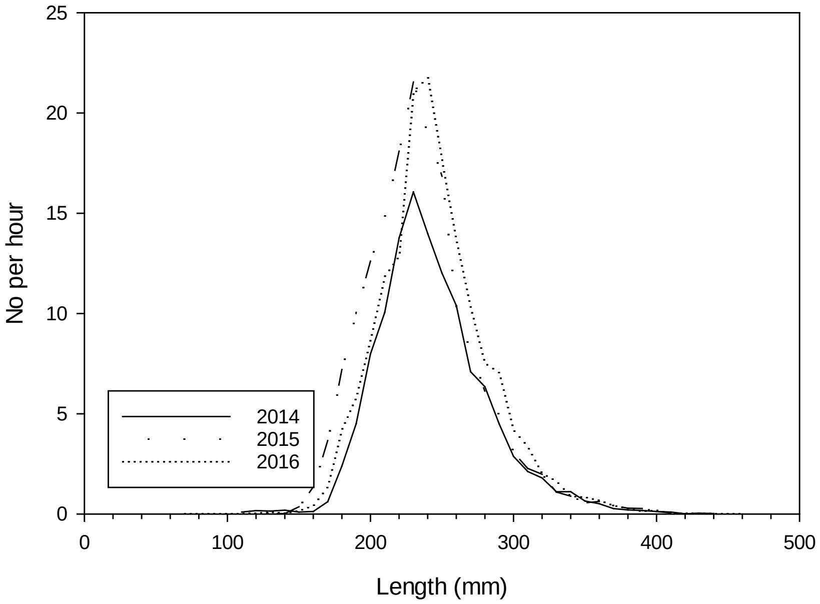


Fig. 6. Length distribution (mm) of sole standardized to number caught per hour in 2014 - 2016.

Biomass and abundance

The biomass of sole was estimated at 1635.4 in 2016 which is a slight decrease compared to 762.67 tons in 2015, which is an increase from 1499.7 tons in 2014 and the estimate is among the largest since 2007 but it is still approximately 25% below the level during 2005-2007 (Table 3).

Table 3. Swept area biomass and abundance of sole with 1* S.E. and number of hauls. Including 5 new stations from Jammerbugt in 2016.

Year	BIOMASS	SE_BM	ABUNDAN	SE_AB	Haul
2004	2391.5	363.4	15935791.3	2969937.0	68
2005	2201.8	284.4	14910144.9	2191447.5	77
2006	2300.8	245.4	16561209.2	2243489.8	78
2007	2254.2	263.3	15653952.9	2196027.4	75
2008	1717.5	215.0	12082628.3	1782711.1	80
2009	1676.0	175.8	11487877.7	1428147.2	78
2010	1379.8	145.0	9660045.5	1138982.9	79
2011	1471.6	193.6	10746623.2	1695182.3	80
2014	1499.7	170.6	9452928.7	1136106.2	77
2015	1762.6	296.2	12108682.6	2456275.6	78
2016	1635.4	233.4	9972025.3	1498233.9	74

The abundance decreased from 12.1 mill. in 2015 to 9.9 mill. in 2016 which is at the level seen since 2011 but still approximately 25% below the level seen during 2004-2010 level, although the difference is not statistically significant (95% level) (Table 3).

The largest total biomass and total abundance was found in ICES area 41G1 as in 2006 - 2015 (Fig. 3, Table 4), while the largest densities were found in Division 41G0. This estimate is, however, based on one haul only.

Table 4. Sole biomass 2016. Area, number of hauls, mean biomass per km^2 (tons), biomass (tons) and Standard Error distributed on ICES squares.

Div.	Area	Hauls	Mean sq km	Biomass	SE
41G0	329	1	0.3145	103.5	.
41G1	3357.6	19	0.2092	702.4	122.5
41G2	1421.2	1	0.0900	127.9	.
42G1	3039.6	13	0.1394	423.7	90.7
42G2	2003.8	4	0.0155	31.1	10.1
43G0	721.5	5	0.0230	16.6	3.7
43G1	2460.9	13	0.0574	141.2	56.9
43G2	331.3	1	0.0012	0.4	.
44G0	1881.5	10	0.0349	65.6	27.2
44G1	1914.9	7	0.0120	22.9	10.5
All			0.0937	1635.4	233.4

Table 5. Sole abundance, 2016. Area, number of hauls, mean abundance per km^2, abundance and Standard Error distributed on ICES squares.

Div.	Area	Hauls	Mean sq km	Abundace	SE
41G0	329	1	1900.6	625313.2	.
41G1	3357.6	19	1301.1	4368480.3	798037.1
41G2	1421.2	1	540.0	767386.6	.
42G1	3039.6	13	864.6	2627961.9	677532.8
42G2	2003.8	4	54.7	109646.6	44017.6
43G0	721.5	5	84.7	61075.6	14560.4
43G1	2460.9	13	384.5	946315.5	383502.5
43G2	331.3	1	15.4	5111.1	.
44G0	1881.5	10	162.4	305471.9	120279.4
44G1	1914.9	7	81.1	155262.8	71939.4
All			571.0	9972025.3	1498233.9

Cod.

In 2016 cod was caught at all the 69 stations (Fig. 8).

CPUE

The CPUE of cod increase between 2010 and 2011 from 26.0 to 190.9 specimens and 4.5 kg to 27.0 kg per hour, respectively (Table 6, Fig. 9 and 10). The increase, especially in weight, was, however, to a large extent driven by one large catch (st. 26: 4720.9 specimens, 1368.6 kg). If this station is exclude from the analysis the CPUE increased (statistically insignificant, 95% level) from 4.5 to 10.1 kg per hour while CPUE in numbers increased from 26.0 to 133.6 specimens per hour (statistically significant, 95% level). The CPUE in numbers decreased in 2014 to 57.1 hr^{-1} and further to 39 hr^{-1} in 2015 while the CPUE in weight increased to 31.0 kg hr^{-1} in 2014 and further to 38.5 kg hr^{-1} in 2015, which is the largest estimates in the time series. The CPUE in weight decreased slightly in 2016 to 32 kg hr^{-1} while the CPUE in number increased to 86.3 specimens hr^{-1}, which is among the highest in the time series and indicate relatively good recruitment (Fig. 9 and 10).

Table 6. CPUE of cod by year in number and kg and number per hour with S.E and number of valid hauls.

Year	Number	SE Number	Weight	SE Weight	n
2004	43.5	7.3	15.9	3.1	69
2005	37.5	3.7	13.0	1.6	78
2006	53.6	11.8	16.9	2.4	76
2007	21.7	4.4	7.4	1.1	75
2008	28.7	5.2	5.5	0.7	80
2009	45.1	13.9	8.6	1.7	78
2010	26.0	4.4	4.5	0.6	79
2011	190.9	63.3	27.0	17.0	80
2011*	133.6	27.1	10.1	9.8	79
2014	57.1	9.9	31.0	5.4	77
2015	39.0	3.9	38.5	4.5	78
2016	86.3	21.8	32.0	3.2	69

* Excluding one large haul on 1368 kg.

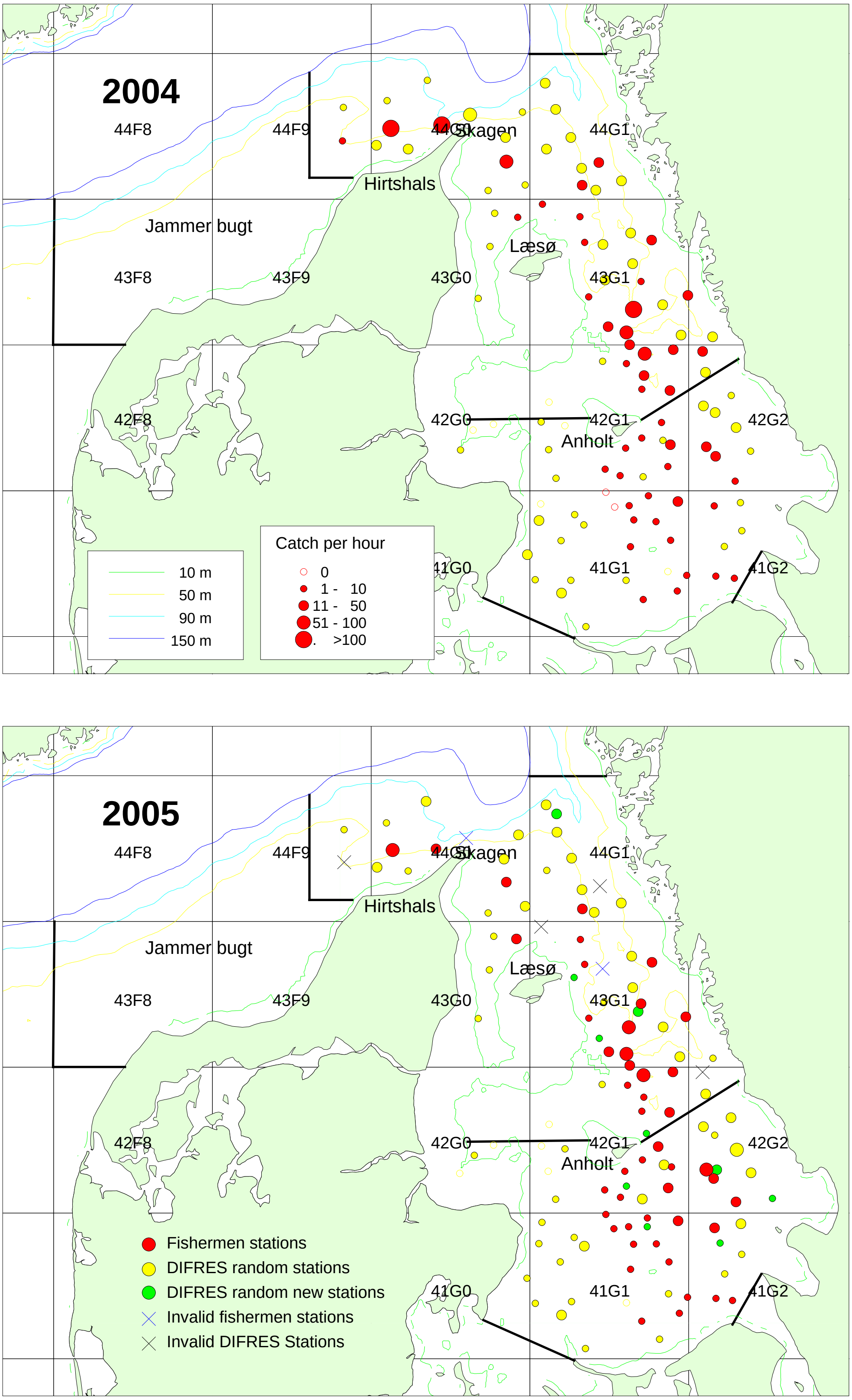


Fig. 8. Catch of cod (kg per hour) in 2004 and 2005. ● DTU AQUA stations ● Fishermen's stations.

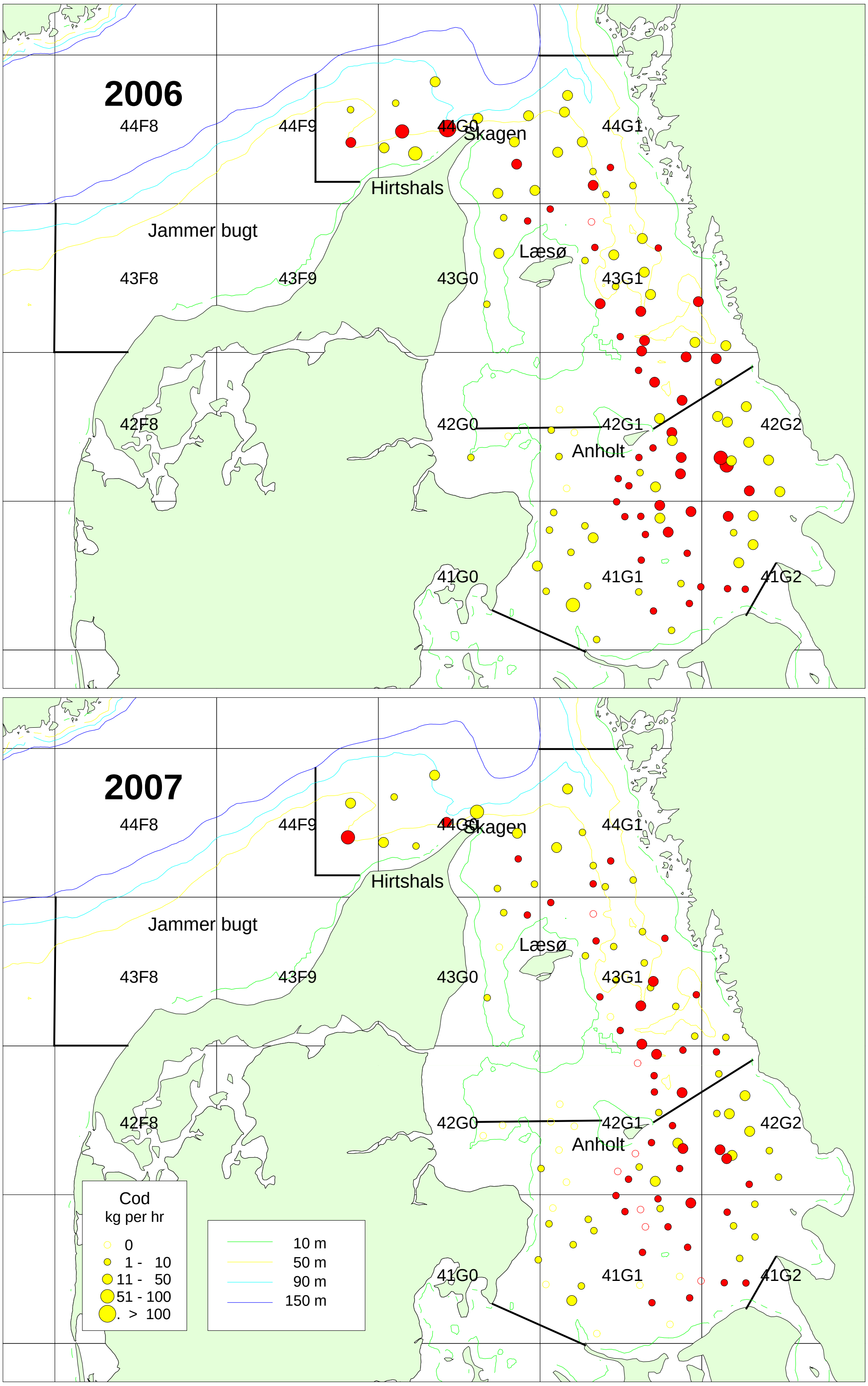


Fig. 8 cont. Catch of cod (kg per hour) in 2006 - 2007. ● DTU AQUA stations ● Fishermen's stations.

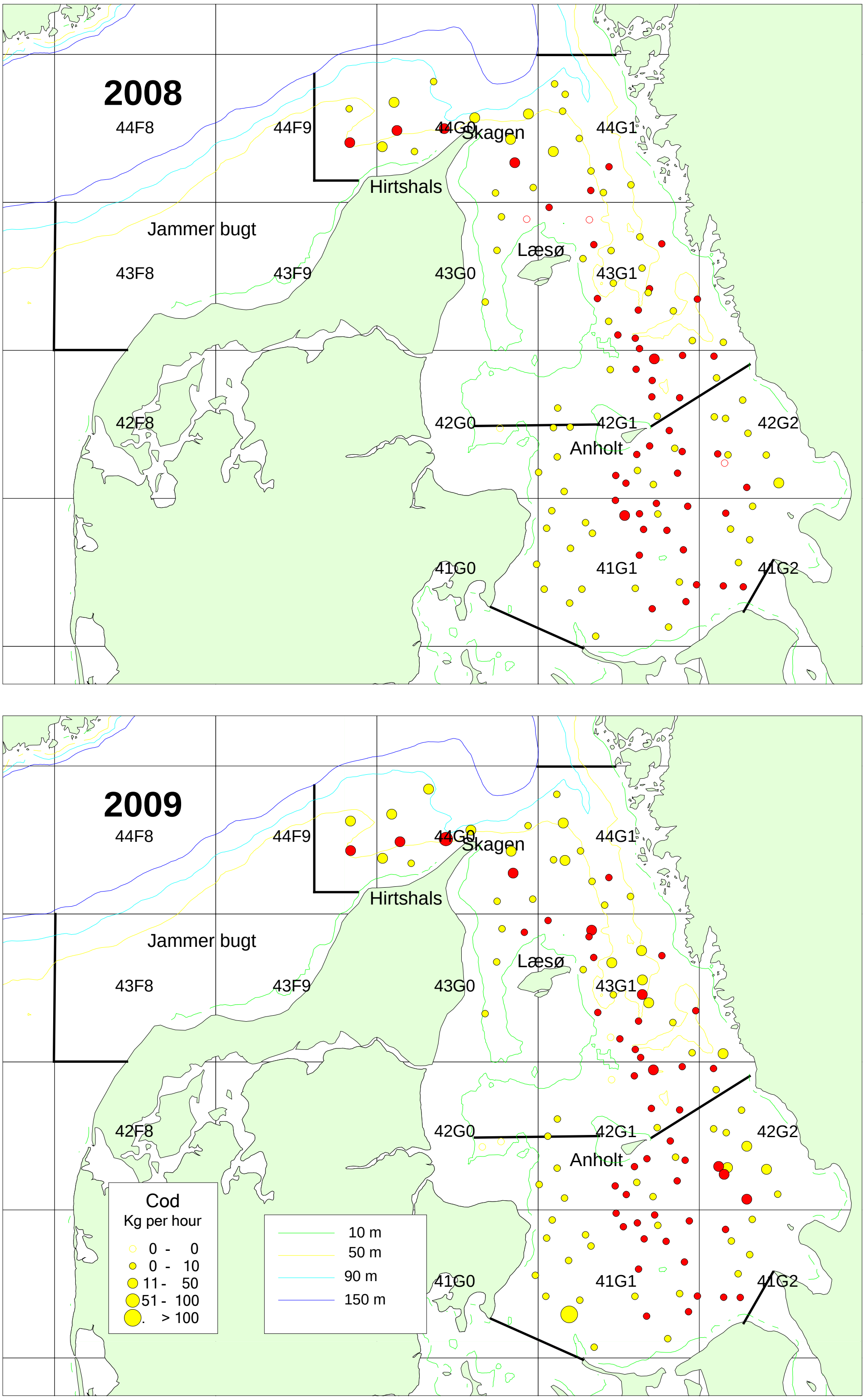
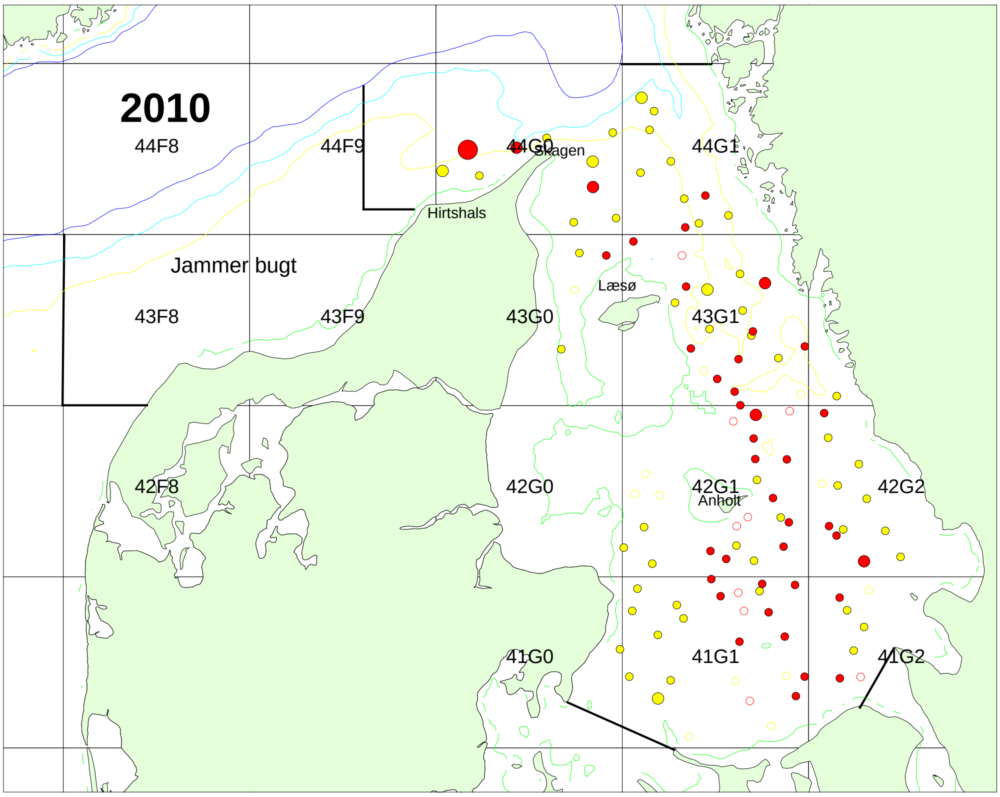


Fig. 8 cont.. Catch of cod (kg per hour) in 2008 and 2009. ● DTU AQUA stations ● Fishermen's stations.



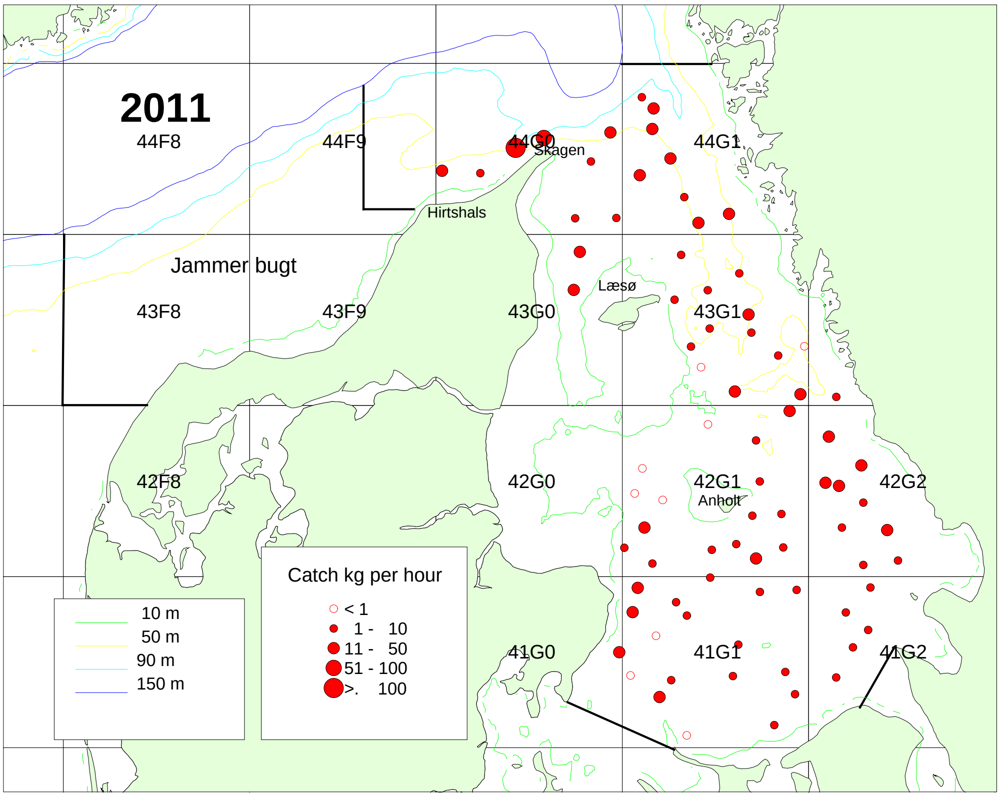
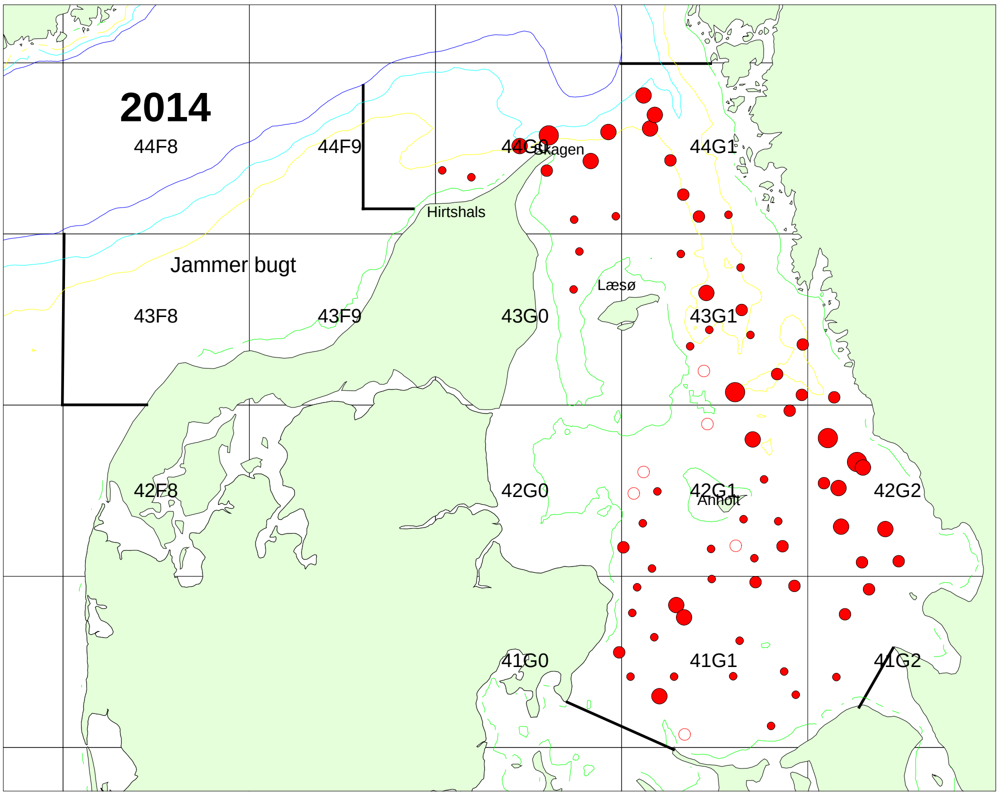


Fig. 8 cont.. Catch of cod (kg per hour) in 2010 and 2011. ● DTU AQUA stations ● Fishermen's stations.



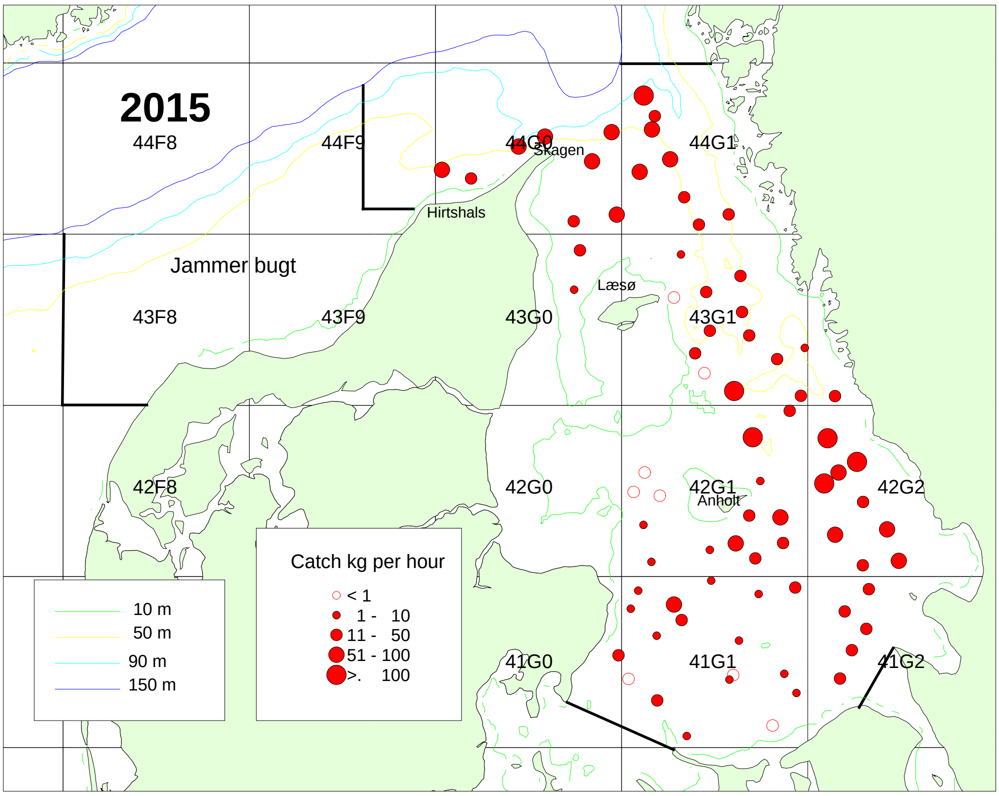


Fig. 8 cont. Catch of cod (kg per hour) in 2014 and 2015.

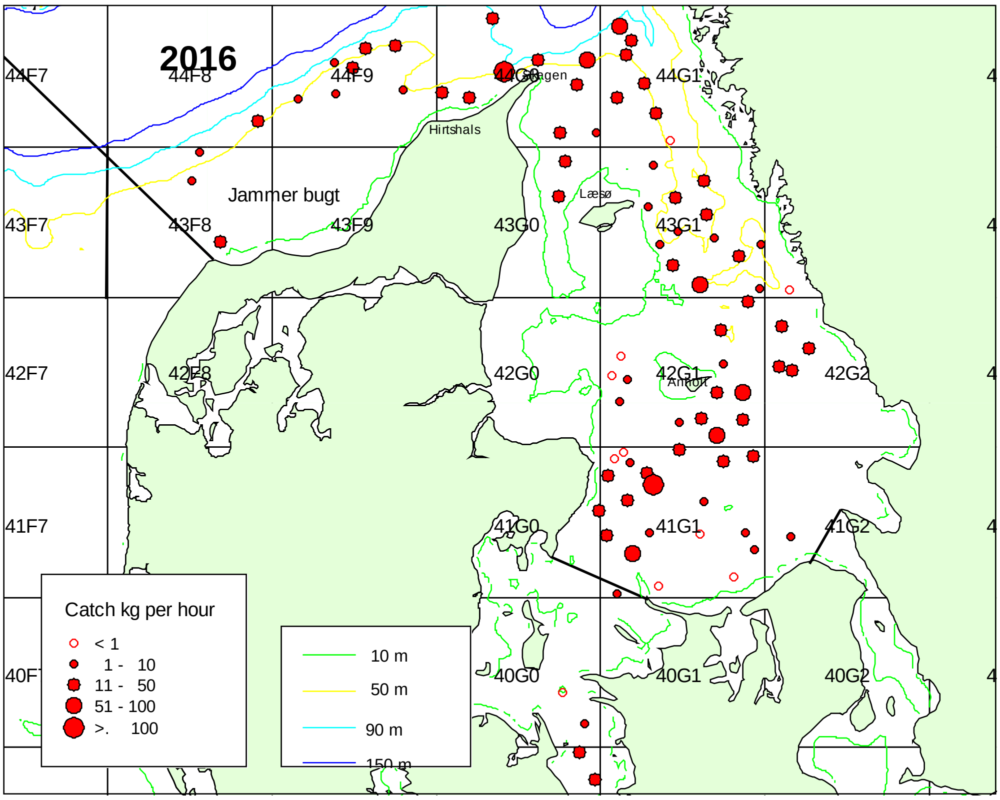


Fig. 8 cont. Catch of cod (kg per hour) in 2016.

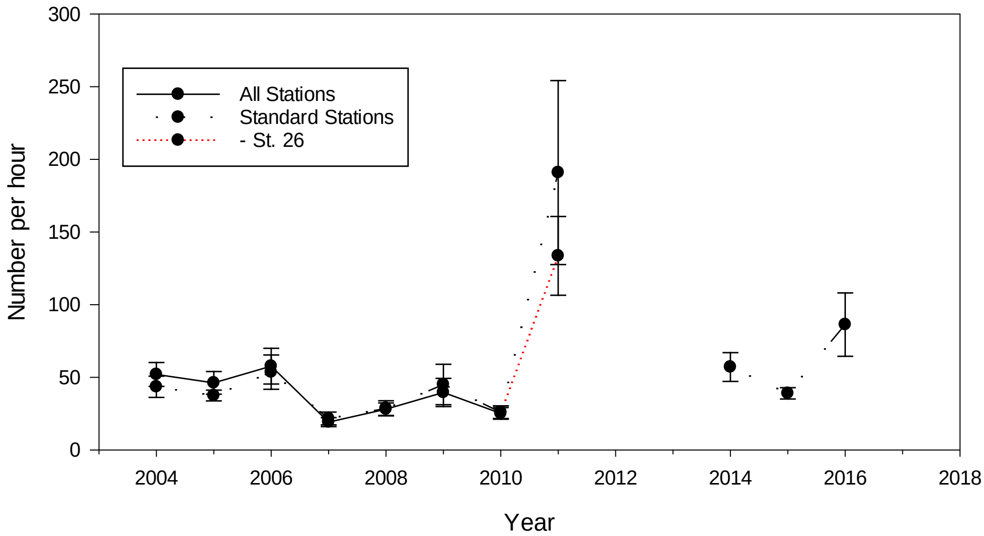


Fig. 9. Catch of cod in number per hour based on 116 and Standard Stations, respectively, with 1* S.E. – St 26 excludes one large catch in 2011.

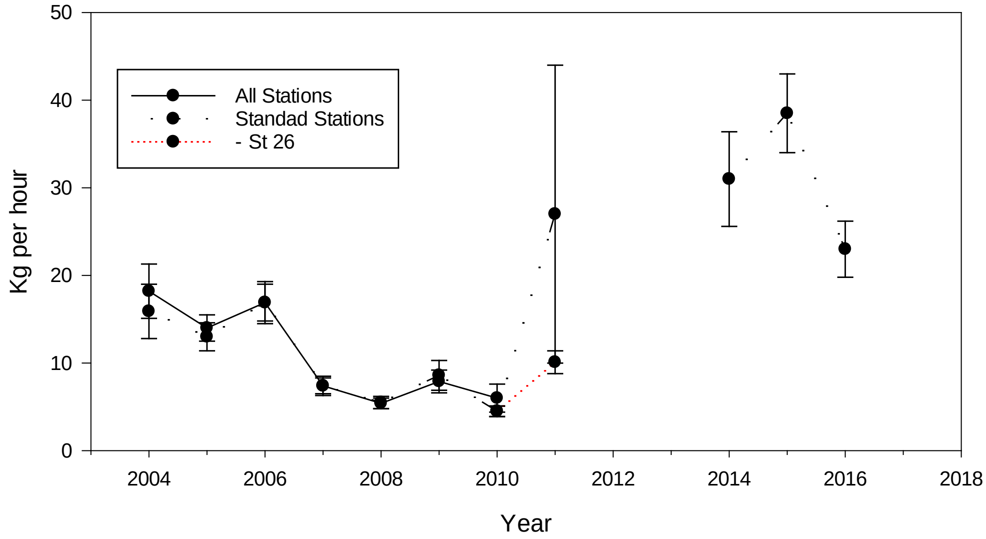


Fig. 10. Catch of cod in kg per hour based on 116 and standard stations, respectively, with 1* S.E. – St 26 excludes one large catch in 2011.

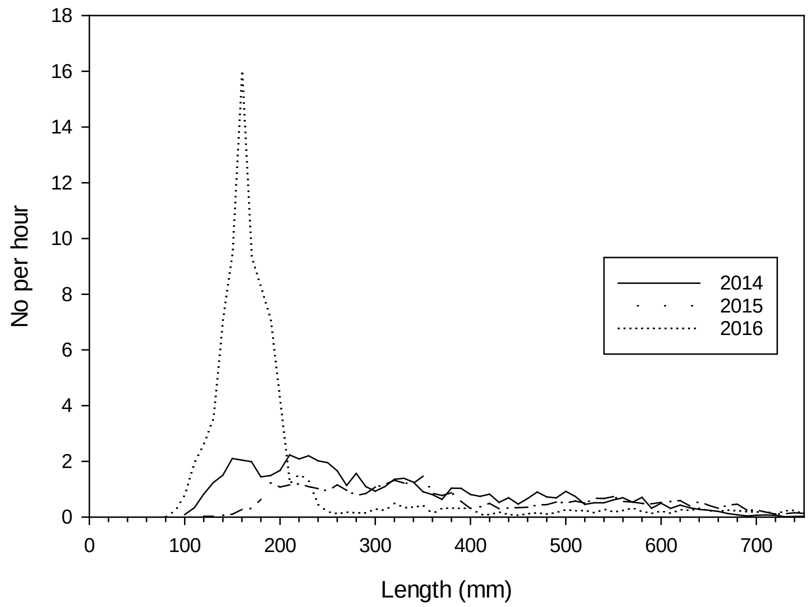


Fig 11. Length distribution of cod standardized to number caught hour^{-1}.

Length distribution

The length ranged from 8 78 cm with a clear mode at 16 cm indicating relatively good recruitment but there are few fish > 21 cm (Fig. 11).

Biomass and abundance

The biomass of cod increased from record low 373.8 tons in 2010 to record high 2308.1 tons in 2011. A similar increase was seen for the abundance from 2.1 mill. to 16.4 mill. (Table 8). The increase in both biomass and abundance was to a large extent driven by the large catch at st. 26. This station is located in Division 44G0 where about ¾ of the biomass and ½ abundance was located (Table 9 and 10), but there was seen an increase in both biomass and abundance in all

Divisions between 2010 and 2011. The biomass remained at the 2011 level in 2014 (2538.6 tons) and 2015 (2812.2 tons) but declined to 1497. 3 tons in 2016, while the abundance almost doubled between 2015 and 2016 to 5.4 mill. (Table 8). The highest biomass was found in 41G1 while highest density in kg was found in 44GO while the highest abundance was found in 41G1(Table 9 and 10).

Table 8. Swept area biomass and abundance of cod with 1* S.E. and number of hauls. Including 5 new stations from Jammerbugt in 2016.

Year	BIOMASS	SE_BM	ABUNDAN	SE_AB	Haul
2004	1479.9	284.2	4021655.9	688225.4	68
2005	1106.7	111.0	3279389.4	294383.8	77
2006	1418.6	161.4	4527585.5	864192.6	78
2007	677.2	92.0	2144422.9	311316.0	75
2008	469.6	50.7	2483771.1	410041.5	80
2009	723.0	133.8	3874034.2	1051067.6	78
2010	373.8	50.1	2096501.5	296055.9	79
2011	2308.1	1465.7	16417225.3	5076904.6	80
2014	2538.6	397.4	4711426.1	755373.0	77
2015	2812.2	261.4	2883636.9	249315.9	78
2016	1497.3	186.7	5483120.6	1225055.4	74

Table 9. Cod 2016. Area, number of hauls, mean biomass per km^2 (tons), biomass (tons) and Standard Error distributed on ICES squares.

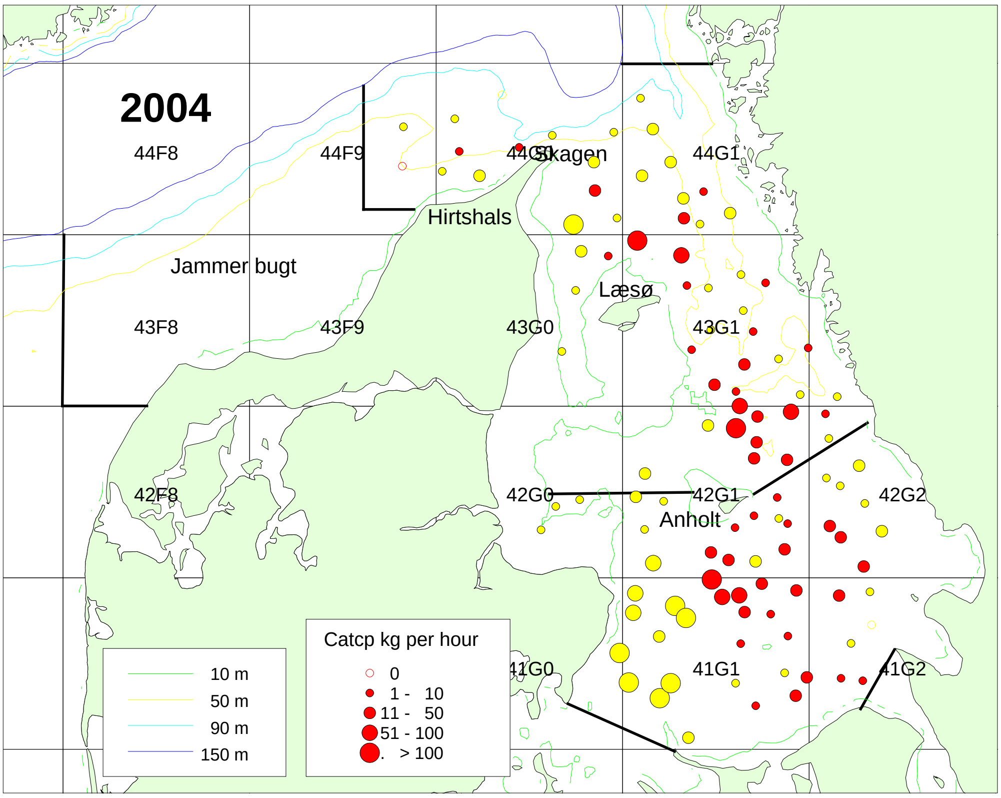
Div.	Area	Hauls	Mean sq km	Biomass	SE
41G0	329	1	0.0674	22.2	.
41G1	3357.6	19	0.0898	301.5	104.9
41G2	1421.2	1	0.0118	16.8	.
42G1	3039.6	13	0.0833	253.3	68.6
42G2	2003.8	4	0.1061	212.5	49.8
43G0	721.5	5	0.0620	44.8	18.3
43G1	2460.9	13	0.0715	176.0	51.6
43G2	331.3	1	0.0032	1.0	.
44G0	1881.5	10	0.1384	260.4	73.9
44G1	1914.9	7	0.1091	208.9	86.1
All			0.0857	1497.3	186.7

Table 10. Cod 2016. Area, number of hauls, mean abundance per km^2, abundance and Standard Error distributed on ICES squares.

Div.	Area	Hauls	Mean sq km	Abundace	SE
41G0	329	1	1071.3	352449.2	.
41G1	3357.6	19	517.7	1738087.7	1066475.8
41G2	1421.2	1	216.0	306954.6	.
42G1	3039.6	13	367.1	1115846.2	304462.8
42G2	2003.8	4	71.5	143370.9	8791.3
43G0	721.5	5	364.0	262619.6	100355.7
43G1	2460.9	13	174.1	428382.0	129311.3
43G2	331.3	1	30.9	10222.2	.
44G0	1881.5	10	370.3	696813.4	145476.7
44G1	1914.9	7	223.7	428374.7	64132.2
All			314.0	5483120.6	1225055.4

Plaice

In 2016 plaice were caught at all 69 valid stations (Fig. 12). The largest catches were generally taken east of Djursland.



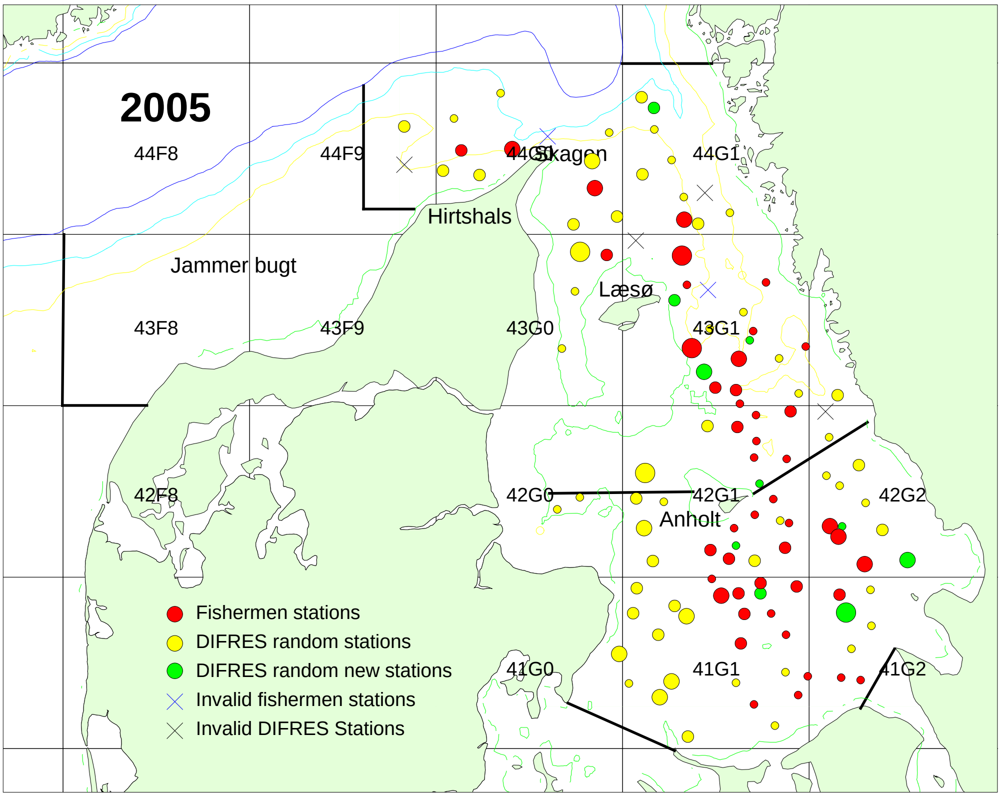
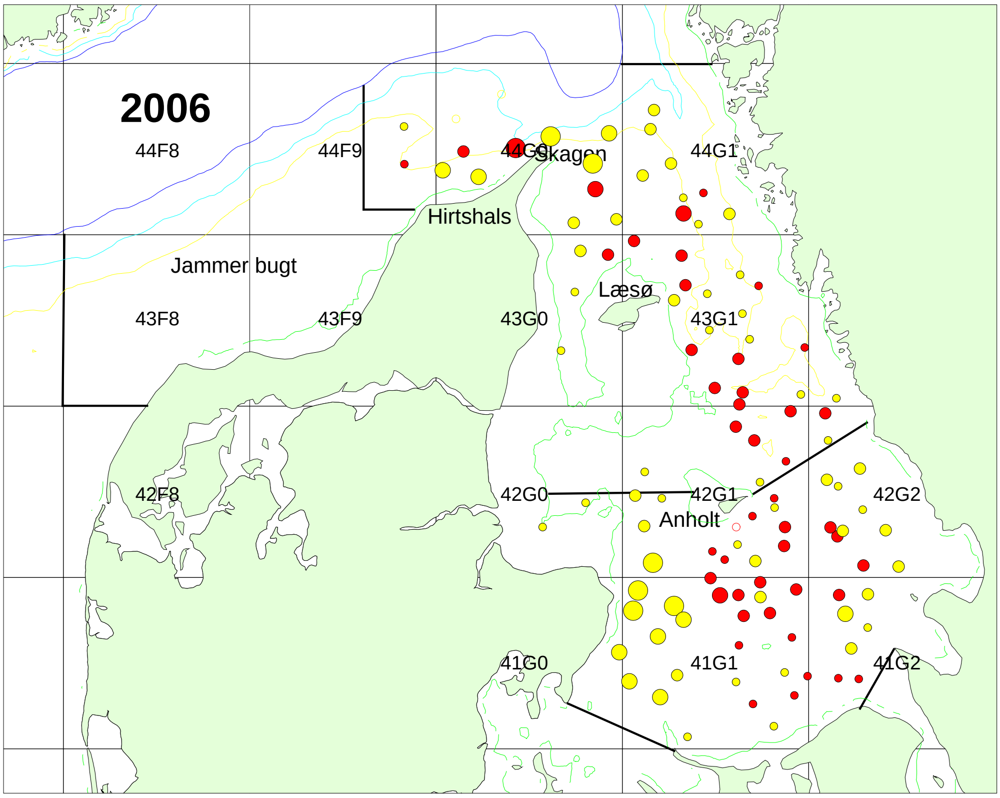


Fig. 12. Catch of plaice (kg per hour) in 2004 and 2005. ● DTU AQUA stations ● Fishermen's stations.



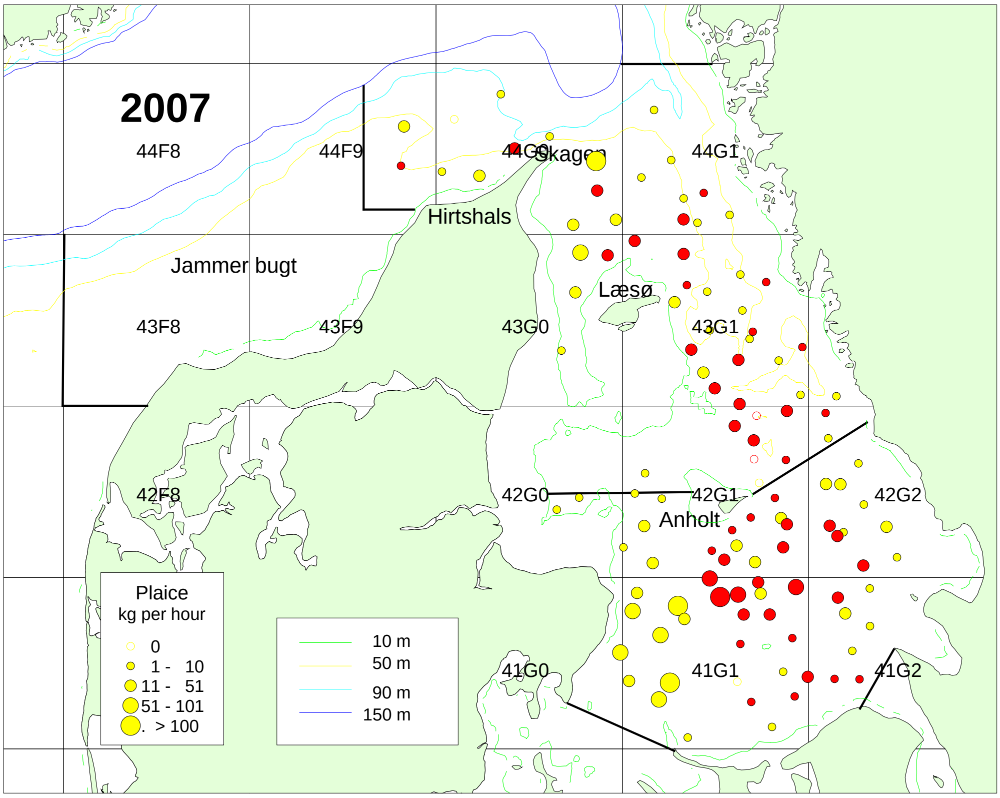


Fig. 12 cont.. Catch of plaice (kg per hour) in 2006 - 2007. ● DTU AQUA stations ● Fishermen's stations.

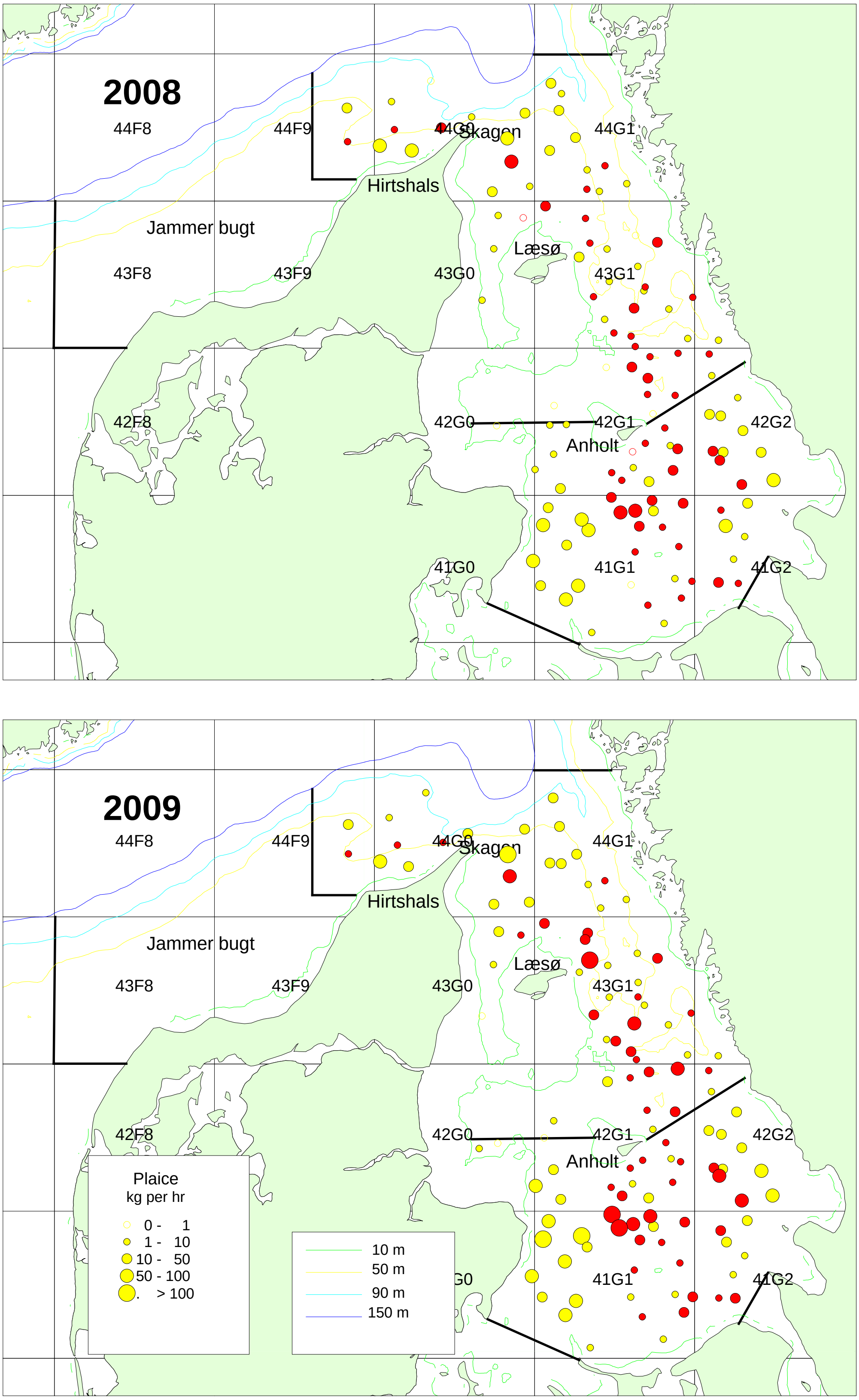


Fig. 12 cont.. Catch of plaice (kg per hour) in 2008 and 2009. ● DTU AQUA stations ● Fishermen's stations.

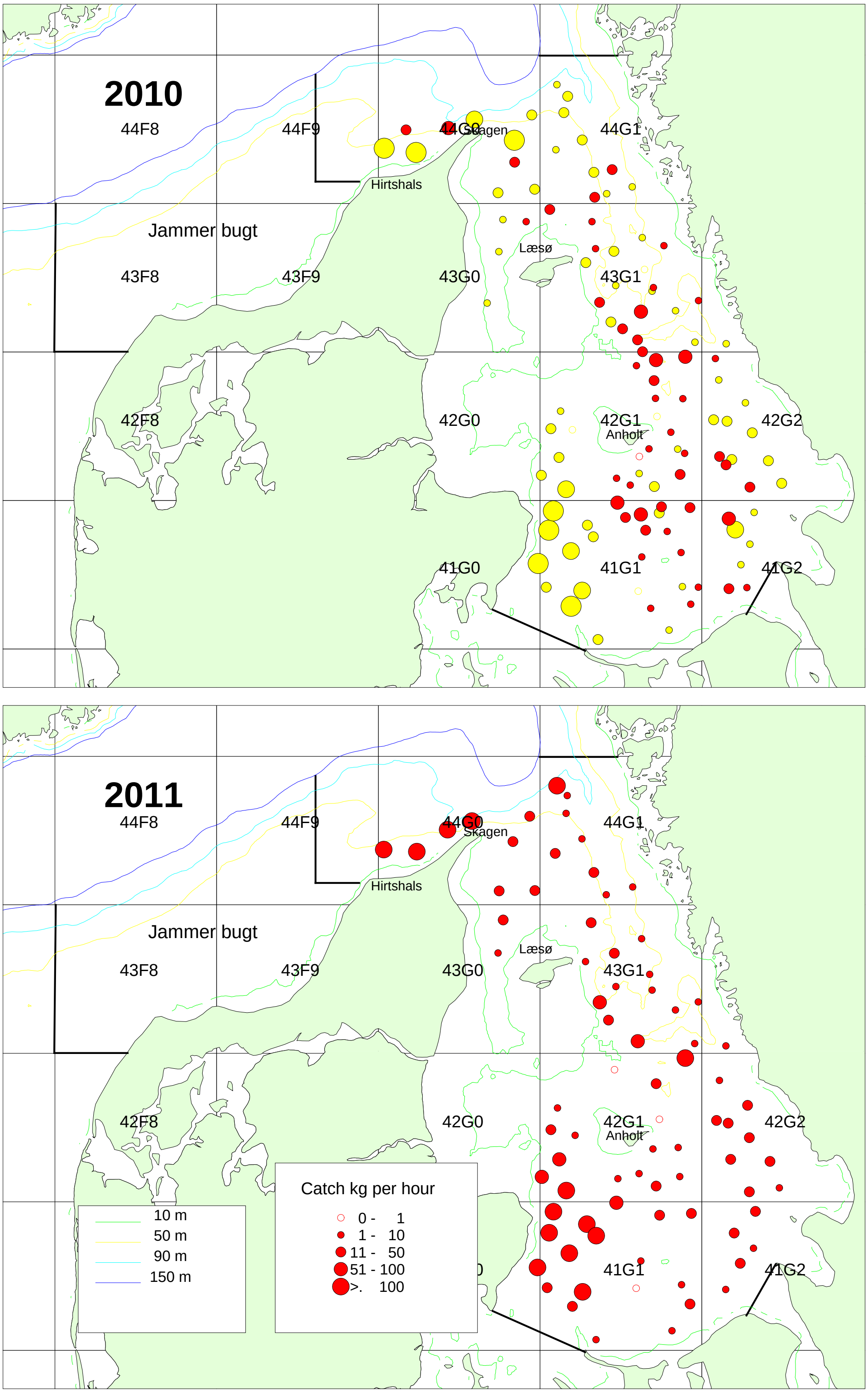
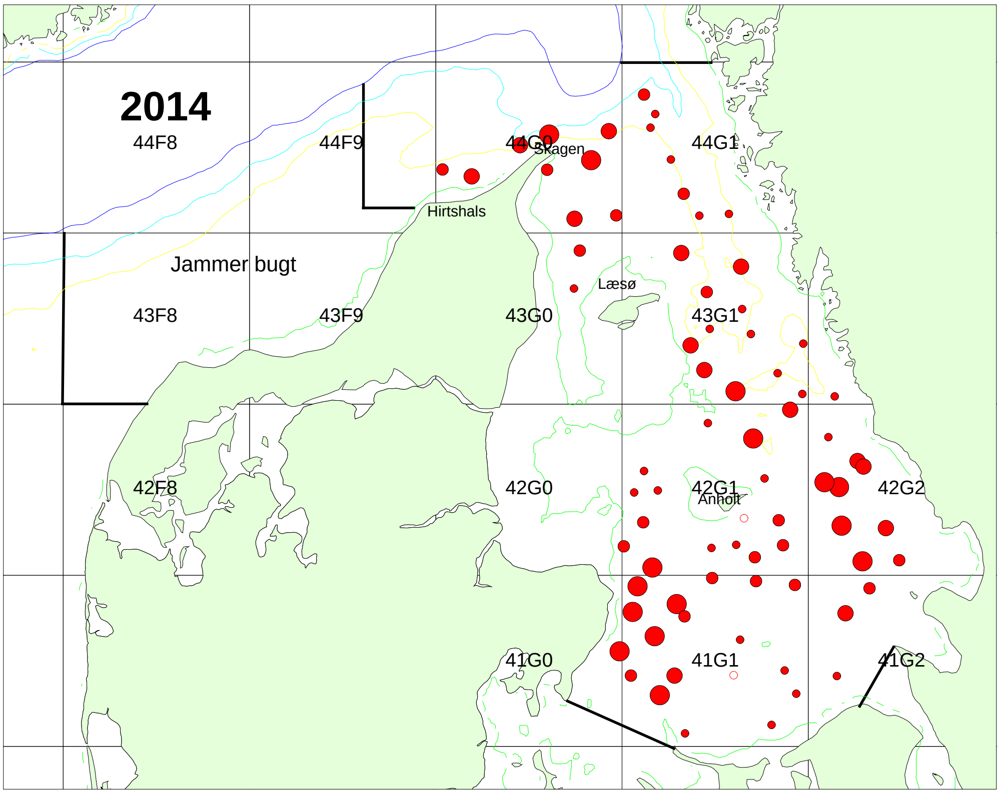


Fig. 12 cont.. Catch of plaice (kg per hour) in 2010 and 2011. 2010 ● DTU AQUA stations ● Fishermen's stations.



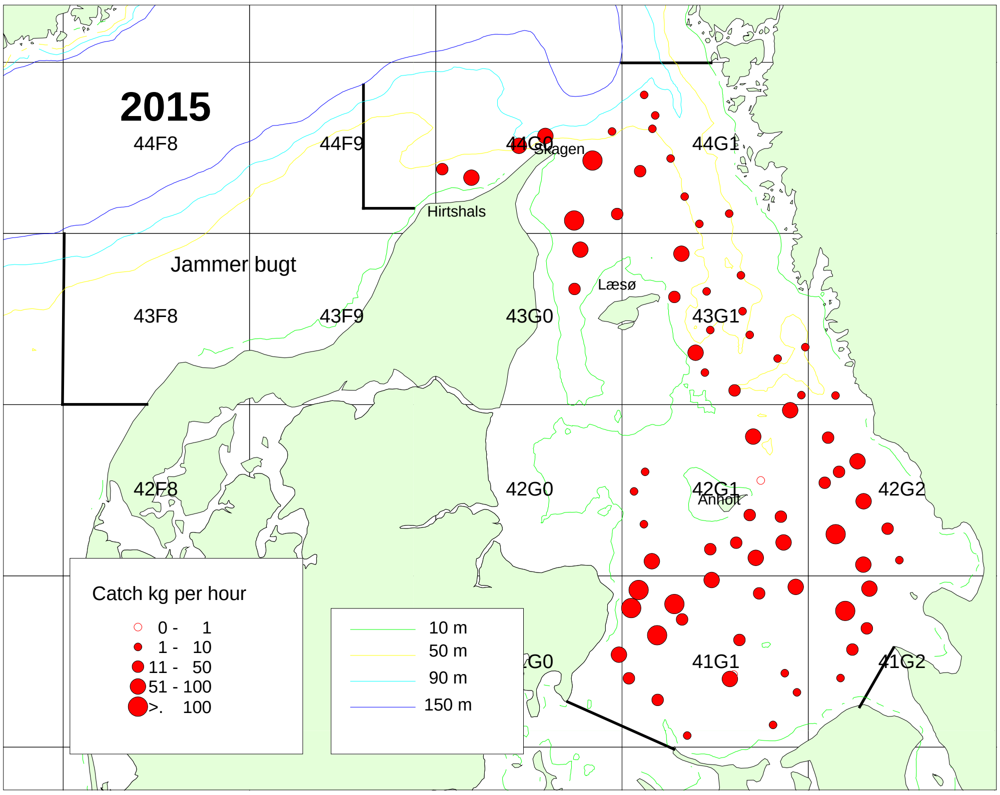


Fig. 12 cont.. Catch of plaice (kg per hour) in 2014 and 2015.

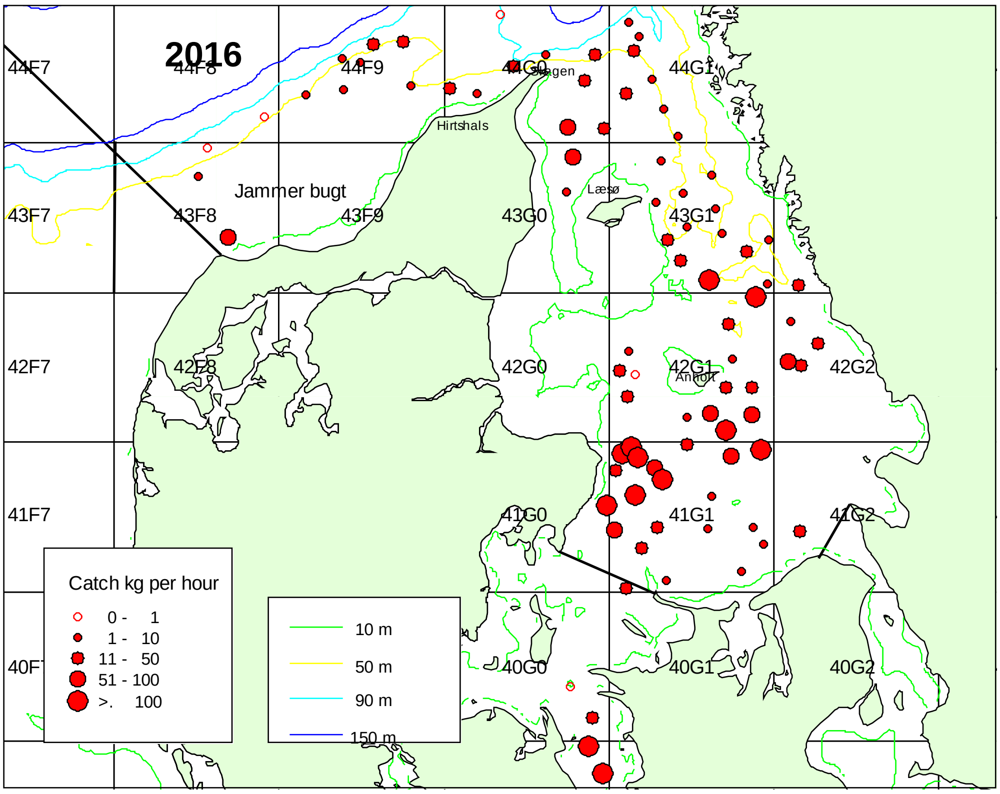


Fig. 12 cont.. Catch of plaice (kg per hour) in 2016.

CPUE

CPUE of plaice was relatively stable between 2004 and 2006 but decreased between 2006 and 2007. Since 2008 the CPUE has been gradually increasing and was 70.2 kg hour^{-1} and 449.5 specimens hour^{-1} in 2011, which is the highest level in the time series (Table 11, Fig. 13 and 14). The increase in CPUE was, however, to some extend driven by one large haul (st. 26 1546.2 kg / 5413.8 specimens). If that haul is excluded the CPUE was 51.5 kg and 386.7 specimens, respectively, which is still the highest in the time series. In 2014 the CPUE in numbers decreased compared to 2011 while the CPUE in weight increased. The CPUE in numbers and weight decreased in 2015 to 221 hr $^{-1}$ and 45.4 kg hr $^{-1}$ to a level slightly above average for the time series. The CPUE both in number and weight increased again in 2016 to the second largest level to 353.3 hr $^{-1}$ and 66.2 kg hr $^{-1}$ (Table 11 and Fig. 13-14).

Table 11. CPUE of plaice by year in number and kg per hour with S.E and number of valid hauls.

Year	Number	SE Number	Weight	SE Weight	n
2004	206.5	41.6	32.1	5.9	69
2005	213.1	41.1	30.6	4.8	78
2006	224.6	47.3	42.3	9.7	76
2007	139.0	25.2	24.5	4.4	75
2008	151.9	31.8	28.0	7.3	80
2009	209.7	33.5	29.5	4.5	78
2010	267.1	65.1	43.8	14.2	79
2011	449.5	100.0	70.2	21.0	80
2011	386.7*	78.9	51.5	9.9	79
2014	296.2	49.3	58.4	9.0	77
2015	221.9	42.7	45.4	7.0	77
2016	353.3	94.2	66.2	15.4	69

*Excluding one large haul.

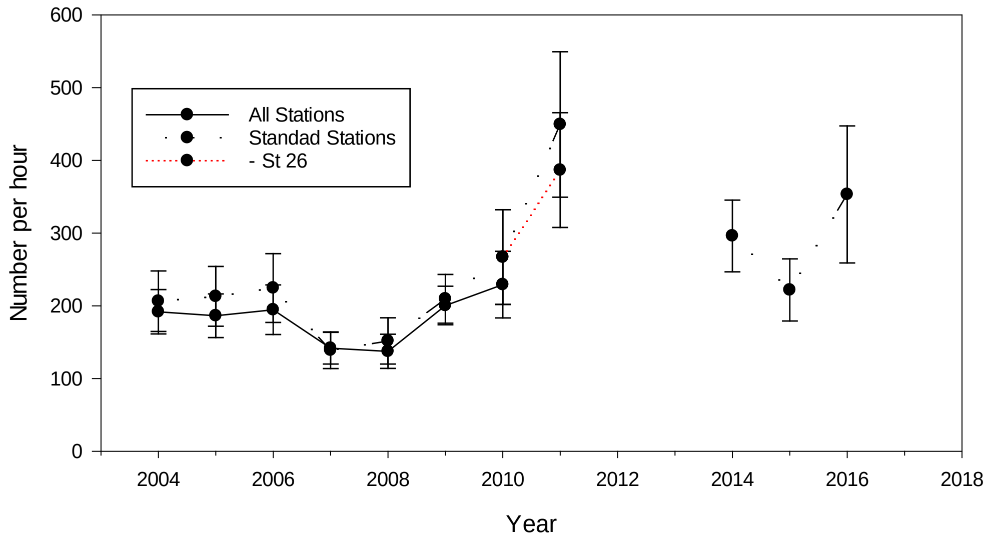


Fig. 13. Catch of plaice in number per hour based on 116 and standard Stations, respectively, with 1* S.E. – St 26 excludes one large catch in 2011.

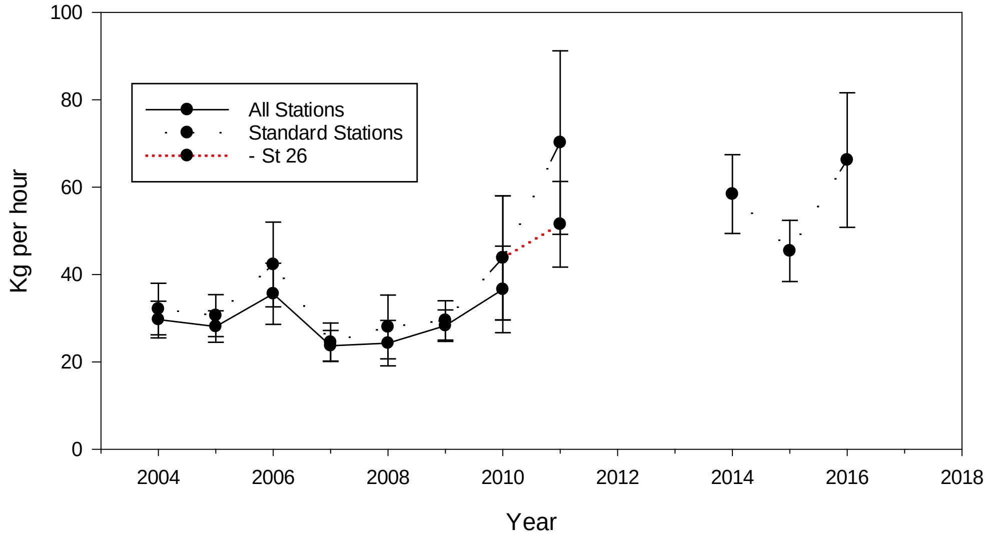


Fig. 14 Catch of plaice in kg per hour based on 116 and standard stations, respectively, with 1* S.E. – St 26 excludes one large catch in 2011.

Length distribution

The length ranged from 12 to 50 cm in 2016. Most of the plaice were between 20 and 30 cm with a mode at 24 cm and there were generally few fish > 30 cm as in previous years (Fig. 15).

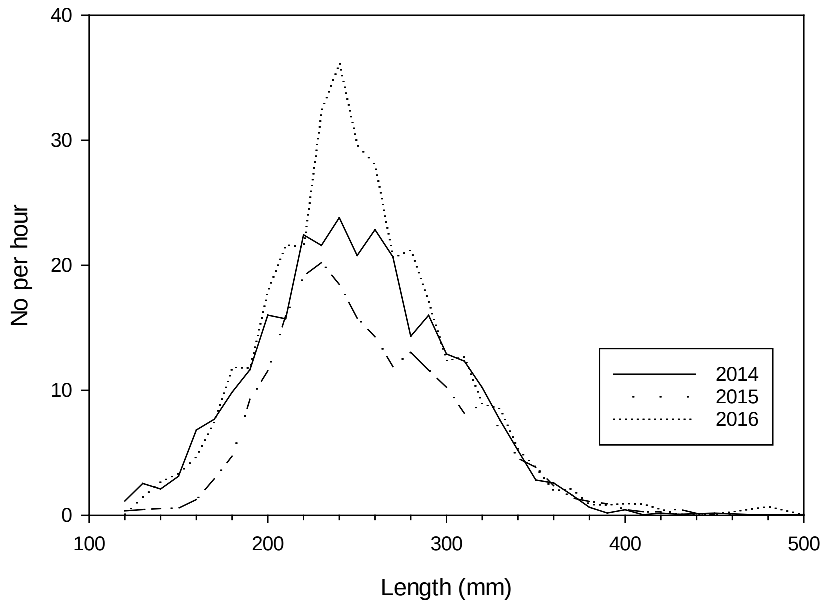


Fig. 15. Length distribution (mm) of plaice standardized to number caught per hour.

Biomass and abundance

The biomass of plaice was in 2011 estimated at 5813.8 tons which was the highest level observed. The biomass has decreased gradually since the and was in 2015 3387.3 tons which is close to the average of the time series. The biomass d increased again in 2016 to 4336.5 tons (Table 12). The largest biomass and highest density was found in 41G as in previous years (Table 13).

Table 12. Swept area biomass and abundance of plaice with 1* S.E. and number of hauls. Including 5 new stations from Jammerbugt in 2016.

Year	BIOMASS	SE BM	ABUNDAN	SE AB	Haul
2004	2532.7	408.7	16162955.2	2826347.1	68
2005	2751.5	477.3	19585025.6	3976342.1	77
2006	3533.3	702.5	18873722.8	3621595.3	78
2007	2008.0	329.9	11296519.2	1819460.1	75
2008	2356.3	571.6	13296773.3	2744645.7	80
2009	2494.1	359.3	17794393.5	2653356.0	78
2010	3766.7	1172.5	22864506.7	5303737.9	79
2011	5813.8	1696.4	37275267.2	7769397.6	80
2014	4689.7	719.6	23654483.8	3832580.1	77
2015	3387.3	495.9	16536570.9	2943734.2	77
2016	4336.5	1084.2	23217565.1	6852968.8	74

The abundance was estimated at 32.3 mill. in 2011 but has been declining gradually since the to 16. 5 mill which is slightly below the average for the time series. The abundance increased again in 2016 to 23.2 mill. The highest densities were found in 41G0 (one haul) and in 41G1 where the highest abundance was found (Table 14).

The biomass and abundance estimates included 5 new stations in Jammnerbugt.

Table 13. Plaice 2016. Area, number of hauls, mean biomass per km^2 (tons), biomass (tons) and Standard Error distributed on ICES squares.

Div.	Area	Hauls	Mean sq km	Biomass	SE
41G0	329	1	1.9594	644.6	.
41G1	3357.6	19	0.4769	1601.2	532.2
41G2	1421.2	1	0.0692	98.3	.
42G1	3039.6	13	0.3961	1204.1	662.5
42G2	2003.8	4	0.1460	292.6	121.6
43G0	721.5	5	0.1126	81.2	43.0
43G1	2460.9	13	0.0753	185.2	90.6
43G2	331.3	1	0.0490	16.2	.
44G0	1881.5	10	0.0790	148.7	52.5
44G1	1914.9	7	0.0336	64.3	17.6
All			0.2484	4336.5	1084.2

Table 14. Plaice 2016. Area, number of hauls, mean abundance per km^2, abundance and Standard Error distributed on ICES squares.

Div.	Area	Hauls	Mean sq km	Abundace	SE
41G0	329	1	12985.2	4272139.6	.
41G1	3357.6	19	2562.5	8603983.2	2947128.0
41G2	1421.2	1	464.0	659384.0	.
42G1	3039.6	13	2142.0	6510753.7	4391189.3
42G2	2003.8	4	340.4	682037.0	233128.1
43G0	721.5	5	658.5	475098.8	273219.4
43G1	2460.9	13	354.0	871128.1	279531.1
43G2	331.3	1	408.8	135443.5	.
44G0	1881.5	10	351.4	661162.3	272128.8
44G1	1914.9	7	180.9	346434.8	97857.2
All			1084.2	23217565.1	6852968.8

Norway lobster (Nephrops)

In 2016 Norway lobster was caught at 53 of the 69 valid stations. The largest catches were taken east and south of Anholt, but the catches were generally low (Fig. 19).

Table 15. CPUE of Norway lobster by year in number and kg per hour with 1*S.E and number of valid hauls.

Year	Number	SE Number	Weight	SE Weight	n
2004	60.6	14.4	3.1	0.7	69
2005	146.1	34.9	5.0	1.0	78
2006	122.9	30.5	4.5	1.0	76
2007	77.8	16.2	3.1	0.5	75
2008	213.4	57.3	7.8	1.9	80
2009	149.3	28.7	7.4	1.4	78
2010	426.0	91.8	17.5	3.5	79
2011	1037.0	291.0	33.2	7.9	80
2014	121.3	31.2	6.0	1.4	77
2015	21.8	6.1	1.4	0.4	77
2016	48.6	16.7	2.4	0.8	69

CPUE

CPUE in kg of Norway lobster peaked in 2011 where the CPUE was estimated as 33.2.1 kg hr^{-1} and 1037.0 specimens hr^{-1}, respectively (Table 15). Since then the CPUE is gradually reduced to mere 1.4 kg and 21.8 specimens hr^{-1} in 2015, respectively, and by far the lowest estimate in the time series. The CPUE in both number and weight increased slightly in 2016 to 46.6 and 2.4 kg hr^{-1} but it is still the second lowest estimate in the time series (Fig. 16 and 17).

Length distribution

The length of Norway lobster at all stations combined ranged from 20 to 70 mm (carapac length), without modes at 30-34 mm (Fig. 18).

Biomass and abundance

The biomass of Norway lobster was estimated at 2751.45 tons in 2011which is by far the highest estimate in the time series (Table 16). The increase in biomass was almost exclusively seen in Division 44G1 where about of ½ the biomass was located (Table 17). The biomass decreased to 501.6 tons in 2014, and further to record high low 107.4 t in 2015. The decrease in biomass was seen in all Divisions. The biomass increased slightly in 2016 to143.5 tons, but is still the second lowest estimate in the timeseries.

Table 16. Swept area biomass and abundance of Norway lobster with 1* S.E. and number of hauls. Including 5 new stations from Jammerbugt in 2016.

Year	BIOMASS	SE BM	ABUNDAN	SE AB	Haul
2004	278.1	48.6	5366356.8	1065200.6	68
2005	438.8	84.9	12791042.7	3092800.0	77
2006	404.7	98.6	11013886.3	2913561.2	78
2007	279.4	54.5	7267886.6	1854763.6	75
2008	627.2	148.6	16889547.2	4367587.2	80
2009	636.0	122.8	13380444.5	2810844.7	78
2010	1407.8	242.5	34238366.5	6813404.0	79
2011	2761.4	613.3	87259234.4	22841241.5	80
2014	501.6	114.2	9570857.6	2242593.5	77
2015	107.4	28.1	1640162.4	429712.2	77
2016	143.5	41.5	2841449.4	888079.2	74

The abundance was estimated at 87.3 mill. in 2011 which is an almost tripling compared to 2010 and by far the highest in the time series (Table 16). Almost all the increase in abundance was seen Division 44G1. The abundance in 2014 decreased to about 1/10 of the estimate in 2011 (9.571 mill). The abundance decreased further to record low 1.6 mill in 2015. The reduction in abundance was seen in all Divisions (Table 18). The abundance increased slightly in 2016 to12.8 mill, but is still the second lowest estimate in the time series.

The highest densities and abundance was found in Div. 41G1 as in previous years

There is no immediate explanation for the great increase in biomass and abundance between 2009 and 2010, but it is probably caused by a change in catchability. The increase between 2010 and

2011 was primarily seen in Division 44G1 and could be caused be a change in the distribution. There is no immediate explanation for the great decrease in biomass and abundance between 2011 and 2015, but it is probably caused by a change in catchability and poor recruitment.

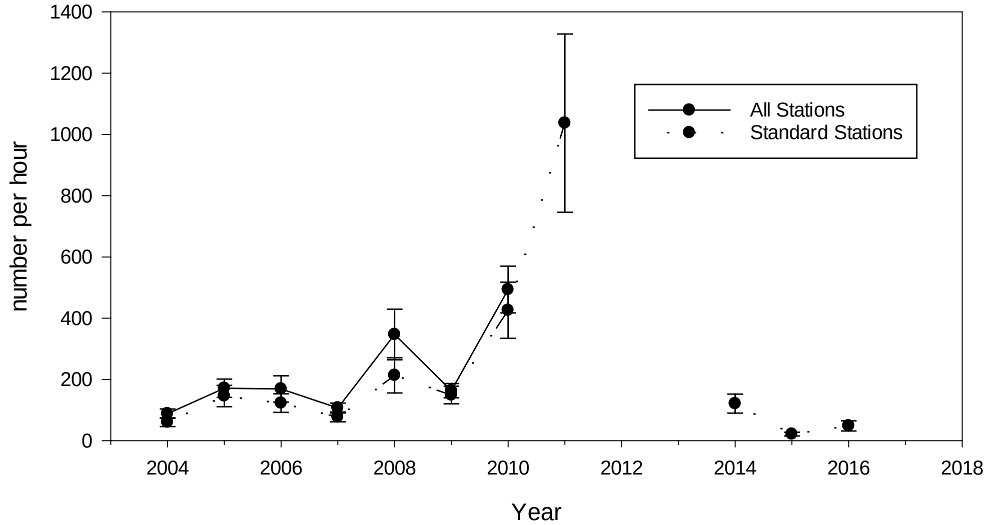


Fig. 16 Catch of Norway lobster in number per hour based on 116 and Standard Stations, respectively, with 1* S.E.

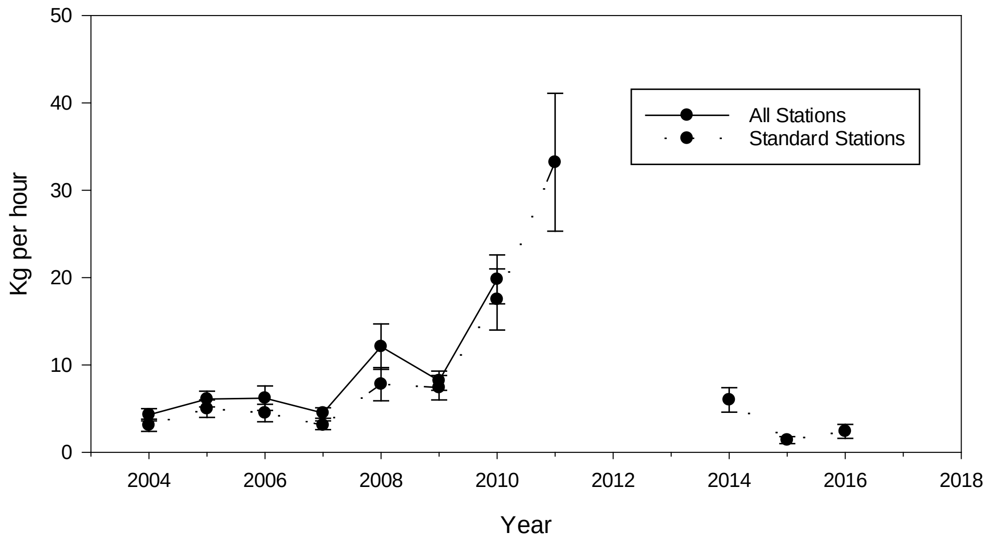


Fig. 17. Catch of Norway lobster kg per hour based on 116 and Standard Stations, respectively, with 1* S.E.

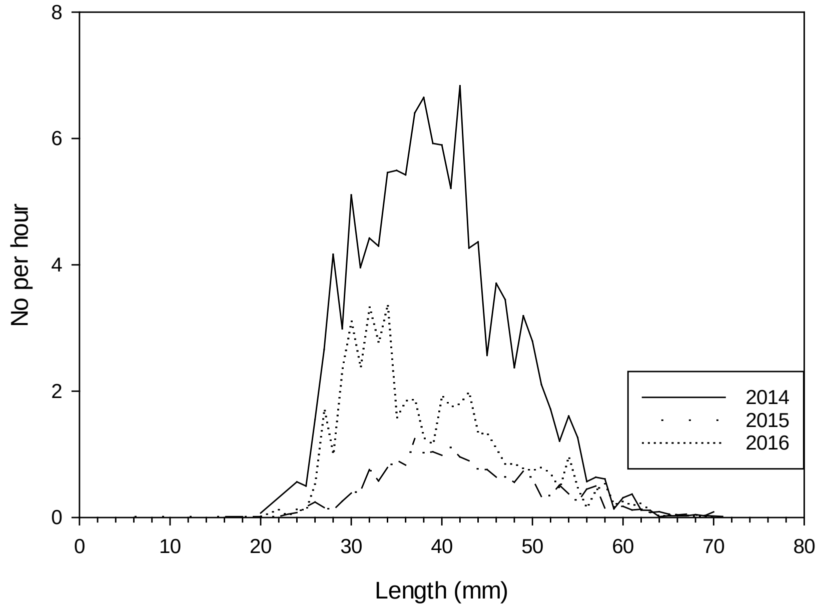
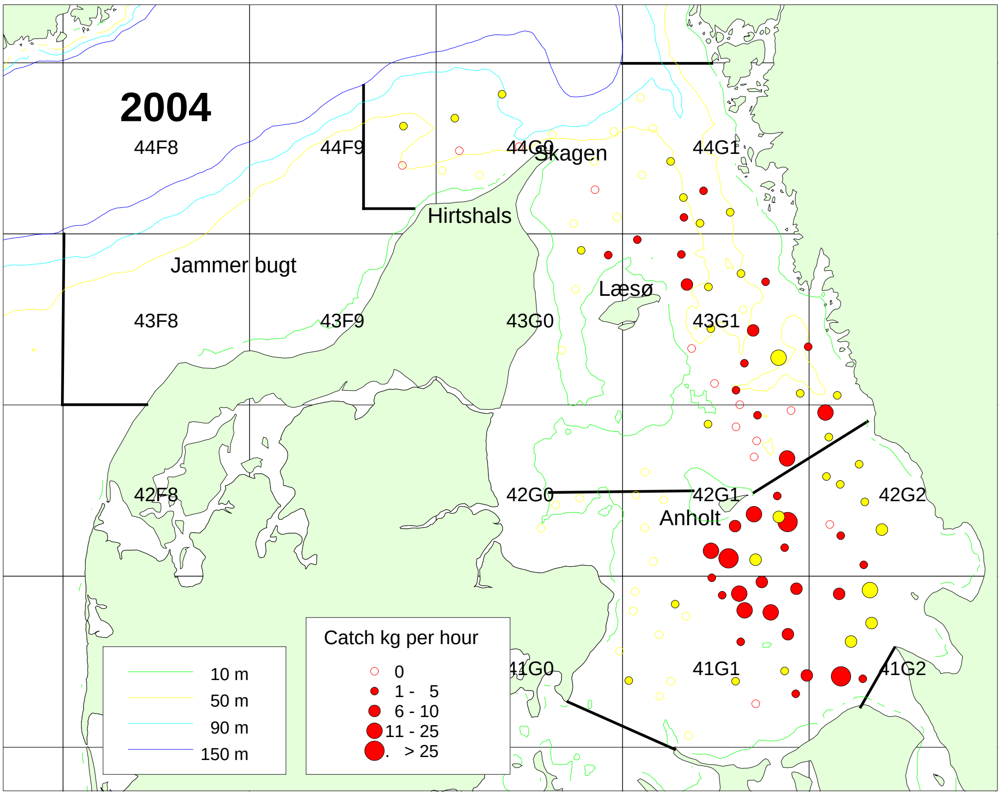


Fig.18. Length distribution (carapac length, mm) of Norway lobster standardized to number caught per hour 2014 - 2016.



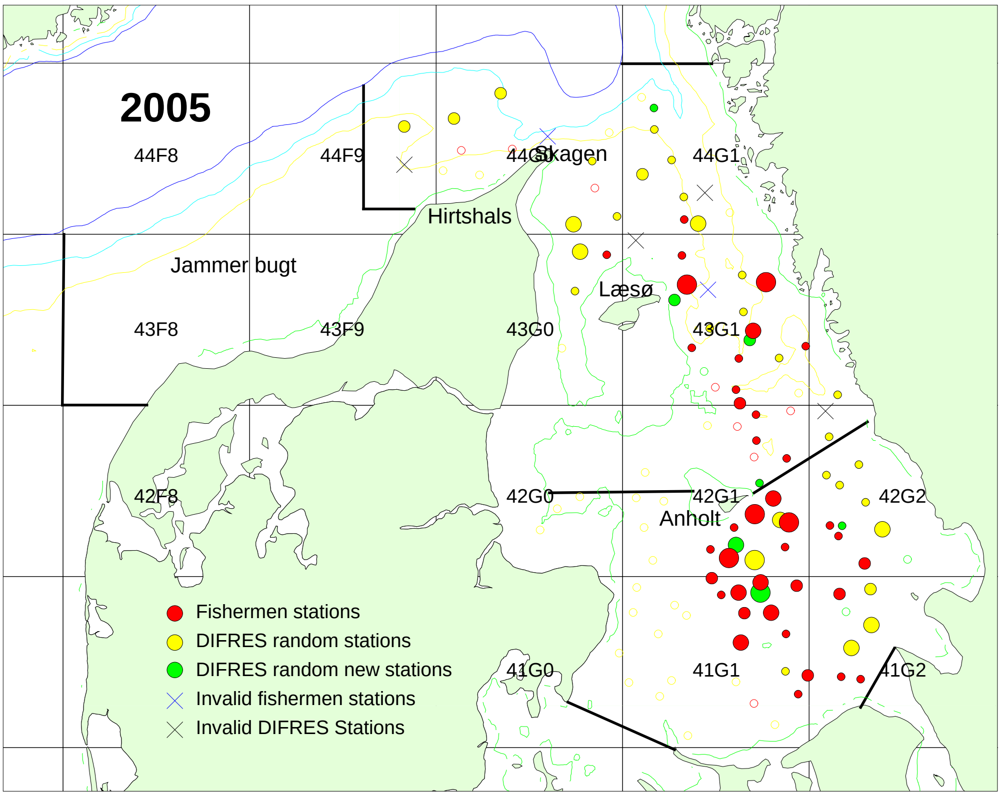
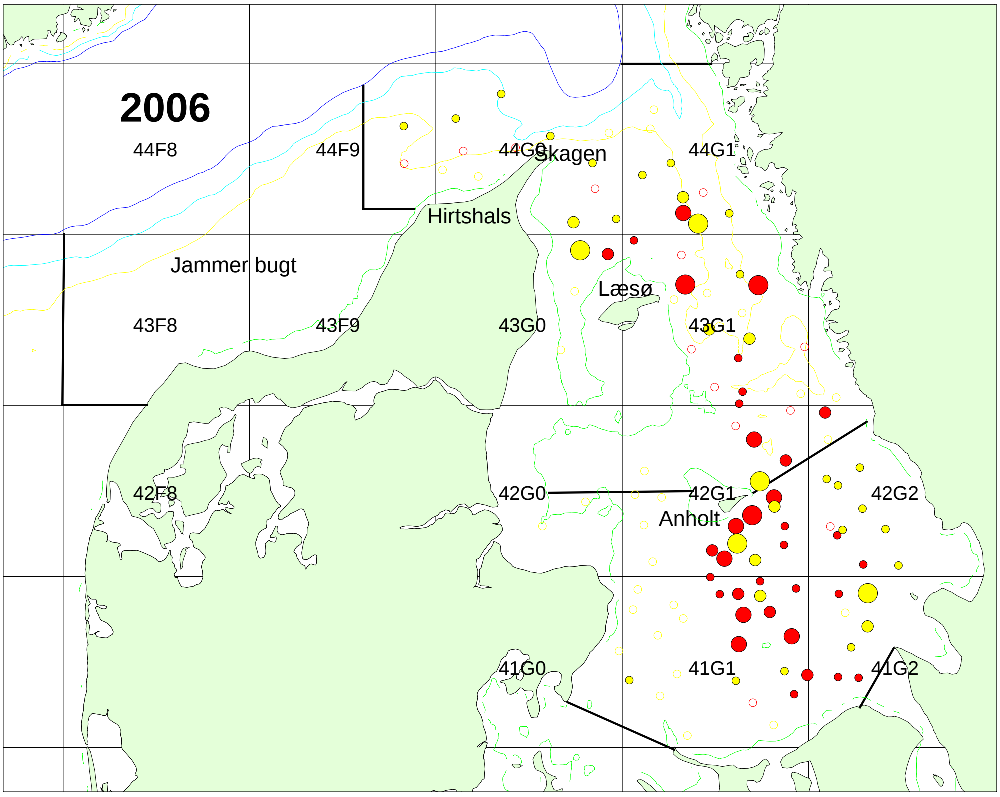


Fig. 19. Catch of Norway lobster (kg per hour) in 2004 and 2005. ● DTU AQUA stations ● Fishermen's stations.



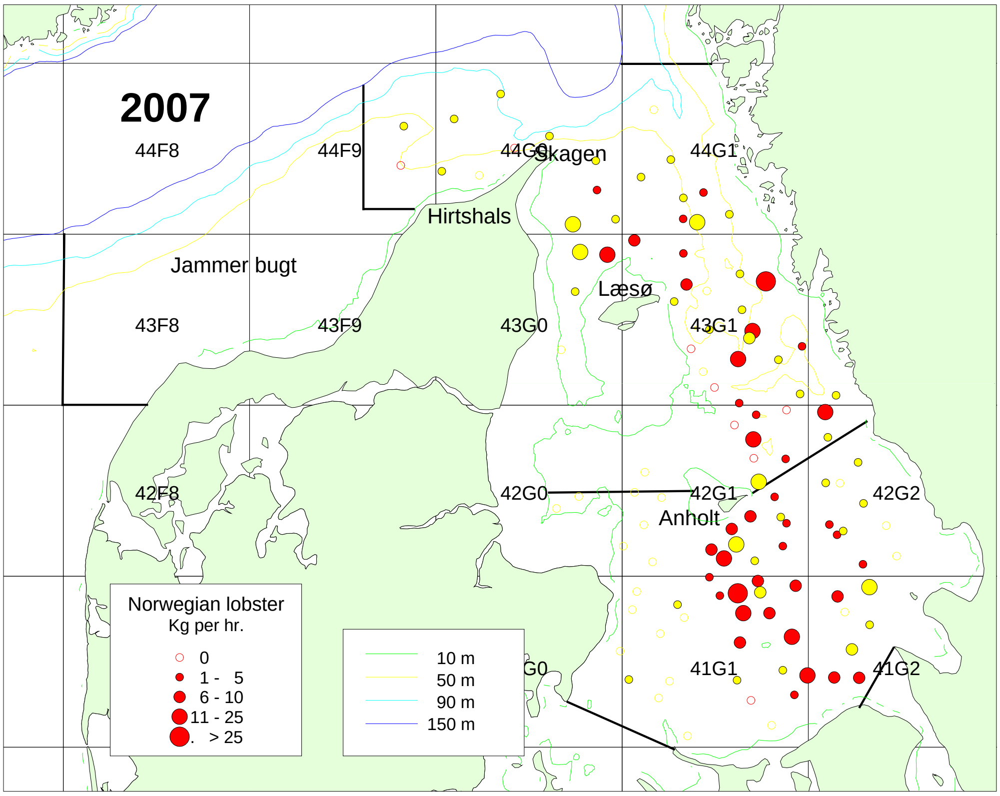
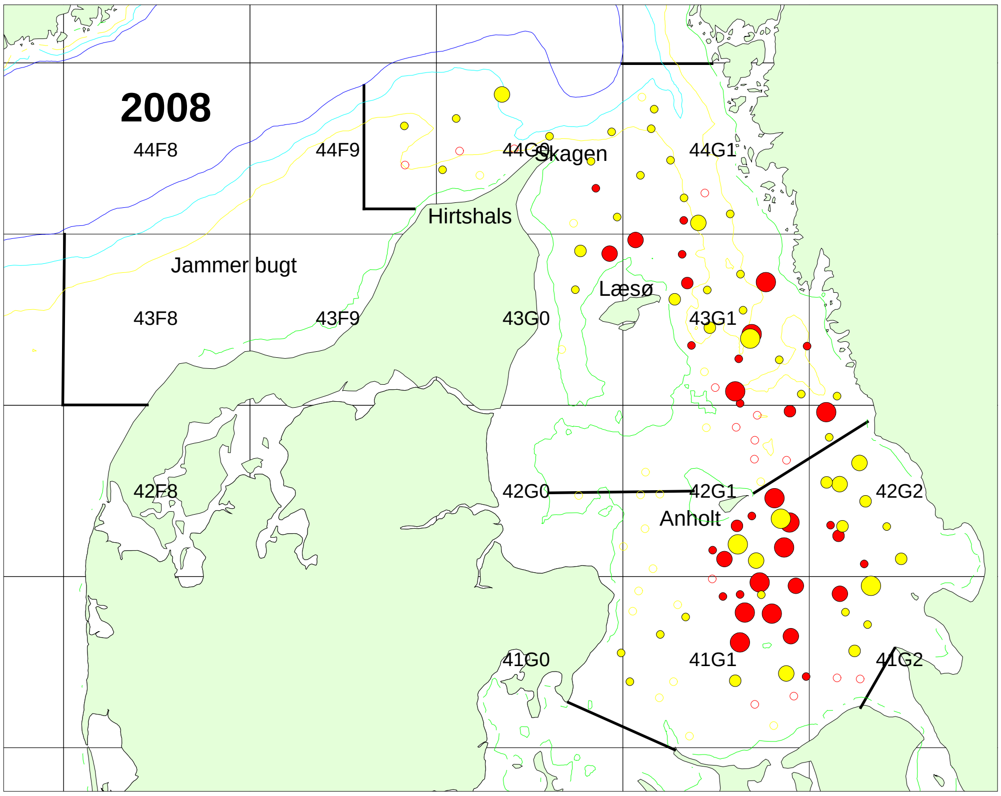


Fig. 19 cont. Catch of Norway lobster (kg per hour) in 2006 2007. ● DTU AQUA stations ● Fishermen's stations.



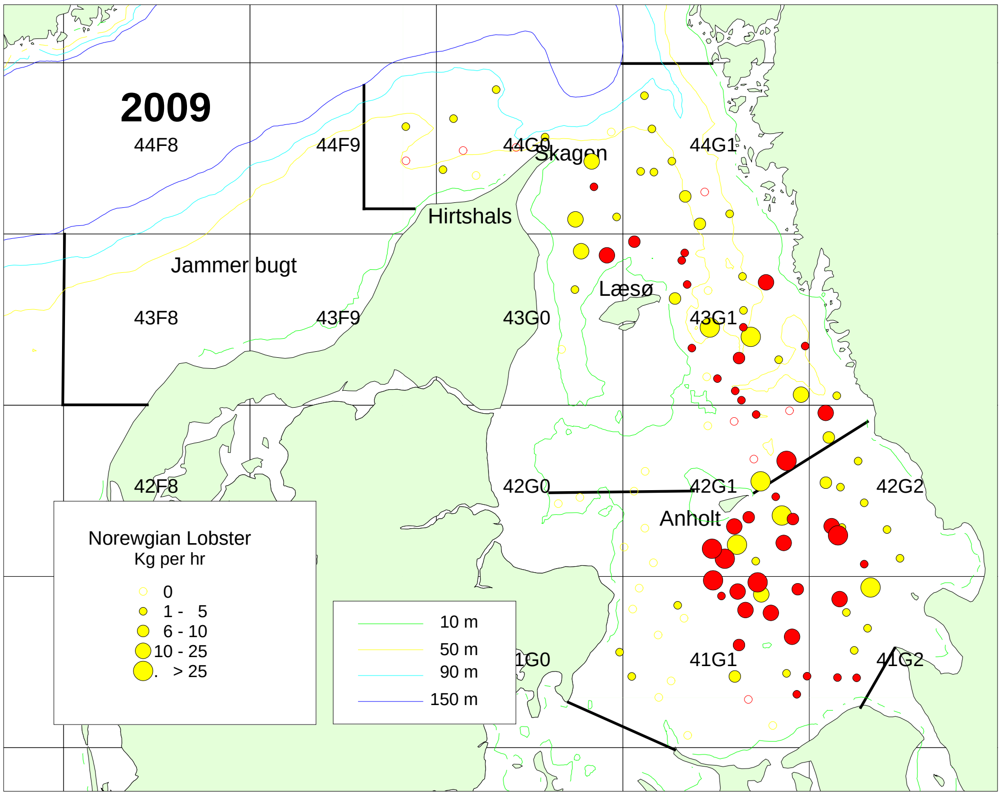


Fig. 19 cont. Catch of Norway lobster (kg per hour) in 2008 and 2009. ● DTU AQUA stations ● Fishermen's stations.

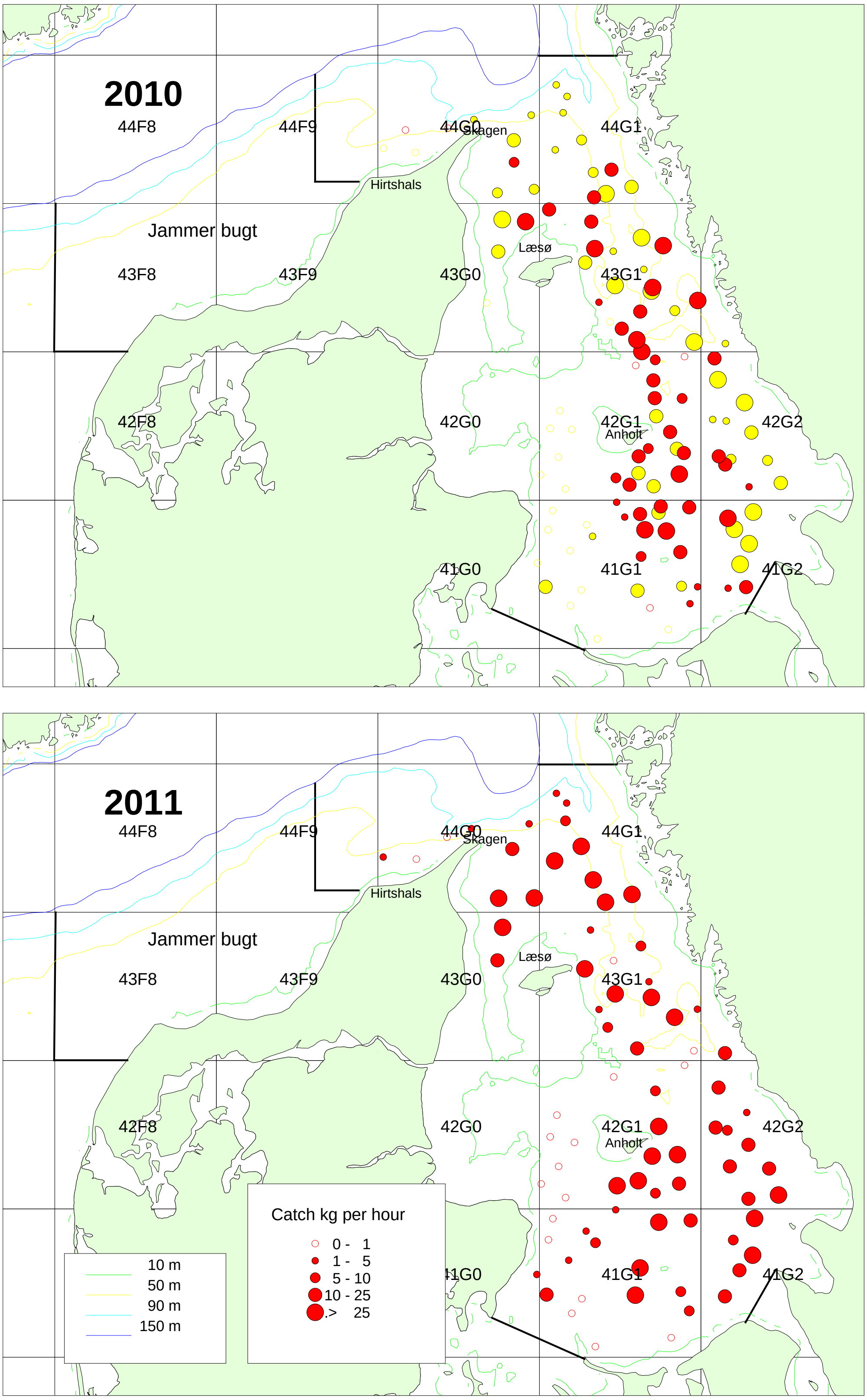


Fig. 19 cont. Catch of Norway lobster (kg per hour) in 2010 and 2011. 2010● DTU AQUA stations ● Fishermen's stations.

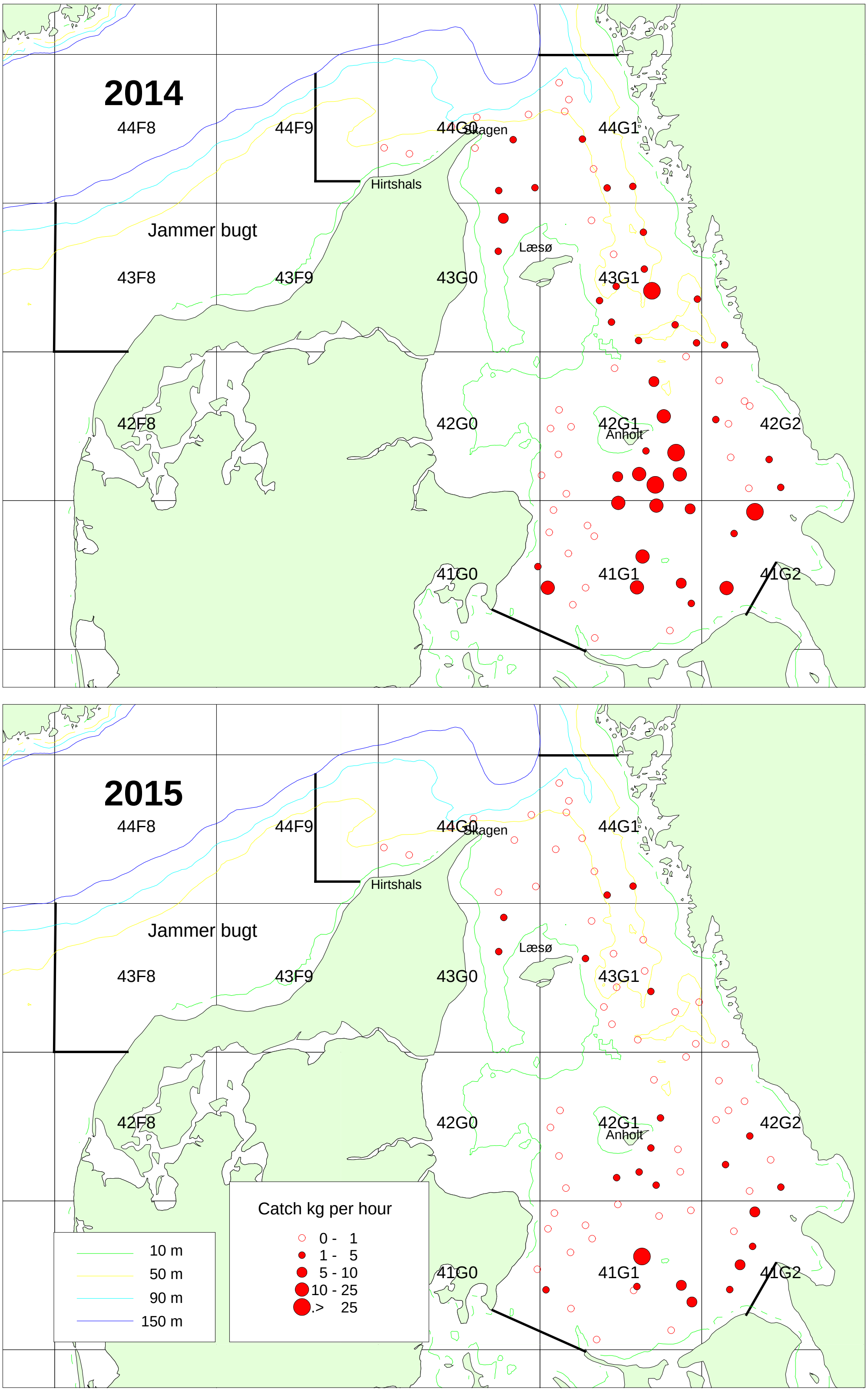


Fig. 19 cont. Catch of Norway lobster (kg per hour) in 2014 and 2015.

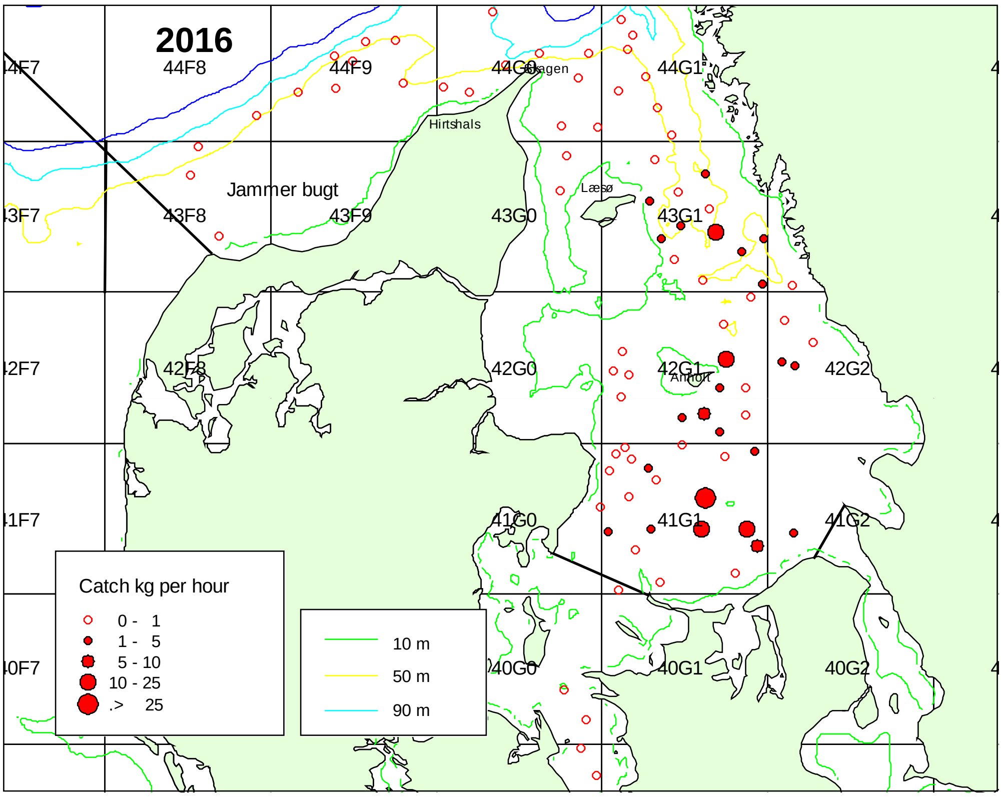


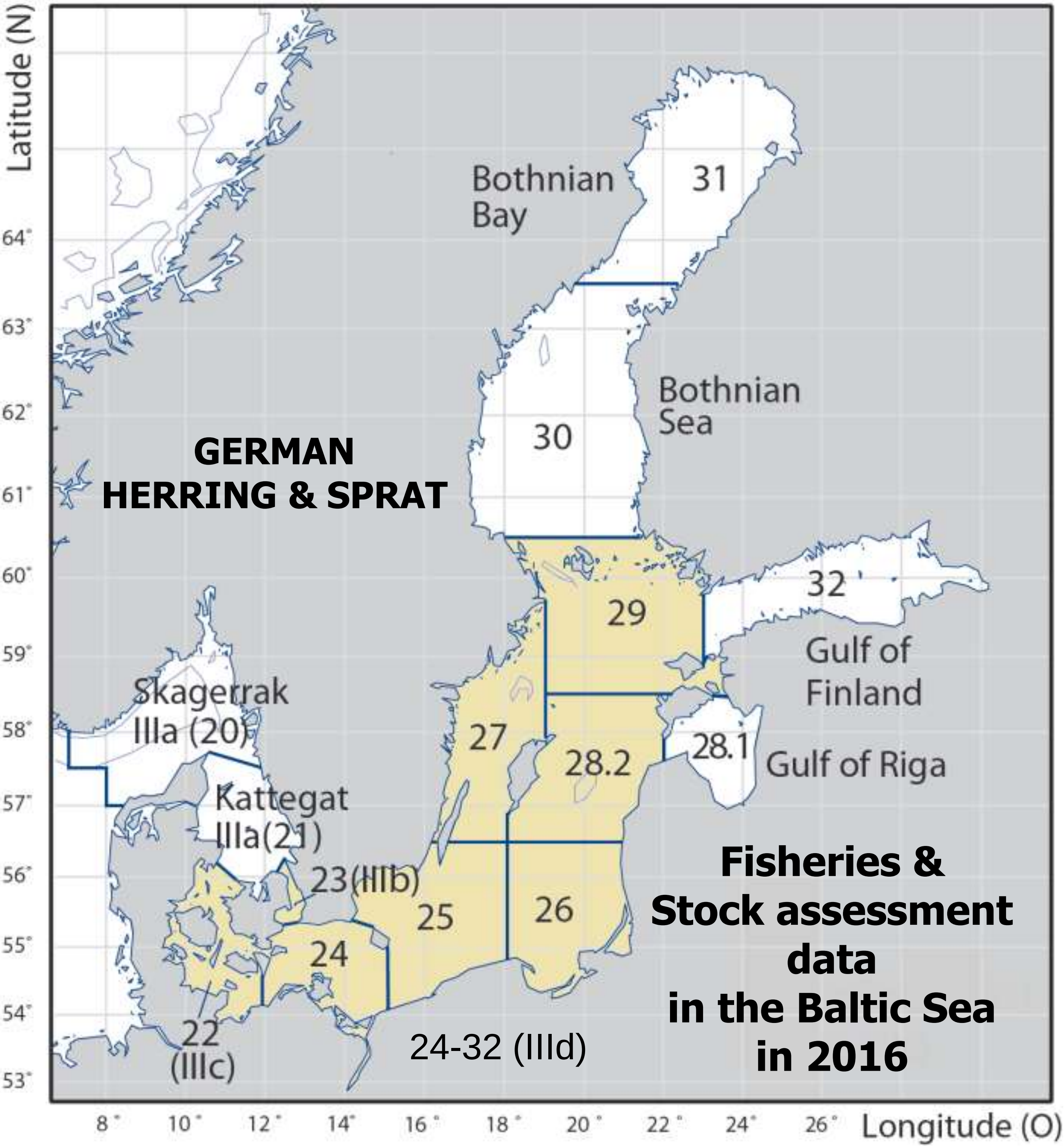
Fig. 19 cont. Catch of Norway lobster (kg per hour) in 2016.

Table 17. Norway lobster 2016. Area, number of hauls, mean biomass per km^2 (tons), biomass (tons) and Standard Error distributed on ICES squares.

Div.	Area	Hauls	Mean sq km	Biomass	SE
41G0	329	1	0.0000	0.0	.
41G1	3357.6	19	0.0199	66.9	32.7
41G2	1421.2	1	0.0101	14.4	.
42G1	3039.6	13	0.0074	22.4	11.3
42G2	2003.8	4	0.0025	5.1	1.9
43G0	721.5	5	0.0008	0.6	0.4
43G1	2460.9	13	0.0123	30.4	17.6
43G2	331.3	1	0.0019	0.6	.
44G0	1881.5	10	0.0003	0.6	0.2
44G1	1914.9	7	0.0013	2.6	1.0
All			0.0082	143.5	41.5

Table 18. Norway lobster 2016. Area, number of hauls, mean abundance per km^2, abundance and Standard Error distributed on ICES squares.

Div.	Area	Hauls	Mean sq km	Abundace	SE
41G0	329	1	0.0	0.0	.
41G1	3357.6	19	386.0	1295945.1	748007.8
41G2	1421.2	1	144.0	204636.4	.
42G1	3039.6	13	150.7	457963.4	248226.4
42G2	2003.8	4	50.4	101009.6	30083.1
43G0	721.5	5	11.2	8088.4	4995.0
43G1	2460.9	13	270.3	665081.9	351487.1
43G2	331.3	1	38.6	12777.7	.
44G0	1881.5	10	7.8	14601.5	7026.2
44G1	1914.9	7	42.5	81345.4	31478.7
All			162.7	2841449.4	888079.2



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1 HERRING

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).

Only a small part of the total German landings was taken **in Subdivisions 25-29** (2016: 4,340, 2015: 2,917 t). The landings taken in the herring fisheries exceeded the existing TAC/quota (2016: 1,035 t) by means of quota transfer (+ 3,330 t) with other countries around the Baltic Sea. The consequent quota of 4,365 t was finally used by 99 %. All landings in this area were

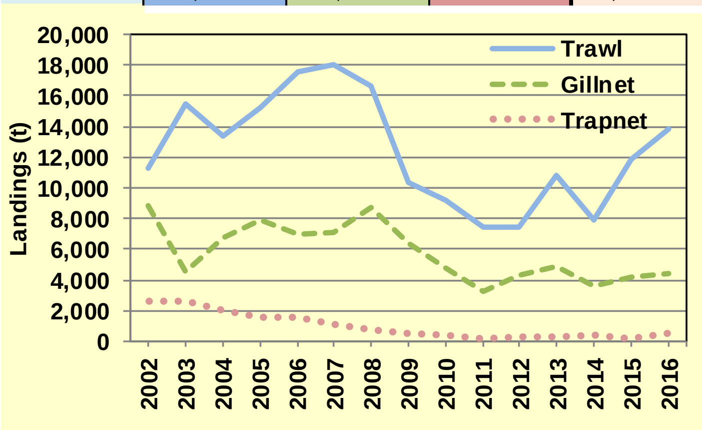
- taken by the trawl fishery and
- landed in foreign ports.

The landings (t) by quarter and Subdivision (SD) including information about the landings in foreign ports are shown in the table below:

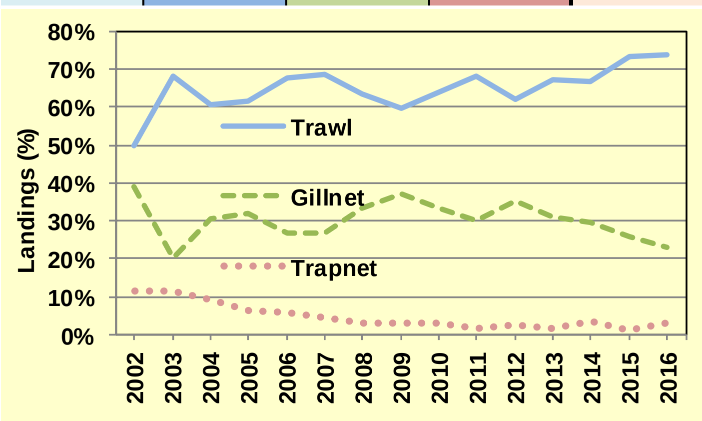
Quarter	SD 22	SD 24	SD 25	SD 26	SD 27	SD 28.2	SD 29	(1) Total SD 25-29	% (1)/(2)	(2) Total SD 22-29	% (2)
I	191.698	9,708.984	276.667	879.915	5.365	1,598.406	611.776	3,372.129	25.4%	**13,272.811**	70.7%
	0.000	209.649	276.667	879.915	5.365	1,598.406	611.776	3,372.129	94.1%	3,581.778	78.0%
II	29.239	2,277.631	379.835	-	-	366.017	138.980	884.832	27.7%	**3,191.702**	17.0%
	0.000	40.250	379.835	-	-	366.017	138.980	884.832	95.6%	925.082	20.2%
III	0.870	0.425	-	-	-	-	-	0.000		**1.295**	0.0%
	0.000	0.000	-	-	-	-	-	0.000		0.000	0.0%
IV	23.972	2,193.778	-	-	-	-	82.857	82.857	3.6%	**2,300.607**	12.3%
	0.000	0.000	-	-	-	-	82.857	82.857	100.0%	82.857	1.8%
Total	**245.779**	**14,180.818**	**656.502**	**879.915**	**5.365**	**1,964.423**	**833.613**	**4,339.818**	**23.1%**	**18,766.415**	**100.0%**
	0.000	249.899	656.502	879.915	5.365	1,964.423	833.613	4,339.818	94.6%	4,589.717	100.0%
								2016/2015:		**2016/2015:**	
								148.8%		115.8%	
	= Fraction of total landings (t) in foreign ports							148.8%		152.2%	
								Proportion landed in foreign ports:		**24.5%**	

The main fishing season was during spring time as in former years. About 87 % of all herring (SDs 22-29) was caught between January and April (2015: 85 %). The majority of the German herring landings (76 %) were taken in Subdivision 24 (2015: 78 %). The German herring fishery in the Baltic Sea is conducted with gillnets, trapnets and trawls. Almost all landings in the area of the Central Baltic Sea are taken by the trawl fishery. Discards (also since 2015: BMS/logbook registered landings) have never been reported. Until 2000 the dominant part of herring was caught in the passive fishery by gillnets and trapnets. Since 2001 the activities in the trawl fishery increased. The total amount of herring, which was caught by trawls, reached 74 % in 2016 (2015: 73 %). The significant change in fishing pattern was caused by the perspective of a new fish factory on the Island of Rügen, which finally started the production in autumn 2003. This factory can process up to 50,000 t fish per year.

Landings in Subdivisions 22-29 (t)				
Year/Gear	Trawl	Gillnet	Trapnet	Total
2002	11,317.813	8,783.392	2,559.662	22,660.867
2003	15,433.154	4,545.312	2,658.148	22,636.614
2004	13,429.394	6,796.747	2,016.542	22,242.683
2005	15,277.320	7,924.007	1,551.530	24,752.857
2006	17,604.485	6,959.530	1,539.467	26,103.482
2007	18,044.233	7,077.135	1,133.806	26,255.174
2008	16,640.802	8,760.611	789.005	26,190.418
2009	10,305.056	6,403.312	523.998	17,232.366
2010	9,216.880	4,804.818	452.182	14,473.880
2011	7,424.844	3,301.890	189.673	10,916.407
2012	7,491.038	4,252.694	322.308	12,066.040
2013	10,768.220	4,933.173	304.427	16,005.820
2014	7,959.719	3,562.980	449.724	11,972.423
2015	11,839.151	4,183.129	183.533	16,205.813
2016	13,834.307	4,362.550	569.558	18,766.415



Landings in Subdivisions 22-29 (% t)				
Year/Gear	Trawl	Gillnet	Trapnet	Total
2002	50%	39%	11%	100%
2003	68%	20%	12%	100%
2004	60%	31%	9%	100%
2005	62%	32%	6%	100%
2006	67%	27%	6%	100%
2007	69%	27%	4%	100%
2008	64%	33%	3%	100%
2009	60%	37%	3%	100%
2010	64%	33%	3%	100%
2011	68%	30%	2%	100%
2012	62%	35%	3%	100%
2013	67%	31%	2%	100%
2014	66%	30%	4%	100%
2015	73%	26%	1%	100%
2016	74%	23%	3%	100%



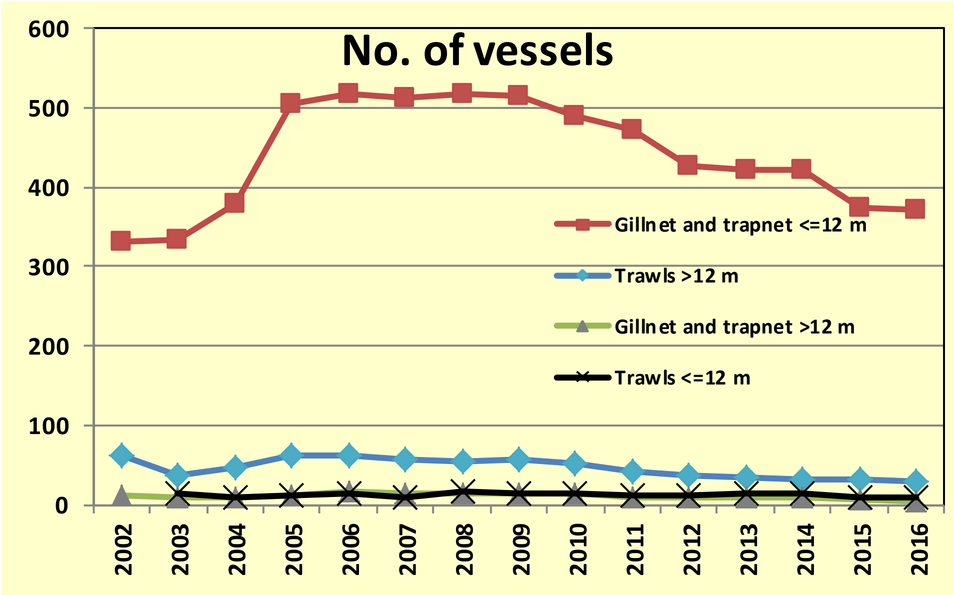
1.2 Fishing fleet

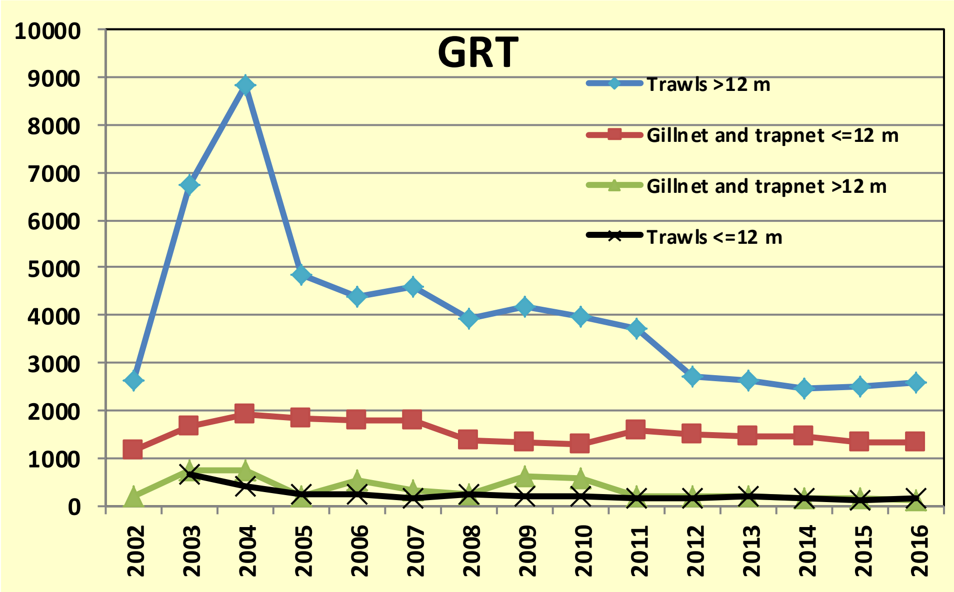
The herring fishing fleet in the Baltic Sea, where all catches are taken in a directed fishery, consists of a:

- coastal fleet with undecked vessels (rowing/motor boats <=12 m and engine power <=100 HP)
- cutter fleet with decked vessels and total lengths between 12 m and 40 m.

In the years from 2008 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
2008	Fixed gears	<=12	518	1,350	11,319
	(gillnet and trapnet)	>12	14	234	1,560
	Trawls	<=12	16	232	2,041
		>12	54	3,912	12,465
	TOTAL		**602**	**5,728**	**27,385**
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
Gillnet and trapnet <=12 m
Trawls >12 m
Gillnet and trapnet >12 m
Trawls <=12 m
0
100
200
300
400
500
600
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016


GRT
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
2002
2003
2004
2005
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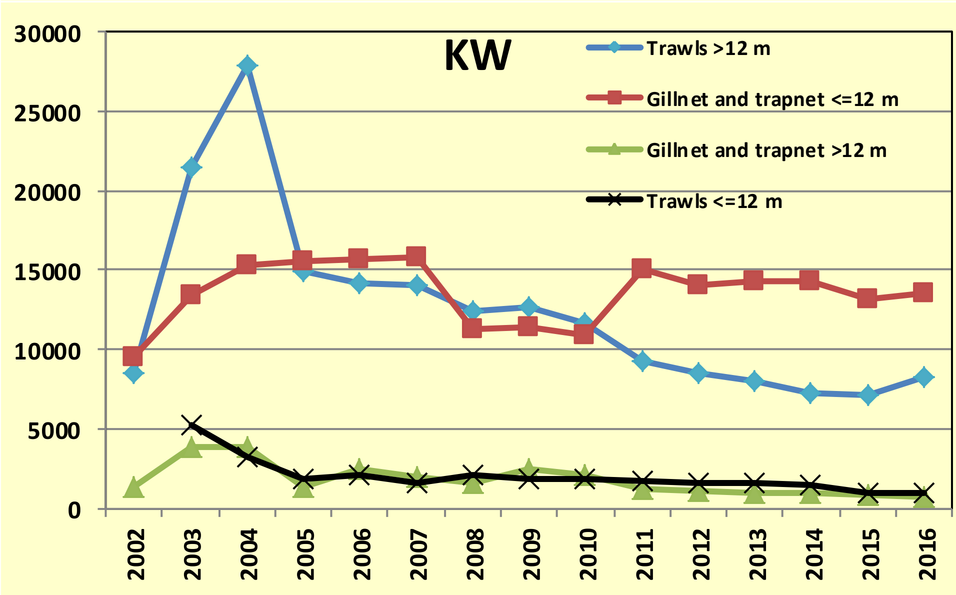
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016


KW
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m
0
5000
10000
15000
20000
25000
30000
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

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

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 chapter 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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1.7 Landings (tons) and sampling effort

1.7.1 Subdivisions 22 and 24

Gear	Quarter	SUBDIVISION 22				SUBDIVISION 24				TOTAL (DIV. IIIa & SUBDIV. 22+24)			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	175.816	0	0	0	6,353.312	5	2,668	634	6,529.128	5	2,668	634
	Q 2	17.215	0	0	0	805.674	2	641	181	822.889	2	641	181
	Q 3	0.000	-	-	-	0.000	-	-	-	no landings	0	0	0
	Q 4	0.094	0	0	0	2,142.378	4	1,971	469	2,142.472	4	1,971	469
	Total	193.125	0	0	0	9,301.364	11	5,280	1,284	9,494.489	11	5,280	1,284
GILLNET	Q 1	15.576	2	805	133	2,914.877	12	4,056	710	2,930.453	14	4,861	843
	Q 2	11.965	1	421	67	1,347.787	3	1,152	205	1,359.752	4	1,573	272
	Q 3	0.791	0	0	0	0.425	0	0	0	1.216	0	0	0
	Q 4	19.729	1	428	80	51.400	1	346	62	71.129	2	774	142
	Total	48.061	4	1,654	280	4,314.489	16	5,554	977	4,362.550	20	7,208	1,257
TRAPNET	Q 1	0.306	2	1,040	157	440.795	2	949	216	441.101	4	1,989	373
	Q 2	0.059	1	833	99	124.170	2	1,066	201	124.229	3	1,899	300
	Q 3	0.079	0	0	0	0.000	-	-	-	0.079	0	0	0
	Q 4	4.149	0	0	0	0.000	-	-	-	4.149	0	0	0
	Total	4.593	3	1,873	256	564.965	4	2,015	417	569.558	7	3,888	673
TOTAL	Q 1	191.698	4	1,845	290	9,708.984	19	7,673	1,560	9,900.682	23	9,518	1,850
	Q 2	29.239	2	1,254	166	2,277.631	7	2,859	587	2,306.870	9	4,113	753
	Q 3	0.870	0	0	0	0.425	0	0	0	1.295	0	0	0
	Q 4	23.972	1	428	80	2,193.778	5	2,317	531	2,217.750	6	2,745	611
	Total	245.779	7	3,527	536	14,180.818	31	12,849	2,678	14,426.597	38	16,376	3,214

1.7.2 Subdivisions 25-29

All herring was caught in this area by trawls. ***<u>No samples could be taken since all herring was landed in foreign ports</u>.***

Gear	Quarter	SUBDIVISION 25				SUBDIVISION 26				SUBDIVISION 27			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	276.667	0	0	0	879.915	0	0	0	5.365	0	0	0
	Q 2	379.835	0	0	0	0.000	-	-	-	0.000	-	-	-
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Total	656.502	0	0	0	879.915	0	0	0	5.365	0	0	0

Gear	Quarter	SUBDIVISION 28.2				SUBDIVISION 29				SUBDIVISION 25-29			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	1,598.406	0	0	0	611.776	0	0	0	3,372.129	0	0	0
	Q 2	366.017	0	0	0	138.980	0	0	0	884.832	0	0	0
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.000	-	-	-	82.857	0	0	0	82.857	0	0	0
	Total	1,964.423	0	0	0	833.613	0	0	0	4,339.818	0	0	0

1.8 Catch in numbers (millions)

1.8.1 Subdivisions 22 and 24

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	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
GILLNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	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
TRAPNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	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
TOTAL	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	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					

1.8.2 Subdivisions 25-29

No sampling.

1.9 Mean weight in the catch (grams)

1.9.1 Subdivisions 22 and 24

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
TRAWL	W-rings	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
	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
	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
	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 1.8.1).

1.9.2 Subdivisions 25 and 29

No sampling.

1.10 Mean length in the catch (cm)

1.10.1 Subdivisions 22 and 24

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	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
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
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
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					

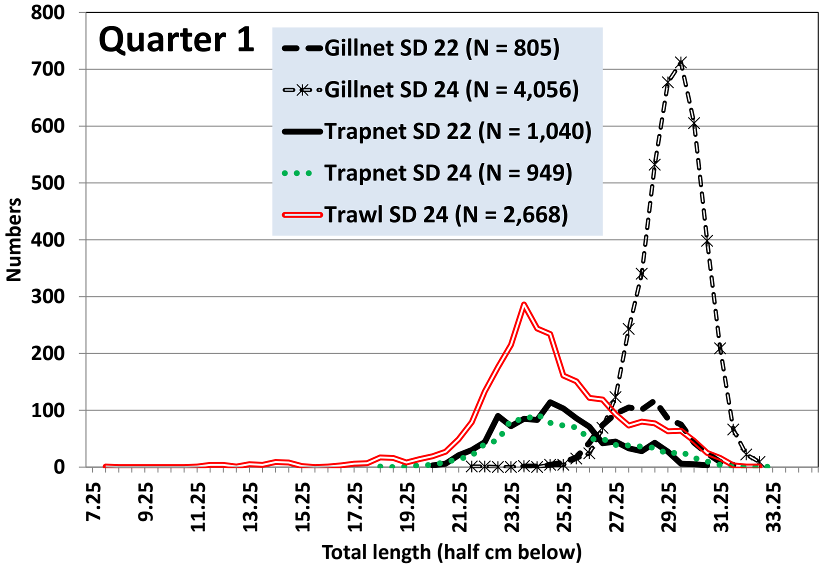
The overall slight drop of mean length in Quarter 4 in the age groups 6 and 8 are caused by some significant contribution of CBH (see Section 1.5) in trawl samples of SD 24. However, the contribution of age 6 and 8 to the overall abundance estimate of herring is less than 0.5 % (see Section 1.8.1).

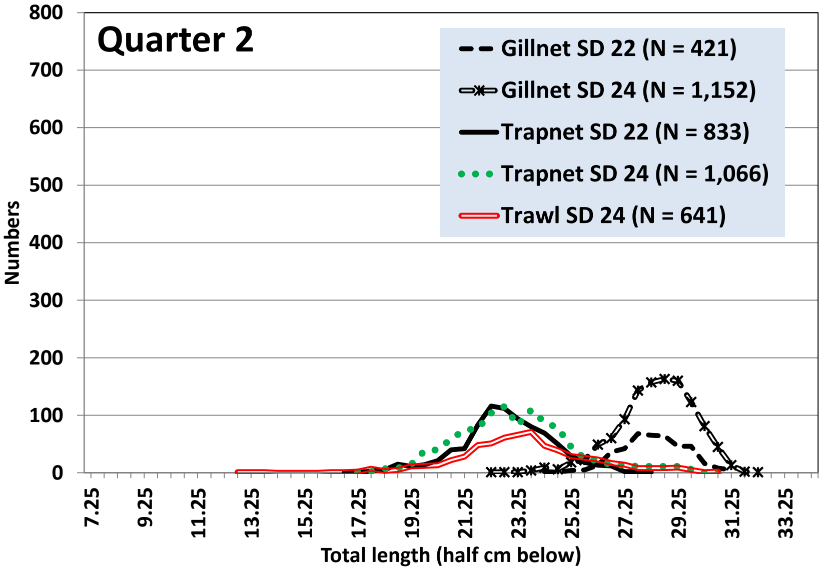
1.10.2 Subdivisions 25 and 29

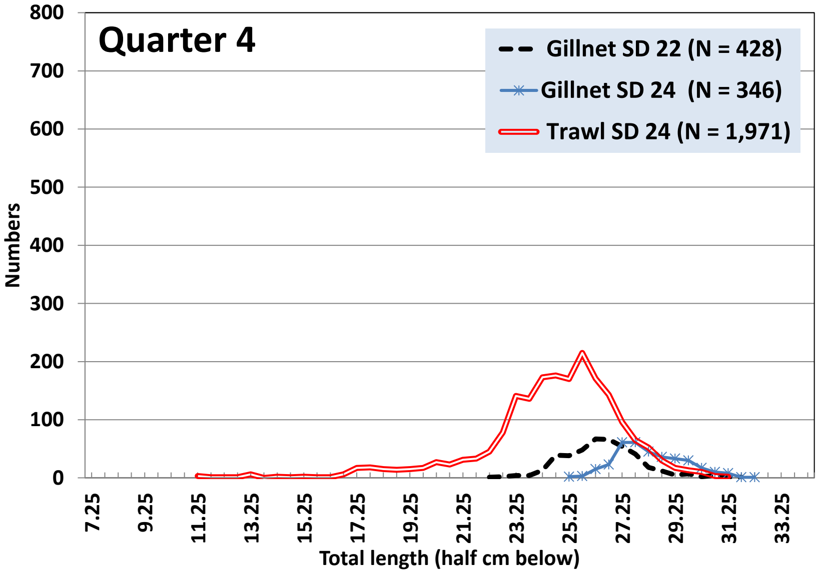
No sampling.

1.11 Sampled length distributions by Subdivision, quarter and type of gear

1.11.1 Subdivisions 22 and 24







1.11.2 Subdivisions 25 and 29

No sampling.

2 SPRAT

2.1 Fisheries

The sprat landings in Subdivisions 22-29 in 2016 reached according to the

(a) share of the EU quota (2015: 12,644 t) and

(b) further transfer of quota (overall 1,678 t were transferred to other Baltic countries)

10,906 t, which represents a final utilization of the overall quota of 10,966 t of 99.5 % (2015: 10,291 t = 98 %).

As in previous years most sprat was

- landed in foreign ports (2016: 96 %, 2015: 93 %)
- caught in the first quarter (2016: 82 %, 2015: 81 %),
- caught in Subdivisions 25-29 (2016: 96 %, 2015: 93 %). These catches were exclusively landed in foreign ports (2010-2016: 100%).

The landings (t) by quarter and Subdivision including information about the landings in foreign ports are shown in the table below:

Quarter	SD 22	SD 24	SD 25	SD 26	SD 27	SD 28	SD 29	(1) Total SD 25-29	% (1)/(2)	(2) Total SD 22-29	% (2)
I	306.969	57.356	367.227	2,378.036	10.153	3,652.029	2,140.352	8,547.797	95.9%	8,912.122	81.7%
	0.000	3.060	367.227	2,378.036	10.153	3,652.029	2,140.352	8,547.797	100.0%	8,550.857	81.9%
II	87.420	14.094	799.272	-	-	531.842	187.889	1,519.003	93.7%	1,620.517	14.9%
	0.000	0.000	799.272	-	-	531.842	187.889	1,519.003	100.0%	1,519.003	14.6%
III	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
IV	0.030	3.568	-	-	-	-	370.000	370.000	99.0%	373.598	3.4%
	0.000	0.000	-	-	-	-	370.000	370.000	100.0%	370.000	3.5%
Total	**394.419**	**75.018**	**1,166.499**	**2,378.036**	**10.153**	**4,183.871**	**2,698.241**	**10,436.800**	**95.7%**	**10,906.237**	100.0%
	0.000	3.060	1,166.499	2,378.036	10.153	4,183.871	2,698.241	10,436.800	100.0%	10,439.860	95.7%
								2016/2015:		**2016/2015:**	
	Fraction of total landings (t) in foreign ports							**109.1%**		**106.0%**	
								109.1%		109.2%	
							Proportion landed in foreign ports in 2016:			**95.7%**	

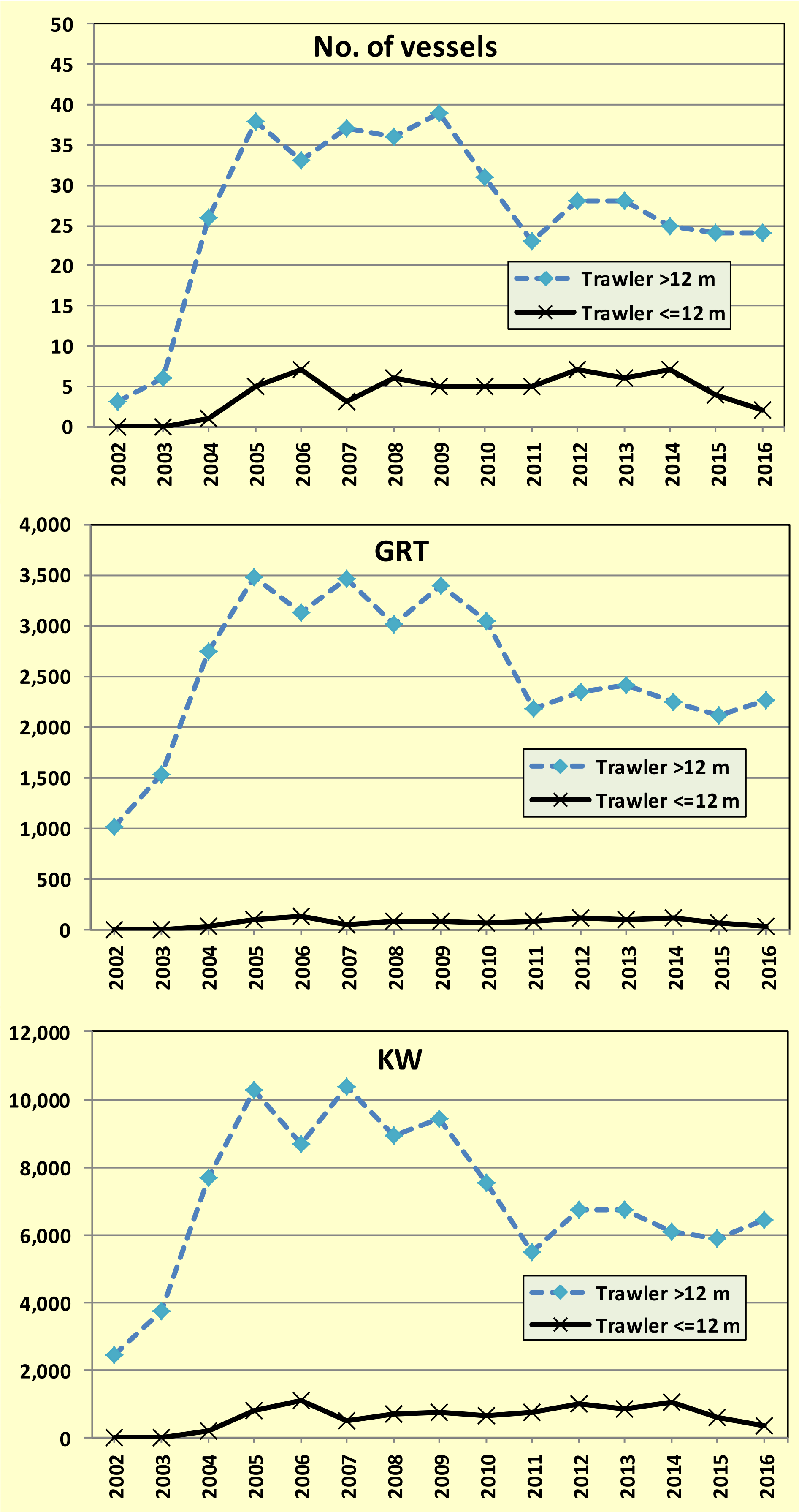
2.2 Fishing fleet

The German fishing fleet in the Baltic Sea consists of only one fleet where all catches for sprat are taken in a directed trawl fishery:

- cutter fleet of total length <= 12 m
- cutter fleet of total length > 12 m

In the years 2009 – 2016 the following type of fishing vessels were available to carry out the sprat fishery in the Baltic Sea (only referring to vessels, which are contributing to the overall total landings per year with more than 20 %):

Year	Vessel length (m)	No. of vessels	GRT	kW
2009	<=12	5	79	761
	>12	39	3,389	9,438
2010	<=12	5	69	664
	>12	31	3,041	7,525
2011	<=12	5	74	756
	>12	23	2,174	5,494
2012	<=12	7	107	1.007
	>12	28	2.345	6.727
2013	<=12	6	94	868
	>12	28	2,411	6,728
2014	<=12	7	112	1,019
	>12	25	2,241	6,070
2015	<=12	4	69	596
	>12	24	2,119	5,892
2016	<=12	2	37	345
	>12	24	2,254	6,424


No. of vessels
Trawler >12 m
Trawler <=12 m
GRT
Trawler >12 m
Trawler <=12 m
KW
Trawler >12 m
Trawler <=12 m

2.3 Species composition of landings

The results from the species composition of German trawl catches, which were sampled in **Subdivision 22 of quarter 1** in 20165, are given below:

SD 22/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January										
	Mean									
February	1	9.2	1.5	0.0	0.0	10.7	86.4	13.6	0.0	0.0
	Mean	9.2	1.5	0.0	0.0	10.7	86.4	13.6	0.0	0.0
March										
	Mean									
Q I	Mean	9.2	1.5	0.0	0.0	10.7	86.4	13.6	0.0	0.0

The results from the species composition of German trawl catches, which were sampled in **Subdivision 25 of quarter 1** in 2016, are given below:

SD 25/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January	1	6.9	0.1	0.0	0.0	7.0	98.1	1.6	0.0	0.3
	Mean	6.9	0.1	0.0	0.0	7.0	98.1	1.6	0.0	0.3
February										
	Mean									
March	1	7.1	0.3	0.0	0.0	7.4	96.0	3.9	0.0	0.1
	Mean	7.1	0.3	0.0	0.0	7.4	96.0	3.9	0.0	0.1
Q I	Mean	7.0	0.2	0.0	0.0	7.2	97.1	2.8	0.0	0.2

The results from the species composition of German trawl catches, which were sampled in **Subdivision 26 of quarter 1** in 2016, are given below:

SD 26/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January	1	6.9	0.3	0.0	0.0	7.1	96.2	3.6	0.0	0.2
	Mean	6.9	0.3	0.0	0.0	7.1	96.2	3.6	0.0	0.2
February										
	Mean									
March	1	4.0	0.2	0.6	0.0	4.8	82.9	4.6	12.5	0.0
	2	7.7	0.1	0.0	0.0	7.9	98.0	1.4	0.0	0.6
	3	4.7	0.0	0.0	0.0	4.7	99.0	1.0	0.0	0.0
	Mean	5.5	0.1	0.2	0.0	5.8	90.5	3.0	6.3	0.3
Q I	Mean	6.2	0.2	0.1	0.0	6.5	93.3	3.3	3.1	0.2

The results from the species composition of German trawl catches, which were sampled in **Subdivision 27 of quarter 1** in 2016, are given below:

SD 27/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January										
	Mean									
February	1	7.8	0.1	0.0	0.0	7.9	98.7	1.3	0.0	0.0
	Mean	7.8	0.1	0.0	0.0	7.9	98.7	1.3	0.0	0.0
March										
	Mean									
Q I	Mean	7.8	0.1	0.0	0.0	7.9	98.7	1.3	0.0	0.0

The results from the species composition of German trawl catches, which were sampled in **Subdivision 28 of quarter 1 and 2** in 2016, are given below:

SD 28/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January	1	5.1	0.2	0.0	0.1	5.4	94.0	4.6	0.0	1.4
	2	4.3	0.6	0.0	0.0	4.9	87.7	12.3	0.0	0.0
	3	6.2	0.8	0.0	0.0	7.0	88.0	12.0	0.0	0.0
	Mean	5.2	0.6	0.0	0.0	5.8	89.9	9.6	0.0	0.5
February	1	6.6	0.1	0.0	0.0	6.7	98.9	1.0	0.0	0.0
	Mean	6.6	0.1	0.0	0.0	6.7	98.9	1.0	0.0	0.0
March	1	7.8	0.1	0.0	0.0	7.9	98.5	1.2	0.0	0.3
	2	0.0	7.2	0.0	0.0	7.2	0.0	100.0	0.0	0.0
	Mean	3.9	3.7	0.0	0.0	7.5	49.3	50.6	0.0	0.1
Q I	Mean	5.2	1.4	0.0	0.0	6.7	79.4	20.4	0.0	0.2

SD 28/Quarter II		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
April	1	6.7	3.8	0.0	0.0	10.5	63.6	36.3	0.0	0.1
	Mean	6.7	3.8	0.0	0.0	10.5	63.6	36.3	0.0	0.1
May										
	Mean									
June										
	Mean									
Q II	Mean	6.7	3.8	0.0	0.0	10.5	63.6	36.3	0.0	0.1

The results from the species composition of German trawl catches, which were sampled in **Subdivision 29 of quarter 1** in 2016, are given below:

SD 29/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January										
	Mean									
February	1	5.8	0.5	0.0	0.0	6.3	92.4	7.5	0.0	0.1
	2	8.4	0.1	0.0	0.0	8.6	98.4	1.6	0.0	0.0
	Mean	7.1	0.3	0.0	0.0	7.4	95.4	4.5	0.0	0.1
March										
	Mean									
Q I	Mean	7.1	0.3	0.0	0.0	7.4	95.4	4.5	0.0	0.1

The officially reported total trawl landings of sprat in Subdivisions 24-29 (see 2.1) in combination with the noticed mean species composition in the samples (see above) would result in the following differences:

Subdiv.	Quarter	Trawl landings (t)	Mean Contribution of Sprat (%)	Total Sprat corrected (t)	Difference (t)
24	**I**	57	86.4	50	-8
25	**I**	367	97.1	357	-11
26	**I**	2,378	93.3	2,219	-159
27	**I**	10	98.7	10	0
28	**I**	3,652	79.4	2,900	-752
	II	532	63.6	338	-194
29	**I**	2,140	95.4	2,042	-98

The overall difference amounted to -1,222 t, which would represent a change of the total landing value for Germany in 2016 of -11 % (total landings in SD 22-29 in 2016 of 10,9061 t – 1,222 t ->9,684 t; 2015: -14 %; 2014: -7 %, 2013: -6 %). The officially reported trawl landings (see 2.1) and the referring assessment input data (see 2.5 and 2.6) were not corrected for these significant differences in 2016 However, an implementation error of about at least 6-14 % regarding the total landing figure for Germany should be explored during the next benchmark process.

2.4 Logbook registered discards/BMS landings

No logbook registered discards (this catch category exists since 2015 as transition year, no discards have been reported in the years before 2016!) of sprat have been reported in 2016. A negligible amount of sprat was recorded as BMS landings (new catch category since 2015: 0.350 t were taken in 2016 as by-catch in the herring trawl fishery in SD 24 of quarter 1, which represents <0.01 % of the total landings in 2016 of 10,906 t). This additional but negligible amount of BMS landings was not added to the total landing figure in 2016.

2.5 Landings (tons) and sampling effort

Even so most of the sprat was landed in foreign port in 2016 (96 %, 2015: 93 %), it was possible to sample 87 % (9,462 t, 2015: 96 %) of the total landings:

Gear	Quarter	SUBDIVISION 22[1]				SUBDIVISION 24[2]					SUBDIVISION 25[3]			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)		No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	306.969	1	346	104	57.356	*	5	366	91	367.227	2	633	107
	Q 2	87.420	0	0	0	14.094	*	1	54	39	799.272	0	0	0
	Q 3	0.000	-	-	-	0.000		-	-	-	0.000	-	-	-
	Q 4	0.030	0	0	0	3.568	*	2	62	16	0.000	-	-	-
	Total	394.419	1	346	104	75.018		8	482	146	1,166.499	2	633	107

Gear	Quarter	SUBDIVISION 26[3]				SUBDIVISION 27[3]				SUBDIVISION 28[3]			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	2,378.036	4	1,249	210	10.153	1	327	58	3,652.029	6	1,469	276
	Q 2	0.000	-	-	-	0.000	-	-	-	531.842	1	310	61
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Total	2,378.036	4	1,249	210	10.153	1	327	58	4,183.871	7	1,779	337

Gear	Quarter	SUBDIVISION 29[3]				SUBDIVISIONS 22-29[4]			
		Landings (tons)	No. samples	No. measured	No. aged	Landings (tons)	No. samples	No. measured	No. aged
TRAWL	Q 1	2,140.352	2	644	110	8,912.122	21	5,034	956
	Q 2	187.889	0	0	0	1,620.517	2	364	100
	Q 3	0.000	-	-	-	0.000	0	0	0
	Q 4	370.000	0	0	0	373.598	2	62	16
	Total	2,698.241	2	644	110	10,906.237	25	5,460	1,072

*samples taken as by-catch in the herring trawl fishery

Fraction of landings in foreign ports:
[1]SD 22: 0 %
[2]SD 24: 0 %
[3]SD 25, 26, 27, 28, 29: 100 %
[4]SD 22-29: 10,443 t (96 %)

2.6 Catch in numbers (millions)

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISION 25				SUBDIVISION 26			
	Age	Q1	Q2	Q3	Q4	*Q1	*Q2	Q3	*Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0								0.760								
	1	4.605				0.116	0.439			4.006				9.740			
	2	31.109				3.424	0.681		0.012	25.221				264.806			
	3	1.586				0.882	0.170			4.826				21.297			
	4	0.328				0.168	0.052			5.283				26.422			
	5	0.219				0.038	0.052			1.300				1.399			
	6									1.014				0.523			
	7									0.488				0.994			
	8+													1.399			
	Sum	37.847				4.628	1.394		0.772	42.138				326.578			

		SUBDIVISION 27				SUBDIVISION 28				SUBDIVISION 29				SUBDIVISIONS 22-29			
	Age	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0																0.760
	1	0.337				34.296	27.672			26.441				79.541	28.111		
	2	1.470				472.841	75.918			328.246				1127.116	76.600		0.012
	3	0.011				28.156	1.147			12.501				69.260	1.317		
	4	0.034				15.818	4.803			10.740				58.794	4.855		
	5	0.011				5.386	0.358							8.353	0.410		
	6					0.381	1.219			0.589				2.507	1.219		
	7	0.011				1.246								2.739			
	8+					1.246				0.825				3.470			
	Sum	1.876				559.371	111.117			379.342				1351.780	112.511		0.772

*samples taken as by-catch in the herring trawl fishery

2.7 Mean weight in the catch (grams)

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISION 25				SUBDIVISION 26			
	Age	Q1	Q2	Q3	Q4	*Q1	*Q2	Q3	*Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0								4.4								
	1	3.8				5.9	5.1			3.8				2.9			
	2	8.6				12.2	11.7		19.0	7.6				6.8			
	3	9.7				13.7	12.5			11.7				10.3			
	4	12.6				12.9	13.7			12.7				10.6			
	5	11.7				19.8	20.0			12.1				11.0			
	6									13.8				12.6			
	7									15.4				11.9			
	8+													11.0			
	Sum	8.1				12.4	10.1		4.6	8.7				7.3			

		SUBDIVISION 27				SUBDIVISION 28				SUBDIVISION 29				SUBDIVISIONS 22-29			
	Age	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0																4.4
	1	2.5				2.5	2.4			2.4				2.7	2.4		
	2	5.9				6.4	5.2			5.6				6.4	5.2		19.0
	3	9.0				10.0	9.9			9.0				10.1	10.2		
	4	10.3				10.5	9.9			9.9				10.7	9.9		
	5	9.7				11.1	9.8							11.3	11.1		
	6					12.1	10.3			12.0				12.9	10.3		
	7	10.2				12.4								12.7			
	8+					12.7				9.5				11.2			
	Sum	5.4				6.5	4.8			5.6				6.6	4.9		4.6

*samples taken as by-catch in the herring trawl fishery

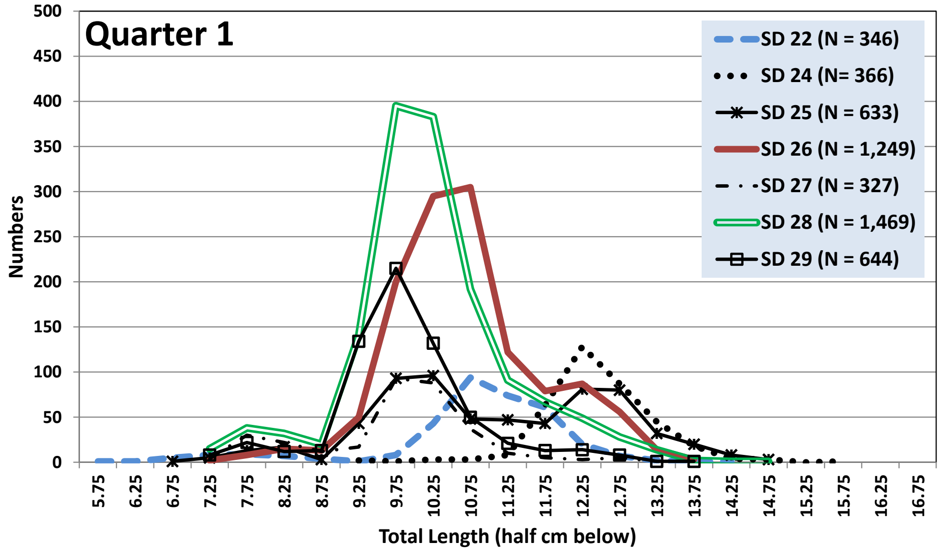
2.8 Mean length in the catch (cm)

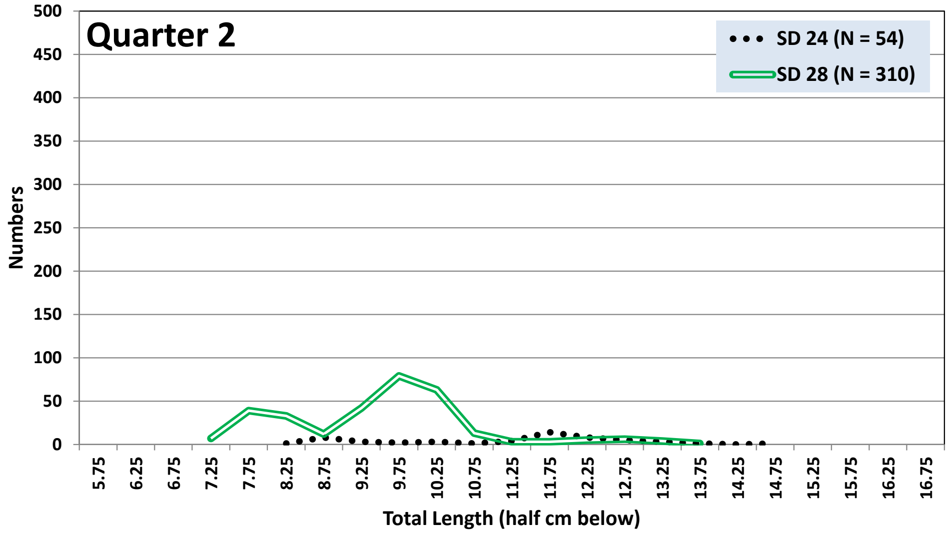
		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISION 25				SUBDIVISION26			
	Age	Q1	Q2	Q3	Q4	*Q1	*Q2	Q3	*Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0								8.9								
	1	8.3				10.2	9.7			8.7				8.3			
	2	11.1				12.4	12.4		13.8	10.7				10.5			
	3	11.6				13.0	13.0			12.4				12.2			
	4	13.1				12.7	13.8			12.7				12.3			
	5	12.8				15.1	14.8			12.5				12.4			
	6									13.1				13.3			
	7									13.7				13.0			
	8+													12.5			
	Sum	10.8				12.5	11.7		9.0	11.1				10.7			

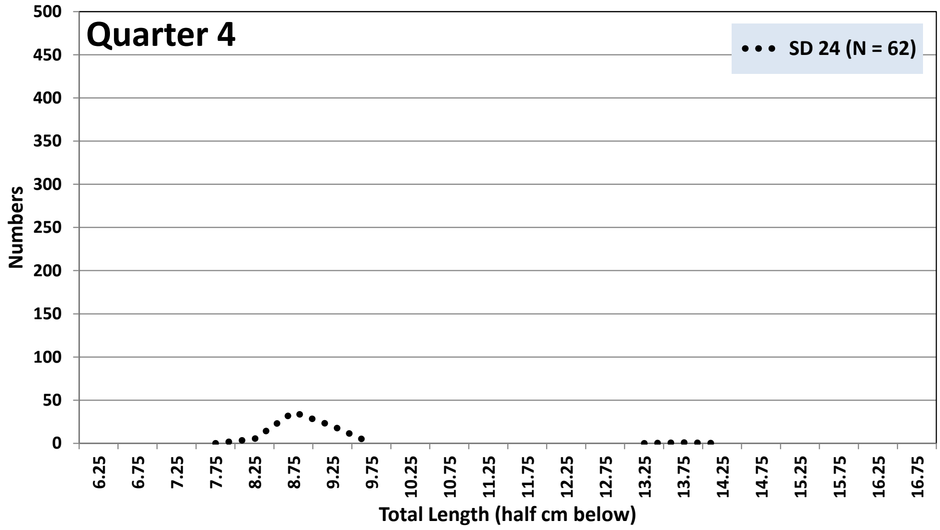
		SUBDIVISION 27				SUBDIVISION 28				SUBDIVISION 29				SUBDIVISIONS 22-29			
	Age	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0																8.9
	1	8.0				7.9	7.9			7.9				8.0	8.0		
	2	10.1				10.2	9.8			9.9				10.2	9.8		13.8
	3	12.3				12.0	12.1			11.9				12.1	12.2		
	4	12.4				12.3	12.5			12.3				12.4	12.5		
	5	12.3				12.7	12.3							12.6	12.6		
	6					13.3	12.9			13.3				13.2	12.9		
	7	12.8				13.4								13.3			
	8+					13.5				12.3				12.8			
	Sum	9.8				10.2	9.5			9.9				10.3	9.5		9.0

*samples taken as by-catch in the herring trawl fishery

2.9 Sampled length distributions of sprat by Subdivision and quarter







Working Document 03 for WGBFAS, 19-26 April, 2017

Assessments

of herring stocks in the Central Baltic Herring area and sprat stock in the whole Baltic by former assessment units (AUs)

(herring in in sub-divisions 25-27, herring in in sub-divisions 28-29+32, sprat in sub-divisions 22-25, sprat in sub-divisions 26+28, and sprat in sub-divisions 27,29-32)

by

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Part of this work resulted from the BONUS INSPIRE project, was supported by BONUS (Art 185), funded jointly from the European Union's Seventh Programme for research, technological development and demonstration and from the Polish National Centre for Research and Development. Polish Ministry of Science and Higher Education has also participated in the financing of this research.

The documents consists of two parts:

Part A refers to assessment of herring stocks

(pages 4-48)

and

Part B presents assessment of sprat stocks

(pages 49-120)

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Part B. Assessment of sprat stocks: sprat in sub-divisions 22-25, sprat in sub-divisions 26+28, and sprat in sub-divisions 27,29-32

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2. Stock of sprat in sub-divisions 26+28

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2.3.1. Assessment with XSA

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3. Stock of sprat in sub-divisions 27,29-32

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4. Summary and conclusions on assessments of sprat stocks in the Baltic

Introduction

Several biological populations of herring and sprat exist in the Baltic. For stock assessment purposes some of them have been combined into larger assessment units (AUs), which has been considered a compromise between complex population structure and possibility to collect data and assess separate populations. For example, presently assessed herring in the central Baltic (CBH) (sub-divisions 25-29+32) and sprat in the whole Baltic (sub-divisions 22-32) were previously (up to beginning of 1990s) considered as five separately assessed stocks/assessment units, namely: herring in sub-divisions 25-27, herring in sub-divisions 28-29+32, sprat in sub-divisions 22-25, sprat in sub-divisions 26+28, and sprat in sub-divisions 27+29-32. In some years separate assessment was also performed for the Gulf of Finland herring.

For several years, however, some changes in fish distribution have been observed; density of herring and sprat has been increasing in north-eastern areas, while cod has been mainly distributed in the southern Baltic (sub-divisions 25-26). Previously, cod usually extended its distribution eastwards when its biomass was increasing. Strong ecological interactions exist between cod and clupeids in the Baltic (e.g., predation) and these are taken into account in the standard ICES assessments by including predation mortality and assuming its uniform distribution effects within the assessment unit. However, due to the recent changes in biomass distribution verification of such assumptions and adapting stock assessment and management to changing pattern of species distribution is needed. Thus, the assessments of herring and sprat stocks by former assessment units have been performed and compared with present routine assessments used by ICES for combined units (ICES, 2016a). The advantage of such approach is that the overlap between clupeids and cod may be considered in the assessment much more realistically. For that purpose the estimates of predation mortality of clupeids related to given sub-division and/or smaller assessment units were used in the assessments instead of predation mortality being assumed for the whole Baltic as in the case of sprat, for example.

Part A. Assessment of herring stocks: herring in sub-divisions 25-27 and herring in sub-divisions 28-29+32

1. Assessment methodology

The basic mathematical models applied for the stock assessments were XSA (Shepherd, 1999) and SAM (Nielsen and Berg, 2014). These models are routinely used by ICES Working Groups including Baltic Fisheries Assessments Working Group (WGBFAS) when performing quantitative analysis of development of stock biomass and intensity of fisheries (ICES, 2016a). However, when performing stock assessment by former assessment units (AUs) it was observed that estimated by assessment model survey catchability was different in different AUs. This was rather unexpected result as all surveys were coordinated by Working Group on Baltic International Fish Survey (WGBIFS) and followed the same methodology (ICES, 2016b). Thus, in addition to assessments with XSA and SAM, a cohort analysis model in which the same catchability could be applied in AUs was developed and used for comparative assessments. The model has been described below.

Cohort analysis with assumed catchability (CohAnalQ)

In this assessment standard cohort analysis (CA) as described by Pope (1972) is applied. Stock numbers in terminal year or at terminal age are estimated from transformed Baranov catch equation

$$N(a,Y) = \frac{C(a,Y)Z(a,Y)}{F(a,Y)(1-e^{-Z(a,Y)})} \quad \text{or} \quad N(A,y) = \frac{C(A,y)Z(A,y)}{F(A,y)(1-e^{-Z(A,y)})}, \qquad [1]$$

stock numbers in earlier years and ages are derived from

$$N(a,y) = [N(a+1,y+1) * e^{M(a,y)/2} + C(a,y)] * e^{M(a,y)/2} \qquad [2]$$

and fishing mortality is obtained from

$$F(a,y) = \ln[N(a,y)/N(a+1,y+1)] - M(a,y), \qquad [3]$$

where:

- N is numbers,
- C is catch in numbers,
- M, F, and Z (Z=M+F) are instantaneous coefficients of natural, fishing, and total mortality, respectively,
- a and y are age and year, respectively,
- A and Y are terminal age and terminal year, respectively.

The model is fitted to survey based estimates of stock numbers at age derived from

$$Nsurvey(a,y) = SurvIndex(a,y)/q(a)$$ [4]

where SurvIndex is survey index of stock size and q is catchability. The parameters estimated within the model were fishing mortalities in terminal year (2015) and fishing mortalities at terminal age (7). Their estimates were obtained by minimisation of sum of squared differences (SS) between stock size estimates from eq. [4] and cohort analysis estimates

$$SS[\overline{F}(a,Y),\overline{F}(A,y)] = \sum_{a,y}[\ln Nsurvey(a,y) - \ln Nca(a,y)]^2$$ [5]

where $\overline{F}(a,Y),\overline{F}(A,y)$ represent vectors of fishing mortality in terminal year or at terminal age, Nca is numbers at survey time estimated in cohort analysis. In the analysis shrinkage to mean F at terminal age and in terminal year was also included by adding relevant terms to eq. [5]. The basic difference between standard cohort analysis and this approach is the use of assumed catchability resulting from catchabilities derived in another assessments (XSA in this case). This cohort analysis will be further referred to as CohAnalQ.

2. Stock of herring in sub-division 25-27

2.1. Biological and survey data

The data needed for assessments were taken from WGBFAS and WGBIFS reports (ICES, 2016 a, b) and ICES/WGBFAS data bases. Each year WGBFAS presents in its report catch-at-age (CANUM) and weight-at-age in the catch or in the stock (WECA/WEST) data by sub-divisions. Such data enabled compiling CANUM and WECA by former assessment units like herring in sub-divisions 25-27.

Mean weights at age in the catch were calculated as mean of weights at age in sub-divisions (25, 26, and 27) weighted by catch at age numbers in each sub-division. Weight-at-age in the stock was assumed to be the same as weight-at-age in the catch. The weights-at-age have decreased substantially in the 1990s and has remained stable since then (Figure 2.1.1).

Maturity at age was assumed the same as for the Central Baltic Herring (CBH) stock, comprising herrings in sub-divisions 25-29+32 (ICES, 2016a).

Natural mortality for the stock was determined using predation mortality estimates (M2) available from area-disaggregated SMS (Stochastic Multispecies Simulation, multispecies stock assessment model) (WKMULTBAL 2012). The M2 at age values for the stock were calculated as means of M2's by sub-divisions weighted by stock abundance from the acoustic survey. However, the SMS series ends in 2011. So, for the period 2012-2015 predation mortality was estimated from the linear regression relating cod biomass estimates and predation mortality of given stock, similarly as at WGBFAS (ICES, 2016a). The estimates of predation mortality mostly range between 0.05 – 0.15. Constant 0.2 was added to M2 values to get total natural mortality.

The tuning data set was available from Baltic International Acoustic Survey (BIAS) in autumn in 1991–2015 covering sub-divisions 25-27. The survey data were corrected for area coverage (ICES, 2016b). Biological and tuning data are provided in Tables 2.1.1-2.1.2.

2.2. Quality and consistency of input data

The consistency of the catch-at-age estimates was checked in bubbles-plot (Figure 2.2.1). The correlation between catches at a given age and the catches of the same generations 1 year later is quite good for ages 4-6 (0.7 – 0.9) but it is low between ages 2 and 3 (0.3). However, in the latter case low correlation is mainly due to the data from the beginning of time series and it will not probably have big effect on the assessment.

The internal consistency of survey at age estimates was checked on graphs (Figures 2.2.2). The correlation between survey indices at given age and the survey indices of the same generations 1 year later is quite good, mostly ranging between 0.6–0.8.

2.3. Stock assessments

Biological and survey data presented in section 2.1 (Tables 2.1.1-2) were used as input for the age structured assessments of the stock.

2.3.1. Assessment with XSA

The best settings for the parameterisation of XSA were found to be the same as specified in benchmark assessment of Central Baltic herring (CBH) stock (ICES, 2013), i.e.:

- tri-cubic time weighting,
- catchability (q) dependent on year class strength at age 1 (only for this age group the slope of regression between survey and XSA numbers was significantly different from 1),
- catchability independent of age for ages 6 and older,
- the SE (standard error) of the F shrinkage mean equal 1.5.

The log q residuals are presented in Figure 2.3.1.1. Residuals show some pattern with more positive values at the beginning of the time series and more negative values in recent years. However, for none of age groups significant linear time trend was detected. The data are moderately noisy as shown by SE of log q in range 0.25-0.4, with exception of age 1, for which regression SE is high (close to 0.7) (Figure 2.3.1.2). The correlations between XSA estimates and survey indices are high (R^2 mostly at level of 0.6–0.9).

The weights of estimates resulting from shrinkage are very low for ages 2 – 7 (up to 5%) (Figure 2.3.1.3a), which generally may be expected from assumption of low shrinkage SE (1.5). However, survivors of age 1 are mainly driven by P-shrinkage and to lower extent by acoustic survey (Figure 2.3.1.3b). The standard errors of the final estimates are mostly in range 0.1 – 0.3 and are markedly higher at age 1 (Figure 2.3.1.4).

Retrospective analysis (Figure 2.3.1.5) shows quite scattered estimates of biomass, fishing mortality, and recruitment (Mohn's Rho equal -0.27, 0.32, and, -0.36, respectively for SSB, F and recruitment). The assessment underestimates biomass and overestimates fishing mortality. Sensitivity of the terminal year estimates of SSB and average fishing mortality to the parameterisation of the XSA is presented in Figure 2.3.1.6. It shows quite strong effect of shrinkage to the population mean when ages 1-5 are assumed to have density dependent catchability.

The assessment is rather uncertain as shown by strong retrospective pattern and moderately large SE of survivors at some ages. Fish stock summary plots are presented in Figures 2.3.1.7.

2.3.2. Assessment with SAM

The SAM model was attempted at benchmark workshop as the second assessment model for herring (ICES, 2013). Results of SAM assessment (residuals plots, biomass and fishing mortality estimates) parameterised in similar way as XSA are presented in Figure 2.3.2.1-2. Residuals do not show clear trend similarly as in XSA assessment. However, biomass estimated with SAM is much lower than XSA biomass (ca. 30% in recent years, 15% on average) and fishing mortality is much higher. The assessment with SAM is available at the https://www.stockassessment.org (short name of the stock is her25-27).

2.3.3. Assessment with cohort analysis with assumed catchability (CohAnalQ)

The survey catchabilities estimated in XSA assessment of herring in sub-divisions 25-27 and herring in sub-divisions 28-29+32 differ as shown in Figure 2.3.3.1 (see next sections for the later assessment). The catchability estimated for herring in sub-divisions 25-27 is lower by 10 – 40% than that estimated for herring in sub-divisions 28-29+32. The reasons for this difference is not clear. It could be effect of lower predation mortality of herring in sub-divisions 25-27 than predation mortality estimated in SMS and used in assessments of that stock. Similarly, it could be effect of higher natural mortality of herring in sub-divisions 28-29+32 than used in the assessment. Other possibility is that coverage of stock in surveys in relation to biomass and catches distribution differs both AUs (e.g. in norther areas marked amount of herring is caught in shallow waters with trap-nets and these waters are usually to shallow to be investigated in the survey). It is also possible that inequality in obtained catchabilities may result from assessment errors. Anyway differences in estimated catchabilities lead to bigger relative differences in estimated biomasses that differences shown in the acoustic surveys. Thus, to correct for the effects of different catchabilities in the XSA estimates, the assessment of both stock was performed with the same catchabilities, using cohort analysis (CohAnalQ) as described in section 1.

The cohort analysis fits the data relatively well. The survey residuals show random distribution, while residuals from "F shrinkage" are mostly positive (but rather low) indicating that fishing mortality at terminal age is somewhat higher than average F of three preceding ages (Figure 2.3.3.2). Standard error of the fit is 0.33.

CohAnalQ assessment results are shown in Figure 3.3.3.2 with the results of XSA estimates for comparison. Spawning stock biomass in recent years is markedly lower than in XSA analysis, but in other years differences disappear or are small. Opposite picture is seen for fishing mortality; cohort analysis estimates it higher in recent years and lower in a few years at the beginning of time series.

Summary of assessments results by assessment model is presented in Table 2.3.1.

Table 2.1.1. Biological Input data for stock assessment, herring in sub-divisions 25-27.

CANUM: Catch in numbers (Thousands)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	149910	404451	502640	268372	224209	175725	105443	102945
1992	188868	254605	414301	410347	181120	148145	105270	90404
1993	115960	607114	748701	731164	395249	160858	89695	54669
1994	189502	220099	517501	535621	562852	277143	138590	78707
1995	390493	269502	580803	618322	279665	183938	78245	47685
1996	346197	413030	350756	387657	303220	188052	88871	42363
1997	172927	243418	583966	418074	322635	179214	85878	43001
1998	404906	285934	777897	827880	345477	198202	58056	43163
1999	354296	319837	241663	462810	386258	155677	71137	44019
2000	620463	481075	528196	250673	378286	261011	93030	48825
2001	347849	412215	208489	342920	131156	122247	125641	75686
2002	385357	316965	477576	189449	252935	77215	77982	85163
2003	318813	291738	236638	300140	105569	107190	41355	88576
2004	168569	281535	238918	230613	204330	77972	66033	67121
2005	176714	251295	327254	234517	191786	135597	60070	123841
2006	253750	210903	280577	312388	141239	115077	59591	55938
2007	131993	293647	173726	243528	287451	116427	67311	65243
2008	155875	255776	247439	108213	164168	137731	46816	53842
2009	127872	377399	269245	197914	89279	124005	112632	82485
2010	112408	169450	526281	292550	212811	99034	129081	126745
2011	115977	186501	190135	364515	159879	101396	65776	84140
2012	142663	167402	101983	131803	231183	100966	65985	84704
2013	73575	251108	106178	98039	156369	180248	81920	108134
2014	154429	185485	336188	138288	103771	151794	117817	118537
2015	763818	235713	403247	493525	154476	121092	164076	194262

WECA (=WEST): Mean weight in the Catch and in the Stock (Kilograms)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	0.0328	0.0399	0.0521	0.0654	0.0645	0.0713	0.0733	0.0858
1992	0.0244	0.0434	0.0517	0.0586	0.0668	0.0718	0.0759	0.0866
1993	0.0236	0.0317	0.0377	0.0435	0.0517	0.0606	0.0651	0.0792
1994	0.021	0.0375	0.0449	0.0484	0.0524	0.0643	0.07	0.088
1995	0.0139	0.0323	0.0353	0.0467	0.0534	0.0547	0.0669	0.0759
1996	0.0168	0.0268	0.0337	0.0407	0.0475	0.0513	0.0556	0.0718
1997	0.0161	0.0285	0.0301	0.0374	0.0435	0.0559	0.0627	0.0672
1998	0.0157	0.0259	0.0254	0.0346	0.0441	0.0499	0.0599	0.0596
1999	0.0153	0.0298	0.0339	0.03	0.0365	0.0449	0.0512	0.071
2000	0.0172	0.031	0.0399	0.0395	0.0375	0.0422	0.0497	0.0696
2001	0.0213	0.0337	0.0442	0.0436	0.0471	0.0507	0.0585	0.059
2002	0.0155	0.0305	0.0395	0.0438	0.0446	0.0516	0.0546	0.0541

2003	0.0127	0.0391	0.0442	0.0486	0.0543	0.0556	0.0615	0.0697
2004	0.0139	0.0238	0.0416	0.0394	0.0466	0.0508	0.0564	0.0679
2005	0.0152	0.0221	0.0291	0.0401	0.0438	0.0507	0.053	0.0586
2006	0.0182	0.0348	0.0349	0.0399	0.0507	0.0569	0.0637	0.074
2007	0.0156	0.0362	0.0479	0.0443	0.0464	0.0578	0.0595	0.0726
2008	0.0212	0.0332	0.042	0.0507	0.0478	0.0499	0.0597	0.069
2009	0.016	0.03	0.0355	0.0447	0.052	0.0518	0.0523	0.0624
2010	0.017	0.0274	0.0345	0.0401	0.0427	0.0478	0.05	0.0575
2011	0.0168	0.0354	0.0385	0.0449	0.0507	0.0551	0.0589	0.0626
2012	0.0193	0.0414	0.0505	0.0497	0.0549	0.0568	0.0627	0.0729
2013	0.0165	0.0266	0.054	0.0499	0.0489	0.0578	0.0596	0.0671
2014	0.0151	0.0352	0.0429	0.063	0.0556	0.0582	0.0617	0.0685
2015	0.0072	0.0365	0.0394	0.0421	0.0538	0.0512	0.0551	0.0601

NATMOR: Natural Mortality

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	0.24	0.23	0.22	0.22	0.22	0.22	0.21	0.21
1992	0.26	0.24	0.24	0.23	0.23	0.22	0.22	0.22
1993	0.32	0.29	0.28	0.26	0.26	0.25	0.24	0.24
1994	0.32	0.29	0.28	0.26	0.26	0.25	0.24	0.24
1995	0.32	0.29	0.28	0.26	0.26	0.25	0.24	0.24
1996	0.33	0.3	0.29	0.27	0.26	0.25	0.24	0.24
1997	0.27	0.26	0.25	0.24	0.23	0.23	0.22	0.22
1998	0.31	0.29	0.27	0.26	0.25	0.25	0.24	0.24
1999	0.39	0.35	0.33	0.3	0.29	0.28	0.26	0.26
2000	0.34	0.31	0.29	0.28	0.27	0.26	0.25	0.25
2001	0.36	0.33	0.31	0.29	0.28	0.27	0.25	0.25
2002	0.34	0.31	0.29	0.28	0.27	0.26	0.25	0.25
2003	0.34	0.31	0.29	0.27	0.27	0.26	0.24	0.24
2004	0.3	0.28	0.27	0.25	0.25	0.24	0.23	0.23
2005	0.29	0.27	0.26	0.25	0.24	0.24	0.23	0.23
2006	0.34	0.31	0.29	0.27	0.27	0.26	0.24	0.24
2007	0.34	0.31	0.29	0.28	0.27	0.26	0.25	0.25
2008	0.36	0.33	0.31	0.29	0.28	0.27	0.25	0.25
2009	0.39	0.35	0.33	0.3	0.29	0.28	0.26	0.26
2010	0.39	0.35	0.33	0.3	0.29	0.28	0.26	0.26
2011	0.56	0.48	0.44	0.39	0.37	0.35	0.32	0.32
2012	0.35	0.31	0.3	0.28	0.27	0.26	0.25	0.25
2013	0.33	0.3	0.29	0.27	0.26	0.25	0.24	0.24
2014	0.33	0.3	0.29	0.27	0.26	0.25	0.24	0.24
2015	0.33	0.3	0.29	0.27	0.26	0.25	0.24	0.24

MATPROP: Proportion of Mature at Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0	0.7	0.9	1	1	1	1	1

MPROP: Proportion of M before Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

FPROP: Proportion of F before Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35

Table 2.1.2. Tuning data for stock assessment, herring in sub-divisions 25-27.

Tuning fleet in SD 22-25 (Millions)

FLT01: International acoustic in October, area corrected

Year	Fish.Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	1	3194	5718	4728	1737	3260	840	1088	1252
1992	1	5275	4802	7077	4376	1898	950	561	355
1993	1	NA	NA	NA	NA	NA	NA	NA	NA
1994	1	2348	4135	9287	6273	2880	1042	523	324
1995	1	4165	1501	2834	4136	3614	2188	1034	564
1996	1	2329	7044	5290	4812	2617	1299	572	326
1997	1	NA	NA	NA	NA	NA	NA	NA	NA
1998	1	2906	1205	3411	3500	1285	923	372	223
1999	1	1537	2837	1673	2606	2139	788	442	387
2000	1	1899	832	2552	1181	1616	1438	558	399
2001	1	2684	4709	1859	3029	959	691	651	278
2002	1	1546	1607	3121	1438	1257	441	371	182
2003	1	5550	4745	4505	3725	1125	1137	354	528
2004	1	2411	6700	3766	2494	1702	553	430	441
2005	1	1252	3156	6019	2316	1947	1140	481	631
2006	1	3250	2243	5358	9162	2717	1618	1100	732
2007	1	1849	2091	1033	1821	2798	796	577	508
2008	1	3746	3137	3018	1445	2870	2355	597	609
2009	1	1231	4975	2937	2572	900	1589	1049	332
2010	1	1116	2383	4780	2380	1701	769	976	575
2011	1	1364	2073	5517	7168	3097	1846	1134	1285
2012	1	4155	1641	2761	4074	4729	1556	1081	1228
2013	1	2481	4663	1243	2089	3646	3532	1594	2369
2014	1	1404	3003	6034	2438	3092	3543	2385	2135
2015	1	3960	5228	8223	9919	3505	3614	2796	2940

Table 2.3.1. Spawning stock biomass (SSB) and fishing mortality (F(3-5)) estimated by XSA, SAM, and CohAnalQ assessments of herring in sub-divisions 25-27.

	SSB			F(3-6)		
	XSA	SAM	CohAnalQ	XSA	SAM	CohAnalQ
1991	519	483	520	0.25	0.33	0.25
1992	547	512	549	0.24	0.32	0.24
1993	399	462	401	0.36	0.39	0.35
1994	406	435	410	0.47	0.42	0.46
1995	331	336	337	0.38	0.39	0.37
1996	325	309	336	0.35	0.38	0.34
1997	326	284	338	0.37	0.40	0.36
1998	264	234	277	0.41	0.46	0.39
1999	255	213	268	0.31	0.41	0.29
2000	243	218	255	0.40	0.46	0.37
2001	280	247	289	0.28	0.39	0.27
2002	263	232	265	0.29	0.37	0.28
2003	319	300	318	0.21	0.29	0.21
2004	302	266	300	0.20	0.26	0.21
2005	305	247	304	0.19	0.27	0.20
2006	362	299	358	0.17	0.24	0.17
2007	390	307	389	0.18	0.25	0.18
2008	405	304	399	0.13	0.20	0.13
2009	484	331	457	0.14	0.21	0.14
2010	474	327	432	0.19	0.23	0.19
2011	521	379	455	0.12	0.18	0.13
2012	550	394	463	0.09	0.15	0.11
2013	603	420	490	0.08	0.14	0.10
2014	774	525	616	0.09	0.14	0.12
2015	710	533	548	0.13	0.18	0.17
mean	414	344	391	0.24	0.30	0.24

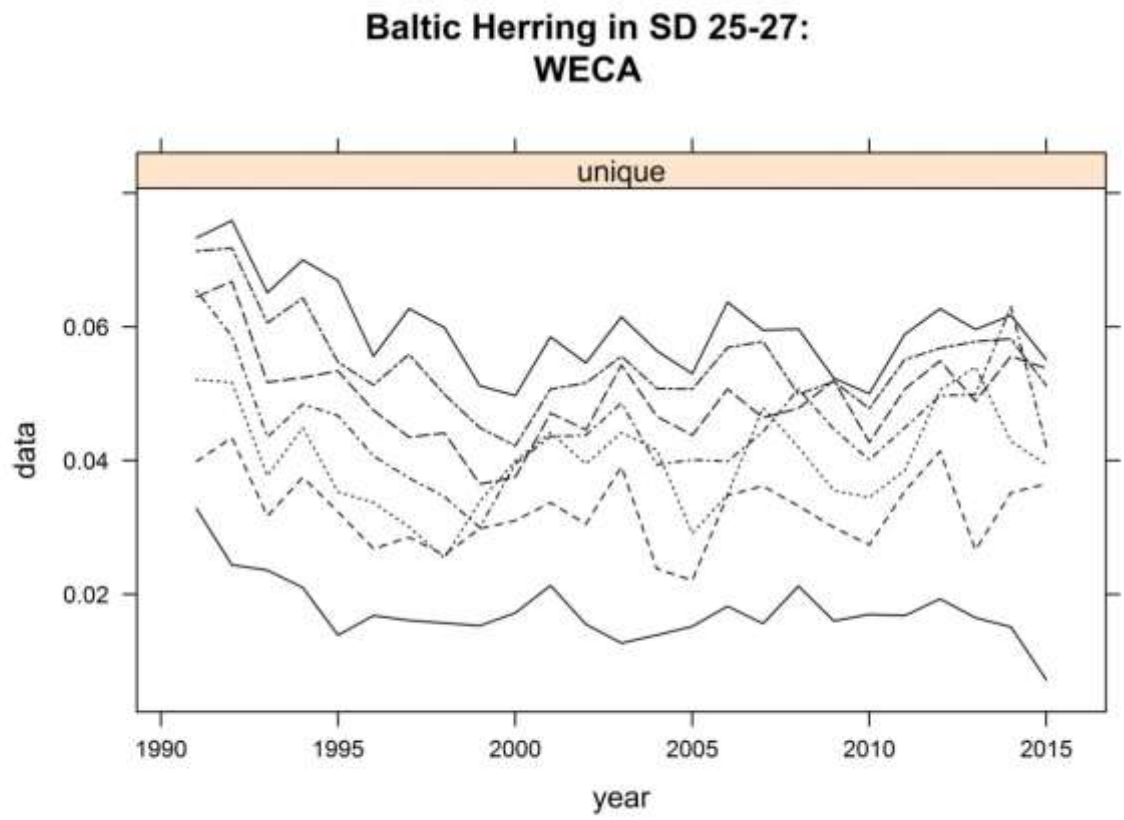


Figure 2.1.1. Herring in SD 25-27. Mean weight-at-age in the catches (weight in the stock assumed as in the catches).

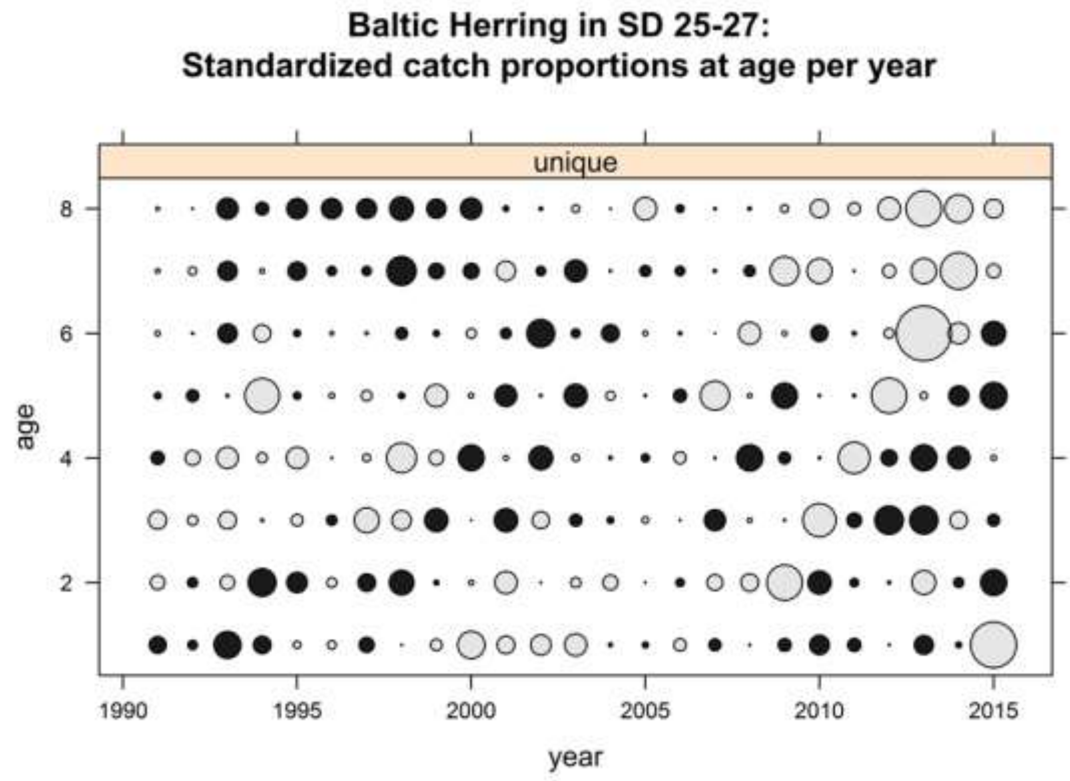


Figure 2.2.1. Herring in SD 25-27. CANUM consistency check.

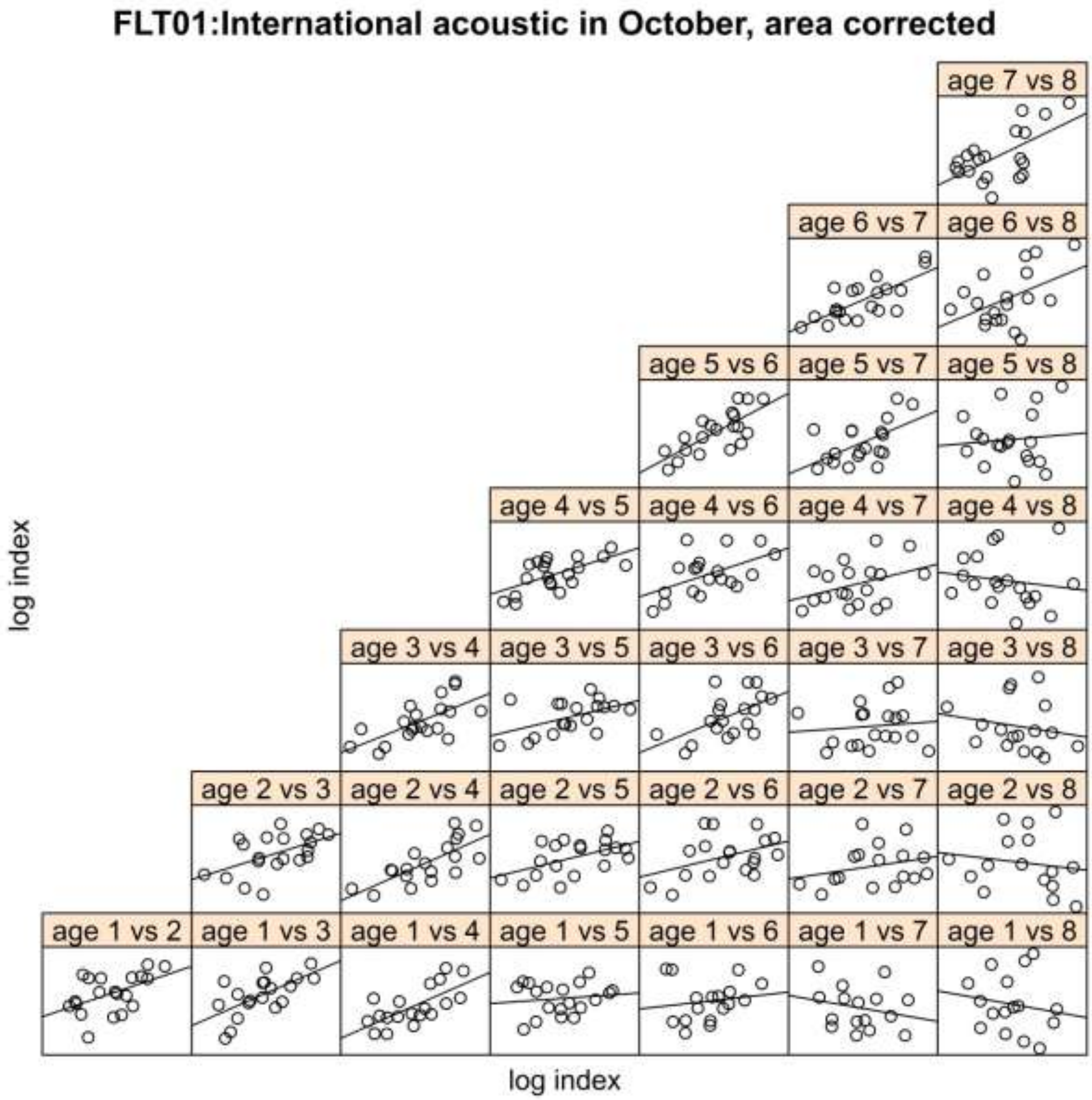


Figure 2.2.2. Herring in SD 25-27. Check for consistency in October acoustic survey (BIAS) estimates.

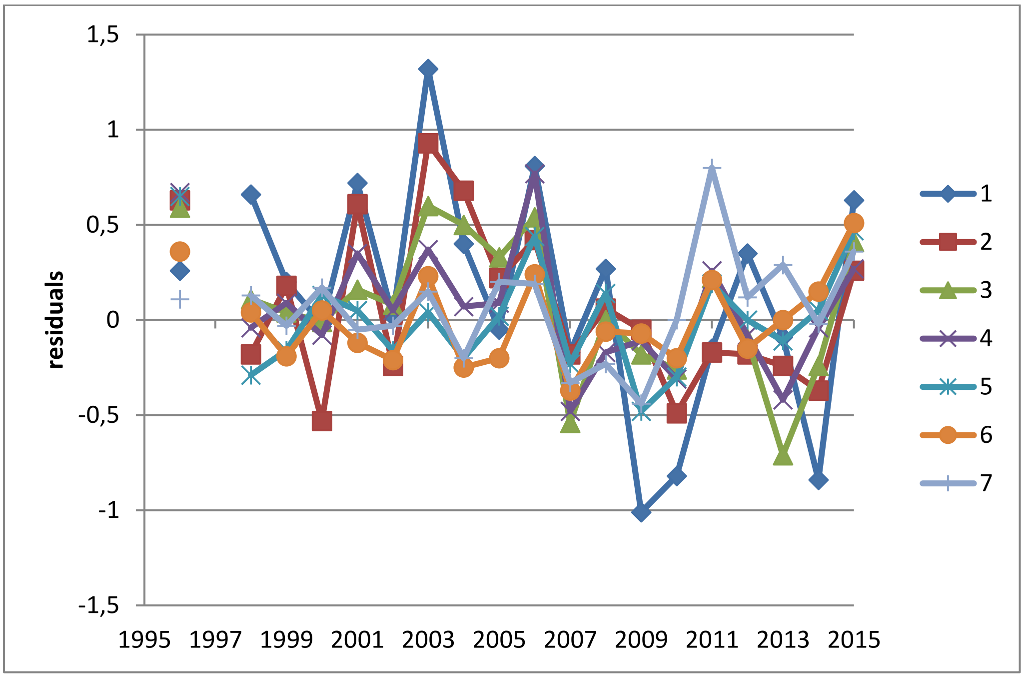


Figure 2.3.1.1. Distribution of survey log-catchability residuals in XSA analysis.

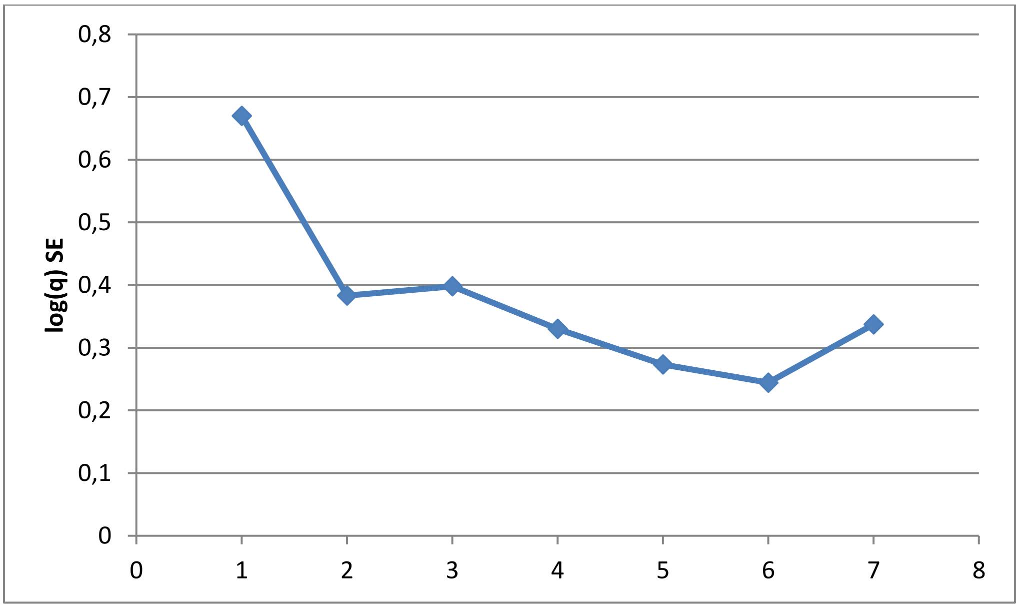
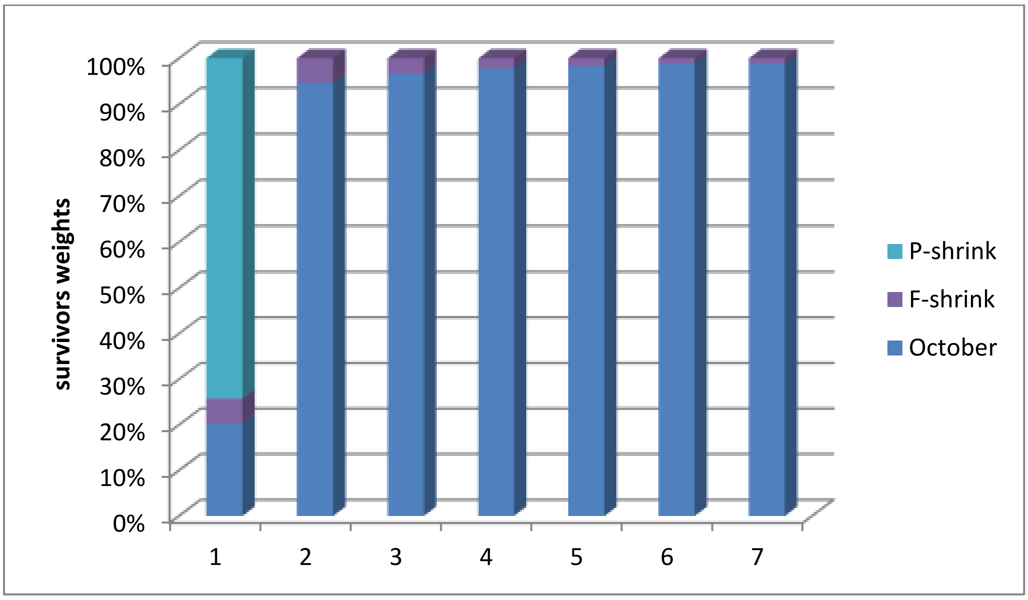


Figure 2.3.1.2. The standard errors (SE) of log-catchability residuals.



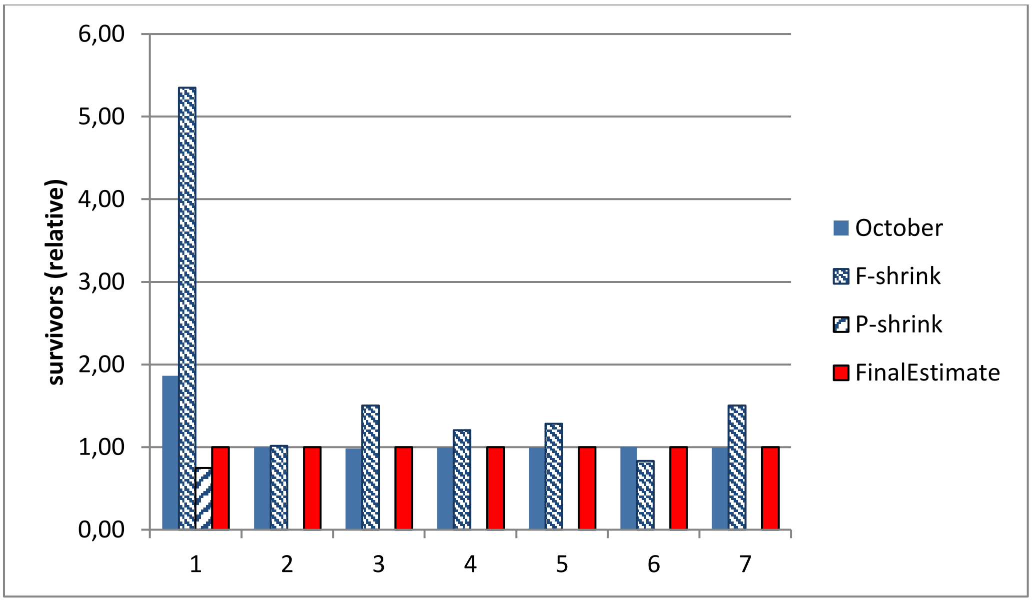


Figure 2.3.1.3. Weights of survivors estimates (upper graph) and survivors estimates relative to final estimate (bottom graph) by tuning fleet and applied shrinkage.

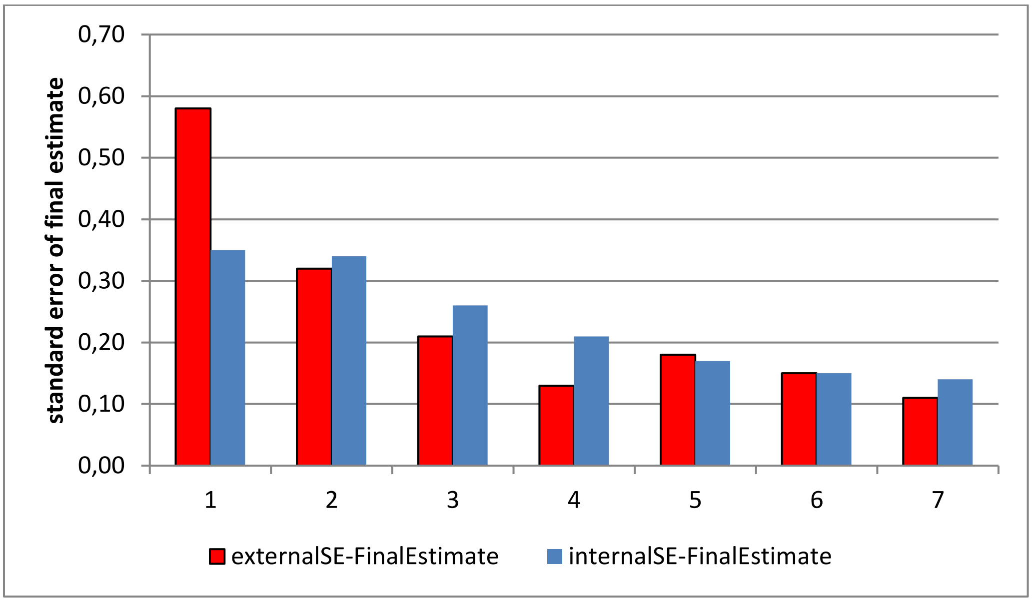


Figure 2.3.1.4. The internal and external standard error (SE) of survivors estimates in XSA.

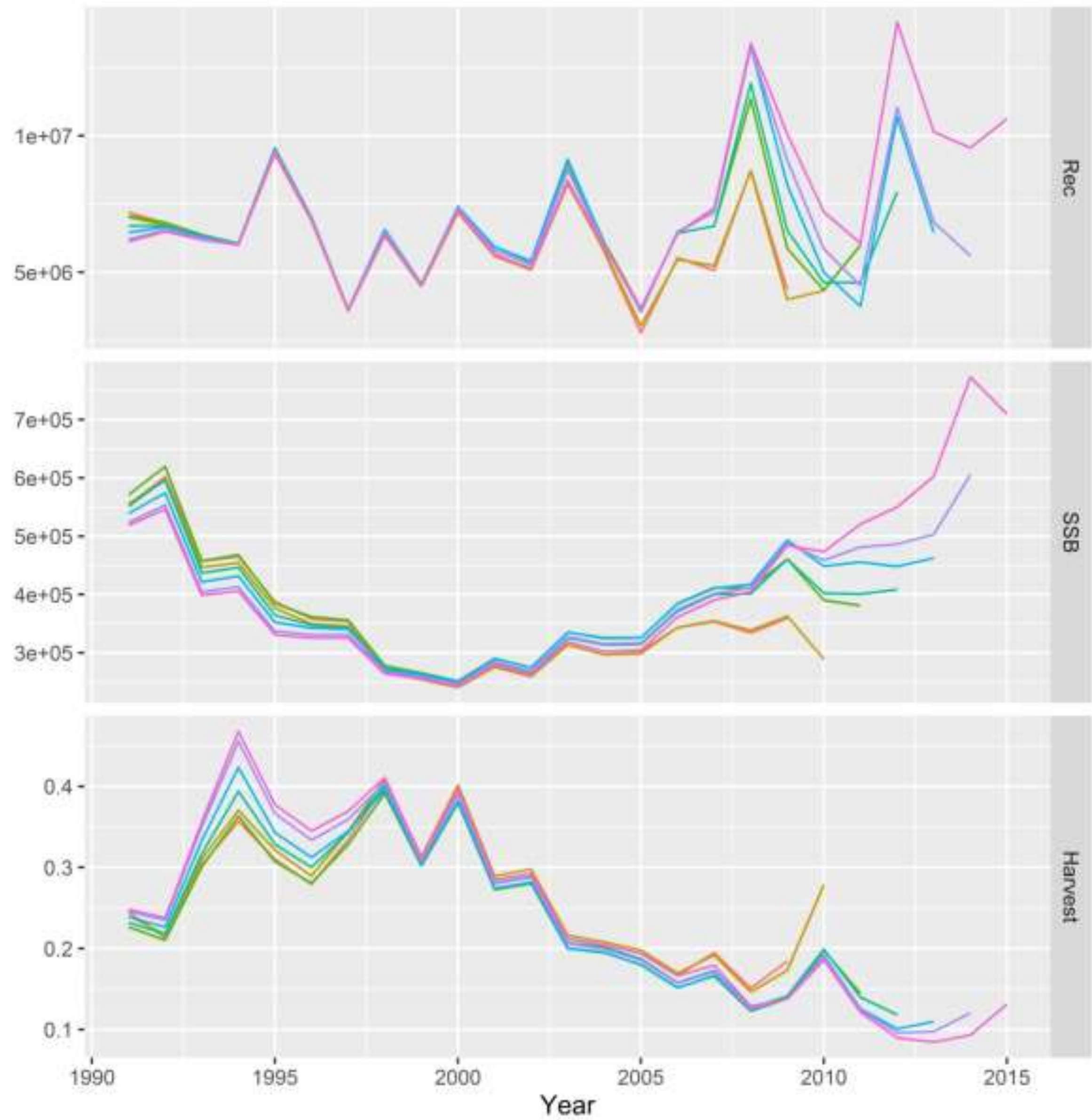
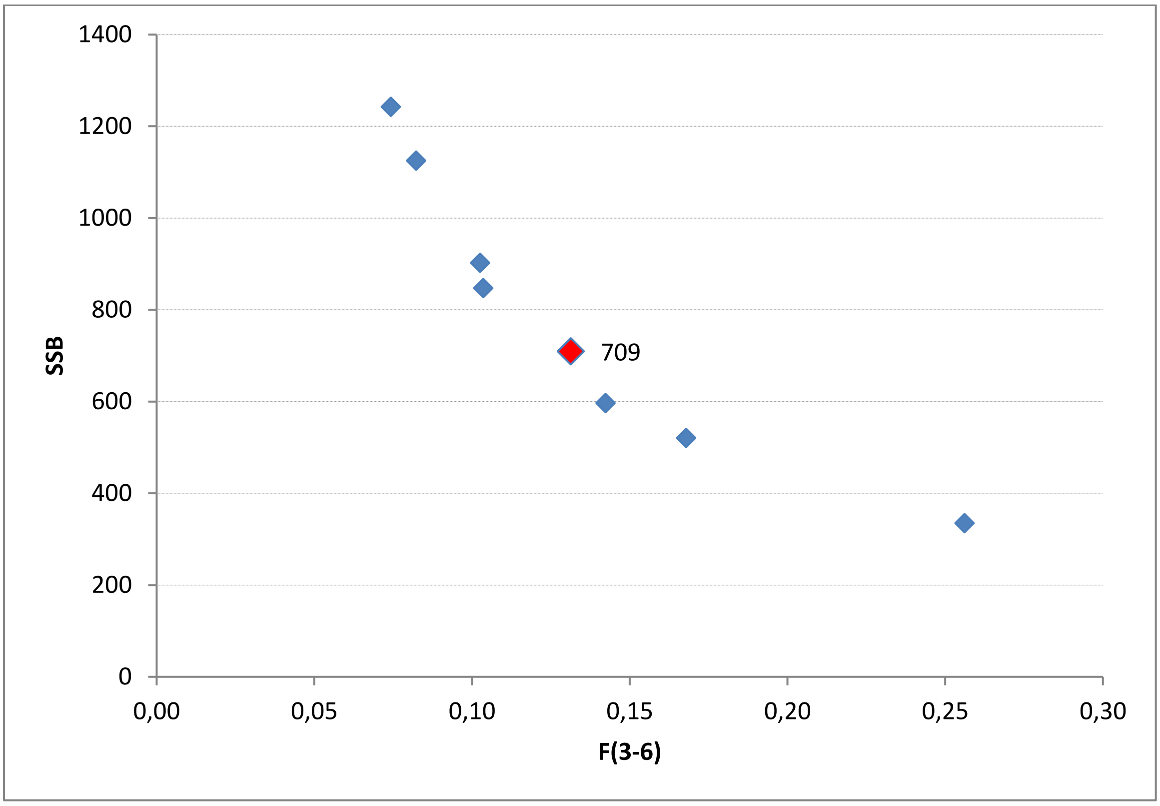


Figure 2.3.1.5. Retrospective estimates of recruitment, spawning stock biomass and fishing mortality for herring in sub-divisions 25-27.



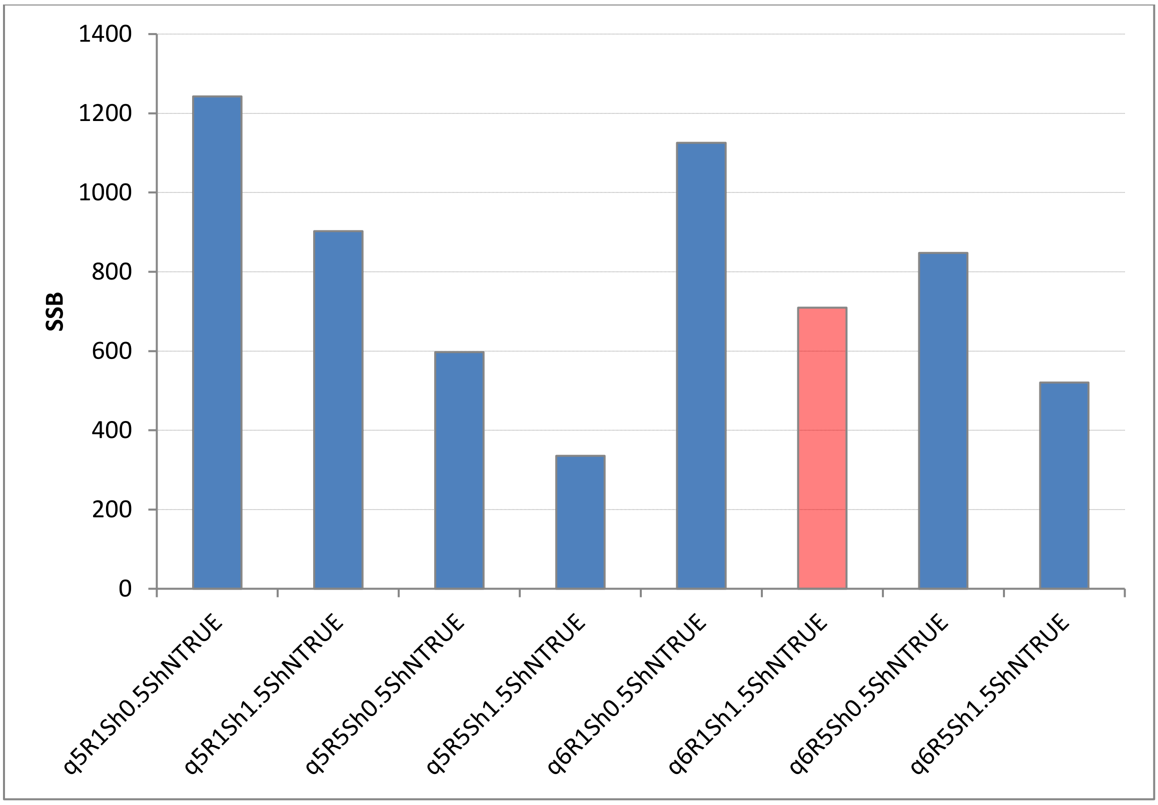
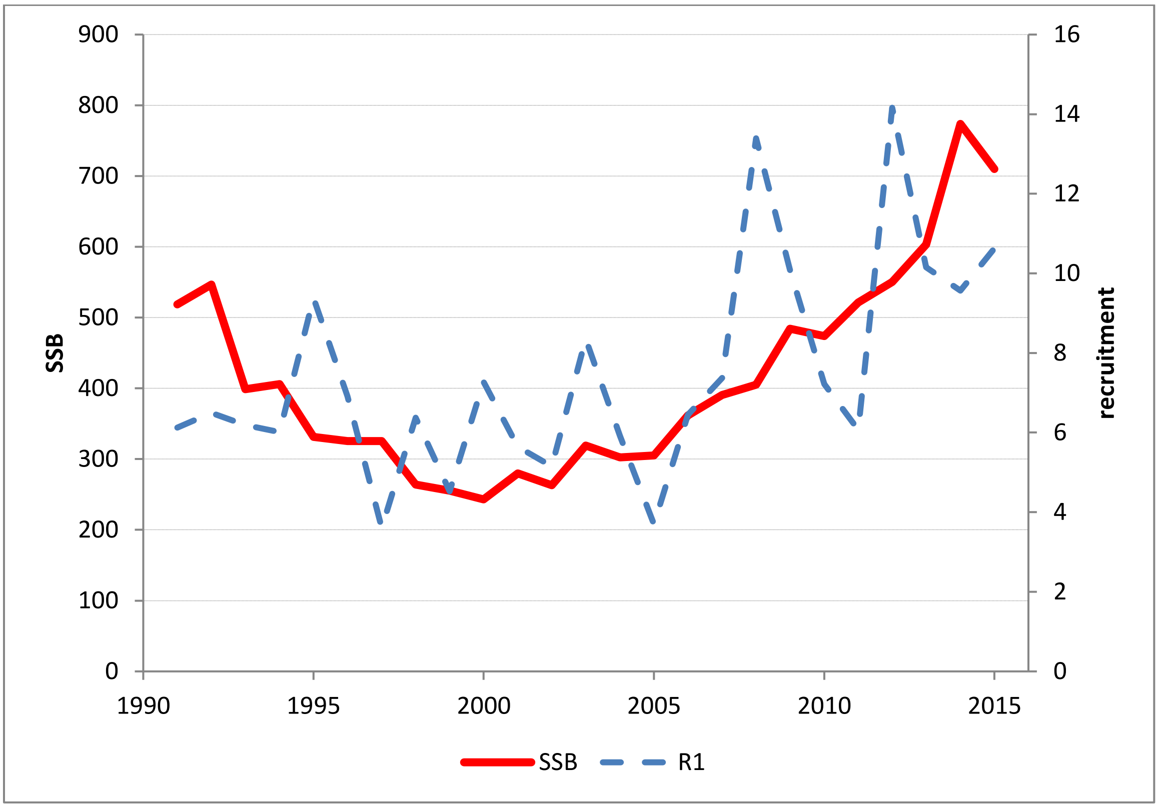


Figure 2.3.1.6. Sensitivity of the terminal year estimates of SSB and average fishing mortality to the parameterisation of the XSA. Final estimates are shown in red.



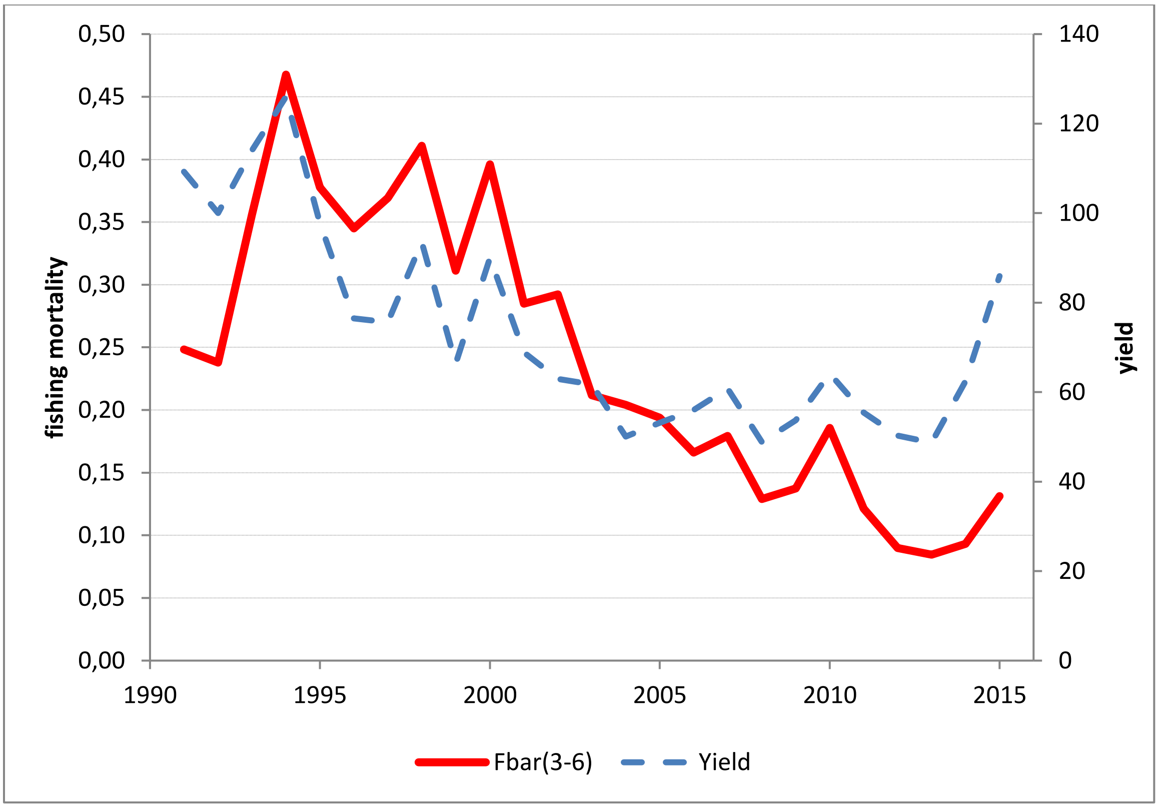


Figure 2.3.1.7. The XSA estimates of spawning stock biomass (10^3 t.), recruitment (10^9 individuals), and fishing mortality. For comparison yield (10^3 t.) is given.

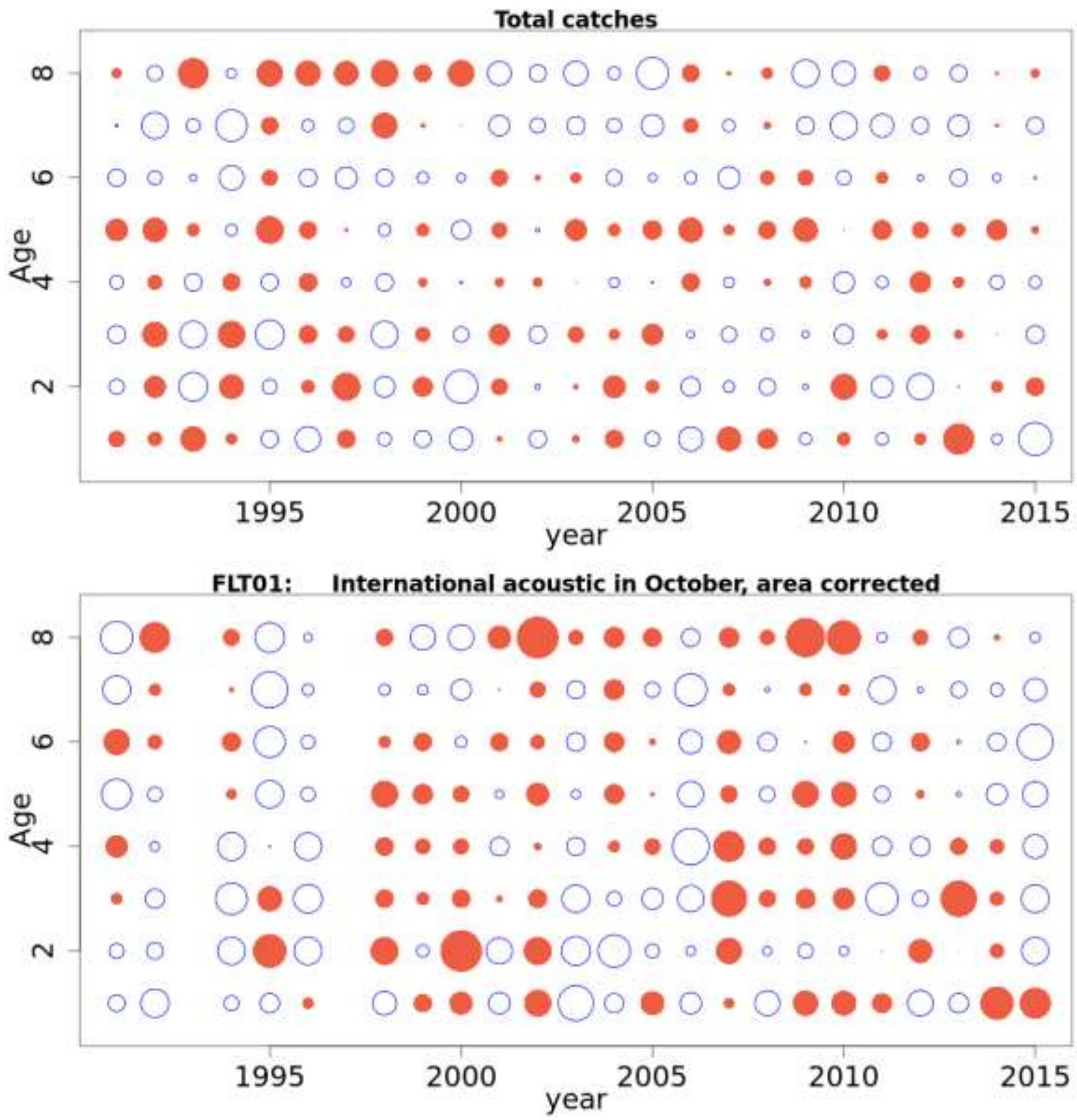


Figure 2.3.2.1. Plot of residuals in the SAM model for catches and tuning fleet.

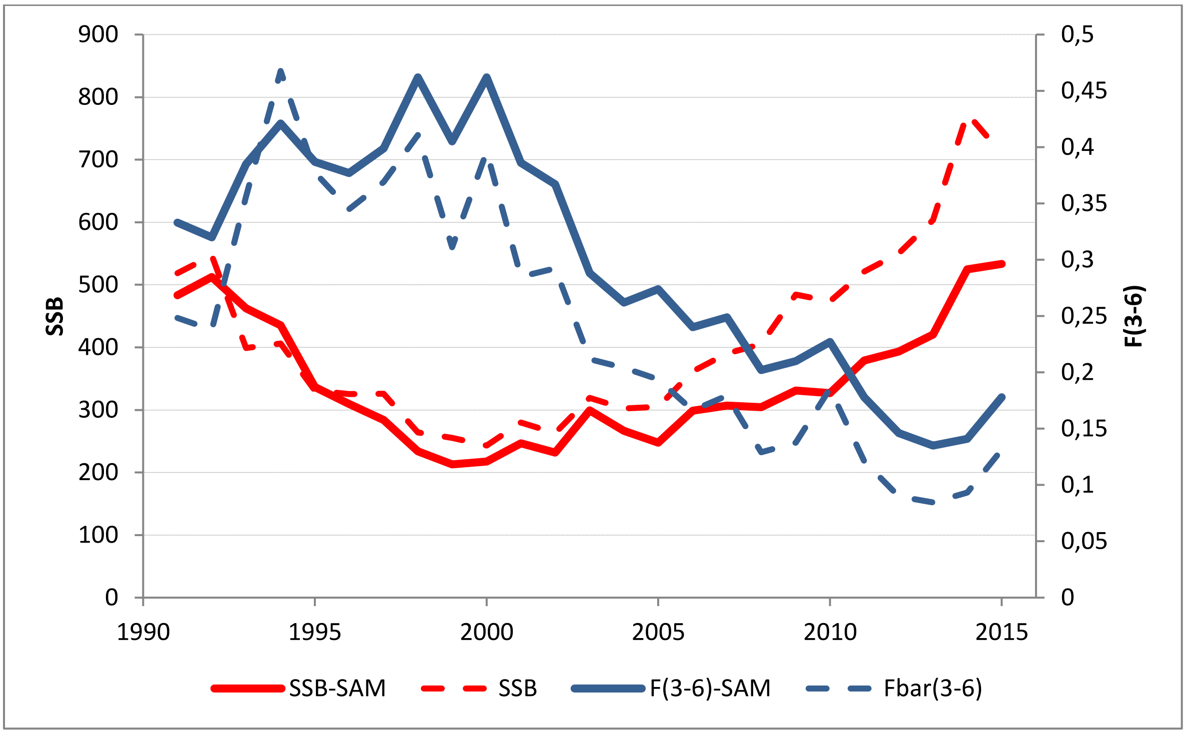


Figure 2.3.2.2. SAM model estimates of spawning stock biomass (10^3 t.) and fishing mortality. For comparison XSA estimates (broken lines) are given.

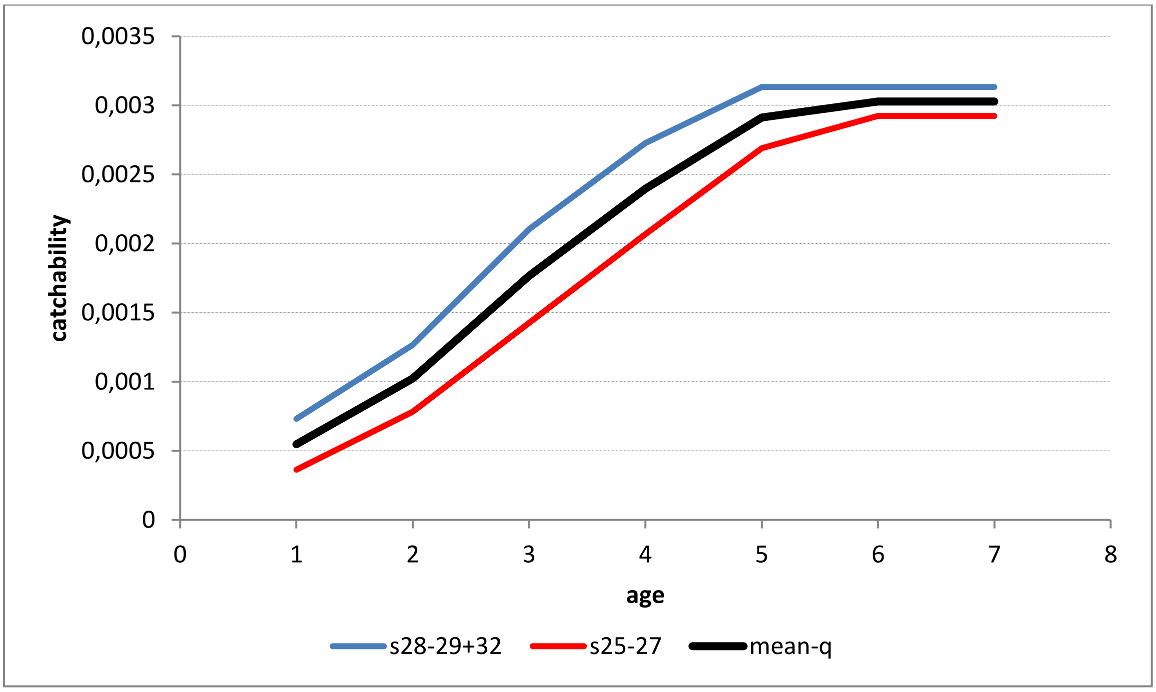
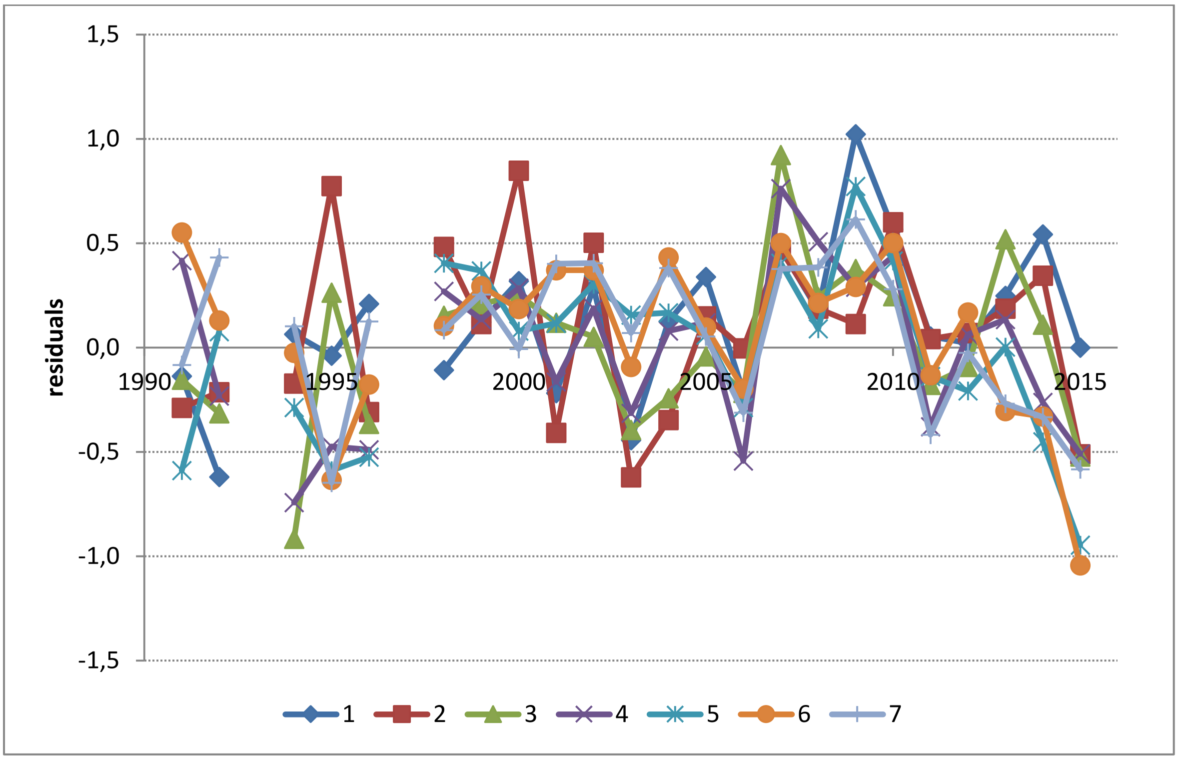


Figure 2.3.3.1. Survey catchability estimated for herring in sub-divisions 25-27 and herring in sub-divisions 28-29+32, and their mean value.



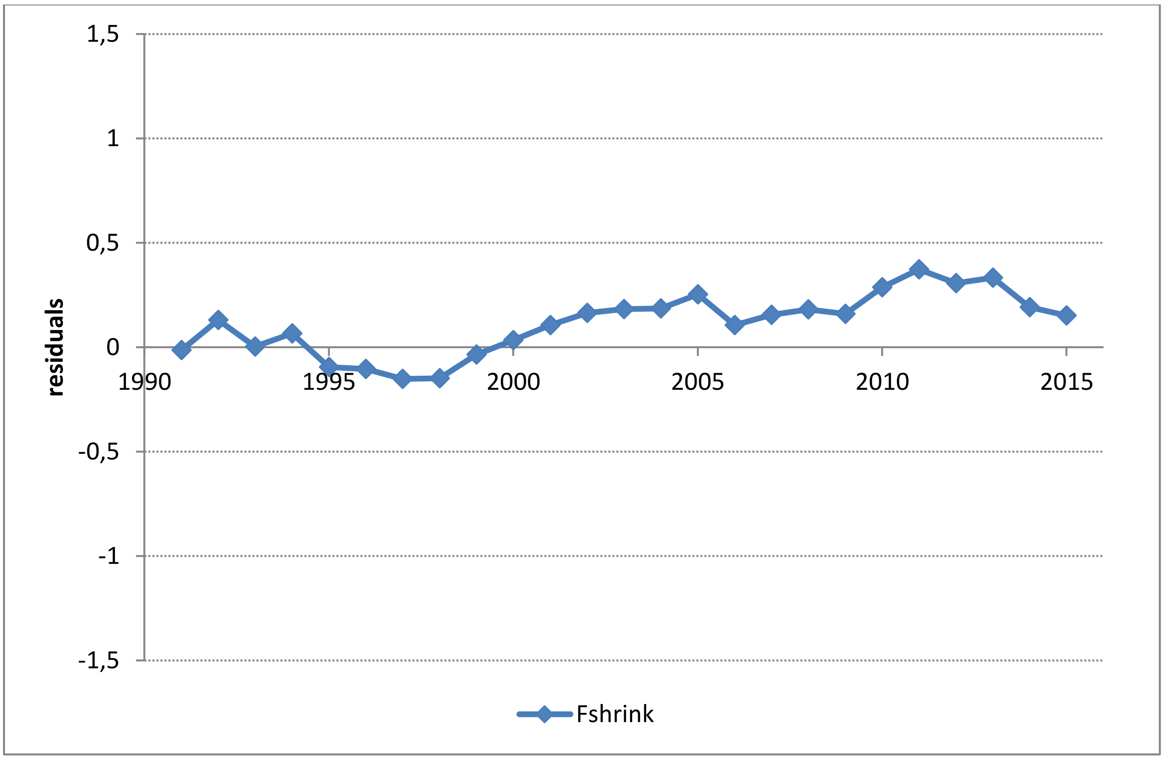


Figure 2.3.3.2. Time series of residuals for stock estimates at age (upper plot) and residuals in fishing mortality at terminal age (bottom plot).

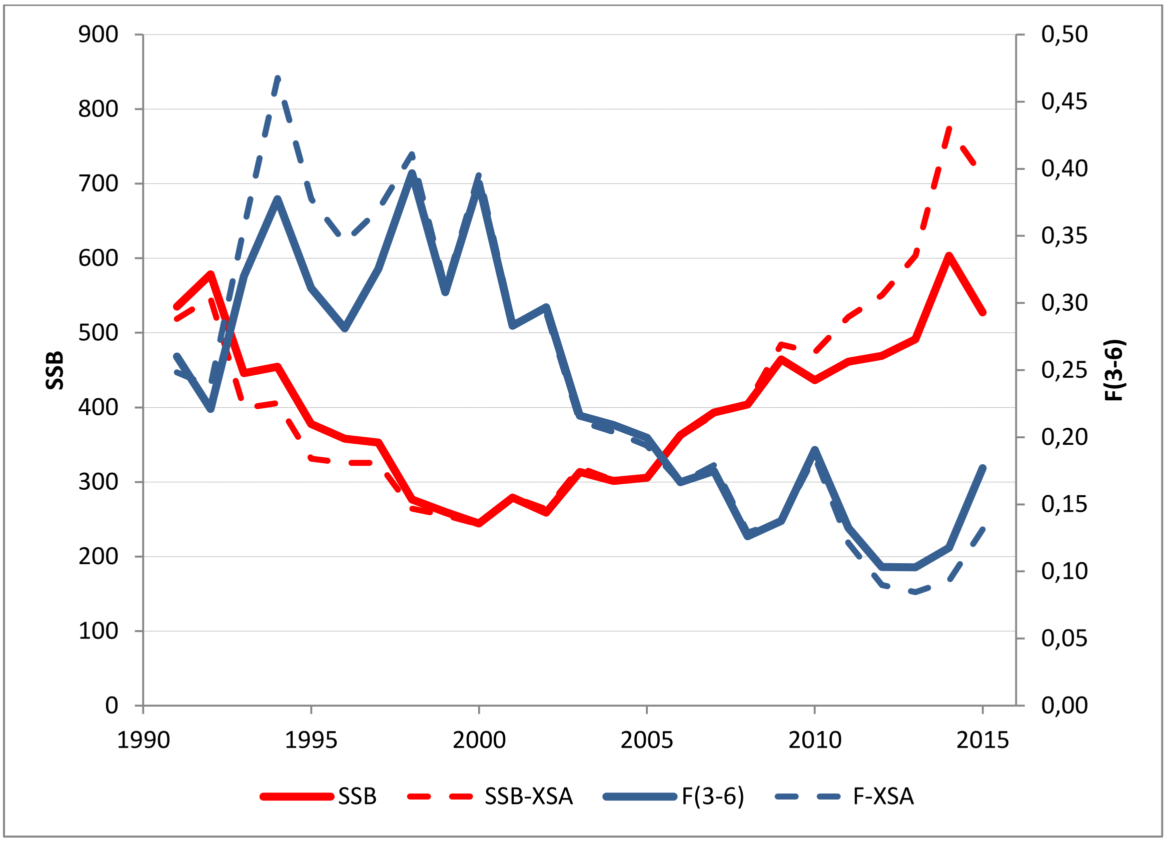


Figure 2.3.3.3. Spawning stock biomass (10^3 t.) and fishing mortality estimated by cohort analysis with assumed catchability (CohAnalQ). For comparison XSA estimates of these variables are given (broken lines).

3. Stock of herring in sub-divisions 28-29+32

3.1. Biological and survey data

The data required for the assessments were taken from WGBFAS and WGBIFS reports (ICES, 2016 a, b) and ICES/WGBFAS data bases. Each year WGBFAS presents in its report catch-at-age (CANUM) and weight-at-age (WECA/WEST) data by sub-divisions. Such data enabled compiling CANUM and WECA by former assessment units like herring in sub-divisions 28-29+32.

Mean weights at age in the catch were calculated as mean of weights at age in sub-divisions (28, 29, and 32) weighted by catch at age numbers in each sub-division. Weight-at-age in the stock was assumed to be the same as weight-at-age in the catch. The weights-at-age have been decreasing from the beginning of 1990s up to 1997 and have shown some increase next (Figure 3.1.1).

Maturity at age was assumed the same as for the CBH stock, comprising herrings in sub-divisions 25-29+32 (ICES, 2016a).

Natural mortality for the stock was determined using predation mortality estimates (M2) available from area-disaggregated SMS (Stochastic Multispecies Simulation, multispecies stock assessment model) (WKMULTBAL 2012). The M2 at age value for the stock was calculated as mean of M2's by sub-divisions weighted by stock abundance from the acoustic survey. However, the SMS series ends in 2011. So, for the period 2012-2015 predation mortality was estimated from the linear regression relating cod biomass estimates and predation mortality of given stock, similarly as at WGBFAS (ICES, 2016a). The estimated predation mortalities for that stock are very low (usually at 0.01-0.02) as cod is mainly distributed in southern areas of the Baltic. Constant 0.2 was added to M2 values to get total natural mortality.

The tuning data set was available from Baltic International Acoustic Survey (BIAS) in autumn in 1991–2015 covering sub-divisions 28-29. The survey data were corrected for area coverage (WGBIFS, ICES, 2016b). Biological and tuning data are provided in Tables 3.1.1-3.1.2.

3.2. Quality and consistency of input data

The consistency of the catch-at-age estimates was checked on bubbles-plot (Figure 3.2.1). The correlation between catches at a given age and the catches of the same generations 1 year later is high, mostly between 0.8-0.9.

The internal consistency of survey at age estimates was checked on graphs (Figure 3.2.2). The correlation between survey indexes at given age and the survey indexes of the same generations 1 year later is rather low, ranging between 0.4–0.6.

3.3. Stock assessments

Biological and survey data presented in section 3.1 (Tables 3.1.1-2) were used as input for the age structured assessments of the stock.

3.3.1. Assessment with XSA

The best settings for the parameterisation of XSA were found to be similar to the specified in benchmark assessment of CBH stock (ICES, 2013). The only exception was catchability plateau, which was set at age 5 instead of 6; it was strong argument for such change as when q plateau was set at age 6 the estimate of catchability at age 5 was almost the same as at age 6. Finally, the settings of the XSA were the following

- tri-cubic time weighting,
- catchability dependent on year class strength at age 1 (only for this age group the slope of regression between survey and XSA numbers was significantly different from 1),
- catchability independent of age for ages 5 and older,
- the SE of the F shrinkage mean equal 1.5.

The log q residuals are presented in Figure 3.3.1.1. Residuals do not show clear pattern except the beginning of the time series when they are mostly negative. The residuals at age 1 show significantly increasing linear time trend but this is not considered to have marked effect on assessment as survey for age 1 has low weight in most of survivors estimates. The data are moderately noisy as shown by SE of log q in range 0.25-0.4 (Figure 3.3.1.2). The correlations between XSA estimates and survey indices are quite high (R^2 in range of 0.5–0.9).

The weight of estimates resulting from shrinkage are very low for ages 2 - 7(up to 2%) (Figure 3.3.1.3a), which generally may be expected from assumption of low shrinkage SE (1.5). However, survivors of age 1 are in about 50% derived from both the P-shrinkage and survey estimates of numbers (Figure 3.3.1.3b). The standard errors of the final estimates are mostly in range 0.1 – 0.2 and are markedly higher at age 1 (Figure 3.3.1.4).

Retrospective analysis (Figure 3.3.1.5) shows relatively consistent estimates of biomass, fishing mortality, and recruitment (Mohn's Rho in range -0.11 – 0.14 for SSB, F and recruitment). The assessment shows tendency to slightly overestimate biomass and underestimate fishing mortality. Sensitivity of the terminal year estimates of SSB and average fishing mortality to the parameterisation of the XSA is presented in Figure 3.3.1.6. It shows moderate effect of F shrinkage on the stock estimates; the effect of other considered parameters is very low.

The assessment is relatively good with rather low retrospective deviations and SE of survivors <0.15 for most of the ages. Fish stock summary plots are presented in Figures 3.3.1.7.

3.3.2. Assessment with SAM

The SAM model was attempted at benchmark workshop as the second assessment model for herring (ICES, 2013). Results of SAM assessment (residuals plots, biomass and fishing mortality estimates) parameterised in similar way as XSA are presented in Figure 3.3.2.1-2. Residuals do not show clear trend similarly as in XSA assessment. However, biomass estimated with SAM is higher than XSA biomass (ca. 20% in recent years, 8% on average) and fishing mortality is lower (10% on average). The assessment with SAM is available at the https://www.stockassessment.org (short name of the stock is her28-29and32).

3.3.3. Assessment with cohort analysis with assumed catchability (CohAnalQ)

As indicated in the section 2.3.3 the survey catchabilities estimated in XSA assessment of herring in sub-divisions 25-27 and herring in sub-divisions 28-29+32 differ (Figure 2.3.3.1). Thus, similarly as in case of herring in sub-divisions 25-27 stock, to correct for the effects of different catchabilities in the XSA estimates of both stocks, the assessment of herring stock in sub-divisions 28-29+32 was performed with average for both stocks catchabilities, using cohort analysis (CohAnalQ) as described in section 1.

The cohort analysis fits the data relatively well. The survey and “F shrinkage” residuals do not show clear pattern (Figure 3.3.3.1). Standard error of the fit is 0.42, somewhat higher than for herring in sub-divisions 25-27.

CohAnalQ assessment results are shown in Figure 3.3.3.2 with the results of XSA estimates for comparison. Estimates of spawning stock biomass in recent years are markedly higher than in XSA analysis, but in other years differences disappear or are small. The fishing mortality estimates from cohort analysis and from XSA are not very different, being slightly higher in recent and very similar in other years.

Summary of assessments results by assessment model is presented in Table 3.3.1.

Table 3.1.1. Biological Input data for stock assessment, herring in sub-divisions 28-29+32.

CANUM: Catch in numbers (Thousands)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	212900	1141358	767446	239325	573964	101949	160085	132188
1992	884010	826818	1227429	405418	128827	258857	47667	100165
1993	694972	1220299	771058	760416	229057	113495	111676	87048
1994	288198	898224	1019386	523180	485049	214185	73641	202523
1995	421807	677517	1139754	919415	359466	252061	124772	162078
1996	661773	1042966	744481	836188	499967	299777	208268	174046
1997	426911	1203556	1256046	821340	635967	344948	173848	157986
1998	1457096	660781	1028311	948285	463273	279200	151943	142983
1999	287966	1362087	717346	854285	570285	187727	116721	77344
2000	1221760	458936	1153932	568317	486225	306164	98250	136256
2001	704614	1517855	396562	667745	244677	268873	177605	123972
2002	649283	696010	862275	267390	269507	102495	91869	144976
2003	1028551	490870	450839	386533	155683	119621	48571	113792
2004	488061	961405	434711	337441	180268	84379	53668	62763
2005	149558	502203	859822	322631	186662	84126	22461	35478
2006	554636	294689	473440	792590	267819	149788	94902	91729
2007	325588	626644	456533	459658	536355	152234	68667	46776
2008	633514	479735	720979	353280	321629	573281	119082	161783
2009	525171	1017682	476690	657134	213207	216493	373443	156855
2010	433944	475819	831032	369185	417418	184729	154639	235643
2011	177140	382391	580661	766016	255626	211369	63104	151147
2012	190693	149607	314657	385939	410820	133458	94724	123737
2013	396752	404571	153862	312664	311070	223340	90959	116005
2014	315631	717157	667516	247383	384305	257959	167480	132222
2015	651757	509417	861385	759237	223561	263719	205879	279158

WECA (=WEST): Mean weight in the Catch and in the Stock (Kilograms)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	0.0147	0.0189	0.0246	0.0299	0.0321	0.0424	0.0471	0.0568
1992	0.0118	0.0168	0.0223	0.0287	0.0385	0.0358	0.0483	0.0549
1993	0.011	0.0158	0.0245	0.0271	0.0289	0.0349	0.0382	0.0575
1994	0.0122	0.0178	0.0206	0.028	0.0308	0.0362	0.0464	0.0518
1995	0.009	0.0162	0.0196	0.0226	0.0308	0.0348	0.0368	0.0486
1996	0.0088	0.0133	0.0186	0.021	0.0238	0.0291	0.0344	0.0457
1997	0.0093	0.0135	0.0166	0.0199	0.0235	0.0248	0.0287	0.0374
1998	0.009	0.0142	0.0183	0.0215	0.0246	0.0284	0.0339	0.045
1999	0.0094	0.0133	0.0184	0.0218	0.0244	0.0289	0.031	0.0436
2000	0.0105	0.0158	0.019	0.0228	0.0266	0.0313	0.0326	0.0381
2001	0.0102	0.0147	0.0208	0.0231	0.0271	0.0303	0.0327	0.0398
2002	0.0119	0.0176	0.0202	0.0254	0.0291	0.0298	0.0346	0.0403

2003	0.0083	0.0154	0.0222	0.0253	0.0283	0.0348	0.0403	0.0434
2004	0.0069	0.0115	0.0183	0.0244	0.0303	0.034	0.0372	0.0414
2005	0.0088	0.0117	0.0156	0.0213	0.0271	0.0317	0.0351	0.0475
2006	0.0092	0.0152	0.0171	0.0209	0.025	0.0332	0.0391	0.0439
2007	0.011	0.0146	0.0168	0.0225	0.0258	0.0312	0.0401	0.0431
2008	0.0113	0.0163	0.02	0.0239	0.0314	0.0296	0.0377	0.0435
2009	0.01	0.0161	0.0218	0.0249	0.0285	0.036	0.0307	0.038
2010	0.0107	0.0151	0.0202	0.026	0.0283	0.0335	0.0408	0.0383
2011	0.0098	0.0148	0.02	0.0254	0.0293	0.0313	0.0354	0.0391
2012	0.0104	0.0154	0.0192	0.0274	0.0344	0.0376	0.0434	0.0506
2013	0.0111	0.0175	0.022	0.0269	0.0335	0.04	0.0423	0.0468
2014	0.0102	0.0162	0.0226	0.0255	0.0294	0.0366	0.0404	0.0434
2015	0.0071	0.0148	0.0214	0.0272	0.0303	0.0353	0.0408	0.045

NATMOR: Natural Mortality

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	0.22	0.21	0.21	0.21	0.21	0.2	0.2	0.2
1992	0.21	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.21	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.21	0.21	0.21	0.2	0.2	0.2	0.2	0.2
1995	0.21	0.21	0.21	0.2	0.2	0.2	0.2	0.2
1996	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1997	0.24	0.23	0.23	0.22	0.22	0.21	0.21	0.21
1998	0.23	0.22	0.22	0.21	0.21	0.21	0.21	0.21
1999	0.21	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.22	0.21	0.21	0.21	0.21	0.2	0.2	0.2
2001	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2003	0.21	0.21	0.21	0.21	0.21	0.2	0.2	0.2
2004	0.21	0.21	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.21	0.21	0.21	0.21	0.2	0.2	0.2	0.2
2006	0.21	0.21	0.21	0.2	0.2	0.2	0.2	0.2
2007	0.21	0.21	0.21	0.2	0.2	0.2	0.2	0.2
2008	0.21	0.21	0.21	0.2	0.2	0.2	0.2	0.2
2009	0.21	0.21	0.2	0.2	0.2	0.2	0.2	0.2
2010	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2011	0.21	0.21	0.2	0.2	0.2	0.2	0.2	0.2
2012	0.23	0.22	0.22	0.22	0.21	0.21	0.21	0.21
2013	0.21	0.21	0.2	0.2	0.2	0.2	0.2	0.2
2014	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2015	0.21	0.2	0.2	0.2	0.2	0.2	0.2	0.2

MATPROP: Proportion of Mature at Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0	0.7	0.9	1	1	1	1	1

MPROP: Proportion of M before Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

FPROP: Proportion of F before Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35

Table 3.1.2. Tuning data for stock assessment, herring in sub-divisions 28-29+32.

Tuning fleet in SD 28-28+32 (Millions)

FLT01: International acoustic in October, area corrected

Year	Fish.Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	1	3749	14285	7236	2412	6382	1670	1193	1201
1992	1	2141	4354	6101	2780	2210	1323	978	812
1993	1	NA	NA	NA	NA	NA	NA	NA	NA
1994	1	1577	7746	11016	5254	2773	1057	419	506
1995	1	NA	NA	NA	NA	NA	NA	NA	NA
1996	1	1656	6719	4698	2549	1916	1060	606	452
1997	1	NA	NA	NA	NA	NA	NA	NA	NA
1998	1	1379	966	3207	3022	1298	601	420	207
1999	1	217	1904	1521	1646	1540	641	391	242
2000	1	8251	1729	7322	3656	3584	1796	2449	1661
2001	1	1344	3485	1427	1632	608	547	211	186
2002	1	1140	2635	3386	1404	1070	429	370	274
2003	1	11154	4370	6138	2966	1195	641	401	628
2004	1	2502	6529	3023	2178	798	579	174	240
2005	1	669	5095	9325	4807	2409	1400	615	497
2006	1	4067	5817	7344	11959	4621	1450	600	479
2007	1	3551	4496	1942	2370	4295	901	305	300
2008	1	3095	3685	4571	2168	2058	1209	280	198
2009	1	5178	7167	3883	2979	1158	1379	1039	282
2010	1	2714	5897	7267	2626	1842	915	926	1025
2011	1	978	3596	5482	5518	2435	1417	318	961
2012	1	10794	1990	4783	5271	4470	1129	1181	854
2013	1	4415	4497	2613	4845	3482	3740	560	1121
2014	1	3683	7110	9374	3478	4277	3121	2549	1518
2015	1	32220	4584	7049	5629	1982	1259	851	1423

Table 3.3.1. Spawning stock biomass (SSB, 10^3 t.) and fishing mortality (F(3-6)) estimated by XSA, SAM, and CohAnalQ assessments of herring in sub-divisions 28,29-32.

	SSB			F(3-6)		
	XSA	SAM	CohAnalQ	XSA	SAM	CohAnalQ
1991	283	295	282	0.34	0.31	0.35
1992	273	276	273	0.29	0.29	0.29
1993	292	302	293	0.28	0.29	0.28
1994	326	324	328	0.31	0.32	0.31
1995	295	275	291	0.34	0.35	0.33
1996	261	229	257	0.38	0.42	0.38
1997	229	206	225	0.49	0.49	0.49
1998	209	186	207	0.45	0.51	0.47
1999	182	180	180	0.42	0.45	0.45
2000	175	159	158	0.58	0.49	0.55
2001	132	150	138	0.56	0.53	0.54
2002	134	147	139	0.46	0.45	0.45
2003	137	149	143	0.40	0.36	0.38
2004	155	174	166	0.30	0.29	0.30
2005	179	198	186	0.25	0.20	0.23
2006	191	212	205	0.33	0.27	0.29
2007	196	227	210	0.31	0.25	0.28
2008	209	242	226	0.36	0.32	0.34
2009	231	264	246	0.33	0.33	0.32
2010	243	270	257	0.39	0.31	0.36
2011	234	275	253	0.30	0.25	0.27
2012	251	290	274	0.22	0.18	0.19
2013	279	328	325	0.18	0.17	0.16
2014	311	392	380	0.26	0.20	0.22
2015	297	430	402	0.32	0.23	0.25
mean	228	247	242	0.35	0.33	0.34

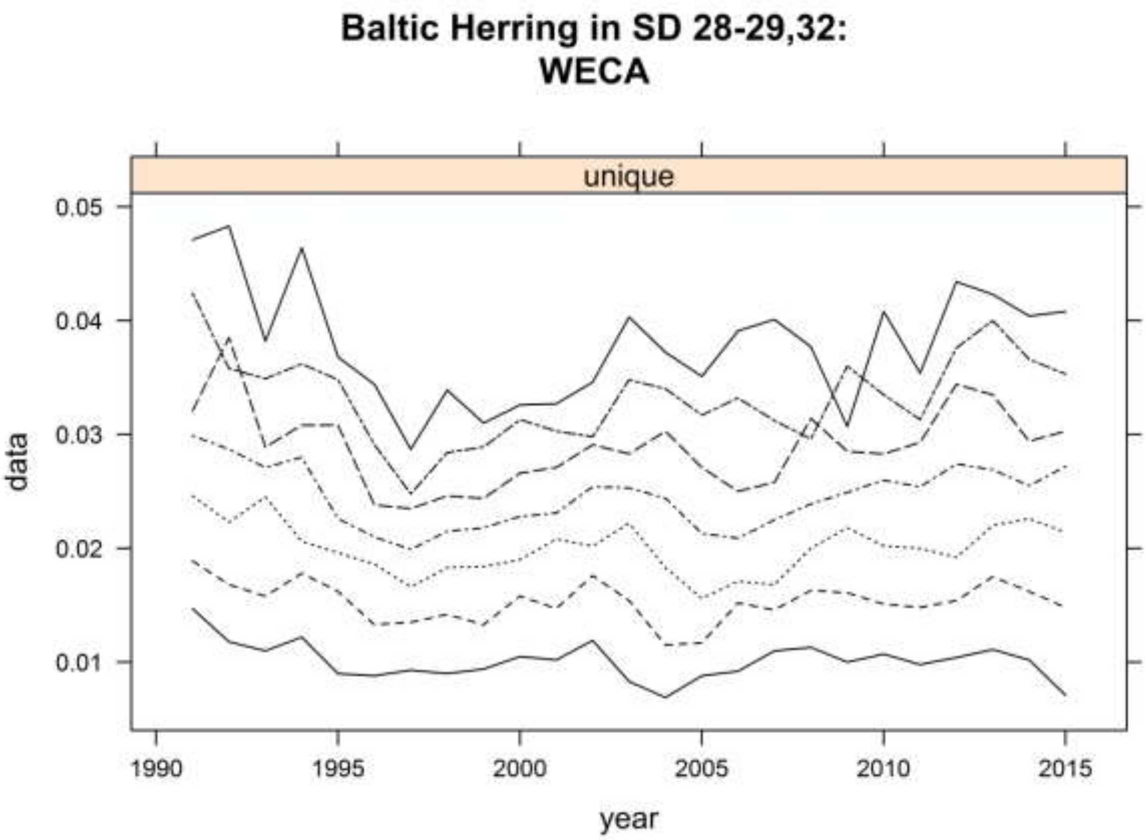


Figure 3.1.1. Herring in SD 28-29+32. Mean weight-at-age in the catches (weight in the stock assumed as in the catches).

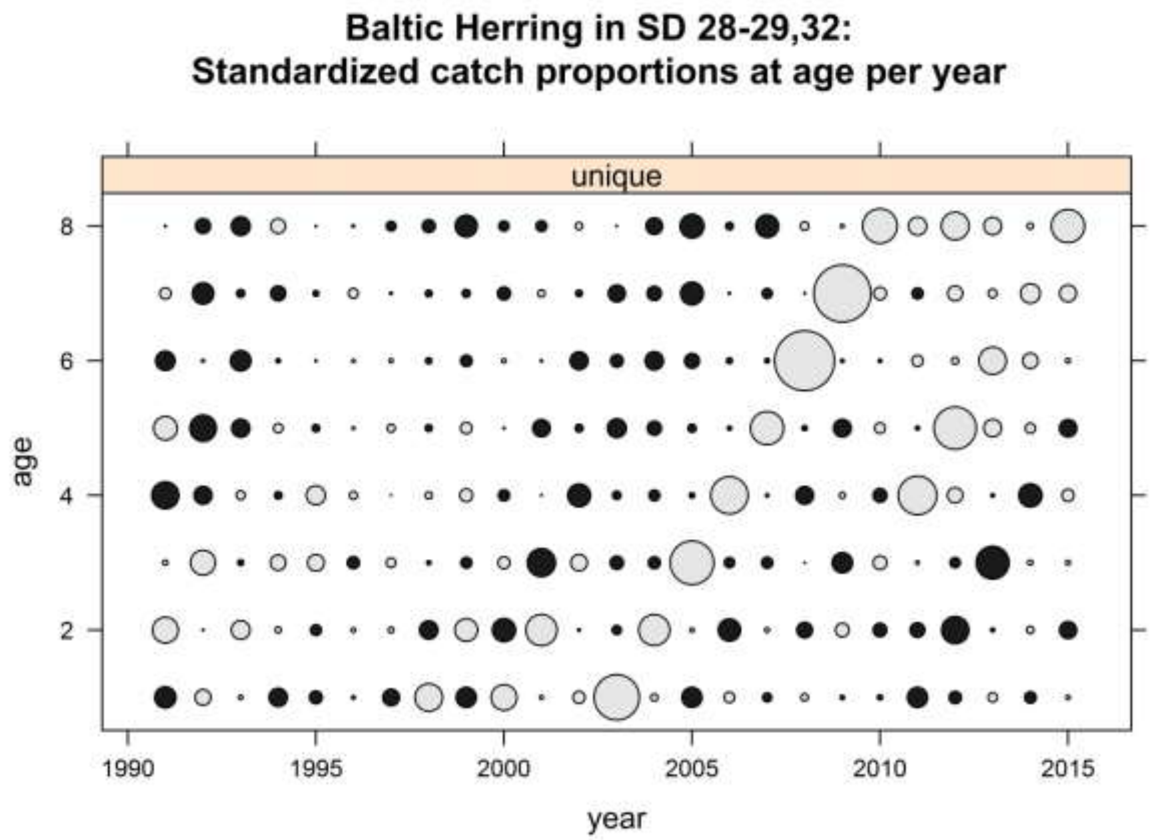


Figure 3.2.1. Herring in SD 28-29+32. CANUM consistency check.

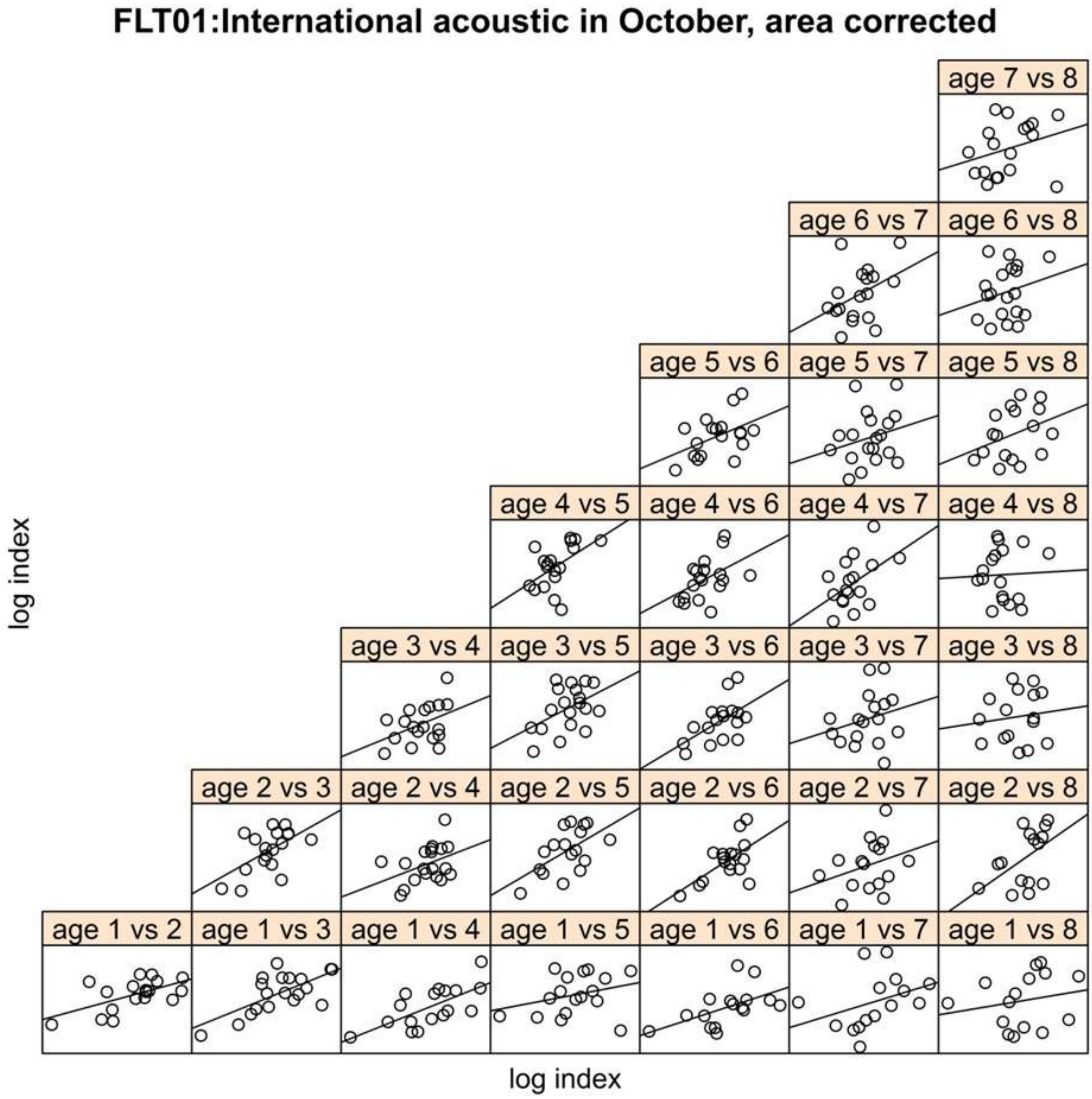


Figure 3.2.2. Herring in SD 28-29+32. Check for consistency in October acoustic survey (BIAS) estimates.

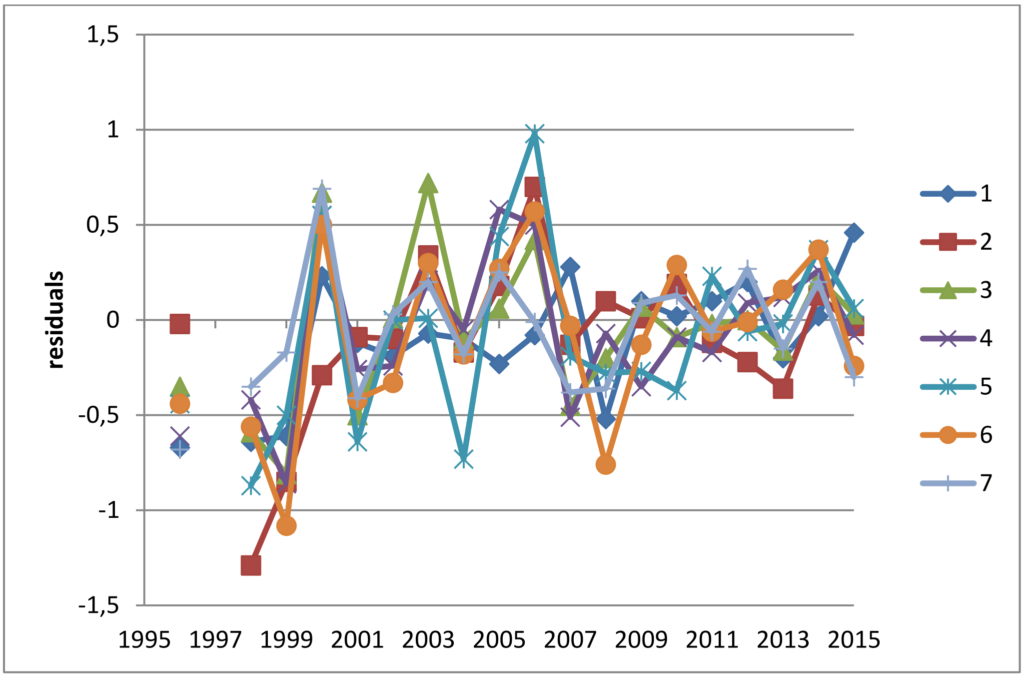


Figure 3.3.1.1. Distribution of survey log-catchability residuals in XSA analysis.

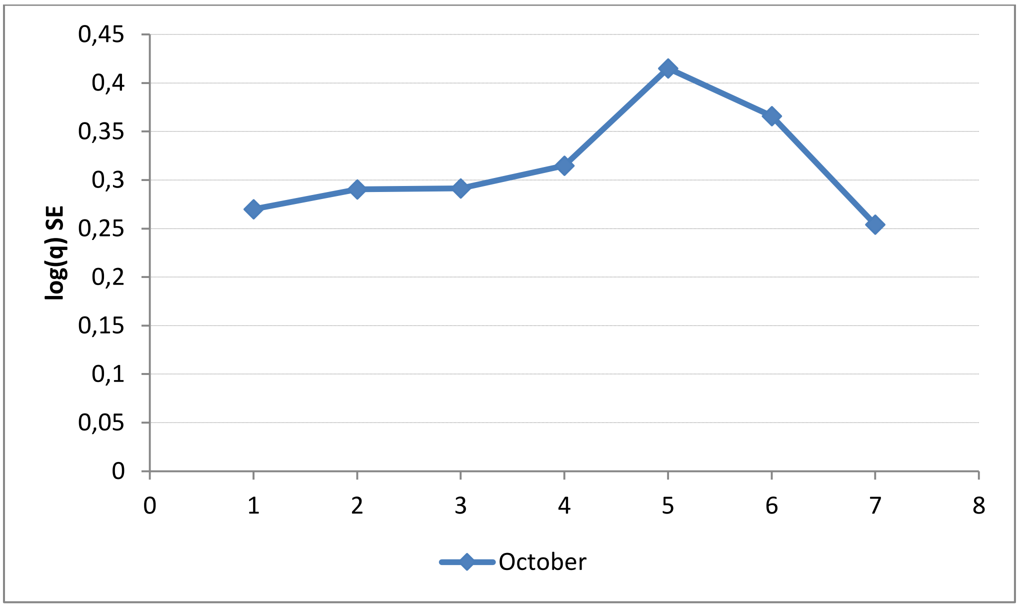


Figure 3.3.1.2. The standard errors (SE) of log-catchability residuals.

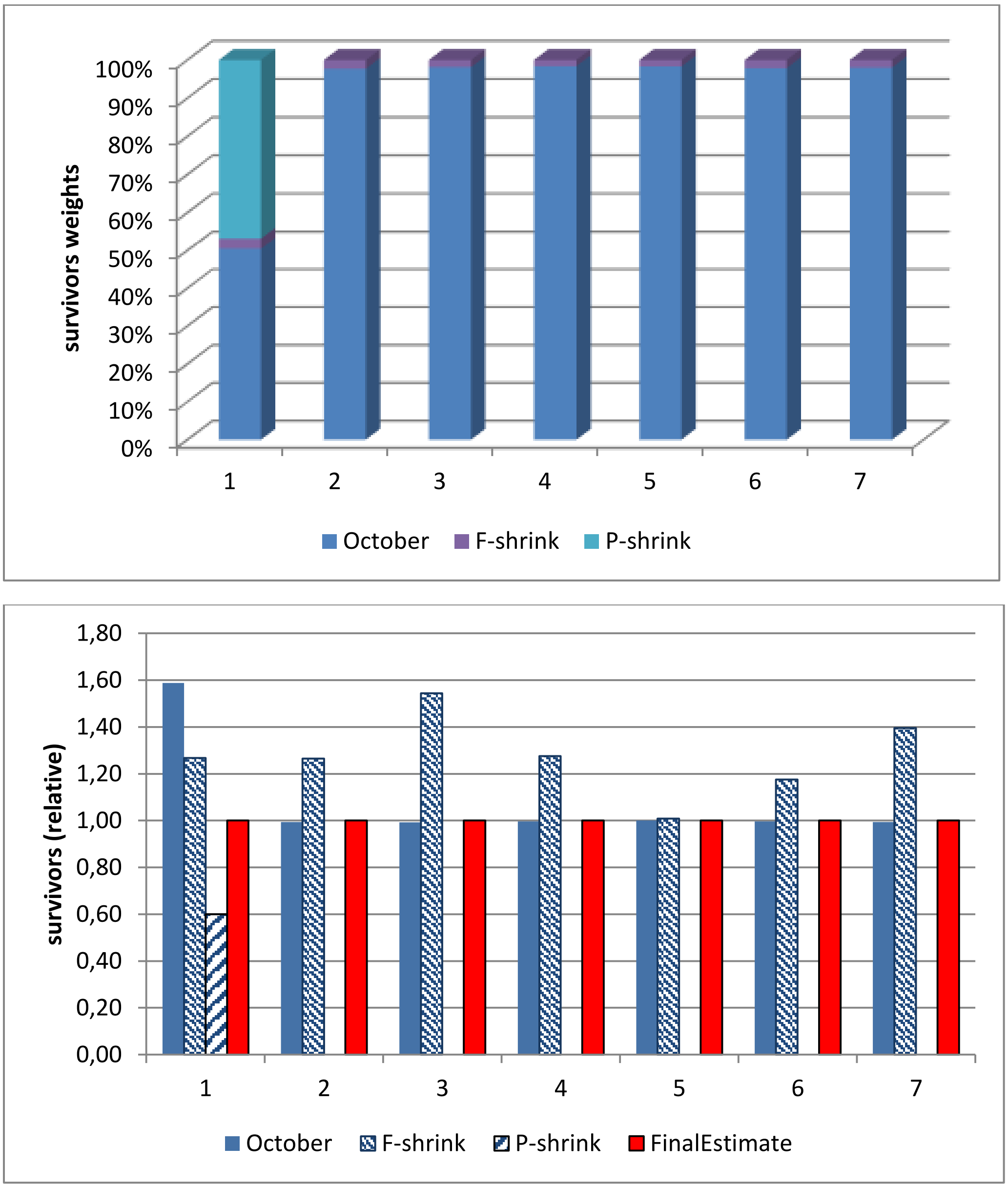


Figure 3.3.1.3. Weights of survivors estimates (upper graph) and survivors estimates relative to final estimate (bottom graph) by tuning fleet and applied shrinkage.

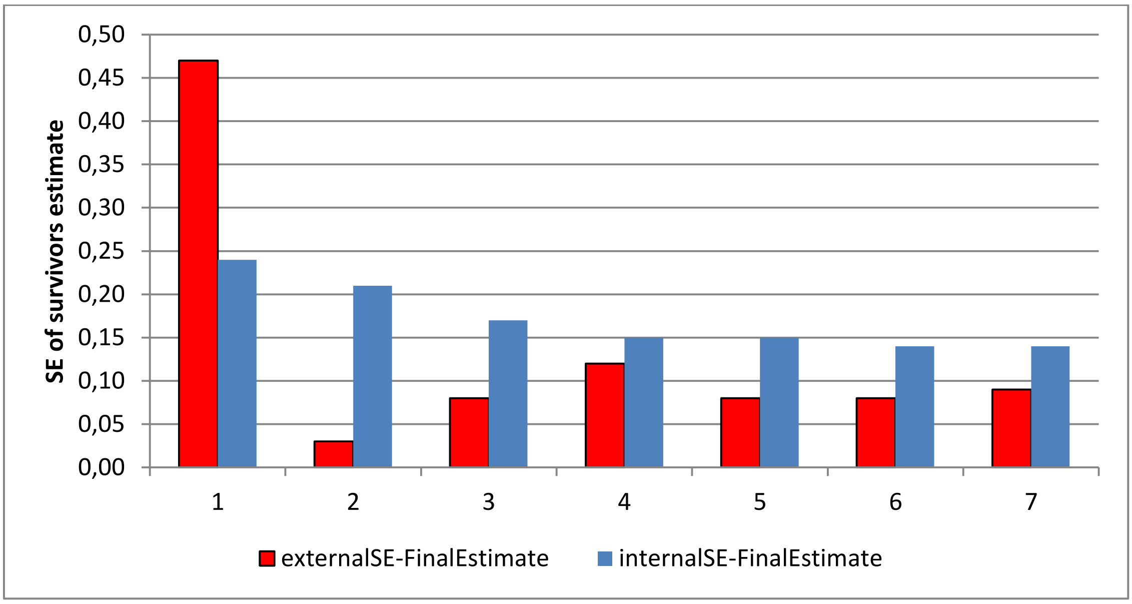


Figure 3.3.1.4. The internal and external standard error (SE) of survivors estimates in XSA.

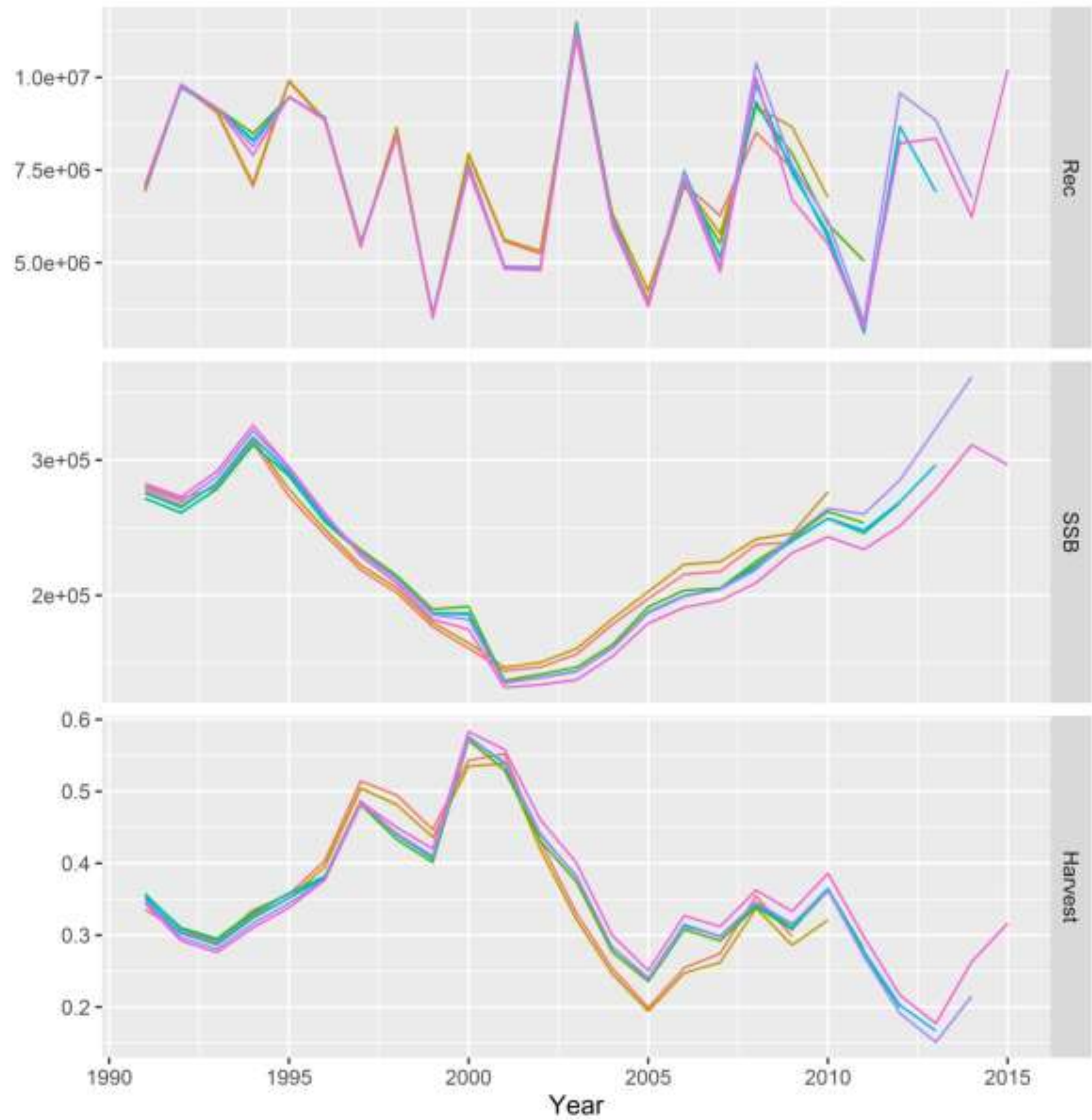
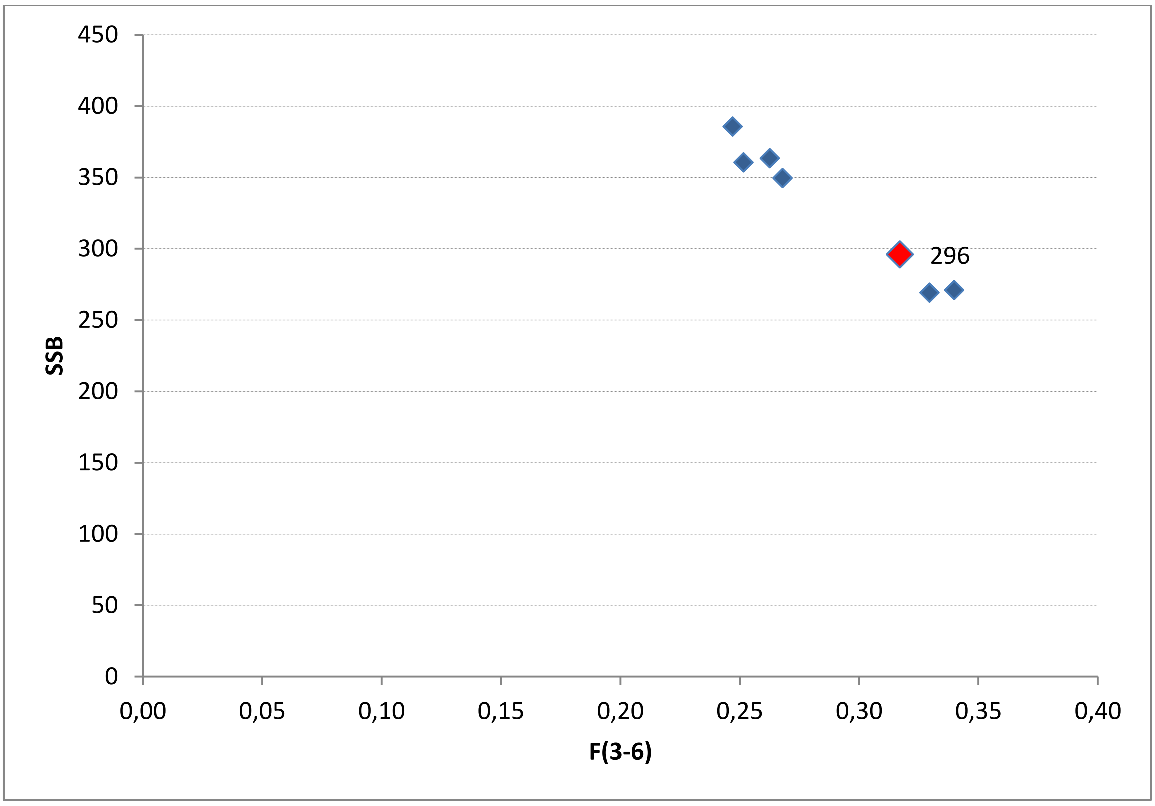


Figure 3.3.1.5. Retrospective estimates of recruitment, spawning stock biomass and fishing mortality for herring in sub-divisions 28-29+32.



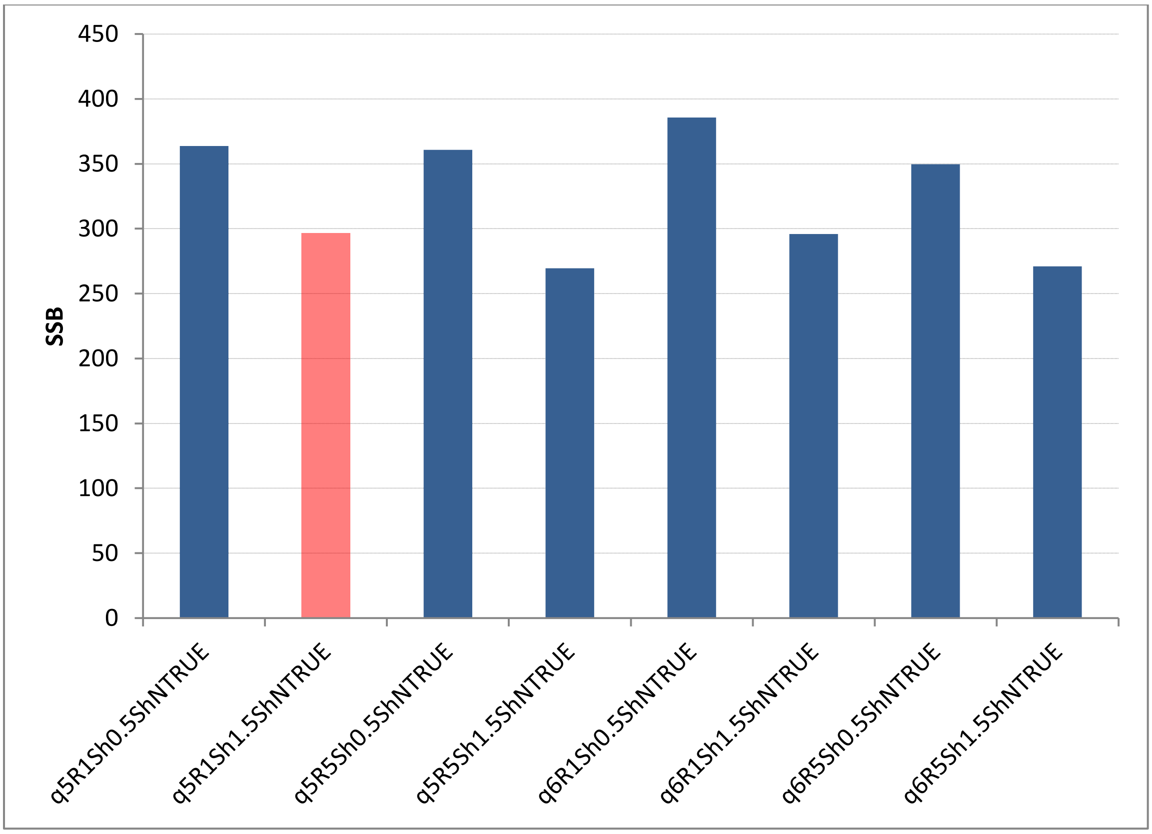
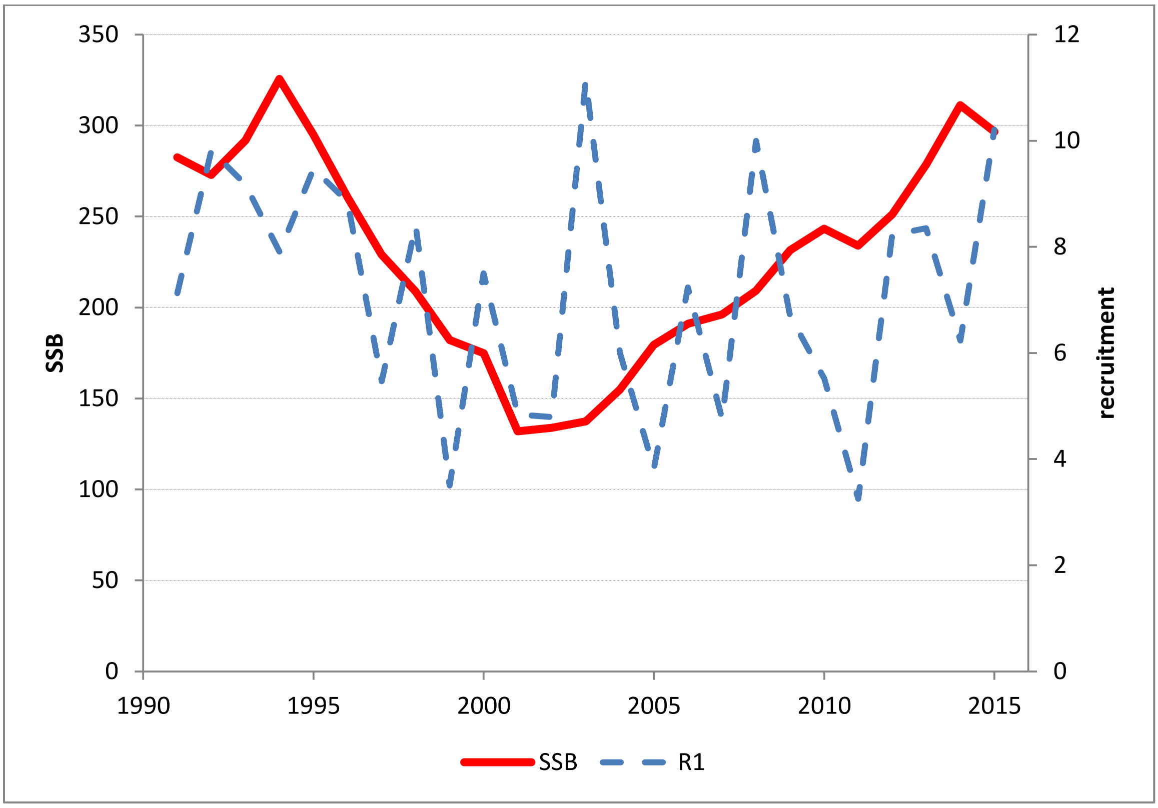


Figure 3.3.1.6. Sensitivity of the XSA to its parameterisation for terminal year estimates of SSB and average fishing mortality. Final estimates are shown in red.



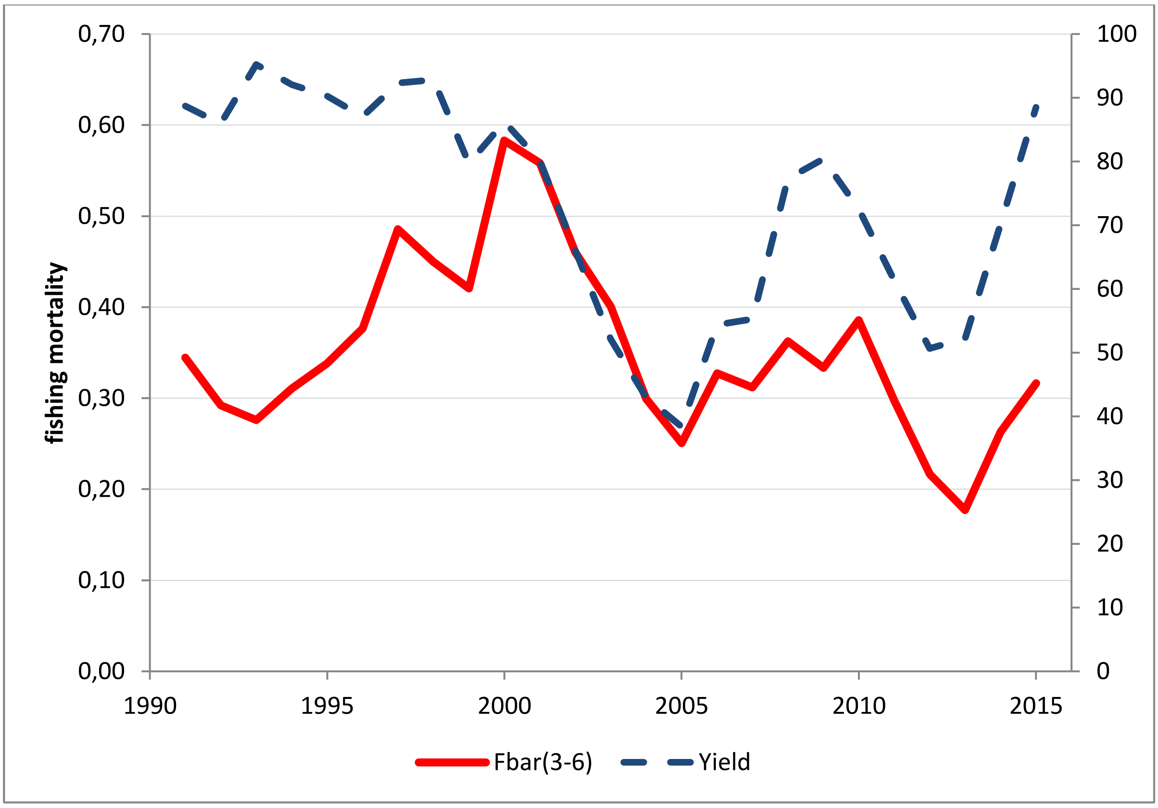


Figure 3.3.1.7. The XSA estimates of spawning stock biomass (10^3 t.), recruitment (10^9 individuals), and fishing mortality. For comparison yield (10^3 t.) is given.

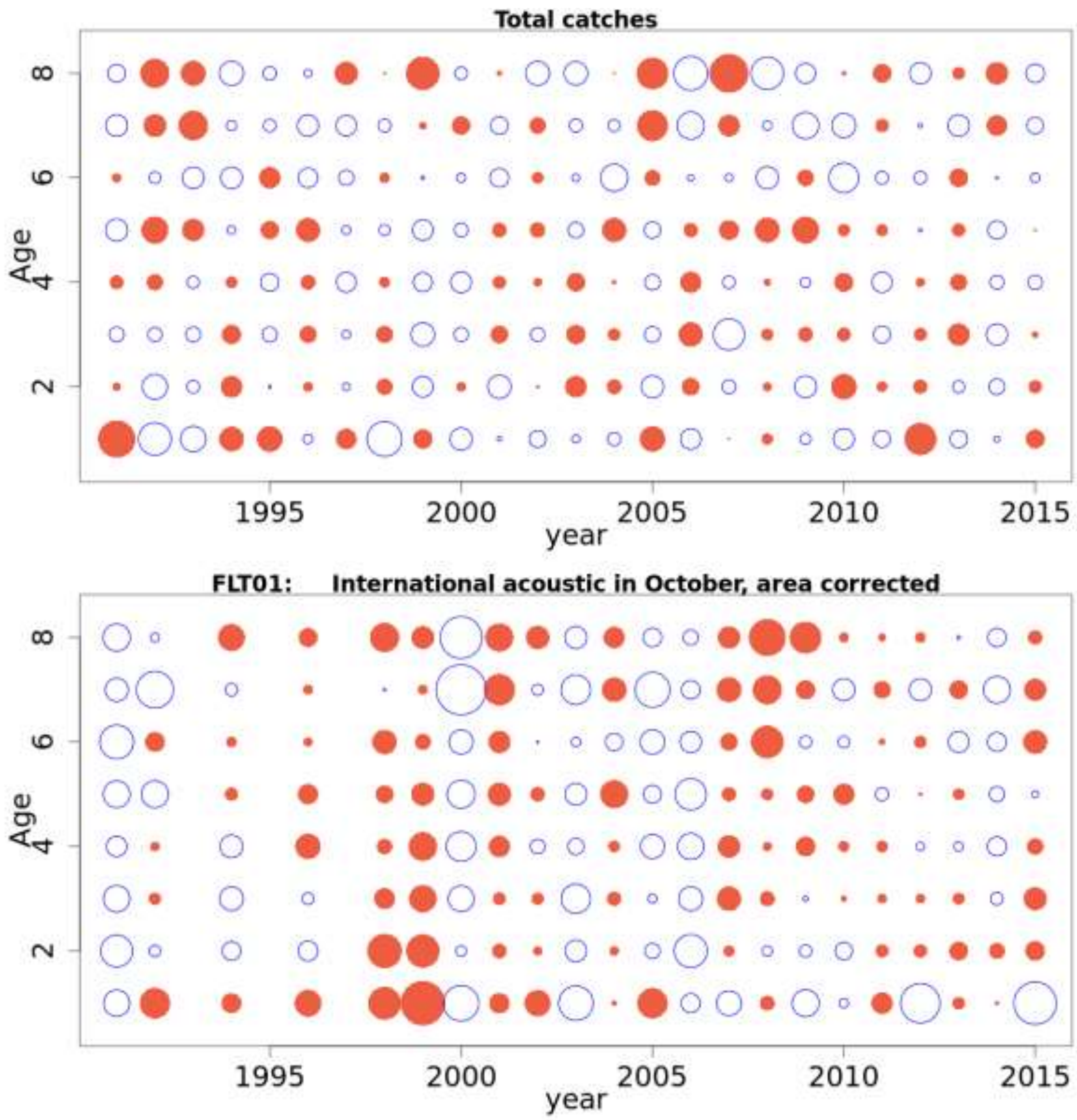


Figure 3.3.2.1. Plot of residuals in the SAM model for catches and tuning fleet.

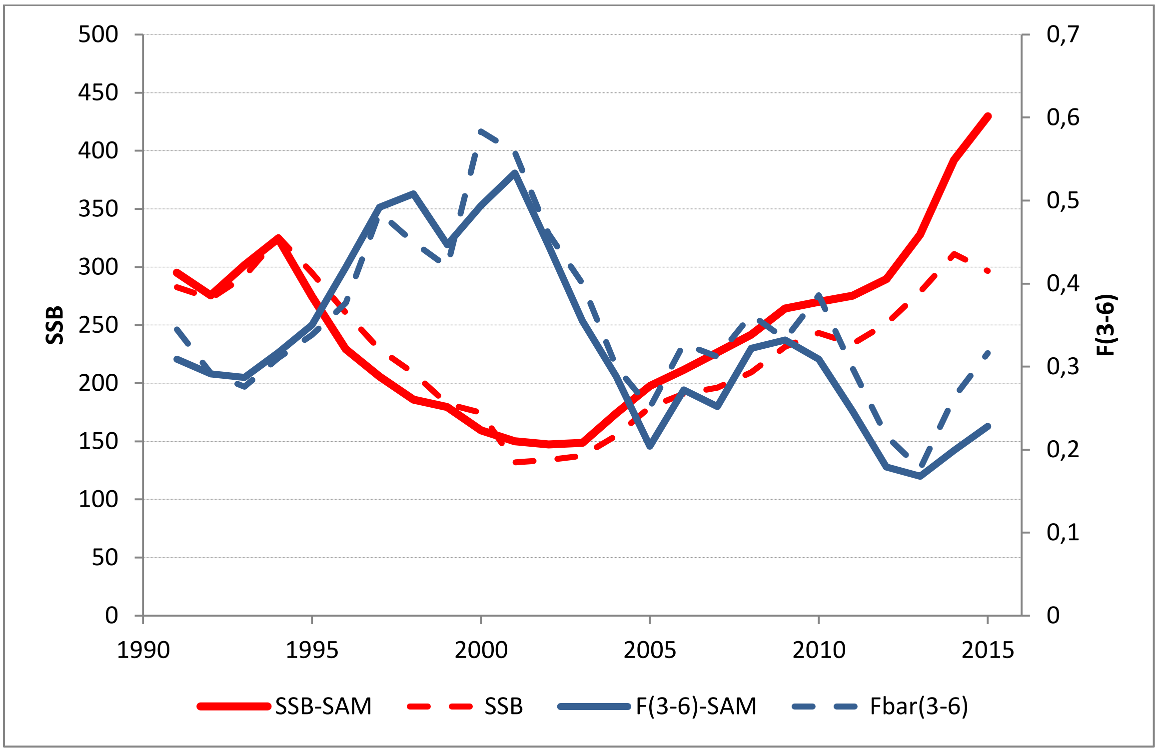
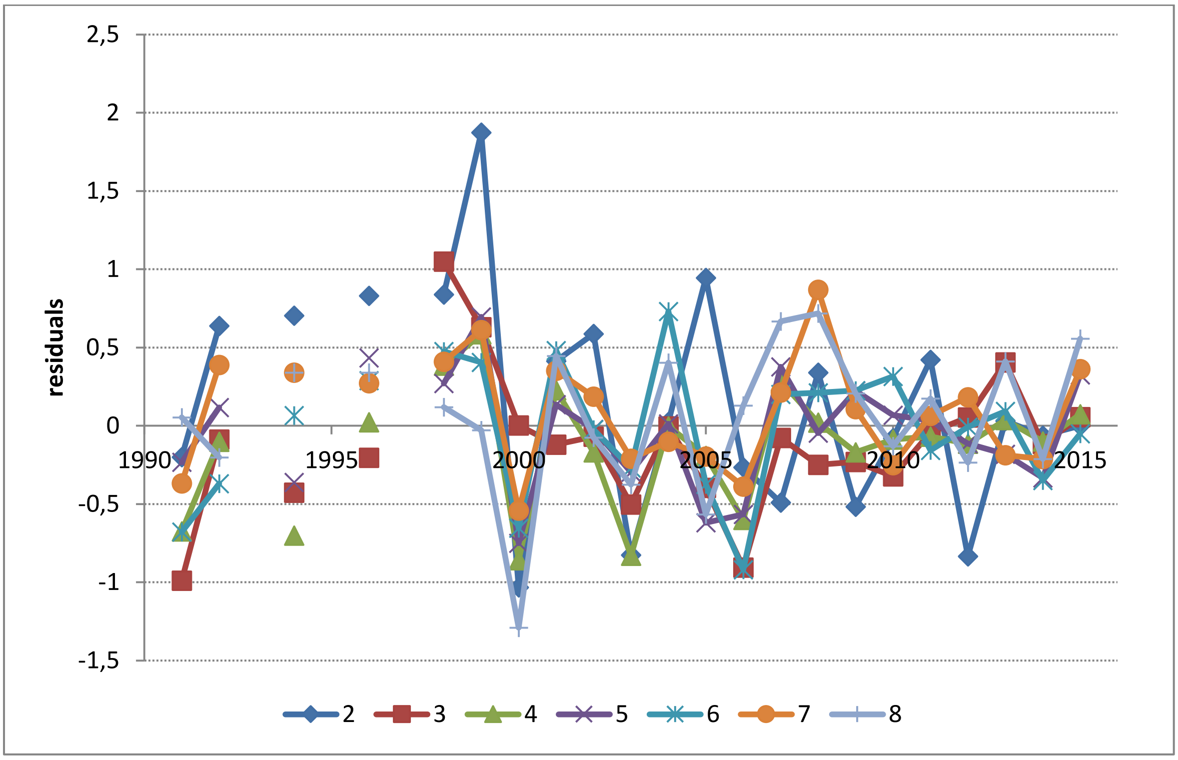


Figure 3.3.2.2. SAM model estimates of spawning stock biomass (10^3 t.) and fishing mortality. For comparison XSA estimates (broken lines) are given.



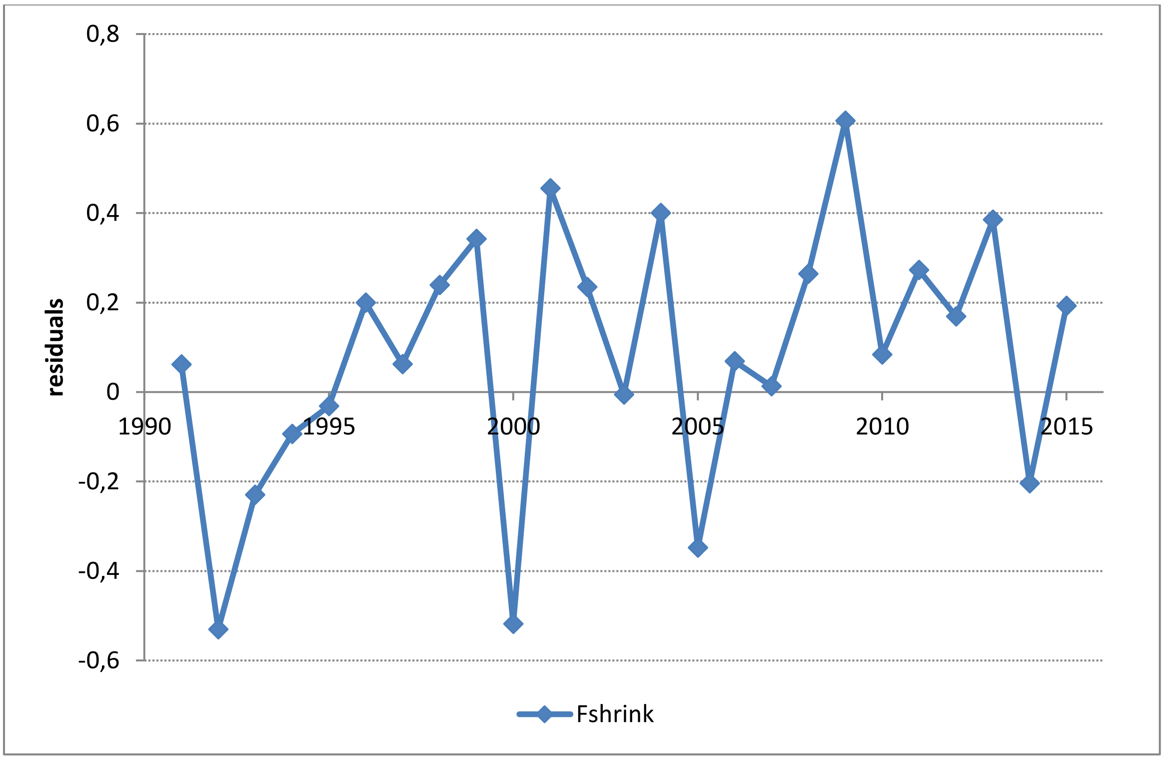


Figure 3.3.3.1. Time series of residuals for stock estimates at age (upper plot) and residuals in fishing mortality at terminal age (bottom plot).

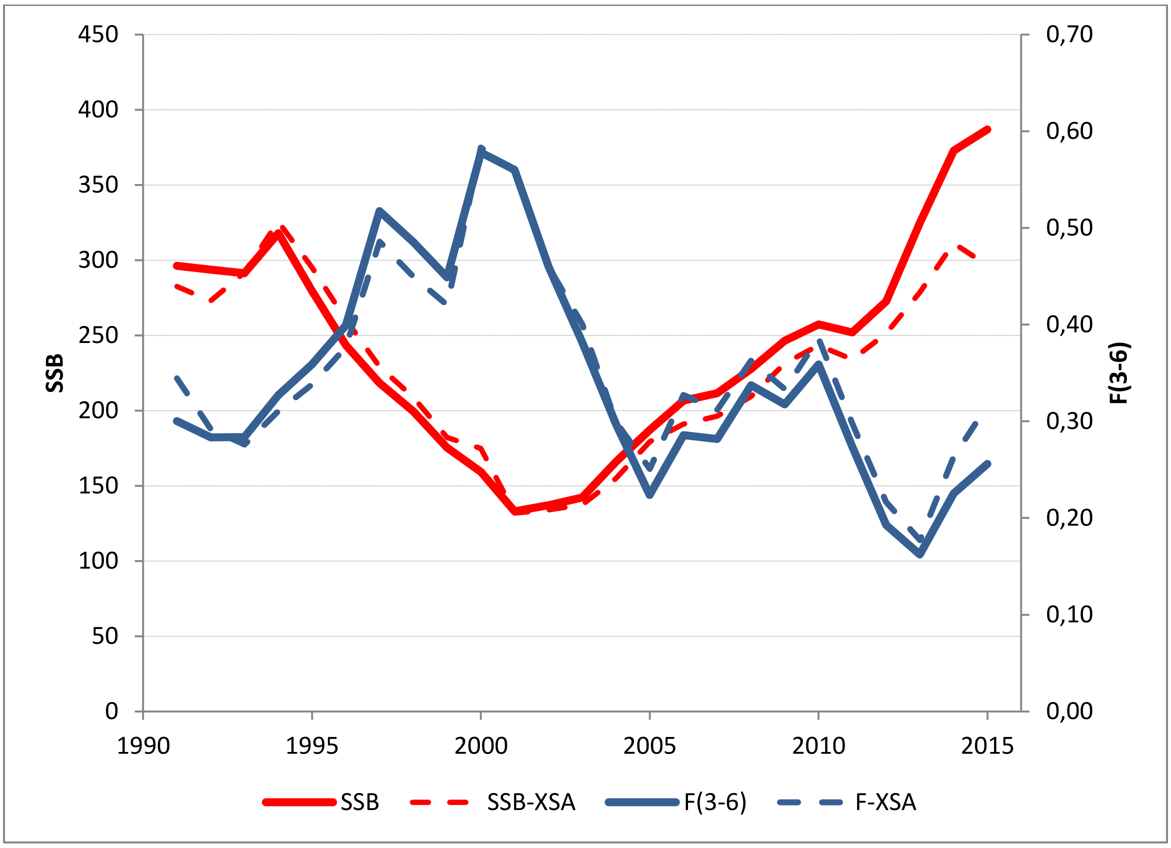


Figure 3.3.3.2. Spawning stock biomass (10^3 t.) and fishing mortality estimated by cohort analysis with assumed catchability (CohAnalQ). For comparison XSA estimates of these variables are given (broken lines).

4. Summary and conclusions on assessments of herring stocks in the Central Baltic

The basic aim of the herring assessment by former stock assessment units, *i.e.* herring in sub-divisions 25-27 and herring in sub-divisions 28-29+32, was to check if the dynamics of herring in these units is similar, so that the merging in 1990s of AUs into one stock of Central Baltic Herring is still justified. The question arises if the stock dynamics in former AUs shows similar trends and if sum of their biomasses is approximately equal to the biomass estimated for CBH using present ICES approach. In addition, the spatial distribution of cod, major predator on herring, changed compared to 1980s and 1990s, so the effects of these changes on herring may be different in different areas and should be investigated.

In Figure 4.1 the biomasses and fishing mortalities from XSA, SAM, and CohAnalQ by former AUs are presented and their sums or average are compared to SSB and fishing mortality estimated for CBH stock. It appears that sums of herring SSB's in both former AUs estimated with XSA and CohAnalQ are very similar to the SSB estimated by ICES (2016a) for CBH. Similarly, average fishing mortality by AUs is similar to the F estimated for CBH. However, the XSA estimates of fishing mortality of herring in sub-divisions 25-27 are unexpectedly low in recent years and the share of biomass of herring in sub-divisions 25-27 to herring biomass in CBH area is in recent years higher than such share estimated in acoustic surveys (Figure

4.2). On the other hand, the biomass estimates from SAM assessment indicate too low share of southern herring biomass (sub-divisions 25-27) in biomasses in CBH area.

As already indicated in sections 2.3.3 and 3.3.3 the catchabilities obtained in XSA analyses were quite different in AUs and that was the reason for conducting additional assessments, using cohort analysis with the same catchability for both AUs. The catchability applied was an average of catchabilities estimated for both AUs in XSA. For such assessment sum of biomasses estimated for AUs is also very similar to biomass of CBH estimated by ICES, and similarly average of F estimates by AUs is close to ICES estimates of fishing mortality. However, now the share of biomasses in both assessment units is much closer to the share of these biomasses resulting from survey (Figure 4.2).

The conducted assessments do not provide clear indication on absolute level of biomass by assessment units in recent years; the biomass estimates for given AU differ in recent years by about +/- 30% depending on the assessment approach applied. However, conducted assessments show very similar trends in biomass development of herring in both AUs and similar are trends in fishing mortality. The biomass of herring in sub-divisions 25-27 is about two times higher than the biomass of herring in sub-divisions 28-29+32. Opposite is estimated for fishing mortality. The prevailing perception that herring biomass distribution have changed in last decade and the stock is mainly distributed in northern areas is true but in terms of stock numbers. Because growth of herring in the northern areas is lower than that in the south, in investigated years the biomass of herring in sub-divisions 25-27 was higher than biomass of herring in sub-division 28-29+ 32 and fishing mortality of that stock was lower. The ICES suggestion in advice for the CBH that fishing pressure for herring should be moved to north (ICES, 2016a) does not have strong support in the light of the results of conducted analyses.

The merging of two AUs (herring in sub-divisions 25-27 and herring in sub-division 28-29+ 32) into one AU of CBH seems to be justified from assessment point of view. However, spatial management of the stocks requires assessment and data by former AU.

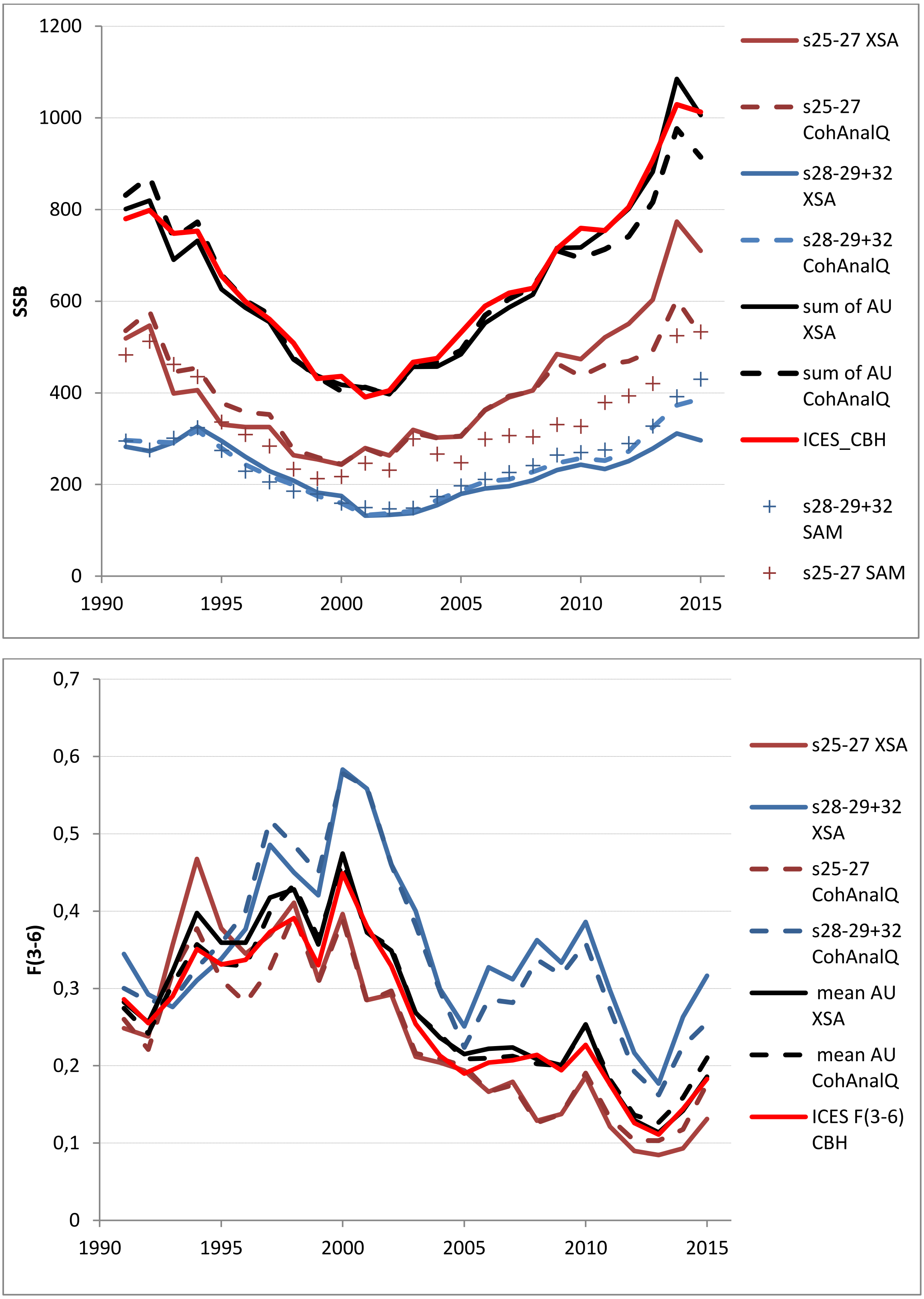


Figure 4.1. Comparison of biomass and fishing mortality estimates by former assessment units (AU) with ICES assessment of central Baltic herring (CBH) stock.

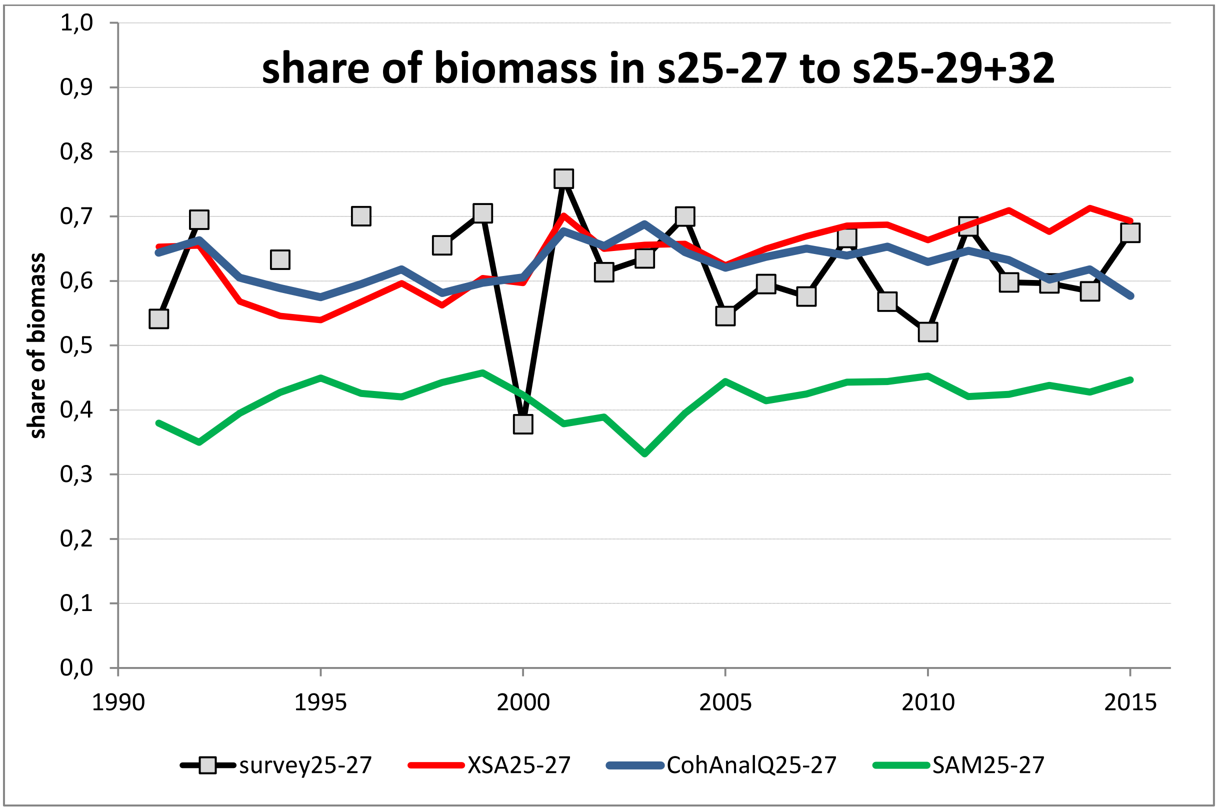


Figure 4.2. Share of biomass estimates of herring in sub-divisions 25-27 to biomass in CBH area (sub-divisions 25-29+32) derived from acoustic surveys, XSA, cohort analysis with assumed catchability (CohAnalQ), and SAM.

Part B. Assessment of sprat stocks: sprat in sub-divisions 22-25, sprat in sub-divisions 26+28, and sprat in sub-divisions 27,29-32

1. Stock of sprat in sub-divisions 22-25

The methods used to conduct assessments of the sprat stocks were described in Part A, section 1.

1.1. Biological and survey data

The data needed for assessments were taken from WGBFAS and WGBIFS reports (ICES, 2016 a, b) and ICES/WGBFAS data bases. Each year WGBFAS presents in its report catch-at-age (CANUM) and weight-at-age in the catch or in the stock (WECA/WEST) data by sub-divisions. Such data enabled compiling CANUM and WECA by former assessment units like sprat in sub-divisions 22-25.

Mean weights at age in the catches were calculated as mean of weights at age in sub-divisions (22, 24, and 25) weighted by catch at age numbers in each sub-division. Weights-at-age in the stock were assumed to be the same as weights-at-age in the catch. The weights-at-age have decreased in 1990s for the age 2 and older, while slight increase has been observed since 2007 onwards (Figure 1.1.1).

Maturity at age was assumed the same as for the sprat in sub-divisions 22-32 assessed routinely by WGBFAS (ICES, 2016a).

Natural mortality for the stock was determined using predation mortality estimates (M2) available from area-disaggregated SMS (Stochastic Multispecies Simulation, multispecies stock assessment model) (WKMULTBAL 2012). Only M2 for sub-division 25 was available from SMS, so the M2 at age for the stock was assumed the same as M2 for sub-division 25. The SMS series ends in 2011 and for the period 2012-2015 predation mortality was estimated from the linear regression relating cod biomass estimates and predation mortality of given stock, similarly as for sprat at WGBFAS (ICES, 2016a). The estimated predation mortalities for that stock are quite high (usually at 0.2-0.4) as sub-division 25 (and 26 to smaller extent) is main area of cod distribution in the Baltic. Constant 0.2 was added to M2 values to get total natural mortality.

Two tuning data sets covering sub-divisions 22-25 were available: from Baltic International Acoustic Survey (BIAS) in autumn (usually October) in 1991–2015 and from international Baltic Acoustic Spring Survey (BASS) in May in 2001–2015. In addition, age 0 was extracted as separate tuning set from autumn survey; this index was shifted to represent age 1 as in standard ICES assessment of sprat stock (ICES, 2016a). The survey data were corrected for area coverage (ICES, 2016b). Biological and tuning data are provided in Tables 1.1.1-1.1.2.

1.2. Quality and consistency of input data

The consistency of the catch-at-age estimates was checked in bubbles-plot (Figure 1.2.1). The correlation between catches at a given age and the catches of the same generations 1 year later is high, mostly between 0.8-0.9.

The internal consistency of survey at age estimates and consistency between surveys was checked on graphs (Figure 1.2.2-3). The correlation between survey indices at given age and the survey indices of the same generations 1 year later for given survey (internal consistency) is relatively good until age 6, (R mostly at 0.6) but it breaks down at age 7. The consistency between surveys is not high; it is acceptable at ages 1, 3-5 (R ca. 0.5 – 0.6), but is low or negative for ages 2, 6-7.

1.3. Stock assessments

Biological and survey data presented in section 1.1 (Tables 1.1.1-1.1.2) were used as input for the age structured assessments of the stock.

1.3.1. Assessment with XSA

The best settings for the parameterisation of XSA were found to be the same as specified in benchmark assessment of Baltic sprat stock (ICES, 2013), i.e.:

- tri-cubic time weighting,
- catchability dependent on year class strength at age 1 (only for this age group the slopes of regressions between survey and XSA numbers were significantly different from 1),
- catchability independent of age for ages 5 and older,
- the SE of the F shrinkage mean equal 0.75.

The log q residuals are presented in Figure 1.3.1.1. Distributions of residuals do not show clear pattern; significantly decreasing time trend in residuals was detected only for age 4 in May survey . The data for October survey are moderately noisy (SE of log q in range 0.4-0.6) but in case of May and age 0 surveys log catchability SE are much larger for ages 1 and 7 (Figure 1.3.1.2). The consistency between XSA estimates and survey indices is mostly low for ages 1-2 and 7 and it is higher for ages 3-6 (R^2 mostly at level of 0.5–0.8).

The weights of estimates resulting from shrinkage are low for ages 3 - 7(up to 10%) (Figure 1.3.1.3), although the shrinkage was not assumed very low (shrinkage SE of 0.75). For survivors of ages 1 the total shrinkage weight exceeds 60% (mainly due to the P-shrinkage) and it equals ca. 15% for survivors of age 2. For ages 2 and older the survivors are mainly determined by survey. The standard errors of the final estimates are mostly in range 0.15 – 0.40, with higher values at ages 1 - 2 (Figure 1.3.1.4).

Retrospective analysis (Figure 1.3.1.5) shows consistent estimates of biomass, fishing mortality, and recruitment) in recent 4-5 years. However, previous estimates of stock and fishery dynamics were much more noisy (overall Mohn's Rho in range -0.22 – 0.28 for SSB, F and recruitment).

Sensitivity of the terminal year estimates of SSB and average fishing mortality to the parameterisation of the XSA is presented in Figure 1.3.1.6. It shows quite big effect of the assumption of age for which catchability is independent on year class strength. As at none of the ages this dependence is significant, the default assumption of setting such dependence only at age 1 is justified. The effect of shrinkage SE on the stock estimates is very low.

The quality of the assessment is moderate: retrospective deviations are low in recent years (although high in some previous) and SEs of survivors are below 0.2 for most of the ages. Fish stock summary plots are presented in Figures 1.3.1.7.

1.3.2. Assessment with SAM

The SAM model was attempted as an alternative assessment model similarly as in benchmark assessment of sprat stock in sub-divisions 22-32 (ICES. 2013). The parameterisation of the model was the same as parameterisation agreed on during benchmark workshop. Results of SAM assessment (residuals plots, biomass, and fishing mortality estimates) are presented in Figure 1.3.2.1-2. Residuals do not show clear trend similarly as in the XSA assessment. Biomasses and fishing mortalities estimated with SAM are quite similar to the XSA estimates. The assessment with SAM is available at the https://www.stockassessment.org (short name of the stock is spr22-25).

1.3.3. Assessment with cohort analysis with assumed catchability (CohAnalQ)

The survey catchabilities estimated in XSA assessment of sprat in sub-divisions 22-25, sprat in sub-divisions 26+28, and sprat in sub-divisions 27,29-32 (see next sections for the later assessments) differ as shown in Figure 1.3.3.1. The difference is substantial and q's for sprat in sub-divisions 27,29-32 is 2 - 4 times higher than catchabilities for sprat in sub-divisions 22-25. The reasons for this difference is not clear and possible explanations may be similar to the ones suggested for herring (Part A, section 2.3.3). The average of the catchabilities for the three stocks is very similar to the catchability estimated in ICES assessment of sprat in sub-divisions 22-32 (Figure 1.3.3.1). However, differences in estimated catchability lead to bigger differences in estimated biomasses in assessment units (AUs) than differences shown in acoustic surveys. Thus, to correct for the effects of different catchabilities in the XSA estimates, the assessment of the three stocks was performed with the same catchabilities, using cohort analysis CohAnalQ as described in Part A, section 1.

The cohort analysis fits the data relatively well. Both survey residuals and residuals from "F shrinkage" do not show time trend in the distribution (Figure 1.3.3.2). F shrinkage residuals are very low at the beginning of time series as for these years the survey observations are down-weighted from the model fit. Standard error of the fit is 0.66 .

Assessment results are shown in Figure 1.3.3.3. Biomass and F estimates from the XSA for the stock and estimates from CohAnalQ using the same catchability as estimated in that XSA are presented for comparison. Spawning stock biomass in recent years is markedly lower than in XSA analysis, but in other years differences disappear. Opposite picture is seen for fishing mortality; cohort analysis estimates are much higher in recent years than the XSA values. The results of XSA and CohAnalQ using q estimated in XSA are almost identical (for tri-cubic weighting applied in CohAnalQ).

Summary of assessments results by assessment model is presented in Table 1.3.1.

Table 1.1.1. Biological Input data for stock assessment, sprat in sub-divisions 22-25.

CANUM: Catch in numbers (Millions)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	145	370	426	106	43	23	11	7
1992	534	1203	1355	507	253	121	55	45
1993	375	862	564	257	79	38	23	7
1994	272	2120	2633	1361	694	239	48	24
1995	2000	896	2100	2645	1340	712	204	66
1996	3971	8854	2536	2336	1123	415	148	115
1997	502	10122	9631	2938	1248	388	73	16
1998	3523	1315	7606	7250	939	558	503	61
1999	1914	8246	2838	3489	2178	259	100	117
2000	3491	1847	4336	827	1014	603	188	144
2001	255	2468	1162	2119	636	522	205	55
2002	1798	1196	2675	1661	858	253	135	131
2003	1113	1554	836	733	390	190	59	60
2004	8174	1690	1126	644	559	249	100	106
2005	605	3913	1168	513	416	147	72	107
2006	1144	428	2178	753	202	82	21	23
2007	2703	1504	696	1867	419	60	27	63
2008	380	2791	1322	616	721	168	38	34
2009	1922	893	2082	749	345	265	54	13
2010	1089	1522	756	596	175	105	59	19
2011	3958	381	1001	321	182	28	25	26
2012	424	1318	705	1219	223	106	28	20
2013	402	853	930	471	632	106	31	29
2014	541	810	1128	578	397	234	38	28
2015	775	710	1103	764	310	236	103	34

WECA (=WEST): Mean weight in the Catch and in the Stock (Kilograms)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	0.0079	0.0143	0.0152	0.0174	0.0182	0.0197	0.0193	0.0166
1992	0.0058	0.0119	0.0150	0.0168	0.0176	0.0193	0.0192	0.0210
1993	0.0059	0.0127	0.0150	0.0165	0.0178	0.0184	0.0188	0.0208
1994	0.0062	0.0114	0.0135	0.0152	0.0155	0.0159	0.0151	0.0164
1995	0.0050	0.0109	0.0106	0.0121	0.0137	0.0142	0.0150	0.0168
1996	0.0050	0.0091	0.0095	0.0111	0.0133	0.0142	0.0153	0.0172
1997	0.0050	0.0073	0.0084	0.0101	0.0129	0.0142	0.0156	0.0176
1998	0.0035	0.0078	0.0085	0.0087	0.0101	0.0101	0.0103	0.0153
1999	0.0060	0.0078	0.0090	0.0092	0.0089	0.0096	0.0120	0.0090
2000	0.0058	0.0117	0.0117	0.0122	0.0133	0.0145	0.0145	0.0160
2001	0.0089	0.0112	0.0122	0.0130	0.0139	0.0138	0.0154	0.0197
2002	0.0065	0.0100	0.0097	0.0100	0.0113	0.0112	0.0116	0.0138

2003	0.0056	0.0111	0.0116	0.0120	0.0125	0.0130	0.0132	0.0098
2004	0.0072	0.0094	0.0126	0.0126	0.0125	0.0122	0.0125	0.0140
2005	0.0055	0.0098	0.0099	0.0122	0.0124	0.0131	0.0120	0.0119
2006	0.0065	0.0112	0.0112	0.0118	0.0136	0.0140	0.0144	0.0117
2007	0.0053	0.0083	0.0102	0.0100	0.0104	0.0127	0.0125	0.0125
2008	0.0057	0.0099	0.0112	0.0125	0.0119	0.0114	0.0128	0.0143
2009	0.0056	0.0100	0.0115	0.0118	0.0125	0.0123	0.0122	0.0113
2010	0.0055	0.0087	0.0118	0.0123	0.0127	0.0137	0.0134	0.0184
2011	0.0023	0.0103	0.0115	0.0129	0.0137	0.0147	0.0157	0.0145
2012	0.0074	0.0112	0.0129	0.0135	0.0148	0.0150	0.0161	0.0161
2013	0.0056	0.0117	0.0136	0.0141	0.0147	0.0155	0.0147	0.0163
2014	0.0058	0.0109	0.0122	0.0140	0.0146	0.0150	0.0152	0.0149
2015	0.0061	0.0117	0.0129	0.0139	0.0155	0.0153	0.0156	0.0164

NATMOR: Natural Mortality

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30
1992	0.35	0.35	0.35	0.34	0.34	0.34	0.33	0.33
1993	0.54	0.54	0.54	0.53	0.52	0.51	0.51	0.51
1994	0.48	0.48	0.48	0.47	0.46	0.46	0.45	0.45
1995	0.38	0.38	0.38	0.38	0.37	0.37	0.37	0.37
1996	0.34	0.34	0.34	0.33	0.33	0.33	0.33	0.33
1997	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
1998	0.40	0.40	0.40	0.39	0.38	0.38	0.38	0.38
1999	0.53	0.53	0.53	0.52	0.51	0.50	0.50	0.50
2000	0.43	0.43	0.43	0.42	0.42	0.41	0.41	0.41
2001	0.41	0.41	0.41	0.41	0.40	0.40	0.39	0.39
2002	0.41	0.41	0.41	0.40	0.40	0.39	0.39	0.39
2003	0.40	0.40	0.40	0.40	0.39	0.39	0.38	0.38
2004	0.41	0.41	0.41	0.40	0.39	0.39	0.39	0.39
2005	0.42	0.42	0.42	0.41	0.41	0.40	0.40	0.40
2006	0.52	0.52	0.52	0.51	0.50	0.50	0.49	0.49
2007	0.52	0.52	0.52	0.51	0.50	0.49	0.49	0.49
2008	0.55	0.55	0.55	0.54	0.53	0.52	0.52	0.52
2009	0.69	0.69	0.69	0.67	0.66	0.65	0.64	0.64
2010	0.70	0.70	0.70	0.68	0.67	0.66	0.65	0.65
2011	0.78	0.78	0.78	0.76	0.75	0.74	0.73	0.73
2012	0.52	0.52	0.52	0.51	0.50	0.49	0.49	0.49
2013	0.45	0.45	0.45	0.45	0.44	0.43	0.43	0.43
2014	0.44	0.44	0.44	0.43	0.43	0.42	0.42	0.42
2015	0.45	0.45	0.45	0.44	0.44	0.43	0.43	0.43

MATPROP: Proportion of Mature at Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.17	0.93	1	1	1	1	1	1

MPROP: Proportion of M before Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

FPROP: Proportion of F before Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table 1.1.2. Tuning data for stock assessment, sprat in sub-divisions 22-25.

Tuning fleets in SD 22-25 (Millions)

FLT01: International acoustic in October, area corrected

Year	Fish.Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	1	7650	6746	9795	1423	2178	489	530	1044
1992	1	4160	6363	5747	2195	517	540	219	128
1993	1	NA	NA	NA	NA	NA	NA	NA	NA
1994	1	617	2847	6115	4072	1968	1061	155	110
1995	1	12825	3869	3913	3591	1978	482	203	120
1996	1	5822	11961	4812	4552	2544	1535	704	260
1997	1	4113	11933	13708	5022	1911	559	45	0
1998	1	8244	1872	5903	4023	857	460	218	24
1999	1	734	6471	1782	2101	1703	497	203	140
2000	1	2087	392	2052	374	599	426	87	134
2001	1	819	3587	1672	3232	614	759	712	403
2002	1	3870	1363	1325	857	410	120	60	61
2003	1	3192	4208	2540	1909	661	841	303	52
2004	1	13911	3769	1992	2026	638	732	257	566
2005	1	473	3937	1581	546	338	125	66	117
2006	1	2101	1029	3475	970	302	235	77	26
2007	1	8168	1477	903	1337	585	70	44	137
2008	1	821	3481	1376	438	827	157	52	69
2009	1	4355	1437	1958	676	314	248	56	9
2010	1	1848	1945	746	604	98	63	50	18
2011	1	5582	2486	3878	679	650	187	61	111
2012	1	3295	3379	1265	2895	586	387	63	78
2013	1	4365	4251	3555	1797	3084	517	85	112
2014	1	5647	2461	3653	1735	1168	1464	285	147
2015	1	6657	2626	4136	2851	915	1036	314	155

FLT02: Intenational acoustic in May, area corrected

Year	Fish.Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2001	1	934	9523	8129	15062	3297	674	46	0
2002	1	13349	10533	16121	13754	6734	1612	2324	0
2003	1	2994	5244	2136	2992	2795	1045	476	273
2004	1	12457	5426	3917	5992	2214	1972	565	679
2005	1	2824	25425	12410	4379	1907	1334	935	595
2006	1	3212	540	13340	4683	1194	871	299	193
2007	1	11258	5022	1974	8296	1860	423	228	13
2008	1	1025	13838	5262	3023	6633	468	182	173
2009	1	10265	10386	15926	4054	1070	4803	1951	210
2010	1	1496	15198	5243	6667	1896	713	1543	501
2011	1	2044	2996	29236	6132	2974	624	980	740
2012	1	2957	8248	5314	16987	2532	2229	500	199
2013	1	5069	8814	6893	4009	6730	1313	644	43
2014	1	2814	12219	8169	3762	3747	1074	503	211
2015	1	21325	7777	15847	8208	5344	2511	1130	739

FLT03: Latvian/Russian acoustic on age 0 shifted to represent age 1

Year	Fish.Effort	Age 1
1992	1	12554
1993	1	5270
1994	1	NA
1995	1	11641
1996	1	12905
1997	1	218
1998	1	5771
1999	1	562
2000	1	8396
2001	1	411
2002	1	5015
2003	1	5803
2004	1	19494
2005	1	949
2006	1	4471
2007	1	22617
2008	1	878
2009	1	3823
2010	1	4618
2011	1	21603
2012	1	2862
2013	1	2009

2014	1	15362
2015	1	20025

Table 1.3.1. Spawning stock biomass (SSB) and fishing mortality (F(3-5)) estimated by XSA, SAM, and CohAnalQ assessments of sprat in sub-divisions 22-25.

	SSB			F(3-5)		
	XSA	SAM	CohAnalQ	XSA	SAM	CohAnalQ
1991	289	567	287	0.09	0.04	0.09
1992	385	524	383	0.28	0.15	0.28
1993	576	652	567	0.06	0.07	0.06
1994	521	583	513	0.29	0.22	0.29
1995	457	353	446	0.52	0.39	0.53
1996	639	600	624	0.39	0.47	0.41
1997	558	648	545	0.57	0.45	0.60
1998	397	323	385	0.58	0.69	0.61
1999	361	331	349	0.61	0.67	0.64
2000	348	246	335	0.44	0.72	0.45
2001	293	277	282	0.44	0.48	0.47
2002	177	168	170	0.62	0.66	0.65
2003	169	217	160	0.35	0.36	0.36
2004	211	280	202	0.53	0.47	0.57
2005	283	290	272	0.45	0.52	0.50
2006	264	195	253	0.33	0.35	0.36
2007	213	176	200	0.36	0.47	0.38
2008	282	245	253	0.36	0.49	0.39
2009	285	181	243	0.44	0.49	0.48
2010	348	188	286	0.24	0.39	0.29
2011	307	217	251	0.15	0.22	0.19
2012	318	342	242	0.22	0.24	0.28
2013	363	334	241	0.20	0.20	0.28
2014	401	341	225	0.20	0.19	0.29
2015	462	405	239	0.15	0.18	0.29
mean	356	347	318	0.35	0.38	0.39

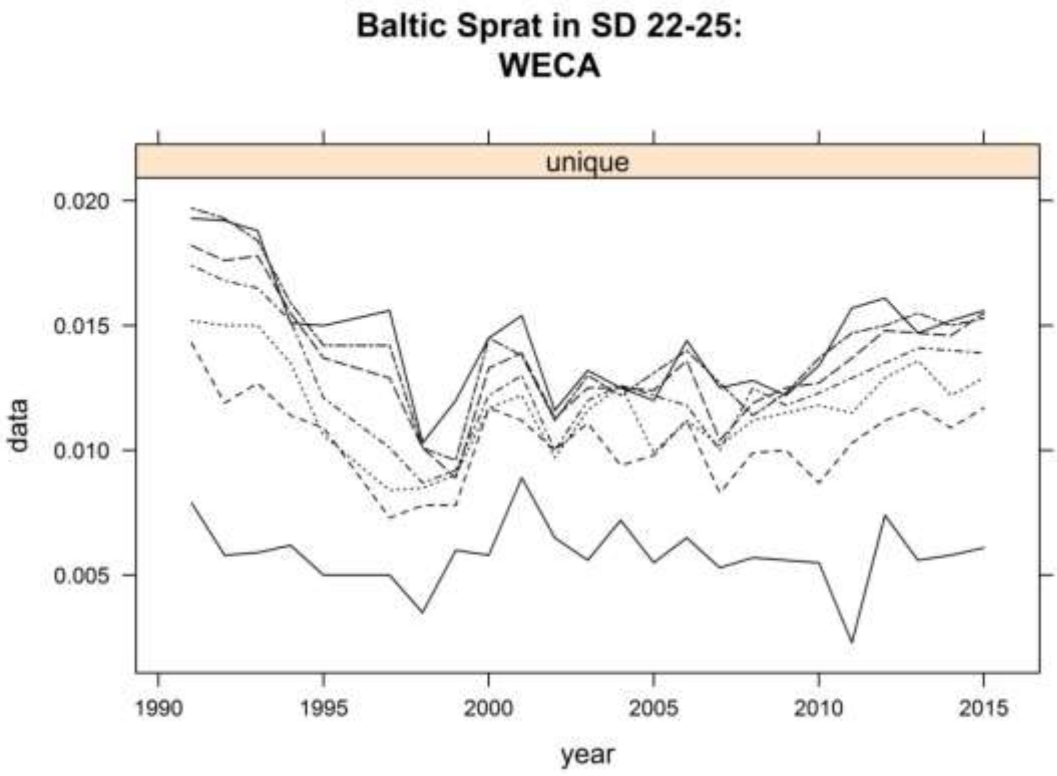


Figure 1.1.1. Sprat in SD 22-32. Mean weight-at-age in the catches (weight in the stock has been assumed as in the catches).

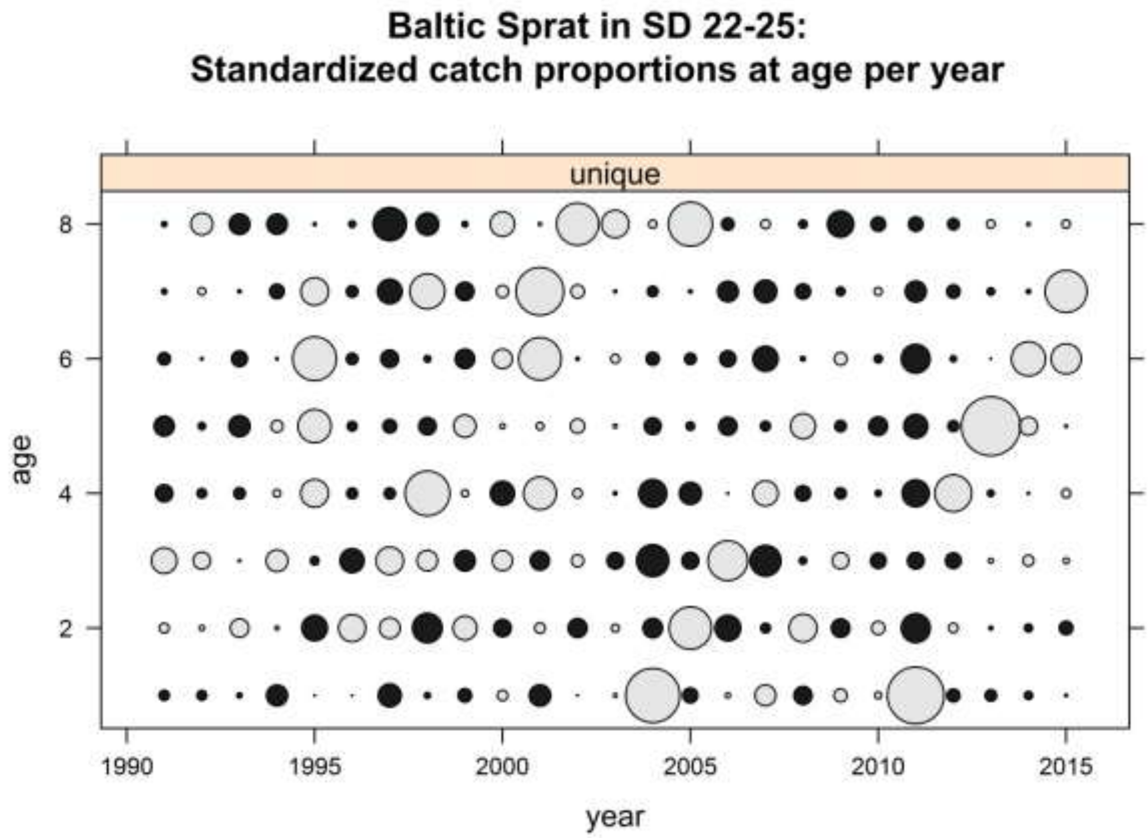
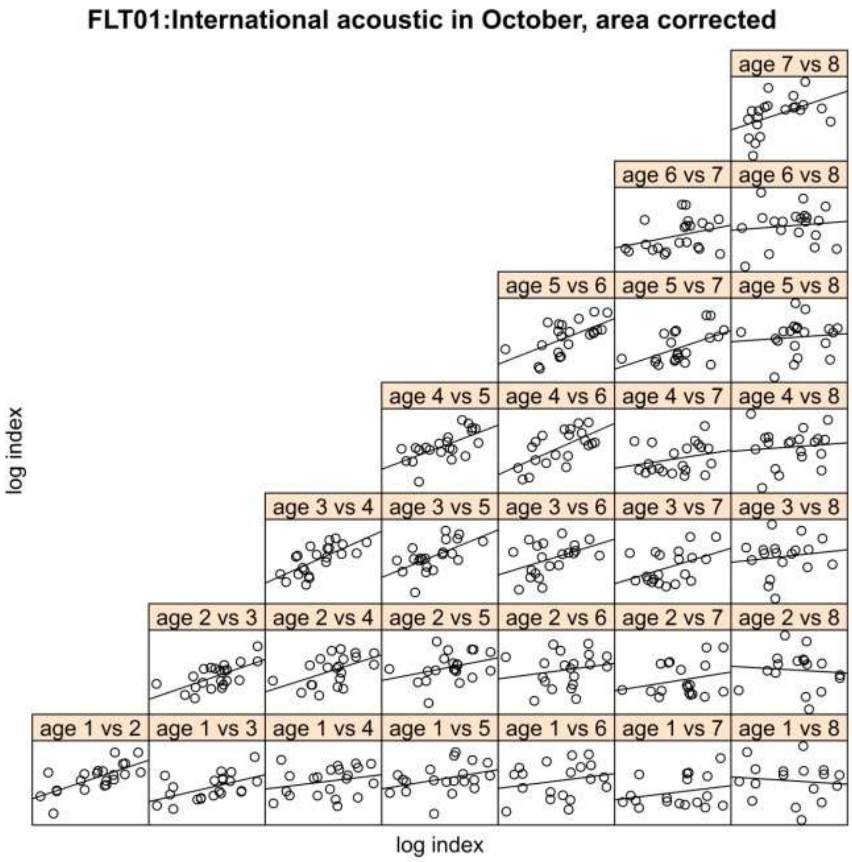


Figure 1.2.1. Sprat in SD 22-25. CANUM consistency check.



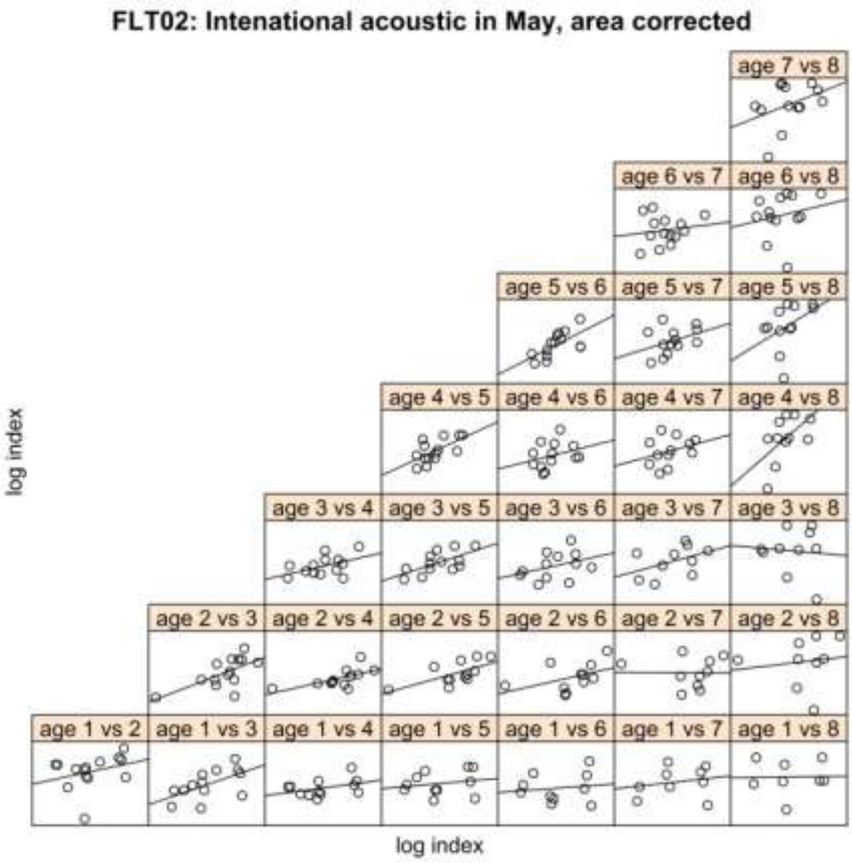


Figure 1.2.2. Sprat in SD 22-25. Check for consistency in October (BIAS) and May (BASS) acoustic survey estimates.

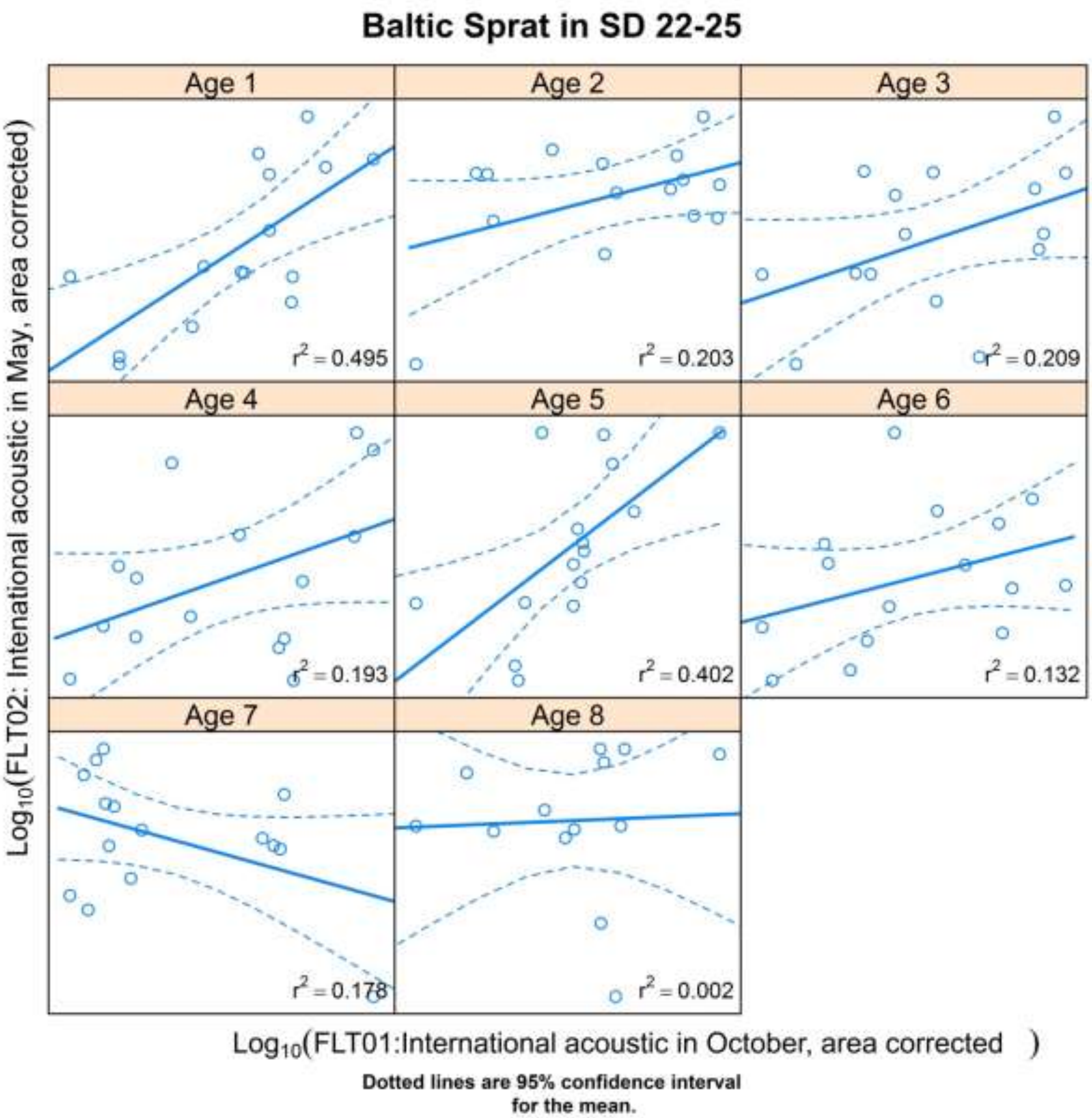


Figure 1.2.3. Sprat in SD 22-25. Between surveys (October and May) consistency check.

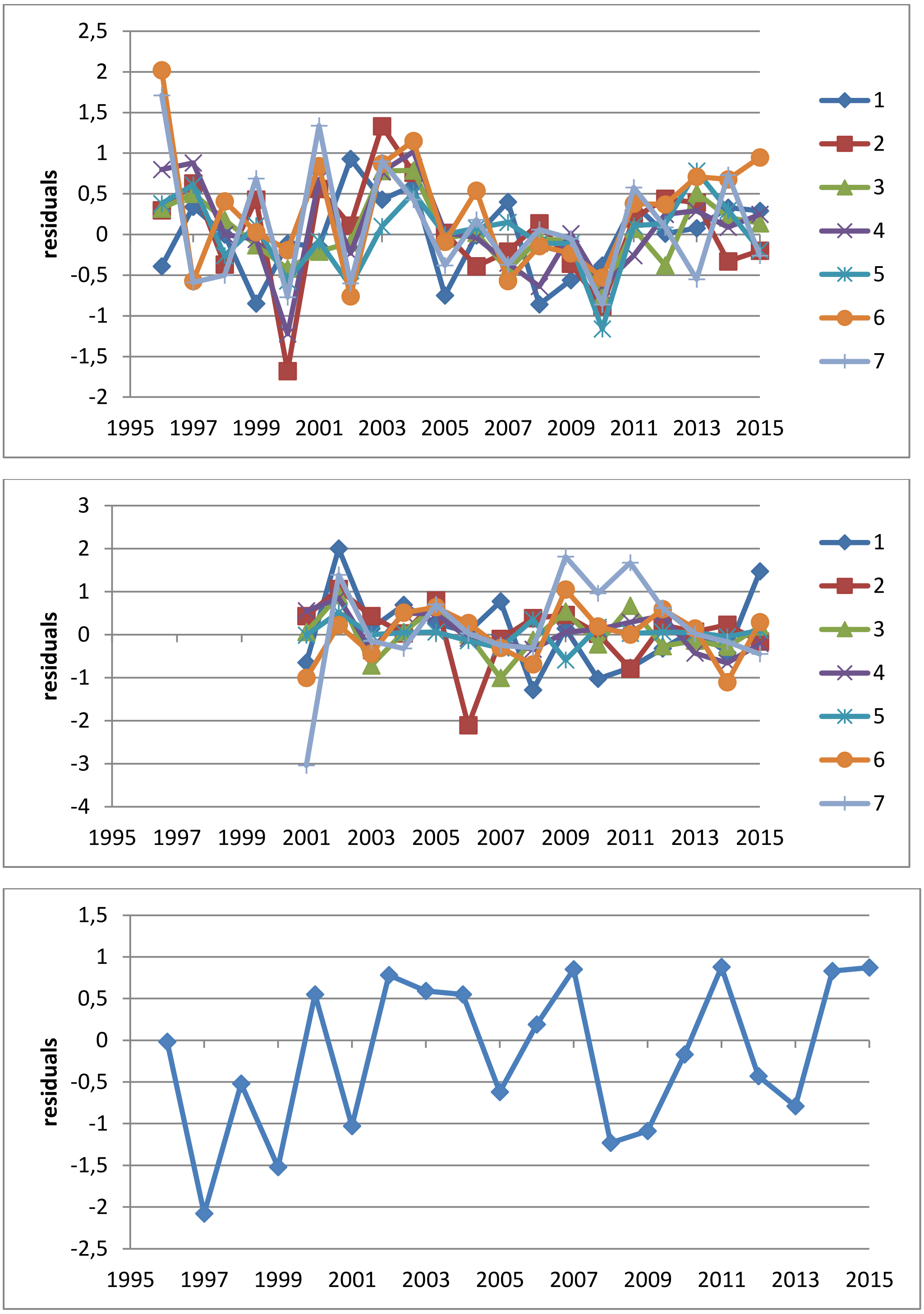


Figure 1.3.1.1. Distribution of survey log-catchability residuals by ages in XSA analysis. October survey =upper plot, May survey = middle plot, age0 survey=bottom plot.

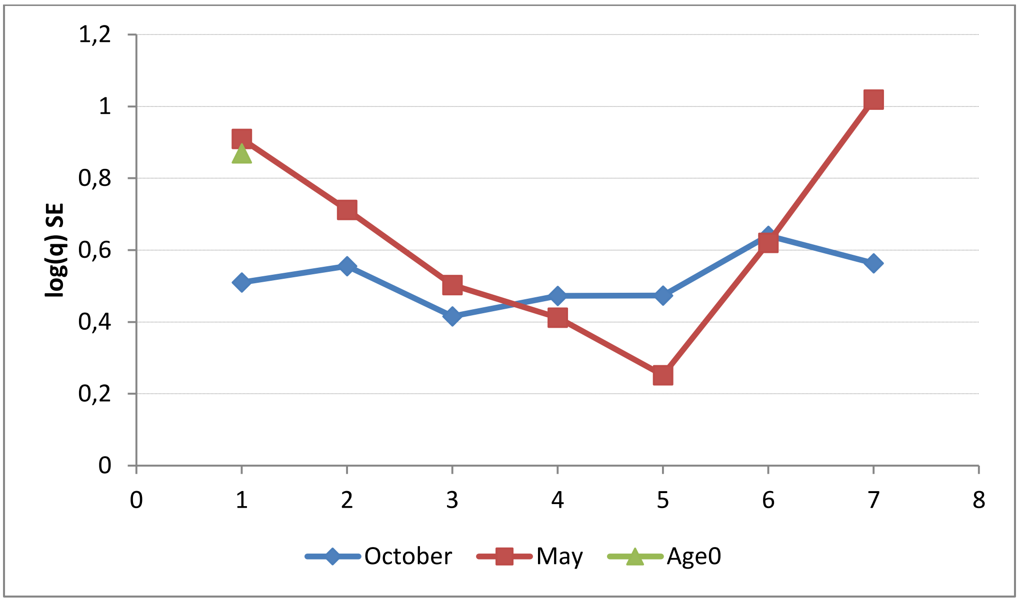


Figure 1.3.1.2. The standard errors (SE) of log-catchability residuals for October, May, and age0 surveys.

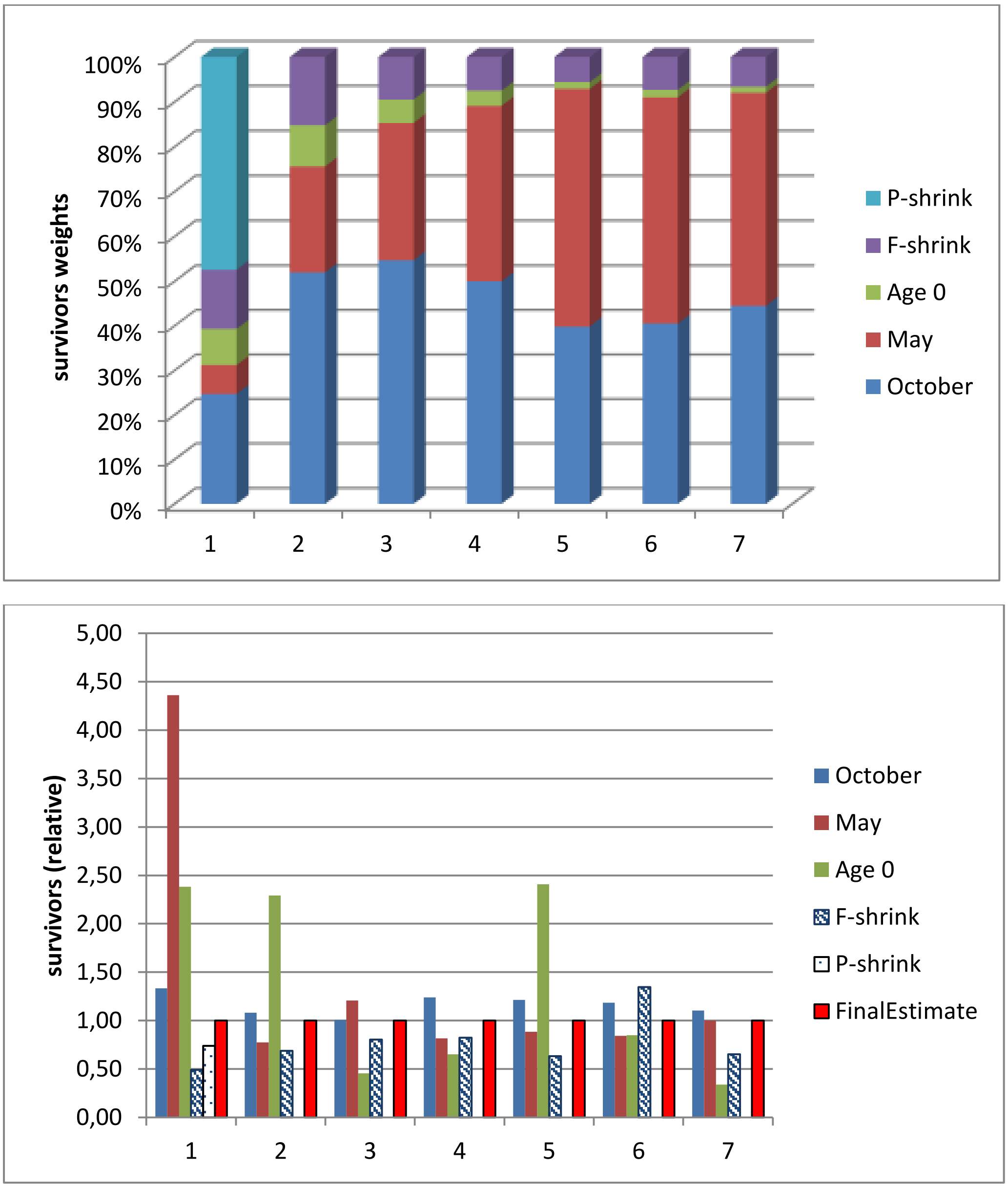


Figure 1.3.1.3. Weight of survivors estimates (upper graph) and survivors estimates relative to final estimate (bottom graph) by tuning fleet and applied shrinkage.

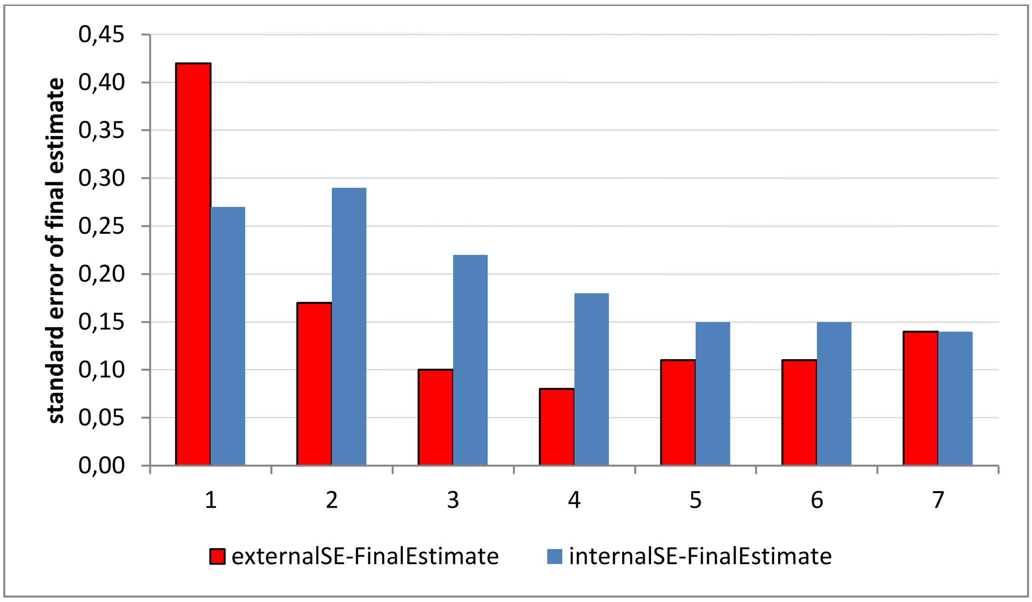


Figure 1.3.1.4. The internal and external standard error (SE) of survivors estimates in XSA.

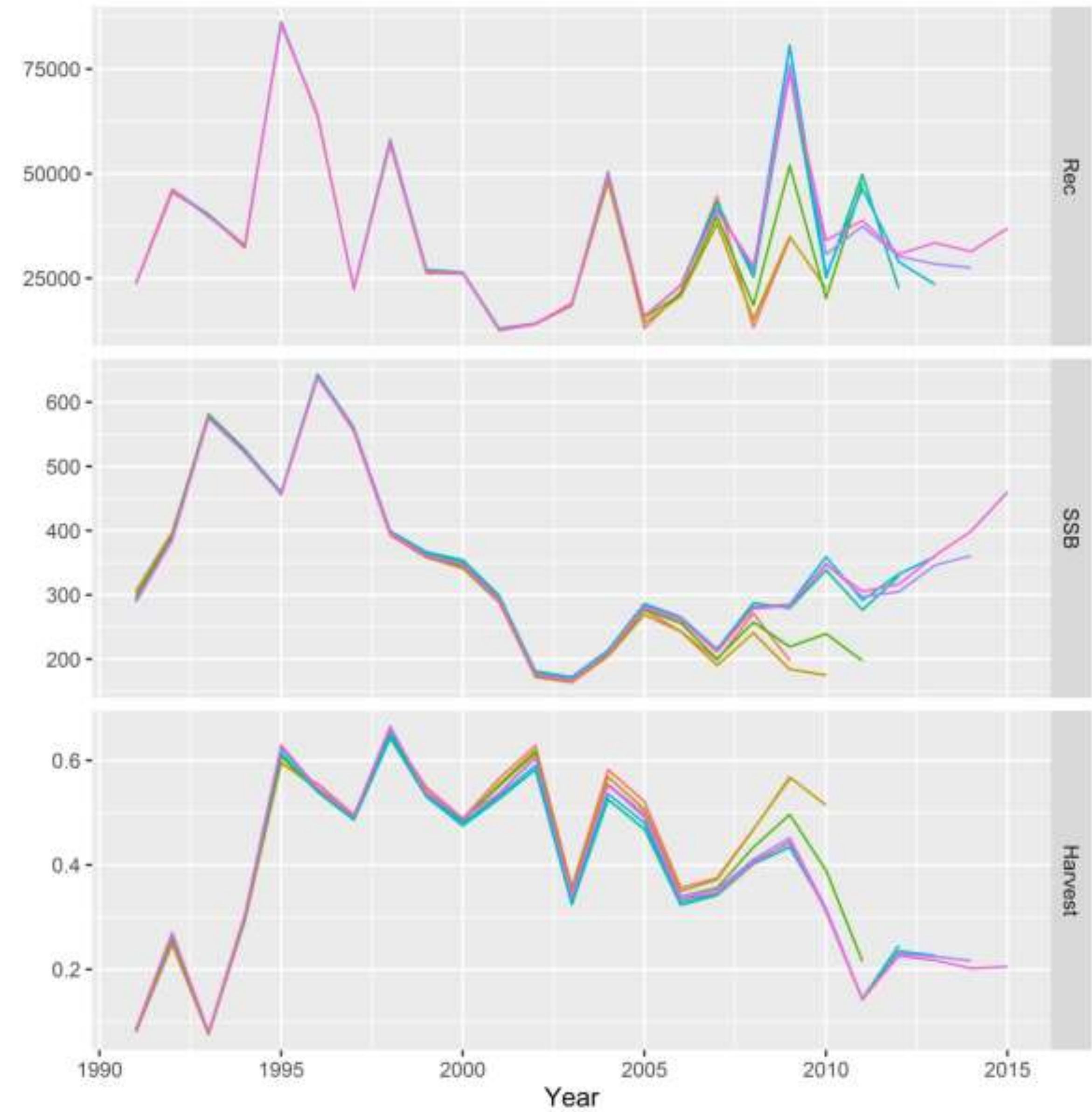
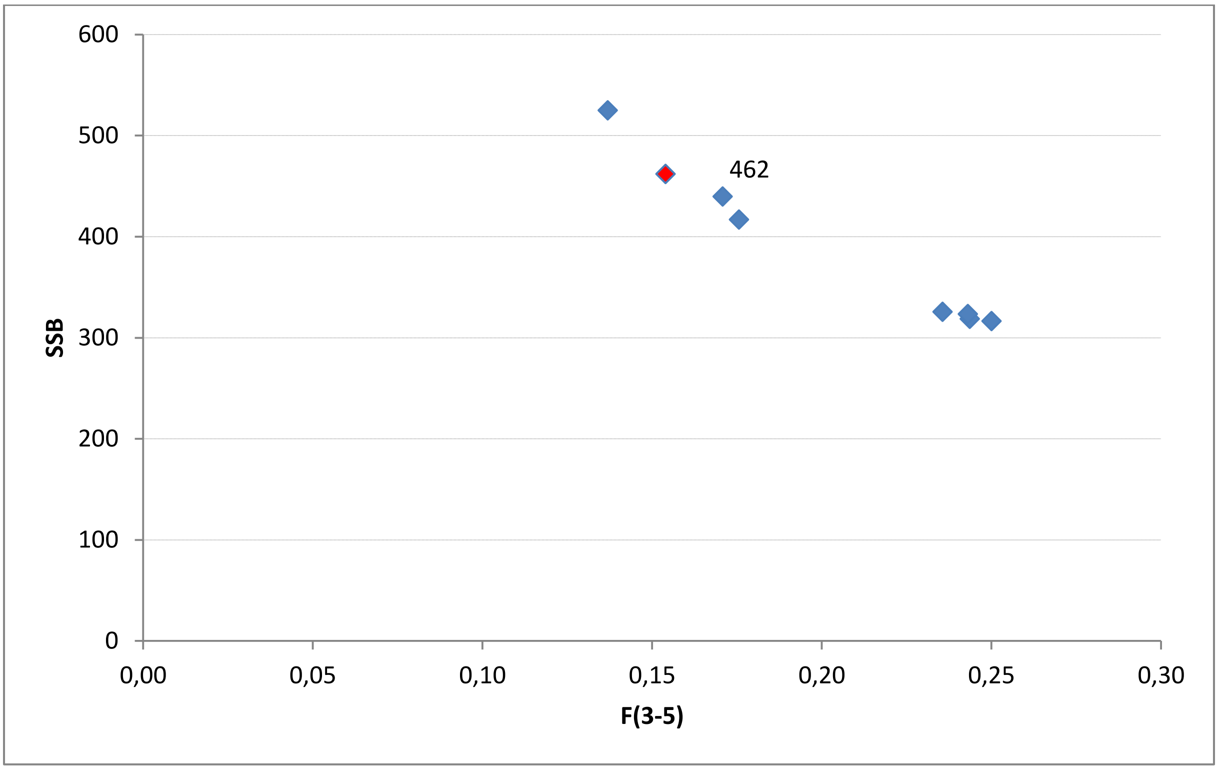


Figure 1.3.1.5. Retrospective estimates of recruitment, spawning stock biomass and fishing mortality for sprat in sub-divisions 22-25.



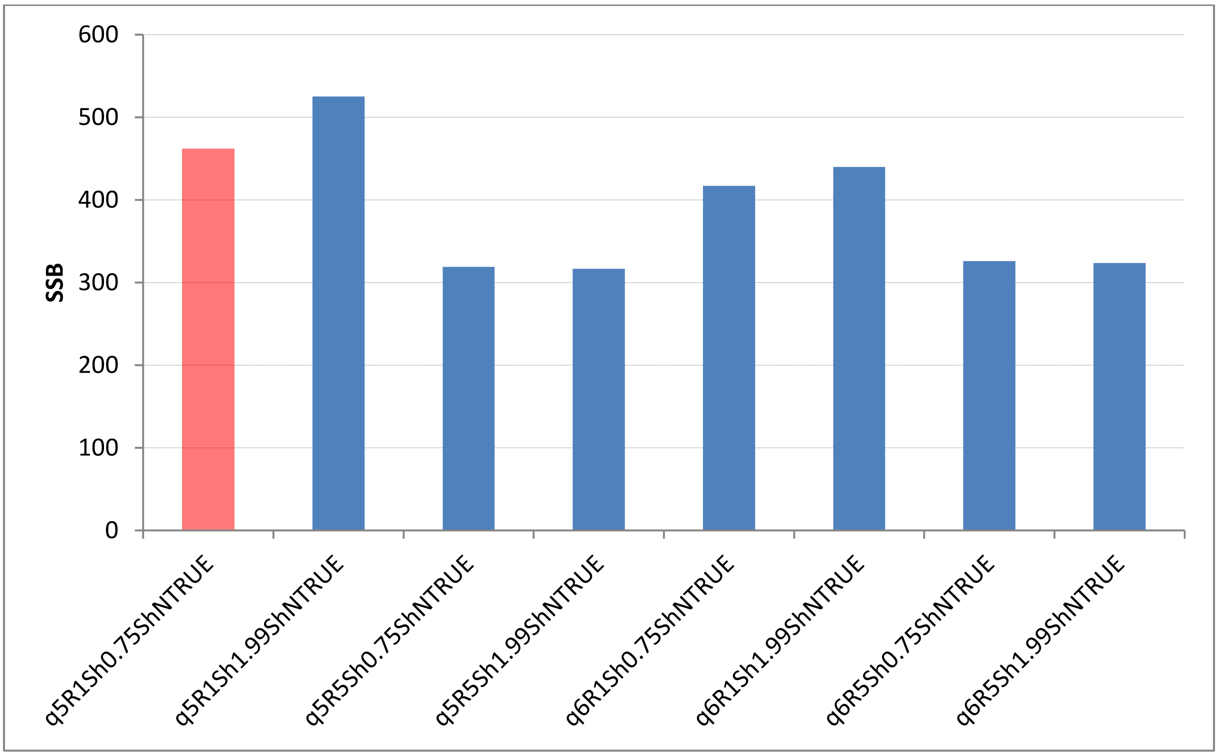
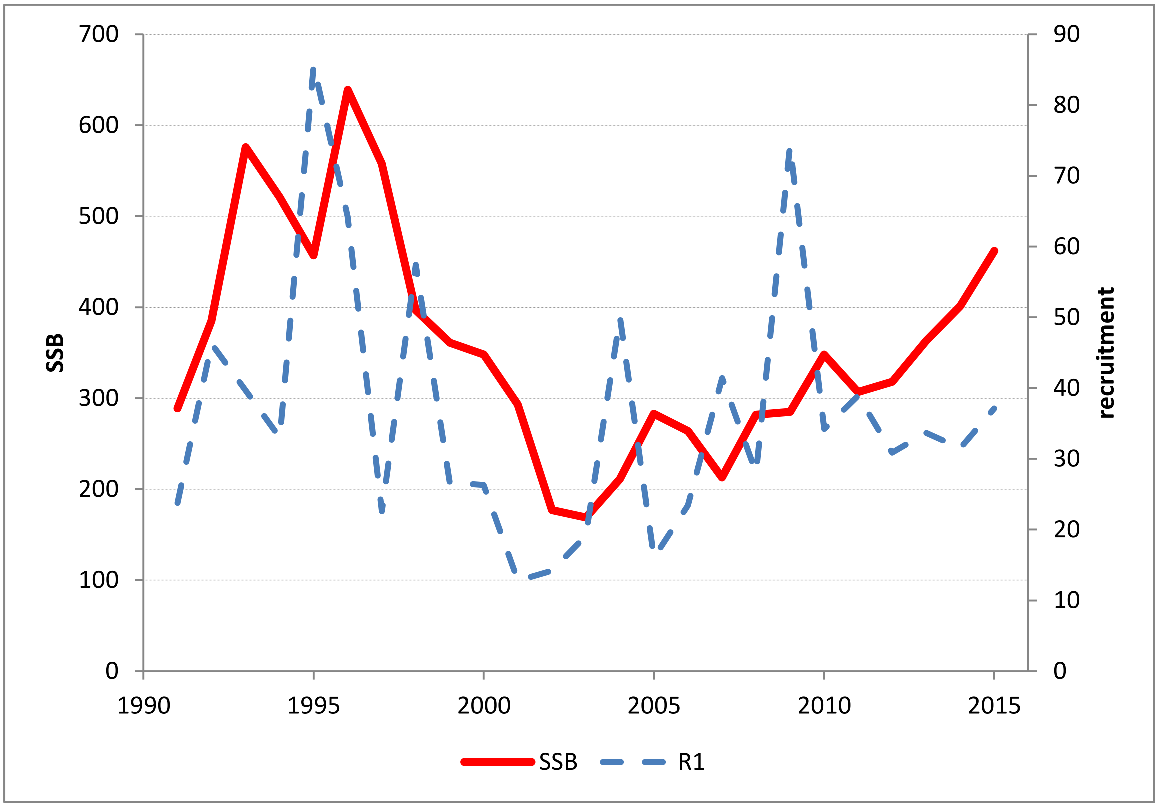


Figure 1.3.1.6. Sensitivity of terminal year estimates of SSB and average fishing mortality to the parameterisation of the XSA. Final estimates are shown in red.



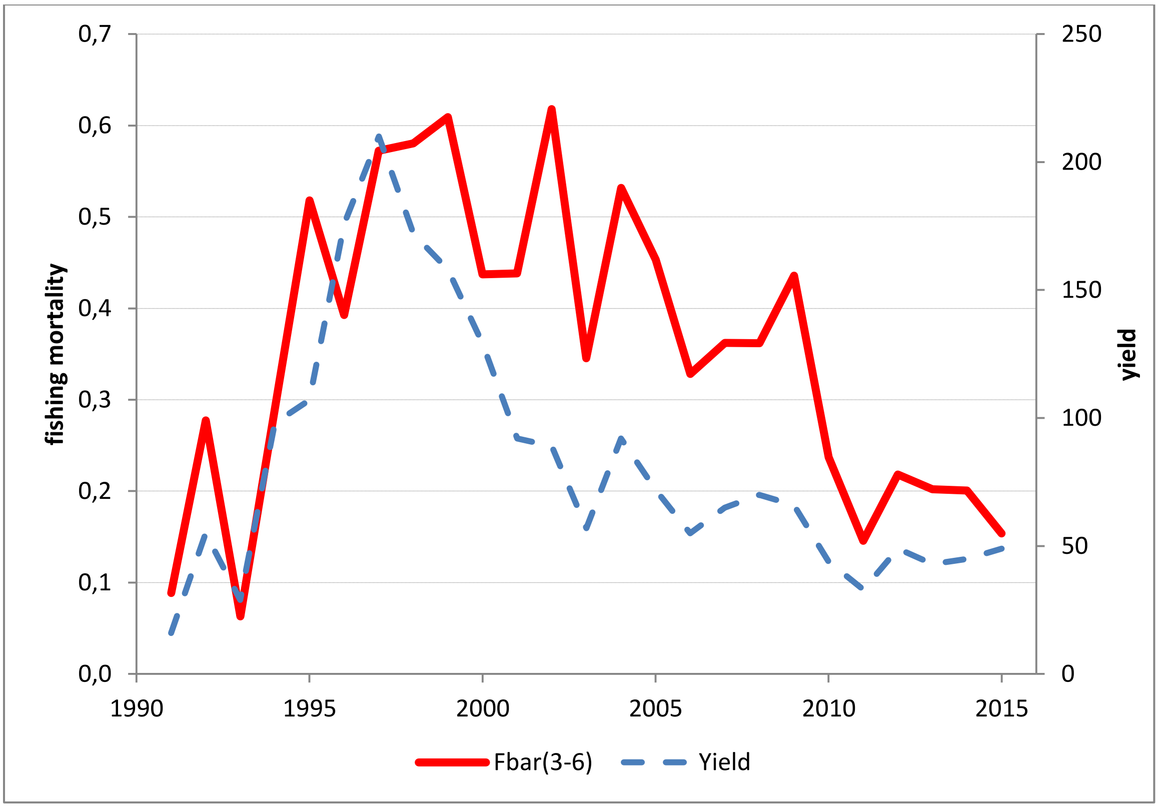


Figure 1.3.1.7. The XSA estimates of spawning stock biomass (10^3 t.), recruitment (10^9 individuals), and fishing mortality. For comparison yield (10^3 t.) is given.

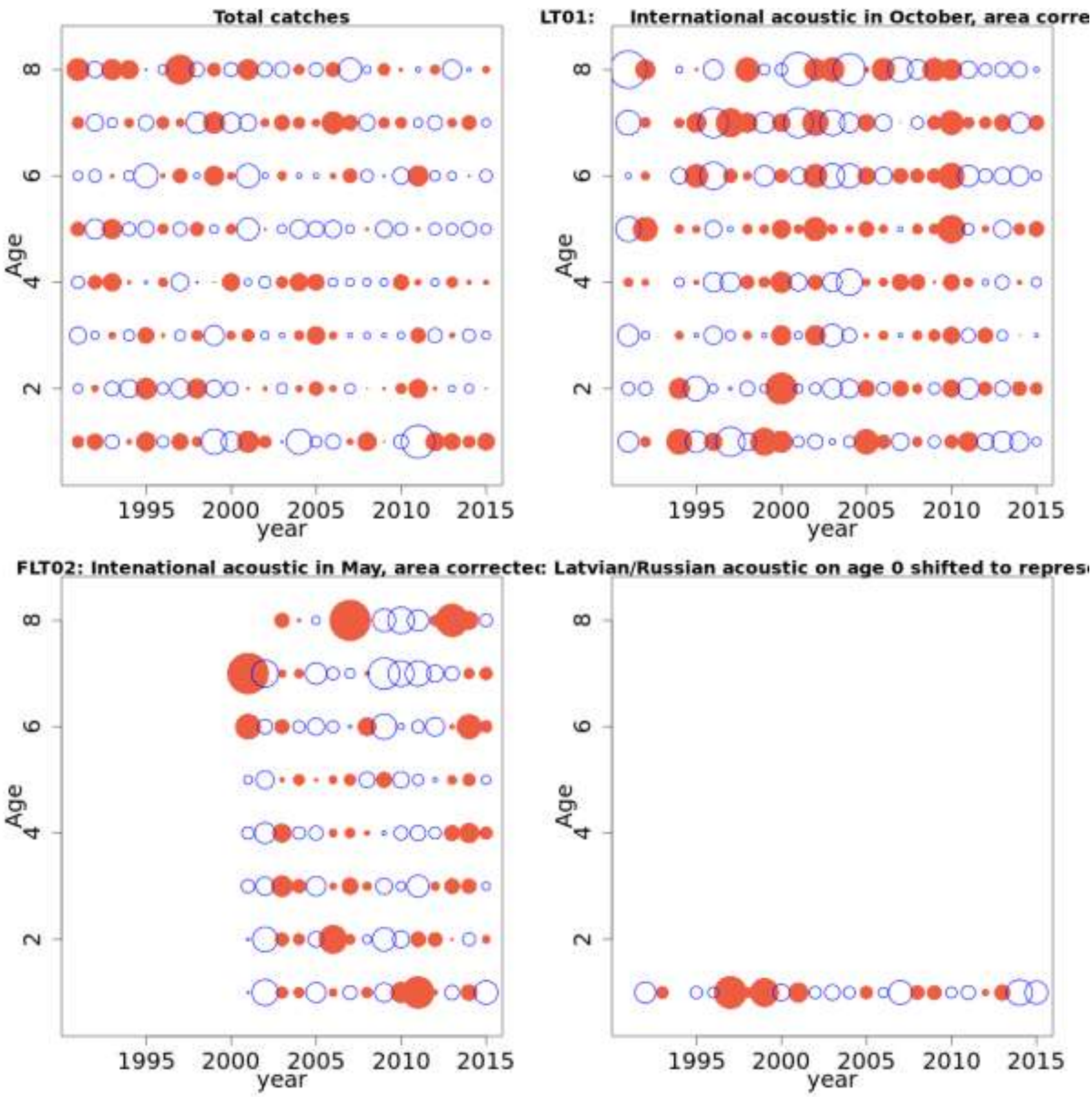


Figure 1.3.2.1. Plot of residuals for catches and three tuning fleets in SAM model

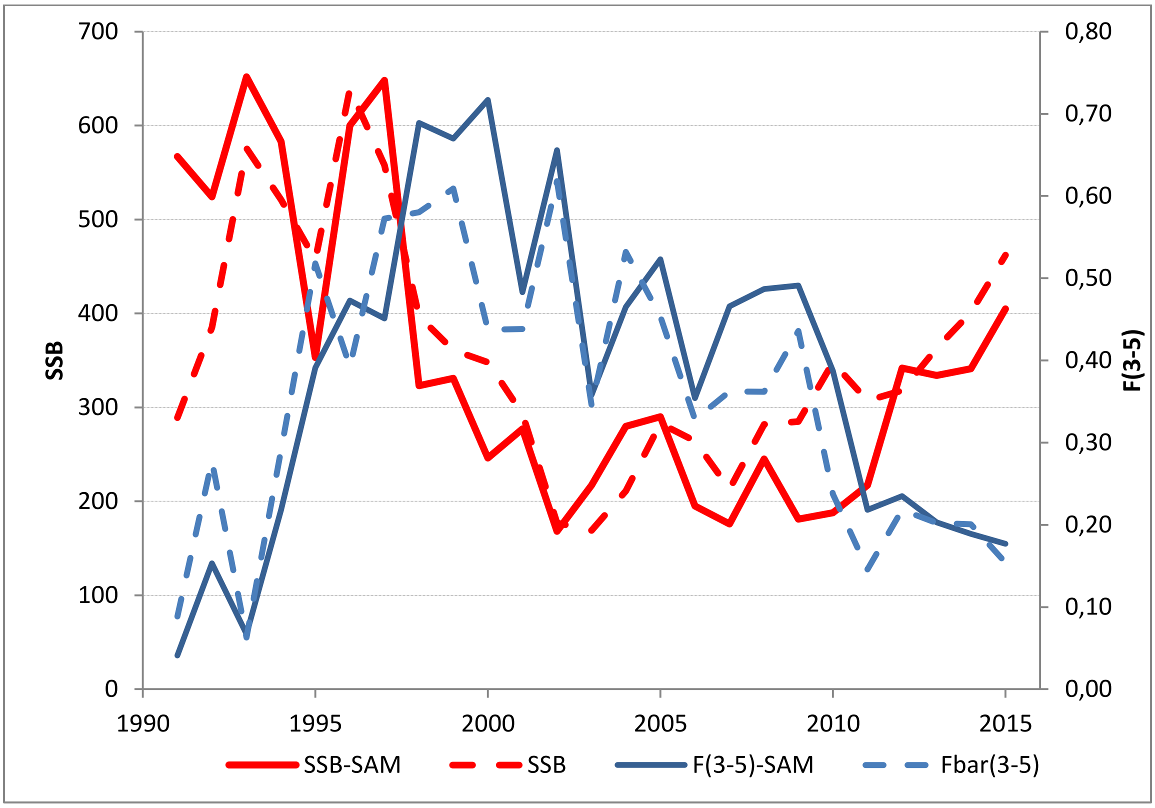
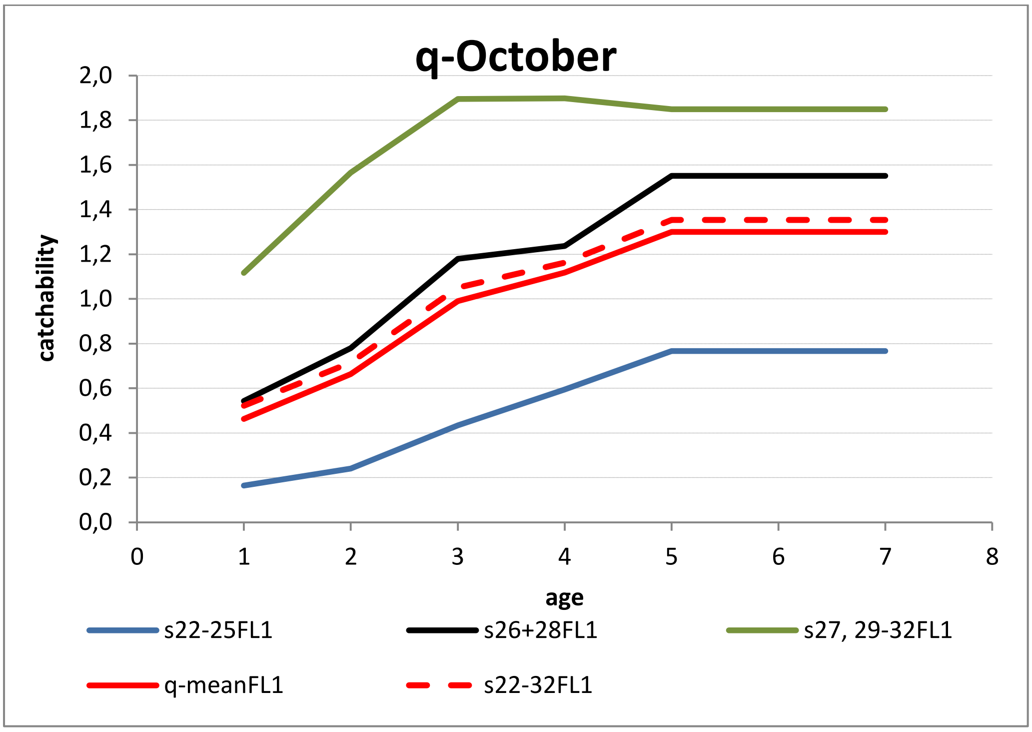


Figure 1.3.2.2. SAM model estimates of spawning stock biomass (10^3 t.) and fishing mortality. For comparison XSA estimates (broken lines) are given.



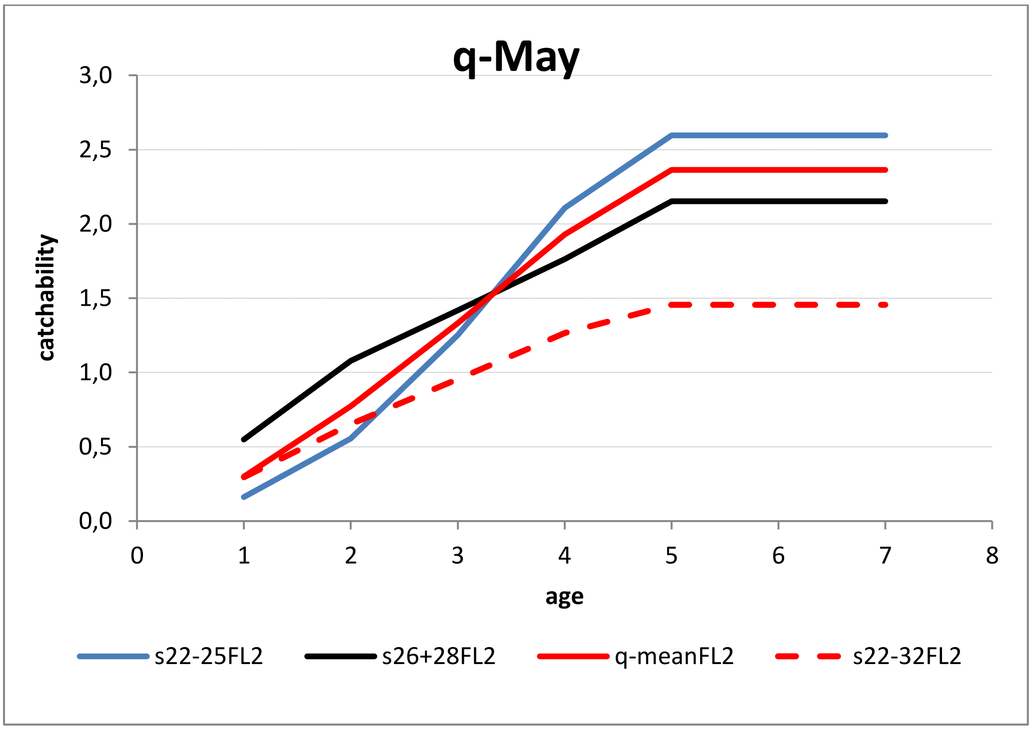


Figure 1.3.3.1. Survey catchability estimated for sprat in sub-divisions 22-25, sprat in sub-divisions 26+28, and sprat in sub-divisions 27,29-32, and their mean value. The catchability estimated for the sprat in sub-divisions 22-32 stock is given for comparison.

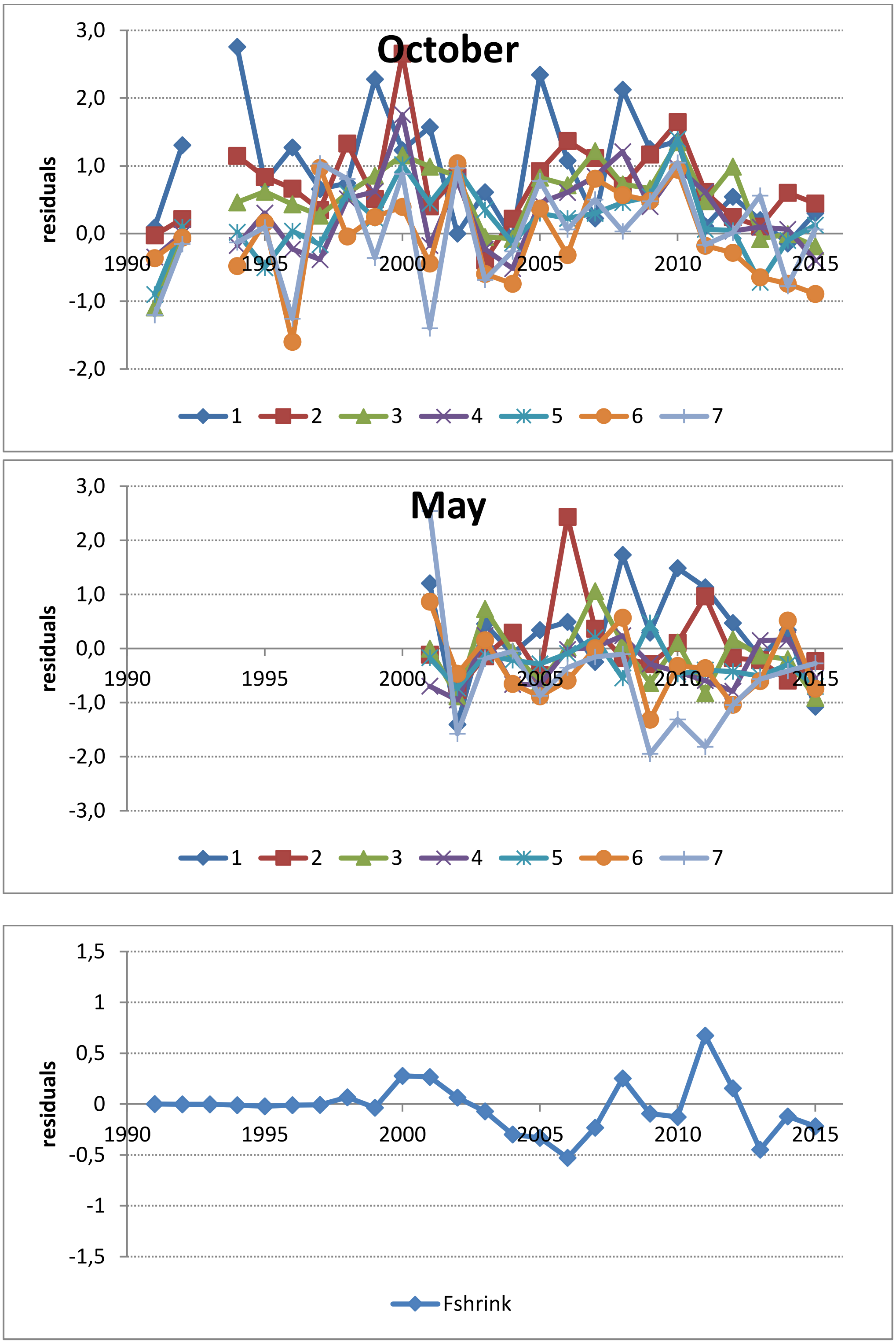


Figure 1.3.3.2. Time series of residuals for stock estimates at age for October and May acoustic surveys. In addition, residuals in fishing mortality estimates at terminal age are shown (bottom plot).

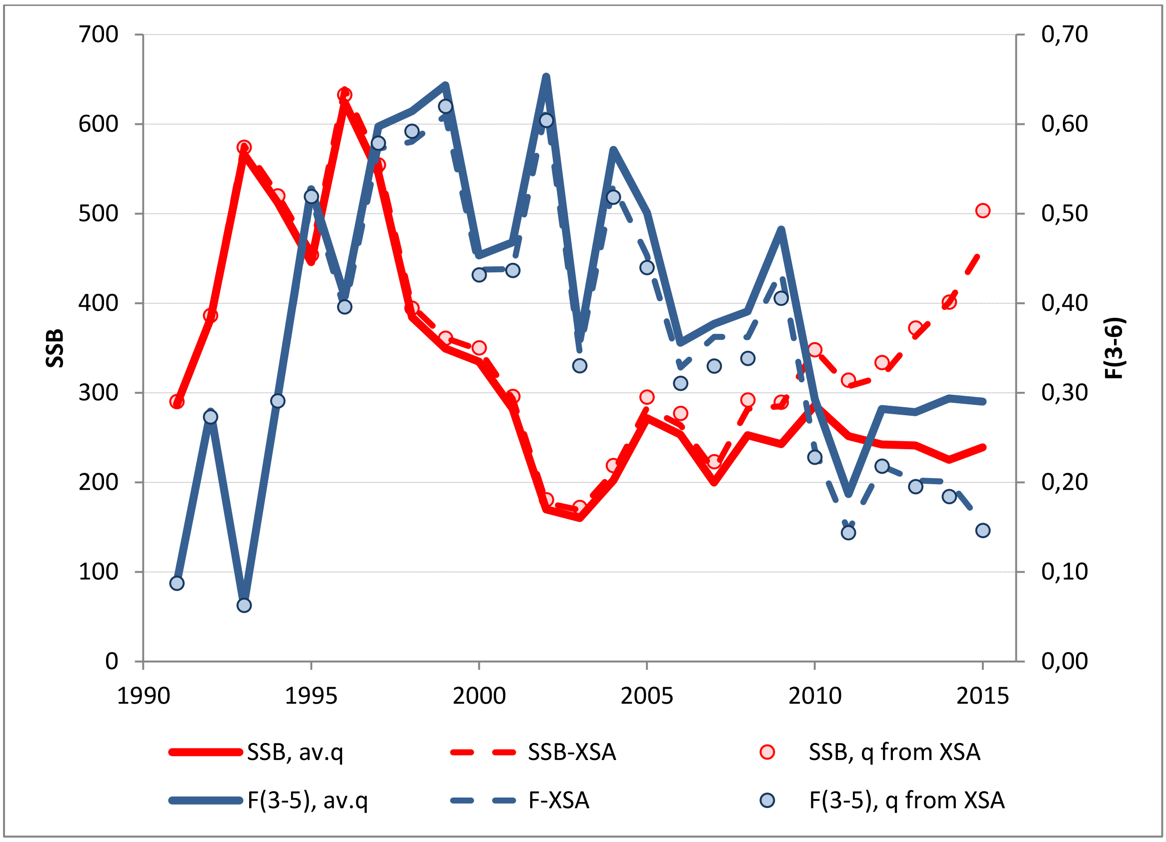


Figure 1.3.3.3. Spawning stock biomass (10^3 t.) and fishing mortality estimated by cohort analysis with assumed catchability (CohAnalQ) using average catchability (av. q). For comparison SSB and F estimates with CohAnalQ using the same catchability as estimated in XSA (q from XSA) and the XSA estimates (broken lines) are given.

2. Stock of sprat in sub-divisions 26+28

2.1. Biological and survey data

The data required for assessments were taken from WGBFAS and WGBIFS reports (ICES, 2016 a, b) and ICES/WGBFAS data bases. Each year WGBFAS presents in its report catch-at-age (CANUM) and weight-at-age (WECA/WEST) data by sub-divisions. Such data enabled compiling CANUM and WECA by former assessment units like sprat in sub-divisions 26+28.

Mean weights at age in the catches were calculated as mean of weights at age in sub-divisions (26 and 28) weighted by catch at age numbers in each sub-division. Weight-at-age in the stock was assumed to be the same as weight-at-age in the catch. The weights-at-age have decreased at the beginning of 1990s for the ages 2 and older, but in recent years some increase has been observed (Figure 2.1.1).

Maturity at age was assumed the same as for the sprat in sub-divisions 22-32 assessed routinely by WGBFAS (ICES, 2016a).

Natural mortality for the stock was determined using predation mortality estimates (M2) available from area-disaggregated SMS (Stochastic Multispecies Simulation, multispecies stock assessment model) (WKMULTBAL 2012). The M2 at age values for the stock were calculated as means of M2's by sub-divisions weighted by stock abundance from the acoustic survey. The SMS series ends in 2011 and for the period 2012-2015 predation mortality were estimated from linear regression relating cod biomass estimates and predation mortality of given stock, similarly as for sprat at WGBFAS (ICES, 2016a). The estimated predation mortalities for that stock are moderate (usually at 0.1 or slightly higher). The moderate M2 levels result from low abundance of cod in sub-division 28. Constant 0.2 was added to M2 values to get total natural mortality.

Two tuning data sets covering Sub-divisions 26+28 were available: from Baltic International Acoustic Survey (BIAS) in autumn (usually October) in 1991–2015 and from international Baltic Acoustic Spring Survey (BASS) in May in 2001–2015. In addition, age 0 was extracted as separate tuning set from autumn survey; this index was shifted to represent age 1 as in standard ICES assessment (ICES, 2016a). The survey data were corrected for area coverage (ICES, 2016b). Biological and tuning data are provided in Tables 2.1.1-2.1.2.

2.2. Quality and consistency of input data

The consistency of the catch-at-age estimates was checked in bubbles-plot (Figure 2.2.1). The correlation between catches at a given age and the catches of the same generations 1 year later is high, mostly close to 0.9.

The internal consistency of survey at age estimates and consistency between surveys was checked on graphs (Figure 2.2.2-3). The correlation between survey indices at given age and the indices of the same generations 1 year later for given survey (internal consistency) is high ranging within 0.7-0.9. The consistency between surveys is also high, with correlation usually in range 0.6 - 0.9.

2.3. Stock assessments

Biological and survey data presented in section 2.1 (Tables 2.1.1-2) were used as input for the age structured assessments of the stock.

2.3.1. Assessment with XSA

The best settings for the parameterisation of XSA were found to be the same as specified in benchmark assessment of Baltic sprat stock (ICES, 2013), i.e.:

- tri-cubic time weighting,
- catchability dependent on year class strength at age 1 (only for this age group the slopes of regressions between survey and XSA numbers were significantly different from 1),
- catchability independent of age for ages 5 and older,
- the SE of the F shrinkage mean equal 0.75.

The log q residuals are presented in Figure 2.3.1.1. Residuals for October survey do not show clear pattern. However, for older ages in May survey residuals show significant tendency to increase with time. The same is also observed for age 0 acoustic. The data are moderately noisy as shown by SE of log q (log catchability) in range 0.3-0.5 (Figure 2.3.1.2). The correlations between XSA estimates and survey indices are high (R^2 mostly at level of 0.6–0.9).

The weights of estimates resulting from shrinkage are low for ages 2 - 7(up to 10%) (Figure 2.3.1.3), although the shrinkage was not assumed very low (shrinkage SE of 0.75). For survivors of age 1 the total shrinkage weight increases to 30%, mainly due to the P-shrinkage. The standard errors of the final estimates are rather low, mostly in range 0.1 – 0.15 (Figure 2.3.1.4).

Retrospective analysis (Figure 2.3.1.5) shows moderately scattered estimates of biomass, fishing mortality, and recruitment (Mohn's Rho in the range -0.04 – 0.18 for SSB, F and recruitment), and in most recent two years the estimates are very consistent.

Sensitivity of the terminal year estimates of SSB and average fishing mortality to the parameterisation of the XSA is presented in Figure 2.3.1.6. It shows somewhat higher variability of SSB estimates when q plateau is set at age 6, than when it is set at age 5. The effect of the shrinkage SE is low.

The quality of the assessment is quite good: input data are consistent, retrospective deviations are rather low and SEs of survivors are below 0.15 for most of the ages. Fish stock summary plots are presented in Figures 2.3.1.7.

2.3.2. Assessment with SAM

The SAM model was attempted as an alternative assessment model similarly as in benchmark assessment of sprat stock in sub-divisions 22-32. The parameterisation of the model was the same as parameterisation agreed on during benchmark workshop (ICES, 2013). Results of SAM assessment (residuals plots, biomass and fishing mortality estimates) are presented in Figure 2.3.2.1-2. Residuals show some pattern, especially for May survey for which blocs of negative and positive values may be observed. Similar picture of residuals distribution was obtained in XSA analysis. Biomasses and fishing mortalities estimated with SAM are very similar to the XSA estimates. The assessment with SAM is available at the https://www.stockassessment.org (short name of the stock is spr26and28).

2.3.3. Assessment with cohort analysis with assumed catchability (CohAnalQ)

As indicated in the section 1.3.3 the survey catchabilities estimated in XSA assessment of sprat in sub-divisions 22-25, sprat in sub-divisions 26+28, and sprat in sub-divisions 27,29-32 differ (Figure 1.3.3.1). Thus, similarly as in case of sprat in sub-divisions 22-25 stock, to correct for the effects of different catchabilities in the XSA estimates of the stocks, the assessment of sprat stock in sub-divisions 26+28 was performed with average for three stocks catchabilities, using cohort analysis (CohAnalQ) as described in Part A, section 1.

The cohort analysis fits the data quite well. Survey residuals do not show clear time pattern. Residuals of the “F shrinkage” are very low at the beginning of time series as at these years tri-cubic weighting applied to the survey down-weights survey data. Standard error of the fit is 0.41 (Figure 2.3.3.1).

Assessment results are shown in Figure 2.3.3.2. Biomass and F estimates from the XSA for the stock and estimates from CohAnalQ using the same catchability as estimated in that XSA are presented for comparison. Spawning stock biomass in most recent years is somewhat higher than in XSA analysis but in other years the estimates are very similar. The estimates of fishing mortality are similar in both CohAnalQ and XSA assessments. The results of XSA and CohAnalQ using q estimated in XSA differ in most recent years (for tri-cubic weighting applied in CohAnalQ).

Summary of assessments results by assessment model is presented in Table 2.3.1.

Table 2.1.1. Biological Input data for stock assessment, sprat in sub-divisions 26+28.

CANUM: Catch in numbers (Millions)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	663	1642	1505	215	346	55	32	59
1992	1638	3075	3529	2207	400	348	117	166
1993	488	1885	1019	619	315	96	77	63
1994	751	5580	4678	1935	1319	464	122	120
1995	2594	1073	3333	2853	1382	809	290	112
1996	3740	13335	1887	3275	1844	760	393	173
1997	617	9265	7582	2442	2024	935	441	189
1998	5167	1454	4895	5130	813	645	421	184
1999	414	7153	1685	2539	2114	452	242	186
2000	4324	855	6942	1138	1809	1324	235	338
2001	1815	5435	1111	4743	756	1194	732	201
2002	3993	2573	5304	1482	2276	430	462	524
2003	6368	4877	3083	3259	951	1252	303	628
2004	9460	7582	3445	1642	1815	579	629	688
2005	1712	16378	5787	1693	842	463	316	449
2006	6610	2238	12656	3324	762	305	200	217
2007	6678	7297	2451	8492	2016	451	184	233
2008	3556	8100	3686	1514	3144	1028	160	123
2009	11777	5763	5212	2202	836	1405	419	105
2010	3150	11278	2738	2025	615	351	409	152
2011	2690	2908	7073	1386	807	269	133	177
2012	3149	2944	1538	3727	640	385	153	170
2013	4305	4941	2260	1278	1875	333	146	111
2014	3152	4013	3474	1175	558	730	136	156
2015	10336	2808	2601	1470	520	184	260	84

WECA (=WEST): Mean weight in the Catch and in the Stock (Kilograms)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	0.0050	0.0130	0.0140	0.0160	0.0170	0.0180	0.0190	0.0160
1992	0.0050	0.0120	0.0140	0.0160	0.0170	0.0180	0.0180	0.0210
1993	0.0050	0.0050	0.0100	0.0120	0.0130	0.0140	0.0140	0.0160
1994	0.0050	0.0080	0.0110	0.0120	0.0140	0.0140	0.0140	0.0160
1995	0.0040	0.0090	0.0100	0.0110	0.0130	0.0140	0.0140	0.0160
1996	0.0030	0.0070	0.0100	0.0110	0.0120	0.0120	0.0120	0.0290
1997	0.0050	0.0070	0.0090	0.0110	0.0120	0.0120	0.0120	0.0160
1998	0.0030	0.0070	0.0080	0.0090	0.0100	0.0100	0.0110	0.0150
1999	0.0040	0.0070	0.0090	0.0090	0.0090	0.0110	0.0120	0.0150
2000	0.0050	0.0090	0.0090	0.0100	0.0110	0.0110	0.0120	0.0140
2001	0.0070	0.0090	0.0110	0.0110	0.0110	0.0110	0.0110	0.0150
2002	0.0050	0.0090	0.0100	0.0110	0.0110	0.0110	0.0110	0.0120

2003	0.0040	0.0090	0.0110	0.0110	0.0110	0.0110	0.0110	0.0110
2004	0.0030	0.0070	0.0100	0.0110	0.0110	0.0110	0.0110	0.0110
2005	0.0040	0.0070	0.0080	0.0100	0.0110	0.0110	0.0110	0.0110
2006	0.0040	0.0070	0.0080	0.0090	0.0110	0.0110	0.0120	0.0120
2007	0.0050	0.0070	0.0080	0.0090	0.0090	0.0100	0.0110	0.0120
2008	0.0050	0.0080	0.0090	0.0100	0.0090	0.0090	0.0100	0.0110
2009	0.0050	0.0090	0.0100	0.0110	0.0110	0.0110	0.0110	0.0110
2010	0.0050	0.0070	0.0090	0.0100	0.0100	0.0110	0.0100	0.0110
2011	0.0056	0.0092	0.0097	0.0107	0.0115	0.0120	0.0117	0.0121
2012	0.0058	0.0094	0.0108	0.0112	0.0120	0.0125	0.0127	0.0125
2013	0.0049	0.0098	0.0113	0.0126	0.0128	0.0127	0.0134	0.0129
2014	0.0049	0.0093	0.0108	0.0119	0.0128	0.0129	0.0127	0.0127
2015	0.0044	0.0093	0.0108	0.0116	0.0124	0.0132	0.0124	0.0123

NATMOR: Natural Mortality

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	0.28	0.28	0.28	0.28	0.28	0.27	0.27	0.27
1992	0.25	0.25	0.25	0.25	0.24	0.24	0.24	0.24
1993	0.23	0.23	0.23	0.23	0.23	0.23	0.22	0.22
1994	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23
1995	0.29	0.29	0.29	0.29	0.29	0.29	0.28	0.28
1996	0.31	0.31	0.30	0.30	0.30	0.29	0.29	0.29
1997	0.34	0.34	0.34	0.33	0.33	0.32	0.32	0.32
1998	0.31	0.31	0.31	0.31	0.31	0.30	0.30	0.30
1999	0.28	0.28	0.28	0.28	0.27	0.27	0.27	0.27
2000	0.32	0.32	0.32	0.32	0.32	0.31	0.31	0.31
2001	0.32	0.32	0.32	0.31	0.31	0.31	0.30	0.30
2002	0.34	0.34	0.34	0.34	0.33	0.33	0.33	0.33
2003	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25
2004	0.27	0.27	0.27	0.27	0.27	0.26	0.26	0.26
2005	0.28	0.28	0.28	0.27	0.27	0.27	0.27	0.27
2006	0.27	0.27	0.27	0.27	0.26	0.26	0.26	0.26
2007	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.28
2008	0.30	0.30	0.30	0.30	0.29	0.29	0.29	0.29
2009	0.31	0.31	0.31	0.30	0.30	0.30	0.29	0.29
2010	0.36	0.36	0.35	0.35	0.34	0.34	0.34	0.34
2011	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30
2012	0.30	0.30	0.30	0.30	0.29	0.29	0.29	0.29
2013	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28
2014	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
2015	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28

MATPROP: Proportion of Mature at Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.17	0.93	1	1	1	1	1	1

MPROP: Proportion of M before Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

FPROP: Proportion of F before Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table 2.1.2. Tuning data for stock assessment, sprat in sub-divisions 26+28.

Tuning fleet in SD 26&28 (Millions)

FLT01: International acoustic in October, area corrected

Year	Fish.Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	1	33719	17545	14328	373	2914	349	251	674
1992	1	30914	18610	16032	6490	1125	1625	173	266
1993	1	30299	30093	15240	12484	4579	978	1452	1175
1994	1	11577	33114	16381	6845	3706	1335	103	472
1995	1	101288	10312	29308	14092	6885	4546	1703	958
1996	1	49358	74937	13287	11679	5083	2098	1759	579
1997	1	5166	45257	42359	3689	5717	2018	1594	417
1998	1	74419	7944	22864	16423	3495	2408	1011	986
1999	1	3892	44947	5736	11047	9145	1557	1510	1134
2000	1	47703	4602	35951	2341	7624	6630	939	1682
2001	1	7003	20968	2802	18187	1688	4716	3200	1266
2002	1	22643	5807	23414	2387	11718	469	2729	1489
2003	1	55747	17987	7203	13331	2406	7406	1071	4793
2004	1	60793	22012	7518	2842	3535	634	1596	1813
2005	1	3304	33975	14329	4867	2122	874	596	488
2006	1	22779	6998	58161	15965	5911	2403	1461	1752
2007	1	15130	10628	3676	10433	3301	786	207	612
2008	1	14838	16658	10348	1602	7458	1846	515	477
2009	1	24111	10345	9348	3563	1526	3243	1042	548
2010	1	6155	21183	5332	3626	1373	697	1058	513
2011	1	8437	4359	20951	3060	3608	1051	996	1082
2012	1	11909	5839	2867	6463	1489	860	375	511
2013	1	7808	9148	4444	2471	4681	913	481	724
2014	1	4111	4693	5164	2338	781	1979	356	513
2015	1	34496	9341	7608	4102	1222	934	979	635

FLT02: Intenational acoustic in May, area corrected

Year	Fish.Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2001	1	7291	26212	4842	22266	2088	3962	4480	600
2002	1	14063	8449	20692	5290	8024	905	1346	2585
2003	1	23475	11227	6287	12541	2859	6125	1184	3334
2004	1	123705	60140	11867	5050	10441	1299	7241	5642
2005	1	1535	63405	11147	2879	1610	1446	895	1648
2006	1	10205	7440	63363	16362	4508	1099	1227	1750
2007	1	40311	23691	4403	27710	5620	838	305	685
2008	1	8004	26432	14902	2604	14555	3742	575	1304
2009	1	29147	16316	20329	6494	5242	9303	3390	754
2010	1	7891	43482	9956	9297	3166	940	4024	772
2011	1	16048	3795	36924	10557	7591	3453	1419	2641
2012	1	19743	13832	5960	18555	4983	2795	868	1960
2013	1	19808	26519	11499	7349	8230	2073	1520	906
2014	1	7330	14688	11688	3695	2351	2737	715	847
2015	1	49428	16883	13898	10727	2737	1563	1451	982

FLT03: Latvian/Russian acoustic on age 0 shifted to represent age 1

Year	Fish.Effort	Age 1
1992	1	36458
1993	1	42741
1994	1	4754
1995	1	39276
1996	1	28302
1997	1	3372
1998	1	40177
1999	1	691
2000	1	22843
2001	1	3549
2002	1	6485
2003	1	32175
2004	1	62523
2005	1	2099
2006	1	18429
2007	1	24705
2008	1	3484
2009	1	53937
2010	1	6438
2011	1	8020
2012	1	17771
2013	1	11583

2014	1	4342
2015	1	84542

Table 2.3.1. Spawning stock biomass (SSB) and fishing mortality (F(3-5)) estimated by XSA, SAM, and CohAnalQ assessments of sprat in sub-divisions 26+28.

	SSB			F(3-5)		
	XSA	SAM	CohAnalQ	XSA	SAM	CohAnalQ
1991	403	447	399	0.18	0.19	0.18
1992	465	508	462	0.44	0.41	0.45
1993	378	382	377	0.11	0.14	0.12
1994	560	615	561	0.31	0.34	0.31
1995	539	534	543	0.31	0.29	0.30
1996	665	754	672	0.33	0.37	0.33
1997	636	713	649	0.44	0.42	0.43
1998	448	442	459	0.33	0.35	0.32
1999	559	564	561	0.27	0.29	0.26
2000	548	479	551	0.31	0.34	0.30
2001	576	521	576	0.28	0.38	0.29
2002	446	407	450	0.36	0.43	0.37
2003	396	408	396	0.47	0.48	0.47
2004	458	405	453	0.56	0.54	0.55
2005	630	535	630	0.49	0.54	0.48
2006	499	451	498	0.41	0.44	0.41
2007	410	367	411	0.46	0.61	0.46
2008	394	360	395	0.46	0.54	0.45
2009	396	363	398	0.54	0.57	0.54
2010	403	368	410	0.43	0.47	0.42
2011	350	349	358	0.43	0.40	0.42
2012	312	288	322	0.42	0.43	0.40
2013	343	309	357	0.51	0.47	0.48
2014	313	266	337	0.46	0.51	0.44
2015	318	302	366	0.37	0.38	0.33
mean	458	445	464	0.39	0.41	0.38

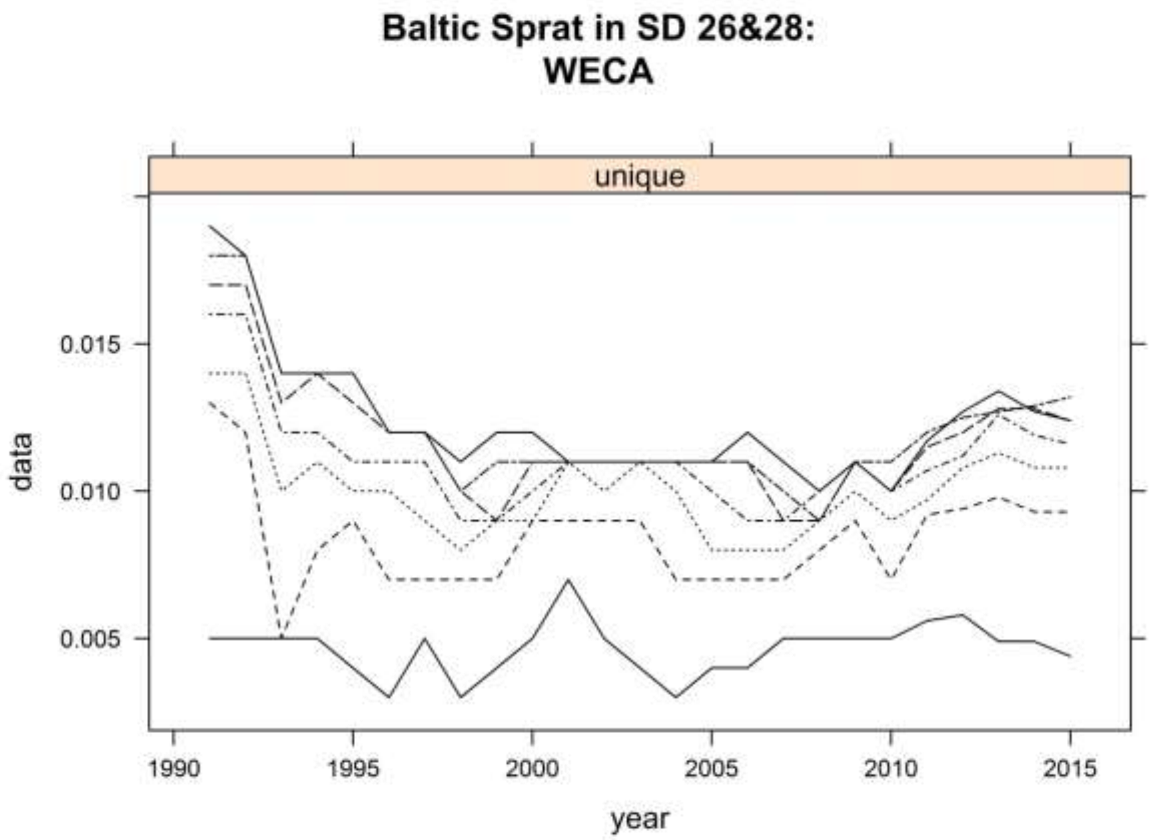


Figure 2.1.1. Sprat in SD 16+28. Mean weight-at-age in the catches (weight in the stock has been assumed as in the catches).

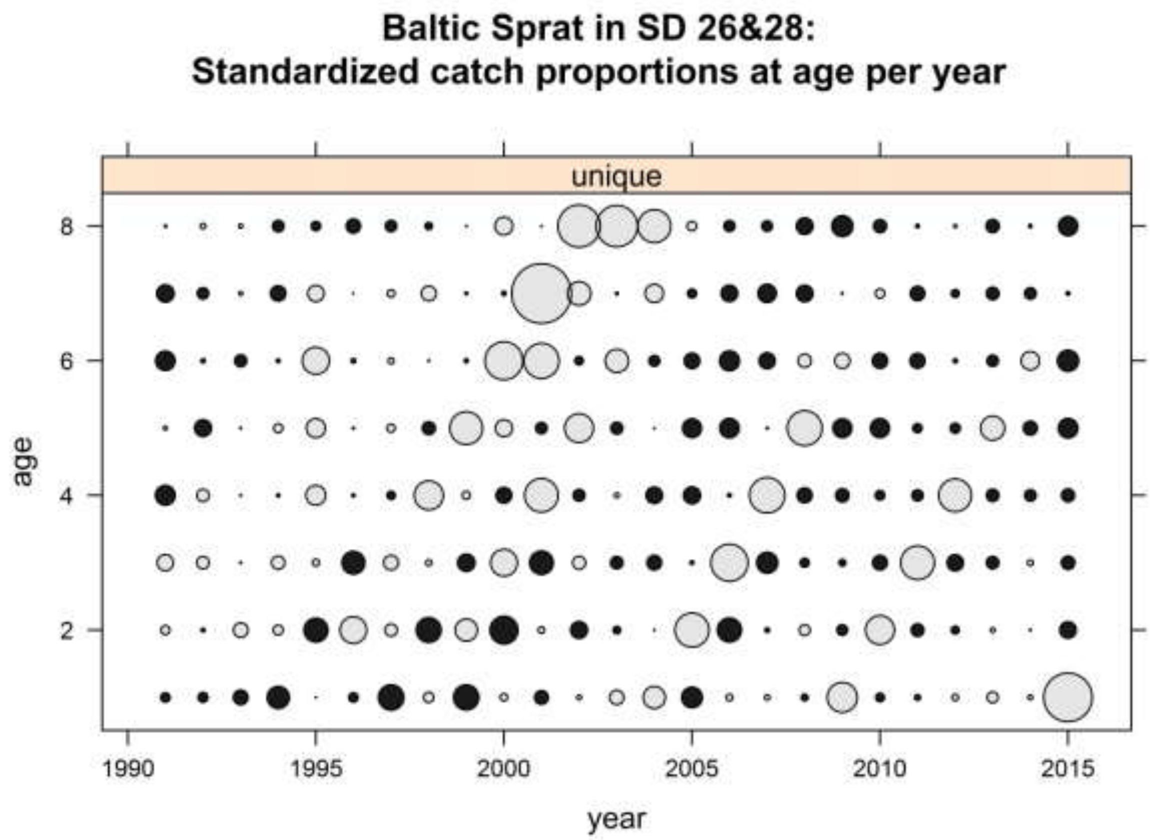
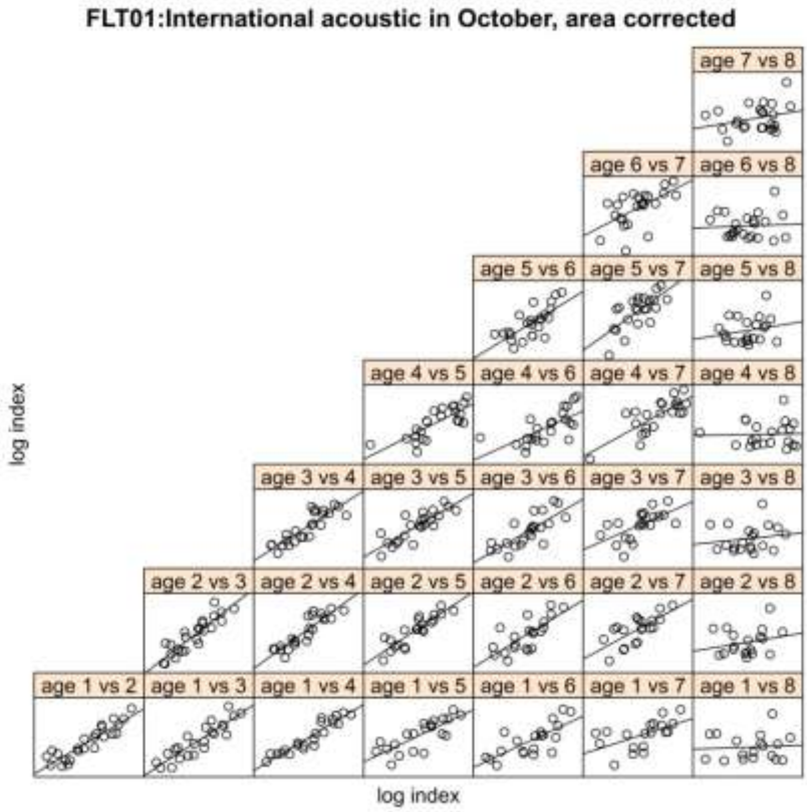


Figure 2.2.1. Sprat in SD 26+28. CANUM consistency check.



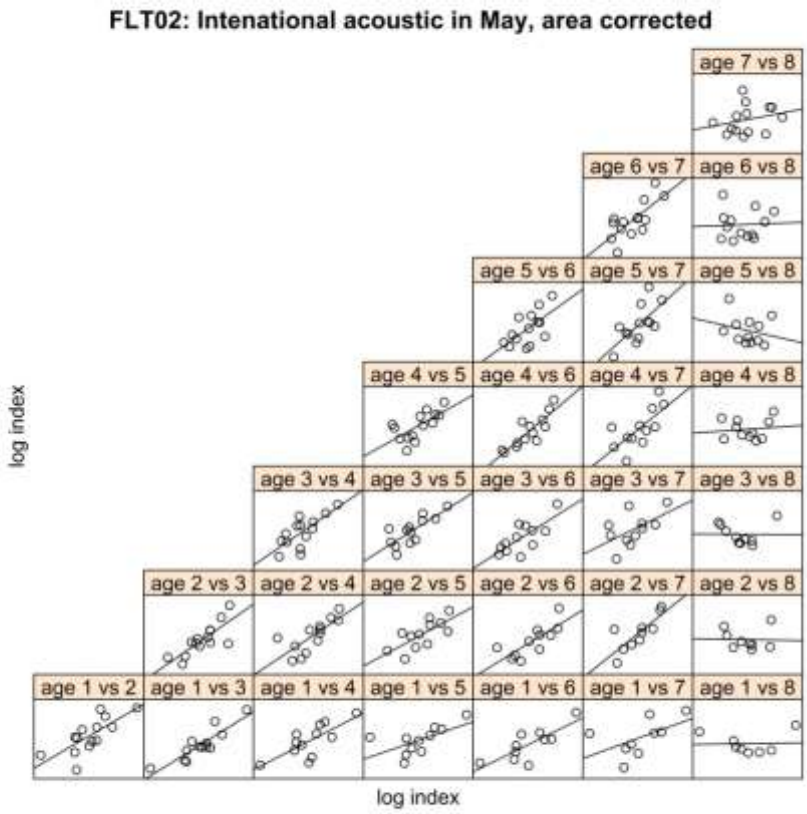


Figure 2.2.2. Sprat in SD 26+28. Check for consistency in October (BIAS) and May (BASS) acoustic survey estimates.

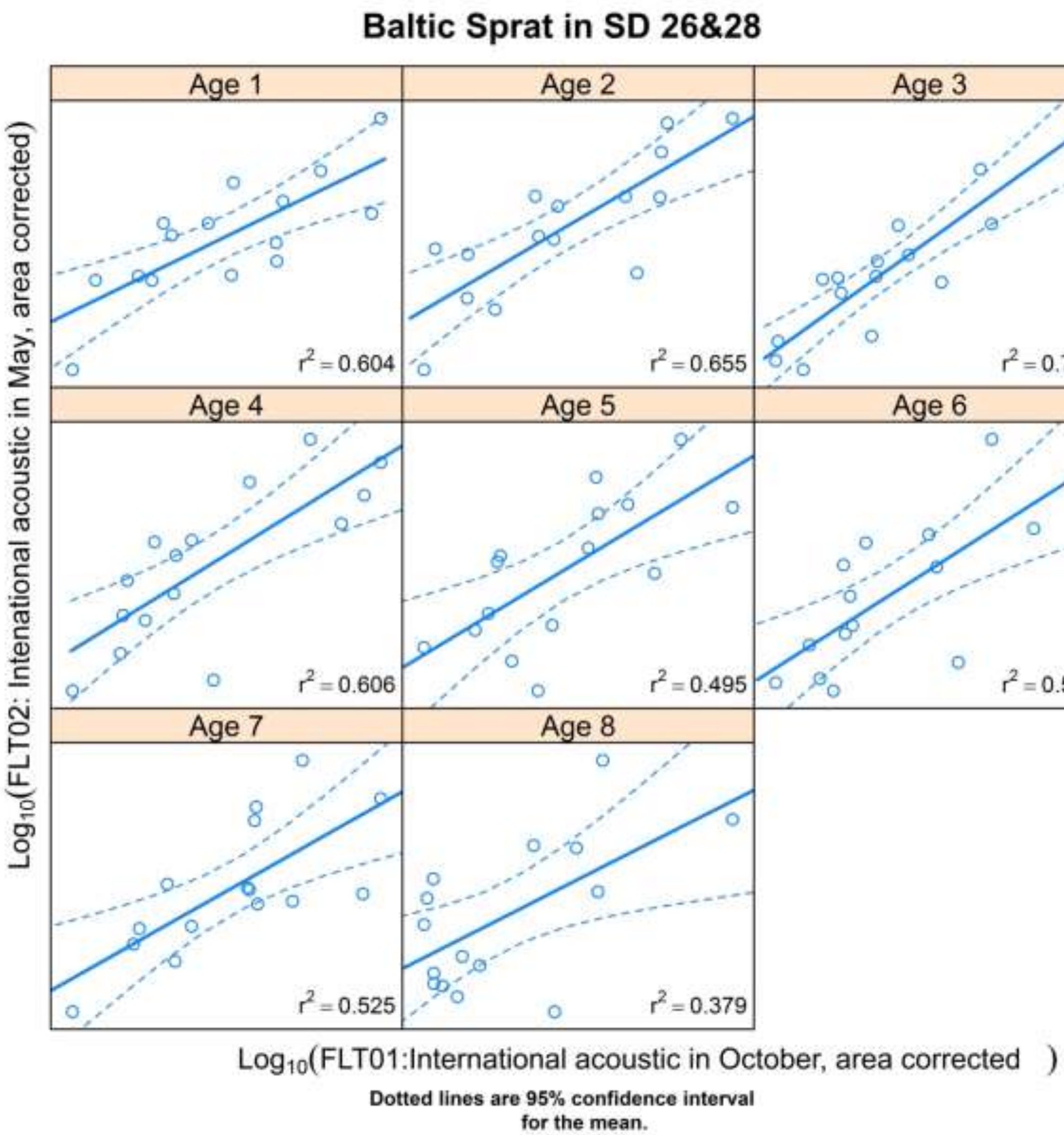


Figure 2.2.3. Sprat in SD 26+28. Between surveys (October and May) consistency check.

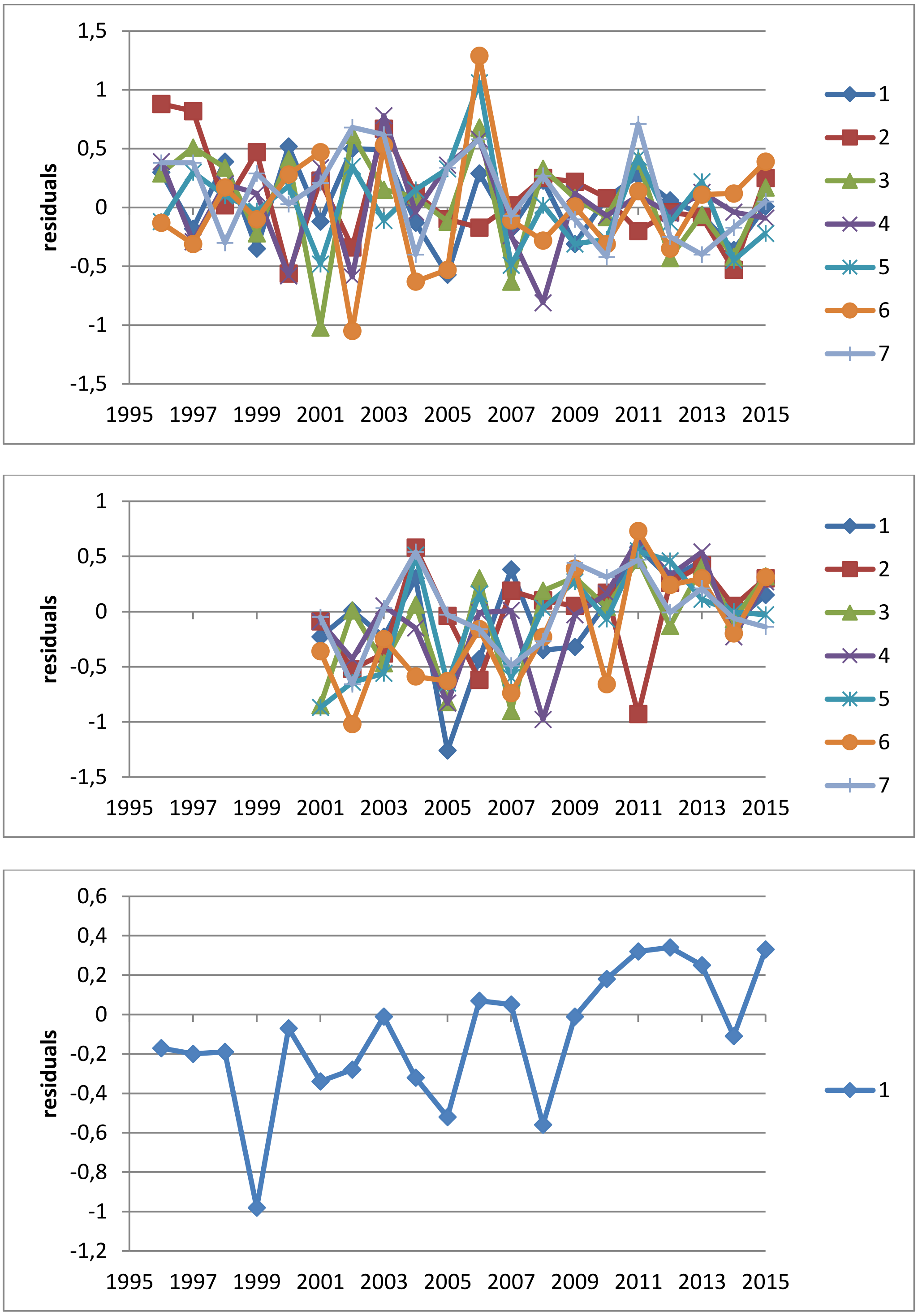


Figure 2.3.1.1. Distribution of survey log-catchability residuals in XSA analysis for October (upper plot), May (middle plot), and age0 acoustics (bottom plot).

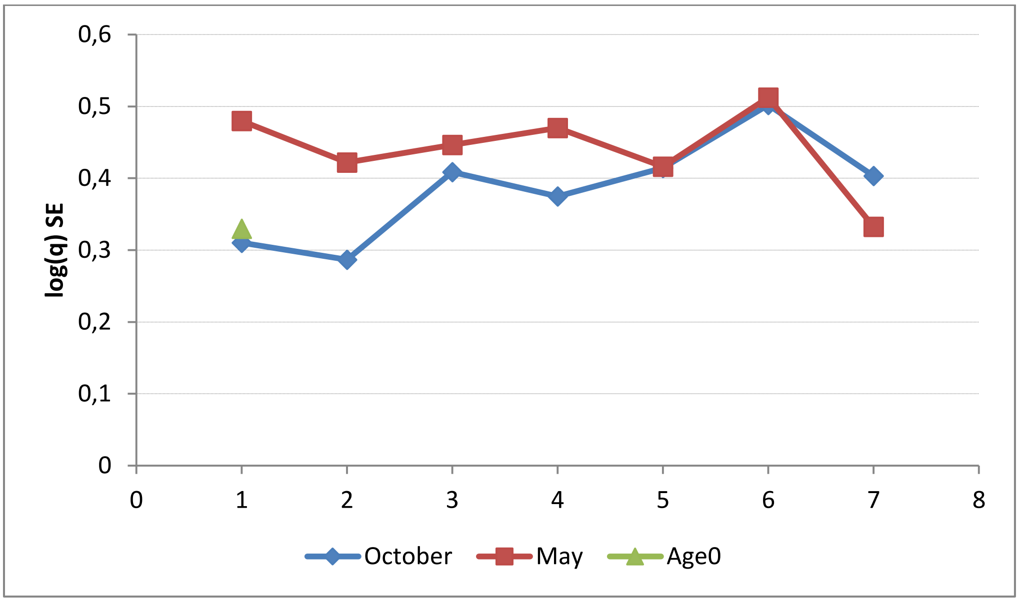
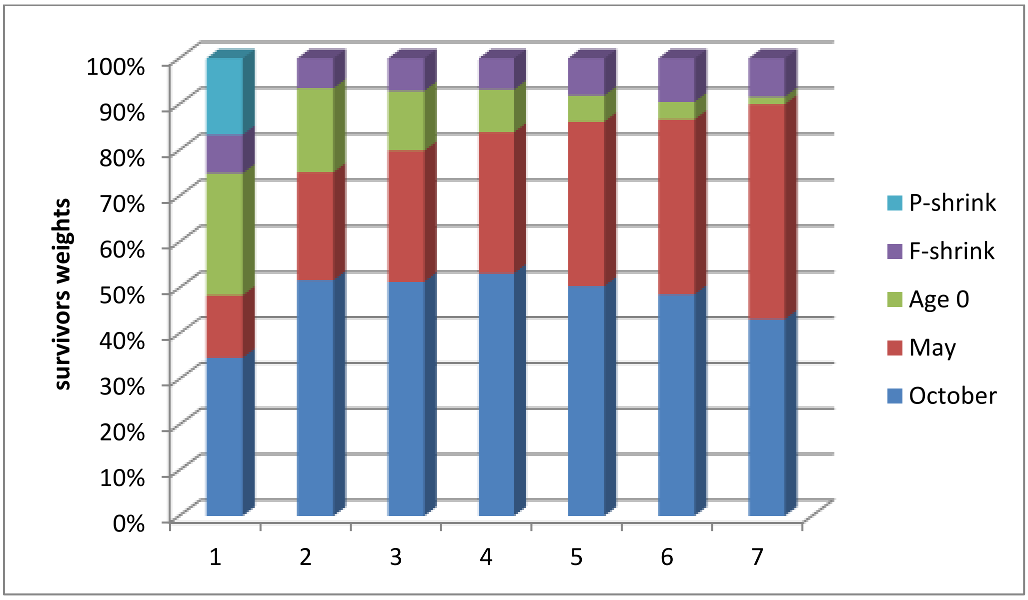


Figure 2.3.1.2. The standard errors (SE) of log-catchability residuals for October, May, and age0 surveys.



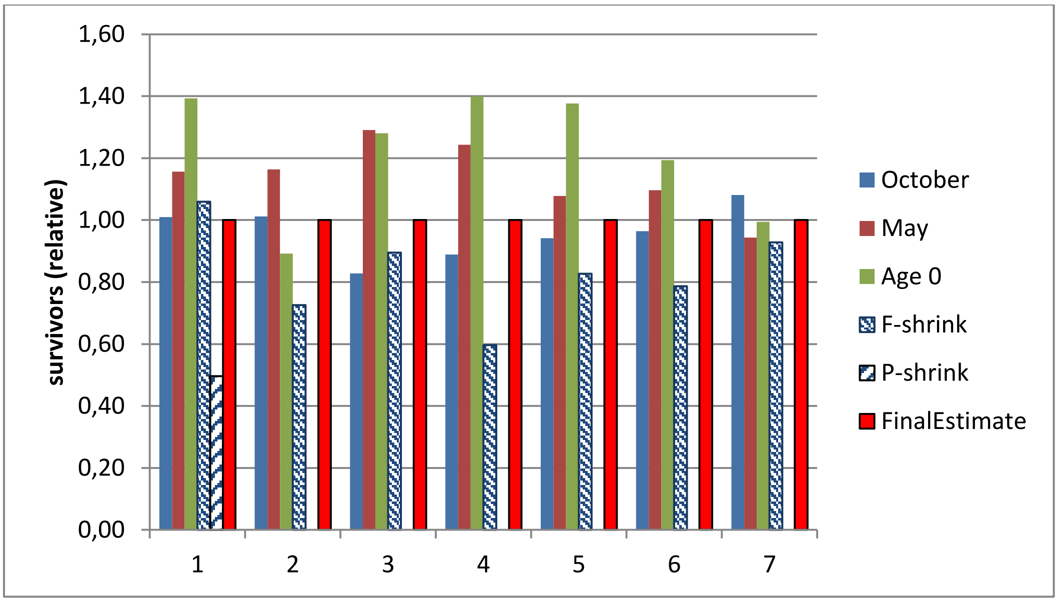


Figure 2.3.1.3. Weight of survivors estimates (upper graph) and survivors estimates relative to final estimate (lower graph) by tuning fleet and applied shrinkage.

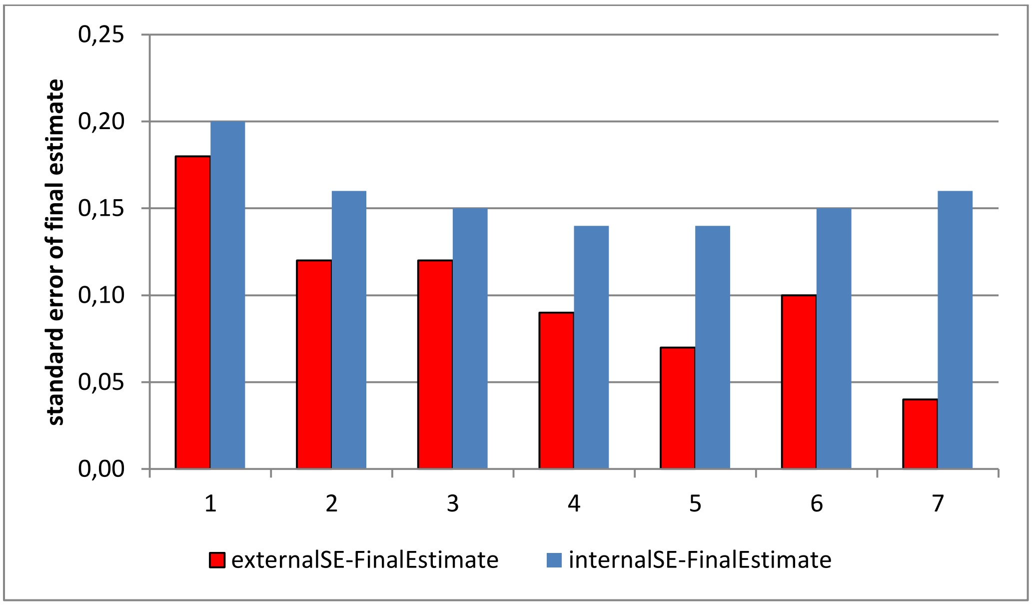


Figure 2.3.1.4. The internal and external standard error (SE) of survivors estimates in XSA.

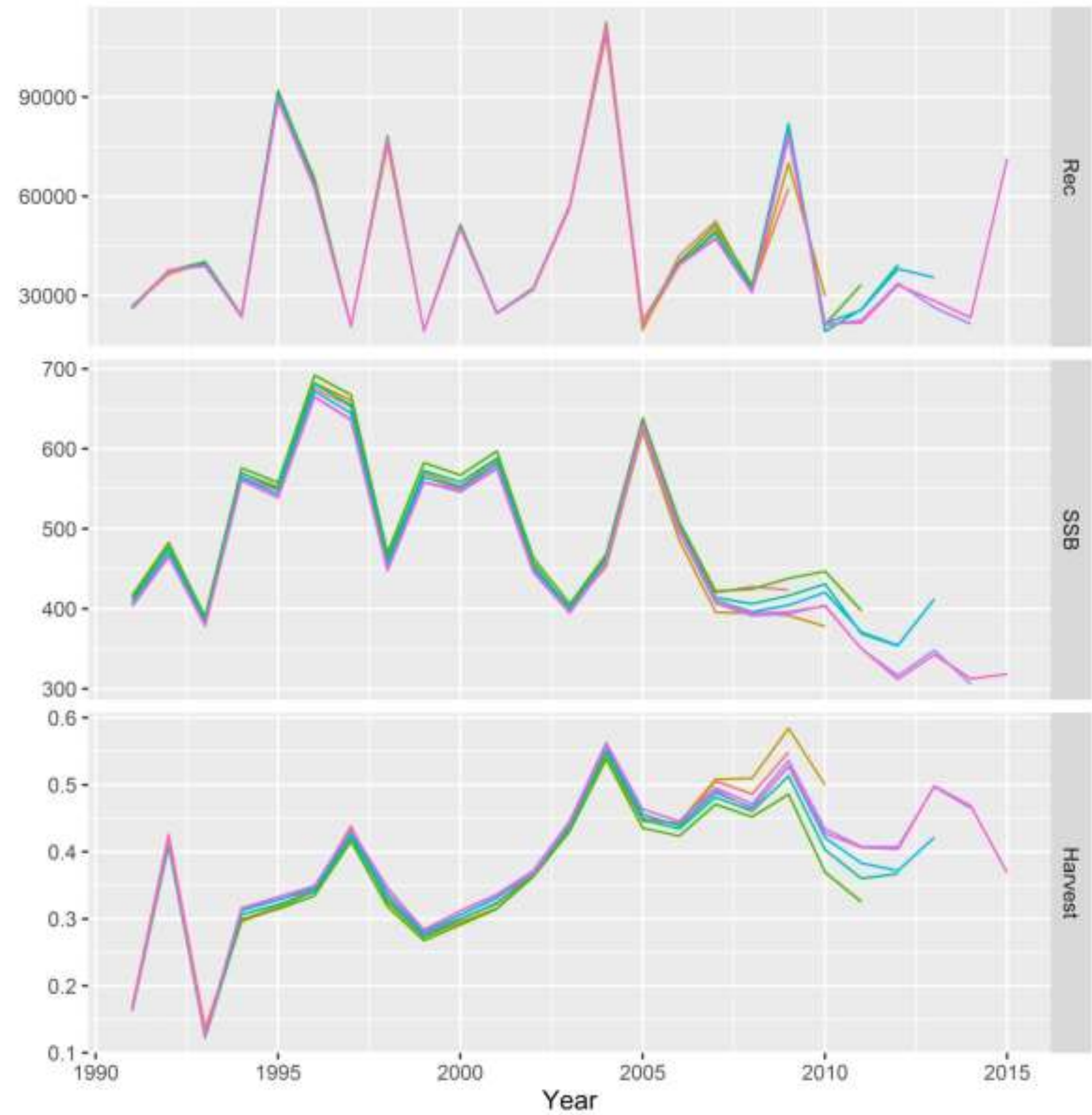
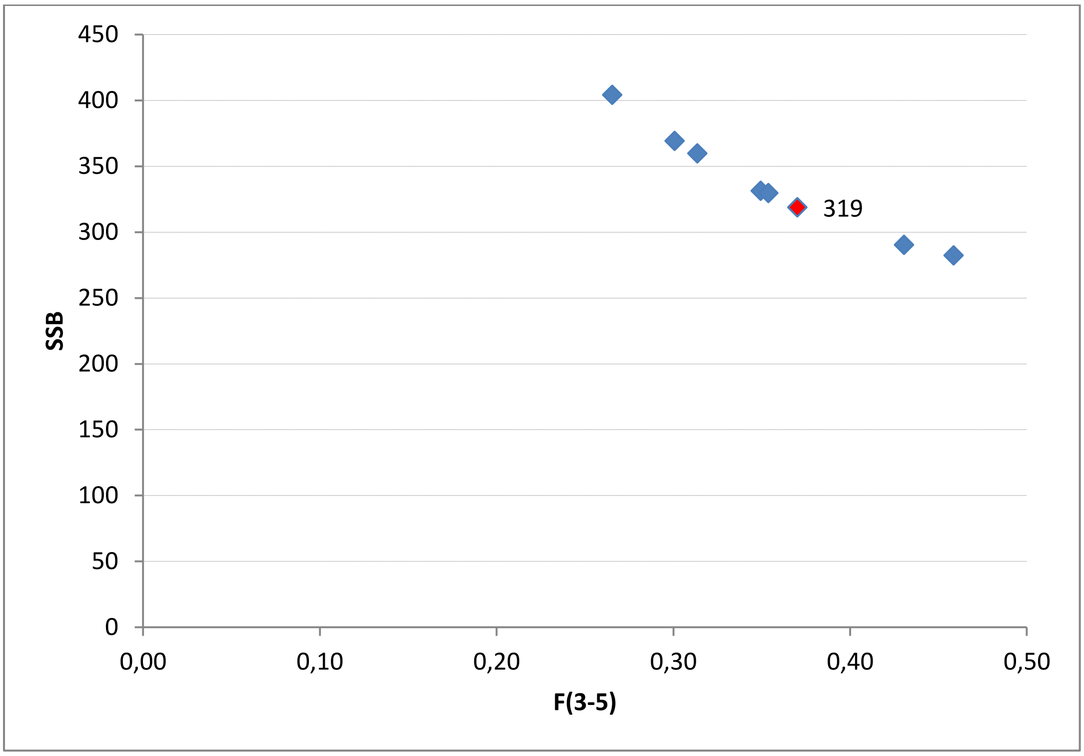


Figure 2.3.1.5. Retrospective estimates of recruitment, spawning stock biomass and fishing mortality for sprat in sub-divisions 26+28.



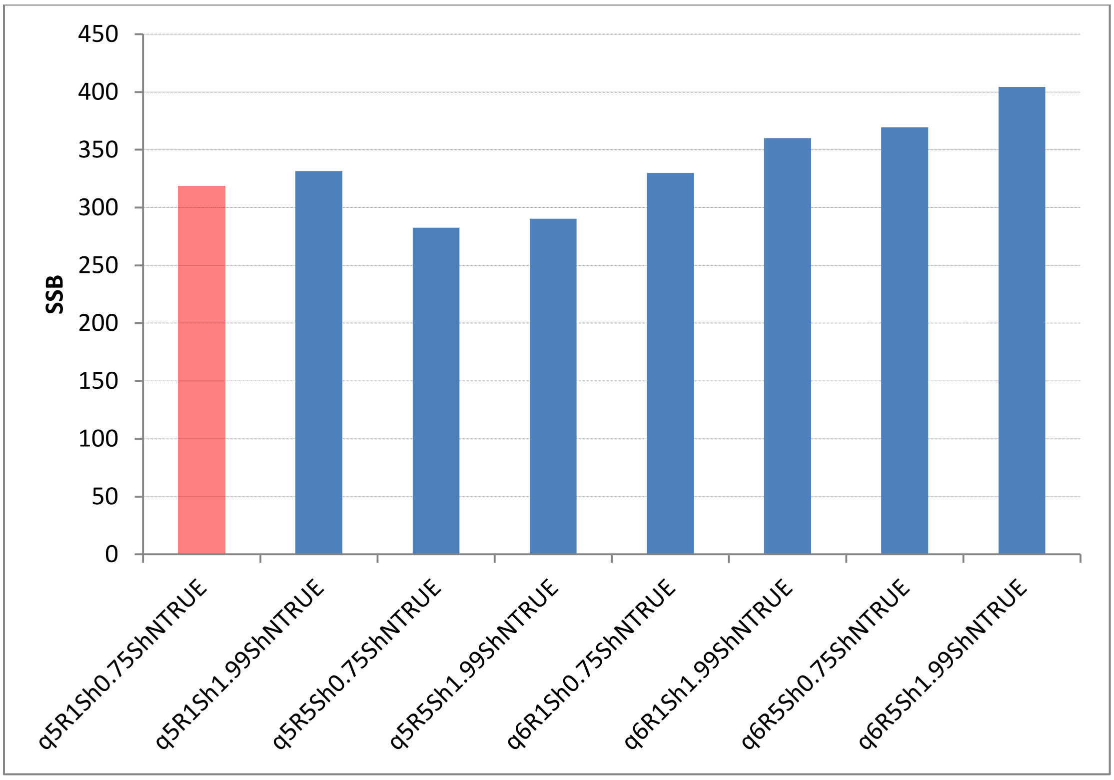
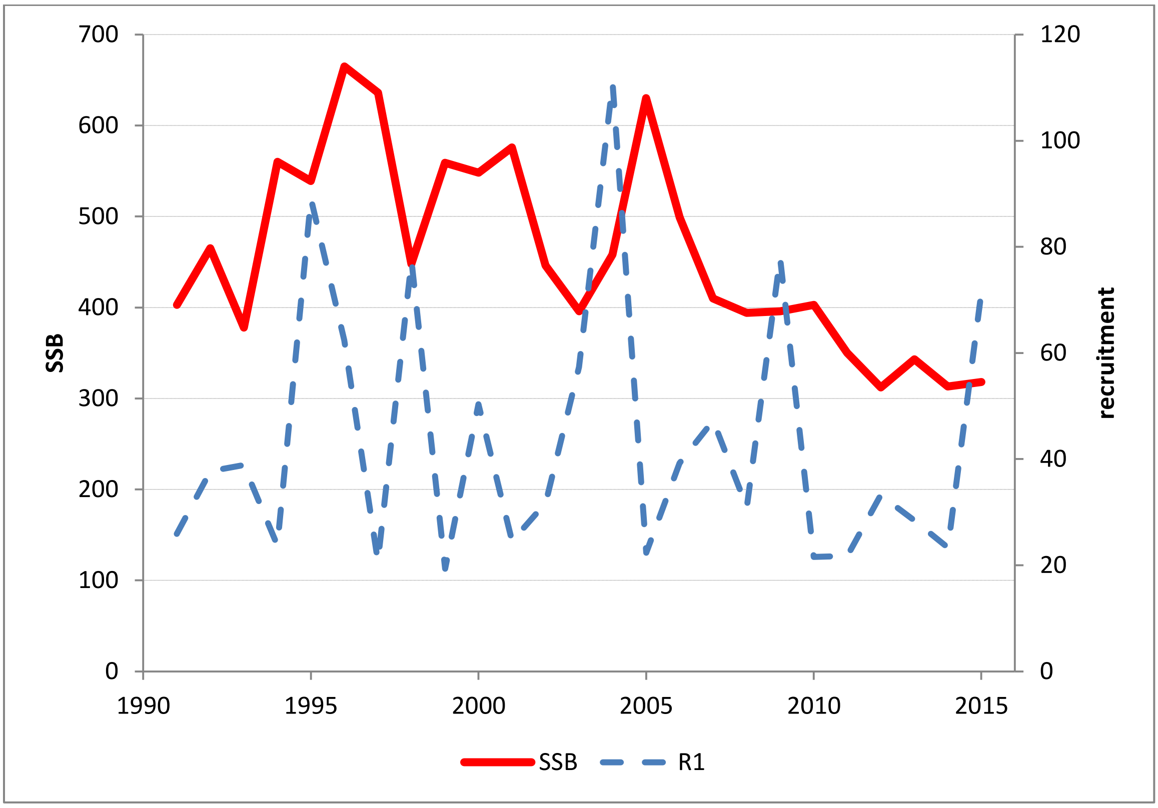


Figure 2.3.1.6. Sensitivity of the terminal year estimates of SSB and average fishing mortality to the parameterisation of the XSA. Final estimate is marked in red; example of reading codes of X-axis in lower plot: q5R1Sh0.75ShNTRUE means q plateau at age 5, recruits at age 1, shrinkage SE=0.75, and shrinking to population mean N for recruits.



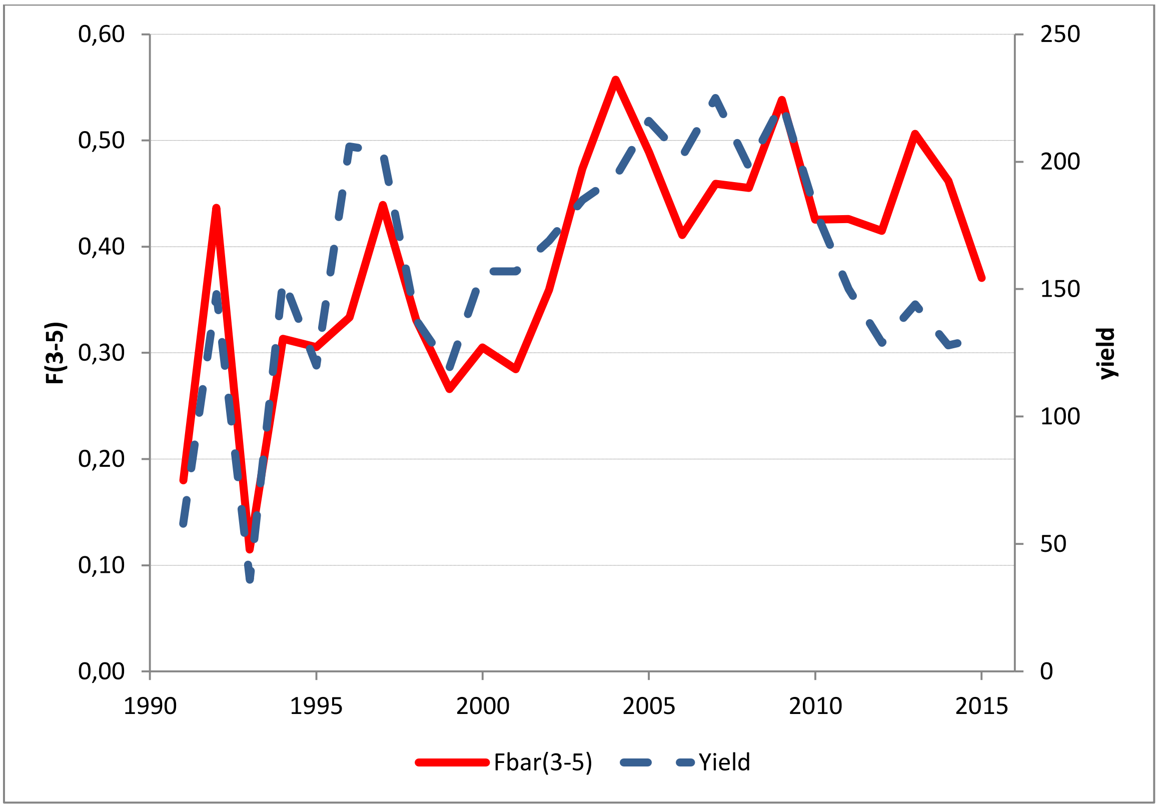


Figure 2.3.1.7. The XSA estimates of spawning stock biomass (10^3 t.), recruitment (10^9 individuals), and fishing mortality. For comparison yield (10^3 t.) is given.

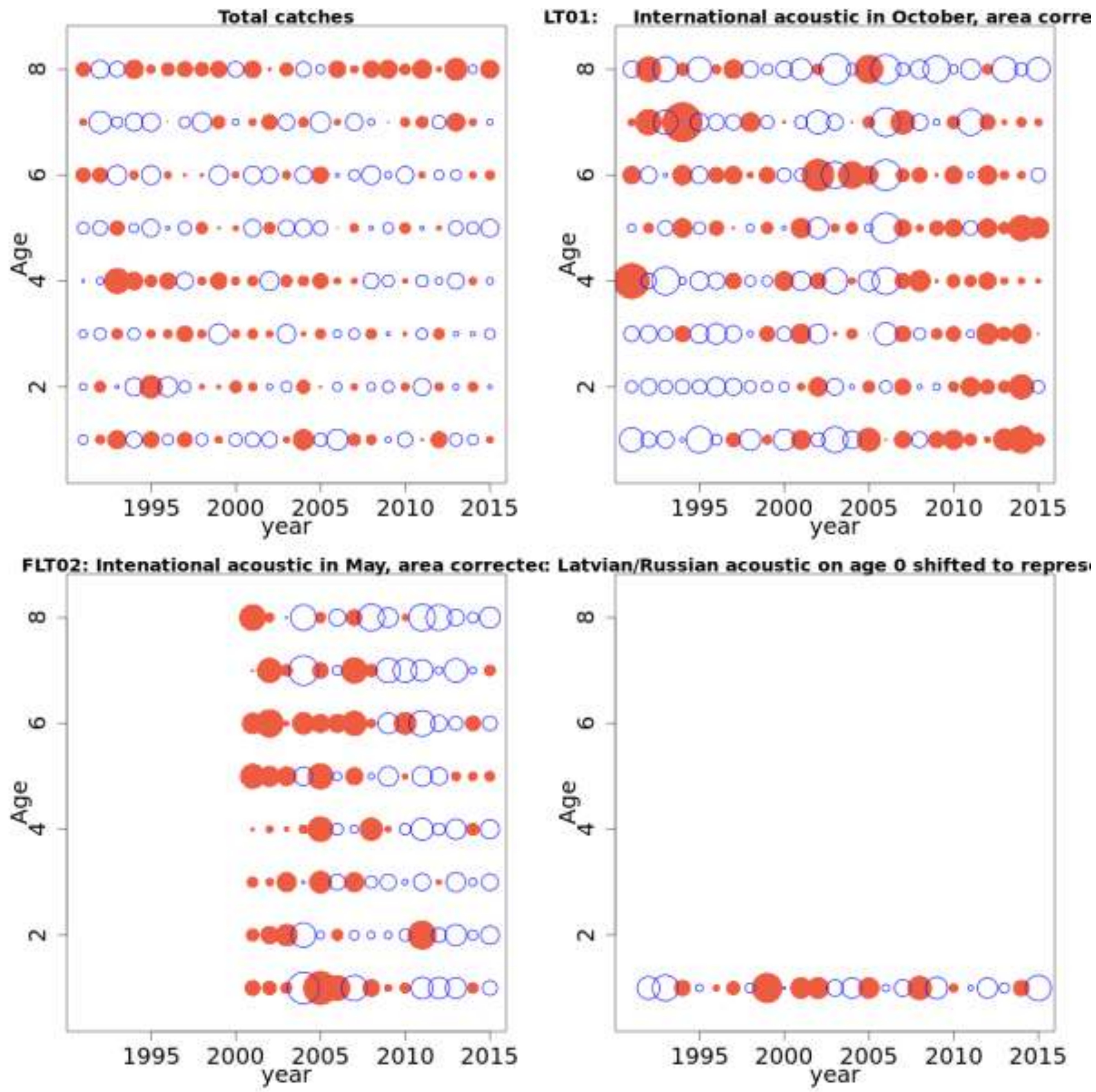


Figure 2.3.2.1. Plot of residuals of catches and three tuning fleets for SAM model.

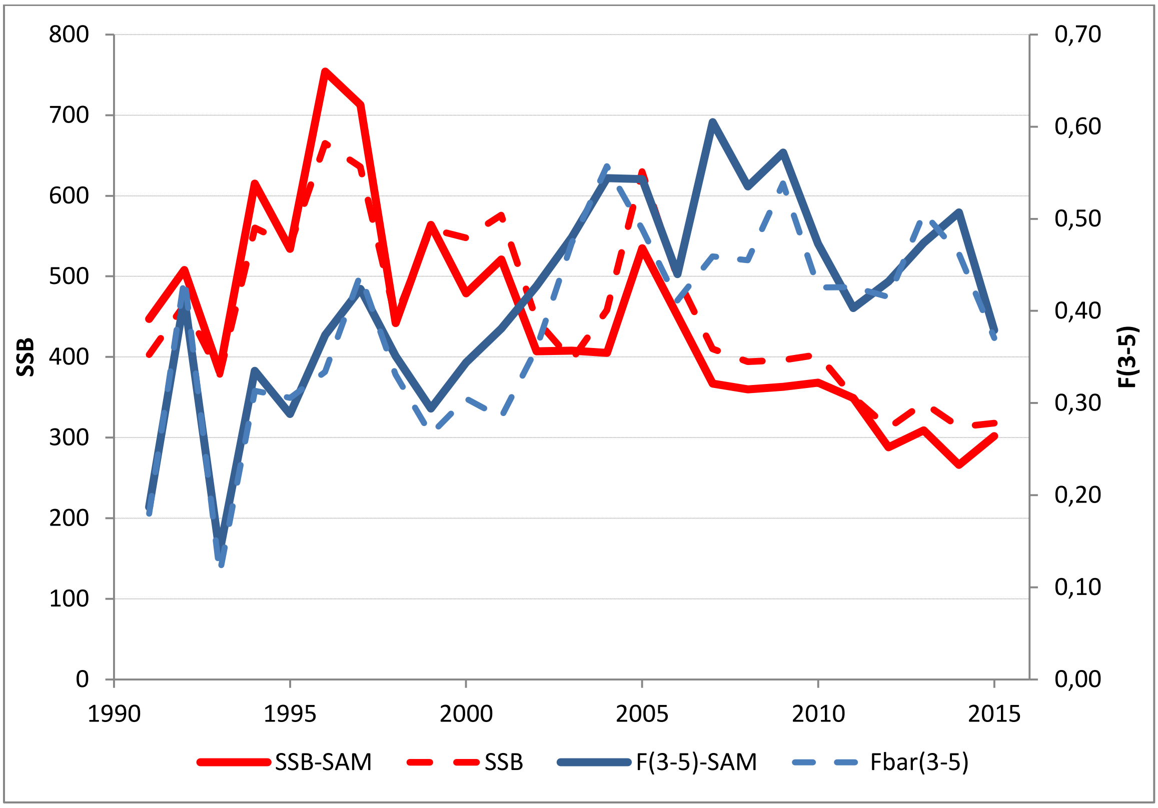
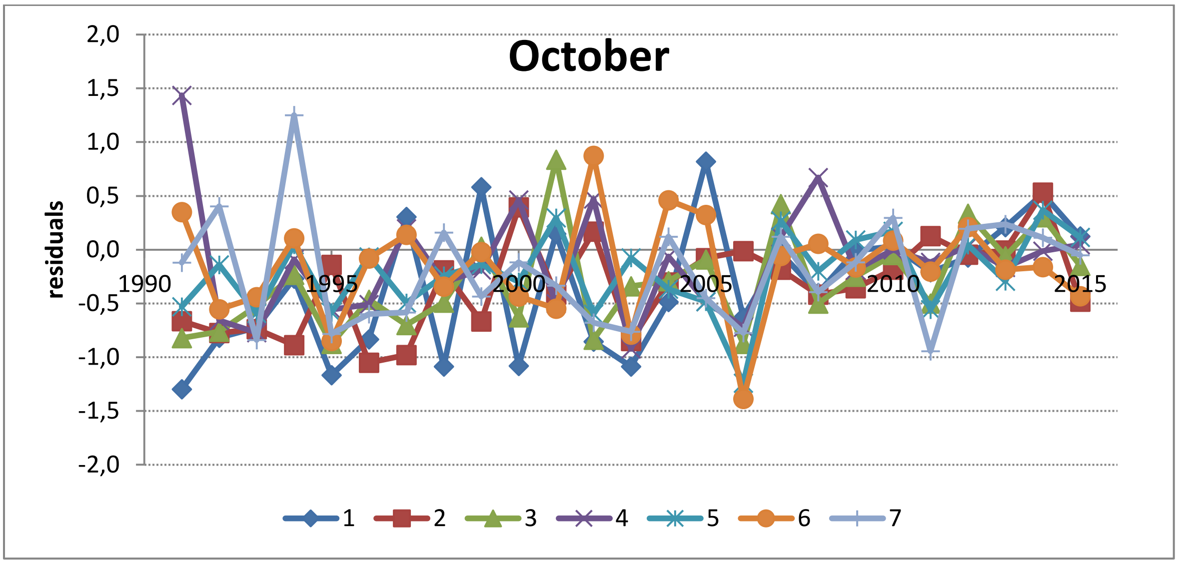
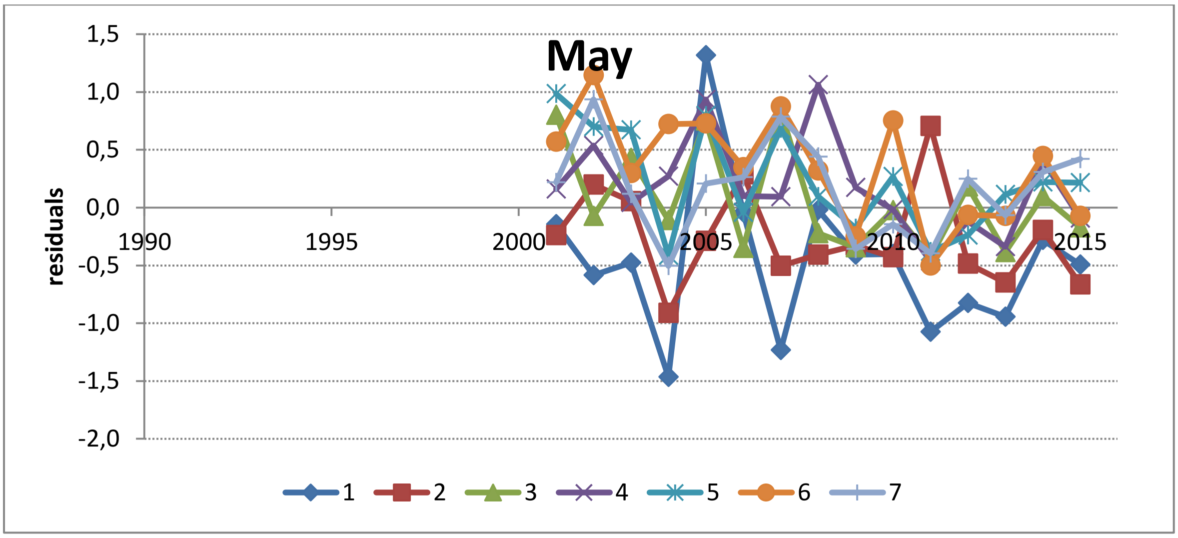


Figure 2.3.2.2. SAM model estimates of spawning stock biomass (10^3 t.) and fishing mortality. For comparison XSA estimates (broken lines) are given.





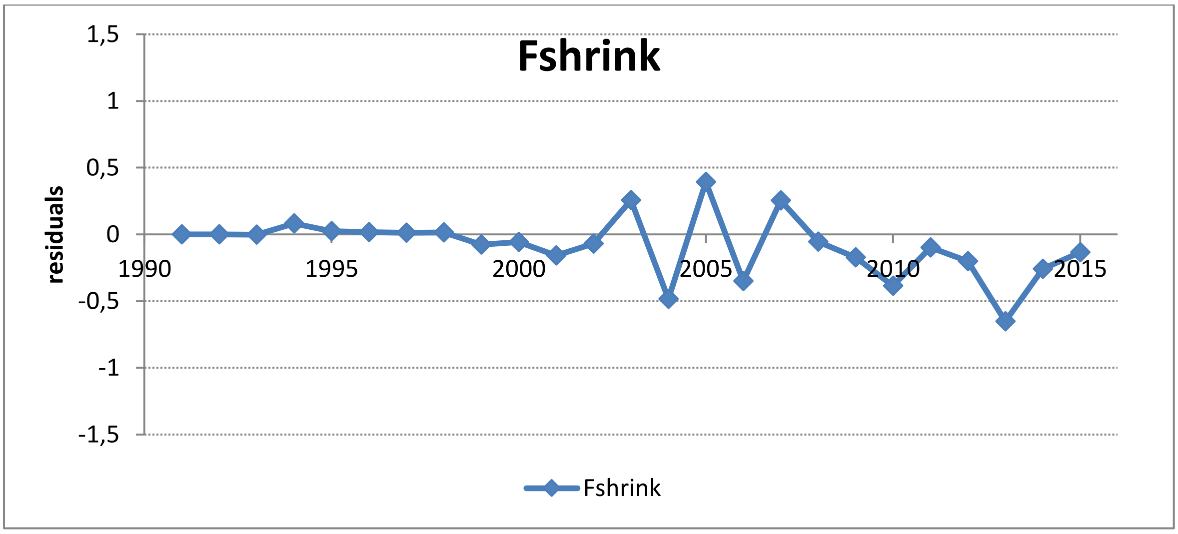


Figure 2.3.3.1. Time series of residuals for stock estimates at age for October and May acoustic surveys. In addition, residuals in fishing mortality estimates at terminal age are shown (bottom plot)

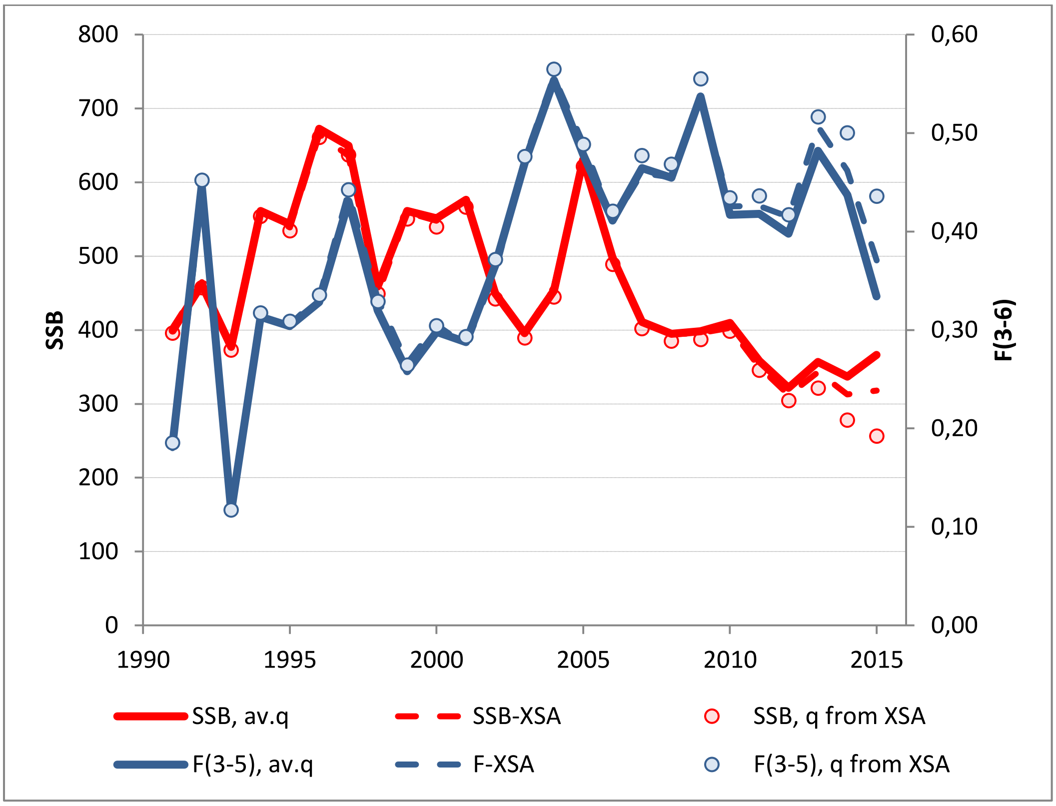


Figure 2.3.3.2. Spawning stock biomass (10^3 t.) and fishing mortality estimated by cohort analysis with assumed catchability (CohAnalQ) using average catchability (av. q) . For comparison SSB and F estimates with CohAnalQ using the same catchability as estimated in XSA (q from XSA) and the XSA estimates (broken lines) are given.

3. Stock of sprat in sub-divisions 27,29-32

3.1. Biological and survey data

The data needed for assessments were taken from WGBFAS and WGBIFS reports (ICES, 2016 a, b) and ICES/WGBFAS data bases. Each year WGBFAS presents in its report catch-at-age (CANUM) and weight-at-age in the catch or in the stock (WECA/WEST) data by sub-divisions. Such data enabled compiling CANUM and WECA by former assessment units like sprat in sub-divisions 27, 29-32.

Mean weights at age in the catches were calculated as mean of weights at age in sub-divisions (27, 29- 32) weighted by catch at age numbers in each sub-division. Weight-at-age in the stock was assumed to be the same as weight-at-age in the catch. The weights-at-age decreased markedly in 1990s, have been at low level in next years but have showed some increase in most recent years (Figure 3.1.1).

Maturity at age was assumed the same as for the whole Baltic sprat stock, comprising sprat in sub-divisions 22-32 (ICES, 2016a).

For years there has been very low overlap between cod and sprat in sub-divisions 27, 29-32, so predation mortality for the stock was assumed zero and consequently total natural mortality was at level of residual natural mortality, *i.e.* 0.2. This low level of M may be questioned as due to lack of predation mortality the residual natural mortality may be higher.

The tuning data set was available from Baltic International Acoustic Survey (BIAS) in autumn in 1991–2015 covering Subdivisions 27 and 29. In addition, age 0 was extracted as separate tuning set from autumn survey; this index was shifted to represent age 1 as in standard ICES assessment (ICES, 2016a). The survey data were corrected for area coverage (ICES, 2016b). Biological and tuning data are provided in Tables 3.1.1-3.1.2.

3.2. Quality and consistency of input data

The consistency of the catch-at-age estimates was checked in bubbles-plot (Figure 3.2.1). The correlation between catches at a given age and the catches of the same generations 1 year later is high at level of 0.9.

The internal consistency of survey at age estimates was checked on graphs (Figure 3.2.2). The correlation between survey indices at given age and the indices of the same generations 1 year later is good, mostly ranging between 0.6–0.8.

3.3. Stock assessments

Biological and survey data presented in section 3.1 (Tables 3.1.1-2) were used as input for the age structured assessments of the stock.

3.3.1. Assessment with XSA

The best settings for the parameterisation of XSA were found to be the same as specified in benchmark assessment of Baltic sprat stock (ICES, 2013), *i.e.*:

- tri-cubic time weighting,
- catchability dependent on year class strength at age 1 (only for this age group the slopes of regressions between survey and XSA numbers were significantly different from 1),
- catchability independent of age for ages 5 and older,
- the SE of the F shrinkage mean equal 0.75.

The analysis showed that the survey indices for 2014 are outliers; most of their log catchability residuals had lower than 5% probability of occurrence. In the final run this year was excluded from the tuning data. The log q residuals are presented in Figure 3.3.1.1. Residuals for October survey do not show clear pattern and only age 1 and age 0 shows significant time trend. The data are rather noisy as shown by SE of log q (log catchability) in range 0.3-0.8 (Figure 3.3.1.2). However, the correlations between XSA estimates and survey indices are quite good (R^2 mostly at level of 0.6–0.9).

The weights of estimates resulting from shrinkage are up to 30% for ages 3 – 7 (Figure 3.3.1.3), and are much higher (30 – 50%) for younger ages. However, survivors estimates resulting from October survey and from the shrinkage are rather consistent. The standard errors of the final estimates are moderate, mostly in range 0.15 – 0.25 (Figure 3.3.1.4).

Retrospective analysis (Figure 3.3.1.5) shows quite consistent estimates of biomass and recruitment, at least in most recent years. The estimates of fishing mortality deviate from assessment using whole time series (Mohn's Rho in the range -0.05 – 0.3 for SSB, F and recruitment).

Sensitivity of the terminal year estimates of SSB and average fishing mortality to the parameterisation of the XSA is presented in Figure 3.3.1.6. The main difference in the terminal biomass estimates comes from assumption of the ages for which catchability is dependent on year class strength. This dependency was significant only for age 1 and runs with such assumption show similar estimates of biomass.

The quality of the assessment is moderate: input data are consistent, but there are retrospective deviations in some years and a few SEs of survivors estimates are above 0.2. Fish stock summary plots are presented in Figures 3.3.1.7.

3.3.2. Assessment with SAM

The SAM model was attempted as an alternative assessment model similarly as in benchmark assessment of sprat stock in sub-divisions 22-32. The parameterisation of the model was the same as parameterisation agreed on during benchmark workshop (ICES, 2013). Results of SAM assessment (residuals plots, biomass and fishing mortality estimates) are presented in Figure 3.3.2.1-2. Residuals do show clear pattern for October survey, but for age 0 survey block of positive and negative residuals are observed. Biomasses and fishing mortalities estimated with SAM are similar to the XSA estimates, with exception of some differences in fishing mortality estimates in most recent years. SAM model estimates recent F higher than the XSA assessment. The assessment with SAM is available at the https://www.stockassessment.org (short name of the stock is spr27and29-32).

3.3.3. Assessment with cohort analysis with assumed catchability

As indicated in the sections 1.3.3 and 2.3.3 the survey catchabilities estimated in XSA assessment of sprat in sub-divisions 22-25, sprat in sub-divisions 26+28, and sprat in sub-divisions 27,29-32 differ (Figure 1.3.3.1). Thus, similarly as in case of sprat in sub-divisions 22-25 stock and sprat in sub-divisions 26+28 stock, to correct for the effects of different catchabilities in the XSA estimates of three stocks, the assessment of sprat stock in sub-divisions 27,29-32 was performed with average for three stocks catchabilities, using cohort analysis (CohAnalQ) as described in Part A, section 1.

The fit of the cohort analysis to the data is not very good. Survey residuals at the beginning of time series are large but they decline in the next years and do not show time trend then (Figure 3.3.3.1). Residuals of the "F shrinkage" are low at the beginning of time series as in these years tri-cubic weighting applied to the survey down-weights survey data. These residuals have been mostly negative since 2000 indicating lower fishing mortality at terminal age than the average F of previous three ages. Standard error of the fit is quite large (0.72) .

Assessment results are shown in Figure 3.3.3.2. Biomass and F estimates from the XSA for the stock and estimates from CohAnalQ using the same catchability as estimated in that XSA are presented for comparison. Spawning stock biomass in most recent years is much higher than in XSA analysis (almost two times) but the difference declines for earlier years. Consequently, the estimates of fishing mortality are markedly lower in CohAnalQ than in the XSA assessment. The biomass and F estimates from CohAnalQ using q estimated in XSA are very similar to the XSA values (for tri-cubic weighting applied in CohAnalQ).

Summary of assessments results by assessment model is presented in Table 3.3.1.

Table 3.1.1. Biological Input data for stock assessment, sprat in sub-divisions 27,29-32.

CANUM: Catch in numbers (Millions)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	127	356	210	3	72	36	124	22
1992	342	149	198	117	22	32	10	17
1993	253	662	265	205	103	22	35	18
1994	56	469	864	229	189	76	23	18
1995	1593	306	1020	947	548	327	115	29
1996	762	5252	383	1007	401	339	152	125
1997	544	3728	5988	953	820	322	158	51
1998	2316	1016	5143	7072	902	573	543	105
1999	35	4995	1471	4010	4322	470	342	143
2000	2695	243	3410	891	1441	1826	281	180
2001	694	3606	378	2350	577	903	1218	133
2002	813	1648	2754	680	1135	303	264	434
2003	1803	672	881	1068	1053	454	466	194
2004	5629	3823	877	801	871	506	415	153
2005	526	10677	4299	727	610	234	271	167
2006	3098	599	6264	2755	417	226	184	104
2007	4415	3167	560	3363	1421	113	90	228
2008	2454	4586	1675	806	1853	1060	101	197
2009	7389	2224	2870	951	612	1167	535	212
2010	345	8693	1868	1613	449	425	526	323
2011	2103	1102	4398	971	448	247	243	317
2012	1646	1451	484	2094	384	246	117	248
2013	1560	3818	1311	648	1340	245	134	178
2014	1217	2796	1897	621	503	438	178	188
2015	5946	1202	1417	1037	415	239	221	174

WECA (=WEST): Mean weight in the Catch and in the Stock (Kilograms)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	0.0040	0.0105	0.0135	0.0200	0.0144	0.0160	0.0155	0.0167
1992	0.0040	0.0111	0.0139	0.0148	0.0156	0.0163	0.0169	0.0168
1993	0.0050	0.0103	0.0132	0.0147	0.0152	0.0159	0.0157	0.0174
1994	0.0020	0.0092	0.0114	0.0126	0.0136	0.0138	0.0143	0.0145
1995	0.0040	0.0094	0.0097	0.0111	0.0129	0.0137	0.0145	0.0150
1996	0.0030	0.0062	0.0092	0.0103	0.0113	0.0114	0.0126	0.0086
1997	0.0040	0.0064	0.0074	0.0098	0.0103	0.0109	0.0114	0.0119
1998	0.0020	0.0067	0.0074	0.0080	0.0089	0.0096	0.0102	0.0115
1999	0.0020	0.0058	0.0072	0.0074	0.0079	0.0084	0.0100	0.0092
2000	0.0030	0.0076	0.0083	0.0090	0.0100	0.0104	0.0116	0.0114
2001	0.0030	0.0078	0.0091	0.0096	0.0095	0.0103	0.0104	0.0115

2002	0.0050	0.0086	0.0095	0.0109	0.0105	0.0104	0.0108	0.0112
2003	0.0030	0.0082	0.0091	0.0094	0.0095	0.0097	0.0084	0.0099
2004	0.0030	0.0060	0.0094	0.0100	0.0103	0.0102	0.0104	0.0107
2005	0.0030	0.0051	0.0060	0.0096	0.0100	0.0105	0.0103	0.0106
2006	0.0030	0.0063	0.0064	0.0066	0.0089	0.0100	0.0092	0.0082
2007	0.0030	0.0055	0.0075	0.0072	0.0073	0.0094	0.0087	0.0105
2008	0.0030	0.0067	0.0077	0.0081	0.0083	0.0085	0.0085	0.0103
2009	0.0030	0.0079	0.0088	0.0093	0.0106	0.0097	0.0101	0.0112
2010	0.0030	0.0063	0.0080	0.0088	0.0092	0.0090	0.0086	0.0090
2011	0.0052	0.0083	0.0089	0.0098	0.0102	0.0105	0.0112	0.0120
2012	0.0057	0.0078	0.0094	0.0097	0.0105	0.0110	0.0109	0.0116
2013	0.0055	0.0089	0.0103	0.0112	0.0114	0.0119	0.0121	0.0116
2014	0.0056	0.0085	0.0098	0.0104	0.0110	0.0111	0.0113	0.0116
2015	0.0035	0.0087	0.0097	0.0104	0.0106	0.0110	0.0112	0.0113

NATMOR: Natural Mortality

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

MATPROP: Proportion of Mature at Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.17	0.93	1	1	1	1	1	1

MPROP: Proportion of M before Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

FPROP: Proportion of F before Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991-2015	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table 3.1.2. Tuning data for stock assessment, sprat in sub-divisions 27,29-32.

Tuning fleet in SD 27&29 (Millions)

FLT01: International acoustic in October, area corrected

Year	Fish.Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1991	1	5119	16007	19558	947	3832	1013	1175	1400
1992	1	1445	2019	2272	605	279	272	322	167

1993	1	NA	NA	NA	NA	NA	NA	NA	NA
1994	1	337	8626	20778	6355	6251	2716	771	977
1995	1	NA	NA	NA	NA	NA	NA	NA	NA
1996	1	14814	43862	2698	7010	5152	2772	1234	472
1997	1	NA	NA	NA	NA	NA	NA	NA	NA
1998	1	17953	12159	26655	15846	3703	1867	394	0
1999	1	266	38632	8471	22569	27973	3176	1577	465
2000	1	8913	291	11631	2960	5709	8779	528	863
2001	1	4226	11132	2453	8818	1726	4130	2458	737
2002	1	4695	7245	12024	2489	6607	2048	2247	2795
2003	1	40189	10075	14293	7958	4949	4916	3456	3690
2004	1	44793	21245	2128	3060	703	1084	535	1173
2005	1	3305	87236	32813	4622	2656	2012	1702	2721
2006	1	11651	3746	41654	15476	1724	1945	572	1169
2007	1	28590	9560	3596	14332	5914	211	219	829
2008	1	13145	24978	8410	3310	10534	3676	675	1371
2009	1	48877	13551	9535	2308	2828	3532	913	818
2010	1	4045	28644	4197	2364	409	1191	1484	652
2011	1	6601	4812	18528	6251	2488	1377	738	1615
2012	1	25312	7307	3803	9055	1419	486	168	779
2013	1	7235	6965	3449	1415	3454	341	194	438
2014	1	689	1469	917	622	85	336	40	114
2015	1	58466	5349	7984	4088	1289	1582	1478	737

FLT03: Latvian/Russian acoustic on age 0 shifted to represent age 1

Year	Fish.Effort	Age 1
1992	1	10461
1993	1	24
1994	1	NA
1995	1	13175
1996	1	NA
1997	1	252
1998	1	NA
1999	1	27
2000	1	2081
2001	1	642
2002	1	501
2003	1	41573
2004	1	64318
2005	1	514
2006	1	18962
2007	1	18803
2008	1	13459
2009	1	57938

2010	1	1742
2011	1	11536
2012	1	24553
2013	1	20061
2014	1	4991
2015	1	58148

Table 3.3. Spawning stock biomass (SSB) and fishing mortality (F(3-5)) estimated by XSA, SAM, and CohAnalQ assessments of sprat in sub-divisions 27,29-32.

	SSB			F(3-5)		
	XSA	SAM	CohAnalQ	XSA	SAM	CohAnalQ
1991	105	129	119	0.09	0.10	0.08
1992	129	92	145	0.08	0.11	0.07
1993	190	171	215	0.10	0.12	0.09
1994	213	203	236	0.12	0.13	0.11
1995	250	201	279	0.24	0.21	0.22
1996	407	300	448	0.16	0.25	0.14
1997	459	369	501	0.27	0.31	0.24
1998	374	317	411	0.40	0.41	0.35
1999	297	295	331	0.41	0.42	0.37
2000	284	198	325	0.32	0.46	0.28
2001	264	219	301	0.25	0.44	0.22
2002	237	211	271	0.39	0.39	0.33
2003	165	155	187	0.36	0.34	0.33
2004	222	201	259	0.45	0.42	0.37
2005	263	332	301	0.49	0.40	0.38
2006	206	221	246	0.43	0.40	0.37
2007	180	187	223	0.32	0.42	0.25
2008	189	224	226	0.40	0.46	0.33
2009	190	208	237	0.50	0.53	0.43
2010	204	233	252	0.59	0.56	0.48
2011	180	177	230	0.47	0.53	0.37
2012	157	133	218	0.31	0.48	0.22
2013	190	175	288	0.44	0.55	0.29
2014	173	163	295	0.43	0.51	0.25
2015	154	158	317	0.39	0.45	0.19
mean	227	211	274	0.34	0.38	0.27

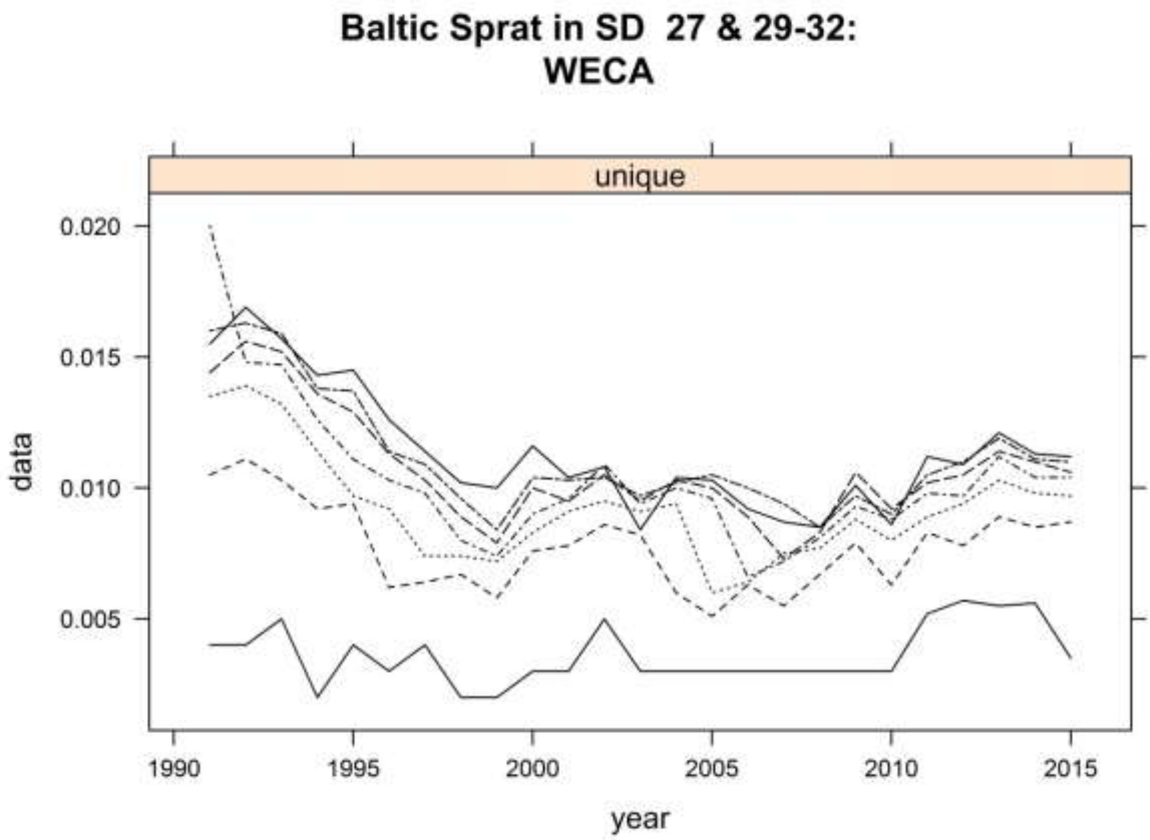


Figure 3.1.1. Sprat in SD 27,29-32. Mean weight-at-age in the catches (weight in the stock has been assumed as in the catches).

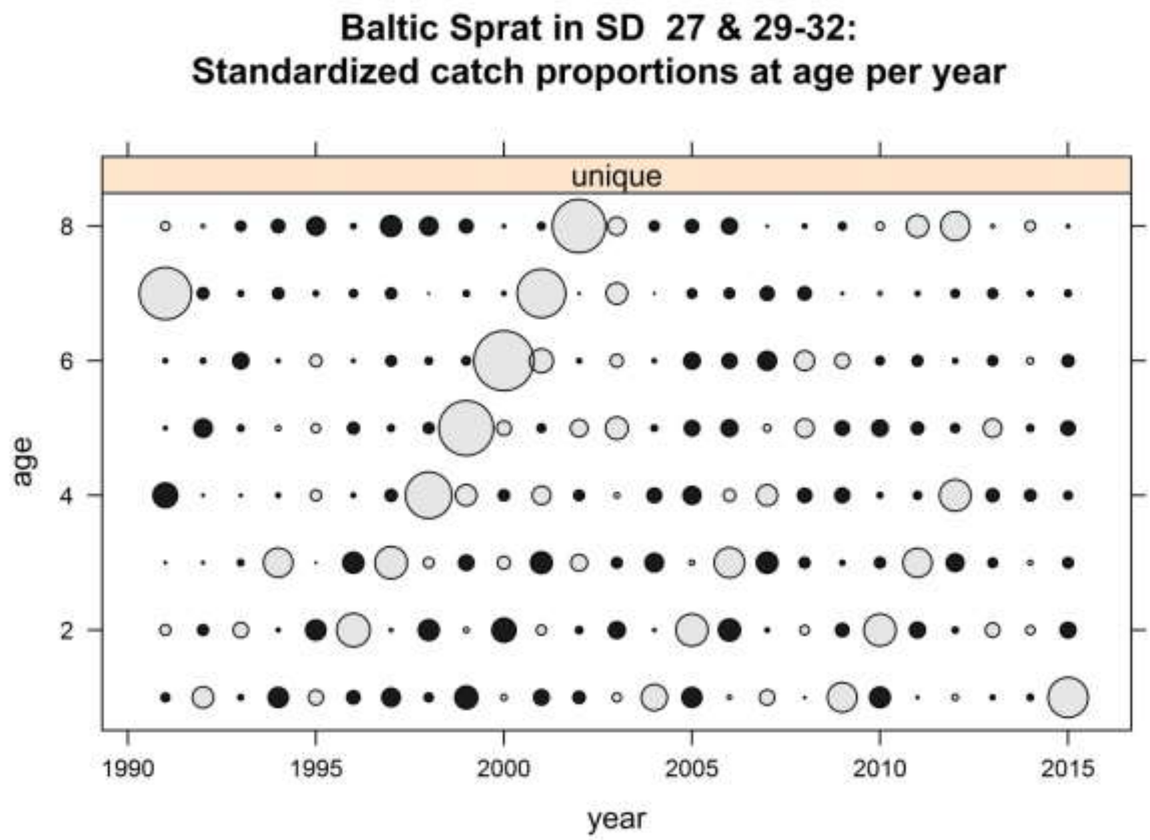


Figure 3.2.1. Sprat in SD 27,29-32. CANUM consistency check.

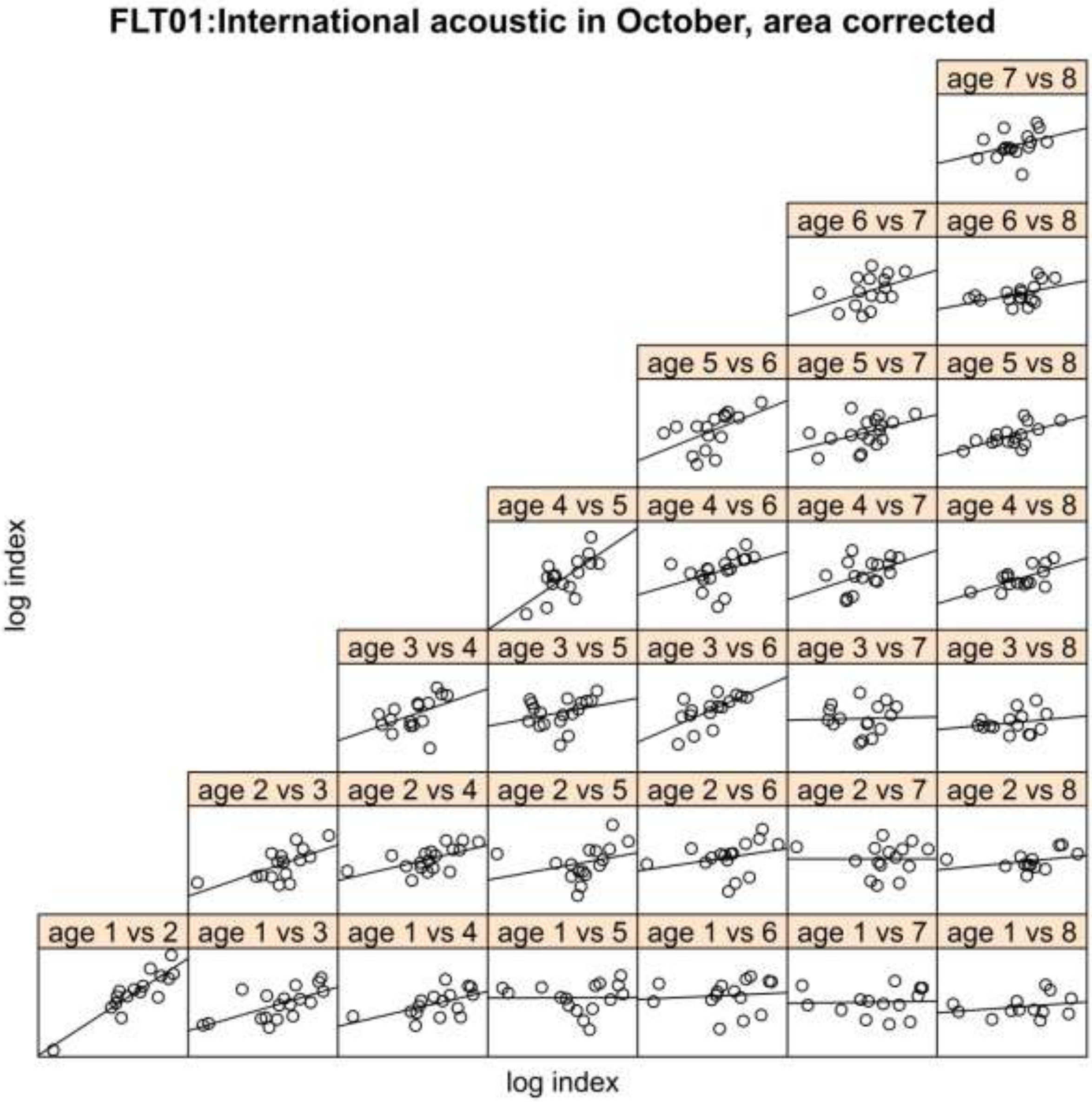
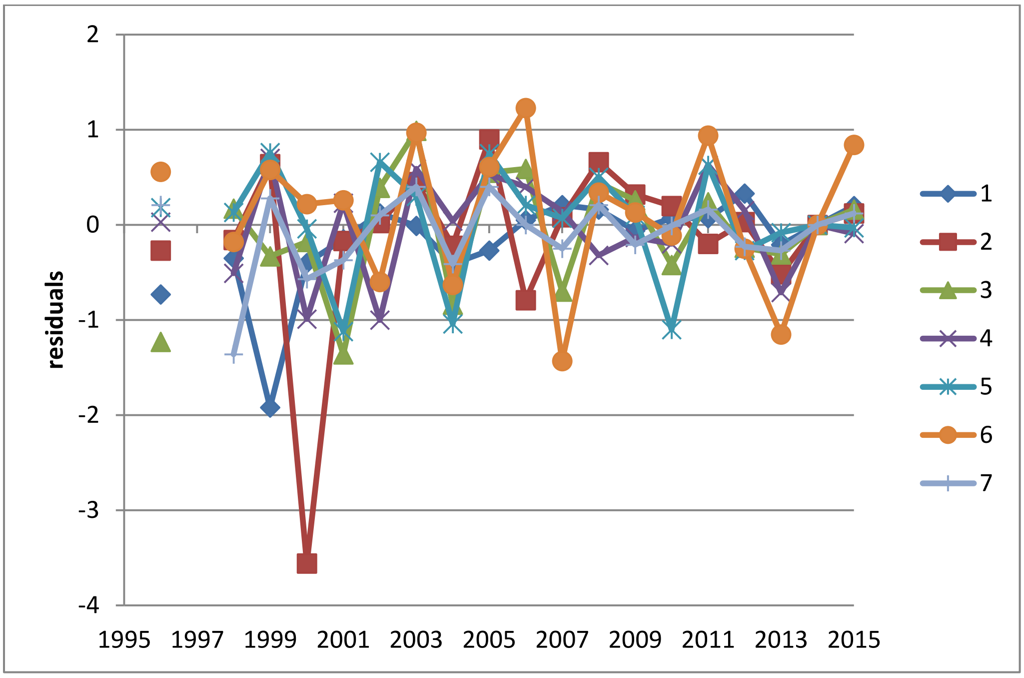


Figure 3.2.2. Sprat in SD 27,29-32. Check for consistency in October (BIAS) acoustic survey estimates.



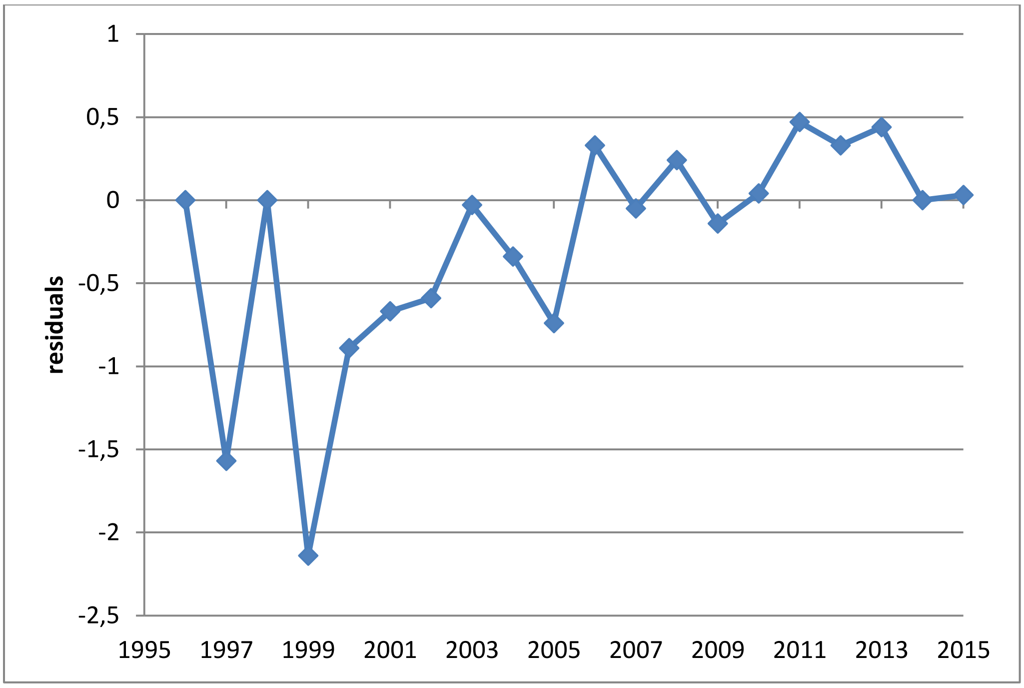


Figure 3.3.1.1. Distribution of survey log-catchability residuals in XSA analysis.

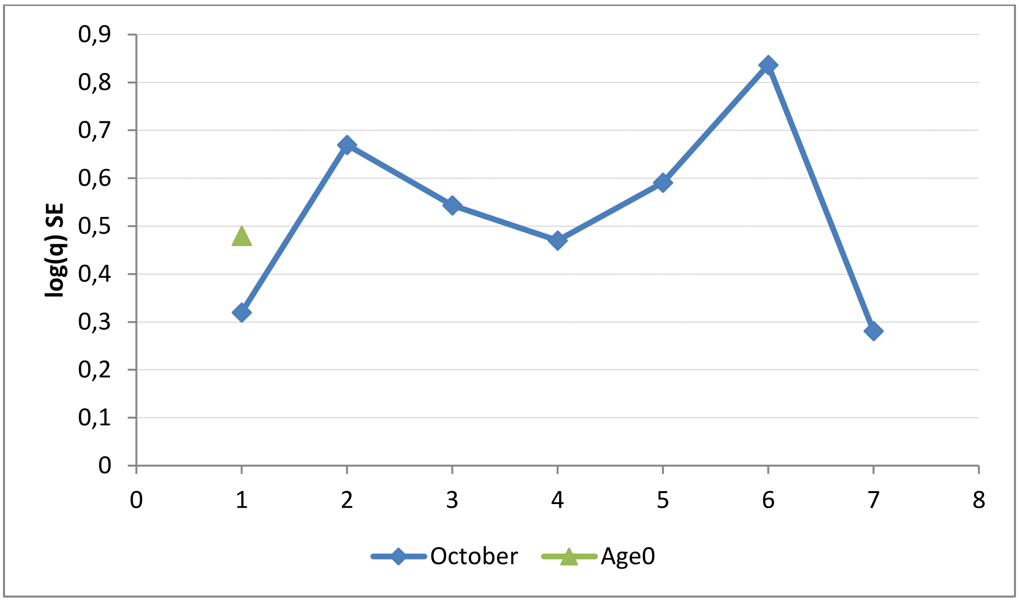


Figure 3.3.1.2. The standard errors (SE) of log-catchability residuals for October and age0 surveys.

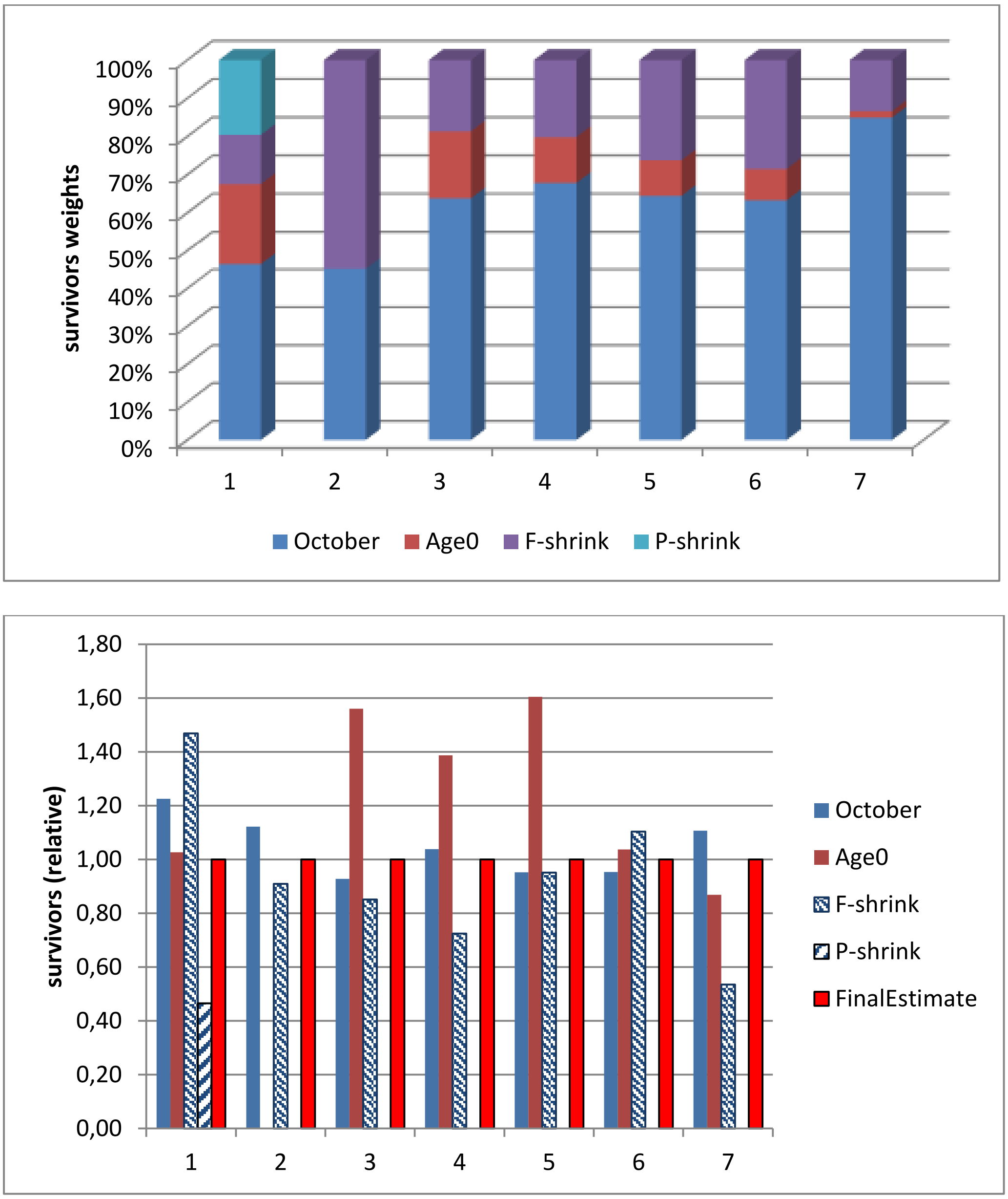


Figure 3.3.1.3. Weight of survivors estimates (upper graph) and survivors estimates relative to final estimate (bottom graph) by tuning fleet and applied shrinkage.

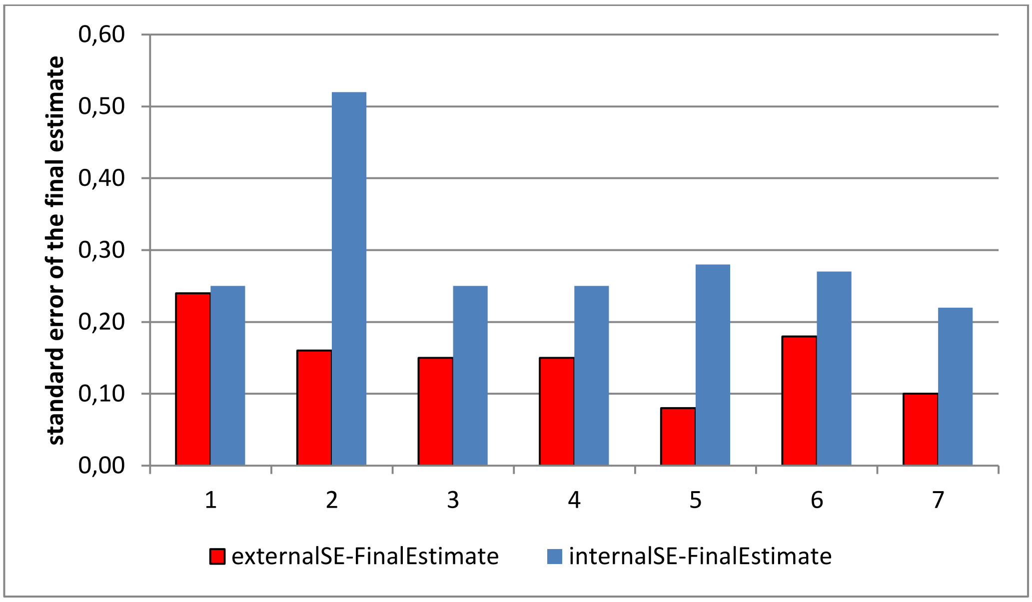


Figure 3.3.1.4. The internal and external standard error (SE) of survivors estimates in XSA as depending on age.

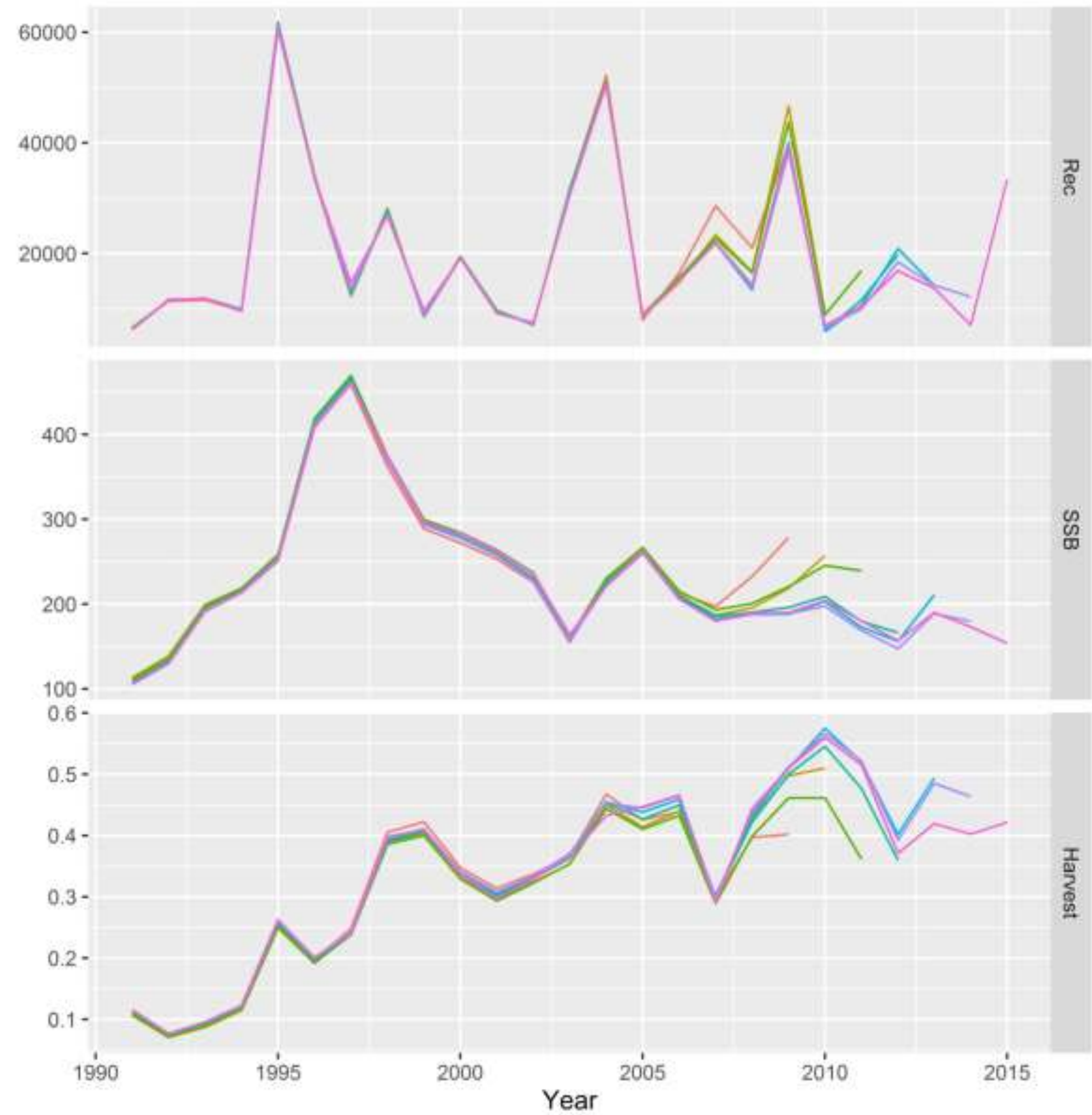
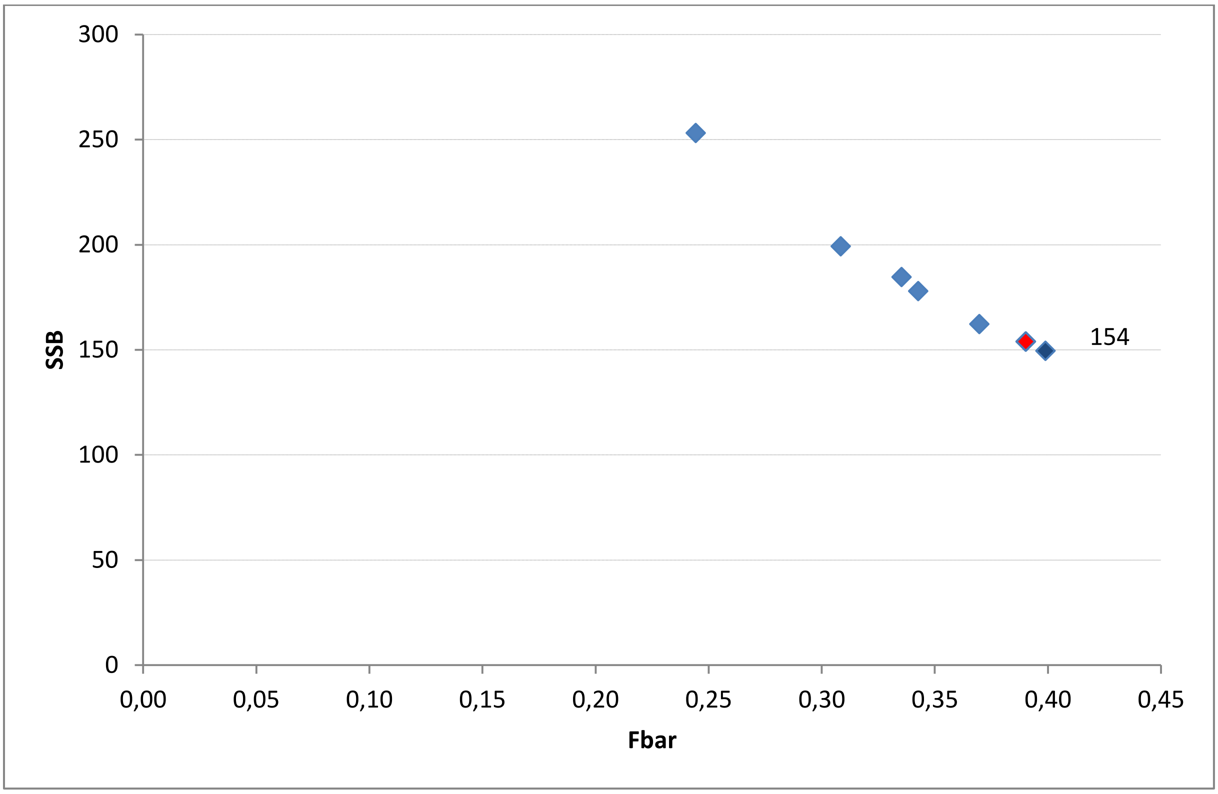


Figure 3.3.1.5. Retrospective estimates of recruitment, spawning stock biomass and fishing mortality for sprat in sub-divisions 27,29-32.



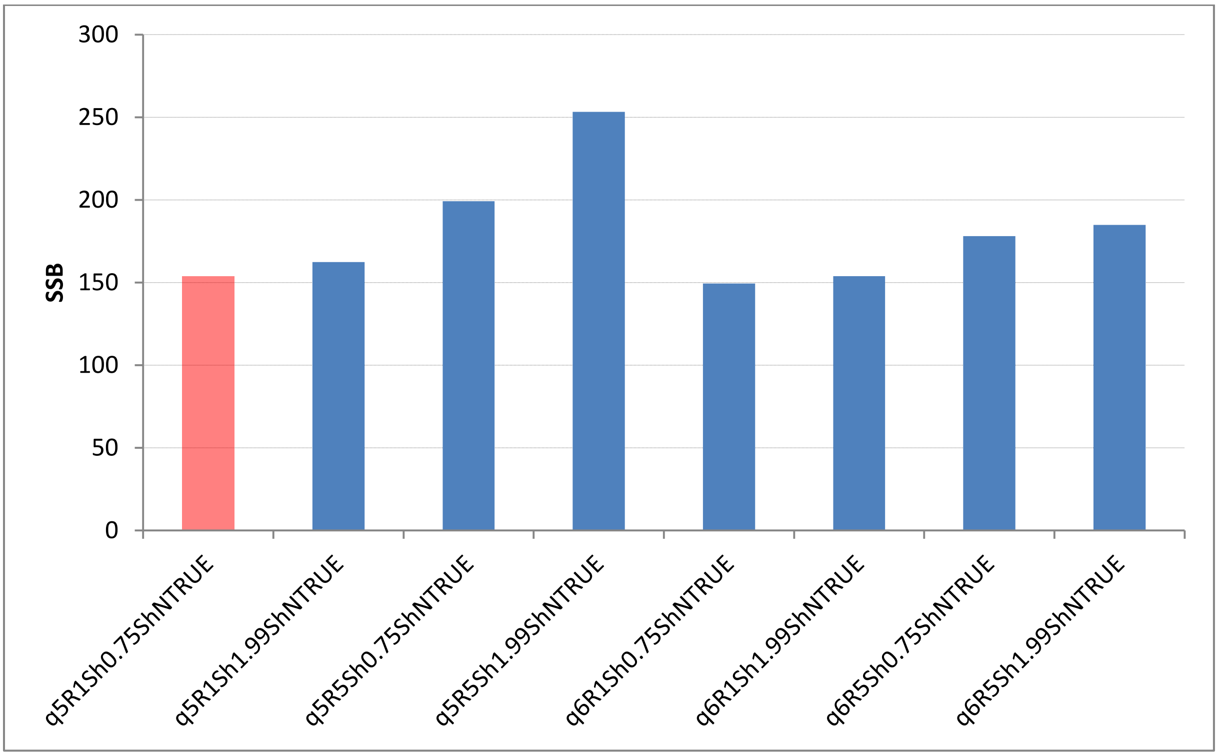


Figure 3.3.1.6. Sensitivity of terminal year estimates of SSB and average fishing mortality to the parameterisation of the XSA. Final estimate is marked in red.

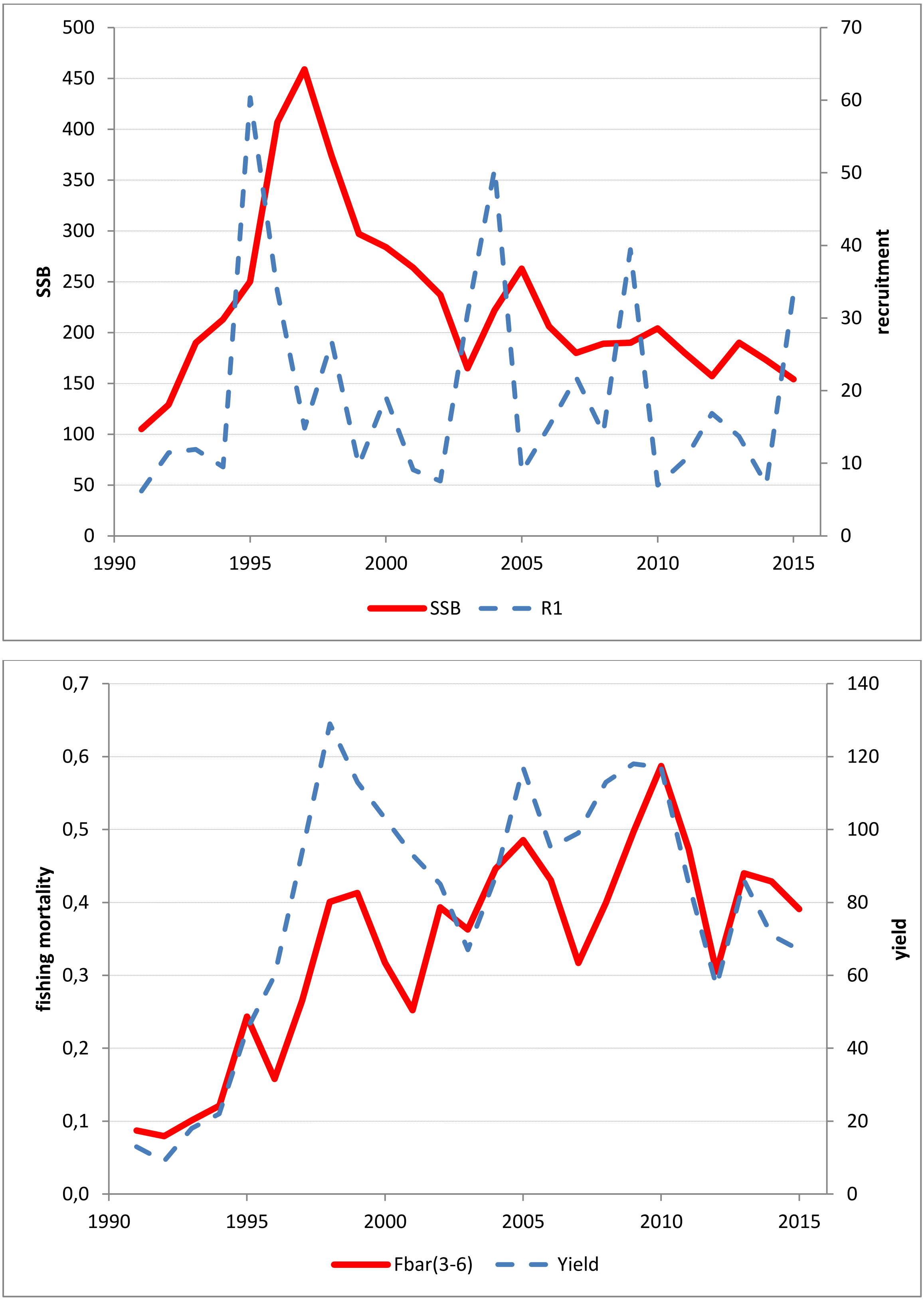


Figure 3.3.1.7. The XSA estimates of spawning stock biomass (10^3 t.), recruitment (10^9 individuals), and fishing mortality. For comparison yield (10^3 t.) is given.

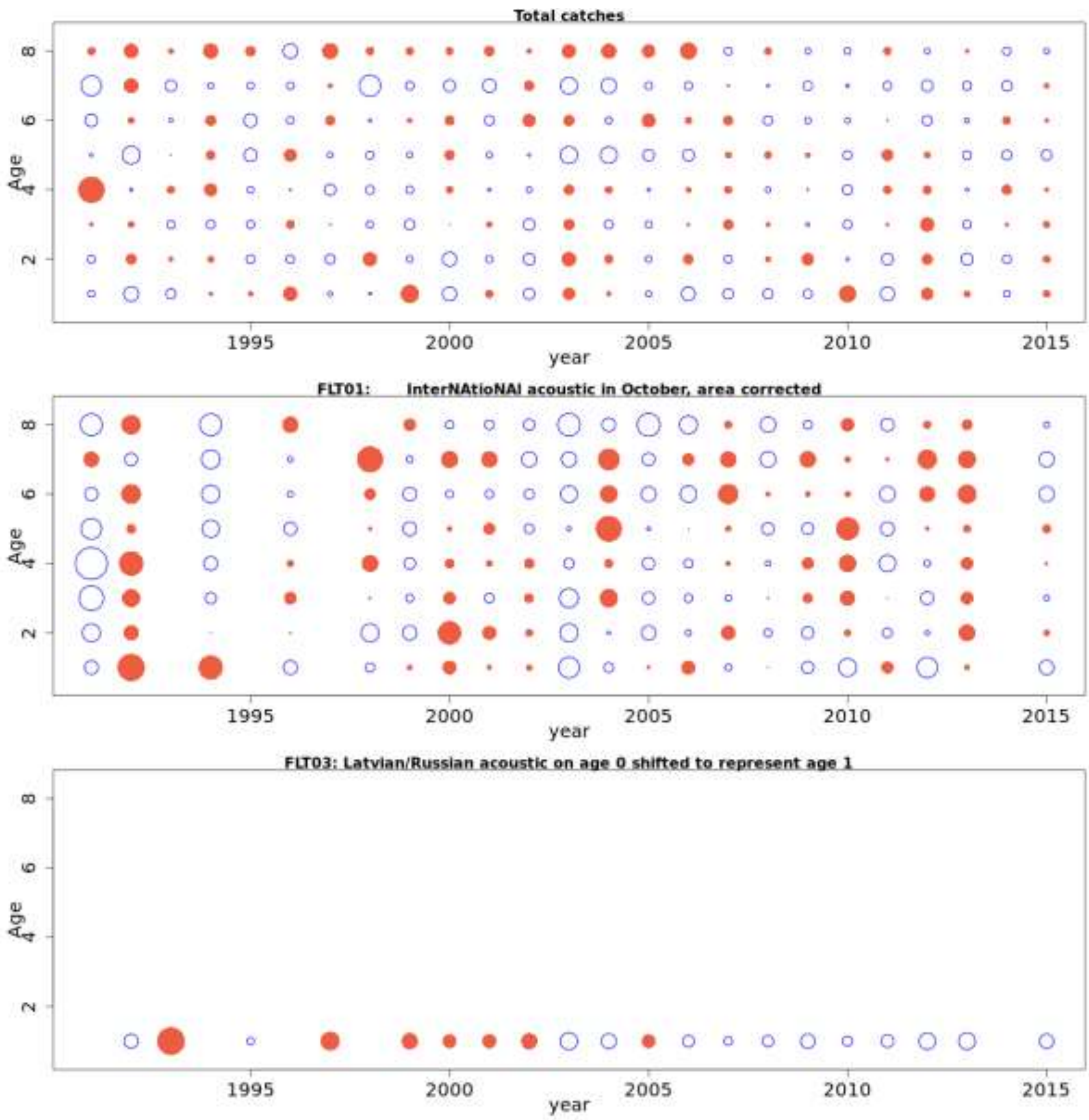


Figure 3.3.2.1. Plot of residuals of catches and two tuning fleets for the SAM model.

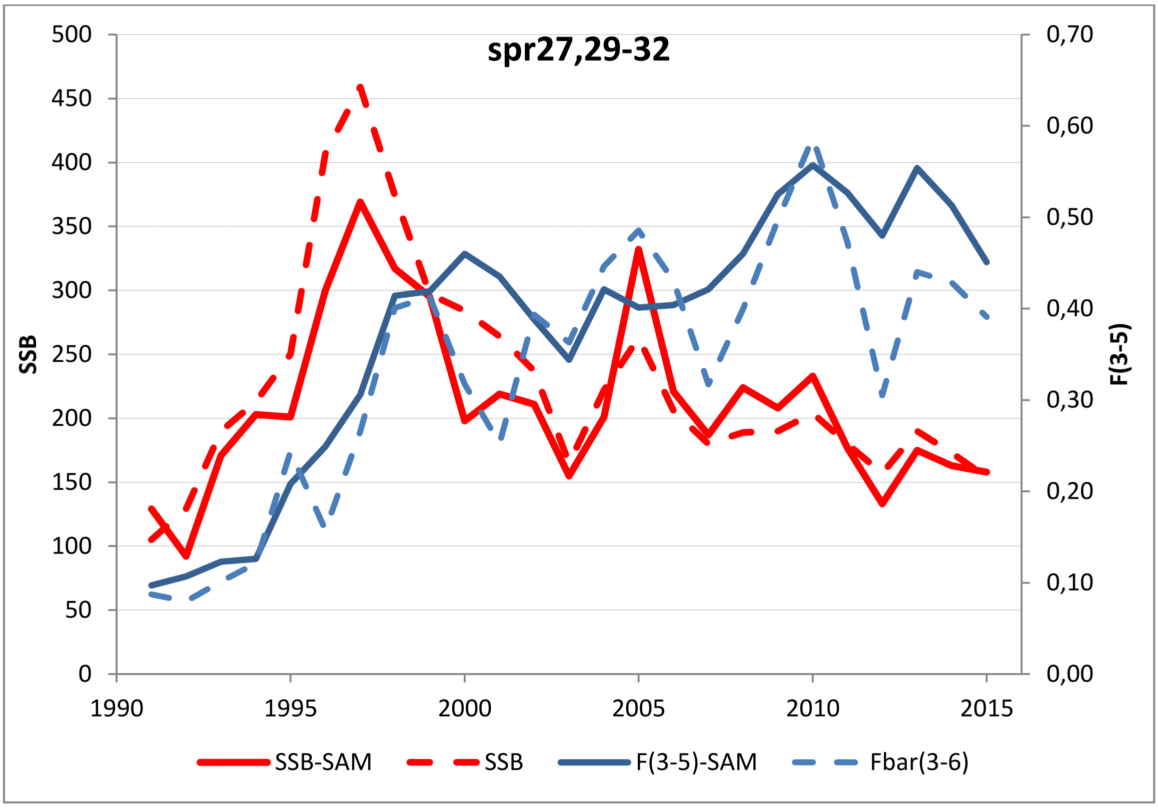
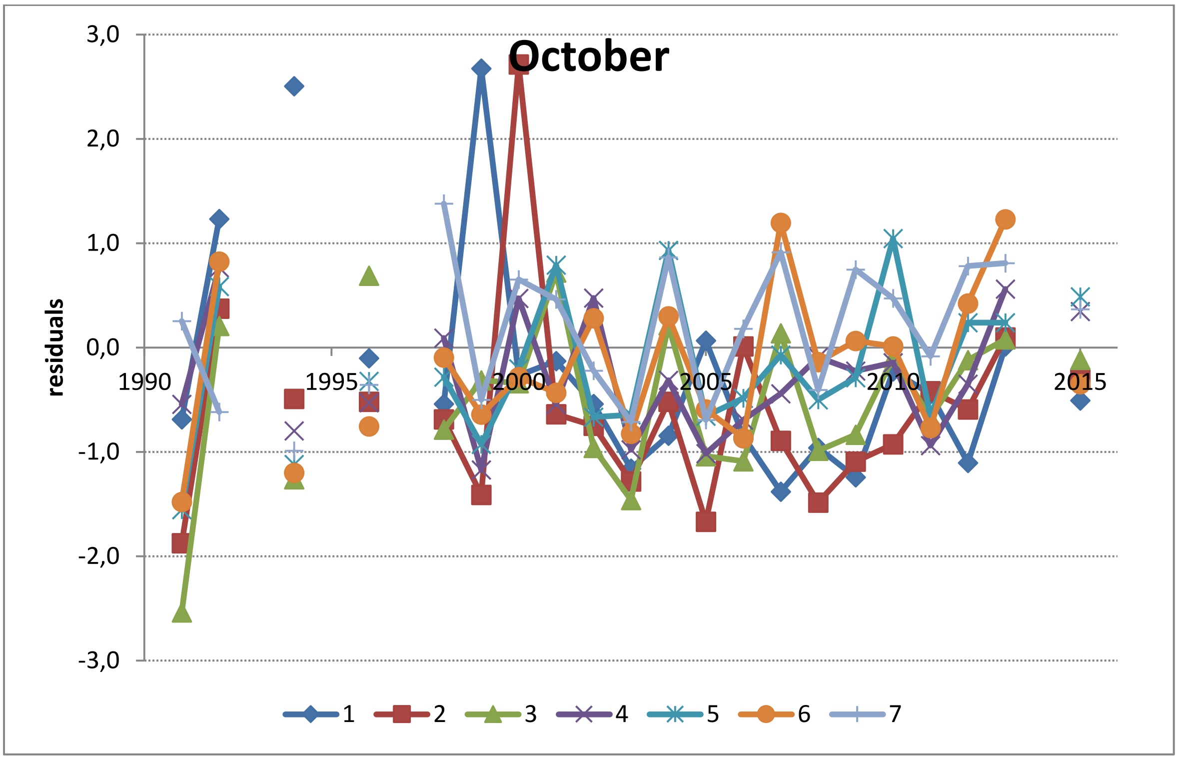


Figure 3.3.2.2. SAM model estimates of spawning stock biomass (10^3 t.) and fishing mortality. For comparison XSA estimates (broken lines) are given.



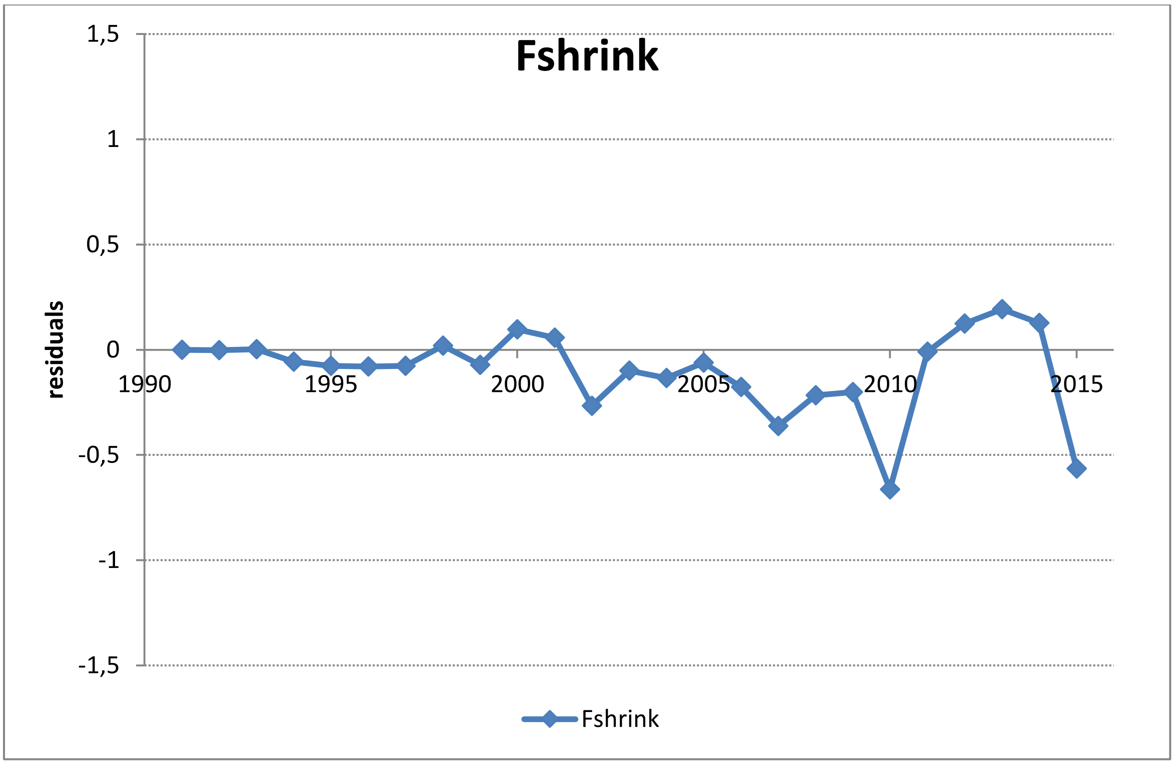


Figure 3.3.3.1. Time series of residuals in CohAnalQ assessment for stock estimates at age for October acoustic survey. In addition, residuals in fishing mortality estimates at terminal age are shown (bottom plot)

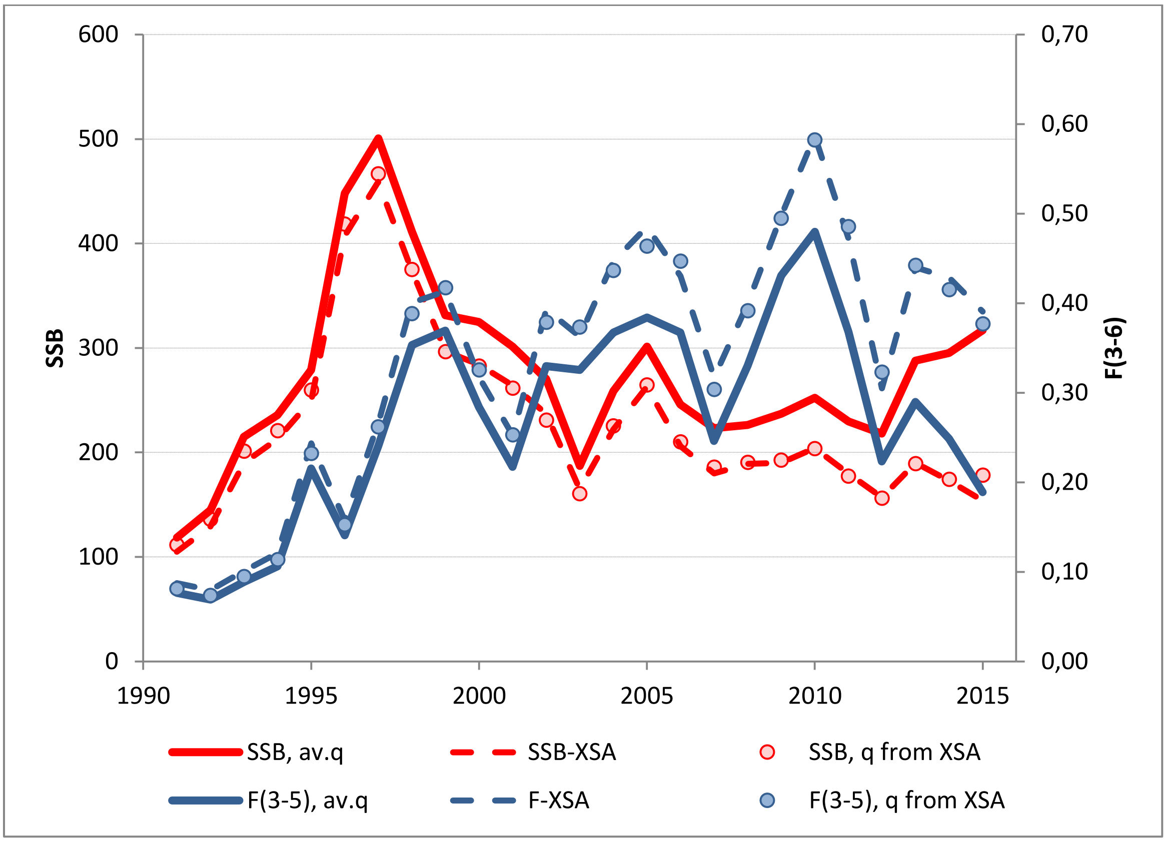


Figure 3.3.3.2. Spawning stock biomass (10^3 t.) and fishing mortality estimated by cohort analysis with assumed catchability (CohAnalQ) using average catchability (av. q). For comparison SSB and F estimates with CohAnalQ using the same catchability as estimated in XSA (q from XSA) and the XSA estimates (broken lines) are given.

4. Summary and conclusions on assessments of sprat stocks in the Baltic

The basic aim of the sprat assessments by former stock assessment units, *i.e.* sprat in sub-divisions 22-25, sprat in sub-divisions 26+28, and sprat in sub-divisions 27,29-32, was to check if the dynamics of sprat in these units is similar, so that the merging in 1990s of former assessment units into one stock of sprat in the Baltic (sub-divisions 22-32) is still justified. The question arises if the stock dynamics in former AUs show similar trends and if sum of AUs biomasses is approximately equal to the biomass estimated for sprat in the whole Baltic using present ICES approach. In addition, the spatial distribution of cod, major predator on sprat, changed compared to 1980s and 1990s, so the effects of these changes on sprat are different in AUs and should be investigated.

In Figure 4.1 the biomasses and fishing mortalities by former AUs are presented and their sums or average are compared to SSB and fishing mortality estimated for sprat stock in the whole Baltic. It appears that sum of sprat SSB's by former AUs estimated with XSA is very similar to the SSB estimated by ICES (2016a) for present assessment of sprat in the Baltic. Similarly, average fishing mortality by AUs is very close to F estimated by ICES for Baltic sprat. Estimates from SAM model are not presented in the Figure as they are similar to the XSA values. In Figure 4.2 the share of biomasses estimated by assessment units in total biomass is shown and for comparison similar share of biomasses recorded in surveys is presented. Survey and assessment results are consistent with this respect for sprat in sub-divisions 26+28. However, for the other AUs results differ: for sprat in sub-divisions 22-25 biomass estimated with XSA has bigger share in total sprat biomass than the survey derived biomass, while for sprat in sub-divisions 27,29-32 the assessed biomass has lower share in the total than the survey biomass.

As already indicated in sections 1.3.3, 2.3.3 i 3.3.3 the catchabilities obtained in XSA analyses were quite different in AUs and that was the reason for conducting additional assessments, using cohort analysis with the same catchability for all AUs (CohAnalQ). The catchability applied was the average of catchabilities estimated for three AUs in XSA. For such assessments sum of biomasses estimated for AUs is also very similar to biomass of sprat in the whole Baltic estimated by ICES, and similarly close to ICES estimates of fishing mortality is average of F estimates by AUs (Figure 4.1). Share of biomass in AU in the total biomass is now somewhat closer to the respective share of biomass from the October survey but differences for sprat in sub-divisions 22-25 and sprat in sub-divisions 27,29-32 are still quite large (Figure 4.2a).

Better consistency in this respect is observed for the May survey – applying CohAnalQ model made share of sprat biomass in sub-divisions 26+28 closer to share of respective survey biomass than in case of XSA estimates (Figure 4.2b).

The conducted assessments provide rather consistent estimates of biomass and fishing mortality by AUs. However, some differences between assessments obtained in biomass estimates for recent years for sprat in sub-divisions 22-25 and sprat in sub-divisions 27,29-

32 made these two assessments uncertain. On the other hand, quite large differences in recent years biomass estimates for these stock between XSA or SAM and CohAnalQ is not surprising as the differences between catchabilities for sprat AUs are big (at a level of 2-4), much bigger than in case of herring assessment. In general, trends in stock biomasses and fishing mortality development are similar for all three stocks. The biggest is biomass of sprat in sub-divisions 26+28; in most years it was close to sum of biomasses of other sprat stocks. Fishing mortality of this stock has been the highest in recent years, and the lowest was exploitation of sprat stock in sub-divisions 22-25.

The assessment of sprat in sub-divisions 27,29-32 was performed with natural mortality of 0.2 (residual natural mortality) as there is almost no overlap with cod in this area. The question arises if this level of natural mortality is not too low. The trial assessment with M of 0.3 produced stock size about 30% higher and fishing mortality almost 25% lower than in the assessment with M=0.2.

The merging of three AUs (sprat in sub-divisions 22-25, sprat in sub-divisions 26+28, and sprat in sub-divisions 27,29-32) into one AU of sprat in the Baltic seems to be justified from assessment point of view. However, spatial management of the stocks requires assessment and data by former AU.

References to Par A and Part B

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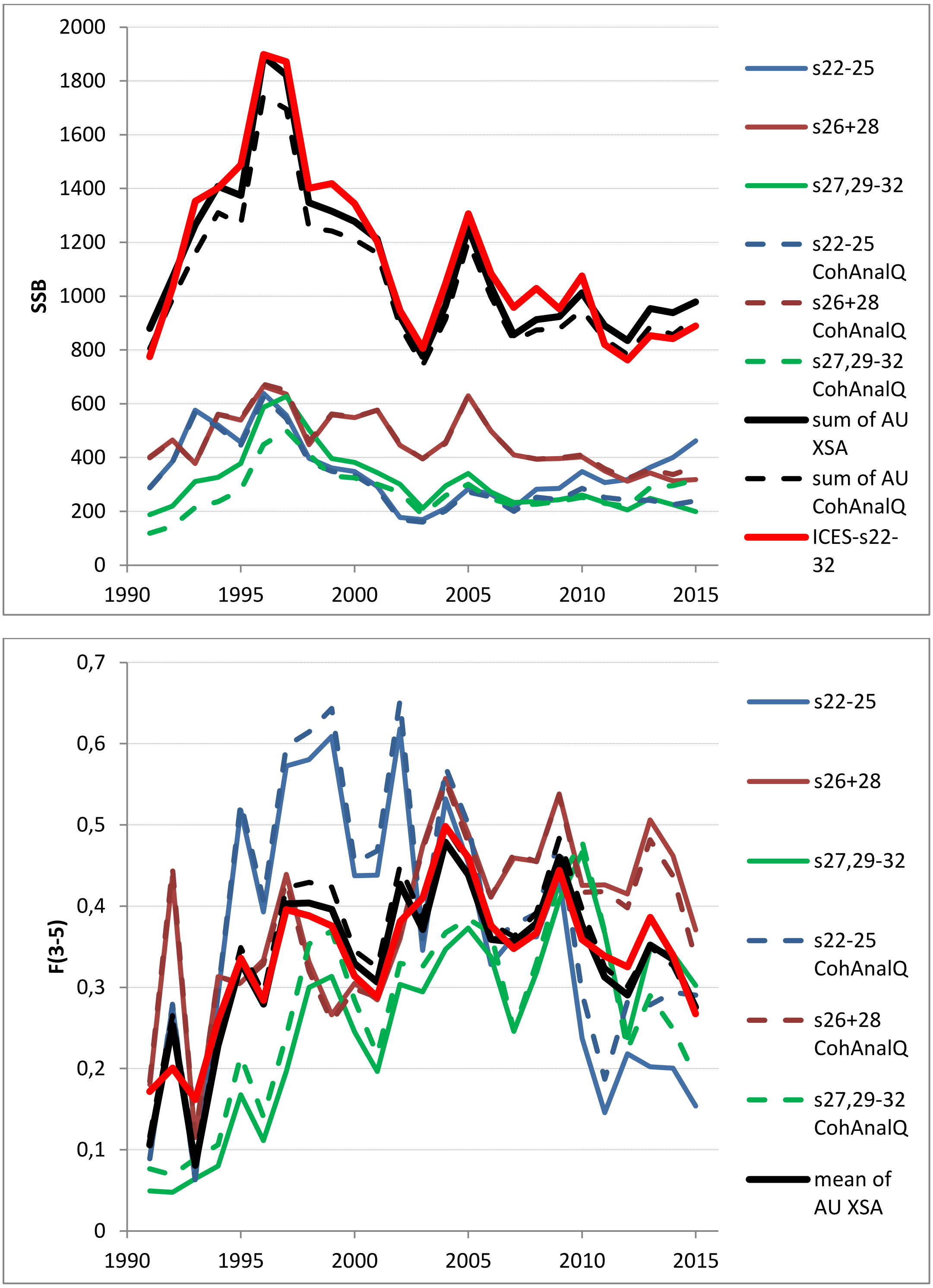
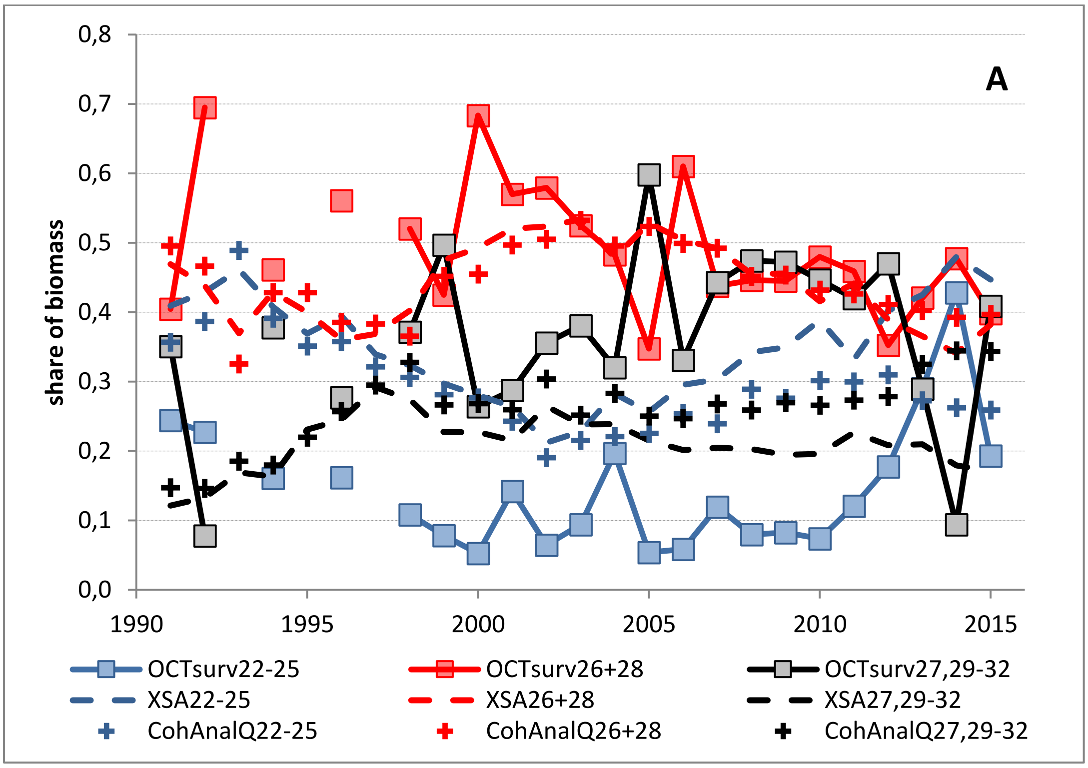


Figure 4.1. Comparison of biomass and fishing mortality estimates by former assessment units (AU) with ICES assessment of sprat in the whole Baltic.



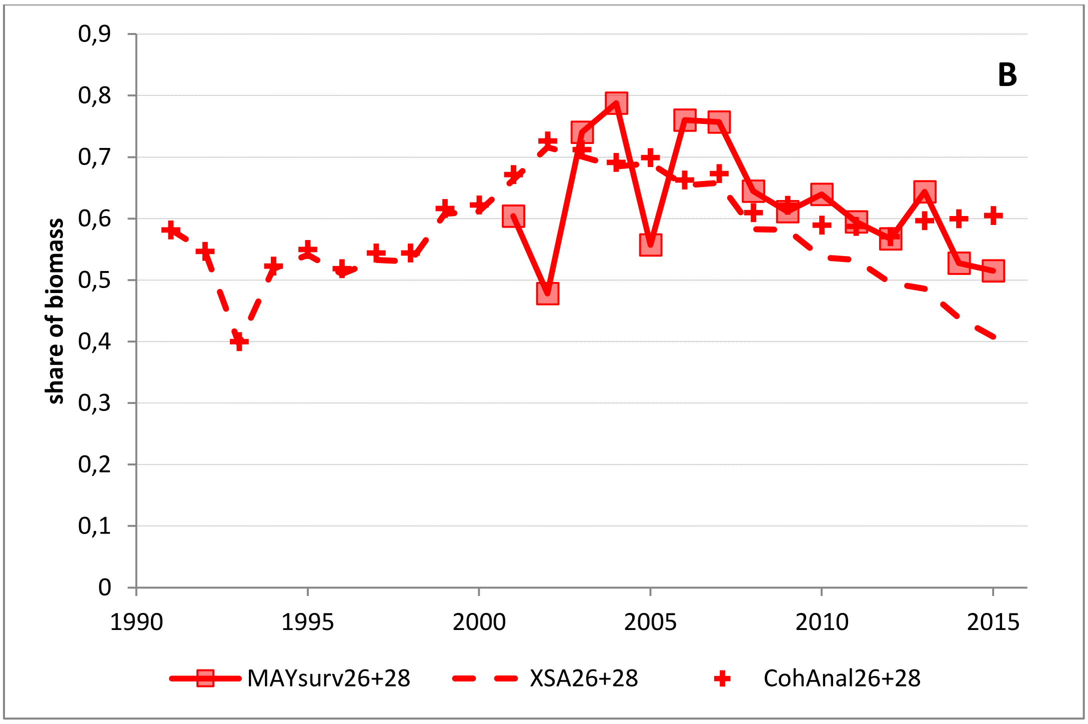


Figure 4.2. Share of biomass estimates of sprat stocks (sprat in sub-divisions 22-25, sprat in sub-divisions 26+28, and sprat in sub-divisions 27,29-32) to biomass of sprat in the whole Baltic (sub-divisions 22-32) derived from acoustic surveys, XSA, cohort analysis with assumed catchability (CohAnalQ). A=October survey, B=May survey.

Working Document 04 for WGBFAS, 19-26 April, 2017

The method for estimating MSY reference points incorporating density dependence and predation effects

by

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Part of this work resulted from the BONUS INSPIRE project, was supported by BONUS (Art 185), funded jointly from the European Union's Seventh Programme for research, technological development and demonstration and from the Polish National Centre for Research and Development. Polish Ministry of Science and Higher Education has also participated in the financing of this research.

Introduction

The presented method for estimating MSY reference points incorporates sprat density-dependent growth and predation mortality (for details see Horbowy and Luzeńczyk 2016). The model is based on the long-term deterministic and stochastic simulations including selected determinants of fish growth and mortality in the estimation of equilibrium yield, biomass, and MSY reference points. The resultant model is a relatively simple tool that allows for streamlined analyses of problems typically approached using complex multispecies models. The model was used to estimate maximum sustainable yield parameters for sprat.

Methods

In the analysis, classical stock dynamics equations (exponential decay of cohort numbers, the Baranov catch equation, and the Beverton and Holt (1957) (B&H) S-R relationship) are combined with equations that describe density-dependent effects.
According to the multispecies theory of fishing of Andersen and Ursin (1977), population growth rate depends on its feeding level, which is hyperbolically related to stock density. In the presented method this relationship and the approaches of Horbowy and Swinder (1989) are used to model weight-at-age as a hyperbolic function of stock density:

$$(1)\quad w(a,t) = \frac{aW}{bW + sprN(t)} w(a, t0),$$

where sprN is the number of sprat of age 2 and older, aW and bW are parameters, and t0 is the reference year.

In predator-prey relationships, predation mortality is typically proportional to a certain measure of predator stock size and inversely related to the amount of food available to the predator (Andersen and Ursin1977; SMS model of Levy and Vinther (2004)).
In the presented analysis hyperbolic function was used to fit the M2 estimates for sprat (averaged across ages by year) to sprat and cod stock size:

$$(2)\quad M2(t) = \frac{aM * codB(t)}{sprB(t) + bM},$$

where sprB is sprat biomass, codB is cod biomass, and aM and bM are parameters.

To check the effects of density dependence on MSY reference points four options for combining density-dependent and constant growth, and natural mortality (the inclusion or exclusion of eqs. 1 and 2) were performed:

1. Growth and natural mortality of sprat are constant (w and M constant option).
2. Growth is density dependent and natural mortality is constant (only w option).
3. Growth is constant and natural mortality (predation natural mortality) is density dependent (only M option).
4. Both growth and natural mortality are density dependent (both w and M option).

Results

Sprat weight-at-age has experienced significant changes since the mid-1970s; it was highest in the 1980s, when sprat stock was largely reduced due to the strong impact of predation by a large cod stock, and started to decline at the beginning of the 1990s as the sprat stock developed. These changes correspond with stock density (Fig. 1), and eq. 1 explains 66% of the variance in sprat weight.

Model 2 fits the M2 values estimated with the SMS very well (Fig. 2a); the only large difference is in the estimate for 1983 (sprB of ca. 1700×10^3 t, M2 of 0.55 from the SMS). The model explains 97% of the variance in average M2. This strong relationship is not surprising as the M2 estimates from the SMS model depend on the sizes of both predator and prey stocks and their size (age) structures. However, the complex relationships in the SMS model that lead to the M2 estimates by age and year may be replace by a simpler model that operates using the average M2 and total stock size values. Fig. 2b shows fitted M2 dependencies on sprat biomass for range of cod biomasses.

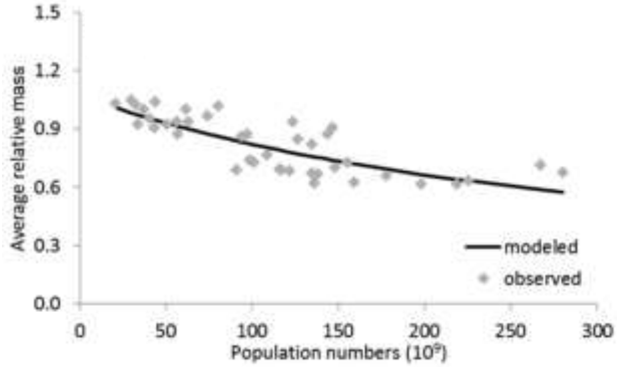

Fig.1 Average weight of sprat dependent on stock numbers from 1974-2014 (observed and modeled, eq.1).

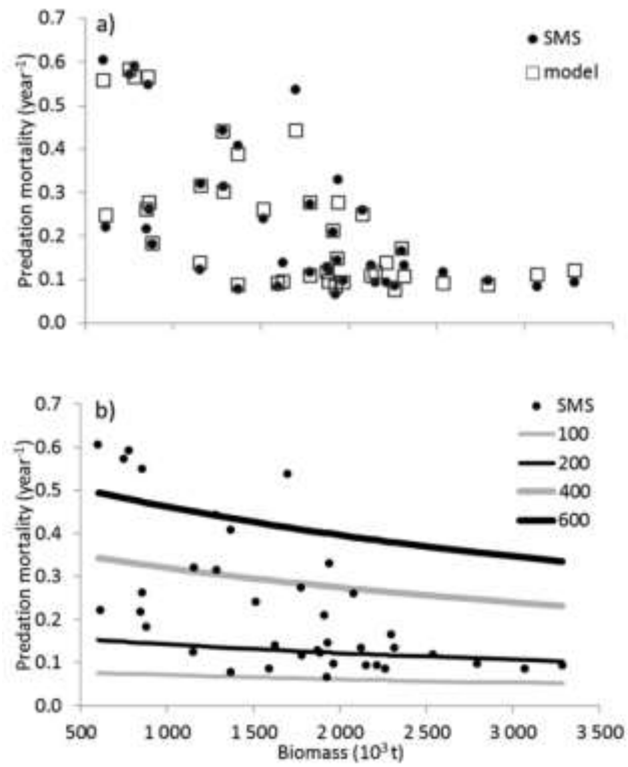

Fig. 2. Values for modeled predation mortality of sprat (eq. 2) and estimated from the SMS model dependent on sprat stock biomass (age 2+) from 1974–2012 (different points at given sprat biomass values represent different cod biomass values) (a). Estimates of M2 resulting from eq. 2 for cod biomasses ranging from 100×10^3 t to 600×10^3 t (solid lines). For comparison, the average M2 estimated in the SMS model is given (b).

First, the results for a codB of 200×10^3 t are presented, as this value approximately corresponds to the average cod biomass since the beginning of the 1990s. Assuming constant growth and constant natural mortality (w and M constant option), F_{MSY} is estimated at 0.32 and MSY at 180×10^3 t (Fig. 3). If density-dependent natural mortality of sprat is considered (only M option), the MSY parameters remain quite similar (F_{MSY} is 0.28 and MSY equals 184×10^3 t). However, the inclusion of density-dependent growth in the simulations (only w option) leads to large changes in the MSY parameters; F_{MSY} is estimated at 0.5 and MSY equals 230 × 10^3 t. When both density-dependent growth and density-dependent mortality are simulated (both w and M option), MSY parameters are similar to those obtained in the simulations that include density-dependent growth; F_{MSY} is lower (0.45), but the MSY values are almost identical.

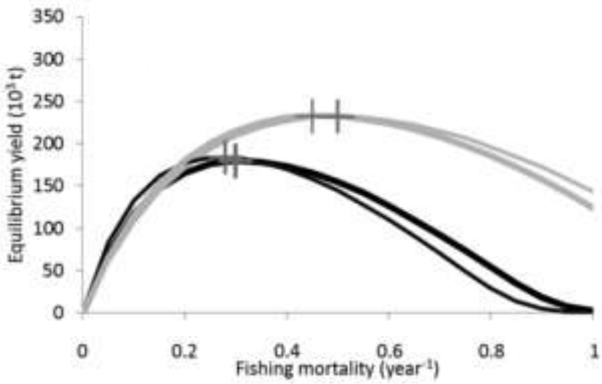

Fig. 3. Equilibrium yield of sprat relative to fishing mortality for the four combinations of density-dependent and constant growth and natural mortality (including or excluding eqs. 1 and 2 in the analyses). Cod biomass assumed at 200 × 10^3 t.

The effects of the density-dependent natural mortality of sprat on the MSY parameters increase with the cod biomass (Fig. 4). The equilibrium yield curves for both options (the one including density-dependent M2 and with constant M) are similar for codB values of 200 × 10^3 t and below, but differ greatly when the cod biomass reaches 500 × 10^3 t.

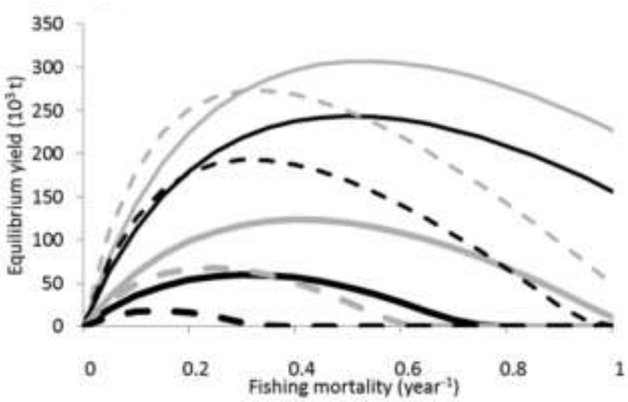

Fig. 4. Comparison of equilibrium yield for sprat density-dependent M (solid lines) and constant M (broken lines). Cod biomasses range from 100×10^3 t to 600×10^3 t and growth is constant.

A summary of how sprat MSY parameters depend on cod biomass and the inclusion or exclusion of the density-dependent effects in the simulations is presented in Fig. 5. The F_{MSY} and MSY values decline (approximately linearly) with the increasing codB. The highest values of F_{MSY} and MSY are obtained when density-dependent growth is simulated, while including only density-dependent natural mortality in the simulation leads to the lowest values of F_{MSY} and MSY. Under the most realistic option, when both density-dependent growth and natural mortality are simulated, the MSY parameters fall between the above-mentioned extremes.

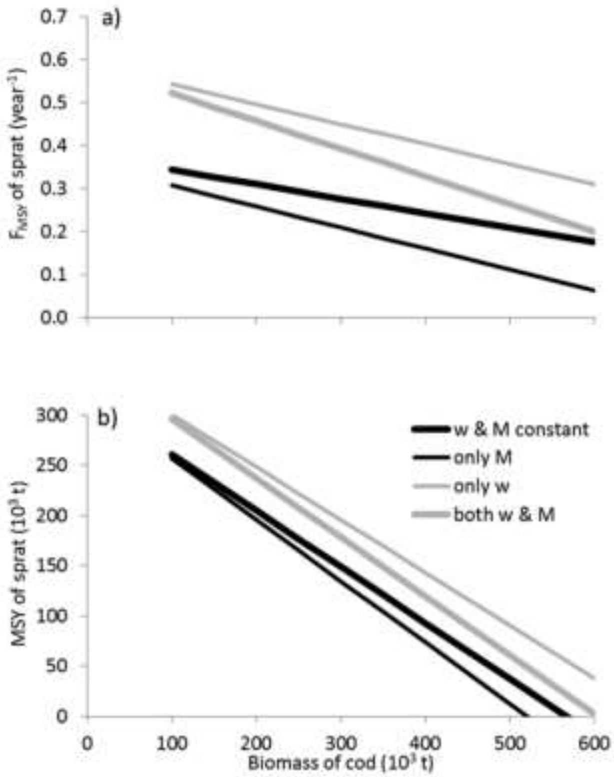

Fig. 5. Dependence of sprat F_{MSY} (a) and MSY (b) on cod biomass.

Conclusions

The analysis indicates that estimates of the MSY parameters (i.e., MSY and F_{MSY}) and equilibrium biomass differ significantly between approaches that hold growth and natural mortality constant, and those that allow for density-dependent growth and natural mortality. The results showed that omitting density-dependent growth, when it exists, leads to underestimation of F_{MSY} and MSY, whereas not taking into account the density-dependent natural mortality can caused overestimation of F_{MSY} and MSY.

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Working Document 05 to ICES WGBFAS 2017

KATTEGAT COD SAM ASSESSMENT, INCLUDING NATAL HOMING MIGRATION OF NORTH SEA COD.

By Morten Vinther, DTU Aqua

Cod within the Kattegat management area consists of cod spawned within Kattegat (Kattegat origin) and cod spawned outside Kattegat. It is assumed that inflow of North Sea cod into Kattegat takes place at the juvenile stage, such that inflow for a cohort is practically fixed at age 1. Migration of cod spawned in the North Sea back to the North Sea is assumed to take place as the cod mature (natal homing). The SAM model was modified to account for inflow and natal homing of North Sea in the Kattegat management area, using the same input data as the default ICES assessment. The model estimates the proportion of juvenile cod with Kattegat origin for each cohort and adjusts the proportion of Kattegat origin for older ages from assumed natal homing migration. This migration is determined outside the SAM model from proportion mature at age, or within the model as age dependent parameters. Several model configurations were tried with various options for catch scaling and migration. The best statistical model fit is obtained for model with just catch scaling. Addition of migration improved the model fit but on the cost of an increased number of model parameters. The assessment results such as SSB and F seem robust to the choice migration model and migration parameters. Consistent estimates of SSB and F (derived from unscaled catches) are obtained for recent years in the assessment time series, while recruitment depend more on model configuration.

1 Introduction

Previous ICES assessments of cod in the Kattegat management area have shown that for some year classes of cod, survey CPUE indicate a much faster stock reduction than possible induced by reported catches. By raising catches (landings and discards) by a year dependent factor estimated by the assessment model (SAM, ref), it has been shown that the model fit become better (higher likelihood in the maximum likelihood model) for both (raised) catch at age and survey indices at age. ICES notes that this "unallocated mortality" due to catch scaling could comprise both unreported catches and biology-driven factors (e.g. migration). At present ICES is not in a position to quantify the proportions of "unallocated mortality" due to fishing or other sources.

Several studies have identified spawning areas for cod in the Kattegat. Other studies have shown that cod migration out the Kattegat area is occurring and migration is possible linked to natal homing of North Sea cod (see the Kattegat cod Stock Annex for a comprehensive review). New genetic analysis (Several presentations to Benchmark 2017) of cod caught in Kattegat show that for some years, the majority of juvenile cod in Kattegat is of North Sea origin (spawned in the North Sea) and that the proportion of North Sea cod within Kattegat decreases by age.

For the present WD it is assumed that cod within the Kattegat management area consists of cod spawned within Kattegat (Kattegat origin) and cod spawned outside Kattegat. For this working document, it is just the contribution from the North Sea stock that is considered. It is assumed that inflow of North Sea cod into Kattegat takes place at the juvenile stage, such that inflow for a cohort is practically fixed at age 1. Migration back to the North Sea of fish spawned in the North Sea is assumed to take place as the cod mature (natal homing). Fishing mortality (F) and natural mortality (M) within the Kattegat area are assumed to be the same for the two stock components.

2 Model formulation

The model comprises all cod within the Kattegat management area and makes use of the same input data as the default SAM assessment, i.e. data for all cod caught and surveyed in Kattegat without information on stock identity.

The suggested new version of the SAM model has the same target function (maximizing the likelihood of the observation of catch and survey CPUE) as the old version. In the new version the discrepancy between survey abundance estimates and catches is however described by an inflow of North Sea cod as juveniles and a later migration back to the North Sea when the cod mature (natal homing). The model estimates the proportion of the two component at age 1 for each year, and adjust the stock development of older ages by a migration rate by year and age. This migration must be given as input, but observations for estimation of return migration are scare. Instead, migration is assumed to follow the observed proportion mature at age, as the migration is assumed due to natal homing.

For future model development, age dependent migration rate can be estimated from observations of stock proportions at age and a binomial likelihood contribution in the target function. Right now the available data on stock proportions are however too limited for such an analysis.

2.1 Equations

As the new model is implemented in the presently used SAM model, which operates with one stock only and uses data for all cod in Kattegat, the model formulation operates with one stock only as far as possible, even though a model with two clearly separated components would have been simpler.

The inflow of North Sea cod as recruits and thereby the annual proportion of recruits (age 1) with Kattegat origin ($P_{y,a=1}$) is mainly unknown and has to be estimated within the model. For the most recent years we have data to estimate P (outside the model), so the vector P is a combination of parameters to be estimated and known input values.

Recruiting (age=1) stock numbers (N) with Kattegat origin (O=kat) are determined from total stock number within the Kattegat area and the proportion with Kattegat origin ($P_{y,a}$).

$$N_{O=kat,y,a=1} = N_{y,a=1} * P_{y,a=1}$$

Similarly for the North Sea component (O=nor)

$$N_{O=nor,y,a=1} = N_{y,a=1} * (1 - P_{y,a=1})$$

The proportion Kattegat cod for older ages in the first assessment year ($P_{y=\text{first year},\ a>1}$) is also a parameter to be estimated by the model (or given as input).

Cod are spawning in the first quarter of the year, but for model purposes it is assumed that spawning takes place the 1st January. Two model options for natal homing are considered:

1) Natal homing is a continuous process described by an instantaneous rate of migration ($L_{y,a}$), (L for leave) such that stock numbers of the North sea component within Kattegat becomes

$$N_{o=nor,y+1,a+1} = N_{o=nor,y,a} * e^{-(F_{y,a}+M_{y,a})} * e^{-(L_{y,a})}$$

While stock number for the Kattegat component is just reduce by M and F

$$N_{o=kat,y+1,a+1} = N_{o=kat,y,a} * e^{-(F_{y,a}+M_{y,a})}$$

With known P and L, the catch at age (C) within the year becomes the sum of catches from the two components.

$$C_{y,a} = \frac{F_{y,a} * N_{y,a} * P_{y,a} * \left(1 - e^{-(F_{y,a}+M_{y,a})}\right)}{F_{y,a} + M_{y,a}} + \frac{F_{y,a} * N_{y,a} * (1 - P_{y,a}) * (1 - e^{-(F_{y,a}+M_{y,a}+L_{y,a})})}{F_{y,a} + M_{y,a} + L_{y,a}}$$

$$= F_{y,a} * N_{y,a} * \left(\frac{P_{y,a} * \left(1 - e^{-(F_{y,a}+M_{y,a})}\right)}{F_{y,a} + M_{y,a}} + \frac{(1 - P_{y,a}) * (1 - e^{-(F_{y,a}+M_{y,a}+L_{y,a})})}{F_{y,a} + M_{y,a} + L_{y,a}} \right)$$

Stock numbers at time t within a year, for use to predict survey observations from stock numbers and catchability are calculated from the two components in a similar way:

$$N_{y+t,a} = N_{y,a} * P_{y,a} * e^{-t*(F_{y,a}+M_{y,a})} + N_{y,a} * \left(1 - P_{y,a}\right) * e^{-t*(F_{y,a}+M_{y,a}+L_{y,a})}$$
$$= N_{y,a} * e^{-t*(F_{y,a}+M_{y,a})} * \left(P_{y,a} + \left(1 - P_{y,a}\right) * e^{-t*(L_{y,a})}\right)$$

The total stock number one time step ahead for a cohort is the sum of the Kattegat and North Sea components:

$$N_{y+1,a+1} = N_{o=kat,y+1,a+1} + N_{o=nor,y+1,a+1}$$
$$= N_{y,a} * P_{y,a} * e^{-(F_{y,a}+M_{y,a})} + N_{y,a} * \left(1 - P_{y,a}\right) * e^{-(F_{y,a}+M_{y,a})} * e^{-(L_{y,a})}$$
$$= N_{y,a} * e^{-(F_{y,a}+M_{y,a})} * \left(P_{y,a} + \left(1 - P_{y,a}\right) * e^{-(L_{y,a})}\right)$$

and for the plus group:

$$N_{y+1,a=plus} = N_{y,a=plus-1} + N_{y,a=plus}$$
$$= N_{y,a=plus-1} * e^{-(F_{y,a=plus-1}+M_{y,a=plus-1})} * \left(P_{y,a=plus-1} + \left(1 - P_{y,a=plus-1}\right) * e^{-(L_{y,a=plus-1})}\right) +$$
$$N_{y,a=plus} * e^{-(F_{y,a=plus}+M_{y,a=plus})} * \left(P_{y,a=plus} + \left(1 - P_{y,a=plus}\right) * e^{-(L_{y,a=plus})}\right)$$

P for the new time step can be calculated from the previous P and migration:

$$P_{y+1,a+1} = \frac{N_{o=kat,y+1,a+1}}{N_{y+1,a+1}} = \left(\frac{N_{y,a} * P_{y,a} * e^{-(F_{y,a}+M_{y,a})}}{N_{y,a} * e^{-(F_{y,a}+M_{y,a})} * \left(P_{y,a} + \left(1 - P_{y,a}\right) * e^{-(L_{y,a})}\right)} \right) =$$
$$= \frac{P_{y,a}}{P_{y,a} + \left(1 - P_{y,a}\right) * e^{-(L_{y,a})}}$$

With these equations it is possible to estimate predicted stock numbers, catch at age and survey indices at age as required by the SAM model.

As another option it is assumed that **2) Natal homing is an abrupt process** taking place instantaneously in the very beginning of the new year (notation y+), such that the stock numbers for North Sea component is adjusted by a factor ($LL_{y,a}$) before M and F influences the stock.

$$N_{o=nor,y+,a} = N_{o=nor,y,a} * LL_{y,a}$$

Catch within the year is calculated from initial stock numbers reduced by the instantaneous natal migration factor.

$$C_{y,a} = \frac{F_{y,a} * N_{y,a} * P_{y,a} * \left(1 - e^{-(F_{y,a}+M_{y,a})}\right)}{F_{y,a} + M_{y,a}} + \frac{F_{y,a} * N_{y,a} * LL_{y,a} * (1 - P_{y,a}) * (1 - e^{-(F_{y,a}+M_{y,a})})}{F_{y,a} + M_{y,a}}$$

$$= \frac{F_{y,a} * N_{y,a} * \left(1 - e^{-(F_{y,a}+M_{y,a})}\right)}{F_{y,a} + M_{y,a}} * \left(P_{y,a} + LL_{y,a} * (1 - P_{y,a})\right)$$

N at time t within a year is:

$$N_{y+t,a} = N_{y,a} * P_{y,a} * e^{-t*(F_{y,a}+M_{y,a})} + N_{y,a} * \left(1 - P_{y,a}\right) * LL_{y,a} * e^{-t*(F_{y,a}+M_{y,a})}$$
$$= N_{y,a} * e^{-t*(F_{y,a}+M_{y,a})} * \left(P_{y,a} + LL_{y,a} * \left(1 - P_{y,a}\right)\right)$$

N at the next time step (before the abrupt migration) becomes:

$$N_{y+1,a+1} = N_{o=kat,y+1,a+1} + N_{o=nor,y+1,a+1}$$
$$= N_{y,a} * P_{y,a} * e^{-(F_{y,a}+M_{y,a})} + N_{y,a} * \left(1 - P_{y,a}\right) * LL_{y,a} * e^{-(F_{y,a}+M_{y,a})}$$
$$= N_{y,a} * e^{-(F_{y,a}+M_{y,a})} * \left(P_{y,a} + LL_{y,a} * \left(1 - P_{y,a}\right)\right)$$

P for the next time step is:

$$P_{y+1,a+1} = \frac{P_{y,a}}{P_{y,a} + LL_{y+1,a+1} * \left(1 - P_{y,a}\right)}$$

2.2 Estimating migration

The return migration for the North Sea origin cod is not known, but given the assumption that migration is due to natal homing, the observed proportion mature at age as used in the assessments (Table 1) can be used to estimate migration. North Sea cod mature later than Kattegat cod according to the data. If this difference is due to heredity or environment is not unclear, so both sets are used in the model.

Table 1. Average proportion mature by age as derived from assessment input

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
Kattegat	0.01	0.50	0.83	0.96	1.00	1.00
North Sea	0.03	0.30	0.63	0.83	0.94	1.00

2.2.1 1) Natal homing is a continuous process

Given the assumption of natal homing migration follows the proportion mature for the North Sea and, 30% of the age 1 stock of North Sea origin will have returned to the North Sea at spawning time (1st January) at age 2, while the rest (70%) will remain in Kattegat.

To estimate a migration rate corresponding to the proportion mature, the North Sea component is divided in the part that stay (N_{stay}) and the part that migrate back to the North Sea (N_{mig}). It is assumed that the results of the migration fit to the proportion mature (PropMat) by age group. F and M are assumed the same for the two components. K is the ratio N_{stay} / N_{mig}

$$K_{y,a=} \frac{\left(1 - PropMat_{y+1,a+1}\right)}{PropMat_{y+1,a+1}} = \frac{N_{stay,y+1,a+1}}{N_{mig,y+1,a+1}} = \frac{N_{y,a} * e^{-(L_{y,a})} * e^{-(F_{y,a}+M_{y,a})}}{N_{y,a} * (1 - e^{-(L_{y,a})}) * e^{-(F_{y,a}+M_{y,a})}} \Leftrightarrow$$

$$K_{y,a} = \frac{e^{-(L_{y,a})}}{1-e^{-(L_{y,a})}} \Leftrightarrow L_{y,a} = log\left(\frac{1+k_{y,a}}{K_{y,a}}\right) \Leftrightarrow L_{y,a} = log\left(\frac{1}{1- propMat_{y+1,a+1}}\right)$$

The equations above are valid only for the first age that migrates back. To take into account, that for older ages some of the cod have already returned at a younger age, the equation for migration mortality becomes

$$L_{y,a} = log\left(\frac{1 - propMat_{y,a}}{1 - propMat_{y+1,a+1}}\right)$$

Table 2. Proportion mature at age and estimated migration rate for the North Sea component, based on proportion mature for the North Sea or the Kattegat.

		Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
North Sea	Proportion mature	0.0*	0.30	0.63	0.83	0.94	1.00
	Natal homing migration rate	0.357	0.638	0.778	1.041	10**	10**
Kattegat	Proportion mature	0.0*	0.50	0.83	0.96	1.00	1.00
	Natal homing migration rate	0.693	1.078	1.447	10**	10**	10**

*Assumed 0 , ** very high, 10 is used to ensure that "all" cod return

2.2.2 2) Natal homing is an abrupt process

Given the assumption that the stock numbers for North Sea component within Kattegat is adjusted by a factor ($LL_{y,a}$) due to an abrupt natal homing migration, and that this factor is given by the proportion, mature, $LL_{y,a}$ for the youngest age becomes:

$$LL_{y,a=1} = 1 - propMat_{y,a=1}$$

and for older ages

$$LL_{y,a>1} = \frac{1 - propMat_{y,a}}{1 - propMat_{y-1,a-1}}$$

Table 3. Proportion mature at age and estimated migration factor the North Sea component, based on proportion mature for the North Sea or the Kattegat.

		Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
North Sea	Proportion mature	0.0*	0.30	0.63	0.83	0.94	1.00
	Natal homing factor ($1-LL_{y,a}$)	0.0	0.3	0.471	0.541	0.647	1
	Natal homing adjustment factor ($LL_{y,a}$)	1.0	0.7	0.529	0.459	0.353	0
Kattegat	Proportion mature	0.0*	0.50	0.83	0.96	1.00	1.00
	Natal homing factor ($1-LL_{y,a}$)	0.0	0.5	0.66	0.765	1	1
	Natal homing adjustment factor ($LL_{y,a}$)	1.0	0.5	0.34	0.235	0	0

*Assumed 0

Table 4 gives examples on proportion Kattegat origin at age given an initial proportion as juveniles. When the same P value for age 1 cod is used the two migration models give the same P values for older ages.

Table 4. Proportion (P) of Kattegat cod within the Kattegat area calculated for given input P at age 1 and two models and data for natal homing.

Migration model: 1, Continuous. Proportion mature: North Sea

	P 5%	P 10%	P 25%	P 50%	P 75%	P 95%
Age 1	0.05	0.10	0.25	0.50	0.75	0.95
Age 2	0.07	0.14	0.32	0.59	0.81	0.96
Age 3	0.12	0.23	0.47	0.73	0.89	0.98
Age 4	0.24	0.40	0.66	0.85	0.95	0.99
Age 5	0.47	0.65	0.85	0.94	0.98	1.00
Age 6	1.00	1.00	1.00	1.00	1.00	1.00

Migration model: 2, Abrupt. Proportion mature: North Sea

	P 5%	P 10%	P 25%	P 50%	P 75%	P 95%
Age 1	0.05	0.10	0.25	0.50	0.75	0.95
Age 2	0.07	0.14	0.32	0.59	0.81	0.96
Age 3	0.12	0.23	0.47	0.73	0.89	0.98
Age 4	0.24	0.40	0.66	0.85	0.95	0.99
Age 5	0.47	0.65	0.85	0.94	0.98	1.00
Age 6	1.00	1.00	1.00	1.00	1.00	1.00

Migration model: 1, Continuous. Proportion mature: Kattegat

	P 5%	P 10%	P 25%	P 50%	P 75%	P 95%
Age 1	0.05	0.10	0.25	0.50	0.75	0.95
Age 2	0.10	0.18	0.40	0.67	0.86	0.97
Age 3	0.24	0.40	0.66	0.85	0.95	0.99
Age 4	0.57	0.74	0.89	0.96	0.99	1.00
Age 5	1.00	1.00	1.00	1.00	1.00	1.00
Age 6	1.00	1.00	1.00	1.00	1.00	1.00

Migration model: 2, Abrupt. Proportion mature: Kattegat

	P 5%	P 10%	P 25%	P 50%	P 75%	P 95%
Age 1	0.05	0.10	0.25	0.50	0.75	0.95
Age 2	0.10	0.18	0.40	0.67	0.86	0.97
Age 3	0.24	0.40	0.66	0.85	0.95	0.99
Age 4	0.57	0.74	0.89	0.96	0.99	1.00
Age 5	1.00	1.00	1.00	1.00	1.00	1.00
Age 6	1.00	1.00	1.00	1.00	1.00	1.00

2.2.3 Migration as free parameters

As a third option, migration parameters at age are also estimated within the model for the two migration models (continuous or abrupt model).

3 Assessment runs

Several runs were made to explore the new SAM model:

1. Default (old) SAM model, with catch scaling 2003-2015.
2. Estimation of one common P (P=proportion Kattegat origin cod at age 1) for all years, no catch scaling
3. Estimation of P values by year, no catch scaling
4. Estimation of P values by year, with catch scaling 2003-2015
5. Estimation of P values by year, with catch scaling 2003-2010
6. Estimation of P values by year, and migration at age parameters with catch scaling 2005-2010

For models with migration, combinations of migration model (M1: continuous migration and M2: Abrupt migration model) and natal homing rate based on either the North Sea or the Kattegat proportion mature.

4 Results

4.1 1. Default (old) SAM model, with catch scaling 2003–2015

The default SAM settings have been changed due to the benchmark and due to changes for quarter 1 surveys. See Annex 1.

4.2 3. Estimation of one common P for all years, no catch scaling

Summary

The estimated proportion Kattegat cod for the juveniles are unrealistically low (5-15%) and other model diagnostics show that this model configuration does not fit adequately to data.

4.2.1 Configuration

This scenario was made using proportion mature from the Kattegat and North Sea stock and the two migration models.

P for juveniles (Pjuv) was estimated using one parameter for all years. P for older ages in the first assessment year (Pold) was given as input. Observation variance for catch observations (CV) was set to 0.09 as estimated in the default SAM run.

4.2.2 Output

The estimated P values for juveniles (Table 5) show an unrealistically low (5-15%) proportion Kattegat cod.

The process noise is very high (Table 6).

Table 5. Estimates of P for the age 1, by migration model and area for proportion mature.

```
2) M:1 Kattegat`
         1997-2015
estimate 0.09
lower    0.02
upper    0.28

3) M:1 North Sea`
         1997-2015
estimate 0.15
lower    0.07
upper    0.29

4) M:2 Kattegat`
         1997-2015
estimate 0.06
lower    0.01
upper    0.38

5) M:2 North Sea`
         1997-2015
estimate 0.05
lower    0.02
upper    0.12
```

Table 6. Process noise log(N) by model configuration.

	Age 1	Age 2+
1) Catch_Scaling	0.85	0.17
2) M:1 Kattegat	0.95	0.46
3) M:1 North Sea	0.95	0.44
4) M:2 Kattegat	0.95	0.47
5) M:2 North Sea	0.95	0.44

4.3 Estimation of P values by year, no catch scaling

Summary

The estimated P values for juveniles show a high proportion Kattegat cod in the beginning of the time series followed by a period (around 2005-2010) with very low proportions and finally a slight increase in proportions. Process noise is (too) high and the pattern of process noise and residuals indicates the more fish are removed than calculated from M, F and migration for the period since 2004.

4.3.1 Configuration

This scenario was made using the North Sea and the Kattegat proportion mature, and the two migration models.

P for juveniles (Pjuv) was estimated for all years except 2015 where Pjuv=0.68 was used (simple mean of 176 observations, see WD: Vinther 2017, "Guestimates of proportion "true" Kattegat cod within the Kattegat management area"). For 2014 Pjuv=0.5 was used as best guess (slightly lower than for the 2015 P value). P for the older ages in the first year (Pold) was given as input. Observation variance for catch observations was fixed.

4.3.2 Output

The estimated P values for juveniles (Table 7 and Figure 1) show a high proportion Kattegat cod in the beginning of the time series followed by a period (around 2005-2010) with very low proportions and finally a slight increase in P. Estimated P values have a large confidence interval and differ considerably between migration model and assumption of return rate.

Catch and survey residuals (Figure 2) show clear year effects for catch at age, and a tendency for large negative residuals (lower than expected catch observations) for catch at ages 5-6 in recent years.

The process noise is generally (too) high (Table 8). Migration rates are based on North Sea proportion mature provides the smallest process noise. Migration model 2 performs better than model 1.

Table 7. Estimates of P for the age 1, by migration model and area for proportion mature

$`2) M:1 Kattegat`

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
estimate	1	0.78	1	0.43	0.28	1	0.21	0.46	0.03	0.04	0.05	0.06	0.24	0.07	0.17	0.31	0.30	0.5	0.68
lower	0	0.00	0	0.04	0.04	NaN	0.03	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.02	0.02	0.01	0.5	0.33
upper	1	1.00	1	0.94	0.80	NaN	0.68	1.00	0.21	0.14	0.19	0.27	0.97	0.28	0.62	0.90	0.95	0.5	0.90

$`3) M:1 North Sea`

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
estimate	1	0.68	1	0.52	0.32	0.65	0.28	0.07	0.09	0.07	0.07	0.13	0.10	0.10	0.30	0.36	0.29	0.5	0.68
lower	0	0.00	0	0.02	0.02	0.00	0.03	0.01	0.02	0.02	0.02	0.03	0.01	0.02	0.05	0.02	0.01	0.5	0.33
upper	1	1.00	1	0.98	0.91	1.00	0.81	0.48	0.35	0.24	0.25	0.44	0.48	0.35	0.79	0.93	0.97	0.5	0.90

$`4) M:2 Kattegat`

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
estimate	1	0.62	1	0.53	1	0.75	1	0.11	0.00	0.01	0.04	0.11	0.01	0.03	0.07	0.08	0.43	0.5	0.68
lower	0	0.00	0	0.01	NaN	0.00	0	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.5	0.33
upper	1	1.00	1	0.99	NaN	1.00	1	0.74	0.38	0.12	0.20	0.56	0.25	0.20	0.52	0.53	1.00	0.5	0.90

$`5) M:2 North Sea`

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
estimate	1	1	1	0.96	1	0.75	1	0.02	0.04	0.01	0.05	0.17	0	0.06	0.14	0.14	0.31	0.5	0.68
lower	0	0	0	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.01	0	0.01	0.01	0.01	0.00	0.5	0.33
upper	1	1	1	1.00	1	1.00	1	0.45	0.29	0.29	0.39	0.79	1	0.37	0.67	0.74	1.00	0.5	0.90

Table 8. Process noise log(N) by model configuration.

	Age 1	Age 2+
1) Catch_Scaling	0.85	0.17
2) M:1 Kattegat	0.88	0.43
3) M:1 North Sea	0.94	0.39
4) M:2 Kattegat	0.95	0.38
5) M:2 North Sea	0.95	0.36

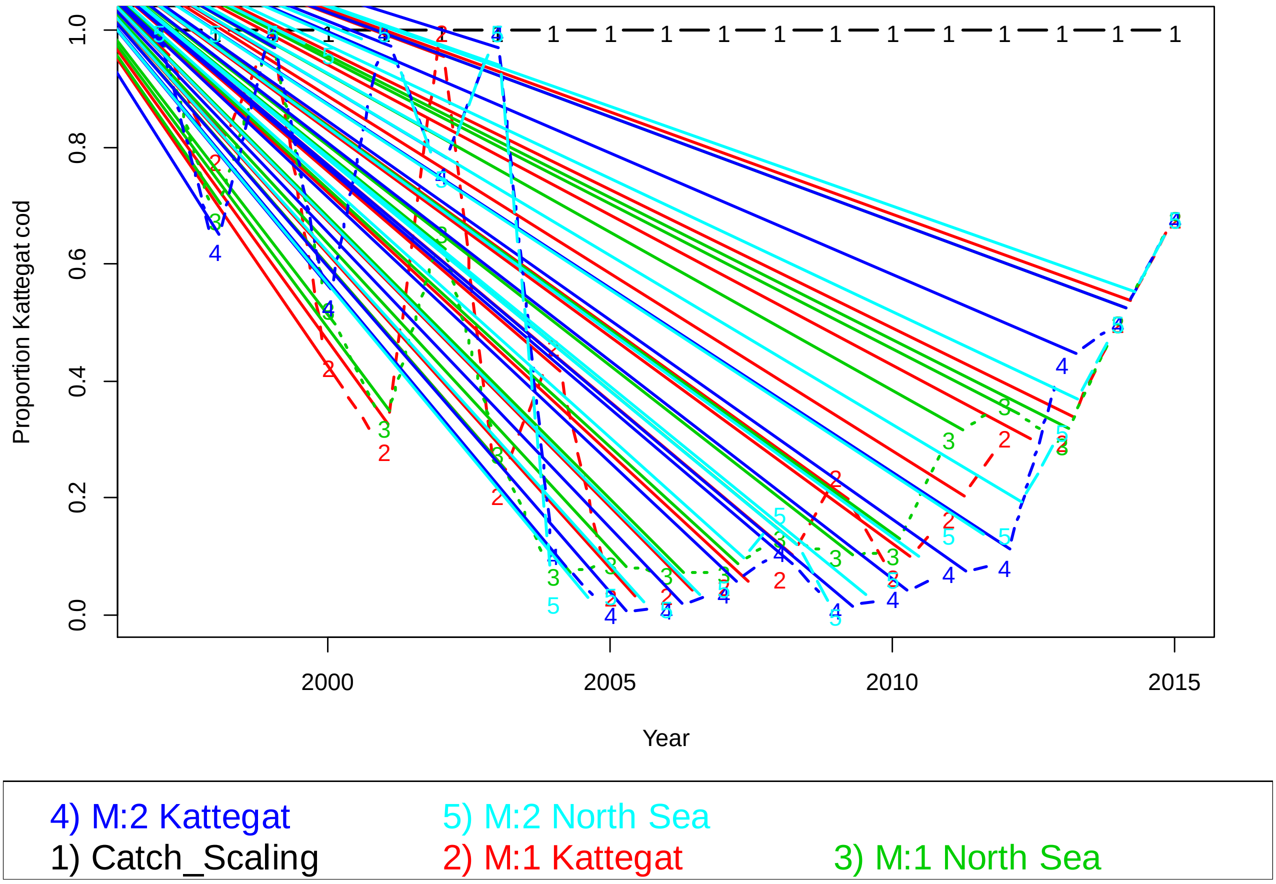

Figure 1. Proportion juveniles with Kattegat origin by year for the run with catch scaling and no migration (model 1) and runs with no catch scaling and migration models (2-5).

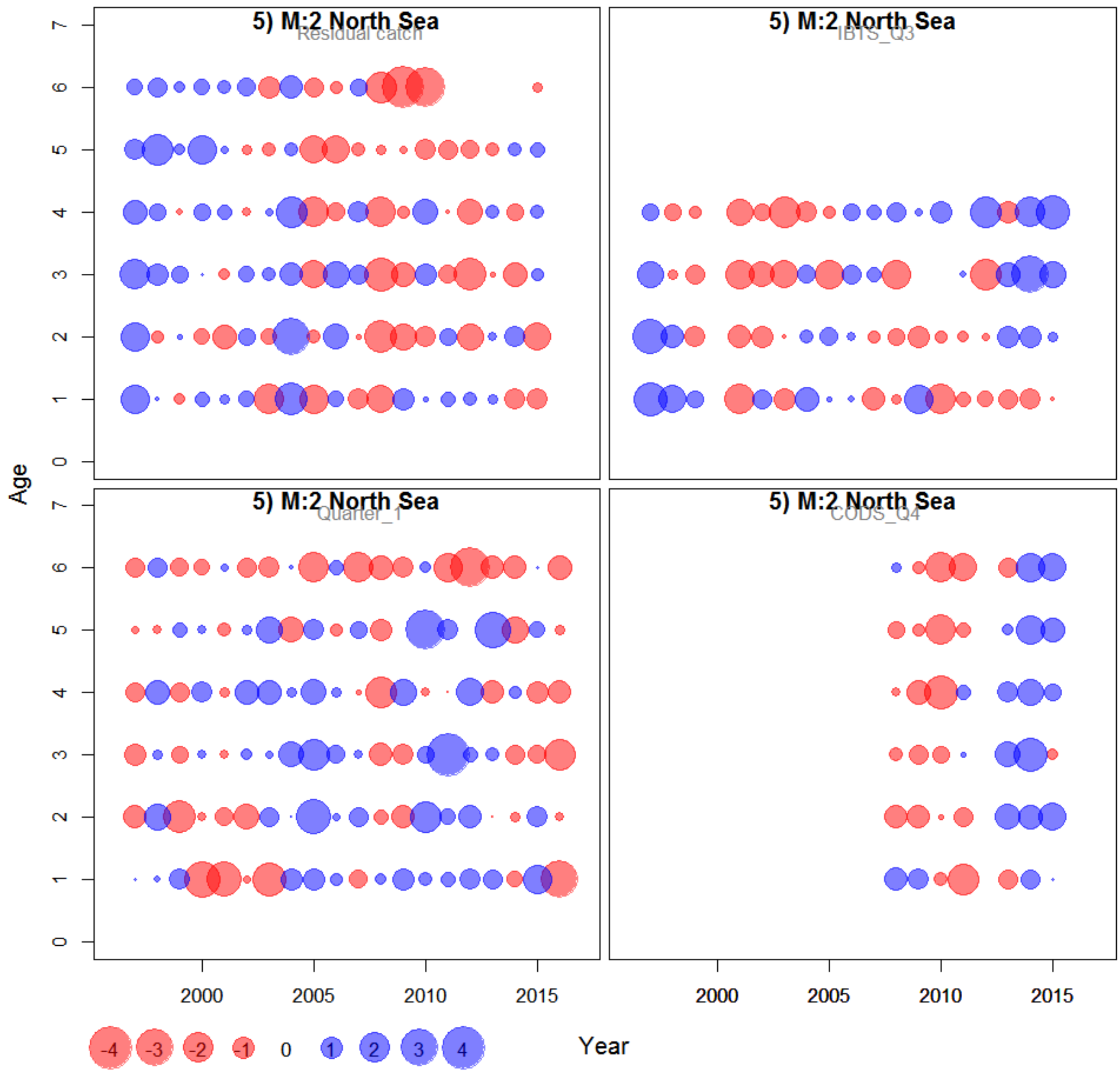

Figure 2. Residuals for model 2 (abrupt migration) based on North Sea proportion mature. Upper left: Catch at age, Upper right: IBTS Q3, Lower left: Combine quarter 1 survey, and Lower right: cod survey. Red "bubbles" show lower observation than expected.

4.4 Estimation of P by year, with catch scaling 2003–2015.

Summary

Models including catch scaling gave the same temporal pattern in proportion Kattegat cod at age 1 as models without catch scaling, but the proportion Kattegat cod increases significantly for the period 2005-2012 for models with scaling. Model fits are better when migration is included in models with catch scaling, but on the cost an increase in number of model parameters. AIC does not improve by including migration. The estimated catch scaling and model outputs are practically the same for catch scaling models with and without migration, but process noise on N is slightly lower for models with migration.

4.4.1 Configuration

Catch scaling was estimated by individual years for the period 2003-2015. P for juveniles (Pjuv) was estimated for all years except for 2015 (Pjuv=0.68) and 2014 (Pjuv=0.5). P for the older ages in the first year (Pold) was given as input. Observation variance for catch observations was fixed.

4.4.2 Output

The log likelihood (Table 9) for runs including migration was better than the likelihood for the default run just using catch scaling. This improvement is however on the cost of an increase in model parameters, such the lowest (best) AIC is obtained by the default run.

Process noise (Table 10) is decreased when migration is included in the model.

The estimate of the proportion Kattegat cod at age 1 (Figure 3) follows the same temporal pattern as for the models without catch scaling (Table 7) but the proportions are much higher when catch scaling are applied.

Totally mortality at age is in general similar for all model runs, however there is some difference for age 1 (Figure 4). Z for age 1 is increasing with time for all models, while Z for older ages is decreasing since 2008. There is practically no difference in model SSB, F and recruitment estimates for the five models (Figure 5).

Table 9. Log likelihood for the models

```
1) CatchScal`
'log Lik.' -291.7119 (df=33)

2) M:1 Kattegat`
'log Lik.' -282.0482 (df=50)

3) M:1 North Sea`
'log Lik.' -284.9088 (df=50)

4) M:2 Kattegat`
'log Lik.' -283.9118 (df=50)

5) M:2 North Sea`
'log Lik.' -285.0103 (df=50)
```

Table 10. Process noise log(N) by model configuration.

	Age 1	Age 2+
1) CatchScal	0.85	0.17
2) M:1 Kattegat	0.81	0.14
3) M:1 North Sea	0.86	0.12
4) M:2 Kattegat	0.88	0.13
5) M:2 North Sea	0.88	0.12

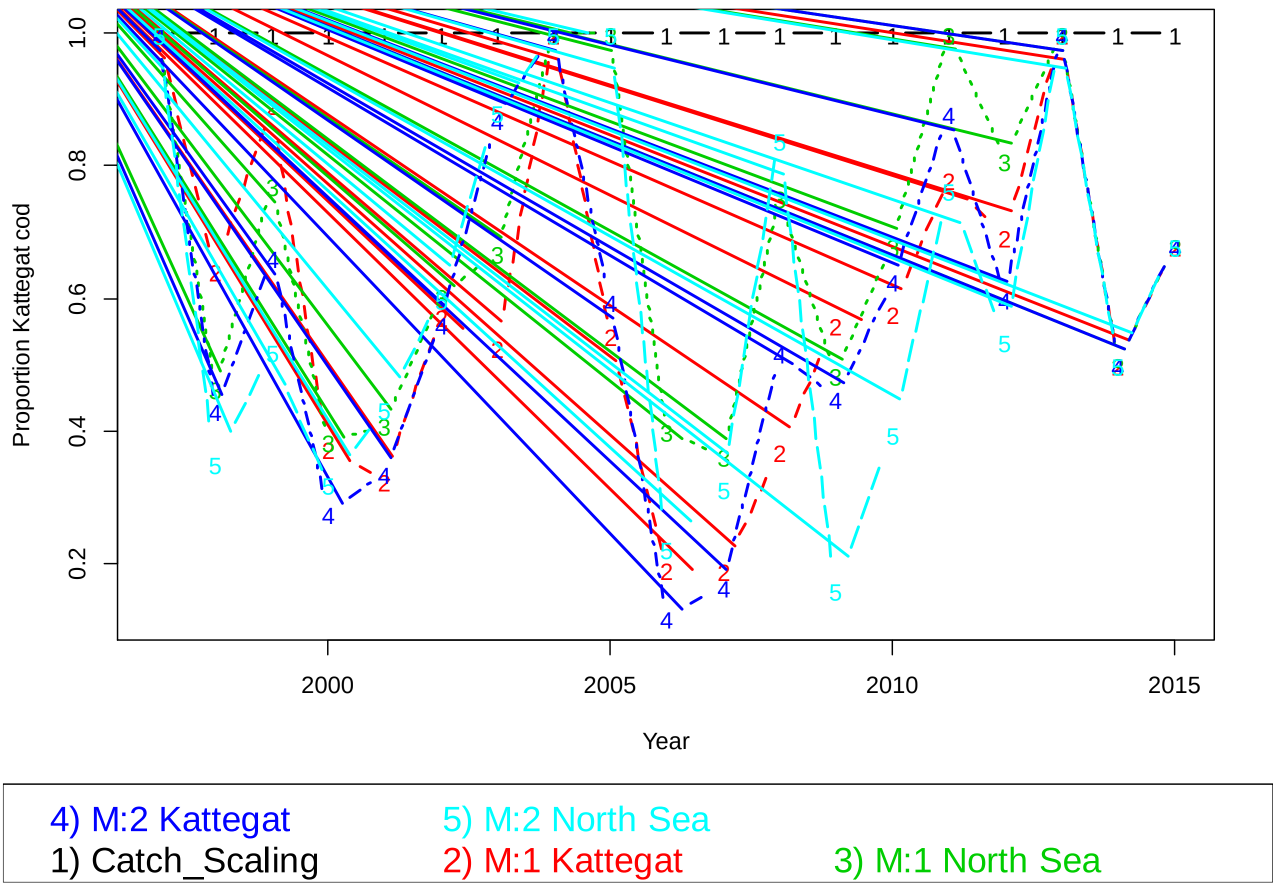

Figure 3. Proportion juveniles with Kattegat origin by year for the run with catch scaling and no migration (model 1) and runs with catch scaling and migration models (2-5).

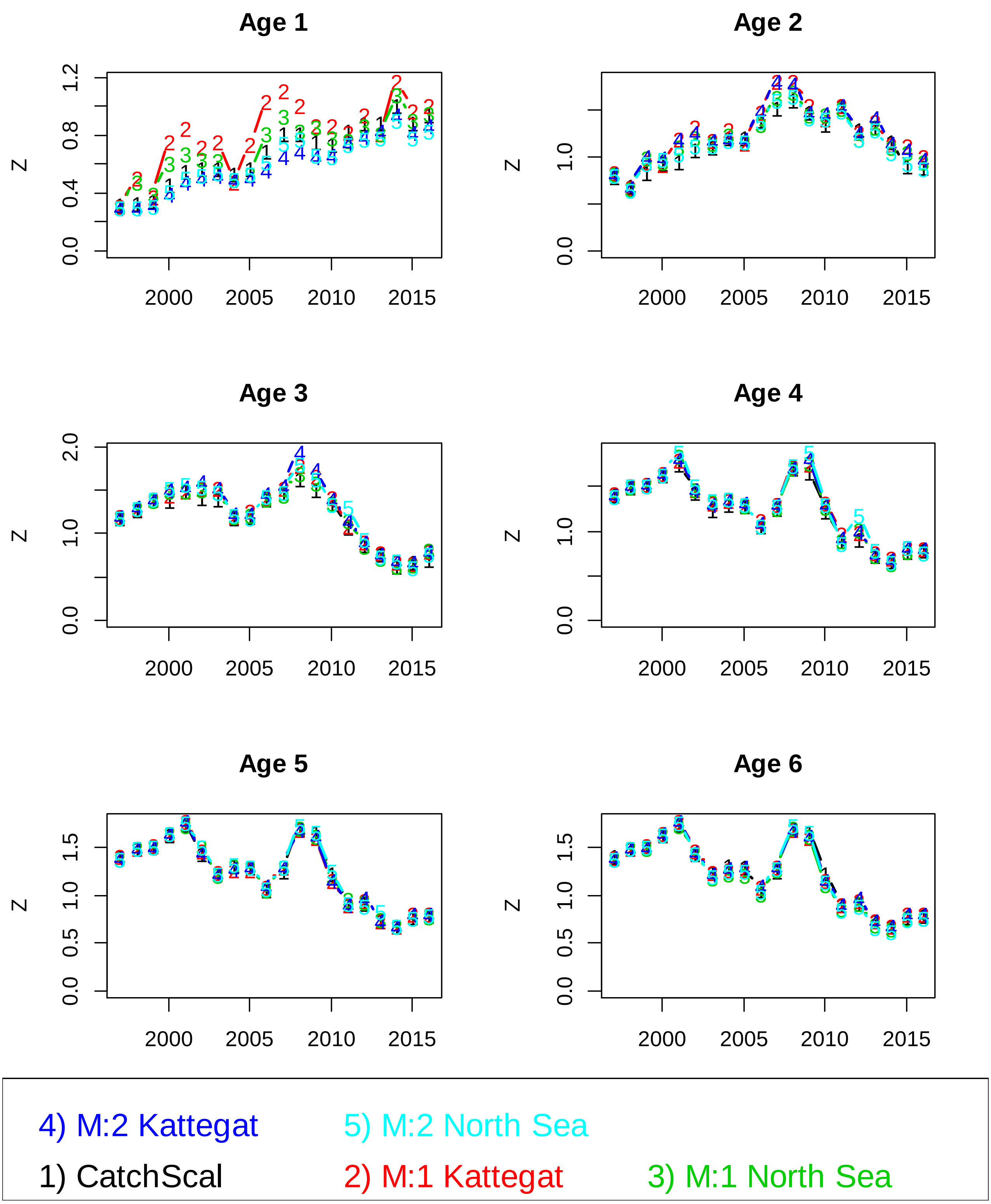

Figure 4. Total motatlity (Z) for run with catch scaling and no migration (model 1) and runs with catch scaling and migration models (2-5).

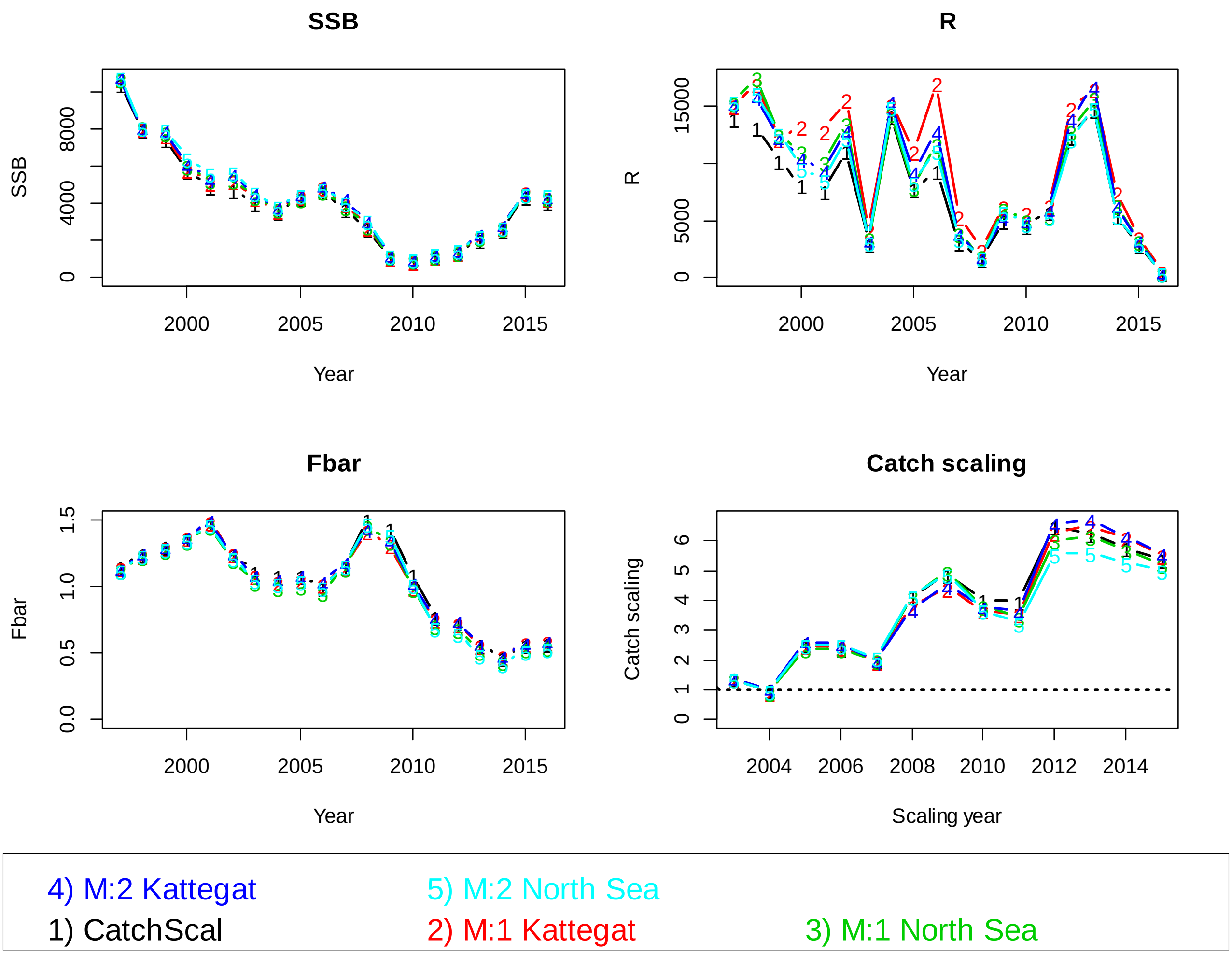

Figure 5. Assessment results for run with catch scaling and no migration (model 1) and runs with catch scaling and migration models (2-5).

4.5 Estimation of P by year, with catch scaling 2003-2010.

At the cod benchmark meeting it was concluded that sampling for catch data was unbiased after 2010, so runs are made catch scaling for just the period 2003-2010.

Catch scaling raises all catch at age by a factor within a year, whereas proportion Kattegat origin at age 1 and the subsequent migration back of the North Sea component follows the cohort. This means that for some years (2003-2010) and ages, both catch scaling and component proportions are estimated, while for other years (2011-2015) only proportions are estimated. The figures below illustrate three configuration of catch scaling end proportions. Upper case P is a parameter to be estimated; while lower case p is derived from P, P* is given by input. Catch scaling is denoted by s, and year -age combinations with both catch scaling and migration are denoted by s and p, e.g. s1P7 (both catch scaling parameter 1 and P parameter 8 are estimated for age 1 in 2013 in the first table).

1) Catch scaling with overlapping estimation of P values

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Age 1	P1	P2	P3	P4	P5	P6	s1P7	s2P8	s3P9	s4P10	s5P11	s6P12	s7P13	s8P14	P15	P16	P17	P18*	P19*
Age 2		p1	p2	p3	p4	p5	s1p6	s2p7	s3p8	s4p9	s5p10	s6p11	s7p12	s8p13	p14	p15	p16	p17	p18*
Age 3			p1	p2	p3	p4	s1p5	s2p6	s3p7	s4p8	s5p9	s6p10	s7p11	s8p12	p13	p14	p15	p16	p17
Age 4				p1	p2	p3	s1p4	s2p5	s3p6	s4p7	s5p8	s6p9	s7p10	s8p11	p12	p13	p14	p15	p16
Age 5					p1	p2	s1p3	s2p4	s3p5	s4p6	s5p7	s6p8	s7p9	s8p10	p11	p12	p13	p14	p15
Age 6						p1	s1p2	s2p3	s3p4	s4p5	s5p6	s6p7	s7p8	s8p9	p10	p11	p12	p13	p14

2) Catch scaling with partly overlapping estimation of P values.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Age 1	P1	P2	P3	P4	P5	P6	s1P7	s2P8	s3P9	P10	P11	P12	P13	P14	P15	P16	P17	P18*	P19*
Age 2		p1	p2	p3	p4	p5	s1p6	s2p7	s3p8	s4p9	p10	p11	p12	p13	p14	p15	p16	p17	p18*
Age 3			p1	p2	p3	p4	s1p5	s2p6	s3p7	s4p8	s4p9	p10	p11	p12	p13	p14	p15	p16	p17
Age 4				p1	p2	p3	s1p4	s2p5	s3p6	s4p7	s5p8	s6p9	p10	p11	p12	p13	p14	p15	p16
Age 5					p1	p2	s1p3	s2p4	s3p5	s4p6	s5p7	s6p8	s7p9	p10	p11	p12	p13	p14	p15
Age 6						p1	s1p2	s2p3	s3p4	s4p5	s5p6	s6p7	s7p8	s8p9	p10	p11	p12	p13	p14

3) Catch scaling with no overlapping estimation of P values.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Age 1	P1	P2	P3	P4	P5	P6	s1	s2	s3	P10	P11	P12	P13	P14	P15	P16	P17	P18*	P19*
Age 2		p1	p2	p3	p4	p5	s1	s2	s3	s4	p10	p11	p12	p13	p14	p15	p16	p17	p18*
Age 3			p1	p2	p3	p4	s1	s2	s3	s4	s5	p10	p11	p12	p13	p14	p15	p16	p17
Age 4				p1	p2	p3	s1	s2	s3	s4	s5	s6	p10	p11	p12	p13	p14	p15	p16
Age 5					p1	p2	s1	s2	s3	s4	s5	s6	s7	p10	p11	p12	p13	p14	p15
Age 6						p1	s1	s2	s3	s4	s5	s6	s7	s8	p10	p11	p12	p13	p14

Runs for the combinations were made.

4.5.1 Catch scaling with overlapping estimation of P values

Summary

Shortening the period for catch scaling from 2003-2015 to 2003-2010 did not improve the model fit. With catch scaling 2003-2010, the estimated proportion Kattegat juveniles becomes quite similar to the proportions estimated when there is no catch scaling and migration.

4.5.1.1 Configuration

Catch scaling was estimated by individual years for the period 2003-2010. P for juveniles (Pjuv) was estimated for all years except for 2015 (Pjuv=0.68) and 2014 (Pjuv=0.5). P for the older ages in the first year (Pold) was given as input. Observation variance for catch observations was fixed.

4.5.1.2 Output

Log likelihood for runs including migration and catch scaling 2003-2010 were poorer than for the run including catch scaling 2003-2015 and no migration. Process noise is however lower (Table 11).

The estimate of the proportion Kattegat cod at age 1 (Figure 6) follows roughly the same temporal pattern as for the models without catch scaling (Figure 1) but the proportions are slightly higher when catch scaling are applied.

There is practically no difference in model SSB and F for the five models (Figure 7), but recruitment is higher for the run without migration. Catch scaling for the models that include migration is lower than for the default model.

Table 11. Process noise log(N) by model configuration.

	Age 1	Age 2+
1) CatchScal	0.85	0.17
2) M:1 Kattegat	0.77	0.12
3) M:1 North Sea	0.80	0.12
4) M:2 Kattegat	0.85	0.14
5) M:2 North Sea	0.84	0.12

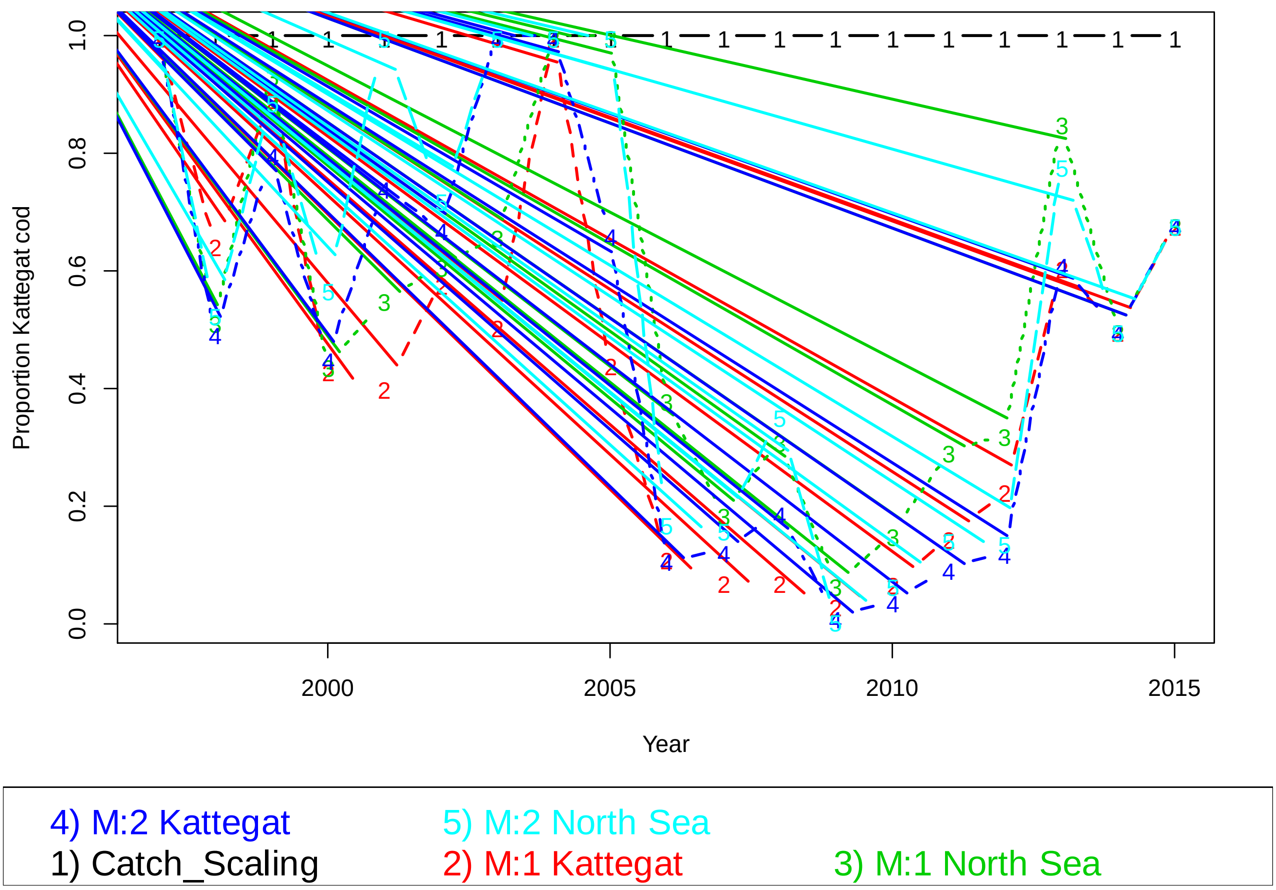

Figure 6. Proportion juveniles with Kattegat origin by year for the run with catch scaling 2003-2015 and no migration (model 1) and runs with catch scaling 2003-2010 and migration models (2-5).

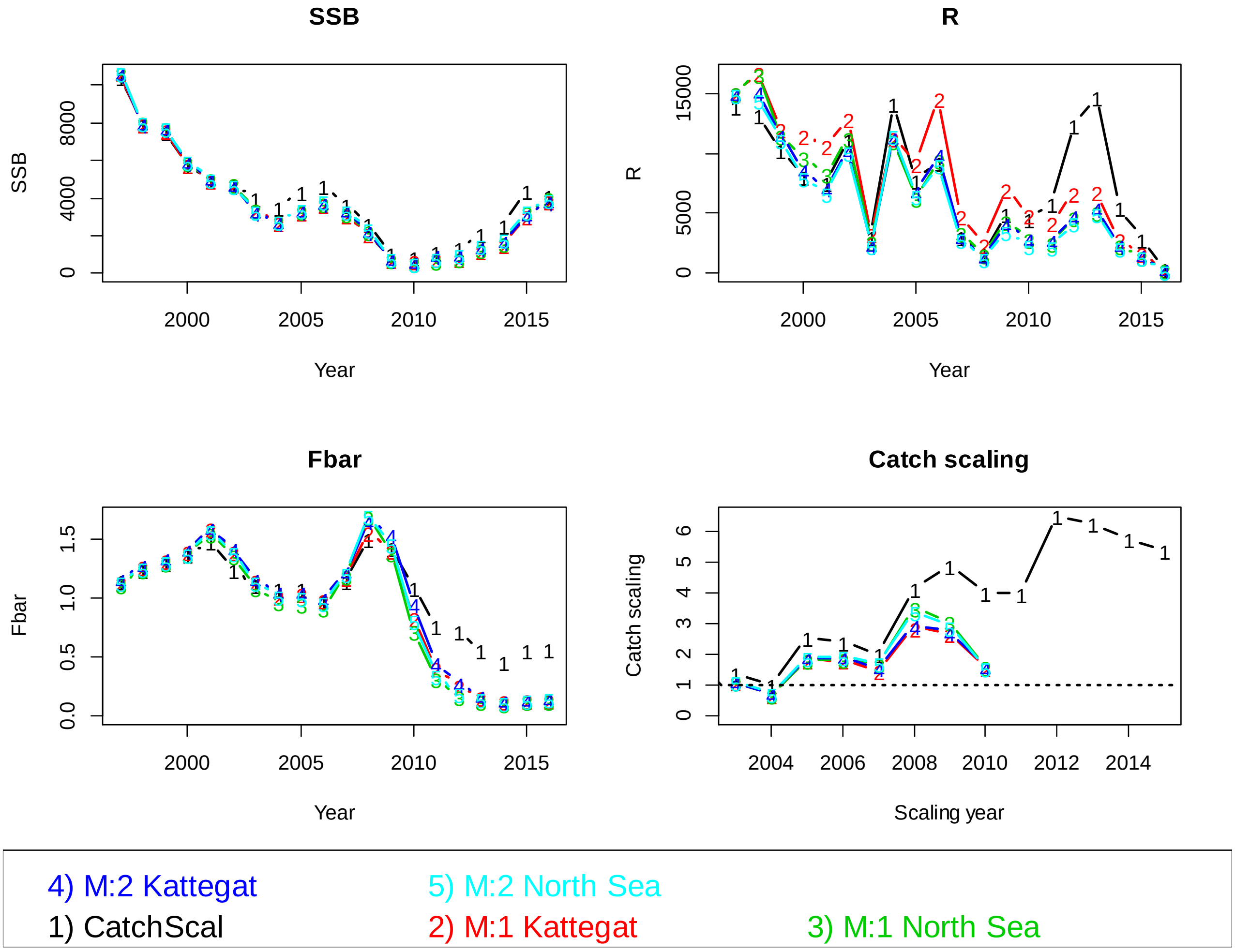

Figure 7. Assessment summary for the run with catch scaling 2003-2015 and no migration (model 1) and runs with catch scaling 2003-2010 and migration models (2-5).

4.5.2 Catch scaling with partly overlapping estimation of P values

Summary

This option did not improve the model fit compared to the run with full overlap of catch scaling and migration.

4.5.3 Catch scaling with no overlapping estimation of P values

Summary

This option did not improve the model fit compared to the run with full overlap of catch scaling and migration.

4.5.4 Comparison of results

The results for the three options for combining migration with catch scaling for the period 2003-2010 are just shown for the abrupt migration model using North Sea proportion mature. The other model configurations showed the same picture.

Option 1 (full overlap between catch scaling and migration) showed the best likelihood and AIC. Assessment results (Figure 17) are practically the same for the three options

Table 12. Log likelihood and AIC for the three options

```
1) full overlap`
'log Lik.' -305.5133 (df=46)

2) partly overlap`
'log Lik.' -318.4777 (df=44)

3) no overlap`
'log Lik.' -321.2389 (df=40)

AIC
1) full overlap`
703.0266

2) partly overlap`
724.9554

3) no overlap`
722.4778
```

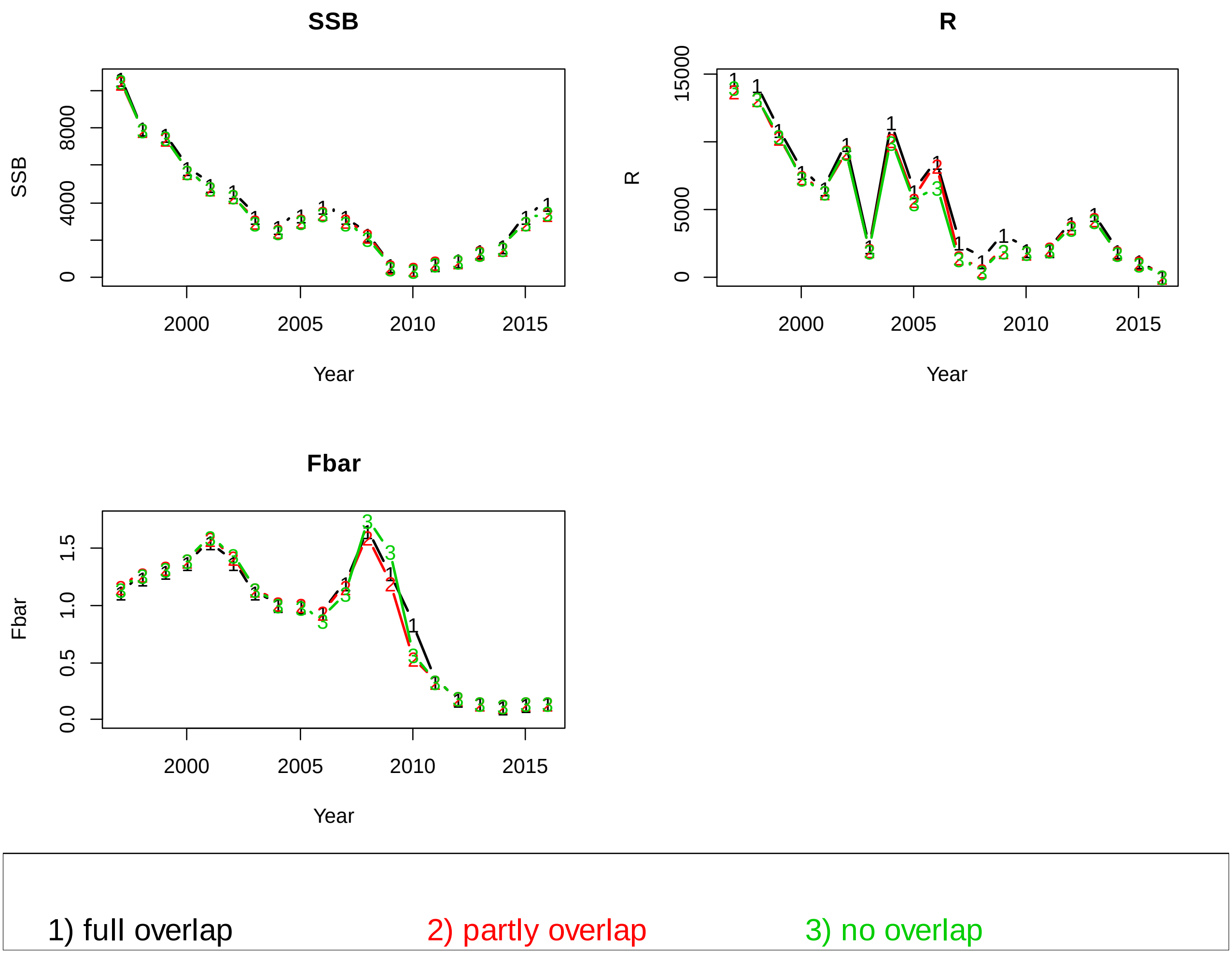

Figure 8.Assessment results for the three options

4.6 Estimation of P values by year, and migration at age parameters with catch scaling 2005-2010

Summary

When migration at age is estimated as free model parameters, it is possible to estimate the parameters for ages 2-4, while migration from the youngest and oldest age must be given as input. The model performance and model results are very similar to the runs where migration parameters are determined by proportion mature.

4.6.1 Configuration

This scenario was made using the abrupt migration model.

Catch scaling was estimated by individual years for the period 2005-2010. P for juveniles (Pjuv) was estimated for all years except for 2015 (Pjuv=0.68) and 2014 (Pjuv=0.5). P for the older ages in the first year (Pold) was given as input. Observation variance for catch observations was fixed.

The migration at age parameters (LL_a) were estimated as free parameters, however LL at age 1 (1) and LL at age 6 (0.0001) were given as input based on the LL values estimated by proportion mature. LL at age 5 was also given as input (0.3), based on the LL values estimated from proportion mature for the Kattegat (0) and the North Sea (0.35), and some initial trial run runs. That leaves the LL at ages 2-4 as free parameters.

Observation variance for catch observations was fixed.

4.6.2 Output

Process noise for log(N) was estimated to 0.13. Catch and survey residuals (Figure 9) show some "year effects"in the surveys and some very large residuals in general.

Migration parameters (Table 13) are estimated with a wide confidence interval, but estimates are close the values estimated from proportion mature (Table 3).

Z at ages (Figure 10) show the same pattern as for the run where migration parameters were given as input. For age 1, Z has been decreasing since 2007 when migration is included, while increasing over the full assessment period for the run with just catch scaling. Estimates of Z without catch data (Benchmark WD: Analysis of fishing impact from VMS, gears and stock distribution) shows a decrease since 2007. This indicates that catch scaling, which operates for all ages, raise the catch numbers of age 1 too much.

Assessment results (Figure 11) are very similar to the results from the run using abrupt migration and migration parameters bases on proportion mature in the North Sea.

Table 13. Estimated migration parameters (LL). Values without confidence bounds are given as input.

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
estimate	1	0.52	0.60	0.32	0.30	0
lower		0.28	0.25	0.09		
upper		0.98	1.41	1.16		

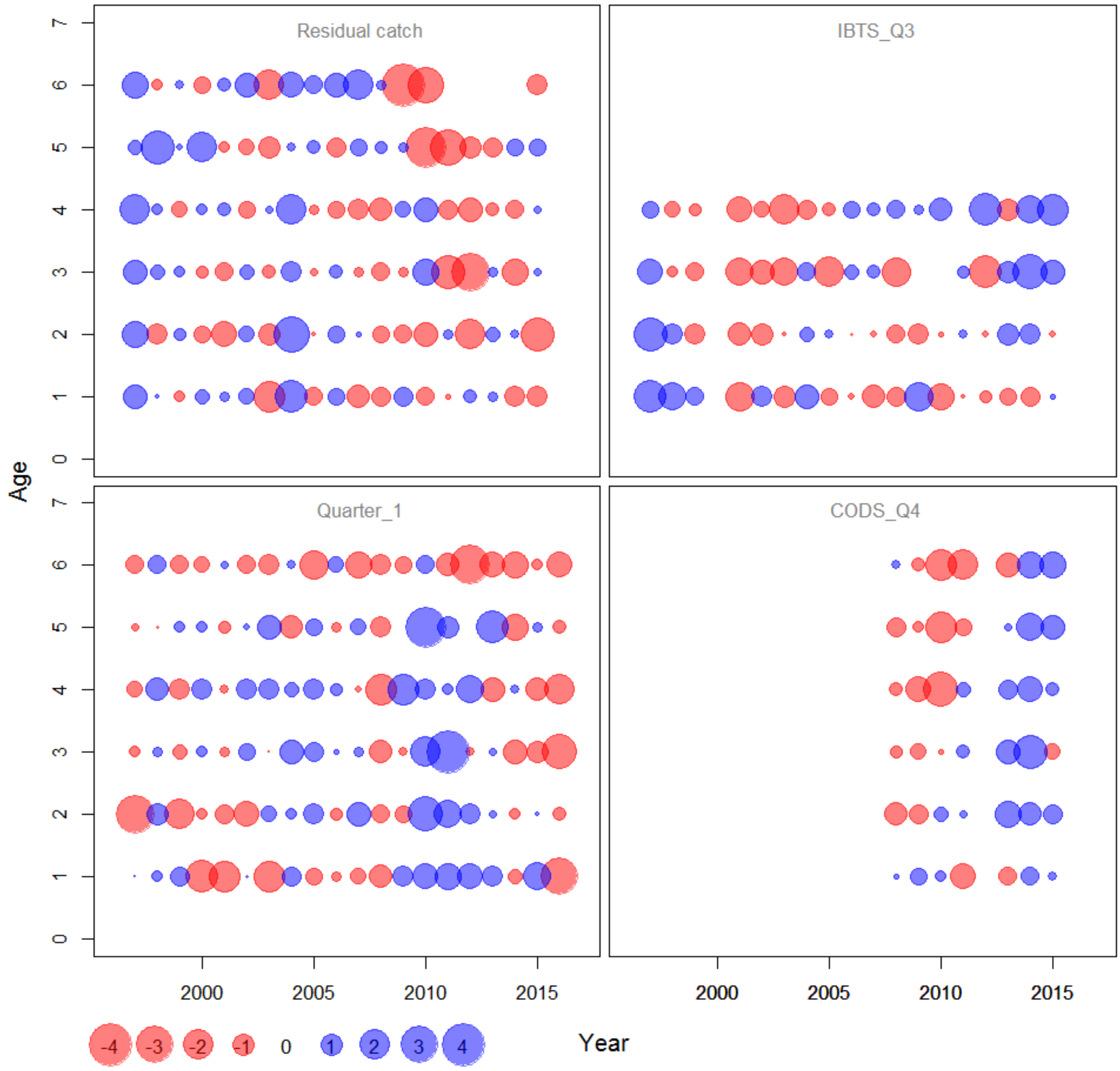

Figure 9. Catch and survey residuals

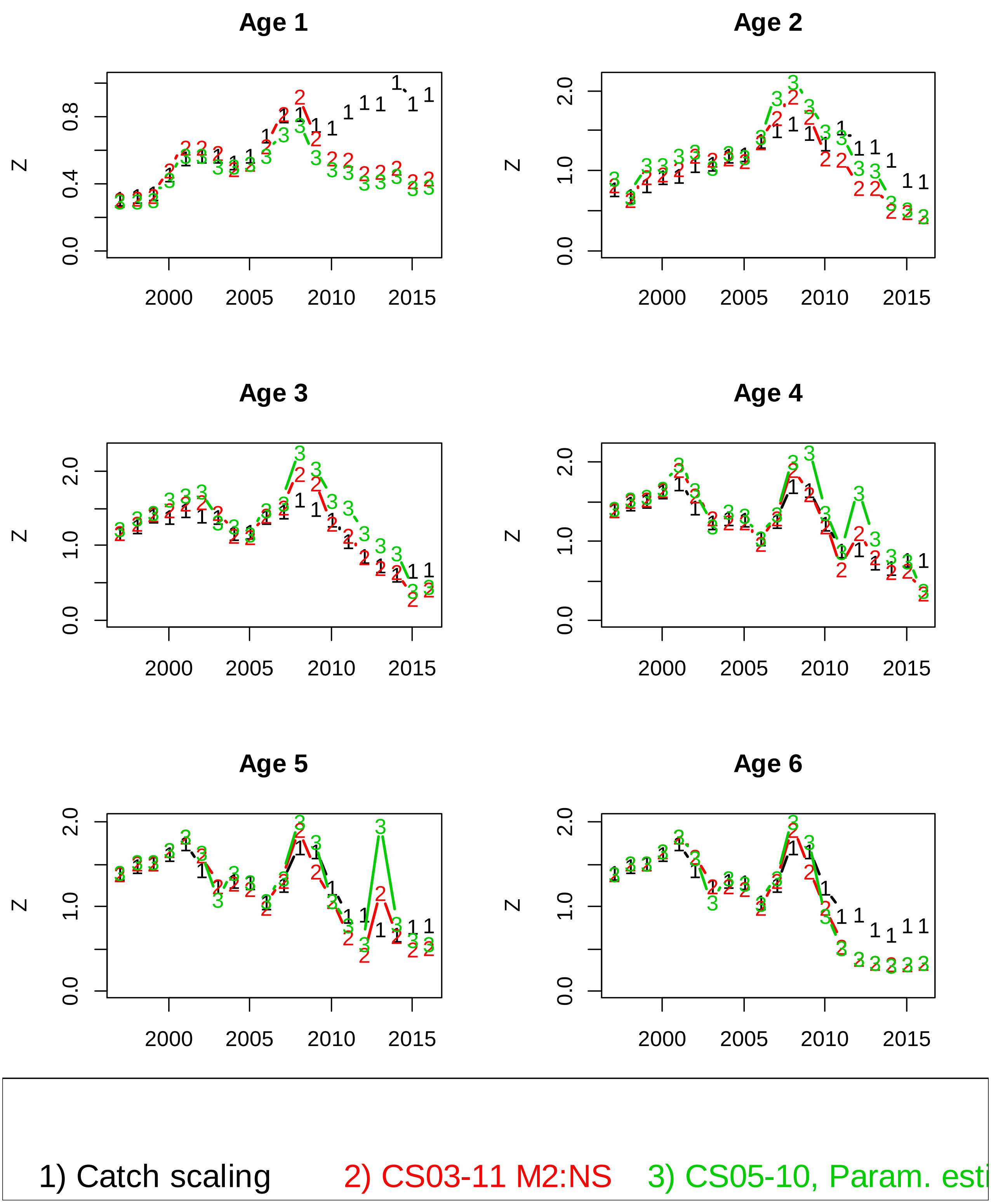

Figure 10. Estimated Z for the run with 1) catch scaling (2003-2015) only, 2) catch scaling 2003-2011 and abrupt migration bases on the North Sea proportion mature and 3) catch scaling 2005-2010, abrupt migration and migration estimated as model parameters. Please note that mortality due to the abrupt migration is not included in Z.

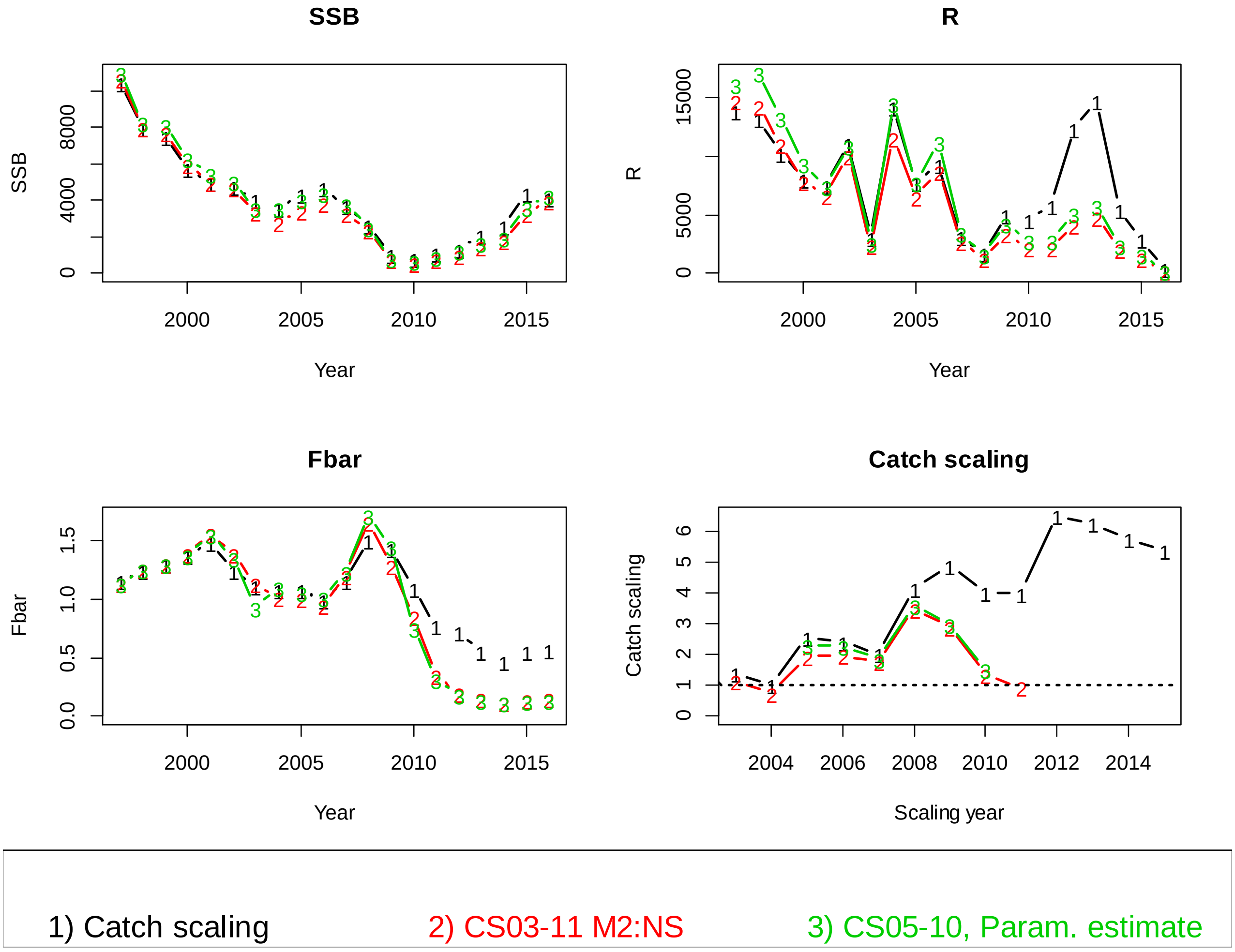

Figure 11. Assessment results runs with 1) catch scaling (2003-2015) only, 2) catch scaling 2003-2011 and abrupt migration bases on the North Sea proportion mature and 3) catch scaling 2005-2010, abrupt migration and migration estimated as model parameters.

4.7 Comparison of runs

The results for five runs are compared

1. Catch scaling 2003-15, no migration
2. No catch scaling, no migration
3. Catch scaling 2003-2015, migration by year
4. Catch scaling 2003-2011, migration by year
5. Catch scaling 2005-2010, migration (estimated parameter) by year

The runs compared use abrupt migration (run 3-5) and migrations from North Sea proportion mature (run 3-5).

The statistical model fit is best for the run using catch scaling 2003-2015 and no migration (Table 14). Using catch scaling 2003-2015 and migration (run 3) improves the log likelihood but on the cost of number of parameters, such that the AIC is worse for run 2. A shorter period for catch scaling and migration (run 3-5), gives a poorer log likelihood and AIC, but also a lower (better) process noise for age 2+ (Table 15).

The assessment results (Figure 12) have all the same trend in recruitment, SSB and mean F, but the levels of recruitment and mean F is higher when catch scaling for 2003-2015 (run 1 and 3) is use.

A more detailed looking at mean F (Figure 13) shows that F in the most recent years is slightly lower when migration is included (run 1) for the two runs with catch scaling 2003-2015. With a shorter period for catch scaling (run 4-5) F is substantially lower in most recent years. Recruitment (Figure 14) by run is grouped in the same way as for mean F, where runs 1&3, and runs 4&5 show similar values. All the runs, except the run with no catch scaling (run 2) show a quite similar development in SSB over time (Figure 15), even though run 1 is most similar to run 3, and runs 4 most similar to run 5.

Given the assumption that catch scaling is entirely due to natal homing migration the proportion of "unallocated morality" that is due to fishing can be calculated (Figure 16). This estimate of F shows a low (<=0.16) F for 2014 and 2015 for all runs, where the highest F is the one estimated without catch scaling (run 2).

Table 14. Model performance by run

Run	logLik	df	AIC
1) CS 2003-15	-291.7	33	649
2) No CS	-350.3	21	743
3) CS 2003-15 mig	-285.0	50	670
4) CS 2003-11 mig	-305.5	46	703
5) CS 2005-10 mig free	-312.0	46	716

Table 15. Process noise log(N) by run

Run	Age 1	Age 2+
1) CS 2003-15	0.85	0.17
2) No CS	0.93	0.48
3) CS 2003-15 mig	0.88	0.12
4) CS 2003-11 mig	0.84	0.12
5) CS 2005-10 mig free	0.87	0.13

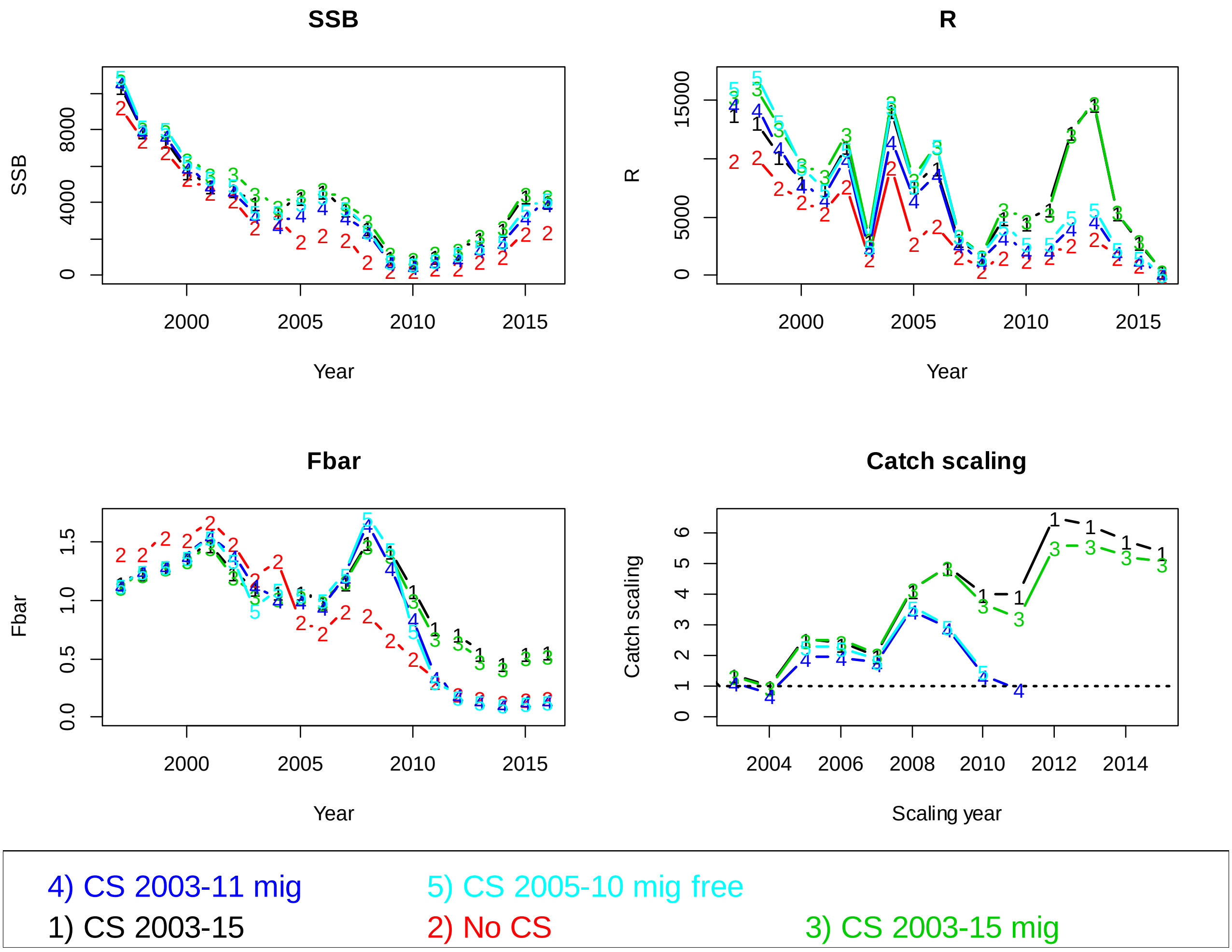

Figure 12. Assessment results

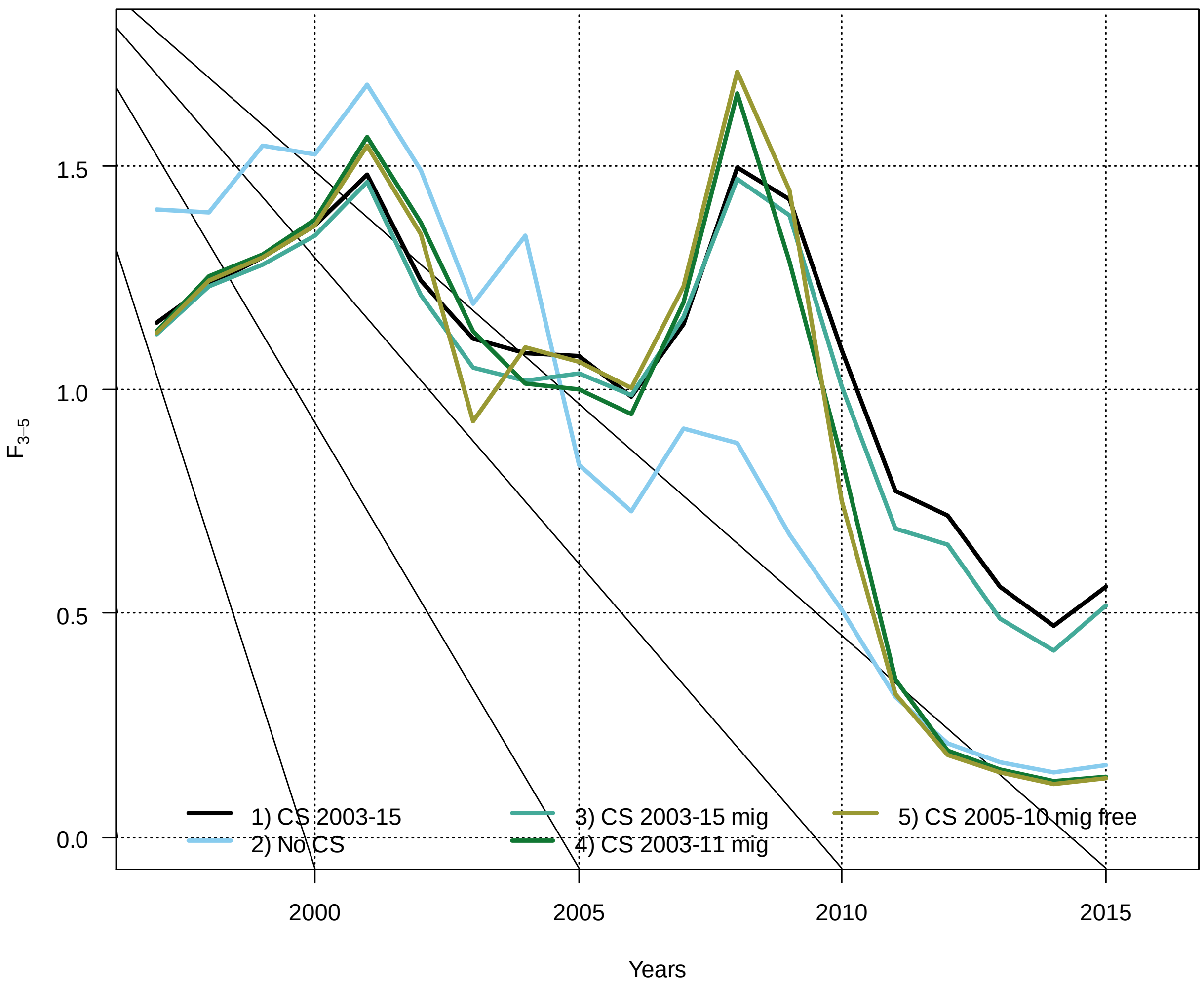

Figure 13. Assessment results, mean F age 3-5

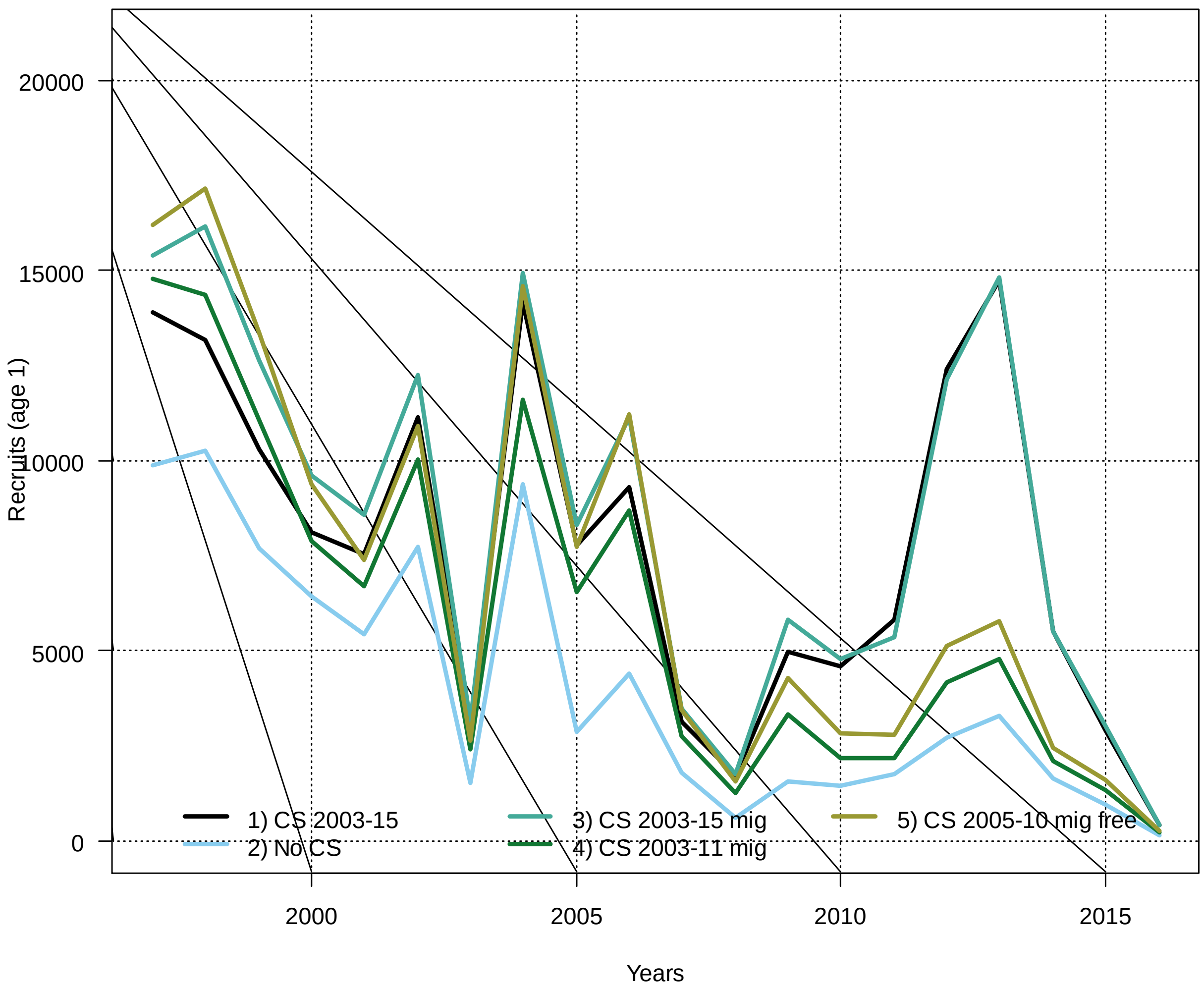

Figure 14. Assessment results, Recruitment in thousands

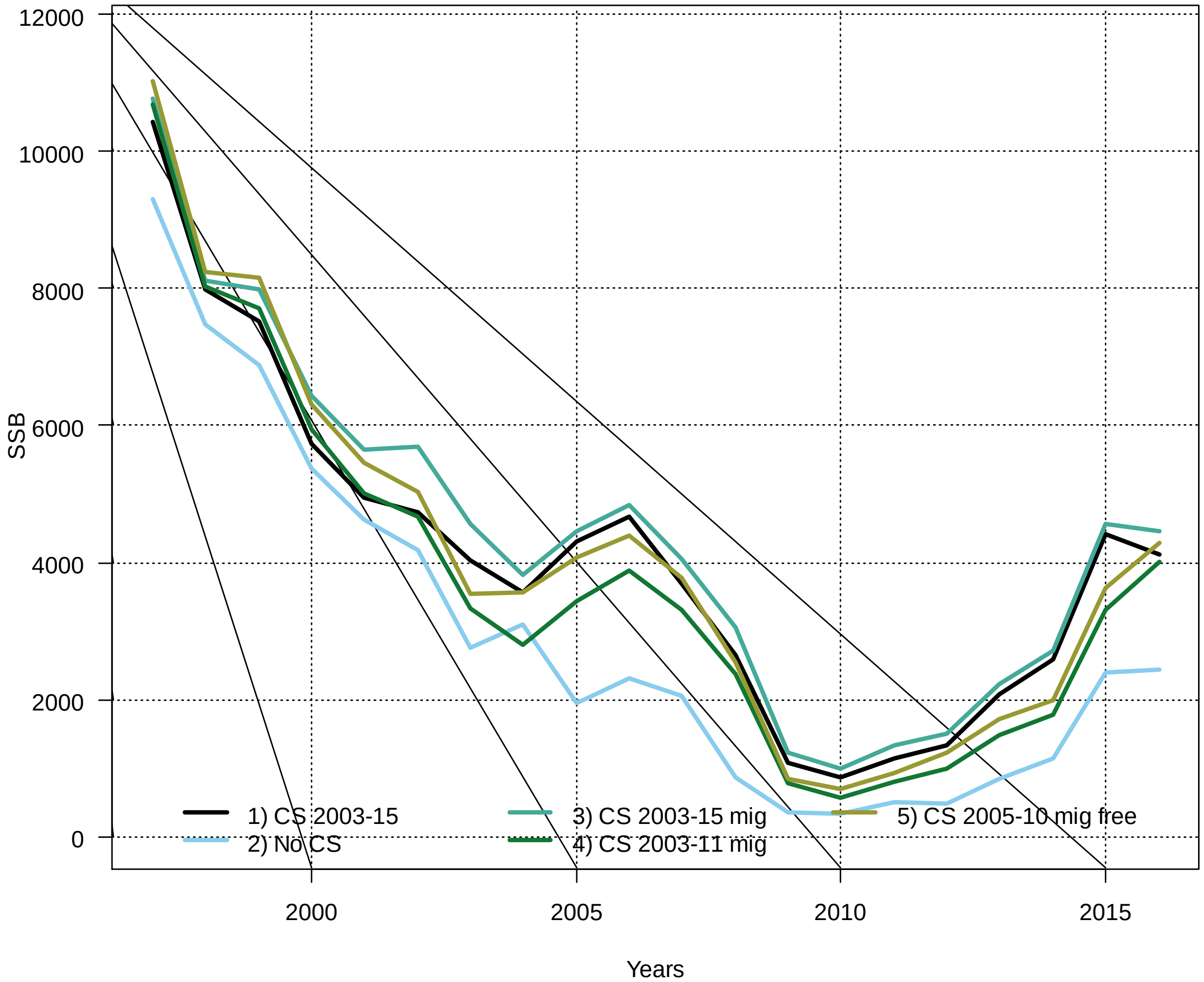

Figure 15. Assessment results, SSB in tonnes.

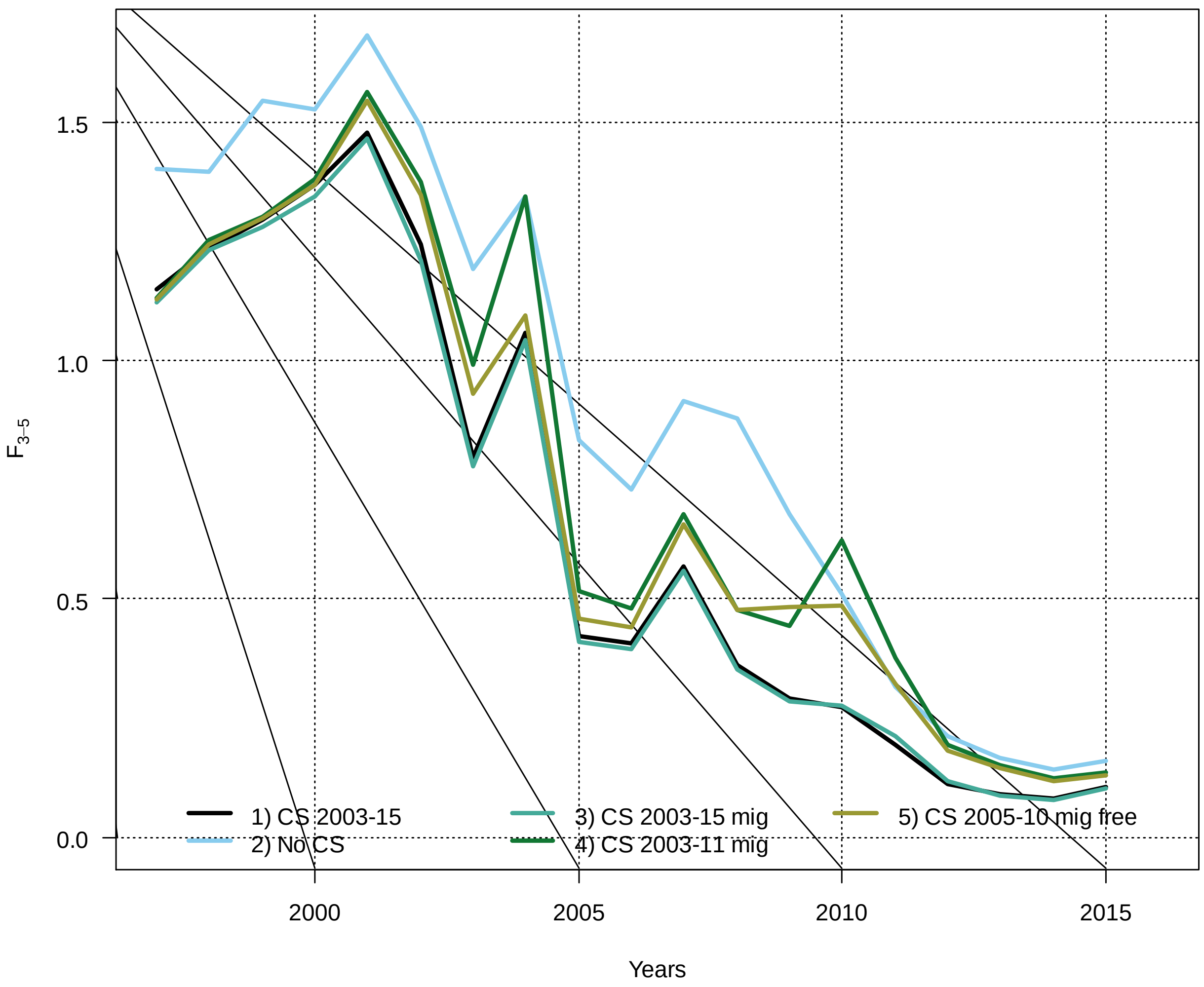

Figure 16. Asssessment results, mean F at age 3-5 where F has been reduced by the catch scaling factor with the assumption that catch scaling is entirely due to natal homing migration.

5 Discussion

6 Annex

Use of combined survey indices

At the benchmark meeting it was concluded not to use the quarter 4 BITS survey. Based on the internal consistency, it was also concluded that there was a limited gain by combining the surveys within a quarter using a GAM approach (see benchmarkWD: Vinther 2016. Survey indices for Cod in the Kattegat). The performance of the combined surveys was however not tested with use of the assessment model.

In this Annex, the performance of the combined, IBTS and BITS quarter 1 surveys, indices are tested within the default SAM model (with catch scaling 2003-2015). Three combinations of survey indices are used:

1. Default, pre benchmark surveys: IBTS Q1, BITS Q1, IBTS Q3, Cod survey Q4 and BITS Q4.
2. As default, but without BITS Q4
3. Combined Q1 (IBTS Q1 and BITS Q1), IBTS Q3 and cod survey Q4

Results

The pre-benchmark assessment has an unrealistically low (0.07) observation variance for catches and high observation variance for surveys (Table 16). Most of the information from surveys comes from the Cod survey, ages 1-3. Removing the BITS Q4 (run 2) does not change that result much. When the combined quarter 1 survey is used (run 3), the combined Q1 survey get a lower observation variance than any of the surveys (IBTS Q1 and BITS Q1) that contributes to the combined indices. Catch observation variance increases slightly (to a more realistic value), probably as an effect of the better fit to survey observations.

Table 16. Observation Variance

1) pre-benchmark`

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
Catch	0.07	0.07	0.07	0.07	0.07	0.07
BITS_Q4	0.85	0.81	0.81	NA	NA	NA
BITS_Q1	0.63	0.72	0.72	NA	NA	NA
IBTS Q1	0.97	0.79	0.79	0.60	0.60	0.60
IBTS_Q3	0.92	0.87	0.87	0.87	NA	NA
CODS_Q4	0.42	0.42	0.42	0.87	0.87	0.87

2) excl BITS Q4`

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
Catch	0.07	0.07	0.07	0.07	0.07	0.07
BITS_Q1	0.63	0.74	0.74	NA	NA	NA
IBTS_Q1	0.96	0.78	0.78	0.59	0.59	0.59
IBTS_Q3	0.91	0.88	0.88	0.88	NA	NA
CODS_Q4	0.35	0.35	0.73	0.73	0.91	0.91

3) Q1 combined`

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
Catch	0.10	0.10	0.10	0.10	0.10	0.10
Quarter_1	0.49	0.49	0.49	0.44	0.44	0.44
IBTS_Q3	0.89	0.93	0.93	0.93	NA	NA
CODS_Q4	0.40	0.40	0.98	0.98	1.13	1.13

Process noise for age 2+ (Table 17) is smallest for the combined Q1 indices.

Table 17. Process noise

	Age 1	Age 2+
1) pre-benchmark	0.88	0.19
2) excl BITS Q4	0.87	0.19
3) Q1 combined	0.84	0.17

Excluding the BITS Q4 has a limited effect on the assessment results (Figure 17), due to its high observation variance and thereby limited weight in the assessment. The combined Q1 survey assessment gives a considerable higher F and lower SSB in recent years. Despite the higher F the catch scaling factors are lower in recent years for the combined Q1 survey assessment.

The lower SSB in the run with combined Q1 survey is probably due to the higher weight (lower variance) on quarter 1 surveys and slightly lower weight (higher variance) on the Cod survey. Both surveys show a steep increase in indices in recent years (Figure 18), but the increase in indices from the Cod survey is highest, especially at age 5+.

Based on the lower observation variance for surveys in general, and lower CV on SSB (Figure 19), it is concluded that the assessment using the combined Q1 survey performs better than an assessment using the two individual quarter 1 surveys.

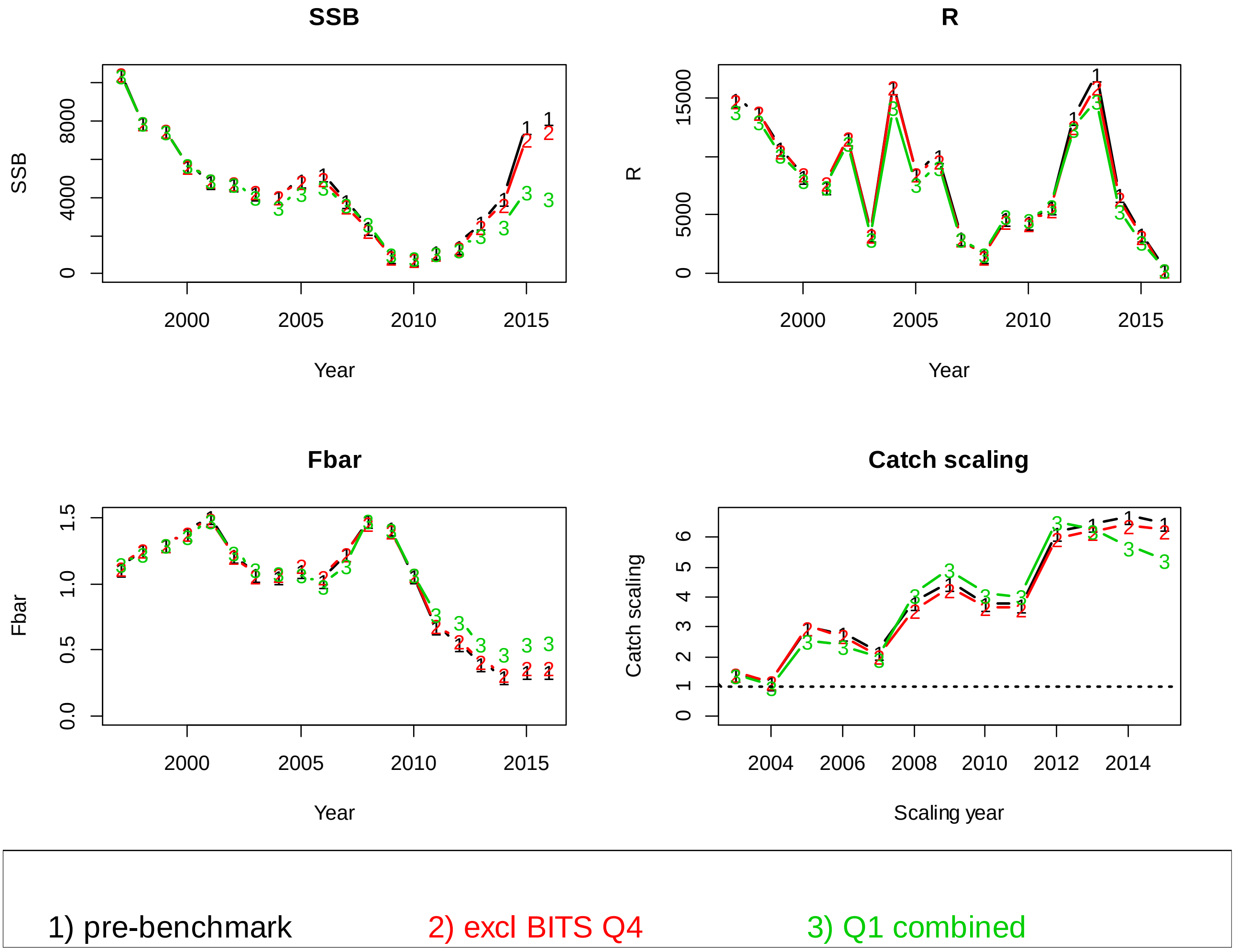

Figure 17. Assessment results using three different set of survey indices.

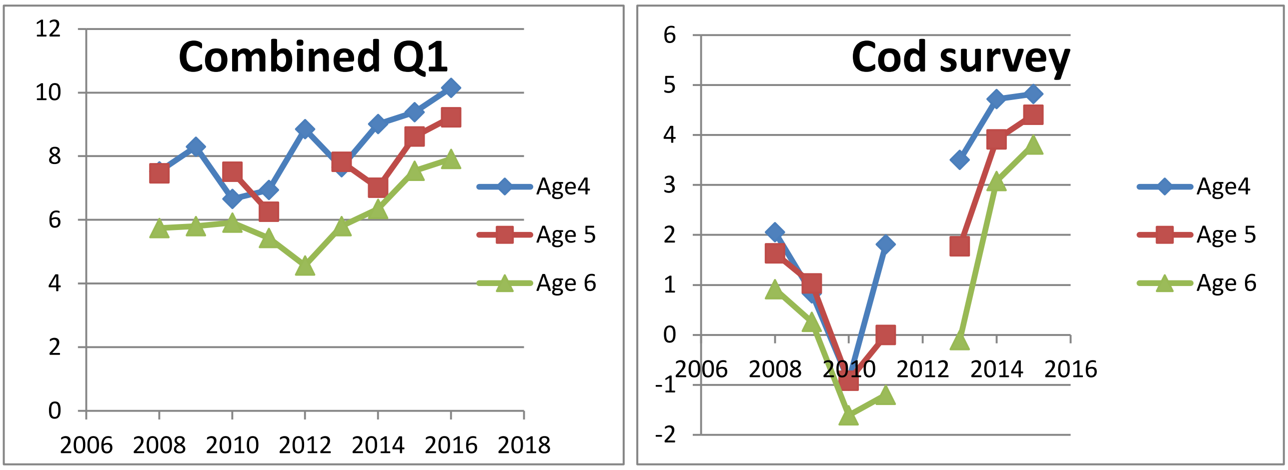

Figure 18. log(survey indices) by age and survey

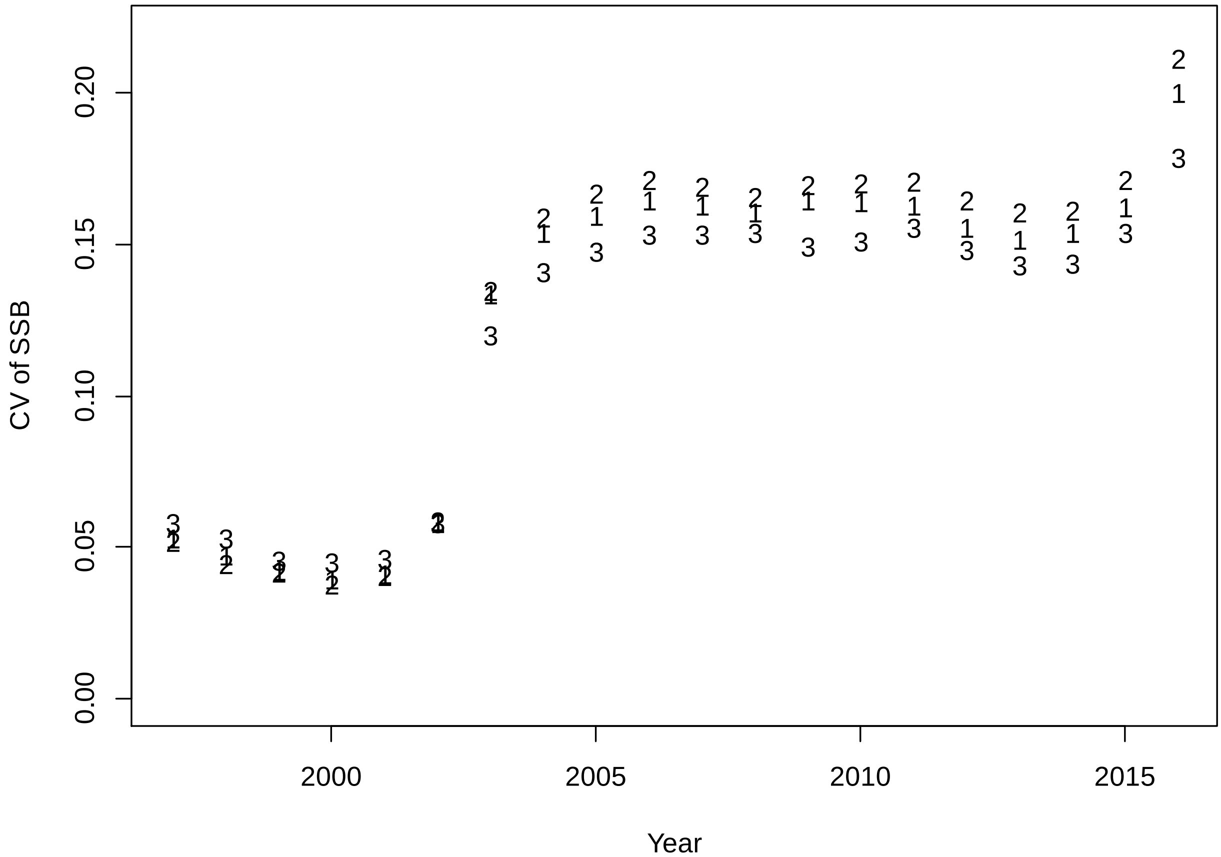

Figure 19. CV of SSB by survey combination and year. (see Figure 17 for figure legends)

Working Document 06 to ICES WGBFAS 2017

Estimating proxy reference points for cod in the Kattegat using SPICT model

by Margit Eero

Survey data

The fraction of the population in terms of age/size used to represent biomass trends should correspond to the fraction represented in commercial catches. At first step, survey indices in numbers at age as used in the SAM assessment were converted to biomass at age, using mean weight at age in the stock. Catch numbers at age were converted to biomass at age, using mean weight in the stock from age 2 onwards; and mean weight in discards for age 1. Next, relative age structure in survey biomass was compared to that in commercial catch (Fig. 1). Based on this comparison, cod survey seems to cover relatively more older cod compared to catches, and the time series is relatively short. BITS (Havfisken) Q1 is considered only useful for the assessment up to age 3. Therefore, the time series of relative biomasses from IBTS Q1 and Q3 that both have longer time series and include most ages, were chosen to be included in the SPICT analyses (Fig. 3).

Catch data

Two versions of catch data were used: i) catches in tons were set equal to reported landings in tons plus estimated discards from observer programs; ii) catch was increased for years 2005-2010, where substantial missing removals have been estimated, and it is known that there have been issues with the quality of catch data in this period. Since 2011, WKBALT considered the quality of catch data to be of reasonable quality. The two catch time series are shown in Fig. 2.

Effort

A run was made that included trend in fishing impact (estimated from VMS, cod distribution and gear selectivity data) (WKBALT 2017), for 2007-2015, as a measure of effort.

Results

Figures 4-6 present SPICT model results from 3 runs:

1) Catches set equal to reported landings and estimated discards from observed program
2) Catches increased for 2005-2010, to account for possible underestimation of catch for these years
3) Same as Run 2, but including additionally time series of relative effort.

All runs used IBTS Q1 and Q3 series of survey biomass. The time series started from 1997.

The diagnostics reveals some issues with all three models (Fig 4b-6b), least for Run 1#.

All three runs estimate F/FMSY below one for recent years, suggesting low fishing pressure. Biomass is mostly estimated to be below BMSY, however, the estimates have a high uncertainty, and the result therefore less conclusive.

The analyses are conducted for the Kattegat area, where the issue of inflow of North Sea cod into the Kattegat and return migration is not taken into account, which may bias the results.

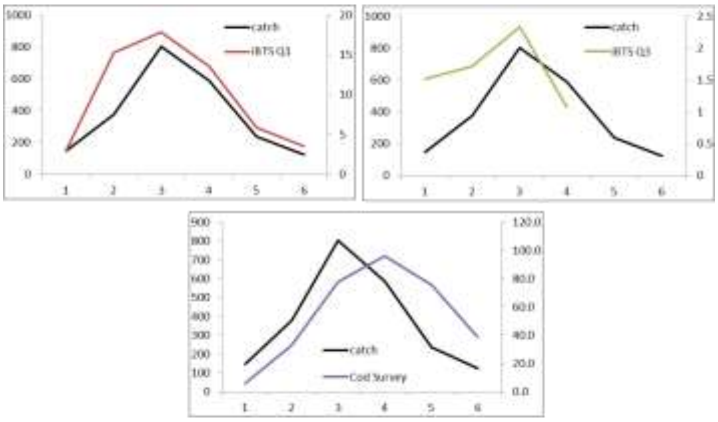

Fig. 1. Biomass at age in commercial catch compared to surveys.

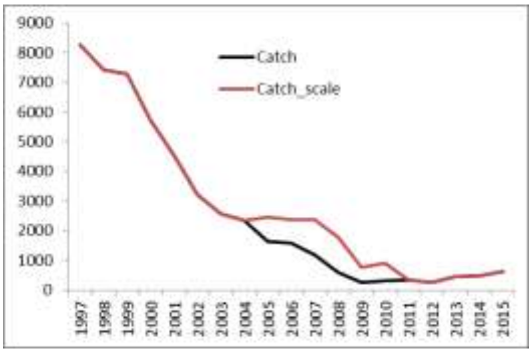

Fig. 2. Catch of Kattegat cod (landings plus discards) as reported (black line), compared to when the catches are increased in 2005-2010, to account for possible missing catch.

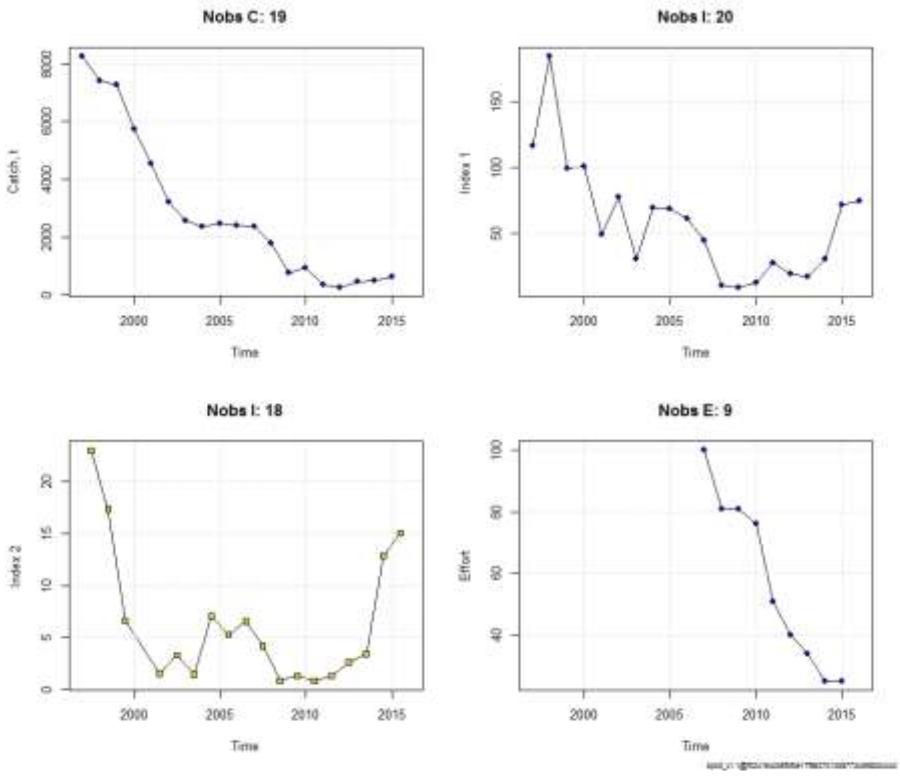

Fig. 3. Input data used in SPICT (shown for Run 3#).

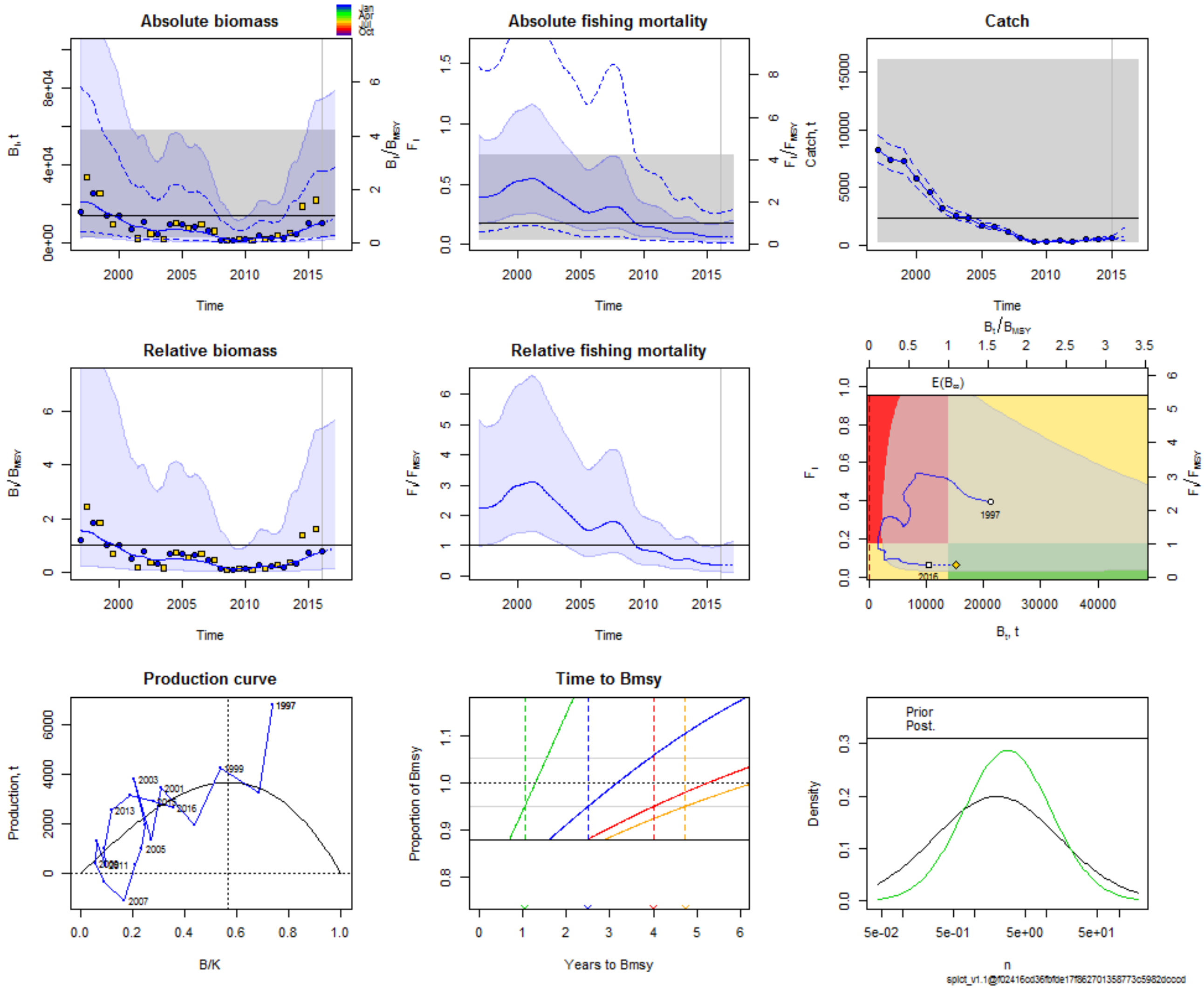

Fig. 4a. Output from SPICT using reported catch (Run 1#)

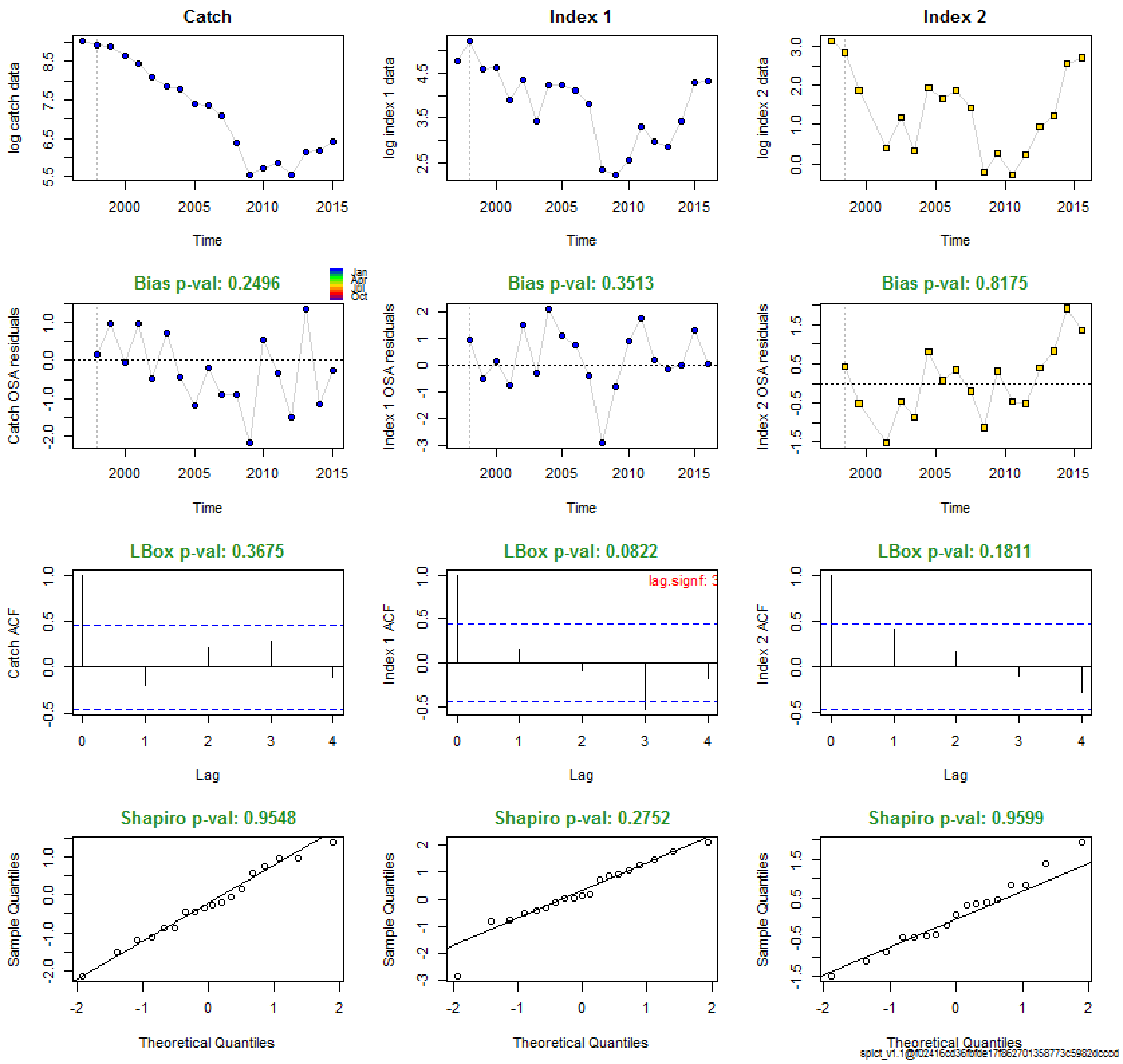

Fig. 4b. Diagnostics of SPICT using reported catch (Run 1#).

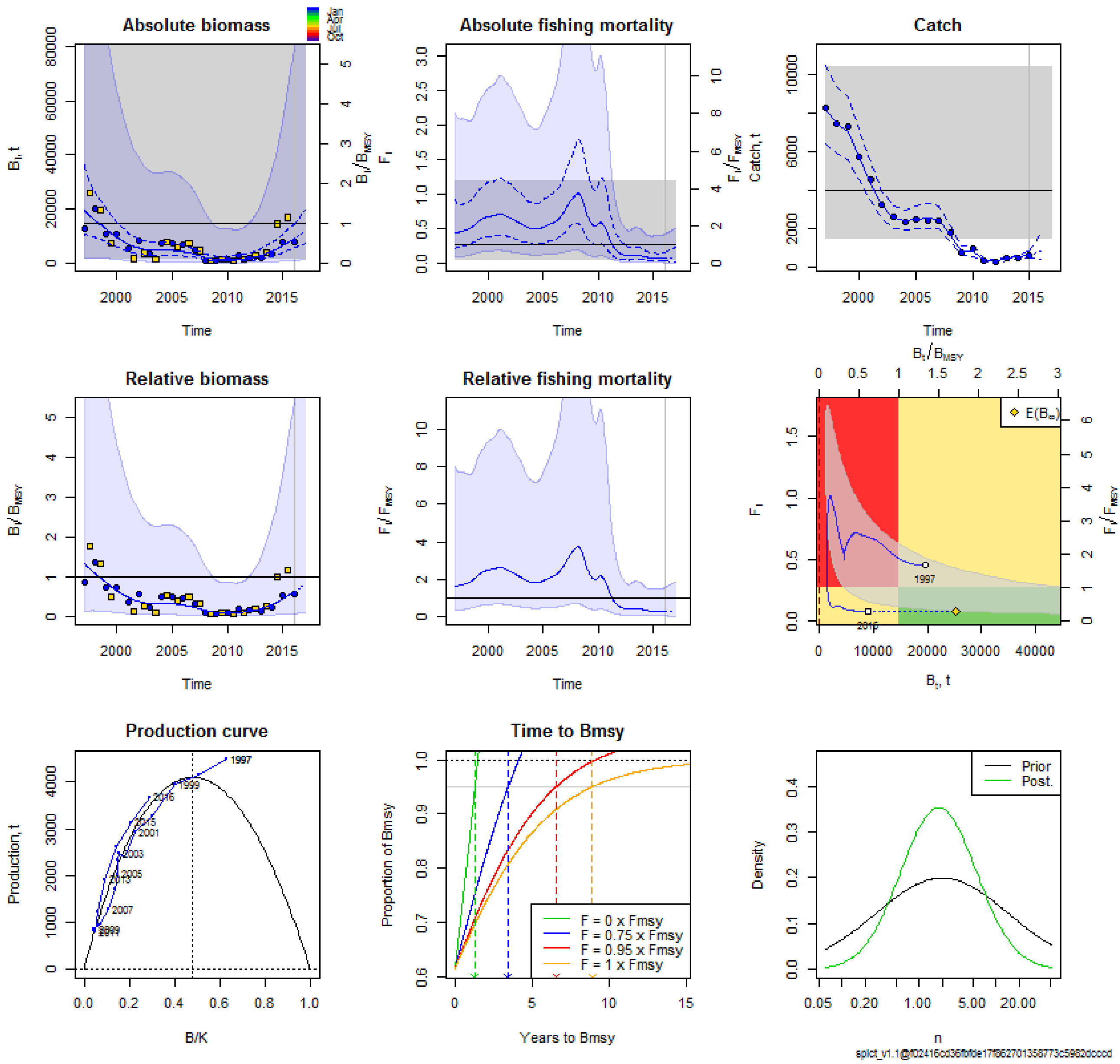

Fig. 5a. Output from SPICT when increasing catches for 2005-2010, from the level corresponding to reported landings and discards estimated from observer programs (Run 2#)

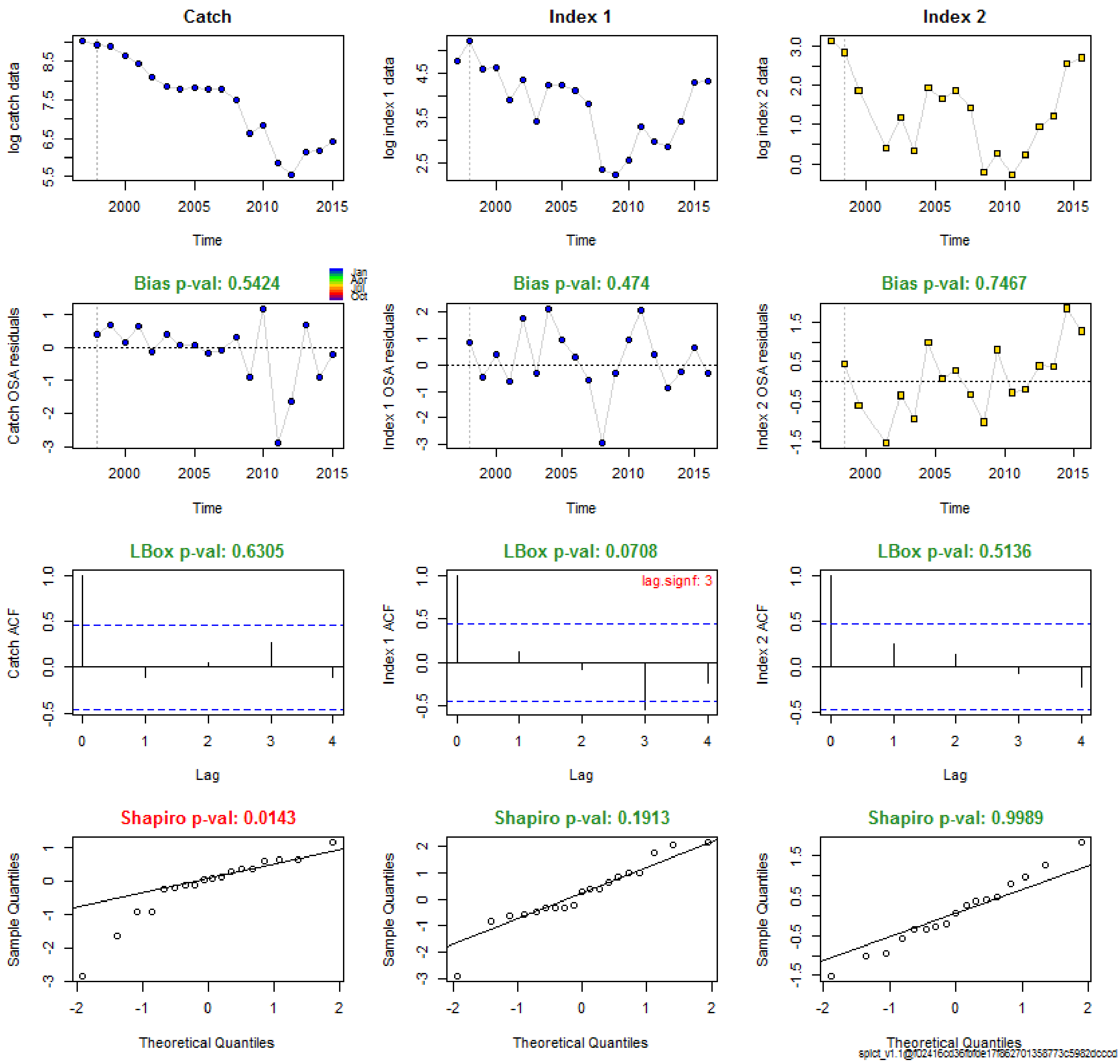

Fig. 5b. Diagnostics of SPICT when increasing catches for 2005-2010, from the level corresponding to reported landings and discards estimated from observer programs (Run 2#).

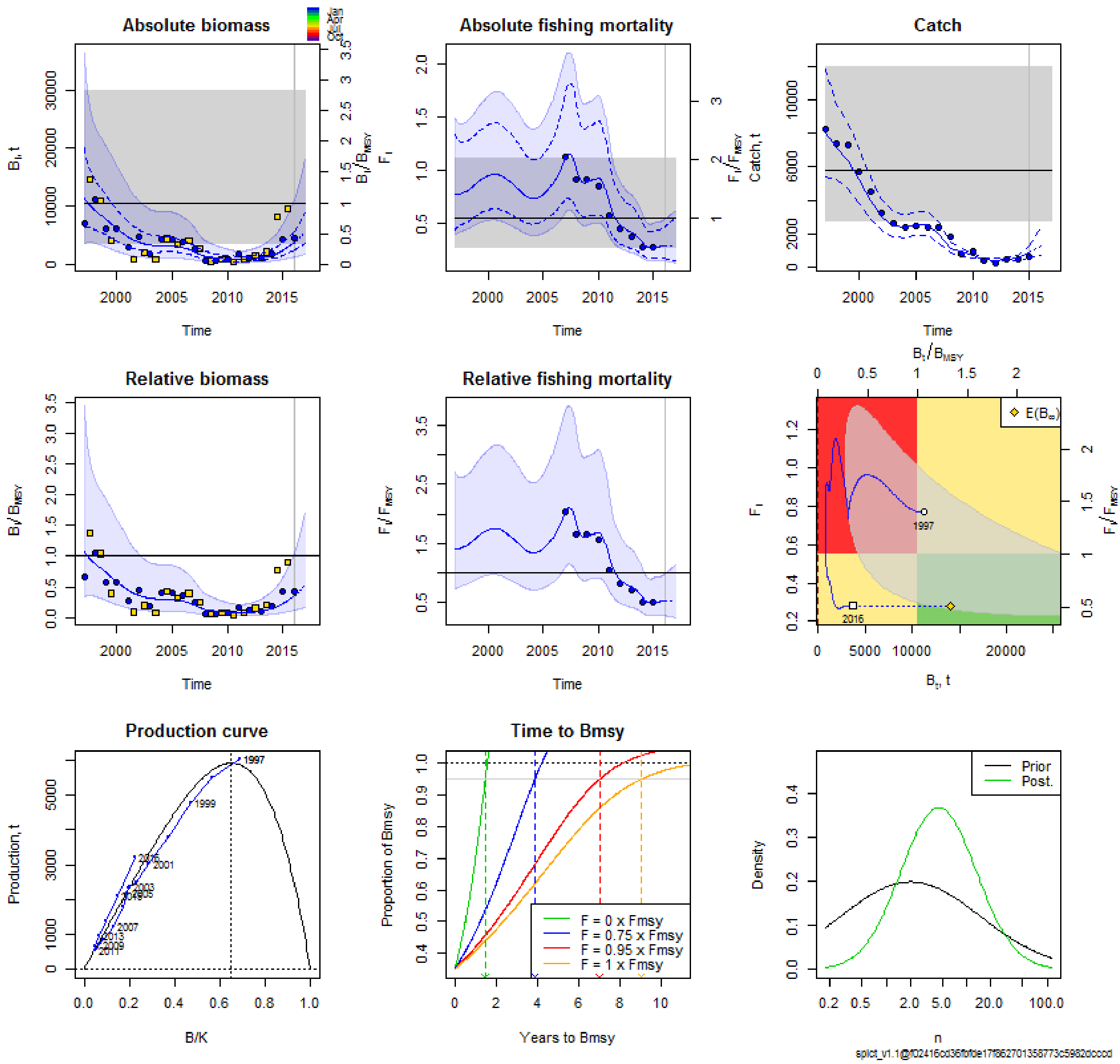

Fig. 6a. Output from SPICT when increasing catches for 2005-2010, from the level corresponding to reported landings and discards estimated from observer programs; and including relative trend in effort (Run 3#).

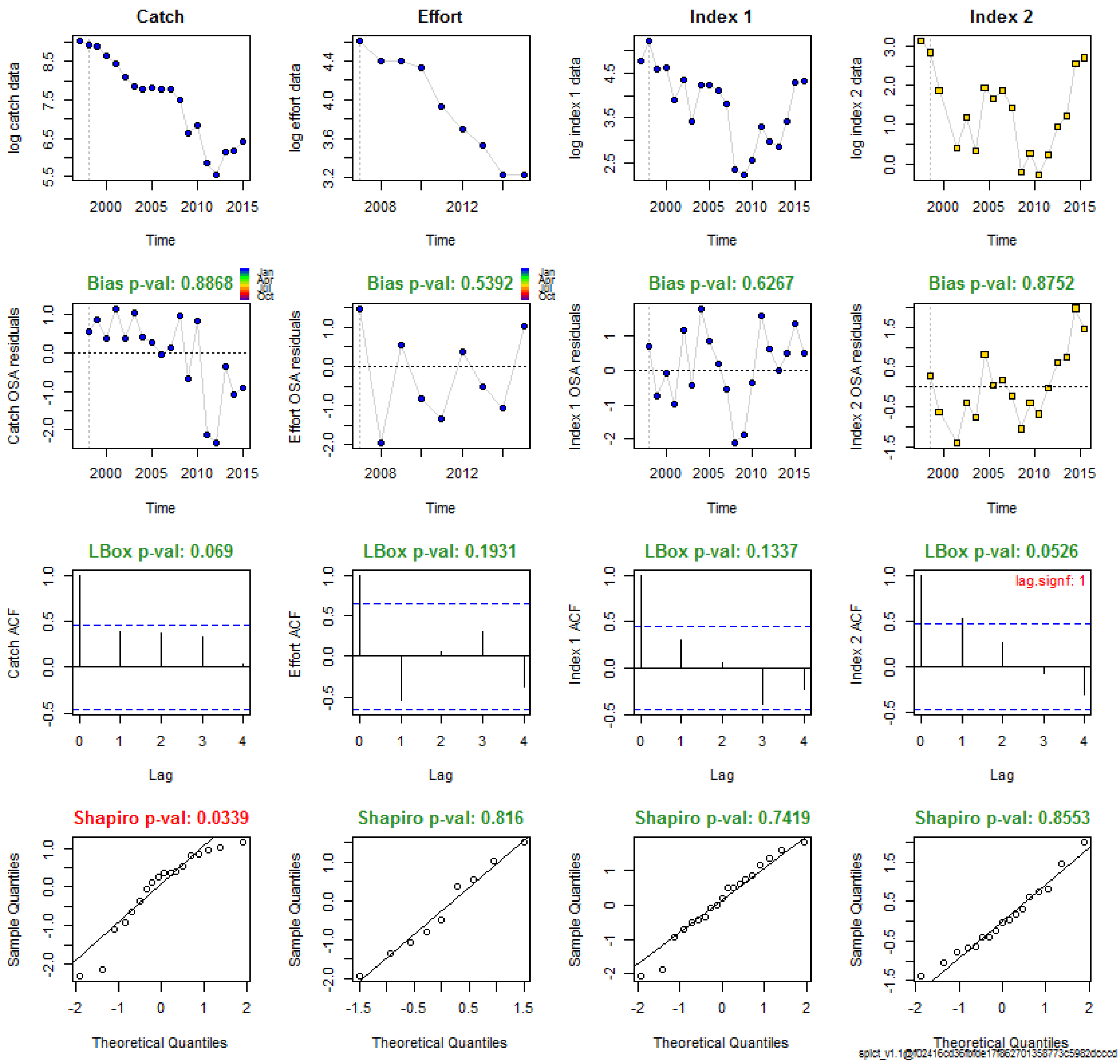

Fig. 6b. Diagnostics of SPICT when increasing catches for 2005-2010, from the level corresponding to reported landings and discards estimated from observer programs; and including relative trend in effort (Run 3#).

Working document 07 to WGBFAS 2017

Eastern Baltic Cod assessment using seasonal data and SPiCT.

Casper W. Berg

April 25, 2017

1 Introduction

This document describes a new assessment of Eastern Baltic Cod using quarterly resolved commercial catch data using the production model called SPiCT [4], which was slightly extended, among other things to deal with regime shifts in surplus production. The first part documents how the survey indices are calculated, the second part concerns the extensions to the SPiCT model and the results of running the assessment.

2 Survey Indices

Survey indices are calculated using data from BITS Quarters 1 and 4.

2.1 ESB correction

Since SPiCT does not model the size distribution of the population, actions should be taken to ensure that surveys and commercial data are covering the same (exploitable) part of the population. This usually entails down-weighting the smallest length groups in the survey data. The factor used to downweight (ESB correction) can be estimated by considering ratio of commercial to survey total catch by length group (only commercial catches from quarters 1 and 4, since this is when the surveys are conducted). Rather than using the raw ratios by length group, a shape constrained GAM is fitted to these ratios as a smooth function of length in order to smooth out some of the sampling error:

```
library(scam)
m <- scam( log(com / surv )  ~ s(length,bs="mpi"), data=d )
```

The ratios are assumed to be lognormal distributed and the GAM is constrained to be increasing, which results in an S-shaped curve (see Figure 2). The estimated curve is then simply multiplied with the observed length distribution in the survey for every haul, such that the overall length distributions are close to identical. Because the same ESB correction is used for all years, then this will not change the relative index for a given length group, it will only change how each length group is weighted when combining all the length groups into a biomass index.

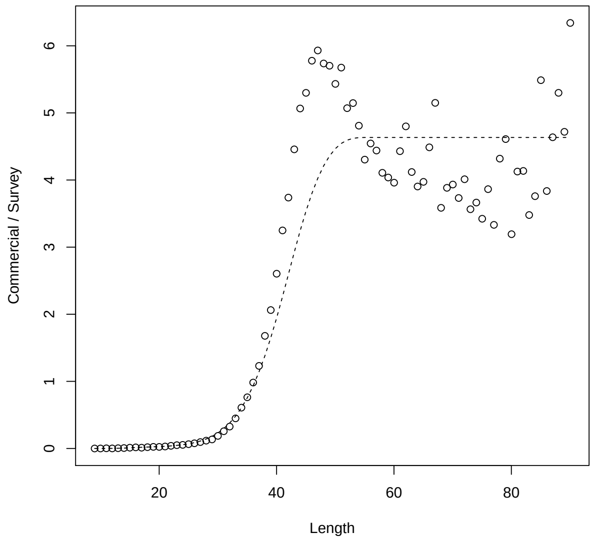

Figure 1: Ratio of commercial to survey total catch at length. Only data from quarters 1 and 4 are considered here.

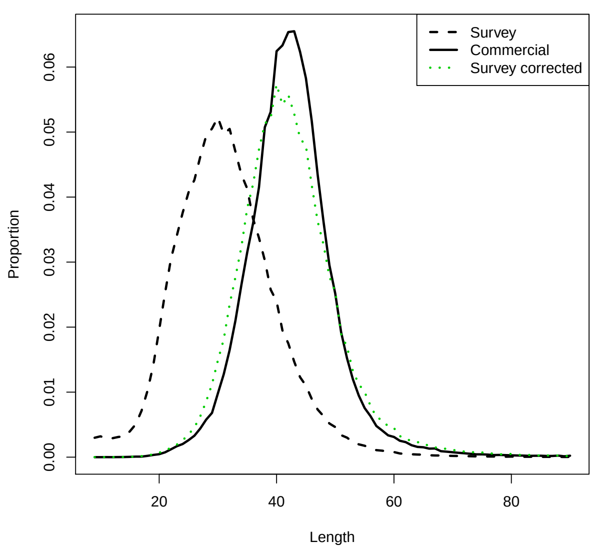

Figure 2: Length distributions in the survey and commercial data, and the ESB corrected survey length distribution obtained when using the correction factor shown in figure 1.

2.2 Index standardization

Once the ESB correction has been applied, numbers-at-length in the survey are converted to biomass by fitting a length-weight relationship

$$log(W) = log(a) + log(b)W + \epsilon$$

for each combination of year and quarter. Biomass-at-length are the aggregated into two size groups, above and below 38 cm, and standardized indices are calculated using Delta-GAM models with biomass in those size groups as the response variable. Independent models are estimated for each combination of quarter and size group. The grouping into two size groups is done in order to allow for different gear effects to be estimated for different size groups. The number of hauls by gear and quarter used to estimate the survey indices are shown in tables 1 and 2.

	FOT	GOV	GRT	LBT	P20	H20	DT	HAK	TVL	TVS
1991	27	3	54	61	36	0	0	0	0	0
1992	10	22	47	0	32	0	0	0	0	0
1993	28	8	60	25	50	30	0	0	0	0
1994	28	8	58	0	40	32	0	0	0	0
1995	0	40	54	0	47	32	67	0	0	0
1996	45	0	46	0	22	31	85	0	0	0
1997	41	0	41	0	71	0	0	41	0	0
1998	40	0	58	0	67	32	0	43	0	0
1999	34	5	55	19	56	28	0	40	7	0
2000	16	28	53	29	51	21	0	37	8	0
2001	0	0	0	0	11	0	0	0	190	28
2002	0	0	0	0	0	0	0	0	114	25
2003	0	0	0	0	0	0	0	0	138	26
2004	0	0	0	0	0	0	0	0	125	31
2005	0	0	0	0	0	0	0	0	144	37
2006	0	0	0	0	0	0	0	0	143	6
2007	0	0	0	0	0	0	0	0	143	8
2008	0	0	0	0	0	0	0	0	138	8
2009	0	0	0	0	0	0	0	0	143	9
2010	0	0	0	0	0	0	0	0	181	8
2011	0	0	0	0	0	0	0	0	181	8
2012	0	0	0	0	0	0	0	0	162	7
2013	0	0	0	0	0	0	0	0	198	7
2014	0	0	0	0	0	0	0	0	109	42
2015	0	0	0	0	0	0	0	0	159	6
2016	0	0	0	0	0	0	0	0	162	5
2017	0	0	0	0	0	0	0	0	190	5

Table 1: Number of hauls by gear and year in Q1

Survey indices by size group are calculated using the methodology described in [1], although we consider a broader class of equations describing the observed abundance in each haul. While [1]

	FOT	GOV	GRT	LBT	TVL	TVS
1991	25	0	0	0	0	0
1993	16	10	0	0	0	0
1994	28	0	0	0	0	0
1995	25	0	0	0	0	0
1996	20	6	0	0	0	0
1997	40	0	0	20	0	0
1998	35	0	0	0	0	0
1999	13	19	0	20	23	0
2000	0	30	1	30	21	12
2001	0	0	0	0	71	25
2002	0	0	0	0	68	25
2003	0	0	0	0	71	25
2004	0	0	0	0	52	30
2005	0	0	0	0	75	42
2006	0	0	0	0	77	11
2007	0	0	0	0	78	18
2008	0	0	0	0	79	14
2009	0	0	0	0	91	35
2010	0	0	0	0	121	17
2011	0	0	0	0	114	14
2012	0	0	0	0	99	16
2013	0	0	0	0	101	14
2014	0	0	0	0	112	16
2015	0	0	0	0	106	13
2016	0	0	0	0	140	15

Table 2: Number of hauls by gear and year in Q4

considered a time-invariant spatial effect and a data set consisting almost exclusively of 30 min hauls, the following model classes contains a space-time smoother, which allows for smooth changes in the spatial distribution of each age group over time, as well as haul duration effect.

$$g(\mu_i) = \text{Year(i)} + \text{Gear(i)} + f_1(\text{Year}_i, \text{lon}_i, \text{lat}_i) \quad (1)$$

$$+ f_2(\text{depth}_i) + f_3(\text{time}_i) + \log(HaulDur_i) \quad (2)$$

where Gear(i) maps the ith haul to a categorical gear effect for each size group and similarly for years. An offset is used for the effect of haul duration ($HaulDur$), i.e. the coefficient is not estimated but taken to be 1.

f_1 is a 3-dimensional tensor product spline (a 2D thin-plate spline for space × a 1D cubic spline for time), f_2 is a 1-dimensional thin plate spline for the effect of bottom depth, and f_3 is a cyclic cubic regression spline on the time of day (i.e. with same start end end point). The function g is the link function, which is taken to be the logit function for the binomial model. The Lognormal part of the delta-Lognormal model is fitted with a log link. Each combination of quarter size group are estimated separately. The fitted models are then used to sum the expected catches over a fine grid by year,size, and subarea to obtain the survey index. Nuisance variable such as gear, time-of-day and haul duration are corrected for in this process.

The final biomass index is obtained simply by adding the estimated biomass indices for the two size groups. Uncertainties on the calculated indices are estimated using parametric bootstrapping.

3 SPiCT assessment

Details about the SPiCT model can be found in [4]. Briefly, the model is based on a reparameterized version of the Pella-Tomlinson model [2] formulated as a stochastic differential equation such that it includes process noise:

$$dB_t = \left(\gamma m \frac{B_t}{K} - \gamma m \left[\frac{B_t}{K}\right]^n - F_t B_t\right) dt + \sigma_B B_t dW_t, \tag{3}$$

where $\gamma = n^{n/(n-1)}/(n-1)$. K represents the carying capacity, m represents the maximum sustainable yield (maximum attainable surplus production), and n determines the shape of the production curve. σ_B is the standard deviation of the process noise, and W_t is Brownian motion.

In addition, the fishing mortality is also modelled as a stochastic process

$$F_t = S_t G_t \tag{4}$$

$$d \log G_t = \sigma_F dV_t \tag{5}$$

where dV_t is standard Brownian motion and σ_F is the standard deviation of the noise. If only annual data are available it is not possible to estimate within-year dynamics and therefore $S_t = 1$ and consequently $F_t = G_t$. In the case of seasonal data F_t follows the model

$$F_t = \exp(D_{s(t)}) G_t \tag{6}$$

where $D_{s(t)}$ is a cyclic B-spline with a period of one year with $s(t) \in [0; 1]$ being a mapping from t to the proportion of the current year that has passed. The possible annual variation allowed by the cyclic B-spline is determined by a chosen number of so-called knots. The number of knots must be smaller than or equal to the number of catch observations per year (e.g. quarterly catches can at most accommodate four temporally equidistant knots). The values of the cyclic B-spline is defined by the parameter vector ϕ of length equal to the number of knots minus one. In the case of annual data (one knot) the cyclic B-spline reduces to a constant ($D_{s(t)} = 1$) and ϕ has zero length and is therefore not estimated. Note that the seasonal pattern represented by the spline remains constant in time. Thus, a spline-based model is not able to adapt to changes in amplitude and timing (phase) of the real seasonal fishing pattern. Such variations in the fishing pattern would, when fitted with a spline-based model, likely lead to autocorrelated catch residuals.

3.1 Seasonal extension

[4] presents an alternative solution to using a cyclic spline for the seasonal fishing pattern in terms of two coupled SDEs which have an oscillating stationary distribution. This can accomodate changes in the fishing pattern over time, however using this solution for EBcod did not converge to a realistic solution, while significant autocorrelation in the catch residuals was detected when using the cyclic spline. To circumvent these problems an extension to SPiCT was developed, which adds an autocorrelated (discrete-time) process A on top of the cyclic spline S and the diffusion component G. Since the A-process is formulated in discrete time, the model cannot technically be written in SDE form, however, numerically the model is well defined and with slight abuse of notation we have,

$$F_t = S_t G_t \exp(A_{q(t)}) \quad (7)$$

$$d \log G_t = \sigma_F dV_t \quad (8)$$

where $A_{q(t)}$ is a discrete time mean zero autoregressive process $A_{q(t)} = \varphi_A A_{q(t-1)} + \varepsilon_{A,q(t)}$, and q maps t to a quarter, i.e. q equals 1 for all $t \in [0; 0.25[$, q=2 for all $t \in [0.25; 0.5[$ etc. The A-process is thus a step-function that is constant within quarters and auto-correlated with a lag one year, and may be thought of as deviations from the mean seasonal pattern described by S_t.

3.2 Regime shift

The SPiCT model is further extended to deal with changes in surplus production over time. This is implemented by allowing different values of the m parameter to be estimated in different time-periods rather than having just one constant value. The break-point may be chosen a priori, but it may also be estimated by varying the break-point and choosing the one with the maximum likelihood value (or equivalently minimum AIC). In both cases the magnitude of change in production is estimated by the model, and in the latter case time of the break-point is also estimated from the data. This was done for the EBcod and there was strong evidence for a drop in surplus production (ΔAIC $>$ 15) at the optimum break-point year, which was found to be in 2010 (Figure 4). The MSY was estimated to be reduced from around 92 ktonnes in the period before 2010 to 43 ktonnes in the period after.

3.3 Commercial catch CV

Some of the years before 2010 have incomplete catch reporting. To prevent bias due to this the missing catches have been imputed, and the percentage of imputed catches are shown below for each year. For years with more than 10% imputed catch we increase the standard deviation to twice the value of the other years (StdevFac) in order to account for these data points being more uncertain relative to the other.

Year	Add	StdevFac
1991	0.00	1
1992	0.00	1
1993	0.36	2
1994	0.43	2
1995	0.17	2
1996	0.09	1
1997	0.00	1
1998	0.00	1
1999	0.00	1
2000	0.24	2
2001	0.25	2
2002	0.25	2
2003	0.31	2

2004	0.28	2
2005	0.26	2
2006	0.25	2
2007	0.23	2
2008	0.06	1
2009	0.06	1
2010	0.00	1

4 Results

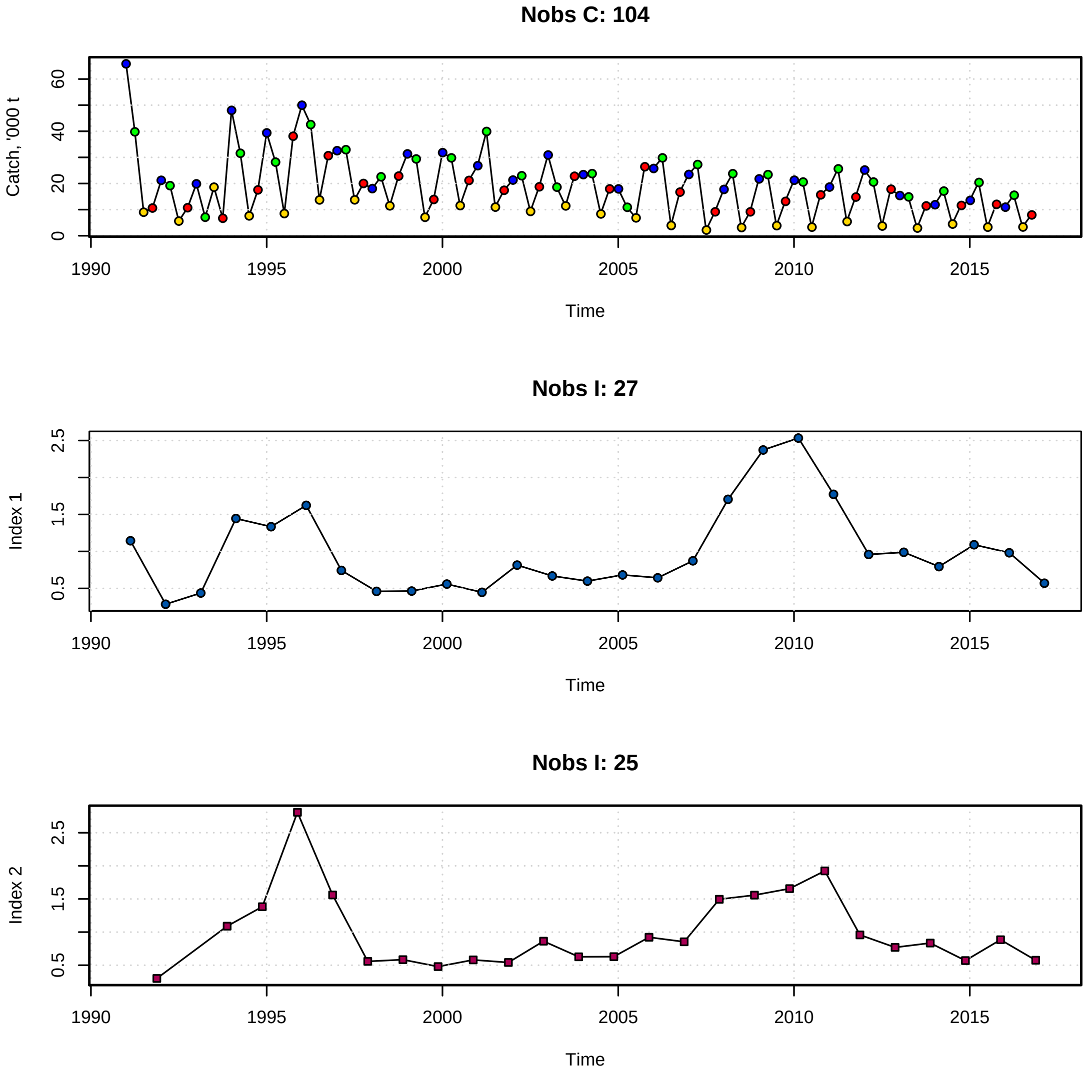

Figure 3: Input data.

Model summary:

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 57.6921715
Euler time step (years):  1/16 or 0.0625
Nobs C: 104,  Nobs I1: 27,  Nobs I2: 25
Catch/biomass unit: '000 t
```

Residual diagnostics (p-values)

	shapiro	bias	acf	LBox	shapiro	bias	acf	LBox
C	0.0249	0.9507	0.1101	0.2161	*	-	-	-
I1	0.5887	0.8068	0.0528	0.2355	-	-	.	-
I2	0.9286	0.4216	0.0549	0.1780	-	-	.	-

Priors

```
     logn  ~  dnorm[log(2), 2^2]
 logalpha  ~  dnorm[log(1), 2^2]
  logbeta  ~  dnorm[log(1), 2^2]
```

Model parameter estimates w 95% CI

	estimate	cilow	ciupp	log.est
alpha1	1.5558583	0.1656663	14.6118692	0.4420273
alpha2	1.7331513	0.1927543	15.5836345	0.5499413
beta	0.4821034	0.3166649	0.7339736	-0.7295967
r	1.0511142	0.3520595	3.1382225	0.0498507
r	0.4870492	0.1668359	1.4218577	-0.7193902
rc	2.7337988	1.7175977	4.3512260	1.0056921
rc	1.2667458	0.7231517	2.2189604	0.2364513
rold	4.5498239	0.0879099	235.4786719	1.5150885
rold	2.1082277	0.0436307	101.8692292	0.7458477
m1	91.9760405	80.7219860	104.7991068	4.5215281
m2	42.6184492	35.3797335	51.3382107	3.7522872
K	209.7831478	104.6798741	420.4148074	5.3460744
q1	0.0173215	0.0113596	0.0264122	-4.0558090
q2	0.0148868	0.0100516	0.0220480	-4.2072782
n	0.7689770	0.3194899	1.8508425	-0.2626943
sdb	0.1314299	0.0205446	0.8407950	-2.0292813
sdf	0.3389528	0.2420863	0.4745785	-1.0818945
sdi1	0.2044864	0.1168615	0.3578139	-1.5872540
sdi2	0.2277880	0.1415378	0.3665972	-1.4793400
sdc	0.1634103	0.1297021	0.2058788	-1.8114912
phi1	0.8548026	0.3844628	1.9005415	-0.1568847
phi2	1.8517381	1.1183661	3.0660208	0.6161247
phi3	0.1417991	0.0636336	0.3159806	-1.9533438
SARphi	0.8390630	0.5640924	0.9545557	1.6512730
SdSAR	0.1995374	0.1237983	0.3216131	-1.6117537

Deterministic reference points (Drp)

	estimate	cilow	ciupp	log.est
Bmsyd1	67.2880829	41.7936527	108.334300	4.2089831
Bmsyd2	67.2880829	41.7936527	108.334300	4.2089831
Fmsyd1	1.3668994	0.8587989	2.175613	0.3125450

```
 Fmsyd2  0.6333729  0.3615759   1.109480 -0.4566959
 MSYd1  91.9760405 80.7219860 104.799107  4.5215281
 MSYd2  42.6184492 35.3797335  51.338211  3.7522872
Stochastic reference points (Srp)
          estimate      cilow      ciupp    log.est rel.diff.Drp
 Bmsys1 66.9514893 41.5531412 107.873960  4.2039683 -0.005027425
 Bmsys2 66.6885610 41.2158983 107.904094  4.2000334 -0.008989876
 Fmsys1  1.3632464  0.8632590   2.152820  0.3098689 -0.002679637
 Fmsys2  0.6341563  0.3620991   1.110619 -0.4554598  0.001235317
 MSYs1  91.2701499 79.5743556 104.684985  4.5138238 -0.007734080
 MSYs2  42.2914399 35.2612835  50.723222  3.7445847 -0.007732282

States w 95% CI (inp$msytype: d)
                  estimate      cilow      ciupp    log.est
 B_2017.12      38.5775327 22.6995195 65.5620059  3.6526701
 F_2017.12       0.9722937  0.4899529  1.9294814 -0.0280974
 B_2017.12/Bmsy  0.5733189  0.3819527  0.8605637 -0.5563131
 F_2017.12/Fmsy  1.5351046  0.8597960  2.7408201  0.4285985

Predictions w 95% CI (inp$msytype: d)
                prediction      cilow      ciupp    log.est
 B_2019.00      41.3552209 17.0333187 100.406405  3.7221987
 F_2019.00       0.9722939  0.3112792   3.037001 -0.0280972
 B_2019.00/Bmsy  0.6145995  0.2592804   1.456849 -0.4867845
 F_2019.00/Fmsy  1.5351049  0.5220037   4.514426  0.4285987
 Catch_2018.00  37.9144197 23.9145158  60.110070  3.6353315
 E(B_inf)       48.4407504         NA         NA  3.8803414
```

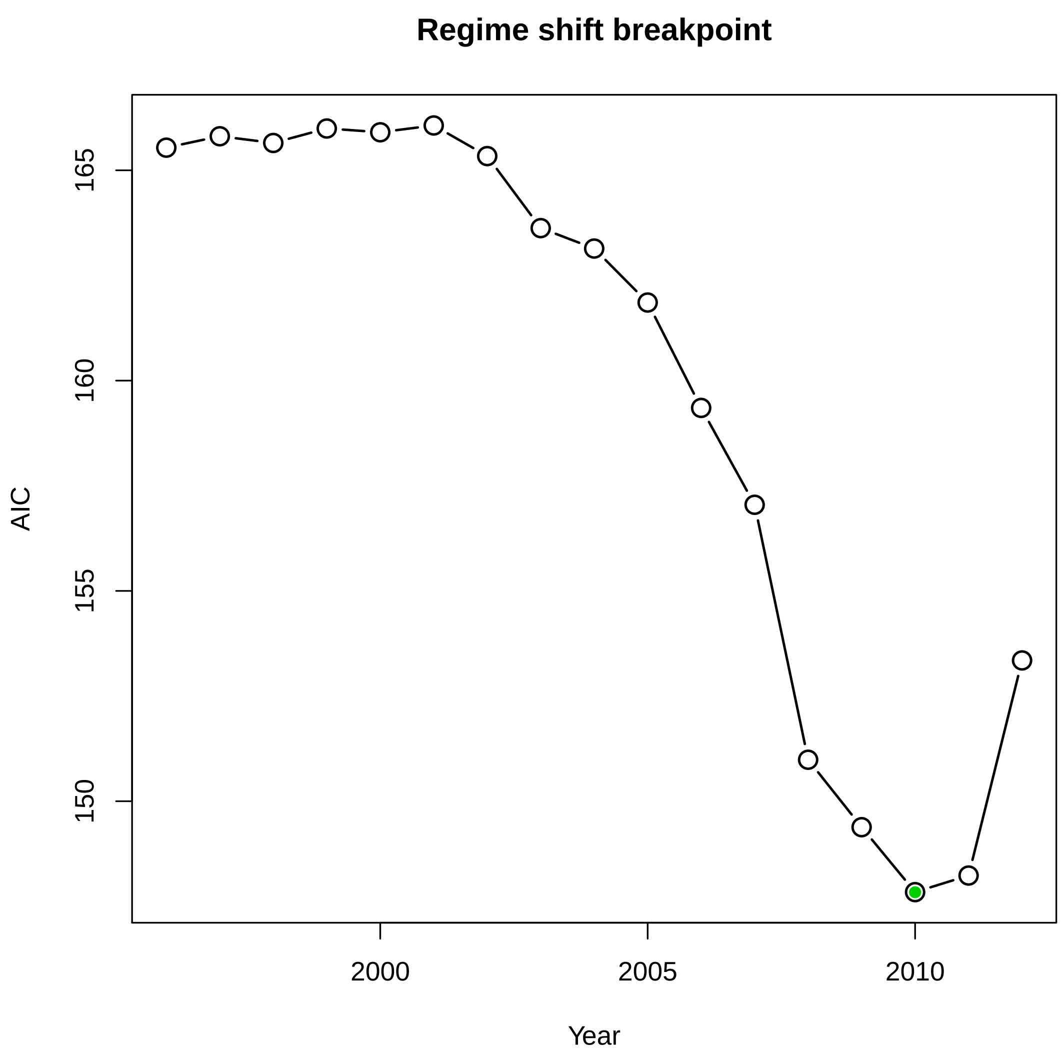

Figure 4: AIC as a function of regime shift break-point.

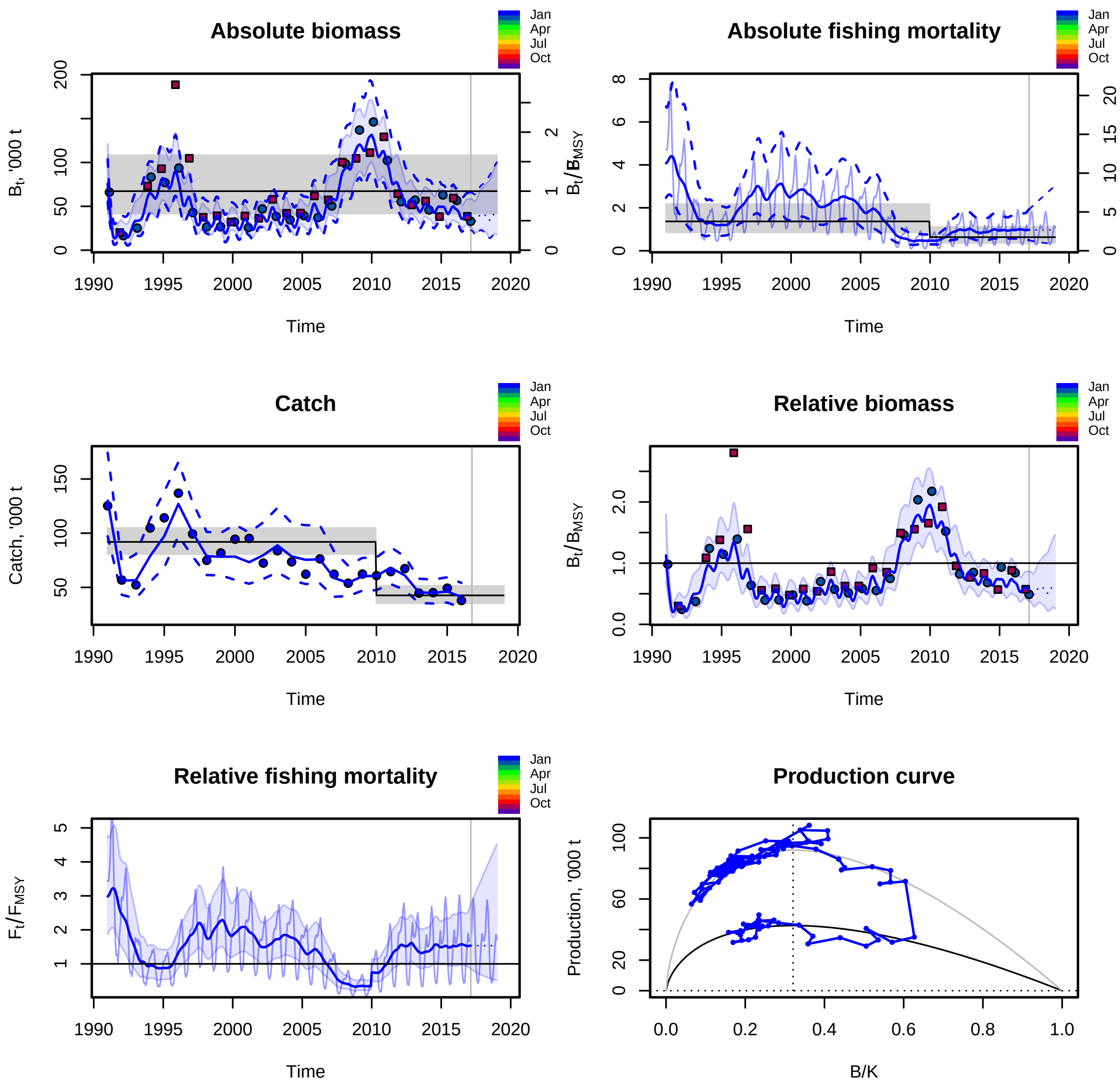

Figure 5: Results using seasonal data and break-point in 2010.

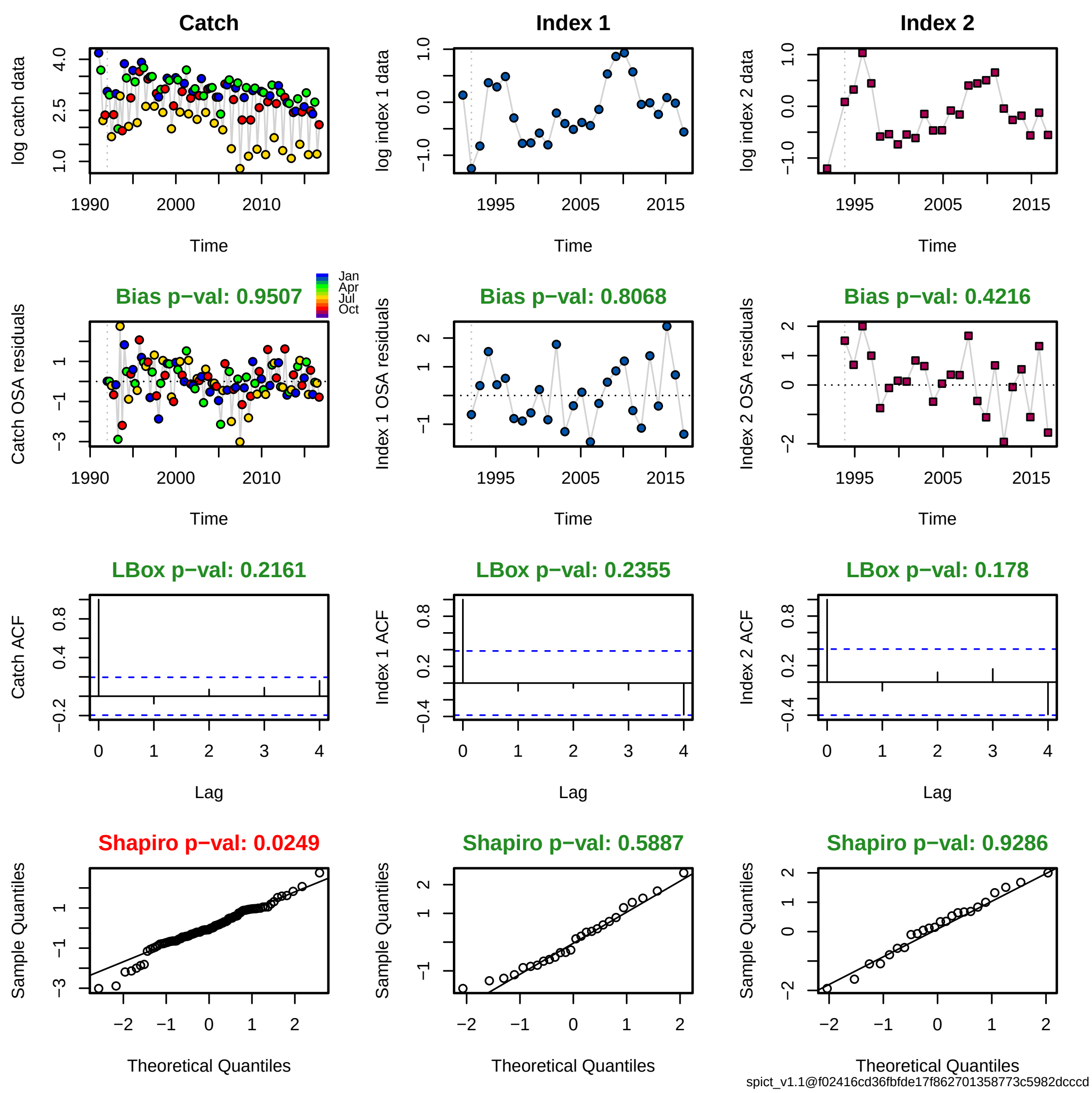

Figure 6: Diagnostics using seasonal data and break-point in 2010.

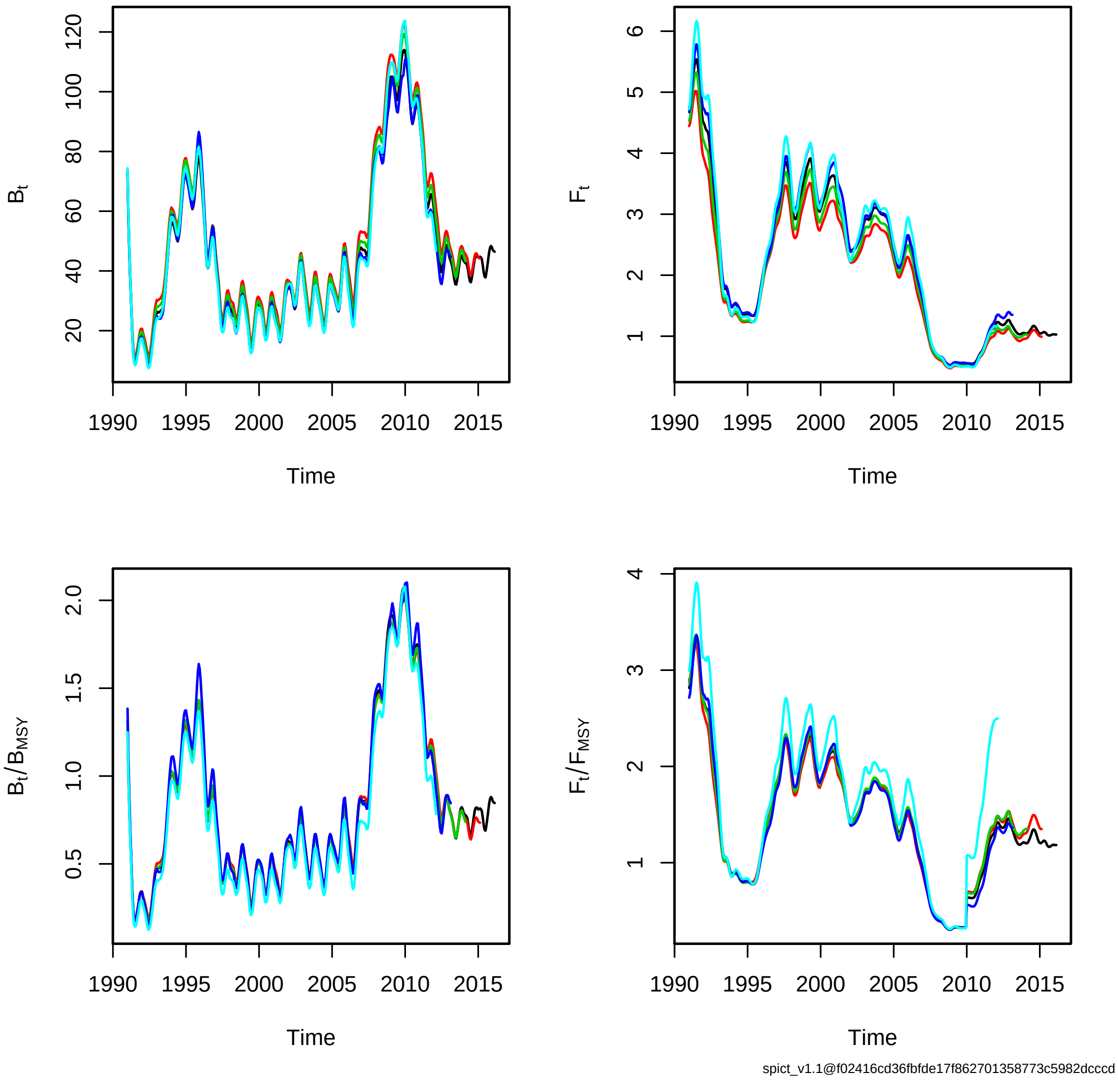

Figure 7: Retrospective analysis using seasonal data and break-point in 2010.

	Year	F/F_{MSY}	B/B_{MSY}
1	1991.00	2.982	1.127
2	1992.00	2.474	0.343
3	1993.00	1.429	0.499
4	1994.00	0.937	0.966
5	1995.00	0.879	1.221
6	1996.00	1.255	1.275
7	1997.00	1.844	0.793
8	1998.00	1.882	0.510
9	1999.00	2.209	0.537
10	2000.00	1.841	0.499
11	2001.00	2.051	0.495
12	2002.00	1.515	0.588
13	2003.00	1.694	0.675
14	2004.00	1.817	0.578
15	2005.00	1.465	0.596
16	2006.00	1.425	0.729
17	2007.00	0.868	0.865
18	2008.00	0.431	1.359
19	2009.00	0.338	1.768
20	2010.00	0.743	1.954
21	2011.00	0.959	1.575
22	2012.00	1.521	1.047
23	2013.00	1.555	0.804
24	2014.00	1.362	0.752
25	2015.00	1.489	0.731
26	2016.00	1.519	0.705
27	2017.00	1.530	0.586

Table 3: Estimated stock status relative to reference points. All estimates are reported at the beginning of the year, however, F/F_{MSY} estimates are corrected for seasonal variability, but B/B_{MSY} is not. F/F_{MSY} is calculated based on F_t less the mean of the seasonal components S_t and A_t.

4.1 Forecast

Forecasting with an intermediate year is carried out by running the model forward in time and conditioning on the catch both in the intermediate and management year (2017 and 2018 respectively). The catch in the intermediate year is assumed to be equal to the quota of 36957 tonnes. The catch in the management year may then be varied until the desired F value is obtained at the end of the management period.

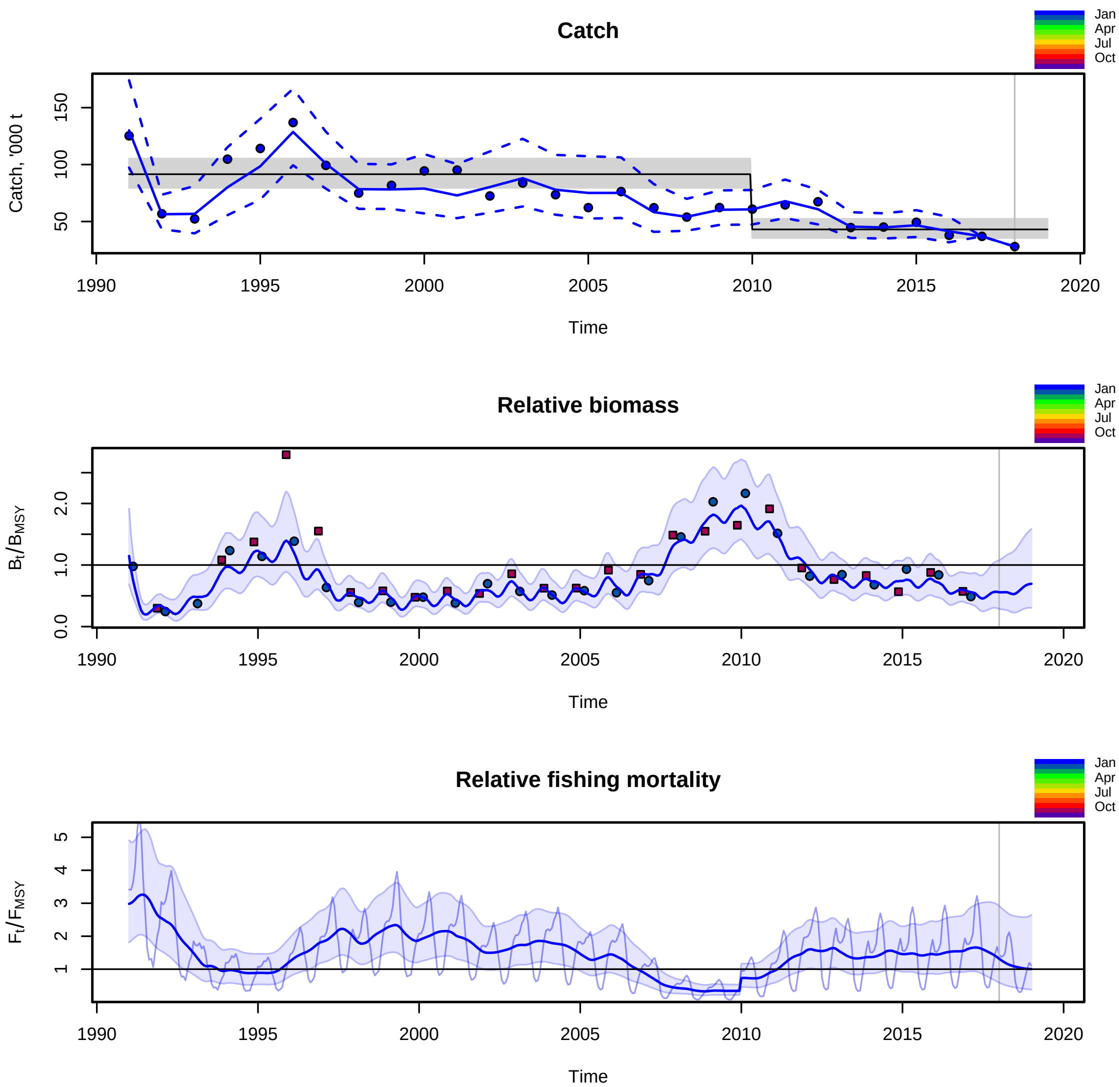

Figure 8: Forecast using seasonal data and break-point in 2010, catch in 2017 assumed to be equal to the quota, and catch in 2018 was set to 28000 tonnes in order to approximately achieve the F_{MSY} target at the end of the management period.

5 Source code

The source code for the SPiCT model is available online at `https://github.com/mawp/spict/tree/regimeshift`. The script and data used to produce the SPiCT output figures and tables in this report are available in the "Software" folder on the ICES sharepoint (`https://community.ices.dk/ExpertGroups/WGBFAS/SitePages/HomePage.aspx`)

References

[1] Casper W Berg, Anders Nielsen, and Kasper Kristensen. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models. *Fisheries Research*, 151:91–99, 2014.

[2] RI Fletcher. On the restructuring of the pella-tomlinson system. *Fish. Bull*, 76(3):515–521, 1978.

[3] Kasper Kristensen and Casper W. Berg. Datras package for r. `http://rforge.net/DATRAS/`, 2012.

[4] Martin W Pedersen and Casper W Berg. A stochastic surplus production model in continuous time. *Fish and Fisheries*, 2016.

Working paper 08 ICES WGBFAS Apr. 19- Apr. 26 2017

Joint Swedish and Danish survey for cod in the Kattegat November-December 2016

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Abstract

An annual survey targeting cod in Kattegat was initiated in 2008 and has then been continued every year with the exemption of 2012. The survey is conducted in November-December by two-four trawlers from Denmark and Sweden. The survey design has been largely unchanged during the years, but a fourth strata representing the closed area in Southern Kattegat was added year 2014. The total swept area biomass of cod was 4977 tonnes in 2016. This corresponds to a reduction of approximately 45% compared to 2015 but is still an increase of over 350% since the survey commenced in 2008. The abundance (numbers) decreased from and 5.8 mill. individuals in 2015 to 3.1 mill. in 2016 (1.6 mill. In 2008), representing lower recruitment of young age classes in the recent years. Length distribution showed a strong increase in individuals over 50 cm, which like in 2015 are dominating the abundance measured as biomass.

Introduction

Cod fishermen in Kattegat has, since 2003, been restricted by steadily decreasing quotas due to low abundance of cod estimated from the cod assessment. ICES consider, however, the cod assessment in Kattegat uncertain due to the catch data quality and the analytic assessment has not been accepted by ACFM/ACOM in recent years. The assessment has shown a discrepancy between the reported landings and total removals from the stock and ICES assumed that the majority of the unallocated mortality was caused by discard, but other factors such as migration, non reported landings and re-allocation of catches also could be part of the problem. Therefore, the assessment has to be largely based on available fisheries independent survey information. The surveys conducted previously in the Kattegat area were however not well suited for estimation of total cod abundance mainly due to poor coverage and sampling intensity. This implies that also the relative abundance indices obtained from these surveys were relatively noisy, especially for older ages. In 2008 a joint Swedish – Danish survey series directly aimed at cod and with better coverage of the area was initiated.

The goal of the Kattegat cod survey is to provide fisheries independent data for estimating the abundance, biomass, recruitment index and distribution of cod. The results should be used to strengthen the scientific advice on the cod stock in Kattegat. Due to it's considerably better coverage compared to hitherto available surveys, the joint Swedish and Danish Kattegat cod survey improves the knowledge of spatial distribution of cod by size/age-groups and provides valuable information for monitoring the effect of the closed area established in the Kattegat from January 1. 2009.

Restrictions

The commercial trawlers participating in the survey conduct the survey without any restrictions in the vessels quota, days at sea regulation and with dispensation from all by-catch regulations.

Materials and Methods

Survey design

Survey area

The survey area is covering Kattegat area restricted northward by a line from Skagen to the Tistlarna lighthouse and south-eastward by a line between Gilleleje and Kullen and south-westward by a line between Gniben and Hassensør on Djursland. Further, the area is restricted by the 20 m depth contour line and the area is split in areas "North" and "South". However, the two fjords Laholmsbugten and Skældervigen are also included in the survey area despite that the depth is shallower than 20 meter

Survey method and stratification

The survey is designed as a stratified random bottom trawl survey. Data is raised by strata allowing for re-stratification between years if necessary. The survey area where during 2008-2013 stratified in three strata: a stratum with expected high density of cod, a stratum with medium density and a stratum with low density of cod based on information from the fishers. In 2010 and 2011 there were a minor re-stratification to adopt the areas to the catch information collected during the former years. In 2014 was a fourth strata added to better assure data from the area closed for fisheries. Each stratum is further subdivided in 5*5 nm squares (sections). The high density, medium density and closed area stratum has been allocated relatively more stations than the other strata (Fig 1a-b) and table 1.

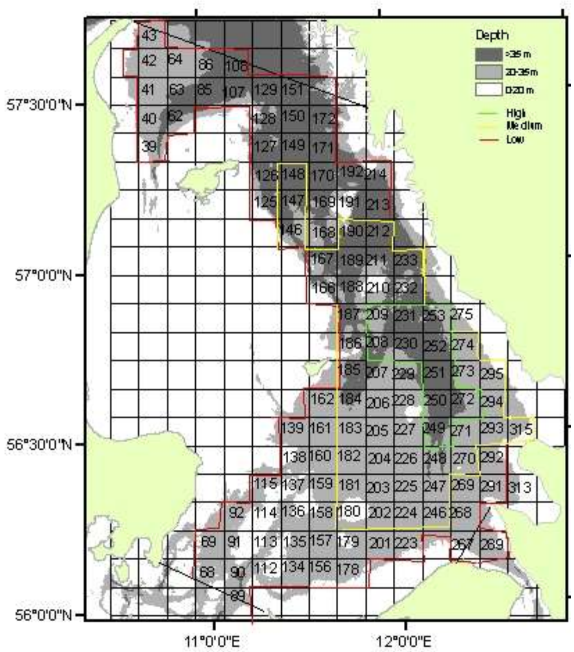


Figure 1a. The stratified survey area (2008-2009) with section numbers. Green High density of cod. Yellow Medium density. Red Low density.

3

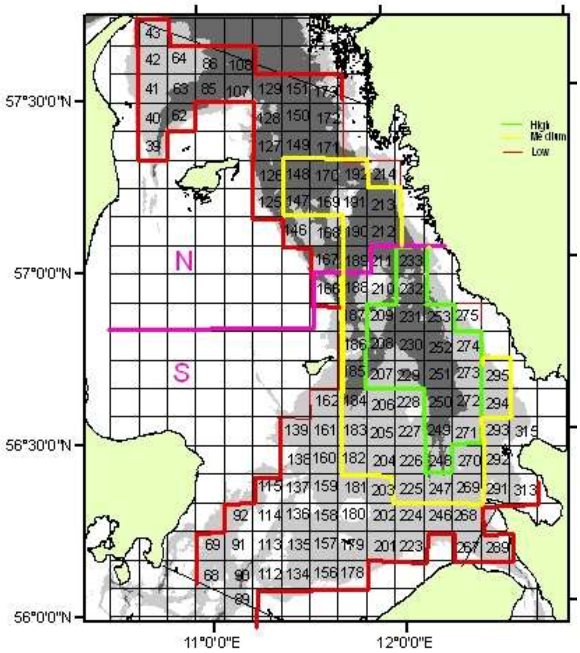


Figure 1b. The stratified survey area (2011) with section numbers. Green High density of cod. Yellow Medium density. Red Low density. N and S Northern and southern area, respectively.

4

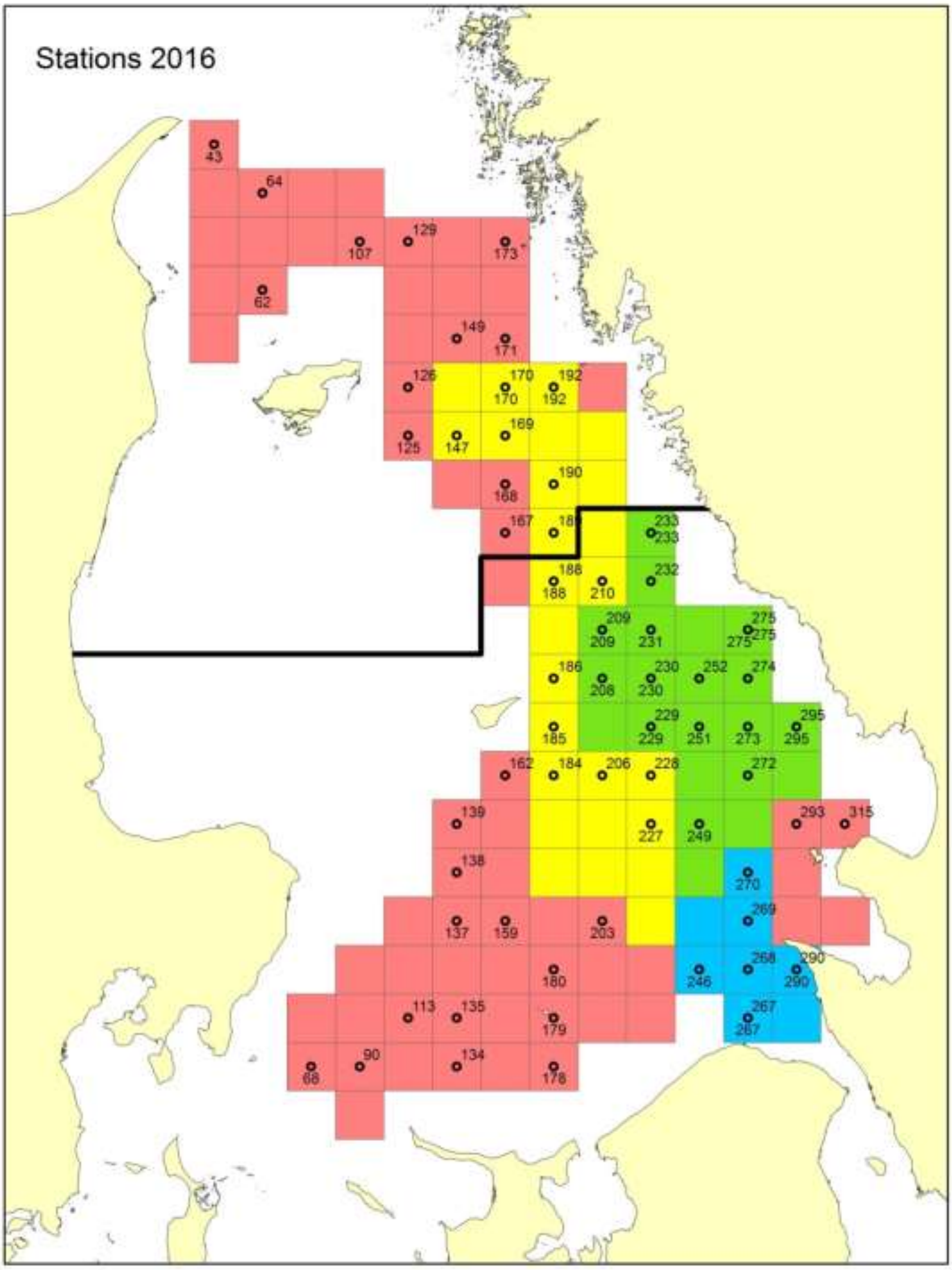


Figure 1c. The stratified survey area (2013-2016) with section numbers. Green High density of cod. Yellow Medium density. Red Low density. Blue Closed area.

Table 1. Showing number of survey squares by strata and year.

year	high density	medium density	low density	closed area	total
2008	10	44	65		**119**
2009	10	44	65		**119**
2010	15	32	72		**119**
2011	18	31	70		**119**
2013	21	26	65	8	**120**
2014	21	26	65	8	**120**
2015	21	26	65	8	**120**
2016	21	26	65	8	**120**

Station (tow) location

The survey is planned with in average 3.3 trawl hauls per day in 6 days for each of the 4 vessels, i.e in total 80 trawl hauls. The hauls are allocated randomly to the 5*5 nm squares and each vessel will fish in 20 different squares. In the closed area, high and medium density strata several vessels are allowed to fish in the same square. In the low density stratum only one haul is allowed in each square. Furthermore the low density area is divided in a Southern and Northern area. 1 Danish and 1 Swedish vessel is fishing in the south area and the other vessels are fishing in the north.

Table 2. Showing number of stations by vessel, stratum and area. In 2013 were only 2 Swedish vessels participating in the survey.

Year	No of vessels	high density	medium density	low density	closed area	total hauls by vessel	total haul survey
2008	4	6	8	6		**20**	**80**
2009	4	6	8	6		**20**	**80**
2010	4	6	8	6		**20**	**80**
2011	4	9	6	5		**20**	**80**
2013	2	15	10	10	5	**40**	**80**
2014	4	6	5	7	2	**20**	**80**
2015	4	6	5	7	2	**20**	**80**
2016	3	6 (12)	5 (10)	7 (14)	2 (4)	**20**	**80**

In 2016 did 2 Swedish vessels and 1 Danish vessel participate in the survey. The Danish vessel fished twice as many hauls as the Swedish vessels keeping the total fished hauls at the same level as previous years.

Target species

The survey is directed against and designed for cod, but the catch of all species is, however, recorded.

Survey period

The survey takes place during second half of November - first half of December.

Vessels and Fishing gear

Vessels

The survey is conducted by four commercial chartered trawlers, two covering the northern and two the southern area, respectively. Two vessels are Swedish and the other two are Danish. The vessels have been appointed due to the similarity in engine power, length and applicability for scientific investigations. Participating vessels are shown in table 3.

Table 3. Vessels participating in the survey

Year	DK1	DK2	SWE1	SWE2
2008	Sören Kanne	Susanne H	Otseco	Yvonne II
2009	H210	Susanne H	Otseco	Yvonne II
2010	Havfisken	Susanne H	Ganler	Tärnan
2011	H292	Susanne H	Cindy Wester	Tärnan
2013			Cindy Wester	Tärnan
2014	Tiki	Stjerne	Cindy Wester	Tärnan
2015	Annie Holm	Stjerne	Cindy Wester	Tärnan
2016	Havfisken	Havfisken	Cindy Wester	Tärnan

Gear
The trawl is a commercial bottom trawl provided by the EC LOT 3 project.

Trawl (see Annex 1): A Swedish TV-trawl 112 ft 24-464 mounted with 13 8’’ balls and 16 6’’balls.
Ground gear: Rock hopper type with 4 thumps rubber discs at 10 cm
Mesh size in cod end: 70 mm stretch mesh.
Otter boards: 64”-66" "Thyborøn"
Warp: 15 mm.

The trawls are checked continuously during the survey.

Fishing operation
Within each square the skipper decides on the best way to fish at the location (e.g. exact position and tow direction). Maximum 5 min of the total trawling time should be outside the allocated square. If the 5 minutes are exceeded the haul should be terminated.

Trawling was restricted to 15 min. before sunrise to 15 min. after sun set.

Trawl procedure
Towing time: 60 min (towing time down to 20 min is accepted).
Towing speed: Between 2.7 kn. and 3.4 over the seabed, but speed should not vary within a station.
Hauls start: when the trawl is considered going stable on the bottom, roughly 5-7 min after wires are connected.
Haul end: when hauling back starts.
Trawled distance: is estimated from the plotter or by the mean of the towing speed recoded every 10 min. and the total towing time.

Sampling of catch
There were two technicians/scientists from DTU-Aqua (Danish vessels) or SLU-Aqua (Swedish vessels), on board each vessel who were responsible for processing the catch.
The catch was processed in accordance with IBTS standard operating procedures for trawl surveys. After each haul the catch was sorted by species and weighed to nearest 0.1 kg and the number of specimens recorded. All fish species are measured as total length (TL) to 1.0 cm below. Norwegian lobster was measured in mm.
For cod are two otoliths per cm class and area (north and south) collected. The Swedish sampling protocol for age changed in 2016 and otoliths were taken from every haul. The number of individuals sampled for age by haul were 1 individual per length class for cod size 10-40 cm, 2

individuals per length class for cod size 41-60 cm and 3 individuals per length class for cod larger than 60 cm.

Screening of data
All trawl data (position, wingspread, towing speed etc.) and catch and length frequency data on cod were screened for unrealistic figures before further estimations.

Data
Data are stored in a standard data base and could, if the survey continues, be uploaded to the ICES DATRAS system.

Survey area
Hence no stations are deeper than 100 m, biomass and abundance is estimated for depths between 20 and 100 m (including the two shallow fjords Laholmsbugten and Skældervigen). The survey area is stratified in three density strata: HIGH, MEDIUM, LOW and CLOSED AREA. The total survey area is 10204 km^2 .

Biomass and abundance

Biomass and abundance was estimated through a traditional Swept area calculation where mean catch km^{-2} is multiplied with the stratum area.

1) Biomass and abundance estimates are obtained by applying the swept area method using the recorded towed distance and wing spread and the stratum area as weighting factor (Cohran, 1977). Wing spread is estimated as:

$$\text{Wing spread} = \frac{\text{Ground gear length X Door spread}}{\text{Bridle length + Ground gear length}}$$

Door spread is estimated for the single hauls, using a warp divergence method (Anon. 2006) (Annex 1).

Swept area=(distance towed (nm)*1.852)*(wing spread(m)/1000)

The catchability coefficient is assumed to be 1.0.

All catches are standardized to 1 km^2 swept prior to further calculations.

Estimation of stock indices

Calculation of biomass and abundance indices was based on the stratified random design, assuming sampling with replacement. Age at length was estimated from Swedish samples only. From 2013 the survey area contained 120 5×5 Nm squares, but for consistency, biomass and abundance was estimated for 119 squares throughout the period. All calculations were carried out in R, using the R-survey package (Lumley 2012). A more detailed explanation of the estimation procedure is found I annex 3.

Reference
T. Lumley (2012) "survey: analysis of complex survey samples". R package version 3.28-2.

Results

Biomass and abundance

Annual data on cod abundance and distribution for 2008-2016 is given in Figure 2A-B. For biomass, 2014 and 2015 stand out with quantities high above the level for 2008-2011. For numbers, year 2014 was the highest in the time series.

The trawlable biomass of cod was in 2016 estimated at 4977 tons, compared to 9378.6 tons in 2015 (Table 4). This corresponds to a reduction in biomass with approximately 45%. The trawlable abundance was in 2016 estimated at 3.1 million compared to an estimated at 5.75 million in 2015 (Table 4) which also corresponds to a reduction of approximately 45%. The highest biomass in 2016 (1100 kg per km^2) and numbers (481 specimen per km^2) was found in high stratum (Table 5 and 6). This differs from 2015 were the highest biomass was found in the mid-density stratum. Catch per effort, as measured by specimen and weight per hour trawl time was highest in the high density area (Table 8). CPUE (by specimen) and numbers per km^2 were in 2016 lowest in the mid-density stratum.

Table 4. Biomass (t) and abundance of cod with Stdev together with weight and number km2 by year

Year	Mean biomass (km2)	Stdev	Biomass (t)	Number (km2)	Stdev	Abundance
2008	129.2	216.1	1318.1	156.8	94.0	1.60e+06
2009	80.6	78.3	822.4	212.0	203.0	2.16e+06
2010	75.7	84.1	772.2	211.7	193.6	2.16e+06
2011	119.6	187.2	1220.0	224.1	175.9	2.29e+06
2013	232.8	330.8	2375.0	540.7	493.4	5.52e+06
2014	776.6	1450.1	7924.5	855.6	1299.1	8.73e+06
2015	919.1	1119.5	9378.6	563.3	495.8	5.75e+06
2016	487.8	562.3	4977.0	303.4	250.1	3.10e+06

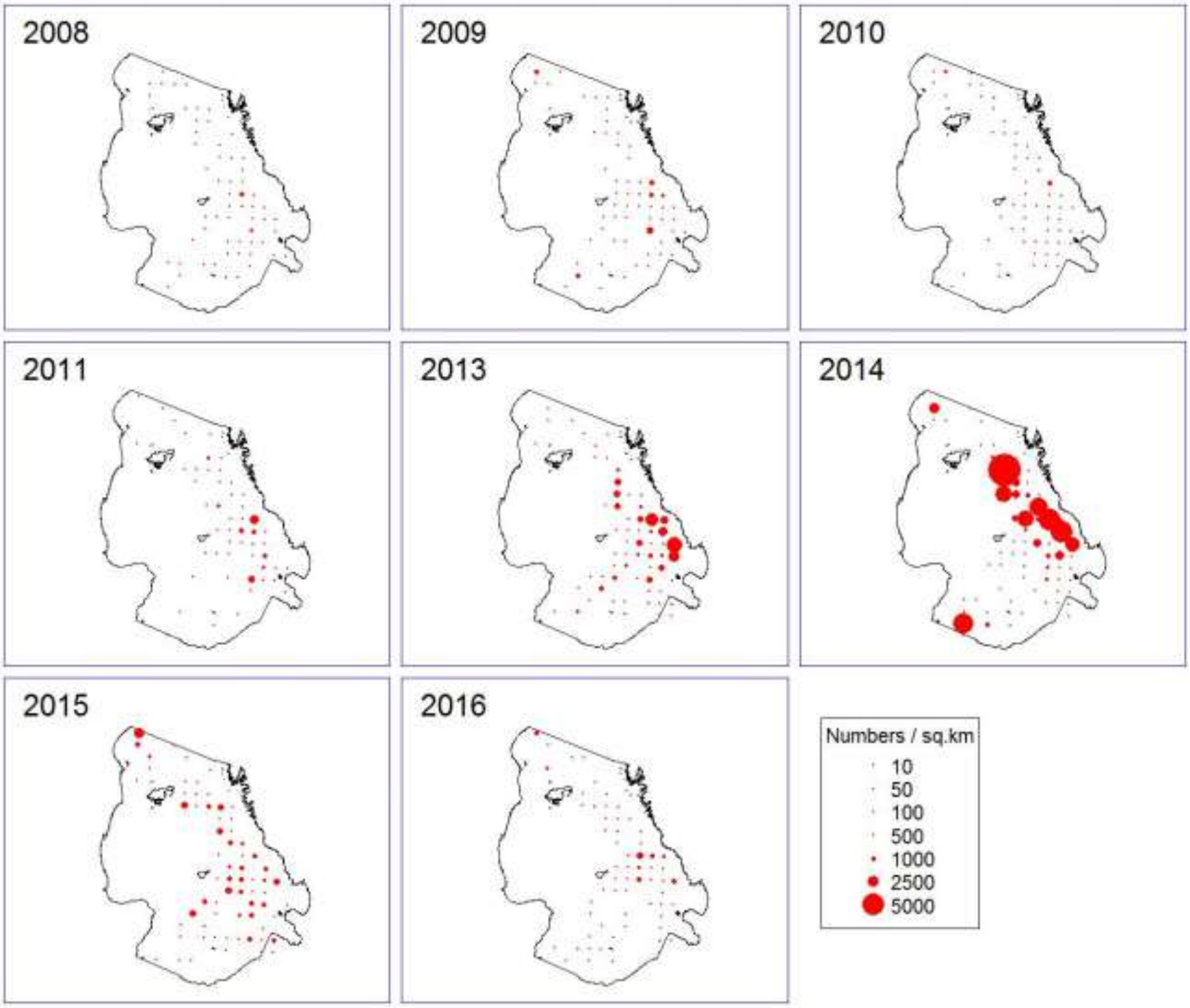


Figure 2A. Abundance of cod per km^2, calculated as an average from all vessels per square.

10

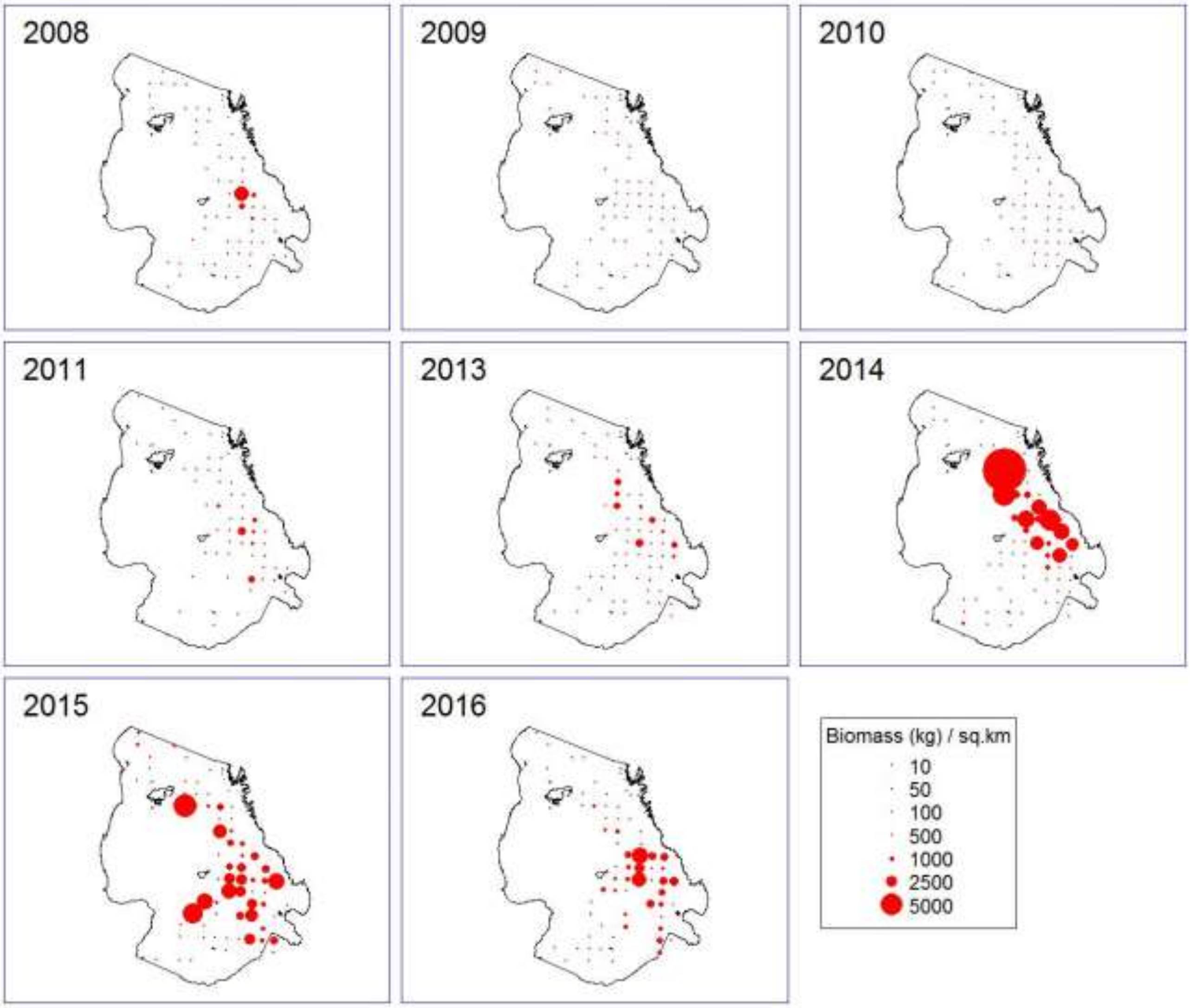


Figure 2B. Biomass of cod per km^2, calculated as an average from all vessels per square.

Table 5. Cod 2016. Stratum area (km), number of hauls, mean biomass per km2 (kg), Stdev and total biomass (tons)

Strata	Area	Hauls	biomass_km2	Stdev	Biomass
Closed	686	6	718.2	158.5	492.7
High	1801	24	1100.2	266.0	1981.4
Medium	2229	19	316.7	132.0	706.0
Low	5574	29	222.0	242.1	1237.5

Table 6. Cod 2016. Stratum area (km), number of hauls, number per km2, Stdev and abundance

Strata	Area	Hauls	Mean_number_km2	Stdev	Abundance
Closed	686	6	302.8	158.5	2.08e+05
High	1801	24	481.3	266.0	8.67e+05
Medium	2229	19	200.5	132.0	4.47e+05
Low	5574	29	261.1	242.1	1.46e+06

Length distribution

The length ranged from 10 to 85 cm. The overall length distribution (weighted by stratum area) showed modes at 18 and 68 cm in 2016 (Figure 5 and 6).

Most small cod were found in the low density area, while large individuals (over 50 cm) dominated in the medium and high density areas (Figure 6).

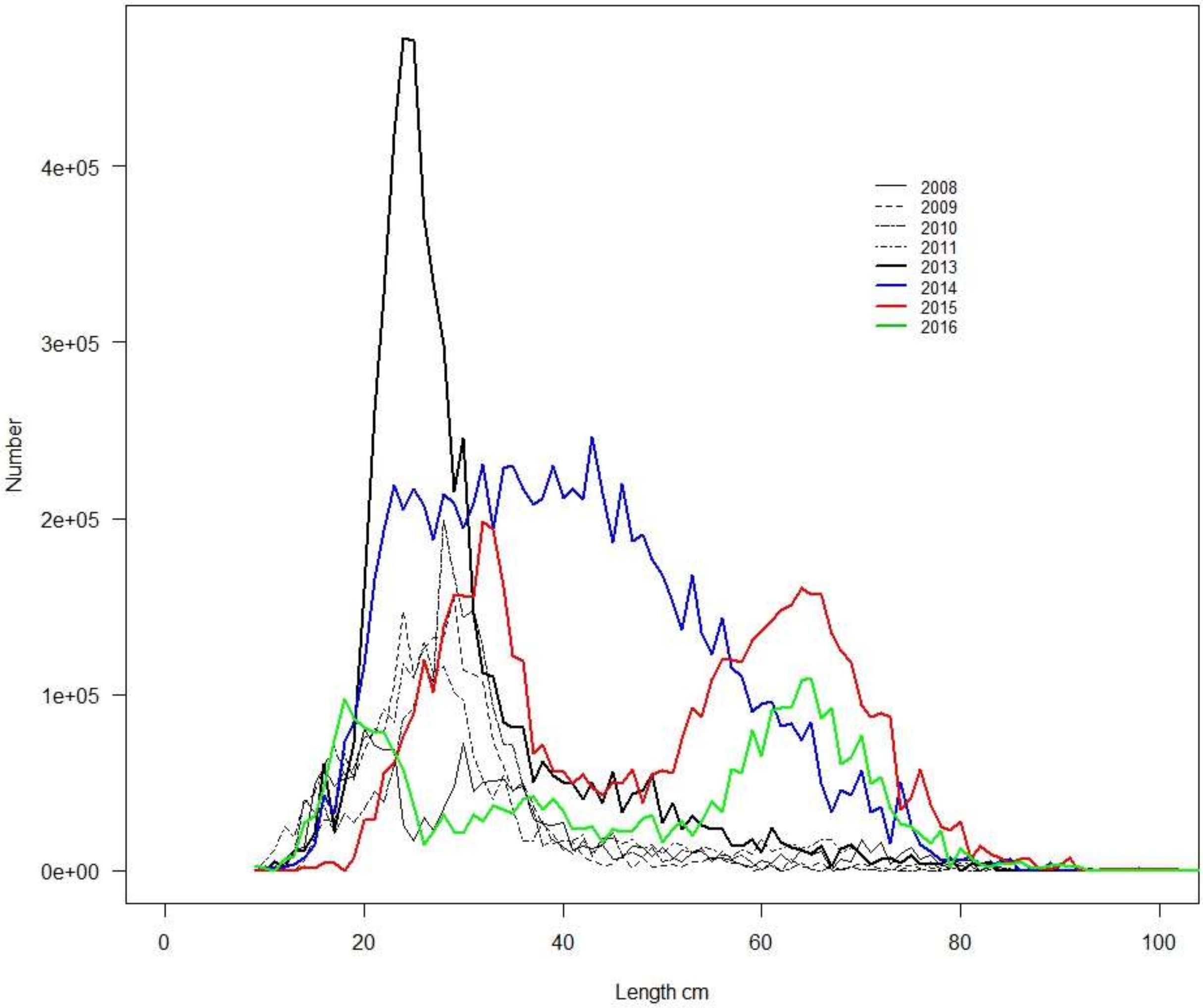


Figure 5. Length distribution in total number of cod weighted by stratum area by year in the total survey area.

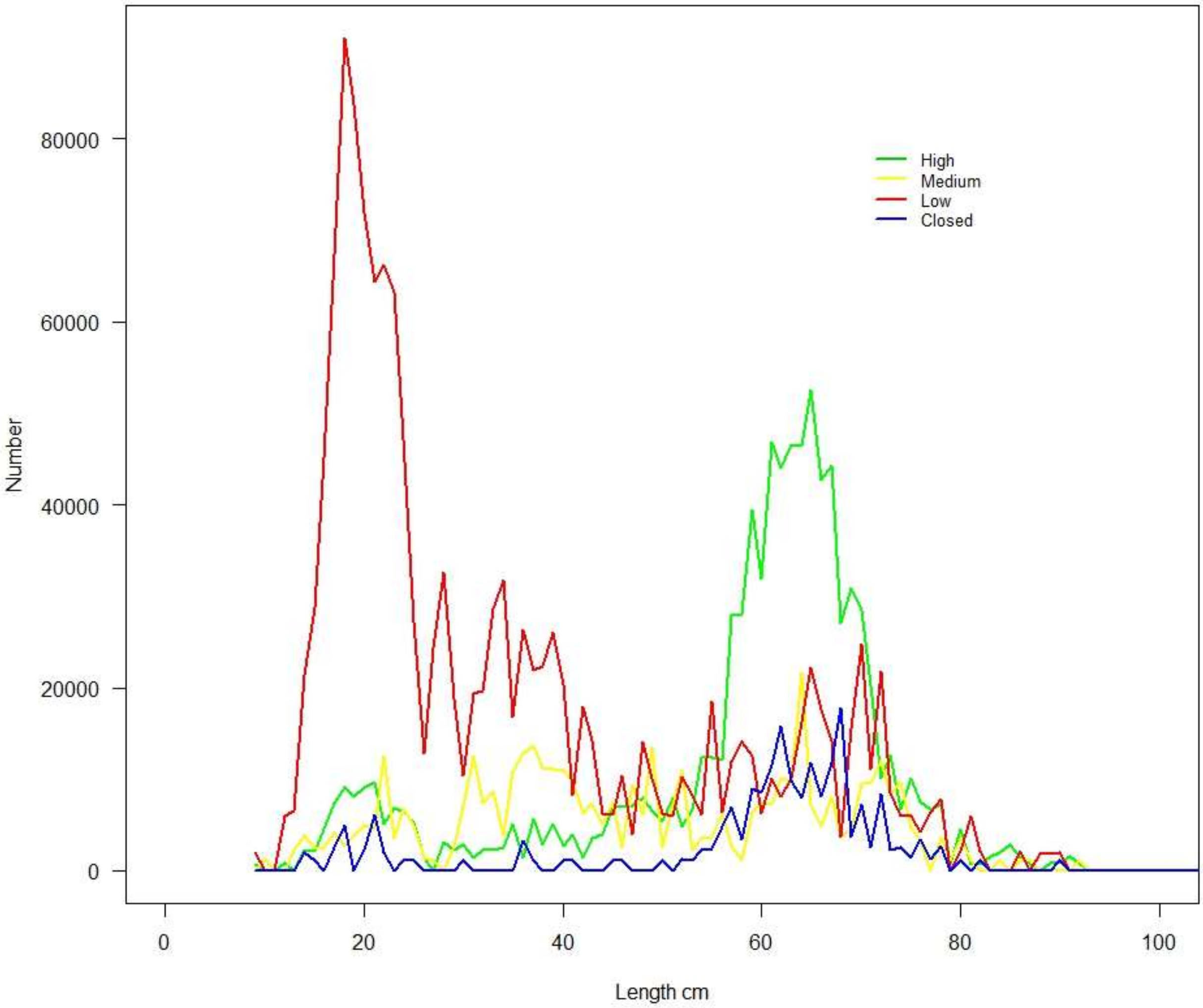


Figure 6. Length distribution of cod in total number by stratum.

Age distribution

The overall age distribution (weighted by stratum area) has throughout the time-series been dominated by ages 1-4. This changed in 2016 where a relatively even distribution of age-classes (age 0- age 6) were found (Table 7). Significantly fewer age-0 was found in 2015 compared to the other years. In 2016 this signal is picked-up in 2016 were the amount of age-1 is low (second lowest in the time-series only comparable to 2008). Significantly more age-0 was found in 2016 compared with 2015 but the number is still low compared to the entire time series. Overall the numbers in the younger age classes decreased in 2015 and 2016 indicating lower recruitment in recent years. The numbers in the higher ages-classes increased in 2015indicating higher abundance of adult fish. In 2016 do however the numbers in the higher age classes decrease, except for age-6.

Table 7. Number at age of cod by year in the survey area.

age	2008	2009	2010	2011	2013	2014	2015	2016
a0	621857.1	308892.5	314833.0	494899.8	240421.0	503903.7	56827.3	254596.7
a1	538686.7	1696834.9	1155123.2	929973.2	2121406.5	1474662.3	944394.8	587052.2
a2	181668.2	83558.0	655670.1	550625.1	2138218.8	2829800.5	1293266.0	378607.0
a3	115502.8	20939.4	24206.3	249026.1	643880.0	2364199.8	1278044.0	498508.1
a4	74567.6	20072.9	4425.3	51917.0	309750.8	955448.1	1077276.3	496950.2
a5	44300.4	22736.5	4621.0	8286.0	54751.9	421553.0	702880.8	437840.7
a6	23527.4	9831.6	1171.1	2232.8	8635.2	180808.0	394743.7	442004.3

CPUE

CPUE in both weight and number per hour was highest in the high density area (Table 8). The overall CPUE in 2016 was 28,4 (compared to 55,6 in 2015) specimen and 46,1 kg (compared to 92.2 kg in 2015) per hour. In 2010 were the corresponding figures 16.1 specimens and 6.6 kg, respectively (Comparable data in 2011 report).

Table 8. CPUE (h) in 2016. Number, Stdev_Number, Weigh, Stdev_weight, by Strata and overall

Strata	Number	Stdev_Number	weight	Stdev_Weight
High	45.3	55.3	103.0	55.3
Medium	19.2	28.2	30.7	28.2
Low	24.1	30.5	21.2	30.5
Closed	28.8	49.4	68.4	49.4
All	28.4	23.7	46.1	52.9

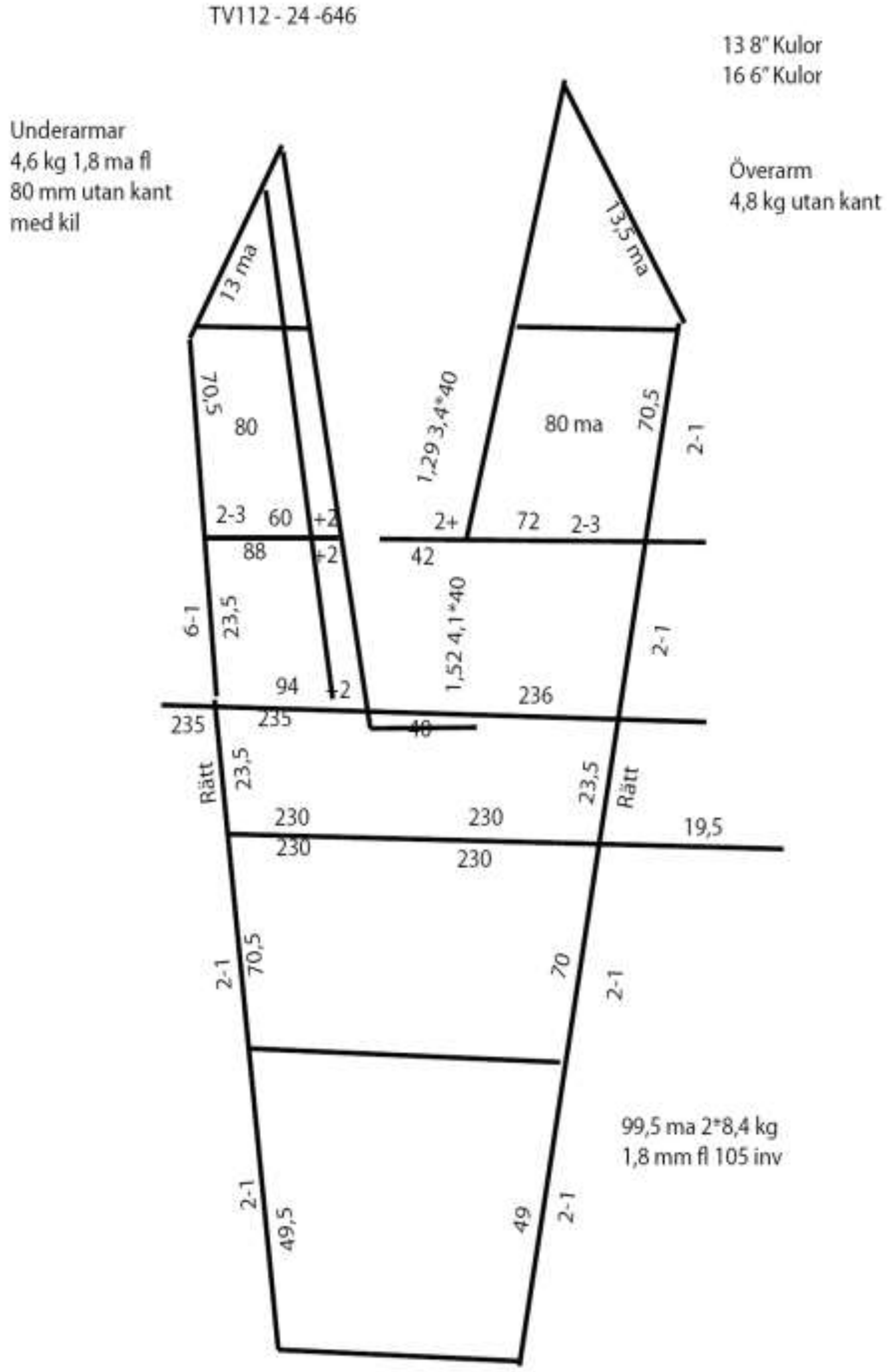
Table 9. CPUE per age and km2 (swept area)

	a0	a1	a2	a3	a4	a5	a6	total
2008	60.94	52.79	17.80	11.32	7.31	4.34	2.31	156.81
2009	30.27	166.29	8.19	2.05	1.97	2.23	0.96	211.96
2010	30.85	113.20	64.26	2.37	0.43	0.45	0.11	211.69
2011	48.50	91.14	53.96	24.40	5.09	0.81	0.22	224.12
2013	23.56	207.90	209.55	63.10	30.36	5.37	0.85	540.68
2014	49.38	144.52	277.32	231.69	93.63	41.31	17.72	855.59
2015	5.57	92.55	126.74	125.25	105.57	68.88	38.69	563.25
2016	24.95	57.53	37.10	48.85	48.70	42.91	43.32	303.37

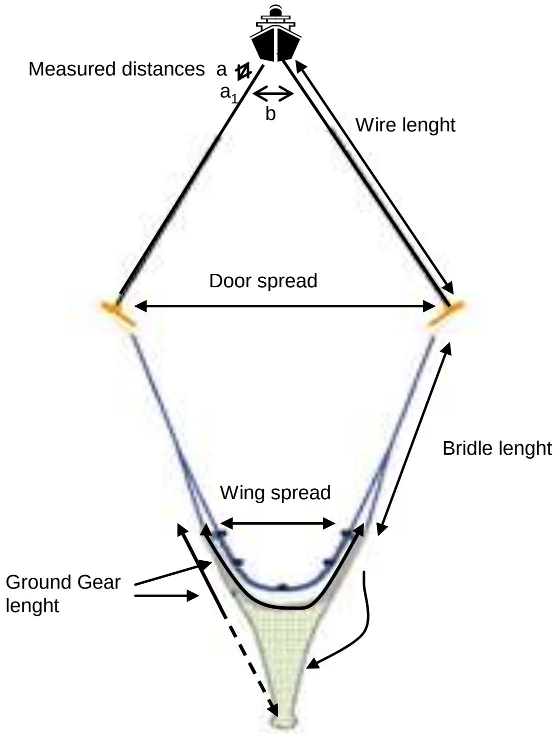
Table 10. WECA, weight at age in tonnes

	a0	a1	a2	a3	a4	a5	a6	total
2008	49.9	198.2	164.7	294.4	245.0	230.7	135.2	1318.1
2009	23.0	426.7	90.8	57.5	66.2	99.3	58.9	822.4
2010	18.0	277.3	380.3	51.9	25.3	15.0	4.4	772.2
2011	27.1	171.5	293.7	499.7	180.6	37.1	10.2	1220.0
2013	14.6	404.8	728.3	529.9	448.5	207.4	41.4	2375.0
2014	41.4	370.4	2039.2	2312.1	1616.1	1040.4	504.9	7924.5
2015	5.2	268.6	1106.3	2146.1	2416.1	2123.9	1312.4	9378.6
2016	12.3	84.5	290.5	761.8	1213.5	1253.8	1360.5	4977.0

Annex 1. TV112 trawl



Annex 2. Calculation of wing spread.



Calculations of door spread and wing spread

Assuming that the distance between the trawl doors and the wires form an equilateral triangle, the door spread have been calculated as

$$\text{Door spread} = \frac{\text{Wire length x measured distance b}}{\text{measured distance a}}$$

For every haul, a length on the wire (distance a) and the length between the wires measured at a_1 (distance b) have been recorded.

Wing spread is estimated as:

$$\text{Wing spread} = \frac{\text{Ground gear length x Door spread}}{\text{Bridle length + Ground gear length}}$$

(Calculation from "Course in Trawl Gear Technology", May 2006, SeaFish Flume Tank, Hull, UK)

NOTE: Figure not according to scale

Annex 3. Kattegat cod survey 4th quarter – Survey design and estimation

Survey design

The Kattegat cod survey has been carried out since 2008 with the exception of 2012. The survey is a joint effort by Sweden and Denmark with the aim to provide fishery independent data with improved spatial coverage for estimating abundance, biomass, recruitment index and distribution of Kattegat cod. The survey is conducted in November-December in by two commercial trawlers from Denmark and two from Sweden.

The bottom-trawl survey follows a stratified random sampling design. From the start the survey area was stratified into three geographic strata based on information from the fishery: (1) a stratum with expected high density of cod, (2) a stratum with medium density and (3) a stratum with low density of cod. In 2010 and 2011 minor re-stratification was done to adapt strata to the catch information collected during the previous years. In 2014 the survey area was partly re-stratified to include a fourth stratum in its south-eastern range to ensure that a sufficient number of samples would be collected from an area closed for fisheries.

The survey is planned with 20 hauls in 6 days for each of the 4 vessels, in total 80 hauls. The sampling frame is a list of 120 5×5 NM squares divided into the four strata. The high density, the medium density and the closed area strata have been allocated relatively more stations than the low density strata. Each vessel fish in 20 different squares allocated to the four strata according to the design. All vessels have the same number of hauls in each stratum. In the high density, the medium density and the closed area strata vessels can get hauls in the same square, i.e, squares are selected with replacement. In the low density areas squares are sampled without replacement, i.e., only one haul can take place in each square. To reduce steaming time, the low density stratum is divided into a northern and a southern part.

Handling of the catch is done by personnel from DTU-AQUA and SLU-AQUA. In each haul, catch and length from all species is recorded but age sampling is only done for cod. The original instructions were to collect two otoliths per cm class and haul, up to five otoliths per cm class and area (North and South). Since then, the instructions for Swedish vessels have been changed to sample more otoliths, and from 2016 otoliths are sampled from all hauls. Samples for genetic analyses have also been collected in 2013, 2105 and 2016.

Estimation

Data from the survey is stored in national data bases and exchanged between countries using the DATRAS format. The Kattegat cod survey indices are calculated by SLU-AQUA.

Biomass and abundance indices are estimated according to the survey design using the Horwitz-Thompson estimator (τ), where y_i are numbers-at-age in haul *i*, π_i, the inclusion probability of haul i, i.e., the probability that haul *i* is included in the sample

$$\hat{\tau} = \sum_{i=1}^{n} \frac{y_i}{\pi_i} \qquad \text{for the population total}$$

In the low density areas where squares are selected without replacement the inclusion probabilities for individual hauls are calculated as *nh*/*Nh*, where *nh* is the total number of sampled squares in stratum *h* and *Nh* is total number of squares in stratum *h*. In the high and medium density areas and in the closed area where squares are selected with replacement the inclusion probabilities are calculated as 1-(1-*nvh*/*Nh*)^*Nv* where *nvh* is the number of sampled squares per vessel in stratum *h*, *Nh* the total number of squares in stratum *h* and *Nv* is the number of vessels.

Annex 08: WKMSYCat34 evaluation

Background

The Workshop on the Development of the ICES approach to providing MSY advice for category 3 and 4 stocks (WKMSYCat34) met on 6 to 10 March 2017. One of the ToRs was "Defining a set of criteria for the identification of category 3 and 4 stocks that should be candidates for full analytical assessment with forecast, and identifying some candidate stocks."

In response to this ToR, WKMSYCat34 developed a template to evaluate if a stock could be a candidate for a full analytical assessment with forecast (i.e. category 1) after a benchmark-type or similar process. The template was tested on three example stocks and was found to provide the necessary information to identify the potential candidate stocks.

WKMSYCat34 recommended that the template be used by the stock assessment expert groups in 2017 to identify candidate stocks for category 1.

The ACOM leadership has discussed the recommendation and agrees that the template is a useful tool to identify candidate category 3 and 4 stocks for full analytical assessment. The leadership also supports the recommendation to request stock assessment groups to apply the template.

The ACOM leadership is aware that adding a new ToR to your group at this stage is not optimal and that it may be difficult to find time to address the request. However, the input from our group is crucial to be able to move forward with this. For this reason, we would like to request that you read the chapter below from the WKMSYCat34 report and consider to what extent you will be able to apply (fully or partly) the template for your category 3 and 4.

1) Criteria for identifying candidate stocks for full analytical assessment and forecast

This section responds to ToR1: *Defining a set of criteria for the identification of category 3 and 4 stocks that should be candidates for full analytical assessment with forecast, and identifying some candidate stocks.*

WKMSYCat34 developed a template to evaluate if a stock could be considered as a candidate for a full analytical assessment with forecast (*i.e.* category 1). This template was completed for three specific stocks (lemon sole in 3.a, 4 and 7.d, witch flounder in 3.a, 4 and 7.d, and dab in 3.a and 4) to test whether the questions and criteria in the template can be readily applied and provide the information needed to identify potential candidate stocks for category 1.

WKMSYCat34 recommends that the template should be used by the stock assessment working groups in 2017 to identify candidate stocks for category 1. After assessment working groups have identified a list of potential stocks, a final prioritization can be made by ACOM, taking into consideration client requests and potentially eco-logical or economic importance of the stocks.

2) Template for evaluation of a stock in categories 3 or 4 as a candidate for a category 1 assessment

WKMSYCat34 developed a template to evaluate if a stock can be considered as a candidate for a reclassification to a category 1 assessment within 1–2 years. The template is presented in Table 2.1.1. It is designed as a series of questions which stock assessment working groups should be requested to complete for each of the category 3 and 4 stocks.

The template starts with questions to find out whether sufficient resources are available in the next 1–2 years to conduct a benchmark (or a similar peer review process). This includes consideration of whether there exist particular drivers for a benchmark assessment (*e.g.* new data, models,…) and whether there is sufficient manpower to conduct the work. The latter includes the availability of external experts and reviewers, ICES' stock coordinator and stock assessor, and sufficient resources within national institutes to meet the data requirements.

The template then considers if sufficient data exist for either a category 1 age/length based assessment or a category 1 assessment based on a production model. In addition to the more "traditional" assessment methods, integrated assessment approaches may also be considered. By integrated assessment approaches we mean flexible models that can combine various types of biological and fishery data, *e.g.* data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may e.g. be developed with the Stock Synthesis software. In completing this section of the template, it may not be sufficient to list only currently available data. Consideration should be given to alternative data which can be made available via an official data call supporting the proposed benchmark process. This often requires communication between the stock experts and people working in national institutes.

The final question in the template asks whether the category 1 assessment envisaged fulfils the particular advice requirements from clients (*e.g.* there is a management based on effort and technical measures but the forecast produces catch advice and vice versa; as this is dependent on how the request for advice is formulated to ICES, communication with the ICES Secretariat will be necessary to understand this correctly).

3) Evaluation of the template from three example stocks

The template was filled for three example stocks during WKMSYCat34 to test whether the questions and criteria in the template can be readily applied and provide the information needed to identify potential candidate stocks for a category 1 assessment. It should be recognised that these are examples and were largely completed in the absence of stock experts. Therefore, changes may occur after consideration by the appropriate assessment working groups. In completing the tem-plate for the example stocks the following observations were made:

1. Overall, the template seems to provide the necessary information to judge whether a stock is a potential candidate for a category 1 assessment benchmark exercise. It also provides an opportunity for stock experts to challenge the in-put data and assessment methods and to identify gaps and issues.

The template could also be used for benchmark preparations in general as it helps to avoid the situation that data are regarded as not sufficient at a late stage of the benchmark process. Furthermore, the communication between stock experts and people working in national institutes would be facilitated.

2. It is often difficult to judge whether available time series can be considered of sufficient quality for input to production models. Questions around the length of the time series and sufficient contrast in the data are to some extent subjective. As a rough guidance, a time series needs to have periods of low and high values (catch and index). Ideally, peaks or plateaus should also be evident. A time series displaying only an increasing or decreasing trend is unlikely to be sufficient to determine F/F_{MSY} and B/B_{MSY} with low uncertainty and an acceptable retrospective behaviour. The time series should be representative for the full range of exploitation levels experienced by the stock. It is recommended to have a preliminary baseline assessment where the diagnostics can directly be used to identify issues.

3. The SPiCT production model can make use of informed priors that can potentially reduce the uncertainty around model estimates. The following model parameters are good candidates for the incorporation of priors:

    - BKfrac (B1/K). This parameter represents the stock biomass in the first year included in the assessment relative to carrying capacity (the biomass expected in the virgin population with no fishing). For stocks that were not exploited, or only very lightly exploited, before the first year in the assessment, this parameter would be expected to be close to 1. The situation is more complicated for stocks with a history of exploitation before the first year in the assessment. As a first rough approximation, this parameter may generally be expected to be around the range 0.3-0.6 for stocks believed to have been exploited somewhere around F_{MSY}, and below that range for stocks believed to have undergone heavier exploitation.
    - sdc (CV of observed catch; could be specified annually). This parameter represents the uncertainty in the catch (in weight) data used in the model as representative of the true stock catch that occurred in reality. Although the uncertainty of landed catch (in weight) might be small, the uncertainty is typically larger for discards.

- sdi (CV of observed index; could be specified annually). This parameter represents the uncertainty in the index used in the model as representative of the stock biomass. The CV derived directly from survey indices is most often an underestimate of the value of this parameter, and sometimes the survey may not fully cover the exploited stock.

The parameters sdc and sdi can also be treated as fixed inputs if their values are known. SPiCT also allows these parameters to be scaled up for parts of the time series, which can be appropriate if some periods are known to be more uncertain.

These prior distributions require careful consideration and can only be used if there is clear evidence that the values used are appropriate. Model results with and without priors should always be compared to quantify the effect of priors.

Other production models (*i.e.* other than SPiCT) may also be able to incorporate prior information.

Brill (*Scophthalmus rhombus*) in subdivisions 22–32 (Baltic Sea)

Table 2.1.1 Template to identify potential candidate stocks for category 1 assessment.
Species, Area

- Which is the current category number (3 or 4)?

Category 3

- Are there already plans for a benchmark in 1–2 years?

No.

- What are the necessary requirements to do the upgrade to category 1?
  - Resources needed:
    - Within ICES

Stock coordinator and stock assessor, survey experts, stock assessment experts

    - Outside ICES

Survey experts, stock assessment experts

  - Drivers for the process leading up to category 1:
    - Revised stock identification and delineation

None, however, the sparse survey observed distributions suggest that the stock might be part of the 27.3.a.21 distributional area, as the stock is basically limited to 27.3.a.22 and 27.3.a.23, and apparently on the edge of the distributional area with tis center in 27.3.a.21.

    - New data that can be made available

Probably not. The CPUE is on average around 1 individual per hour.

    - Want to achieve models with assessment and reference points

Would be nice, but data are too sparse, only 2012-recent have discard estimates

    - Want to achieve models with forecasts (according to management requirements)

Probably not achievable

- Could there be sufficient data suitable for age or length based models and fore-cast?
  - Necessary information on stock identity/delineation

No.

  - Catch/landings by age or length time series (incl. levels of sampling)

Length data on landings and discards are available from 2011-2016 but very sparse

  - Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)

CPUE index (no/hour) from length distributions of BITS

- o Weight, maturity and natural mortality at age or length

weight per length are available from survey(2002-recent) and commercial sampling (probably only 2014-2016), sampling intensity is extremely low.

- Could there be sufficient data suitable for surplus production models and fore-cast?
  - o Necessary information on stock identity/delineation

No.

- o Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)

No.

- o Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast

CPUE index (no/hour) from length distributions of BITS

- o Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)

Standardized effort (standardized days at sea divided by cod landings) is available for 2009 to 2016 only

- o If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})

No.

- o If necessary potential priors on model external or internal parameters

-

- Integrated stock assessment models (*i.e.* flexible models that can combine various types of biological and fishery data, *e.g.* data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may *e.g.* be developed with the Stock Synthesis software) considered?

Currently not considered

- Assessment and forecasts consistent with client management needs

No.

CONCLUSIONS:

Bll.27.22-32 should not be considered for a Cat.1 stock, catch advice is given since 2016, and only 5 years of discards estimates are available. It might be however considered to have a look at the stock boundaries, as there are indications that bll.27.22-32 might be part of a larger stock in 27.3.a.21

Cod (*Gadus morhua*) in Subdivision 21 (Kattegat)

Table 2.1.1 Template to identify potential candidate stocks for category 1 assessment.
COD, Kattegat

- Which is the current category number (3 or 4)?

3

- Are there already plans for a benchmark in 1–2 years?

Yes

- What are the necessary requirements to do the upgrade to category 1?

  Resources needed:
    - Within ICES: **NA**
    - Outside ICES: **Yes**

  - Drivers for the process leading up to category 1:
    - Revised stock identification and delineation
    - New data that can be made available
    - Want to achieve models with assessment and reference points
    - Want to achieve models with forecasts (according to management requirements)

All the above

- Could there be sufficient data suitable for age or length based models and fore-cast?

Genetic data for sock identification

- Could there be sufficient data suitable for surplus production models and fore-cast?
  - Necessary information on stock identity/delineation

    Yes
  - Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)

    Yes
  - Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast

    Yes
  - Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)

    Yes
  - If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})

    Yes
  - If necessary potential priors on model external or internal parameters

    Yes

Yes, in general

- Integrated stock assessment models (*i.e.* flexible models that can combine various types of biological and fishery data, *e.g.* data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may *e.g.* be developed with the Stock Synthesis software) considered?

Yes

- Assessment and forecasts consistent with client management needs

Yes

CONCLUSIONS:

Can be considered as potential candidate for Category 1. Several different models are available, including SAM, SS3 and baseline SPiCT. Information is needed on stock identity i.e. genetics.

Cod (*Gadus morhua*) in subdivisions 25–32, eastern Baltic stock (eastern Baltic Sea)

Table 2.1.1 Template to identify potential candidate stocks for category 1 assessment. ***Cod, 27.25-32***

- Which is the current category number (3 or 4)?
  3

- Are there already plans for a benchmark in 1–2 years?

  Improving the assessment of this stock is a continuous process running since 2015, with specific TORs allocated to WGBFAS. In WGBFAS 2017, SPICT model was presented that is intended to be reviewed in 2017 as part MSY proxies. If approved, it remains to be clarified whether and how this model could be used for providing advice on this stock in future. At the same time, intersessional work with age/length based models will continue, and will be presented at WGBFAS in 2018. Based on the outcome of this work, next necessary steps can be identified.

- What are the necessary requirements to do the upgrade to category 1?
  - Resources needed:
    - Within ICES
    - Outside ICES

  - Drivers for the process leading up to category 1:
    - Revised stock identification and delineation
    - New data that can be made available
    - Want to achieve models with assessment and reference points
    - Want to achieve models with forecasts (according to management requirements)

- Could there be sufficient data suitable for age or length based models and fore-cast?
  - Necessary information on stock identity/delineation

  - Catch/landings by age or length time series (incl. levels of sampling)

  - Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)

  - Weight, maturity and natural mortality at age or length

- Could there be sufficient data suitable for surplus production models and fore-cast?
  - Necessary information on stock identity/delineation

    Yes

  - Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)

    Yes

  - Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast

    Yes

- o Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)

- o If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})

Yes

- o If necessary potential priors on model external or internal parameters

- Integrated stock assessment models (*i.e.* flexible models that can combine various types of biological and fishery data, *e.g.* data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may *e.g.* be developed with the Stock Synthesis software) considered?

Work with Stock Synthesis is ongoing

- Assessment and forecasts consistent with client management needs

CONCLUSIONS:

Age-based model for this stock is currently not available due to i) reduced quality of age readings in later years. At the same time growth is assumed to have changed, but the change has not been quantified; ii) natural mortality has likely increased, but not quantified. Thus, it is difficult to distinguish between mortality and growth. Work is ongoing to derive reasonable assumptions for growth changes that could be verified when tagging data (from TABACOD project) becomes available. After the assumption on changed growth will be resolved, age/length based model can likely be set up, and this work is currently ongoing.

SPICT model for Eastern Baltic cod was developed and presented at WGBFAS 2017. This model is not dependent on being able to distinguish between growth and mortality, but is taking into account a changed productivity of the stock in recent years.

Dab (*Limanda limanda*) in subdivisions 22–32 (Baltic Sea)

Table 2.1.1 Template to identify potential candidate stocks for category 1 assessment. *Dab in 27.3.c.22, 27.3.b.23, 27.3.d.24-32 (tur.27.22-32)*

- Which is the current category number (3 or 4)?
  Category 3
- Are there already plans for a benchmark in 1–2 years?
  No, last benchmark during WKBALFLAT 2014
- What are the necessary requirements to do the upgrade to category 1?
  - Resources needed:
    - Within ICES
      Stock coordinator and stock assessor, survey experts, stock assessment experts
    - Outside ICES
      survey experts, stock assessment experts
  - Drivers for the process leading up to category 1:
    - Revised stock identification and delineation
      None, however, survey observed distributions suggest that 27.3.a.21 might be part of the stock, as there is huge overlap
    - New data that can be made available
      Probably not
    - Want to achieve models with assessment and reference points
      Would be nice, but data are sparse, only 2012-recent have discard estimates
    - Want to achieve models with forecasts (according to management requirements)
      Probably not achievable
- Could there be sufficient data suitable for age or length based models and fore-cast?
  - Necessary information on stock identity/delineation
    No, WKBALFLAT 2014
  - Catch/landings by age or length time series (incl. levels of sampling)
    Length data on landings and discards are available from 2014-2016
    Age readings are available but rare
  - Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)
    BITS data available from 2002-2016, only few age readings
  - Weight, maturity and natural mortality at age or length
    weight per length (and age) are available from survey(2002-recent) and commercial sampling (~2009-recent, rather only 2014-2016), sampling intensity is low however.
- Could there be sufficient data suitable for surplus production models and fore-cast?
  - Necessary information on stock identity/delineation
    Evaluated by WKBALFLAT 2014, no change since then
  - Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)
    No
  - Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast
    CPUE index (no/hour) from length distributions of BITS
  - Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)
    standardized effort (standardized days at sea divided by cod landings) is available for 2009 to 2016 only
  - If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})
    No, only landings available, discards can be considerably high
  - If necessary potential priors on model external or internal parameters

?

- Integrated stock assessment models (*i.e.* flexible models that can combine various types of biological and fishery data, *e.g.* data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may *e.g.* be developed with the Stock Synthesis software) considered?
  Currently not considered
- Assessment and forecasts consistent with client management needs
  No

CONCLUSIONS:

Dab.27.22-32 should not be considered for a Cat.1 stock, catch advice is given since 2016, and only 5 years of discards estimates are available. It might be however considered to have a look at the stock boundaries, as there are indications that dab.27.22-32 might be part of the larger stock in 27.3.a.21

Flounder (*Platichthys flesus*) in subdivisions 22 and 23 (Belt Seas and the Sound)

Table 2.1.1 Template to identify potential candidate stocks for category 1 assessment. ***Flounder in 27.3.c.22 and 27.3.b.23***

- Which is the current category number (3 or 4)?
  Category 3
- Are there already plans for a benchmark in 1–2 years?
  Stock was benchmarked in 2014 (WKBALFLAT 2014), no plans for the near future
- What are the necessary requirements to do the upgrade to category 1?
  - Resources needed:
    - Within ICES
      Stock coordinator and stock assessor, survey experts, stock assessment experts
    - Outside ICES
      survey experts, stock assessment experts
  - Drivers for the process leading up to category 1:
    - Revised stock identification and delineation
      Done during WKBALFAT 2014
    - New data that can be made available
      Probably not
    - Want to achieve models with assessment and reference points
      Would be nice, exploratory SAM was done in 2014 and 2015, LBI in 2017
    - Want to achieve models with forecasts (according to management requirements)
      Probably not achievable
- Could there be sufficient data suitable for age or length based models and fore-cast?
  - Necessary information on stock identity/delineation
    stock ID was recently confirmed in 2014
  - Catch/landings by age or length time series (incl. levels of sampling)
    Length data on landings are available from 2002 to 2016 from DNK and DEU. Age data are rarely in 2002 to 2009, afterwards the amount is increasing and covering the catches quite well since 2012. Discard estimates are available from ca. 2006 to 2016 (2006-2012 are considered less reliable than recent years due to the poorer sampling coverage, data backwards in time are gained by slicing and applying recent age-length data, but are not confirmed to be reliable)

  - Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)
    BITS data available from 2002-2016, however with a change in ageing method in between
  - Weight, maturity and natural mortality at age or length
    weight per length and age are available from survey(2002-recent) and commercial sampling (~2009-recent, rather only 2014-2016)
- Could there be sufficient data suitable for surplus production models and fore-cast?
  - Necessary information on stock identity/delineation
    No
  - Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)
    No
  - Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast
    Several Indices (age, length, biomass) from BITS 2002-recent
  - Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)
    standardized effort (standardized days at sea divided by cod landings) is available for 2009 to 2016 only

- If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})
  Time series of catches is very short. Discards are a considerable part of the catch (~30-45%). SPiCT would not reflect the catches correctly when using only the landings
- If necessary potential priors on model external or internal parameters
  ?

- Integrated stock assessment models (*i.e.* flexible models that can combine various types of biological and fishery data, *e.g.* data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may *e.g.* be developed with the Stock Synthesis software) considered?
  Currently not considered
- Assessment and forecasts consistent with client management needs
  Guess so?

CONCLUSIONS:

Given the problems in providing catch estimates and the relatively short time series currently available, the stock is not a candidate for a category 1 assessment in the short term. However, if reconstruction of discards is possible and surveys with a longer time–series can be regarded as representative for the stock development, this conclusion may be re-evaluated. It will also depend on the decision whether management will be based on TACs in the future as this will determine which model and advice is needed. Currently, flounder have no TAC in the Baltic Sea.

Flounder (*Platichthys flesus*) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic)

Table 2.1.1 Template to identify potential candidate stocks for category 1 assessment.
Species, Area

- Which is the current category number (3 or 4)?

3

- Are there already plans for a benchmark in 1–2 years?

No plans for the next 1-2 years.

- What are the necessary requirements to do the upgrade to category 1?
  - Resources needed:
    - Within ICES
    - Outside ICES

    Discard reconstruction (discard available only for the last 3 years)
    Longer time series of age-based data provided by using statistical slicing.
  - Drivers for the process leading up to category 1:
    - Revised stock identification and delineation

      It was done during WKBALFLAT 2014.
    - New data that can be made available

      Longer length-based data series.
    - Want to achieve models with assessment and reference points

      Yes
    - Want to achieve models with forecasts (according to management requirements)

      Yes
- Could there be sufficient data suitable for age or length based models and fore-cast?
  - Necessary information on stock identity/delineation

    No
  - Catch/landings by age or length time series (incl. levels of sampling)

    Longer length-based data series.
  - Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)

    BITS data are used, but they are appropriate for estimate the stock status only of the fish bigger than or equal to 20 cm. The smaller fish are in the shallow waters, which are not covered by this survey.
  - Weight, maturity and natural mortality at age or length

    It was calculated during WKBALFLAT 2014.
- Could there be sufficient data suitable for surplus production models and fore-cast?
  - Necessary information on stock identity/delineation

    No
  - Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)

    Accepted discard data is available only since 2014.
  - Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast

    Several Indices (age, length, biomass) from BITS 2001-recent
  - Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)

    Standardized effort is available since 2009
  - If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})

    No (catch available since 2014, discard rate around 0.3)
  - If necessary potential priors on model external or internal parameters

- Integrated stock assessment models (*i.e.* flexible models that can combine various types of biological and fishery data, *e.g.* data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may *e.g.* be developed with the Stock Synthesis software) considered?

Yes, for example to include sexual dimorphism in growth.

- Assessment and forecasts consistent with client management needs

There is no TAC for this stock

CONCLUSIONS:

Taking into account high discard rate estimated only for the last three years, aged-based data series since 2012 (only for some of the countries, the data series is longer) the stock is not a candidate for a category 1 assessment in the short term.

Flounder (*Platichthys flesus*) in subdivisions 26 and 28 (east of Gotland and Gulf of Gdansk)

Table 2.1.1 Template to identify potential candidate stocks for category 1 assessment.
Flounder, 27.26-28

- Which is the current category number (3 or 4)?

Category 3

- Are there already plans for a benchmark in 1–2 years?

No plans

- What are the necessary requirements to do the upgrade to category 1?
  - Resources needed:
    - Within ICES

    Stock assessment experts
    - Outside ICES

    Fishery information, survival estimations

  - Drivers for the process leading up to category 1:
    - Revised stock identification and delineation

    Done in WKBALFLAT 2014
    - New data that can be made available

    New data is prepared in BONUS INSPIRE project
    - Want to achieve models with assessment and reference points

    Yes, SAM, production models
    - Want to achieve models with forecasts (according to management requirements)

    No TAC for flounder in the Baltic Sea

- Could there be sufficient data suitable for age or length based models and fore-cast?
  - Necessary information on stock identity/delineation

  Stock identification was done in benchmark WKBALFLAT 2014. Two flounder populations SD26 and SD 28 were merged together as one stock
  - Catch/landings by age or length time series (incl. levels of sampling)

  Age and length data from Latvia and Poland (two major fishing countries for the stock) is prepared in INSPIRE project

  - Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)

  BITS data are available. However, it is not possible to recognize in DATRAS what age data was aged using improved ageing method (recommended by ICES)
  - Weight, maturity and natural mortality at age or length

  Data in IC and DATRAS are available. Quality problems were described in previous paragraph.
- Could there be sufficient data suitable for surplus production models and fore-cast?
  - Necessary information on stock identity/delineation

  Effor data by countries are available from 2011. However flounder is mostly taken as bycatch therefore effort data could not always indicate a stock status, as discard amount is determined by different factors – market capacity, cod fishing etc
  - Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)

  Accepted discard data is available from 2015 and 2016 only.
  - Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast

  BITS survey gives sufficient estimate of stock biomass index

- o Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)
  Data from 2011 available. Effort data problems were described in previous paragraph

- o If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})
  Not available for this stock

- o If necessary potential priors on model external or internal parameters
  Not available for this stock

- Integrated stock assessment models (*i.e.* flexible models that can combine various types of biological and fishery data, *e.g.* data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may *e.g.* be developed with the Stock Synthesis software) considered?

Not available for this stock

- Assessment and forecasts consistent with client management needs

No forecast for this stock, no TAC as well. Management actions include other measures (spawning ban etc)

CONCLUSIONS:

Given the problems in providing catch estimates and the relatively short time series (discard estimates only two years) currently available, the stock is not a candidate for a category 1 assessment in the short term. However, if reconstruction of discards is possible, age data is verified, this conclusion may be re-evaluated. It will also depend on the decision whether management will be based on TACs in the future as this will determine which model and advice is needed. For the moment there is no TAC for any flounder stock in the Baltic Sea.

Flounder (*Platichthys flesus*) in subdivisions 27 and 29–32 (northern central and northern Baltic Sea)

Table 2.1.1 Template to identify potential candidate stocks for category 1 assessment. ***Flounder in subdivisions 27 and 29-32 (fle.27.2729-32)***

- Which is the current category number (3 or 4)?

Category 3.

- Are there already plans for a benchmark in 1–2 years?

No

- What are the necessary requirements to do the upgrade to category 1?
  - o Resources needed:
    - Within ICES
    - Outside ICES

  - o Drivers for the process leading up to category 1:
    - Revised stock identification and delineation

    No
    - New data that can be made available

    Currently no.
    - Want to achieve models with assessment and reference points

    Yes
    - Want to achieve models with forecasts (according to management requirements)

    Yes

- Could there be sufficient data suitable for age or length based models and fore-cast?

  o Necessary information on stock identity/delineation

  No

  o Catch/landings by age or length time series (incl. levels of sampling)

  Currently no

  o Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)

  No

  o Weight, maturity and natural mortality at age or length

  Weight at age and length can be calculated from the surveys (2 in SD27, 1 in SD29 and 32). Weight data is available also for commercial trap nets. Length at 50% maturity is calculated using one-time survey data (Q2) from Hiiumaa island (SD29). Age-at maturity is more difficult to achieve and needs more data. Estimates of natural mortality are not available.

- Could there be sufficient data suitable for surplus production models and fore-cast?

  o Necessary information on stock identity/delineation

  No

  o Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)

  No (discards can't be quantified)

  o Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast

  No

  o Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)

  No

  o If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})

  -

  o If necessary potential priors on model external or internal parameters

- Integrated stock assessment models (*i.e.* flexible models that can combine various types of biological and fishery data, *e.g.* data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may *e.g.* be developed with the Stock Synthesis software) considered?

No

- Assessment and forecasts consistent with client management needs

No

CONCLUSIONS: *Current available data for this stock is scares and with bad quality. Therefore, in near future it would not be possible to upgrade this stock from category 3 to category 1.*

Plaice (*Pleuronectes platessa*) in subdivisions 24–32 (Baltic Sea, excluding the Sound and Belt Seas)

Table 2.1.1 Template to identify potential candidate stocks for category 1 assessment. *Plaice in 27.3.d.24-32*

- Which is the current category number (3 or 4)?
  Category 3
- Are there already plans for a benchmark in 1–2 years?
  Stock was benchmarked in 2015 (WKPLE 2015), no plans for the near future
- What are the necessary requirements to do the upgrade to category 1?
  - Resources needed:
    - Within ICES
      Stock coordinator and stock assessor, survey experts, stock assessment experts
    - Outside ICES
      survey experts, stock assessment experts
  - Drivers for the process leading up to category 1:
    - Revised stock identification and delineation
      Done during WKPLE 2015
    - New data that can be made available
      Probably not
    - Want to achieve models with assessment and reference points
      Would be nice, exploratory SAM is done since 2015 to give advice (rel. SSB), LBI in 2017
    - Want to achieve models with forecasts (according to management requirements)
      Probably not achievable
- Could there be sufficient data suitable for age or length based models and fore-cast?
  - Necessary information on stock identity/delineation
    stock ID was recently confirmed in 2015
  - Catch/landings by age or length time series (incl. levels of sampling)
    Length data on landings and discards are available from 2014-2016
    Age data on landings and discards are available from 2002-2016 (e.g.as Lowestoft matrices used for SAM)

  o Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)
  BITS data available from 2002-2016, however with a change in ageing method in between
  - Weight, maturity and natural mortality at age or length
    weight per length and age are available from survey(2002-recent) and commercial sampling (~2009-recent, rather only 2014-2016).
- Could there be sufficient data suitable for surplus production models and fore-cast?
  - Necessary information on stock identity/delineation
    No
  - Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)
    No
  - Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast
    Several Indices (age, length, biomass) from BITS 2002-recent
  - Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)
    standardized effort (standardized days at sea divided by cod landings) is available for 2009 to 2016 only
  - If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})

Time series of catches is very short. Discards are a considerable part of the catch (~30-45%). SPiCT would not reflect the catches correctly when using only the landings

- o If necessary potential priors on model external or internal parameters

?

- Integrated stock assessment models (*i.e.* flexible models that can combine various types of biological and fishery data, *e.g.* data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may *e.g.* be developed with the Stock Synthesis software) considered?
  Currently not considered
- Assessment and forecasts consistent with client management needs
  Guess so?

CONCLUSIONS:
Not ready for an upgrade to Cat. 1

The last benchmark took place in 2015 (WKPLE 2015), ple.27.3.24-32 was considered as not suitable for Cat. 1, due to insufficient sampling coverage of the fisheries and discard estimations. No new data has been added since then and more years with better coverage are needed to make a consideration in the future reasonable

Turbot (*Scophthalmus maximus*) in subdivisions 22–32 (Baltic Sea)

Table 2.1.1 Template to identify potential candidate stocks for category 1 assessment.
Turbot in27.3.c.22, 27.3.b.23, 27.3.d.24-32 (tur.27.22-32)

- Which is the current category number (3 or 4)?
  Category 3
- Are there already plans for a benchmark in 1–2 years?
  No, last benchmark during WKFLABA 2012
- What are the necessary requirements to do the upgrade to category 1?
  - o Resources needed:
    - Within ICES
      Stock coordinator and stock assessor, survey experts, stock assessment experts
    - Outside ICES
      survey experts, stock assessment experts
  - o Drivers for the process leading up to category 1:
    - Revised stock identification and delineation
      None, also not considered
    - New data that can be made available
      Probably not
    - Want to achieve models with assessment and reference points
      Would be nice, but data are sparse
    - Want to achieve models with forecasts (according to management requirements)
      Probably not achievable
- Could there be sufficient data suitable for age or length based models and fore-cast?
  - o Necessary information on stock identity/delineation

  - o Catch/landings by age or length time series (incl. levels of sampling)
    Length data on landings and discards are available from 2014-2016

  o Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)
  BITS data available from 2002-2016, only few age readings
  - o Weight, maturity and natural mortality at age or length
  weight per length and age are available from survey(2002-recent) and commercial sampling (~2009-recent, rather only 2014-2016), sampling intensity is low however.
- Could there be sufficient data suitable for surplus production models and fore-cast?
  o Necessary information on stock identity/delineation
  Evaluated by WKFLABA 2012, no change since then
  o Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)
  No
  o Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast
  CPUE index (no/hour) from length distributions of BITS
  o Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)
  standardized effort (standardized days at sea divided by cod landings) is available for 2009 to 2016 only
  o If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})
  No, only landings available, discards can be considerably high
  o If necessary potential priors on model external or internal parameters
  ?

- Integrated stock assessment models (*i.e.* flexible models that can combine various types of biological and fishery data, *e.g.* data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may *e.g.* be developed with the Stock Synthesis software) considered?
  Currently not considered
- Assessment and forecasts consistent with client management needs
  No

CONCLUSIONS:

Tur.27.22-32 should not be considered for a Cat.1 stock, only landings advice is given so far due to poor sampling and unknown discards. Landings are regularly higher than the recommended landings of the advice