BALTIC FISHERIES ASSESSMENT WORKING GROUP (WGBFAS)

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

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Editors

Mikaela Bergenius

Authors

Viktoriia Amosova • Casper Berg • Jesper Boje • Massimiliano Cardinale • Sofia Carlshamre • Margit Eero • Tomas Gröhsler • Julita Gutkowska • Kristiina Hommik • Jan Horbowy • Bastian Huwer • Pekka Jounela • Olavi Kaljuste • Igor Karpushevskiy • Richard Klinger • Uwe Krumme • Johan Lövgren • Zuzanna Mirny • Christoffer Moesgaard Albertsen • Stefan Neuenfeldt • Anders Nielsen • Kristin Öhman • Zeynep Pekcan Hekim • Maris Plikshs • Jukka Pönni • Ivars Putnis • Krzysztof Radtke • Tiit Raid • Jari Raitaniemi • Paco Rodriguez-Tress • Franziska M. Schade • Romas Statkus • Sven Stoetera • Marie Storr-Paulsen • Harry V. Strehlow • Clara Ulrich • Didzis Ustups • Tomas Zolubas

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Contents

i Executive summary

The main objective of WGBFAS was to assess the status and produce a draft advice of the following stocks:

- Sole in Division 3.a, SDs 20–24
- Cod in Kattegat, Cod in SDs 22–24, Cod in SDs 24–32
- 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 24–32
- Flounder in SDs 22–23 (no catch advice)
- Flounder in SDs 24–25 (no catch advice)

The WG was not requested to assess the following stocks in 2019, as no advice was needed:

- Flounder in SDs 26+28
- Flounder in SDs 27+29–32
- Brill in SDs 22–32
- Dab in SDs 22–32
- Turbot in SDs 22–32

It was, however, decided by the group to compile and update the input data for 2018 and thereby also conduct update assessments for these latest five stocks.

In the introductory chapter of this report the WG, in agreement with the ToRs, considers and comments on the ecosystem and fisheries overviews, reviews the progress on benchmark processes, identifies the data needed for next year's data call with some suggestions for improvements in the data call, and summarizes general and stock-specific research needs. The introduction further summarizes the work of other WGs relevant to the WGBFAS, and the assessment methods used. Finally, the introduction presents a brief overview of each stock and quite extensively discusses the ecosystem considerations of the Baltic Sea and ecosystem changes that have been analytically considered in the stock assessments.

The results of the analytical stock assessment or survey trends for the species listed above are presented for all the stocks with the same species in the same sections.

The analytical models used for the stock assessments were XSA, SAM and SS3. For most flatfish (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 cod in SDs 24–32, a full analytical assessment (using SS3) could be performed, after the compilation/benchmark work undertaken in 2018–2019.

The report ends with references, annexes with the response to a special request, links to Stock Annexes, and list of Working Documents.

ii Expert group information

Expert group name	Baltic Fisheries Assessment Working Group (WGBFAS)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair	Mikaela Bergenius, Sweden
Meeting venue and dates	8-15 April 2019, Copenhagen Denmark (35 participants)

1 Introduction

1.1 List of meeting participants

NAME	COUNTRY
Amosova, Viktoriia	Russia
Berg, Casper	Denmark, part-time
Bergenius, Mikaela (Chair)	Sweden
Boje, Jesper	Denmark
Carlshamre, Sofia	Sweden
Eero, Margit	Denmark
Gröhsler, Tomas	Germany
Gutkowska, Julita	Poland
Hommik, Kristiina	Estonia
Horbowy, Jan	Poland
Jounela, Pekka	Finland
Kaljuste, Olavi	Sweden
Karpushevskiy, Igor	Russia
Klinger, Richard	Germany
Krumme, Uwe	Germany
Lövgren, Johan	Sweden
Mirny, Zuzanna	Poland
Neuenfeldt, Stefan	Denmark, part-time
Nielsen, Anders	Denmark, part-time
Pekcan Hekim, Zeynep	Sweden, part-time
Plikshs, Maris	Latvia
Putnis, Ivars	Latvia
Pönni, Jukka	Finland
Raid, Tiit	Estonia
Raitaniemi, Jari	Finland

NAME	COUNTRY
Rodriguez-Tress, Paco	Germany, part-time
Statkus, Romas	Lithuania, part-time
Stoetera, Sven	Germany
Storr-Paulsen, Marie	Denmark
Ulrich, Clara	Denmark
Ustups, Didzis	Latvia, part-time
Zolubas, Tomas	Lithuania
Öhman, Kristin	Sweden

1.2 Terms of reference

2018/2/ACOM11 The Baltic Fisheries Assessment Working Group (WGBFAS), chaired by Mikaela Bergenius*, Sweden, will meet at ICES, Denmark, 8–15 April 2019 to:

a) Address generic ToRs for Regional and Species Working Groups

b) Review the main results from Working Groups of interest to WGBFAS such as WGIAB, WGSAM, WKMixHer and PGDATA with main focus on the biological processes and interactions of key species in the Baltic Sea;

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 to the meeting must be available to the group on the dates specified in the 2019 ICES data call.

WGBFAS will report by 29 April 2019 for the attention of ACOM.

2018/2/ACOM05 The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

a) Consider and comment on Ecosystem and Fisheries overviews where available;

b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:

   i) descriptions of ecosystem impacts of fisheries

   ii) descriptions of developments and recent changes to the fisheries

   iii) mixed fisheries considerations, and

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

c) Conduct an assessment on the stock(s) to be addressed in 2019 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a **brief** report of the work carried out regarding the stock, summarizing where the item is relevant:

   i) Input data and examination of data quality;

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

   iii) For relevant stocks (i.e. all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2018.

   iv) Estimate MSY proxy reference points for the category 3 and 4 stocks

   v) The developments in spawning-stock biomass, total-stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;

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

   vii) Catch scenarios for next year(s) for the stocks for which ICES has been requested to provide advice on fishing opportunities;

   viii)Historical and analytical performance of the assessment and catch options and brief description of quality issues with these; .For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

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

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 planned data evaluation workshops;

g) Identify research needs of relevance for the work of the Expert Group.

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

1.3 Consider and comment on Ecosystem and Fisheries overviews where available

1.3.1 Ecosystem overviews

WGBFAS was asked to consider and comment on 'Baltic Sea Ecoregion – Ecosystem overview'. The work was undertaken by a subgroup that made comments and suggestions using 'track changes' to the the original MS Word file. These were communicated to the ICES Secretariat. The group also made some general comments listed below.

General comments:

The expression of 'overfishing' needs to be clarified: In the overview, fishing seems to be regarded as overfishing when F is found to be above F_{MSY}. This can be misleading, as it is not unusual for stocks that are fished according to catches at F_{MSY} end up with an estimated F the following year that is above or below the F_{MSY} point value, but which is in fact within the uncertainty bounds of the estimate. Thus in long term, F may in fact be fluctuating around the msy level and it is therefore is therefore misleading to say that a fishery is 'overfishing' when F is temporarily above msy level, and the fish stock is generally fine. In the advice, EU Management Plan utilizes values such as F_{MSY}, $F_{MSYlower}$ and $F_{MSYupper}$. Fishing at least temporarily at $F_{MSYupper}$ is regarded acceptable, although $F_{MSYupper}$ is often above F_{MSY}. Thus, instead of using 'overfishing' with normally fluctuating fish populations that are in good condition, the expression should be used in cases, where the extent or way of fishing is in one or the other way detrimental to the fish population. In the text, the expression 'overfishing' on the basis of F_{MSY} values seems largely exaggerated when talking about Baltic herring and sprat populations. But concerning e.g. the history of Eastern Baltic cod fisheries, it is justified to talk about overfishing.

With pelagic fish, it should also be remembered that conducting a fishery is the most efficient way to actively remove phosphorus from the Baltic Sea. When sprat population is very abundant, it may also be ecologically harmful, as there is no cod to reduce the size of the population, and sprat competes efficiently with herring. Very abundant sprat may even eat cod eggs and thus affect negatively to the situation of weak cod stocks, not to mention effects on the zooplankton and phytoplankton.

In the paper, the Baltic fish are grouped in three functional groups: demersal fish, benthic fish and pelagic fish. However, the separation of demersal fish and benthic fish is confusing and not generally accepted. It is not used by ICES either, where these fish are regarded as 'demersal species'. In the overview, it would be clearer to talk about cod, flatfish, and pelagic species or herring and sprat.

Other things:

- A short description is needed about the management of fish stocks with TACs, and the use of F_{MSY}, $MSYB_{trigger}$ and reference points, as e.g. msy is discussed in the overview.
- Among the changes observed in fish species in recent decades we suggest that whitefish (*Coregonus lavaretus*) and grayling (*Thymallus thymallus*) are included in the text, as their sea-spawning populations have severely suffered.
- In the fish communities, there are also species and populations that reproduce in the rivers flowing to the Baltic Sea; thus, the conditions in those rivers affect these populations and this should be explained.
- There are many factors suggested to be important in affecting Baltic cod populations and these should all be mentioned.

- Clarifications about how different factors are in relation or linked to each other are needed: Describe the specific interactions between the main pressures (nutrient and organic enrichment, selective extraction of species, introduction of contaminating compounds, introduction of non-indigenous species and abrasion and substrate loss). Describe also the complete concept of regime shift and its causes and consequences to fish populations.
- Include a description how increasing abundances of seals and cormorants affect fish populations and fisheries.
- A short description of the two Baltic flounder species (*Platichthys*), in relation to the differences in life histories, and how the abundances in these species have changed in accordance to the hydrological changes (similarly as for cod), is needed.

1.3.2 Fisheries overviews

WGBFAS was asked to consider and comment on 'Baltic Sea Ecoregion – Fisheries overview', with particular focus on the section `who is fishing´. Members from each country had the opportunity to comment on the current text and the final texts are included below.

Fishing vessels from nine nations operate in the Baltic Sea, with the largest number of large vessels (>12 m) coming from Sweden, Denmark, and Poland. Total finfish landings from the Baltic Sea peaked in the mid-1970s and again in the mid-1990s, corresponding to peaks in the abundance of cod and sprat stocks respectively. The proportion of the total annual landings caught by each country has varied little over time, except for the redistribution of catches by former USSR countries (Figure 2, *the Figure can be found in the Fisheries overview*). Total fishing effort has declined since 2003 (Figure 3, *the Figure can be found in the Fisheries overview*). The following country paragraphs highlight features of the fleets and fisheries of each country and are not exhaustive descriptions.

Denmark

The Danish fleet comprises close to 350 vessels divided into offshore fisheries (approximately 100 vessels 8–12 m and 80 vessels >12 m) and coastal fisheries (approximately 150 vessels). The large-vessel offshore fisheries target (a) sprat and herring in the northern Baltic Sea using small-meshed pelagic trawls and (b) cod and plaice in the southwestern Baltic fisheries using demersal trawls. In the western Baltic Sea, a flatfish fishery exists targeting plaice, which also catches turbot, dab, flounder, and brill. The coastal fisheries target species such as eel, flatfish, and cod using mainly trapnets, poundnets, and gillnets and are prosecuted off all coasts and in the Belt area. Recreational fisheries target different species depending on the season with, cod, salmon, and trout being among the most important species. For cod, the main fishing area is the Sound (Subdivision 23) while for salmon most recreational fishing takes place from the island of Bornholm in subdivisions 24 and 25.

Estonia

The active offshore fleet comprises around 30 fishing vessels (17–42 m), while the coastal fishery consists of several hundred small vessels of <12 m. The pelagic fleet consists of stern trawlers mainly targeting herring and sprat in subdivisions 28.1, 28.2, 29, and 32. Trawlers also catch cod in subdivisions 25 and 26. About 25–30% of the herring catch is taken in coastal fisheries, mainly in the Gulf of Riga (Subdivision 28.1) and the Gulf of Finland (Subdivision 32) using trapnets and poundnets. Flounder is also taken (using Danish seines and gillnets) in the coastal fisheries in the Gulf of Riga and subdivisions 29 and 32. Recreational fisheries primarily target perch, pikeperch, flounder, and whitefish, mainly in the Gulf of Riga.

Finland

The fleet comprises around 3200 vessels, of which almost 1500 vessels are actively used in the fishery. The vast majority of the vessels are < 12 m and operate in coastal fisheries. The offshore fleet is composed of 64 vessels between 12 and 40 m in the Baltic main basin, the Archipelago Sea, the Gulf of Bothnia, and the Gulf of Finland and mainly targets Baltic herring stocks (with sprat taken mainly as bycatch) with pelagic trawls. Occasionally, offshore vessels will fish for cod using bottom trawls in the southern Baltic. The coastal fisheries occur on all parts of the coast using trapnets, fykenets, and gillnets, and catch salmon, whitefish, pikeperch, perch, pike, vendace, burbot, and occasionally flounder and turbot. Recreational fisheries target mainly perch, pike, pikeperch, whitefish, bream, and herring using gillnets, rods, fish traps, and fykenets along the coast of Gulf of Finland and in the Archipelago Sea and Gulf of Bothnia

Germany

The German commercial fleet in the Baltic Sea consists of about 60 trawlers and larger (>10 m total length) polyvalent vessels, and about 650 vessels using exclusively passive gear (<12 m total length). The German herring fleet in the Baltic Sea, where all catches are taken in a directed fishery, consists of a coastal fleet with mostly undecked boats (rowing/motor boats ≤12 m) and a cutter fleet with decked vessels (total length 12–40 m). The German herring fishery in the Baltic Sea is conducted with gillnets, trapnets, and trawls; passive and active gear now share the landings about 50:50. Herring are fished mostly in the spring-spawning season and in Subdivision 24. In the central Baltic Sea, almost all landings are taken by the trawl fishery. All catches of sprat are taken in a directed trawl fishery by cutters >12 m in length. Most sprat is caught in subdivisions 25–29 in the first quarter. Demersal species are caught with bottom trawls and passive gears, particularly gillnets but also trammelnets. There are major targeted fisheries for cod and flounder (subdivisions 22, 24, 25; active, passive; year-round except peak summer months), plaice (Subdivision 22; active, passive; fourth/first quarter), dab (Subdivision 22, active; fourth quarter), turbot (Subdivision 24, gillnet, second quarter), and whiting (Subdivision 22, active, first/second quarter). Freshwater species are mainly targeted by passive gear fishers in coastal lagoons and river mouths.

Recreational fisheries are carried out by an estimated 161 000 fishers, from all German shores and from boats (charter and private boats) mostly within 5 nautical miles (NM) of the coast and the main target species are cod, herring, trout, salmon, whiting, and flatfish.

Latvia

The fleet comprises around 55 registered offshore vessels (12–40 m) and 610 coastal vessels (<12 m). The offshore vessels target sprat in the Baltic main basin and herring in the Gulf of Riga using pelagic trawls, and cod and flounder in subdivisions 25, 26 and 28 using demersal trawls. Since 2000, sprat and herring have accounted for 92% of the total annual landings. Most vessels in the coastal fleet are <5 m and target herring, round goby, flounder, smelt, salmon, sea trout, vimba bream, turbot, eelpout, and cod using fykenets, trapnets, and gillnets. Recreational fisheries occur on all coasts and target flounder, cod, perch, and round goby.

Lithuania

The Lithuanian fishing fleet in 2018 comprised 21 offshore vessels (>18 m) and 59 coastal vessels (<12 m). The offshore fishing fleet uses pelagic and bottom trawls, with vessels switching between gears depending on target species, fishing conditions, and quota availability. The main target species are sprat, herring, cod, and flounder caught mainly in subdivisions 25, 26, and 28 and to a lesser extent in subdivisions 27 and 29. The coastal fisheries target herring, smelt, flounder, turbot, and cod using gillnets and trapnets within Lithuanian coastal area of Subdivision 26.

Recreational fisheries also occur in these waters and focus on cod, herring, salmon, and sea trout using hooks and trolls.

Poland

The fishing fleet consists of around 153 active offshore vessels (12–35 m) and approximately 502 coastal vessels (<12 m). The larger offshore vessels (>18.5 m) target sprat and herring using pelagic trawls for fishing sprat and herring, while smaller offshore vessels (12–18.5 m) target cod, flounder, and sandeel using bottom trawls. Fishing occurs mainly in subdivisions 24, 25, and 26 and these species form about 98% of the total annual landings. The coastal fisheries harvest salmon, trout, turbot, plaice, eel, roach, perch, bream, pikeperch, whiting, european whitefish, crucian carp, and garfish. Recreational fisheries mostly target cod and salmon primarily along the central Polish coast and off the Hel Peninsula.

Russia

The fishing fleet is composed of about 51 vessels divided into offshore fisheries (44 vessels by 25–31 m size class) and coastal fisheries (seven vessels by 15–25 m size class). In subdivision 26, the vessels fleet MRTK targets sprat and herring while the demersal trawl fleet (about 27 m), targets cod and flounder. The gillnet fleet targets cod with flounder as by catch. A poundnet fishery targeting herring occurs in the Vistula Lagoon. In the eastern part of the Gulf of Finland (Subdivision 32), the MRTK fleet operates mainly in I, II, and IV quarters and is orientated to herring. Recreational fisheries targeting cod, flounder, turbot, and salmon, goby and others non-commercial species occur on all Russian coasts.

Sweden

The fleet is comprised of around 20 offshore vessels (around 10 vessels >40 m) and around 550 coastal vessels (the vast majority <12 m). The offshore fleet mostly targets herring and sprat using pelagic trawls in the main basin of the Baltic Sea, but also uses bottom trawls to fish for cod in the southern Baltic. Coastal fisheries use a mixture of gillnets, longlines, and fish traps to catch flatfish and cod as well as a variety of freshwater species (in the archipelagic areas) and herring, whitefish, and salmon in the Bothnian Bay. A coastal fishery using fykenets targets eel and other species along the southeastern coast. Along the eastern Swedish coast, trawl fisheries target herring and sprat. Recreational fisheries take place along the entire Baltic Sea coast and target marine and freshwater species including cod, salmon, pike, perch, and trout.

1.3.3 Further input to the Fisheries overviews.

In the generic ToRs WGBFGAS was asked to provide further input for the Fisheries Overviews and therefore consider and comment for the fisheries relevant to the working group on: descriptions of ecosystem impacts of fisheries, descriptions of developments and recent changes to the fisheries, mixed fisheries considerations and emerging issues of relevance for the management of the fisheries. The WG believes that with our comments to the fisheries and ecosystem overviews (section 1.3), the text on ecosystem considerations (section 1.10), stock overviews (section 1.11), stock and associated fisheries sections (sections 2 to 8) and draft advice, we have addressed this ToR to the best of our knowledge within the time frame provided. WGBFAS further suggests that the issues of mixed fisheries are addressed at the WKBALTIC in May 2019.

1.4 Review progress on benchmark processes of relevance to the Expert Group

The group have no stocks for benchmark in 2020. Sole in 20-24 was formerly scheduled for benchmark in 2020 after finalization of a project that aimed to improve the assessment quality for that stock. However, most issues solved in the project did not lead to suggest changes to input data or assessment methodology, but rather aimed for further investigation due to inconclusive results (see section 6.10). The benchmark for sole is therefore postponed. Further research is planned for this stock on stock structure. The dab and brill stocks will likely be included in the research structure (genetics and otolith trace elements).

At present candidate stocks were identified for benchmark in 2021. An issue list is available for each stock with research needs and prioritization according to preliminary decisions by ACOM (see section 1.6.). Issue lists will be continually updated and benchmarks called for when a likely research outcome will validate it.

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

A data call subgroup discussed the ICES data call for WGBFAS 2020. The group reviewed the parameters requested for each stock and minor changes were. In addition, it was decided to make a recommendation to ICES Data Centre, about making information available on eventual data updates in DATRAS to stock coordinators and stock assessors.

1.6 Identify research needs of relevance for the work of the Expert Group.

The WG recognizes that the core of appropriate stock assessment and fisheries management 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. 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 intra- and interspecific interactions. The move requires an increase in the quantity and quality of data for use in new advanced stock assessment methods. The changing ecological situation in the Baltic Sea urges the need for combining knowledge of ecosystem processes with single species assessments. Several ICES ecosystem working groups exists, which 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 to 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 needed for a reliable stock assessment. All parameters are dependent on the understanding of current ecosystem processes:

- *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,

Responsible persons for updating stock research needs/issue list during WGBFAS 2019:

Fish Stock	Stock Coordinator	Assessment Coordinator
bll-2232	Stefan Neuenfeldt	Stefan Neuenfeldt
dab-2232	Sven Stötera	Sven Stötera
tur-2232	Sven Stötera	Sven Stötera
cod-kat	Johan Lövgren	Johan Lövgren
cod-2224	Uwe Krumme	Marie Storr-Paulsen
cod-2432	Sofia Carlshamre	Margit Eero
sol-kask	Jesper Boje	Jesper Boje
ple-2123	Henrik Degel	Clara Ulrich
ple-2432	Sven Stötera	Sven Stötera
fle-2223	Sven Stötera	Sven Stötera
fle-2425	Zuzanna Mirny	Zuzanna Mirny
fle-2628	Didzis Ustups	Didzis Ustups
fle-2732	Kristiina Hommik	Kristiina Hommik
her-2532	Kristin Öhman	Tomas Gröhsler

Fish Stock	Stock Coordinator	Assessment Coordinator
her-riga	Tiit Raid	Maris Plikshs
her-30+31	Jukka Pönni	Zeynep Pekcan-Hekim
spr-2232	Olavi Kaljuste	Jan Horbowy

STOCK	**BRILL SD 22-32**					
Stock coordinator	Stefan Neuenfeldt		**Last benchmark**	-		
Stock assessor	Stefan Neuenfeldt		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Stock identity	At the edge of its distributional area, with the center of gravity being positioned in Kattegat (ICES Subdivision 21). Survey CPUE are very low in the Western Baltic, and 0 in the Eastern Baltic Sea.	Production of a working document for SIMWG to review	Data to produce a combined survey index for brill; update on brill distribution for demersal surveys in Kattegat and Western Baltic Sea			

STOCK	**DAB SD 22-32**					
Stock coordinator	Sven Stötera		**Last benchmark**	2014 (ICES 2014)		
Stock assessor	Sven Stötera		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Biological parameter	Young fish are poorly covered covered/caught by BITS, high uncertainty in biological parameters (used for LBI, e.g. Lmat, Linf)	Better coverage of younger age classes/smaller dab in the survey	Biological data (age. Length, sex, maturity) from smaller/younger dab	WGBIFS	Starting with the next BITS (autumn 2019)	Low
Survey data quality	Units in the HL and CA differ, working with DATRAS data requires beforehand corrections	A unified scale would be beneficial, e.g. for length units, maturity scales and weights	DATRAS database	WGBIFS	To be discussed at the next WGBIFS in 2020?	Medium

STOCK	TURBOT SD 22-32					
Stock coordinator	Sven Stötera		**Last benchmark**	-		
Stock assessor	Sven Stötera		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Biological parameter	Young fish are poorly covered covered/caught by BITS, high uncertainty in biological parameters (used for LBI, e.g. Lmat, Linf)	Better coverage of younger age classes/smaller turbot in the survey	Biological data (age. Length, sex, maturity) from smaller/younger turbot	WGBIFS	Starting with the next BITS (autumn 2019)	Low
Survey data quality	Units in the HL and CA differ, working with DATRAS data requires beforehand corrections	A unified scale would be beneficial, e.g. for length units, maturity scales and weights	DATRAS database	WGBIFS	To be discussed at the next WGBIFS in 2020?	Medium

STOCK	COD SD 21 (COD IN KATTEGAT)					
Stock coordinator	Johan Lövgren		**Last benchmark**	2017 (ICES 2017)		
Stock assessor	Johan Lövgren		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Stock id	data on the proportion of North sea cod in the Kattegat.	Analyses of data sampled in future surveys and analyses of otholits from historical records.	National institutes, Danish /Swedish	WGBFAS	Started Finished by 2021	high
Natural mortality	What is the impact of the seal population on the cod stock in Kattegat?	Analyses and sampling of seal diet data Investigate models to estimate natural mortality	National institutes, Danish /Swedish	WGBFAS	Started Finished by 2021	medium
Assessment model	Formulation of a Stock synthesis model (SS3).	modelling	National institutes, Danish/ Swedish	WGBFAS	Starting 2020-end 2021	medium

STOCK	COD SD 22-24 (WESTERN BALTIC COD)					
Stock coordinator	Uwe Krumme		**Last benchmark**	2019 (ICES 2019b)		
Stock assessor	Marie Storr-Paulsen		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Catch sampling	Port sampling	Data on the number of sampled boxes by size sorting category and stratum	Compile a time-series and provide it to the RDBES		Before next benchmark	Medium
Mixing	Sampling in area 1 and area 2 in SD24	Improve and document improved coverage	Better coverage of area 1		Before next benchmark	Medium

Mixing	Otoliths from commercial catches	Include SD24 otoliths from commercial catches of SWE and POL in the otolith shape analysis	Otolith shape images from SWE and POL according the image requirements of the Danish or German otolith shape analysis		Before next benchmark	Medium
Mixing	Genetics	Move from otolith shape analysis to full genetic analysis			Mid-term aim	
Mixing	Develop a testable theory about the mixing	Genetic sampling	Biological samples		ongoing	
Age reading	Improve precision of the age reading based on age-validated material	Regular reports by GER Regular exchange of otolith images			ongoing	
Age reading	Different methods used for otolith preparation	Assess if method can be standardized (cut and reflecting light; sliced and transmitted light)			ongoing	
Survey	Bias due to use of shallow-water habitats and habitat types not covered by BITS by cod, uncertain abundance estimates	Assess quality of BITS		Develop alternative survey approaches	Mid-term aim	medium

STOCK	**COD SD 24–32 (EASTERN BALTIC COD)**					
Stock coordinator	Sofia Carlshamre		**Last benchmark**	2019 (ICES 2019b)		
Stock assessor	Margit Eero		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Growth	Validated quantitative information on growth in recent years and in future	Analyses of recent tagging, new method for growth monitoring in future (e.g. otolith microchemistry)	Ongoing TABACOD project	Estimate recent growth from tagging and establish a method for future growth monitoring (e.g. otolith microchemistry) (TABACOD)	Some years	high
Ageing error	Age error matrix	Developing an age-error matrix to account for past uncertainties in age information in Stock Synthesis model	Past otolith exchanges plus tagging information	Develop age error matirx	Some years	high
Sample sizes	Sample size information associated with length distributions of commercial catches	The input to Stock Synthesis model could be improved, if a meaningful measure representing sample size of combined international commercial data could be developed.			some years	Medium/low

STOCK	SOLE SD 20-24					
Stock coordinator	Jesper Boje		Last benchmark	2015 IBP (ICES 2015a)		
Stock assessor	Jesper Boje		Stock category	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Stock identity	Validation of stock entity and connectivity to adjacent stocks (North Sea)	Genetics	Genetic samples Div 4, SD20-21/collaboration with NS surveys/labs	DTU Aqua genetic lab	2020-21	high
		Otolith trace elements	Otoliths from annual sampling	DTU Aqua	2020-21	medium
		Tagging	Conventional tagging program	DTU Aqua	2020-24	medium
		Egg/Larvae drift modelling	Biological and hydrographic data	DTU Aqua	2020-21	medium
		Identification of nursery grounds	Sampling from potential grounds		2020-21	medium
WEST	Establishment of stock weight at age	Data compilation	Sole survey	Compilation work	2020	medium
MAT	Establishment of maturity-at-age	Data compilation	Fishery sampling	Compilation work	2020-21	medium

STOCK	PLAICE SD 21-23					
Stock coordinator	Henrik Degel		**Last bench-mark**	2015 (ICES 2015b)		
Stock assessor	Clara Ulrich		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Stock identification	How many stocks are there in the Baltic Sea?	Genetics	Genetic samples		ongoing	
Age reading	Collect age-validated otoliths	Mark-recapture study involving chemical tagging of otoliths	Age-validated otoliths		ongoing	
Age reading	Improve precision of the age reading based on age-validated material	Exchange of otolith images		Otolith exchange workshop		
Age reading	Different methods used for otolith preparation	Assess if method can be standardized (whole and reflecting light; sliced and transmitted light)				
Timing of age reading in Q1 survey	Otoliths from Q1 survey are not read by Denmark in time for the assessment EWG, so the intermediate year data cannot be used for the assessment and prediction of recruitment	National planning of the timing of age reading	Otoliths are available but the planning needs to be adapted to make the data available			

STOCK	PLAICE SD 24-32					
Stock coordinator	Sven Stötera		**Last benchmark**	2015 (ICES 2015b)		
Stock assessor	Sven Stötera		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Stock identification	How many stocks are there in the Baltic Sea?	Genetics	Genetic samples		ongoing	
Age reading	Collect age-validated otoliths	Mark-recapture study involving chemical tagging of otoliths	Age-validated otoliths		ongoing	
Age reading	Improve precision of the age reading based on age-validated material	Exchange of otolith images		Otolith exchange workshop		
Age reading	Different methods used for otolith preparation	Assess if method can be standardized (whole and reflecting light; sliced and transmitted light)				
Stock identification	Improve knowledge of seasonal and annual migration of plaice in the Baltic, explore possible stock mixing	Tagging experiments, including western and eastern stock	Recaptures of tagged fish		Starting in 2019	

STOCK	Flounder SD 22-23					
Stock coordinator	Sven Stötera		**Last benchmark**	2014 (ICES 2014)		
Stock assessor	Sven Stötera		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Biological parameter	Young fish are poorly covered covered/caught by BITS, high uncertainty in biological parameters (used for LBI, e.g. Lmat, Linf)	Better coverage of younger age classes/smaller flounder in the survey	Biological data (age. Length, sex, maturity) from smaller/younger flounder	WGBIFS	Starting with the next BITS (autumn 2019)	Low
Survey data quality	Units in the HL and CA differ, working with DATRAS data requires beforehand corrections	A unified scale would be beneficial, e.g. for length units, maturity scales and weights	DATRAS database	WGBIFS	To be discussed at the next WGBIFS in 2020?	Medium

STOCK	**Flounder SD 24-25**					
Stock coordinator	Zuzanna Mirny		**Last benchmark**	2014 (ICES 2014)		
Stock assessor	Zuzanna Mirny		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Stock identity	Newly described Baltic flounder species share this stock (approx. 20%). It is not possible at this stage to separate the proportion of this species in either stock assessment or fisheries.	Genetic sampling	from commercial samples			
Age reading	Collect age-validated otoliths	Mark-recapture study involving chemical tagging of otoliths	Age-validated otoliths		ongoing	
	Improve precision of the age reading based on age-validated material	Exchange of otolith images		Otolith exchange	After age validated otoliths are available	

STOCK	Flounder SD 26+28					
Stock coordinator	Didzis Ustups		**Last benchmark**	2014 (ICES 2014)		
Stock assessor	Didzis Ustups		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Stock identity	Newly described Baltic flounder species share this stock (approx. 55%). It is not possible at this stage to separate the proportion of this species in either stock assessment or fisheries.	Genetic sampling	from commercial samples			**High**
	Newly described Baltic flounder species share this stock (approx. 55%). It is not possible at this stage to separate the proportion of this species in either stock assessment or fisheries.	Morphologic measurements to find the way to separate two species without genetic analyses	**Surveys/commercial**			**High**
Age reading	Improve precision of the age reading based on age-validated material to estimate reference points for the stock	Exchange of otolith images	**Surveys**	Otolith exchange	After age validated otoliths are available	**Medium**

STOCK	Flounder SD 27, 29-32					
Stock coordinator	Kristiina Hommik		**Last benchmark**	2014 (ICES 2014)		
Stock assessor	Kristiina Hommik		**Stock category**	3		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
Stock ID	Two species in this management area	Genetic analysis	Data from commercial samples			Low
Fishing effort	Fishing effort for Estonia passive gears is missing	Quantifying the effort, as exact data are available only partially	Data are partially available from Estonian ministry			Medium
Age/length data from commercial fishery (gillnets)	Data missing from commercial gillnetters.	Collecting samples from commercial gillnetters.	Data available for two years (2017,2018). Data collecting is ongoing work		Ongoing	High/medium

STOCK	**Herring SD 25-27, 28.2, 29, 32 (CENTRAL BALTIC HERR.)**		
Stock coordinator	Kristin Öhman	**Last benchmark**	2013 (ICES 2013)
Stock assessor	Tomas Gröhsler	**Stock category**	1

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Stock identity	Mixing of Western Baltic spring spawners and CBH components in SD 24–26.	Test the of different of methods	Genetic samples, morphometrics, otolith shapes etc.	Project		high
Tuning series	BIAS data. Do we have new bias data from SD 32 that could be used in the assessment?	Compare new indeces with spaly.	Index produced by WGBIFS members	WGBIFS		high
Biological Parameters	Mortality. Investigate new estimates for natural mortality.	Update SMS model and M values	To be decided	WGSAM	2019	high
	Mean weight in the stock. Equals currently mean weight in the catch!	Sensitivity analyses:	Mean weights at age and landings per SD and quarter.			medium
Assessment method	A possible change to the SAM model instead of the currently used XSA.	Configuration and subsequent testing of the SAM model.	CANUM, WECA, maturity, mortality, etc	DTU aqua		medium
Misreporting of herring and sprat.	Misreporting of herring and sprat in the mixed catches.	To be decided	Logbooks data and VMS data	Project		(high)
Age reading	Quality	Comparison of age readings	Reference otolith collection	Age reading WK		medium

<table>
<tr><th colspan="2">STOCK</th><th colspan="5">HERRING SD 28.1 (HERRING IN GULF OF RIGA)</th></tr>
<tr><td colspan="2">Stock coordinator</td><td>Tiit Raid</td><td>Last benchmark</td><td colspan="3">2008 (ICES 2008)</td></tr>
<tr><td colspan="2">Stock assessor</td><td>MarisPliksh s</td><td>Stock category</td><td colspan="3">1</td></tr>
<tr><td>Issue</td><td>Problem/Aim</td><td>Work needed / possible direction of solution</td><td>Data needed / are these available / where should these come from?</td><td>Research/ WG input needed</td><td>Timeframe</td><td>Priority</td></tr>
<tr><td rowspan="2">Stock ID and Age reading</td><td>Taken outside the SD28.1 in SD 28. 2. Additionally CBH fished in the Gulf of Riga (Sd28.1)</td><td>Separation of herring stocks based on otolith macrostructure</td><td>Data available from Latvia and Estonia</td><td>No</td><td>2019</td><td>High</td></tr>
<tr><td>Change of age reader of one nation (Latvia)</td><td>Intercalibration workshop between Estonia and Latvia</td><td>Data available from Latvia and Estonia collaborators</td><td>No</td><td>2019</td><td>High</td></tr>
<tr><td>Tuning series</td><td>Trapnet fleet</td><td>Estimation of trapnet fleet effort</td><td>Data available in national laboratories</td><td>No</td><td>2019</td><td>High</td></tr>
<tr><td>Recruitment</td><td>Estimation of recruitment in the forecast basing it on environmental factors</td><td>Recruitment modelling</td><td>Data available in national laboratories</td><td>No</td><td>2020</td><td>Medium</td></tr>
</table>

STOCK	**HERRING SD 30-31 (HERRING IN GULF OF BOTHNIA)**					
Stock coordinator	Jukka Pönni		**Last benchmark**	2018 IBP (ICES 2019a)		
Stock assessor	Zeynep Pekcan-Hekim		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Timeframe**	**Priority**
30 and 31 stock merging/separation	No strong biological evidence of merging or separating the stocks	Tagging and genetic studies suggested in Benchmark	No available data. Provision by Sweden and/or Finland.	Tagging and genetic studies	**<u>Next benchmark</u>**	Low
Possible extension of acoustic survey to SD 31	Aiming for better coverage for the whole stock	Most probably **not possible** due to limited funds and vessel time.			**<u>Next benchmark</u>**	Low
Analysing maturity ogive (suggestion by 2019 WGBFAS; last examined for 2012 WKPELA benchmark)	Reduction of annual variation	**1**) Examining the correlation of maturity@age to temperature and other environmental aspects. **2**) Testing ogive with e.g. 3-year running averages	Mat data are available from Finnish catch sampling. Finnish environmental institute and Swedish meteorological institute have earlier provided env. data and could be expected to provide update data.		**<u>Next benchmark</u>**	Medium
Examining of taking the regime shift in account in recruitment estimates			Data are available		**<u>Next benchmark</u>**	Medium

STOCK	**SPRAT SD 22-32 (BALTIC SPRAT)**					
Stock coordinator	Olavi Kaljuste		**Last benchmark**	2013 (ICES 2013)		
Stock assessor	Jan Horbowy		**Stock category**	1		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed / are these available / where should these come from?**	**Research/ WG input needed**	**Time-frame**	**Priority**
Natural mortality	Last 6 years M has been estimated from regression of M against cod biomass..	Update SMS model and M values	To be decided	WGSAM	2019	
Misreporting of herring and sprat.	Misreporting of herring and sprat in the mixed catches.	To be decided	Logbooks data and VMS data	Project		(high)

Summary/Research needs

Stock	Issue	Problem/Aim	Research
Cod SD 22-24	Shallow waters not covered by BITS	Assess quality of BITS	Develop alternative survey approaches
Cod SD 24-32	Growth	Quantitative information on growth	Growth from tagging, otolith microchemistry (TABCOD)
	Ageing	Age error matrix	Otolith exchange and tagging information
Sole SD 20-24 Plaice SD 21-23/SD 24-32 Flounder SD 24-25 Flounder SD 26+28 Flounder SD 27, 29-32 Herring SD 25-27, 28.2, 29, 32 Herring SD 30-31	Stock identity	Validation of stock identity	e.g. Genetics
Sole SD 20-24	Stock weight at age/WEST	Not available	Compilation by using Sole survey
	Maturity-at-age	constant	Compilation by using fishery sampling
Plaice SD 21-23/SD 24-32 Flounder SD 24-25 Herring SD 25-27, 28.2, 29, 32	Age reading	Age-validated otoliths	Tagging
		Precision of age reading	Otolith exchange/WK

Herring SD 25-27, 28.2, 29, 32 Sprat SD 22-32	Mixed fishery on herring and sprat	Quantification of misre-porting	Logbook data/VMS

1.7 Review the main results of Working Groups of interest to WGBFAS

The following sections review, according to the ToRs, the main results from WGIAB, WGSAM, WKMixHer, and PGDATA. They also review briefly the main results from WGBIFS, the progress on mixed fisheries considerations, the working group of WGCHAIRS and finally summarizes a subgroup held at the WGBFAS meeting on means to increase the collaboration between the working group and other ecosystem working groups.

1.7.1 Working group on integrated assessments of the Baltic Sea (WGIAB)

The main working activities of the ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (WGIAB) in 2018 were to i) investigate and compare long-term trends in community weighted mean (CWM) traits across subsystems; (ii) discuss and prepare an Ecosystem Overview document for the Baltic Sea; (iii) plan an overall synthesis paper of past and recent ecosystem trends and dynamics across Baltic Sea subsystems, (iv) revisit the Integrated Ecosystem Assessment (IEA) cycle and discuss ways to better align our work within this conceptual framework in future. In terms of the first activity, the WG completed preliminary trait-based assessments of CMW traits in the Kattegat, Central Baltic Sea, and Gulf of Riga. These assessments demonstrate long-term changes in CWM traits across areas and multiple organism groups (including phytoplankton, zooplankton, benthos, and fish), largely related to changes in temperature, salinity, oxygen, and nutrients. Regarding the second activity, the WG provided a qualitative (expert judgement based) ranking of key stressors and their impacts on ecosystem states, and drafted the ecosystem overview document that was also used as input for the ecosystem considerations in this WGBFAS report (section 1.10). In terms of the third activity, the WG made a work plan outlining what areas, variables and methods to use for a synthesis paper. Due to time constraints, work on this activity will be carried out intersessionally. Under the fourth activity, the WG discussed the various steps in the IEA cycle, primarily focusing on the first and crucial "scoping" process that aims to identify key ecosystem objectives. Consensus was reached to focus on already available policies (e.g. the Marine Strategy Directive and the Baltic Sea Action Plan) from which key objectives and indicators have been defined and can be used in future efforts to close the IEA loop and make it operational for management.

1.7.2 Working group on integrated assessment methods (WGSAM)

The ICES Working Group on Multispecies Assessment Methods (WGSAM) did in 2018 not work on Baltic Sea multispecies models, however, it is scheduled for the 2019 to prepare new multi-species model runs for Western and Eastern Baltic Sea

1.7.3 Workshop on mixing of western and central Baltic herring stocks (WKMixHER)

WKMixHER was held in Gdynia (Poland) 11–13 September 2018. Different methods for herring stock identification were reviewed at the workshop based on old and ongoing analyses carried on samples from the western and central Baltic Sea. Presented and reviewed methods included the comparison of stocks components based on growth rate (separation function), otolith shape analysis, body morphometry, meristic characters, otolith chemistry, parasitic infection, genetics (microsatellite and SNPs). The suitability of presented methods for stock separation was discussed. At the workshop, it was shown how the central Baltic herring (CBH) actually shares numerous characters with the adjacent western Baltic herring (WBH) stock.

Results presented at the workshop motivated, on the short term, *ad hoc* preliminary analyses that were performed during the weeks following the workshop. The aim of these analyses was to test the hypothesis that spring-spawning herring from coastal Polish waters represent a population component that is reproductively isolated from both the major WBSSH component (i.e. Rügen) and from the other (northern component) spring-spawning herring from the Central Baltic. The preliminary results from the genetic analyses performed after the workshop supported the hypothesis. More work is, however, required to conclude on the issue, and to provide an operative approach to separate herring of different origins in mixed catches from the western and central Baltic Sea for assessment purposes. This motivated the proposal of a long-term plan to collect data for two years, that will then form the basis to (a) identify herring population/stock components, (b) validate herring assessment units, and (c) find methods for herring separation in mixed samples routinely collected within the data collection. The long-term plan also includes developing operational methods to allocate thousands of herrings sampled currently and (depending on method) historically in catch and survey to their respective spawning components.

1.7.4 Working group on data needs for assessment and advice (PGDATA) and regional coordination groups (RCG)

PGDATA meet in ICES headquarter in February 2019. The aim of PGDATA is to

- **Design a Quality Assurance Framework** to ensure that information on data quality is adequately documented and applied in assessments;
- **Ensure consistency of approach** for fishery dependent and fishery-independent data quality framework, and complementarity with approaches developed in other fora such as STECF, EU-MAP;
- Develop and test analytical methods for **identifying improvements in data quality**, or collections of new data, that have the greatest impacts on the quality of advice;
- **Improve or create communication routes between data collectors, data managers and end-users,** and advise on new approaches to ease the implementation of the QAF (through publication, RDB-development and cooperation with other WG including shared workshops);

To improve communications between ICES groups and ICES groups and data collectors and to increase the knowledge of the available data and data quality the RCGs and PGDATA are in the process to developed standardized stock and fishery overview maps and tables. These can improve the awareness of available data as well as improve the knowledge of data quality for the stock assessment working groups. Some of these overview maps developed from the international fishery database hosted by ICES RDB was presented during the WGBFAS on Baltic herring and sprat stocks. The maps and tables gave an overview of the reported fishery by ICES square and month as well as maps showing vessel size and flag country. The figures presented was shown as examples of data already available but currently not very much utilized at the EWG and PGDATA and the RCGs will further develop graphs and plots for the EWG and benchmarks depending on end-user needs.

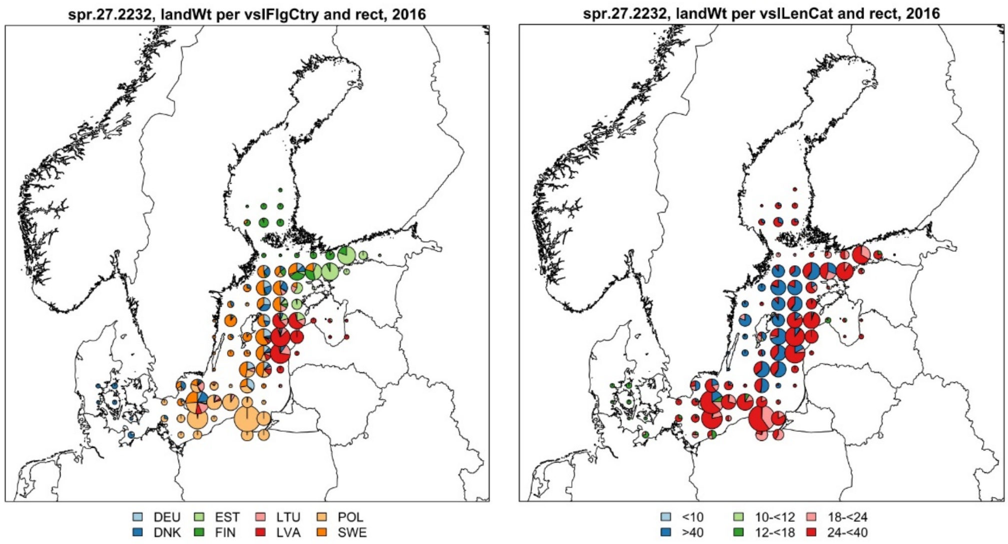


Figure 1.1. Sprat data from the RDB showing landings by member state and ICES square and by vessel length.

1.7.5 Baltic international fish survey working group (WGBIFS)

The presentation of WGBIFS 2019 was composed from two parts focused on the:

- Baltic acoustic-trawl surveys (BIAS, BASS) in 2018,
- BITS surveys in 2018-Q4 and 2019-Q1,

BIAS

The Baltic International Acoustic Survey (BIAS) in September-October 2018 was completed according to the plan. However, it did not cover the Russian EEZ, which was not planned either. The geographical distribution of herring and sprat abundance at age 1+ and age 0, and cod in the Baltic Sea, calculated per the ICES rectangles in 2018 was demonstrated in consecutive graphs. In September-October 2018, the highest concentrations of herring (age 1+) were detected in the ICES SDs 28, 29, and 32. At the same time, the geographical distribution of age 0 herring abundance was limited mainly to the SD 30 and to the ICES Subdivisions 21-24. Sprat (age 1+) dense shoals were mostly distributed in north-eastern part of the Baltic Proper, in the Gulf of Finland (SD 32) and in the Lithuanian EEZ. Total abundance of age 0 sprat was relatively low. Somewhat higher abundances of age 0 sprat were recorded in the ICES Subdivisions 26, 28, and 29. Cod was concentrated mostly in the southwestern part of Baltic Proper. Extremely high concentrations were recorded in the Lithuanian EEZ.

<u>WGBIFS recommended:</u>

The BIAS-dataset, including the valid data from 2018 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.

BASS

The Baltic Acoustic Spring Survey (BASS) in May 2017 was also completed according to the plan. However, it did not cover the Russian EEZ, which was not planned either. In the May survey, the highest concentrations of sprat were distributed in the southern part of the Baltic Proper.

WGBIFS recommended:

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.

BITS

The realization of valid ground trawl hauls vs. planned during the Baltic International Trawl Survey BITS-Q4/2018 and the BITS-Q1/2019 was on the level of 102 and 97% (by numbers), respectively and was considered by the WGBIFS-2019 as appropriate tuning series data for the assessment of Baltic and Kattegat cod and flatfish stocks. Somewhat lower coverage of some depth strata in both BITS surveys has been due to the restrictions enforced by the Swedish military. There were no trawl hauls performed in the Russian EEZ as Russia did not plan to participate in these surveys.

WGBIFS recommends that the data obtained and uploaded to DATRAS for both the 4th quarter 2018 and the 1st quarter 2019 BITS are used for calculating survey indices for the relevant cod and flatfish stocks.

1.7.6 Progress on mixed fisheries considerations

In 2018, ICES received a special request from the European Commission regarding further development of mixed fisheries considerations and biological interactions including the Baltic Sea. The WGBFAS had a Term of Reference in 2018 related to this request;

ToR a) Collate and summarize available information on the pelagic fishery and provide a description of the pelagic fisheries in the Baltic Sea including the degree of mixing of herring and sprat by season, area and métier.

The information collated by WGBFAS was incorporated into the fisheries overviews advice (see link http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/BalticSeaEcoregion_FisheriesOverviews_2018_November.pdf) and communicated to the European Commission.

Further work regarding mixed fisheries considerations and biological interactions in the Baltic is currently ongoing and includes;

i. preparation of a scoping meeting (WKBALTIC) in 2019 including stakeholders to identify management needs regarding mixed-fisheries interactions and potentially adapt existing mixed fisheries methodology for application in the Baltic;
ii. further developments of the data call for mixed fisheries data in the Baltic Sea in collaboration with WGMIXFISH-advice;
iii. assessing other sources of valuable input data such as European Fisheries Control Agency databases.

1.7.7 Annual meeting of expert group chairs (WGCHAIRS)

The WGBFAS chair attended the WGCHAIRS meeting in January 2019. Of the many topics discussed the following where brought up and discussed at the WGBFAS meeting:

The change of the parentage of ACOM associated expert groups, and that a new steering group called Fisheries Resources will instead parent the majority of ACOM expert groups.

The guidelines for ICES groups, which will be updated twice a year, ones after the ASC and ones after the WGCHAIRS.

The ICES new code of conduct and the importance of identifying, reporting and deal with any potential conflict of interest. This was discussed at the start of the meeting and no conflict of interest was identified. Information about the code can be found in the guidelines for ICES groups.

The new ICES scientific report series and the guidelines for authorship for these reports.

1.7.8 Interactions between WGBFAS and other ICES ecosystem working groups

The group identified several ways to improve the interaction and communication between the WGBFAS and ecosystem working groups. Issue lists were, and will in future, be produced by WGBFAS members for each stock and communicated to the relevant working group for data and information needs/gaps. Such issue lists are one means of communicating the needs of the assessment group to certain groups working on specific issues. WGBFAS will additionally direct recommendations to specific working groups for knowledge gaps or needs.

WGBFAS appointed persons that will specifically identify ICES working groups that may produce knowledge that can feed into the assessment group. Their work can then be summarized at the next WGBFAS meeting.

The subgroup also suggested that it would be beneficial for the communication of WGBFAS and other ecosystem groups, if multiple participants of the assessment group could join for example WGIAB, WGSAM or other relevant groups in order to act as interfaces and to see if WGBFAS can make use of the knowledge produced by these groups. Inviting someone from one of the ecosystem groups to join WGBFAS to learn about our work and future collaborations would likewise be highly beneficial. This will be suggested to ICES.

The subgroup identified that the ICES Annual Science conference in September will provide a good opportunity to gather members from WGBFAS and other ecosystem groups, to discuss how we could improve our communication and interaction. At this meeting, we would discuss our mutual needs and ability to produce eco-system information. WGBFAS will ask ICES to arrange a meeting during the conference week.

The RCG provides many maps and plots on the data that are used in the assessment and that could be supplementary information for many stocks and for issues of the assessment group. WGBFAS identified that these maps and plots would be very useful for the WGBFAS report.

Ecosystem overviews should permanently include and annually update sections including commercial fish populations. This would include biotic and abiotic components of the ecosystem and their impacts on growth, mortality, spatial distribution or reproduction. Additionally the impacts of fisheries on the ecosystem, for example on the food basis for marine mammals and seabirds, or impacts on the seabed due to trawling should also be considered.

1.8 Methods used by the working group

1.8.1 Analyses of catch-at-age data

Full analytical assessments with subsequent short-term forecasts were conducted for the following stocks:

a) Cod in the subdivisions 22—24
b) Cod in the subdivisions 24—32
c) Sole in Division 3.a + SDs 22—24

d) Plaice in subdivisions 21—23
e) Herring in the subdivisions 25—29 and 32, excluding Gulf of Riga
f) Herring in the Gulf of Riga (Subdivision 28.1)
g) Herring in Subdivisions 30 and 31
h) Sprat in the subdivisions 22—32.

Trend-based assessments were carried out for the following stocks:

a) Cod in the Kattegat
b) Plaice in subdivisions 24–32
c) Flounder in subdivisions 22–23
d) Flounder in subdivisions 24–25
e) Flounder in subdivisions 26 and 28,
f) Flounder in subdivisions 27, 29–32,
g) Brill in subdivisions 22–32,
h) Dab22–32 in subdivisions
i) Turbot in subdivisions 22–32.

No advice was requires for stocks e) to i), but update assessment were conducted and included in the report.

The stochastic state-space model (SAM) (Nielsen, ICES 2008) 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. Details on model configuration, including all input data and the results can be viewed at www.stockassessment.org. A VPA tuned assessment using the Extended Survival Analysis (XSA) method (Darby and Flatman, 1994) was used for herring in the subdivisions 25—29 and 32, excluding Gulf of Riga, Herring in the Gulf of Riga (Subdivision 28.1) and Sprat in the subdivisions 22—32. The assessment of cod in SDs 24-32 was conducted using the Stock Synthesis (SS) model (Methot and Wetzel, 2013).

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

1.8.2 Assessment software

Overview of the software used:

Software	Purpose
MSVPA	Outout for further assessment
XSA	Historical assessment
RETVPA	Retrospective analysis
RCT3	Recruitment estimates
MFDP	Short-term prediction
SAM	Historical and exploratory assessment
SS3	Historical assessmwent and short-term prediction

1.8.3 Methods applied in subsequent assessment

Assessment classifications:

Stock	Classification in 2018	Assessment in 2019
Cod in Kattegat	Trend based	Trend based
Cod in SD 22–24	Update	Update
Cod in SD 24–32	Trend based	Update
Sole in SDs 20–24	Update	Update
Flounder in SD 22–23	Not obligatory	Trend based
Flounder in SD 24–25	Not obligatory	Trend based
Flounder in SD 26–28	Not obligatory	Not obligatory
Flounder in SD 27–32	Not obligatory	Not obligatory
Plaice SD 21–23	Update	Update
Plaice SD 24–32	Trend based	Trend based
Dab SD 22–32	Not obligatory	Not obligatory
Brill SD 22–32	Not obligatory	Not obligatory
Turbot SD 22–32	Trend based	Not obligatory
Herring in SD 25–27, 28.2, 29 and32	Update	Update
Herring in GOR (SD 28.1)	Update	Update
Herring in SD’s 30 and 31 (Gulf of Bothnia)	Update	Update
Sprat in SD 22–32	Update	Update

1.9 Stock annex

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

1.10 Ecosystem considerations

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 the Ecosystem Overview produced by WGIAB 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.

1.10.1 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 subregions of the Baltic Sea: i) the Sound (ÖS), ii) the Central Baltic Sea (CBS), encompassing the three deep basins, Bornholm Basin, Gdańsk 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 subregions, but they all include the increasing temperature and decreasing salinity (Figure 1.2). 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 1.2). 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 1.2).

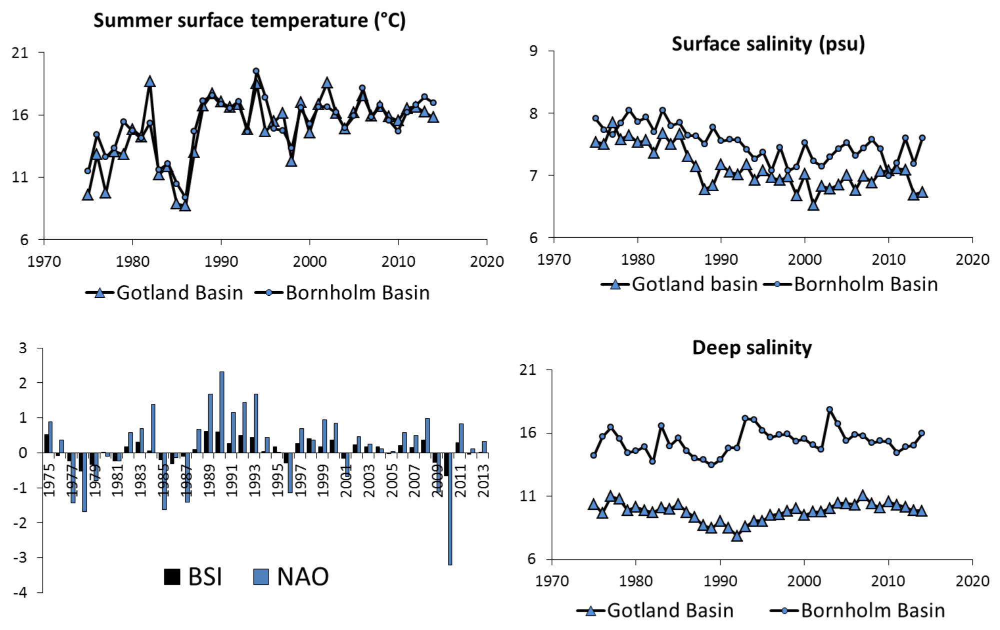


Figure 1.2. Time-series in summer surface temperature and surface salinity (top panels), BSI (Baltic Sea Index) and NAO (North Atlantic Oscillation index) and deep salinity (lower panel) in the Gotland Basin and Bornholm Basin.

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 subregions; 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 subregions, 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 run-off.

The suggested driving forces of the observed regime shift in all subregions, 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).

Contaminant levels in general remain elevated, and the overall contamination status has been at the same level for the past two decades, but many potential contaminants are not monitored. Some of the main contaminants have been reduced (e.g. DDT, dioxins, and PCBs).
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 1.3).

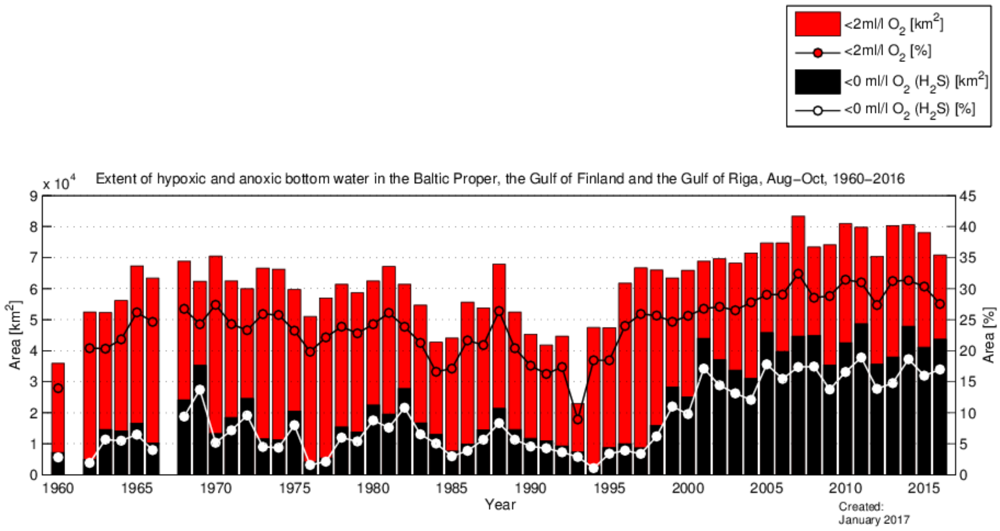


Figure 1.3. Time-series of anoxic and hypoxic seabed in the entire Baltic Proper. From the Swedish Meteorological and Hydrological Institute (SMHI) annual report.

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 fisheriess. 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 1.4.

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 1.5) was derived using the quantitative relationship between recruitment residuals and reproductive volume (WGIAB, 2013).

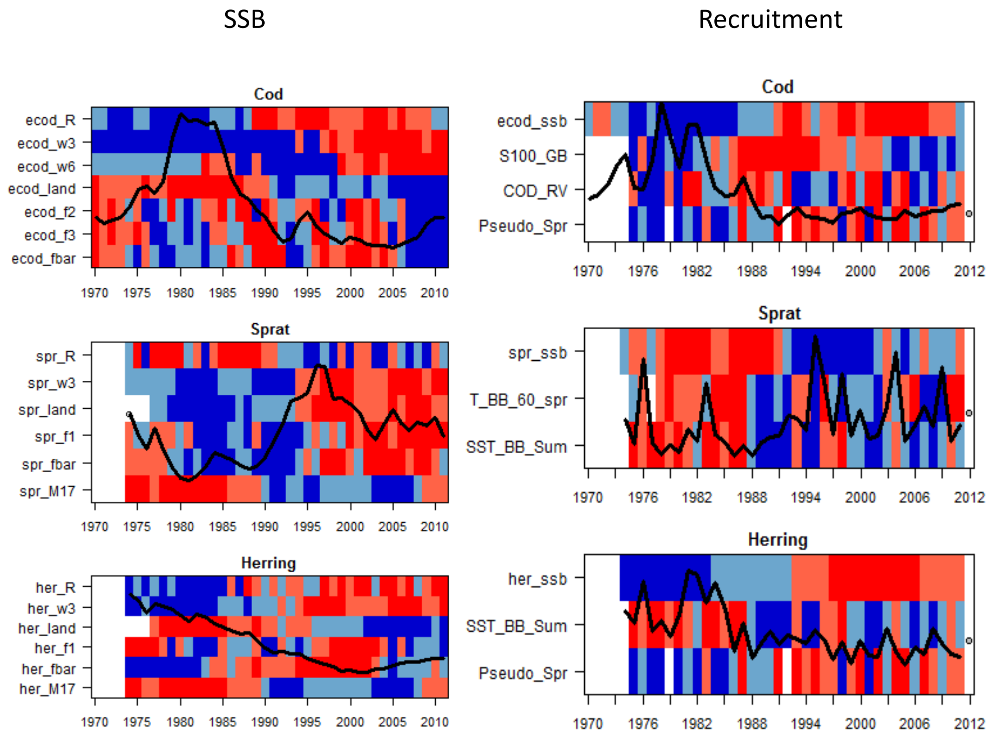


Figure 1.4. Temporal changes in indicators influencing the SSB and recruitment of the eastern Baltic cod, sprat and central Baltic herring. The colours refer to quartiles of the values observed in the time-series, high values are marked with blue and low values with red colours, except for mortality 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).

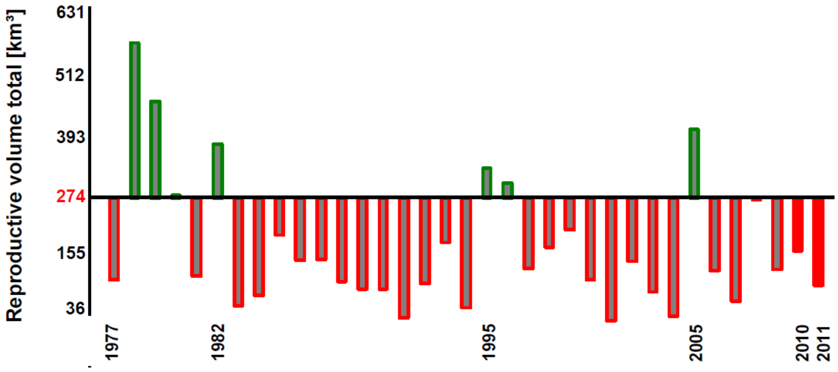


Figure 1.5. Time-series of reproductive volume for Eastern Baltic cod (summed across the three deep basins in the Baltic Sea), assembled by WGIAB 2013. Relationships between each variable and residuals from cod recruitment (back shifted) vs. cod SSB were derived during WGIAB 2013, using linear models 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).

1.10.2 Biotic factors

1.10.2.1 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 1.6), 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), indicating a spatial density-dependent effect (Casini *et al.*, 2011). These results show the importance of spatial analyses to deepen the knowledge of 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 intraspecific and inter-specific competition among clupeids.

Evidence highlighting the importance of coastal shallow waters as major nursery and feeding grounds for pre-mature young cod and to some extent mature individuals keeps increasing during very recent years. Standardized Baltic International Trawl Surveys (BITS) cover mostly deeper waters (>15m water depth) and thus possibly misestimate abundances of species inhabiting coastal areas.

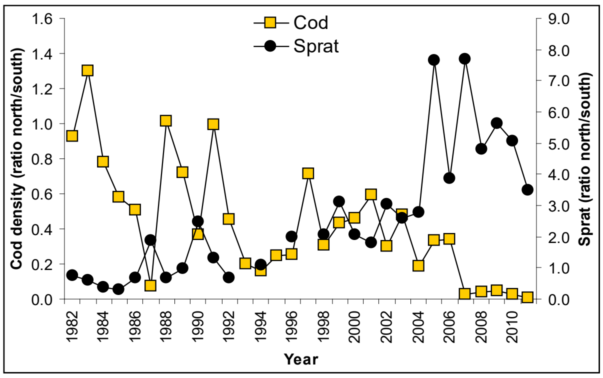


Figure 1.6. Ratio between sprat stock in northern Baltic Proper (SDs 27–29) and southern areas (SDs 25–26) as calculated by acoustic surveys, and ratio between cod stock in the northern Baltic Proper (SDs 27–28) and southern areas (SDs 25–26) from bottom-trawl surveys. Modified from Casini *et al.* (2011).

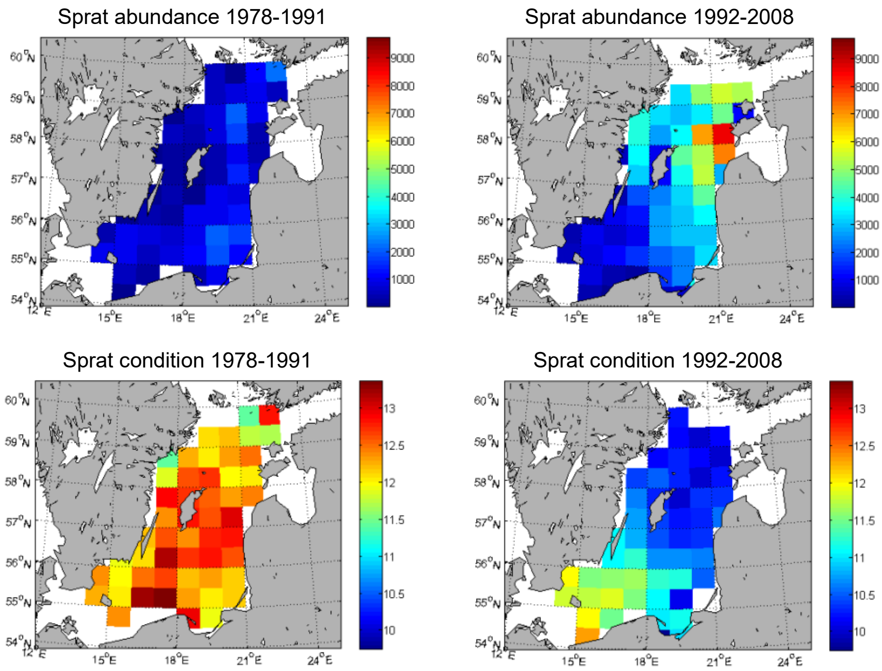


Figure 1.7. Spatial patterns in mean sprat abundance and clupeid condition in 1984–1991 and 1992–2008, from autumn acoustic survey. Only years with at least 10 individuals per rectangle were used in the condition calculation. From Casini *et al. (*2011).

1.10.2.2 Non-indigenous species and changes in fish community

The ecoregion has a total known number of 173 non-indigenous (NIS) and cryptogenic (of unknown origin) species. Since the beginning of the 21st century the apparent annual introduction rate has been almost two times higher (3.2 and 1.4 species per year, respectively) than between 1950 and 1999. The ballast water of ships and hull fouling are the main vectors of primary introductions, followed by natural spread of NIS introduced via rivers and the North Sea. Most of the NIS originate from the North American east coast, the Ponto-Caspian region, and East Asia. Introductions of subtropical NIS have been increasing recently.

The observed ecological impacts include (a) changes in the physio-chemical habitat of sediments and water, (b) declines in abundance/biomass of several native species, and (c) changes in food-webs. Other key impacts include fouling of industrial installations, water supply systems, boats, and fishing gear.

Around 230 fish species have been recorded in the Baltic Sea (including the Kattegat and the Sound), of which 90 reproduce regularly in the Baltic Sea and the Sound. Thirty to forty freshwater fish species occur in the inner Baltic Sea and coastal areas.

Changes in coastal fish communities over the past decades have been linked to increasing water temperatures, decreasing salinities, and eutrophication. Increasing abundances of fish from the carp family (Cyprinidae) and decreases in piscivorous fish have been seen in many coastal areas during the past decade.

1.10.2.3 Seabed abrasion and substrate loss

Disturbance of seabed habitats due to physical abrasion from mobile bottom-contacting fishing gears occurs mostly in the southern parts of the Baltic Sea (Figure 1.8). This is mainly abrasion from otter trawls targeting demersal and benthic fish. Abrasion may affect the surface (top 2 cm of sediments) or the subsurface (>2 cm). Few studies examine the impact of fishing-related abrasion on benthic communities in this part of the Baltic Sea, but from neighboring regions, such as the North Sea and Kattegat, it is known that frequent disturbance by bottom trawls reduces benthic diversity and biomass and changes the composition of benthic species. Some of the trawled parts of the Baltic Sea are also affected by low oxygen concentrations at the seabed. Oxygen depletion can induce burrowing organisms to migrate to the sediment surface, making them potentially more vulnerable to trawling disturbance. For areas with even lower concentrations of oxygen, bottom trawling is unlikely to have any marked effects on habitats as the benthic biomass has already been reduced by hypoxia. Habitat loss in the Baltic Sea is connected to human activities such as sand extraction, dredging and deposit of dredged material, harbours and marinas, and to a lesser extent offshore installations and mariculture. Less than 1% of the Baltic Sea seabed is assessed as potentially lost due to human activities.

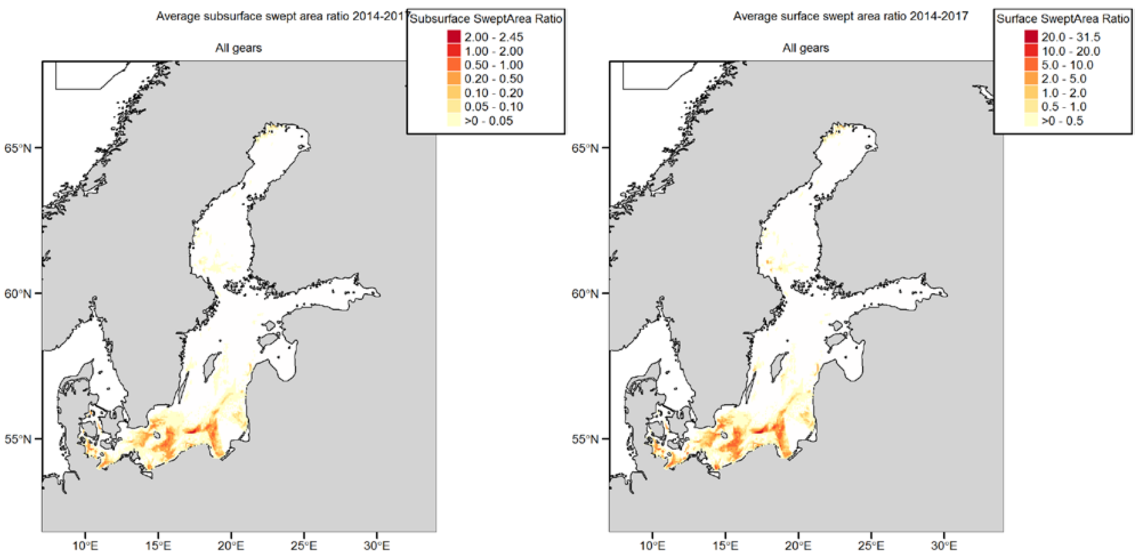


Figure 1.8. Average annual subsurface (left) and surface (right) disturbance by mobile bottom-contacting fishing gear (bottom otter trawls, bottom seines, beam trawls) in the Baltic Sea during 2014–2017, expressed as average swept-area ratios (SAR).

1.10.2.4 Seabirds

Many species of seabirds breed on the coasts of the Baltic Sea. Different species have shown different trends in breeding numbers: nine species have declined, ten have increased, nine were stable, and the trend was uncertain in one species. The greatest declines in breeding numbers were observed in common eider (*Somateria molllissima)* and great black-backed gull (*Larus mari-*

nus). Three species that feed mainly on herring and sprat (common guillemot, razorbill, and Arctic tern) have increased in number over recent decades. White-tailed sea eagle and great cormorant have increased, following the cessation of hunting and the decline in persistent pollutants.

The Baltic Sea is an important wintering area for many species, including the globally threatened long-tailed duck, velvet scoter (*Melanitta fusca)*, and Steller's eider (*Polysticta stelleri)*. These three species have been declining in number during the last 25 years, as have many other benthic-feeding species.

1.10.2.5 Marine mammals

Three seal species occur regularly in the Baltic Sea: grey seal (*Halichoerus grypus)*, harbour seal (*Phoca vitulina*), and ringed seal (*Phoca hispida*). Grey seals occur throughout the Baltic Sea and the population grew rapidly from 2000 to 2014, before levelling off at above 30 000 individuals. Harbour seals mainly occur in the southern Baltic Sea and the population in this area had an estimated growth rate of 8.4% between 2002 and 2014. The neighbouring Kalmarsund population had a lower growth rate. The population of ringed seal in the Gulf of Finland is low, at around 100 animals, and is listed as vulnerable by IUCN. This is probably due to recent lack of ice for breeding during the winter. The Bothnian Bay population of ringed seal exceeds 10 000 animals.

The only cetacean species to occur regularly in the Baltic Sea is the harbour porpoise (*Phocoena phocoena*). East of Bornholm, a large population decline has occurred in the past 50–100 years. With an estimation of 447 individuals (95% CI: 90–997), this population is listed as critically endangered by IUCN. The Belt Sea population has a much higher abundance, estimated at 40 475 (95% CI: 25 614-65 041).

1.10.2.6 SGPSTIAL 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). Five decades of stomach content data allowed detailed insight into the long-term development of consumption, diet composition, and the resulting somatic growth of *Gadus morhua* (Atlantic cod) in the Eastern Baltic Sea. Post-settlement, prespawning cod feed almost exclusively on benthic prey. A recent reversal has occurred in the ontogenetic development of feeding level over body length, resulting in present feeding levels of these small cod that indicate severe growth limitation and increased starvation-related mortality. Young cod manifest the low growth rate and high mortality rate in a reduction in size-at-age and low population abundance. The low feeding levels most probably result from a decrease in benthic prey availability due to increased hypoxic areas. Our study emphasizes that under the current environmental regime environmental forcing likely dominates the changes in consumption and growth rates of Atlantic cod in the Baltic Sea by reducing the availability of benthic prey. This food reduction is amplified by accumulation of cod of smaller size competing for the scarce benthic resources. Only the fish with feeding levels well above average will survive, though growing slowly (Figure 1.9). These results suggest that the relation between consumption rate, somatic growth and population density, as well as its consequences for species interactions and ecosystem functioning, are environmentally mediated and hence not stable under environmental change.

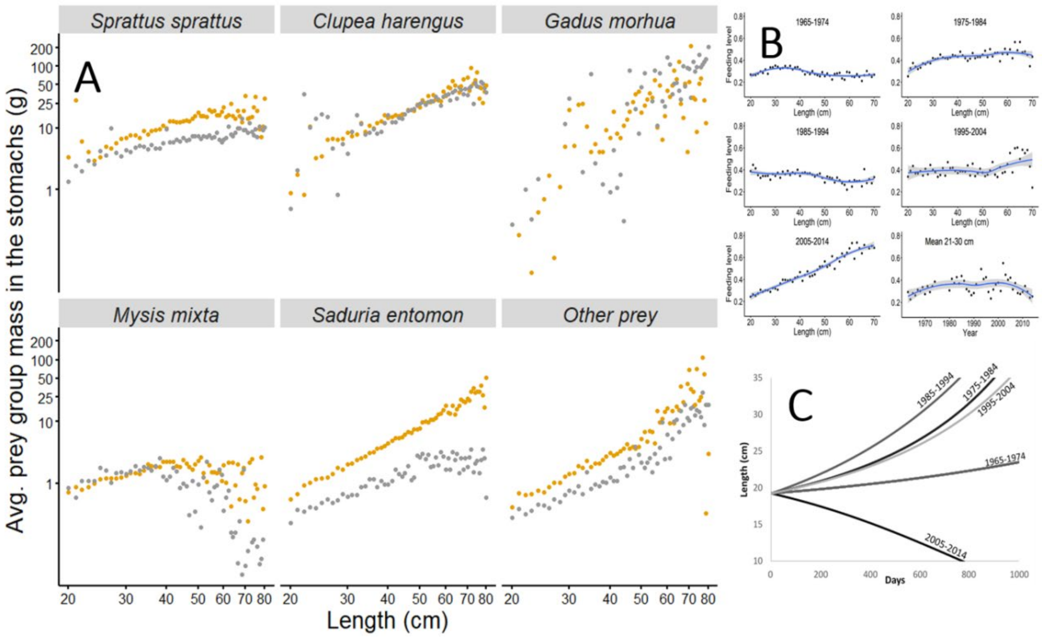


Figure 1.9. A Diet composition in *Gadus morhua* stomachs by mass before 1988 (orange) and after 1994 (grey). The transition period between ecological regimes from 1988 to 1993 (Moellmann *et al.*, 2009) is left out. B Feeding levels of *Gadus morhua* by length during the past five decades. LOESS-based smoothed trends are plotted in blue together with shadowed confidence limits. The lower right panel: feeding level over time for G. *morhua* of 21–30 cm total length. C Simulated average growth trajectories of *Gadus morhua* in the total length range 20–35 cm for the five decades covered by the stomach sampling programme. (Neuenfeldt *et al.* in prep.)

1.10.2.7 Baltic cod body condition is related to hypoxic areas, density-dependence, food limitation and liver worms (Nematodes) infestation rates

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 1.10). The statistical analyses corroborated 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 1.11 and 1.12). Hypoxic areas can act on cod condition through different mechanisms related directly to species physiology, or indirectly to behavior and trophic interactions (Figure 1.13). Our analyses found statistical evidence of 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.

Multiple studies were able to reveal a correspondence between the occurrence of grey seals and infestation rates of cod with the liver worm *Contracaeum osculatum*. Their life cycle includes crustaceans and several fish species as intermediate – and marine mammals as final host. With the beginning of the 2010s infection levels increased drastically, resulting in a negative correlation between the amounts of worms found in cod livers and cod condition (lower HSI-values as well as corresponding decreased liver lipid contents). With less energy sored as fat in the liver, chances to withstand periods of food limitation decrease and fish mortality increases due to insufficient energy reserves not fulfilling metabolic needs (Horbowy *et al.*, 2016).

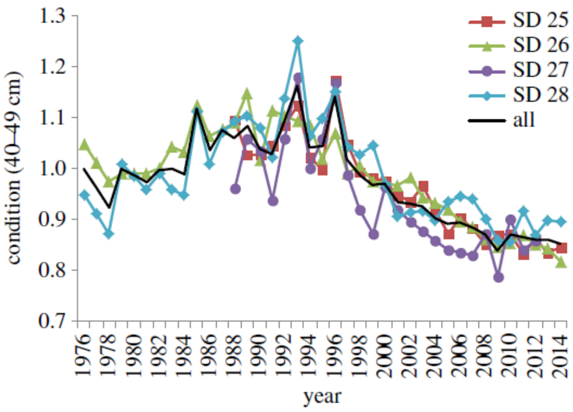


Figure 1.10. Temporal developments of mean cod condition in the different subdivisions (SDs) of the Central Baltic Sea for cod 40–49 cm. The black thick line is the average between the SDs. From Casini *et al.*, 2016.

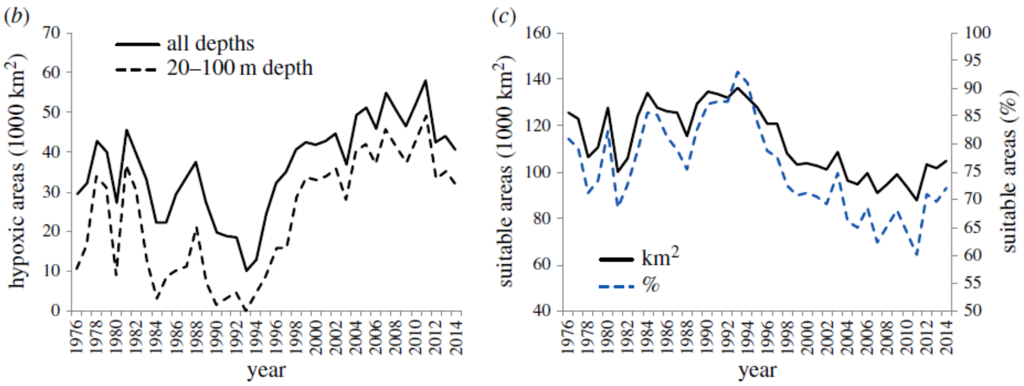


Figure 1.11. (b) time-series of total hypoxic areas (all depths), and hypoxic areas between 20–100 m depth, the latter used as predictors to explain cod condition in the GAMs; c) time-series of suitable areas for cod (> 1 ml/l oxygen concentration) between 20–100 m depth, in absolute values and in percentage. The time-series refer to the Central Baltic Sea (SDs 25-28). From Casini *et al.*, 2016.

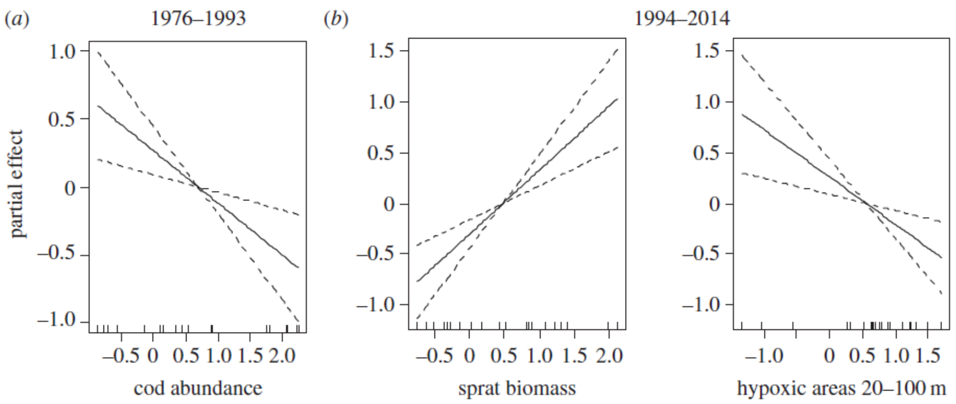


Figure 1.12. Results of the GAM (final model) for the two separated periods (1976–1993 and 1994–2014). The partial effects of each predictor on cod condition are shown. From Casini *et al.* 2016.

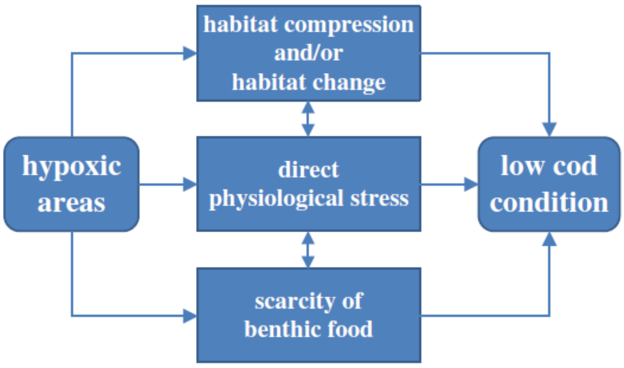


Figure 1.13. Schematic representation of the mechanisms potentially explaining the negative relationship between hypoxic areas and cod condition. From Casini *et al.*, 2016.

1.10.2.8 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 1990s, the share of benthic invertebrates and fish has decreased significantly. The dominant species in the cod diet were clupeid fish. 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 30 m) 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 until 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.

1.10.2.9 Analyses of cod stomachs, biological and hydrological components

A study was conducted regarding recent (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 (Amosova *et al.*, 2017). 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. Even taking a decreasing gutted-weight at length into account, hepatosomatic indices (HSI) keep declining since the beginning of the 2000s. Statistically significant HSI correlations between all parameters are found only in component 2, which characterizes the interannual 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 1.14.). The organ liver represents next to its physiological importance an energy storage within gadoid fish. Thus, decreasing HSI values and a shrinking liver fat content display an ongoing deterioration of cod condition in the study area.

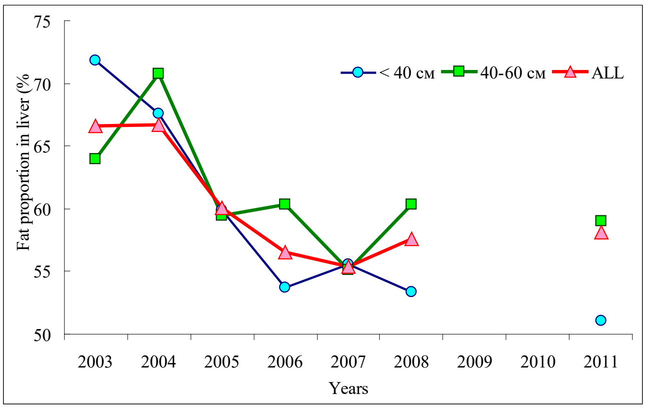


Figure 1.14. Fat proportion in liver of different cod size groups (in %) based on chemical analysis (data obtained by L.I. Perova and M.L. Vinokur, technological direction of AtlantNIRO: Reports on the research work "Investigation of nutrition and biological value of commercial and non-commercial fish of the Atlantic Ocean and the Baltic Sea based on the catches for the period of 2003–2011").

The reduced consumption rate of sprat and benthic crustaceans goes hand in hand with the worsening of cod condition. Therefore, it can be assumed that mentioned species represent a main biotic driver (in terms of prey items) especially during fish fattening in fall-winter season, influencing 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.

1.10.3 Ecosystem and multispecies models

Three papers have been published 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 and 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 1.1). This raised the B_{MSY} for herring above B_{pa}, which was already achieved for cod and sprat.

Table 1.1. 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 F_{MSY} ranges are shown. ICES current single-species MSY, MSY ranges, B_{lim} and B_{pa} 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 (2017). 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 analysed across the range. The greatest collective long-term benefits from mixed multispecies fisheries will be achieved when F-PGY is close to or below F_{MSY} as defined at the Nash equilibrium.

A Baltic implementation of the spatially-explicit end-to-end Atlantis ecosystem model linked to two external models has been developed (Bossier *et al.*, 2018), to explore the different pressures on the Baltic ecosystem. The HBM-ERGOM initializes the Atlantis model with high-resolution physical-chemical-biological and hydrodynamic information while the FISHRENT model analyses the fisheries economics of the output of commercial fish biomass for the Atlantis terminal projection year. The Baltic Atlantis model composes 29 subareas, 9 vertical layers and 30 biological functional groups. The balanced calibration provides realistic levels of biomass for, among others, known stock sizes of top predators and of key fish species. Furthermore, it gives realistic levels of phytoplankton biomass and shows reasonable diet compositions and geographical distribution patterns for the functional groups. By simulating several scenarios of nutrient load reductions on the ecosystem and testing sensitivity to different fishing pressures, the model has shown to be sensitive to those changes and capable of evaluating the impacts on different trophic levels, fish stocks, and fisheries associated with changed benthic oxygen conditions. The Baltic Atlantis forms hence an initial basis for strategic management evaluation suited for conducting medium to long-term ecosystem assessments, which are of importance for a number of pan-Baltic stakeholders in relation to anthropogenic pressures such as eutrophication, climate change and fishing pressure, as well as changed biological interactions between functional groups.

1.10.4 Ecosystem considerations in the stock assessments

The WGBFAS recognizes 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.

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

1.11 Stock Overviews

In WGBFAS, a total of 3 cod stocks, 3 herring stocks, 1 sprat stock and 10 flatfish stocks, are considered. In 2019 analytical assessments were carried out for, cod in SD 22–24, cod in 25–32, 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 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.

1.11.1 Cod in Kattegat

The reported catches of cod in Kattegat have declined from more than 15 000 tonnes in the 1970s, 10 000 tonnes in the late 1990s. In 2018, reported landings were 212 t. The SSB has decreased from historical high levels in the 1997. There were some signs of a recovery in the 2015 but the SSB level is at historical low levels again in 2018. The mortality has decreased since 2008 to low levels 2014, but are again increasing. The recruitment the last six years has been below average.

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

The cod stock in the Western Baltic has historically been much smaller than the neighboring 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 as TACs have been decreasing. Recruitment is rather variable and the stock is highly dependent upon the strength of incoming year classes. Between 2015 and 2018 only one strong year class occurred (2016) which showed up in the landings in 2018. The year classes 2015, 2017 and 2018 were very low. Therefore, the mayor part of the catches in 2018 and 2019 is comprised of the large 2016 year class. In 2018, F was 0.37 and the stock size in 2019 was just below Blim (<14 500 t). The prospects of this stock depend on the strength of the next year classes. However, even a strong 2019 year class would only allow a TAC increase in 2021.

1.11.3 Cod in Subdivisions 24–32 (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 SSB has been at the highest level in the late 1970s-early 1980s. In the period since the 1990s, the SSB has fluctuated, but has declined in most recent years close to the lowest level in record. The development of the stock size is not entirely represented by the spawning-stock biomass in recent years, due to a large decline in size at maturation. The SSB is currently largely consisting of small individuals that were not part of the spawning stock in earlier years. The biomass of commercial sized cod (>35 cm) is currently at the lowest level observed since the 1950s. Fishing mortality has declined over the last years and the value for 2018 is estimated to be at the lowest level in record. Latest stronger year class was formed in 2012. The recruitment (age 2) in 2019 is the lowest in record. The poor status of the Eastern Baltic cod is largely driven by biological changes in the stock during the last decades. Growth, condition (weight at length) and size at maturation have substantially declined. These developments indicate that the stock is distressed and is expected to have reduced reproductive potential. Natural mortality has increased, and is estimated to be considerably higher than the fishing mortality in recent years. Population size structure has continuously deteriorated during the last years.

1.11.4 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 about or less than 500 t. Sole has mainly been caught in a mixed fishery as a valuable bycatch; 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 MSY $B_{trigger}$ and B_{lim} but increased to above MSY $B_{trigger}$ in the past two years. Fishing mortality has decreased continuously until 2015 and has recently increased to about F_{MSY}/F_{pa}. A slight improved recruitment since 2014 have likely contributed to the good status of the SSB in recent years. This changed biological regime with lower productivity (recruitment) since 2004 have been used as basis for the defined MSY reference points and is also assumed in the basis for the forecast.

1.11.5 Plaice in 21–23

Plaice is caught all year-round, mainly from winter to spring. In Subdivision 22 plaice is mostly taken in mixed fisheries together with cod. In Subdivision 21 plaice is almost exclusively a bycatch in the combined Nephrops–sole fishery. Discarding remains important, around 30% of catch volume. The stock is in good condition, with SSB largely above the MSY $B_{trigger}$ (=B_{pa}), and with a constant increase in biomass over the last decade, from a lowest observed SSB at 3.6 kt in 2009 to above 11.9 kt in 2019. Older fish (age 6 and above) are increasingly observed both in catches and in surveys. The two last year classes (recruitment age 1 in 2017 and 2018) are the largest observed since the beginning of the time-series in 1999, around twice the size of the median recruitment of the time-series.

1.11.6 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 fivefold since the start of the survey time-series in 2001. Especially the years 2017 and 2018 (Q1) display a strong increase in plaice abundance. The stock size indicator (rel. SSB) in the last two years (2018–2019) is two times (2.012) higher than the abundance indices in the three previous years (2015–2017). In 2014 discard data were 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 38% in 2015. Discards in 2016 were exceptional high (~67%) and decreased to about 30% in the two recent years. Since 2017, plaice is under a landing obligation, resulting in an additional landings of 8.6 tonnes of "unwanted catch" (BMS landings) in 2018.

1.11.7 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. Recently, a new flounder species (*Platichthys solemdali*), mainly distributed in the northern Baltic, was described.

1.11.8 Flounder in 22–23

The stock size indicator from surveys has increased steadily since 2005 about fourfold and shows a decrease in recent years. The average stock size indicator (biomass-index) in the last two years (2017–2018) is 51% lower than the biomass-indices in the three previous years (2014–2016). 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.

1.11.9 Flounder in 24–25

This stock is the largest flounder stock in the Baltic. There are two flounder species in this area. According to survey data from 2014 and 2015, the share of *Platichthys flesus* and the newly described species (*Platichthys solemdali*) was estimated to be approximately 80 and 20% respectively. It is not possible at this stage to separate the proportion of this species in either stock assessment or fisheries. The stock size indicator from surveys has increased until 2016, after which it has decreased.The average stock size indicator (biomass index) in the last two years (2017–2018) is 10% lower than the biomass-indices in the three previous years (2014–2016). 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 of discard ratios, discard estimates since 2014 have been used in the advice because discards reporting has improved.

1.11.10 Flounder in 26 and 28

Flounder is taken as bycatch 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 showed a decreasing trend from the beginning of the century although the estimated indices in last four years are on stable level. The stock abundance is estimated to have slight increase by 0.7% between 2013–2015 (average of the three years) and 2016–2017 (average of the two years).

1.11.11 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 (80-90% of landings). 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 uniform trend is evident between the surveys. The total stock size indicator value seems to show a slight increasing trend from 2012 onwards. However, this trend is largely thrived by one survey in SD29 (Küdema Bay survey, Estonia).

1.11.12 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 threefold. The survey index in SD 22– 24 varied around 115-120 kg hour-1 in the last 3 years and remains stable.

1.11.13 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.

1.11.14 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 (Ind./hour, ≥20cm length) from surveys increased steadily in the last five years in SD 22–28 and increased to about 4-5 individuals/hour in the two last recent years.

1.11.15 Herring in subdivisions 25–29 and 32 excluding Gulf of Riga (Central Baltic herring)

The stock 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. This year class is still the main contributor in the catches in 2018. The spawning stock size has shown an increasing trend, with minor fluctuations, since the beginning of the 2000s. The present SSB estimate for 2018 is above the long-term average (1974–2018). The last four year classes are below or on average and if such low recruitment continues, a marked decline in biomass development can be expected in the coming years. 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 has been above F_{MSY} (0.22) since 2016.

1.11.16 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 71 000–133 000 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 abundant year classes and increase of SSB.

1.11.17 Herring in subdivisions 30 and 31

The spawning stock of Gulf of Bothnia herring was at relatively low level of 200 000 t at 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 with a peak in 2013–2014, after which the spawning stock has showed a decreasing trend in 2015–2018. 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, and 2014. The 2017 year class is weakest since 2004. In the biomass estimates from the acoustic surveys in 2007–2018, there is an increasing trend in 2007 – 2015 and a decreasing trend thereafter. This suggests that the recent exploitation may have affected the state of the stock. SSB in 2018 is estimated to have decreased from its highest peak in 2014, but it is still regarded to be clearly above the MSY $B_{trigger}$ like it has been since the end of the 1980s.

1.11.17.1 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 tonnes since the beginning of 2000s. Spawning-stock biomass for over 30 years was higher than precautionary levels. Very strong year class of 2014 has led to marked increase in stock size, SSB reached 1.2 million tonnes in 2016–17, and it is predicted to stay above 1 million tonnes until 2021, if the stock is exploited at F_{MSY}. After 2000, fishing mortality increased and next fluctuated, exceeding F_{lim} in several years. In recent years, F declined towards the F_{pa}. Among the year classes 2009–2018 only one (2014) was strong, which contributed to previous stock decline.

During recent two decades, the stock distribution has been changing with tendency to increase density in north-eastern Baltic.

1.12 Audits

Audits were completed successfully for each stock for which the WG formulated a draft advice. All audits can be found in Annex 5.

2 Cod in the Baltic Sea and Kattegat

2.1 Cod in Subdivisions 24-32 (eastern Baltic)

The fishery

A 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).

There were two different options for submission of BMS landings data to InterCatch:

1. Landings, discards and BMS landings were submitted separately.
2. BMS landings were included in the discard estimate and were only reported as "Official landings" to InterCatch (The "Official landings" field is merely informative and is not included in the catch estimate when data are extracted). This option could be used if the design of the discard sampling does not allow discards and BMS to be separated in the discard estimation, for example when an observer effect on the discard pattern is suspected. In this case the estimate provided as discards is actually an estimate of "unwanted catch" and includes all cod that was not landed for human consumption.

Regardless of how BMS landings were provided in IC, the statistics on BMS landings presented in this report are derived from logbook data (or other official data sources) and not estimated from sampling.

BMS landings were provided separately from discards by Latvia, Lithuania, Estonia and Sweden. Poland, Denmark and Germany included BMS landings in the discard estimate in the data submission and provided separate information on BMS only as "official landings". In order to quantify the different catch categories in such case, BMS landings of cod reported only as "official landings" are included in the BMS landings and subtracted from the discard estimates in this report. However, this could not be done for number of fish by length, and therefore tables showing length distribution by catch category show BMS landings and discards together as "unwanted catch".

For years before 2017, official BMS landings are not possible to show separately, due to inconsistencies in data reporting and submission in different countries. The available information indicates that BMS landings were a very small fraction of total landings, similar to 2017–2018.

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 2018 are shown in Table 2.1.2. The total provided landings in SD 25-32 in 2018 summed up to 15 907 t, whereof 99% were above MCRS and only 108 t were BMS landings (Table 2.1.3, 2.1.4).

The total landings in the management area in 2018 were 38% lower compared to 2017 and the lowest in the time-series. The available TAC for eastern Baltic cod has not been taken since 2009. In 2018, 55% of the TAC was caught, BMS landings and discards included (Figure 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 (Figure 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 WKBALTCOD2 2019). 13% of total landings of Eastern Baltic stock are estimated to have been taken in SD 24 in 2018 (Figure 2.1.2; Table 2.1.4).

Unallocated landings

For 2018, similar to 2010–2017, 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 considered to be up to 35–40%. 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.

Discards

In addition to landings above MCRS and BMS landings, discard estimates were submitted from most countries. Even though there is a landing obligation in the Baltic Sea from 2015, discards were still estimated to occur, based on-board sampling by most countries. The total discards in 2018, in subdivision 25-32, were estimated to 3103 t (not including any BMS landings), which constituted 16% of the total catch in weight. This was an increase from 11% in 2017 and the highest discard rate since the introduction of the landing obligation. 91% of the estimated discards in weight was caught by active gears.

Since some countries provided discards and BMS landings together as one estimate in terms of number of fish at length (see section 2.1.1.1 for further information on how BMS data/discards were submitted), it was not possible to show length distributions for BMS landings and discards separately. Therefore, length distributions can only be separated by wanted (landings above MCRS) and unwanted (BMS + discards) catch.

The most abundant length class of the unwanted catch in 2018 was length class 30-34 cm (50% in numbers) followed by length classes 25-29 cm and 35-37 cm (27% and 14%, respectively) (Table 2.1.5). This is a change towards smaller fish compared to 2017, when the second most abundant length class in the unwanted catch was 35-37 cm (27%).

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 generally low sampling intensity, of particularly passive gears, and thus large uncertainties in the estimates. Since 2015, discard estimation for Eastern Baltic cod has been further complicated by the fact that discarding under the landing obligation is illegal, which increases the risk of an observer effect on discard patterns in sampled trips and can also lead to increased difficulties for observers to be allowed on board fishing vessels.

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 300 tonnes of estimated discards of eastern Baltic stock in SD 24 in 2018 (Table 2.1.4). This results in estimated discard rate of 16% in weight, for the entire eastern Baltic stock, including both the SDs 25-32 and the fraction of the stock in SD24.

2.1.1.2 Effort and CPUE data

No data on commercial CPUEs was presented at WGBFAS. The effort data from EU STECF (2017) shows a decline in kw-days for demersal trawls in 2012-2016 in the central Baltic Sea, while the effort in gill-net fishery is more stable in these years.

2.1.2 Biological information for catch

2.1.2.1 Catch in numbers and length composition of the catch

The catch numbers for SDs 25-32 were derived from compilation of biological information submitted to Intercatch. The most abundant length class in the total catch in 2018 was 38-44 cm (37% in numbers), followed by 35-37 cm (18%) and 30-34 cm (20%) (Table 2.1.5). Table 2.1.6 gives the estimated mean weight per length class and gear in the landings and discards 2017.

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.

2.1.2.2 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 2018. All countries biological data was estimated nationally before being uploaded and further processed in InterCatch. Numbers and mean weight at length were provided for 73% of the total landings (>MCRS) in weight, 76% of the BMS landings and 71% of the estimated discards. This was similar to 2017. 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. 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 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 2013–2018 and the data compiled in previous years.

2.1.3 Fishery independent information on stock status

Stock distribution

Data from BITS surveys indicate that with the management area of ICES SDs 25-32, cod is mainly distributed in SDs 25 and 26 (Figure 2.1.3). 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. There are issues with coverage of SD 26, as Russia did not participate in the 2018 Q4 and 2019 Q1 surveys (Figure 2.1.3).

Nutritional condition

Nutritional condition (Fulton K) of the eastern Baltic cod has substantially declined since the 1990s in all SDs 24-28 and has been at a relatively stable low level since 2010 (Figure 2.1.4). The proportion of cod at 40-60cm in length 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, and is around 15% in latest years. In Q4, condition is generally more poor than in Q1, and the condition values for 2017-2018 are the lowest observed in the time series (Figure 2.1.5).

Growth and natural mortality

The growth of the Eastern Baltic cod is expected to have declined since the 1990s, due to a reduced size at maturation, poor condition of cod, hypoxia, and parasite infestation (ICES WKBEBCA 2017, WKIDEBCA 2018). The same factors have presumably contributed to an increase in natural mortality. Recent changes in growth and natural mortality are estimated in stock assessment model (see section 2.1.5).

Maturity

Size at maturation has substantially declined in the period from the 1990s to 2000s. The L50 (50% percent mature) has been estimated at around 35-40cm (males and females combined) in the early 1990s and has declined to around 20cm since the late 2000s (Figure 2.1.6).

Recruitment

The CPUE of <25 cm cod has been variable over time, the most recent value from 2018 Q4 and 2019 Q1 surveys combined is among the lowest in the time-series (Figure 2.1.7). Larval abundances from ichthyoplankton surveys suggest that last stronger year classes occurred in 2011 and 2012, which are also visible in length frequency data from BITS surveys. The larval abundance in 2018 is among the lowest observed (Figure 2.1.8).

Relative biomass trends and size distribution from surveys

Time series of CPUE by size-groups of cod shows a decline in biomass in all size groups in latest surveys (Figure 2.1.7). Since 2013, relative abundance of larger (>45 cm) cod has been very low and the main part of the survey catch consists of 20-40 cm cod. The SSB index based on egg abundance data from ichthyoplankton surveys and annual egg production method shows a sharp decline in SSB index from 2017 to 2018, to the lowest level in record since the late 1980s (Figure 2.1.9).

2.1.4 Input data for stock assessment

Overview of the times series included in stock assessment with Stock Synthesis model is provided in Figure 2.1.10 and Table 2.1.7.

2.1.4.1 Catch data

The time series of catch data used in stock assessment starts in 1946 (Figure 2.1.11). Total catch biomass is divided between Active (trawls) and Passive (mainly gill-nets) fleets from 1987 onwards. The catches of both fleets are divided to quarters. The fleet and quarter specific data for 2018 were compiled from national data provided in IC. For documentation of data used in the entire time series, see ICES WKBALTCOD2 2019. The catches used in the assessment include the fraction of Eastern Baltic cod catches taken in SD24.

The actual catch data are available until 2018. However, to be able to use the survey information from 2019 Q1, the last data year in the Stock Synthesis model is set to 2019. This implies that catches for 2019 need be assumed. The catch in 2019 was set to the level assuming F in 2019 to be equal to F in 2018. Based on this, total catch in 2019 was assumed to be 12% lower than in 2018.

2.1.4.2 Age and length composition of catch

Age composition of catches is included in the model for 1946-2006 (effectively until 1999 as the age composition of catches for 2000-2006 is set to not contribute to the model likelihood and are treated as “ghost fleet” by Stock Synthesis). Thus, no new information on age composition of commercial catch was included in this years’ assessment.

Length compositions of commercial catch are included from 2000 onwards. The landings that have not been specified in IC whether active or passive were all allocated to Active. The length compositions used in Stock Synthesis are by quarter and fleet (Active, Passive).

2.1.4.3 Conditional age-at-length (age-length key)

Age length keys are used in Stock Synthesis model from 1991 onwards to inform the estimated deviations in Von Bertalanffy growth parameters. The ALKs used are based on age readings from BITS surveys, available in DATRAS (Figure 2.1.12). Both ALKs from Q1 (1991-2018) and Q4

(1998-2018) were included. The average length at age in the individual fish data from BITS, used as basis for ALK, are presented in Figure 2.1.13.

2.1.4.4 Tuning indices

List of the indices used in the Stock Synthesis assessment is provided in the table below.

Fleet name	Years	Description
#BITSQ1	1991-2019	Baltic International Bottom Trawl Survey, Q1, data for SD 25-32, including the area east of 13 degrees latitude in SD 24. Modelled indices of total abundance.
#BITSQ4	1993-2018	Baltic International Bottom Trawl Survey, Q4, data for SD 25-32, including the area east of 13 degrees latitude in SD 24. Modelled indices of total abundance.
#TrawlSurvey1	1975-1992	CPUE (kg*h–1) by German RV Solea in SD 25 (Thurow and Weber, 1992)
#TrawlSurvey2	1978-1990	CPUE (g/hour) from bottom trawl surveys by the Swedish Board of Fisheries and Baltic Fisheries Research institute (BaltNIIRH), SDs 25–28, yearly average. The index refers to total CPUE in biomass of all length groups caught in the survey (Orio *et al.*, 2017).
#CommCpue1	1948-1956	Commercial CPUE (kg/h) of former USSR , February–June (Dementjeva, 1959)
#CommCpue2	1957-1964	Commercial CPUE (kg/h) of former USSR in Gdansk area, February-June (Birjukov, 1970)
#CommCpue3	1954-1989	Commercial CPUE (kg/day) of USSR (Latvian republic), SDs 26-28, annual average (Lablaika *et al.* 1991)
#SSBEggProd	1986-2018	SSB indices based on annual egg production method. Used in SS model to represent spawning stock biomass trends (survey type 30 in SS). Data from ichthyoplankton surveys.
#Larvae	1987-2018	Abundance of larvae during peak spawning, used in SS as pre-recruit survey (survey type 32). Data from ichthyoplankton surveys.

2.1.5 Stock Assessment: Stock Synthesis

2.1.5.1 Update of Stock Synthesis software and adjustments to model configuration

After the benchmark in 2019 (WKBALTCOD2), an updated version of Stock Synthesis software was released. The improvements to the software were related to the estimation of parameter deviations (R. Methot, pers. comm). As the model for the eastern Baltic cod is estimating deviations for growth and natural mortality, this revision in the software had some effect on the assessment results (Figure 2.1.14).

As an updated software was applied, slight tuning of the model configuration was also made. The changes made in the model configuration after the benchmark were related to the estimation of recruitment deviations (recdev). This was on order to better reflect the difference between early and main recruitment deviations, and is a more robust procedure as it makes the main recdev more normally distributed around the 0. Thus, this modification is considered to be an improvement of the model configuration.

An adjustment was also made in the assumed CV of the BITS survey. This was because the combination of the updated software and improvements to the configuration of recdev resulted in deterioration of model fits to BITS indices. The benchmark (WKBALTCOD2 2019) concluded the trends from BITS surveys to reflect the true stock dynamics, thus the model should fit the BITS indices as closely as possible. To achieve a similar fit to BITS indices as achieved at the benchmark, the average CV of the BITS surveys was reduced from 0.15 to 0.11. The value of 0.15 had been chosen arbitrarily at benchmark, as no information is available on the precision of the BITS survey.

After these adjustments to the configuration and BITS CV, the assessment results became similar to the results from the benchmark. Also, the fits to the data were similar to those achieved at the benchmark. These explorations were made using the time series for years that were available at benchmark, thus before updating the data series with the latest year that was added to the assessment at WGBFAS 2019. SSB estimates of these exploratory runs are presented in Figure 2.1.14, full outputs of the runs are available in WGBFAS 2019 SharePoint and upon request to the stock assessors.

2.1.5.2 Model configuration and assumptions

The assessment of the Eastern Baltic cod (SD24-32) was conducted using the Stock Synthesis (SS) model (Methot and Wetzel, 2013). The assessment was conducted using the 3.30 version of the Stock Synthesis software under the windows platform. The Stock Synthesis model of Eastern Baltic cod is a one area quarterly model where the population is comprised of 15+ age-classes with both sexes combined. The model is a length based model where the numbers at length in the fisheries and survey data are converted into ages using the Von Bertalanffy growth curve. The last age-class (i.e. 15+) represents a “plus group” in which mortality and other characteristics are assumed to be constant. Fishing mortality was modelled using the hybrid method that the harvest rate using the Pope’s approximation then converts it to an approximation of the corresponding F (Methot and Wetzel, 2013).

Spawning stock and recruitment

Spawning stock biomass is estimated for spawning time (month 5 is used as an average for the entire time period). Sex ratio is set to 50% females and males. Recruitment was derived from a Beverton and Holt (BH) stock recruitment relationship (SRR) and variation in recruitment was estimated as deviations from the SRR. Main recruitment deviations were estimated for 1950 to 2017, representing the period for which age and length compositions are available. Recruitment deviates were assumed to have a standard deviation (σR which corresponds to the stochastic recruitment process error) of 0.6. The model assumes a level of steepness (h) of 0.99 for the SRR, assuming that recruitment is mainly environmentally driven in EBC. Settlement time for recruitment is set to month 8 as an average for the entire time period.

Growth

Growth parameters were fixed for the period 1946-1990, at the values estimated using historical tagging data. The tagging estimates covered the period 1955-1970 (L_{inf} = 125.27, k= 0.10). Deviations in both L_{inf} and k were estimated between 1991 and 2018 when age-length keys were available from BITS surveys. Age-Length Keys (ALK) are used to inform the estimation of growth deviations from 1991 onwards. Numbers of fish in ALK are used as sample size for each year. The variance in length-at-age was fixed for older fish and estimated for younger individuals (Table 2.1.8).

The parameters a and b in length-weight relationships are estimated from Q1 BITS survey, pooled for SD 25-32. The parameters were estimated for each year, after which the data were averaged by 3-year blocks. These externally estimated parameters were used as inputs in the model (Table 2.1.8).

Natural mortality

Natural mortality is assumed to be age dependent and was estimated using methods described in Then *et al.*, (2015) and Lorenzen (1996) for the historical period (1946-1999). Then *et al.*, (2015) estimation of M is based on maximum age (*tmax*) and parameters of the Von Bertalanffy growth curve. The Lorenzen type (Lorenzen, 1996) of M-at-age function assumes a declining relationship between M and the mean weight of fish in successively older age classes. Historical natural mortality was assumed to be equal to the average of the two methods (*tmax* and *growth*) scaled using Lorenzen (1996). In Stock Synthesis, age break-points 0.5, 1.5, 5.5 and 15.5 were used. Natural mortality from 2000 to 2018 for-age break 5.5. was estimated within the model as annual deviations from the historical values. For the other age-breaks, M is kept constant for the entire time series (Table 2.1.8).

Maturity

The input for maturity is L_{50} (length at 50% mature) and the slope of the maturity ogive curve. These are estimated outside of the stock assessment model from BITS Q1 data, for females and males combined. L_{50} of Eastern Baltic cod has substantially declined over time (Figure 2.1.6), which is captured by using time blocks in the assessment model (Table 2.1.8). For the slope, a constant value (0.23) is used for the entire time period.

Selectivity

Fishery selectivity is assumed to be length-specific and time-invariant. For both the trawlers (i.e. active gears) and the gillnetters (i.e. passive gears) selectivity was estimated assuming a logistic function that constrains the older age classes to be fully selected (“flat top”). A logistic selectivity was also used for BITS surveys (both quarter 1 and quarter 4). Selectivity of Trawlsurveys 1 and 2 was assumed to mirror selectivity of BITS Q1 survey, while selectivity for commercial CPUE1, 2 and 3 was assumed to mirror selectivity of the active gears.

2.1.5.3 Uncertainty measures

The CV of catch was set to 0.05 for all years. No meaningful information is available on the annual sample size associated with age or length distribution data for commercial catches. Therefore, the same value (100) is applied for each quarter and fleet in all years.

The average CV of the BITS survey indices was assumed to be equal to 0.11 (see section 2.1.5.1) while the yearly deviation of the coefficient of variation of the BITS survey indices was estimated as part of the modelling of the survey indices outside of the stock assessment model. Numbers of hauls in BITS in each year were used as input for sample size associated with BITS length distribution data.

For the remaining surveys and CPUE indices, the CV was estimated internally in the model, except for the larval index, for which the CV was set to 0.3.

The data weighting method used for the size-composition data followed the advice of Francis (2011) (Method TA1.8). For weighting the conditional age-at-length data we used the Francis-B approach described in Punt (2017). The Hessian matrix computed at the mode of the posterior distribution was used to obtain estimates of the covariance matrix, which was used in combination with the Delta method to compute approximate confidence intervals for parameters of interest.

2.1.5.4 Stock assessment results

From the year 2000 onwards, age composition data of the commercial catch are not available, thus the length compositions are used within the assessment model, to derive the estimated catch at age. These estimated values for catch at age from the Stock Synthesis model are presented in Table 2.1.9.

The settings and estimated parameters by the model are presented in Table 2.1.8. Natural mortality is estimated to have substantially increased (Figure 2.1.15) and growth declined, since around the year 2000 (Figure 2.1.16), which is in line with the available biological knowledge on the stock (WKBALTCOD2 2019). The estimated time invariant selectivity is shown in Figure 2.1.17.

Model fits and residuals for length compositions show a pattern of underestimating the peak in length distribution and slightly overestimating the proportion of the larger cod (Figure 2.1.18, 2.1.19), however the residuals are generally small. For most fleets, there is a reasonable overall fit to the length and age composition data. Overall, the model reasonably fit to the trends in the CPUE indices (Figure 2.1.20), besides the BITS surveys indices for 2008-2011, which were always underestimated in the model.

The retrospectives of the model were reasonable (Figure 2.1.21). The estimated Hurtado-Ferro (2014) variant of the Mohn´s index was 0.22 for SSB and -0.23 for F. The index was relatively large for recruitment at age 0 (-0.70). However, this is expected as it takes about 2-3 years of data for a year class to be determined with high precision as shown by the squid plot of retrospectives of recruitment deviations (Figure 2.1.21). The recruitment presented for stock status table (Table 2.1.10) is for age 2.

The spawning stock biomass is estimated to have declined since 2015 (Figure 2.1.22, Table 2.1.10). The development of the stock size is not entirely represented by the spawning stock biomass in recent years, due to the large decline in size at maturation (Figure 2.1.6). The SSB is presently largely consisting of small individuals that were not part of the spawning stock in earlier years. The biomass of commercial sized cod (>35 cm) is presently at the lowest level observed since the 1950s (Figure 2.1.23). Fishing mortality has declined over the last years and the value for 2018 is estimated to be at the lowest level in record (Figure 2.1.22). Latest stronger year-class was formed in 2012. The recruitment (age 2) in 2019 is the lowest in record (Figure 2.1.22, Table 2.1.10).

The stock numbers and fishing mortalities at age are given in Tables 2.1.11 and 2.1.12.

2.1.6 Exploratory stock assessment with SPICT

SPICT stands for a stochastic surplus production model in continuous time (Pedersen and Berg, 2017). A specific version of SPICT was applied for Eastern Baltic cod, to allow taking into account a change in surplus production over time.

SPICT operates internally with absolute values, but produces output, including the uncertainties also in relative terms (F/F_{MSY} and B/B_{MSY}), 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 relative values for F/F_{MSY} and B/B_{MSY} are reasonably well estimated in the model for Eastern Baltic cod, and the model passes all the evaluation criteria in diagnostics (Figure 2.1.24).

SPICT estimates the fishing mortality of the stock to be far above $F_{MSY\ Proxy}$ in 2018 and the biomass below $B_{MSY\ trigger\ proxy}$ in 2018-2019 (Figure 2.1.25). The results are in line with the stock status estimates based on Stock Synthesis model.

At last benchmark (WKBALTCOD2 2019), it was decided to maintain SPICT as an exploratory model in WGBFAS, while Stock Synthesis is used as the basis for fisheries management advice.

2.1.7 Short term forecast and management options

The short-term projections were done with Stock Synthesis, using probabilistic MCMC forecast with 10000 iterations saving each 100 (so 100 replicates). Using MCMC makes it possible to also include the associated probability/risk of the SSB to be below B_{lim} and $B_{trigger}$ for each year of forecast. The forecast settings in terms of F and recruitment are shown in the table below. The growth and natural mortality were kept at values estimated for 2018. For maturity and weight at length, the values for the latest time-block were used.

Variable	Value	Notes
Fages 4–6 (2019)	0.21	Assumed equal to F in 2018
SSB (2019)	66 412	Stock Synthesis assessment estimate
R_{age0} (2018-2021)	2 358 730	Average of 2013-2017
R_{age2} (2020)	454 740	Resulting from the assumption for R_{age0} in 2018
Total catch (2019)	18 904	Based on assumption of F in 2019 = F in 2018

At WKBALTCOD2 (2019), it was decided that recruitment in the forecast period should be set to the average from 2013 until the last year in the assessment time series for which recruitment deviations are estimated in the Stock Synthesis model. This presently corresponds to the low-average recruitment, i.e. not including in recruitment predictions the latest relatively strong year-classes from 2011-2012.

It should be noted that the recruitment at age 0 for 2018, based on average of 2013-2017 is likely over-optimistic, given the very low observed larval abundance in 2018 (Figure 2.1.8). However, as this year-class has not yet been measured in trawl surveys (it will first appear representatively in BITS survey in Q4 2019), and can therefore not yet be quantified in the assessment model, the default assumption of the average year-class strength was maintained in this forecast. The assumption on recruitment has an impact on SSB in the forecast, as SSB presently largely consists of small individuals. The probably over-optimistic assumption for 2018 year-class therefore implies that the estimated increase in SSB from 2020 to 2021 in the forecast (Table 2.1.13) is over-optimistic as well, though not affecting the perception of the stock status in relation to biomass reference points. Even at no fishing, the SSB is estimated to remain below B_{lim} in 2021, with very high probability.

2.1.8 Reference points

WKBALTCOD2 (2019) concluded that B_{lim} should presently not be set lower than the most recent SSB that was still able to produce a strong year-class, while much of the adverse developments affecting the quality of the SSB (small size at maturation, poor condition, small size of the individuals) had already taken place (see WKBALTCOD2 2019 for further background). The latest relatively strong year class was formed in 2012. The SSB in 2012 was at estimated to correspond to 98 000 t, at benchmark.

The update of Stock Synthesis software and some adjustments to the model configuration after the benchmark (see section 2.1.5.1) resulted in SSB estimate of 94 500 t in 2012. After updating all the time series by adding one more year at WGBFAS 2019, the SSB in 2012 was estimated at

96 550 t, in the final assessment. Since the B_{lim} is defined as corresponding to the SSB in one particular year, WGBFAS (2019) concluded it to be appropriate that the exact value for B_{lim} is not fixed, but it is adjusted on an annual basis, to correspond to the most updated assessment.

WGBFAS (2019) estimated the B_{lim} to be at 96 550 t (SSB in 2012 in the present assessment).

B_{lim} at 96 550 t corresponds to B_{pa} at 108 035 t ($B_{lim} \times \exp(1.645 \times \sigma)$, where σ=0.07).

The Eastern Baltic cod stock has experienced a large decline in productivity, which questions the applicability of the F_{MSY} concept for this stock that assumes long-term equilibrium. The Eqsim analyses conducted at WKBALTCOD2 (2019) showed that even with F_{MSY} at 0 the SSB would not be kept above B_{lim} in the long term, with 95% probability. For this reason, no F reference points were defined for this stock.

2.1.9 Quality of the assessment

The decrease in growth may have affected the catchability of the BITS surveys. Survey coverage in SD 26 has been relatively poor in later years, which could affect the CPUE estimates for these years.

It is recognized that age readings for the Eastern Baltic cod are uncertain, especially for later years, while age imprecision is not explicitly accounted for in the stock assessment model. Age length keys up to the present are applied to estimate the yearly values and thus the trend in Von Bertalanffy growth parameters, which are thereafter used to derive catch at age from catch at length information.

WKBALTCOD2 (2019) investigated the effects of uncertain age information on the assessment results and concluded that the ALKs presently used provide a reasonable proxy for informing growth for stock assessment purposes. This is considered a temporary solution, as an alternative method for estimating growth is being developed. The exact values for Von Bertalanffy growth parameters are associated with uncertainties due to imprecise age information. This is affecting also natural mortality estimates, as growth and M are confounded. However, the results of stock assessment in terms of stock status were found to be robust to these uncertainties. See WKBALTCOD2 (2019) for further details.

2.1.10 Comparison with previous assessment

The assessment has changed from a survey based to a full analytical assessment using Stock Synthesis.

2.1.11 Management considerations

Reported BMS landings in 2018 were very low and discarding still occurs, with estimated discard rate at 16% for the Eastern Baltic cod stock.

At the presently low productivity, the stock is estimated not to recover above B_{lim} in long-term even at no fishing, with 95% probability. Furthermore, fishing at any level will target the remaining few commercial sized (≥35 cm) cod, and by that further deteriorate the stock structure and reduce its reproductive potential.

The poor status of the Eastern Baltic cod is largely driven by biological changes in the stock during the last decades. Growth, condition (weight-at-length) and size at maturation have substantially declined (Figure 2.1.26). These developments indicate that the stock is distressed and is expected to have reduced reproductive potential. Natural mortality has increased, and is estimated to be considerably higher than the fishing mortality in recent years. Population size structure has continuously deteriorated during the last years (Figure 2.1.26).

The low growth, poor condition and high natural mortality of cod are related to changes in the ecosystem, which include: i) Poor oxygen conditions that can affect cod directly via altering metabolism and via shortage of benthic prey, and additionally affect the survival of offspring. ii) Low availability of fish prey in the main distribution area of cod, as sprat and herring are more northerly distributed with little overlap with cod. (iii) High infestation with parasites, which is related to increased abundance of grey seals. The relative impact of these drivers for the cod stock is unclear.

The present distribution pattern of cod, sprat and herring (cod mainly concentrated in SDs 25 and 26, and clupeids in the more northern SDs), implies that a reduction of clupeid F in SDs 25-26 can possibly improve feeding conditions for cod and improve its growth. However, as the relative contribution of different factors to poor condition of cod is not fully understood, the potential effect of reduced clupeid F on cod condition and growth is unclear.

2.1.12 Review of the post-benchmark updates to the Eastern Baltic cod assessment model

April 2019

by Dr. Vladlena Gertseva

This document provides a review of the updated assessment model for the Eastern Baltic cod stock following updates made to the model after the 2019 benchmark. The changes made to the model are related to use of the newest version of Stock Synthesis software (SS, Version 3.30.13), released after the benchmark, in March 2019.

The use of the latest version of SS caused deterioration of model fit to the BITS survey, and the inputted index CV values (estimated outside the model) needed to be adjusted in the updated model. Also, the updated model exhibited degraded convergence, which was evident from increase of the final model gradient.

Given that the output from the updated model is almost identical to the benchmark reference model (after changes made to index CV and composition data weighting), and the benchmark reference model convergence was fully evaluated, my suggestion is to **use the benchmark model** for management advice. The SS platform is being continuously improved, to address growing needs for stock assessments to incorporate variety of processes affecting fish population dynamics. However, it is common practice *not* to update to the latest version of the software *after* the review process, since potential changes caused by the update should be fully evaluated.

Regarding the reference point, the proposal to have B_{lim} adjusted on an annual basis, to correspond to the most updated assessment is reasonable and support this approach.

Table 2.1.1 Cod SDs 25-32. Landings (tonnes) by country (wanted catch, i.e. excluding BMS).

Year	Denmark	Estonia	Finland	German Dem.Rep.**	Germany Fed. Rep.	Latvia	Lithuania	Poland	Russia	Sweden	USSR	Faroe Islands^	Norway	Unallocated***	Total
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

Year	Denmark	Estonia	Finland	German Dem.Rep.**	Germany Fed. Rep.	Latvia	Lithuania	Poland	Russia	Sweden	USSR	Faroe Islands^	Norway	Unallocated***	Total
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	69477
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	65531
2007	7280	877	615		1529	3996	2486	8599	3383	9660				12418	50843
2008	7374	841	670		2341	3990	2835	8721	3888	8901				2673	42234
2009	8295	623			3665	4588	2789	10625	4482	10182				3189	48438
2010	10739	796	826		3908	5001	3140	11433	4264	10169					50276
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					28909
2015	9526	183	388		1477	2873	1845	12896	3845	4438					37471
2016	6756	2	57		918	2656	1637	9583	3392	3995					28996
2017	6109	1	191		337	2058	1712	6468	4124	4316					25317
2018	2668	1	53		231	1237	684	5687	3376	1862					15800

*** 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. Landings (tonnes) by fleet, country and subdivision in 2018. (Wanted catch, i.e. BMS excluded).

Subdiv		25	26	27	28	29	30	31	32	Total 25-32
Fleet	Country									
Active	Denmark	1605	1032	0		0				2637
	Estonia	0	0		0	0			0	0
	Finland	2	2		1		0			5
	Germany	186	44							231
	Latvia	166	966		2					1135
	Lithuania	114	471							584
	Poland	2112	1766	0	0	0				3878
	Russia		3044							3044
	Sweden	724	895	0	1	0	0	0		1619
Total Active gears		**4909**	**8220**	**0**	**4**	**0**	**0**	**0**	**0**	**13133**
Passive	Denmark	31	0	0		0				31
	Estonia	0	0		0	0			0	1
	Finland					48	0	0		48
	Germany	0								0
	Latvia		77		25					102
	Lithuania	0	99							100
	Poland	1663	146	0	0	0				1809
	Russia		333							333
	Sweden	194	0	15	2	32	0			243
Total Passive gears		**1889**	**655**	**15**	**27**	**80**	**0**	**0**	**0**	**2667**
Total All gears		**6798**	**8875**	**15**	**31**	**80**	**0**	**0**	**0**	**15800**

Table 2.1.3. Cod in SD 25-32. Total landings (tons) by country in 2018, separated between landings for human consumption (above MCRS) and the reported BMS landings.

Country	Landings for human consumption (t)	BMS landings (t)
Denmark	2668	16
Estonia	1	0
Finland	53	0
Germany	231	10
Latvia	1237	16
Lithuania	684	10
Poland	5687	8
Russia	3376	0
Sweden	1862	49
Total	15800	108

Table 2.1.4. Eastern Baltic cod stock in Subdivisions 25–32 and Subdivision 24. History of ICES estimates of landings, discards, and catch by area. Landings below minimum conservation reference size (BMS) were only possible to separate from 2017 onwards. Weights in tonnes.

Year	Eastern Baltic cod stock in SD 25-32						Eastern Baltic cod stock in Subdivision 24			Eastern Baltic cod stock in Subdivisions 24+25–32		
	Un allo-cated*	Land-ings AMS	Land-ings BMS	Total landings	Dis-cards	Catch	Total land-ings	Dis-cards	Catch	Total landings	Dis-cards	Total catch
1966				177318	8735	186053	6624		6624	183942	8735	192677
1967				195446	11733	207179	6899		6899	202345	11733	214078
1968				216353	9700	226053	8614		8614	224967	9700	234667
1969				212160	10654	222814	5980		5980	218140	10654	228794
1970				198451	7625	206076	5720		5720	204171	7625	211796
1971				164840	5426	170266	6586		6586	171426	5426	176852
1972				143833	8490	152323	7307		7307	151140	8490	159630
1973				143164	7491	150655	7320		7320	150484	7491	157975
1974				147815	7933	155748	6923		6923	154738	7933	162671
1975				194649	9576	204225	5676		5676	200325	9576	209901
1976				203303	4341	207644	6972		6972	210275	4341	214616
1977				164792	2978	167770	6643		6643	171435	2978	174413

Year	Eastern Baltic cod stock in SD 25-32						Eastern Baltic cod stock in Subdivision 24			Eastern Baltic cod stock in Subdivisions 24+25–32		
	Un allo-cated*	Land-ings AMS	Land-ings BMS	Total landings	Dis-cards	Catch	Total land-ings	Dis-cards	Catch	Total landings	Dis-cards	Total catch
1978				154009	9875	163884	6553		6553	160562	9875	170437
1979				227699	14576	242275	7745		7745	235444	14576	250020
1980				347619	8544	356163	7721		7721	355340	8544	363884
1981				331642	6185	337827	13759		13759	345401	6185	351586
1982				316052	11548	327600	12239		12239	328291	11548	339839
1983				332148	10998	343146	9853		9853	342001	10998	352999
1984				391952	8521	400473	8709		8709	400661	8521	409182
1985				315083	8199	323282	6971		6971	322054	8199	330253
1986				252558	3848	256406	6604		6604	259162	3848	263010
1987				207081	9340	216421	6874		6874	213955	9340	223295
1988				194787	7253	202040	8487		8487	203274	7253	210527
1989				179178	3462	182640	5721		5721	184899	3462	188361
1990				153546	4187	157733	5543		5543	159089	4187	163276
1991				122517	2741	125258	3762		3762	126279	2741	129020
1992				54882	1904	56786	2324		2324	57206	1904	59110
1993	18978			50711	1558	52269	3885		3885	54596	1558	56154
1994	44000			100856	1956	102812	6551	621	7172	107407	2577	109984
1995	18993			107718	1872	109590	5585	668	6253	113303	2540	115843
1996	10815			124189	1443	125632	10040	1116	11156	134229	2559	136788
1997**				88600	3462	92062	6547	641	7189	95147	4103	99251
1998				67428	2299	69727	4582	631	5213	72010	2930	74940
1999				72995	1838	74833	6221	599	6820	79216	2437	81653
2000	23118			89289	6019	95308	6316	1209	7525	95605	7228	102833
2001	23677			91328	2891	94219	7794	389	8183	99122	3280	102402
2002	17562			67740	1462	69202	5060	562	5622	72800	2024	74824
2003	22147			69477	2024	71501	5729	862	6592	75206	2886	78093
2004	19563			68578	1201	69779	5309	188	5497	73887	1389	75276

Year	Eastern Baltic cod stock in SD 25-32						Eastern Baltic cod stock in Subdivision 24			Eastern Baltic cod stock in Subdivisions 24+25–32		
	Un allo-cated*	Land-ings AMS	Land-ings BMS	Total landings	Dis-cards	Catch	Total land-ings	Dis-cards	Catch	Total landings	Dis-cards	Total catch
2005	14991			55032	1670	56702	6064	1729	7793	61096	3399	64495
2006	17836			65531	4644	70175	6767	144	6911	72298	4788	77086
2007	12418			50843	4146	54989	8792	875	9667	59635	5021	64656
2008	2673			42234	3746	45980	8811	787	9598	51045	4533	55578
2009	3189			48438	3328	51766	8284	464	8747	56722	3792	60513
2010				50276	3543	53819	6049	533	6581	56325	4076	60400
2011				50368	3850	54218	7545	482	8027	57913	4332	62245
2012				51225	6795	58020	8469	536	9004	59694	7331	67024
2013				31355	5020	36375	5359	1243	6602	36714	6263	42977
2014				28909	9627	38536	5455	1298	6753	34364	10925	45289
2015				38079	5970	44049	5029	930	5959	43108	6900	50008
2016				29313	3279	32591	4541	306	4847	33854	3585	37438
2017		25317	179	25496	3238	28734	2004	227	2231	27500	3465	30965
2018		15800	108	15907	3103	3103	2295	300	2595	18202	3403	21605

***ICES estimates. No information available for years prior to 1993 or after 2009.**

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

Table 2.1.5. Cod in SD 25-32. Numbers (in thousands) of cod by length-groups in landings for wanted (human consumption landings) and unwanted catch (includes both BMS landings and estimated discards) in SDs 25-32 in 2018.

Length class (cm)	Wanted catch	Unwanted catch	Total
<20		4	4
20-24	64	562	625
25-29	516	3019	3534
30-34	1686	5529	7215
35-37	4825	1584	6410
38-44	13018	299	13317
45-49	3352	58	3410
>=50	1528	40	1569

Total	24989	11095	36084

Table 2.1.6 Cod in SD 25-32.Mean weight (g) by length class in wanted (human consumption landings) and unwanted catch (includes both BMS landings and estimated discards), in 2018.

Fleet	Length class (cm)	Wanted catch	Unwanted catch
Active	<20		58
	20-24	105	111
	25-29	179	192
	25-37	432	392
	30-34	320	304
	38-44	597	454
	45-49	896	687
	≥50	1400	1039
Passive	<20		65
	20-24	118	108
	25-29	209	205
	25-37	451	402
	30-34	378	315
	38-44	666	621
	45-49	950	956
	≥50	1394	1394

Table 2.1.7. Eastern Baltic cod in SDs 24-32. Input data for Stock Synthesis model.

Type	Name	Year range	Range	Time variant
Catches	Catch in tonnes split into Active/Passive and quarters	1946-2018	0 - 15+	
Age compositions of catch	Catch in numbers per age class , by fleets, by Q	1946-2006	0 - 12+	
Length compositions of catch	Catch in numbers per length class of the fleets, by Q,	2000-2018	5 – 120 cm	
Maturity ogives	Size at 50%maturity(L50) and slope	1946-2018		Yes (1998-2018, Lmat)
Growth	Von Bertalanffy growth parameters	1946-1990		No
Age length keys	Age length keys from BITS Q1 and Q4	1991-2018	0 – 12+	Yes
Natural mortality	Natural mortality by age class	1946-1999	0 - 15+	No
Trawl survey indices	CPUE from BITS Q1, Q4, and two historical trawl surveys	1975-2019		
Length composition of survey catch	Length composition of BITS Q1 and Q4	1991-2019		
Commercial CPUE indices	Commercial CPUE 1-3	1948-1989		
SSB index	SSB index from egg production method	1986-2018		
Larval index	Larval abundance	1987-2018		

Table 2.1.8. Eastern Baltic cod in SDs 24-32. Settings and estimated parameters. The columns show: number of estimated parameters, the initial values (from which the numerical optimization is started), the intervals allowed for the parameters, the priors used, and the value estimated by maximum likelihood. Parameters in bold are set and not estimated by the model.

Parameter	Number estimated	Initial value	Bounds (low, high)	Prior	Value (MLE)
Natural mortality (age classes 0.5, 1.5, 5.5, 15.5)		1.243, 0.857, 0.361, 0.215			
M (2000-2018) of age class 5.5	19	Estimated using random walk annual deviations	(0.1,2.0)	no prior	0.35-0.65
Stock and recruitment					
$Ln(R_0)$	1	14.8	(13,16)	no prior	15.23
Steepness (h)		0.99			
Recruitment variability (σ_R)		0.60			
Ln (recruitment deviations): 1946-2017	72				

Parameter	Number estimated	Initial value	Bounds (low, high)	Prior	Value (MLE)
Recruitment autocorrelation		0			
<u>Growth</u>					
L_{inf} (cm) (1946-1990)		125.27			
L_{inf} (cm) (1991-2018)	28	Estimated using random walk annual deviations	(40-150)	no prior	122-54
k (1946-1990)		0.10			
k (1991-2018)	28	Estimated using random walk annual deviations	(0.07-0.45)	no prior	0.10-0.2)
L at minimum age (0.5 years) t_0		12			
CV of young individuals	1	0.290	(0.05-0.8)	no prior	0.26
CV of old individuals		0.05			
<u>Weight (kg) at length (cm)</u>					
a (1946-1990)		6.58e-06			
b (1946-1990)		3.1353			
a (1991-1993, 1994- 1996, 1997- 1999, 2000 -2002, 2003-2005, 2006-2008, 2009-2011, 2012-2014, 2015-2019)		6.58E-06, 8.05E-06, 6.81E-06, 6.78E-06 6.76E-06, 7.47E-06 6.70E-06, 7.73E-06 8.54E-06			
b (1991-1993, 1994- 1996, 1997- 1999, 2000 -2002, 2003-2005, 2006-2008, 2009-2011, 2012-2014, 2015-2019)		3.1353, 3.0636, 3.1062 3.0992, 3.0972, 3.0637 3.0831, 3.0406, 3.0169			
<u>Maturity</u>					
Length (cm) at 50% mature (1946-1990)		38			
Slope of the length at maturity ogive		-0.23			
Length (cm) at 50% mature (1991-1997, 1998-2000, 2001-2007, 2008-2014, 2015-2019)		38, 36, 31, 26, 21			
<u>Initial fishing mortality</u>					
Active gears		0.60			

Parameter	Number estimated	Initial value	Bounds (low, high)	Prior	Value (MLE)
Selectivity (logistic)					
Active gears					
Time-invariant length based logistic selectivity	2	35; 12.68	(20,45; 0.01,50)	no prior	(38.9; 8.5)
Passive gears					
Time-invariant length based logistic selectivity	2	35; 10	(20,65; -12,15)	no prior	(42.1; 9.0)
BITS Q1 survey					
Time-invariant length based logistic selectivity	2	25,10	(15,50; -12,15)	no prior	(27.7;10.3)
BITS Q4 survey					
Time-invariant length based logistic selectivity	2	25,10	(15,50; -12,15)	no prior	(28.8; 10.6)
Commercial CPUE 1-3		Mirror active fleet			
Trawl surveys 1-2		Mirror BITS Q1			
Catchability					
BITSQ1					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation		0.001			
BITSQ4					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation		0.001			
Trawl survey 1					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.303
Trawl survey 2					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.02
Commercial CPUE 1					

Parameter	Number estimated	Initial value	Bounds (low, high)	Prior	Value (MLE)
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.10
Commercial CPUE 2					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.06
Commercial CPUE 3					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,0.8)	no prior	0.32
SSBEggProd					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,1.2)	no prior	0.49
Larvae index					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation		0.3			

Table 2.1.9. Eastern Baltic cod in SDs 24-32. Catch at age, estimated from Stock Synthesis.

Year	a1	a2	a3	a4	a5	a6	a7	a8
1946	776	8119	14166	5790	3034	1556	632	762
1947	550	17126	27764	14553	3744	1735	858	756
1948	963	11023	50653	23579	7507	1675	743	677
1949	1133	15768	27259	36423	10231	2809	598	495
1950	1196	19403	41379	21059	17078	4147	1087	413
1951	942	19956	49218	30565	9367	6539	1513	533
1952	870	17689	55474	39195	14537	3821	2538	772
1953	729	10402	32751	30363	12890	4101	1025	863
1954	1159	12979	28470	27126	15656	5829	1781	800
1955	1003	17161	30372	20351	12042	6077	2170	938

Year	a1	a2	a3	a4	a5	a6	a7	a8
1956	771	20785	53924	28300	11683	6033	2919	1456
1957	826	15852	62052	45563	14158	4990	2448	1724
1958	1096	11459	33000	36949	15813	4144	1378	1116
1959	960	18674	29520	24703	16442	6005	1493	874
1960	1398	20121	56604	24726	11900	6645	2287	873
1961	993	17828	38387	29452	7135	2812	1464	670
1962	1031	16369	43342	25905	11429	2321	862	633
1963	1208	18212	42171	30719	10502	3875	741	461
1964	1415	14831	34234	22431	9404	2690	934	280
1965	1749	22739	36610	24516	9622	3461	943	413
1966	2315	44426	83150	36627	14283	4750	1620	615
1967	2159	37302	102573	49997	11994	3803	1176	532
1968	2087	37522	91823	65890	17602	3449	1019	440
1969	1642	34081	87615	56433	22167	4827	880	358
1970	1726	26400	78405	53447	18925	6073	1232	304
1971	1935	25109	56362	45432	17243	5018	1503	366
1972	2262	28136	54916	34344	15789	4992	1365	491
1973	2318	31807	60526	33502	12200	4730	1413	508
1974	1174	31144	65315	36128	12009	3757	1387	547
1975	1064	20485	83007	51699	17656	5133	1542	774
1976	1250	15869	51267	63931	24768	7403	2066	910
1977	2262	18887	36221	34254	26477	8996	2585	1014
1978	2010	38283	44145	24973	15011	10354	3404	1334
1979	1174	33408	105042	40538	15224	8287	5554	2496
1980	2713	26267	106116	104314	26069	8782	4625	4405
1981	2196	39481	62790	83642	53104	11783	3822	3848
1982	1592	39580	100411	47429	39533	22095	4715	3005
1983	926	26366	102505	79833	23742	17487	9413	3223
1984	969	19898	85784	101888	49844	13021	9213	6506
1985	1137	18681	55923	66660	46628	19466	4836	5670

Year	a1	a2	a3	a4	a5	a6	a7	a8
1986	1708	20646	52545	44261	30887	18309	7246	3796
1987	1147	33461	58828	39358	18705	10868	6067	3540
1988	776	21510	89670	40470	14988	5871	3197	2726
1989	759	13711	54538	59458	14915	4557	1671	1625
1990	731	16181	37961	39378	23930	4943	1410	984
1991	1058	10970	40397	25435	14215	6930	1321	613
1992	1029	10817	15773	14949	5022	2233	998	266
1993	495	11787	21630	8972	4952	1401	584	319
1994	524	11720	43792	29750	7654	3633	972	606
1995	803	10931	29309	32092	13957	3038	1350	564
1996	615	13223	33020	29243	20293	7778	1588	964
1997	1208	8478	30700	22498	10956	6208	2206	687
1998	1487	16223	20516	20354	7772	2902	1476	652
1999	1271	16488	41477	17560	8839	2490	807	551
2000	1015	20636	48845	34710	7147	2474	584	287
2001	1338	14151	49188	33048	12013	1769	505	158
2002	686	14172	27188	25915	9090	2458	306	102
2003	798	8633	35361	22456	11640	3172	755	115
2004	1512	9991	22454	29342	10334	4014	952	239
2005	1286	17987	22467	15409	10766	2862	946	255
2006	911	11595	43327	21725	8758	4758	1112	429
2007	699	7933	24776	30801	8971	2752	1291	381
2008	661	7802	21526	19470	13148	2945	781	434
2009	702	8547	24098	23027	11258	5746	1126	425
2010	654	8048	22222	22854	13129	4865	2161	541
2011	758	7334	23348	22968	14424	6549	2106	1083
2012	1396	9215	25108	28640	16021	7680	3009	1318
2013	1098	8306	18114	18593	11560	4564	1814	899
2014	883	9718	24215	19771	11049	4816	1544	806
2015	823	7287	26194	26219	12057	4729	1648	684

Year	a1	a2	a3	a4	a5	a6	a7	a8
2016	334	4698	13837	20611	12297	4109	1311	553
2017	361	2469	11157	13148	11877	5379	1514	604
2018	111	2163	5086	9594	6941	4856	1905	677

Table 2.1.10. Eastern Baltic cod in SDs 24-32. Spawning stock biomass (SSB, at the spawning time), recruitment at age 2 and fishing mortality (F_{bar} for ages 4-6). "High" and "low" values correspond to 90% confidence intervals.

Year	SSB	SSB high	SSB low	R, a2	F_{bar}	F_{bar} high	F_{bar} low
1946	61032	67254	54810	441747	0.406	0.444	0.368
1947	80827	87908	73747	729371	0.524	0.566	0.481
1948	104117	112350	95884	406490	0.590	0.632	0.548
1949	112508	121886	103130	592533	0.571	0.613	0.529
1950	118593	128263	108923	701980	0.597	0.641	0.554
1951	130709	140518	120900	718366	0.601	0.641	0.561
1952	134205	144261	124149	563182	0.670	0.714	0.626
1953	140002	150884	129120	449890	0.492	0.526	0.458
1954	134379	145712	123046	516329	0.532	0.571	0.493
1955	135899	146993	124805	748939	0.493	0.529	0.457
1956	140676	150485	130867	728105	0.614	0.652	0.576
1957	132041	140515	123567	444969	0.751	0.793	0.709
1958	116992	124960	109024	369415	0.650	0.688	0.612
1959	98892	105954	91830	562817	0.701	0.744	0.659
1960	83536	90033	77039	465476	0.920	0.989	0.852
1961	82647	89015	76280	516156	0.745	0.795	0.694
1962	84913	91457	78370	471566	0.747	0.797	0.697
1963	82716	90071	75361	485481	0.804	0.865	0.742
1964	89835	99255	80415	521944	0.617	0.673	0.560
1965	104057	116407	91707	829652	0.602	0.666	0.539
1966	114848	126236	103460	1082730	0.905	0.959	0.852
1967	134457	146605	122309	942648	0.870	0.951	0.789
1968	140536	151510	129562	906337	0.896	0.968	0.825
1969	137015	146370	127660	821258	0.892	0.953	0.831

Year	SSB	SSB high	SSB low	R, a2	F_{bar}	F_{bar} high	F_{bar} low
1970	128210	137261	119159	639493	0.879	0.937	0.822
1971	119046	128719	109373	669009	0.801	0.856	0.745
1972	119948	130641	109255	832177	0.732	0.789	0.676
1973	141644	153908	129380	1105640	0.634	0.683	0.585
1974	193900	208433	179367	1367190	0.499	0.534	0.464
1975	243042	260065	226019	859656	0.508	0.541	0.476
1976	242977	262872	223082	725234	0.500	0.535	0.464
1977	249828	272622	227034	1043660	0.410	0.443	0.377
1978	309156	334248	284064	2255760	0.340	0.365	0.314
1979	406198	432839	379557	1833820	0.376	0.399	0.353
1980	455714	484284	427144	1087240	0.475	0.502	0.449
1981	420481	449652	391310	1805100	0.482	0.511	0.453
1982	445574	472970	418178	1824130	0.461	0.486	0.435
1983	442740	465473	420007	1203470	0.464	0.485	0.443
1984	376271	393710	358832	747342	0.607	0.631	0.583
1985	281995	295206	268784	642022	0.645	0.670	0.620
1986	194991	206398	183584	671009	0.719	0.757	0.681
1987	150537	157056	144018	1007490	0.781	0.796	0.766
1988	143167	148833	137501	612275	0.800	0.831	0.769
1989	119913	124898	114928	382572	0.804	0.832	0.777
1990	90482	95190	85774	386959	0.926	0.967	0.886
1991	58079	61575	54582	285359	1.041	1.077	1.005
1992	61425	67583	55267	571742	0.553	0.600	0.506
1993	103948	113907	93989	676908	0.347	0.377	0.317
1994	120851	130879	110823	458979	0.538	0.574	0.502
1995	131360	140447	122273	387785	0.552	0.581	0.522
1996	92747	99470	86024	380190	0.855	0.901	0.808
1997	62171	67348	56993	287971	0.920	0.982	0.859
1998	55596	60274	50917	532410	0.885	0.953	0.817

Year	SSB	SSB high	SSB low	R, a2	F_{bar}	F_{bar} high	F_{bar} low
1999	52238	56659	47817	536775	0.942	1.016	0.869
2000	61539	65919	57158	552414	1.035	1.103	0.967
2001	73925	78840	69011	432047	1.027	1.094	0.959
2002	83271	88549	77993	555691	0.733	0.781	0.685
2003	85560	90843	80277	361342	0.738	0.785	0.691
2004	74394	79633	69155	436661	0.756	0.808	0.703
2005	91596	97514	85678	750623	0.599	0.639	0.558
2006	91172	97442	84902	585236	0.673	0.719	0.627
2007	88455	95154	81755	702735	0.546	0.586	0.506
2008	123707	132586	114828	729327	0.417	0.449	0.386
2009	134370	143982	124758	679790	0.401	0.431	0.371
2010	135445	145138	125752	702304	0.387	0.416	0.358
2011	119244	128095	110393	650061	0.443	0.477	0.409
2012	96551	104327	88774	698970	0.604	0.655	0.553
2013	92070	99659	84481	934474	0.443	0.483	0.403
2014	100548	108754	92342	969212	0.433	0.471	0.394
2015	123082	132971	113193	685034	0.419	0.457	0.382
2016	115368	124621	106115	637004	0.305	0.332	0.278
2017	97284	105274	89295	378506	0.268	0.293	0.244
2018	83754	91067	76440	409775	0.208	0.228	0.187
2019	66412	73877	58947	162699			

Table 2.1.11. Eastern Baltic cod in SDs 24-32. Stock numbers at age (in the beginning of the year).

Year	1	2	3	4	5	6	7	8
1946	2242460	441747	121082	25207	10180	4651	1820	2149
1947	1250020	729371	187804	51074	10249	4256	2035	1756
1948	1822520	406490	307592	75528	18890	3790	1625	1452
1949	2159150	592533	170315	120047	26451	6521	1342	1089
1950	2209620	701980	248411	66892	42656	9312	2361	880
1951	1732300	718366	293838	96575	23279	14613	3271	1133

1952	1384100	563182	300633	114075	33509	7944	5111	1530
1953	1587890	449890	234182	113181	37401	10644	2569	2125
1954	2303490	516329	189669	95003	42861	14298	4222	1862
1955	2239110	748939	216930	75623	34829	15723	5420	2301
1956	1368750	728105	315923	88063	28634	13304	6229	3056
1957	1136790	444969	304278	121906	30233	9643	4587	3180
1958	1731570	369415	183649	110504	37400	8828	2843	2262
1959	1432200	562817	153643	69568	36788	12132	2923	1681
1960	1588900	465476	233288	57009	22224	11312	3787	1424
1961	1450970	516156	189688	78957	15253	5441	2746	1238
1962	1493800	471566	213565	69302	24385	4483	1614	1167
1963	1606230	485481	195048	77927	21359	7149	1327	813
1964	2552000	521944	199829	69440	22932	5903	1983	585
1965	3330210	829652	218216	77104	23799	7701	2029	876
1966	2901140	1082730	347548	84820	26747	8109	2688	1007
1967	2789250	942648	443441	119133	23038	6649	1999	891
1968	2527750	906337	386951	154178	33286	5941	1706	727
1969	1968340	821258	370711	132701	42114	8352	1480	594
1970	2059230	639493	335777	127203	36355	10616	2093	509
1971	2560970	669009	261476	115652	35184	9287	2700	648
1972	3401780	832177	275329	93143	34103	9755	2585	916
1973	4205380	1105640	344797	101178	29062	10151	2935	1039
1974	2643640	1367190	462147	132322	34222	9584	3417	1325
1975	2230450	859656	576914	187498	49906	12988	3768	1860
1976	3208980	725234	361963	232550	70103	18761	5057	2187
1977	6934950	1043660	306832	147301	87777	26583	7363	2837
1978	5638430	2255760	444117	129437	59744	36545	11570	4449
1979	3342780	1833820	959921	191283	55361	26779	17294	7631
1980	5551690	1087240	779380	407862	79490	23891	12150	11365
1981	5608730	1805100	457231	315914	156001	30946	9690	9570
1982	3700820	1824130	763468	186806	120780	60284	12414	7753

1983	2297960	1203470	770778	313845	72579	47716	24792	8325
1984	1974510	747342	508730	316080	121519	28580	19564	13593
1985	2063960	642022	313678	198224	109460	41195	9908	11419
1986	3098840	671009	268259	119917	66461	35668	13683	7042
1987	1883520	1007490	279945	100164	38002	20045	10857	6235
1988	1177030	612275	418593	102045	30218	10742	5676	4763
1989	1190420	382572	253403	150717	30262	8377	2980	2850
1990	878318	386959	158253	90787	44468	8354	2315	1588
1991	1758670	285359	158115	53872	24306	10812	2004	915
1992	2081900	571742	117649	52959	13353	5232	2243	585
1993	1411160	676908	242526	48015	19468	4780	1902	1014
1994	1192530	458979	287842	105840	20662	8652	2219	1355
1995	1170000	387785	192781	114612	39211	7526	3209	1310
1996	886141	380190	161251	74955	41076	14171	2791	1661
1997	1638480	287971	156554	57171	21299	10750	3690	1125
1998	1652670	532410	119622	56044	15888	5178	2528	1093
1999	1699950	536775	220263	44225	16286	4018	1245	833
2000	1329610	552414	223254	81755	12765	3866	873	419
2001	1710130	432047	227011	77722	21636	2798	761	233
2002	1111690	555691	179068	79401	20475	4781	563	182
2003	1343360	361342	232689	69911	25992	6093	1370	202
2004	2309540	436661	151514	90424	22990	7599	1696	413
2005	1801130	750623	183296	59001	29208	6567	2024	526
2006	2160900	585236	313155	73280	20969	9655	2108	781
2007	2242030	702735	246682	123517	24770	6301	2720	764
2008	2089850	729327	300001	103162	45464	8323	2001	1045
2009	2159150	679790	310713	129290	41080	16968	3011	1059
2010	1998580	702304	287911	131127	51185	15225	6063	1410
2011	2149030	650061	297124	120060	51014	18897	5405	2574
2012	2874010	698970	274572	122358	44394	17339	6094	2450
2013	2979990	934474	293660	109729	41182	12522	4349	1948

2014	2106480	969212	395132	122725	41250	13611	3733	1737
2015	1958780	685034	408534	164187	46152	13667	4035	1470
2016	1163550	637004	288226	168487	61587	15379	4088	1488
2017	1259680	378506	269355	121720	67064	22863	5358	1829
2018	500078	409775	160160	114553	49283	25660	8360	2522
2019	1397720	162699	173748	69136	48184	20017	10159	4236

Table 2.1.12. Eastern Baltic cod in SDs 24-32. Fishing mortality-at-age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1946	0.001	0.029	0.166	0.327	0.423	0.468	0.486	0.493	0.495	0.495	0.495	0.495	0.495	0.501
1947	0.001	0.037	0.214	0.422	0.546	0.604	0.627	0.636	0.639	0.639	0.639	0.639	0.639	0.645
1948	0.001	0.044	0.244	0.476	0.615	0.679	0.705	0.715	0.718	0.718	0.718	0.718	0.718	0.724
1949	0.001	0.043	0.238	0.462	0.595	0.657	0.682	0.691	0.694	0.695	0.695	0.695	0.695	0.700
1950	0.001	0.045	0.248	0.483	0.622	0.687	0.713	0.723	0.726	0.727	0.727	0.727	0.727	0.732
1951	0.001	0.045	0.249	0.486	0.626	0.691	0.718	0.728	0.731	0.731	0.732	0.732	0.732	0.736
1952	0.001	0.051	0.280	0.542	0.698	0.770	0.799	0.810	0.813	0.814	0.814	0.814	0.814	0.819
1953	0.001	0.037	0.205	0.398	0.513	0.566	0.587	0.595	0.598	0.598	0.598	0.598	0.598	0.603
1954	0.001	0.041	0.223	0.431	0.554	0.611	0.634	0.643	0.645	0.646	0.646	0.646	0.646	0.652
1955	0.001	0.037	0.205	0.398	0.514	0.567	0.589	0.597	0.599	0.600	0.600	0.600	0.600	0.606
1956	0.001	0.046	0.255	0.496	0.640	0.706	0.733	0.743	0.746	0.746	0.747	0.747	0.747	0.753
1957	0.002	0.059	0.316	0.609	0.782	0.862	0.895	0.907	0.910	0.911	0.912	0.912	0.912	0.919
1958	0.001	0.051	0.274	0.527	0.677	0.746	0.774	0.785	0.788	0.789	0.789	0.789	0.789	0.795
1959	0.002	0.054	0.295	0.568	0.730	0.805	0.836	0.847	0.851	0.851	0.852	0.852	0.852	0.857
1960	0.002	0.071	0.387	0.746	0.958	1.057	1.097	1.111	1.116	1.117	1.117	1.117	1.117	1.122
1961	0.002	0.056	0.310	0.602	0.776	0.856	0.889	0.901	0.904	0.905	0.905	0.905	0.905	0.911
1962	0.002	0.057	0.311	0.604	0.778	0.859	0.891	0.903	0.907	0.908	0.908	0.908	0.908	0.914
1963	0.002	0.061	0.336	0.650	0.837	0.923	0.959	0.971	0.975	0.976	0.977	0.977	0.977	0.982
1964	0.001	0.046	0.255	0.498	0.642	0.709	0.736	0.746	0.750	0.750	0.750	0.750	0.750	0.756
1965	0.001	0.044	0.248	0.486	0.628	0.693	0.720	0.730	0.733	0.734	0.734	0.734	0.734	0.739
1966	0.002	0.066	0.374	0.731	0.943	1.042	1.082	1.096	1.101	1.102	1.102	1.102	1.102	1.108
1967	0.002	0.064	0.360	0.702	0.906	1.001	1.040	1.054	1.058	1.059	1.059	1.059	1.059	1.066

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1968	0.002	0.068	0.373	0.725	0.934	1.030	1.070	1.084	1.089	1.090	1.090	1.090	1.090	1.096
1969	0.002	0.068	0.373	0.722	0.929	1.025	1.064	1.078	1.083	1.084	1.084	1.084	1.084	1.090
1970	0.002	0.068	0.369	0.712	0.916	1.010	1.048	1.062	1.067	1.068	1.068	1.068	1.068	1.074
1971	0.002	0.062	0.335	0.648	0.834	0.920	0.955	0.968	0.972	0.973	0.973	0.973	0.973	0.980
1972	0.002	0.055	0.304	0.592	0.763	0.842	0.874	0.886	0.890	0.891	0.891	0.891	0.891	0.898
1973	0.001	0.046	0.261	0.511	0.661	0.730	0.758	0.768	0.772	0.772	0.772	0.772	0.772	0.780
1974	0.001	0.037	0.205	0.402	0.520	0.575	0.597	0.605	0.608	0.608	0.608	0.608	0.608	0.615
1975	0.001	0.039	0.212	0.411	0.530	0.584	0.607	0.615	0.617	0.618	0.618	0.618	0.618	0.625
1976	0.001	0.034	0.202	0.401	0.521	0.576	0.599	0.607	0.610	0.610	0.611	0.611	0.611	0.618
1977	0.001	0.028	0.166	0.330	0.427	0.473	0.491	0.498	0.500	0.501	0.501	0.501	0.501	0.508
1978	0.001	0.028	0.146	0.276	0.354	0.389	0.404	0.409	0.410	0.411	0.411	0.411	0.411	0.418
1979	0.001	0.029	0.159	0.305	0.392	0.431	0.448	0.453	0.455	0.456	0.456	0.456	0.456	0.462
1980	0.001	0.040	0.206	0.388	0.495	0.543	0.563	0.570	0.573	0.573	0.573	0.573	0.573	0.580
1981	0.001	0.034	0.198	0.389	0.502	0.554	0.576	0.584	0.586	0.587	0.587	0.587	0.587	0.594
1982	0.001	0.035	0.192	0.373	0.480	0.530	0.550	0.557	0.559	0.560	0.560	0.560	0.560	0.567
1983	0.001	0.035	0.195	0.376	0.483	0.533	0.553	0.560	0.562	0.563	0.563	0.563	0.563	0.570
1984	0.001	0.042	0.246	0.488	0.633	0.700	0.728	0.738	0.741	0.742	0.742	0.742	0.742	0.749
1985	0.001	0.046	0.265	0.520	0.672	0.743	0.772	0.783	0.786	0.787	0.787	0.787	0.787	0.793
1986	0.001	0.048	0.288	0.576	0.750	0.830	0.863	0.876	0.879	0.880	0.880	0.880	0.880	0.886
1987	0.001	0.052	0.312	0.626	0.815	0.903	0.939	0.952	0.956	0.957	0.958	0.958	0.958	0.962
1988	0.001	0.056	0.325	0.643	0.834	0.923	0.960	0.973	0.978	0.979	0.979	0.979	0.979	0.983
1989	0.001	0.056	0.330	0.648	0.838	0.927	0.963	0.977	0.981	0.982	0.982	0.982	0.982	0.987
1990	0.002	0.069	0.381	0.745	0.965	1.069	1.112	1.128	1.133	1.134	1.134	1.134	1.134	1.139
1991	0.001	0.060	0.397	0.822	1.087	1.214	1.267	1.287	1.293	1.295	1.295	1.295	1.295	1.299
1992	0.001	0.031	0.199	0.428	0.578	0.653	0.685	0.697	0.701	0.702	0.703	0.703	0.703	0.706
1993	0.001	0.029	0.132	0.270	0.362	0.408	0.428	0.436	0.439	0.439	0.440	0.440	0.440	0.445
1994	0.001	0.041	0.224	0.420	0.561	0.633	0.665	0.677	0.681	0.683	0.683	0.683	0.683	0.688
1995	0.002	0.051	0.248	0.453	0.569	0.633	0.662	0.673	0.677	0.678	0.678	0.678	0.678	0.683
1996	0.002	0.061	0.340	0.685	0.892	0.987	1.034	1.053	1.059	1.061	1.062	1.062	1.062	1.067
1997	0.002	0.052	0.330	0.708	0.965	1.088	1.140	1.163	1.171	1.173	1.174	1.174	1.174	1.180

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1998	0.002	0.056	0.298	0.663	0.926	1.066	1.126	1.149	1.158	1.161	1.162	1.162	1.162	1.170
1999	0.002	0.051	0.294	0.670	0.989	1.168	1.253	1.287	1.298	1.302	1.303	1.303	1.303	1.312
2000	0.002	0.063	0.360	0.760	1.074	1.272	1.368	1.409	1.424	1.428	1.429	1.430	1.430	1.436
2001	0.002	0.055	0.356	0.765	1.066	1.250	1.352	1.397	1.414	1.420	1.421	1.421	1.421	1.428
2002	0.001	0.044	0.244	0.544	0.763	0.891	0.961	0.997	1.011	1.016	1.017	1.017	1.017	1.026
2003	0.001	0.042	0.245	0.533	0.772	0.910	0.982	1.018	1.035	1.041	1.043	1.043	1.043	1.051
2004	0.002	0.040	0.238	0.543	0.784	0.940	1.021	1.061	1.080	1.087	1.090	1.090	1.090	1.100
2005	0.002	0.045	0.206	0.437	0.623	0.736	0.801	0.832	0.847	0.852	0.854	0.855	0.855	0.864
2006	0.001	0.033	0.212	0.475	0.700	0.845	0.926	0.969	0.988	0.996	0.999	1.000	1.000	1.009
2007	0.001	0.018	0.145	0.374	0.566	0.699	0.778	0.819	0.840	0.849	0.852	0.853	0.854	0.866
2008	0.001	0.017	0.105	0.277	0.435	0.539	0.604	0.641	0.660	0.668	0.672	0.673	0.673	0.689
2009	0.001	0.021	0.116	0.265	0.417	0.521	0.583	0.620	0.639	0.649	0.652	0.654	0.654	0.673
2010	0.001	0.020	0.118	0.266	0.396	0.499	0.564	0.600	0.621	0.631	0.636	0.637	0.638	0.660
2011	0.001	0.019	0.123	0.302	0.457	0.570	0.652	0.702	0.729	0.744	0.751	0.754	0.755	0.776
2012	0.001	0.023	0.146	0.384	0.627	0.802	0.921	1.006	1.056	1.084	1.098	1.104	1.107	1.129
2013	0.001	0.015	0.096	0.263	0.454	0.612	0.719	0.792	0.843	0.873	0.889	0.898	0.901	0.925
2014	0.001	0.017	0.097	0.255	0.440	0.604	0.729	0.812	0.868	0.907	0.929	0.941	0.948	0.974
2015	0.001	0.018	0.100	0.250	0.424	0.583	0.712	0.806	0.869	0.911	0.940	0.956	0.964	0.990
2016	0.001	0.012	0.073	0.186	0.308	0.421	0.516	0.591	0.645	0.681	0.705	0.721	0.730	0.760
2017	0.001	0.011	0.064	0.165	0.273	0.367	0.447	0.511	0.561	0.597	0.620	0.636	0.646	0.678
2018	0.000	0.009	0.049	0.126	0.211	0.286	0.346	0.395	0.435	0.466	0.488	0.502	0.511	0.542

Table 2.1.13. Eastern Baltic cod in SDs 24-32. Catch scenarios.

Basis	Total catch (2020)	F (2020)	SSB (2020)	SSB (2021)	Probability of SSB (2021) >B_{lim} (%)	% SSB change
F= 0	0	0	64981	73447	<0.01	13
F=0.05	4195	0.05	63213	70069	<0.01	11
F=0.5*F (2018)	7735	0.10	61737	67337	<0.01	9
F=F (2018)	14762	0.21	58782	62364	<0.01	6

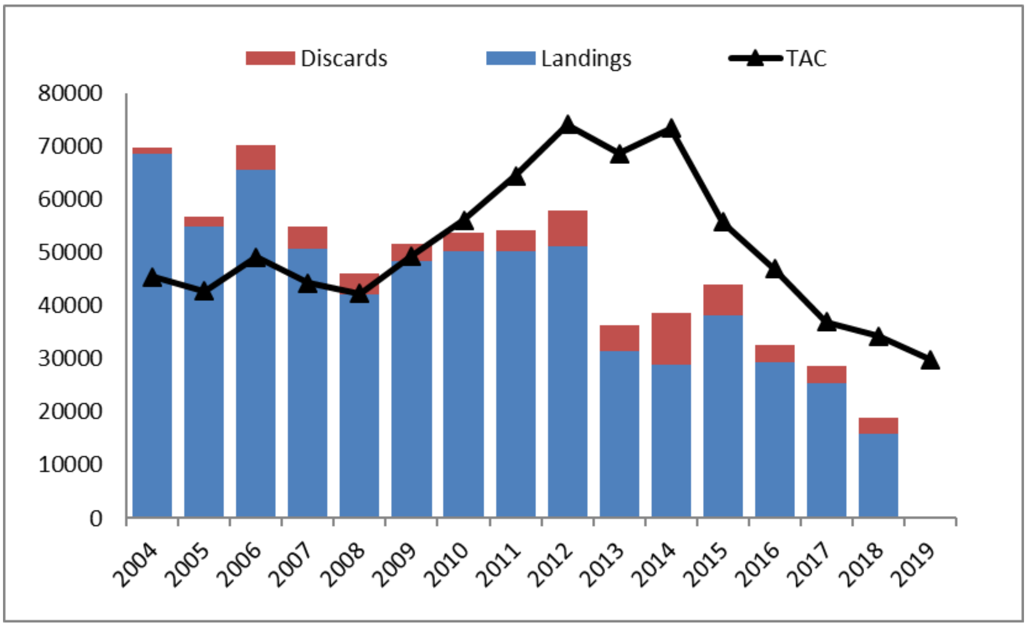


Figure 2.1.1 Eastern Baltic cod in SDs 24-32. Total landings (incl. unallocated for years before 2010), estimated discards and TAC for management area of SD 25-32.

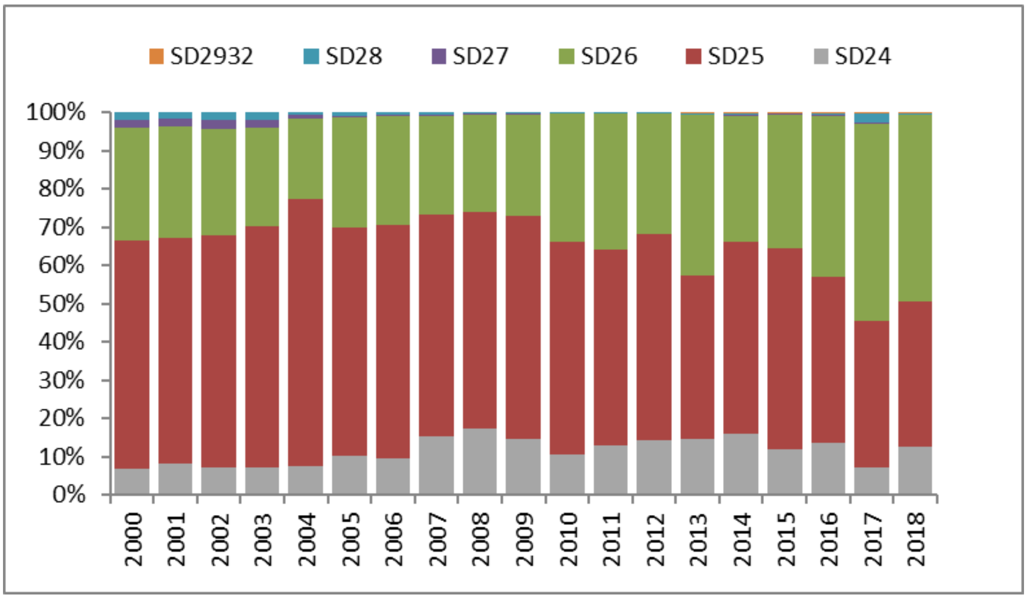


Figure 2.1.2 Eastern Baltic cod in SDs 24-32. Relative distribution of landings of the eastern Baltic cod stock by SD.

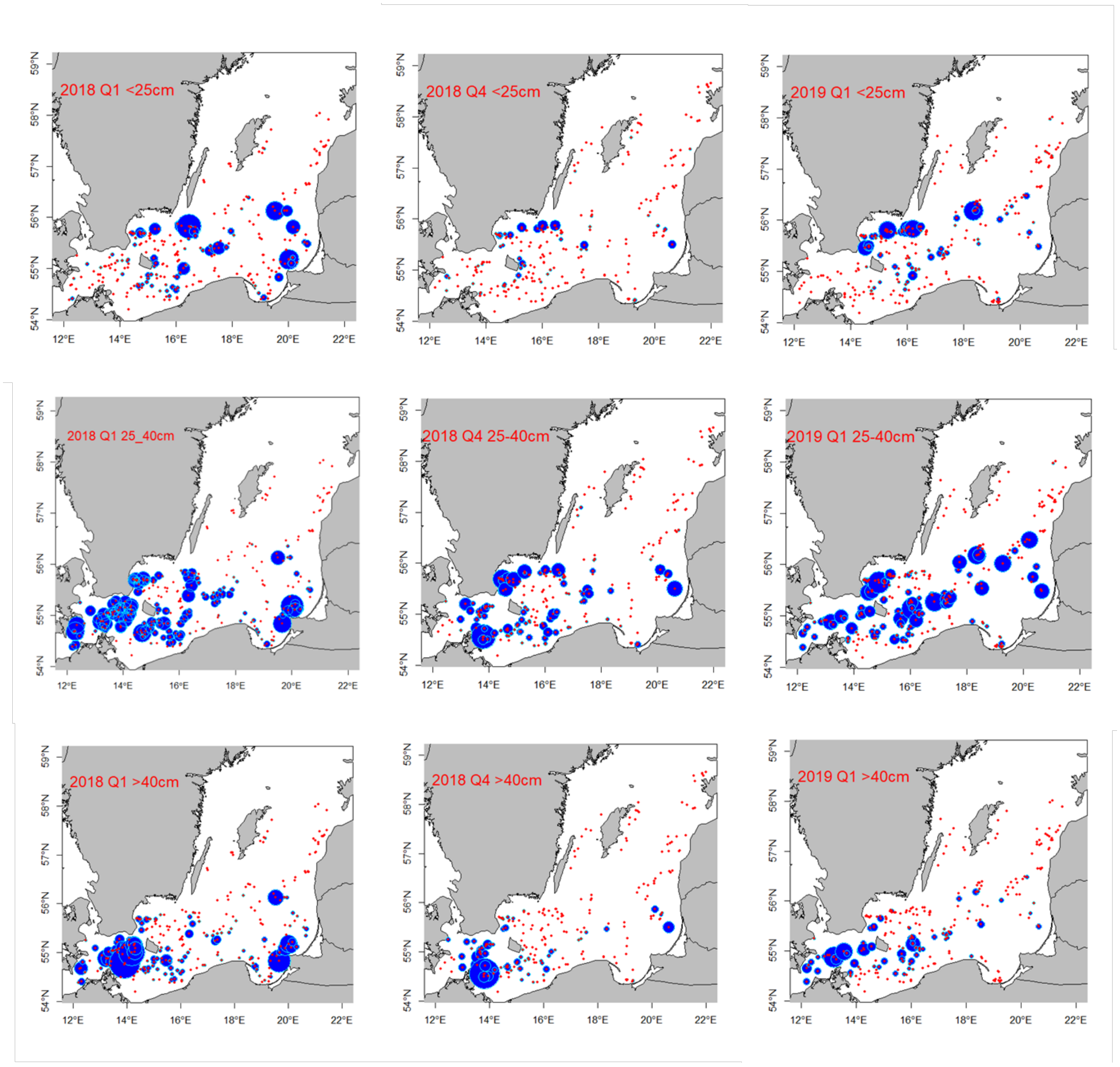


Figure 2.1.3. Eastern Baltic cod in SDs 24-32. Distribution of cod from BITS surveys in Q1 and Q4 in 2018 and Q1 in 2019, by 3 size-groups (<25 cm, 25-40 cm and >40 cm cod). The scale is comparable between surveys within a size group, but not between size-groups.

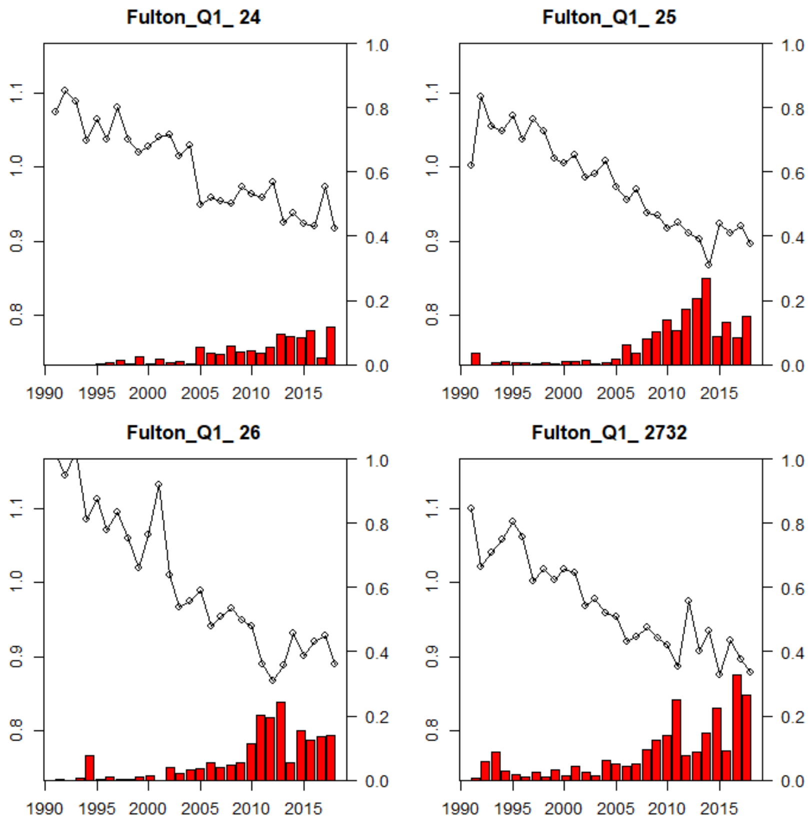


Figure 2.1.4. Eastern Baltic cod in SDs 24-32. Condition (Fulton K) of cod at 40-60 cm in length in Q1 BITS survey, by SDs. The lines show mean values for Fulton K, the bars show the proportion of cod at Fulton K <0.8.

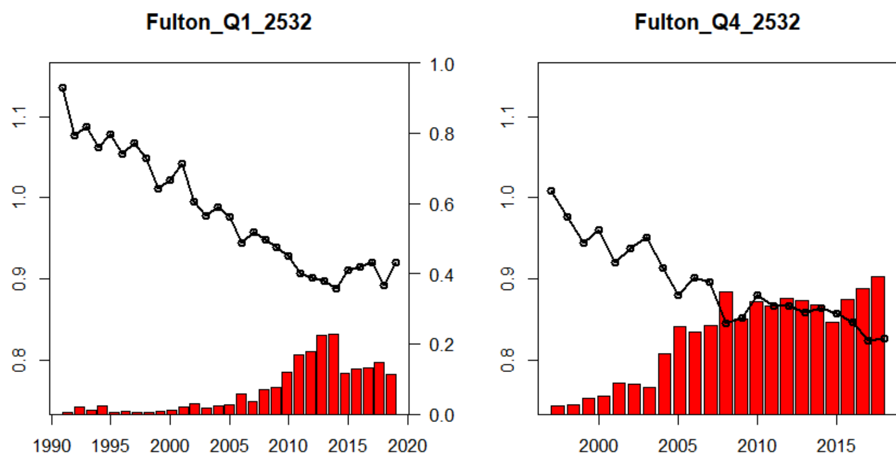


Figure 2.1.5. Eastern Baltic cod in SDs 24-32. Average condition (Fulton K) of cod at 40-60 cm in length in Q1 and Q4 BITS survey in SD 25-32. The lines show mean values for Fulton K, the bars show the proportion of cod at Fulton K <0.8.

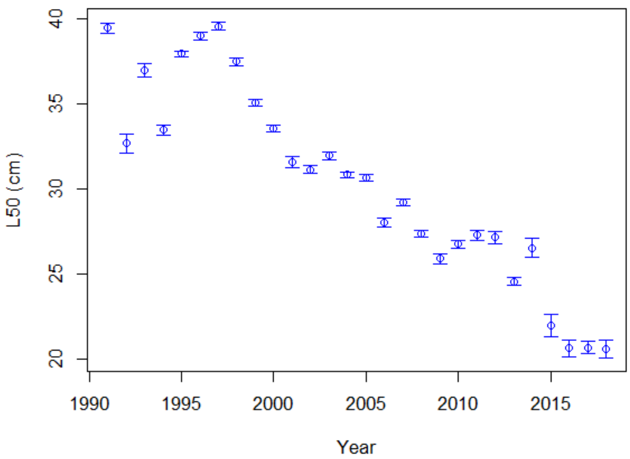


Figure 2.1.6. Eastern Baltic cod in SDs 24-32. Length at which 50% of the cod are mature (L50), data from BITS Q1 survey, males and females combined.

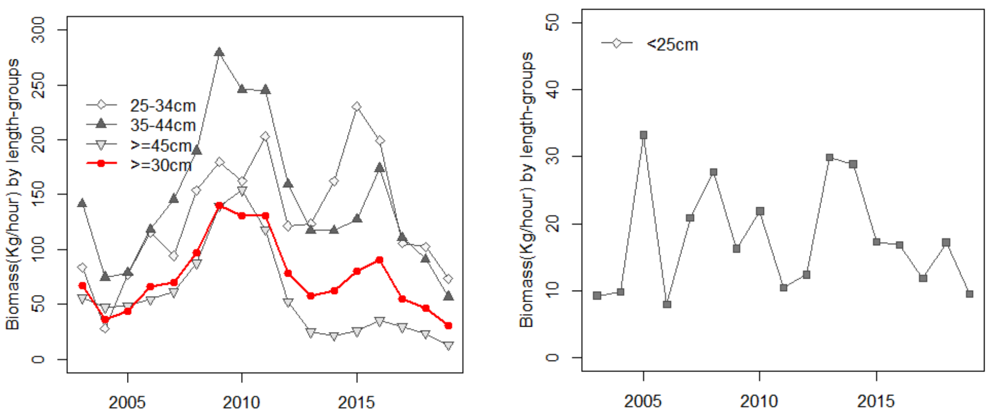


Figure 2.1.7. Eastern Baltic cod in SDs 24-32. Relative biomass index of different lengths groups of cod, estimated from Q1 and Q4 BITS surveys combined.

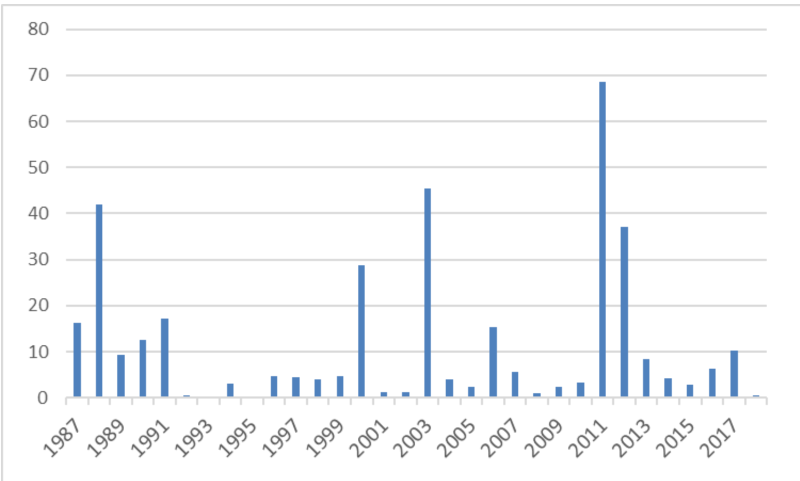


Figure 2.1.8. Eastern Baltic cod in SDs 24-32. Abundance of larvae in the main spawning area during peak spawning time.

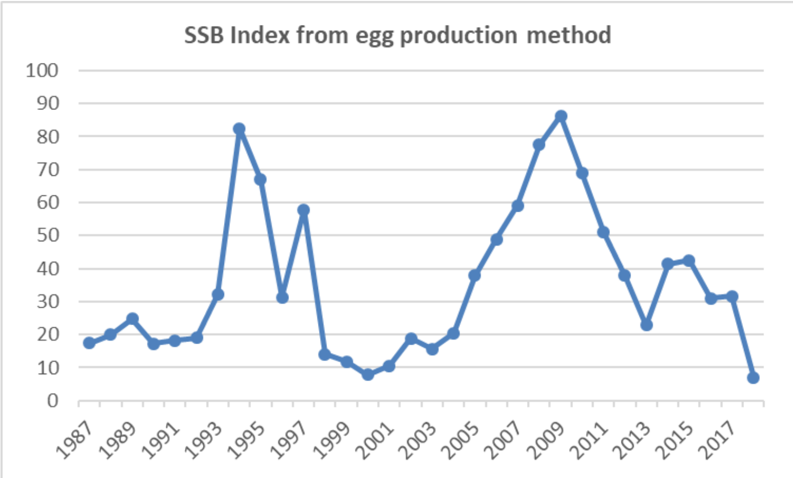


Figure 2.1.9. Eastern Baltic cod in SDs 24-32. Index of spawning stock biomass, calculated from egg production method. Data are from ichthyoplankton surveys.

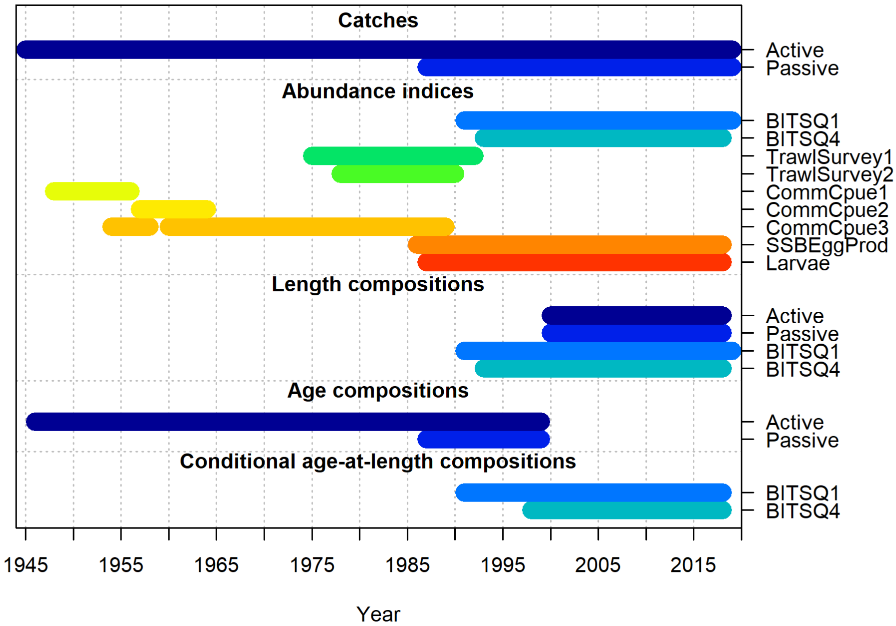


Figure 2.1.10. Eastern Baltic cod in SDs 24-32. Overview of the time series included in stock assessment.

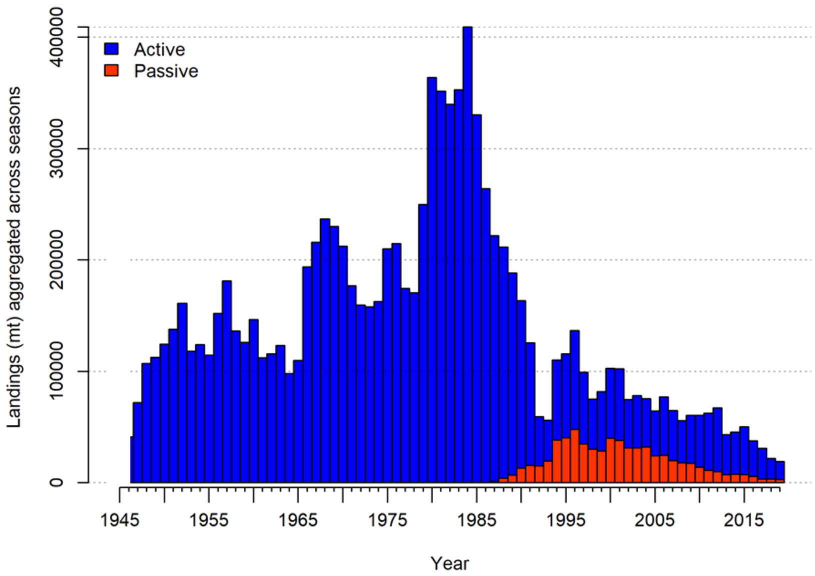


Figure 2.1.11. Eastern Baltic cod in SDs 24-32. Time series of total catch used in the assessment, by fleets).

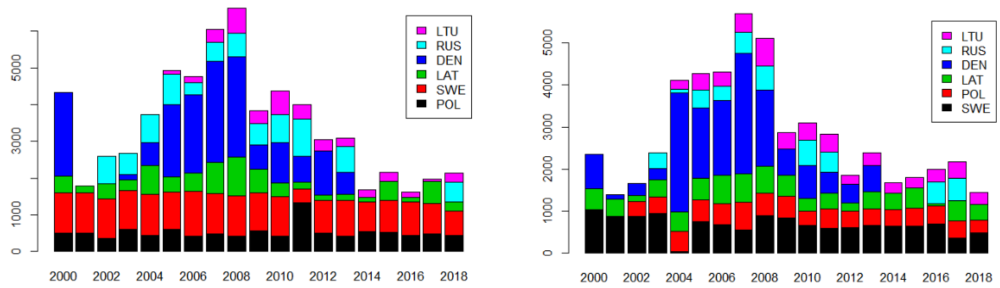


Figure 2.1.12. Eastern Baltic cod in SDs 24-32. Numbers of cod with age readings, for BITS Q1 (left panel) and Q4 (right panel), by country.

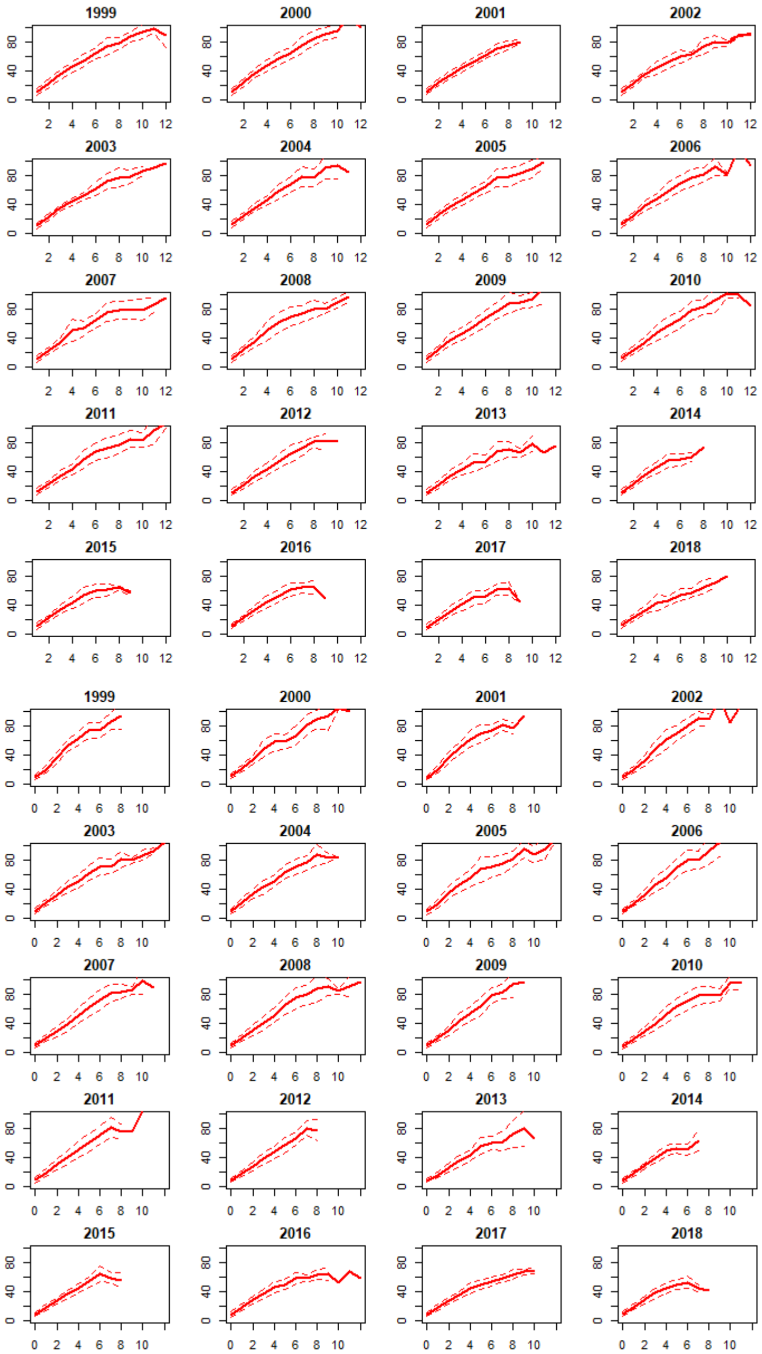


Figure 2.1.13. Eastern Baltic cod in SDs 24-32. Mean length at age (LAA) based on average annual ALKs of all countries included in DATRAS, for BITS Q1 (upper panels) and BITS Q4 (lower panels) (individual sample data only, not raised to the population).

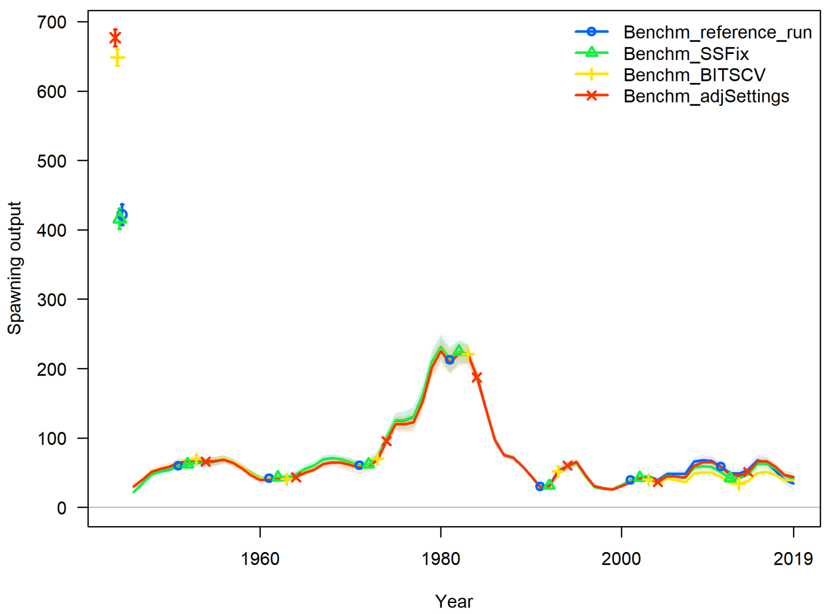


Figure 2.1.14. Eastern Baltic cod in SDs 24-32. Spawning stock biomass i) as estimated at benchmark 2019 ("Benchm_reference_run"), ii) from the run with the updated Stock Synthesis software, but keeping all configuration settings as at the benchmark ("Benchm_SSFix"); iii) from the run with updated Stock Synthesis software and slight improvement of model configuration, but keeping the CV of BITS surveys at the value applied at benchmark ("Benchm_BITSCV"); iv) from the run with updated Stock Synthesis software and including the slight improvements of model configuration, including adjusting BITS CV from 0.15 to 0.11. All these runs are based on data for the years as used at benchmark, i.e. not updated with the latest year available to WGBFAS 2019.

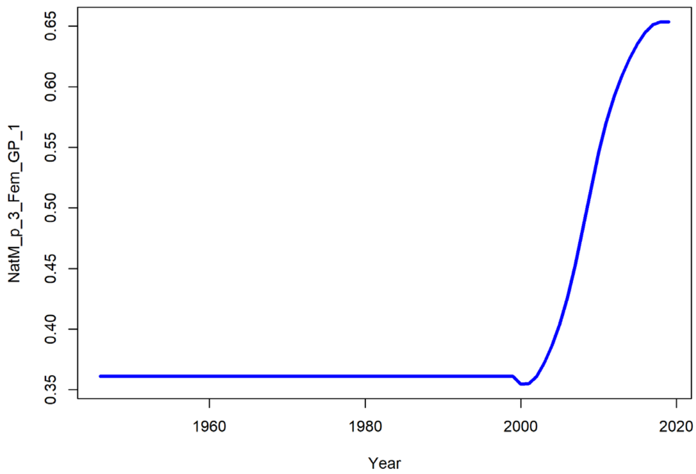


Figure 2.1.15. Eastern Baltic cod in SDs 24-32. Change in natural mortality for age-break 5.5, estimated in Stock Synthesis model.

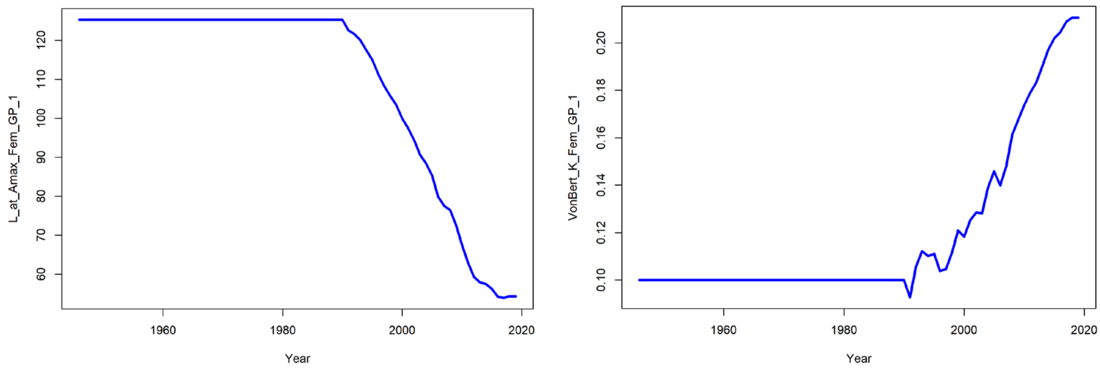


Figure 2.1.16. Eastern Baltic cod in SDs 24-32. Estimated change in von Bertalanffy growth parameters Linf (left panel) and K (right panel) from Stock Synthesis model.

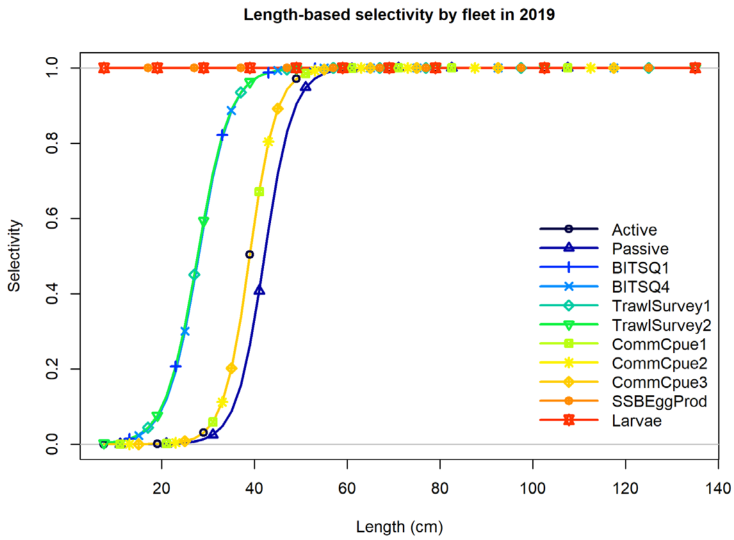


Figure 2.1.17. Eastern Baltic cod in SDs 24-32. Selectivity of different fleets.

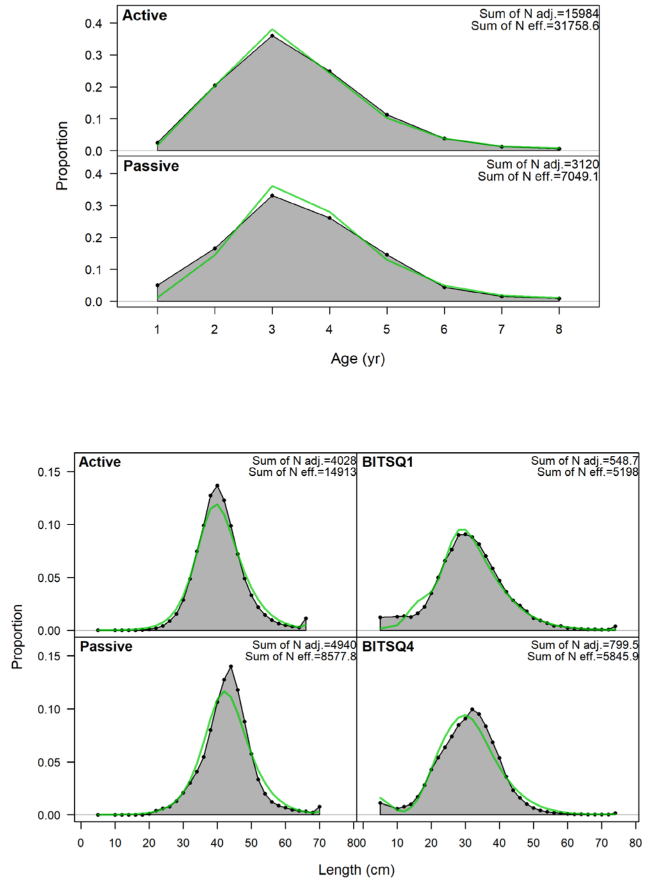


Figure 2.1.18. Eastern Baltic cod in SDs 24-32. Fits to age (upper panels) and length (lower panels) composition data, aggregated across years.

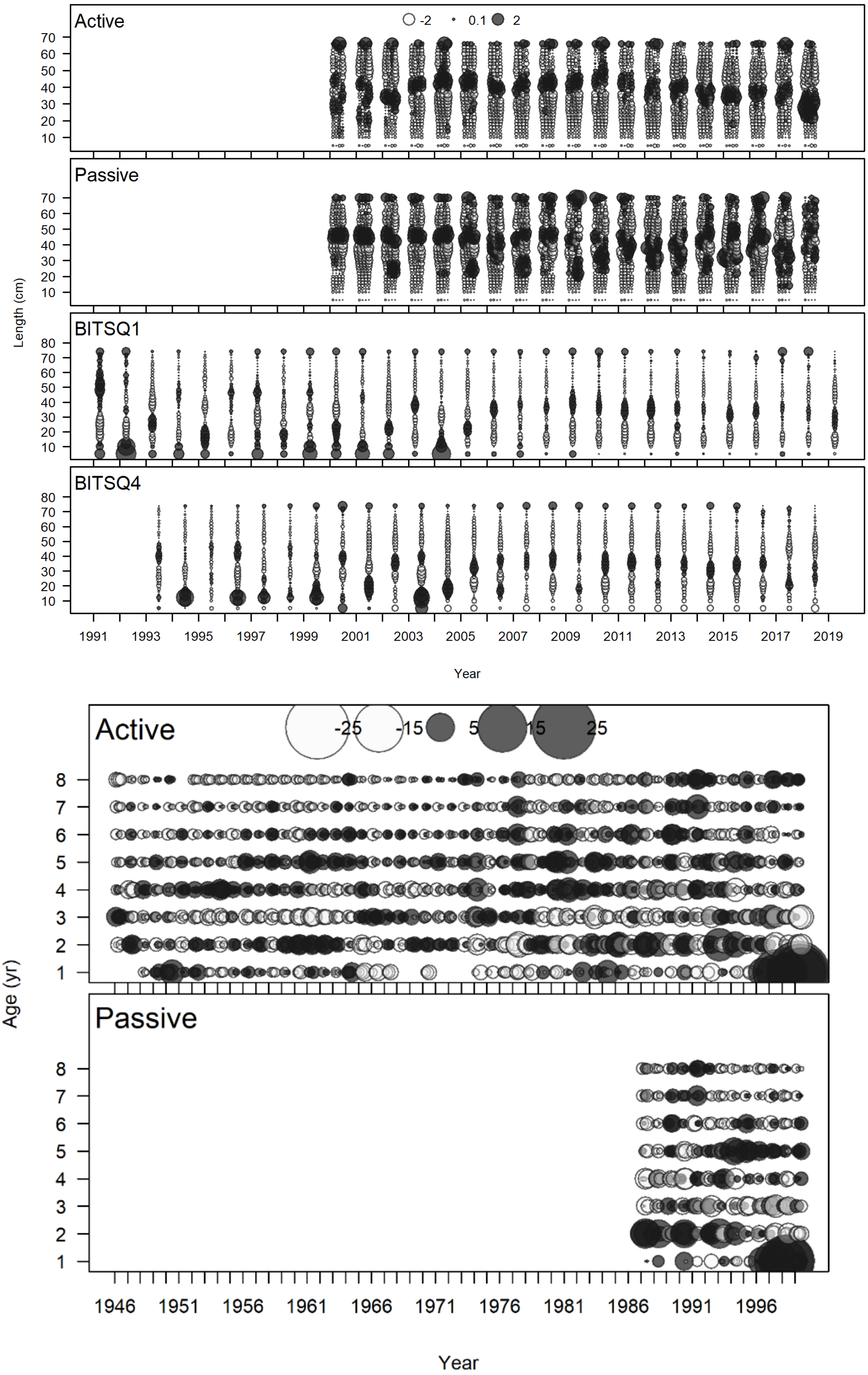


Figure 2.1.19. Eastern Baltic cod in SDs 24-32. Residuals of fits to length (upper panels) and age (lower panels) composition data for different fleets.

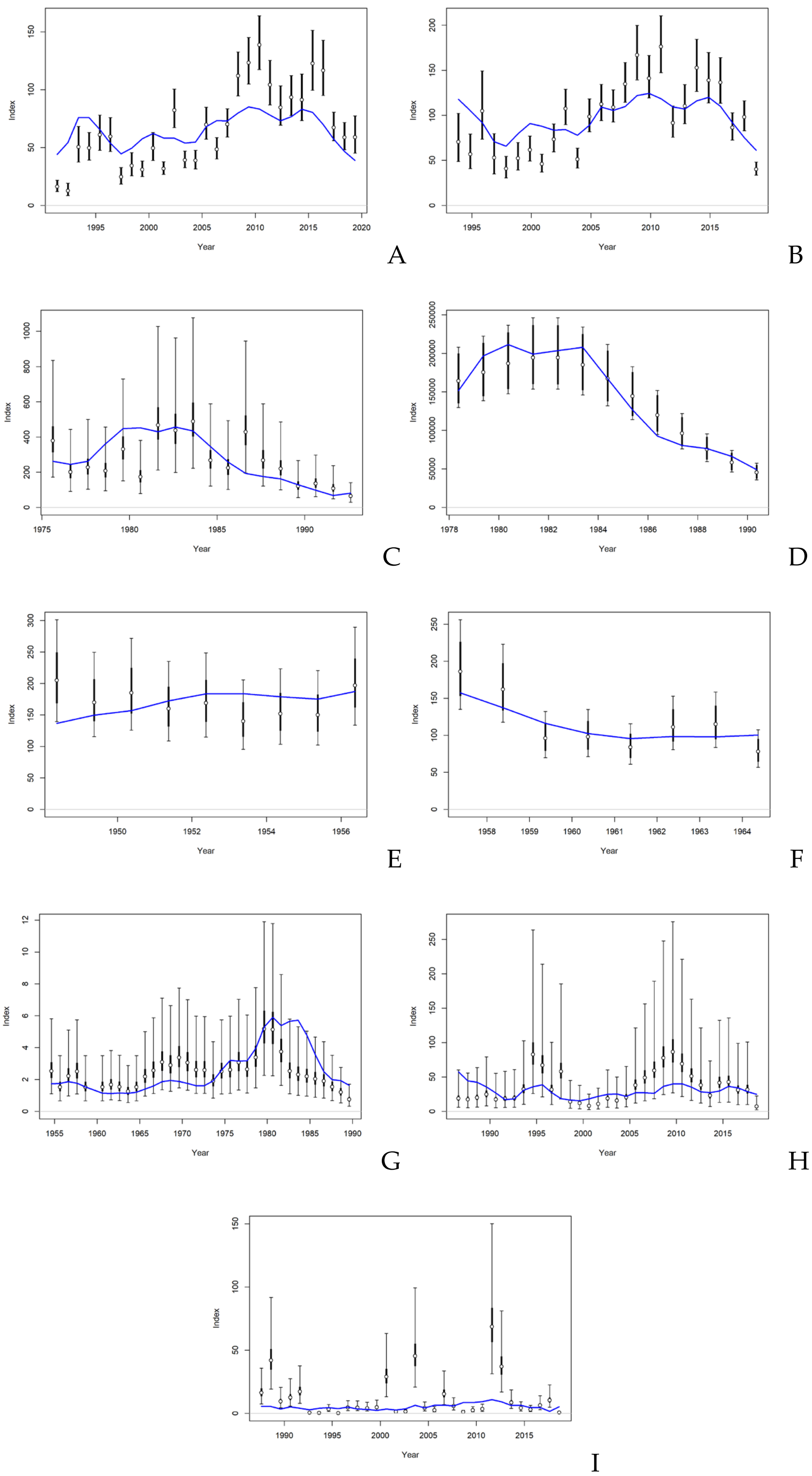


Figure 2.1.20. Eastern Baltic cod in SDs 24-32. Model fits to different tuning indices. A- BITSQ1; B-BITSQ4; C- TrawlSurvey1; D- TrawlSurvey2; E- CommCpue1; F- CommCpue2; G- CommCpue3; H- SSBEggProd; I- Larvae.

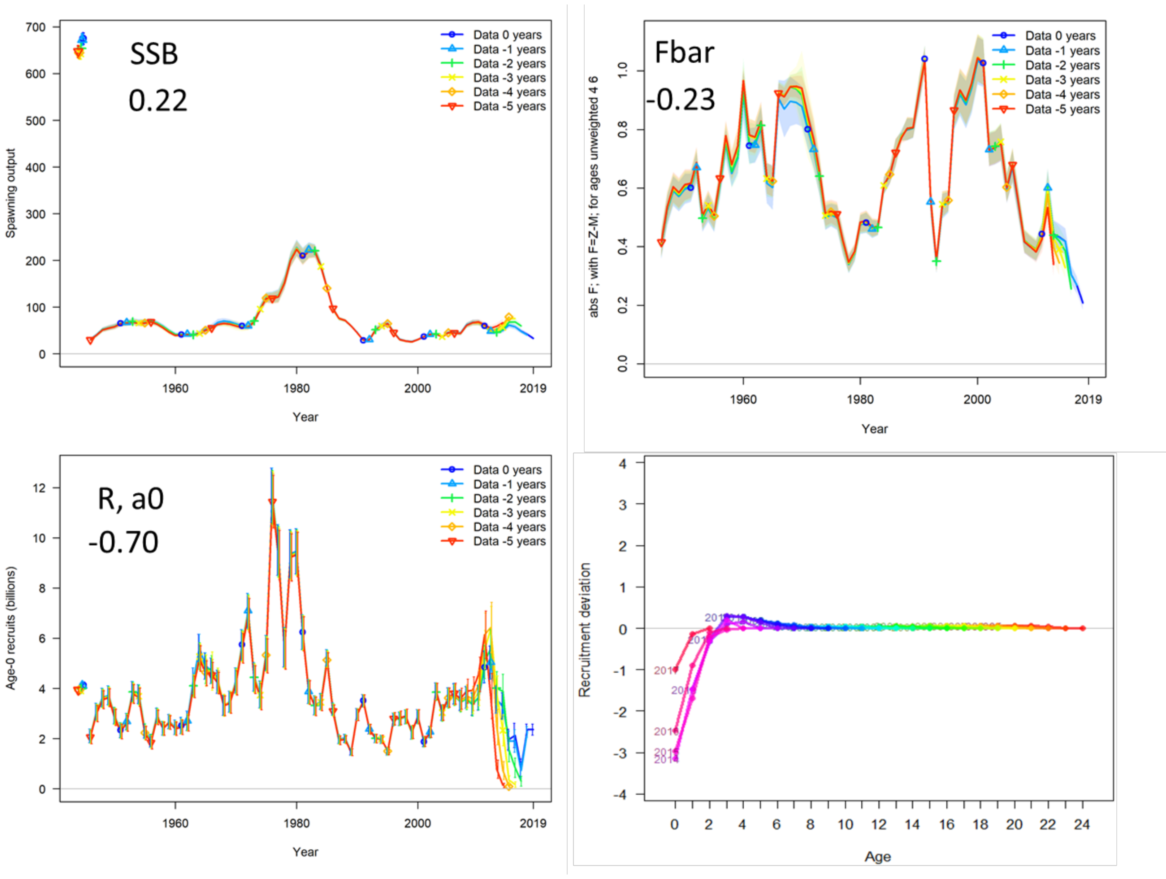


Figure 2.1.21. Eastern Baltic cod in SDs 24-32. Retrospective analyses.

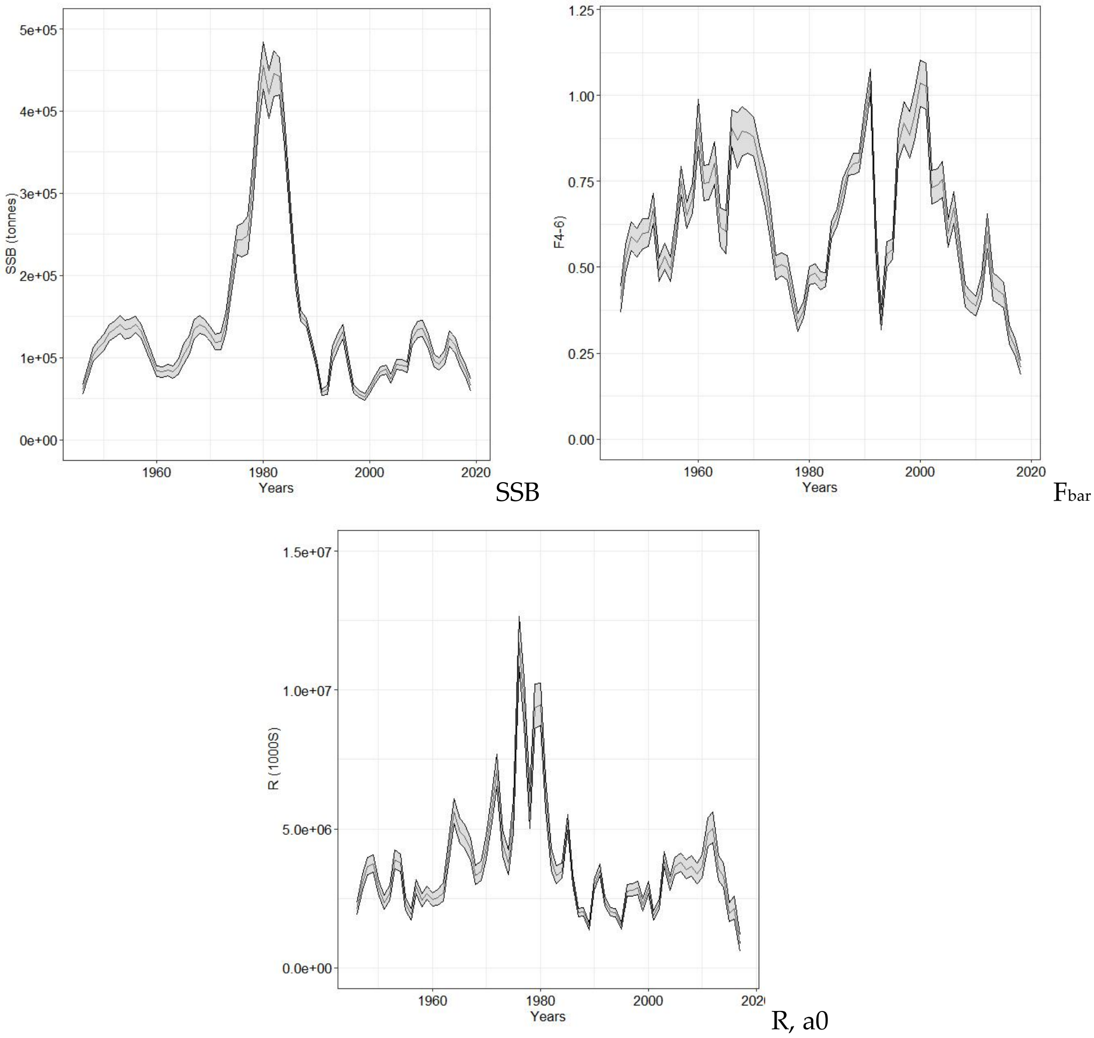


Figure 2.1.22. Eastern Baltic cod in SDs 24-32. Spawning stock biomass, fishing mortality (average of ages 4-6) and recruitment (age 0).

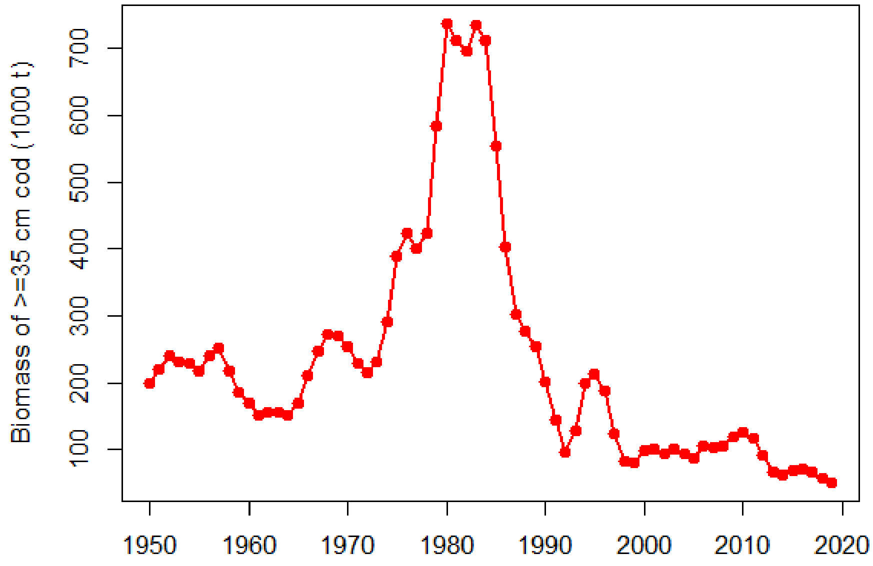


Figure 2.1.23. Eastern Baltic cod in SDs 24-32. Biomass of commercial sized cod (>=35 cm in length).

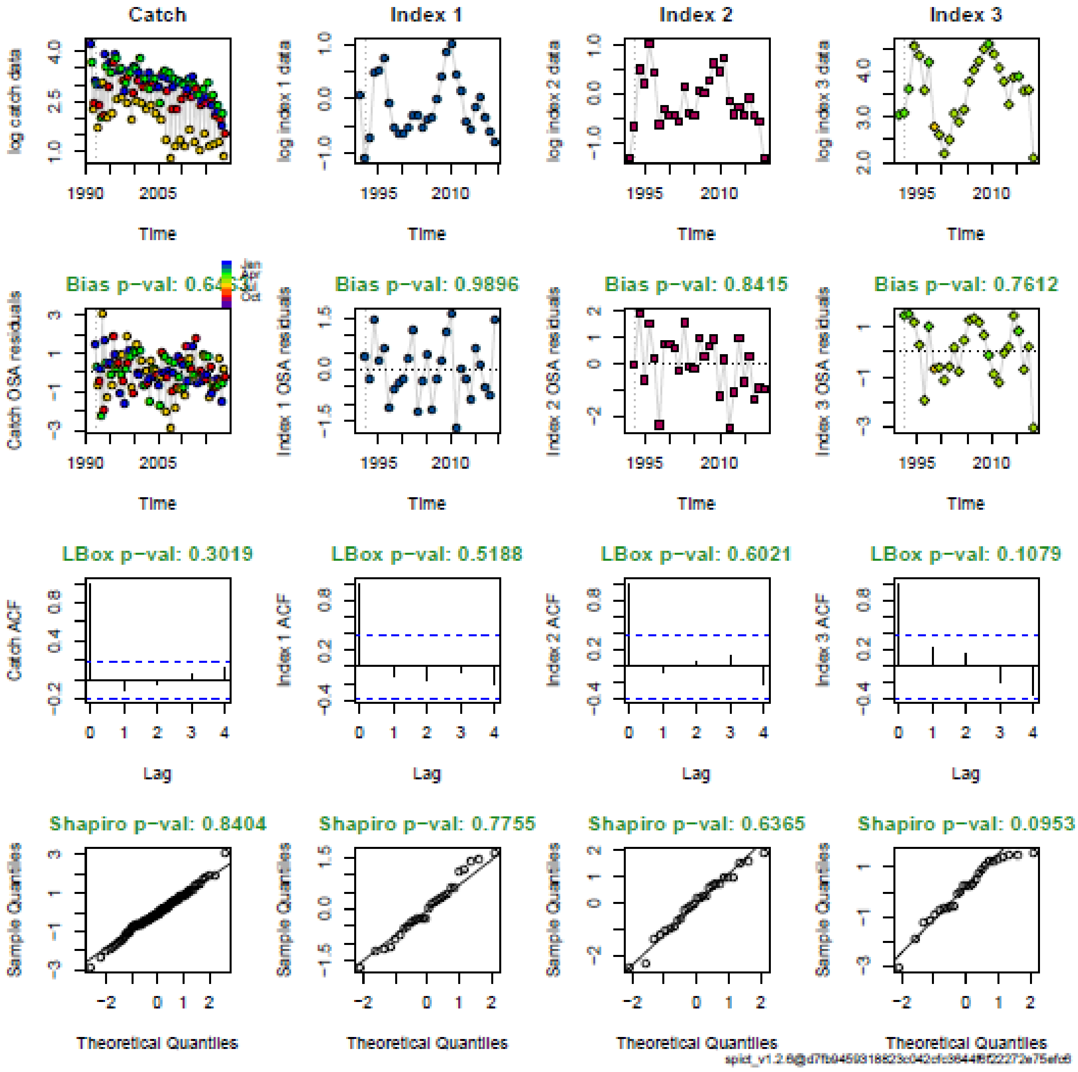


Figure 2.1.24. Eastern Baltic cod in SDs 24-32. Diagnostics of SPICT model.

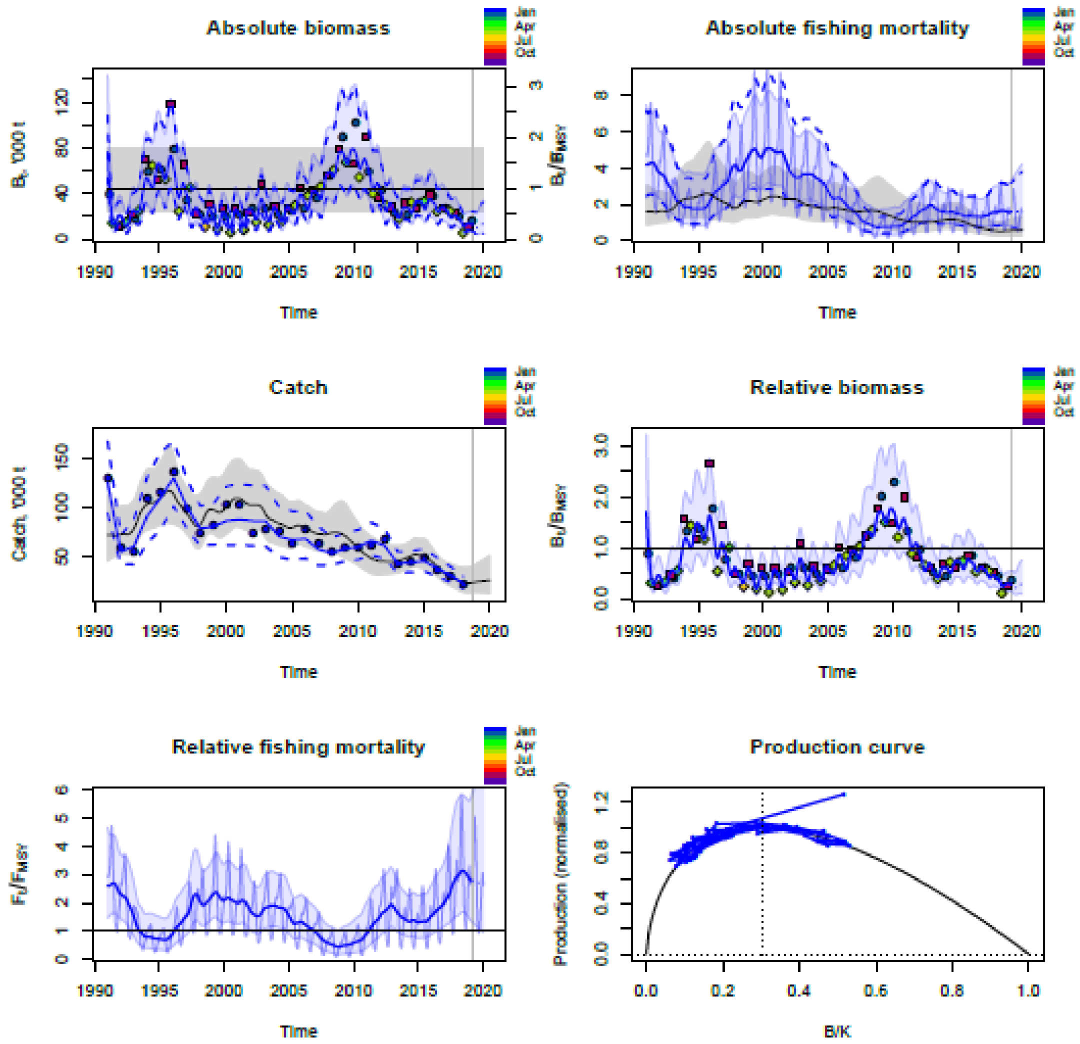


Figure 2.1.25. Eastern Baltic cod in SDs 24-32. Results of SPICT model.

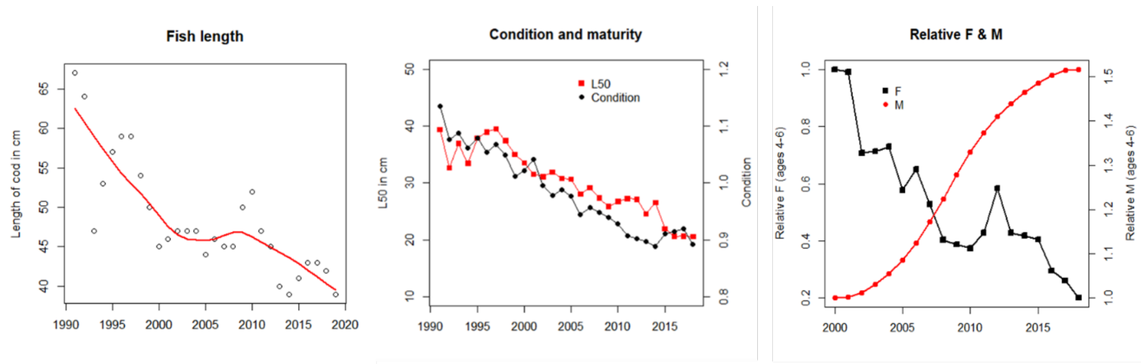


Figure 2.1.26. Eastern Baltic cod in SDs 24-32. Left panel: Indicator of size structure of the stock (length at 95 percentile of the length distribution, data from BITS-Q1 survey). Middle panel: length at which half of the stock has become mature (L50) and condition (weight at length) of 40-60 cm cod (data from BITS-Q1 survey). Right panel: Fishing mortality (F) and natural mortality (M) for ages 4-6, relative to the values estimated for 2000.

2.2 Cod in Subdivision 21 (Kattegat)

2.2.1 The fishery

2.2.1.1 Recent changes in fisheries regulations

TAC is mainly regulating the fishing in subdivision 21, 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 bycatch-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 32 mm 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 2018 were 212 tonnes, lower 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 1997–2018 and from Denmark for 2000–2018.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 2018, the estimated discards formed about 25% 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 77% 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 years class of 2016 was a higher than the previous years (although below average) and is now, as age 2, constituting to 62% of the total numbers of cod in Kategatt 2018 a (Figure 2.2.4). The large amount of 2 year cod 2018, increased the discard in numbers as the discard was constituting of mainly two year old fish (Figure 2.2.2, 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 composition of the landings

2.2.2.1 Age composition

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

2.2.2.2 Quality of the biological data

Both Danish and Swedish sampling data were available from the commercial fishery in 2018. 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 2018, 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.

2.2.2.3 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.

2.2.2.4 Natural mortality

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

2.2.3 Assessment

2.2.3.1 Survey data

The CPUE-values used were from IBTS 1st and 3rd quarter surveys ,from the BITS surveys in the 1st quarter (Danish RV 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, RV Havfisken (age 1-3) (1997-2019)
IBTS-3Q	International Bottom Trawl Survey, 3rd quarter, Kattegat (age 1-4) (1997-2018)
IBTS-1Q	International Bottom Trawl Survey, 1st quarter, Kattegat; (Ages 1-6) (1997-2019)
CODS-4Q	Cod survey, 4th Quarter, Kattegat, (ages 1-6). (2008-2018)

Due to corrections of the survey data from previous years during 2019, some indices from past times differ this year compared to previous year's assessment.

2.2.3.2 Assessment using 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 1997–2018 with estimating total removals from 2003–2018 within the model based on survey information. (SPALY _Scaling)

Catch (landings and discards) from 1997–2018 without estimating total. (SPALY _)

Unallocated removals were estimated separately for the years 2003–2018, but common for all age-groups within a year. The scaling factors estimated for 2005—2018 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 2004) 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 (Figure 2.2.11.)

2.2.3.3 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 2014 and 2015 are the lowest in the times-series (Figure 2.2.5, Figure 2.2.6). The year class of 2016 is higher that the low recruitment the years after 2012, but still below average. (Figure 2.2.5, Figure 2.2.6).

Conclusions on trends in SSB and fishing mortality

The assessment is indicative of trends only, and shows that spawning-stock biomass (SSB) has decreased from historical high levels in the 1997. There was some signs of a recovery in the 2015 but the SSB level are at historical low levels again in 2018.

The increase in SSB trend in 2013-2015 was solely due to the strong year classes of 2011 and 2012. The decrease in SSB since 2015 is due getting progressively eroded under the lack of new good incoming year classes.

The mortality decreased from 2008 to historically low levels 2014. However, the mortality is again increasing, approaching the high mortality levels found before 2008. For Kattegat cod, 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 0.75 to 1.6. In contrast the run without estimating total removals in the interval of 0.17 to 0.54. (Table 2.2.11—2.2.12, Figure 2.2.8).

2.2.4 Short term forecast and management options

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

2.2.5 Medium-term predictions

No medium-term predictions were performed.

2.2.6 Reference points

Reference points are not defined or updated for this stock (see Stock Annex for further explanation).

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—2018, 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 miss-match.

Therefore, current level of fishing mortality cannot be reliably estimated and are in the range of 1.6-0.17 in the SPALY runs. The exact estimates of SSB are considered uncertain, however all available information consistently indicates that SSB is at historical low levels in 2018, in the vicinity of 706 to 821 tonnes.

2.2.8 Comparison with previous assessment

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 Tables 2.2.11 and 2.2.12.

2.2.9 Technical minutes

There were no major comments on last year's assessment.

2.2.10 Management considerations

Management measures taken so far have not been sufficient to ensure the recovery of the stock.

There is no targeted cod fishery in Kattegat presently and cod is mainly taken as bycatch in the Norway lobster fishery. This implies that the mortality of the stock is strongly correlated with the uptake of the Norway lobster quota and the effort directed to the Norway lobster fishery.

The fishing effort regulation is no longer present since 2016 and the TAC of Norway lobster has increased substantially the last years.

The removal of the effort system has led to reduction in the uptake of selective gears in the Norway lobster fishery which itself has increased the mortality of Kattegat cod. The unregulated effort and the increased Norway lobster quota will dramatically increase the fishing mortality of the Kattegat cod.

Furthermore, the substantial decrease in the fishing opportunities of the eastern Baltic cod fishery will likely also lead to that capacity is moved from the eastern Baltic cod fishery to the Norway lobster fishery in the Kattegat. The movement of capacity will increase the fishing mortality of the Kattegat cod

There are fishing gears developed that keep the bycatch levels of cod to an absolute minimum in the fishery for Norway lobster and flatfish (plaice, sole).

The Swedish sorting grid has a bycatch of less than 1.5% of cod in the Norway lobster fishery, which is well documented (Valentinsson and Ulmestrand, 2006) and has been extensively used in former years. However, the removal of the effort system reduced the incentives to use this gear

In addition, there are gears available that successfully reduce cod bycatches from flatfish catches (Andersson and Lövgren, 2018), these gears are however not in use presently.

2.2.10.1 Future plans

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 analyse 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).

2.2.10.2 MSY Proxies

During the assessment in 2017 two different approaches of proxy reference points was explored

The reference points was evaluated by the proxy reference group in 2017, they concluded:

1. "The EG concluded that the proxies for MSY estimated using both LBI and SPiCT were unreliable. The EG notes that, should the problem with stock mixing be resolved, the SPiCT model would likely be useful in determining proxy reference points. The RG does not have sufficient information to comment on the conditions of the stock based on the given information and proxy reference points. Discussions of model sensitivity to changes in parameterization would have been beneficial.
2. The RG suggests, in the future, the suite of methods for establishing proxy reference points be reviewed and, for each method, the strengths and weaknesses of the method for the stock being considered should be discussed to justify why each method was accepted or rejected.

Although the Reference group suggested future elaboration on the proxy reference point during the assessment 2018, because of time limitation, no further elaboration was performed this year.

Table 2.2.1 Cod in the Kattegat. Landings (in tonnes) 1971-2018.

Year	Kattegat			Total
	Denmark	Sweden	Germany[1]	
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
2017	208	85	0.0	294
2018	175	37	0.0	212

[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 pollack

[7] the catch reported to the EU exceeds the catch reported to the WG (shown in the

Table 2.2.2 **Cod in the 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
2017	819	99	32	1	3	1
2018	22	180	3	4	1	2

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
2017	270	16	1	0	0	0
2018	5	46	3	0	0	0

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	653
2001	2110	1105	146	17	1.7	0.0	657
2002	3176	1645	383	12	1.3	0.0	820
2003	628	1591	89	3	0.9	0.2	616
2004	3544	934	591	2	2.1	0.3	1086
2005	853	1749	6	5	0.0	0.0	624
2006	1398	1200	386	7	2.6	0.3	862
2007	668	1377	291	32	0.5	0.1	624
2008	168	147	67	4	1	0	156
2009	389	55	2	0	0	0	67
2010	430	282	14	0	0	0	170
2011	631	405	31	0	0	0	211
2012	887	215	15	0	0	0	157
2013	1067	512	29	4	2	0	355
2014	510	795	42	5	4	0	348
2015	239	143	140	43	11	4	481
2016	16	83	28	38	16	5	222
2017	1089	115	33	1	3	1	258
2018	27	226	6	4	1	2	72

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	2017	2018
Denmark	24	38	34	43	48	58	55	46	37	61	51
Sweden	50	49	58	48	41	44	39	40	40	51	41
Total	74	87	92	91	89	102	94	86	77	112	92

Table 2.2.4 a Cod in the Kattegat. Sampling level of Danish landings, 2018

Quarter	n. of size distributions sampled	n. of cod aged	n. of cod weighed	n. of cod measured
1	5	153	153	153
2	4	997	997	997
3	9	116	116	116
4	6	221	221	221
Total	24	1487	1487	1487

Table 2.2.4 b Cod in the Kattegat. Sampling level of Swedish landings, 2018

Quarter	n. of size distributions sampled	n. of cod aged	n. of cod weighed	n. of cod measured
1	5	172	172	172
2	12	152	152	152
3	10	165	165	165
4	7	163	153	153
Total	34	652	642	642

Table 2.2.5. Cod in the Kattegat. Landings numbers and mean weight at age by quarter and country for 2

Sub-div	21					
Year	2018	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	0.767061	548.6221	0.557	511.2	1.32	532.88
3	0.989665	1222.882	0.336	1040.934	1.33	1176.77
4	9.580893	2624.149	0.498	1974.621	10.08	2592.06
5	11.39062	3578.095	1.04	2624.067	12.43	3498.28
6	5.816247	3429.129	1.198	3599.159	7.01	3458.17
7	1.00	5735.44	1.619	3547.991	2.62	4385.74
8	0.68	4141.29	0.159	4485.527	0.84	4206.62
9			0.06	8060.05	0.06	8060.05
10						
SOP (t)	96.05			15.62	111.67	
Landings (t)	95.14			15.27	110.41	

Sub-div	21					
Year	2018	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	0.577565	624.124	2.022	520.0735	2.60	543.19
3	0.908622	1088.123	0.875	946.0931	1.78	1018.45
4	3.419143	2570.618	0.719	2032.266	4.14	2477.08
5	2.348259	2849.515	0.772	2496.618	3.12	2762.20
6	5.755959	3647.665	0.967	3967.245	6.72	3693.63
7	0.69	6115.97	0.677	3291.839	1.36	4715.00
8	0.50	6165.90	0.027	3387.15	0.53	6024.59
9			0.15	8065.97	0.15	8065.97
10						
SOP (t)	45.14			12.64	57.78	
Landings (t)	41.57			12.13	53.70	

Sub-div	21					
Year	2018	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	1.647486	773.3189	0.639	572.9559	2.29	717.32
3	0.292433	2671.114	0.214	688.4303	0.51	1833.30
4	3.080894	3113.033	0.123	2569.393	3.20	3092.16
5	1.198841	3573.804	0.373	3138.337	1.57	3470.47
6	2.130086	3897.092	0.3	4974.014	2.43	4030.04
7	0.06	3456.01	0.251	4737.572	0.31	4481.08
8			0.031	3703.05	0.03	3703.05
9			0.03	9322.88	0.03	9322.88
10						
SOP (t)	24.45			5.03	29.48	
Landings (t)	23.81			4.38	28.19	

Sub-div	21					
Year	2018	Quarter	4			
Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1	0.35	455.42			0.35	455.42
2	6.51411	880.3331	1.832	1613.349	8.35	1041.23
3	1.13662	1723.563	0.793	1646.83	1.93	1692.03
4	0.933851	3065.612	0.161	2788.931	1.09	3024.93
5	0.402268	4018.834	0.218	3906.39	0.62	3979.31
6	0.237482	4069.593	0.128	4610.416	0.37	4259.00
7	0.11	5221.71	0.066	4710.314	0.17	5027.73
8						
9			0.01	9430.20	0.01	9430.20
10						
SOP (t)	13.86			6.55	20.41	
Landings (t)	13.65			5.30	18.95	

Sub-div	21					
Year	2018	Quarter	all			
Country	Denmark		Sweden		Grand Total	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1	0.348929	455.417			0.35	455.42
2	9.506222	880.3331	5.05	1613.349	14.56	1134.64
3	3.32734	2671.114	2.218	1646.83	5.55	2261.43
4	17.01478	3113.033	1.501	2788.931	18.52	3086.76
5	15.33999	4018.834	2.403	3906.39	17.74	4003.61
6	13.94	4069.59	2.593	4974.014	16.53	4211.44
7	1.86	6115.97	2.613	4737.572	4.48	5311.37
8	1.182722	6165.9	0.217	4485.527	0.22	4485.53
9			0.25	9430.20	0.25	9430.20
10						
SOP (t)	207.45			53.96	254.12	
Landings (t)	175.00			37.00	212.00	

Table 2.2.6 **Cod in the Kattegat**. Catches (Landings +Discards) in numbers (in thousands) by year anc
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
2017	1090	119	68	28	30	14
2018	28	240	12	23	19	25

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
2017	0.434	0.915	1.996	2.942	3.453	3.921	NA	NA
2018	0.434	0.249	0.783	2.511	3.265	3.766	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+

Year	Age 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
2017	0.037	0.275	0.993	2.91	3.353	3.858	NA	NA
2018	0.038	0.202	1.103	2.511	3.265	3.766	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
2017	0.00	0.52	0.77	0.85	1.00	1.00	1.00	1.00
2018	0.00	0.47	0.84	0.94	1.00	1.00	1.00	1.00

Table 2.2.10 Tuning data in the Kattegat

Tuning Data; Cod in the Kattegat (part of Division IIIa)_30/03/11						
104						
Havfisken_SD21_Q1						
1997 2019						
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	1.09	4.59	1.2			
1	47.5	1.91	1.33			
1	2.2	8.58	0.72			
1	0	1.083	1.07			
IBTSQ1_1-6						
1997 2019						
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	21.15	15.4	14.689	3.273	1.066
1	2.34	52.554	3.55	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	0.241	0.33	0	0.333
1	14.636	22.46	0.242	0.333	0.529	0.542
1	43.727	24.426	17.48	0.6	0.177	0.125
1	47.11	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	30.88	9.95	3.13	0.47	0.33
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
1	2.99	7.59	0.8	0.89	0.38	0.625
1	2.06	0.125	4.2	1.47	0.479	0.3
IBTS_Q3						
1997 2018						
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	1.56	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	2.97	0.17		
1	5.33	4.22	1.15	0.62		
1	1.94	0.47	0.07	0.15		
1	19.49	0.22	0	0.08		
1	2.5	1.28	0	0.08		
1	8.35	1.59	0.45	0		
1	8.29	1.25	0.05	0.58		
1	9.92	7.54	1.08	0.05		
1	3.71	6.84	7.54	0.81		
1	4.71	2.12	7.36	3.23		
1	0.38	0.69	1.63	2.24		
1	12.38	0.01	0.47	0.29		
1	1.33	0.55	0.09	0.05		
CODS_Q4						
2008	2018					
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
1	110.6	111.6	71.81	15.73	14.67	17.44
1	24.2	30.5	16.3	0.78	2.53	3.54

Table 2.2.11 summary run SPALY with scaling

Table 1. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), and average fishing mortality for ages 3 to 5 (F35).

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F35	Low	High
1997	16222	11051	23812	12675	11169	14385	10530	9188	12068	1.126	0.964	1.315
1998	13462	9060	20002	10520	9373	11807	7960	6996	9057	1.259	1.093	1.45
1999	13491	9022	20175	9394	8404	10500	7526	6735	8410	1.298	1.131	1.489
2000	7309	4970	10750	7127	6417	7916	5743	5152	6403	1.395	1.222	1.592
2001	6429	4428	9333	6199	5592	6871	4941	4433	5508	1.489	1.3	1.706
2002	11692	8087	16905	6000	5386	6684	4788	4265	5374	1.233	1.064	1.428
2003	2893	1942	4310	5068	4555	5640	4186	3756	4665	1.082	0.92	1.274
2004	18168	12534	26333	5318	4700	6017	3842	3397	4346	1.044	0.893	1.221
2005	9232	6340	13442	7441	6589	8402	4877	4345	5473	1.109	0.949	1.294
2006	9509	6388	14155	7077	6259	8001	5193	4583	5883	1.097	0.945	1.274
2007	2542	1651	3914	4526	4060	5046	3648	3265	4075	1.31	1.136	1.511
2008	1440	973	2131	2438	2208	2692	2167	1948	2410	1.497	1.306	1.715
2009	4583	3129	6713	1216	1084	1365	860	772	957	1.386	1.197	1.605
2010	4479	3066	6543	1326	1160	1516	766	678	865	1.059	0.87	1.289
2011	5421	3679	7988	1689	1471	1939	1109	962	1278	0.719	0.573	0.902
2012	12475	8422	18479	2318	1975	2720	1441	1226	1693	0.614	0.485	0.777
2013	18372	12200	27668	4244	3646	4940	2558	2184	2997	0.485	0.378	0.621
2014	5533	3641	8407	6627	5720	7678	3640	3128	4237	0.465	0.368	0.588
2015	3339	2249	4958	8042	6793	9520	5801	4859	6925	0.643	0.514	0.806
2016	929	564	1531	5450	4606	6448	4472	3725	5368	0.92	0.717	1.181
2017	4669	2978	7319	2879	2437	3402	2330	1940	2799	0.754	0.585	0.972
2018	458	250	839	2087	1705	2555	1750	1406	2179	1.119	0.758	1.653
2019							821	485	1391			

Table 2.2.12 summary run SPALY without scaling

Table 1. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), and average fishing mortality for ages 3 to 5 (F35).

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F35	Low	High
1997	14050	7649	25808	11832	9312	15035	9821	7615	12667	1.276	0.938	1.735
1998	14126	7545	26449	10040	8143	12379	7485	5965	9391	1.411	1.062	1.875
1999	12318	6862	22113	8496	6921	10430	6795	5505	8387	1.511	1.155	1.978
2000	6162	3396	11180	6544	5422	7899	5293	4345	6448	1.568	1.196	2.055
2001	3598	1986	6521	5326	4409	6433	4403	3605	5377	1.711	1.302	2.248
2002	8195	4868	13797	4886	4036	5916	4003	3276	4893	1.522	1.13	2.051
2003	955	509	1791	3159	2607	3829	2662	2182	3248	1.244	0.906	1.706
2004	9753	5751	16538	3871	3032	4942	2968	2286	3852	1.26	0.835	1.901
2005	2951	1747	4985	3133	2327	4220	2133	1554	2928	0.806	0.483	1.342
2006	4856	2856	8256	3325	2447	4518	2458	1749	3454	0.677	0.391	1.171
2007	1509	876	2599	2550	1845	3525	2077	1467	2942	0.875	0.493	1.552
2008	533	324	879	1029	717	1476	935	634	1379	0.806	0.466	1.393
2009	1748	1026	2978	496	342	718	368	236	573	0.638	0.365	1.116
2010	1243	744	2075	567	405	793	368	249	544	0.453	0.253	0.81
2011	1801	1062	3053	851	577	1256	627	406	971	0.237	0.132	0.425
2012	2957	1718	5089	980	646	1485	738	456	1195	0.141	0.079	0.25
2013	3579	2116	6052	1753	1169	2629	1288	820	2021	0.097	0.057	0.165
2014	1301	752	2252	3216	2062	5014	2034	1265	3271	0.078	0.044	0.14
2015	1044	620	1758	5490	3261	9240	4258	2480	7310	0.092	0.052	0.161
2016	129	68	245	3994	2326	6859	3478	1991	6076	0.136	0.08	0.232
2017	2123	1187	3796	2111	1300	3429	1826	1087	3068	0.194	0.116	0.323
2018	164	91	292	1030	667	1591	899	564	1434	0.309	0.175	0.548
2019							706	403	1237			

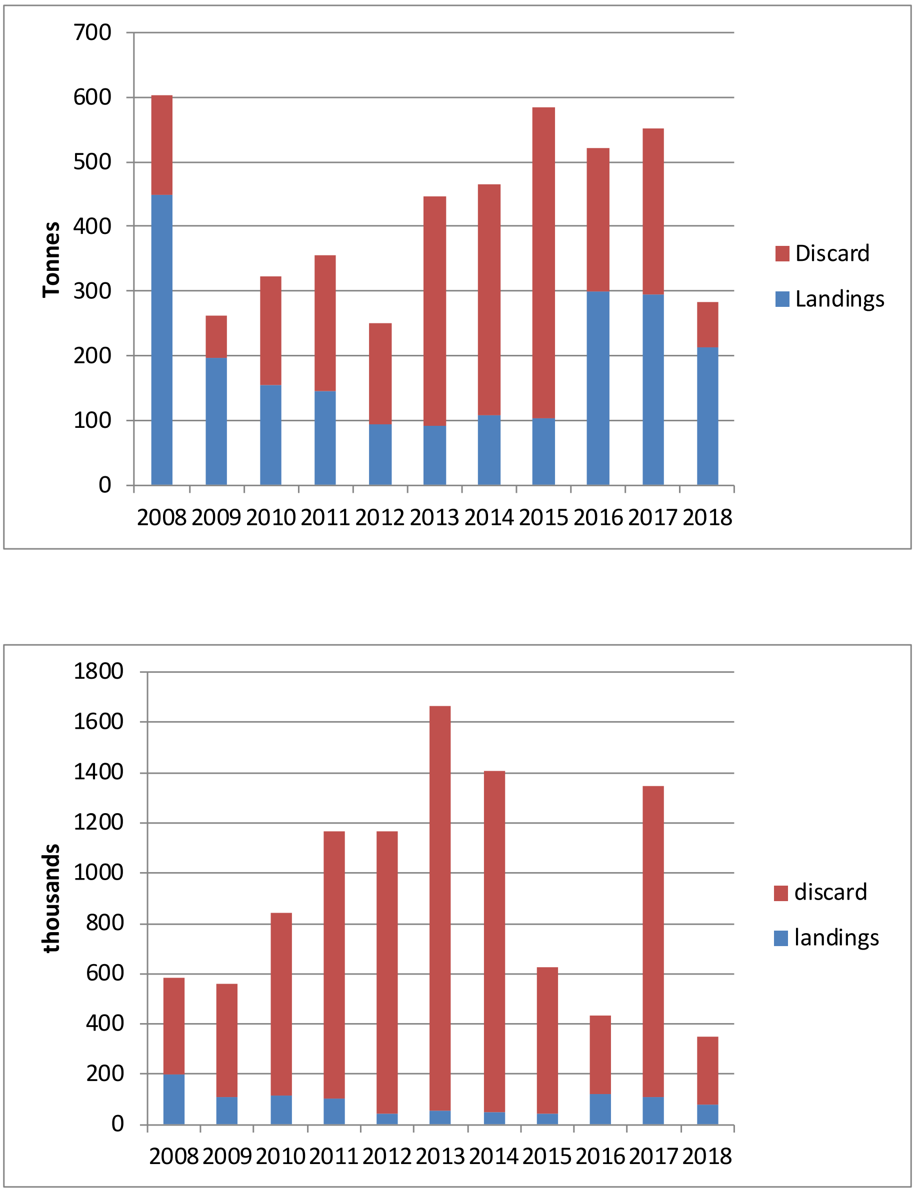


Figure. 2.2.1. Cod in the Kattegat.Estimates of discards (Denmark and Sweden combined) compared to reported landings, both in tons (upper panel) and in numbers (lower panel)

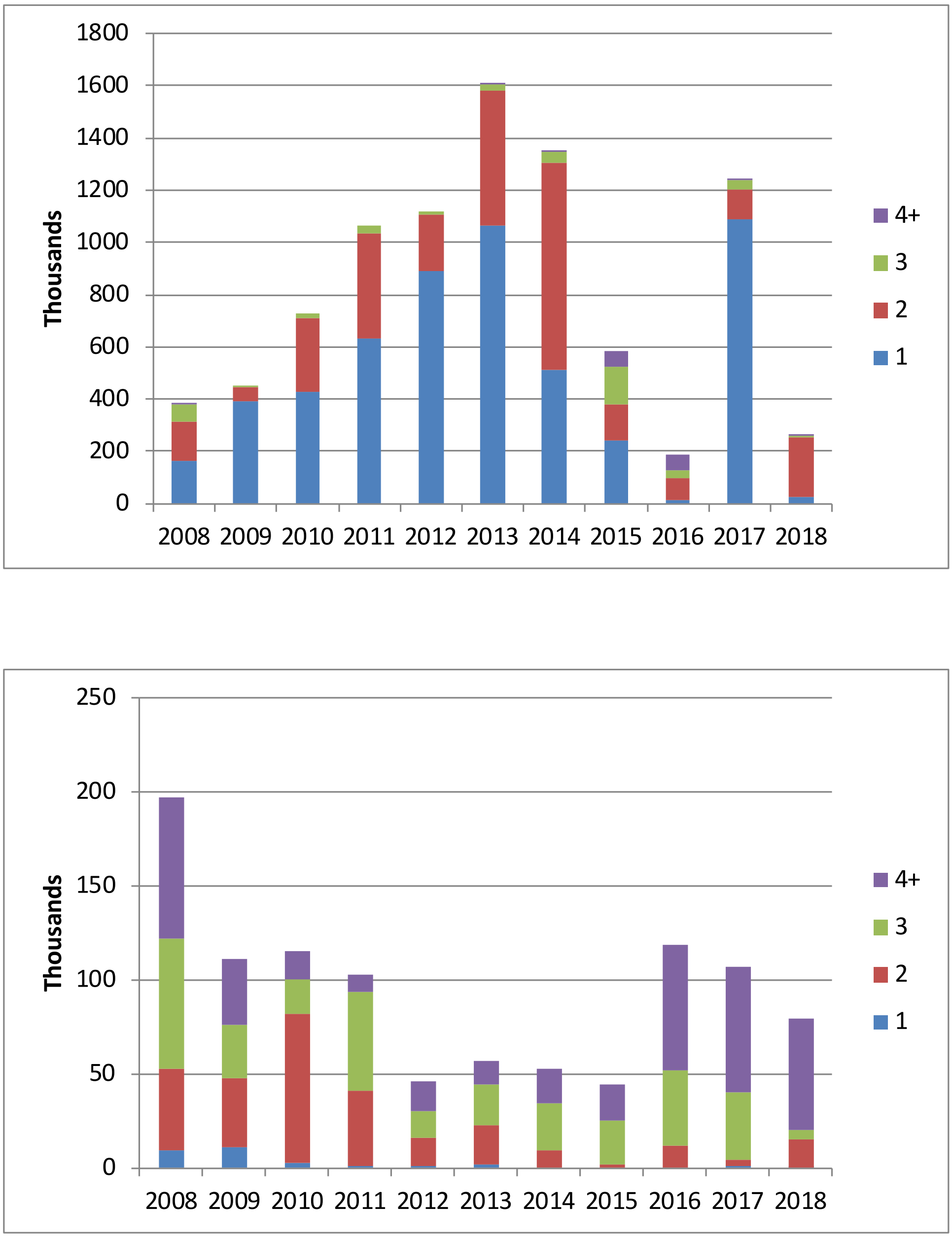
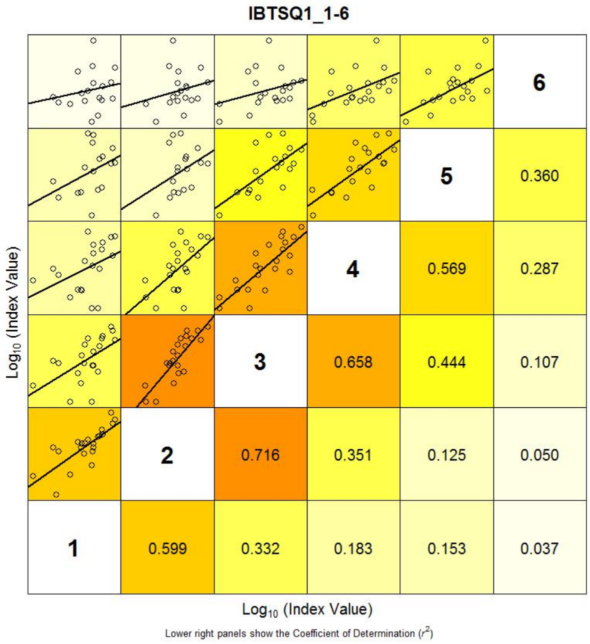
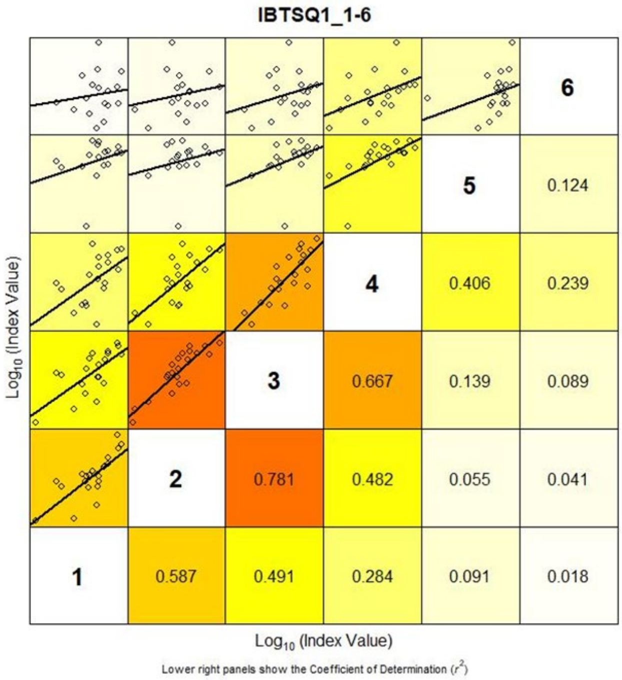


Figure. 2.2.2. Cod in the Kattegat . Estimates of discards age in numbers by upper panel. Landings in numbers by age lower panel (Sweden and Denmark combined)

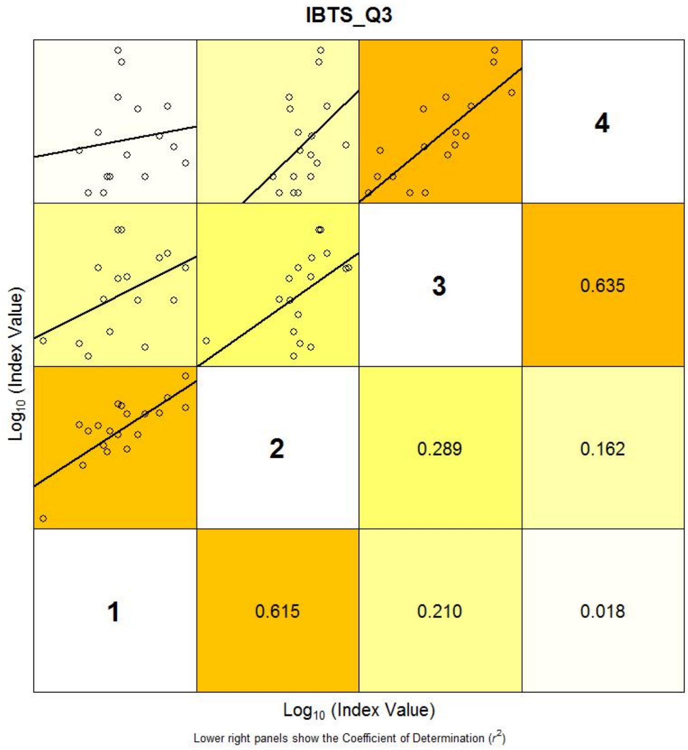


2018

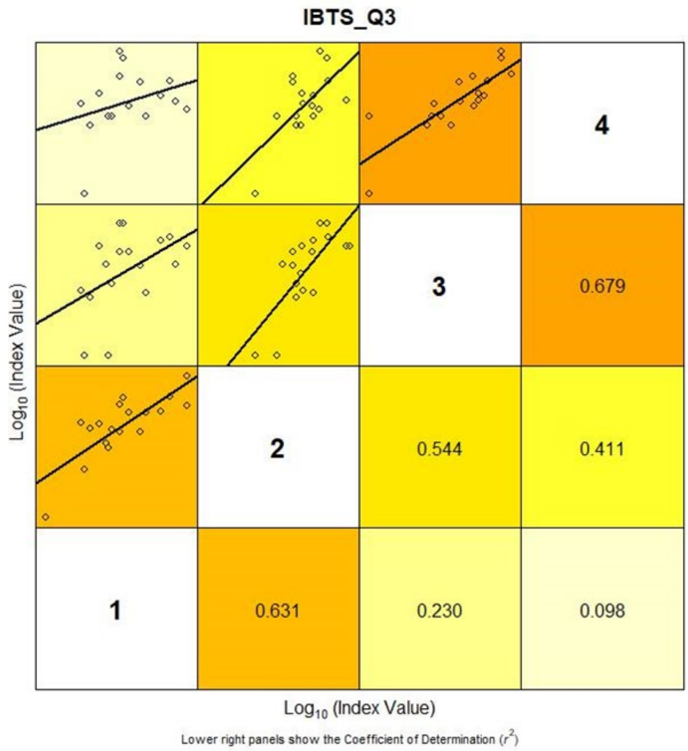


2017

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 2000-2018. Upper 2018 and lower 2017

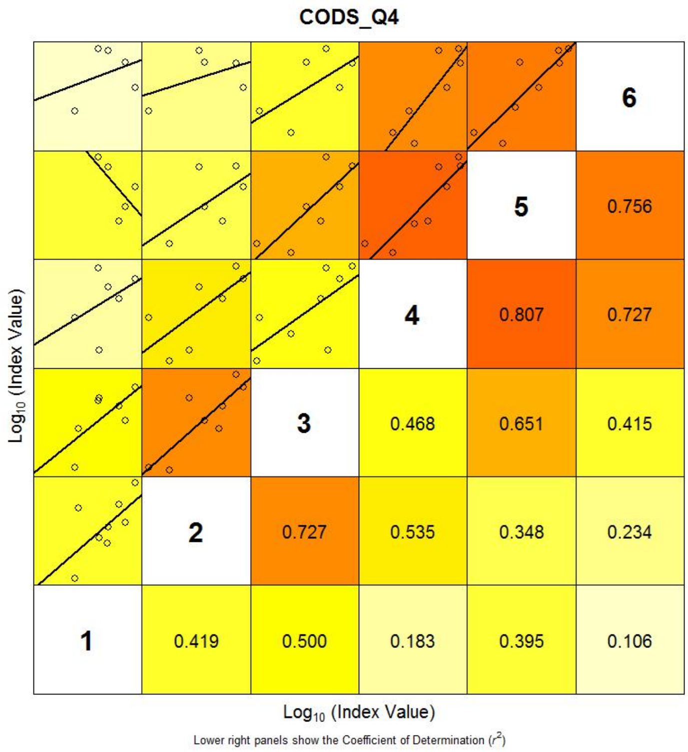


2018

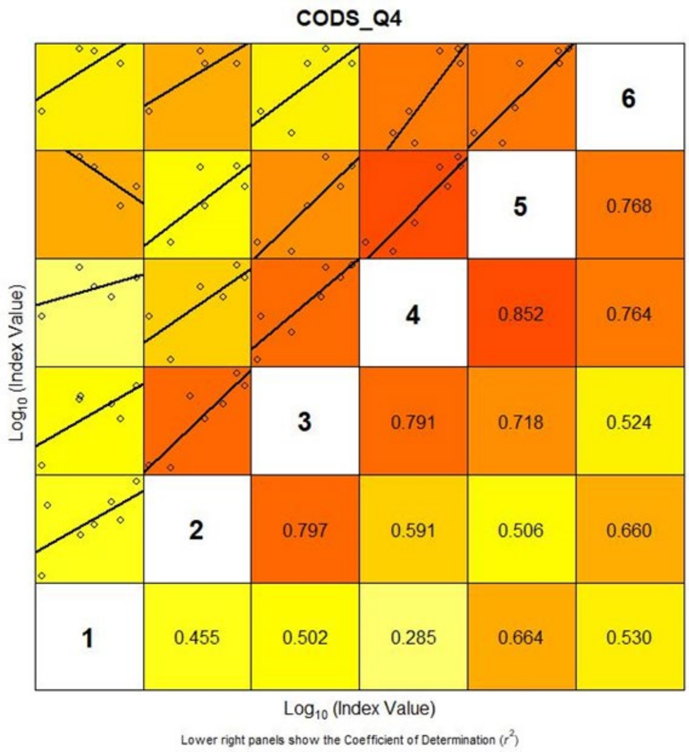


2017

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 2000-2018. Individual points are given by year class. Upper plot 2018 and lower 2017



2018



2017

Figure 2.2.3d. Cod survey quarter 4survey numbers at age vs. numbers at age +1 of the same cohort in the following year in the period 2008-2018. Individual points are given by year-class. Red dots highlight the information from the latest year. Upper plot 2018, lower plot 2017

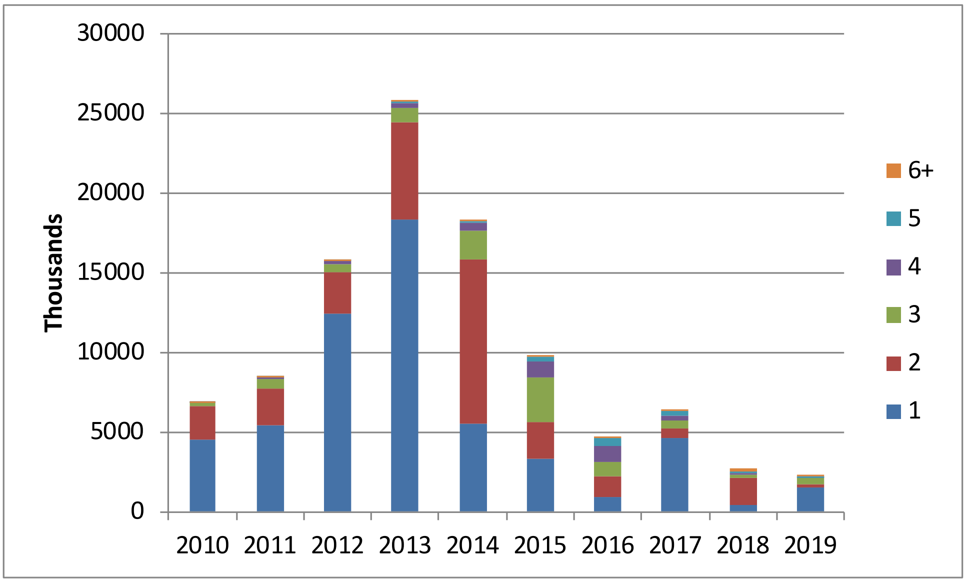


Figure 2.2.4. Stocknumbers by age 2010-2019 from SAM output

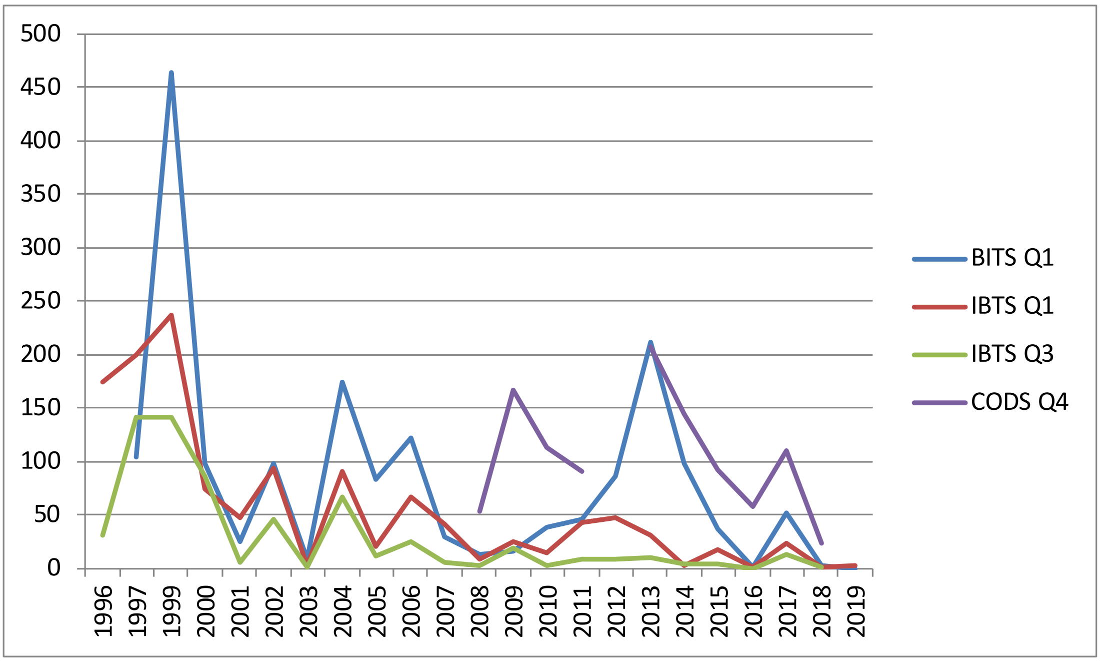


Figure 2.2.5. Cod in the Kattegat. Trends in recruitment index (Age 1) from different surveys.

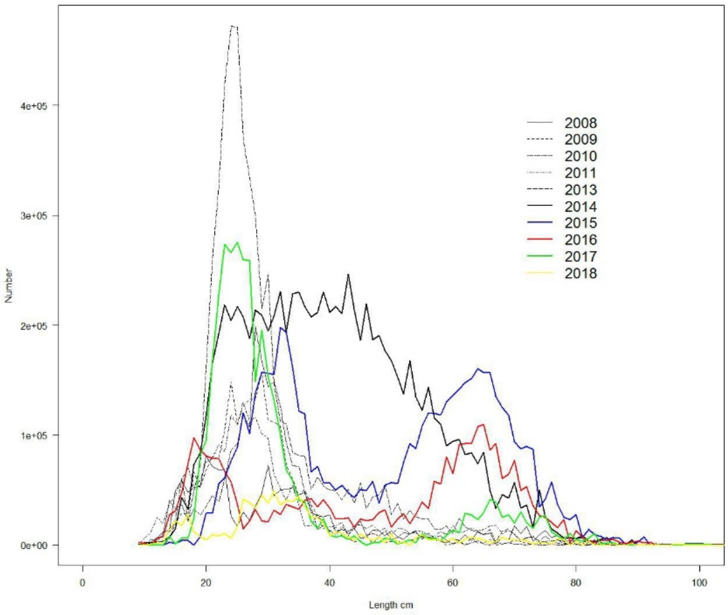


Figure 2.2.6. Length distributions from the Cod survey 2008-2018.

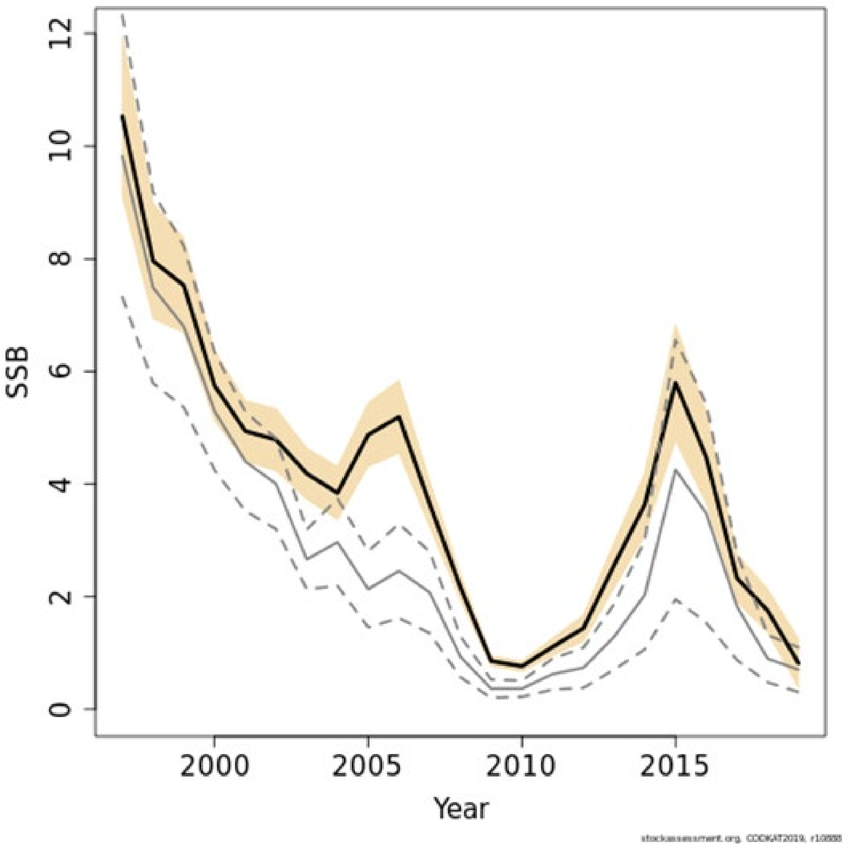


Figure 2.2.7 SSB .SAM run without scaling (grey lines) and Sam run with scaling.(black line with brown 95 % confidence interval)

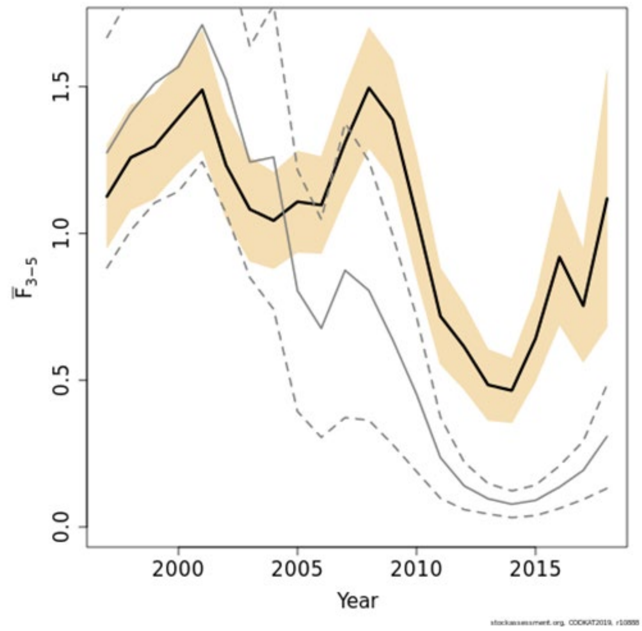


Figure 2.2.8. Unallocated mortality (Z-0.2) SAM run without scaling (grey lines) and Sam run with scaling (black line with brown 95 % confidence interval)

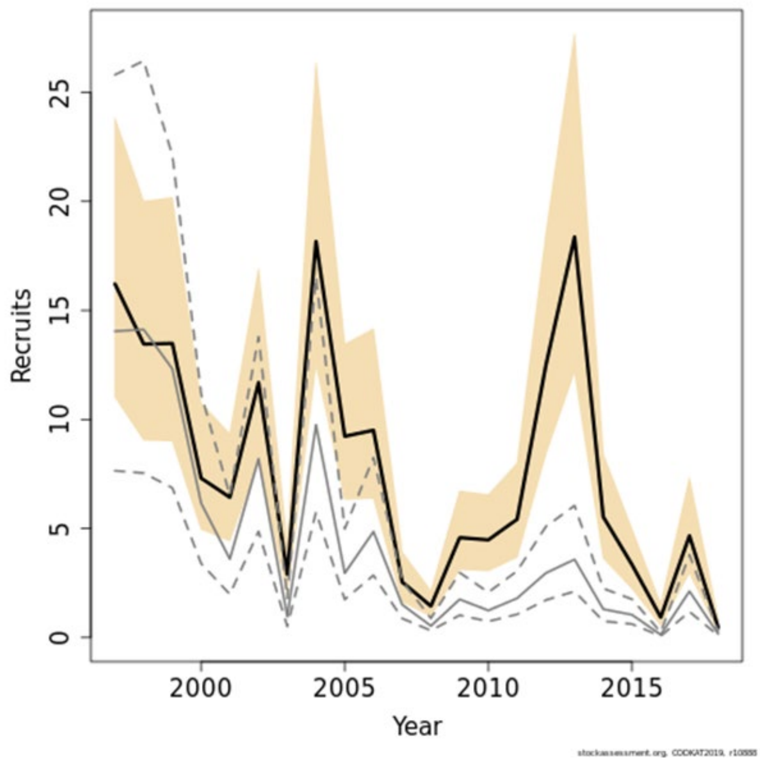
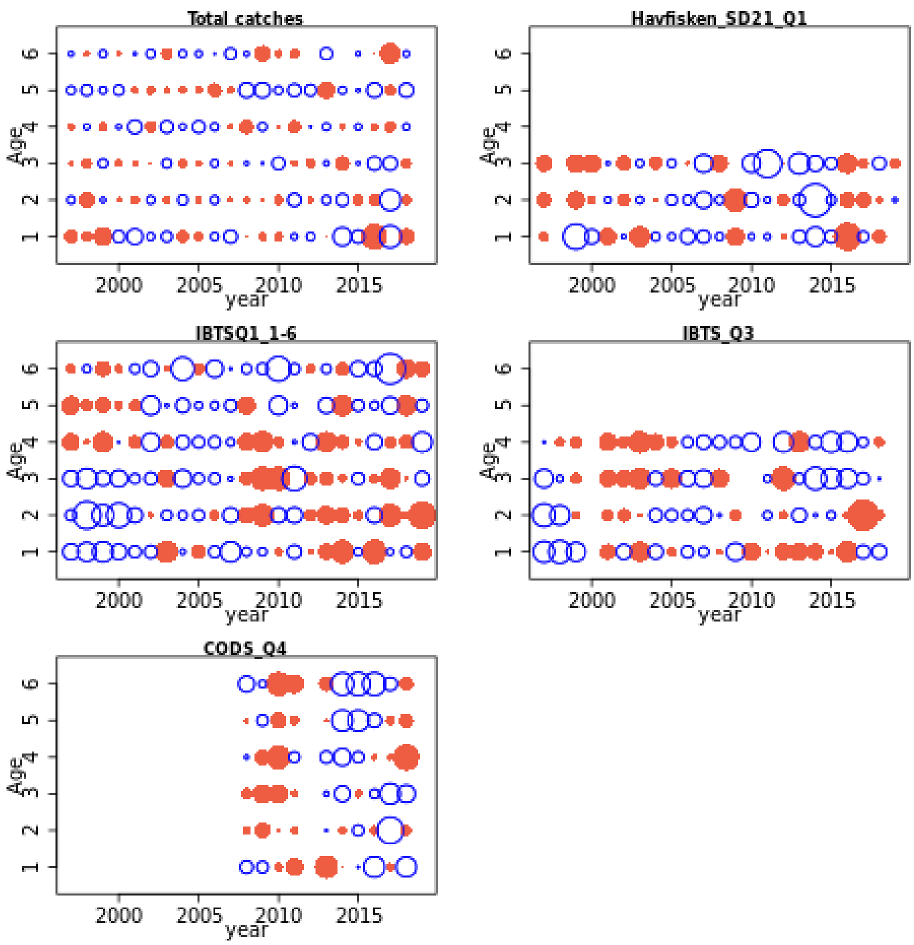


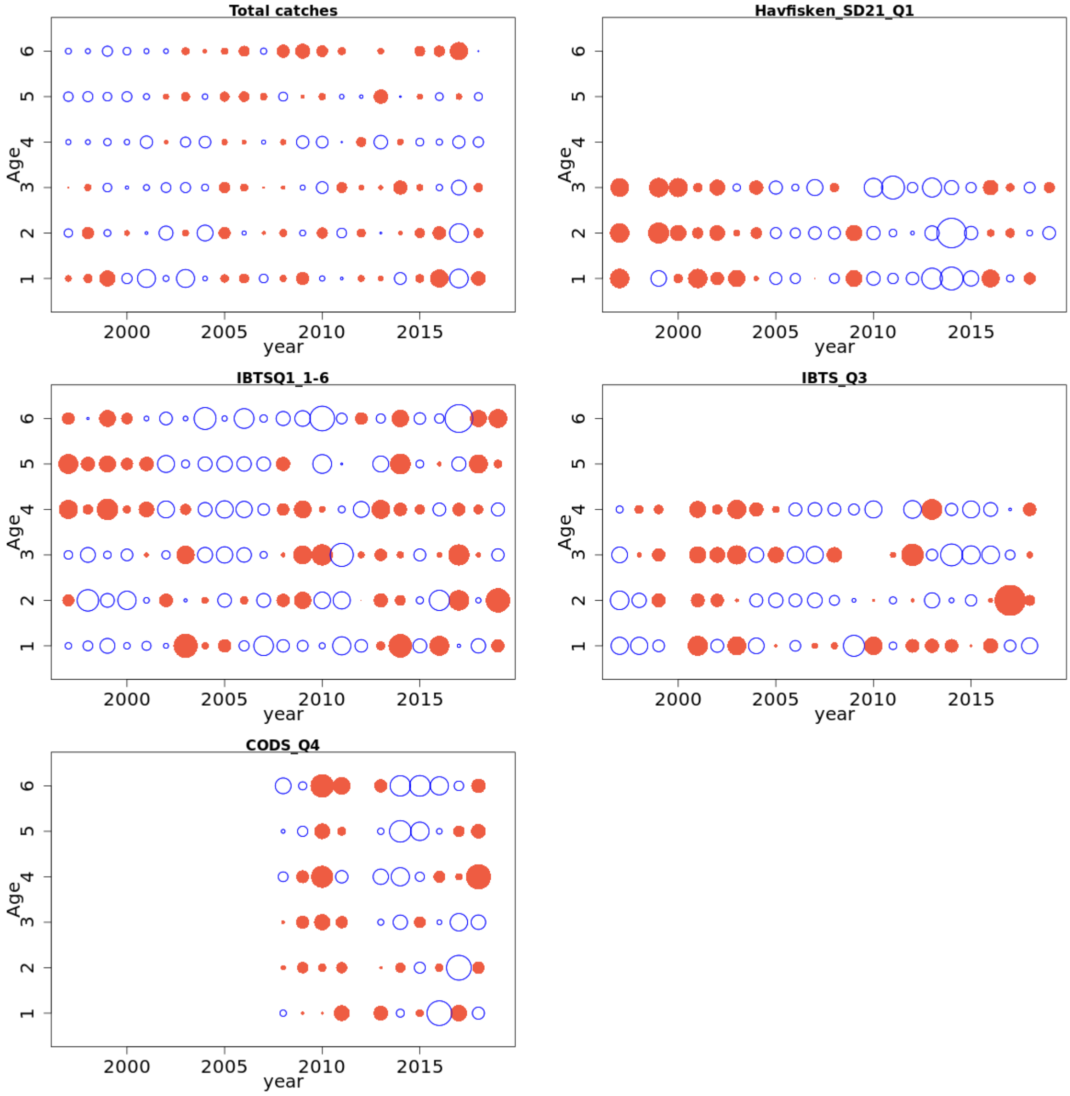
Figure 2.2.9 Recruitment. SAM run without scaling (grey lines) and Sam run with scaling.(black line with brown 95% confidence interval)

Year	Catch multiplier
2003	1.4
2004	1.1
2005	2.9
2006	2.9
2007	2.1
2008	3.4
2009	3.9
2010	3.4
2011	3.7
2012	6.4
2013	7.0
2014	8.2
2015	7.8
2016	7.4
2017	4.1
2018	4.6

Figure 2.10 catch multiplier. The scaling factor by year from the SAM run with scaling..



a)



b)

Figure 2.2.11 residuals .a) SPALY with scaling b) 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).

2.3 Cod in Subdivisions 22-24 (western Baltic)

1. Assessment type: Update assessment
2. Assessment: Analytical
3. Forecast: SAM
4. Assessment model: SAM
5. Stock status: SSB (just below) < B_{lim} in 2019. F (3–5) in 2018 is estimated to be 0.37.
6. Management plan. A multi annual Baltic management plan has been implemented in 2016. In 2019 the benchmark has updated the reference values.

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; 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. Overall catches are predominantly Danish, German, with smaller amounts from Sweden and 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. Since 2017 landing numbers include the BMS fraction, which was 24 t in 2018, slightly lower than officially reported BMS landings in 2017 (32 t). Landings by SD, passive and active gear in 2018 are given in Table 2.3.2 (both include eastern Baltic cod landings in SD 24).

The total commercial human consumption landings was 5826 t, 4% above the TAC for the area (5597 t). The last 10 years slightly more than half of the total western Baltic area landings have been fished in SD 24 (Figure 2.3.1).

24 t of BMS (below minimum conservation reference size) cod was landed in 2018, or 0.5% of the total landings in the management area SD 22–24, the main part of BMS (20 t) was reported from SD 24. There were zero logbook registered discards. In the western Baltic cod stock recreational fishing is also included in the stock assessment, as this fraction is a large part of the total catch (close to 30%) Figure 2.3.2.

As the western and eastern cod stock is mixing in SD 24, a splitting factor (based on genetics and otolith shape analysis) has been applied to the commercial cod landings in SD 24 to include only those fish belonging to the WB cod stock (Table 2.3.10). To do this, a weighted average of the proportions of WB cod in SD 24 in the two sub-areas was applied (Area 1 and Area 2 in Figure 2.3.3 for separation between the stocks). The weightings for each year represented relative proportions of commercial cod landings taken in areas 1 and 2.

2.3.1.1 Regulation

Since 01.01.2015, the EU landing obligation has been in place in the Baltic, 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.

In 2018, the spawning closure in the western Baltic (SD 22–24) covered an 8 weeks period, from 1st of February to 31st of March. Vessels >12 m were not allowed to fish for cod during the spawning closure (use of cod ends with ≥105 mm mesh size) while vessel <12 m were allowed to fish for cod if they could prove that fishing took place in areas shallower than 20 m (e.g. using logbooks or in Germany using the Smartphone App ;Mofi). The Danish fishing pattern can be seen by VMS plots Figure 2.3.4. The plot indicates a change in fishing pattern with lower fishing intensity in SD 22.

2.3.1.2 Discards

All relevant countries uploaded their discard data to InterCatch. Discard data from at-sea observer programs for 2018 were available from Germany, Sweden, Denmark, and Poland for SD 22–24. Denmark does not sample and report discards of passive gears, assuming very low discards, these assumptions are confirmed by the Danish last haul data available from the control agency since 2016. Discards of the passive gear of Denmark were raised using mainly discard ratios from Germany and Sweden (Table 2.3.4). Besides the sample level shown in table 2.3.3, several observer trips have been conducted in SD 24, however due to the mixing of the eastern and western Baltic cod stock in this area otoliths are only used for stock ID and not for age reading.

The discard rate of the active and passive gear was estimated to be 1.7% for active and 1.4% for passive gear in SD 22 and 5.8% and 2.7% in SD 23, respectively. For cod in SD 24, the discard rate of the active and passive gear was estimated to be 14.7% and 4.9%, respectively. Catches of longliners (LLS) were minor in 2018 and only from SD 24 and therefore, this fleet was not considered separately in the raising process. The effort reduction in this fleet is most likely due to the landing obligation since this gear is linked to relatively high discard rates (one order of magnitude higher than gillnetters).

The discard weights at age for SD 22 and SD 23 for 2018 were included in the catch-at-age weights, and were also applied for the discard estimates in SD 24 (see section 2.3.2.3).

2.3.1.3 Recreational catch

At the benchmark 2019 (WKBALTCOD2 2019), recreational catches from Sweden and Denmark were included in the assessment, German recreational data has been available since 2013 (WKBALTCOD 2015). The recreational catch included in the assessment has in average the last 10 years been just above 3000 t although much lower the last 2 years due to bag limitation. The recreational catches are mainly taken by private and charter boats and to a small degree by land-based fishing methods. The amount in 2018 is estimated to be 1600 t, the second lowest estimate in the time series.

The amount of recreational catches included in the assessment compared to commercial landings and discards is shown in Figure 2.3.2 and Table 2.3.6. All recreational cod caught in SD 22–24 is assumed to be WB cod (WKBALTCOD2, 2019).

2.3.1.4 Unallocated removals

Recreational fisheries data of Germany, Denmark and Sweden are included in the assessment since 2019. 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 (Part-time fishers and German vessels <8 m). 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 targeting herring in SD24 (PTB_SPF); in 2018, the estimate was 9.7 t.

2.3.1.5 Total catch

Total catches of the western Baltic cod stock (SD 22–24), including commercial landings (and for the last 3 years including reported BMS), discards and recreational catches, were estimated to be 5312 t in 2018. Landings and discards of eastern Baltic cod in SD 24 is estimated to be 2595 t and are shown in Table 2.3.6. By management area the total catch is estimated to be 7907 t in the western Baltic.

2.3.1.6 Data quality

Denmark, Germany and Sweden provided quarterly landings, LANUM and WELA by gear type (active, gillnets set) for SD 22–23 (Table 2.3.2, Table 2.3.7). Poland provided discard ratios for SD 24. Minor landings in SD 24 were reported by Finland.

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 2018 (i.e. the allocation overview) applied in InterCatch is given for landings and discards in Table 2.3.4

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, Denmark (only active gear), Sweden (passive gear) and Germany (both active and passive) have been able to conduct observer trips on board commercial vessels in 2018. Sweden had no active gear fishery in SD 22–24 in 2018 because the national TAC was provided exclusively to the passive gear fleet.

In Sweden, on passive gear trips both landings and discards are sampled. 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 2018 are given in Table 2.3.3. Denmark samples landings via harbour-sampling with harbour trips being the primary sampling unit and discard via at-sea sampling with a random selection of all active vessels above 10 meter.

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 do 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 RDBES which should be able to contain this information.

The different sampling units (number of harbour days, number of trips) render between-country comparisons difficult. However, sampling coverage and the number of age-read otoliths increased compared to the previous year (Table 2.3.3). Possible effects of the differences between national sampling levels on data quality of the international data set have not been assessed.

The numbers-at-age per stratum in the catch data suggest that all countries consistently identified the strong 2016 cohort and the weak 2015 and 2017 cohorts in their age readings.

Sampling data from 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

During the benchmark the time series of estimated mixing proportions of eastern and western Baltic cod within SD 24 was updated (WKBALTCOD2 2019). The proportions of eastern and western cod in SD 24 are estimated separately for 2 subareas, marked as Area 1 (Darss sill and entrance of SD 23) and Area 2 (Arkona basin, Rönnebank, Oderbank) in Figure 2.3.3.

In 2018, 51% of cod in SD 24 was found to be WB cod in Area 1 and 20% in Area 2 based on otolith shape analysis (Table 2.3.10). The split is conducted on the cod otoliths sampled from the commercial Danish and German trawl fisheries in SD 24. Samples for otolith shape analysis were collected during all four quarters. The spilt is weighted with landings from Germany, Denmark, Sweden and Poland based on 2018 landings by ICES square in SD 24.

Mixing proportions from a German historic survey were used to calculate a splitting proportion on the historic part of the time series (1985-1995). For more details on the mixing proportions please refer to WKBALTCOD2 (2019).

2.3.2.2 Catch in numbers

Time-series of the western Baltic stock 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 the WB cod stock for SD 22–24.

The major part of commercial landings in 2018 was age-group 2, the large 2016 year class amounting 73% of the total catch. The share of age 3 cod in terms of numbers was 6% due to the very low 2015 year class (Figure 2.3.6). However, the strong 2016 year class was large in both the discard and recreational catches, accounting for 96% and 76% of the total share, respectively. (Figure 2.3.2 and 2.3.5).

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 Q1 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 Q1 surveys in SD 22–23 (Table 2.3.19) and represent spawning probability (see Stock Annex and WKBALTCOD2 2019 for details). A moving average over 5 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 (1985-1996). These predation mortalities have not been updated since 1997; and presently the value 0.242 is applied for age 1 (1997-present). 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 BITS survey quarter 1 and quarter 4 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 report from 2016.

In addition, a survey of juvenile cod abundances from commercial pound nets (Fehmarn Juvenile Cod Survey - FEJUCS) was included in the assessment in the benchmark (WKBALTCOD2 2019).

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. Internal consistency of BITS Q1 and Q4 series is presented in Figure 2.3.6 and the time series in Figure 2.3.7.

The CPUE by age from the BITS tuning series are shown in Figure 2.3.8. 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 SD 24 is not included in the index.

FLEET	YEAR RANGE	AGE RANGE
BITS, Q4, SD22–24W (12–13 degrees)	2001–2018	age 0–4
BITS, Q1, SD22–24W (12–13 degrees)	2001–2019	age 1–4
FEJUCS, SD22	2011-2018	age 0

2.3.3.1 Recruitment estimates

The 2015, 2017 and 2018 year class were very weak and among the lowest in the time series (Figures 2.3.8 and 2.3.9). In contrast, a strong year class was detected in the Q4 BITS 2016 (as age 0) and in both the German and Danish pound nets in SD 22. The 2016 year class was confirmed in Q1 BITS 2017 as age 1 cod (Figures 2.3.10, 2.3.10) and reencountered in Q4 BITS 2017 and as age 2 cod in Q1 BITS 2018. However, in 2018 Q4 and 2019 Q1 surveys, the estimated strong 2016 year class was downscaled as much fewer cod than expected were found during the surveys (Figure 2.3.8). This is indicated in figure 2.3.7 where the age 2 cod (red dots) are below the trend line.

Possible reasons for the low 2017 year class are the low SSB in spring 2017, which may have resulted in a relatively low number of fertilized eggs. Even if egg production was not an issue, the extraordinary large number of very small age 1 cod from the 2016 cohort in spring 2017 (smallest individuals had only 10 cm total length in April/May; determined by age readings from pound net samples) may have led to food limitation for the settling year class 2017. (Figure 2.3.9). The very poor 2018 year class may be related to a still low SSB in spring 2018, relatively low bottom water salinities in Q1 2018 measured in SD 22 during the BITS and low water temperatures until April (due to a return of winter conditions from February to early April after a mild winter).

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 were conducted to explore the effect of the low value found in the 2018 Q4 survey. If the 2018 Q4 survey was left out of the assessment, the recruitment estimate of the 2016 year class was not downscaled and the estimated SSB value close to the predicted estimate from last assessment (Figure 2.3.10). This indicates that the assessment is rather sensitive due to one large dominating year class. It was discussed during the meeting if the effect of a very warm summer could have affected the catchability of the cod in the Q4 survey. However, as it was not possible to confirm if the weather condition affected the catchability and there was no indication that the surveys were not representative, it was decided to use the assessment as in former years. Further, exploratory run were conducted where catch was estimated to be known without uncertainties. This was done because a retro was detected in previous assessments where catch in the terminal year is estimated to be higher than the actual value. However, when catch were estimated to be known without uncertainties, the final estimate in SSB was nearly identical (Figure 2.3.11).

The model fit relatively well to the catch data (Figure 2.3.12), however for the surveys especially very low or high values are not fitted to the model (Figures 2.3.13 and 2.3.14), this is particularly true for the Q1 survey. The residuals indicate that there is a mismatch between catch and survey data (a pattern of negative residuals for the later years in the catch matrix). The reason is that the survey is estimating more fish than the catch matrix (Figure 2.3.15). This is also evident in the leaving out plots where one tuning series at a time is excluded (Figure 2.3.16). If one of the surveys is excluded in the model, then F increased and SSB decreased, indicating relatively consistent influence of both surveys on the SSB.

The retrospective pattern for SSB and F was relatively good (Mohn's Rho at 0.12 and 0.01, respectively), however much larger for the recruitment (0.47) which is mainly driven by the downscaling of the strong 2016 year class. As in last year's assessment there is some retrospective pattern in the catches estimated by the model, indicating that the model every year believes catches are higher than the observations (Figure 2.3.17).

The summaries for SSB, Recruitment and F from the final run are shown in Figure 2.3.18 and Table 2.3.22. Stock number and fishing mortalities are presented in Tables 2.3.23 and 2.3.24, respectively.

The input data and settings and final run are visible in www.stockassessment.org, the stock is "WBcod_2019".

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 2.3.25. Last year a TAC (catch) constraint was used in the intermediate year. This was derived from the splitting factor (0.59) applied to the TAC (9515 t) and recreational catches added (2140 t). This gives a total catch of 7988 t in 2019 and an F at 0.33.

The recreational catch in the intermediate year was derived by using a 3-year-mean in catch 2016–2018 (2140 t) where the assumed reduction in catch due to the introduced a bag limitation of a maximum of 5 cod per angler per day has been introduced in 2017 and 2018. Given the lack of a valid estimate for the intermediate year 2019, a 3-year-mean value was applied for the intermediate year (Table 2.3.26).

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. In the most recent three years the total commercial catch of WB cod stock commercial catch have been on average quite stable between subdivisions 22–23 and Subdivision 24, amounting to 76% and 24%, respectively. In the most recent three years, the overall ratio EB cod /WB cod in the commercial catch in Subdivision 24 has been 2.9. This means that every time one WB cod is caught in SD 24, 2.9 eastern Baltic cod is caught at the same time. The advice based on the management plan indicates that the total catch can be between 5205 t (F_{MSY} lower) and 11006 t (F_{MSY} higher) with F_{MSY} at 7245 t for the western Baltic cod stock in 2020. If fishing patterns are similar to former years 24% will be caught in SD.

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. These values were updated at the benchmark to 0.18 (lower) 0.25 (F_{MSY}) and 0.43 (Higher).

Biomass reference points B_{lim}= 14.5kt and B_{pa} at 21.8kt (WKBALTCOD2 2019). 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 Fcv=0, F_{phi}=0. This estimation gave a F_{lim} at 1.45 and an F_{pa} at 0.99.

2.3.7 Quality of assessment

The uncertainty on the catch matrix is relatively high in this assessment and the model seems to consistently overestimate the catches in the last year. Two possible reasons for the high uncertainty could be the splitting factor applied in SD 24, and the 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 22–23 + 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.

2.3.8 Comparison with previous assessment

The assessment this year has downscaled the 2016 year class by 54%. As this is the only abundant year class, it had a large effect on SSB in 2018 which was downscaled by 45% compared to last year.

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.

Given the poor recruitment in 2015 and 2017 and 2018 the commercial fisheries in 2020 and the present stock status are mainly based on the 2016 cohort. Further, stronger year classes are needed to ensure continuance of a commercial fishery.

Table 2.3.1. Cod in management area of SD 22–24. Total landings (tonnes) and discard of cod in the ICES subdivisions 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 for managment area							
																Human consumption landings (HC)							
	22	23	22+24	24	22+24	22	22+24	22	24	24	24	24	22	23	22+24	22	23	24	HC (SD22-24)	BMS	Discard	Unalloc.	Total catch
1965			19457		9705		13350								2182	27867		17007	44874				44874
1966			20500		8393		11448								2110	27864		14587	42451				42451
1967			19181		10007		12884								1996	28875		15193	44068				44068
1968			22593		12360		14815								2113	32911		18970	51881				51881
1969			20602		7519		12717								1413	29082		13169	42251				42251
1970			20085		7996		14589								1289	31363		12596	43959				43959
1971			23715		8007		13482								1419	32119		14504	46623				46623
1972			25645		9665		12313								1277	32808		16092	48900				48900
1973			30595		8374		13733								1655	38237		16120	54357				54357
1974			25782		8459		10393								1937	31326		15245	46571				46571
1975			23481		6042		12912								1932	31867		12500	44367				44367
1976		712	29446		4582		12893								1800	33368	712	15353	49433				49433
1977		1166	27939		3448		11686							550	1516	29510	1716	15079	46305				46305
1978		1177	19168		7085		10852							600	1730	24232	1777	14603	40612				40612
1979		2029	23325		7594		9598							700	1800	26027	2729	16290	45046				45046
1980		2425	23400		5580		6657							1300	2610	22881	3725	15366	41972				41972
1981		1473	22654		11659		11260							900	5700	26340	2373	24933	53646				53646
1982		1638	19138		10615		8060							140	7933	20971	1778	24775	47524				47524
1983		1257	21961		9097		9260							120	6910	24478	1377	22750	48605				48605
1984		1703	21909		8093		11548							228	6014	27058	1931	20506	49495				49495
1985		1076	23024		5378		5523							263	4895	22063	1339	16757	40159				40159
1986		748	16195		2998		2902							227	3622	11975	975	13742	26692				26692
1987		1503	13460		4896		4256							137	4314	12105	1640	14821	28566				28566
1988		1121	13185		4632		4217							155	5849	9680	1276	18203	29159				29159
1989		636	8059		2144		2498							192	4987	5738	828	11950	18516				18516
1990		722	8584		1629		3054							120	3671	5361	842	11577	17780				17780
1991		1431	9383				2879							232	2768	7184	1663	7846	16693				16693
1992		2449	9946				3656							290	1655	9887	2739	5370	17996				17996
1993		1001	8666				4084							274	1675	7296	1275	7129	15700			5528	21228
1994		1073	13831				4023							555	3711	8229	1628	13336	23193		2235	7502	32930
1995		2547	18762	132			9196				15			611	2632	16936	3158	13801	33895		3684		37579
1996		2999	27946	50			12018		50		32			1032	4418	21417	4031	23097	48545		7984	2300	58829
1997		1886	28887	11			9269		6			263		777	2525	21966	2663	18995	43624		4623		48247
1998		2467	19192	13			9722		8		13	623		607	1571	15093	3074	16049	34216		6207		40423
1999		2839	23074	116			13224		10		25	660		682	1525	20409	3521	18225	42155		4978		47133
2000		2451	19876	171			11572		5		84	926		698	2564	18934	3149	16264	38347		4947		43294
2001		2124	17446	191			10579		40		46	646		693	2479	14976	2817	16451	34244		2839		37083
2002		2055	11657	191			7322				71	782		354	1727	11968	2409	9781	24158		1958		26116
2003		1373	13275	59			6775				124	568		551	1899	9573	1925	13127	24624		4336		28960
2004		1927	11386				4651				221	538		393	1727	9091	2320	9430	20841		2377	13	23231
2005		1902	9867	2			7002	72	67		476	1093		720	835	8729	2621	10686	22036		4994	9	27039
2006		1899	9761	242			7516		91		586	801			1855	9979	1914	10858	22751		1831		24582
2007		2169	8975	220			6802		69		273	2371		534	2322	7840	2713	13183	23736		2199		25935
2008		1612	8582	159			5489		134		30	1361		525	2189	5687	2139	12256	20082		1123		21205
2009		567	7871	259			4020		194		23	529		269	1817	3451	839	11259	15549		815		16364
2010		689	6849	203			4250			9	159	319		490	1151	3925	1179	9016	14120		1371		15491
2011		783	7799	149			4521				24	487		414	2153	5493	1198	9641	16332		780		17112
2012		733	8381	260			4522		3		11	818		390	1955	4896	1123	11053	17072		905		17977
2013		580	6566	50			3237				128	708		380	1317	4675	960	7333	12968		2250		15218
2014	2206	795	6804	7		2109	3243				39	854	1	565	1231	4316	1361	7862	13538		2135		15673
2015	2781	738	6623	28		2213	2915				7	755		493	1858	4994	1232	7193	13419		1361		14780
2016	1576	675	4881	29		1617	2390					657	1	448	1550	3193	1123	6313	10629	34	449		11112
2017	1167	506	2352			1029	1267					926		435	348	2195	941	2697	5833	32	421		6286
2018	1010	475	2235	1		1005	1373					886		395	462	2014	870	2942	5826	24	476		6326

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

Year:	**2018**	**Gear:**	**Active and passive gear combined**	
Subdiv.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	1010	475	1225	2710
Germany	1005	0	368	1373
Sweden	0	395	462	857
Poland	0	0	886	886
Total	2014	870	2942	5826

Year:	**2018**		**Gear:**	**Active gear**
Subdiv.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	936	146	1027	2109
Germany	541	0	184	725
Sweden	0	0	233	233
Poland	0	0	741	741
Total	1476	146	2184	3807

Year:	**2018**		**Gear:**	**Passive gear**
Subdiv.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	74	329	198	601
Germany	464	0	185	648
Sweden	0	395	230	625
Poland	0	0	145	145
Total	538	724	758	2019

Table 2.3.3. Cod in subdivisions 22–23 only. Overview of the number of samples (number of trips, harbour visits or number of boxes), number of length measurements and number of otoliths available per stratum in 2018 (upper, middle and lower table, respectively). Colour codes indicate sampling coverage (see legend below). Also SD 24 has otolith and length samples.

			Area	Season									
Number of samples			27,3,c,22				27,3,b,23				Total	Country sum	%
Country	Catch Category	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards *1	Active	5	8	2	7					22		
TAC 44%		Gillnets set										77	**44%**
	Landings *2	Active	17	17	5	9			2	5	55		
		Gillnets set									--		
Germany	Discards *1	Active	9	3	3	2					17		
TAC 21%		Gillnets set		3		5					8	52	**30%**
	Landings *1	Active	9	3	3	2					17		
		Gillnets set	3	3		4					10		
Sweden	Discards *1	Passive					2	4	5	7	18	45	**26%**
TAC 16%		Passive					2	9	8	8	27		
Total			43	37	13	29	4	13	15	20	174		

*1: number of sampled trips; *2: habor days

			Area	Season									
Number of length measurements			27,3,c,22				27,3,b,23				Total	Country sum	%
Country	Catch Category	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards	Active	28	12	1	3					44		
TAC 44%		Gillnets set										1375	**22%**
	Landings	Active	339	257	92	277			54	312	1331		
		Gillnets set									--		
Germany	Discards	Active	274	46	6	2					328		
TAC 21%		Gillnets set		11		6					17	3234	**51%**
	Landings	Active	768	330	473	5					1576		
		Gillnets set	350	178		785					1313		
Sweden	Discards	Passive					129	191	169	294	783	1694	**27%**
TAC 16%	Landings	Passive					97	296	238	280	911		
Total			1759	834	572	1078	226	487	461	886	6303		

Number of otoliths age-read											Total	Country sum	%
Country	Catch Category	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards	Active	22	12	1	3					38		
TAC 44%		Gillnets set										1367	**29%**
	Landings	Active	339	255	92	277			54	312	1329		
		Gillnets set									--		
Germany	Discards	Active	151	46	6	2					205		
TAC 21%		Gillnets set		2		5					7	1595	**34%**
	Landings	Active	265	330	377	5					977		
		Gillnets set	97	38		271					406		
Sweden	Discards	Passive					129	191	169	294	783	1694	**36%**
TAC 16%	Landings	Passive					97	296	238	280	911		
Total			874	683	476	563	226	487	461	886	4656		

Table 2.3.4. Cod 22–23. Unsampled landing and discard strata and allocated sampled strata in 2018.

DE_27.3.c.22_Gillnets set_3_L,DK_27.3.b.23_Gillnets set_3_L,X
DE_27.3.c.22_Gillnets set_3_L,DK_27.3.c.22_Gillnets set_3_L,X
DE_27.3.c.22_Gillnets set_3_L,SE_27.3.b.23_Passive_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,DE_27.3.c.22_Active_2_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_1_L,DK_27.3.c.22_Active_2_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_1_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,SE_27.3.b.23_Passive_1_L,X
DK_27.3.b.23_Gillnets set_1_L,SE_27.3.b.23_Passive_2_L,X
DK_27.3.b.23_Gillnets set_2_L,SE_27.3.b.23_Passive_1_L,X
DK_27.3.b.23_Gillnets set_2_L,SE_27.3.b.23_Passive_2_L,X
SE_27.3.c.22_Passive_3_L,DE_27.3.c.22_Gillnets set_4_L,X
SE_27.3.c.22_Passive_3_L,DK_27.3.c.22_Gillnets set_3_L,X
SE_27.3.c.22_Passive_3_L,DK_27.3.c.22_Gillnets set_4_L,X

Table 2.3.4. Unsampled discard strata and allocated sampled strata for Western Baltic cod in 2018 (SD22-23).

DE_27.3.c.22_1_Gillnets set_D,DE_27.3.c.22_2_Gillnets set_D,X
DE_27.3.c.22_1_Gillnets set_D,SE_27.3.b.23_1_Passive_D,X
DE_27.3.c.22_1_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_4_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_3_Gillnets set_D,SE_27.3.b.23_4_Passive_D,X
DK_27.3.b.23_1_Active_D,DE_27.3.c.22_1_Active_D,X
DK_27.3.b.23_1_Active_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.b.23_1_Active_D,DK_27.3.c.22_1_Active_D,X
DK_27.3.b.23_1_Active_D,DK_27.3.c.22_2_Active_D,X
DK_27.3.b.23_1_Gillnets set_D,DE_27.3.c.22_2_Gillnets set_D,X
DK_27.3.b.23_1_Gillnets set_D,SE_27.3.b.23_1_Passive_D,X
DK_27.3.b.23_1_Gillnets set_D,SE_27.3.b.23_2_Passive_D,X
DK_27.3.b.23_2_Active_D,DE_27.3.c.22_1_Active_D,X
DK_27.3.b.23_2_Active_D,DE_27.3.c.22_2_Active_D,X
DK_27.3.b.23_2_Active_D,DK_27.3.c.22_1_Active_D,X
DK_27.3.b.23_2_Active_D,DK_27.3.c.22_2_Active_D,X
DK_27.3.b.23_2_Gillnets set_D,DE_27.3.c.22_2_Gillnets set_D,X
DK_27.3.b.23_2_Gillnets set_D,SE_27.3.b.23_1_Passive_D,X
DK_27.3.b.23_2_Gillnets set_D,SE_27.3.b.23_2_Passive_D,X
DK_27.3.b.23_3_Active_D,DE_27.3.c.22_3_Active_D,X
DK_27.3.b.23_3_Active_D,DE_27.3.c.22_4_Active_D,X
DK_27.3.b.23_3_Active_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.b.23_3_Active_D,DK_27.3.c.22_4_Active_D,X
DK_27.3.b.23_3_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DK_27.3.b.23_3_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X
DK_27.3.b.23_3_Gillnets set_D,SE_27.3.b.23_4_Passive_D,X
DK_27.3.b.23_4_Active_D,DE_27.3.c.22_3_Active_D,X
DK_27.3.b.23_4_Active_D,DE_27.3.c.22_4_Active_D,X
DK_27.3.b.23_4_Active_D,DK_27.3.c.22_3_Active_D,X
DK_27.3.b.23_4_Active_D,DK_27.3.c.22_4_Active_D,X
DK_27.3.b.23_4_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DK_27.3.b.23_4_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X
DK_27.3.b.23_4_Gillnets set_D,SE_27.3.b.23_4_Passive_D,X
DK_27.3.c.22_1_Gillnets set_D,DE_27.3.c.22_2_Gillnets set_D,X
DK_27.3.c.22_1_Gillnets set_D,SE_27.3.b.23_1_Passive_D,X
DK_27.3.c.22_1_Gillnets set_D,SE_27.3.b.23_2_Passive_D,X
DK_27.3.c.22_2_Gillnets set_D,DE_27.3.c.22_2_Gillnets set_D,X
DK_27.3.c.22_2_Gillnets set_D,SE_27.3.b.23_1_Passive_D,X
DK_27.3.c.22_2_Gillnets set_D,SE_27.3.b.23_2_Passive_D,X
DK_27.3.c.22_3_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DK_27.3.c.22_3_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X
DK_27.3.c.22_3_Gillnets set_D,SE_27.3.b.23_4_Passive_D,X
DK_27.3.c.22_4_Gillnets set_D,DE_27.3.c.22_4_Gillnets set_D,X
DK_27.3.c.22_4_Gillnets set_D,SE_27.3.b.23_3_Passive_D,X
DK_27.3.c.22_4_Gillnets set_D,SE_27.3.b.23_4_Passiv

Table 2.3.5. Cod 22–23. 2018. Discard (Number * 1000) by quarter and gear type.

Sum of DISCARD	Quarter				Grand Total
Gear type	1	2	3	4	
Passive gears	17	14	14	14	59
Active gears	107	17	4	31	159
Grand Total	124	31	19	45	219

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 (Germany, Denmark and Sweden).

Year	WB cod stock					EB cod stock					EB+WB cod stock		
	Landings	Discards	Recreational catch	% discard	% 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	% commercial catch of west cod	stock Comm. catch in SD 24
1985	33188		2075		0.29	6971		315083	8199	2	42234	0.83	0.71
1986	20088		2078		0.36	6604		252558	3848	3	28770	0.75	0.93
1987	21692		2081		0.37	6874		207081	9340	3	30647	0.76	0.86
1988	20672		2082		0.47	8487		194787	7253	4	31241	0.71	0.87
1989	12795		2083		0.49	5721		179178	3462	3	20599	0.69	0.92
1990	12237		2085		0.49	5543		153546	4187	3	19865	0.69	0.92
1991	12931		2087		0.32	3762		122517	2741	3	18780	0.77	0.92
1992	15672		2420		0.19	2324		54882	1904	4	20416	0.87	0.76
1993	11815		2752		0.27	3885		50711	1558	7	18452	0.75	1.20
1994	16642	1614	3088	0.09	0.41	6551	621	100856	1956	7	28516	0.72	0.97
1995	28310	3016	3417	0.10	0.29	5585	668	107718	1872	5	40996	0.83	0.68
1996	38505	6868	3419	0.15	0.32	10040	1116	124189	1443	8	59948	0.80	0.77
1997	37077	3981	3420	0.10	0.33	6547	641	88600	3462	7	51666	0.85	0.53
1998	29634	5575	3410	0.16	0.37	4582	631	67428	2299	7	43833	0.87	0.40
1999	35934	4378	3416	0.11	0.32	6221	599	72995	1838	8	50549	0.86	0.52
2000	31132	3738	3432	0.11	0.32	6316	1209	89289	6019	7	45827	0.82	0.68
2001	27781	2449	3427	0.08	0.36	7794	389	91328	2891	8	41840	0.79	0.75
2002	20410	1395	3437	0.06	0.31	5060	562	67740	1462	8	30864	0.80	0.84
2003	17205	3473	3448	0.17	0.34	5729	862	69477	2024	8	30718	0.76	0.95
2004	17686	2189	3445	0.11	0.27	5309	188	68578	1201	7	28817	0.78	1.04
2005	18493	3265	3771	0.15	0.42	6064	1729	55032	1670	12	33322	0.74	0.86
2006	18503	1686	2923	0.08	0.27	6767	144	65531	4644	9	30024	0.74	1.28
2007	17384	1325	2782	0.07	0.35	8792	875	50843	4146	15	31158	0.66	1.46
2008	11302	336	3039	0.03	0.31	8811	787	42234	3746	17	24274	0.55	2.66
2009	7313	351	2648	0.05	0.42	8284	464	48438	3328	14	19060	0.47	2.75
2010	8007	838	3367	0.09	0.36	6049	533	50276	3543	11	18793	0.57	2.08
2011	9107	299	2595	0.03	0.24	7545	482	50368	3850	13	20029	0.54	3.59
2012	8622	370	3661	0.04	0.31	8469	536	51225	6795	13	21657	0.50	3.28
2013	7697	1007	3106	0.12	0.29	5359	1243	31355	5020	15	18413	0.57	2.62
2014	8083	837	4044	0.09	0.33	5455	1298	28909	9627	15	19716	0.57	2.30
2015	8390	432	4568	0.05	0.29	5029	930	38079	5970	12	19348	0.60	2.35
2016	6122	143	3505	0.02	0.31	4541	306	29313	3279	13	14617	0.56	2.53
2017	3861	180	1315	0.04	0.20	1994	238	25496	3238	7	7587	0.64	2.79
2018	3555	157	1600	0.04	0.21	2284	311	15907	3103	12	7907	0.59	3.39
3 avr.					0.24								2.90

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 2018.

Year:		Gear:	Trawl, gillnet and longlines combined			
Year:	2018	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		282		282		282
2	184	858	43	892	227	874
3	27	1760	10	1670	37	1719
4	78	2666	50	2381	128	2524
5	31	3606	14	3020	45	3313
6	16	5198	8	4144	24	4671
7	4	6250	1	5087	4	5669
8	1	8693	0.2	7521	1	8107
9		7077	0.004	9407	0.004	8475
10		11636	0.004	11636	0.004	11636
SOP [t]	632		224		857	
Landings (t)	626		222		848	

Year:	2018	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		282		282		282
2	57	905	39.9	923	96	914
3	20	2572	7	1637	27	2147
4	63	3141	19	2343	82	2779
5	31	4110	4	3020	35	3615
6	14	5857	2	4394	17	5125
7	2	5220	0.52	4736	3	5000
8	0.7	9273	0.2	6684	1	7835
9	0.1	10572	0.0004	9407	0.1	10073
10	0.05	11636	0.0004	11636	0.05	11636
SOP [t]	554		98		652	
Landings (t)	549		97		646	

Year:	2018	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		282		282		282
2	64	1003	57	921	122	969
3	18	1989	10	1629	29	1881
4	26	3395	15	2424	41	2990
5	17	4202	12	2914	29	3665
6	14	5251	7	3662	21	4589
7	2	6851	3.5	3648	6	5516
8	2.8	9389	0.002	8166	2.8	9023
9	0.4	6303	0.18	5563	0.5	5986
10		11636		11636		11636
SOP [t]	383		159		542	
Landings (t)	387		161		547	

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 2018. 2/2

Year:	**2018**	**Quarter:**	**4**			
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		282		416		371
2	350	1176	253	1082	603	1134
3	9	2491	18	1671	27	2081
4	11	3624	20	2570	31	3038
5	4	4581	2	3351	6	3898
6	0.2	7906	4	3774	4	5611
7		5157	0.7	4178	0.7	4570
8		8908	0.05	6901	0.05	7704
9		7077		7077		7077
10		11636		11636		11636
SOP [t]	461		395		857	
Landings (t)	457		392		848	

Year:	**2018**	**Quarter:**	**All**			
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		282		336		312
2	655	986	393	955	1048	972
3	74	2182	46	1654	120	1956
4	178	3202	104	2429	283	2834
5	83	4110	32	3076	116	3618
6	44	5888	21	3993	66	4964
7	8	6031	5	4400	14	5261
8	4	9141	0.4	7247	5	8253
9	0.4	7984	0.2	7935	1	7961
10	0.05	11636	0.004	11636	0.05	11636
SOP [t]	2034		879		2913	
Landings (t)	2014		870		2884	

Table 2.3.8. Western Baltic Cod. Overview of the recreational total catch data used in stock assessment

	SD 22	SD23	SD24
CATON			
DK	1985-2008: Catch per year is calculated as the mean catch per year for the period 2009-2018, which is then weighted for each year with the number of Danish citizens being 18 – 65 years old.	Same as in SD 22	Same as in SD 22
	2009-2018: Statistics Denmark recall survey with adjusted estimates using correction factor from REKREA on-site studies on tour boats and private boats in SD23 in 2016-2018.	2009-2018: Statistics Denmark recall survey with adjusted estimates using correction factor from REKREA on-site studies on tour boats and private boats in 2016-2018.	Same as in SD 22
DE	1980-2004: reconstruction of the time-series is based on the average catch from 2009-2015. To account for the historic development (former GDR) catches in Mecklenburg-Western Pomerania were set to 20% from 1980-1991 with an annual linear increase by 20% between 1991-1995		Same as in SD 22
	2005-2014: Annual catch is calculated on the basis of a mail-diary study (effort) corrected with annual license sales and using CPUE data from an annual on-site intercept survey.		Same as in SD 22
	2015-2017: Annual catch is calculated on the basis of a national telephone-diary study (effort) corrected with annual license sales and using CPUE data from an annual on-site intercept survey.		Same as in SD 22
SE		1985-2010: Catch per year was calculated as the mean catch per year for the period 2011-2018	No estimate for 1985-2016.
		2011-2018: Tour boat census 2011-2018 and marina sampling of private boats 2017-2018	2017-2018; Marina sampling of private boats

Table 2.3.9. Western Baltic Cod. Overview of the recreational biological catch data used in stock assessment

Length			
DK	Same as for German data	From on-site studies 2012, 2013, 2016, 2017 and 2018 used in combination with Danish and Swedish data. An average of the time series was used to estimate the historic data (1985-2012)	Same as German data
DE	1980-2004: pooled length distribution from 2005-2017 on-site measurement from national survey onboard tour boats, private boats (sea-based), and from self-sampling during fishing competitions (land-based)		Same as in SD 22
	2005-2017: annual values from on-site measurement from national survey onboard tour boats, private boats (sea-based) and from self-sampling during fishing competitions (land-based)		Same as in SD 22
SE		Same as for Danish data	
Age			
DK	Same as for German data	Data from both Danish and Swedish recreational surveys, commercial landings and BITS survey. Data lacking from 1985 – 1990 and 2001-2003. Age length key based on mean values of the years 1991-1994 applied to the years 1985-1990. Mean age length key based on mean values of the years 1997-2000 and 2004-2008 applied to the years 2001-2003. Face value from 2016-2017.	Same as for German data
SE		Same as for Danish data.	
DE	1980-2002: matching the recreational catch length distribution (total numbers-at-length) with ALK from BITS data for each year.		Same as in SD 22
	2002-2017: matching the recreational length distribution (total numbers-at-length) with ALK from German commercial sampling data for each year.		Same as in SD 22

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	Percent WBC in landings for SD 24
1985	65	56	58
1986	65	46	52
1987	65	50	54
1988	65	50	53
1989	65	50	52
1990	65	50	52
1991	65	50	52
1992	65	54	57
1993	65	41	46
1994	65	47	51
1995	65	57	60
1996	66	49	57
1997	69	60	66
1998	72	71	71
1999	72	60	66
2000	71	49	60
2001	65	48	57
2002	63	45	54
2003	62	43	52
2004	61	40	49
2005	63	50	54
2006	54	35	44
2007	54	35	41
2008	46	20	27
2009	52	23	27
2010	57	26	33
2011	51	15	22

year	Area 1 _ W	Area 2_ E	Percent WBC in landings for SD 24
2012	52	19	23
2013	53	23	28
2014	51	25	31
2015	50	25	30
2016	58	23	28
2017	62	20	27
2018	51	20	23

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

age	a1	a2	a3	a4	a5	a6	a7+
1985	1569	6360	13467	2795	628	220	126
1986	3394	4885	4093	2838	439	169	77
1987	923	21491	3093	901	448	81	52
1988	948	5110	10932	912	205	141	62
1989	363	1068	3506	2368	210	58	47
1990	580	2739	1527	1376	689	80	43
1991	1415	5238	1917	441	266	221	65
1992	4021	6361	2492	472	94	73	71
1993	2	10171	3718	727	79	5	33
1994	669	3741	11158	1685	61	14	12
1995	676	10765	4638	5317	1141	123	3
1996	96	23597	17390	721	2068	108	2
1997	1831	2000	28844	2563	322	325	77
1998	2413	18597	2129	5721	654	105	76
1999	661	23558	12559	1602	1219	245	92
2000	813	6484	20538	3078	127	245	47
2001	1503	11121	7013	5111	841	49	95
2002	450	8615	8716	1659	923	269	18
2003	647	10092	4525	1303	230	190	65
2004	65	1519	8842	1923	340	123	84
2005	293	9153	1810	3256	374	99	53
2006	260	1575	11186	527	586	79	15
2007	58	3372	2657	3697	419	223	34
2008	20	597	2585	942	867	256	127
2009	179	453	1540	1007	521	189	83
2010	196	3503	1064	634	448	139	56
2011	70	848	3377	1268	285	81	40
2012	112	1300	1264	1919	523	60	14

age	a1	a2	a3	a4	a5	a6	a7+
2013	286	597	1719	802	734	311	68
2014	42	2657	1077	819	138	145	24
2015	172	943	3018	376	227	34	61
2016	1	876	1371	1028	140	55	34
2017	116	130	854	448	277	53	30
2018	0	1265	144	341	143	80	23

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

age	a1	a2	a3	a4	a5	a6	a7+
1985	3721	2575	667	14	0	0	0
1986	7215	1774	182	13	0	0	0
1987	1837	7305	129	4	0	0	0
1988	1583	1458	382	3	0	0	0
1989	581	292	117	8	0	0	0
1990	906	731	50	5	0	0	0
1991	2803	1772	79	2	0	0	0
1992	9048	2444	117	2	0	0	0
1993	1290	3826	171	3	0	0	0
1994	1962	1873	684	11	0	0	0
1995	2139	5819	307	36	0	0	0
1996	22617	2408	10	0	0	0	0
1997	15207	0	0	0	0	0	0
1998	17005	2708	121	0	0	0	0
1999	2662	9002	302	0	0	0	0
2000	2679	4390	2486	0	0	0	0
2001	1982	4463	306	48	0	0	0
2002	1510	2243	217	16	0	0	0
2003	1065	7587	414	13	0	0	0
2004	2240	864	2371	0	0	0	0
2005	968	7640	44	0	0	0	0
2006	872	2633	763	43	2	0	0
2007	277	2466	504	39	5	0	0
2008	72	543	193	4	0	0	0
2009	197	499	185	13	0	0	0
2010	225	942	490	313	7	0	0
2011	188	144	177	206	6	0	0
2012	366	310	176	124	3	0	0

age	a1	a2	a3	a4	a5	a6	a7+
2013	903	666	500	469	52	0	0
2014	667	1592	48	7	0	0	0
2015	220	829	303	23	0	0	0
2016	40	282	50	1	0	0	0
2017	451	99	54	12	1	0	0
2018	10	563	7	3	3	0	0

Table 2.3.13. Western Baltic cod. Recreational catch (in numbers (000)) by year and age for the western Baltic cod stock. Data from Germany, Denmark and Sweden.*

age	a1	a2	a3	a4	a5	a6	a7+
1985	403	621	640	231	82	21	8
1986	390	749	628	215	64	15	2
1987	323	654	630	209	95	30	9
1988	325	670	631	240	71	11	1
1989	357	589	640	306	84	17	4
1990	327	626	624	222	133	14	6
1991	342	792	562	159	21	6	1
1992	470	566	850	182	33	10	2
1993	421	942	524	312	96	7	1
1994	551	933	1057	139	67	8	1
1995	554	1408	783	443	43	15	1
1996	342	1584	814	354	102	12	4
1997	851	822	1130	299	66	16	2
1998	602	1450	611	495	58	13	4
1999	273	1543	806	289	131	15	3
2000	571	1231	935	372	77	25	3
2001	437	1348	734	442	79	12	4
2002	767	1138	921	218	118	12	3
2003	244	1682	746	269	71	13	3
2004	738	1203	992	231	45	5	1
2005	99	2517	506	561	22	3	2
2006	356	608	1375	83	77	7	1
2007	140	1352	415	457	28	15	2
2008	30	577	927	338	129	11	3
2009	367	1701	568	313	54	36	10
2010	293	1944	446	245	127	31	13
2011	209	857	1139	85	23	10	5
2012	284	1138	760	732	63	14	0

age	a1	a2	a3	a4	a5	a6	a7+
2013	517	1450	848	158	121	11	5
2014	367	1930	959	442	68	26	10
2015	160	1596	1663	222	101	24	13
2016	159	1178	1019	502	95	20	5
2017	384	306	491	140	67	11	4
2018	38	1260	113	192	44	13	3

***An error was discovered and the table was updated in August 2019. The correct numbers had been used in the assessment model.**

Table 2.3.14. Western Baltic cod. Total catch in numbers ('000) at age (incl. Landing, discards, recreational catch) for the western Baltic cod stock.

age	a1	a2	a3	a4	a5	a6	a7+
1985	5693	9556	14775	3040	709	241	134
1986	10999	7407	4903	3066	504	184	79
1987	3083	29450	3851	1114	543	111	61
1988	2857	7238	11945	1155	276	152	63
1989	1302	1949	4263	2682	293	75	51
1990	1813	4096	2201	1603	822	94	49
1991	4560	7802	2558	602	287	227	65
1992	13539	9372	3459	656	127	83	73
1993	1713	14939	4414	1042	175	12	33
1994	3182	6548	12898	1834	128	22	14
1995	3369	17992	5727	5796	1184	138	4
1996	23055	27589	18214	1074	2170	120	5
1997	17889	2822	29974	2863	388	340	79
1998	20020	22756	2861	6217	712	118	80
1999	3596	34103	13667	1890	1349	260	95
2000	4063	12105	23958	3450	204	269	50
2001	3922	16931	8052	5601	920	61	98
2002	2727	11996	9854	1892	1041	282	21
2003	1956	19362	5684	1585	301	203	69
2004	3042	3586	12205	2153	385	128	84
2005	1360	19310	2360	3816	396	101	55
2006	1488	4816	13324	652	665	86	16
2007	475	7190	3575	4194	453	239	36
2008	123	1717	3705	1284	996	267	130
2009	743	2653	2293	1333	575	225	93
2010	714	6389	2000	1191	583	170	69
2011	467	1849	4693	1558	315	90	45
2012	762	2748	2199	2775	588	74	14

age	a1	a2	a3	a4	a5	a6	a7+
2013	1706	2714	3067	1429	907	322	74
2014	1076	6179	2084	1269	206	170	34
2015	553	3367	4984	621	328	57	75
2016	200	2336	2440	1530	235	75	39
2017	951	536	1398	601	345	64	34
2018	49	3088	264	536	190	93	26

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

age	a1	a2	a3	a4	a5	a6	a7+
1985	0.456	0.744	1.159	2.113	3.605	5.768	8.812
1986	0.457	0.747	1.160	2.102	3.578	5.714	8.131
1987	0.462	0.756	1.162	2.075	3.512	5.581	8.128
1988	0.461	0.756	1.162	2.077	3.516	5.590	8.191
1989	0.462	0.757	1.162	2.071	3.502	5.561	7.982
1990	0.463	0.759	1.163	2.065	3.487	5.532	8.181
1991	0.468	0.770	1.165	2.033	3.409	5.374	7.508
1992	0.471	0.776	1.167	2.015	3.366	5.287	7.379
1993	0.464	0.762	1.163	2.057	3.468	5.492	7.627
1994	0.445	0.834	1.367	2.378	4.491	6.436	5.045
1995	0.398	0.792	1.215	2.112	3.643	6.064	10.446
1996	0.442	0.685	1.086	2.091	2.879	5.544	8.371
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	7.303
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	6.132
2005	0.599	0.738	1.270	2.207	3.362	4.875	6.874
2006	0.217	0.625	1.086	2.485	3.674	4.205	5.725
2007	0.412	0.862	1.186	2.093	3.185	4.747	6.423
2008	0.437	0.906	1.347	2.187	3.234	4.352	6.953
2009	0.768	0.702	1.158	1.794	3.120	4.979	4.986
2010	0.807	0.944	1.111	1.805	2.924	3.384	4.305
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

age	a1	a2	a3	a4	a5	a6	a7+
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	0.710	1.027	1.239	2.488	3.273	4.947	6.306
2017	0.796	1.059	1.423	2.265	3.650	4.274	5.478
2018	0.550	1.015	1.870	2.702	3.674	4.937	6.050

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

age	a1	a2	a3	a4	a5
1985-2014	0.262	0.391	0.531	0.469	0.469
2015	0.155	0.333	0.363	0.352	0.352
2016	0.297	0.371	0.487	0.962	0.962
2017	0.221	0.405	0.649	0.789	0.789
2018	0.239	0.268	0.719	1.336	1.336

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+
1985	0.313	0.647	1.131	2.092	3.502	5.599	8.526
1986	0.319	0.660	1.151	2.084	3.479	5.563	8.049
1987	0.322	0.666	1.140	2.027	3.318	4.932	7.495
1988	0.328	0.682	1.144	2.041	3.342	5.468	8.170
1989	0.303	0.697	1.139	2.028	3.258	5.186	7.743
1990	0.326	0.697	1.145	2.028	3.277	5.260	7.676
1991	0.326	0.685	1.180	2.024	3.389	5.359	7.499
1992	0.333	0.682	1.165	2.039	3.357	5.105	7.338
1993	0.341	0.678	1.158	1.997	2.861	4.257	7.591
1994	0.328	0.700	1.324	2.387	3.793	5.589	5.220
1995	0.292	0.665	1.180	2.097	3.635	5.871	9.176
1996	0.261	0.664	1.097	2.026	2.875	5.412	6.501
1997	0.294	0.763	1.006	1.712	2.354	4.021	6.387
1998	0.294	0.704	1.145	1.917	2.953	3.983	6.405
1999	0.308	0.601	1.131	1.481	3.087	3.908	4.965
2000	0.314	0.600	0.930	1.699	3.421	5.103	6.975
2001	0.372	0.620	1.089	1.753	3.171	4.944	6.988
2002	0.340	0.671	1.131	1.746	3.332	4.089	6.495
2003	0.373	0.647	1.103	2.008	3.531	5.102	7.164
2004	0.287	0.710	0.952	1.548	3.363	4.171	6.128
2005	0.326	0.605	1.271	2.144	3.345	4.889	6.830
2006	0.306	0.525	1.076	2.323	3.542	4.202	5.765
2007	0.359	0.692	1.114	2.055	3.146	4.694	6.478
2008	0.431	0.805	1.326	2.118	3.153	4.323	6.945
2009	0.425	0.464	1.170	1.869	3.129	4.680	4.798
2010	0.518	0.803	1.048	1.563	2.828	3.369	4.596
2011	0.434	0.967	1.259	1.309	1.938	2.599	2.359
2012	0.410	0.820	1.188	1.890	2.654	2.500	3.546

age	a1	a2	a3	a4	a5	a6	a7+
2013	0.385	0.743	1.161	1.406	2.354	3.286	3.495
2014	0.334	0.762	1.336	2.456	3.308	5.090	4.395
2015	0.341	0.665	1.452	2.373	4.184	3.652	6.172
2016	0.482	0.835	1.209	2.260	2.919	4.461	6.011
2017	0.280	0.712	1.293	2.123	3.430	4.131	5.458
2018	0.155	0.761	1.680	2.361	3.364	4.690	5.910

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

age	a0	a1	a2	a3	a4	a5	a6	a7+
1985	0.005	0.063	0.301	0.874	2.092	3.502	5.599	8.526
1986	0.005	0.063	0.301	0.874	2.084	3.479	5.563	8.049
1987	0.005	0.063	0.301	0.874	2.027	3.318	4.932	7.495
1988	0.005	0.063	0.301	0.874	2.041	3.342	5.468	8.170
1989	0.005	0.063	0.301	0.874	2.028	3.258	5.186	7.743
1990	0.005	0.063	0.301	0.874	2.028	3.277	5.260	7.676
1991	0.005	0.063	0.301	0.874	2.024	3.389	5.359	7.499
1992	0.005	0.063	0.301	0.874	2.039	3.357	5.105	7.338
1993	0.005	0.063	0.301	0.874	1.997	2.861	4.257	7.591
1994	0.005	0.063	0.301	0.874	2.387	3.793	5.589	5.220
1995	0.005	0.063	0.301	0.874	2.097	3.635	5.871	9.176
1996	0.005	0.057	0.259	0.990	2.026	2.875	5.412	6.501
1997	0.005	0.050	0.327	0.896	1.712	2.354	4.021	6.387
1998	0.005	0.081	0.316	0.735	1.917	2.953	3.983	6.405
1999	0.005	0.042	0.285	0.801	1.481	3.087	3.908	4.965
2000	0.005	0.059	0.234	0.801	1.699	3.421	5.103	6.975
2001	0.005	0.043	0.388	0.895	1.753	3.171	4.944	6.988
2002	0.005	0.043	0.433	1.117	1.746	3.332	4.089	6.495
2003	0.005	0.054	0.321	1.032	2.008	3.531	5.102	7.164
2004	0.005	0.067	0.536	0.870	1.548	3.363	4.171	6.128

2005	0.005	0.051	0.350	1.038	2.144	3.345	4.889	6.830
2006	0.005	0.043	0.310	0.795	2.323	3.542	4.202	5.765
2007	0.005	0.073	0.411	0.908	2.055	3.146	4.694	6.478
2008	0.005	0.043	0.465	1.019	2.118	3.153	4.323	6.945
2009	0.005	0.051	0.559	1.327	1.869	3.129	4.680	4.798
2010	0.005	0.066	0.369	1.082	1.563	2.828	3.369	4.596
2011	0.005	0.045	0.360	0.767	1.309	1.938	2.599	2.359
2012	0.005	0.050	0.301	0.882	1.890	2.654	2.500	3.546
2013	0.005	0.049	0.391	0.866	1.406	2.354	3.286	3.495
2014	0.005	0.039	0.345	0.965	2.456	3.308	5.090	4.395
2015	0.005	0.055	0.409	0.924	2.373	4.184	3.652	6.172
2016	0.005	0.047	0.341	0.690	2.260	2.919	4.461	6.011
2017	0.005	0.031	0.195	1.022	2.123	3.430	4.131	5.458
2018	0.005	0.075	0.319	0.678	2.361	3.364	4.690	5.910
2019	0.005	0.051	0.285	0.797	2.248	3.238	4.428	5.793

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

age	a1	a2	a3	a4	a5	a6	a7+
1985	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1986	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1987	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1988	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1989	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1990	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1991	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1992	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1993	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1994	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1995	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1996	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1997	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1998	0.03	0.34	0.77	0.72	1.0	1.0	1.0
1999	0.03	0.34	0.77	0.72	1.0	1.0	1.0
2000	0.03	0.34	0.77	0.72	1.0	1.0	1.0
2001	0.02	0.39	0.76	0.73	1.0	1.0	1.0
2002	0.02	0.41	0.76	0.72	1.0	1.0	1.0
2003	0.01	0.40	0.78	0.77	1.0	1.0	1.0
2004	0.01	0.47	0.80	0.81	1.0	1.0	1.0
2005	0.01	0.46	0.78	0.87	1.0	1.0	1.0
2006	0.01	0.40	0.79	0.89	1.0	1.0	1.0
2007	0.02	0.44	0.76	0.90	1.0	1.0	1.0
2008	0.01	0.53	0.79	0.89	1.0	1.0	1.0
2009	0.01	0.58	0.82	0.90	1.0	1.0	1.0
2010	0.06	0.70	0.84	0.93	1.0	1.0	1.0
2011	0.07	0.72	0.85	0.91	1.0	1.0	1.0
2012	0.07	0.75	0.88	0.91	1.0	1.0	1.0

age	a1	a2	a3	a4	a5	a6	a7+
2013	0.07	0.71	0.87	0.91	1.0	1.0	1.0
2014	0.07	0.64	0.85	0.89	1.0	1.0	1.0
2015	0.04	0.61	0.88	0.91	1.0	1.0	1.0
2016	0.06	0.68	0.89	0.89	1.0	1.0	1.0
2017	0.04	0.59	0.88	0.90	1.0	1.0	1.0
2018	0.07	0.64	0.87	0.88	1.0	1.0	1.0
2019*	0.06	0.64	0.88	0.89	1.0	1.0	1.0

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

age	a0	a1	a2	a3	a4	a5	a6	a7+
1985	0.8	0.32	0.2	0.2	0.2	0.2	0.2	0.2
1986	0.8	0.261	0.2	0.2	0.2	0.2	0.2	0.2
1987	0.8	0.259	0.2	0.2	0.2	0.2	0.2	0.2
1988	0.8	0.274	0.2	0.2	0.2	0.2	0.2	0.2
1989	0.8	0.263	0.2	0.2	0.2	0.2	0.2	0.2
1990	0.8	0.25	0.2	0.2	0.2	0.2	0.2	0.2
1991	0.8	0.235	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.8	0.228	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.8	0.245	0.2	0.2	0.2	0.2	0.2	0.2
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
1997-2018	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, Q1 and pound net survey FEJUCS.

BITS Q1	a1	a2	a3	a4
1996	15644	112846	16465	224
1997	15318	2575	14144	484
1998	33027	7707	675	498
1999	9027	14087	2992	63
2000	13081	6285	7867	1195
2001	6007	4496	1069	500
2002	14054	2718	1623	101
2003	1195	3908	480	139
2004	12408	1415	2013	50
2005	11184	30183	1114	522
2006	16380	5464	6140	103
2007	3199	8475	1933	1083
2008	157	914	958	233
2009	10510	649	722	217
2010	4127	9381	319	113
2011	14945	6832	11324	37
2012	2730	3146	1392	825
2013	10000	2710	1976	184
2014	6052	4402	527	163
2015	3952	4820	1630	113
2016	96	920	518	334
2017	25742	572	971	164
2018	550	24776	904	435
2019	352	1900	7467	310

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

BITS Q4	a0	a1	a2	a3	a4
1999	10962	6701	3137	178	32
2000	3659	3658	933	139	33
2001	12935	890	457	57	106
2002	1420	2174	336	107	18
2003	14362	1387	875	42	55
2004	5121	12355	985	165	40
2005	4113	2738	1693	63	93
2006	2272	4059	359	398	102
2007	477	459	194	104	379
2008	19816	58	61	47	96
2009	2729	2683	70	61	30
2010	9533	982	618	17	15
2011	3460	1885	130	103	9
2012	16518	1779	430	54	67
2013	7328	4229	206	49	31
2014	5801	1878	813	81	76
2015	307	1063	357	145	66
2016	37980	404	86	18	137
2017	232	16894	85	58	80
2018	1664	1081	441	23	41

Continued
Table 2.3.21. Western Baltic cod. Tuning fleets. Pound net survey (FEJUCS).

FEJUCS	a0
2011	20.7
2012	NA
2013	16.9
2014	25.6
2015	4.3

FEJUCS	a0
2016	164.2
2017	0.4
2018	2.2

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

Year	R(age 1)	Low	High	SSB	Low	High	F_{bar}(3-5)	Low	High	Landings	Discard	Recreational
1985	28685	15994	51446	30167	24187	37625	1.33	1.10	1.62	33188		2075
1986	79493	44993	140449	18852	15637	22728	1.25	1.04	1.50	20088		2078
1987	25929	14928	45037	17492	14533	21054	1.14	0.95	1.38	21692		2081
1988	11334	6447	19924	21628	17027	27473	1.12	0.93	1.35	20672		2082
1989	13917	8007	24189	15794	12778	19521	1.01	0.83	1.23	12795		2083
1990	21545	12402	37430	12279	10171	14823	1.15	0.96	1.38	12237		2085
1991	32863	18925	57065	9710	8190	11511	1.30	1.09	1.55	12931		2087
1992	64599	36929	112999	9547	7876	11573	1.34	1.13	1.60	15672		2420
1993	26179	15001	45686	13817	11017	17329	1.18	0.98	1.41	11815		2752
1994	59916	34320	104602	24937	19363	32116	1.07	0.89	1.30	16642	1614	3088
1995	93089	52872	163896	29086	23619	35817	1.28	1.06	1.55	28310	3016	3417
1996	25133	14078	44868	35958	29144	44366	1.14	0.95	1.37	38505	6868	3419
1997	80526	47918	135323	40762	31648	52501	1.15	0.96	1.38	37077	3981	3420
1998	125200	75175	208514	27947	22892	34119	1.12	0.94	1.35	29634	5575	3410
1999	43392	26754	70377	33310	27530	40304	1.33	1.12	1.58	35934	4378	3416
2000	44495	27876	71021	33990	27368	42214	1.28	1.08	1.52	31132	3738	3432

Year	R(age 1)	Low	High	SSB	Low	High	F_{bar}(3-5)	Low	High	Landings	Discard	Recreational
2001	27508	17035	44421	28683	23976	34315	1.38	1.17	1.63	27781	2449	3427
2002	48892	30224	79090	25137	20826	30341	1.33	1.13	1.58	20410	1395	3437
2003	15230	9377	24734	20519	17287	24356	1.16	0.98	1.39	17205	3473	3448
2004	66051	40920	106615	23390	18927	28904	1.15	0.96	1.37	17686	2189	3445
2005	22142	13785	35566	26537	21979	32041	1.08	0.90	1.31	18493	3265	3771
2006	24905	15345	40422	27471	22137	34089	0.83	0.67	1.03	18503	1686	2923
2007	7986	4956	12866	28691	23451	35102	0.89	0.73	1.08	17384	1325	2782
2008	4090	2322	7206	21230	17849	25250	0.97	0.80	1.17	11302	336	3039
2009	28372	17291	46557	15546	13157	18367	1.05	0.87	1.26	7313	351	2648
2010	10620	6610	17061	14459	12073	17318	1.09	0.90	1.31	8007	838	3367
2011	15517	9580	25133	13529	10851	16869	0.97	0.80	1.18	9107	299	2595
2012	12418	7762	19867	16711	13717	20358	0.87	0.71	1.07	8622	370	3661
2013	29082	17984	47030	14076	11853	16715	1.13	0.92	1.38	7697	1007	3106
2014	17003	10507	27514	15775	13224	18818	0.94	0.77	1.15	8083	837	4044
2015	10697	6593	17354	17368	14286	21114	0.88	0.70	1.11	8390	432	4568
2016	2996	1759	5103	13679	10967	17060	0.80	0.60	1.07	6122	143	3505
2017	39319	21007	73594	11374	8458	15296	0.56	0.37	0.85	3861	180	1315

Year	R(age 1)	Low	High	SSB	Low	High	F_{bar}(3-5)	Low	High	Landings	Discard	Recreational
2018	2946	1385	6266	14509	9338	22544	0.37	0.20	0.69	3555	157	1600
2019*	2226	682	7079	21297	11129	38450						

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

Year Age	0	1	2	3	4	5	6	7
1985	167081	28685	19552	21058	4170	1127	358	200
1986	58528	79493	16635	7477	4411	806	275	126
1987	26574	25929	54840	6597	1775	922	198	102
1988	31408	11334	17080	20094	1836	455	250	92
1989	47969	13917	6353	7397	4862	501	132	93
1990	73790	21545	9442	3182	2247	1346	163	76
1991	133614	32863	15267	4031	822	500	354	78
1992	63151	64599	21838	5825	960	156	117	101
1993	130826	26179	44264	9220	1396	196	24	48
1994	191002	59916	17822	23708	3280	296	34	18
1995	62813	93089	45286	8515	8896	1228	97	9
1996	173320	25133	77692	23178	2009	2444	252	13
1997	259006	80526	10927	41727	5210	604	553	89
1998	101345	125200	53059	5430	9806	1239	178	150
1999	96084	43392	83419	23750	1873	2168	334	107
2000	60149	44495	28060	33538	5723	347	436	83
2001	100327	27508	32094	11173	8141	1430	80	122
2002	34548	48892	20368	13534	2440	1559	365	36
2003	128783	15230	41091	8254	2775	536	337	96
2004	50790	66051	10870	20133	2494	611	164	119
2005	50336	22142	53926	4910	5694	618	139	73
2006	18169	24905	15094	26000	1702	1370	157	40
2007	9522	7986	17373	7649	8219	788	461	64
2008	60145	4090	6021	7345	2817	1853	323	185
2009	24997	28372	4741	4236	2421	887	400	139
2010	36161	10620	22647	3115	1692	700	228	115
2011	29545	15517	7194	12704	1547	501	135	71
2012	64929	12418	10894	4461	4754	779	148	38

Year Age	0	1	2	3	4	5	6	7
2013	39218	29082	8292	6206	1831	1434	308	77
2014	25245	17003	20188	4127	2147	388	314	71
2015	7348	10697	11151	9789	1419	577	105	120
2016	82092	2996	7440	4637	3322	444	157	70
2017	5904	39319	2295	4091	1694	911	146	77
2018	4820	2946	25478	1409	1926	687	345	90

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

Year Age	age 1	age 2	age 3	age 4	age 5-7
1985	0.17	0.77	1.34	1.40	1.26
1986	0.16	0.72	1.25	1.31	1.19
1987	0.14	0.66	1.14	1.20	1.09
1988	0.14	0.63	1.11	1.17	1.08
1989	0.12	0.55	0.99	1.06	0.99
1990	0.13	0.61	1.11	1.20	1.14
1991	0.14	0.67	1.22	1.36	1.32
1992	0.14	0.66	1.23	1.40	1.41
1993	0.12	0.56	1.06	1.22	1.27
1994	0.11	0.51	0.96	1.10	1.16
1995	0.12	0.61	1.16	1.31	1.38
1996	0.12	0.56	1.06	1.17	1.19
1997	0.11	0.57	1.07	1.19	1.19
1998	0.11	0.56	1.05	1.17	1.15
1999	0.13	0.66	1.24	1.39	1.36
2000	0.12	0.65	1.21	1.34	1.30
2001	0.13	0.70	1.31	1.44	1.39
2002	0.12	0.67	1.26	1.40	1.35
2003	0.10	0.58	1.08	1.22	1.20
2004	0.10	0.55	1.03	1.19	1.21
2005	0.09	0.51	0.95	1.12	1.17
2006	0.07	0.40	0.74	0.86	0.91
2007	0.07	0.42	0.77	0.92	0.98
2008	0.07	0.43	0.81	1.00	1.10
2009	0.07	0.45	0.86	1.08	1.20
2010	0.07	0.45	0.87	1.13	1.26
2011	0.07	0.40	0.77	1.01	1.13
2012	0.06	0.37	0.71	0.91	1.00

Year Age	age 1	age 2	age 3	age 4	age 5-7
2013	0.08	0.47	0.91	1.18	1.29
2014	0.07	0.41	0.78	0.98	1.06
2015	0.06	0.39	0.74	0.92	0.99
2016	0.06	0.36	0.68	0.83	0.89
2017	0.04	0.26	0.47	0.58	0.63
2018	0.03	0.17	0.31	0.39	0.42

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

2019								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt***	**Sel**	**CWt**
1	2226	0.242	0.06	0	0	0.05	0.028	0.31
2		0.2	0.64	0	0	0.29	0.17	0.77
3		0.2	0.88	0	0	0.80	0.312	1.39
4		0.2	0.89	0	0	2.25	0.386	2.25
5		0.2	1.00	0	0	3.24	0.417	3.24
6		0.2	1.00	0	0	4.43	0.417	4.43
7		0.2	1.00	0	0	5.79	0.417	5.79

2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt***	**Sel**	**CWt**
1	11659	0.242	0.06	0	0	0.05	0.028	0.31
2		0.2	0.64	0	0	0.29	0.17	0.77
3		0.2	0.88	0	0	0.80	0.312	1.39
4		0.2	0.89	0	0	2.25	0.386	2.25
5		0.2	1.00	0	0	3.24	0.417	3.24
6		0.2	1.00	0	0	4.43	0.417	4.43
7		0.2	1.00	0	0	5.79	0.417	5.79

2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt***	**Sel**	**CWt**
1	11622	0.242	0.06	0	0	0.05	0.028	0.31
2		0.2	0.64	0	0	0.29	0.17	0.77
3		0.2	0.88	0	0	0.80	0.312	1.39
4		0.2	0.89	0	0	2.25	0.386	2.25
5		0.2	1.00	0	0	3.24	0.417	3.24
6		0.2	1.00	0	0	4.43	0.417	4.43
7		0.2	1.00	0	0	5.79	0.417	5.79

Input units are thousands and kg -

M = Natural Mortality
Mat = Maturity ogive
PF = Proportion of F before spawning
PM = Proportion of M before spawning
SWt = Weight in stock (Kg);
Sel = 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 2015–2017
Weight in the stock (SWt): average of 2015–2017
Exploitation pattern (Sel.): average of 2017

Table 2.3.26. Western Baltic Cod. Short-term intermediate year (2019).

Variable	Value	Notes
Fages 3–5 (2019)	0.33	Based on catch constrain in 2019
SSB (2020)	29613	Based on catch constrain in 2019
Rage1 (2019)	2226	SAM assessment
Rage1 (2020)	11659	Sampled from the last ten years
Rage1 (2021)	11622	Sampled from the last ten years
Total catch (2019)	7988	Commercial + recreational catches.
Commercial catches (2019)	5848	Calculated as the 2019 TAC (9515 tonnes) plus an assumed discard ratio as in 2018 (4.2%), and accounting for the proportion of western Baltic cod in commercial catches in subdivisions 22–24 in 2018 (59%).
Recreational catches (2019)	2140	As it is unclear how the new bag limit will affect the fisheries in 2019 (from 5-7 cod/ day), an average over 3 years (2016–2018) of recreational catch has been used.

Table 2.3.27. Western Baltic Cod. Output of short-term forecast.

Rationale	Total catch 2020*	Commercial catch, assuming a Recreational catch of 2140 tonnes	Basis	F_{total} 2020	SSB 2021	%SSB change^	Unwanted Catch 2020	Wanted Catch	%change in advice
F_{MSY}	7245	5105	F_{MSY}	0.26	32310	10	216	4889	-52
Zero commercial catch	2140	0	Zero commercial catch	0.07***	38560	32	0	0	-86
F_{MSY} ranges	5205	3065	lower	0.18	34657	18	130	2935	-43
	11006	8866	upper	0.43	27251	-7	376	8490	-54
Other options	19551	17411	F_{pa}	0.99	16350	-44	738	16673	30
	23904	21764	F_{lim}	1.45	11054	-62	922	20842	59
	20972	18832	B_{lim}	1.11	14500	-51	798	18034	40
	15148	13008	$B_{trigger}$	0.66	21876	-25	551	12457	0.85
	9089	6949	$F=F_{2019}$	0.34	29818	2	294	6655	-39
upper	11006	9549	upper	0.43	27251	-7	405	9144	-54
F_{MSY}	7245	5788	F_{MSY}	0.26	32310	10	245	5543	-52
lower	5205	3748	lower	0.18	34657	18	159	3589	-43

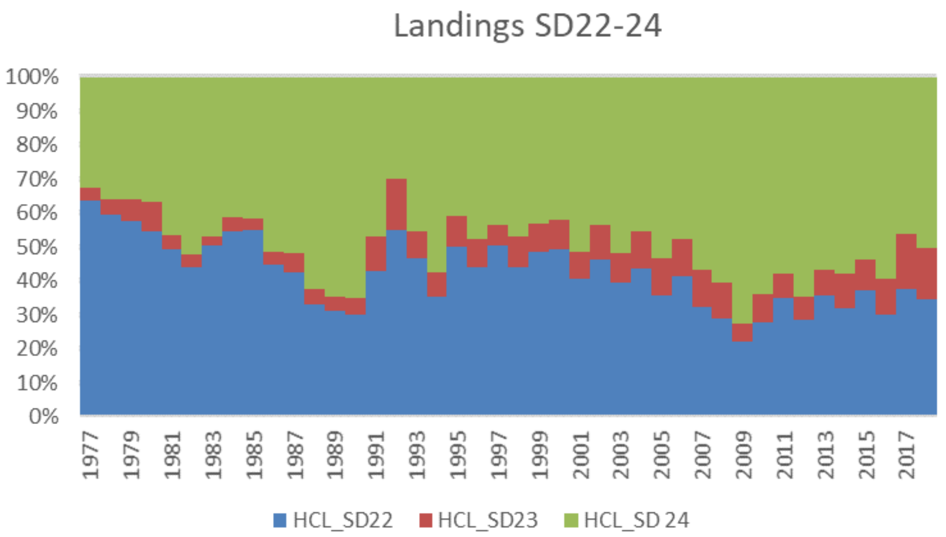


Figure 2.3.1. Western Baltic cod. Relative landings by SD (tonnes) for the western Baltic management area (both east and west cod included). HCL: human consumption landings.

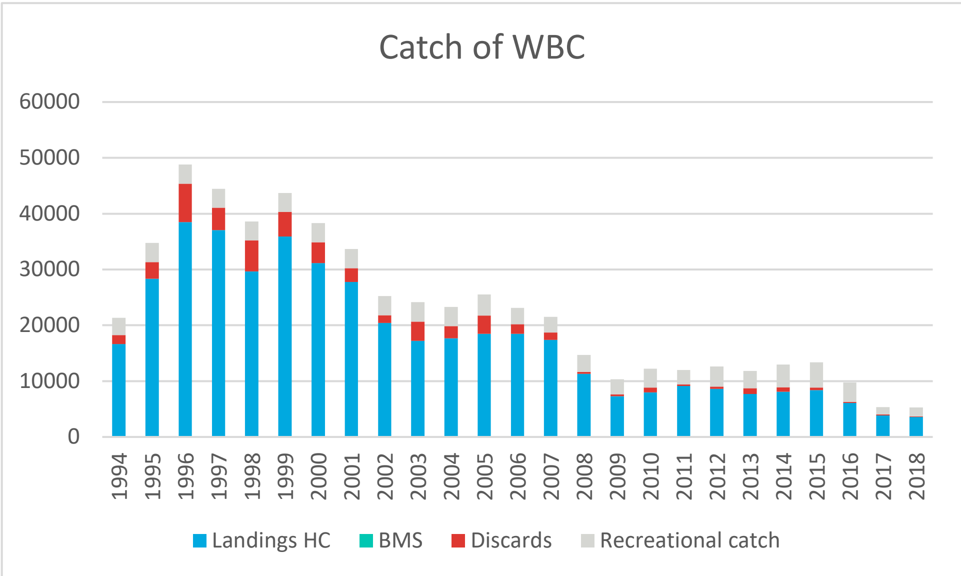


Figure 2.3.2. Western Baltic cod. Commercial landings, discard and recreational catch (tonnes) of the WBC stock.

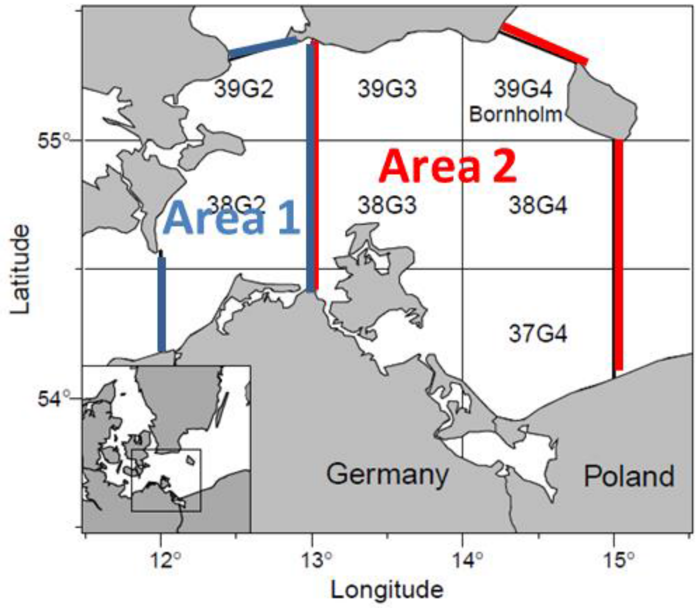


Figure 2.3.3. Western Baltic cod. Subareas (Area 1 and Area 2 within SD 24) for which different keys for splitting between eastern and western Baltic cod catches in SD 24 were applied.

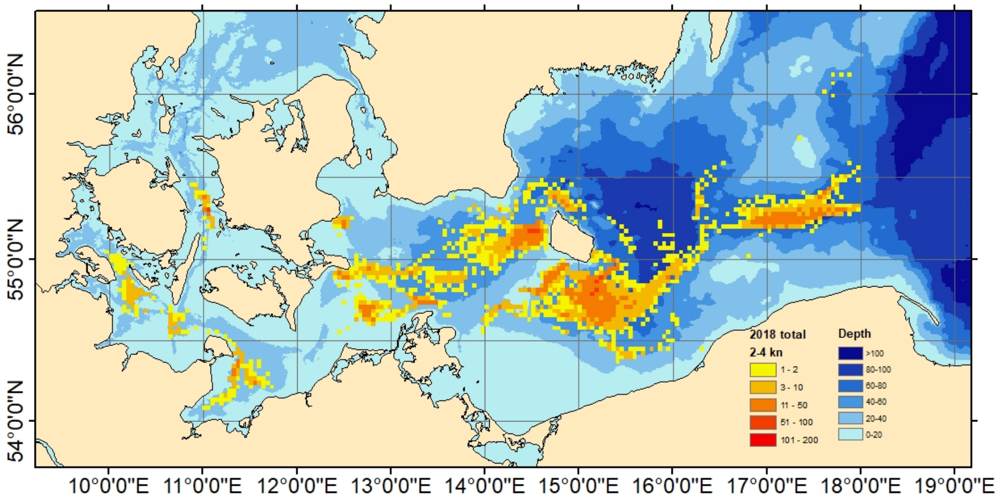


Figure 2.3.4. Danish VMS data from 2018.

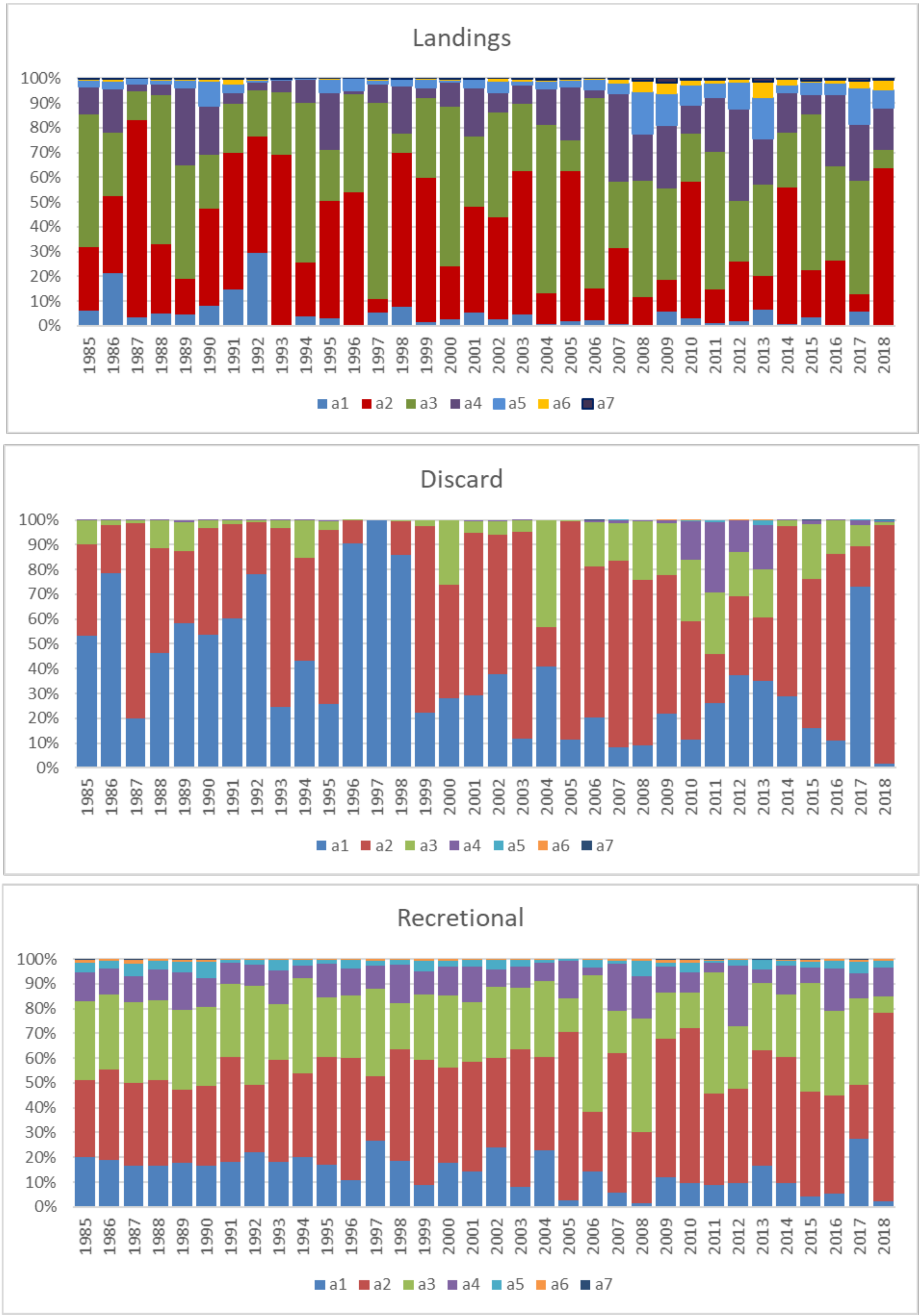


Figure 2.3.5. Western Baltic cod. Number at age distribution of cod in commercial landings, discards and recreational catch (relative proportions).

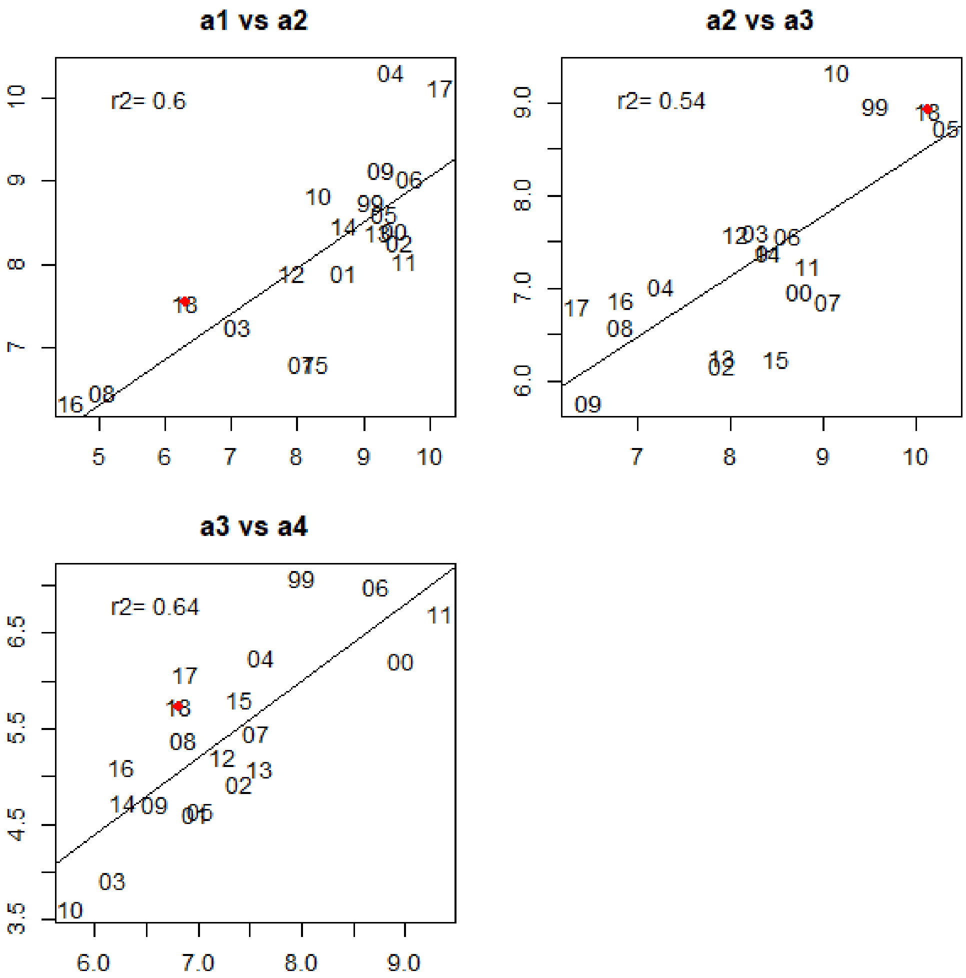


Figure 2.3.6. Western Baltic cod. CPUE at age i vs. numbers at age i+1 in the following year, in BITS Q1 survey. Red dots highlight the information from the latest year.

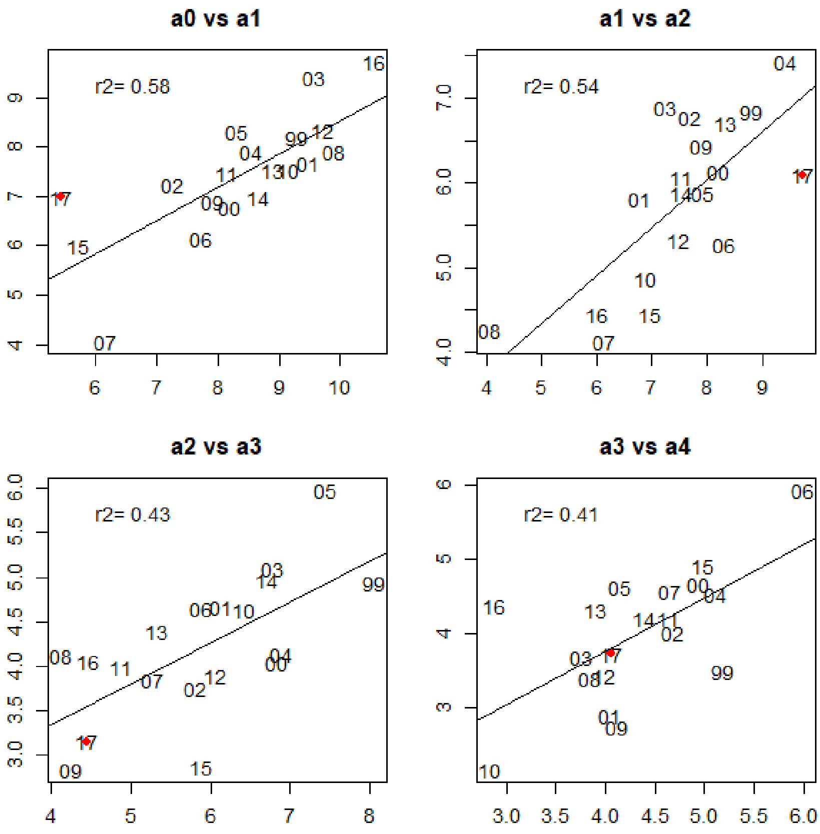


Figure 2.3.7. Western Baltic cod. CPUE at age i vs. numbers at age i +1 in the following year, in BITS Q4 survey. Red dots highlight the information from the latest year.

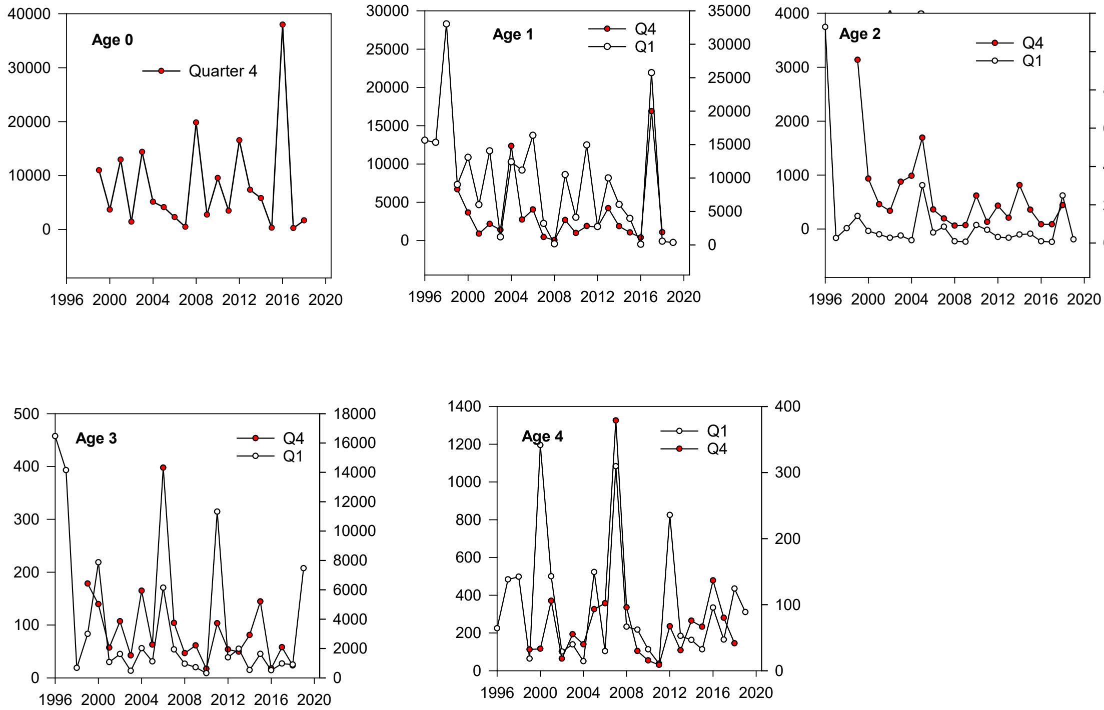


Figure 2.3.8. Western Baltic cod. Time series of BITS Q1 and BITS Q4 in numbers by age groups.

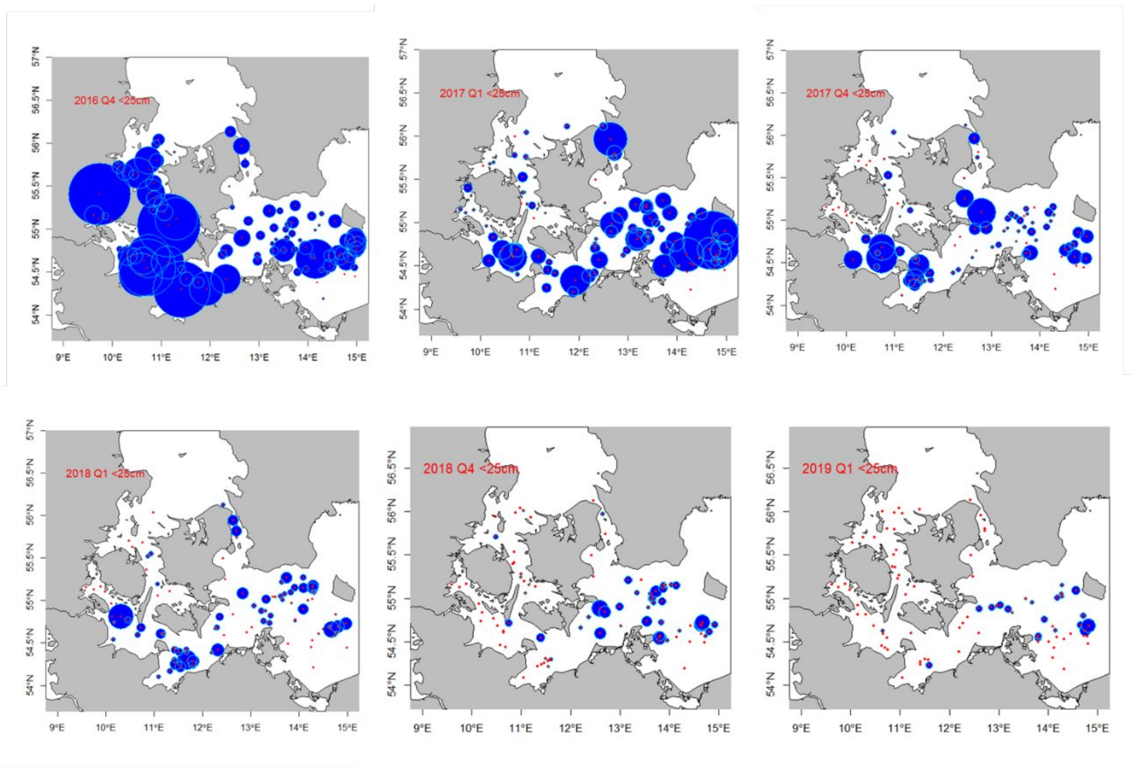


Figure 2.3.9. Western Baltic cod. Distribution of cod<25 cm from BITS Q4 2016, 2017 and 2018.

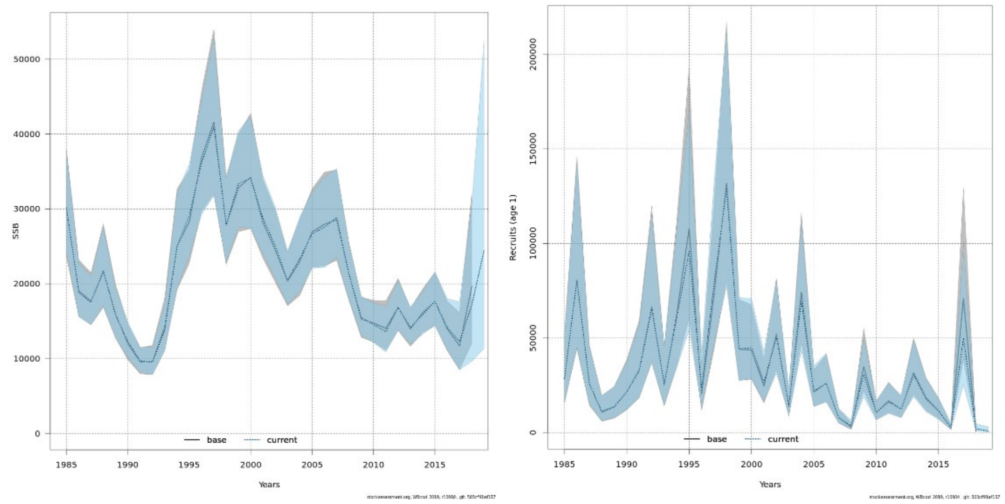


Figure 2.3.10. Western Baltic cod. The SSB and R from exploratory runs were BITS-Q4 survey in 2018 has been excluded.

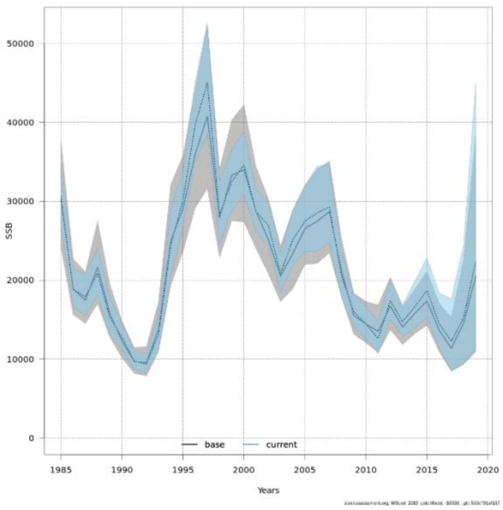


Figure 2.3.11. Western Baltic cod. Exploratory run showing the SSB, where catch has been used without uncertainties on catch data.

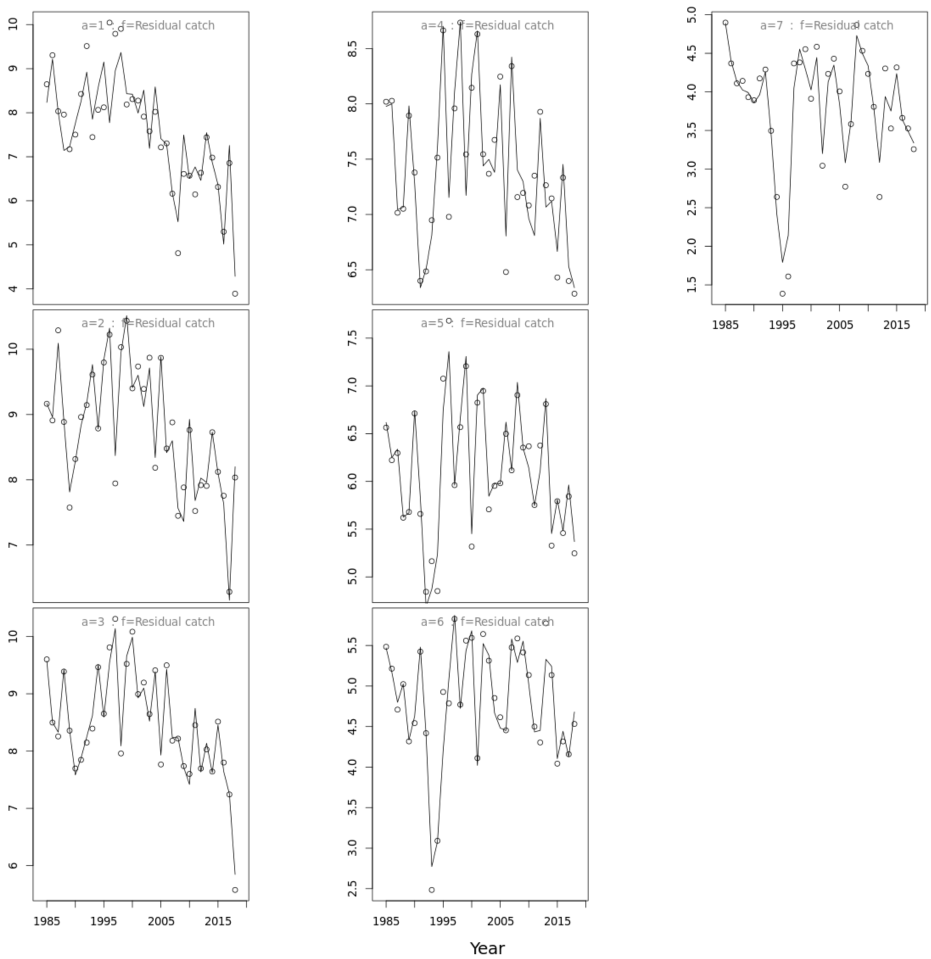


Figure 2.3.12. Western Baltic cod. Commercial catch data fit to the model by age and year.

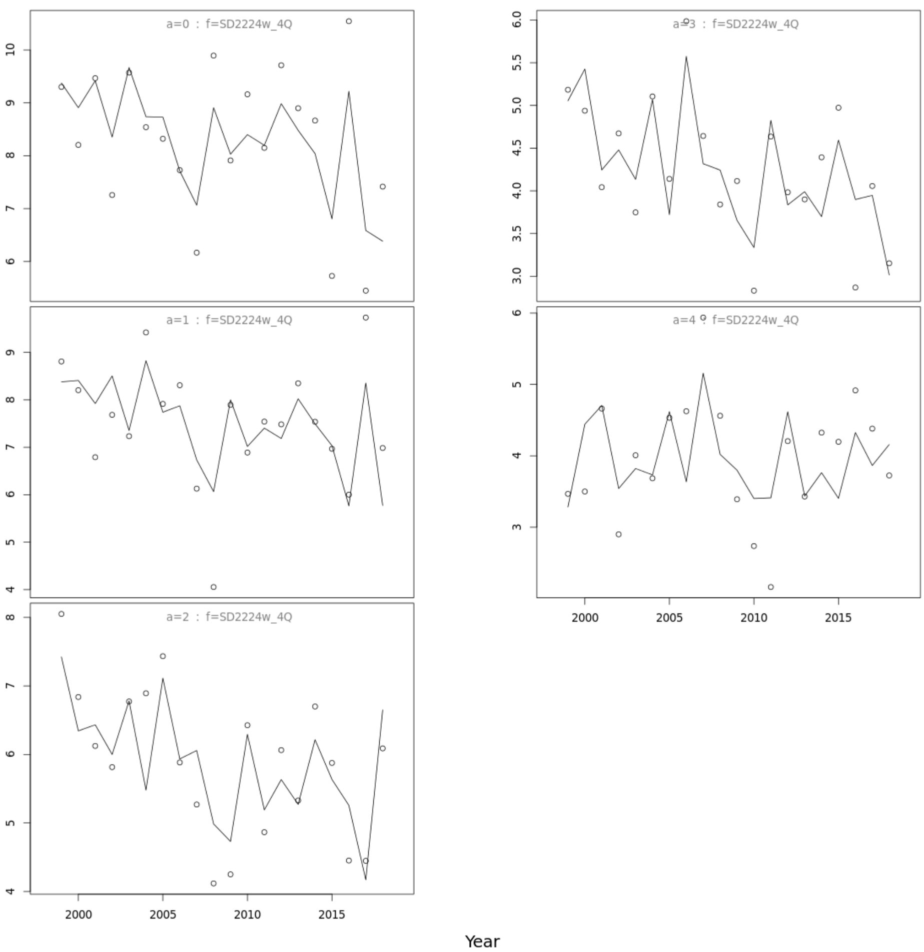


Figure 2.3.13. Western Baltic cod. BITS Q4 data fit to the model by age and year.

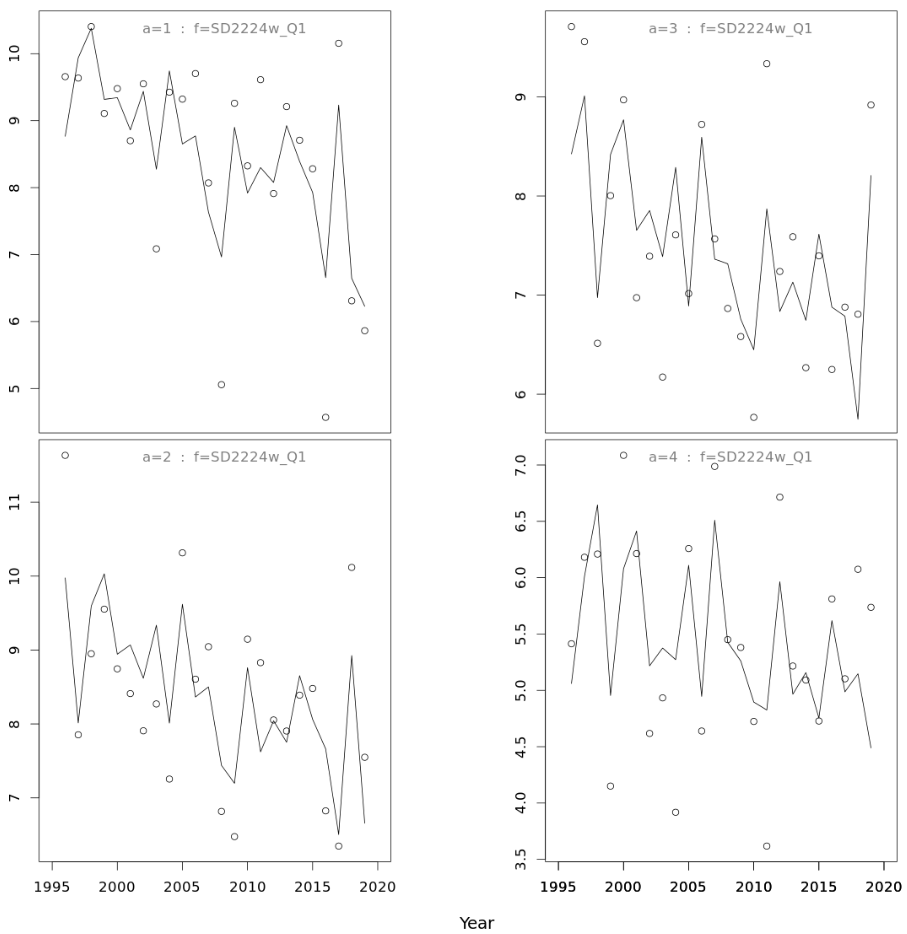


Figure 2.3.14. Western Baltic cod. BITS Q1 data fit to the model by age and year.

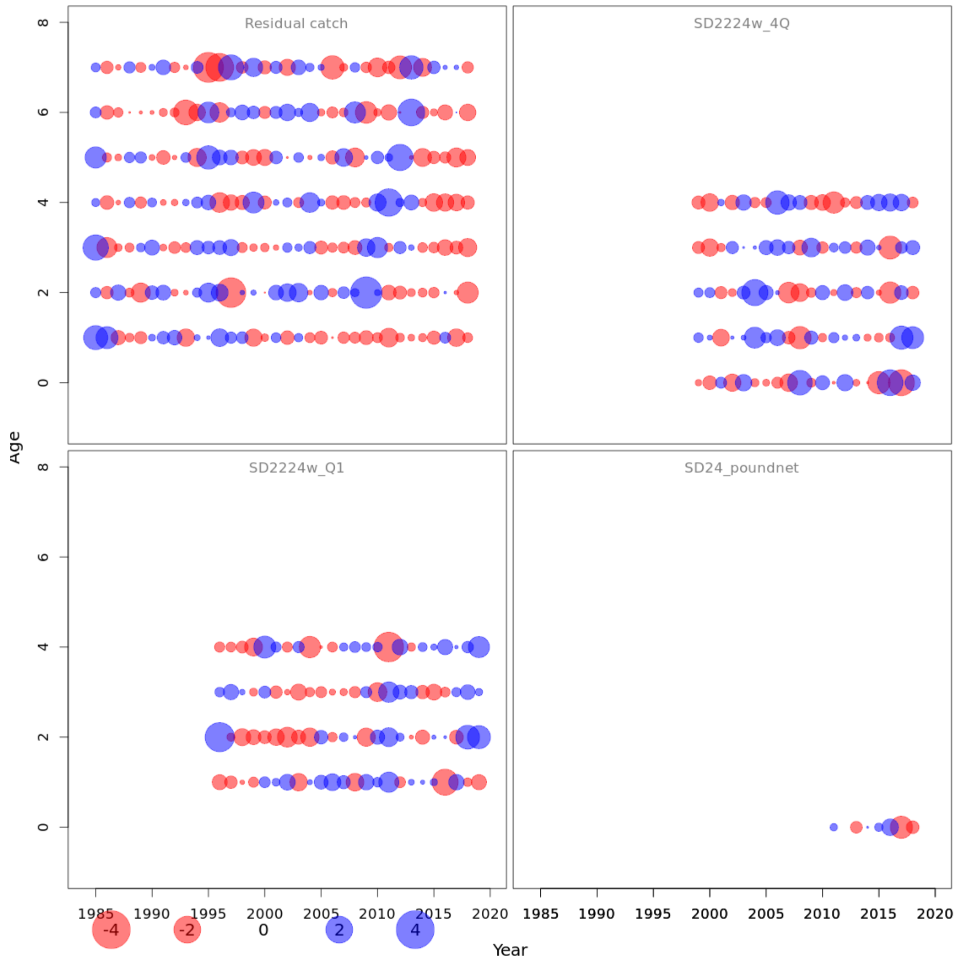


Figure 2.3.15. Western Baltic cod. Standardized residuals from the final SAM run where open circles are positive and filled circles are negative residuals.

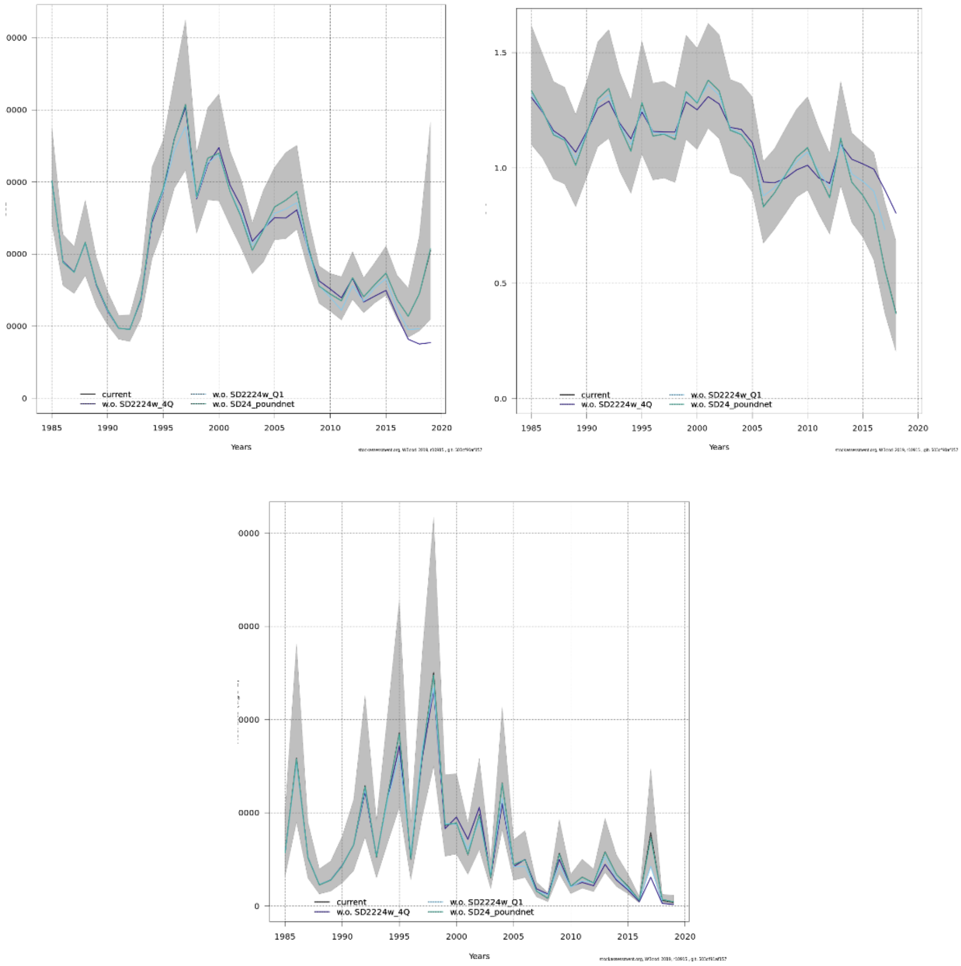


Figure 2.3.16. Western Baltic cod. Leave one out plots on SSB, F and Recruitment.

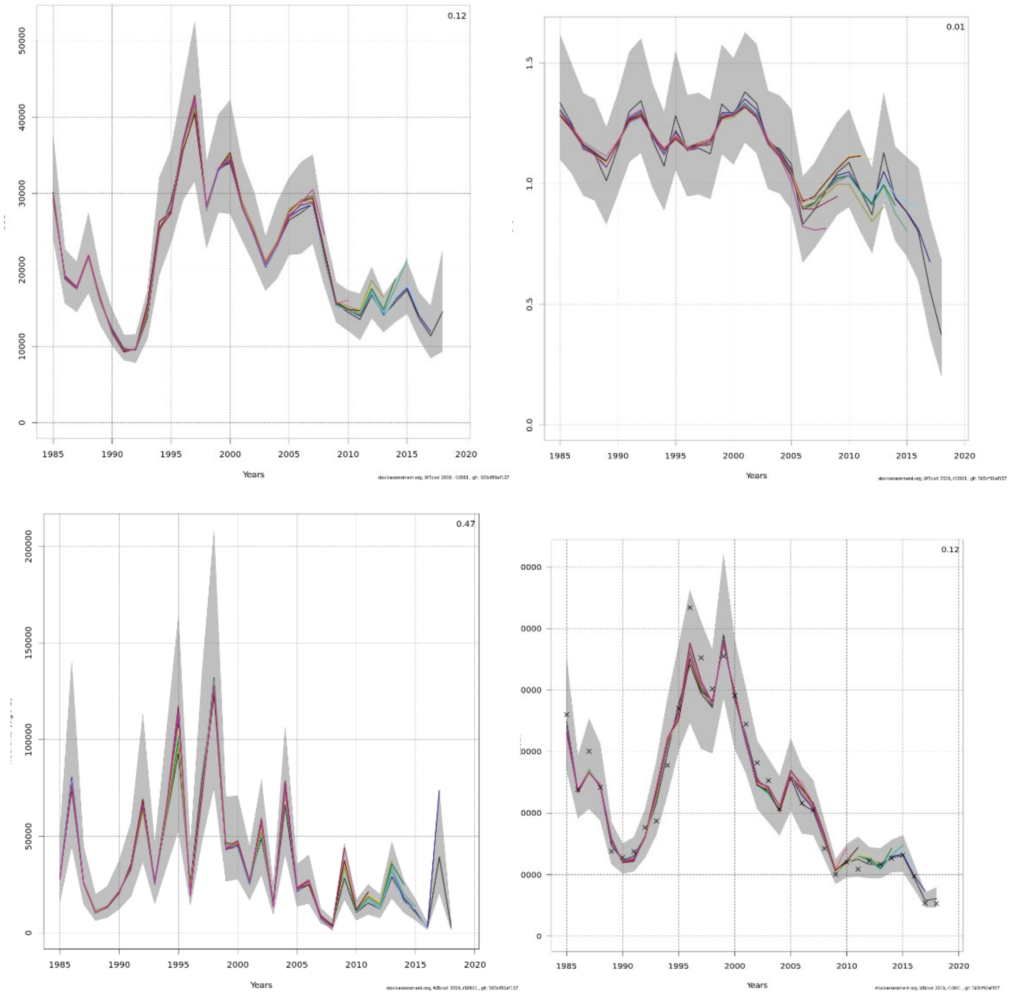


Figure 2.3.17. Western Baltic cod. Retrospective analyses of SSB, F(3–5), recruitment (age 1) and catch.

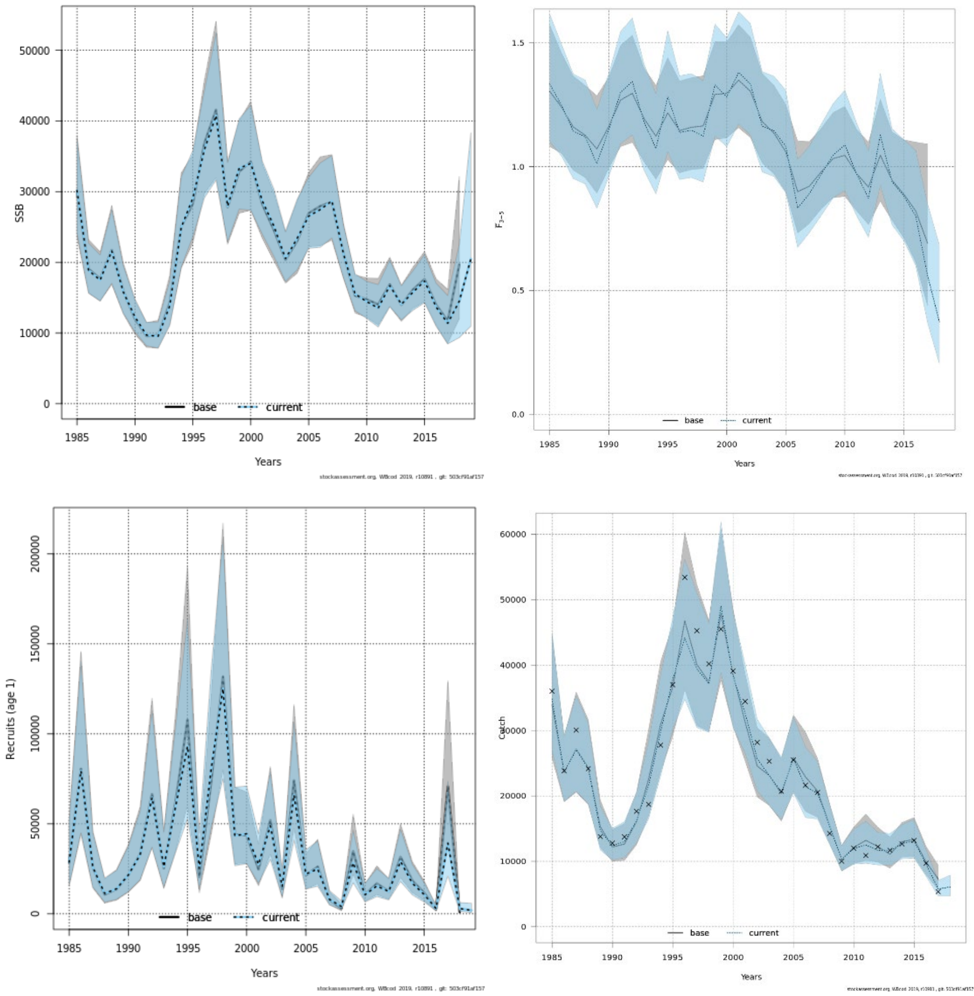
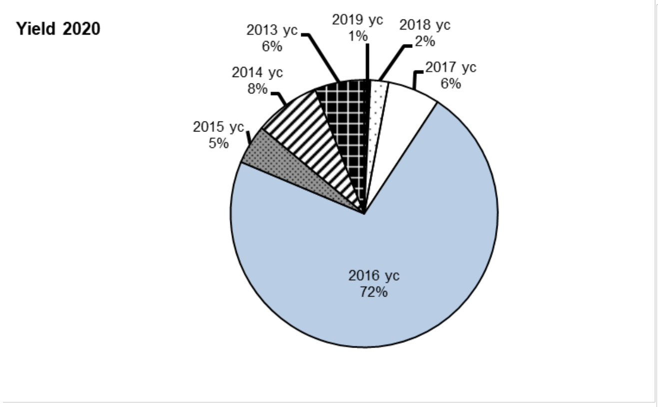


Figure 2.3.18. Western Baltic cod. SSB (upper left), F (3–5) (upper right) and stock numbers at age 0 (lower left) and catch (lower right) from the final assessment. Grey line is assessment results from the benchmark and blue stippled line is the updated final assessment.



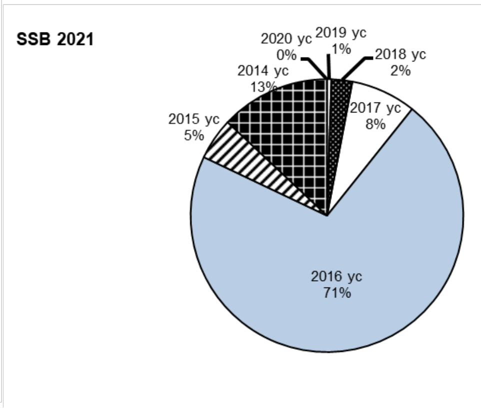


Figure 2.3.19. Cod stock in SD 22–24. Short-term forecast for 2020-2021. Yield and SBB at-age 1–7+.

3 Flounder in the Baltic

3.1 Introduction

3.1.1 Stock identification

Previously it was believed that in the Baltic Sea European flounder has two distinctively different ecotypes (sometimes also considered as two sympatric flounder populations) – the pelagic and demersal spawners. In 2018 Momigliano *et al.* (2018) revealed that these two ecotypes are in fact two different species - flounder *Platichthys flesus* (pelagic spawners) and *Platichthys solemdali* (demersal spawners).

There are significant disparities between two sympatric flounder populations (since 2018 considered as two separate species) 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 DCWKBALFLAT: 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 Annex 07.

In BONUS INSPIRE project (Ojaveer *et al.*, 2017) genetic samples of flounder during spawning time were collected to determine the proportions of the two flounder ecotypes (demersal vs. pelagic spawners) in subdivisions. An estimate of proportion of pelagic ecotype per SD was calculated (Table 3.1). It revealed that the current management unit of SD26 & 28 is problematic since approximately half of the flounders in the unit are of each ecotype, furthermore the proportion differs between SD 26 and 28 such that 28 is dominated by demersal ecotype while SD 26 is dominated by the pelagic ecotype. Considering the new findings that the two ecotypes are in fact different species, meaning that the assessment unit SD26+28 consist of two flounder species, complicates the matter even more.

Currently these two flounder species can be separated only through genetic analysis, therefore at current times there is no easy and inexpensive way to separate these species in commercial catches nor in BITS survey trawl. Therefore, in current state it is acknowledged that there are two different flounder species in the Baltic, and in all of the management units there is a mix of these two species, however no separation is attempted during the assessment process.

Table 3.1. Proportion of pelagic ecotypes per SD.

Subdivision	Proportion of pelagic spawners
32	8%
28	24%
26	98%
25	76%
24	97%

3.1.2 WKBALFLAT ‑ Benchmark

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

3.1.3 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.

3.1.4 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 1st and 4th 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 two surveys were available as well.

3.1.5 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 were 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.

3.1.6 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).

3.1.7 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).

3.1.8 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: L_{inf} and L_{mat} were calculated using survey data from DATRAS. For estimating L_{inf} data from Q1 and Q4 were taken unsorted by sex. In the case of L_{mat} 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 from this flatfish stock 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 the Swedish fleet 98–100%) in this area. Flounder is mostly 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 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 2018 were relatively low at about 809 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 takes place, but removals are considered to be minor and not taken into account in the catches.

3.2.2.2 Discards

Discards of flounder are known to vary greatly 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, quality and quota of target species (e.g. cod), discards vary between hauls, trips, vessels, areas, quarters and years. The discarded fraction can cover all length-classes and rise up to 100% of a catch.

Denmark is not sampling discard data from the passive gear segment because amounts are considered minor; empty strata are extrapolated with sampling data from other countries. The quality of the discard data increased in recent years, as the national data submitters conducted more estimation. In strata without landings, no discard information was extrapolated.

Subdivision 22 (the Belt) shows a relatively 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 were available. The discards in 2018 are estimated to be around 173 tonnes, which would result in a discard ratio of 17% of the total catch, which is at around the same level as in 2017 and lower than in the previous five years, where about 25–30% of the total catch was discarded.

3.2.3 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 (1^{st} and 4^{th} 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.

3.2.4 Assessment

The flounder stock in SD 22–23 is categorized as a data-limited-stock (DLS). Especially sampling data from the beginning of the period 2000–2006 are 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 had to be 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.

The update on the stock status is based on the data-limited approach of ICES. The "advice based on landings" has been changed to "advice based on catch" in 2016 and was based on estimated discards of the respective last three years. The intermediate stock status update for 2018 was also a catch advice. The mean biomass index of 2017 and 2018 was 50% lower than the mean of the mean biomass index from 2014–2016 (Figure 8.2.3). Therefore, a precautionary truncation was applied. The precautionary buffer was not applied because the length-based indicators are suggesting a good status of the stock. A precautionary buffer was applied the last time in 2014. Length-based indicators are used to assess the stock status in terms of overexploitation of immatures and/or large individuals following the guidelines provided by WKLIFE V (2015). The 3 year average (2016–2018) absolute value of $L_{F=M}$ was used as a F_{MSY} Proxy.

3.2.5 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 2014–2018 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

- L_{inf}: average of 2002–2018, both quarter and sexes → L_{inf} = 44.3 cm
- L_{mat}: average of 2002–2018, quarter 1, only females → L_{mat} = 20.5 cm

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

The rNesults of LBI (Table 3.2.5) show that stock status of fle.27.2223 is above possible reference points (Table 2). $L_{max5\%}$ is well above the lower limit of 0.80 (i.e. 1.15 in 2018), some truncation in the length distribution in the catches might take place. Compared to last year's data, no more over proportional amounts of mega spawners occur, P_{mega} is larger than 31% of 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 yield. Exploitation consistent with F_{MSY} proxy ($L_{F=M}$).

3.2.6 Catch advice based on the harvest control rule

WKLIFE VIII developed a harvest control rule to provide MSY advice for category 3 and 4 stocks based on the "2-over-3 rule", which compares the trend in stock index of the two most recent years to the preceding three years (WKMSYcat34; ICES, 2017a). The recommended harvest rule improves on 2-over-3 with the addition of multipliers based on the stock's life-history characteristics, the status of the stock in terms of relative biomass, and the status of the stock relative to a target reference length (Section 3, WKLIFE VIII; ICES, 2018). The catch rule is defined as:

$$C_{y+1} = m \times C_y \times r \times f \times b$$

where the catch (C) for next year y+1 is based on the current year's catch C_y adjusted by three additional components (Table 3.2.6), which are defined by the length-distribution of the catch, a relative index factor and a multiplier, using the van Bertalanffy growth ration k.

Table 3.2.6. Definition and use of the LBI-based harvest control rule for category 3 and 4 stocks

	Definition and use
r	The rate of change in the index, based on the average of the two most recent years of data (y−2 to y−1) relative to the average of the three years prior to the most recent two (y−3 to y−5), and termed the "2-over-3" rule.
f	The ratio of the mean length in the observed catch that is above the length of first capture relative to the target reference length (mean length/target reference length).
b	Adjustment to reduce catch when the most recent index data I_{y-1} is less than 1.4 × $I_{trigger}$ such that *b* is set equal to I_{y-1}/(1.4 × $I_{trigger}$). When the most recent index data I_{y-1} is greater than 1.4 × $I_{trigger}$, *b* is set equal to 1. $I_{trigger}$ is generally defined as the lowest observed index value for that stock.
m	Multiplier applied to the harvest control rule to maintain the probability of the biomass declining below B_{lim} to less than 5%. May range from 0 to 1.0.
Stability clause	Limits the amount the advised catch can change upwards or downwards between years. The recommended values are +20% and −30%, i.e. the catch would be limited to a 20% increase or a 30% decrease relative to the previous year's catch.

Flounder advice will be given again in 2022 for the proceeding three years. However, the new method of calculation was already exploratorily conducted on the data of 2018.

C_y = **982** t (total catch), 809 t (total landings)

r = **0.51** (last 2-y index of *40.1* kg/h vs. last 3-y index of *79.4 kg/h*)

f = **1.1627** (avg L_{CAT} = *26.74 cm* L_{target} = *23 cm*) #please note, that L_{target} has not been defined, therefore the MCRS was used (alternatively, L_{opt} (29.53 cm) might be applicable as well.

b = **1** ($I_{trigger}$ = 12.87 I_{y-1} = 38.95 → $I_{y-1} > 1.4 \times I_{trigger}$)

m = **0.85** (v.B. growth rate k = 0.188)

Using these values, the advised catch would be $Advice_{catch}$ = **496 tonnes total catch**, if applying the „*Stability clause*“ (max -30% decrease) the advised catch for 2020 would be **687 tonnes.** Applying the current „2-over-3 rule“of the previous advice, the advised total catch would have been at 503 tonnes total catch.

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	1983		181	349		
1974	2097		165	304		
1975	1992		163	469		
1976	2038		174	392		
1977	1974		555	393		
1978	2965		348	477		
1979	2451		189	259		
1980	2185		138	212		
1981	1964		271	351		
1982	1563	104	263	248		
1983	1714	115	280	418		
1984	1733	85	349	371		
1985	1561	130	236	199		
1986	1525	65	127	125		
1987	1208	122	71	114		
1988	1162	125	92	133		
1989	1321	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	1041	227		189	2	58
1997	1356			655		42
1998	1372			411		61
1999	1473			510		37
2000	1896			660		41
2001	2030			458		52
2002	1490			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
2016	436	63		641		15
2017	508	61		575	0	13
2018	406	59		330	0	15

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
1973	2513	0	2513
1974	2566	0	2566
1975	2624	0	2624
1976	2604	0	2604
1977	2922	0	2922
1978	3790	0	3790
1979	2899	0	2899
1980	2535	0	2535
1981	2586	0	2586
1982	2074	104	2178
1983	2412	115	2527
1984	2453	85	2538
1985	1996	130	2126
1986	1777	65	1842
1987	1393	122	1515
1988	1387	125	1512
1989	1569	83	1652
1990	1176	0	1176
1991	1171	0	1171
1992	940	185	1125
1993	884	220	1104
1994	926	265	1191
1995	1145	289	1434
1996	1232	285	1517
1997	2011	42	2053
1998	1783	61	1844
1999	1983	37	2020
2000	2556	41	2597
2001	2488	52	2540
2002	1807	42	1849
2003	1304	33	1337
2004	1267	31	1298
2005	819	222	1041
2006	654	212	866
2007	991	259	1250
2008	1181	246	1427
2009	1026	150	1176
2010	933	120	1053
2011	938	106	1044
2012	1099	120	1219
2013	1352	102	1454
2014	1103	91	1193
2015	1040	90	1130
2016	1077	78	1155
2017	1083	74	1158
2018	736	73	809

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
2017	1158	249	0.18	31	13
2018	809	173	0.18	29	16

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
$L_{max5\%}$	Mean length of largest 5%	L_{inf}	$L_{max5\%}$ / L_{inf}	>0.8	Conservation (large individuals)
$L_{95\%}$	95th percentile	L_{inf}	$L_{95\%}$ / L_{inf}		Conservation (large individuals)
P_{mega}	Proportion of individuals above L_{opt} +10%	0.3–0.4	P_{mega}	>0.3	Conservation (large individuals)
$L_{25\%}$	25th percentile of length distribution	L_{mat}	$L_{25\%}$ / L_{mat}	>1	Conservation (immatures)
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c/L_{mat}	>1	Conservation (immatures)
L_{mean}	Mean length of individuals >Lc	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	L_{mean}/L_{opt}	≈1	Optimal yield
L_{maxy}	Length class with maximum biomass in catch	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	L_{maxy} / L_{opt}	≈1	Optimal yield
L_{mean}	Mean length of individuals >Lc	$L_{F=M} = (0.75L_c + 0.25L_{inf})$	L_{mean} / $L_{F=M}$	≥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	L_c / L_{mat}	$L_{25\%}$ / L_{mat}	$L_{max 5}$ / L_{inf}	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
2016	0.46	1.34	0.89	0.29	1.02	1.65
2017	1.20	1.34	0.91	0.35	1.05	1.05
2018	1.15	1.29	0.90	0.31	1.03	1.06

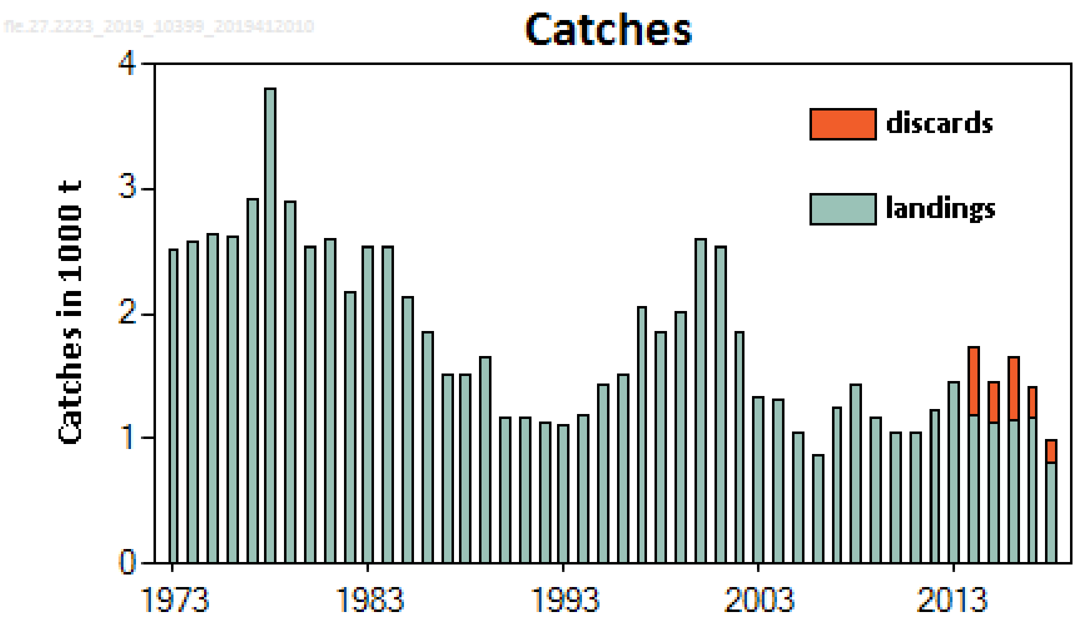


Figure 3.2.1. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings of flounder in tonnes for subdivisions SD 22–23 (Western Baltic Sea). ICES discard estimates are included from 2006 onwards.

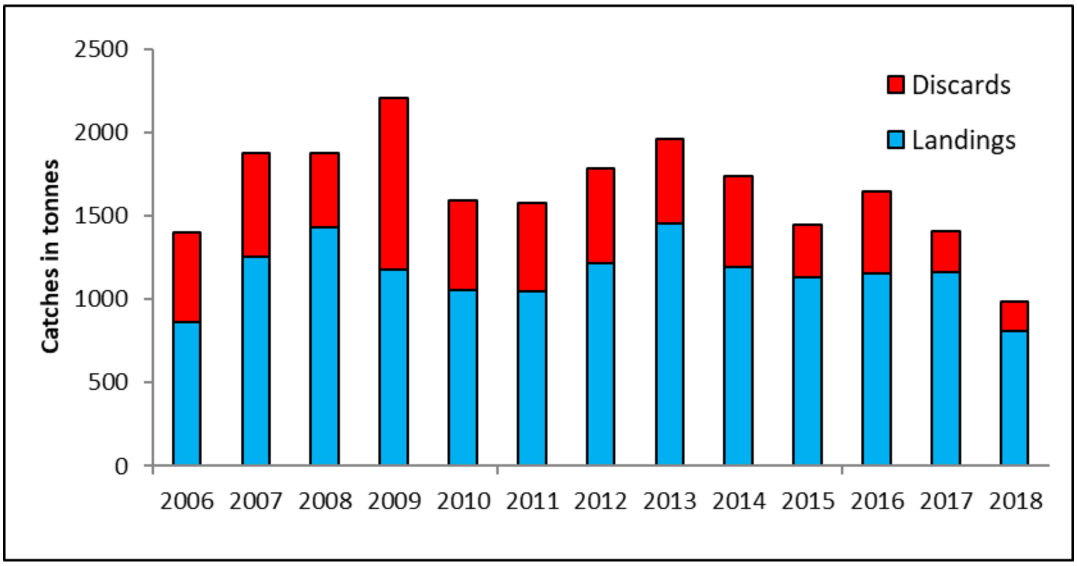


Figure 3.2.2. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings and calculated discards (in tonnes) of flounder for subdivisions SD 22–23 (Western Baltic Sea).

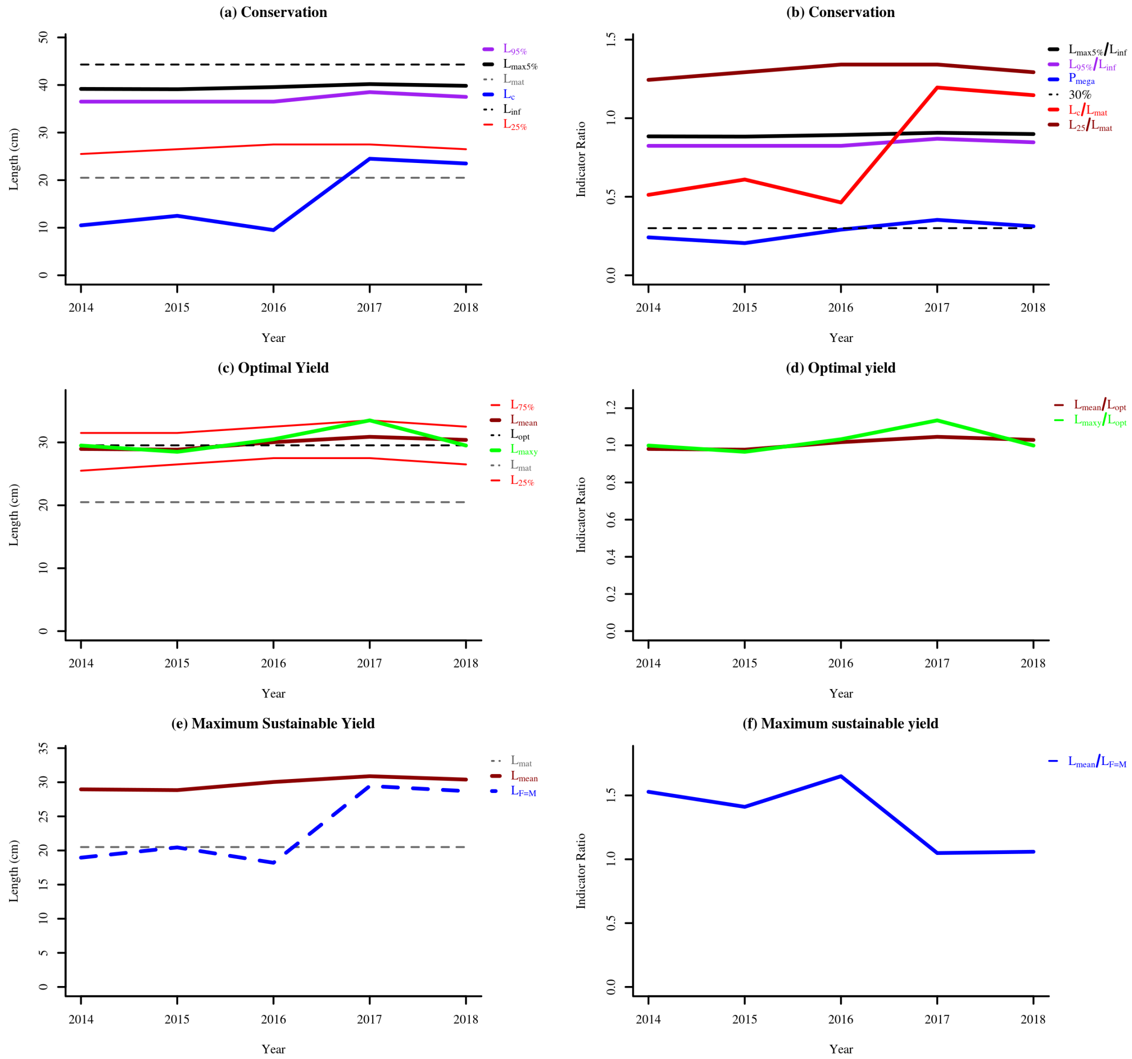


Figure 3.2.3. fle.27.2223. LBI indicator trends.

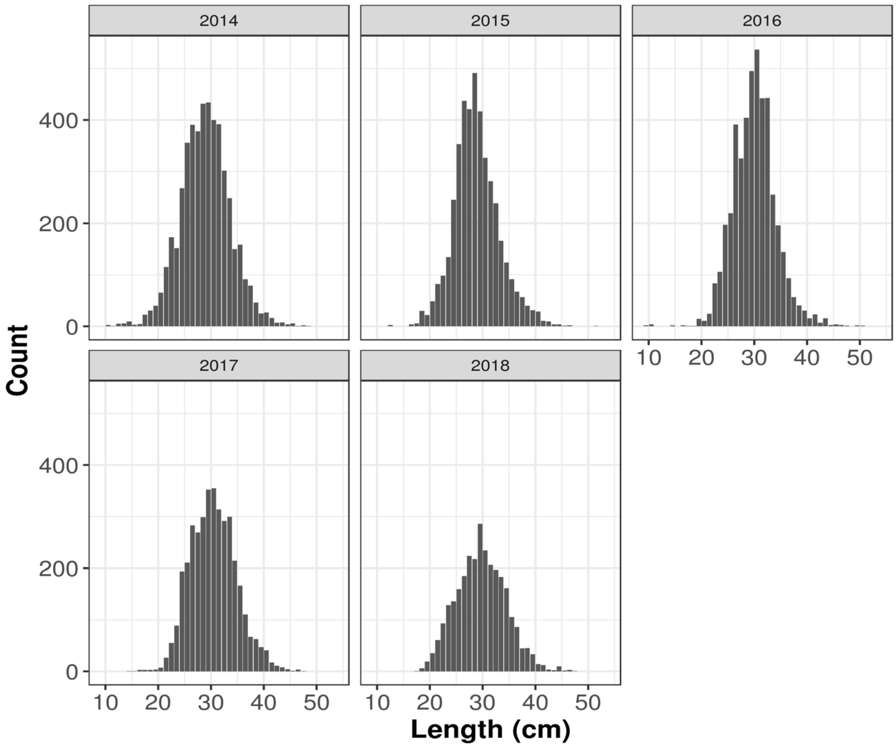


Figure 3.2.4. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Catch in numbers per length class in Subdivision 22 and 23 (Belts and Sound). All countries and fleets were combined.

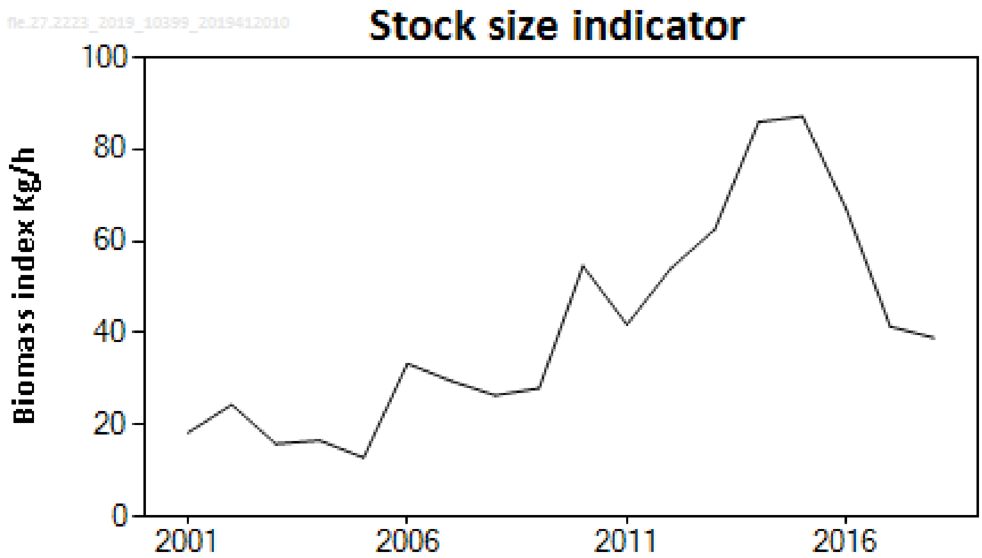


Figure 3.2.7. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Survey-biomass-index (BITS). Dashed lines indicate the average values used for advice (i.e. avg. of the last two years and the avg. of the three years before).

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.

Taking into account contrasting reproductive flounder behaviors in the Baltic Sea: offshore spawning of pelagic eggs and coastal spawning of demersal eggs Momigliano *et al.* (2018) distinguished two flounder species in the Baltic Sea. Both of them are present in the management area. According to survey data from 2014 and 2015, the share of offshore spawning *Platichthys flesus* and the coastal spawning - newly described species *Platichthys solemdali*, was estimated to be approximately 85 and 15% respectively (Ojaveer *et al.*, 2017). It is not possible at this stage to separate the proportion of this species in either stock assessment or fisheries.

3.3.1 The Fishery

3.3.1.1 Landings

Landings from SD 25 are substantially higher than in SD 24 (Figure 3.3.1). The majority of landings in both SD’s is taken by Poland. The other fishing nations which take significant landings is Germany in SD 24 and Denmark in SD 25 (Figure 3.3.2, Table 3.3.1a).

Flounder landings in both SD’s are dominated by active gears, taking around 73% of total landings in 2018 (Figure 3.3.3).

In 2018 landings were 12 788 tonnes (2530 and 10 259 tonnes for SD 24 and SD 25, respectively). Since 2014 the discard has been estimated according to the methodology suggested during WKBALFLAT (ICES, 2014). The total catch for flounder in subdivisions 24–25 reached 19 107 tonnes in 2018 (Figure 3.3.4).

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. Discard estimations in 2018 is available for 47% strata with landings. For stratum with no discards estimates available, discard rate was borrowed from other strata according to allocation scheme considering differences in discard patterns between subdivisions, countries, gear types and quarters (Table 3.3.2). Then the discard rate was raised by demersal fish landings. Such discard estimations have been performed since 2014. 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. The highest discards in subdivisions 24 and 25 can be assigned to Denmark and Sweden. Germany and Poland have the moderate discards (Table 3.3.1b; Figure 3.3.5).

Mean discard rate for 2018 for both subdivisions is 0.09 with discard equal to 6318 tonnes.

3.3.1.3 Effort 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 (cod and flounder) landings from SD 24–25.

Standardized (SE) effort by average effort by country (*se*) was calculated from equation:

$$se = \frac{f_c}{avg\ f_c}$$

where: f_c – effort by country c

Standardized effort by total demersal landings (SE) in year (y) by country (c) was calculated from equation:

$$\mathrm{SE} = \sum (L_{\mathrm{y,c}} \cdot se_{y,\mathrm{c}}) \div \sum L_{y,\mathrm{c}}$$

$L_{y,c}$ – landings by country and year

The effort in 2018 has slightly increased comparing to 2017, when it was the lowest over the time-series (Figure 3.3.6). Although the effort in the last year was relatively low the catches were higher than in 2015 with higher effort (Figure 3.3.4).

3.3.2 Biological information

The number of sampled fish in SD 24 is slightly higher than in SD 25, although the landings in SD 25 are much higher (Table 3.3.3). Most of the samples are analysed by Denmark and Germany in SD 24 and Poland in SD 25.

Sampling coverage of discards differs between years and subdivisions and in 2018 was similar to those obtained in 2017 (Table 3.3.3). 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 3.3.4).

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 3.3.7) 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 3.3.7). The advice index for this year is 0.90.

Stock trends from Baltic International Trawl Survey (BITS) for SD 24 and 25 have been increasing until 2016, after which it has decreased. (Figure 3.3.7).

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 2014–2018 were used to estimate CANUM (Figure 3.3.8). Whereas the biological parameters: L_{inf} and L_{mat} were calculated using survey data from DATRAS. For estimating L_{inf} data from 2012–2018 (as the recommended ageing technique was implemented by all of the countries since 2012 onwards) from Q1 and Q4, and for both sexes were taken. In the case of L_{mat} data for females were derived from 2001–2019, only from Q1, as distinguishing between mature and immature fish were possible only for this time of the year. Biological parameters mentioned above are as follows:

L_{inf} = 328 mm
L_{mat} = 220 mm

The results were compared to standard length-based reference values to estimate the status of the stock (Table 3.3.5).

The results of LBI (Table 3.3.6) show that stock status of fle.27.2425 is above possible reference points.

Average $L_{F=M}$ for three most recent years (2016–2018) is equal to 25.4 cm and L_{mean} - 27.4 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. The catch is close to the theoretical length of optimal yield. The mean length is stable across the time-series and is close to the MSY proxy of $L_{F=M}$ (Figure 3.3.9).

The overall perception from the length-based indicators analysis is that the stock is fished sustainably at levels close to optimum yield and with exploitation at the MSY level.

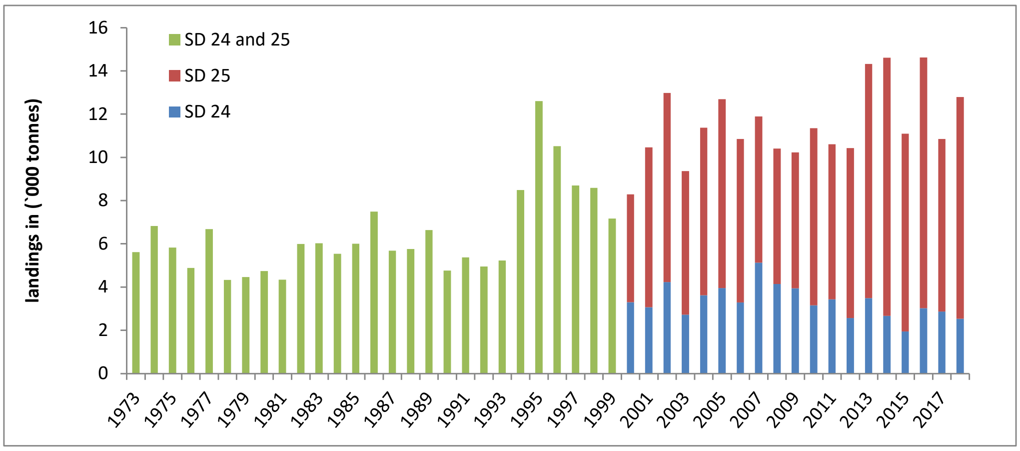


Figure 3.3.1. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Landings in thousand tonnes.

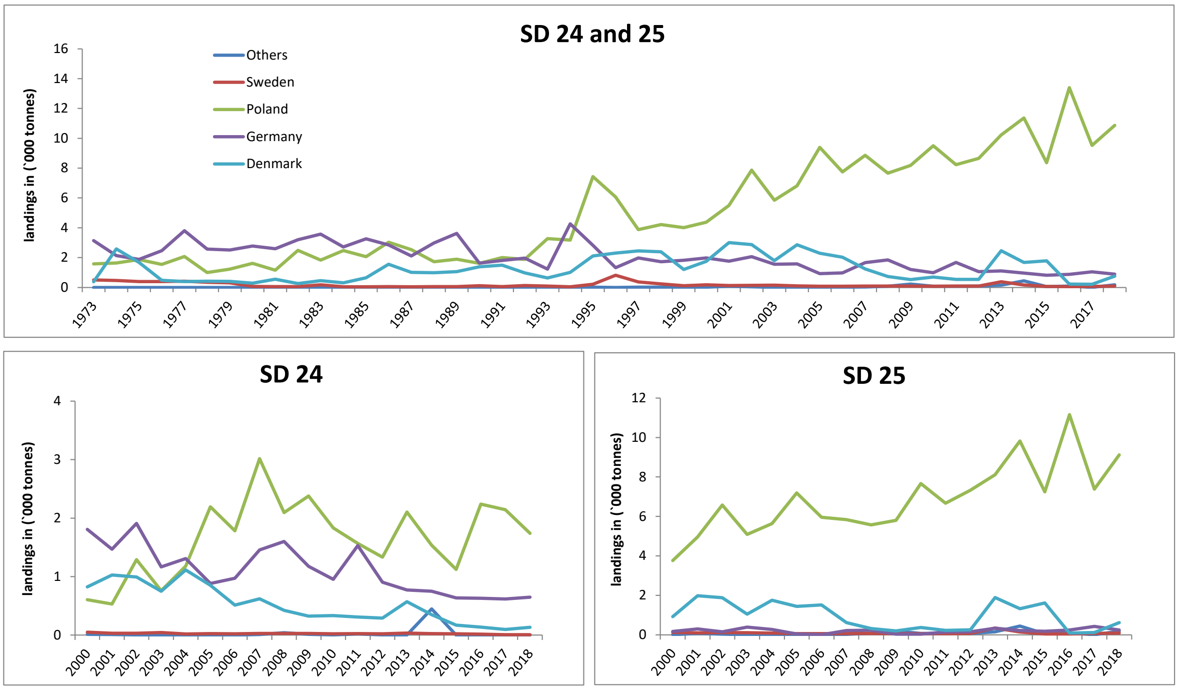


Figure 3.3.2. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Landings by country in thousand tonnes (for merged SD 24–25 – upper plot and separately for SD 24 and SD 25 – lower plots).

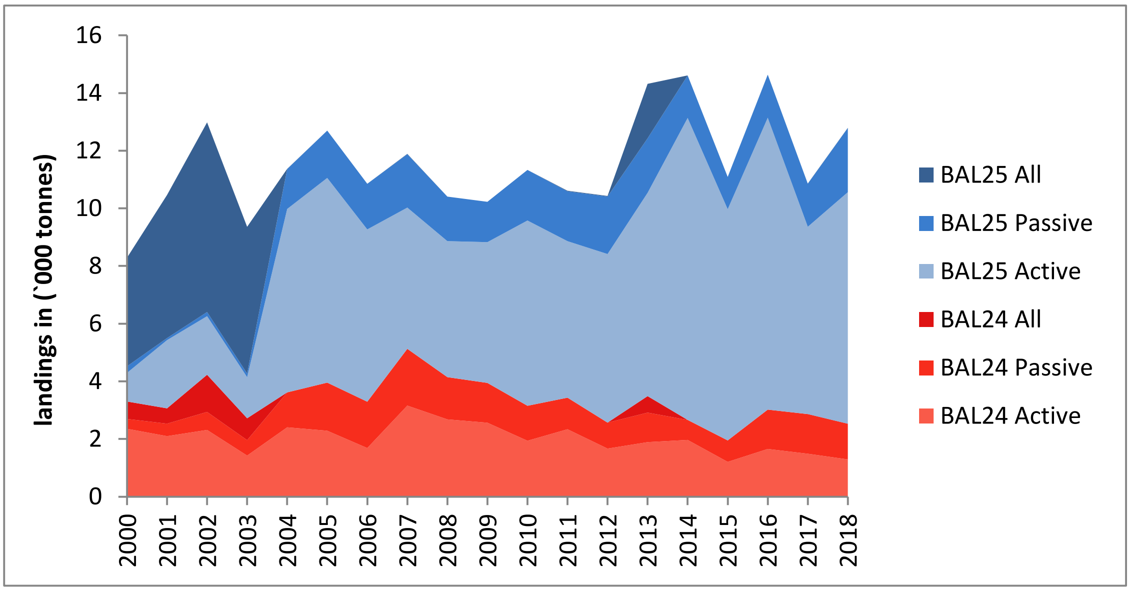


Figure 3.3.3. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Landings by fleet type in thousand tonnes (SD 24 - reddish colors, SD 25 – bluish).

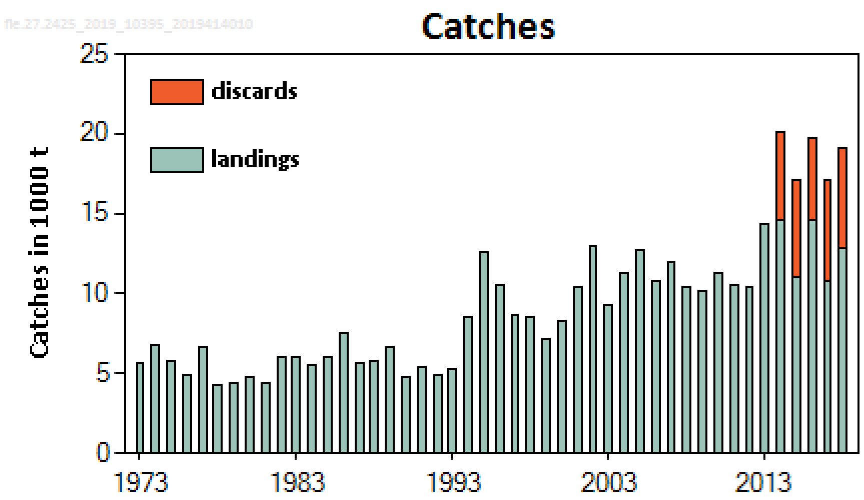


Figure 3.3.4. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Landings and catches in thousand tonnes (catch available since 2014).

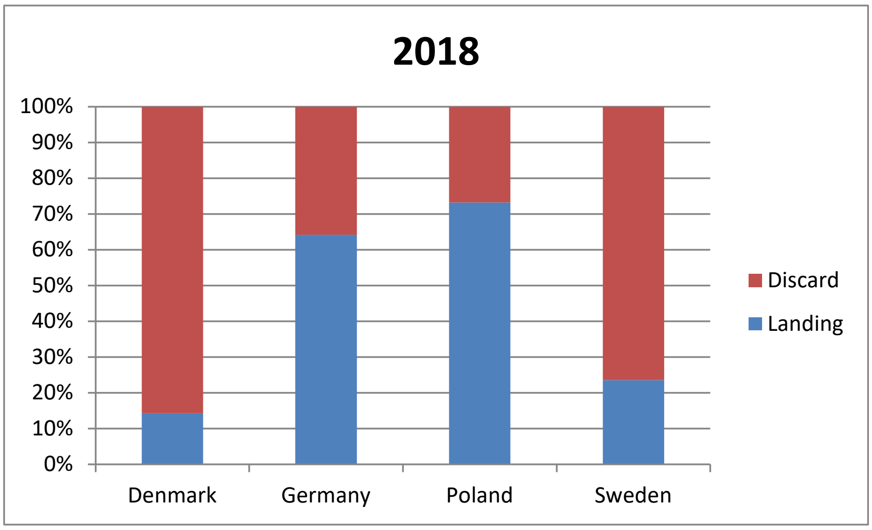


Figure 3.3.5. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Discard and landing proportion in 2018 catches in main fishing countries.

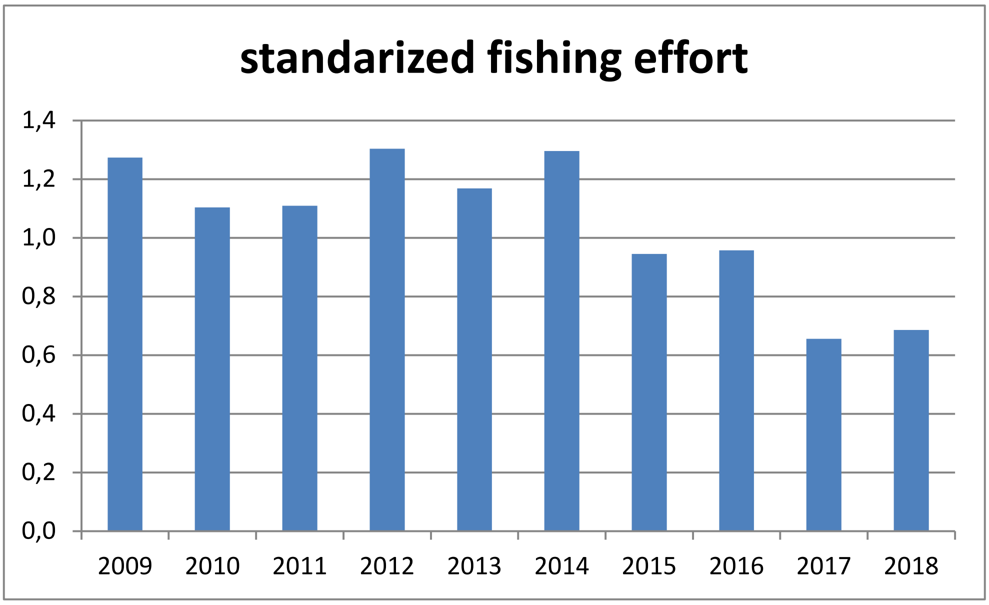


Figure 3.3.6. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Standardized fishing effort (days at sea standardized within each country and weighted by the national demersal fish landings from SD 24–25).

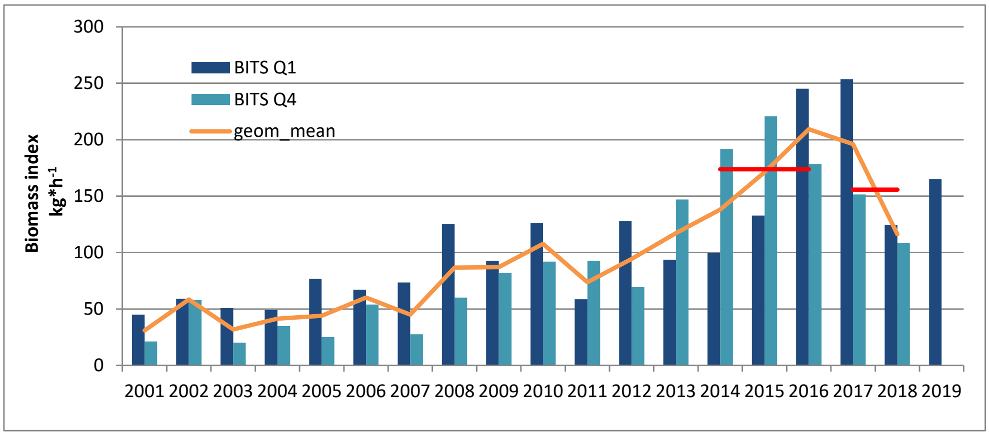


Figure 3.3.7. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Survey-biomass-index (BITS) for Q1 and Q4 from 2001–2018 and geometric mean (line). Stock trends from Baltic International Trawl Survey (BITS).

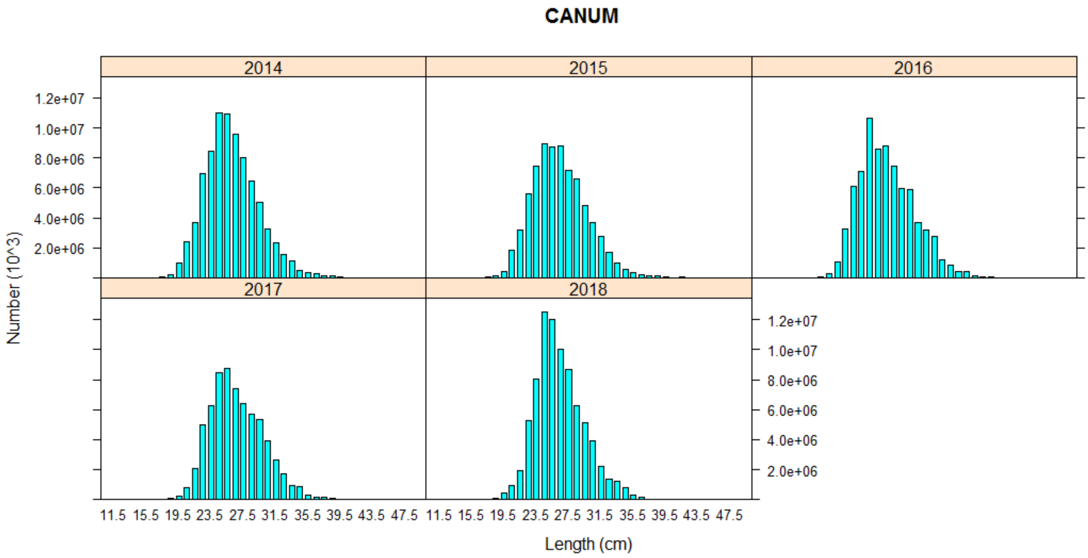


Figure 3.3.8. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Catch in numbers (CANUM) per length classes

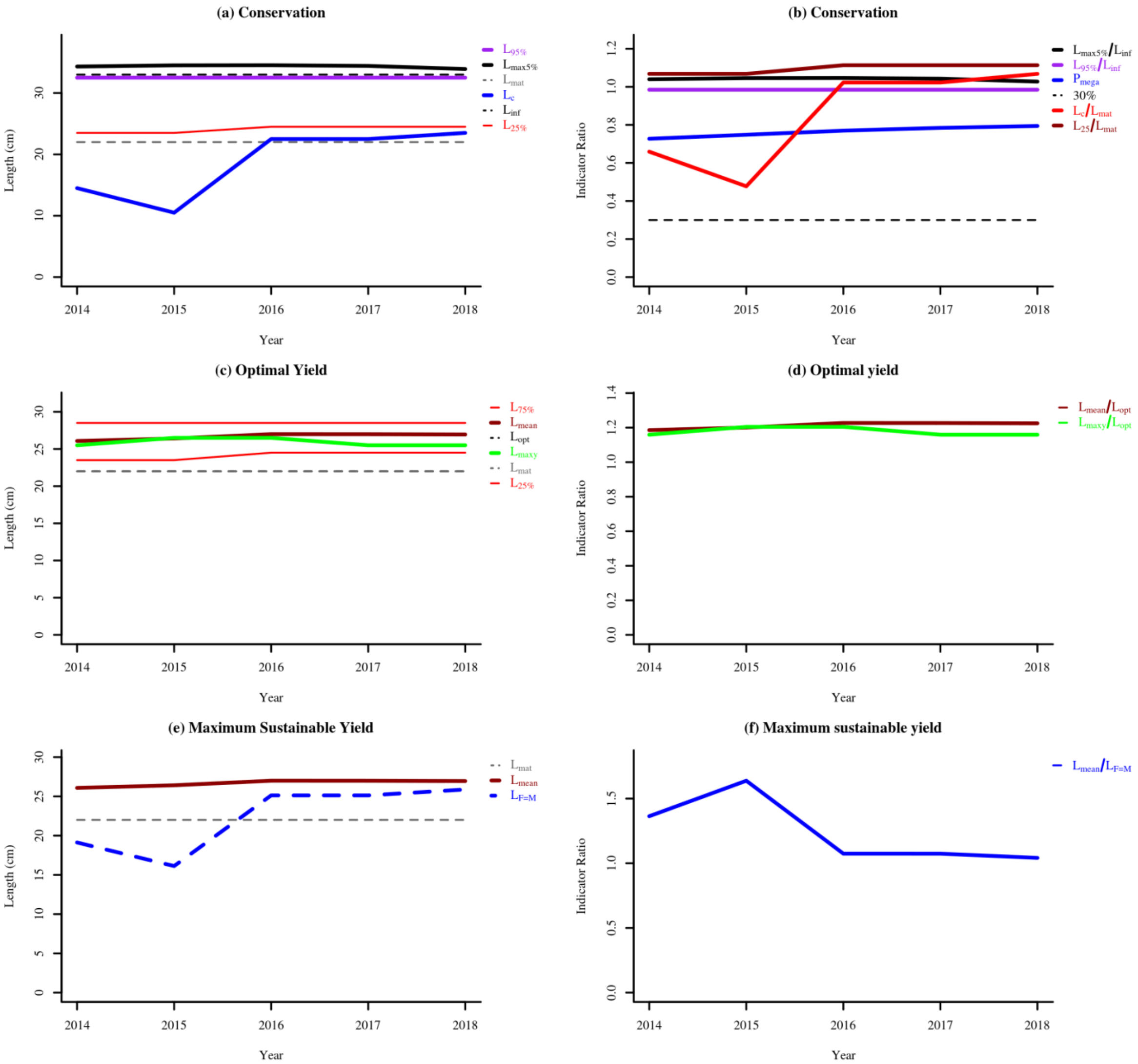


Figure 3.3.7. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). LBI indicators trends

Table 3.3.1a. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Total landings (tonnes) 1973–2018 by subdivision and country.

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	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

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	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
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
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

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	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
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

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	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
2017	97	112	209	0	0	0	1	0	1	619	423	1042	0	2	2	0	2	2	2143	7383	9525	5	68	73	10855
2018	133	623	756	0	0	0	0	0	0	650	243	893	0	119	119	0	61	61	1740	9123	10863	6	90	96	12788

Table 3.3.1b. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Estimated discards (tonnes) 2014–2018 by Subdivision and country.

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	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
2017	467	3915	4382	0	0	0	0	1	1	121	177	298	0	6	6	0	0	0	144	767	911	390	212	602	6201
2018	286	4242	4528	0	0	0	0	0	0	80	180	260	0	13	13	0	0	0	110	1065	1175	54	288	342	6318

Table 3.3.2. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Discard allocation scheme for 2018

24		2018						
fleet	**quarter**	**Denmark**	**Germany**	**Poland**	**Sweden**	**Finland**	**Latvia**	**Lithuania**
Active	1		DK_A_1_24	PL_A_1_25		PL_A_1_25		
	2							
	3	DE_A_3_24		SE_A_3_24				
	4				DK_A_4_24			
Passive	1	DK_A_1_24	DK_A_1_24	DK_A_1_24	SE_P_1_25			
	2	SE_P_2_24		DE_A_3_24				
	3	SE_P_3_24						
	4	SE_P_4_24	SE_P_4_24	SE_P_4_24				

25		2018						
fleet	**quarter**	**Denmark**	**Germany**	**Poland**	**Sweden**	**Finland**	**Latvia**	**Lithuania**
Active	1				DE_A_1_25	PL_A_1_25	PL_A_1_25	
	2						SE_A_1_25	
	3		SE_A_3_25	SE_A_3_25				SE_A_3_25
	4		DK_A_3_25				PL_A_4_25	
Passive	1			SE_P_1_25				DK_P_1_25
	2	SE_P_2_25	SE_P_2_25	SE_P_2_25				
	3	SE_P_3_25	SE_P_3_25	PL_P_3_24				
	4	SE_P_4_25		SE_P_4_25				

Table 3.3.3. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). The coverage of sampled landings and discards in subdivisions 24 and 25.

SD24

Catch category	**Catch t**	**No. of length samples in numbers**	**No. Measured in numbers**	**No. of age samples in numbers**	**No. Aged in numbers**
Landings	133	8	852	8	89
	650	11	3101	11	751
	1740	9	978	7	148
	6	0	0	0	0
Discards	198	11	2249	11	290
	69	10	496	10	161
	48	6	101	5	24
	26	13	1008	0	0
Total	2871	68	8785	52	1463

SD25

Country	Catch category	Catch t	No. of length samples in numbers	No. Measured in numbers	No. of age samples in numbers	No. Aged in numbers
Denmark	Landings	623	0	0	0	0
Germany		243	4	699	4	222
Latvia		119	0	0	0	0
Lithuania		61	0	0	0	0
Poland		9123	8	819	3	87
Sweden		90	3	87	0	0
Denmark	Discards	4238	10	1335	10	220
Germany		180	4	837	4	158
Poland		724	8	332	4	45
Sweden		64	24	1661	0	0
	Total	15465247	61	5770	25	732

Table 3.3.4. 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

	SD 24		SD 25	
	Q1	Q4	Q1	Q4
2015	50	38	97	73
2016	53	47	85	81
2017	55	51	102	96
2018	56	43	107	99
2019	41		107	
Average	49	45	97	75

Table 3.3.5. 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
$L_{max5\%}$	Mean length of largest 5%	L_{inf}	$L_{max5\%}$ / L_{inf}	>0.8	Conservation (large individuals)
$L_{95\%}$	95th percentile		$L_{95\%}$ / L_{inf}		
P_{mega}	Proportion of individuals above L_{opt} + 10%	0.3–0.4	P_{mega}	>0.3	
$L_{25\%}$	25th percentile of length distribution	L_{mat}	$L_{25\%}$ / L_{mat}	>1	Conservation (immatures)
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c/L_{mat}	>1	
L_{mean}	Mean length of individuals >Lc	$L_{opt} = \frac{3}{3+M/k} \times \mathbf{L_{inf}}$	L_{mean}/L_{opt}	≈1	Optimal yield
L_{maxy}	Length class with maximum biomass in catch	$L_{opt} = \frac{3}{3+M/k} \times \mathbf{L_{inf}}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals >L_c	$L_{F=M}$ = $(0.75L_c + 0.25L_{inf})$	L_{mean} / $L_{F=M}$	≥1	MSY

Table 3.3.6. 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} = 32.8 cm and L_{mat} = 22.0 cm.

	Conservation				Optimizing Yield	MSY
Year	L_c / L_{mat}	$L_{25\%}$ / L_{mat}	L_{max5} / L_{inf}	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
2016	1.02	1.11	1.05	0.77	1.23	1.07
2017	1.02	1.11	1.04	0.78	1.23	1.07
2018	1.07	1.11	1.03	0.79	1.22	1.04

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

ICES SD 26 and 28 were defined as a new assessment unit for flounder at a Benchmark Workshop on Baltic Flatfish Stocks (WKBALFLAT; ICES, 2014) in 2014.

Taking into account contrasting reproductive flounder behaviors in the Baltic Sea: offshore spawning of pelagic eggs and coastal spawning of demersal eggs Momigliano *et al.* (2018) distinguished two flounder species in the Baltic Sea. Both of them are present in the management area. According to survey data from 2014 and 2015, the share of offshore spawning *Platichthys flesus* and the coastal spawning - newly described species *Platichthys solemdali*, was estimated to be approximately 45 and 55% respectively (Florin *et al.*, unpublished data). It is not possible at this stage to separate the proportion of this species in either stock assessment or fisheries.

3.4.1 Fishery

The main fishing countries in Subdivision 26 are Latvia, Poland, Russia, and Lithuania while in Subdivision 28 – Latvia (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 continued to decrease in 2017 and were 3475 tonnes. Decrease of landings was observed since 2014. (Figures 3.4.1. and 3.4.2.). The highest landings were recorded in Russia (1493 tonnes), Latvia (1207 tonnes), and Poland (473 tonnes). The major part of the landings was realized with active fishing gears (2980 tonnes).

Major part of the landings was taken in Subdivision 26 (68%) and in trawl fishery (85.8%). The total landings in Subdivision 28 amounted to about 1112, what was lower than one year before but still a remarkable higher than long-term average. The landings in Subdivision 28 started to increase from 2011 and last five years are more than 1000 tonnes. The Latvian landings were 1036 tonnes (increased 5 to 10 times comparing to 10 years ago).

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, however effort decreased of this fishery decreased in 2018.

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 database in 2014. It was found that raising procedure in InterCatch for such bycatch species as flounder gives underestimated and imprecise discard estimates. Therefore, WK decided that discard raising should be performed outside InterCatch.

Discard data of flounder from 2018 according to ICES Data Call were submitted in InterCatch. Discards rates from Denmark, Germany, Sweden, Latvia, Lithuania, and Poland 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 Sweden (550 t), Poland (318 t) and Lithuania (217 t) (Table 3.4.2) what was significantly higher than one year ago. Significant decrease of discard was observed in Latvia in last years where major part of flounder was landed. Weighted average of flounder discard in subdivisions 26 and 28 in 2018 was estimated 26.6% what is significantly higher than estimate for 2017 (9.7%).

3.4.1.4 Effort and CPUE data

Time-series from 2009–2018 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.

Standardization and weighting factor were applied for submitted effort data to calculate a common effort index for the stock. First, every country's data were standardized using proportion for given year from the national average. Standardized 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 and in 2018 it was the lowest observed in time-series since 2009. (Figure 3.4.3). Decrease of effort in 2018 was observed in all four main fishing countries (Latvia, Lithuania, Poland, and Russia). This decrease could be related with very bed cod fishing possibilities in SD 26 and 28, while flounder often were fished as bycatch in cod fishery. Due to stopped cod fishery in this area, bycatch of flounder also decreased and specialised flounder fishery was not popular in most of fishing countries (Figure 3.4.4).

The highest landings per unit effort in 2018 were registered in Latvia and Russia (Figure 3.4.5) which indicated a target flounder fishery in those two countries. Flounder landings per day at sea in other countries 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, 1924 otoliths were collected from the catch (1623 from landings and 301 from discards, Table 3.4.3). Otoliths from Estonia, Poland, and Russia covering landings, while otoliths from discards were available from Estonia, Germany, and Poland.

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 database 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= a L^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 showed a decreasing trend from the beginning of the century although the estimated indices in last four years are on stable level (Figure 3.4.6, Table 3.4.4). The stock abundance is estimated to have slight increase by 5.8% between 2014–2016 (average of the three years) and 2017–2018 (average of the two years). For this stock scientific advice was not produced in 2019.

3.4.5 Reference points

No new reference points for the stock were calculated in 2019. New reference points will be calculated together with next Advice on 2020.

Table 3.4.1. Flounder in Subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdańsk). 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**	0.872	0	**1**	0	0	**0**
Finland	1		**1**	10		**10**	8		**8**	0.459	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**	1209.74	0	**1,210**	981	0	**981**
Sweden	1	20	**20**	2	13	**14**	21	24	**45**	0.271	0	**0**	0	17	**18**
Estonia	15	74	**89**	11	70	**81**	24	52	**76**	25.457	53.771	**79**	2	53	**55**
Latvia	114	166	**280**	378	244	**622**	780	619	**1,399**	298.9	1278.9	**1,578**	281	1,744	**2,025**
Lithuania	418	0	**418**	640	12	**651**	947	1	**949**	698.075	0	**698**	258	0	**258**
Russia	1,139		**1,139**	1,079		**1,079**	1,010		**1,010**	1047.1	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			2017			2018		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	0	0	**0**			**0**	8		**8**
Finland			**0**			**0**			**0**
Germany	1	0	**1**			**0**			**0**
Poland	912	0	**912**	701		**701**	473		**473**
Sweden	3	14	**16**	2	10	**12**	4	16	**20**
Estonia	0	52	**52**		59	**59**		60	**60**
Latvia	161	1683	**1,843**	190	1386	**1,576**	171	1036	**1,207**
Lithuania	295	0	**295**	255		**255**	214		**214**
Russia	1133	0	**1,133**	1304		**1,304**	1493		**1,493**
Total	2503	1748	**4,252**	2452	1455	**3,907**	2363	1112	**3,475**

Table 3.4.2. Flounder in Subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdańsk). Estimated discard rate by countries for flounder in the Baltic Sea, Subdivisions 26 and 28 in 2018.

Country	Landings	Discards	Discard ratio
Denmark	7.6	1.6	17.2
Estonia	60.1	0.0	0.0
Germany	0.0	1.2	100.0
Latvia	1207.0	171.5	12.4
Lithuania	214.2	216.9	50.3
Poland	472.7	318.4	40.2
Russia	1493.4	0.0	0.0
Sweden	19.6	549.6	96.6
Total	3474.8	1259.1	26.6

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

Country	Discards	Landings	Total
Estonia	42	202	244
Germany	131		131
Poland	128	239	367
Russia		1182	1182
Total	301	1623	1924

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

Biomass index (kg hour−1)			
Year	**1st quarter**	**4th quarter**	**Combined index**
1991	124.2	0.0	124.2
1992	51.1	0.0	51.1
1993	91.3	48.4	66.5
1994	60.5	30.2	42.8
1995	132.4	68.3	95.1
1996	127.8	30.2	62.1

Biomass index (kg hour−1)			
Year	**1st quarter**	**4th quarter**	**Combined index**
1997	143.7	80.9	107.9
1998	96.4	67.9	80.9
1999	102.3	73.7	86.8
2000	197.8	65.2	113.5
2001	278.9	404.1	335.8
2002	238.2	316.5	274.6
2003	159.9	143.3	151.4
2004	145.6	366.1	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	146.0	153.2
2010	242.2	196.4	218.1
2011	230.4	209.9	219.9
2012	211.7	134.2	168.5
2013	133.7	175.8	153.3
2014	82.7	95.8	89.0
2015	105.2	72.4	87.2
2016	132.6	55.1	85.5
2017	128.7	116.1	122.2
2018	87.9	68.5	77.6
2019	203.9		203.9

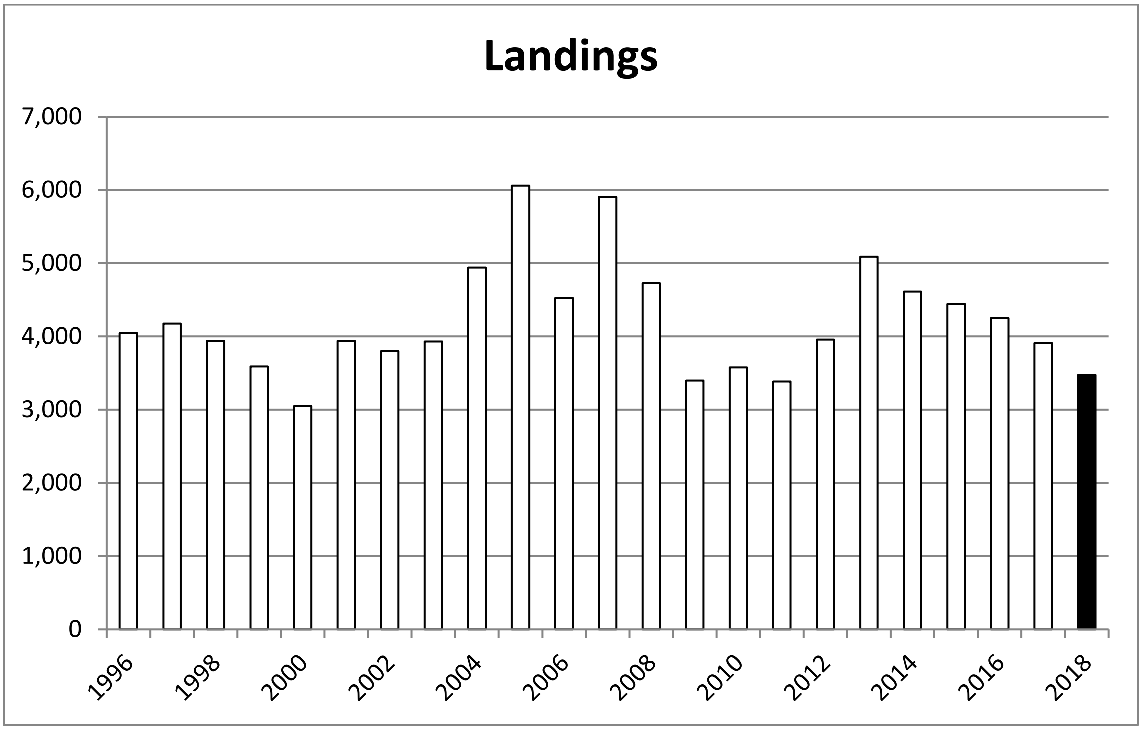


Figure 3.4.1. Flounder in Subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdańsk). ICES landings of flounder in Subdivisions 26 and 28.

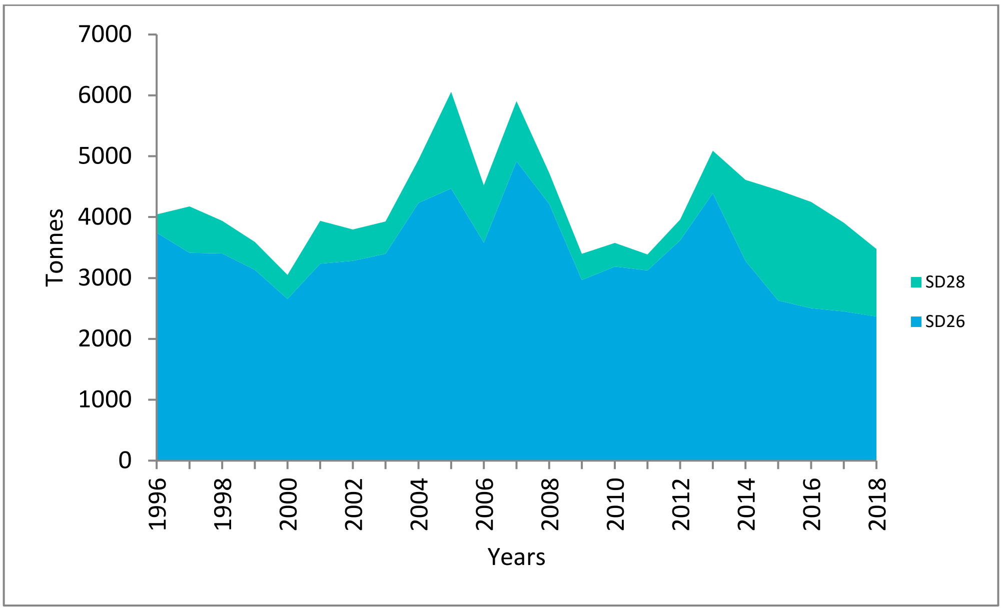


Figure 3.4.2. Flounder in Subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdańsk). ICES landings of flounder by subdivisions.

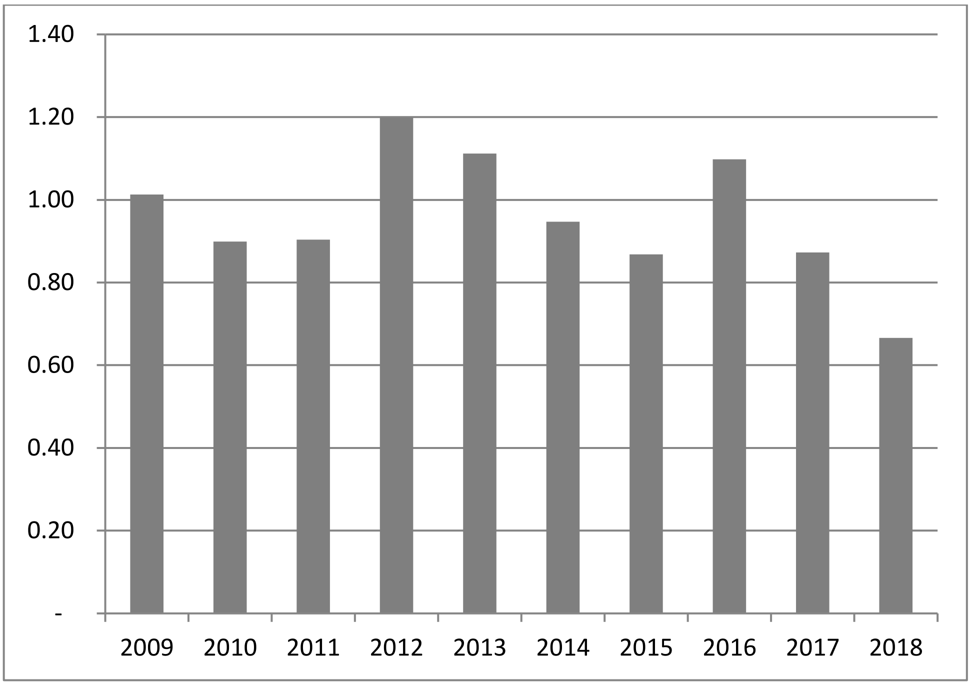


Figure 3.4.3. Flounder in Subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdańsk). Effort data (days-at-sea) of flounder in Subdivisions 26 and 28 (days-at-sea).

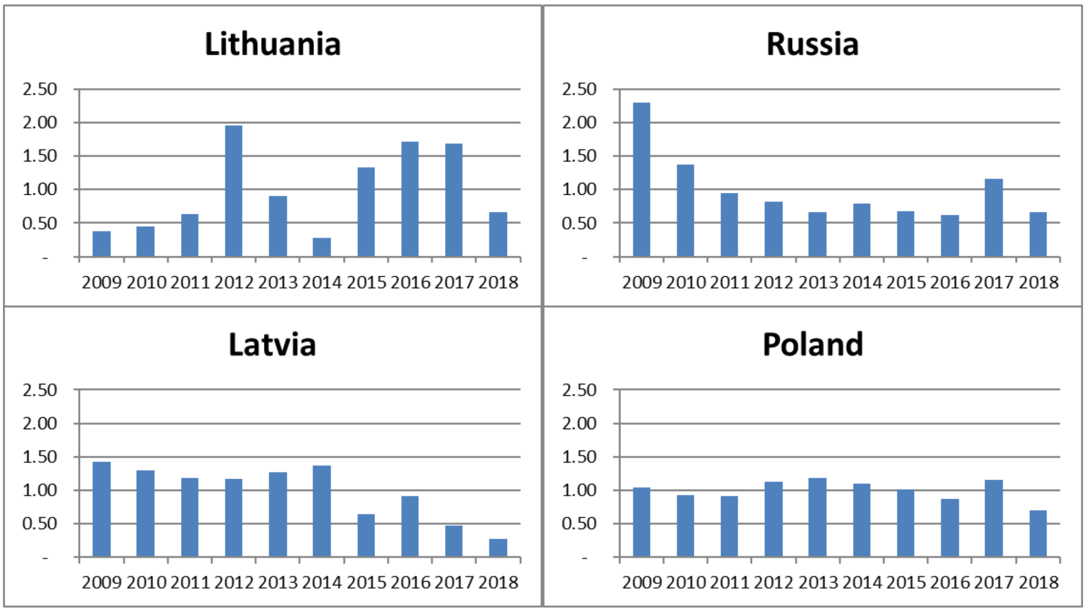


Figure 3.4.4. Flounder in Subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdańsk). Effort data of flounder in Subdivisions 26 and 28 by main fishing countries (days-at-sea).

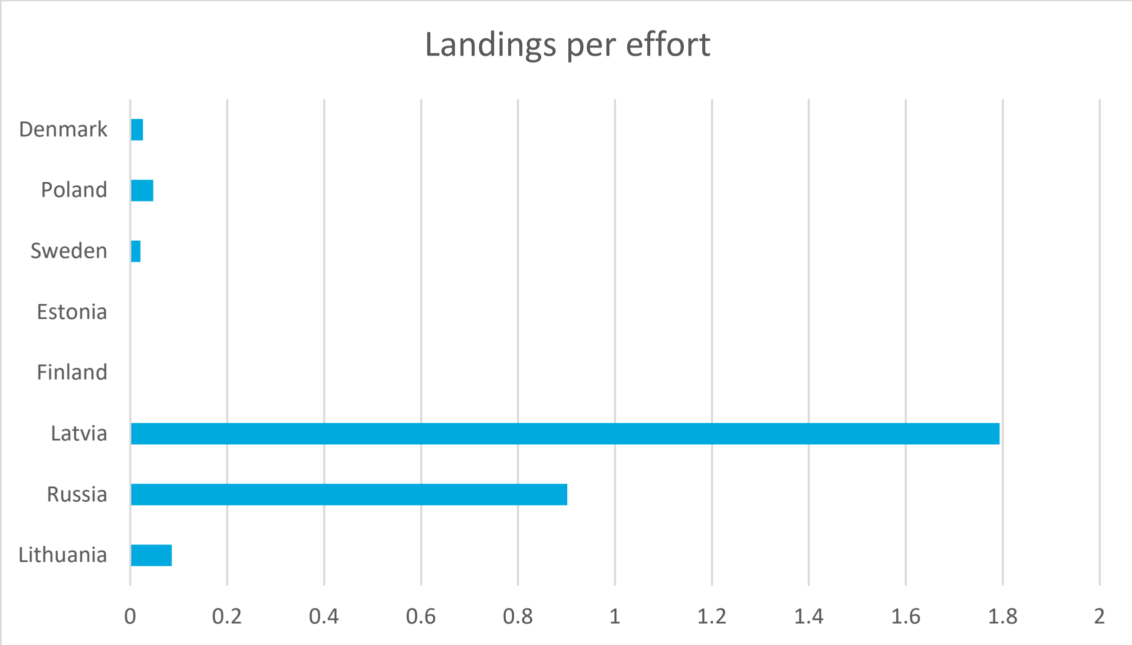


Figure 3.4.5. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdańsk). Landings of flounder in tonnes per days-at-sea by country in Subdivisions 26 and 28.

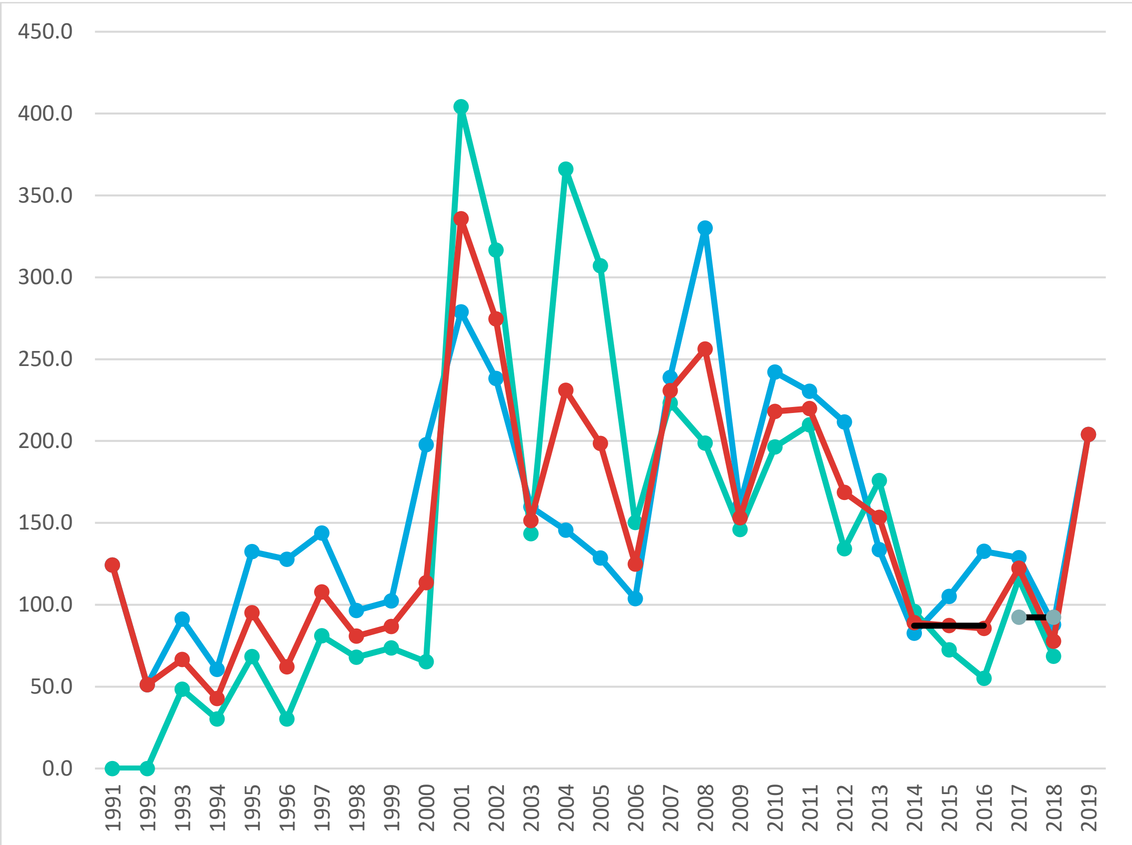


Figure 3.4.6. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdańsk). Catch per unit of effort (kg per hour) from BIT Survey in 1st and 4th Quarters, subdivisions 26 and 28.

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

Based on the decision by Benchmark Workshop on Baltic Flatfish Stocks (WKBALFLAT; 26–28 November 2013; 27—31 January 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 (2018, 127 t) 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 2018 the total discard is estimated below 10 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 below 1 tonne for the last three years.

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 flatfish, 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 are 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 roughly constitute up to 30% of the commercial landings.

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 trapnets between 2011 and 2016 in SD29 and 32. Age data were not sampled in commercial landings in Finland, for Sweden age data exists only for the years 2009–2010.

Estonia commercial landings length distribution is available only form trapnets and some extent from Danish seine landings. In addition, from 2017 gillnet catches from SD29 and 32 are sampled during main fishing months (quarter 2 and 3). 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 fisher use mainly 6–70 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 commercial fishery. To incorporate the effect of catching fish with gears such as trapnets, Danish seine, and smaller mesh size gillnets (<55 mm), 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 not 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 for Estonia commercial trapnet 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 seems to be more stable compared to commercial data (Figure 3.5.4).

3.5.3 Fishery-independent data

Fishery-independent data are gathered form four national gillnet surveys since the BITS survey was deemed inappropriate to 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 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. From 2017 ICES does not give any catch advice for stock without TAC (total allowable catch).

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). Extremely high CPUE value for Küdema bay in 2015 is probably not representative, although consistent increase in all survey biomasses (except Muuga bay) is evident for years before 2015. There will be no further attempt to correct the 2015 Küdema bay biomass index value. The stock size indicator value seems to show slight increasing trend from 2012 onwards.

3.5.5 MSY proxy reference points

Year 2017 MSY proxy reference points were calculated for this stock using two different methods, length-based indicators and length-based spawning potential ratio (LB-SPR; Hordyk *et al*., 2015). In the end it was decided that only length- based indicators are used for providing MSY proxy reference points.

Length-based indicator (LBI) analysis was done using the Küdema survey data. Parameters used in the analysis are shown in Table 3.5.5.

LBI calculations were made using code that was used by WKIND3.3i group (ICES 2016d). The L_c and L_{mean} calculations differ little bit form the calculations that are presented by WKLIFE V (ICES, 2015). 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. Based on the LB-indicators flounder 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.

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

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
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
	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

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	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

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Estonia**		166			126	292
	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

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	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
	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

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
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
2017	Finland		3	0	0	1	4
	Poland						0
	Sweden	18	0				18
	Estonia		95			33	128
	Total	18	98	0	0	34	150
2018	Finland		2	0	0	1	3
	Sweden	14	0				14
	Estonia		78			31	109
	Total	14	80	0	0	32	127

*** Finland 1980–2007: Catches of SDs 27 and 28 are included in SD 29 and 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 SD27, 29-32 (Northern Baltic Sea). Recreational fishery catch estimates 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	6	5	0	0
2017	13.1	12.9	6	5	0	0
2018	14.8	13.7	6	5	0	0

Table 3.5.3. Flounder SD27, 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
2016	19	1985	72	3028.0
2017	6	1394	59	2826.0
2018	20	1232	5	2234.0

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-Q4[1)]	Muskö-Q4[1)]	Combined for SD27[2)]	Combined[3)]
	(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			1.21			
1990			1.79			
1991			0.57			
1992			1.97	5.20	3.58	
1993	0.49		1.99	4.84	3.42	
1994	0.20		1.29	1.26	1.28	
1995	0.43		1.18	0.97	1.07	
1996	0.40		0.60	0.18	0.39	
1997	0.47		0.74	0.64	0.69	
1998	0.73		1.24	0.71	0.97	
1999	0.28		0.90	0.20	0.55	
2000	0.25	3.45	1.51	1.12	1.32	2.01

SD	32	29	27			
Survey	Muuga-Q4	Kudema-Q4	Kvädöfjärden-Q4[1)]	Muskö-Q4[1)]	Combined for SD27[2)]	Combined[3)]
	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	kg gear-night-1)
2001	0.65	2.32	1.42	1.17	1.29	1.34
2002	0.17	1.01	1.46	0.60	1.03	0.63
2003	0.30	2.89	0.54	1.14	0.84	1.60
2004	0.47	1.37	0.51	0.89	0.70	0.86
2005	0.39	1.70	0.20	0.55	0.37	1.03
2006	0.42	1.57	0.32	1.09	0.70	1.04
2007	0.10	2.24	0.60	2.61	1.60	1.27
2008	0.11	2.68	1.33	4.67	3.00	1.80
2009	0.36	0.86	0.20	2.19	1.19	0.71
2010	0.14	0.79	0.45	1.04	0.75	0.50
2011	0.24	0.97	0.16	0.50	0.33	0.59
2012	0.13	1.03	0.14	0.48	0.31	0.56
2013	0.13	2.03	0.32	0.95	0.63	1.22
2014	0.09	2.35	0.43	0.98	0.70	1.26
2015	0.07	8.70	0.53	1.32	0.92	4.36
2016	0.11	1.90	0.43	0.76	0.60	1.18
2017	0.16	2.72	0.58	0.50	0.54	1.88
2018	0.15	1.57	0.09	0.08	0.08	1.04

[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 SD27, 29-32 (Northern Baltic Sea). Input parameters for the length-based indicators analysis (LBI).

Data type	Source	Years/Value	Notes
Length frequency distribution	Küdema survey	2014-2018	
L_{inf}	Commercial trapnet data SD29+32 (2011-2016)	27.45 cm	combined sex
K		0.344 year^{-1}	
L_{mat}	2011 survey in Hiiumaa (Q2)	16.8 cm	females only
L_{mat95}		20.89 cm	
M/K		1	

Table 3.5.6. Flounder SD27, 29-32 (Northern Baltic Sea). Length-based indicators analysis results.

	Conservation	Optimaizing Yield	MSY		
Year	**Lc/Lmat**	**Lmean/Lopt**	**Lmean/Lf=m**	**Lmean**	**Lf=m**
Ref	**>1**	**~1(>0.9)**	**≥1**	**cm**	**cm**
2014	1.07	1.05	1.06	21.5	20.4
2015	1.01	1.02	1.07	21.1	19.6
2016	1.11	1.08	1.06	22.2	20.9
2017	0.95	1.01	1.10	20.7	18.9
2018	1.10	1.06	1.05	21.8	20.7

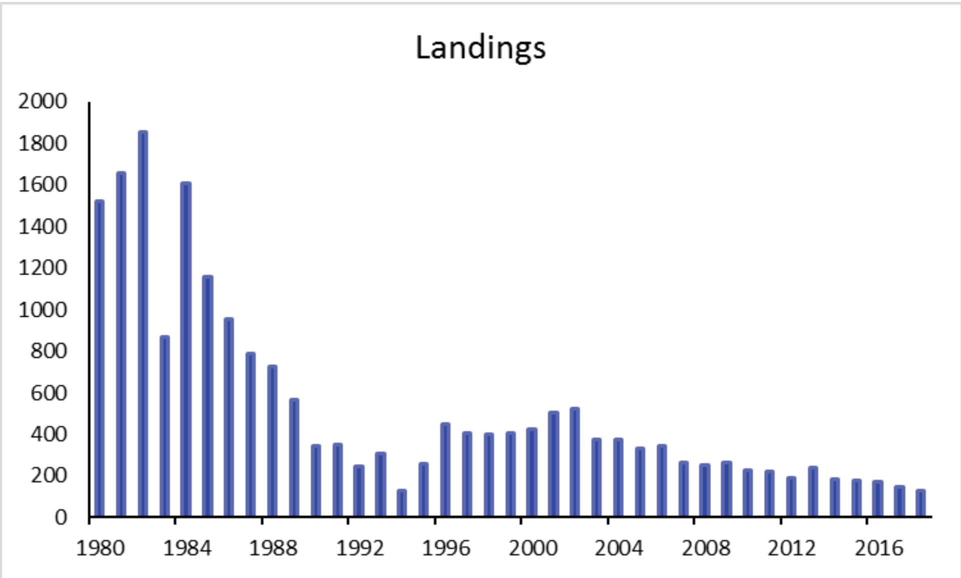


Figure 3.5.1. Flounder SD27, 29-32 (Northern Baltic Sea). Landings (tonnes) in Subdivisions (SDs) 27 and 29-32 from 1980–2018.

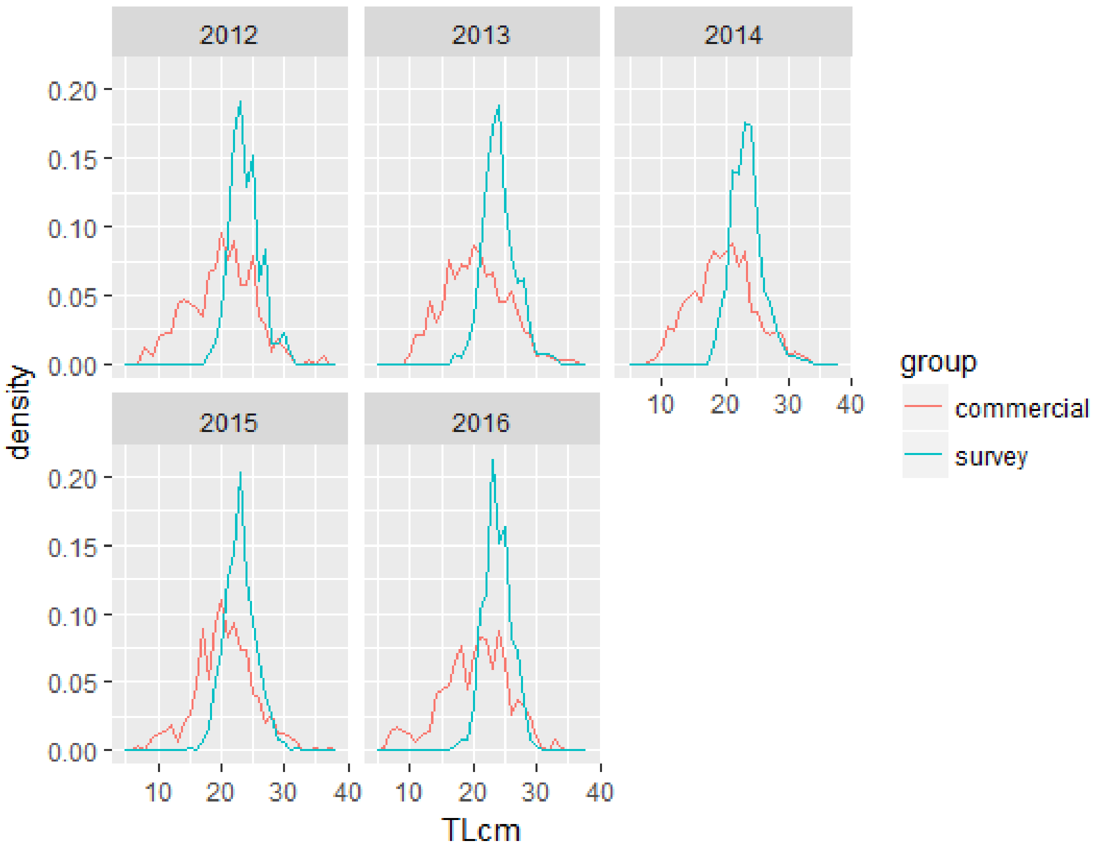


Figure 3.5.2. Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Comparison of commercial trapnet length distribution with SD29 survey length distribution (mesh sizes 50 and 60 mm).

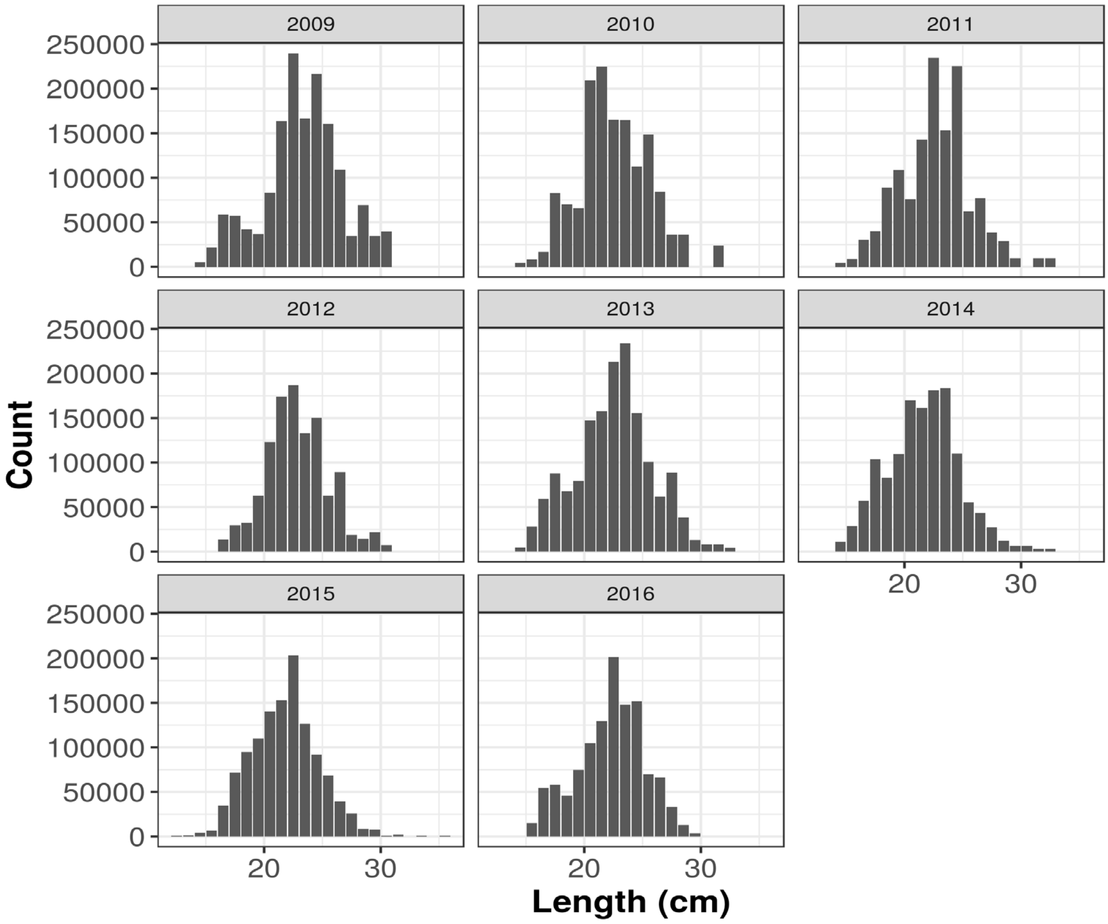


Figure 3.5.3. Flounder in Subdivisions 27 and 29-32 (Norther Baltic Sea). Representative catch in numbers by length class for flounder commercial landings in subdivisions 27 and 29-32.

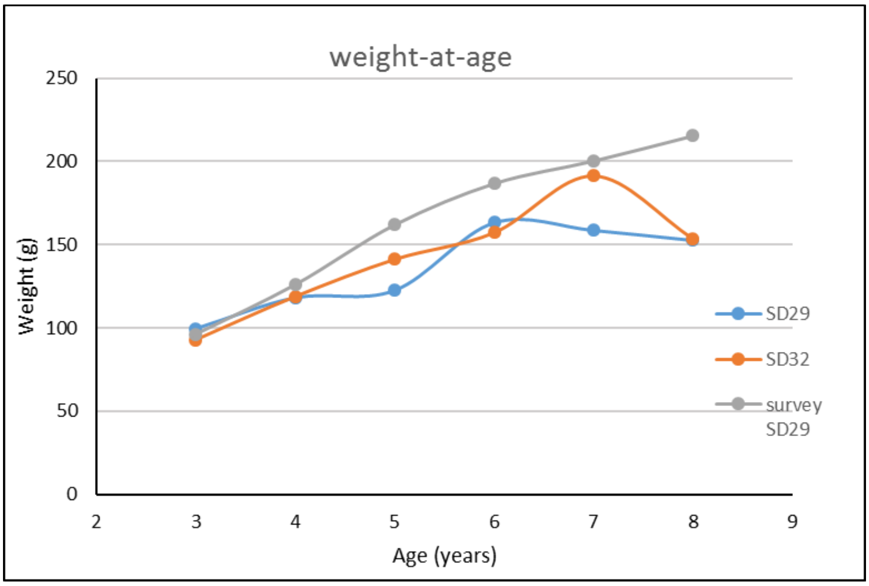


Figure 3.5.4. Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Mean weights per age for Estonian commercial trapnet landings per subdivision (Q3+4) and for survey in SD29 (Küdema bay).

4 Herring in the Baltic Sea

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 2018 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 2018 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 2018, 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 TACs:

- 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 2018 and 2019 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 2018		ICES Advice for 2019 (Basis) (t)	TAC 2019 (t)
	in relation to SSB	in relation to F		
SPRAT				
SD 22-32	Above trigger and Full reproductivity	Above target & Harvested sustainably	225 752 – 311 523 (MAP applied)	*313 072
HERRING				
SD 25–29&32 (excl. GOR)	Above trigger & Full reproductivity	Above target & Harvested sustainably	115 591 – 192 787 (MAP applied)	*200 260
SD 28.1 (Gulf of Riga)	Above trigger & Full reproductivity	At target & Harvested sustainably	20 664 – 31 237 (MAP applied)	31 044
SD 30–31 (Bothnian Sea)	Above trigger & Full reproductivity	Above target & Increased risk	88 703 (MSY approach)	88 703

***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 tonnes)*	Total catches of the WBSSH stock (1000 tonnes)*	% 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%

Year	WBSSH** caught in SD 22–24 (1000 tonnes)*	Total catches of the WBSSH stock (1000 tonnes)*	% of WBSSH caught in SD 22–24
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%
2017	26.5	46.3	57.2%
2018	19.0	41.1	46.2%
Mean	33.9	64.6	52.6%

***Finnish data not included.**

**** In SD 22–26 the herring stocks are known to be mixed, but the degree of this mixing is not yet quantified.**

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

Year	CBH caught in Gulf of Riga (SD 28.1) (1000 tonnes)	Total catches of the CBH stock (SD 25–27, 28.2,29 &32) (1000 tonnes)	% of CBH caught in Gulfof 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%

Year	CBH caught in Gulf of Riga (SD 28.1) (1000 tonnes)	Total catches of the CBH stock (SD 25–27, 28.2,29 &32) (1000 tonnes)	% of CBH caught in Gulfof Riga (SD 28.1)
2016	4.3	192.1	2.2%
2017	3.9	202.5	1.9%
2018	4.2	244.4	1.7%
Mean	4.1	138.9	3.1%

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 tonnes)	Total stock GORH catches (1000 tonnes)	% 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	26.5	1.0%
2014	0.2	26.3	0.8%
2015	0.3	32.9	1.0%
2016	0.3	30.9	0.9%
2017	0.2	28.1	0.8%
2018	0.5	27.0	2.0%
Mean	0.4	32.3	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 2018 by subdivision and quarter.

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
SD 25	Landings ('000 t)	34.25	27.46	8.52	20.98	**91.21**
	Herring (%)	29.82	32.77	77.36	67.73	**38.87**
	Sprat (%)	70.18	67.23	22.64	32.27	**47.64**
SD 26	Landings ('000 t)	101.48	47.38	6.36	27.82	**183.04**
	Herring (%)	27.50	34.69	83.49	45.30	**22.51**
	Sprat (%)	72.50	65.31	16.51	54.70	**58.32**
SD 27	Landings ('000 t)	18.26	5.94	0.34	1.12	**25.65**
	Herring (%)	72.69	66.90	72.54	72.10	**67.31**
	Sprat (%)	27.31	33.10	27.46	27.90	**68.15**
SD 28*	Landings ('000 t)	63.06	28.79	8.84	45.04	**145.72**
	Herring (%)	36.94	77.12	66.96	47.46	**46.75**
	Sprat (%)	63.06	22.88	33.04	52.54	**41.95**
SD 29	Landings ('000 t)	33.91	10.52	1.19	35.27	**80.89**
	Herring (%)	60.99	78.92	62.05	63.24	**54.86**
	Sprat (%)	39.01	21.08	37.95	36.76	**36.99**
SD 30	Landings ('000 t)	40.36	39.21	3.76	13.72	**97.05**
	Herring (%)	98.30	98.14	99.92	95.26	**104.24**
	Sprat (%)	1.70	1.86	0.08	4.74	**2.43**
SD 31	Landings ('000 t)	0.00	1.45	0.71	0.41	**2.57**
	Herring (%)	0.00	99.25	100.00	58.10	**124.46**
	Sprat (%)	0.00	0.75	0.00	41.90	**0.03**
SD 32	Landings ('000 t)	14.77	6.80	2.15	21.87	**45.58**
	Herring (%)	61.03	80.41	49.59	58.84	**61.02**
	Sprat (%)	38.97	19.59	50.41	41.16	**37.77**
Total	Landings ('000 t)	**306.09**	**167.55**	**31.85**	**166.22**	**671.71**
	Herring (%)	**47.06**	**62.85**	**76.37**	**58.64**	**55.26**
	Sprat (%)	**52.94**	**37.15**	**23.63**	**41.36**	**44.74**

* Gulf of Riga included

Table 4.1.2. Proportion of herring in landings 2018.

COUNTRY	QUARTER	SUBDIVISION 25	26	27	28*	29	30	31	32
DEN	1	0.06	0.34	0.48	0.33	0.57			
	2	0.40	0.55	0.61	0.44	0.52			
	3								
	4	0.45	0.41	0.81	0.62	0.56			
EST*	1				0.65	0.35			0.48
	2				0.99	0.57			0.68
	3				1.00	0.54			0.40
	4				0.39	0.35			0.42
FIN	1	0.77	0.81	0.69	0.61	0.83	0.98		0.71
	2		0.63	0.86	0.88	0.91	0.98	0.99	0.87
	3	0.98	0.98	0.97	0.98	0.65	1.00	1.00	0.63
	4	0.90		0.52	0.77	0.75	0.94	1.00	0.66
GER	1	0.30	0.24	0.47	0.21	0.27			
	2	0.31	0.12	0.43	0.20				
	3								
	4					0.06			
LAT*	1	0.05	0.16		0.31	1.00			
	2	0.32	0.12		0.56	1.00			
	3	0.86	0.68		0.59	1.00			
	4		0.42		0.43	1.00			
LIT	1	0.18	0.24		0.29	0.29			
	2	0.24	0.29		0.27				
	3		0.48		0.18				
	4	0.69	0.71		0.34				
POL	1	0.27	0.26		0.17				
	2	0.31	0.35						
	3	0.77	0.85		0.29				
	4	0.67	0.59		0.23	0.17			
RUS	1	0.00	8.19		0.00				
	2	0.00	0.07		0.00	0.00			
	3	0.00	0.08		0.00				
	4	0.00	0.23						
SWE	1	0.53	0.39	0.74	0.35	0.65	1.00		
	2	0.65	0.32	0.70	0.47	0.64	0.99	1.00	
	3	0.78	0.95	0.70	0.94	1.00	1.00	1.00	
	4	0.75	0.79	0.73	0.60	0.66	1.00	0.56	1.00
Total	1	0.30	0.27	0.73	0.28	0.64	0.98		0.70
	2	0.32	0.35	0.67	0.53	0.81	0.98	0.99	0.86
	3	0.77	0.83	0.73	0.42	0.68	1.00	1.00	0.59
	4	0.68	0.45	0.72	0.36	0.66	0.95	0.58	0.67
Acoust. Stock**	4	0.36	0.28	0.52	0.39	0.35	0.96		0.43

* 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 2018 available to the Working Group.

Subdivision	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 25	1	10,214	18	853	698
	2	8,999	17	1,355	831
	3	6,590	18	1,901	974
	4	14,207	11	1,331	734
	Total	40,009	64	5,440	3,237
Subdivision 26	1	27,910	33	2,787	1,135
	2	16,436	16	1,803	956
	3	5,310	15	3,886	563
	4	12,602	13	2,312	1,150
	Total	62,257	77	10,788	3,804
Subdivision 27	1	13,272	8	677	677
	2	3,973	5	411	409
	3	247	0	0	0
	4	806	0	0	0
	Total	18,298	13	1,088	1,086
Subdivision 28*	1	22,834	27	3,788	2,586
	2	18,757	61	6,830	6,020
	3	5,941	9	1,590	958
	4	21,577	28	4,140	2,508
	Total	69,110	125	16,348	12,072
Subdivision 29	1	20,684	13	1,691	762
	2	8,300	15	3,157	726
	3	736	4	744	155
	4	22,306	10	1,224	544
	Total	52,025	42	6,816	2,187
Subdivision 30	1	39,675	13	4,195	13
	2	38,479	29	10,962	14
	3	3,754	10	3,212	10
	4	13,071	18	6,084	15
	Total	94,980	70	24,453	52
Subdivision 31	1	0	0	0	0
	2	1,439	14	4426	8
	3	711	7	1006	8
	4	236	4	800	4
	Total	2,386	25	6,232	20
Subdivision 32	1	9,011	38	3,938	1,694
	2	5,468	63	6,717	2,285
	3	1,064	9	1,210	691
	4	12,868	55	3,906	1,081
	Total	28,412	165	15,771	5,751
Subdivisions 25-32	**1**	**143,600**	**150**	**17,929**	**7,565**
	2	**101,852**	**220**	**35,661**	**11,249**
	3	**24,353**	**72**	**13,549**	**3,359**
	4	**97,673**	**139**	**19,797**	**6,036**
	Total	**367,478**	**581**	**86,936**	**28,209**

* Gulf of Riga included

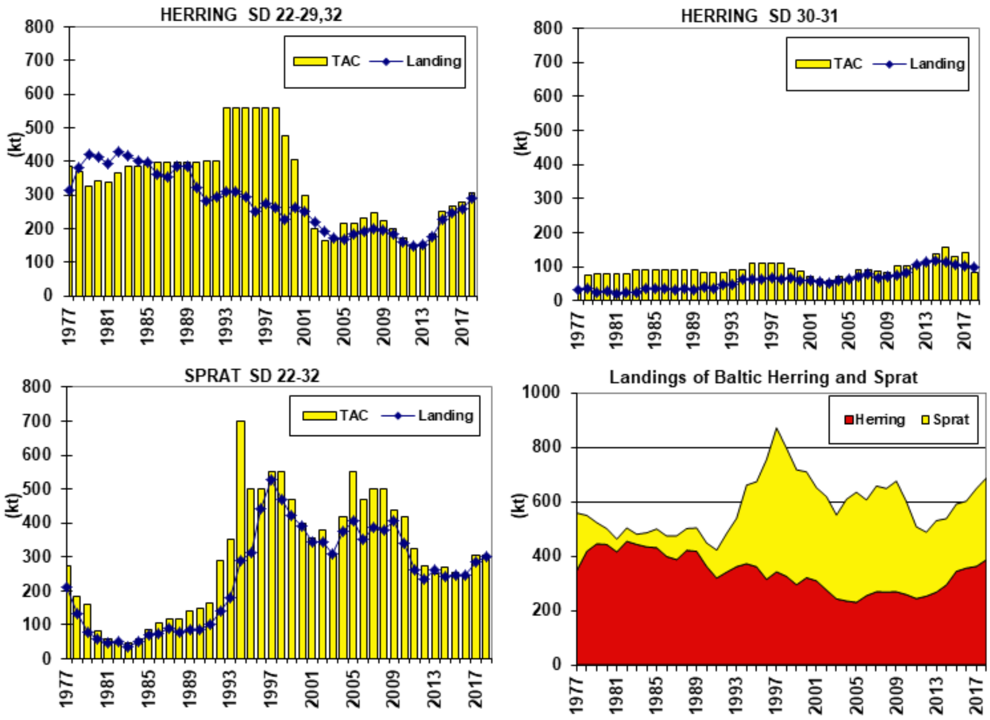


Figure 4.1.1. Reported landings of herring and sprat and agreed TACs in the Baltic Sea. (since 2007 TACs for herring and sprat: EC quota + Russian TAC).

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 2018 amounted to 244 365 t, which is 21% higher than last year. Catches increased for all countries (Denmark (22%), Estonia (4%), and Finland (11%), Germany (10%), Latvia (41%), Lithuania (63%), Poland (23%), Russia (14%), and Sweden (31%). The largest part of the catches in 2018 was taken by Sweden (27%), followed by Poland (20%) and by Finland (19%).

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 26, 28.2 and 29. In 2018 the distribution of catches was as follows: 21% in SD 29, 26% in SD 26 and 18% in SD 28.2.

4.2.1.2 Discards

There were only two countries, Sweden and Finland, reporting logbook registered discard of 34 t (0.01% of total catch) in 2018. No discards have been reported before 2016. Discarding at sea is 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 and Poland. 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 26% of the total catches in 2018. 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 2018 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 2018 over 76% of the catches in numbers (Figure 4.2.1) which is a larger proportions as in 2017 (68%). The strong year class of 2014 is now 4 years old and is still the main contributor to the fishery with 29% 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). The results (R^2) are similar compared to the last year. 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 2018 (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, 2007 and 2014, 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 tonnes/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). 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 1974-2018 (Table 4.2.8).

4.2.2.4 Natural mortality

In the benchmarking assessment (ICES CM 2013/ACOM:43) a new dataseries 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 the last four year's assessment it was decided to use M values for 2012–2018 estimated from the regression of M values taken from SMS against cod SSB in 1974–2011 (Figure 4.2.5a). The index of cod SSB obtained from the BITS surveys 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 2018 is given in Table 4.2.2. The overall frequency was 1.8 samples, 220 fish measured and 106 fish aged per 1000 tonnes landed. In 2018, sampling was most frequent in SD 32 followed by SD 28 and SD 26. Compared to 2017 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 2018, ICES WKPELA 2018). 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 and novel methods (e.g. genetic) a first workshop was conducted in 2018 (ICES CM 2018/ACOM:63).

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 (Hentati-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.

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. 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 2018 data showed only small differences on the strength of the internal consistency compared to last year.

4.2.4 Assessment

4.2.4.1 Recruitment estimates

The dataseries of 0 group herring from the acoustic surveys in subdivisions 25–27, 28.2 and 29 (including southern and northern data) in 1991–2018 was used in a RCT3 analysis to estimate the year class 2018 at age 1 for 2019. The RCT3 input and result are presented in tables 4.2.17 and 4.2.18. The estimate of the year class 2018 (Age 1 in 2019: 14.437 billions) is below the estimated average recruitment of the whole time-series (1974–2018: 17.397 billions).

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, CHB_WGBFAS_2019_01. 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 from the XSA output showing a tendency to 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).

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 69* iterations, are shown in Table 4.2.12. Including the latest acoustic estimates for 2018 led to similar regression statistics as last year. Fishing mortalities and stock number are given in Table 4.2.13 and Table 4.2.14, respec-tively. The summary is presented in Table 4.2.15.

* updated on 7 January 2020.

The development of herring biomass as estimated by the acoustic surveys and by XSA is illustrated in Figure 4.2.7. The 2018 acoustic SSB and total biomass show a higher increase in biomass compared to the XSA estimates. The acoustic estimates in 2018 reached again higher levels compared to the very low values in 2017.

A retrospective analysis for the whole time-series is given in Figure 4.2.8. Fishing mortality has been overestimated, whereas the spawning-stock biomass has been underestimated comparing the last year two years. This retrospective pattern is the opposite for the years before, where the fishing mortality has been underestimated, whereas the spawning-stock biomass has been overestimated.

The log-catchability residuals show some year effects with only positive or negative residuals (Figure 4.2.9). Residuals were however overall small and therefore are considered acceptable.

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 0.4–0.9, which is slightly worse than last year's estimates.

4.2.4.4 Historical stock trend

The spawning stock size has shown an increasing trend, with minor fluctuations, since the beginning of the 2000s (Figure 4.2.13). The present SSB estimate of 938 kt for 2018 is 3% above the long-term average (1974–2018). 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 years the catches in SD 25 have decreased slightly, whereas the catches in SD 26 increased slightly. The corresponding mean weight-at-age, which are higher in SD 25 than in SD 26 can influence the estimation of SSB. In numbers the metrics shows a spawning stock that varies around 23–37 billion fish in the period 1974–1997. The stock starts to decrease in 1998, to reach a value of 16 billion fish in 2003, which is the lowest value of the time-series. Since then the spawning stock numbers increased to 45 billon fish in 2016, which is the highest value of the time-series. The last two years the numbers decreased and reached 38 billion fish in 2018 (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 northeastern 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.

Recruitment-at-age 1 was high at 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 26 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 (48.5 billion). This year class is still the main contributor in the catches in 2018. The last four year classes are below or on average and if such low recruitment continues, a marked decline in biomass development can be expected in the coming years.

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 2016-2018. The estimate of recruitment of age 1 for 2019 was taken from the RCT3 analysis (Tables 4.2.17 and 4.2.18), whereas recruits in 2020 and 2021 were the GM for 1988–2017 , 14.9 billions). The natural mortalities at age were assumed as the average of 2016–2018. The exploitation pattern was taken as the average over 2016–2018. The TAC constraint of 204 360 tonnes (EU share 170 360 tonnes + Russian quota 29 900 tonnes + central Baltic herring stock caught in Gulf of Riga 4360 tonnes (mean 2013–2017) − Gulf of Riga herring stock caught in central Baltic Sea 260 tonnes (mean 2013–2017)) was used in the predictions in the intermediate year 2019 since the total TAC in 2018 was almost fully exploited (and status quo F resulted in 225 kt, which is above this TAC constraint). This resulted in a fishing mortality of 0.24 (Table 4.2.20), which lies below the present estimated F in 2018 of 0.29. The SSB is expected to decrease to 844 663 t in 2019.

It is important to note that the large 2014 year class will still be the main contributor to the yield in 2019 (2020) and SSB in 2020 (2021), and no substantial new incoming year classes are predicted (Figure 4.2.15). It is uncommon to see such large contribution of one year class to the SSB as seen in the short-term prediction for 2020 (2021). This makes the stock more vulnerable to over exploitation.

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 F_{lower}	F_{MSY}	MSY F_{upper} with AR	MSY $B_{trigger}$ (1000 t)	MSY F_{upper} 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 natural mortality was provided from multispecies models for the years 1974–2011, and from a regression of M against the Eastern Baltic cod SSB in 2012–2018.

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, see also section 4.2.2.5). 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 was therefore 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 and preliminary analyses by Sweden suggests that misreporting of herring and sprat is significantly worse than 5 and 4%, this issue needs to be investigated as soon as possible and when data available addressed in a benchmark. Significant misreporting can potentially be a large problem with regards to our perception of these stocks.

Likewise important to investigate further is the mixing of Central Baltic herring (CBH) and Western Baltic spring spawning herring (WBSSH) in SDs 24–26 (see also section 4.2.2.5). Depending on the degree of mixing it could have significant impacts on our perception of both herring stocks. A working group has been initiated to look further into this issue.

4.2.8 Comparison with previous assessment

Compared to last year, the present assessment resulted in 8% more SSB for 2017. $F_{(3–6)}$ in 2017 was estimated to be 11% lower compared to last year's assessment and recruitment-at-age 1 in 2017 was estimated to be 12% more in this year's assessment.

Category	Parameter	Assessment 2018	Assessment 2019	Diff. (+/-) %
Data input	Maturity ogives	age 1: 0%, age 2/ 3: 70% age >=4: 100%	age 1: 0%, age 2/3: 70% age >=4:100%	No
	Natural mortality	$M_{1974–2011}$ = SMS, M_{2012}– M_{2017} = regression of M against cod SSB	$M_{1974–2011}$ = SMS, M_{2012}– M_{2018} = 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 2017 (1000 t)	838	902	+8%
	TSB 2017 (1000 t)	1235	1330	+8%
	F(3–5) 2017	0.28	0.25	-11%

Recruitment (age 1) 2017 (billions)	14.2	15.9	+12%

***FLR XSA setting of qage=5 was used instead of qage=6 since FLR diagnostic output shows wrongly >6 instead of correctly≥6 (qage=5 gives wrongly >5 instead of correctly ≥5).**

4.2.9 Management considerations

The spawning stock size has shown an increasing trend, with minor fluctuations, since the beginning of the 2000s. The present SSB estimate for 2018 is above the long-term average (1974–2018). Fishing mortality (F3–6; 0.29) is higher than 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 since 2007 (2007, 2008, 2011, 2012 and 2014). It is also important to note that the large 2014 year class will be the main contributor to the yield in 2019 and 2020 and SSB in 2020 (to a lesser extend in 2021), and no substantial new incoming year classes are predicted (Figure 4.2.15). It is uncommon to see such large contribution of one year class to the SSB as seen in the short-term prediction for 2019 and 2020. This makes the stock more vulnerable to over exploitation. The last four year classes are below or on average and if such low recruitment continues, a marked decline in biomass development can be expected in the coming years.

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. New M values are expected from WGSAM in 2019.

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				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				70.4	101.0	71.3	302.5
1980	10.6		44.0				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				65.8	89.8	56.9	273.1
1985	7.6		54.2				72.8	95.2	42.5	272.3
1986	3.9		49.4				67.8	98.8	29.7	249.6
1987	4.2		50.4				55.5	100.9	25.4	236.4
1988	10.8		58.1				57.2	106.0	33.4	265.5
1989	7.3		50.0				51.8	105.0	55.4	269.5
1990	4.6		26.9				52.3	101.3	44.2	229.3
1991	6.8	27.0	18.1		20.7	6.5	47.1	31.9	36.5	194.6
1992	8.1	22.3	30.0		12.5	4.6	39.2	29.5	43.0	189.2
1993	8.9	25.4	32.3		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
2017	9.3	23.3	40.7	3.6	7.9	4.0	40.1	22.3	51.2	202.5
*2018	11.4	24.3	45.4	4.0	11.2	6.6	49.3	25.4	66.9	244.4

*** 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 (WGBFAS 2014).**

Table 4.2.2 Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2018 available to the Working Group.(1/6)

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 25	Denmark	1	307	6	80	80
		2	108	0	0	0
		3				
		4	711	1	12	12
		Total	1 125	7	92	92
	Finland	1	613	0	0	0
		2				
		3	65	0	0	0
		4	51	0	0	0
		Total	729	0	0	0
	Germany	1	48	0	0	0
		2	351	0	0	0
		3				
		4				
		Total	399	0	0	0
	Latvia	1	67	0	0	0
		2	178	0	0	0
		3	71	0	0	0
		4				
		Total	316	0	0	0
	Lithuania	1	274	0	0	0
		2	692	0	0	0
		3				
		4	100	0	0	0
		Total	1 067	0	0	0
	Poland	1	4 836	1	217	65
		2	6 296	14	905	385
		3	4 477	5	1 021	100
		4	8 393	4	769	173
		Total	24 002	24	2 912	723
	Sweden	1	4 068	11	556	553
		2	1 374	3	450	446
		3	1 977	13	880	874
		4	4 952	6	550	549
		Total	12 371	33	2 436	2 422
	Total	1	10 214	18	853	698
		2	8 999	17	1 355	831
		3	6 590	18	1 901	974
		4	14 207	11	1 331	734
		Total	40 009	64	5 440	3 237

(cont'). Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2018 available to the Working Group. (2/6)

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 26	Denmark	1	2 581	8	40	40
		2	1 598	0	0	0
		3				
		4	20	0	0	0
		Total	4 199	8	40	40
	Finland	1	2 543	0	0	0
		2	1 077	0	0	0
		3	45	0	0	0
		4				
		Total	3 666	0	0	0
	Germany	1	1 556	0	0	0
		2	408	0	0	0
		3				
		4				
		Total	1 964	0	0	0
	Latvia	1	536	0	0	0
		2	122	0	0	0
		3	265	0	0	0
		4	321	0	0	0
		Total	1 244	0	0	0
	Lithuania	1	1 502	2	313	313
		2	1 285	1	163	163
		3	79	0	0	0
		4	502	2	383	381
		Total	3 368	5	859	857
	Poland	1	8 901	11	377	233
		2	6 210	3	99	68
		3	2 002	0	0	0
		4	7 539	3	452	135
		Total	24 652	17	928	436
	Russia	1	5 765	12	2 057	549
		2	4 611	12	1 541	725
		3	2 724	15	3 886	563
		4	4 054	8	1 477	634
		Total	17 155	47	8 961	2 471
	Sweden	1	4 526	0	0	0
		2	1 125	0	0	0
		3	195	0	0	0
		4	165	0	0	0
		Total	6 010	0	0	0
	Total	1	27 910	33	2 787	1 135
		2	16 436	16	1 803	956
		3	5 310	15	3 886	563
		4	12 602	13	2 312	1 150
		Total	62 257	77	10 788	3 804

(cont'). Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2018 available to the Working Group. (3/6)

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Subdivision 27	Denmark	1	335	0	0	0
		2	237	0	0	0
		3				
		4	24	0	0	0
		Total	596	0	0	0
	Finland	1	628	0	0	0
		2	241	0	0	0
		3	27	0	0	0
		4	23	0	0	0
		Total	919	0	0	0
	Germany	1	130	0	0	0
		2	313	0	0	0
		3				
		4				
		Total	443	0	0	0
	Sweden	1	12 180	8	677	677
		2	3 182	5	411	409
		3	220	0	0	0
		4	759	0	0	0
		Total	16 341	13	1 088	1 086
	Total	1	13 142	8	677	677
		2	3 973	5	411	409
		3	247	0	0	0
		4	806	0	0	0
		Total	18 298	13	1 088	1 086

(cont'). Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2018 available to the Working Group. (4/6)

Subdivision 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	2 657	1	4	4
	2	78	0	0	0
	3				
	4	991	2	58	58
	Total	3 726	3	62	62
Estonia	1	1 096	5	320	318
	2	2 773	5	500	400
	3	0.011	1	75	75
	4	996	6	314	307
	Total	4 864	17	1 209	1 100
Finland	1	2 611	0	0	0
	2	158	0	0	0
	3	260	0	0	0
	4	1 505	0	0	0
	Total	4 533	0	0	0
Germany	1	936	0	0	0
	2	34	0	0	0
	3				
	4				
	Total	970	0	0	0
Latvia	1	2 815	11	2 497	1 301
	2	2 192	40	4 680	4 076
	3	679	6	1 240	615
	4	3 941	13	3 079	1 457
	Total	9 627	70	11 496	7 449
Lithuania	1	596	0	0	0
	2	41	0	0	0
	3	22	0	0	0
	4	1 313	0	0	0
	Total	1 971	0	0	0
Poland	1	164	0	0	0
	2				
	3	22	0	0	0
	4	435	0	0	0
	Total	621	0	0	0
Sweden	1	6 505	6	567	563
	2	1 495	1	150	149
	3	1 845	1	150	148
	4	7 206	4	339	336
	Total	17 051	12	1 206	1 196
Total	1	17 380	23	3 388	2 186
	2	6 735	46	5 330	4 625
	3	2 827	8	1 465	838
	4	16 387	25	3 790	2 158
	Total	43 363	102	13 973	9 807

(cont'). Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2018 available to the Working Group. (5/6)

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Subdivision 29	Denmark	1	1 263	1	20	20
		2	145	0	0	0
		3				
		4	313	0	0	0
		Total	1 721	1	20	20
	Estonia	1	2 957	6	457	455
		2	1 063	7	595	591
		3	205	2	75	75
		4	2 683	6	430	430
		Total	6 908	21	1 557	1 551
	Finland	1	8 089	3	1 051	124
		2	5 815	8	2 562	135
		3	517	2	669	80
		4	13 703	4	794	114
		Total	28 124	17	5 076	453
	Germany	1	150	0	0	0
		2				
		3				
		4	25	0	0	0
		Total	175	0	0	0
	Lithuania	1	159	0	0	0
		2				
		3				
		4				
		Total	159	0	0	0
	Poland	1				
		2				
		3				
		4	5	0	0	0
		Total	5	0	0	0
	Sweden	1	8 065	3	163	163
		2	1 278	0	0	0
		3	13	0	0	0
		4	5 577	0	0	0
		Total	14 933	3	163	163
	Total	1	20 684	13	1 691	762
		2	8 300	15	3 157	726
		3	736	4	744	155
		4	22 306	10	1 224	544
		Total	52 025	42	6 816	2 187

(cont'). Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2018 available to the Working Group. (6/6)

	Country	Quarter	Catches in tons	Number of samples	Number of fish meas,	Number of fish aged
Subdivision 32	Estonia	1	4 372	15	1 441	1 441
		2	2 565	18	1 800	1 800
		3	499	6	560	560
		4	5 060	8	730	730
		Total	12 498	47	4 531	4 531
	Finland	1	2 372	3	842	178
		2	764	5	1 400	200
		3	565	3	650	131
		4	3 691	6	406	140
		Total	7 392	17	3 298	649
	Russia	1	2 267	20	1 655	75
		2	2 138	40	3 517	285
		3				
		4	3 877	41	2 770	211
		Total	8 282	101	7 942	571
	Sweden	1				
		2				
		3				
		4	240	0	0	0
		Total	240	0	0	0
	Total	1	9 011	38	3 938	1 694
		2	5 468	63	6 717	2 285
		3	1 064	9	1 210	691
		4	12 868	55	3 906	1 081
		Total	28 412	165	15 771	5 751
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	**98 340**	**133**	**13 334**	**7 152**
		2	**49 912**	**162**	**18 773**	**9 832**
		3	**16 774**	**54**	**9 206**	**3 221**
		4	**79 176**	**114**	**12 563**	**5 667**
		Total	**244 365**	**463**	**53 876**	**25 872**

Table 4.2.3. Herring in SD 25–29, 32 (excl. GoR). Catch by country and SD and mean weight by SD in 2018.

CATCH (1000 T) BY COUNTRY AND SD							
Country	**Total**	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
Denmark	11.368	1.125	4.199	0.596	3.726	1.721	0.000
Estonia	24.269	0.000	0.000	0.000	4.864	6.908	12.498
Finland	45.363	0.729	3.666	0.919	4.533	28.124	7.392
Germany	3.951	0.399	1.964	0.443	0.970	0.175	0.000
Latvia*	11.187	0.316	1.244	0.000	9.627	0.000	0.000
Lithuania	6.564	1.067	3.368	0.000	1.971	0.159	0.000
Poland	49.280	24.002	24.652	0.000	0.621	0.005	0.000
Russia	25.437	0.000	17.155	0.000	0.000	0.000	8.282
Sweden	66.946	12.371	6.010	16.341	17.051	14.933	0.240
Total	**244.365**	**40.009**	**62.257**	**18.298**	**43.363**	**52.025**	**28.412**

*Catches in SD 28.2 include 1 733 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	210363	5286	4206	0	364	129669	70838
1	1737640	39570	223584	171805	132026	772046	398608
2	1280367	45548	146356	101837	81666	591385	313575
3	1174100	124201	239803	82325	160728	291720	275323
4	2637412	231054	379801	396728	582344	616172	431313
5	789008	135745	172082	79437	162087	146053	93603
6	663989	91935	181895	36601	169312	127463	56783
7	398905	45476	107880	14894	134923	70111	25620
8	214380	35480	68290	6697	31057	56310	16546
9	68521	12280	34747	2078	16341	2128	947
10+	52349	4652	28300	0	15575	3364	458
Total N	**9227034**	**771229**	**1586943**	**892403**	**1486424**	**2806420**	**1683614**
CATON	**244.365**	**40.009**	**62.257**	**18.298**	**43.363**	**52.025**	**28.412**

Mean weight (g)							
AGE	Mean	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
0	5.3	13.3	11.0	0.0	5.5	5.4	4.2
1	11.1	32.2	13.4	5.0	7.5	11.8	10.3
2	18.7	44.8	31.3	15.7	18.8	15.9	15.4
3	27.9	47.1	39.2	21.0	25.7	21.8	18.9
4	28.4	45.2	39.8	24.3	28.3	23.2	20.6
5	39.8	68.4	45.7	29.2	34.9	26.9	24.6
6	40.8	57.2	48.5	35.0	37.0	29.7	29.5
7	43.2	60.8	52.3	33.9	40.8	30.7	25.0
8	47.6	56.6	56.9	40.6	45.5	39.0	25.9
9	57.0	60.6	63.6	37.3	47.3	33.1	31.2
10+	63.9	98.9	71.9	0.0	47.4	28.4	39.2

CATON is given in 1000 tons

Table 4.2.4. Herring in SD 25–29, 32 (excl. GoR). Catch in number-at-age (millions) per SD and quarter in 2018. 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	537.996	1.641	143.977	144.988	106.725	110.938	29.728
2	439.133	8.766	60.718	76.412	9.132	213.577	70.527
3	434.983	28.522	114.290	55.840	25.737	109.561	101.034
4	1320.383	59.988	172.471	274.301	242.270	381.396	189.957
5	361.374	37.542	80.208	62.697	58.295	83.076	39.555
6	296.931	34.221	76.239	28.410	68.911	62.206	26.943
7	212.801	20.249	54.340	12.735	83.896	32.715	8.865
8	90.760	15.365	31.245	5.878	13.655	20.679	3.937
9	32.108	5.764	15.615	1.959	7.116	1.016	0.638
10+	19.961	3.217	8.711	0.000	6.360	1.354	0.319
Total N	3746.429	215.276	757.813	663.221	622.097	1016.520	471.502
CATON	98.470	10.214	27.910	13.272	17.380	20.684	9.011
Quarter:	**2**						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	0.172	0.000	0.172	0.000	0.000	0.000	0.000
1	119.202	4.633	33.537	16.959	3.186	37.186	23.702
2	255.183	7.585	62.884	19.568	35.563	100.521	29.063
3	336.287	42.421	87.296	21.742	36.492	84.042	64.294
4	540.272	38.745	113.434	99.578	94.895	78.984	114.635
5	167.851	39.852	35.153	12.175	14.312	34.345	32.014
6	154.223	34.116	29.591	6.088	35.357	33.993	15.078
7	84.031	11.994	21.830	1.305	23.614	21.407	3.880
8	57.986	15.041	11.879	0.435	2.385	23.045	5.202
9	15.295	5.719	5.366	0.000	3.431	0.469	0.310
10+	14.879	0.869	7.177	0.000	5.755	0.939	0.139
Total N	1745.382	200.976	408.320	177.849	254.989	414.929	288.318
CATON	49.946	8.999	16.436	3.973	6.769	8.300	5.468
Quarter:	**3**						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	12.550	0.219	1.119	0.000	0.000	8.339	2.873
1	89.692	9.927	17.136	1.055	1.359	18.092	42.125
2	47.515	12.119	5.528	1.217	9.290	9.816	9.545
3	57.989	16.930	9.212	1.352	21.281	3.951	5.263
4	131.491	37.713	30.184	6.193	44.177	3.733	9.492
5	52.719	19.288	17.793	0.757	10.623	0.860	3.398
6	39.085	8.778	21.092	0.379	6.056	1.478	1.303
7	21.172	2.901	13.275	0.081	2.578	0.680	1.656
8	14.802	0.888	8.744	0.027	2.251	1.398	1.494
9	6.894	0.122	5.872	0.000	0.900	0.000	0.000
10+	4.792	0.124	4.340	0.000	0.327	0.000	0.000
Total N	478.701	109.009	134.294	11.060	98.843	48.348	77.149
CATON	16.774	6.590	5.310	0.247	2.827	0.736	1.064
Quarter:	**4**						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	197.640	5.067	2.915	0.000	0.364	121.330	67.965
1	990.749	23.369	28.935	8.804	20.756	605.831	303.054
2	538.535	17.078	17.225	4.640	27.682	267.471	204.439
3	344.842	36.329	29.005	3.391	77.219	94.166	104.733
4	645.266	94.608	63.712	16.657	201.002	152.058	117.229
5	207.064	39.063	38.928	3.807	78.857	27.771	18.636
6	173.750	14.820	54.973	1.725	58.988	29.785	13.459
7	80.902	10.331	18.437	0.773	24.835	15.308	11.218
8	50.832	4.186	16.422	0.357	12.766	11.189	5.912
9	14.223	0.675	7.893	0.119	4.893	0.643	0.000
10+	12.717	0.442	8.071	0.000	3.132	1.071	0.000
Total N	3256.521	245.968	286.516	40.273	510.496	1326.624	846.644
CATON	79.176	14.207	12.602	0.806	16.387	22.306	12.868

Table 4.2.4. Herring in SD 25–29, 32 (excl. GoR). Mean weight-at-age per SD and quarter in 2018. 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	6.2	13.2	10.0	4.9	4.3	5.2	4.5
2	16.3	38.8	29.9	15.5	18.8	12.6	13.3
3	26.2	40.8	37.9	20.8	27.2	21.0	17.1
4	26.6	39.7	38.4	24.3	27.6	23.3	20.6
5	35.0	49.5	45.4	29.1	34.5	28.0	25.3
6	40.0	50.6	49.3	34.8	37.8	30.3	33.8
7	43.8	56.6	53.1	33.5	42.4	32.1	28.8
8	49.9	56.4	58.3	39.7	43.9	43.0	29.3
9	59.0	62.9	68.9	37.3	46.9	30.7	27.6
10+	70.6	113.5	79.3	NA	47.1	30.9	35.5
Quarter:	**2**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	16.6	NA	16.6	NA	NA	NA	NA
1	7.4	15.9	12.1	5.1	5.0	4.9	4.9
2	18.7	33.0	31.4	16.6	15.7	12.7	13.7
3	27.2	35.5	41.4	21.7	21.5	20.0	17.0
4	28.2	39.3	42.5	24.5	25.8	20.5	20.9
5	37.0	49.1	48.5	29.9	33.5	26.4	24.8
6	39.7	52.1	51.8	36.0	33.4	29.9	26.4
7	40.6	58.5	49.7	38.0	33.9	31.3	27.1
8	46.7	55.3	57.6	53.2	45.2	39.6	28.7
9	54.2	57.0	61.4	NA	43.4	26.7	38.6
10+	54.9	67.0	65.4	NA	45.2	23.3	47.5
Quarter:	**3**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	5.3	15.1	9.0	NA	5.0	4.9	4.4
1	15.5	37.6	20.1	5.1	23.6	12.1	9.9
2	29.2	54.6	30.4	16.6	22.1	17.3	16.9
3	36.7	64.0	33.9	21.7	24.5	21.0	19.1
4	37.2	58.7	34.9	24.5	27.0	23.3	20.3
5	49.4	69.7	42.9	29.9	35.1	26.3	22.4
6	47.8	69.8	44.8	36.0	37.5	27.3	23.5
7	49.5	71.7	49.8	38.0	45.3	27.0	24.3
8	49.6	80.9	52.5	53.2	49.1	39.9	23.6
9	53.1	95.1	53.5	NA	44.6	NA	NA
10+	62.4	81.5	63.5	NA	40.0	NA	NA
Quarter:	**4**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	5.3	13.2	11.4	NA	5.5	5.4	4.2
1	13.8	34.5	27.4	4.9	22.8	13.4	11.3
2	19.9	46.1	36.5	15.5	21.7	19.7	16.3
3	29.1	57.9	39.6	20.8	27.5	24.5	21.9
4	30.5	45.8	41.1	24.3	30.7	24.4	20.6
5	47.8	105.7	45.2	29.1	35.4	24.0	23.5
6	41.6	76.5	47.3	34.8	38.1	28.4	24.9
7	42.4	68.8	54.9	33.5	41.4	27.0	21.5
8	44.0	56.7	56.2	39.7	46.6	30.1	21.8
9	57.2	65.0	62.0	37.3	51.0	41.6	NA
10+	64.6	60.0	74.0	NA	53.0	29.7	NA

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)								
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	100.0
2017	983743	823614	2898360	840730	923686	527598	248465	411819	100.0
2018	1737640	1280367	1174100	2637412	789008	663989	398905	335250	99.9

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	0.0470
2017	0.0109	0.0192	0.0208	0.0321	0.0347	0.0403	0.0482	0.0518
2018	0.0111	0.0187	0.0279	0.0284	0.0398	0.0408	0.0432	0.0521

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
*2017	0.2813	0.2645	0.2532	0.2433	0.2374	0.2304	0.2244	0.2190
*2018	0.2782	0.2621	0.2511	0.2417	0.2359	0.2292	0.2235	0.2183

1971–2011 based on latest MSVPA/SMS-data provided by WGSAM 2012
***2012–2018 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+
1974-2018	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+
1974-2018	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+
1974-2018	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	6830	27755	7212	7277	4050	2032	1493	1471
2017	1	4454	5362	20367	3945	3663	1824	628	1210
2018	1	6306	9085	8408	26663	5606	4625	2016	1311

*not used due to incomplete coverage

Table 4.2.12. Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run: Diagnostics. (1/3)*

Lowestoft VPA Version 3.1
3/04/2019 12:59
Extended Survivors Analysis
Herring in Sub-div. 25 to 29 and 32 (excl. Gulf of Riga)
CPUE data from file BIAS_CBH_WGBFAS 2019.tun

Catch data for 41 years. 1974 to 2014. Ages 1 to 8.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
BIAS SD25-27&28.2&29S&N	1991	2018	1	7	0,8	0,9

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 >= 6

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 = 1.500
Minimum standard error for population
estimates derived from each fleet = .300
Prior weighting not applied

Tuning converged after 69 iterations

Regression weights

0,751	0,82	0,877	0,921	0,954	0,976	0,99	0,997	1	1

Fishing mortalities

Age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0,04	0,047	0,043	0,022	0,029	0,039	0,035	0,05	0,074	0,12
2	0,089	0,056	0,072	0,066	0,061	0,076	0,087	0,104	0,097	0,14
3	0,133	0,13	0,1	0,076	0,076	0,134	0,156	0,161	0,148	0,209
4	0,208	0,186	0,172	0,099	0,107	0,163	0,262	0,228	0,226	0,206
5	0,195	0,259	0,194	0,154	0,129	0,187	0,251	0,295	0,292	0,36
6	0,223	0,314	0,223	0,174	0,142	0,165	0,23	0,381	0,319	0,368
7	0,413	0,32	0,257	0,186	0,195	0,146	0,228	0,5	0,575	0,442

XSA population numbers (Thousands)

YEAR	1	2	3	4	5	6	7
2009	1,93E+07	1,90E+07	6,92E+06	5,25E+06	1,96E+06	1,95E+06	1,65E+06
2010	1,39E+07	1,38E+07	1,30E+07	4,54E+06	3,21E+06	1,22E+06	1,19E+06
2011	8,31E+06	9,67E+06	9,52E+06	8,41E+06	2,77E+06	1,83E+06	6,63E+05
2012	1,74E+07	5,70E+06	6,46E+06	6,21E+06	5,10E+06	1,65E+06	1,06E+06
2013	1,93E+07	1,27E+07	4,04E+06	4,60E+06	4,37E+06	3,42E+06	1,09E+06
2014	1,41E+07	1,41E+07	9,09E+06	2,89E+06	3,23E+06	3,02E+06	2,35E+06
2015	4,80E+07	1,02E+07	9,98E+06	6,16E+06	1,92E+06	2,11E+06	2,03E+06
2016	1,43E+07	3,48E+07	7,16E+06	6,61E+06	3,70E+06	1,18E+06	1,33E+06
2017	1,59E+07	1,02E+07	2,39E+07	4,70E+06	4,10E+06	2,17E+06	6,36E+05
2018	1,77E+07	1,11E+07	7,07E+06	1,60E+07	2,94E+06	2,42E+06	1,25E+06

Estimated population abundance at 1st Jan 2019

0,00E+00	1,19E+07	7,45E+06	4,47E+06	1,02E+07	1,62E+06	1,33E+06

Taper weighted geometric mean of the VPA populations:

1,68E+07	1,18E+07	8,14E+06	5,40E+06	3,06E+06	1,85E+06	1,06E+06

Standard error of the weighted Log(VPA populations) :

0,428	0,4523	0,4641	0,4721	0,3501	0,4063	0,4764

* Table 4.2.12 was updated on 7 January 2020

continued

Table 4.2.12. Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run: Diagnostics. (2/3)

Log catchability residuals.

Fleet : Baltic International Acoustic Survey (BIAS)

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	99,99	99,99	99,99	99,99	99,99	99,99	99,99	99,99	-0,18	0,42
2	99,99	99,99	99,99	99,99	99,99	99,99	99,99	99,99	-0,33	-0,40
3	99,99	99,99	99,99	99,99	99,99	99,99	99,99	99,99	-0,38	0,52
4	99,99	99,99	99,99	99,99	99,99	99,99	99,99	99,99	-0,31	0,42
5	99,99	99,99	99,99	99,99	99,99	99,99	99,99	99,99	-0,26	0,49
6	99,99	99,99	99,99	99,99	99,99	99,99	99,99	99,99	-0,36	0,28
7	99,99	99,99	99,99	99,99	99,99	99,99	99,99	99,99	-0,19	1,00

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0,12	-0,09	0,41	0,02	-0,21	0,14	0,07	-0,42	-0,15	-0,16
2	0,23	-0,17	0,60	0,18	0,14	0,51	-0,22	-0,05	-0,11	-0,17
3	-0,17	0,05	0,68	0,22	0,22	0,45	-0,57	-0,16	-0,13	-0,17
4	0,15	-0,08	0,29	0,02	0,44	0,68	-0,51	-0,21	-0,28	-0,23
5	-0,22	-0,01	0,05	-0,39	0,27	0,82	-0,09	-0,04	-0,45	-0,33
6	-0,25	-0,26	0,29	-0,23	0,01	0,39	-0,16	-0,26	-0,10	-0,10
7	-0,30	-0,08	0,12	-0,23	0,17	0,04	-0,39	-0,28	-0,12	0,04

Age	2011	2012	2013	2014	2015	2016	2017	2018
1	0,03	0,51	-0,12	-0,01	0,09	0,19	-0,2	-0,04
2	-0,17	-0,14	-0,02	-0,02	0,28	0,11	-0,31	0,16
3	0,04	-0,02	-0,23	0,39	0,31	-0,1	-0,29	0,09
4	0,08	-0,04	-0,04	0,31	0,61	-0,25	-0,53	0,14
5	0,23	0,03	-0,10	0,29	0,56	-0,36	-0,57	0,25
6	0,10	-0,10	0,13	0,19	0,29	0,13	-0,64	0,22
7	0,32	0,17	0,10	0,12	0,03	-0,21	-0,27	0,1

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	-6,9286	-6,4386	-6,157	-6,0057	-5,9673	-5,9673
S.E(Log q)	0,2214	0,2793	0,3593	0,3813	0,2729	0,2062

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	lean Log q
1	0,67	1,961	10,51	0,78	20	0,24	-7,56

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	ean Log q
2	1	0,003	6,93	0,81	20	0,23	-6,93
3	1,01	-0,035	6,37	0,73	20	0,29	-6,44
4	0,91	0,402	6,97	0,68	20	0,34	-6,16
5	1,76	-1,367	-0,75	0,24	20	0,65	-6,01
6	0,96	0,193	6,3	0,71	20	0,27	-5,97
7	0,93	0,572	6,54	0,87	20	0,2	-5,98

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 2017

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD25-27&28.2&29S&N	1,1E+07	0,3	0	0	1	0,649	0,125
P shrinkage mean	1,2E+07	0,45				0,322	0,121
F shrinkage mean	3,3E+07	1,5				0,029	0,045

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
11859310	0,25	0,13	3	0,519	0,12

continued

Table 4.2.12. Herring in SD 25–29, 32 (excl. GoR). Output from XSA final run: Diagnostics. (3/3)

Age 2 Catchability constant w.r.t. time and dependent on age
Year class = 2016

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD25-27&28.2&29S&N	7357275	0,212	0,178	0,840	2	0,977	0,142
F shrinkage mean	1,3E+07	1,5				0,023	0,086

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7449722	0,21	0,14	3	0,652	0,14

Age 3 Catchability constant w.r.t. time and dependent on age
Year class = 2015

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD25-27&28.2&29S&N	4428949	0,174	0,152	0,870	3	0,983	0,21
F shrinkage mean	7128187	1,5				0,017	0,136

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4465973	0,17	0,13	4	0,741	0,209

Age 4 Catchability constant w.r.t. time and dependent on age
Year class = 2014

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD25-27&28.2&29S&N	1E+07	0,158	0,105	0,660	4	0,984	0,206
F shrinkage mean	1,1E+07	1,5				0,016	0,198

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
10226180	0,16	0,09	5	0,574	0,206

Age 5 Catchability constant w.r.t. time and dependent on age
Year class = 2013

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD25-27&28.2&29S&N	1605228	0,149	0,141	0,940	5	0,981	0,362
F shrinkage mean	2683953	1,5				0,019	0,232

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1620956	0,15	0,13	6	0,862	0,36

Age 6 Catchability constant w.r.t. time and dependent on age
Year class = 2012

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD25-27&28.2&29S&N	1318772	0,139	0,127	0,920	6	0,982	0,371
F shrinkage mean	2093631	1,5				0,018	0,249

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1329602	0,14	0,12	7	0,847	0,368

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 6
Year class = 2011

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD25-27&28.2&29S&N	637428	0,134	0,172	1,290	7	0,981	0,444
F shrinkage mean	969431	1,5				0,019	0,313

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
642406	0,13	0,16	8	1,186	0,442

Table 4.2.13. Herring in SD 25–29, 32 (excl. GoR). Fishing Mortality (F) at age.

Run title : Herring SD 25-29, 32 (excl. GOR)
Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Age 1	0.1715	0.1809	0.0973	0.1176	0.0856	0.0407	0.0737	0.0550	0.0391	0.0436	0.0347	0.0671
Age 2	0.1270	0.1385	0.1772	0.1289	0.1933	0.1565	0.1550	0.1937	0.1634	0.1330	0.1138	0.1413
Age 3	0.1708	0.1783	0.1823	0.1954	0.1737	0.2066	0.2072	0.2016	0.1812	0.2434	0.1723	0.1686
Age 4	0.2264	0.2010	0.1786	0.1645	0.1719	0.2016	0.1923	0.2213	0.1658	0.2436	0.2655	0.1911
Age 5	0.1685	0.2311	0.1770	0.1867	0.1434	0.2066	0.1799	0.1969	0.1826	0.1839	0.2553	0.2817
Age 6	0.1724	0.1911	0.2361	0.2085	0.1688	0.1669	0.1698	0.1920	0.1664	0.2264	0.2022	0.2780
Age 7	0.1900	0.2088	0.1983	0.1876	0.1621	0.1926	0.1815	0.2044	0.1726	0.2191	0.2423	0.2518
Age 8+	0.1900	0.2088	0.1983	0.1876	0.1621	0.1926	0.1815	0.2044	0.1726	0.2191	0.2423	0.2518
FBAR 3-6	**0.1845**	**0.2004**	**0.1935**	**0.1888**	**0.1644**	**0.1954**	**0.1873**	**0.2029**	**0.1740**	**0.2243**	**0.2238**	**0.2299**

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Age 1	0.0585	0.0528	0.0609	0.0671	0.0395	0.0296	0.0735	0.0589	0.0403	0.0481	0.0695	0.0661
Age 2	0.1468	0.1139	0.1836	0.1009	0.1478	0.1353	0.1240	0.1771	0.1134	0.1101	0.1176	0.1356
Age 3	0.1715	0.1950	0.1786	0.2951	0.1621	0.2468	0.2201	0.2504	0.2342	0.2687	0.1866	0.2148
Age 4	0.2125	0.2139	0.2193	0.2216	0.3289	0.2170	0.2134	0.3151	0.2982	0.4097	0.3219	0.3312
Age 5	0.2173	0.2506	0.2413	0.3070	0.2623	0.3872	0.2116	0.3034	0.4125	0.3117	0.4029	0.4486
Age 6	0.2085	0.2638	0.2373	0.3382	0.3498	0.2878	0.3703	0.2849	0.4460	0.3161	0.4387	0.4972
Age 7	0.2139	0.2442	0.2340	0.2908	0.3159	0.2993	0.2666	0.3031	0.3886	0.3485	0.3911	0.4296
Age 8+	0.2139	0.2442	0.2340	0.2908	0.3159	0.2993	0.2666	0.3031	0.3886	0.3485	0.3911	0.4296
FBAR 3-6	**0.2024**	**0.2308**	**0.2191**	**0.2905**	**0.2758**	**0.2847**	**0.2539**	**0.2884**	**0.3477**	**0.3266**	**0.3375**	**0.3729**

YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Age 1	0.1502	0.0902	0.1466	0.1164	0.1209	0.0763	0.0576	0.0428	0.0611	0.0397	0.0357	0.0401
Age 2	0.1656	0.2076	0.2043	0.2429	0.1685	0.1342	0.0979	0.0911	0.0910	0.0972	0.0888	0.0887
Age 3	0.2903	0.2681	0.3642	0.2105	0.2853	0.1752	0.1708	0.1341	0.1307	0.1659	0.1498	0.1330
Age 4	0.3813	0.3799	0.4248	0.4195	0.2604	0.2444	0.2241	0.2180	0.1879	0.1834	0.1876	0.2078
Age 5	0.4312	0.3875	0.5054	0.3771	0.4295	0.2457	0.2178	0.2381	0.2599	0.2205	0.1980	0.1952
Age 6	0.4893	0.3447	0.4572	0.4837	0.3307	0.3536	0.2461	0.1923	0.2716	0.2859	0.3209	0.2229
Age 7	0.4380	0.3770	0.3548	0.5086	0.4257	0.2865	0.3303	0.1960	0.2079	0.2265	0.3019	0.4132
Age 8+	0.4380	0.3770	0.3548	0.5086	0.4257	0.2865	0.3303	0.1960	0.2079	0.2265	0.3019	0.4132
FBAR 3-6	**0.3980**	**0.3450**	**0.4379**	**0.3727**	**0.3265**	**0.2548**	**0.2147**	**0.1956**	**0.2125**	**0.2139**	**0.2141**	**0.1897**

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	FBAR 16-18
Age 1	0.0471	0.0426	0.0224	0.0285	0.0391	0.0346	0.0500	0.0739	0.1200	0.0813
Age 2	0.0564	0.0720	0.0661	0.0611	0.0761	0.0871	0.1045	0.0972	0.1404	0.1140
Age 3	0.1297	0.1002	0.0764	0.0761	0.1341	0.1556	0.1610	0.1481	0.2085	0.1726
Age 4	0.1864	0.1725	0.0994	0.1066	0.1634	0.2616	0.2278	0.2257	0.2058	0.2198
Age 5	0.2591	0.1941	0.1536	0.1287	0.1869	0.2507	0.2950	0.2922	0.3595	0.3156
Age 6	0.3143	0.2234	0.1744	0.1422	0.1654	0.2295	0.3812	0.3194	0.3683	0.3563
Age 7	0.3202	0.2567	0.1855	0.1950	0.1460	0.2284	0.4995	0.5745	0.4417	0.5052
Age 8+	0.3202	0.2567	0.1855	0.1950	0.1460	0.2284	0.4995	0.5745	0.4417	
FBAR 3-6	**0.2223**	**0.1725**	**0.1260**	**0.1134**	**0.1624**	**0.2244**	**0.2662**	**0.2464**	**0.2856**	

Table 4.2.14. Herring in SD 25–29, 32 (excl. GoR). Stock number-at-age (Number*10-4).**

Table 10 Stock number at age (start of year) Numbers*10-4**

YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Age 1	1811190	1332732	2635377	1339659	1569673	1284973	1870520	3117323	2907172	2210408	2941251	2284256
Age 2	1508771	1111590	792222	1754391	854406	946427	772251	1057163	1860302	1691621	1319292	1911658
Age 3	789334	990207	706978	498432	1142406	526806	615422	442860	583065	1041358	963407	811662
Age 4	745657	515494	626254	453622	313561	718335	337857	360331	256160	341783	567530	573776
Age 5	347514	473368	329581	411074	300842	205362	458999	219628	213526	158306	191888	326232
Age 6	242885	235995	298630	219532	268904	203352	130566	288065	138205	136310	101248	111434
Age 7	398049	162985	153254	186493	139323	179000	136862	88240	178793	92234	86072	65964
Age 8+	181587	319956	303317	352849	354965	302420	366082	314729	293099	243965	216015	171552
TOTAL	**6024985**	**5142327**	**5845615**	**5216052**	**4944080**	**4366676**	**4688558**	**5888338**	**6430322**	**5915985**	**6386702**	**6256534**

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Age 1	1149728	2095786	935973	1414280	1892664	1446198	1773943	1637122	1397257	1982231	1659657	975099
Age 2	1487047	777528	1447019	646959	987928	1399709	1100853	1292454	1203559	1044152	1468944	1210050
Age 3	1180823	936121	522418	893944	443036	660313	962994	765967	844832	836944	727833	1021477
Age 4	500522	737381	584791	333269	504131	293942	409255	614496	468049	522831	499574	472358
Age 5	357935	310113	452032	360831	204722	282060	189135	264163	352785	272481	271785	283554
Age 6	191860	222632	188142	272867	206215	124171	152336	123536	154713	183635	156239	142457
Age 7	66622	122535	136361	117890	153345	114860	74831	84411	74386	78464	104832	79215
Age 8+	119634	98950	111376	147430	125683	101919	103023	59159	97545	80053	76879	59679
TOTAL	**5054172**	**5301046**	**4378112**	**4187471**	**4517723**	**4423172**	**4766371**	**4841308**	**4593125**	**5000791**	**4965743**	**4243889**

YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Age 1	1530389	834645	1544706	1092585	1040191	2070390	1325454	882371	1552277	1339469	2578624	1926336
Age 2	706836	1014309	581419	1019893	747956	702914	1505679	980759	658734	1127645	989586	1898532
Age 3	818295	462021	628326	362843	616000	481942	482951	1070112	697685	468159	793652	692108
Age 4	639003	472162	269787	335777	226895	355697	318519	321244	731070	476561	307638	525488
Age 5	263582	337505	247972	135694	170370	134879	220827	200874	202556	471584	307733	196140
Age 6	141056	132815	175907	115516	72325	85521	83384	140682	125184	121582	294735	194966
Age 7	67509	67374	72661	85992	55513	40472	47600	51945	92508	75486	72139	165136
Age 8+	58410	42934	69468	55893	74159	90271	51226	99225	87411	61142	92674	79717
TOTAL	**4225081**	**3363767**	**3590247**	**3204193**	**3003408**	**3962087**	**4035638**	**3747212**	**4147426**	**4141628**	**5436780**	**5678423**

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	GMST 74-16	AMST 74-16
Age 1	1394003	830931	1744468	1931904	1413872	4804544	1427887	1589313	1765996	0	1620835	1742547
Age 2	1376183	966587	569838	1265560	1408171	1021759	3483233	1015307	1114149	1185932	1119585	1201672
Age 3	1301013	952428	646264	403866	909190	998177	715560	2389802	707181	744972	717349	753703
Age 4	453742	840764	620738	459611	289349	615531	660816	469909	1599863	446597	455934	480729
Age 5	320990	277069	509758	436591	322790	192207	370350	410433	293983	1022618	275995	292032
Age 6	122037	183340	164890	342081	301880	210766	117667	216506	241668	162096	165416	177215
Age 7	119150	66266	106456	109298	235136	202887	132785	63606	124934	132960	102447	114915
Age 8+	151099	120192	136865	140499	205108	257264	176714	103846	103686	117832		
TOTAL	**5238218**	**4237578**	**4499279**	**5089410**	**5085495**	**8303134**	**7085011**	**6258721**	**5951459**	**3813006**		

Geometric mean 1988-2017: 14,907,185 thousands

Table 4.2.15. Herring in SD 25–29, 32 (excl. GoR). Output from XSA: Stock Summary.

Year	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 6
1974	18111898	2659027	1682551	368652	0.2191	0.1845
1975	13327324	2382673	1575411	354851	0.2252	0.2004
1976	26353772	2295392	1366922	305420	0.2234	0.1935
1977	13396593	2317602	1518985	301952	0.1988	0.1888
1978	15696733	2238629	1441323	278966	0.1935	0.1644
1979	12849732	2077290	1409129	278182	0.1974	0.1954
1980	18705202	2140040	1357790	270282	0.1991	0.1873
1981	31173224	2453390	1286823	293615	0.2282	0.2029
1982	29071714	2555925	1428553	273134	0.1912	0.174
1983	22104082	2282790	1406334	307601	0.2187	0.2243
1984	29412506	2184817	1319221	277926	0.2107	0.2238
1985	22842560	2012054	1266825	275760	0.2177	0.2299
1986	11497281	1752603	1202450	240516	0.2000	0.2024
1987	20957864	1761985	1147445	248653	0.2167	0.2308
1988	9359733	1666123	1150920	255734	0.2222	0.2191
1989	14142804	1628793	1013490	275501	0.2718	0.2905
1990	18926644	1475226	870621	228572	0.2625	0.2758
1991	14461978	1368490	782481	197676	0.2526	0.2847
1992	17739430	1261483	801325	189781	0.2368	0.2539
1993	16371223	1204910	752237	209094	0.2780	0.2884
1994	13972566	1227145	760267	218260	0.2871	0.3477
1995	19822314	1076010	649175	188181	0.2899	0.3266
1996	16596566	975482	593262	162578	0.2740	0.3375
1997	9750989	853378	555004	160002	0.2883	0.3729
1998	15303886	824753	505557	185780	0.3675	0.398
1999	8346454	685629	427964	145922	0.3410	0.345
2000	15447064	775387	420361	175646	0.4178	0.4379
2001	10925852	705682	397888	148404	0.3730	0.3727
2002	10401909	690405	406593	129222	0.3178	0.3265
2003	20703902	794924	462156	113584	0.2458	0.2548
2004	13254539	725093	465745	93006	0.1997	0.2147
2005	8823710	770277	524421	91592	0.1747	0.1956
2006	15522767	914459	581137	110372	0.1899	0.2125
2007	13394685	951002	611477	116030	0.1898	0.2139
2008	25786242	1149938	623954	126155	0.2022	0.2141
2009	19263358	1180933	719152	134127	0.1865	0.1897
2010	13940027	1176053	772795	136706	0.1769	0.2223
2011	8309309	1076407	762253	116785	0.1532	0.1725
2012	17444682	1215156	799912	100893	0.1261	0.126
2013	19319040	1255708	829457	100954	0.1217	0.1134
2014	14138718	1306754	910224	132700	0.1458	0.1624
2015	48045440	1426997	860498	174433	0.2027	0.2244
2016	14278865	1234693	825405	192056	0.2327	0.2662
2017	15893128	1330216	902291	202517	0.2244	0.2464
2018	17659964	1379633	938281	244365	0.2604	0.2856
Arith. Mean	17396628	1453808	913024	202936	0.2323	0.2443
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 4.2.16. Herring in SD 25–29, 32 (excl. GoR). Configuration settings of SAM.

Min Age (should not be modified unless data are modified accordingly)

1

Max Age (should not be modified unless data are 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 (millions)	Acoustic (SD 25-29S+N) Age 0 (millions)
1991	17,739	13,733
1992	16,371	1,608
1993	13,973	-11
1994	19,822	6,122
1995	16,597	-11
1996	9,751	336
1997	15,304	-11
1998	8,346	508
1999	15,447	2,591
2000	10,926	1,319
2001	10,402	2,123
2002	20,704	16,046
2003	13,255	9,067
2004	8,824	1,587
2005	15,523	5,568
2006	13,395	1,990
2007	25,786	12,197
2008	19,263	8,673
2009	13,940	3,366
2010	8,309	1,178
2011	17,445	10,098
2012	19,319	11,141
2013	14,139	3,068
2014	48,045	35,061
2015	14,279	7,662
2016	15,893	2,957
2017	-11	7,184
2018	-11	2,052

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 : rct3in.txt
Herring 25-32 (excl. GOR). RCT3 input data
Data for 1 surveys over 28 years : 1991 - 2018
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 2012

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.39	6.31	0.21	0.766	18	9.32	9.96	0.246	0.666
					VPA	Mean =	9.55	0.348	0.334

Yearclass 2013

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.39	6.3	0.19	0.791	19	8.03	9.44	0.218	0.718
					VPA	Mean =	9.58	0.348	0.282

Yearclass = 2014

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.40	6.24	0.18	0.794	20	10.46	10.42	0.243	0.653
					VPA	Mean =	9.59	0.334	0.347

Yearclass = 2015

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.48	5.55	0.21	0.84	21	8.94	9.87	0.246	0.783
					VPA	Mean =	9.69	0.467	0.217

Yearclass = 2016

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.5	5.38	0.22	0.822	22	7.99	9.37	0.258	0.757
					VPA	Mean =	9.70	0.456	0.243

Yearclass = 2017

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.51	5.35	0.23	0.804	23	8.88	9.84	0.262	0.741
					VPA	Mean =	9.71	0.442	0.259

Yearclass = 2018

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.51	5.31	0.23	0.809	23	7.63	9.2	0.278	0.722
					VPA	Mean =	9.72	0.448	0.278

Year Class	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2012	18499	9.83	0.20	0.20	0.96	19320	9.87
2013	13132	9.48	0.18	0.06	0.11	14139	9.56
2014	25094	10.13	0.20	0.40	4.07	48045	10.78
2015	18585	9.83	0.22	0.07	0.11	14279	9.57
2016	12703	9.45	0.22	0.14	0.39	15893	9.67
2017	18103	9.80	0.23	0.06	0.06		
2018	11437	9.34	0.24	0.23	0.98		

Table 4.2.19. Herring in SD 25–29, 32 (excl. GoR). Input data for short-term predictions.

MFDP version 1a
Run: WGBFAS 2019_TAC constraint FINAL
Time and date: 13:17 10.04.2019
Fbar age range: 3-6

2019

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	11437000	0.2835	0	0.35	0.3	0.0102	0.0813	0.0102
2	11859320	0.2663	0.7	0.35	0.3	0.0167	0.1140	0.0167
3	7449720	0.2546	0.9	0.35	0.3	0.0248	0.1725	0.0248
4	4465970	0.2445	1	0.35	0.3	0.0299	0.2198	0.0299
5	10226180	0.2384	1	0.35	0.3	0.0361	0.3156	0.0361
6	1620960	0.2312	1	0.35	0.3	0.0395	0.3563	0.0395
7	1329600	0.2251	1	0.35	0.3	0.0440	0.5052	0.0440
8	1178320	0.2195	1	0.35	0.3	0.0503	0.5052	0.0503

2020

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	14907185	0.2835	0	0.35	0.3	0.0102	0.0813	0.0102
2		0.2663	0.7	0.35	0.3	0.0167	0.1140	0.0167
3		0.2546	0.9	0.35	0.3	0.0248	0.1725	0.0248
4		0.2445	1	0.35	0.3	0.0299	0.2198	0.0299
5		0.2384	1	0.35	0.3	0.0361	0.3156	0.0361
6		0.2312	1	0.35	0.3	0.0395	0.3563	0.0395
7		0.2251	1	0.35	0.3	0.0440	0.5052	0.0440
8		0.2195	1	0.35	0.3	0.0503	0.5052	0.0503

2021

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	14907185	0.2835	0	0.35	0.3	0.0102	0.0813	0.0102
2		0.2663	0.7	0.35	0.3	0.0167	0.1140	0.0167
3		0.2546	0.9	0.35	0.3	0.0248	0.1725	0.0248
4		0.2445	1	0.35	0.3	0.0299	0.2198	0.0299
5		0.2384	1	0.35	0.3	0.0361	0.3156	0.0361
6		0.2312	1	0.35	0.3	0.0395	0.3563	0.0395
7		0.2251	1	0.35	0.3	0.0440	0.5052	0.0440
8		0.2195	1	0.35	0.3	0.0503	0.5052	0.0503

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)

N_{2019} Age 1:	Output form RCT3 Analysis (Table 6.2.17)
N_{2019} Age 2-8+:	Output from VPA (Table 6.2.14)
$N_{2020/2021}$ Age 1:	Geometric Mean from VPA-Output of age 1 (Table 6.2.14) for the years **1988-2017**
Natural Mortality (M):	Average of 2016-2018
Weight in the Catch/Stock (CWt/SWt)	Average of 2016-2018
Expoitation pattern (Sel):	Average of 2016-2018

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 2019.

MFDP version 1a
Run: WGBFAS 2019_TAC constraint FINAL
Herring in Sd 25-32 (excl. GOR).
Time and date: 13:17 10.04.2019
Fbar age range: 3-6

2019

Biomass	SSB	FMult	FBar	Landings
1184640	844663	0.8942	0.2379	204360

2020					2021	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
1086782	813028	0	0	0	1213326	920881
	805881	0.1	0.0238	20941	1191693	892508
	798807	0.2	0.0476	41326	1170635	865223
	791806	0.3	0.0714	61173	1150135	838979
	784877	0.4	0.0952	80499	1130174	813729
	778020	0.5	0.1190	99319	1110737	789430
	771232	0.6	0.1428	118061	1115905	774302
	764514	0.7	0.1666	135984	1097371	751695
	757865	0.8	0.1903	153448	1079313	729922
	751284	0.9	0.2141	170466	1061716	708946
	744769	1.0	0.2379	187052	1044567	688735
	738321	1.1	0.2617	203219	1027852	669255
	731939	1.2	0.2855	218980	1011558	650476
	725622	1.3	0.3093	234346	995672	632368
	719368	1.4	0.3331	249332	980181	614902
	713178	1.5	0.3569	263946	965074	598053
	707051	1.6	0.3807	278202	950339	581794
	700986	1.7	0.4045	292109	935965	566100
	694982	1.8	0.4283	305677	921942	550950
	689038	1.9	0.4521	318918	908258	536319
	683154	2.0	0.4759	331840	894905	522188

Input units are thousands and kg - output in tonnes

*'TAC constraint' in 2019:		
EU	170,630	t
+ EU/Russia	29,900	t
+ CBH in GOR	4,360	t (= mean catches 13-17)
- GORH	260	t (= mean catches 13-17)
Total	204,630	t

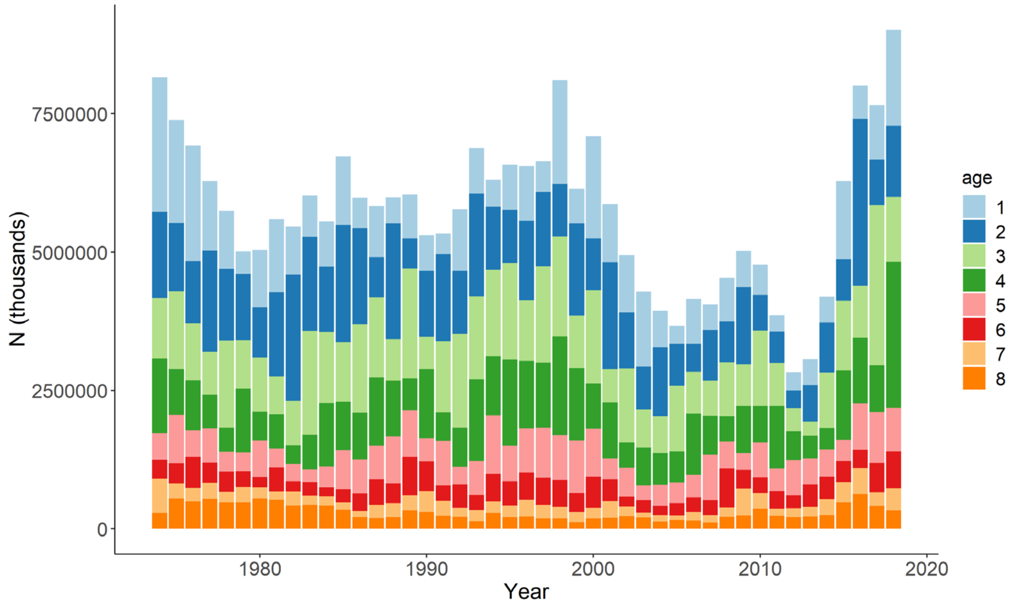


Figure 4.2.1 Herring in SD 25–29, 32 (excl. GoR). Proportions of age groups (numbers) in total catch (CANUM).

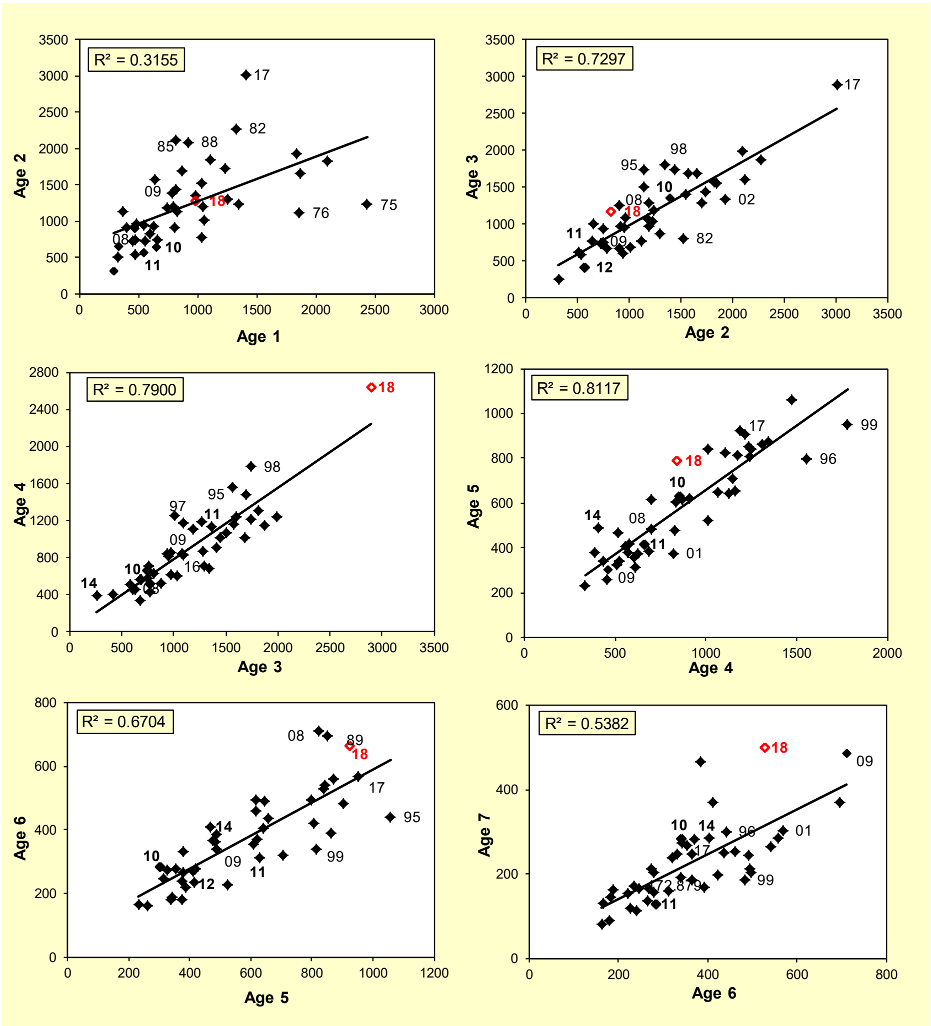


Figure 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Catch in numbers (thousands) at age vs. numbers-at-age +1 of the same cohort in the following year in the period 1974–2018.

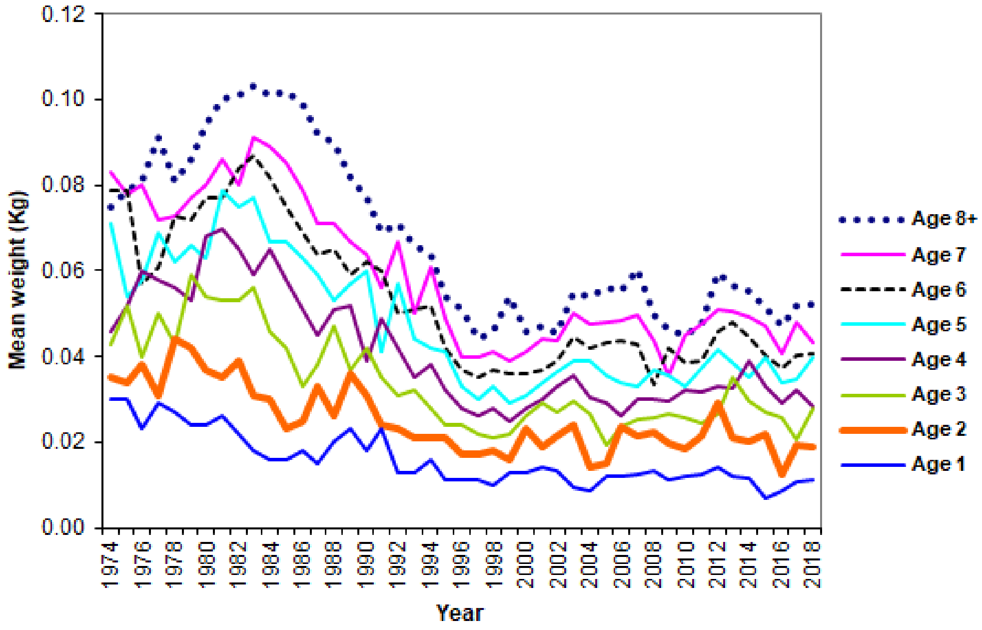


Figure 4.2.3. Herring in SD 25–29, 32 (excl. GoR). Trends in the mean weights-at-age (kg) in the catch (WECA).

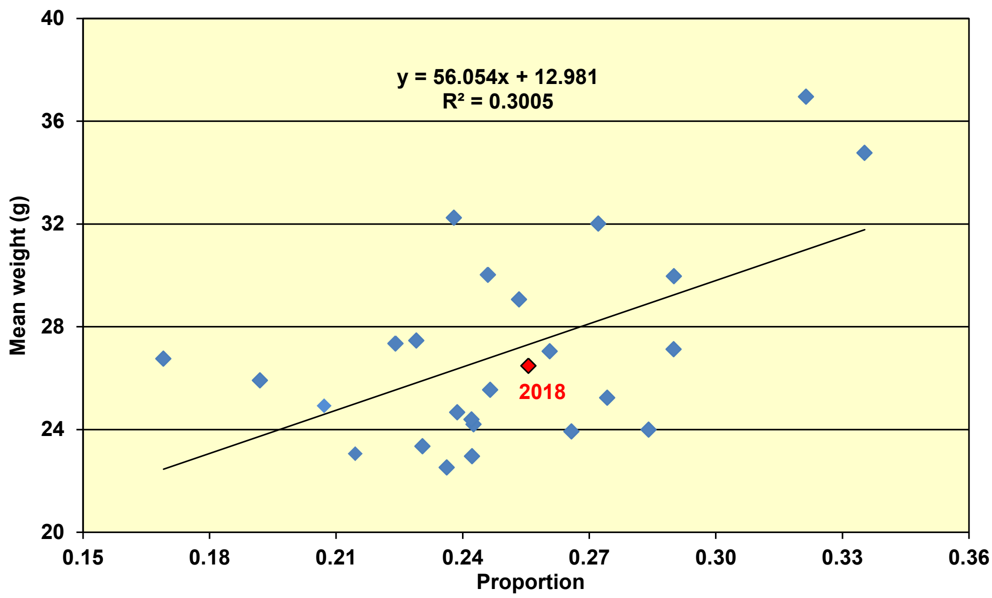


Figure 4.2.4. Herring in SD 25–29, 32 (excl. GoR).Average individual weight in catches vs. the proportion of catches taken in SD 25 and 26 (1993–2018).

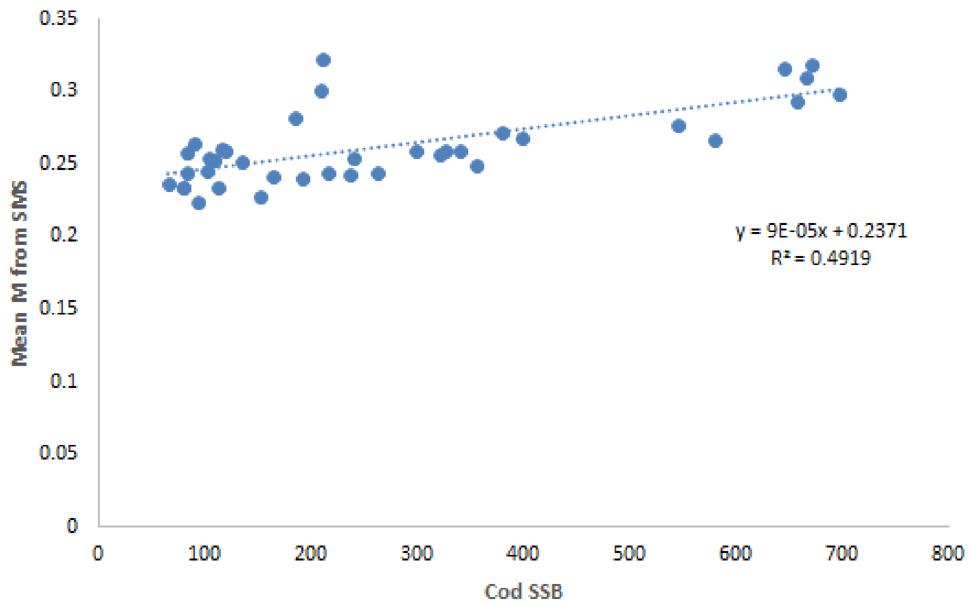


Figure 4.2.5a. Herring in SD 25–29, 32 (excl. GoR). The dependence of average M for herring on cod SSB (years 1974-2011).

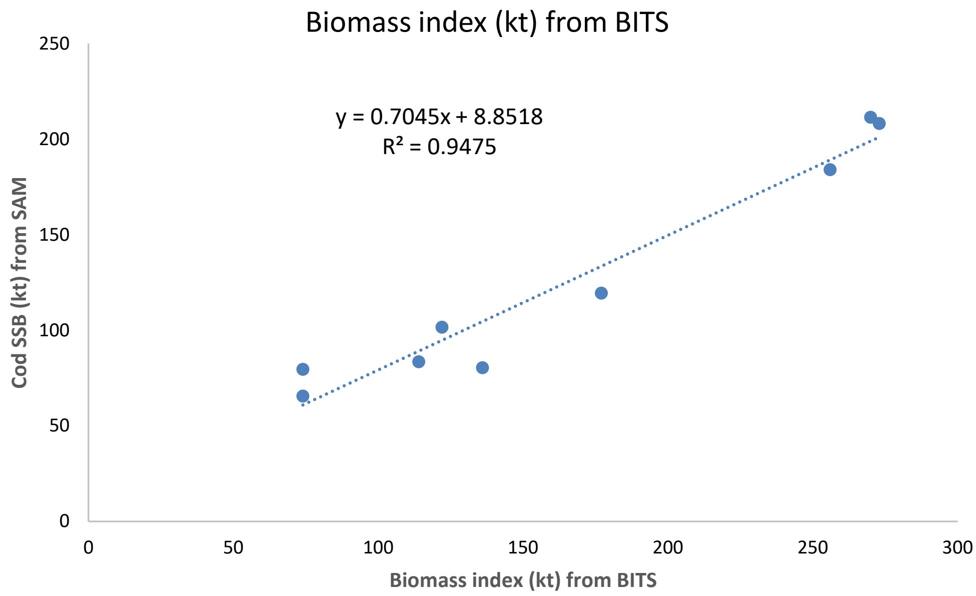


Figure 4.2.5b. Herring in SD 25–29, 32 (excl. GoR). The relationship between cod SSB and biomass index from BITS (years 2003–2011).

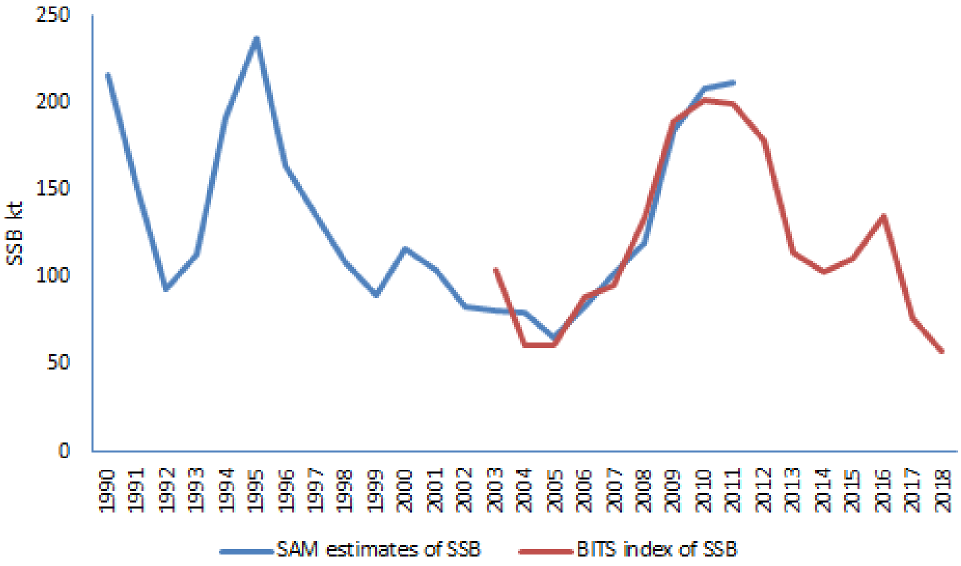


Figure 4.2.5c. Herring in SD 25–29, 32 (excl. GoR). The biomass index from BITS rescaled to level of cod SSB from last accepted assessment (2012).

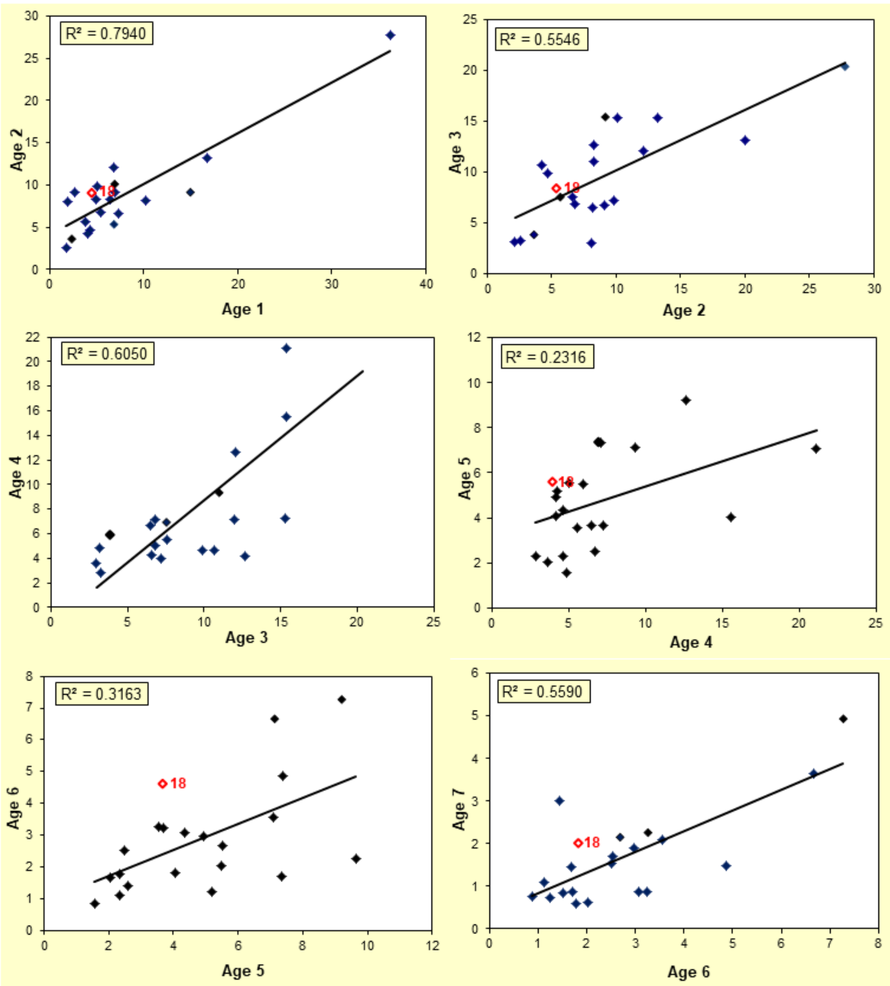


Figure 4.2.6. Herring in SD 25–29, 32 (excl. GoR). Acoustic survey numbers-at-age vs. numbers-at-age +1 of the same cohort in the following year in the period 1991–2016 (STANDARD INDEX). Years 1993, 1995, and 1997 were excluded.

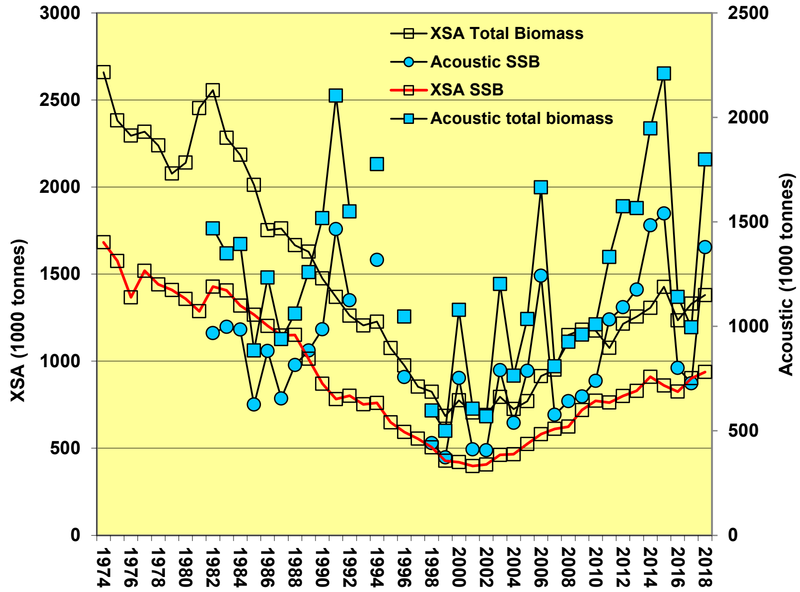


Figure 4.2.7. Herring in SD 25–29, 32 (excl. GoR). Estimates of biomass and SSB from acoustic surveys (BIAS) and from XSA. Acoustic biomasses = Acoustic abundance x WECA; Acoustic SSB = Acoustic abundance x WECA x MATPROP

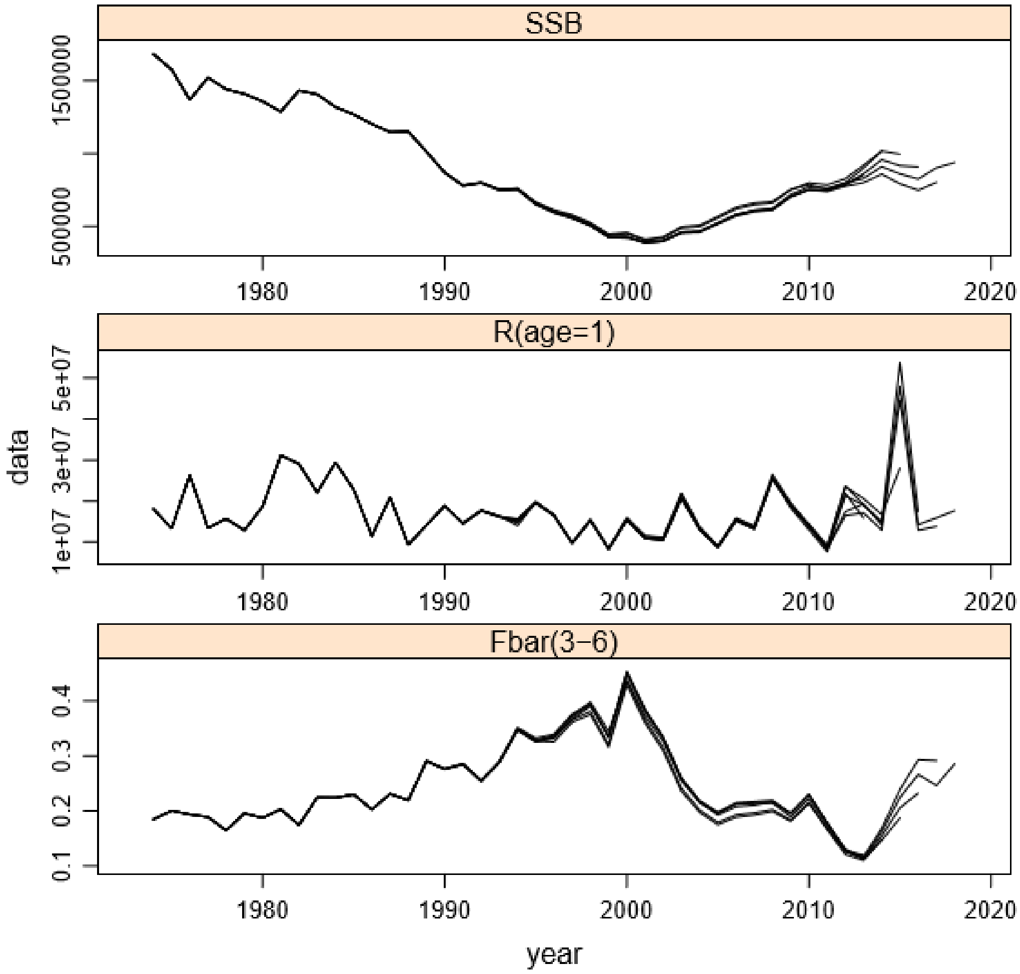


Figure 4.2.8. Herring in SD 25–29, 32 (excl. GoR). Retrospective Analysis.
Mohn's rho

SSB:	**0.06681156**
F_{bar}:	**-0.04920581**
Recruitment:	**-0.06916053**

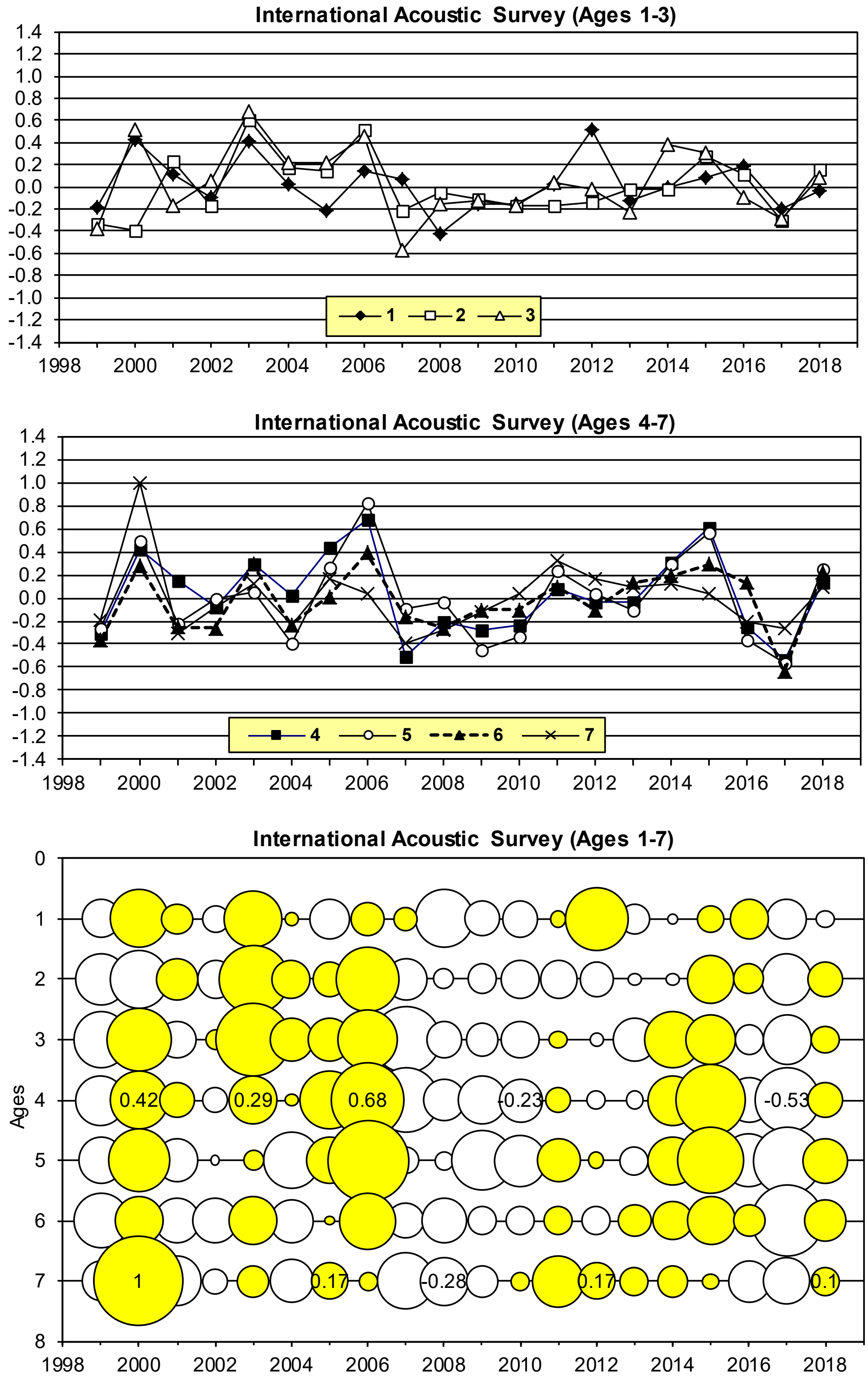


Figure 4.2.9. Herring in SD 25–29, 32 (excl. GoR). International Acoustic Survey (Ages 1–7): Log-catchability residuals. Standardized log-catchability residuals (top figure). Observed (circles)vs.predicted (line) numbers (bottom figure).

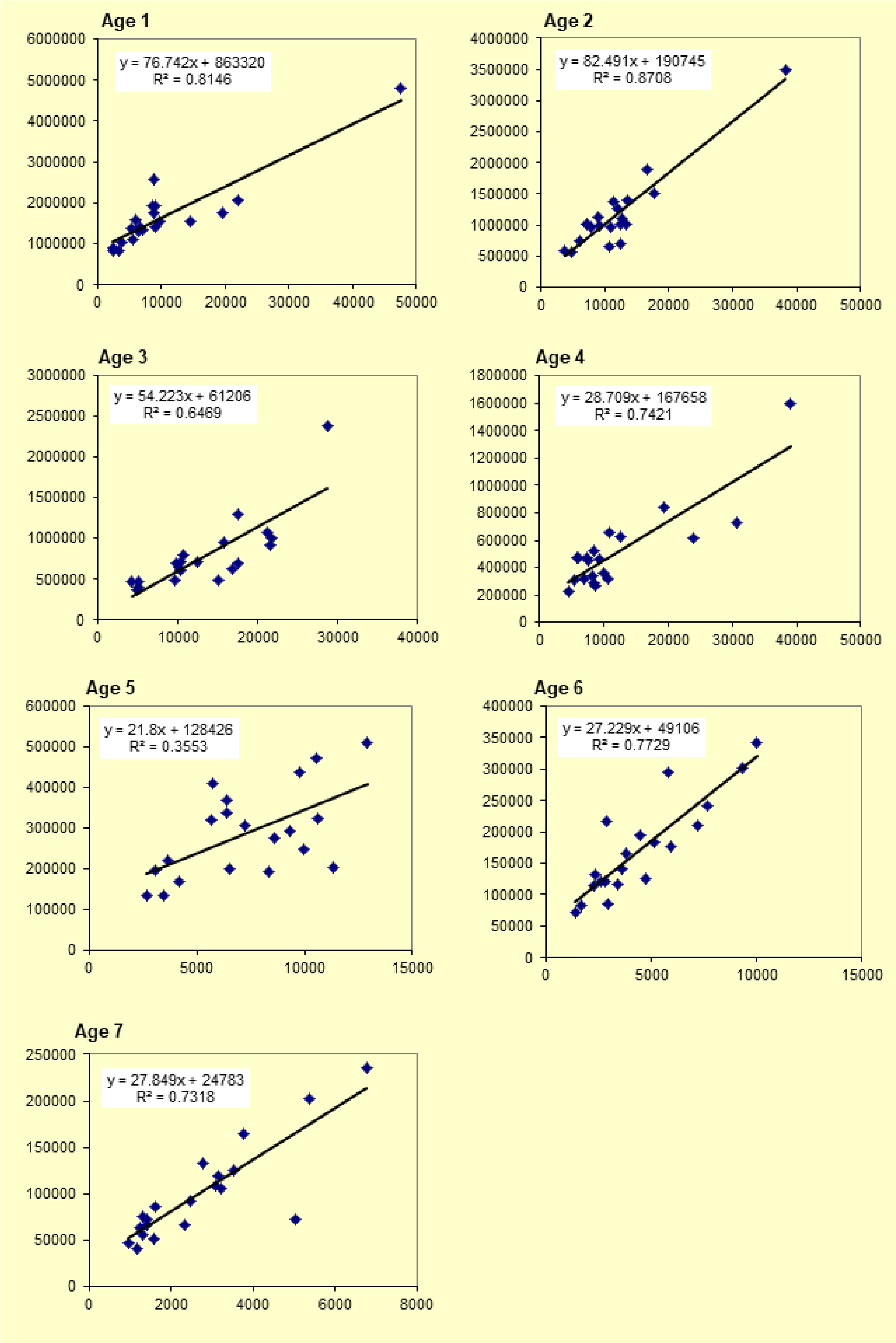


Figure 4.2.10. Herring in SD 25–29, 32 (excl. GoR). Regression of XSA population vs. acoustic survey population numbers. x-axis = Acoustic estimates; y-axis = XSA.

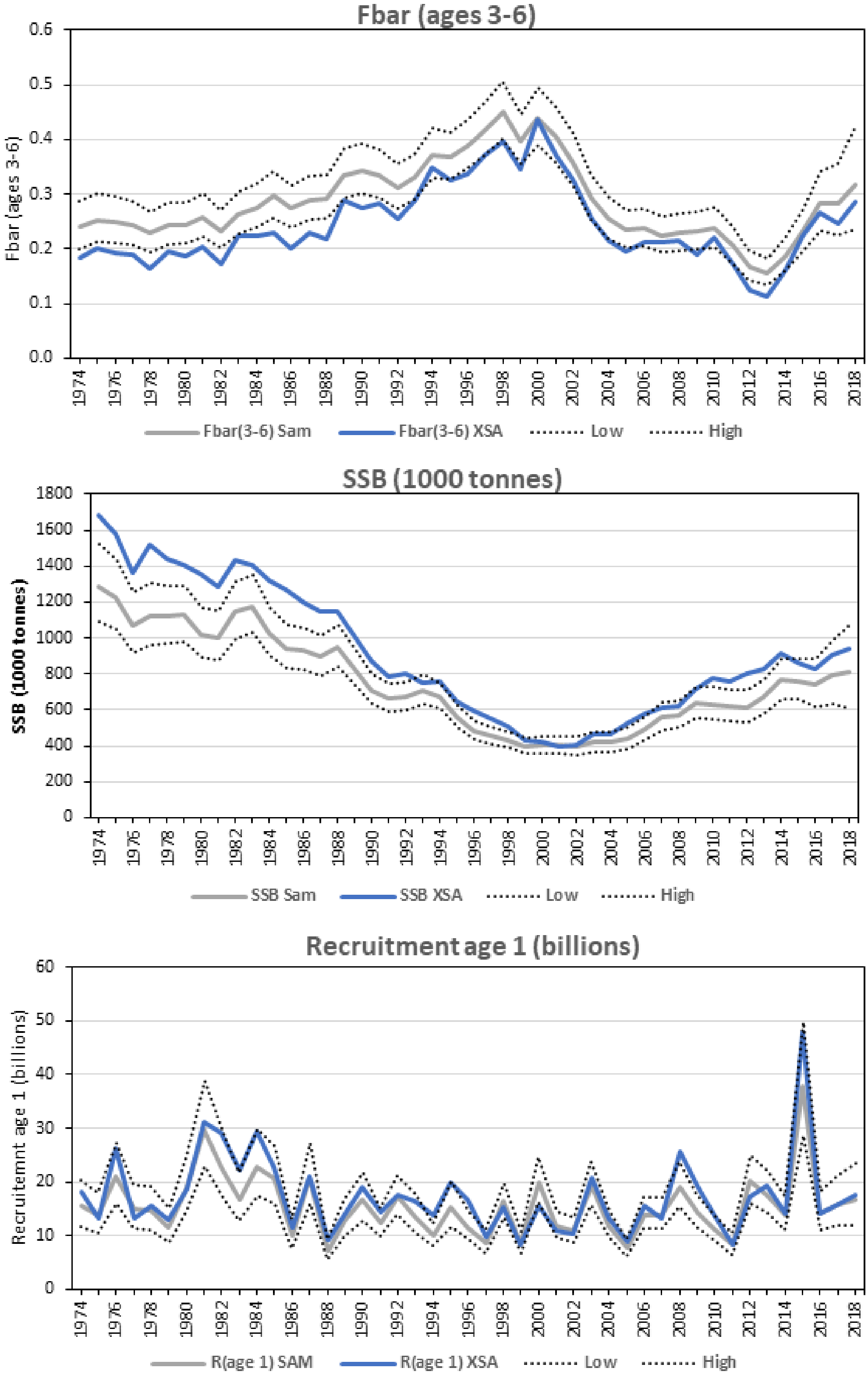


Figure 4.2.11. Herring in SD 25–29, 32 (excl. GoR). Comparison of fishing mortality (F_{3-6}), spawning-stock biomass (SSB) and recruitment (age 1) from XSA and SAM (dotted line represents the 95% confidence intervals of the SAM results).

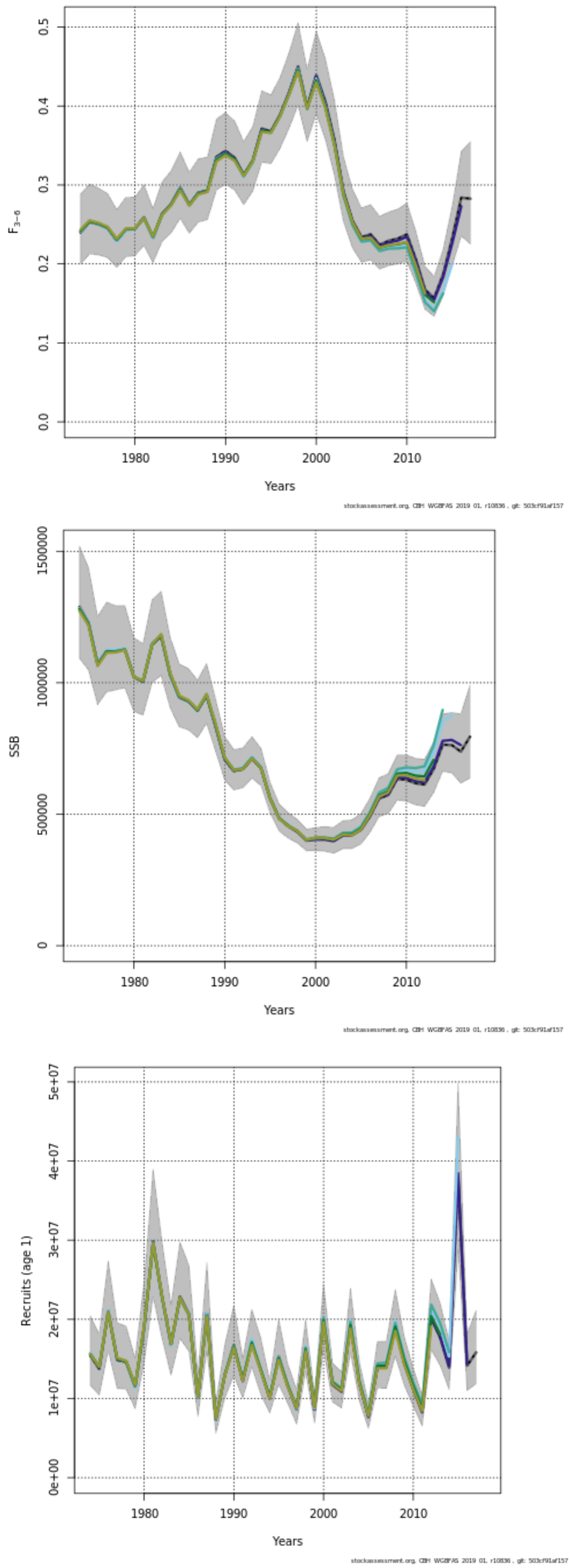


Figure 4.2.12. Herring in SD 25–29, 32 (excl. GoR). Retrospective of SAM.

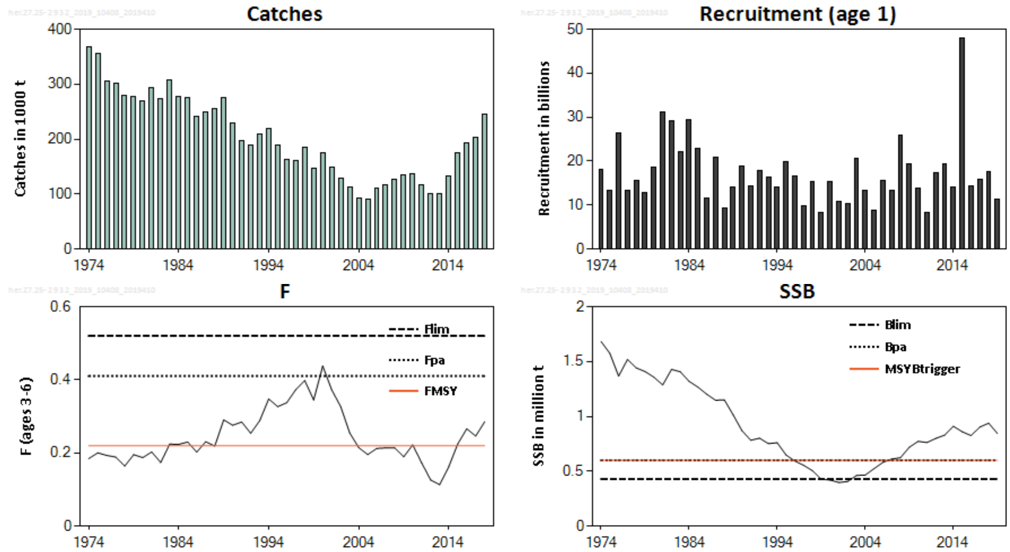


Figure 4.2.13. Herring in SD 25–29, 32 (excl. GoR). Summary sheet plots: Catches, fishing mortality, recruitment (age 1) and SSB. (Recruitment in 2017 from RCT3 & SSB in 2016 predicted)

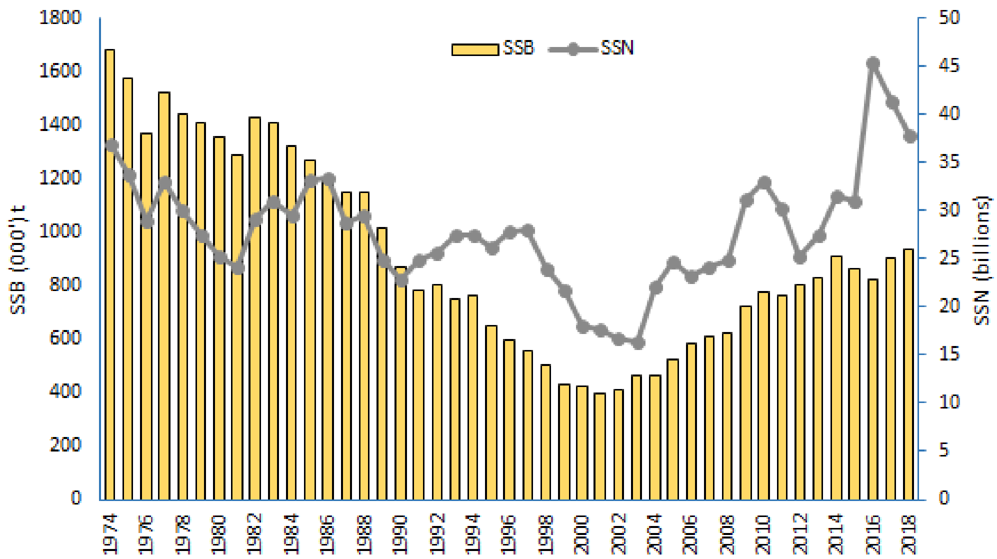


Figure 4.2.14. Herring in SD 25–29, 32 (excl. GoR). SSB (000' t) and Spawning Stock in Numbers (SSN) (billions).

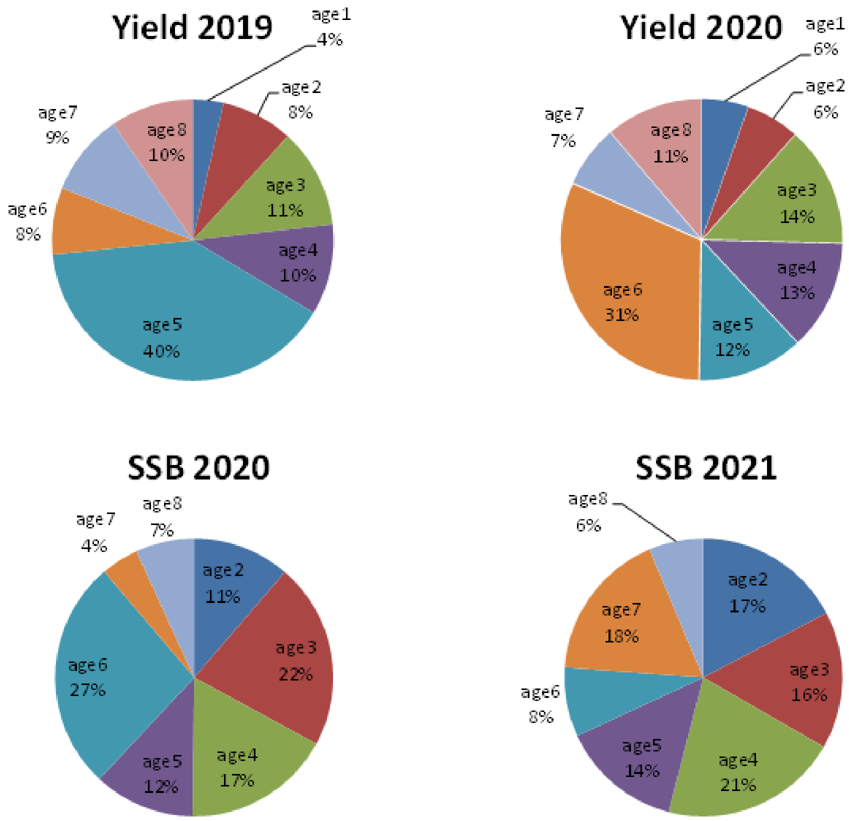


Figure 4.2.15. Herring in SD 25–29, 32 (excl. GoR). Yield and SSB at age 1-8+ as estimated in the short-term forecast for 2018-2020 under the TAC constraint 2018.

4.3 Gulf of Riga herring (Subdivision 28.1) (update assessment)

Gulf of Riga herring is a separate population of Baltic herring (*Clupea harengus*) 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 fish 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 fish 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 fish was considered negligible. At the beginning of 1990s when the stock size increased also the number of migrating fish 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 trapnets. 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 2018 these catches were 530 t, while the average catches in the last five years were 314 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 44 703 t in 2003. In 2005 the total herring landings decreased to 34 025 t and since then have been rather stable following the changes of TAC which is usually almost fully utilized. In 2015 the catches considerably increased to 37 519 t being the highest in the last 11 years. In 2018 the total catches of herring in the Gulf of Riga were 29 424 t (Table 4.3.1a).

The landings from the Gulf of Riga herring stock showed similar pattern as the total caches of herring in the Gulf of Riga. They were the highest at the beginning of 2000s and then gradually decreased. In 2017 and 2018 the catches of the Gulf of Riga herring stock were 28 058 t and 25 747 t respectively.

The landings of open-sea herring in the Gulf of Riga were 4208 t in 2018 (Table 4.3.1b). The average catch of open-sea herring in the last five years was 4377 t.

The trapnet catches of Gulf herring were 6152 t in 2018 being 2721 t or 31% lower than in 2017. The fishing effort in trapnet fishery remained the same as in 2017. The trapnet catches comprised 19% of the total catches of Gulf of Riga herring in 2018.

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, in Latvia the trawl fishing fleet has decreased almost three times, therefore it is considered that the fishing capacities now are more or less balanced with the fishing possibilities and no unallocated landings were assumed in 2011–2018. The level of misreporting in Estonian herring fishery has been low in 1995–2018 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 trapnets 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 2018 the number of trapnets remained at 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 2005–2018. In Latvia the number of trawl fleet vessels is gradually decreasing due to scrapping and there were 23 active vessels in 2018. 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 composition of the catch

4.3.2.1 Age composition

The quarterly catches of Gulf herring from Estonian and Latvian trawl and trapnet fishery were compiled to get the annual catch in numbers (Table 4.3.3, Figures 4.3.1 and 4.3.2). 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 Quality of catch and biological data

The sampling of biological data from commercial trawl and trapnet catches was performed by Estonia and Latvia on monthly basis (from trapnets on weekly basis). The sampling intensity of both countries is described in Table 4.3.2. In 2018 the sample number per 1000 t was as follows: in Estonia 2.2 samples and in Latvia 3.6 samples. The check of consistency of catch-at-age data is shown in Figure 4.3.3.

4.3.2.3 Mean weight-at-age

The annual mean weights by age groups used for assessment were compiled from quarterly data on the trapnet and trawl fishery of Estonia and Latvia (Table 4.3.6, Figure 4.3.4.). 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 mean 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 compared 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 2018 the mean weight-at age was close to the values of the previous years (Figure 4.3.4.)

4.3.2.4 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).

4.3.2.5 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.

4.3.3 Fishery-independent information

Two tuning fleets were available: from trapnet fishery (1996–present) and from joint Estonian-Latvian hydroacoustic 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 4.3.5 and 4.3.6.

In trapnet fleet (Figure 4.3.5) the correlation was high and in 2018 was similar to the previous year. In acoustic fleet the correlation did not change significantly, however the survey results of 2018 indicate a strong year effect (Figures 4.3.7 and 4.3.8b). Due to exceptional environment situation (very warm summer) age group 0 herring were more distributed offshore in main survey area giving strong acoustic signal. The echo energy of those individuals is represented in NASC estimates, but not representatively represented in control catches (e.g. some scatters in the water may not be represented in the hauls). Thus, the total acoustic estimate was elevated.

4.3.4 Assessment (update 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 million at age 1 at the beginning of the year.

Until 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 Gdańsk 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 characterized 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 3099.2 million of age group 1 at the beginning of 2019, which is the geometric mean value for 1989–2016 year classes. The same value for recruitment was used also for year classes 2019 and 2020.

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 trapnets directed at the Gulf herring in the Estonian and Latvian trapnet fishery and the corresponding abundance of Gulf herring in trapnet catches and the data from the hydroacoustic 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 trapnet fleet. Log-catchability, survival estimated and scaled weights are shown in Figures 4.3.8a,b and 4.3.9.For acoustic fleet some year effect is seen in 2010–2011and on 2018 (Figure 4.3.8b). The retrospective analysis is shown in Figure 4.3.10. Compared with assessment of the previous year this year assessment produced higher SSB estimate (12.0%) and lower fishing mortality estimate (-11%). The recruitment estimate of 2016 year class was 21% higher than obtained in 2018 (Table 4.3.11).

4.3.4.3 Exploration of SAM

During WGBFAS 2019 the state-space assessment model SAM was explored as an alternative method to assess the Gulf of Riga herring stock. This year's preliminary configuration of SAM is given in Table 4.3.14. The assessment run and the software internal code are available at https:/www.stockassessment.org, HGoR. Log-catchability residuals of SAM run by fleets are shown in Figure 4.3.11. Results of SAM and it comparison with updated XSA run are presented in Figure 4.3.12. In general SAM produces lower estimates of SSB and recruitment (age 1), whereas it shows higher fishing mortality (F_{3-7}). However, all XSA estimates are in the confidence intervals of the SAM run.

4.3.4.4 Historical stock trends

The resulting estimates of the main stock parameters (Table 4.3.13, Figure 4.3.13 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 124 663 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 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. After appearance of very rich year classes in 2011 and 2012 the SSB reached 128 714 t in 2014 but has decreased since then. In 2017–2018 the SSB stayed stable at the level of 110 000 t. 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 until 1996. Afterwards the fishing mortality increased above 0.4 that was regarded as F_{pa}. Since 2010 the fishing mortality has decreased below 0.4 and in 2013–2014 even below 0.3. In 2018 the fishing mortality was 0.254 that is below the F_{MSY} (0.32).

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 4.3.15- 4.3.17. For prediction the mean weights-at-age were taken to be equal to the average of the last three years 2016–2018. The exploitation pattern was taken equal to the average of 2016–2018 and was 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 2019–2021 (year classes of 2018, 2019, 2020) were taken to be equal to the geometric mean of year classes over the period 1989–2016.

Taking into account the strong year effect during acoustic surveys (see chapter 4.1.3), the abundance of the year class 2017 at age 2 were obtained from GM mean value of recent recruitment estimates over 1989-2016 (e.g. 3099.173 million), based on Popes VPA cohort's equation. Thus, the age 2 number in 2019 were set as 2213, 777 million.

Taking into account that the herring TAC for the Gulf of Riga is usually almost utilized the catch constraint of 26 932 t for the intermediate year was used. The value is equal with the ICES last year's advice for the Gulf of Riga herring which was accepted by the managers. The SSB in 2019 would be 109.2 thousand t (according to the 2018 prediction 89.9 thousand t). In 2020–2021 SSB will remains on high level of 105-108 thousand t. The catch corresponding to F_{MSY} (0.32) would be 30.4 thousand t in 2020. In 2019 the catches will be dominated by year class of 2015-2017 by 57% The SSB in 2020 will be dominated by year classes of 2015–2018 (85%) and in 2021 will be dominated by the younger age groups of 2 and 3 year-old herring (Figure 4.3.14). The share of younger age groups (1–3) in the yield of 2019–2020 will be 46% and 50% respectively.

4.3.6 Reference points

The biological reference points for the Gulf of Riga herring were estimated at WGBFAS meeting in 2015 (ICES, 2015) and in 2019 were not recalculated.

The B_{lim} value was obtained estimating the stock–recruitment relationship and the knowledge of 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 B_{lim}=B_{loss} is applied. The corresponding value is B_{lim}=40 800 t. The B_{pa} value was obtained from the following equation:

$B_{pa} = B_{lim} \times \exp(\sigma \times 1.645) = B_{lim} x1.4 = 57\ 100$ t.

F_{lim} was then derived from B_{lim} in the following way. R/SSB was calculated at B_{lim}, and the slope of the replacement line at B_{lim}, and then it was inverted to give SSB/R. This SSB/R was used to derive F_{lim} from the curve of SSB/R against F. The obtained value F_{lim} = 0.88. The F_{pa} value was obtained from the equation F_{lim}=F_{pa}/1.4 and was F_{pa}=0.63.

Instead of MBAL estimate of 50 000 t used previously, the $B_{trigger}$ 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 trapnets directed at the Gulf herring in the Estonian and Latvian trapnet fishery and the corresponding abundance of Gulf herring in trapnet 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 hydroacoustic surveys were started in 1999 to obtain the additional tuning data, which were implemented for the first time in 2004 assessment. The Mohn's Rho index (average for last 5 years) for fishing mortality, SSB and recruitment is 0.22, -0.18 and -0.21 respectively.

4.3.8 Comparison with the previous assessment

The comparison between main input parameters for assessment and the results of XSA and predictions from 2018 and 2019 are presented in the text table below.

Comparison of XSA settings from assessments performed in 2018 and 2019

Category	Parameter	Assessment 2018	Assessment 2019	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	Trapnets	1996–2017	1996–2018	No
	Acoustic survey	1999–2017	1999–2018	No

Comparison of SSB and F estimates from assessments performed in 2018 and 2019

Assessment year	**Tuning fleet**	**SSB (2017) (t)**	**FBAR3-7 (2017)**	
2018 (update)	Trapnets+acoustics	96 144	0.3512	
2019 (update)	Trapnets+acoustics	109 734	0.2889	
Diff. (+/-)%		+11.7%	-10.6%	
Comparison of prediction results performed in 2017 and 2018 Parameter	**Prediction 2018**	**Prediction 2019**	**Actual yield 2018 (t)**	**Diff. (+/-)%**
Yield 2018 (t)	24 919		25747	+3.2
SSB 2019 (t)	90 051	109 238		+17.6
Yield 2019 (t)	26 932	26 932		0.0

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 Subdivisions 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 Subdivisions 25–27, 28.2, 29, 32.

Table 4.3.1a Total catches of herring in the Gulf of Riga by nation (official + unallocated landings). All weights are in tonnes.

Year	Estonia	Latvia	Unallocated landings	Total
1991	7410	13481	-	20891
1992	9742	14204	-	23946
1993	9537	13554	2209	25300
1994	9636	14050	3514	27200
1995	16008	17016	3332	36356
1996	11788	17362	3534	32684
1997	15819	21116	4308	41243
1998	11313	16125	3305	30743
1999	10245	20511	3077	33803
2000	12514	21624	2631	36769
2001	14311	22775	3399	40485
2002	16962	22441	3398	42801
2003	19647	21780	3276	44703
2004	18218	20903	3094	42215
2005	11213	19741	3071	34025
2006	11924	19186	2922	34032
2007	12764	19425	2953	35142
2008	15877	19290	1970	37137
2009	17167	18323	1864	37354
2010	15422	17751	1791	34974
2011	14721	20218	-	35039
2012	13789	17926	-	31715
2013	11898	18413	-	30311
2014	10541	20012	-	30553
2015	16509	21010	-	37519
2016	15814	19066	-	34880
2017	13772	17948	-	31720
2018	12521	16904	-	29424

Table 4.3.1b. Herring caught in the Gulf of Riga and Gulf of Riga herring catches in central Baltic. All weights are in tonnes.

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	24186	2400	26586	-	24186
1978	16728	6300	23028	-	16728
1979	17142	4700	21842	-	17142
1980	14998	5700	20698	-	14998
1981	16769	5900	22669	-	16769
1982	12777	4700	17477	-	12777
1983	15541	4800	20341	-	15541
1984	15843	3800	19643	-	15843
1985	15575	4600	20175	-	15575
1986	16927	1300	18227	-	16927
1987	12884	4800	17684	-	12884
1988	16791	3000	19791	-	16791
1989	16783	5900	22683	-	16783
1990	14931	6000	20931	-	14931
1991	14791	6100	20891	-	14791
1992	18700	3500	23946	1300	20000
1993	21000	4300	25300	1200	22200
1994	22200	5000	27200	2100	24300
1995	30256	6100	36356	2400	32656
1996	28284	4400	32684	4300	32584
1997	36943	4300	41243	2900	39843
1998	26643	4100	30743	2800	29443
1999	29503	4300	33803	1900	31403
2000	32169	4600	36769	1900	34069
2001	37585	2900	40485	1200	38785
2002	39301	3500	42801	400	39701
2003	40403	4300	44703	400	40803
2004	38915	3300	42215	200	39115

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
2005	31725	2300	34025	500	32225
2006	30832	3200	34032	400	31232
2007	33642	1500	35142	100	33742
2008	31037	6100	37137	100	31137
2009	32454	4900	37354	100	32554
2010	29774	5200	34974	400	30174
2011	29539	5500	35039	100	29639
2012	27915	3800	31715	200	28115
2013	26211	4100	30311	300	26511
2014	26053	4500	30553	200	26253
2015	32551	4968	37519	316	32851
2016	30565	4315	34880	289	30865
2017	27824	3896	31720	234	28058
2018	25217	4208	29424	530	25747

Table 4.3.2. Sampling of herring landings in the Gulf of Riga in 2018

Country	Quarter	Landings	Samples	Measured	Aged
Estonia	I	2170	4	400	400
	II	10011	19	1900	1696
	III	7	2	200	195
	IV	333	3	350	350
	Total	12521	28	2850	2641
Latvia	I	3740	8	1865	963
	II	5424	39	4477	3966
	III	3082	5	1034	540
	IV	4658	9	2046	1011
	Total	16904	61	9422	6480
Total	I	5910	12	2265	1363
	II	15434	58	6377	5662
	III	3089	7	1234	735
	IV	4991	12	2396	1361
Grand total	Total	29424	89	12272	9121

Table 4.3.3. Gulf of Riga herring. Catch in numbers 1977-2018 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

Year	1	2	3	4	5	6	7	8+
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

Year	1	2	3	4	5	6	7	8+
2016	467310	287890	110350	427240	291430	43770	50850	94760
2017	291780	449000	219830	59410	251400	183300	24030	94910
2018	357867	295664	329437	150533	46463	149032	88866	36412

Table 4.3.4. Gulf of Riga herring. Catch in tonnes (CATON).

Year	Catch
1977	24186
1978	16728
1979	17142
1980	14998
1981	16769
1982	12777
1983	15541
1984	15843
1985	15575
1986	16927
1987	12884
1988	16791
1989	16783
1990	14931
1991	14791
1992	20000
1993	22200
1994	24300
1995	32656
1996	32584
1997	39843
1998	29443
1999	31403

Year	Catch
2000	34069
2001	38785
2002	39701
2003	40803
2004	39115
2005	32225
2006	31232
2007	33742
2008	31137
2009	32554
2010	30174
2011	29639
2012	28115
2013	26511
2014	26253
2015	32851
2016	30865
2017	28058
2018	25747

Table 4.3.5. Gulf of Riga herring. Proportion of mature at beginning the year in 1977-2018.

Period	1	2	3	4	5	6	7	8+
1977-2018	0	0.93	0.98	0.98	1	1	1	1

Table 4.3.6. Gulf of Riga herring. Weights (kg) in catch and stock in 1977-2018.

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

Year	Age 1	2	3	4	5	6	7	8+
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
2017	0.0087	0.0147	0.0185	0.0209	0.0225	0.0241	0.0248	0.0276
2018	0.0097	0.0153	0.0191	0.0216	0.0230	0.0245	0.0256	0.0284

Table 4.3.7. Gulf of Riga herring. Natural mortality.

Year	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
1984-2018	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: trapnets (effort number of trapnets).

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
2017	43.0	59.77	57.57	14.58	85.75	56.75	5.08	6.19
2018	43.0	57.64	100.37	49.12	11.54	44.28	28.32	2.26

***Age 8 is true age group**

Table 4.3.9. Gulf of Riga herring. Tuning fleet: hydroacoustics 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	94	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
2017	1	3231	3442	874	402	1632	982	137	459
2018	1	11216	4529	3607	776	338	1439	755	165

***Age 8 is true age group**

Table 4.3.10. Gulf of Riga herring. XSA diagnostics.

Lowestoft VPA Version 3.1
30/03/2019 23:15
Extended Survivors Analysis
Index File; Gulf of Riga herring
CPUE data from file Tuning.dat
Catch data for 42 years. 1977 to 2018. Ages 1 to 8.

Fleet	First year	Last	First year	Last age	Alpha age	Beta
Trap-nets	1996	2018	2	7	.330	.580
Acoustics	1999	2018	1	7	.550	.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 = .500
Minimum standard error for population
estimates derived from each fleet = .300
Prior weighting not applied

Tuning had not converged after 30 iterations

Total absolute residual between iterations
29 and 30 = .00026

Final year F values

Age	1	2	3	4	5	6	7
Iteration 29:	0763	1643	2045	2526	3023	2427	2660
Iteration 30:	0763	1643	2045	2525	3023	2427	2660

Regression weights: .751 .820 .877 .921 .954 .976 .990 .997 1.000 1.000

Fishing mortalities

Age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0.115	0.203	0.096	0.097	0.088	0.088	0.136	0.136	0.115	0.076
2	0.243	0.25	0.226	0.175	0.176	0.154	0.229	0.204	0.188	0.164
3	0.32	0.256	0.324	0.284	0.199	0.192	0.236	0.282	0.237	0.205
4	0.351	0.292	0.323	0.331	0.234	0.214	0.261	0.277	0.241	0.253

5	0.362	0.337	0.391	0.337	0.238	0.3	0.342	0.313	0.261	0.302
6	0.483	0.323	0.355	0.31	0.296	0.268	0.364	0.385	0.332	0.243
7	0.405	0.339	0.348	0.33	0.276	0.307	0.481	0.401	0.379	0.266

XSA population numbers (Thousands)

YEAR/AGE	1	2	3	4	5	6	7
2009	2.79E+06	3.93E+06	8.09E+05	1.85E+06	3.90E+05	5.91E+04	3.32E+05
2010	2.83E+06	2.04E+06	2.52E+06	4.81E+05	1.06E+06	2.23E+05	2.98E+04
2011	1.15E+06	1.89E+06	1.30E+06	1.60E+06	2.94E+05	6.22E+05	1.32E+05
2012	5.50E+06	8.53E+05	1.23E+06	7.70E+05	9.48E+05	1.63E+05	3.57E+05
2013	5.73E+06	4.09E+06	5.86E+05	7.61E+05	4.53E+05	5.54E+05	9.78E+04
2014	1.02E+06	4.30E+06	2.81E+06	3.93E+05	4.93E+05	2.92E+05	3.37E+05
2015	2.42E+06	7.62E+05	3.02E+06	1.90E+06	2.60E+05	2.99E+05	1.83E+05
2016	4.06E+06	1.73E+06	4.96E+05	1.95E+06	1.20E+06	1.51E+05	1.70E+05
2017	2.96E+06	2.90E+06	1.15E+06	3.06E+05	1.21E+06	7.16E+05	8.42E+04
2018	5.38E+06	2.16E+06	1.97E+06	7.46E+05	1.97E+05	7.64E+05	4.21E+05

Estimated population abundance at 1st Jan 2019

0.00E+00	4.08E+06	1.50E+06	1.31E+06	4.74E+05	1.19E+05	4.91E+05

Taper weighted geometric mean of the VPA populations:

3.07E+06	2.12E+06	1.37E+06	8.02E+05	4.69E+05	2.81E+05	1.37E+05

Standard error of the weighted Log(VPA populations) :

0.6275	0.6363	0.6781	0.7116	0.7615	0.776	0.8356

Log-catchability residuals.
Fleet : Trap-nets

Age	1996	1997	1998
1	No data for this fleet et this age		
2	99.99	99.99	99.99
3	99.99	99.99	99.99
4	99.99	99.99	99.99
5	99.99	99.99	99.99
6	99.99	99.99	99.99
7	99.99	99.99	99.99

Age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	No	data	for	this	fleet	at	this	age		
2	-0.97	-0.03	0.14	0	0.02	-0.59	0.2	0.3	-0.23	0.54
3	-0.94	-0.22	0.24	0.02	0.3	0.22	0.01	0.35	0.39	0.1
4	-0.09	-0.36	0.36	-0.07	0.17	0.33	0.06	-0.03	0.6	0.15
5	-0.05	0.49	0.31	-0.06	-0.46	0.16	0.54	0.82	0.18	0.03
6	0.18	0	0.45	-0.28	0.25	0.1	0.48	0.51	0.88	-0.03
7	-0.05	-0.64	0.38	-0.3	-0.52	0.05	0.16	0.48	0.15	-0.29

Age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	No	data	for	this	fleet	at	this	age		
2	0.16	-0.18	-0.19	-0.12	-0.02	0.25	-0.17	0.14	-0.21	0.04
3	-0.13	-0.23	0.01	-0.15	-0.11	-0.17	-0.11	0.09	0.05	0.06
4	0.18	-0.26	0.07	0.15	-0.19	-0.31	-0.32	0.09	-0.16	0.17
5	0.21	0	-0.19	-0.05	-0.15	-0.35	-0.46	0.23	0.12	-0.05
6	0.42	0.09	0.13	-0.26	0	-0.8	-0.42	0.18	0.26	-0.09
7	0.26	0.1	-0.08	0	-0.31	-0.35	-0.19	0.19	0.01	0.07

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)	-14.1647	-13.5213	-13.3485	-13.2247	-13.2247	-13.2247
S.E(Log q)	0.2386	0.1751	0.2457	0.3016	0.4045	0.238

Regression statistics:

Ages with q independent of year-class strength and constant w.r.t. time.

Age	Slope	t-value	intercept	Rsquare	No	Reg.s.e	Mean Q
2	1.02	-0.127	14.16	0.87	20	0.25	-14.16
3	1.09	-1.044	13.47	0.93	20	0.19	-13.52
4	1.01	-0.071	13.35	0.89	20	0.26	-13.35
5	0.93	0.577	13.21	0.88	20	0.29	-13.22
6	1.18	-0.955	13.3	0.75	20	0.48	-13.19
7	1	0.007	13.25	0.93	20	0.25	-13.25

Fleet: Acoustics

Age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.19	0.09	-0.19	0.15	0.12	0.75	0.53	0.13	-0.7	0.1
2	0.62	0.58	-0.08	0.26	-0.09	0.61	0.75	-0.22	-0.43	0.32
3	0.71	0.37	0.28	-0.03	0.07	-0.26	0.43	-0.54	0.06	0.36
4	0.13	0.58	0.27	0	-0.21	0.48	-0.2	-0.5	-0.15	0.3
5	-0.08	0.15	0.06	-0.41	-0.16	-0.18	0.51	-0.68	0	0.27
6	0.48	0.23	0.09	-0.08	0.51	0.26	-0.25	0.09	0.32	-0.48
7	0.15	0.45	-0.83	0.24	0.04	0.24	0.04	-0.54	-0.05	-0.84

Age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0.4	0.25	0.57	-0.37	0.05	-0.36	-0.14	-0.31	-0.35	0.28
2	0.02	0.02	0.86	-0.31	0.11	-0.32	-0.51	-0.65	-0.02	0.54
3	0.07	-0.37	0.66	0.2	-0.06	-0.3	-0.51	-0.01	-0.33	0.54
4	0.03	-0.56	0.7	0.1	0.53	-0.33	-0.48	-0.29	0.31	0.09
5	-0.34	-0.57	0.71	0.06	-0.03	0.09	-0.05	-0.6	0.22	0.49
6	-0.69	-0.74	0.31	0.78	0.35	0.34	0.13	0	0.28	0.55
7	-0.39	-0.86	0.19	-0.18	0.58	0.27	0.04	-0.4	0.48	0.51

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)	-6.2901	-6.4957	-6.6082	-6.6948	-6.5672	-6.5672	-6.5672
S.E.(Log q)	0.3792	0.4623	0.3807	0.401	0.4094	0.4648	0.4772

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	1.04	-0.19	5.97	0.72	20	0.41	-6.29
2	0.95	0.224	6.89	0.68	20	0.46	-6.5
3	0.98	0.128	6.77	0.77	20	0.39	-6.61
4	1.02	-0.125	6.54	0.75	20	0.43	-6.69
5	1.27	-1.364	4.82	0.72	20	0.5	-6.57
6	0.82	1.285	7.53	0.84	20	0.36	-6.44
7	0.81	1.479	7.61	0.85	20	0.36	-6.59

Terminal year survivor and F summaries:

Age 1 Catchability constant w.r.t. time and dependent on age

Year class = 2017

Fleet	Estimated survivors	Int. s.e.	Ext. s.e.	Var. ratio	N	Scaled weights	Estimated F
Trapnets	1	0	0	0	0	0	0
Acoustics	5377602	0.395	0	0	1	0.598	0.058
F shrinkage mean	2710533	0.5				0.402	0.113

Weighted prediction:

Survivors at end of year	Int. s.e.	Ext. s.e.	N	Var. ratio	F
4083092	0.31	0.43	2	1.401	0.076

Age 2 Catchability constant w.r.t. time and dependent on age

Year class = 2016

Fleet	Estimated survivors	Int. s.e.	Ext. s.e.	Var. ratio	N	Scaled weights	Estimated F
Trap-nets	1557931	0.3	0	0	1	0.43	0.158
Acoustics	1550201	0.306	0.439	1.44	2	0.388	0.159
F shrinkage mean	1272832	0.5				0.182	0.191

Weighted prediction:

Survivors at end of year	Int. s.e.	Ext. s.e.	N	Var. ratio	F
1498692	0.2	0.17	4	0.838	0.164

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2015

Fleet	Estimated survivors	Int. s.e.	Ext. s.e.	Var. ratio	N	Scaled weights	Estimated F
Trapnets	1233803	0.213	0.135	0.63	2	0.51	0.216
Acoustics	1498596	0.244	0.265	1.08	3	0.366	0.181
F shrinkage mean	1151203	0.5				0.123	0.23

Weighted prediction:

Survivors at end of year	Int. s.e.	Ext. s.e.	N	Var. ratio	F
1313625	0.15	0.12	6	0.778	0.205

Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 2014

Fleet	Estimated survivors	Int. s.e.	Ext. s.e.	Var. ratio	N	Scaled weights	Estimated F
Trapnets	535760	0.176	0.035	0.2	3	0.548	0.227
Acoustics	388153	0.215	0.148	0.69	4	0.347	0.301
F shrinkage mean	486666	0.5				0.104	0.247

Weighted prediction:

Survivors at end of year	Int. s.e.	Ext. s.e.	N	Var. ratio	F
474224	0.13	0.08	8	0.613	0.253

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2013

Fleet	Estimated survivors	Int. s.e.	Ext. s.e.	Var. ratio	N	Scaled weights	Estimated F
Trapnets	110624	0.158	0.058	0.37	4	0.561	0.322
Acoustics	133235	0.198	0.181	0.91	5	0.339	0.274
F shrinkage mean	123697	0.5				0.099	0.293

Weighted prediction:

Survivors at end of year	Int. s.e.	Ext. s.e.	N	Var. ratio	F
119144	0.12	0.08	10	0.656	0.302

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2012

Fleet	Estimated survivors	Int. s.e.	Ext. s.e.	Var. ratio	N	Scaled weights	Estimated F
Trapnets	515869	0.151	0.062	0.41	5	0.552	0.232
Acoustics	501142	0.188	0.17	0.91	6	0.352	0.238
F shrinkage mean	343501	0.5				0.096	0.331

Weighted prediction:

Survivors at end of year	Int. s.e.	Ext. s.e.	N	Var. ratio	F
491071	0.12	0.08	12	0.706	0.243

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2011

Fleet	Estimated survivors	Int. s.e.	Ext. s.e.	Var. ratio	N	Scaled weights	Estimated F
Trapnets	272254	0.144	0.085	0.59	6	0.586	0.259
Acoustics	249724	0.187	0.178	0.95	7	0.317	0.279
F shrinkage mean	262464	0.5				0.097	0.267

Survivors at end of year	Int. s.e.	Ext. s.e.	N	Var. ratio	F
263962	0.11	0.08	14	0.7	0.266

Table 4.3.11. Gulf of Riga herring. XSA output: Fishing mortality-at-age.

YEAR/AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.0849	0.1222	0.0932	0.1088	0.0812	0.0552	0.046	0.0243	0.0186	0.0091
2	0.4228	0.1644	0.2963	0.2304	0.2904	0.1824	0.2295	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	0.2946
4	0.618	0.3809	0.5812	0.2419	0.4407	0.403	0.437	0.7187	0.4097	0.4665
5	0.6456	0.4184	0.3965	0.4997	0.3946	0.4594	0.4468	0.6948	0.552	0.4125
6	0.8246	0.3452	0.4304	0.3523	0.5949	0.4485	0.5205	0.8899	0.7179	0.8087
7	0.7027	0.384	0.474	0.3678	0.4815	0.4411	0.4727	0.7755	0.5646	0.5673
8 +	0.7027	0.384	0.474	0.3678	0.4815	0.4411	0.4727	0.7755	0.5646	0.5673
F_{BAR} 3- 7	0.6903	0.3751	0.431	0.3498	0.4525	0.4198	0.4679	0.7069	0.5381	0.5099

YEAR/AGE	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.0199	0.0119	0.0537	0.0271	0.0365	0.0393	0.0675	0.0675	0.077	0.1074
2	0.0614	0.0718	0.1227	0.0961	0.0933	0.1378	0.1325	0.1371	0.1798	0.21
3	0.1612	0.196	0.2571	0.2558	0.151	0.2089	0.1728	0.1832	0.2559	0.2403
4	0.4268	0.2463	0.4089	0.2126	0.244	0.2135	0.1893	0.2277	0.3343	0.2784
5	0.6779	0.6138	0.2634	0.34	0.2209	0.321	0.2392	0.2466	0.3983	0.4012
6	0.3568	0.9445	0.4874	0.1429	0.3565	0.3055	0.3073	0.2584	0.3608	0.5047
7	0.4909	0.6068	0.3892	0.233	0.2753	0.2816	0.2465	0.2455	0.3668	0.3974
8+	0.4909	0.6068	0.3892	0.233	0.2753	0.2816	0.2465	0.2455	0.3668	0.3974
F_{BAR} 3- 7	0.4227	0.5215	0.3612	0.2368	0.2495	0.2661	0.231	0.2322	0.3432	0.3644

YEAR/AGE	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.1534	0.1006	0.149	0.1147	0.1614	0.16	0.0984	0.199	0.1437	0.1339
2	0.3574	0.328	0.2759	0.3558	0.3073	0.3693	0.323	0.3339	0.3835	0.3503
3	0.4383	0.3354	0.3065	0.3745	0.4422	0.4204	0.5546	0.4462	0.3787	0.3979
4	0.5228	0.4004	0.3635	0.4234	0.5158	0.4511	0.5264	0.6855	0.4854	0.3578
5	0.4852	0.5428	0.4215	0.5738	0.5488	0.4711	0.4622	0.6402	0.5843	0.5963
6	0.489	0.4435	0.5568	0.4186	0.5865	0.51	0.5722	0.5624	0.5658	0.4572
7	0.5029	0.4657	0.4506	0.4814	0.5512	0.4894	0.5931	0.587	0.51	0.3572

YEAR/AGE	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
8+	0.5029	0.4657	0.4506	0.4814	0.5512	0.4894	0.5931	0.587	0.51	0.3572
F_{BAR} 3- 7	0.4876	0.4375	0.4198	0.4543	0.5289	0.4684	0.5417	0.5843	0.5048	0.4333

YEAR/AGE	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.1843	0.1294	0.1149	0.2026	0.0956	0.0967	0.0876	0.0875	0.1357	0.1361
2	0.2938	0.3225	0.2427	0.2498	0.2263	0.1751	0.1758	0.1535	0.2291	0.2036
3	0.4729	0.2977	0.3202	0.2561	0.3243	0.2839	0.1987	0.1917	0.2364	0.2823
4	0.5812	0.3256	0.3512	0.2915	0.3227	0.3306	0.2341	0.2138	0.2613	0.277
5	0.4181	0.289	0.3623	0.3375	0.3906	0.3372	0.2382	0.3005	0.342	0.3135
6	0.8894	0.2675	0.4832	0.3234	0.3549	0.3103	0.2963	0.2676	0.3641	0.3853
7	0.4138	0.416	0.4049	0.339	0.3476	0.3296	0.2761	0.3071	0.4805	0.4014
8 +	0.4138	0.416	0.4049	0.339	0.3476	0.3296	0.2761	0.3071	0.4805	0.4014
F_{BAR} 3- 7	0.5551	0.3191	0.3844	0.3095	0.348	0.3183	0.2487	0.2562	0.3368	0.3319

YEAR/AGE	2017	2018	FBAR
1	0.1155	0.0763	0.1093
2	0.1876	0.1643	0.1852
3	0.2365	0.2045	0.2411
4	0.2414	0.2525	0.257
5	0.2605	0.3023	0.2921
6	0.3325	0.2427	0.3202
7	0.3787	0.266	0.3487
8+	0.3787	0.266	
F_{BAR} 3- 7	0.2899	0.2536	

Table 4.3.12. Gulf of Riga herring. XSA output: Stock numbers-at-age (start of year) (10^4)

Year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	94322	107648	97694	111034	90842	168897	125363	202711	138778	112015
2	283694	70936	78001	69316	77560	65232	124477	93247	161985	111523
3	32331	152182	49273	45171	42872	45181	42331	77060	62582	106933
4	26299	13676	88050	29214	26389	23505	24870	20762	40009	32788
5	8202	11606	7650	38348	17863	13227	12234	12512	8285	21745
6	3090	3521	6253	4007	18119	9375	6507	6095	5114	3906
7	3503	1109	2041	3167	2194	7784	4663	3011	2050	2042
8+	130	1960	1631	911	1025	1036	2852	2403	1546	1464
TOTAL	451570	362637	330593	301167	276864	334237	343297	417802	420347	392416
Year	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
1	392740	56078	129168	364288	368698	431471	325232	278154	346498	465465
2	90878	315215	45370	100225	290282	291052	339659	248887	212873	262660
3	81653	69971	240187	32857	74538	216489	207610	243579	177672	145611
4	65209	56898	47090	152068	20829	52476	143831	143004	166049	112620
5	16837	34840	36414	25615	100660	13362	34703	97454	93239	97322
6	11786	6999	15440	22909	14927	66081	7936	22368	62353	51256
7	1424	6754	2228	7764	16259	8557	39860	4778	14144	35586
8+	564	1417	1836	2168	18623	21301	13529	28348	18391	19051
TOTAL	661091	548171	517734	707894	904817	1100790	1112360	1066571	1091218	1189570
Year	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1	158719	276426	288994	264122	607628	227358	704022	102156	316454	694800
2	342291	111471	204660	203863	192807	423334	158623	522410	68549	224407
3	174321	196031	65743	127161	116935	116092	239583	94022	306282	38248
4	93754	92078	114765	39615	71588	61521	62425	112652	49272	171717
5	69802	45506	50514	65326	21239	34991	32080	30191	46468	24829
6	53349	35179	21652	27133	30133	10044	17885	16543	13032	21210
7	25334	26786	18485	10158	14616	13724	4938	8263	7718	6059
8+	16915	19895	24470	15289	18245	12708	14321	18068	7896	7306
TOTAL	934485	803373	789284	752667	1073189	899772	1233878	904305	815670	1188576

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	200288	545771	279372	282745	114637	550272	573334	101515	241601	405904
2	497564	136378	392601	203911	189038	85296	409000	430026	76150	172708
3	129428	303680	80879	252173	130041	123422	58617	280875	301969	49581
4	21035	66039	184618	48073	159820	76979	76075	39342	189837	195183
5	98300	9631	39043	106388	29407	94760	45282	49287	26009	119689
6	11198	52979	5907	22252	62155	16292	55375	29215	29879	15127
7	10993	3767	33195	2983	13184	35684	9780	33710	18304	16998
8+	7815	8456	9542	28897	16490	13277	26366	24421	33695	31414
TOTAL	976621	1126700	1025156	947422	714771	995982	1253830	988392	917445	1006604

Year	2017	2018	2019	GMST	AMST
1	295718	538228	0	231241	283580
2	290042	215712	408309	170847	209454
3	115352	196839	149869	106878	133279
4	30609	74551	131363	62646	80301
5	121144	19685	47422	32425	43521
6	71623	76437	11914	15826	22365
7	8425	42055	49107	7822	12090
8+	33011	17127	37144		
TOTAL	965923	1180633	835129		

Table 4.3.13. Gulf of Riga herring. XSA output: Summary.

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	F_{BAR}(3-7)
1977	943221	76734	54522	24186	0.4436	0.6903
1978	1076481	66256	49356	16728	0.3389	0.3751
1979	976942	66130	46738	17142	0.3668	0.431
1980	1110337	69530	46712	14998	0.3211	0.3498
1981	908417	65532	47221	16769	0.3551	0.4525
1982	1688965	72905	42757	12777	0.2988	0.4198
1983	1253633	76283	50857	15541	0.3056	0.4679

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	F_{BAR}(3-7)
1984	2027111	66157	39913	15843	0.3969	0.7069
1985	1387782	77476	51934	15575	0.2999	0.5381
1986	1120150	86755	64278	16927	0.2633	0.5099
1987	3927405	97590	51515	12884	0.2501	0.4227
1988	560782	116297	96676	16791	0.1737	0.5215
1989	1291682	86074	63272	16783	0.2653	0.3612
1990	3642876	139113	77297	14931	0.1932	0.2368
1991	3686985	141522	87221	14791	0.1696	0.2495
1992	4314711	167089	106057	20000	0.1886	0.2661
1993	3252321	175565	120663	22200	0.184	0.231
1994	2781537	170185	124799	24300	0.1947	0.2322
1995	3464975	166685	116489	32656	0.2803	0.3432
1996	4654652	167612	105555	32584	0.3087	0.3644
1997	1587189	133755	103245	39843	0.3859	0.4876
1998	2764262	120165	81694	29443	0.3604	0.4375
1999	2889936	136313	83717	31403	0.3751	0.4198
2000	2641219	132430	83474	34069	0.4081	0.4543
2001	6076275	156552	78961	38785	0.4912	0.5289
2002	2273578	143697	100416	39701	0.3954	0.4684
2003	7040221	156605	86068	40803	0.4741	0.5417
2004	1021556	120679	92027	39115	0.425	0.5843
2005	3164539	124884	73487	32225	0.4385	0.5048
2006	6947996	144112	71109	31232	0.4392	0.4333
2007	2002875	127294	91553	33742	0.3686	0.5551
2008	5457706	158286	90401	31137	0.3444	0.3191
2009	2793720	150764	106457	32554	0.3058	0.3844
2010	2827451	141524	100381	30174	0.3006	0.3095
2011	1146369	131509	101608	29639	0.2917	0.348
2012	5502721	152266	87579	28115	0.321	0.3183

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	F_{BAR}(3-7)
2013	5733345	182693	110321	26511	0.2403	0.2487
2014	1015152	162758	133363	26253	0.1969	0.2562
2015	2416008	156370	117640	32851	0.2792	0.3368
2016	4059037	153567	103000	30865	0.2997	0.3319
2017	2957179	151820	109734	28058	0.2557	0.2899
2018	5382282	177796	110182	25747	0.2337	0.2536
Arith. Mean	2899323	127794	84768	25873	0.315	0.4043
Units	*Thousands*	*Tonnes*	*Tonnes*	*Tonnes*		

Table 4.3.14. The configuration of SAM model for Gulf of Riga herring

```
$minAge
# The minimium age class in the assessment
 1
$maxAge
# The maximum age class in the assessment
 8
$maxAgePlusGroup
# Is last age group considered a plus group (1 yes, or 0 no).
 1
$keyLogFsta
# Coupling of the fishing mortality states (nomally only first row is used).
  0  1  2  3  4  5  6  6
 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1
$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)
 2
$keyLogFpar
# Coupling of the survey catchability parameters (nomally first row is not used, as that is covered by fishing mortality).
 -1 -1 -1 -1 -1 -1 -1 -1
 -1  0  1  2  3  4  5  6
  7  8  9 10 11 12 13 14
```

```
$keyQpow
# Density-dependent catchability power parameters (if any).
 -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1
$keyVarF
# Coupling of process variance parameters for log(F)-process (nomally only first row is used)
  0   0   0   0   0   0   0   0
 -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1
$keyVarLogN
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1 1
$keyVarObs
# Coupling of the variance parameters for the observations.
  0   1   1   1   1   1   1   1
 -1   2   2   2   2   2   2   2
  3   3   3   3   3   3   3   3
$obsCorStruct
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"
 "ID" "ID" "ID"
$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#1-2 2-3 3-4 4-5 5-6 6-7 7-8
 NA  NA  NA  NA  NA  NA  NA
 -1  NA  NA  NA  NA  NA  NA
 NA  NA  NA  NA  NA  NA  NA
$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton–Holt).
 2
$noScaledYears
# Number of years where catch scaling is applied.
 0
$keyScaledYears
```

A vector of the years where catch scaling is applied.

$keyParScaledYA

A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).

$fbarRange

lowest and higest age included in Fbar

3 7

$keyBiomassTreat

To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).

-1 -1 -1

$obsLikelihoodFlag

Option for observational likelihood | Possible values are: "LN" "ALN"

"LN" "LN" "LN"

$fixVarToWeight

If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight).

0

$fracMixF

The fraction of t(3) distribution used in logF increment distribution

0

$fracMixN

The fraction of t(3) distribution used in logN increment distribution

0

$fracMixObs

A vector with same length as number of fleets, where each element is the fraction of t(3) distribution used in the distribution of that fleet

0 0 0

Table 4.3.15. Gulf of Riga herring. Short-term forecast input.

2019								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	3099173	0.2	0	0.2	0.3	0.0090	0.1093	0.0087
2	2213577	0.2	0.93	0.2	0.3	0.0151	0.1852	0.0150
3	1498690	0.2	0.98	0.2	0.3	0.0186	0.2411	0.0183
4	1313630	0.2	0.98	0.2	0.3	0.0210	0.2570	0.0208
5	474220	0.2	1	0.2	0.3	0.0226	0.2921	0.0226

6	119140	0.2	1	0.2	0.3	0.0242	0.3202	0.0244
7	491070	0.2	1	0.2	0.3	0.0255	0.3487	0.0260
8	371440	0.2	1	0.2	0.3	0.0281	0.3487	0.0285

2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	3099173	0.2	0	0.2	0.3	0.0090	0.1093	0.0087
2	.	0.2	0.93	0.2	0.3	0.0151	0.1852	0.0150
3	.	0.2	0.98	0.2	0.3	0.0186	0.2411	0.0183
4	.	0.2	0.98	0.2	0.3	0.0210	0.2570	0.0208
5	.	0.2	1	0.2	0.3	0.0226	0.2921	0.0226
6	.	0.2	1	0.2	0.3	0.0242	0.3202	0.0244
7	.	0.2	1	0.2	0.3	0.0255	0.3487	0.0260
8	.	0.2	1	0.2	0.3	0.0281	0.3487	0.0285

2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	3099173	0.2	0	0.2	0.3	0.0090	0.1093	0.0087
2	.	0.2	0.93	0.2	0.3	0.0151	0.1852	0.0150
3	.	0.2	0.98	0.2	0.3	0.0186	0.2411	0.0183
4	.	0.2	0.98	0.2	0.3	0.0210	0.2570	0.0208
5	.	0.2	1	0.2	0.3	0.0226	0.2921	0.0226
6	.	0.2	1	0.2	0.3	0.0242	0.3202	0.0244
7	.	0.2	1	0.2	0.3	0.0255	0.3487	0.0260
8	.	0.2	1	0.2	0.3	0.0281	0.3487	0.0285

Input units are thousand and kg

M= natural mortality

Mat=maturity ogive

PF=proportion of F before spawning

PM=proportion of M before spawning

SWt=weight in stock (kg)

Sel=exploitation pattern

CWt=weight in catch (kg)

$N_{2019-2021}$ Age1: geometric mean from XSA-estimates at age 1 for the year classes 1989-2016

N_{2019} Age 2: calculated using formula $N_{age2,\,2019}=(N_{age1,\,2018} * \exp(-M/2) - C_{age1,\,2018}) * \exp(-M/2)$,

where $N_{age1,\ 2018}$=geometric mean of year classes 1989-2016

N_{2019} Age 3-8+: survivors estimates from XSA

Natural mortality (M): average 2016-2018

CWt/SWt=average 2016-2018

Sel=average 2016-2018

Table 4.3.16. Gulf of Riga herring. Short-term prediction results.

2019						
Biomass	SSB	F_{Mult}	F_{Bar}	Landings		
153152	109238	0.9543	0.2785	26932		
2020					**2021**	
Biomass	**SSB**	**F_{Mult}**	**F_{Bar}**	**Landings**	**Biomass**	**SSB**
153150	114776	0	0	0	181061	140582
	114191	0.1	0.0292	3109	177801	136853
	113609	0.2	0.0584	6143	174619	133232
	113029	0.3	0.0875	9103	171513	129717
	112453	0.4	0.1167	11993	168481	126304
	111880	0.5	0.1459	14814	165522	122991
	111310	0.6	0.1751	17567	162633	119774
	110743	0.7	0.2043	20254	159812	116649
	110179	0.8	0.2334	22878	157058	113615
	109618	0.9	0.2626	25439	154369	110669
	109060	1	0.2918	27940	151743	107807
	108505	1.1	0.321	30382	149179	105027
	107953	1.2	0.3502	32766	146676	102326
	107403	1.3	0.3793	35094	144230	99703
	106857	1.4	0.4085	37367	141842	97154
	106314	1.5	0.4377	39588	139510	94678
	105773	1.6	0.4669	41756	137231	92271
	105236	1.7	0.4961	43874	135006	89933
	104701	1.8	0.5253	45943	132832	87661
	104169	1.9	0.5544	47963	130708	85452
	103640	2	0.5836	49937	128633	83306

Input units are thousand and kg – output in tonnes

Table 4.3.17. Gulf of Riga herring. Short-term results as used in ICES advice.

Basis	Total catch (2020)	F total(2020)	SSB (2020)	SSB (2021)	%SSB change**	%Advice change***
ICES advice basis						
EU MAP: F_{MSY} *	30 382	0.32	108 505	105 027	-3.2%	12.8%
EU MAP: F_{MSY} lower^	23 395	0.24	110 066	113 019	2.7%	13.2%
EU MAP: F_{MSY} upper^^	35 094	0.38	107 403	99 703	-7.2%	12.3%
Other options						
ICES MSY approach: F_{MSY}	30 382	0.32	108 505	105 027	-3.2%	12.8%
F= 0	0	0	114 776	140 582	22.5%	-100%
F_{pa}	53 002	0.63	102 799	79 995	-22.2%	96.8%
F_{lim}	67 664	0.88	98 401	64 540	-34.4%	151.2%
SSB (2021) = B_{lim}	92 465	1.46	88 952	40 800	-54.1%	243.3%
SSB (2021) = B_{pa}	74 971	1.03	95 930	57 100	-40.5%	178.4%
SSB (2021) = MSY $B_{trigger}$	72 138	0.97	96 913	60 000	-38.1%	167.85%
F=F_{2019}	26 947	0.28	109 283	108 942	-0.312%	0.0557%

*** MAP Multiannual plan (EU, 2016)**

**** SSB 2021 relative to SSB 2020.**

*****Total catch in 2020 relative to ICES advice for 2019 (26 932 t) for the Gulf of Riga herring stock**

^ ICES advice for F_{lower} in 2020 relative to ICES advice F_{lower} in 2019 (20 664 tonnes).

^^ ICES advice for F_{upper} in 2020 relative to ICES advice F_{upper} in 2019 (31 237 tonnes).

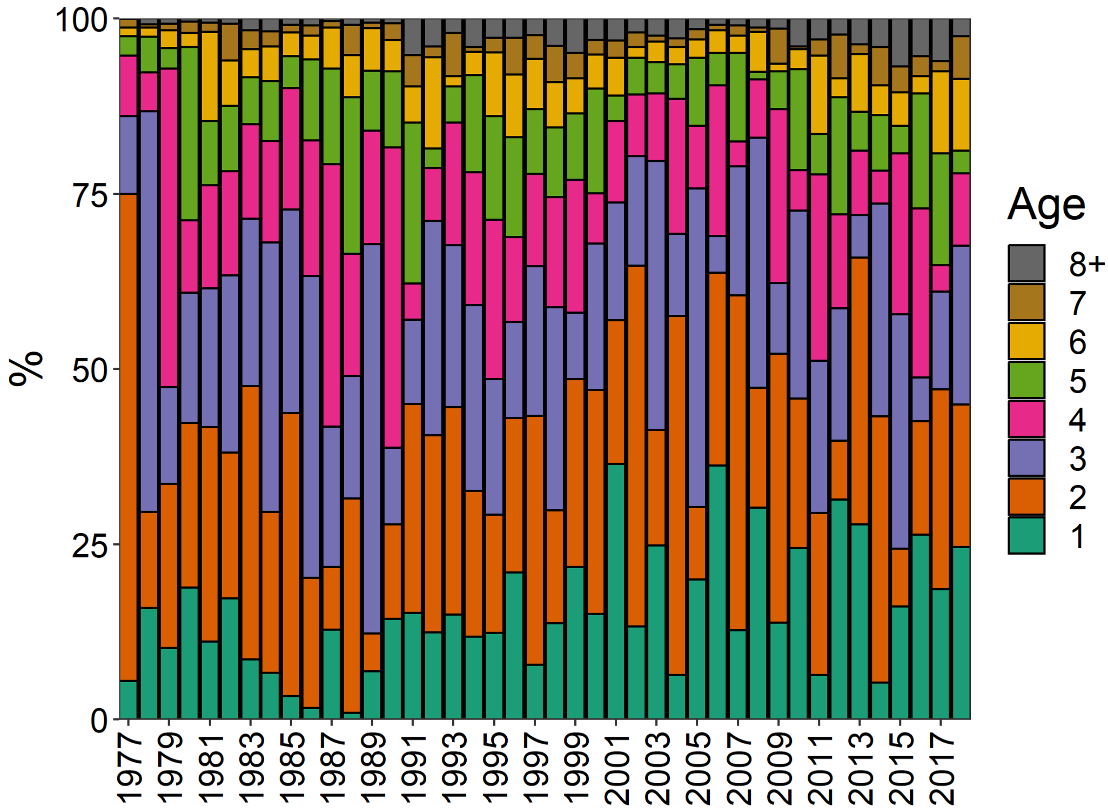


Figure 4.3.1. Gulf of Riga herring. Relative catch-at-age in numbers in 1977-2018.

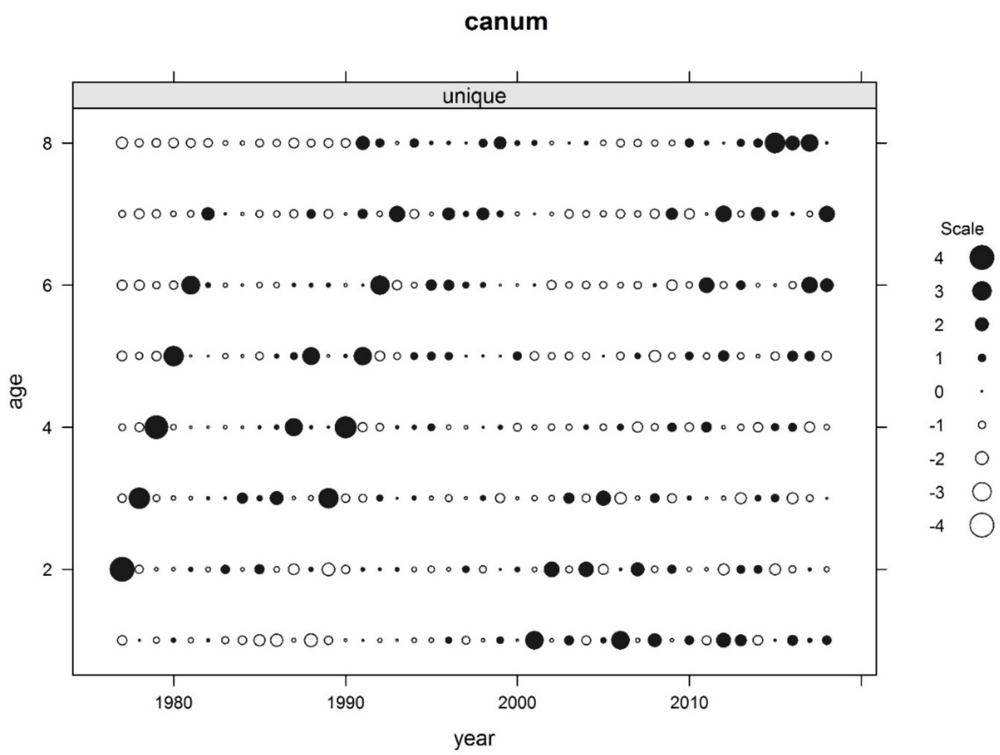


Figure 4.3.2. Gulf of Riga herring. Catch proportion at age.

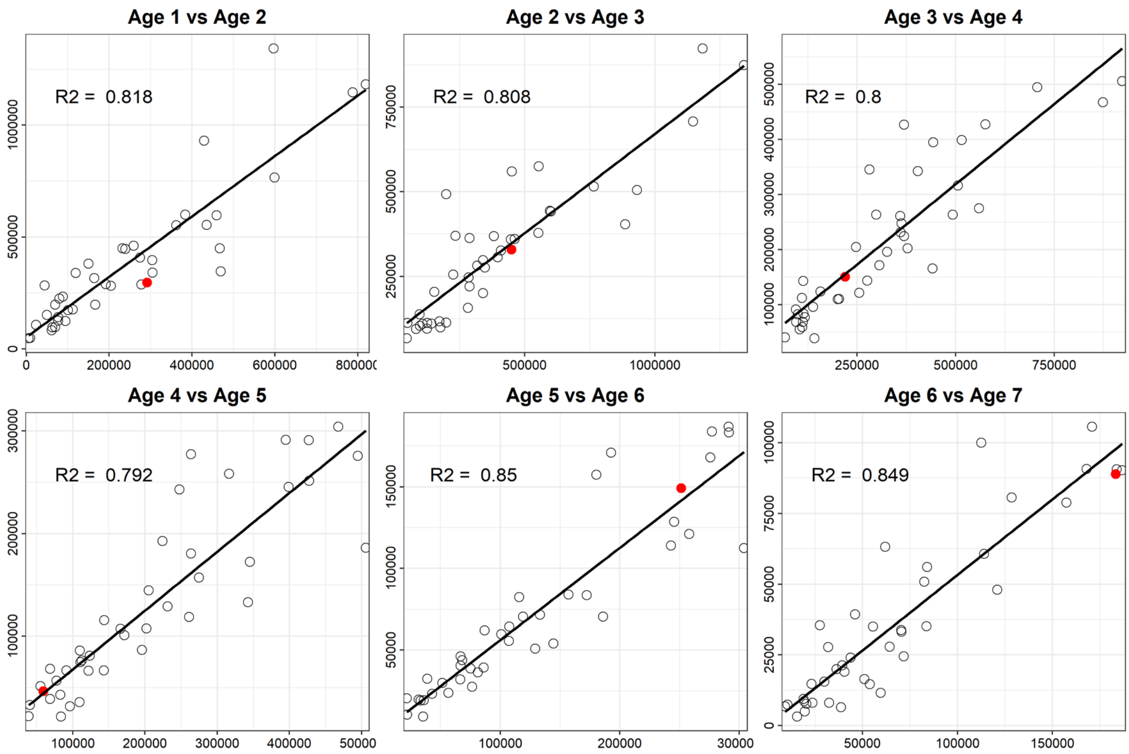


Figure 4.3.3. Gulf of Riga herring. Internal consistency in catch-at-age. Red dot is the latest year.

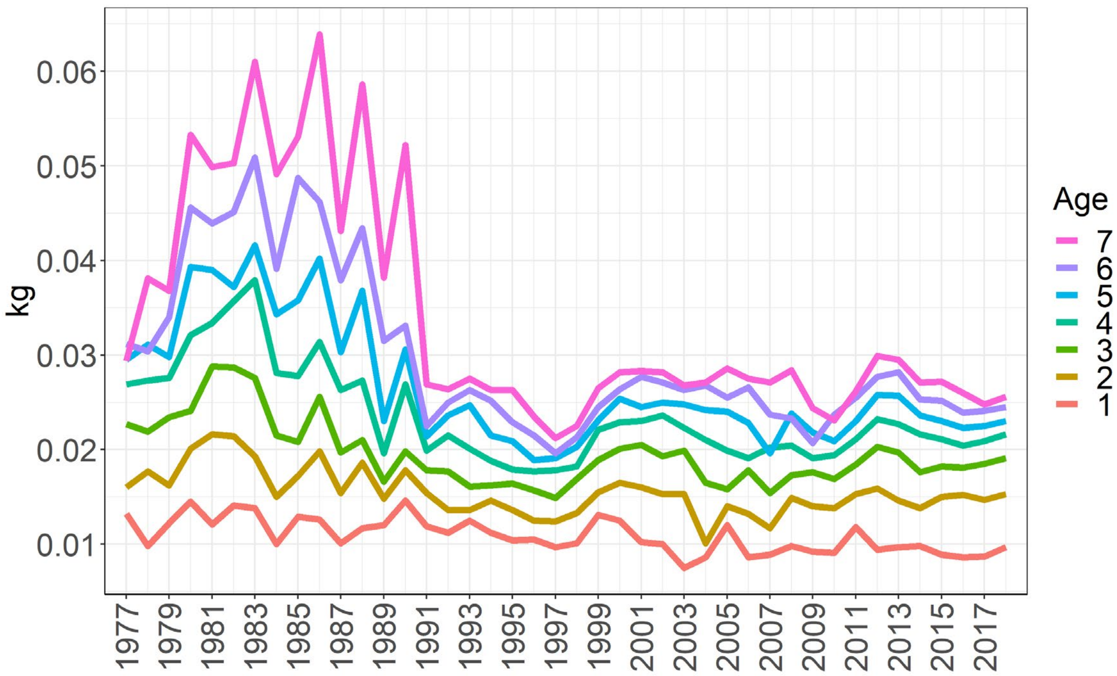


Figure 4.3.4. Gulf of Riga herring. Mean weight-at-age in the catches.

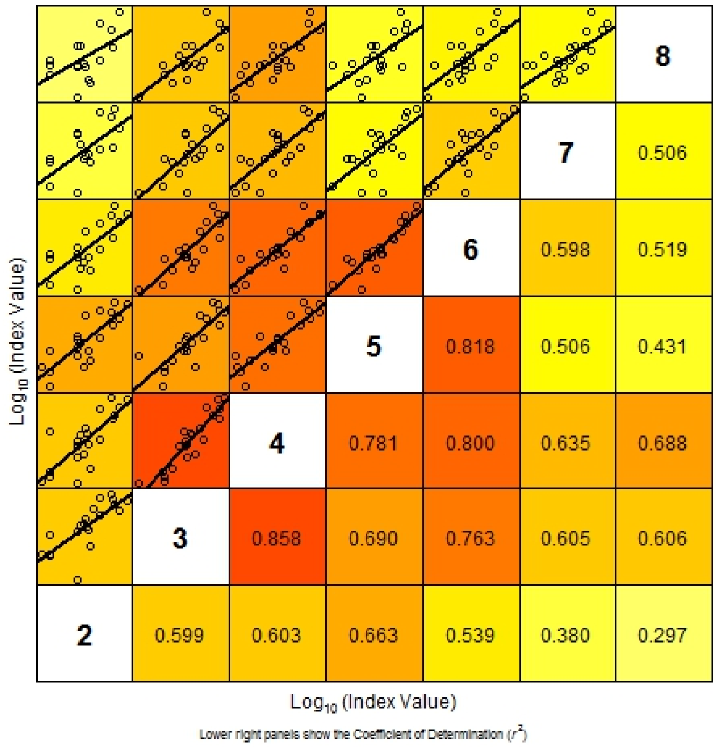


Figure 4.3.5. Gulf of Riga herring. Internal consistency in trapnet tuning fleet.

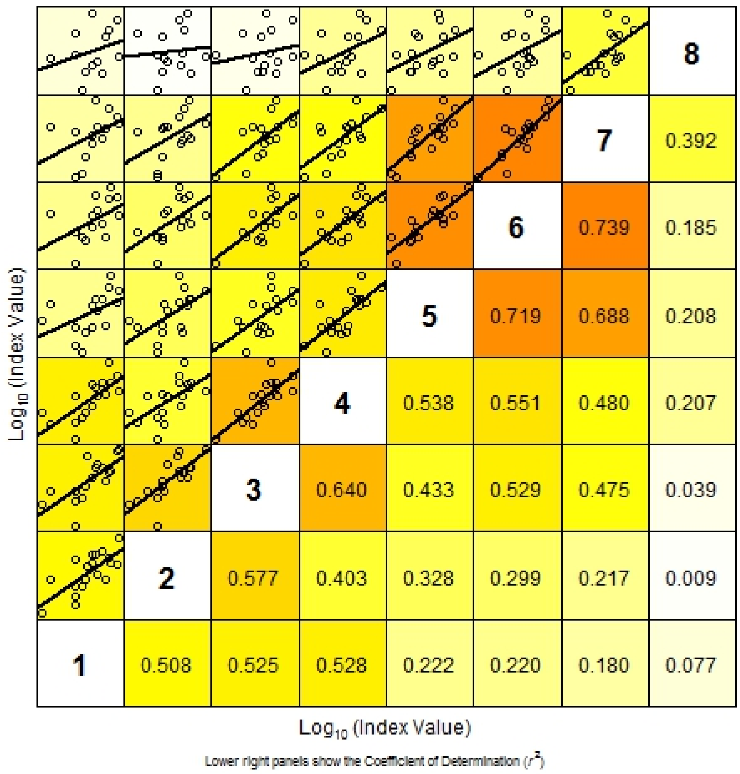


Figure 4.3.6. Gulf of Riga herring. Internal consistency in hydroacoustics tuning fleet.

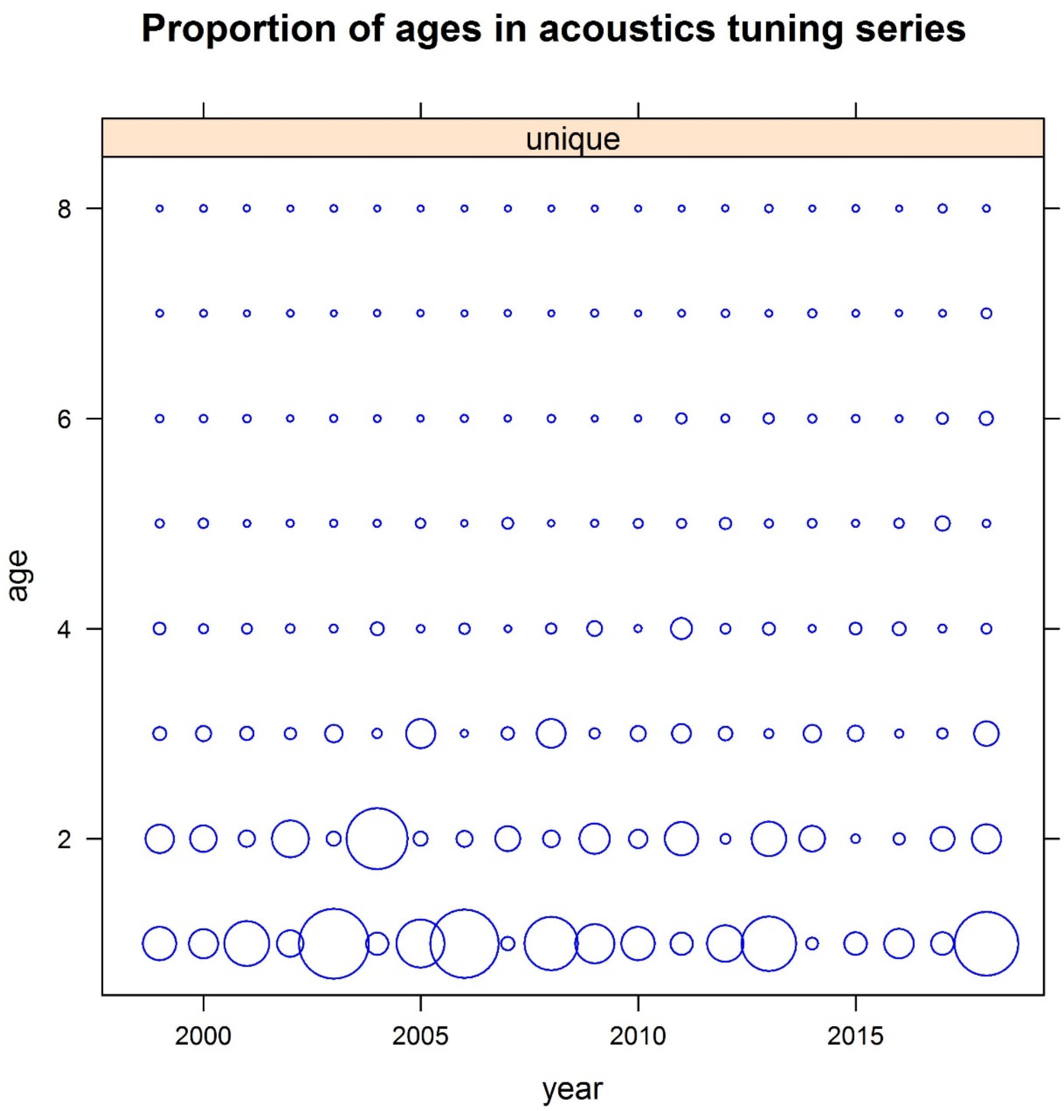


Figure 4.3.7. Gulf of Riga herring. Proportion of ages in hydroacoustics tuning fleet.

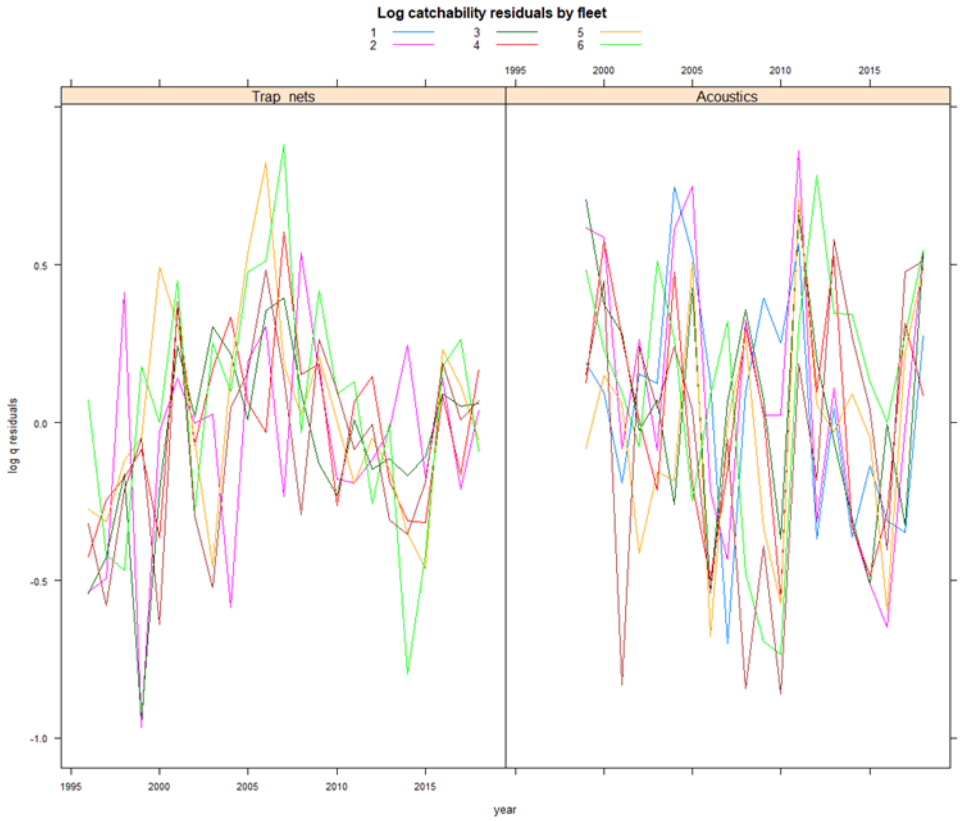


Figure 4.3.8a. Gulf of Riga herring. Log-catchability residuals by fleet.

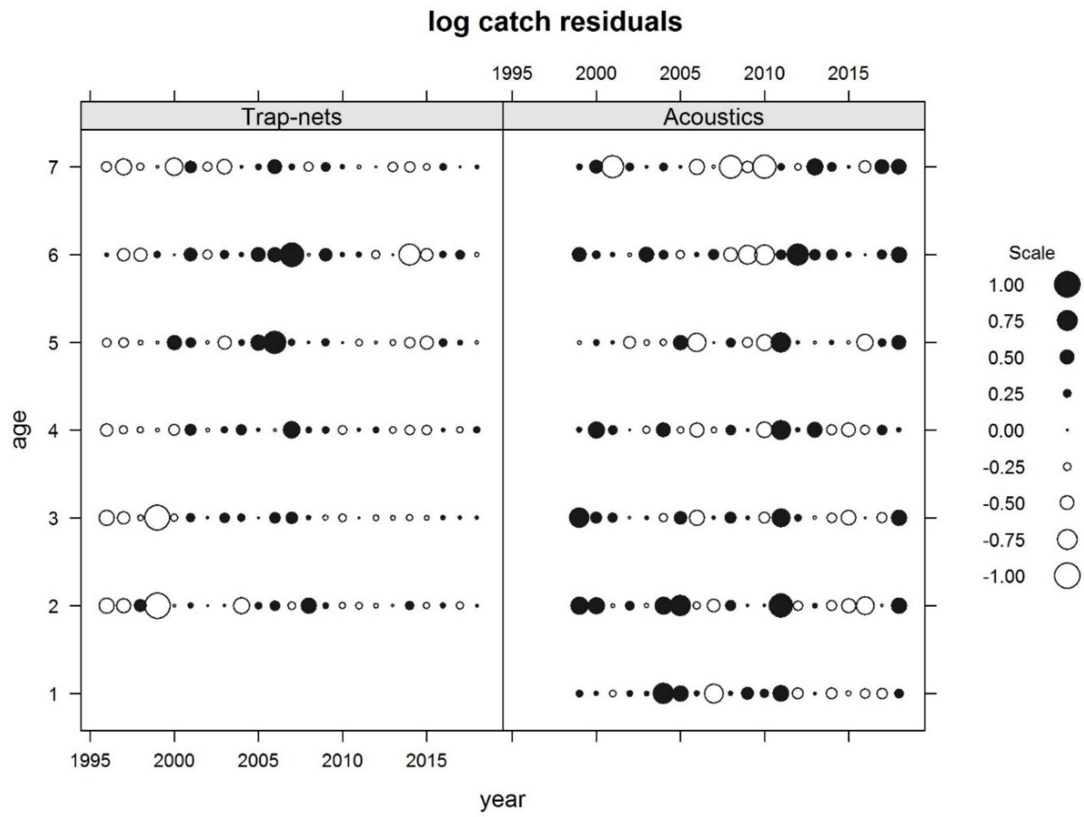


Figure 4.3.8b. Gulf of Riga herring. Log-catchability residuals of trapnet fleet (left) and hydroacoustics fleet (right).

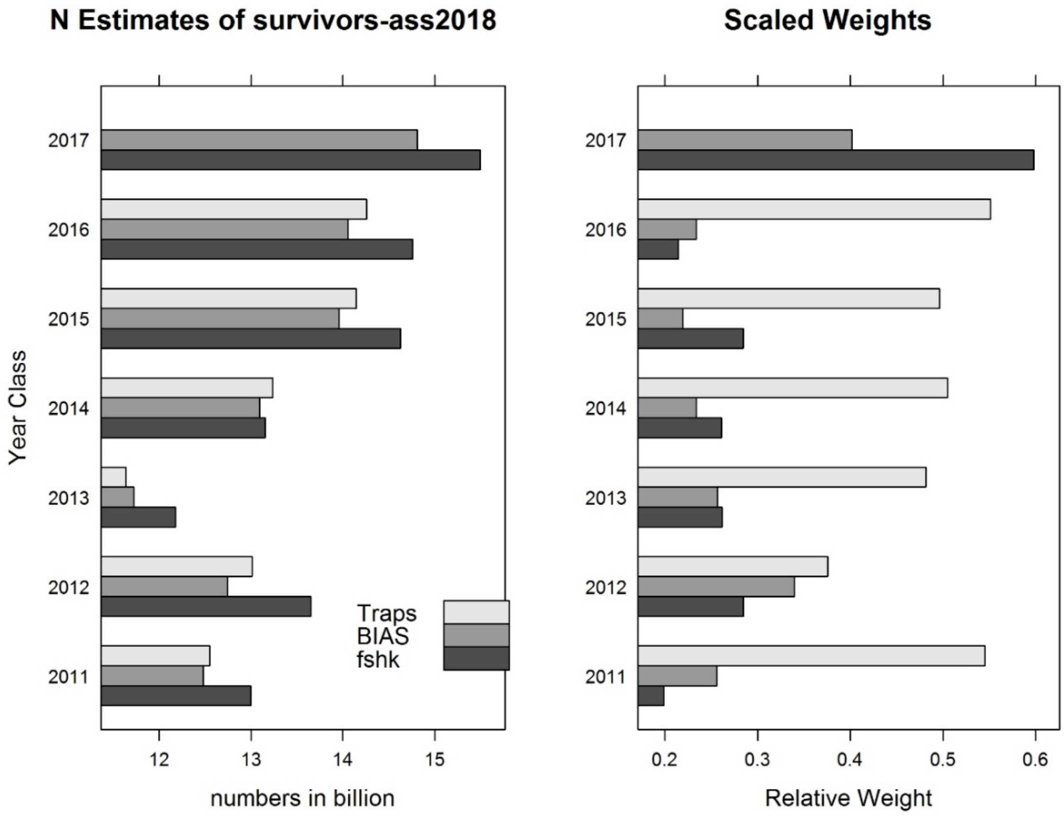


Figure 4.3.9. Gulf of Riga herring. Survivors' estimates and scaled weights for both tuning fleets.

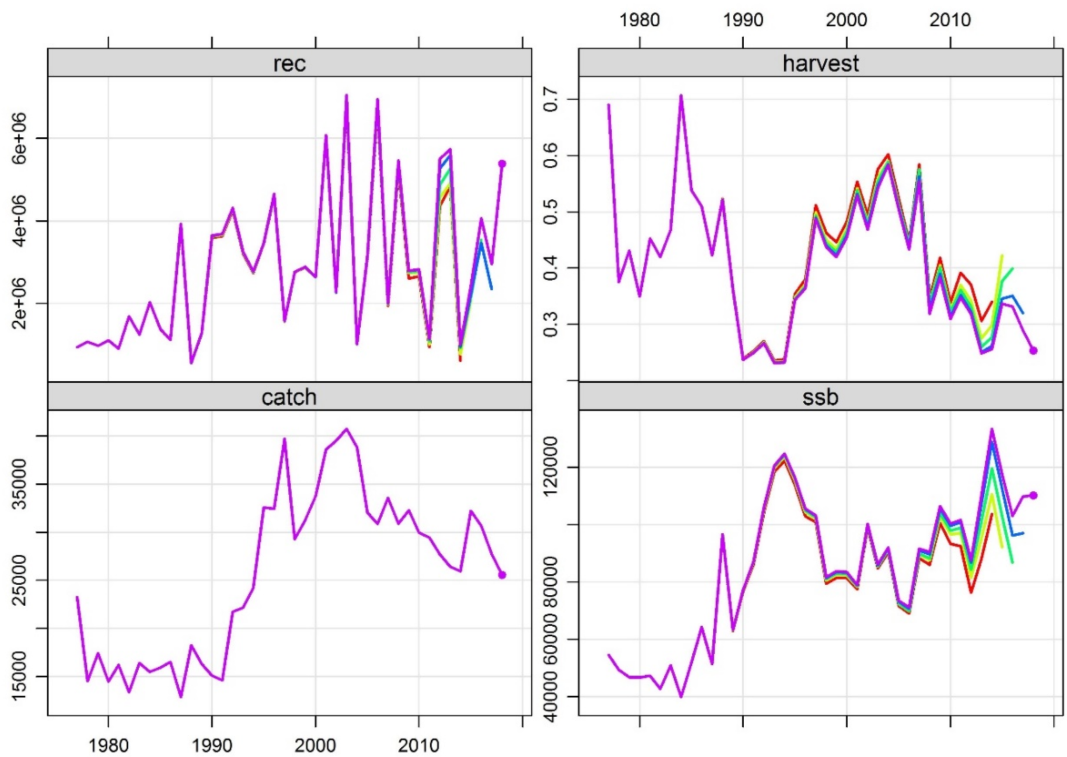


Figure 4.3.10. Gulf of Riga herring. Retrospective analysis.

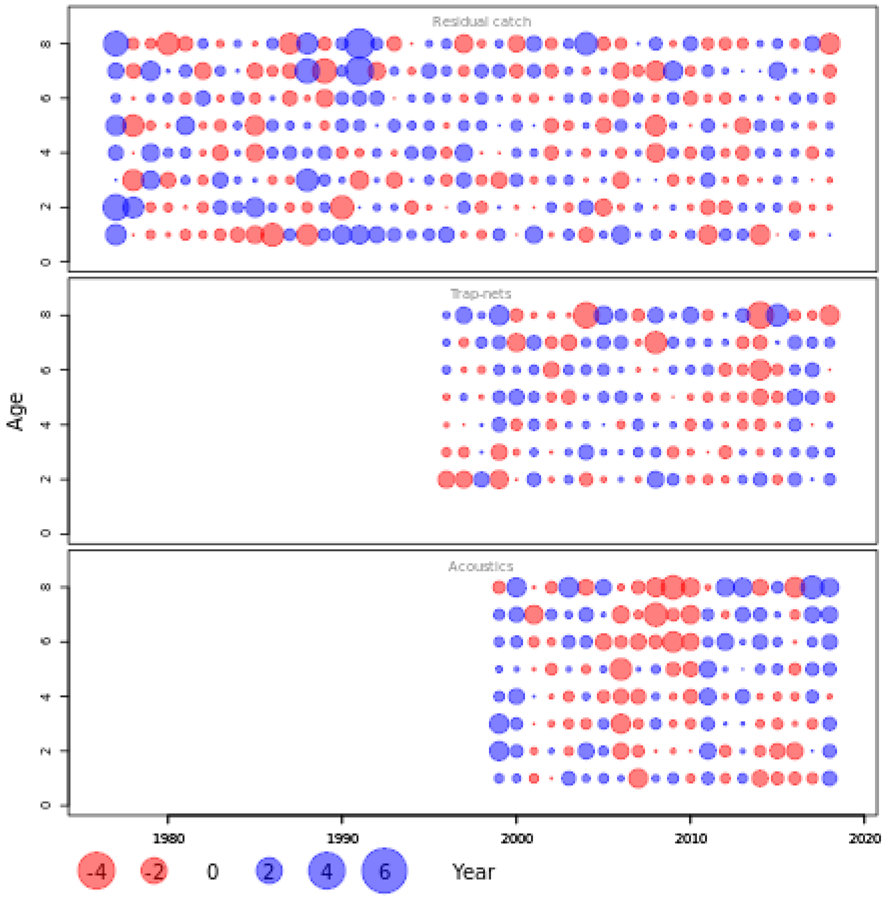


Figure 4.3.11. Gulf of Riga herring. Log-catchability residuals from SAM run by fleet and catch.

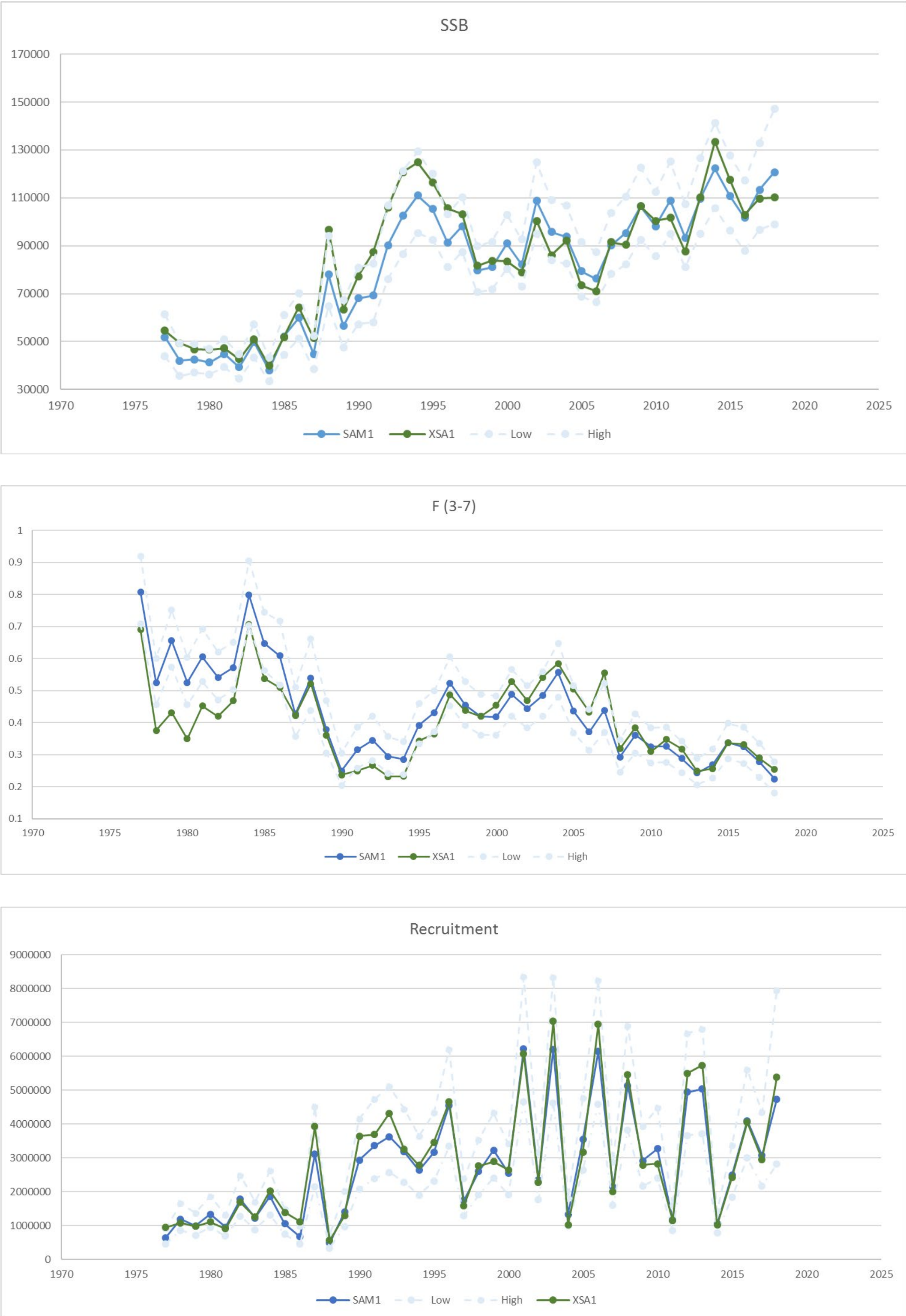


Figure 4.3.12. Gulf of Riga herring. Comparison of spawning-stock biomass (SSB in tonnes), fishing mortality (F_{3-7}) and recruitment (age 1 in thousands) from XSA (green line) and SAM (blue, dotted light blue line represents the 95% confidence intervals of the SAM results).

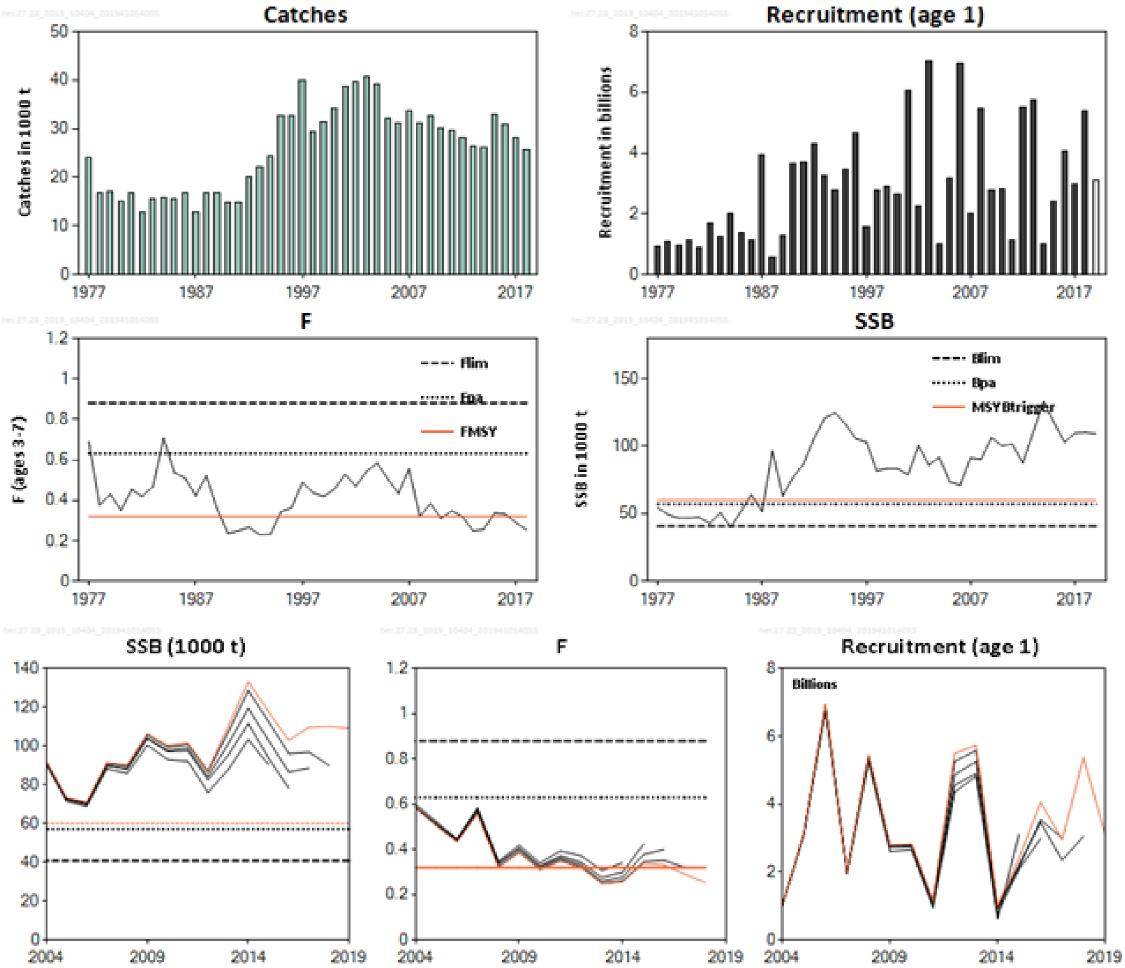


Figure 4.3.13. Gulf of Riga herring. Summary sheet plots: Catches, fishing mortality, recruitment (age 1) and SSB. (Recruitment and SSB in 2019 is predicted). Historical assessment results.

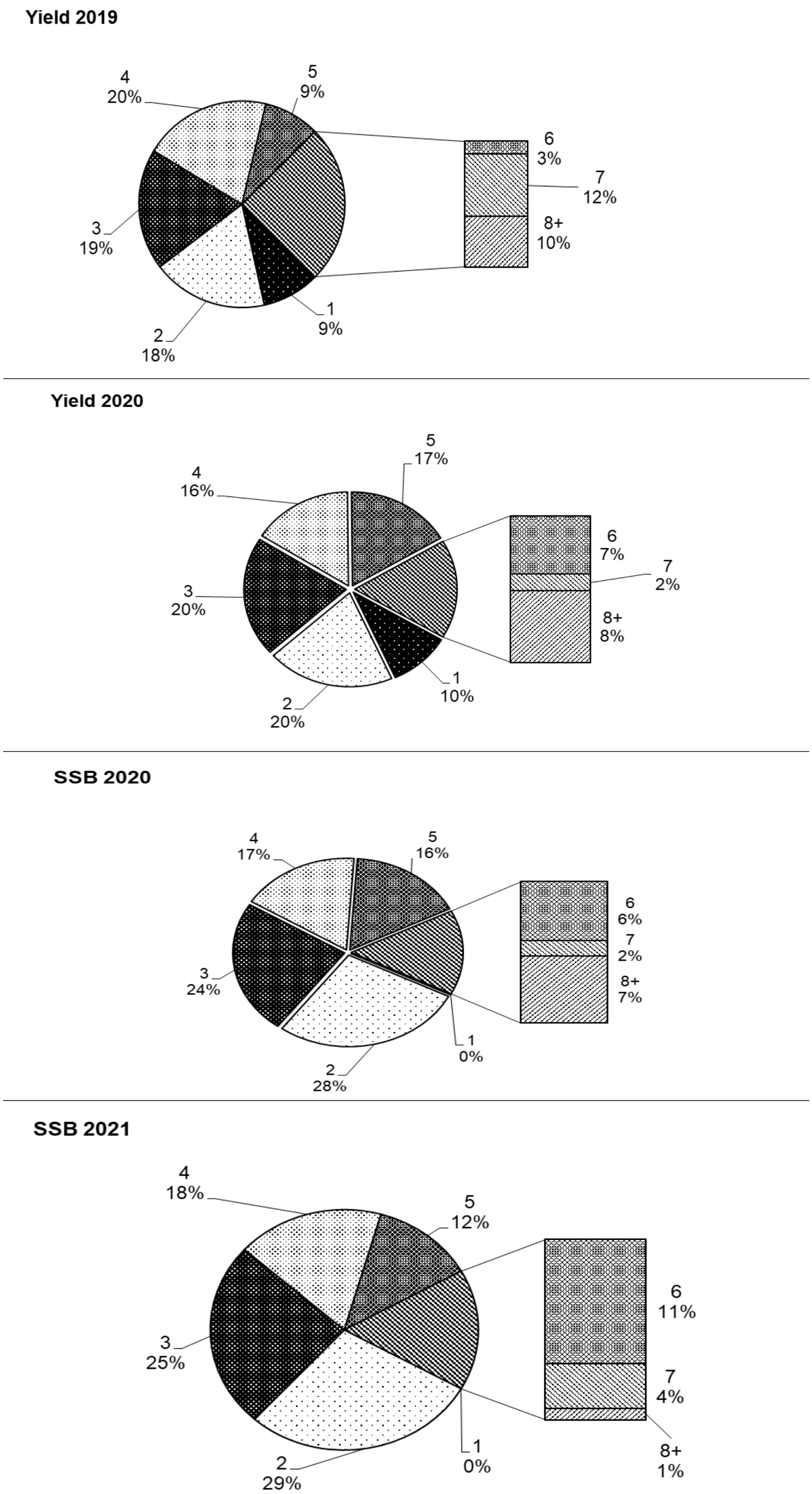


Figure 4.3.14. Gulf of Riga herring. Short-term forecast 2019-2021. Yield and SSB maintaining in the present fishing mortality.

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 midwater. In 2018, 95.4% of the Finnish landings came from trawl fishery, 4.5% with trapnets, and 0.1% with gillnets. In 2018, 96.2% of the Swedish catches came from trawls: 97.5% from pelagic trawls, 2.5% from demersal trawls and 3.8% were caught with gillnets and other passive gears.

4.4.1.1 Landings

The total catch in Gulf of Bothnia decreased by 6991 tonnes (7%) from 2017 to 97 366 tonnes in 2018 (Figure 4.4.1), of which 83% (80 870 tonnes) was Finnish catch and 17% (16 496 tonnes) was Swedish catch (Table 4.4.1). The Finnish catch decreased by 14% (12 688 tonnes) while the Swedish catch increased by 53% (5697 tonnes) compared to 2017.

4.4.1.2 Unallocated removals

No unallocated removals were reported.

4.4.1.3 Discards

Discarding rates in both Finnish and Swedish fisheries are small (reported discards sum up less than 0.5% of total catches) and those have been taken into account in the assessment. 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, however, the interviews of fishers 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 has constituted at most up to 1% of the total herring catches in SD 30 and discards are therefore regarded as negligible.

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 set trapnets decreased drastically, in 1991 the amount of set-nets had declined by 80% compared with 1980.Since then the amount 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 is consisting of gapless catch and effort time-series, combined from three areas within the 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 originally 1990–2014 to 1990–2006, due to a declining effort trend (Figure 4.4.3).

4.4.2 Biological information

4.4.2.1 Catch in numbers

During the WKBALT meeting in 2017 several different age groups (9+ to 15+) in the age-matrices of the assessment input data were examined. Age group 10+ was chosen to be used in the final assessment instead of age group 9+, which has been previously used for SD 30 and SD 31 stocks before merging them as one (Figure 4.4.4). Finnish catch-at-age data from the Bothnian Sea were available for all years and have been applied on Swedish catches, excluding the years: 1987, 1989–1991, 1993 and 2000–2015. During mentioned years the Swedish catches were mostly allocated according to Swedish catch sampling. In 2018 Swedish unsampled catches were allocated in InterCatch according to the Finnish sampling mostly from respective fisheries (Table 4.4.2). Finnish and Swedish sampled catches are shown in Table 4.4.3. The SD 30 time-series was shortened (starting in 1980) to increase the compatibility with the SD 31 time-series, which doesn't contain any Finnish data before 1980. The most common age class (in numbers) during2018 catches was age group 2, largest in terms of biomass age group 4. 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 stock (Table 4.4.5) was assumed to be similar to the mean weight at age in the catches. The average weight at age decreased for all ages since about 1990 (Figure 4.4.5), but stabilized at the beginning of the 2000. During recent years weights-at-age have been stable for age groups 1 through 9, but has clearly decreased in age group 10+ since year 2016.

4.4.2.3 Maturity-at-age

Constant maturity ogives have been used for the period 1980–1982. Since 1983 the proportion of mature individuals at age have been annually updated from the samples taken before spawning time. Updated maturity ogives for 1980–2018 are shown in Table 4.4.6 and Figure 4.4.6. In general, there is a high variability of maturity ogives among years, which causes some noise in assessments. The annual maturation variation in age group 2 is usually quite large. The sensitivity of the variability of maturity ogives from year to year was evaluated during the benchmark assessment in 2012 and it was concluded to continue the annual determination of maturity ogives (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 predation by seals, cormorants and cod on herring do not seem to have major impacts 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, 79 length-samples and 61 age-samples were taken during 2018, as well as 16 length-samples and 11 age-samples from the Swedish fisheries. In total, during 2018, 30 685 herring were length-measured, besides 2772 aged individuals from commercial catches and 3272 aged from acoustic survey (Table 4.4.3).

4.4.3 Fishery-independent information

A joint Finnish - Swedish –hydroacoustic survey has been annually conducted in late September – early October in the Bothnian Sea. Vessels used during the periods: 2007-2010:Swedish RV Argos and continued in 2011-2012 with Danish RV Dana, during: 2013-2016 with Finnish RV Aranda, in late October 2017 with RV Dana and in 2018 with RV Aranda . This survey is coordinated by ICES within the frame of Baltic International Acoustic Surveys (BIAS). The survey covers most of the SD 30 area, excluding only the shallow areas mainly along the Finnish coast and SD 31, which has not been surveyed. The survey generally tracks all age groups well, with the exception of the ages 1 and 2 (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 the other age groups (ICES 2017).

In 2012 the survey was not performed according to standard coverage (60 nautical mile per 1000 nmi^2 = statistical rectangle), instead only half of it and with 50% less control 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, 2017 and 2018 the survey coverage was good. Acoustic surveys have shown to be essential to 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 2007–2018 have been annually used for 3^{rd} and/or 4^{th} quarter ALK's for length distributions from commercial sampling and calculations for 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 inter-benchmarked at the IBPClub Workshop in 2018, (ICES 2019) 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_Herring_2019_clonedversfinal.

The spawning stock size peaked in mid-90s and in 2013. The update assessment shows a decreased SSB in 2018 (Figure 4.4.8.). The average F has in general been increasing since 2010 and showed a peak in 2016 (0.32), and a current decline to 0.30 in 2018. The recruitment has shown an increasing trend from 1980 to 2015, with a peak in 2015. Recruitment in 2016 and 2017 is lower compared to 2015 but still above average values, and is currently below average in 2018. The normalized residuals in the catches are higher for age groups 8 and 9 compared to other age groups in 2018 (Figure 4.4.9.), whereas for the acoustic fleet the normalized residuals are higher for age groups 2, 4 and 5 in 2018. Consistencies of the different ages within acoustic abundances, trapnet CPUE and catch data are presented in Figures 4.4.12. – 4.4.14. In the acoustic internal consistency, there are higher correlations for age 5 and older compared to younger ages in 2017.

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 4.4.10.). 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 datasets. When excluding the acoustics there is a 100 000 t increase in SSB in the last year. The acoustic survey is still relatively short and samples a younger part of the population compared to the size selective trapnet fishery which could explain the differences in the patterns. Excluding either survey indices does not have much impact on recruitment. The retrospective analysis shows an overestimated SSB (Mohn's rho=37%) and underestimated fishing mortality during the last 5 years (Mohn's rho= -27%). Retrospective analysis for recruits are highly unstable (Mohn's rho=68%) (Figure 4.4.11.)[1]. The acoustic survey data based abundance index resulted in its highest values during 2015 and lowest during 2018. This caused major uncertainty in SSB estimates for the years 2016–2018.

4.4.4.2 Recruitment estimates

According to the estimates from SAM, the recruitment of herring in the Gulf of Bothnia peaked in 1990 and 2015 (Figure 4.4.8.). As visible in several other Baltic pelagic stocks, the estimated year-class strength 2014 was very large (22.8 times bigger) and in 2015 still 9.1 times bigger compared to the mean value of 2007–2012. As a madder of fact, the 2014 year class was exceptionally abundant in the Baltic Sea area also for other pelagic stocks. The Gulf of Bothnia herring 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. The recruitment (age 1) for years 2016 – 2018 show lower values compared to 2015. The recruitment shows an overall increasing trend but is below average in 2018. It should be noted however, that the confidence intervals, particularly around the more recent years, are very large.

4.4.4.3 Historical trends

Herring spawning-stock biomass increased rapidly since 1981 (Table 4.4.7.), peaked during 1994, decreased until 2002, and thereafter increased again in 2013. However, the spawning-stock biomass follows a declining trend since 2014. The large uncertainty regarding the SSB estimate has reduced after the model was revised in the inter-benchmark. During the current period of high recruitment, the spawning-stock biomass is approximately three times larger than it was during the low recruitment period in the early 1980s.

4.4.5 Short-term forecast and management options

The short-term forecast is based on the SAM short-term forecast module, applied settings are displayed in the following paragraph.

Mean weights at age were assumed to be equal to the average mean weights at age across the years 2016–2018. Natural mortality was set to 0.15, average fishing mortality rate in 2016–2018 were scaled to the last year. Recruitment in 2019–2021 were estimated based on resampling from the sampled distribution in 1980–2018. 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 forecast runs were conducted with 2019 catch constraints because the forecasted

[1] Please note that given the high Mohn's rho value for SSB, ADGBS 2019 decided to use the SAM assessment as indicative of trends only (i.e. category 3 stock).

catch without constraints overestimated the TAC for 2019 (TAC 88 703 t). 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 with a fishing mortality at MSY (F_{MSY} = 0.23), herring catches in the Gulf of Bothnia would be 65 158 tonnes in 2020 with a decrease of SSB by -6%. (SSB of 2019 not given, therefore -6% change not comprehendible)

Details on the forecast scenarios and results can also be viewed at https://www.stockassessment.org (login:guest, password:guest), choose stock GoB_Herring_2019_clonedversfinal.

4.4.6 Reference points

Reference points for the GoB herring stock were calculated in IBPClub (ICES 2019) inter-benchmark with upper and lower ranges. Summary table of the Gulf of Bothnia stock reference points:

Summary table of reference points:	VALUE
$F_{P.05}$ (5% risk to B_{lim}) with MSY $B_{trigger}$	0.23
$F_{P.05}$ (5% risk to B_{lim}) without MSY $B_{trigger}$	0.21
F_{MSY}	0.26
$F_{MSY\ precautionary}$	0.23
$F_{MSY\ lower}$	0.167
$F_{MSY\ upper}$	0.36
F_{pa}	0.23
F_{lim}	0.31
$F_{MSY\ upper\ precautionary}$	0.23
F_{MSY} range with MSY $B_{trigger}$	0.164–0.23
F_{MSY} range without MSY $B_{trigger}$	0.156–0.21
MSY $B_{trigger}$	279 110 t
B_{pa}	279 110 t
B_{lim}	199 364 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 considered to be too unreliable. Currently the acoustic survey data time-series is too short to be used by itself (WKBALT 2017).

Especially the results from the acoustic surveys of 2016–2018 give a very uncertain picture 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 displays high variations within the estimated age-structure during recent years. The survey time-series is still relatively short, thus it is expected 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)

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
2017	93558	10 800	104 358
2018	80870	16496	97 366

Table 4.4.2. Herring in GOB. Allocation of Swedish unsampled 2018 catches.

Swedish non-sampled landings and discards					Allocated according to					
SD	**Q**	**Gear**	**Category**	**Tonnes**	**SD**	**Country**	**Q**	**Gear**	**Category**	**Tonnes**
30	1	Gillnet	L	0.4	30	FI	1	Gillnet	L	0.5
30	1	Pelagic trawl	L	6084.7	30	FI	1	Pelagic trawl	L	33589.6
30	2	Gillnet	R	0.4	30	FI	2	Gillnet	L	76.1
30	2	Pelagic trawl	L	6433.1	30	FI	2	Pelagic trawl	L	28238.8
30	3	Gillnet	R	0.0	30	FI	3	Gillnet	L	18.4
30	3	Passive gears	L	0.004	30	FI	3	Trapnet	L	357.6
30	4	Gillnet	L	24.6	30	FI	4	Gillnet	L	3.3
30	4	Passive gears	L	0.01	30	FI	4	Trapnet	L	0.4
30	4	Pelagic trawl	L	2968.1	30	FI	4	Pelagic trawl	L	10045.5
31	2	Passive gears	L	6.2	31	FI	2	Trapnet	L	125.1
31	2	Passive gears	R	0.02	31	FI	2	Trapnet	L	125.1
31	3	Bottom Trawl	L	45.1	31	FI	3	Pelagic trawl	L	634.2
31	3	Passive gears	L	2.0	31	FI	3	Trapnet	L	25.8
31	4	Bottom Trawl	L	213.5	31	FI	4	Pelagic trawl	L	20.1
31	4	Gillnet	L	0.3	31	FI	4	Gillnet	L	1.0
31	4	Passive gears	L	0.5	31	FI	4	Trapnet	L	0.4

Table 4.4.3. Herring in SD's 30 and 31. Landings and sampling by country in 2018.

Country	ICES Sub Division	Landings	Quarter	Number of length samples	Number of fish measured	Number of age samples	Number of fish aged
Finland	30	33590	1	13	4195	13	257
		31453	2	23	7531	11	347
		3678	3	7	2187	7	177
		10049	4	16	4736	15	265
		78770	**Total**	59	18649	46	1046
Sweden	30	6085	1				
		7027	2	6	3431	3	324
		76	3	3	1025	3	327
		3022	4	2	1348		
		16210	**Total**	11	5804	6	651
Finland	31		1				
		1417	2	11	3318	5	145
		661	3	5	606	6	267
		21	4	4	800	4	138
		2100	**Total**	20	4724	15	550
Sweden	31		1				
		22	2	3	1108	3	299
		50	3	2	400	2	226
		214	4				
		286	**Total**	5	1508	5	525
Finland & Sweden	30 + 31	39675	1	13	4195	13	257
		39918	2	43	15388	22	1115
		4465	3	17	4218	18	997
		13307	4	22	6884	19	403
		97366	**Total**	95	30685	72	2772

SD 30 Q 4 age sampling has in addition 29 age samples with 3272 aged fish from acoustic survey .

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
2017	742230	859392	1172496	435129	294949	133535	101620	128330	87524	297165
2018	380825	1153980	573477	737475	299808	184311	104431	100232	60145	240512

Table 4.4.5 Herring in SD's 30 and 31. Weight at age in the catches.

	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
2017	9	16	23	28	33	38	38	42	50	55
2018	8	16	24	29	31	37	38	43	51	53

Table 4.4.6 Herring in Gulf of Bothnia. Maturiy ogive

	1	2	3	4	5	6	7	8	9	10+
1973	0	0.29	0.92	0.97	1	1	1	1	1	1
1974	0	0.29	0.92	0.97	1	1	1	1	1	1
1975	0	0.29	0.92	0.97	1	1	1	1	1	1
1976	0	0.29	0.92	0.97	1	1	1	1	1	1
1977	0	0.29	0.92	0.97	1	1	1	1	1	1
1978	0	0.29	0.92	0.97	1	1	1	1	1	1
1979	0	0.29	0.92	0.97	1	1	1	1	1	1
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
2017	0.11	0.76	0.98	1	1	1	1	1	1	0.99
2018	0.16	0.88	1	1	1	1	1	1	1	0.98

Table 4.4.7. Herring in SD's 30 and 31. SAM output summary table. Historical stock trends of Gulf of Bothnia herring in 1980-2018.

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(3-7)	Low	High	TSB	Low	High
1980	3662659	2387194	5619598	125105	94118	166295	0.23	0.171	0.31	178039	137504	230522
1981	1302726	854902	1985136	121159	89599	163835	0.175	0.128	0.238	169437	128945	222646
1982	1265873	819373	1955683	131367	96516	178803	0.196	0.143	0.268	163631	122673	218262
1983	3973024	2609981	6047907	138801	100045	192570	0.181	0.13	0.252	194327	144103	262057
1984	5326968	3480061	8154049	167928	120064	234874	0.19	0.135	0.269	283321	208869	384312
1985	4101070	2639845	6371120	199195	141258	280894	0.166	0.115	0.239	302813	220021	416758
1986	1037179	659604	1630888	228178	160508	324378	0.15	0.102	0.219	306812	219341	429167
1987	2601539	1649589	4102845	270479	187965	389216	0.13	0.088	0.194	339571	240049	480353
1988	1050902	666187	1657785	270850	183831	399061	0.124	0.083	0.184	357242	248988	512562
1989	5952924	3844553	9217534	323537	219757	476327	0.103	0.069	0.154	426227	297341	610980
1990	9973254	6531772	15227997	384462	264913	557961	0.096	0.065	0.142	549613	388913	776714
1991	3270151	2163594	4942650	428049	303390	603930	0.081	0.055	0.119	538424	388420	746358
1992	4780438	3253736	7023493	463523	336018	639411	0.098	0.07	0.138	599158	444489	807648
1993	8763851	6014391	12770217	461138	346120	614377	0.1	0.074	0.136	676751	522409	876690
1994	3335762	2318079	4800228	536383	416629	690560	0.121	0.092	0.158	647993	511015	821689
1995	3742385	2591119	5405170	473169	374507	597822	0.143	0.112	0.181	578054	464668	719109
1996	3367729	2345729	4834999	469446	377534	583734	0.144	0.114	0.181	559287	454943	687563
1997	3379654	2353985	4852222	411586	331404	511168	0.177	0.141	0.222	520050	425333	635860
1998	6537877	4562066	9369405	385060	307393	482350	0.173	0.138	0.216	501663	408038	616770
1999	3118269	2174510	4471628	380375	305143	474155	0.191	0.152	0.24	474315	386515	582060
2000	5972265	4177555	8537995	347477	279549	431911	0.181	0.145	0.226	431137	351542	528753
2001	5646521	3942019	8088037	340637	275847	420646	0.172	0.138	0.214	437210	358834	532705
2002	7604296	5322427	10864465	352760	286350	434572	0.143	0.115	0.178	464952	381940	566007
2003	8491567	5933305	12152873	355786	290882	435172	0.138	0.111	0.171	476072	393095	576565
2004	2662888	1870004	3791955	362718	299860	438754	0.147	0.119	0.181	497368	413695	597964
2005	3749668	2639062	5327654	387007	321535	465809	0.15	0.122	0.184	490837	410778	586498
2006	4086847	2862440	5834993	379160	315940	455032	0.161	0.132	0.198	477306	400921	568244
2007	8629433	6125986	12155939	363807	304160	435152	0.183	0.149	0.224	484772	408282	575593
2008	4892130	3469286	6898519	345649	288571	414015	0.178	0.145	0.218	460328	386465	548307
2009	5275160	3745525	7429482	392281	326821	470852	0.162	0.132	0.199	521401	436996	622108
2010	5544912	3947514	7788713	466028	388793	558605	0.157	0.128	0.193	561784	470970	670108
2011	4387709	3129435	6151907	434823	364548	518644	0.169	0.139	0.206	548560	463140	649734
2012	7700380	5467860	10844436	459535	386715	546069	0.217	0.179	0.264	572161	485079	674875
2013	5847441	4167209	8205147	466597	394270	552191	0.243	0.2	0.295	584786	497130	687898
2014	5970198	4232884	8420561	463651	389653	551701	0.244	0.2	0.298	582768	493031	688838
2015	13409348	9342749	19246008	431208	360686	515520	0.267	0.217	0.328	605522	505065	725960
2016	6570122	4525536	9538429	390357	322555	472412	0.322	0.257	0.403	548230	455678	659579
2017	6897055	4619500	10297514	370930	296407	464190	0.29	0.224	0.377	481416	387611	597924
2018	3744827	2292112	6118257	342952	258863	454356	0.304	0.22	0.42	411769	314289	539485

Table 4.4.8. Herring in SD's 30 and 31. Short-term forecast with different scenarios for the Gulf of Bothnia herring stock. All weights are in tonnes.

Basis	Total catch (2020)	F_{total} (2020)	SSB(2020)	SSB (2021)	% SSB change*	% advice change**
MSY approach = F_{MSY}	65158	0.230	285276	288766	100%	-27%
F = $F_{MSY\ lower}$^	48727	0.167	288203	308279	7%	-26%
Other Scenarios						
F = 0	0	0	295353	365673	24%	-100%
F_{pa}	65158	0.23	285276	288766	1%	-27%
F = F_{lim}	84630	0.310	281698	266340	-5%	-5%
SSB(2021) = B_{lim}	143047	0.598	269956	199364	-26%	61%
SSB (2021) = B_{pa}	73581	0.264	283730	279110	-2%	-17%
SSB(2021) = MSY $B_{trigger}$	73581	0.264	283730	279110	-2%	-17%
F = $F_{MSY\ upper}$ ^^	65158	0.23	285276	288766	1%	-27%‡
F = F_{2019}	82287	0.300	282114	269246	-5%	-7%

*** SSB 2021 relative to SSB 2020.**

****Advice value 2020 relative to advice value 2019.**

^ Lower F_{MSY} range calculated during the stock benchmark in 2018 (ICES, 2019).

^^ Upper F_{MSY} range calculated during the stock benchmark in 2018 (ICES, 2019).

^^^ Advice value for in 2020 relative to Advice value for the proposed $F_{MSY\ lower}$ 2019 (65 662 tonnes).

‡ Advice value for 2020 relative to Advice value for the proposed $F_{MSY\ upper}$ 2019 (88 703 tonnes).

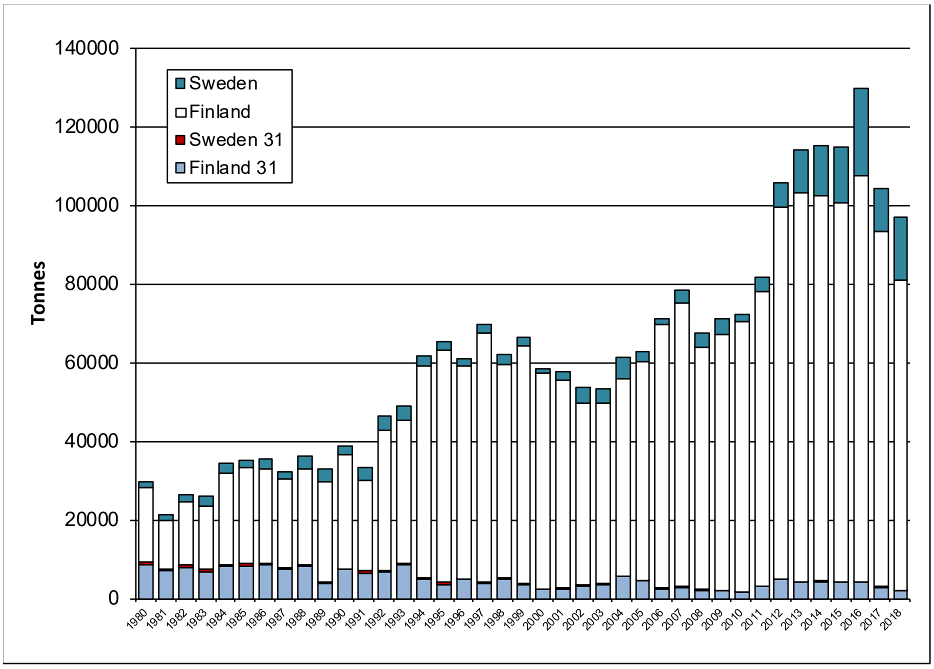


Figure 4.4.1. Herring in SD's 30 and 31. Landings by country.

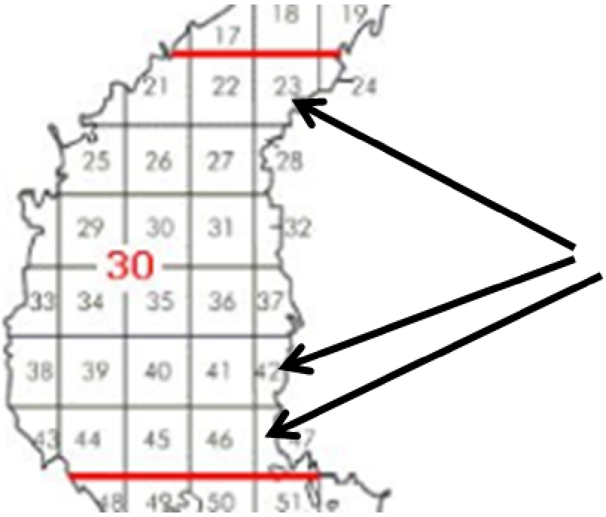


Figure 4.4.2 Herring in SD 30. The areas of unbroken timeseries of catch and effort data for trapnet tuning-series.

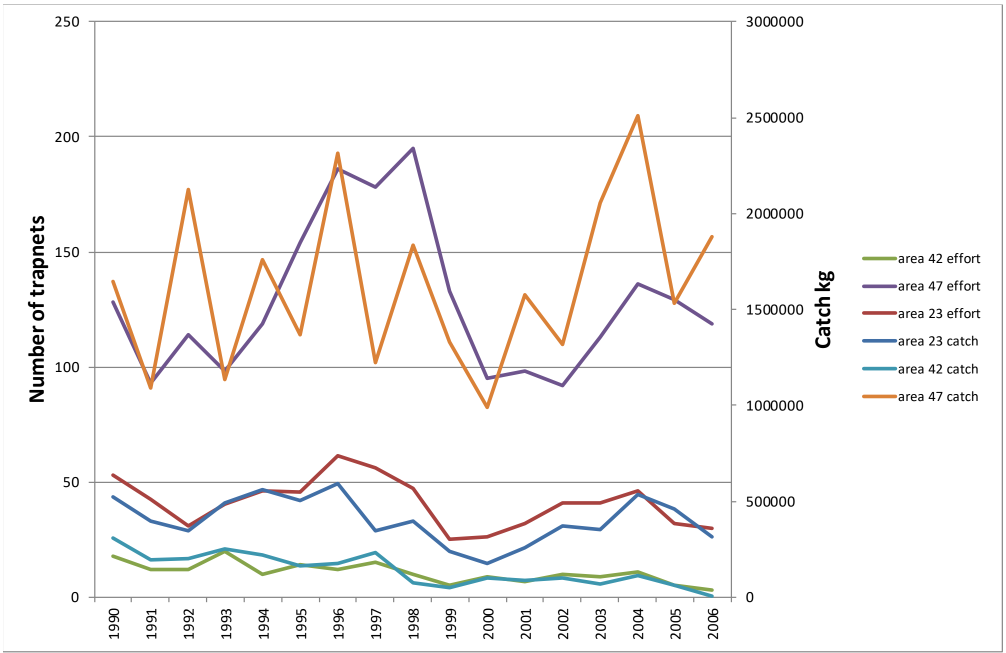
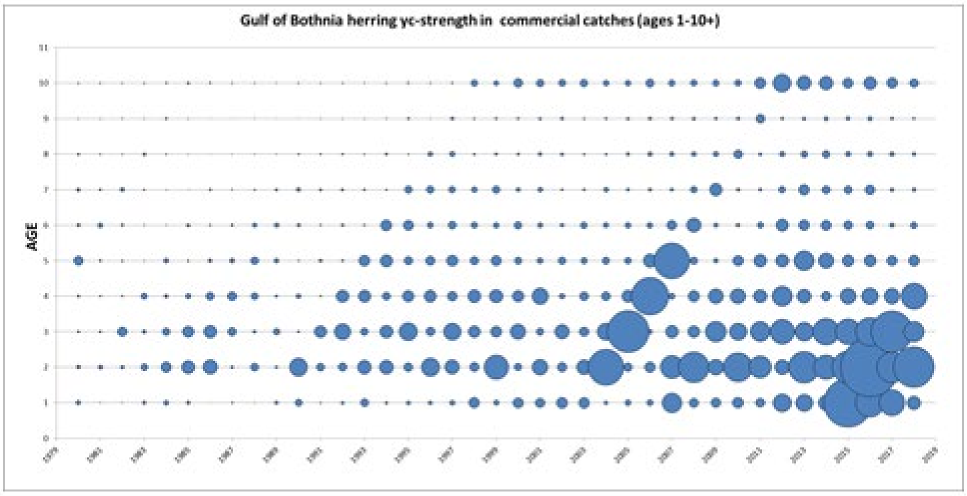
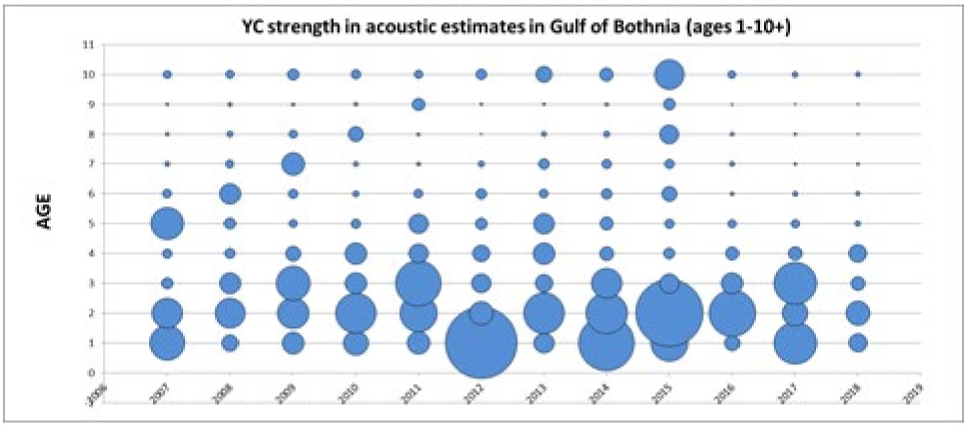


Figure 4.4.3. Herring in Gulf of Bothnia. Trapnets catch (kg) and effort (number of traps) in three different areas (see map Fig 4.4.2) used to calculate the trap net tuning index for the spaly assessment.





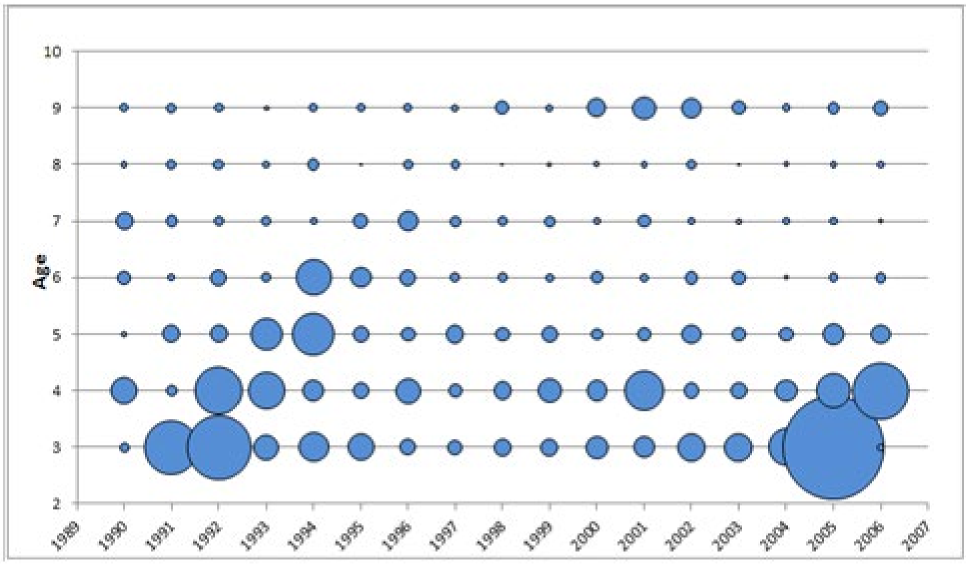


Figure 4.4.4. Herring in SD's 30 and 31 Age composition in commercial catch and CPUE by age in acoustic survey

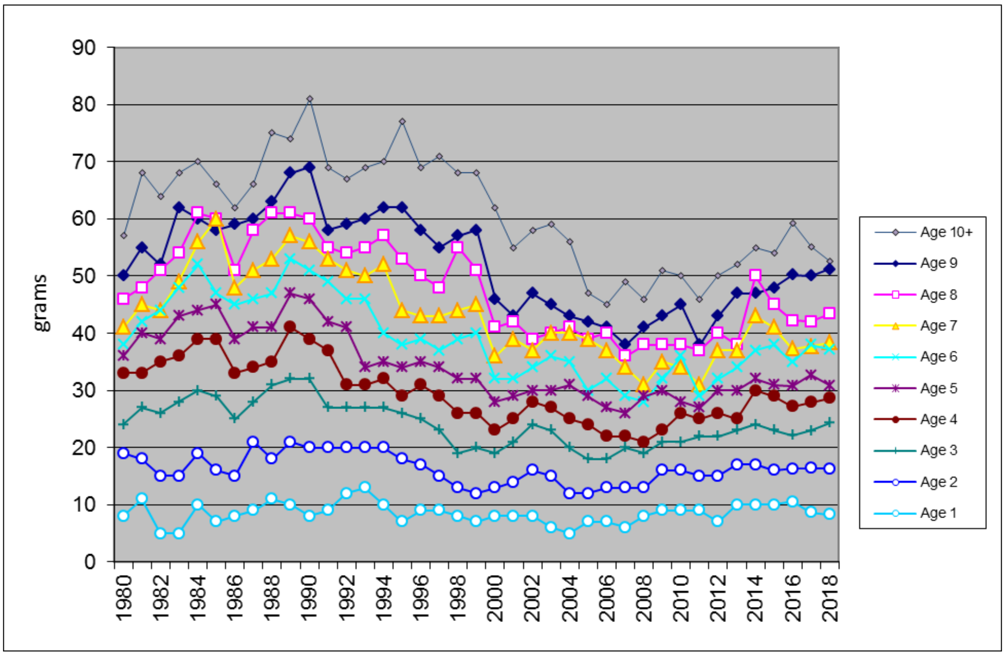


Figure 4.4.5. Herring in SD's 30 and 31. Weights-at-age in catches

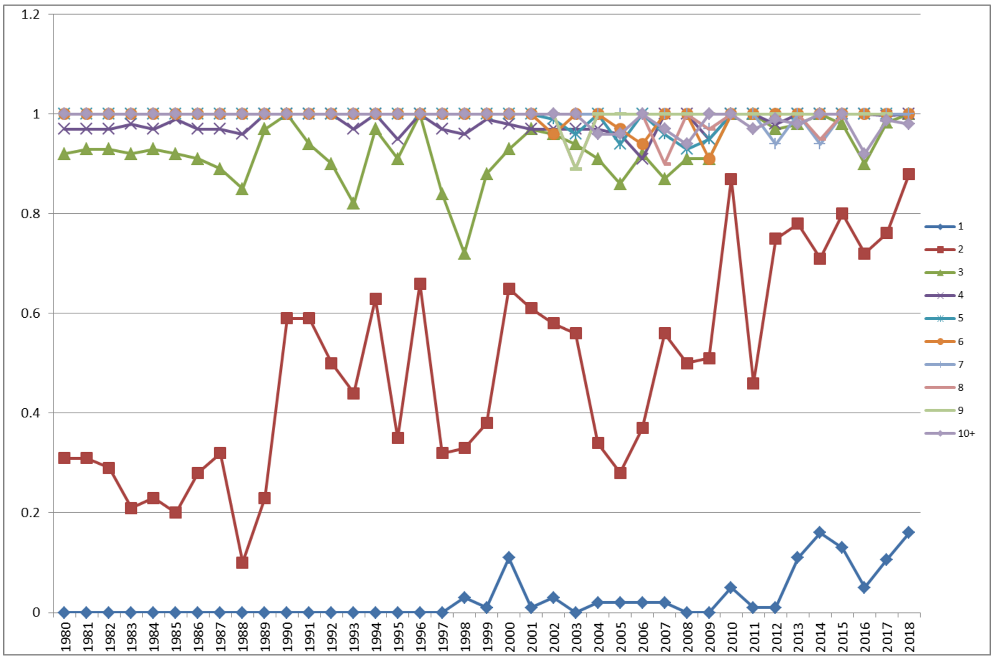


Figure 4.4.6. Maturity ogive

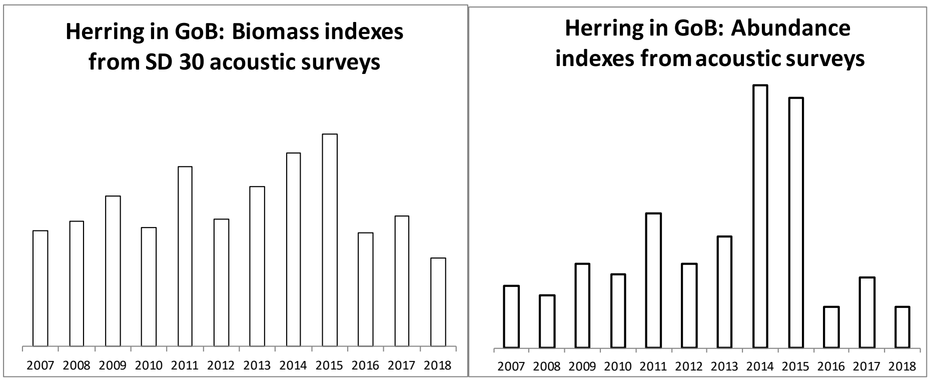
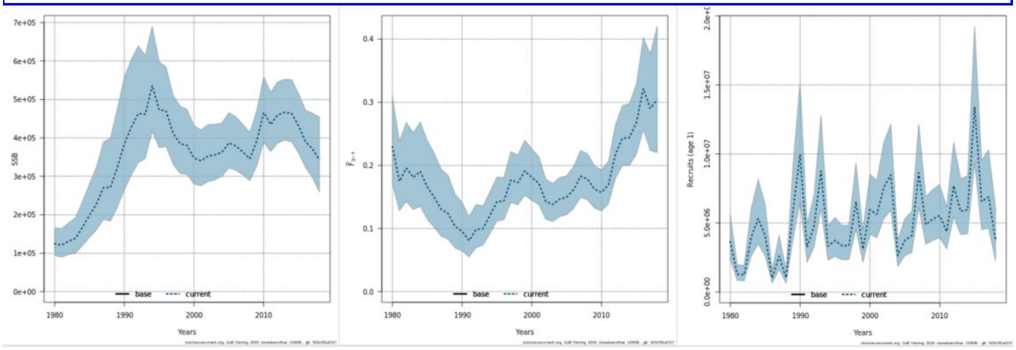


Figure 4.4.7. Herring in SD's 30 and 31. Abundance and biomass indexes from 2007-2018 Bothnian Sea acoustic surveys.



Figures 4.4.8. Herring in SD's 30 and 31. Estimated SSB, F and age 1 recruitment of Gulf of Bothnia herring in 1980-2018.

Figure 4.4.9. Herring in SD's 30 and 31. Normalized residuals of three Gulf of Bothnia fleets in 1980-2018, catch data (top), trapnet data (center) and acoustic index (low). Red filled circles indicate negative residuals and blue circles positive residuals.

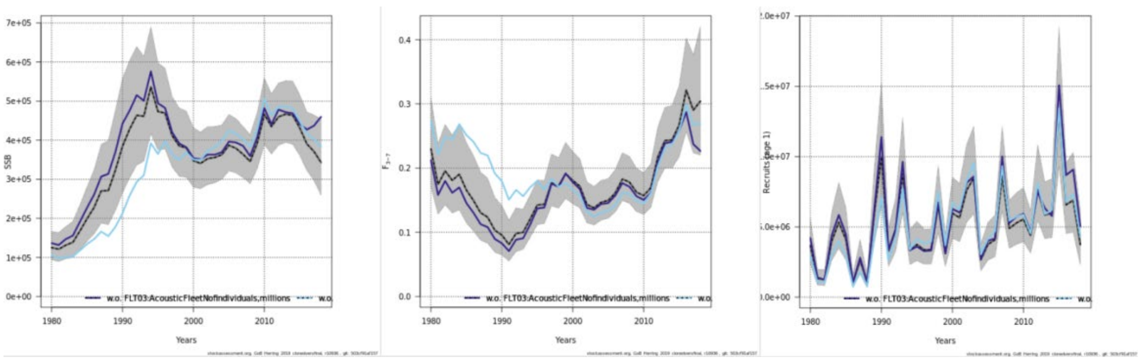


Figure 4.4.10. Herring in SD's 30 and 31. Leave-one-out runs of the Gulf of Bothnia herring stock in 1980–2018.

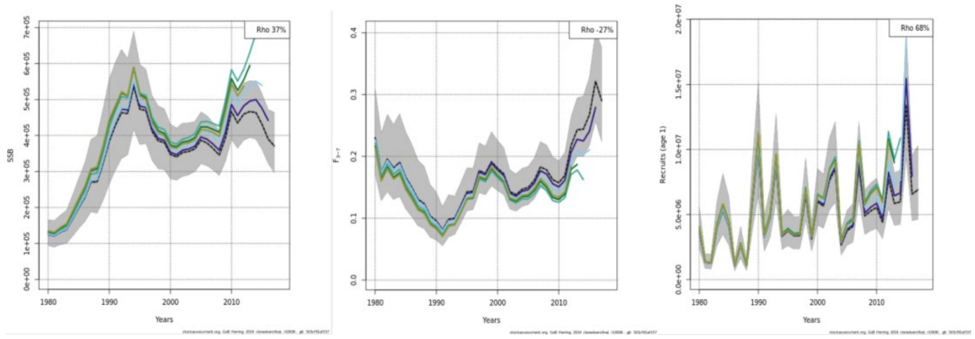
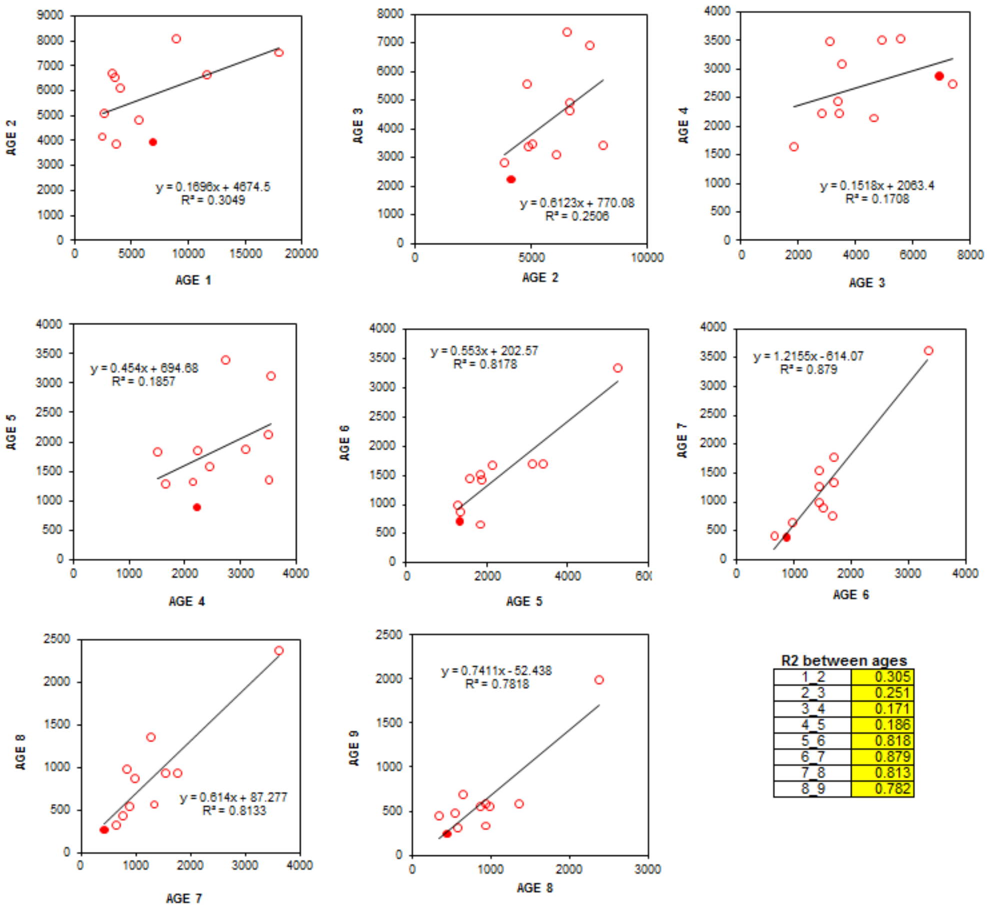


Figure 4.4.11. Herring in SD's 30 and 31. Retrospective analysis of the Gulf of Bothnia herring stock in 1980–2018.



R2 between ages

1_2	0.305
2_3	0.251
3_4	0.171
4_5	0.186
5_6	0.818
6_7	0.879
7_8	0.813
8_9	0.782

Figure 4.4.12. Consistency in Acoustic estimates.

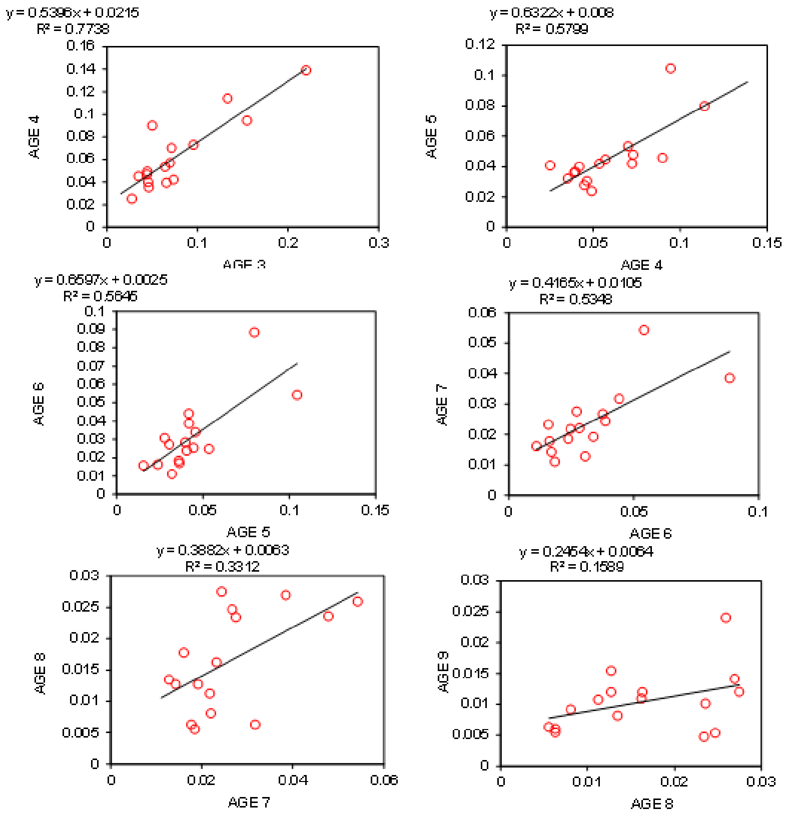
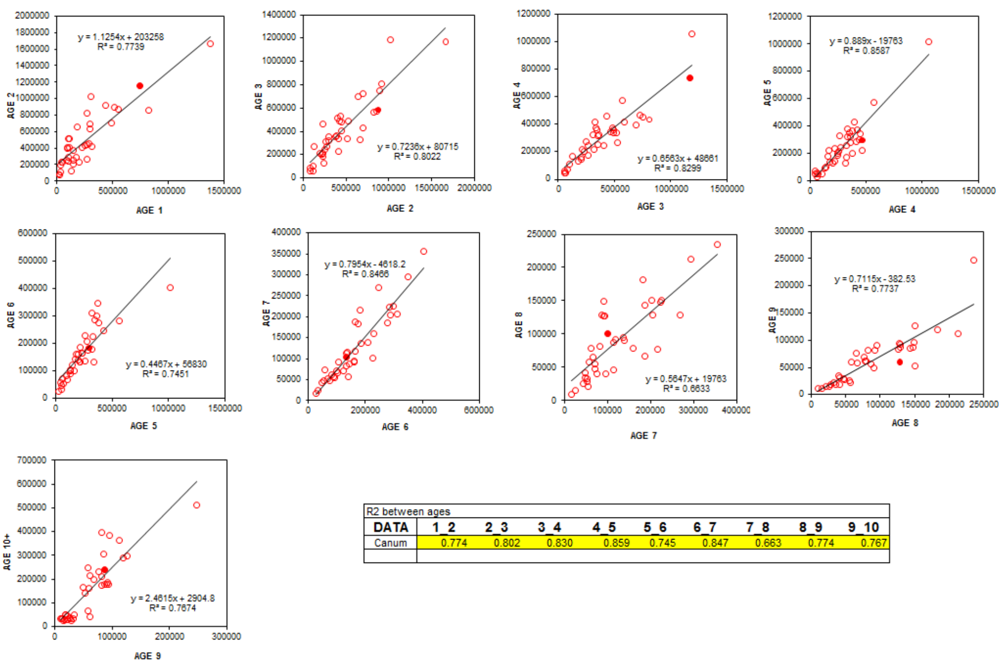


Figure 4.4.13. Herring in SD's 30 and 31. Consistencies of the different ages within Gulf of Bothnia herring trapnet abundance indices.



R2 between ages									
DATA	**1_2**	**2_3**	**3_4**	**4_5**	**5_6**	**6_7**	**7_8**	**8_9**	**9_10**
Canum	0.774	0.802	0.830	0.859	0.745	0.847	0.663	0.774	0.767

Figure 4.4.14. Herring in SD's 30 and 31. Consistency in Canum estimates.

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 (ple.27.21–23) is defined by the Subdivision 21 (=Kattegat), Subdivision 23 (= the Sound) and Subdivision 22 (=Belt area and western part of the Baltic Sea). The other stock (ple.27.24–32) is defined by the area east of Bornholm in the Baltic Sea. Each stock is managed based on individual assessments. ple.27.21–23 is category 1 stock and ple.27.24–32 is a category 3 stock.

5.2 Plaice in subdivisions 27.21–23 (Kattegat, the Sound and Western Baltic)

This stock identity 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 subdivisions 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 Regulations in place

Minimum Landing Size in SD 21 is 27 cm.

Minimum Landing Size in SD 22 and SD 23 is 25 cm.

The closed season for spawning females in SD 22 and SD 23 from 15/1 to 30/4, which was introduced in the mid-1960s has been abandoned since 2017.

In the Sound (SD 23) trawling is only allowed in the northern-most part. Additionally, this area was also included in the closed areas to protect spawning cod in Kattegat, so 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 codend. The mesh size in the exit panel was increased to from 110 to 120 mm in 2010, and reduced to 115 in 2018 [Commission Delegated Regulation (EU) 2018/47].

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 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 1 January 2017, the EU landing obligation was introduced in SD 22 and 23. In the Kattegat, the landing obligation applies as part of the discards plan for the North Sea. In 2018, (Commission Delegated Regulation (EU) 2018/45 of 20 October 2017), plaice was subjected to the landing obligation in TR1 (trawls and seines ≥100mm), BT1 (Beam trawls ≥120 mm), hooks and lines and trawls 32–69 mm. For the period 2019–2021 the landing obligation is fully in force, but the following exemptions apply in the Kattegat (Commission Delegated Regulation (EU) 2018/2035 of 18 October 2018):

- A survivability exemption applies to plaice caught with nets (GNS, GTR, GTN, GEN), with Danish seines; with bottom trawls (OTB, PTB) with a mesh size of at least 120 mm when targeting flatfish or roundfish in winter months (from 1 November to 30 April).
- a combined *de minimis* quantity of common sole, haddock, whiting, cod, plaice, saithe, herring, Norway pout, greater silver smelt, and blue whiting below minimum conservation reference size (MCRS), which shall not exceed 5% of the total annual catches of Norway lobster, common sole, haddock, whiting, cod, saithe, plaice, Northern prawn, hake, Norway pout, greater silver smelt, herring, and blue whiting.

This has implications for the management since 2017, but because of the insignificant amount of the landings below minimum size (BMS) so far (10 t in 2017, 13 t in 2018), the impact cannot be detected.

5.2.1.2 Landings

The annual landings are available since 1970 (SD 22) and 1972 (SD 21) and are given by subdivision and country separately in Table 5.2.1 and Figures 5.2.1 and 5.2.2. The landings by country and the TAC for each subdivision is given in Figures 5.2.3a and 5.2.3b.

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. SAM can handle if minor gaps exist the dataseries 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 (based on average discards from 2002–2004) 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 (2002–2018).

In InterCatch, the BMS have so far not been reported as a separate category, but are including in the discards estimates for raising and age-estimation. As such, Intercatch "discards" data represent "unwanted catches".

The proportion of Landings with Discards associated (same strata) is 89%. For these strata, the discards ratio was estimated as 64% in Kattegat, 12% in SD 22 and 26% in SD 23.

After raising, the discard ratio for the stock was 29% in 2018. It is higher than in 2017, but the discard ratio has globally decreased in the last five years (Figure 5.2.4b)

Discard and landings (2018) by gear type and quarter is given in Table 5.2.2 and Figure 5.2.4a.

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 occur 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. The results show varying levels of accuracy and precision depending on reader expertise, method applied and sample origin, but there were no consistent patterns where one method always produced better results compared to the other. Results of Swedish inter-calibration studies in 2017 and 2018 showed that most uncertainty (differences between readers) appear for ages 4-5. There is so far no solution proposed to solve the age-reading discrepancies,

Catch-at-age data were raised using ICES InterCatch database. Age-distribution information was available for most strata (Table 5.2.3), summing up to 93% of the total landings, and 83% of the discards.

Relative age distributions in the discard and landing by year are presented on Table 5.2.4a and Figures 5.2.5a and 5.2.5b.

Total catches are presented on Table 5.2.4h. The proportion of older fish age 5 and above has increased in the recent years.

5.2.2.2 Mean weight-at-age

Weight-at-age in catch is presented in Table 5.2.4c (landings), 4e (discards) and 4g (catch), and in Figure 5.2.6.

Mean weight in stock is obtained from Combined 1 quarter surveys but is used as an average from 2002–2018. However, in 2019 it was found out that the procedure used for computing this average was erroneous, computing only a simple average across all length classes without weighting by the number of individuals within each length class. This lead to a very high estimate of the mean weight of the older fish, being driven up by very few observations.

A more standard procedure with weighted average was used in 2019 (the same procedure as used for Western Baltic cod) (Table 5.2.4f), and the difference between the two is displayed in Figure 5.2.7.

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 2002–2018 from information from the Combined 1q survey Table 5.2.4b.

5.2.2.5 Quality of catch and biological data

The sampling of the commercial catches is relatively god except for Subdivision 23 where no sampling is made by either Sweden or Denmark (Table 5.2.3). This has to be seen in the light of the relative limited catches from that area (4.9% 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. But this supports the use of a statistical assessment model that can account for some uncertainties in the catch-at-age data.

Globally, the internal consistency of the catch matrix is not very high, and it is difficult to follow clearly the large year classes over time (Figure 5.2.8).

5.2.3 Fishery-independent information

Only scientific tuning fleets are used. Two tuning series are produced (Table 5.2.4i). These two series are constructed by the combination of 1st quarter NS-IBTS and the 1st quarter BITS on the one hand, and the combination of 3rd quarter NS-IBTS and 4th quarter BITS on the other hand. The surveys are combined using the GAM approach (Berg *et al.*, 2013) considering the uneven distributions of the two surveys. The following effects are considered using a Delta-Gamma distribution (zeroes and positive catches are modelled separately) to estimate the indices. Explanatory variables included in the model are year, spatial position, depth, gear, time of the day, and haul duration. Estimation of the gear effect is possible due to some spatio-temporal overlap of sampling between BITS and NSIBTS, which use different gears. The survey index is derived by letting the model predict the catch rates by year in an ideal experimental design, i.e. in a spatial grid covering the stock area using the same gear, at the same time of day etc. Variation in catch rates caused by changes in the sampling are filtered out in this process and the influence of single hauls with large catches are also reduced.

Very few plaice aged 0 (4th quarter) are caught during the surveys and these are removed from the analysis.

A major change was introduced during WGBFAS 2019, in an attempt to reduce the large retrospective patterns observed with the standard setup (SPALY, same procedure as last year, see below). Age 6 are little represented in the surveys until 2012, which is the reason why the Benchmark in 2015 decided not to include that age in the tuning series. However, considering the increasing proportion of older fish in the catches in the recent years, it was decided to re-investigate the frequency of age 6 in the survey, and its added value in terms of survey consistency. A new extended index was computed, following the same GAM approach. Because this is a statistical model, minor differences occur between the index for ages 1-5 computed with or without the inclusion of age 6.

As in the catches, age 6 fish have been increasingly observed in both surveys after 2012 (Figure 5.2.9), and its consistency with other ages is rather good (Figure 5.2.10). Additionally, the consistency of age 6 is also good between the two surveys (Figure 5.2.11).

The inclusion of this age 6 in the tuning improved significantly the retrospective pattern in the assessment (See below), and it was therefore decided to keep this new dataseries in the final assessment.

Another change in the survey data was introduced in 2019. It has been realized in 2019 that at the time where WGBFAS meets, the age-readings for the most recent Q1 survey are usually completed by Sweden and Germany, but not by Denmark. These age readings represent more than half of the total age readings for the combined survey. As a consequence, the in-year Q1 survey index is highly uncertain, with strong deviations between the index calculated in one year and the same index calculated the following year when all age readings have been uploaded to DATRAS. (Figure 5.2.12).

It was decided in WGBFAS 2019 to remove that point from the time-series, until procedures are changed in Denmark and plaice otoliths are read before the Working Group. As such the assessment in 2019 only have survey data until 2018.

5.2.4 Assessment

The stock is a Category 1 (Full annual age based analytical assessment). The State based Assessment Model (SAM) is used.

The SPALY assessment (though with new stock weight at age) deviated substantially from last year (Figure 5.2.13), and performed poorly. Mainly, a very large retrospective pattern was observed, with a Mohn's rho estimate of 48% for the SSB and -38% for F (Figure 5.2.14).

The final assessment presented by WGBFAS includes 4 changes compared to SPALY 2018, three of which are described above: the inclusion of age 6 in the survey, the removal of 2019 Q1 survey data, and the changes in the stock weight at age. The fourth change follows the inclusion of the age 6 in the survey. Since there is now enough information for that age for the model to compute separate fishing mortality, the settings from the benchmark were thus appended to decouple the fishing mortality of the ages 6-7+ from the age 5.

These four changes made to the assessment in 2019 did not significantly affect the perception of the stock in 2019 compared to the SPALY run (Figure 5.2.15), but led to substantial revisions in the perception of the stock compared to previous assessments. Most importantly, they contributed to reducing significantly the retrospective pattern of the assessment, with a new Mohn's rho estimated at 14% for the SSB and 13% for F (Figure 5.2.16).

The "Leave one-out analysis" shows that 1q combined survey is given significant weight (Figure. 5.2.17) more weight than the combined 3-4q. No year effect can be seen in the residuals, which are without any major pattern.

This final run in SAM is named: PLE21_23_WGBFAS 2019_final_run. The assessment available at "stockassessment.org" and is visible for everybody.

The input data are given in the Table 5.2.4a to Table 5.2.4i, and the summary of the results is given Table 5.2.5. Estimated fishing mortality is given on Table 5.2.6 and stock numbers-at-age in Table 5.2.7

5.2.4.1 Recruitment estimates

In WGBFAS 2018, the recruitment in 2017 was estimated to around 60 millions. This high recruitment was confirmed in 2019, where it was estimated at 55 millions. The 2018 recruitment is also considered very high, at 60 millions, making the last two year classes the two largest observed in the time-series, around twice the size of the median recruitment of the time-series. The historic trend is given in Figure 5.2.15 and Table 5.2.5.

5.2.4.2 Historical stock trends

The stock is in a very good condition, largely above the MSY $B_{trigger}$. The result shows a constant increase in biomass over the last decade, from a lowest observed SSB at 3.6 kt t in 2009 to above 11.9 kt in 2019.

The fishing mortality has reduced since 2008, but this reduction has levelled off since 2014 and F remains above F_{MSY}.

5.2.5 Short-term forecast and management options

The procedures for the short-term forecast were changed slightly in 2019, and the stock annex was updated accordingly.

Since the Q1 survey in the intermediate year is not used anymore, the forecast use 2018 as the basis year and projects until 2021. Intermediate year (2019) assumption is status quo F (0.41 in 2019, = F2018). Recruitment for 2019 and 2020 is resampled from the entire time-series. Weight at age, selectivity and landings fraction at age are taken as average over the last three years (2016-2018).

5.2.6 Reference points

Following the revisions in the assessment setup described above, reference points were recomputed during WGBFAS 2019, using the 2019 Final run and the EqSim software.

B_{lim} was set at B_{loss}, lowest observed at 3635 tonnes. varSSB = 0.16, then
B_{pa} = B_{lim}*(exp(1.645*SSBvar)) = 4730.

WGBFAS noticed that the last two year classes (recruitment in 2017 and 2018) were high recruitment obtained with a large SSB, and these two points contribute significantly to a Beverton–Holt fit to the stock-recruitment relationship, instead of the segmented regression previously used. However, the WG agreed that this functional relationship would need to be confirmed by more data years in future before being used as the basis for F_{MSY}. Therefore, EqSim was still run with segmented regression, using B_{lim} as the breakpoint for the SRR. The outcomes of EqSim gave the following results:

FmsyMedianC	0.312
FmsylowerMedianC	0.181
FmsyupperMedianC	0.603
FmsyMedianL	0.312
FmsylowerMedianL	0.181
FmsyupperMedianL	0.603
F5percRiskBlim	0.808
Btrigger	4729

Final reference points are

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	4 730	= B_{pa}
	F_{MSY}	0.31	Equilibrium scenarios stochastic recruitment.
	$F_{p\ 0.5}$	0.81*	
Precautionary approach	B_{lim}	3 635	B_{loss} (lowest observed biomass=Biomass in 2009)
	B_{pa}	4 730	$B_{lim} \times e^{1.645\sigma}$, σ = 0.16
	F_{lim}	1.00	Equilibrium scenarios prob(SSB< B_{lim})< 50% with stochastic recruitment.
	F_{pa}	0.74	$F_{lim} \times e^{-1.645x\sigma(F)}$, σ_F = 0.18

*** $F_{p0.5}$ = 0.81 was calculated taking into account the ICES advice rule. Without the advice rule, $F_{p0.5}$ = 0.68. This was corrected at ADGBS in 2019 and the $F_{p0.5}$ = 0.68 was used to calculate the final catch scenarios for 2020 for this stock.**

5.2.7 Quality of assessment

The quality of the assessment has improved in 2019, following the adjustments described above. The confidence intervals remain large, but the retrospective patterns have reduced significantly and the current perception of the stock appear more robust than in previous years.

These adjustments did not substantially affect the perception of the stock in 2019 (i.e. the 2019 advice would be largely the same with or without these adjustments [SPALY]), but led to substantial revisions of the historical perception of the stock over time. Previous assessments consequently overestimated the biomass and underestimated the fishing mortality. As such, the perception of the stock differs significantly from last year, with a downward estimation of SSB and of 2017 recruitment, and upward estimation of F.

5.2.8 Management issues

The management areas for plaice in the Baltic Sea (*i.e.* Subdivision 21 and subdivisions 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 2018. This procedure was adopted in 2016 and used since then.

The catch ratio between SD 21 and SDs 22–23 in 2018 was used to calculate a split of the advised catches for 2020, 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 1606 tonnes in SD 21 and 6798 tonnes in SDs 22–32.[1]

[1] Please note that the final advice for both plaice stocks was modified at ADGBS 2019. Consequently, corresponding catches by management were also modified.

5.2.9 Review of changes in the 2019 assessment of ple.27.21-23

By Arni Magnusson

6 May 2019

5.2.9.1 Background

Plaice in Kattegat, Belt Seas, and the Sound (ple.27.21-23) is a category 1 stock, assessed by WGBFAS using the SAM model.

The basis of this review is the WGBFAS draft report, slides presented at WGBFAS, and the draft advice sheet. For the purposes of the review, a TAF repository was created (2019_ple.27.21-23_review) where results are read from stockassessment.org

(PLE.27.21-23_WGBFAS_2019_SPALY and PLE.27.21-23_WGBFAS_2019_final_run).

The main reason to make changes in the assessment procedure is to improve retrospective bias. The 2019 SPALY assessment deviated substantially from last year (Figure 5.2.13) with a large retrospective pattern: Mohn's rho 0.48 for SSB and -0.38 for Fbar (Figure 5.2.14). In other words, the model has a tendency to overestimate the current stock size.

5.2.9.2 List of changes

Four changes were made:

1. Inclusion of age 6 in the survey
2. Removal of 2019 Q1 survey data
3. Corrected stock weight at age
4. Decouple F at ages 6-7 from age 5

The reasoning behind including age 6 in the survey is that older fish are becoming common in the population in recent years. The removal of 2019 Q1 survey data was necessary since the age readings from this survey are not completed yet, so the final survey indices cannot be calculated at this time. The stock weight at age had been calculated erroneously and is now calculated by weighting the number of individuals in each length class, in the same way as is done for Western

Baltic cod. Finally, the decoupling of F at age 6-7 from age 5 is based on the additional information coming from survey indices at age 6.

5.2.9.3 Effect of changes

After the four changes were made, the retrospective pattern improved greatly and Mohn's rho decreased from 0.48 to 0.14 (SSB) and -0.38 to -0.13 (F_{bar}).

The updated stock weights at age are somewhat lower than those used in the past, which is one of the factors resulting in a lower estimated SSB and higher F_{bar} for the final (proposed) model.

All reference points were recalculated with the new data and model settings. The overall change is a slightly lower MSY $B_{trigger}$ and lower F_{MSY}.

Quantity	SPALY	Final (proposed)
2019 SSB	13348	11907
2018 F_{bar}	0.363	0.406
2020 MSY Advice	-	5675
MSY $B_{trigger}$	5550	4730

F_{MSY}	0.37	0.31

5.2.9.4 Comments

- The modified assessment was discussed and reviewed by WGBFAS in plenary, and decisions were made as a group
- The retrospective pattern improved
- The stock weights at age are now correctly calculated
- All reference points have been updated accordingly
- The effects are considerable, but not extreme, affecting both the estimated stock status and the reference points
- Overall, the analysis looks more correct and consistent after making the changes

Basis		Catch 2018	Landings 2018	ICES stock advice 2020 (catch)
Stock area-based	SDs 21–23	4846	3459	5675
	SDs 24–32	2355	1644	2729
Total advised catch, 2019 (SDs 21–32)				8404
Management area-based	SD 21	1372	534	
	SDs 22–23	3474	2925	
	SDs 22–32	5829	4569	

	calculation	results
Share of SD 21 of the total catch in SDs 21–23 in 2018	1372 t / 4846 t	0.283
	(catch in 2018 SD 21 / catch in 2018 SDs 21–23)	
Catch in 2020 for SD 21	5675 t * 0.283	1606
	(ICES stock advice in 2019 (catch) for SDs 21–23 × share)	
Catch in 2020 for SDs 22–32	8404 t – 1606 t	6798
	(total advised catch in 2019 SDs 21–32 – catch SD 21)	
Share of SD 21 of the total landings in SDs 21–23 in 2018	534 t / 3459 t (landings in 2018 SD 21 / landings in 2018 SDs 21–23)	0.154

Table 5.2 1. Plaice in SD 27.21–23. Official landings (t) by subdivision and country. 1970–2018.

Year /SD	21-Denmark	21-Germany	21-Sweden	22-Denmark	22-Germany	22-Sweden	23-Sweden	23-Denmark	BMS landings
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	
2017	703	1	97	1424	936	0	13	70	10
2018	479	1	51	1698	1086	0	111	13	13

Table 5.2.2. Plaice in SD 27.21–23. Landings (tonnes) and discard (tonnes) in 2018 by subdivision, fleet, and quarter.

	1	2	3	4	Total
27.3.a.21	340	272	410	350	1372
Discards	198	118	299	224	838
Active	191	107	299	224	821
Passive	6	11	0	0	17
Landings	143	154	111	126	534
Active	120	116	100	123	458
Passive	23	38	12	3	76
27.3.b.23	22	48	61	40	171
Discards	9	16	17	4	47
Active	5	10	15	3	33
Passive	4	6	3	1	14
Landings	13	32	44	35	125
Active	5	11	5	2	23
Passive	8	22	39	34	102
27.3.c.22	1086	618	284	1315	3303
Discards	254	92	7	162	515
Active	91	63	7	160	321
Passive	163	29	0	2	194
Landings	832	526	278	1152	2788
Active	760	421	221	1034	2437
Passive	72	105	56	118	351
Grand Total	1449	938	756	1704	4846

Table 5.2.3. Plaice in SD 27.21–23. Sampling effort 2018 by country, gear type and area.

Area	Catch Category	Country	Fleet	CATON	No. of Length Samples	No. of Length Measured	No. of Age Samples	No. Age Readings
27.3.a.21	**BMS landing**	Denmark	Active	0	0	0	0	0
		Sweden	Active	0	0	0	0	0
	Discards	Denmark	Active	761	52	2760	52	626
			Passive	15	0	0	0	0
		Germany	Active	1	0	0	0	0
			OTB_CRU_90-119_0_0_all	0	0	0	0	0
		Sweden	Active	59	21	2349	21	1412
			Passive	2	0	0	0	0
	Landings	Denmark	Active	419	20	3580	20	954
			Passive	63	20	3580	20	954
		Germany	Active	1	0	0	0	0
			OTB_CRU_90-119_0_0_all	0	0	0	0	0
		Sweden	Active	39	0	0	0	0
			Passive	13	0	0	0	0
27.3.b.23	**Discards**	Denmark	Active	33	0	0	0	0
			Passive	9	0	0	0	0

		Sweden	Passive	5	0	0	0	0
	Landings	Denmark	Active	23	0	0	0	0
			Passive	88	0	0	0	0
		Sweden	Passive	13	0	0	0	0
27.3.c.22	**BMS landing**	Germany	Active	0	0	0	0	0
	Discards	Denmark	Active	131	22	1555	22	275
			Passive	20	0	0	0	0
		Germany	Active	190	14	1721	14	689
			Passive	174	6	44	6	0
		Sweden	Passive	0	0	0	0	0
	Landings	Denmark	Active	1580	21	3127	21	806
			Passive	127	21	3127	21	806
		Germany	Active	857	16	2980	16	1246
			Passive	223	12	1865	12	271
		Sweden	Passive	0	0	0	0	0
Grand Total				**4846**	**225**	**26688**	**225**	**8039**

Table 5.2 4a. Plaice in SD 27.21–23. Landing fraction.

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1999	0.00	0.24	0.30	0.59	0.80	0.55	0.64	0.89	0.98	0.99
2000	0.14	0.23	0.48	0.49	0.78	0.85	0.81	0.94	0.97	0.97
2001	0.02	0.44	0.51	0.41	0.64	0.83	0.85	0.93	0.99	0.98
2002	0.09	0.09	0.38	0.34	0.47	0.42	0.62	1.00	0.78	0.91
2003	0.06	0.24	0.50	0.67	0.74	0.67	0.59	1.00	1.00	1.00
2004	0.05	0.29	0.52	0.67	0.75	0.92	1.00	0.99	1.00	1.00
2005	0.12	0.34	0.76	0.82	0.73	0.72	0.75	0.49	0.38	0.68
2006	0.00	0.18	0.37	0.56	0.90	0.77	0.79	0.96	1.00	1.00
2007	0.02	0.37	0.44	0.68	0.80	0.67	0.55	0.57	0.78	0.98
2008	0.00	0.07	0.53	0.78	0.87	0.95	0.97	0.88	0.93	0.98
2009	0.07	0.15	0.35	0.61	0.53	0.32	0.37	0.15	1.00	0.37
2010	0.08	0.14	0.45	0.63	0.71	0.91	0.97	0.97	0.98	0.99
2011	0.07	0.15	0.28	0.42	0.56	0.55	0.73	0.73	0.86	0.98
2012	0.02	0.23	0.46	0.63	0.82	0.96	0.99	0.93	1.00	0.83
2013	0.01	0.16	0.47	0.59	0.57	0.85	0.88	0.82	1.00	0.87
2014	0.00	0.20	0.42	0.42	0.49	0.55	0.56	0.54	0.68	0.83
2015	0.00	0.20	0.50	0.58	0.74	0.85	0.93	0.88	0.84	0.82
2016	0.02	0.23	0.49	0.61	0.62	0.73	0.86	0.94	0.90	1.00
2017	0.01	0.27	0.58	0.80	0.81	0.95	0.92	0.89	0.83	0.94
2018	0.01	0.24	0.41	0.66	0.86	0.97	0.88	0.99	0.96	0.97

Table 5.2 4b. Plaice in SD 27.21–23. Maturity ogive.

	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10
Mean (2002-2018)	0.20	0.54	0.72	0.86	0.94	0.96	0.97	0.98	0.98	0.99

Table 5.2 4c. Plaice in SD 27.21–23. Landings mean weight (kg)

Year	1	2	3	4	5	6	7	8	9	10+
1999	0.220	0.283	0.291	0.329	0.374	0.371	0.412	0.862	0.569	1.274
2000	0.220	0.276	0.289	0.309	0.334	0.447	0.569	0.648	1.016	1.221
2001	0.227	0.264	0.271	0.304	0.323	0.397	0.457	0.596	0.851	1.190
2002	0.239	0.261	0.279	0.265	0.317	0.363	0.432	0.424	0.533	0.523
2003	0.272	0.275	0.283	0.308	0.300	0.474	0.468	0.498	0.548	0.746
2004	0.257	0.242	0.266	0.302	0.324	0.373	0.426	0.618	0.478	1.195
2005	0.202	0.256	0.270	0.308	0.326	0.319	0.350	0.411	0.598	1.451
2006	0.166	0.243	0.294	0.313	0.335	0.316	0.344	0.451	0.530	0.884
2007	0.238	0.236	0.273	0.323	0.455	0.482	0.515	0.540	0.398	0.773
2008	0.225	0.225	0.256	0.303	0.376	0.442	0.499	0.558	0.481	0.529
2009	0.212	0.240	0.280	0.316	0.430	0.577	0.621	0.877	0.644	1.152
2010	0.227	0.292	0.292	0.310	0.379	0.403	0.399	0.372	0.369	0.421
2011	0.237	0.308	0.322	0.343	0.340	0.427	0.481	0.462	0.446	0.441
2012	0.265	0.300	0.335	0.393	0.404	0.462	0.426	0.466	0.565	0.546
2013	0.241	0.301	0.317	0.390	0.489	0.565	0.574	0.562	0.648	0.807
2014	0.241	0.270	0.308	0.341	0.408	0.433	0.509	0.682	1.106	0.780
2015	0.241	0.274	0.303	0.327	0.374	0.441	0.536	0.782	0.792	0.868
2016	0.213	0.295	0.298	0.346	0.376	0.415	0.534	0.518	0.753	0.649
2017	0.126	0.254	0.307	0.333	0.383	0.438	0.458	0.598	0.615	0.771
2018	0.211	0.254	0.295	0.300	0.360	0.422	0.504	0.477	0.568	0.553

Table 5.2 4d. Plaice in SD 27.21–23. Natural mortality.

	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 5.2 4e. 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
2017	0.072	0.118	0.157	0.206	0.301	0.382	0.333	0.490	0.579	0.460
2018	0.075	0.116	0.142	0.215	0.257	0.175	0.463	0.204	0.152	0.215

Table 5.2.4f. Plaice in SD 27.21–23. Mean weight (kg) in stock by age.

	1	2	3	4	5	6	7	8	9	10+
Mean(1999–2018)	0.031	0.077	0.131	0.202	0.249	0.286	0.302	0.335	0.453	0.458

Table 5.2.4g. 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
2017	0.073	0.146	0.238	0.307	0.367	0.435	0.448	0.586	0.609	0.753
2018	0.076	0.150	0.205	0.271	0.345	0.415	0.499	0.475	0.551	0.543

Table 5.2.4h. 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
2017	1298124	2985733	4028499	3913709	1721828	1028901	623925	218615	132563	82287
2018	665693	6292779	4775073	3661795	2587740	1151678	557017	189004	104599	138207

Table 5.2.4i. Plaice in SD 27.21–23. Survey indices NS-IBTS and BITS combined.

1st quarter

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1999	1144.623	9269.906	3961.226	963.7343	495.2836	47.8245
2000	2797.504	23965.52	10152.83	1559.923	460.5379	277.0256
2001	995.6623	13720.26	13195.75	2899.584	409.1882	171.8556
2002	1530.998	3984.683	9898.474	4765.419	954.3745	229.3627
2003	1510.877	16431.52	6942.07	6839.13	3413.926	492.6498
2004	1004.576	5904.042	11145.76	4714.023	2862.366	1836.197
2005	1140.177	13151.05	10859.23	5307.038	1767.362	1618.2
2006	298.6948	8027.184	16259.26	6104.058	2593.614	492.9846
2007	976.0346	7186.429	12052.69	8720.292	2138.52	920.889
2008	1405.914	5534.511	6748.244	3312.862	1056.288	370.1625
2009	885.0114	4695.006	7351.028	3394.152	1185.213	443.2453
2010	3313.785	9057.775	11243.51	5560.795	1995.657	475.5224
2011	1390.765	14080.17	11729.76	5592.188	2401.802	941.0415
2012	2307.067	12376.9	12640.59	4774.925	1191.744	419.9401
2013	459.999	6894.229	18372.34	8757.317	4725.819	1090.145
2014	235.7243	8421.242	12958.52	11826.87	5512.458	1970.377
2015	858.0163	12280.14	15074.33	10297.91	6829.713	3321.69
2016	1094.238	18468.47	22176.62	10912.83	6078.633	3251.147
2017	3933.786	15471.15	20233.9	10215.01	5017.321	2462.482
2018	4424.87	27993.1	29566.13	17538.05	11258	2964.811

3rd and 4th quarter

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1999	27625.244	17086.466	2868.7729	303.837	383.6633	81.4433
2000	12429.7104	20859.8198	6738.3409	117.2612	91.3046	150.3871
2001	4703.6952	12773.5122	5337.9443	1302.6799	133.1952	177.255
2002	9891.9265	4999.4125	5348.0908	3535.6703	739.9863	136.9186
2003	4352.948	13606.9027	3403.2778	2508.4646	1291.9801	227.7244
2004	7977.4211	7563.654	11382.6227	3263.7975	1938.2175	1442.9272
2005	7973.2033	10278.3701	2729.5648	1424.7633	400.7473	500.3652
2006	7037.3537	9646.016	7981.1514	1859.6926	899.5827	567.0211
2007	5966.668	9950.5467	3607.0944	2225.5315	603.2792	293.6921
2008	2694.1198	10041.5604	7693.0132	2938.6525	773.7178	185.7041
2009	5203.6113	9655.4606	9343.9767	1740.9449	348.1847	206.5172
2010	5431.8294	7295.2202	4471.8866	3451.4126	1056.8475	573.6127
2011	13684.3979	13202.5455	7452.6146	2518.1156	555.9812	261.0976
2012	10853.3041	13451.2597	9933.1725	4989.3125	1115.7338	289.8966
2013	5416.9993	10197.5041	9656.8155	4249.6795	2007.1605	821.3689
2014	11342.9219	11135.6795	9295.3775	5474.3746	3021.339	830.9017
2015	7474.5249	15429.1454	11037.8178	8039.6961	4249.183	1146.2248
2016	13260.792	13593.4957	10105.1115	4560.8727	2309.9299	1289.9008
2017	32971.7936	13919.8916	7380.874	4695.8602	2039.5647	1416.9173
2018	20219.7488	24259.0236	9729.0972	3484.4554	1379.9286	1238.8211

Table 5.2.5. Plaice in SD 27.21–23. SAM results from the final assessment. Estimated recruitment, total-stock biomass (TBS in tonnes), spawning-stock biomass (SSB in tonnes), and average fishing mortality for ages 3 to 5 (F_{35}).

Year	Recruit	High	Low	SSB	High	Low	Landings	Discards	F	High	Low
1999	52781	71358	39041	4279	5344	3426	3406	2313	1.02	1.26	0.83
2000	44729	58241	34352	4961	5970	4122	3935	2313	1.01	1.20	0.86
2001	25936	34334	19591	5811	6980	4837	4054	2313	0.95	1.11	0.81
2002	35014	47090	26036	5920	7083	4947	3939	4357	0.89	1.05	0.75
2003	23550	30837	17986	5426	6424	4584	3618	2004	0.80	0.95	0.68
2004	28260	36663	21782	4941	5820	4195	2766	1369	0.77	0.91	0.64
2005	24153	31281	18648	4691	5546	3968	2354	1197	0.78	0.93	0.65
2006	18679	25228	13831	4537	5380	3826	2580	1770	0.81	0.96	0.68
2007	19657	25532	15134	4168	4940	3516	2691	1191	0.81	0.96	0.68
2008	21977	28739	16806	3851	4558	3254	2028	1902	0.81	0.97	0.69
2009	24345	31419	18864	3635	4302	3071	1635	1448	0.76	0.91	0.64
2010	33350	43391	25632	3785	4463	3210	1570	1489	0.70	0.84	0.58
2011	35831	46252	27758	4403	5189	3736	1584	2045	0.67	0.83	0.55
2012	33553	43794	25707	5244	6215	4425	1845	1351	0.54	0.67	0.43
2013	29103	37470	22605	6343	7513	5355	1956	1638	0.47	0.60	0.38
2014	26360	34927	19894	7224	8573	6086	1931	1946	0.44	0.55	0.34
2015	27975	36819	21256	7772	9275	6513	2687	1021	0.42	0.54	0.33
2016	33319	45013	24662	8249	9972	6824	3020	1501	0.44	0.56	0.34
2017	55037	79304	38196	8741	10819	7062	3257	768	0.42	0.56	0.31
2018	60066	95920	37614	10004	12936	7737	3459	1387	0.41	0.57	0.29
2019	29103	60066	18679	11907	16241	8541					
Average	32513	44937	24004	5995	7312	4916	2716	1766	0.70	0.85	0.57

Table 5.2.6. Plaice in SD 27.21–23. Estimated fishing mortality (F) at-age.

Year Age	1	2	3	4	5	6	7
1999	0.056	0.429	0.821	1.146	1.104	0.936	0.936
2000	0.055	0.425	0.813	1.135	1.094	0.927	0.927
2001	0.051	0.397	0.759	1.060	1.021	0.865	0.865
2002	0.048	0.373	0.713	0.996	0.959	0.813	0.813
2003	0.044	0.336	0.643	0.898	0.865	0.734	0.734
2004	0.042	0.321	0.614	0.858	0.826	0.700	0.700
2005	0.042	0.325	0.621	0.868	0.836	0.709	0.709
2006	0.044	0.339	0.648	0.905	0.872	0.739	0.739
2007	0.044	0.339	0.648	0.905	0.872	0.739	0.739
2008	0.044	0.341	0.652	0.911	0.878	0.744	0.744
2009	0.041	0.320	0.612	0.855	0.823	0.698	0.698
2010	0.038	0.293	0.560	0.782	0.753	0.639	0.639
2011	0.037	0.282	0.540	0.755	0.727	0.616	0.616
2012	0.029	0.225	0.430	0.600	0.578	0.490	0.490
2013	0.026	0.199	0.380	0.531	0.511	0.433	0.433
2014	0.024	0.182	0.349	0.487	0.469	0.398	0.398
2015	0.023	0.177	0.339	0.473	0.456	0.386	0.386
2016	0.024	0.183	0.350	0.489	0.471	0.399	0.399
2017	0.023	0.175	0.335	0.468	0.451	0.382	0.382
2018	0.022	0.170	0.325	0.455	0.438	0.371	0.371

Table 5.2.7. Plaice in SD 27.21–23. Estimated stock numbers-at-age..

Year Age	1	2	3	4	5	6	7
1999	52781	29560	9120	4303	2658	289	1164
2000	44729	42537	17003	3553	1287	810	531
2001	25936	35687	26256	6723	1060	414	494
2002	35014	18774	22414	12154	2090	359	347
2003	23550	26906	11510	10150	4386	718	283
2004	28260	17474	16371	5690	3823	1762	432
2005	24153	22824	11260	7509	2156	1540	978
2006	18679	19171	15126	5530	2832	858	1117
2007	19657	15372	12224	6990	2003	1053	832
2008	21977	15686	10493	5758	2430	747	808
2009	24345	16503	10320	5110	2035	895	663
2010	33350	18860	10557	4955	2005	797	708
2011	35831	26051	13152	5282	1944	853	729
2012	33553	27819	17253	7171	2163	806	764
2013	29103	25680	20466	9914	3619	1076	845
2014	26360	23571	18554	12693	5295	1942	1095
2015	27975	22548	17176	11732	6986	2965	1814
2016	33319	23458	17638	10734	6449	3905	2874
2017	55037	26035	17535	11397	5802	3562	4067
2018	60066	43191	19834	11260	6587	3261	4656

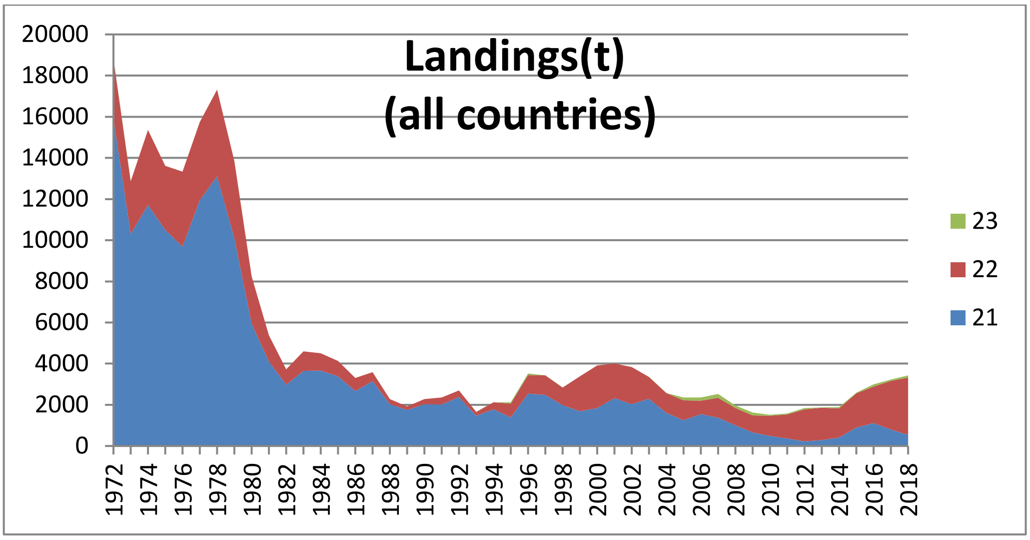


Figure 5.2.1. Plaice in SD 27.21–23. Landings by subdivision by year.

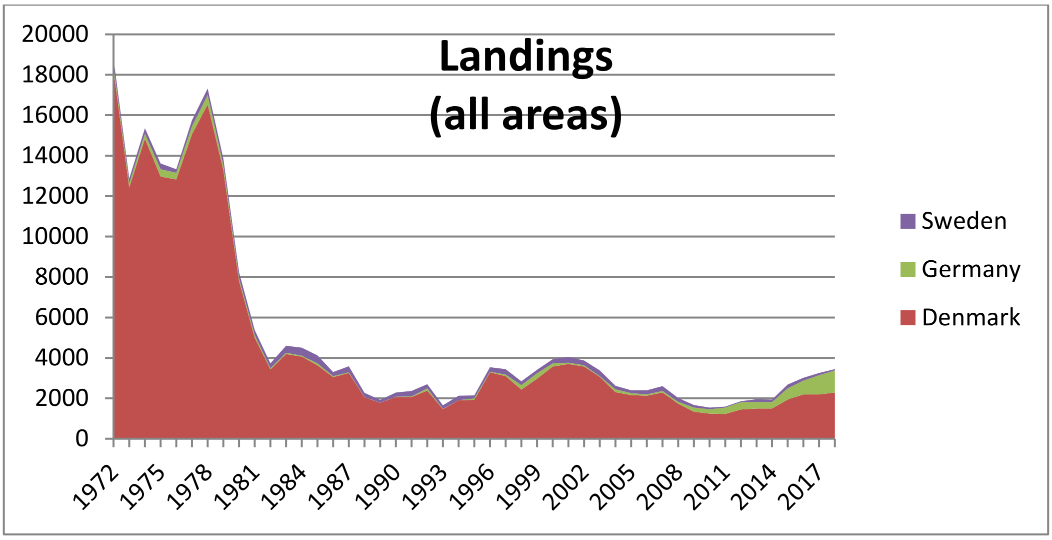


Figure 5.2.2. Plaice in SD 27.21–23. Landings (t) by country by year.

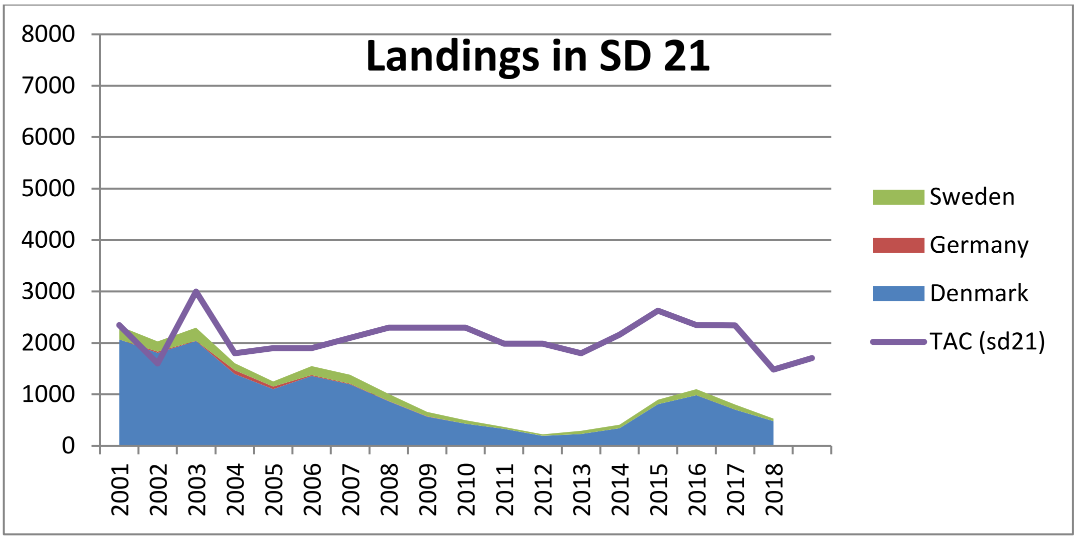


Figure 5.2.3a. Plaice in SD 27.21–23. Landings (t) in SD 27.21 by country by year. TAC is plotted as well.

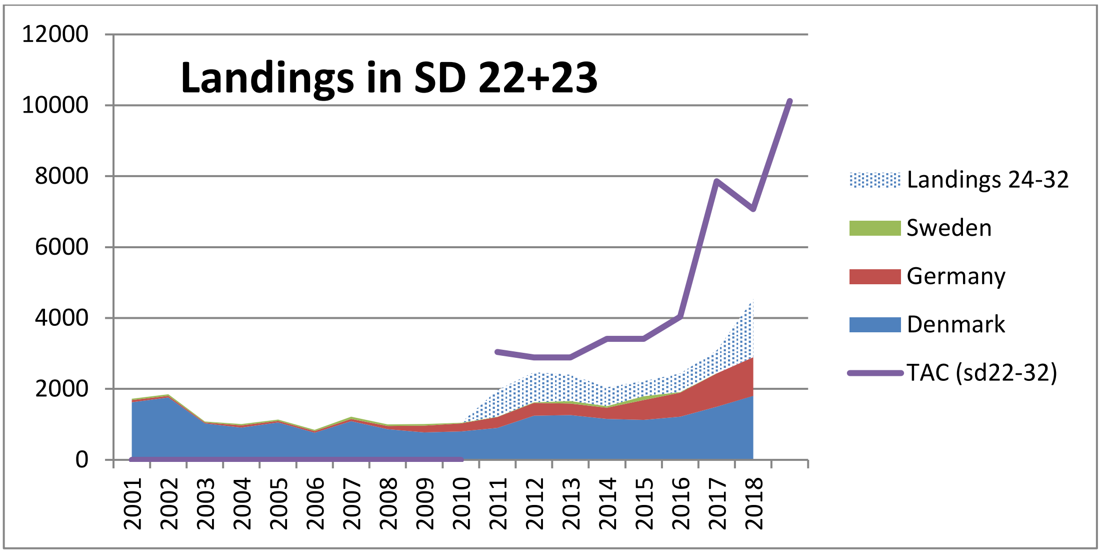


Figure 5.2.3b. Plaice in SD 27.21–23. Landings (t) in SD 27.22+23 by country by year. TAC is plotted as well.

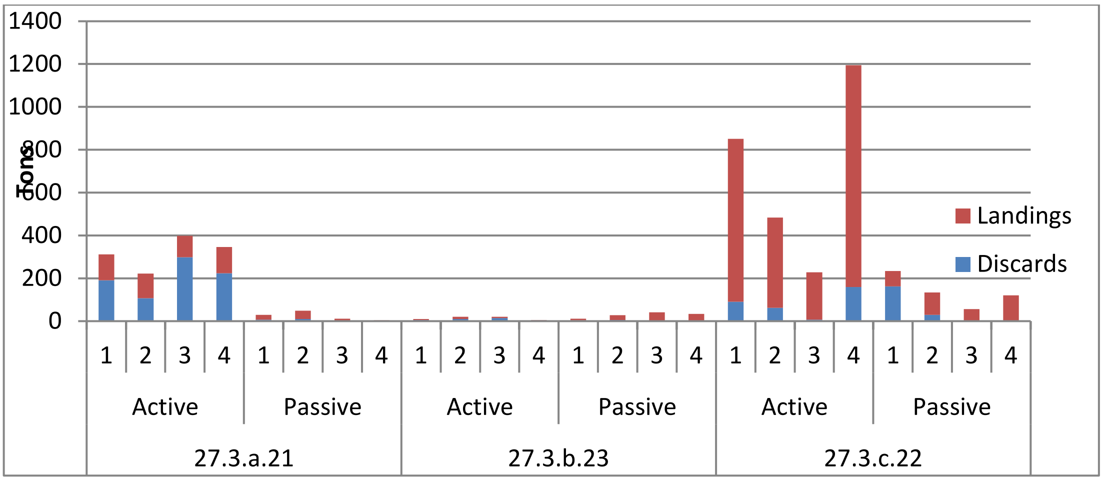


Figure 5.2.4a. Plaice in SD 27.21–23. Catches (t) in 2017 by gear type, area, quarter and catch category.

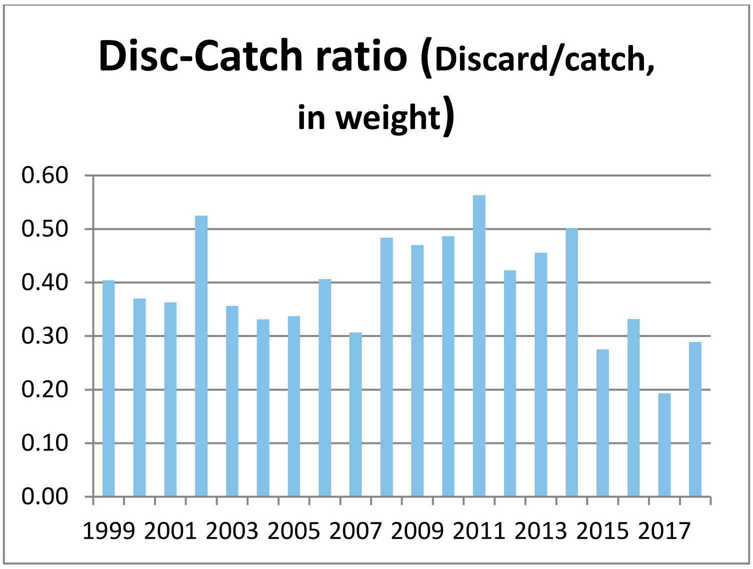


Figure 5.2.4b. Plaice in SD 27.21–23. Discard ratio over time.

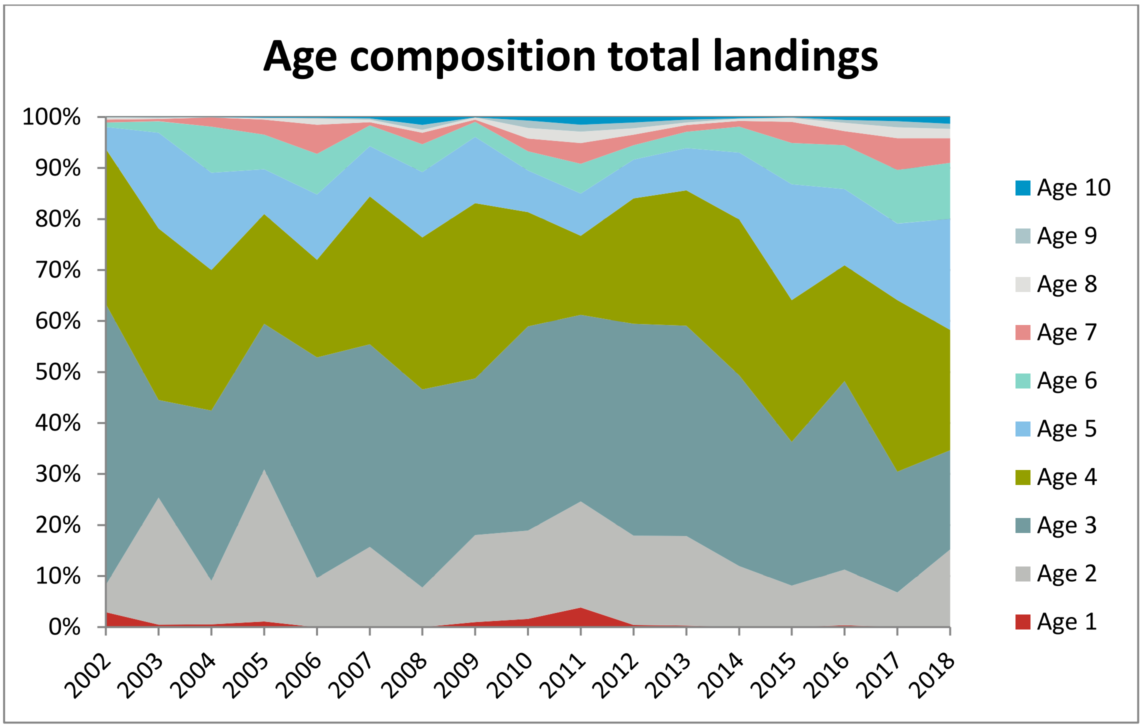


Figure 5.2.5a. Plaice in SD 27.21–23. Age composition for landings from 2002 to 2018.

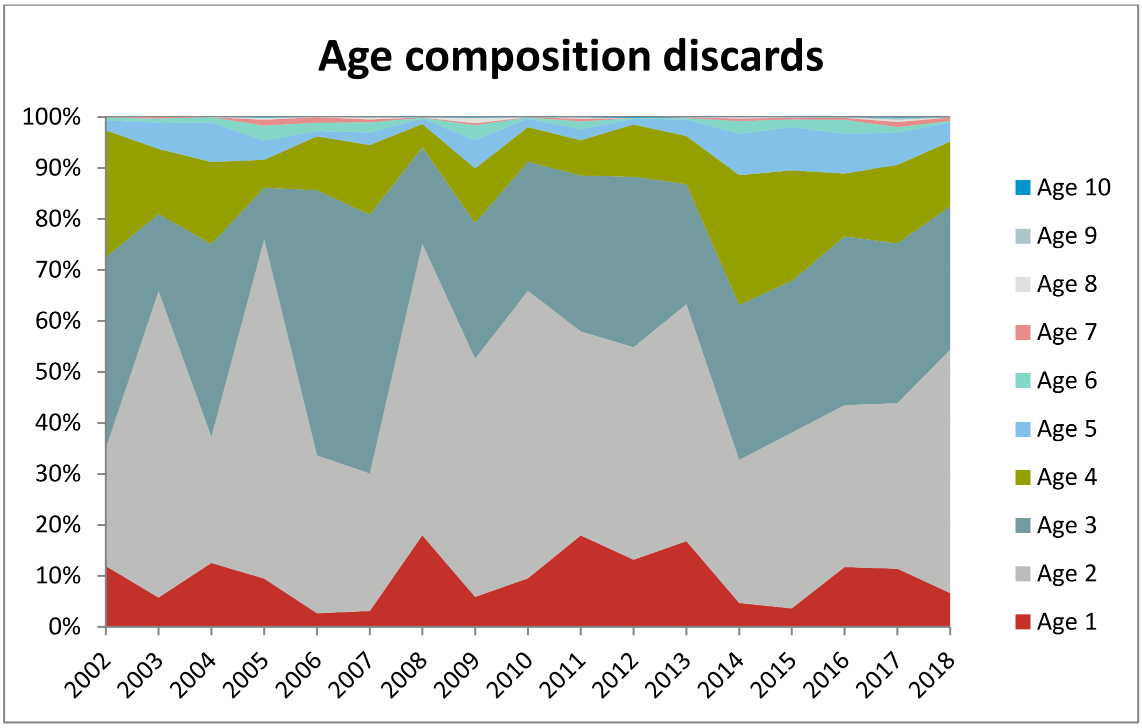


Figure 5.2.5b. Plaice in SD 27.21–23. Age composition for discards from 2002 to 2018.

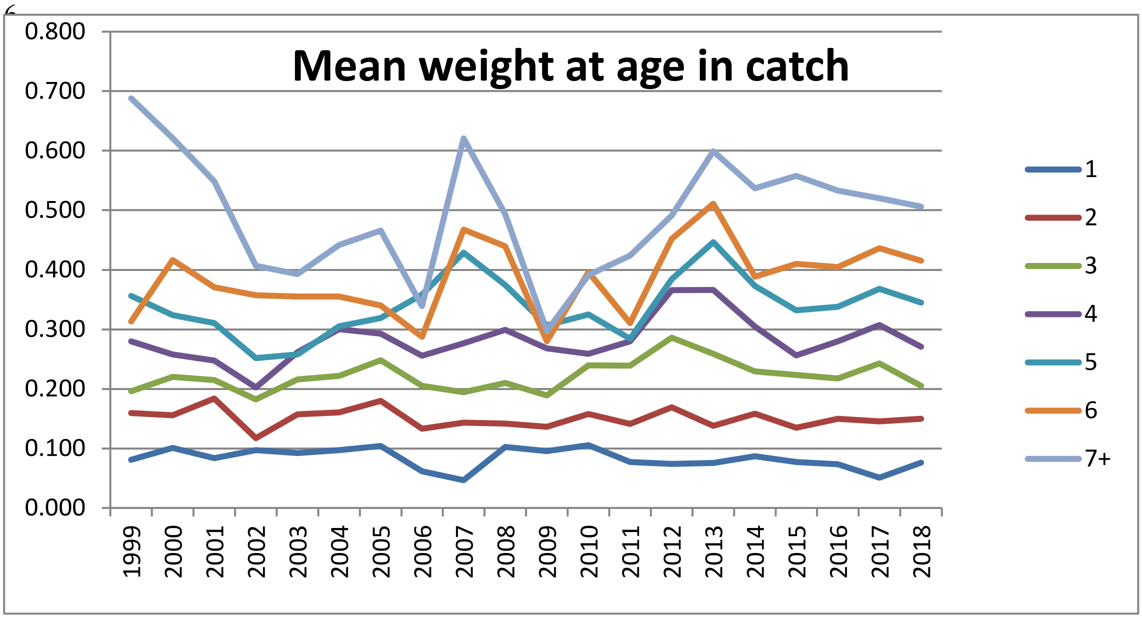


Figure 5.2.6. Plaice in SD 27.21–23. Mean weight (kg) at-age in catch.

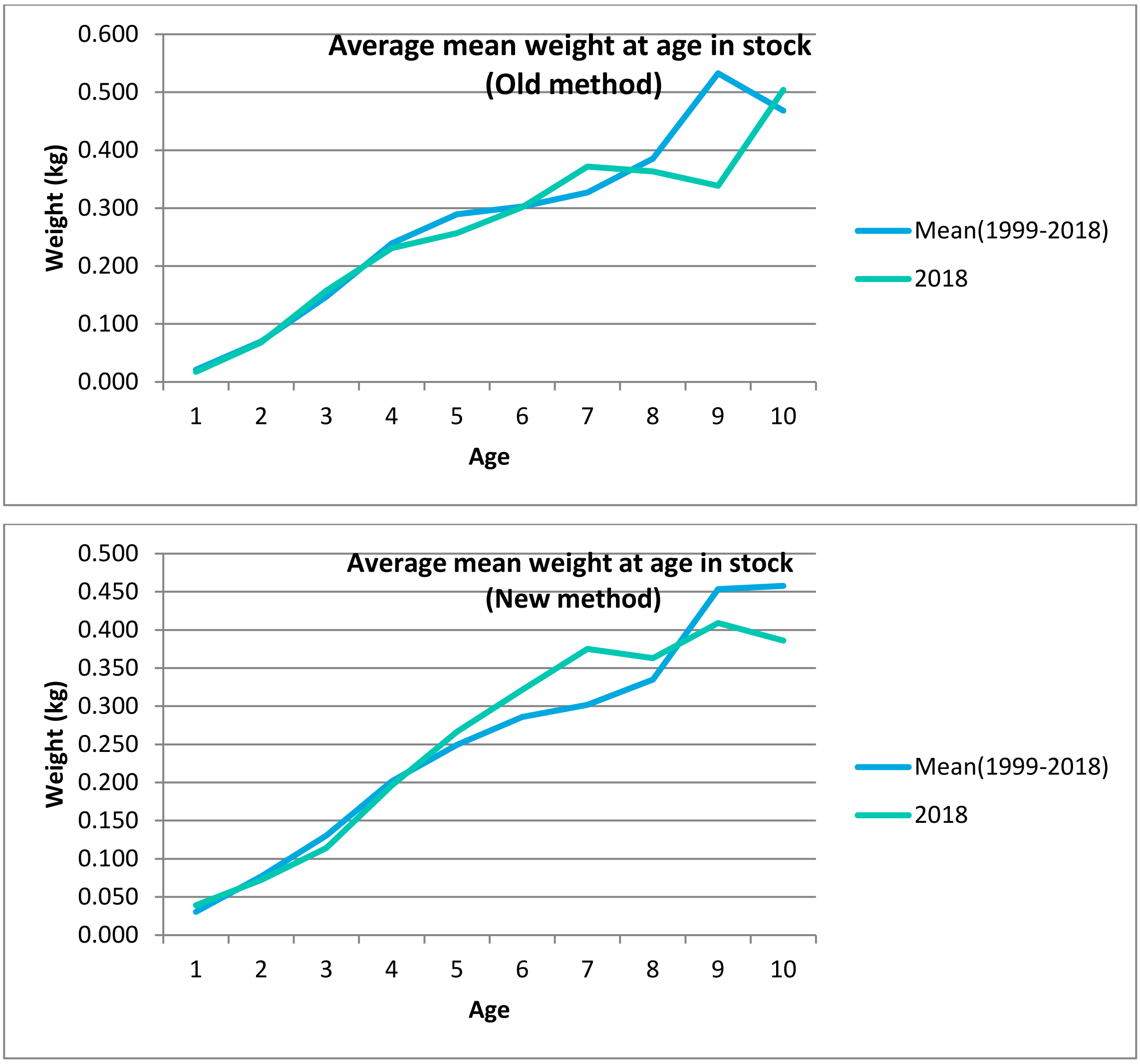


Figure 5.2.7. Plaice in SD 27.21–23. Mean weight (kg) at-age in stock.

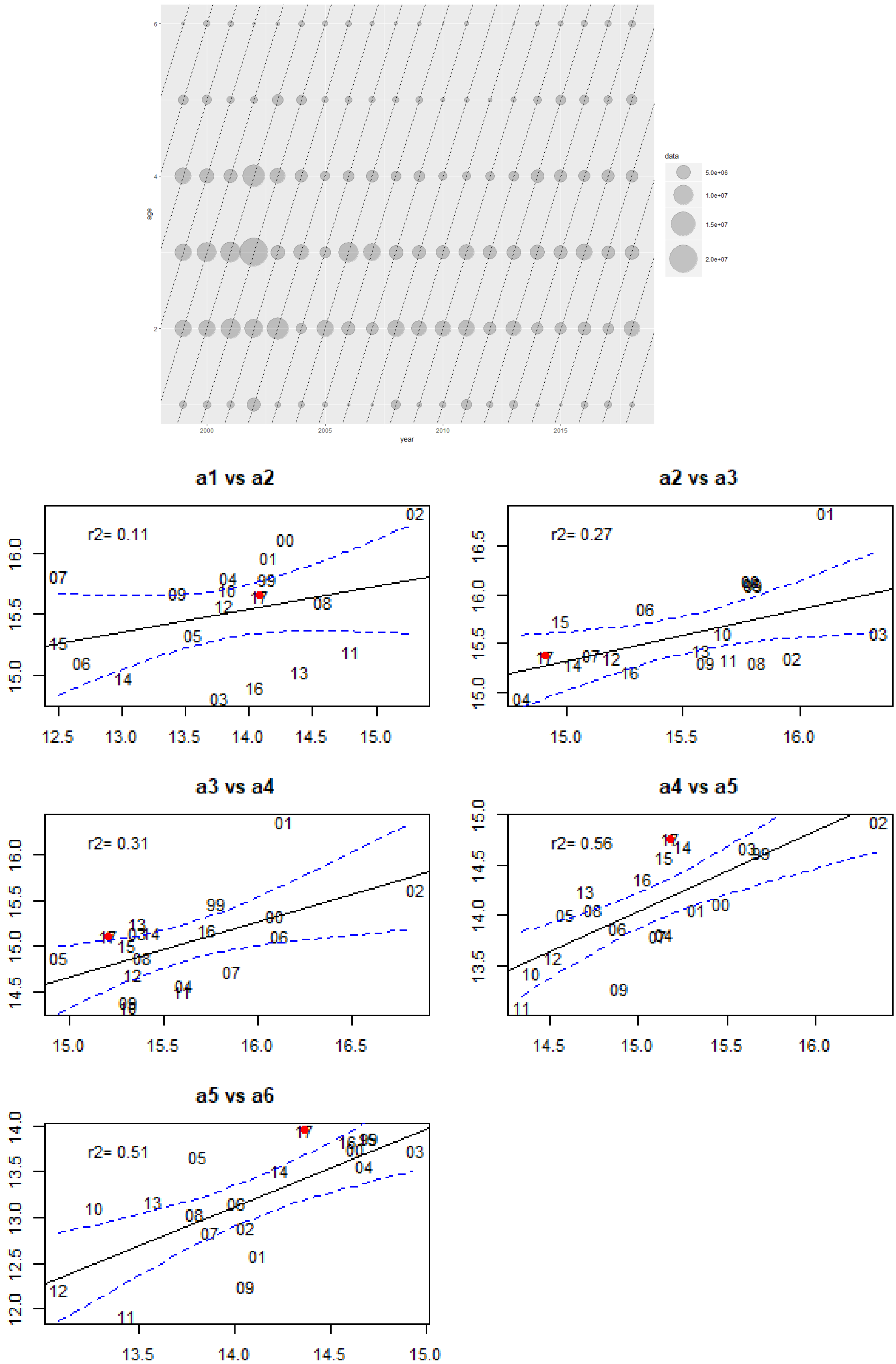


Figure 5.2.8. Plaice in SD 27.21–23. Cohort tracking (Top) and internal consistency (Bottom) of the catch-at-age matrix.

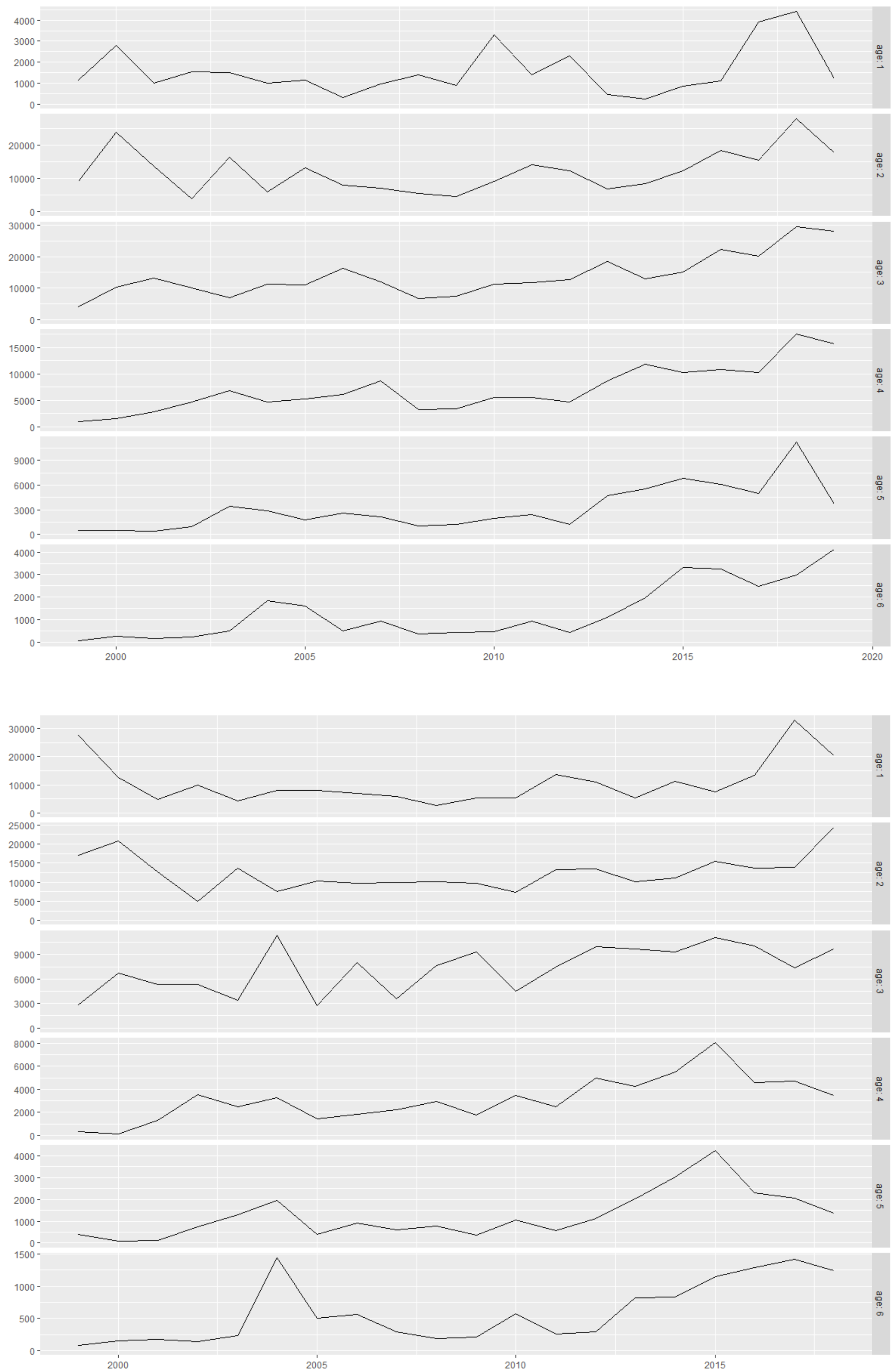
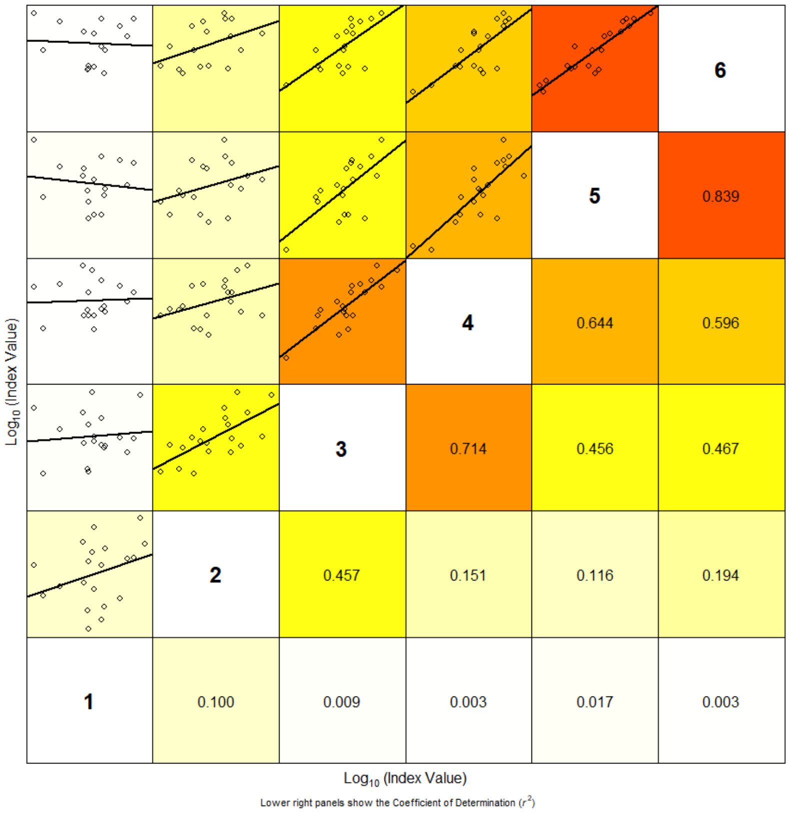


Figure 5.2.9. Plaice in SD 27.21–23. Cohort tracking (Top) and internal consistency (Bottom) of the catch-at-age matrix



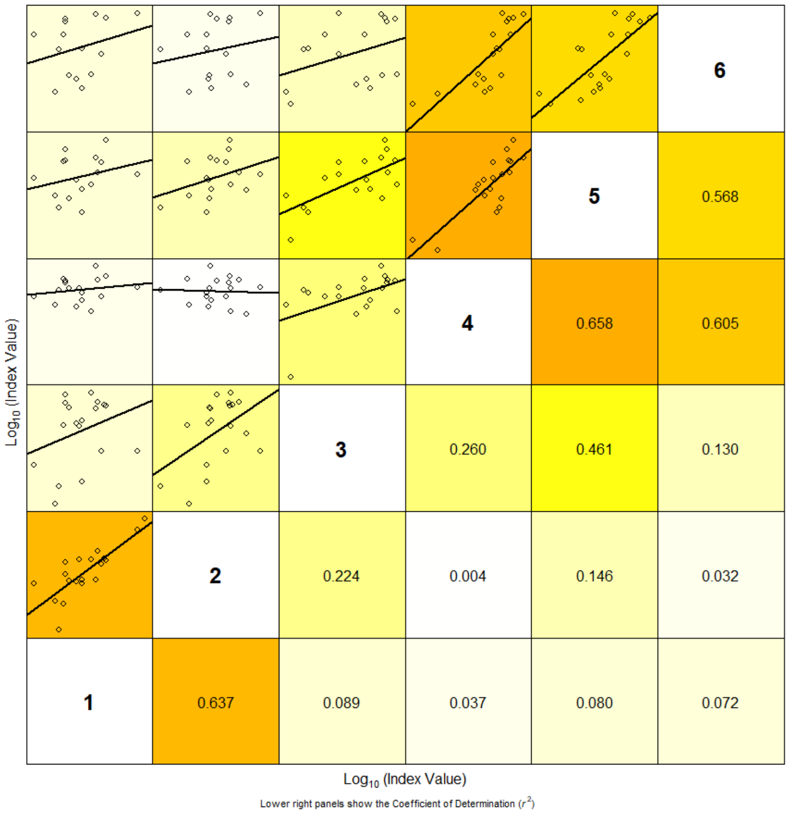


Figure 5.2.10. Plaice in SD 27.21–23. Internal consistency of the two survey indices. Top: Q1 survey. Bottom: Q3-4 survey.

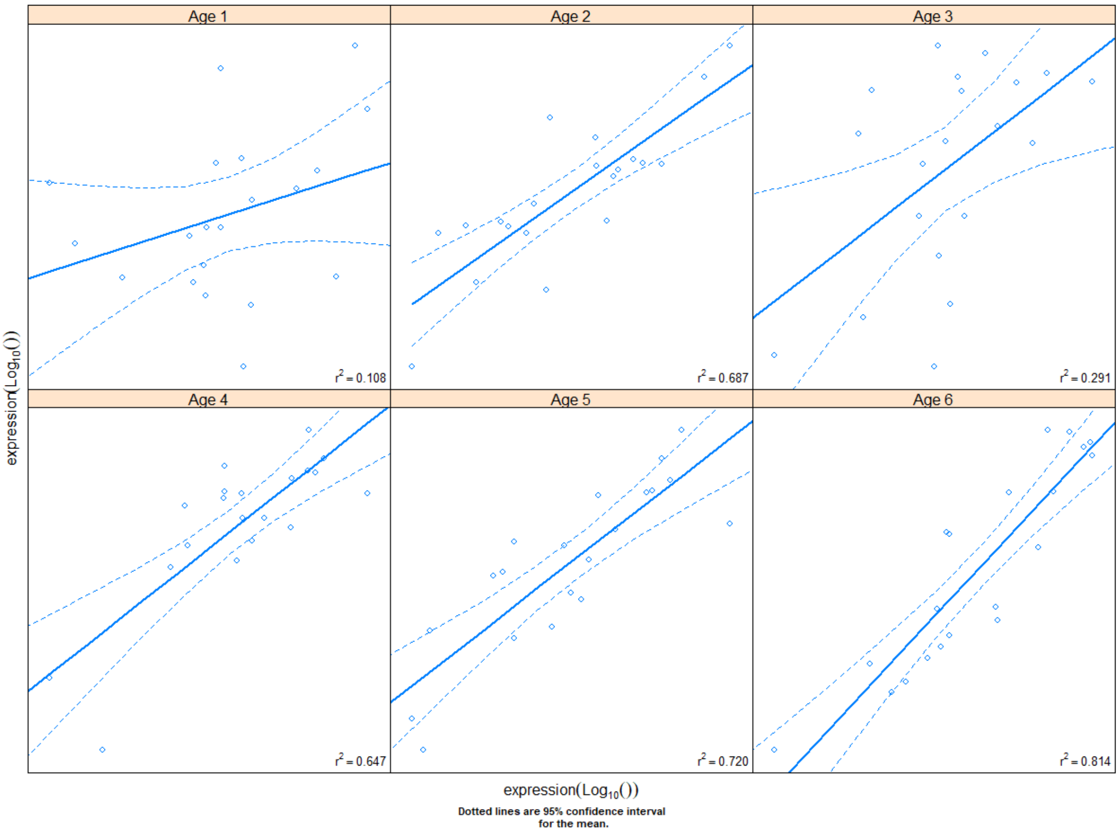


Figure 5.2.11. Plaice in SD 27.21–23. Inter-survey consistency by age between Q1 survey (in x-axis) and Q3-4 survey (y-axis).

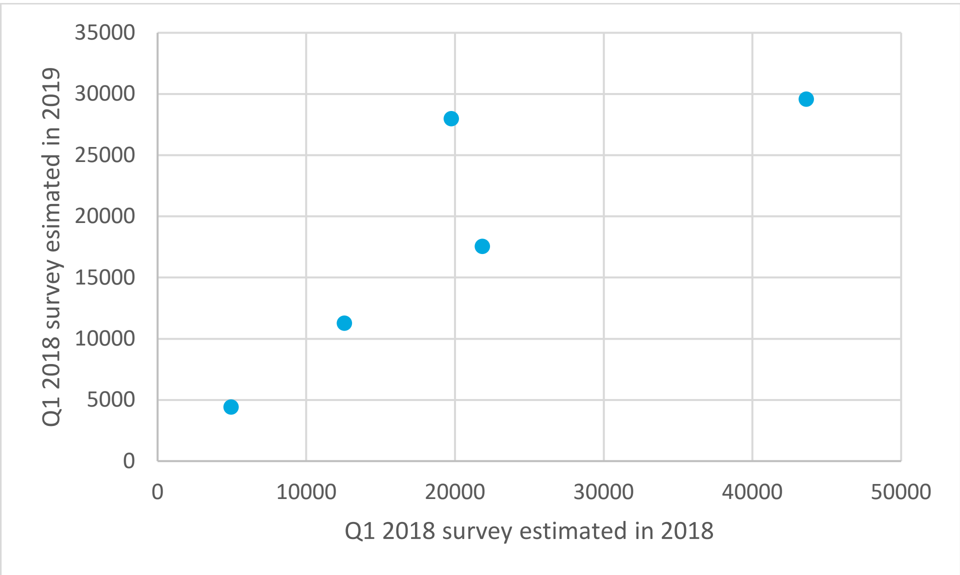


Figure 5.2.12. Plaice in SD 27.21–23. Effect of the missing age readings in 2018 on the 2018 Q1 survey estimates.

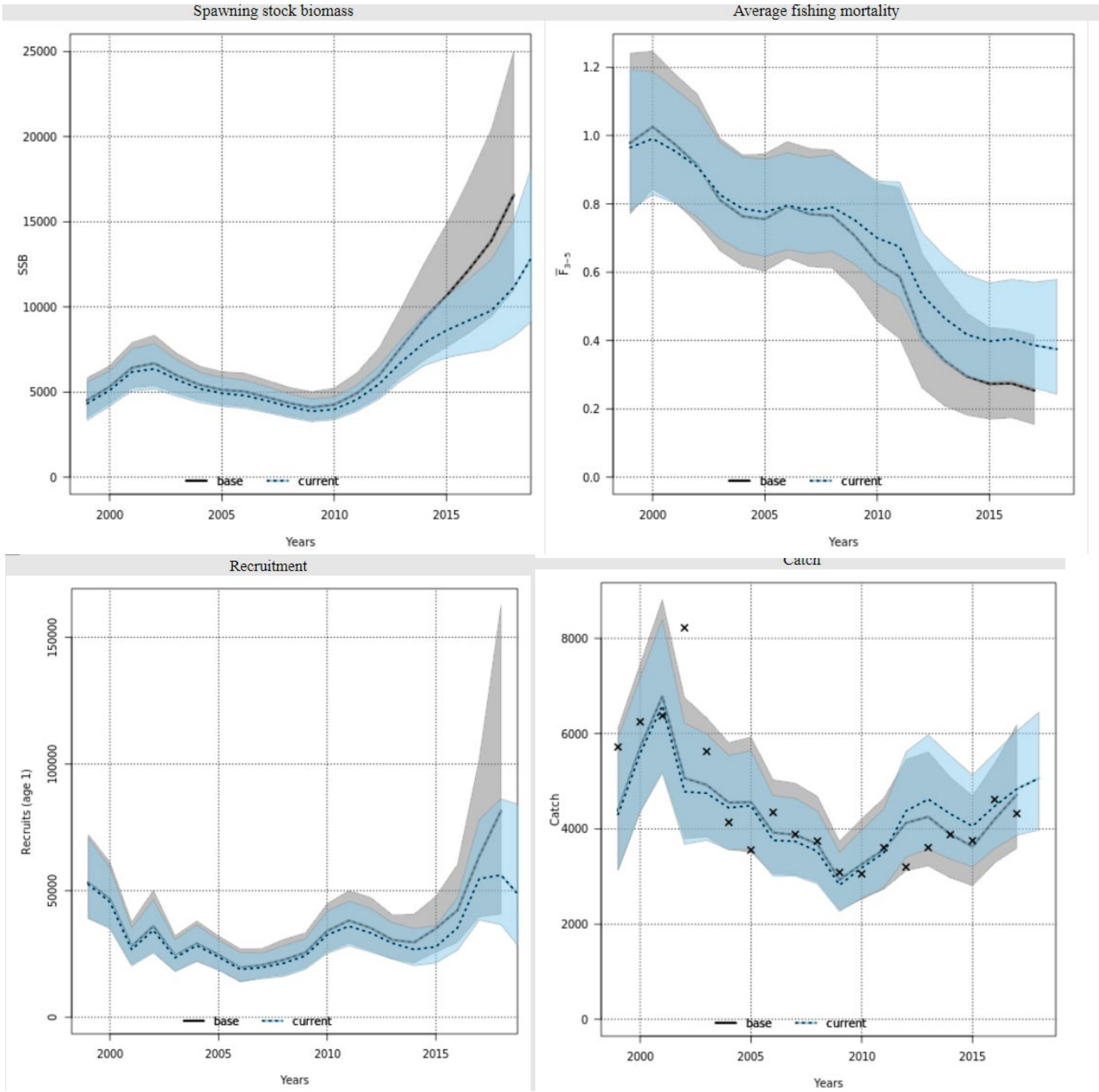


Figure 5.2.13. Plaice in SD 27.21–23. SPALY SAM run (in blue) compared with the 2018 assessment (in grey)

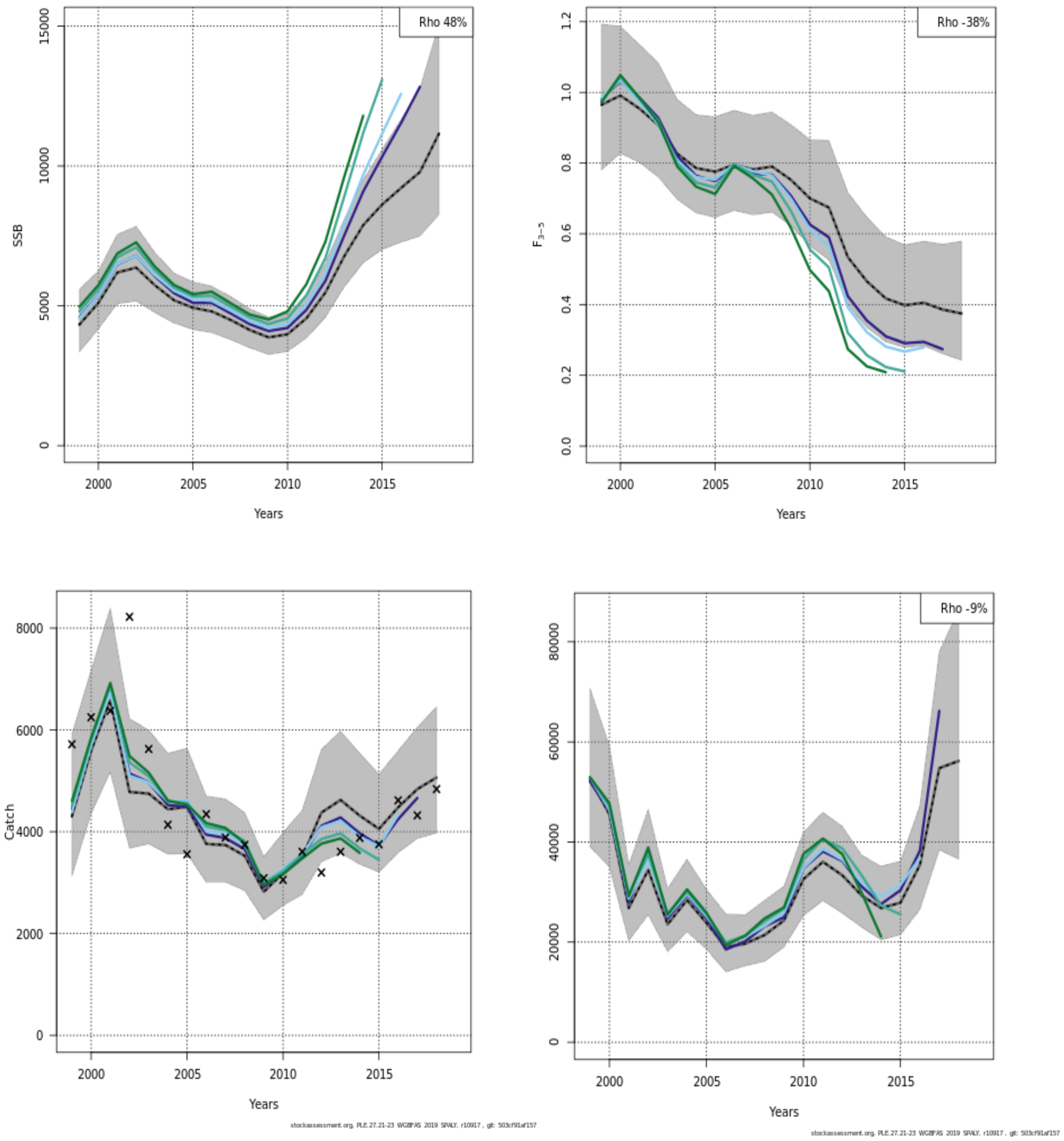


Figure 5.2.14. Plaice in SD 27.21–23. SPALY SAM run. Retrospective pattern.

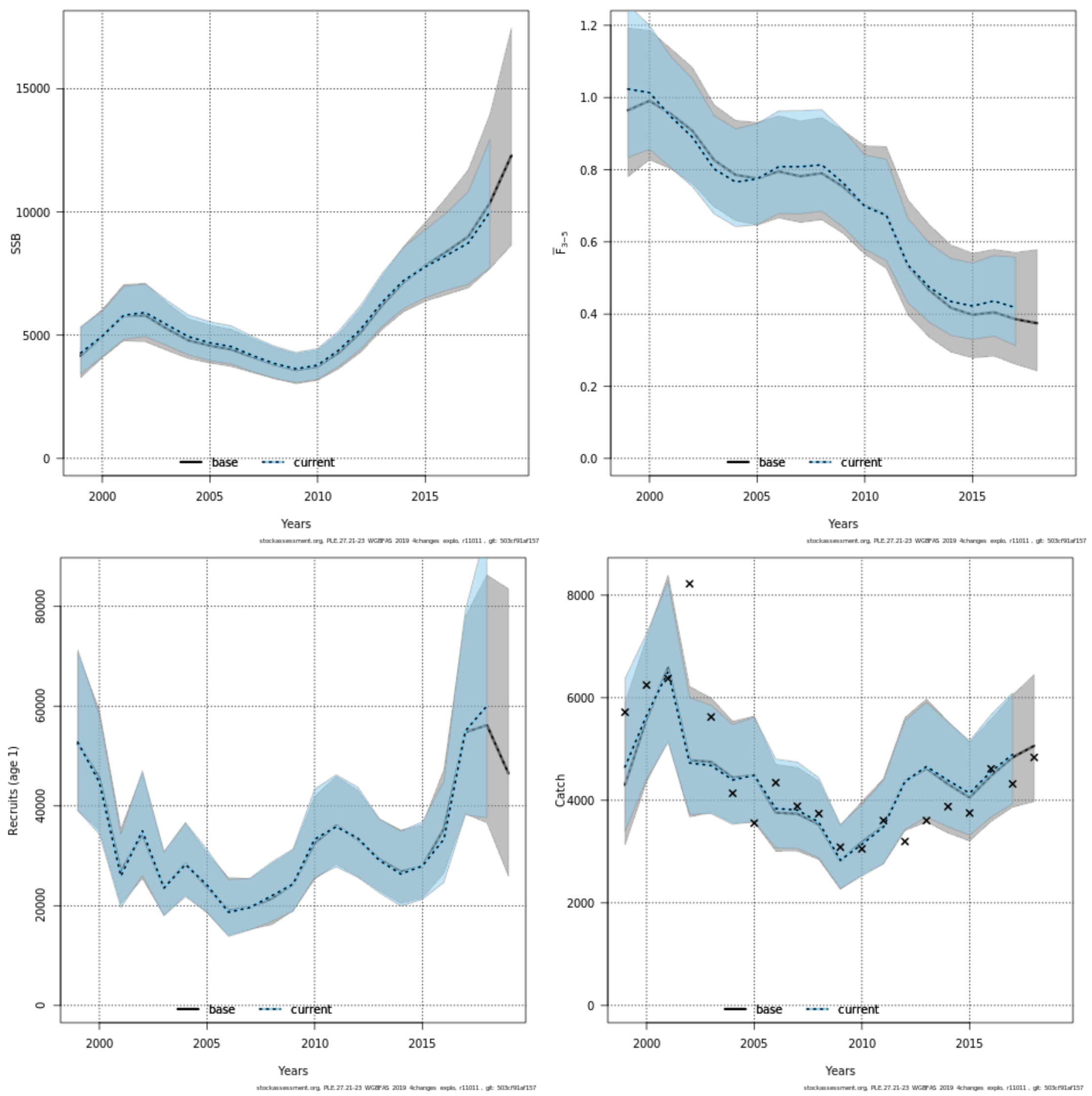


Figure 5.2.15. Plaice in SD 27.21–23. Final SAM run with 4 changes (in blue) compared with the SPALY assessment (in grey).

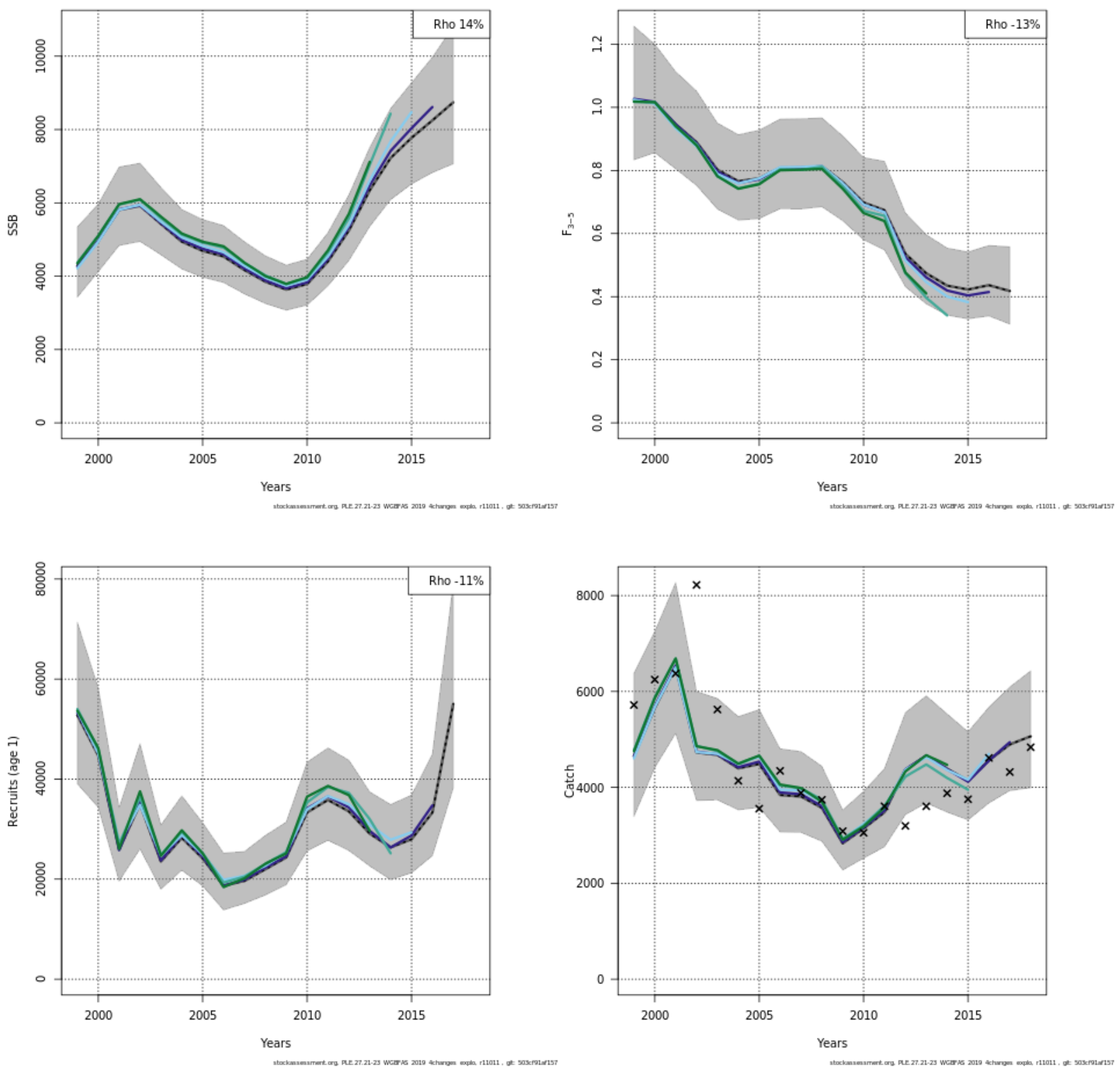


Figure 5.2.16. Plaice in SD 27.21–23. Final SAM run. Retrospective pattern

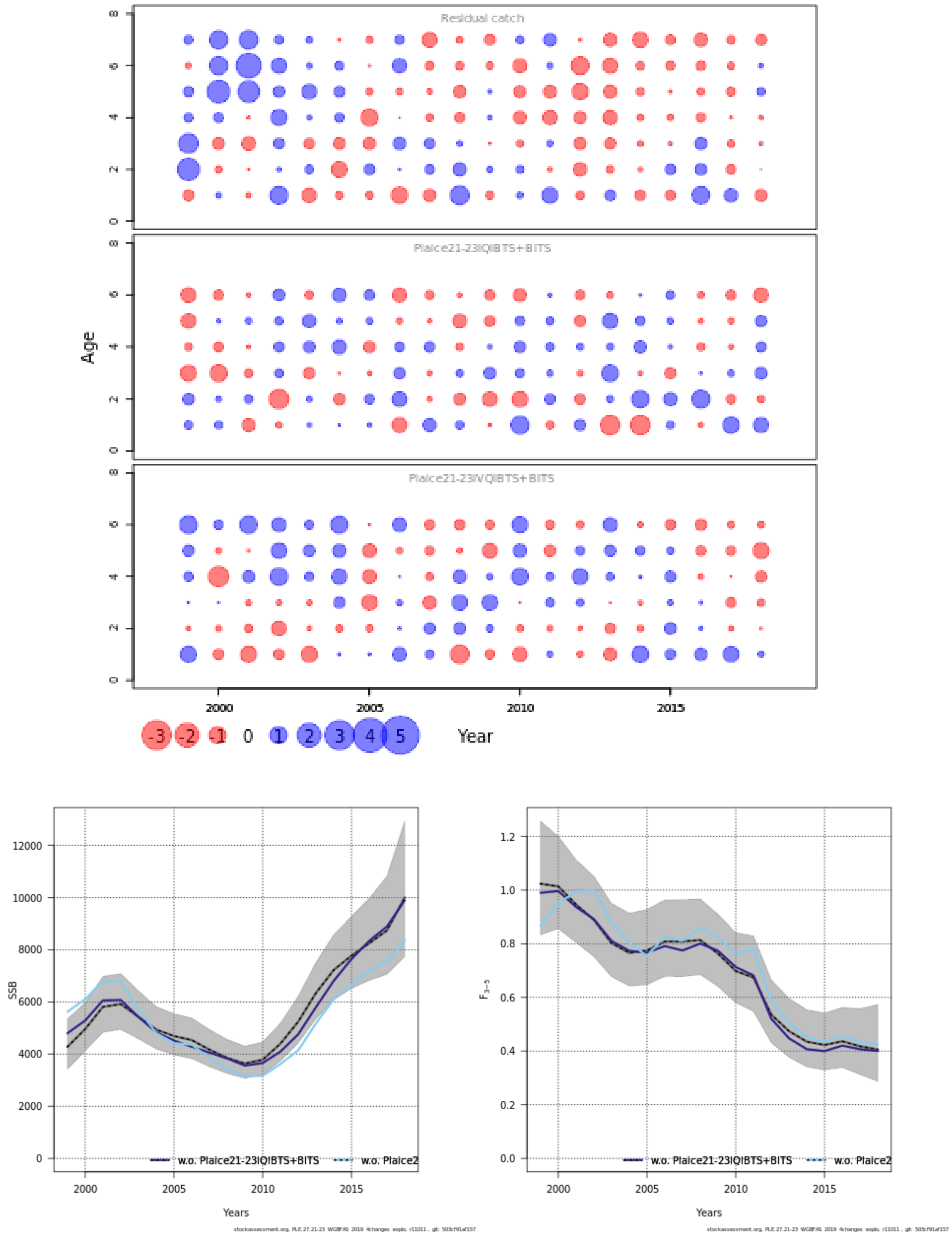


Figure 5.2.17. Plaice in SD 27.21–23. Final SAM run. Residuals (top) and "leave-one-out" (bottom).

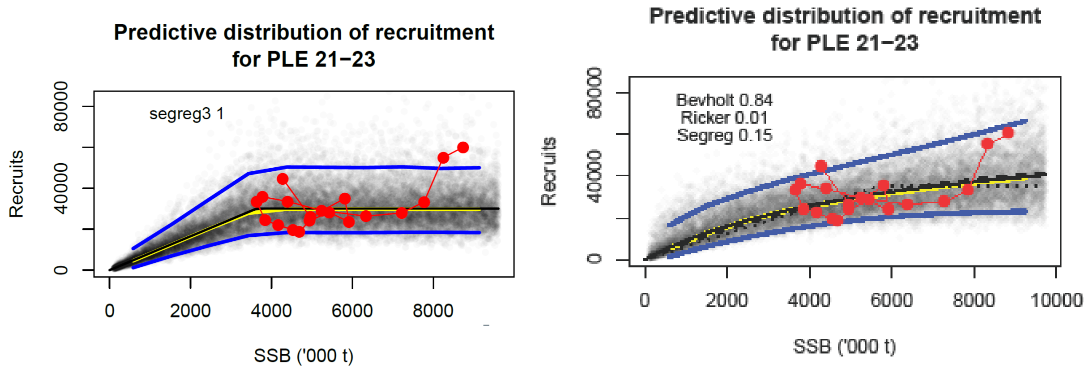


Figure 5.2.18. Plaice in SD 27.21–23. Stock recruitment relationships with EqSim, using either a segmented regression with breakpoint at B_{lim} (B_{loss}) (Left) or with a functional fit to the data (Right).

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 was reduced to 7076 tonnes for 2018 and increased to 10 772 tonnes for 2019[2]. The decrease in 2018 was related to the outcome in assessment of the ple.27.21-23 stock, which is now assessed via an analytical assessment. The analytical assessment of ple.27.21-23 indicated a decrease in recruitment which was considered when combining the results with ple.27.24-32.

5.3.1.1 Technical Conservation Measures

Plaice in the eastern Baltic Sea 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 Gdańsk basin (SD 26). Marginal catches of plaice in other SD are found occasionally in some years, but were usually lower than 1 tonne/year.

Plaice are caught by trawlers and gillnetters mostly. The minimum landing size is 25 cm in 2018, active gears provide most of the landings in SD 24 (ca. 78%), SD 25 (ca. 73%) and SD 26 (ca. 75%), passive gears provided on average 25% of total plaice landings in 2018.

5.3.1.2 Landings

The catch and 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 is 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 1970s (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 748 t in 2011, slightly increased in 2012 to around 848 tonnes and decreased to 427 tonnes in 2015. Landings (wanted catch) in 2018 were about three times higher than in 2017 with about 1644 tonnes. Since 2017, a landing obligation is in place, resulting in an additional 8.6 tonnes of "BMS landings" (i.e. landings of plaice below the minimum conservation reference size of 25 cm) in 2018, which accounted for 0.4% of the total catch.

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

Although a landings obligation is in place since 2017, discards in the commercial fisheries remain to be high and seems to vary greatly between countries. For example the trawl-fishery targeting

[2] Please note that the final advice for both plaice stocks was modified at ADGBS 2019. Consequently, corresponding catches by management were also modified.

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 discards in 2016 were exceptional high and estimated to be around 1050 tonnes, which would result in a discard ratio of 67% of the total catch. Discards in the most recent year (2018) were around 720 tonnes (i.e. 30.5% of the total catch).

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 two most recent years (2017, 2018) ages classes 5 and 6 have increased. In the discard fraction, age classes 2–3 are the most abundant. Almost no plaice above age class 5 is found in the discards (Figure 5.3.2).

5.3.2.2 Mean weight-at-age

Recent years show a decrease in the average weight for almost all age classes (Figure 5.3.3). 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 fish 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 is set at 0.2, age classes 3+ are set at 0.1 as a default.

5.1.1.1 Maturity-at-age

The maturity ogive was taken from the BITS from SD22 and SD24 (since they are more reliable and consistent than SD24+, see WKPLE 2015 report). Both quarters from the period 2002 to 2018 (2018, 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 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. 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 5.3.4).

The internal consistency plots of the surveys (Figures 5.3.5.a and 5.3.5.b) indicate a good consistency between the age classes. Younger fish in Q1 show low consistency following the cohorts because the trend in some cases is defined by one outlying measuring point. The medium and older aged fish show better consistency. The latest Survey index (2017 Q4) however has a bad internal consistency, as the catch data of plaice were exceptional high, a trend that is also showing in the preliminary 2019 Q1 survey.

The internal consistency in the commercial catches is also quite good (Figure 5.3.6). Only the medium aged fish show a lesser consistency.

5.1.2 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 settings are according to the stock annex (ple.27.24-32).

The final run in SAM is named: ple.27.2432_2019

A stochastic surplus production model (SPiCT) is additionally conducted to get information on the stock status by proxy reference points (B_{MSY}, $B_{trigger}$, and $F_{MSY\,proxy}$). In 2019, advice will be given by the results of the exploratory SAM results, applying the “2 over 3” rule on the relative SSB to set the wanted catch for the next year.

The final run in SAM is named: ple.27.2432_SAM_2019

5.3.3.1 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 tonnes in 2010 to >5600 tonnes in 2015 and estimated to 17 800 tonnes in 2019. The increase is probably resulting out of the high amount of discard in 2016 and 2017and the very high index values of the survey index and the respective higher total catch in 2018. The F in 2018 is higher than last year (0.299 in 2018, 0.19 in 2017), but 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 increasing F is most likely a result of more plaice-targeted fisheries in 2018 due to the bad condition and reduced availability of the eastern cod stock. The recruitment is regarded as constantly increasing but with significant variation. The recruitment in 2018 is estimated to 35.8 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. 5.3.9). Year effects also occur in the CPUE of BITS, especially for the latest surveys, which have large numbers of plaice in the catches, resulting in a high index value. 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 confidence intervals (Figure. 5.3.11).

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 using the “2-over-3-rule” for data-limited stocks. For plaice, the ratio is calculated by the relative SSB average of 2 most recent years (2018–2019) divided with the relative SSB average of the preceding three years (2015–2017) - this estimate gives an increase of 201%, driven by a very steep increase in relative SSB in the last two years. The most recent survey indices however stating a decrease in abundance in late 2018 and early 2019. An uncertainty cap is applied as the calculated trend exceeds the limit of 20% changes.

No F_{MSY} is available for the stock; however, an exploratorySPiCT model conducted on the stock states a $F_{MSY\ proxy}$ of 1.42.

After a period of decreasing total landings (and catch) in the last three years, the most recent year (2018) showed a very strong increase in total catch. Advice will be given based on the advised catch of the last year (2018[3]). Following that approach, the advised total catch for 2020 is 4470 tonnes.

Since the difference between the advised (3725 tonnes in 2018) and the taken catch (2355 tonnes in 2018) 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.[3]

If advice is given on the most recent catch (2355 tonnes in 2018), the advised catch for 2020 would be at around 2826 tonnes, following the same approach for the calculation.[3]

Two other approaches to give advice are presented in this report, following the suggested calculations of WKMSYCat34 (ICES, 2017a), by applying a harvest control rule to give advice for the total catch in 2020. This exploratory SPiCT advice should not be used for advice until it has been further validated.

The harvest control rule was applied to the results of the SPiCT model (described in 5.1.7.2) and results in an advised total catch of 2729 tonnes in 2020.

When applying the harvest control rule to the results of the LBI model (described in 5.1.7.1), the total advised catch for 2020 would be 4307 tonnes. A "stability clause" would have to be added, resulting in an advised total catch of 2826 tonnes in 2020.

The methods are described in the respective chapters. The LBI calculations should be seen as "exploratory" as the method is not used for the advice and has not been reviewed by an external expert.

5.3.3.2 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 5.3.4. See section 5.3.1 under "Description of the fishery" for historical trend details.

5.3.4 Recruitment estimates

The recruitment in 2018 is estimated to around 35.9 mills. This is an increase since 2013 and can be considered as a stable recruitment in the whole time-series (2002–2018). The historic trend is given in Figure 5.3.7 and Table 5.3.3.

5.3.5 Short-term forecast and management options

No short-term forecast is given for the stock.

5.3.6 Reference points

5.3.6.1 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 2014–2018

[3] Please note that this was modified at ADGBS 2019. To calculate the final catch advice for 2020, the realized catches in 2018 were used in the calculations.

were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

- L_{inf}: average of 2002–2018, both quarter and sexes → L_{inf} = 51.652 cm
- L_{mat}: average of 2002–2018, quarter 1, only females → L_{mat} = 26.5 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 below possible reference points (Table 5.3.6). $L_{max5\%}$ is close to the lower limit of 0.80 (i.e. 0.71 in 2018), 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 0.75, indicating fishing above the optimal yield. Exploitation (Figure 5.3.11) is consistent with F_{MSY} proxy ($L_{F=M}$).

WKLIFE VIII developed a harvest control rule to provide MSY advice for category 3 and 4 stocks based on the "2-over-3 rule", which compares the trend in stock index of the two most recent years to the preceding three years (WKMSYcat34; ICES, 2017a). The recommended harvest rule improves on 2-over-3 with the addition of multipliers based on the stock's life-history characteristics, the status of the stock in terms of relative biomass, and the status of the stock relative to a target reference length (Section 3, WKLIFE VIII; ICES, 2018). The catch rule is defined as:

$$C_{y+1} = m \times C_y \times r \times f \times b$$

where the catch (C) for next year y+1 is based on the current year's catch C_y adjusted by three additional components (Table 5.3.8), which are defined by the length-distribution of the catch, a relative index factor and a multiplier, using the van Bertalnaffy growth ration k.

Table 5.3.8.: Definition and use of the LBI-based harvest control rule for category 3 and 4 stocks

	Definition and use
r	The rate of change in the index, based on the average of the two most recent years of data (y−2 to y−1) relative to the average of the three years prior to the most recent two (y−3 to y−5), and termed the "2-over-3" rule.
f	The ratio of the mean length in the observed catch that is above the length of first capture relative to the target reference length (mean length/target reference length).
b	Adjustment to reduce catch when the most recent index data I_{y-1} is less than 1.4 × $I_{trigger}$ such that b is set equal to I_{y-1}/(1.4 × $I_{trigger}$). When the most recent index data I_{y-1} is greater than 1.4 × $I_{trigger}$, b is set equal to 1. $I_{trigger}$ is generally defined as the lowest observed index value for that stock.
m	Multiplier applied to the harvest control rule to maintain the probability of the biomass declining below B_{lim} to less than 5%. May range from 0 to 1.0.
Stability clause	Limits the amount the advised catch can change upwards or downwards between years. The recommended values are +20% and −30%, i.e. the catch would be limited to a 20% increase or a 30% decrease relative to the previous year's catch.

Applying the harvest control rule on the LBI results of plaice,

C_y = **2355** t (total catch), 1644 t (total landings)

r = **0.51** (last 2-y index of *3.3* vs. last 3-y index of *1.64*)

f = **1.07** (avg L_{CAT} = *26.74cm* L_{target} = *25cm*) #please note, that L_{target} has not been defined, therefore the MCRS was used (alternatively, L_{opt} (29.53cm) might be applicable as well as L_{mean}/L_{opt}:

f = 0.78 (L_{mean}/L_{opt} of the LBI results)

b = **1** ($I_{trigger}$ = 0.22 I_{y-1} = 3.0 → $I_{y-1} > 1.4xI_{trigger}$)

m = **0.85** (v.B. growth rate k = 0.131)

Using these values, the advised catch for 2020 would be:

$Advice_{catch}$ 2020 = **4308 tonnes total catch**,

if applying the „*Stability clause*" (max 20% increase) on the advised catch:

$Advice_{catch}$ 2020 = **2826 tonnes total catch,**

if using the alternative f value (L_{mean}/L_{opt}):

$Advice_{catch}$ 2020 = **3141 tonnes total catch**

5.3.6.2 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 2018 and the BITS biomass index Q1 and Q4. No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios $F/F_{MSY\ proxy}$ and $B/B_{MSY\ proxy}$ are used to estimate stock status relative to the MSY reference points and are used in the catch advice as an additional indicator of the stock status.

The results of the assessment are stating a good status of the stock, below or above the respective reference points and thus confirming the results of the SAM assessment and the stock trend of the BITS index. The results are however uncertain with large confidence intervals (Figure 5.3.12, Table 5.3.7). 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. From 2018, SPiCT results are used to give information on proxy reference points. The recent time-series of 15 years combined with continuously increasing data quality (in terms of spatio-temporal sampling coverage, amount of samples and error/consistency checks) and the comparison with the other stock trends (SAM, BITS) justifies the use of this model for the proxy reference points.

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}.

5.3.6.2.1 Advice calculation based on SPiCT

WKMSYCat34 developed a harvest control rule for assessments using surplus production models such as SPiCT (a stochastic surplus production model in continuous time) (Section 3.1, WKMSYCat34; ICES, 2017a), which includes the following components:

Quantity	Definition and purpose
$B_{y+1}/B_{trigger}$	The ratio of the estimated biomass *B* in the next year *y +1* (B_{y+1}) and the lower limit of biomass ($B_{trigger}$). $B_{trigger}$ is set equal to 0.5 B_{MSY}, which is determined based on life history and on the assumed shape of the yield curve as defined by the shape parameter of the stock production curve. Technical note: The median of [$B_{y+1}/B_{trigger}$] should be used in the below calculation.

F_y/F_{MSY}	The ratio of the estimated fishing rate *F* in year *y* (F_y) and the estimated fishing rate that would achieve maximum sustainable yield (F_{MSY}). Technical note: The median of [F_y/F_{MSY}] should be used in the below calculation.
B_{lim}	Set equal to 0.3 B_{MSY}, where B_{MSY} is the biomass level which would produce maximum sustainable yield.
PA buffer	The probability of the biomass being above the B_{lim}, where B_{lim} is the biomass limit below which future recruitment will be impaired.

The harvest control rule to establish the fishing mortality for next year is based on F_{MSY} that is reduced linearly if the next year's biomass is forecasted to fall below $B_{trigger}$, and it is defined as:

$$F_{y+1} = F_y \times \frac{\min\{1, B_{y+1}/B_{trigger}\}}{F_y/F_{MSY}}$$

Technical criteria for accepting a SPiCT assessment

When determining harvest limits using output from SPiCT, the application of the harvest control rule first depends on appropriate model performance. An accepted assessment using SPiCT would ideally fulfil all of the following points:

- Model converged;
- All parameter uncertainties could be estimated and finite;
- No violation of model assumptions such as bias, autocorrelation of OSA residuals, and normality. This means that p-values are not significant (p>0.05);
- Consistent trend in the retrospective analysis. There should not be a tendency to consistently under- or overestimate relative fishing mortality and biomass in successive assessments, in particular if the retrospective estimates are outside the confidence intervals of the base run;
- Non-influential starting values – the results should be the same for all starting value;
- Model parameter estimates and variance parameters should be meaningful. This means that the parameter of the production curve (*n*) should not be very skewed away from the symmetrical curve (B_{MSY}/K should be between 10% and 90%) and the variance parameters (sdb, sdc, sdi, sdf) should not be unrealistically low. In these cases, a prior on the unrealistic parameter could be considered.

The plaice dataset and results of the SpiCT were tested for all the above criteria. All technical criteria were fulfilled. The current B_{MSY}/K is at 55% (2019 estimates). Several different runs with manually changed priors were conducted to test the variance parameters and determined if the calculated default values are reliable.

Applying the harvest control rule on the exploratory SPiCT, the advised total catch for 2020 is 2729 tonnes. This is just an exemplary calculation to test the method and compare the results with the SAM assessment (which is used for the advice).

The final run in SPiCT is named: ple.27.2432_SPICT_2019_index.

5.3.7 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. The relative SSB was used as index for estimating the stock trend. The calculated trend was used for calculating the catch in 2019 by applying the "2 over 3 rule" in the same way as the previous year. Although the SAM assessment is premature, the assessment shows surprisingly robustness despite the relatively short time-series available. This is expressed in the leave one out analysis which looks acceptable (Figure 5.3.10). The F by-age group is shown in Figure 5.3.8. The final summary plots (F_{bar}, Spawning-stock biomass (SSB) and recruitment) for the SAM run are shown in Figure 5.3.7.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. The additionally conducted SPiCT assessment shows results that are very similar to those gained from the SAM assessment. The proxy reference points confirm the overall status of the stock. Also the exemplary LBI assessment further confirming the stock status.

5.3.8 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 2016 and 2017. The estimated relative F for 2018 (0.29) increased compared to 2017 (0.19), which resulted out of a more plaice-targeted fisheries; the relative recruitment estimates (2.6) increased compared to the previous assessment (2.4). The relative SSB also increased (2.2 in 2017, 3.0 in 2018; for 2019, a SSB of 3.6 is estimated). Data quality is improving annually and with increased sampling by the member states.

5.3.9 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.

The additionally conducted SPiCT assessment relies strongly on survey data and catches; adding a tuning fleet using commercial effort might be beneficial to improve the quality of the output.

BMS landings should be sampled additionally to the ongoing discard-sampling to allow reasonable data extrapolation for this part of the catch.

Table 5.3.1. ple.27.24–32. Plaice in the Baltic Sea. Total landings (tonnes) by ICES Subdivision and country.

Year/SD	Denmark			Germ. Dem. Rep*	Germany, FRG		Poland		Sweden**						Finland		
Area	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				

Year/SD	Denmark	Germ. Dem. Rep*	Germany, FRG	Poland		Sweden**					Finland
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				

Year/SD	Denmark			Germ. Dem. Rep*	Germany, FRG		Poland		Sweden**						Finland		
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				
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		

Year/SD	Denmark			Germ. Dem. Rep*	Germany, FRG		Poland		Sweden**						Finland		
2016	187	60	1		93	2	151	3	15	10	<1	<1	0	0	0	0	0
2017	124	68	<1		143	1.4	293	3	6	12	<1	0	0	0	0	0	0
2018	435	158	2		353	3	667	1	13	11	0	0	<1	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 (tonnes), BMS landings (tonnes) and discard (tonnes) in 2018 by Subdivision, catch category, country and quarter.

Area	Country	CatchCategory	1	2	3	4	Total*
27.3.d.24	**Denmark**	Landings	9.933	42.482	76.641	305.270	434.326
		Discards	14.839	72.454	8.483	13.733	109.509
		BMS landing	0.000	0.032	0.186	0.920	1.138
	Germany	Landings	3.670	60.834	141.427	144.598	350.529
		Discards	1.844	15.597	12.473	25.358	55.272
		BMS landing	0.000	0.000	1.000	1.000	2.000
	Poland	Landings	48.684	106.744	138.849	45.663	339.940
		Discards	7.566	80.252	58.600	19.134	165.552
		BMS landing		0.176			0.176
	Sweden	Landings	0.005	0.830	2.445	8.647	11.927
		Discards	0.005	0.584	10.784	0.806	12.179
		BMS landing	0.000	0.000	0.000	1.000	1.000
27.3.d.25	**Denmark**	Landings	52.515	0.975	0.612	102.930	157.032
		Discards	109.664	0.439	0.470	67.090	177.663
		BMS landing	0.029	0.002	0.065	0.816	0.912
	Germany	Landings	2.028		0.001	0.001	2.030
		Discards	11.440	0.105	0.000	0.001	11.546
		BMS landing	1.000	0.000		0.000	1.000
	Latvia	Landings				0.001	0.001
		Discards	1.238			0.401	1.639
		BMS landing				0.000	0.000
	Poland	Landings	89.327	35.251	101.244	100.681	326.503
		Discards	76.113	42.880	20.918	31.048	170.959
		BMS landing	0.420				0.000
	Sweden	Landings	1.201	0.590	1.542	5.519	8.852
		Discards	1.671	1.167	0.222	6.489	9.549
		BMS landing	1.000	0.000	0.000	1.000	2.000
	Lithuania	Landings	0.000	0.000			0.000

Area	Country	CatchCategory	1	2	3	4	Total*
27.3.d.26	**Denmark**	Landings	0.013	0.000	0.000	2.290	2.303
		Discards	0.018			1.192	1.210
		BMS landing	0.000	0.000	0.000	0.000	0.000
	Latvia	Landings	0.060				0.060
		Discards	0.711	0.046		0.568	1.325
		BMS landing	0.000				0.000
	Poland	Landings	0.140	0.170	0.832	0.267	1.409
		Discards	1.179	0.137	0.179	0.094	1.589
		BMS landing	0.002				0.000
	Sweden	Landings	0.000	0.000	0.000	0.000	0.000
		Discards		0.997	0.192	0.673	1.862
		BMS landing	0.000	0.000	0.000	0.000	0.000
	Lithuania	Landings	0.000	0.000	0.000	0.000	0.000
		Discards	0.000	0.000	0.000	0.000	0.000

***BMS landings are included in the discards and need to be substracted from the total sum.**

Table 5.3.3. ple.27.24-32. Estimated recruitment (thousands), total-stock biomass (TBS), spawning-stock biomass (SSB), and average fishing mortality for ages 2 to 5 (F_{25}).

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F_{25}	Low	High
2002	4691	3151	6982	2286	1556	3357	1075	687	1681	0.862	0.58	1.28
2003	5755	4112	8052	2552	1919	3392	1179	858	1620	1.127	0.82	1.549
2004	7052	4948	10050	2909	2228	3797	1271	974	1659	0.659	0.484	0.898
2005	5901	4138	8415	3396	2615	4409	1697	1312	2195	0.385	0.264	0.561
2006	4700	3296	6703	3760	2915	4849	2181	1683	2827	0.471	0.339	0.654
2007	4295	2970	6211	3731	2908	4787	2330	1804	3009	0.59	0.434	0.801
2008	4832	3310	7055	3520	2761	4488	2159	1694	2753	0.542	0.403	0.729
2009	8277	5680	12061	4062	3186	5180	2211	1752	2790	0.536	0.395	0.727
2010	13946	9235	21060	5619	4287	7365	2678	2112	3397	0.63	0.464	0.854
2011	14522	9607	21949	7057	5233	9517	3420	2601	4497	0.715	0.531	0.963
2012	10070	7022	14441	7162	5378	9538	3863	2884	5174	0.684	0.502	0.932
2013	13850	9793	19586	7454	5769	9630	3952	3034	5148	0.764	0.56	1.042
2014	16788	11791	23903	8113	6385	10307	4051	3225	5089	0.373	0.238	0.584
2015	22656	15634	32831	11028	8718	13952	5618	4528	6970	0.272	0.176	0.42
2016	30685	20161	46701	15379	11948	19795	8051	6427	10085	0.256	0.16	0.409
2017	34142	20980	55564	20063	15109	26640	11154	8666	14357	0.194	0.108	0.348
2018	35880	19350	66530	25298	18179	35206	15183	11307	20388	0.298	0.159	0.556
2019							17887	12239	26142			

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 2–5)
2002	0.34	0.22	915	353	1.57
2003	0.41	0.24	1281	271	2
2004	0.5	0.25	1081	214	1.2
2005	0.42	0.34	1081	166	0.7
2006	0.34	0.44	1012	818	0.86
2007	0.31	0.47	1167	491	1.07
2008	0.35	0.43	1102	294	0.98
2009	0.59	0.44	1226	418	0.97
2010	1.00	0.54	903	998	1.14
2011	1.04	0.68	748	1377	1.3
2012	0.72	0.77	848	917	1.24
2013	0.99	0.79	738	781	1.39
2014	1.2	0.81	534	481	0.68
2015	1.62	1.12	427	220	0.49
2016	2.2	1.61	521	1058	0.47
2017	2.4	2.2	650	408	0.35
2018	2.6	3	1640	710	0.54
2019		3.6			

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
$L_{max5\%}$	Mean length of largest 5%	L_{inf}	$L_{max5\%}$ / L_{inf}	> 0.8	Conservation (large individuals)
$L_{95\%}$	95th percentile		$L_{95\%}$ / L_{inf}		
P_{mega}	Proportion of individuals above Lopt + 10%	0.3–0.4	P_{mega}	> 0.3	
$L_{25\%}$	25th percentile of length distribution	L_{mat}	$L_{25\%}$ / L_{mat}	> 1	Conservation (immatures)
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c/L_{mat}	> 1	
L_{mean}	Mean length of individuals > Lc	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{maxy}	Length class with maximum biomass in catch	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals > Lc	LF=M = $(0.75L_c+0.25L_{inf})$	L_{mean} / 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	L_c / L_{mat}	$L_{25\%}$ / L_{mat}	L_{max5} / L_{inf}	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
2016	0.51	0.85	0.70	0.01	0.75	1.12
2017	0.77	0.85	0.73	0.02	0.77	0.93
2018	0.85	0.89	0.71	0.01	0.78	0.91

Table 5.3.7. ple.27.24-32. Overview of SPiCT result values on catalogue and survey data 2002–2018.

Deterministic reference points (Drp)					
		estimate	cilow	ciupp	log.est
	B_{MSYd}	1290.4113	566.4942	2939.4147	7.1627
	F_{MSYd}	1.4200	0.6550	3.0784	0.3507
	M_{MSYd}	1832.4327	1632.8584	2056.3998	7.5134
Stochastic reference points (Srp)					
		estimate	cilow	ciupp	log.est
	B_{MSYs}	1293.5592	597.9732	2798.2784	7.1652
	F_{MSYs}	1.4060	0.7007	2.8211	0.3407
	MSYs	1818.7262	1607.0404	2058.2960	7.5059
States	**w**	**0.95**	**CI**	**(inp$msytype:**	**s)**
		estimate	cilow	ciupp	log.est
	B_2018.88	2693.9462	1265.6681	5734.0040	7.8988
	F_2018.88	0.9606	0.3662	2.5200	-0.0402
	B_2018.88/B_{MSY}	2.0826	1.5913	2.7255	0.7336
	F_2018.88/F_{MSY}	0.6833	0.3635	1.2844	-0.3809
Predictions	**w**	**0.950**	**CI**	**(inp$msytype:**	**s)**
		prediction	cilow	ciupp	log.est
	B_2019.00	2556.4420	1133.1014	5767.7059	7.8464
	F_2019.00	0.9697	0.3430	2.7416	-0.0308
	B_2019.00/B_{MSY}	1.9763	1.4721	2.6532	0.6812
	F_2019.00/F_{MSY}	0.6897	0.3302	1.4406	-0.3715
	Catch_2019.00	2168.0783	1156.3987	4064.8293	7.6816
	E(B_inf)	1796.2137			7.4934

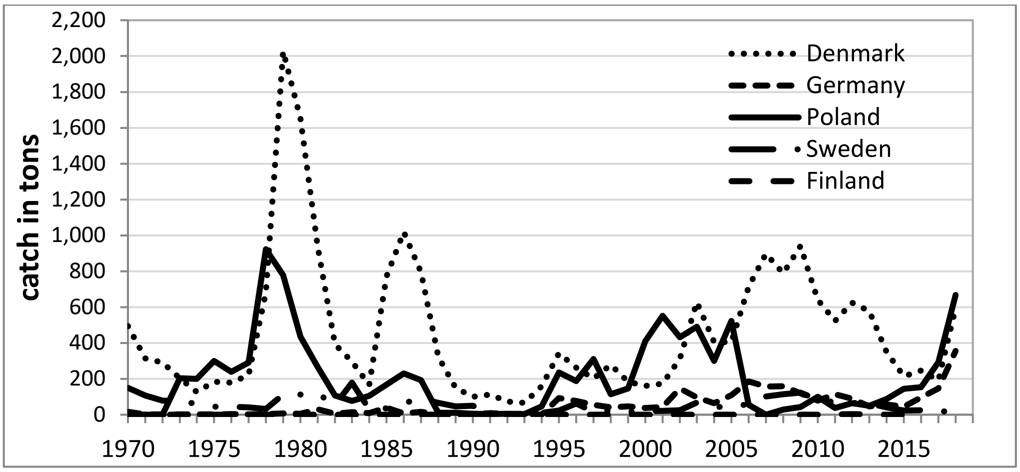


Figure 5.3.1. ple.27.24-32. Historical landings per country (in tonnes).

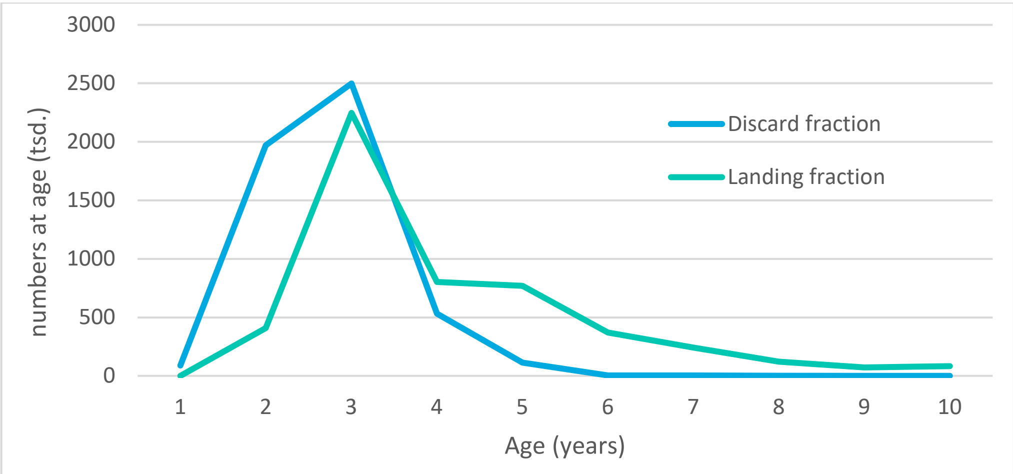


Figure 5.3.2. ple.27.24-32. Catch in numbers per age class and catch category in Subdivision 24 and 25. All countries and fleets were combined.

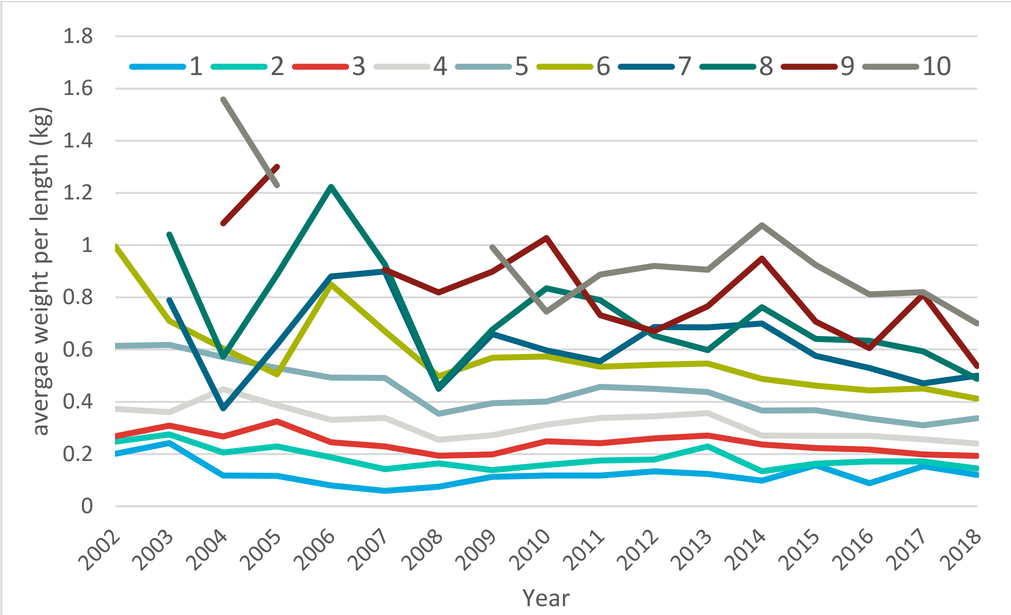


Figure 5.3.3. ple.27.24-32. Average weight-at-age for the age classes 1 to 10 in subdivisions 24 and 25. All countries and fleets were combined.

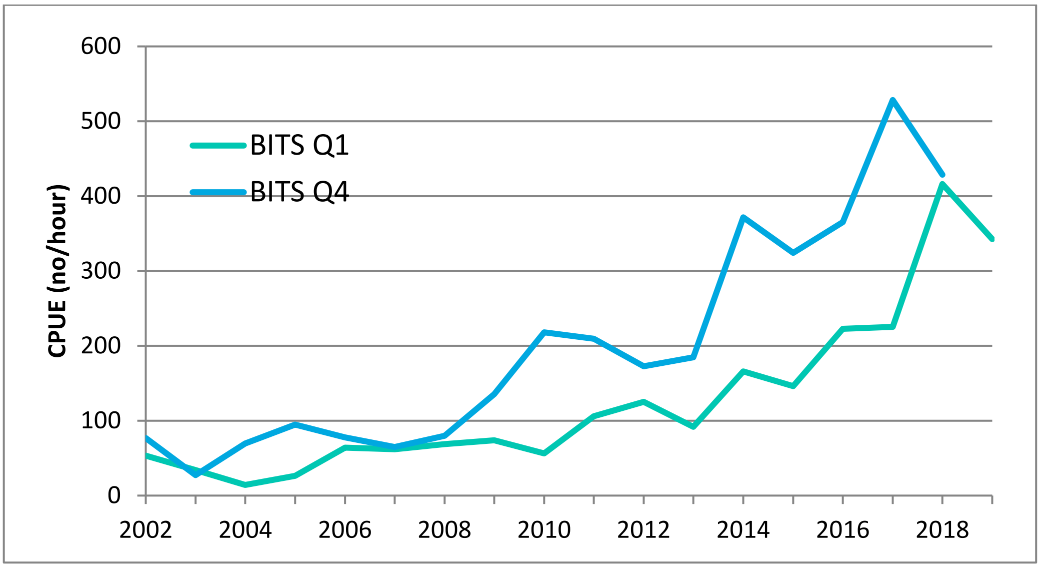


Figure 5.3.4. ple.27.24-32. Average CPUE index from Q1 and Q4 BITS from SD24-SD26 (no plaice catches in SD27+). 2019 data (Q1) are preliminary.

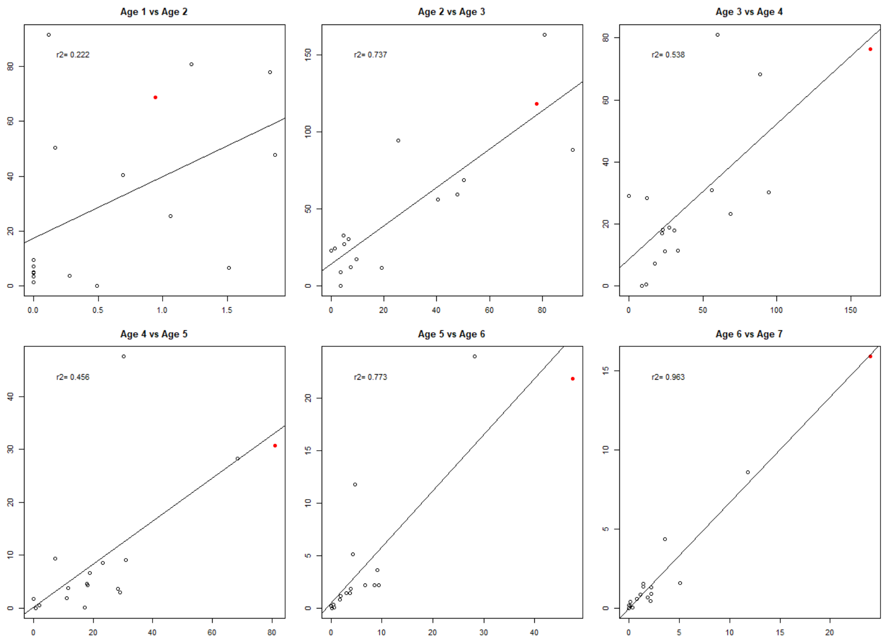


Figure 5.3.56.a. ple.27.24-32. Internal consistency of age classes 1–7 from Q1 BITS.

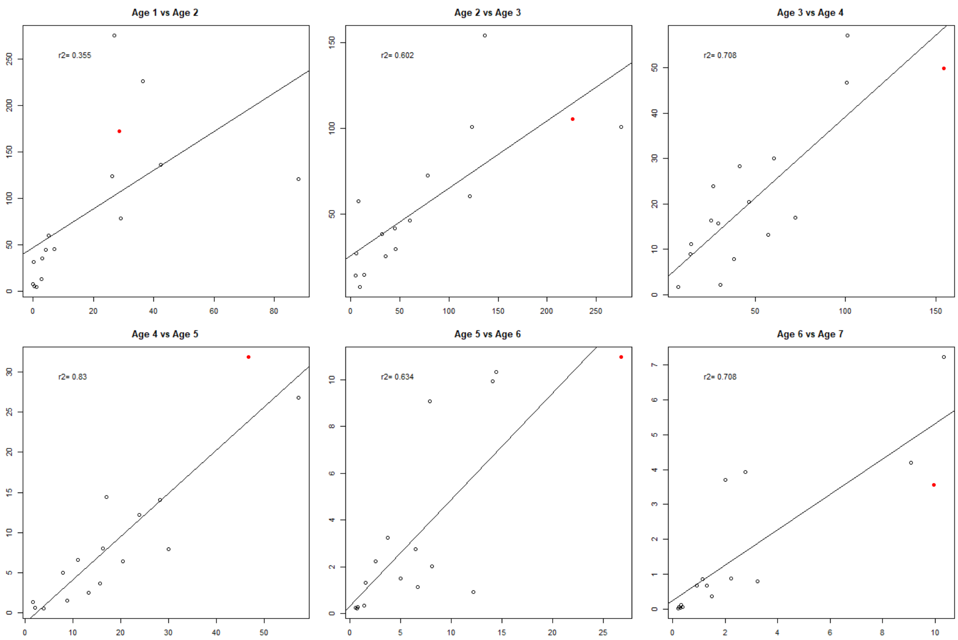


Figure 5.3.5.b. ple.27.24-32. Internal consistency of age classes 1–7 from Q4 BITS.

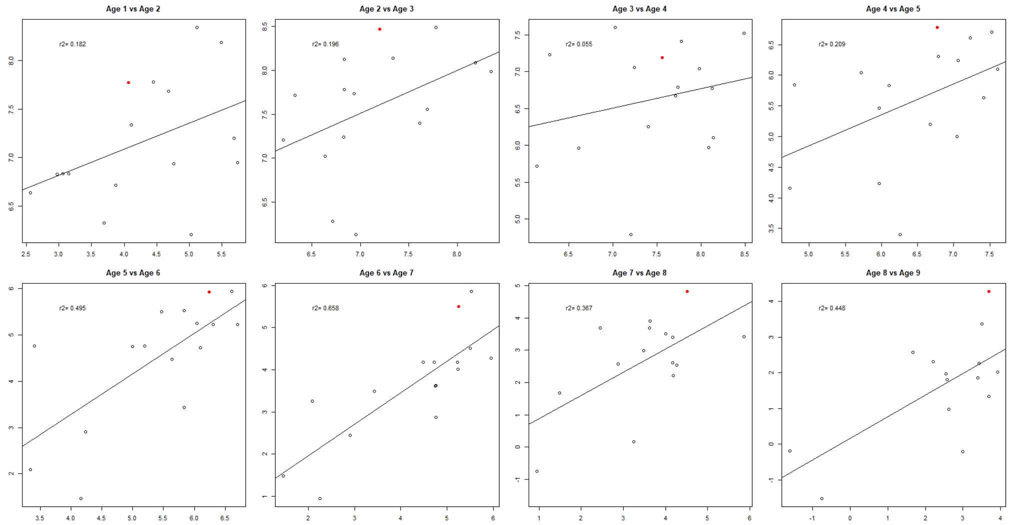


Figure 5.3.6. ple.27.24-32. Internal consistency of age classes 1–7 from commercial catches. All fleets and countries were combined.

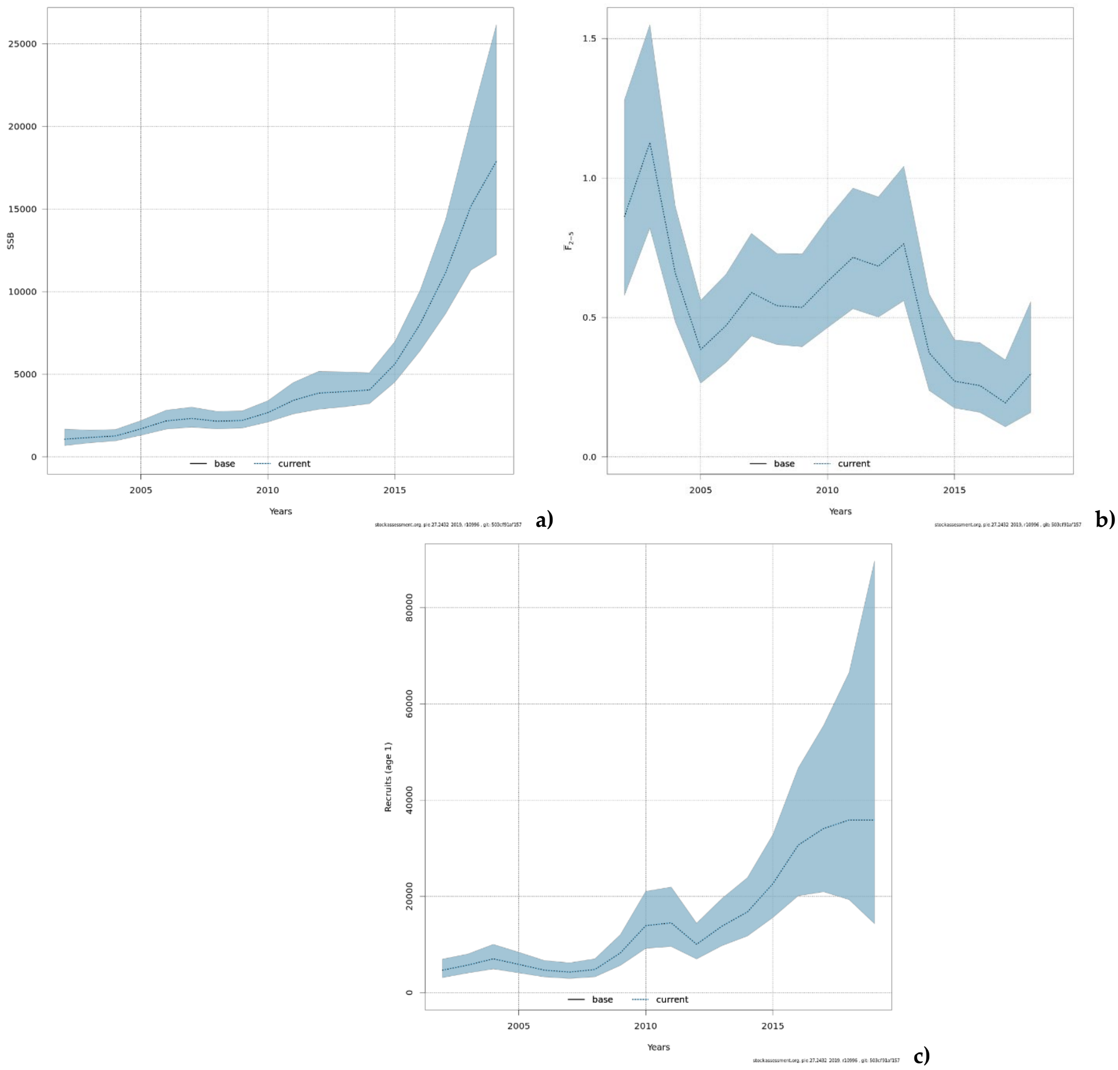


Figure 5.3.7. ple.27.24-32. Results from the exploratory SAM assessment: a) total SSB, b) F (age2–5,) and c) recruitment.

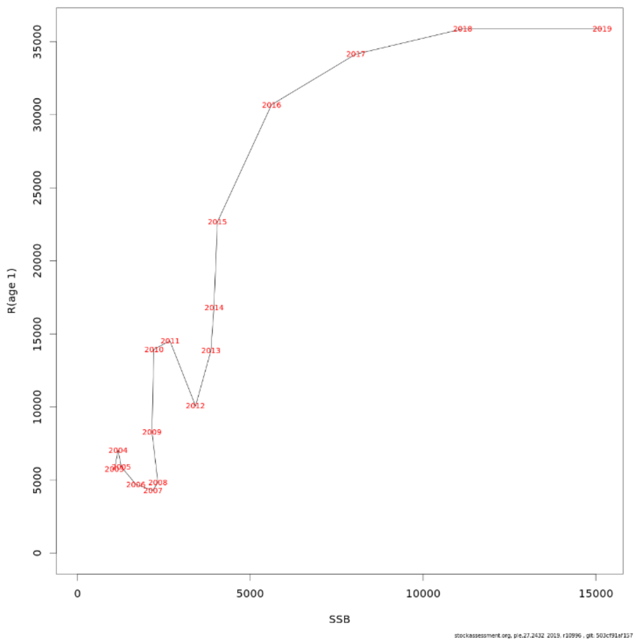


Figure 5.3.8. ple.27.24-32. Estimated recruitment as a function of spawning-stock biomass.

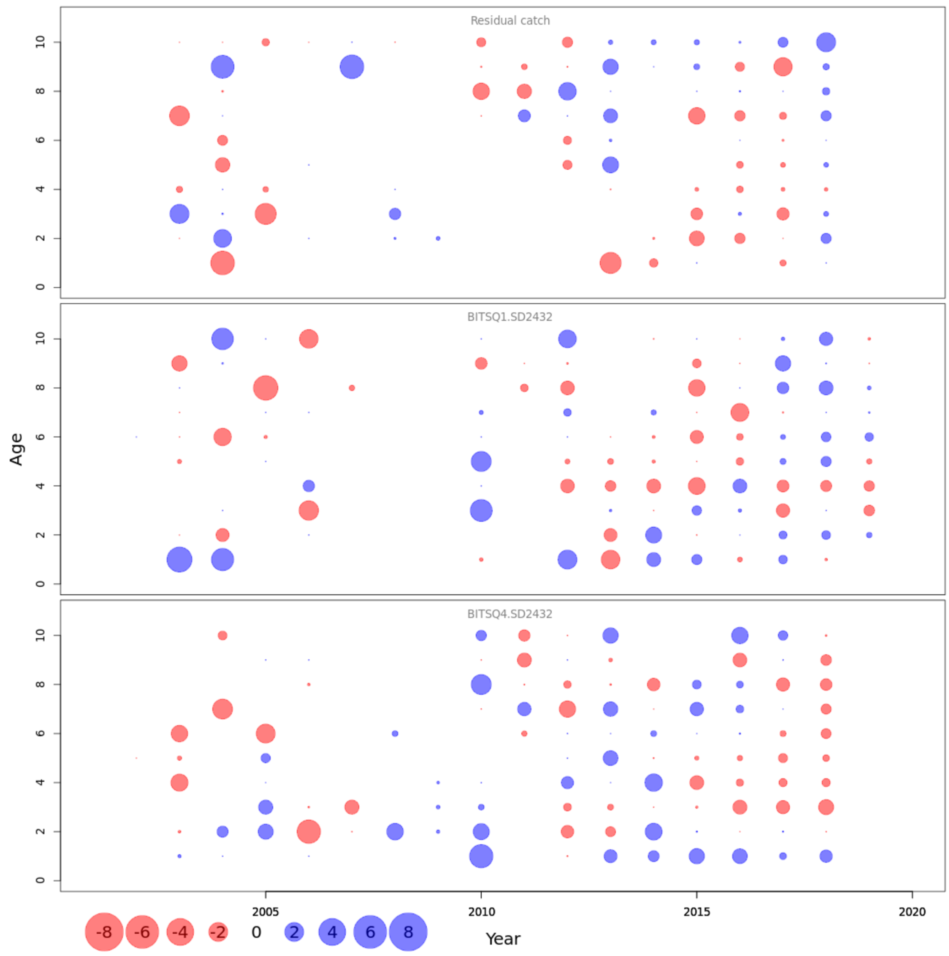


Figure 5.3.9. ple.27.24-32. Normalized residuals for the current run. Blue circles indicate positive residuals (observations larger than predicted) and filled circles indicate negative residuals.

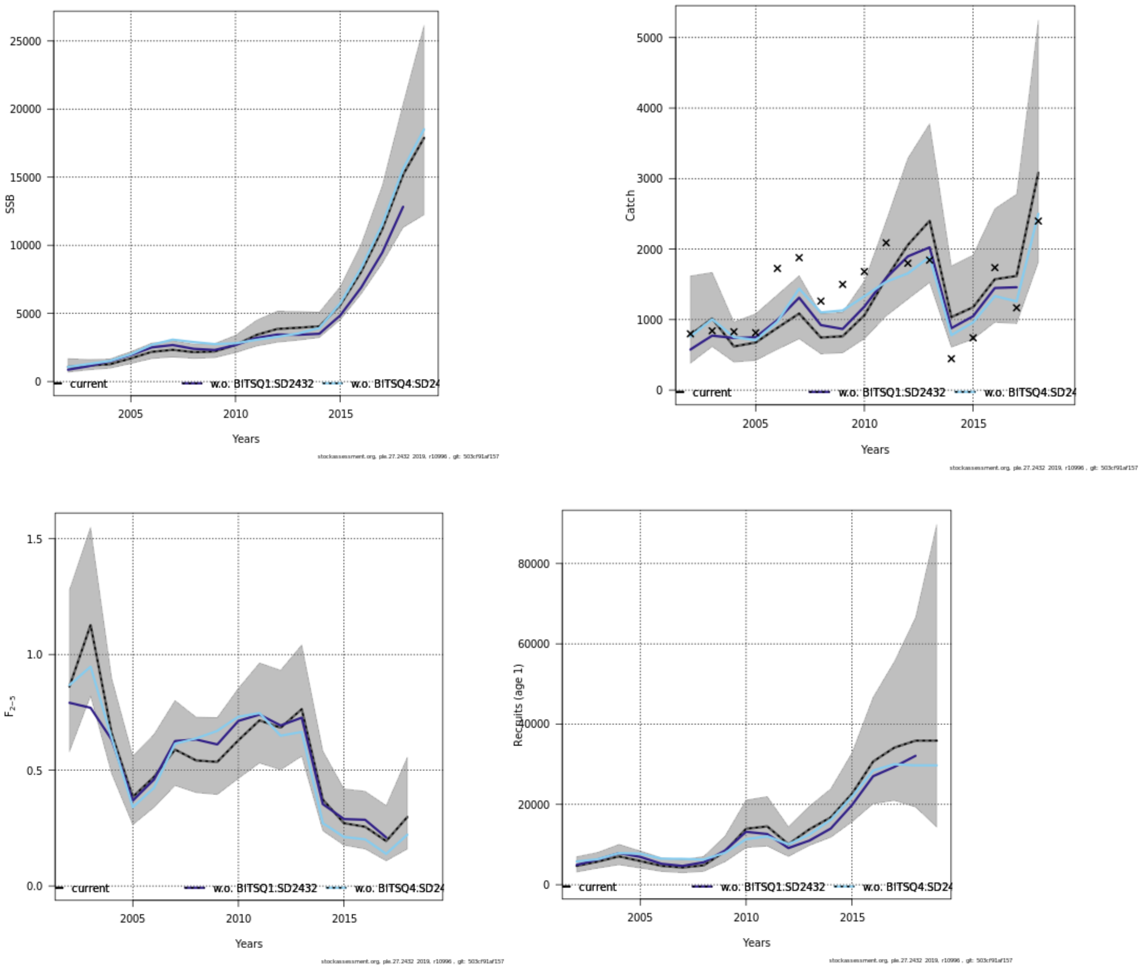


Figure 5.3.10. ple.27.24-32. The results of the leave one out analysis showing SSB, total catch, F (3–5) and recruitment.

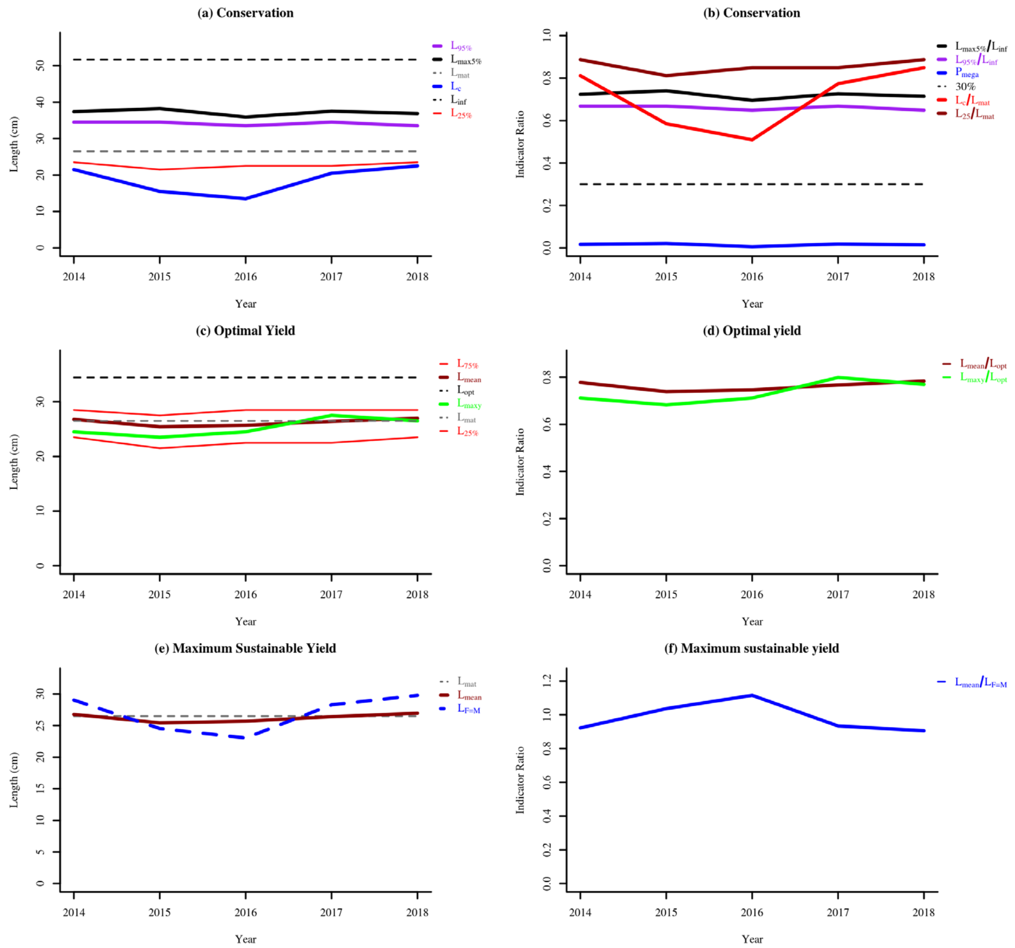


Figure 5.3.11. ple.27.24-32 Indicator trends of the Length-based Indicator calculations.

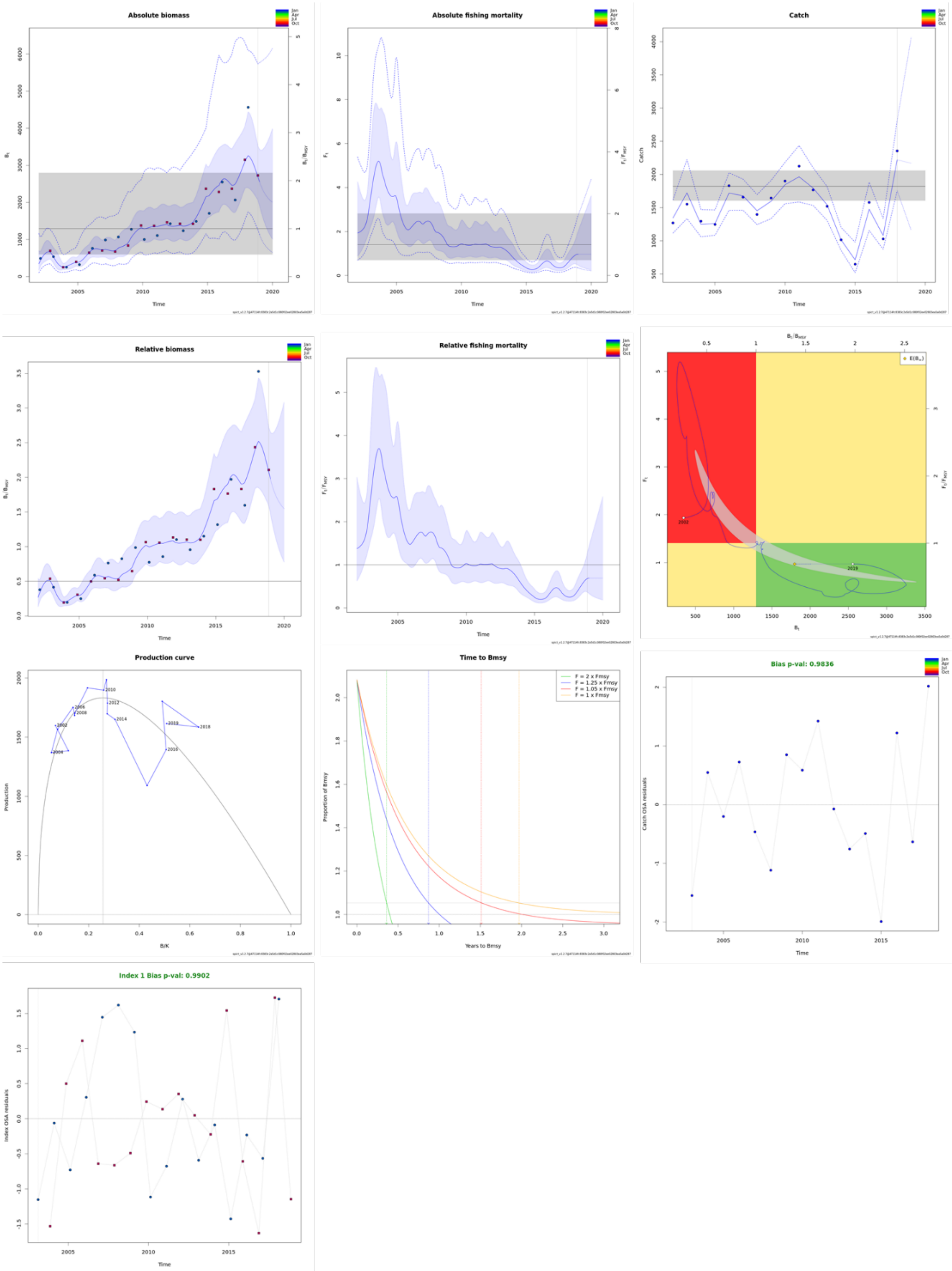


Figure 5.3.12. ple.27.24-32. Overview of the results of the surplus production model (SPiCT) on catch and survey data 2002–2018.

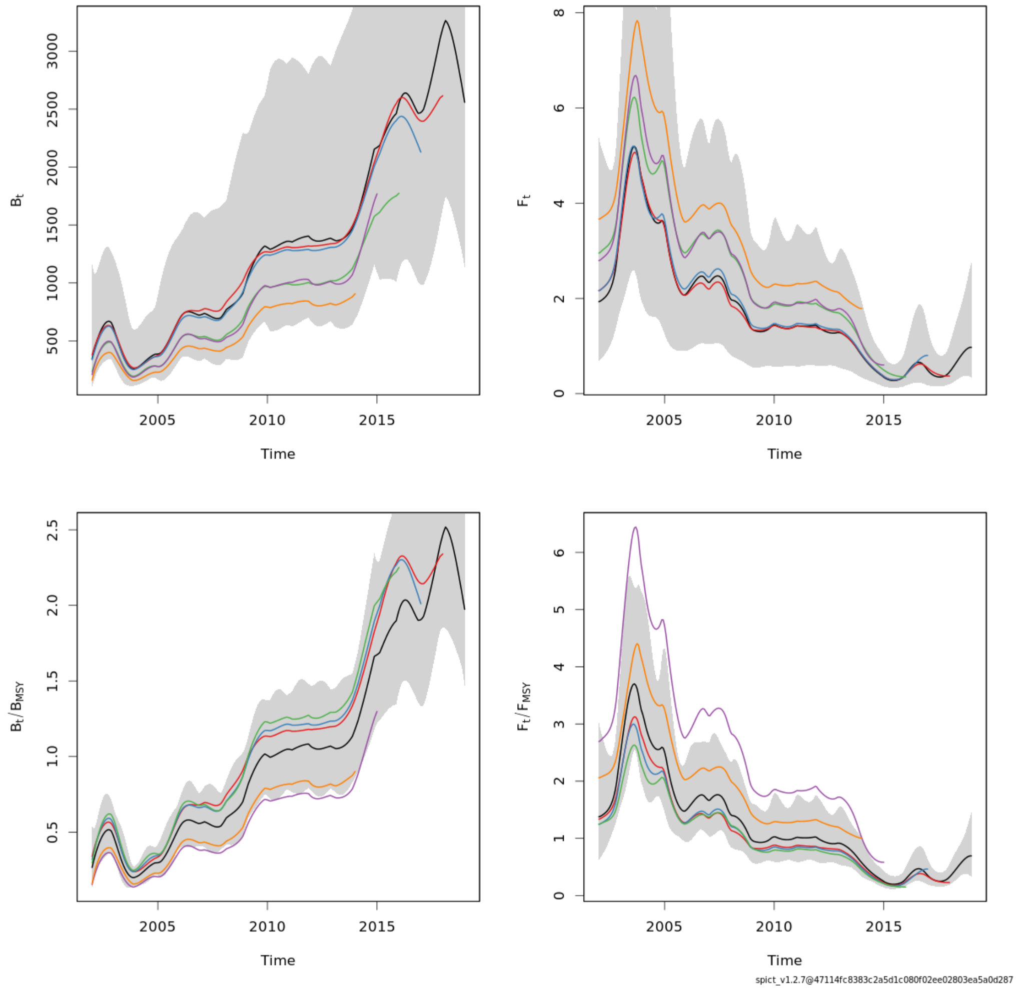


Figure 5.3.13. ple.27.24-32. Overview of the retrospective analysis of the surplus production model (SPiCT) on catch and survey data 2002–2018

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 with an increasing proportion for trawl. Minimum legal landing size is 24.5 cm.

There is seasonality in sole fishery with both gillnet and trawl. The low season for trawl is from May to September (Figure 6.2). The season for gillnet fishery for sole is from April to September. During this season, about 80% of the gillnet catches are sole. Additional information of the sole fishery are in the Stock Annex.

6.1.1 Landings

The officially reported landings by area, gear and country for 2018 are given in Table 6.1. Denmark took 82% of the total catch in 2018. Kattegat has traditionally been the most important area accounting for 60% of the annual catches in average, but in recent years this proportion has decreased to less than 40%, while the proportion of landings from the Skagerrak and the Belts increased to 40% and 20%, respectively.

Historical catches, including the working group corrections, are provided 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 a high in 1993 (1400 t). Since then, landings have decreased along with decreasing TACs. Figure 6.2 provide the Danish catches cumulated by month since 1998 including preliminary 1st quarter catches of 2019, indicating seasonal trends in the fishery.

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 2018 amounts to 2% of the catches by weight based on sampling from trawlers(Table 6.3) and the average of the recent 5 years are 4% discard (used in advice, to add up to total catches).

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 but added only in the advice.

6.1.3 Effort and CPUE Data

Currently only private logbook data time-series from selected Danish trawlers and gillnetters are kept from the past to calibrate the assessment: trawl CPUE's from 1987–2008 and gillnet CPUE's from 1994–2007 (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). Despite the decrease in landings in 2018 sampling increased significantly from previous years due to more effort by observes and from port sampling (686 specimens from the catches). The age structure of the Danish catch was applied 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 larger proportion of the catch (Table 6.6 and 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. In 2018 weight-at-age increased for ages 4 and older.

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 2018 improved significantly especially for Skagerrak where no sampling was achieved in previous years. However, gillnetters were still not sampled in 2018 although they took 35% of the catches. The small and scattered catches in the fishery for sole mainly caught as bycatch requires a huge effort in port sampling. The increase in this sampling effort in 2018 seem to have a positive effect on the assessment quality in reducing retrospective patterns in stock and fishery development.

6.3 Fishery-independent information

Since 2004 a survey conducted cooperatively by DTU Aqua and with Danish fishers was designed with fixed haul positions chosen by both scientific and fishers. The survey takes place in November-December and covers the central part of the stock (Figure 6.4). The survey ceased in 2012–2013 but resumed in 2014. Since 2016 the survey was redesigned to cover more areas in Skagerrak and also in the Belts (Figure 6.5); 20 stations in Skagerrak (Jammerbugt) and 6 stations in the Belts (northern part of Storebælt). The extended area has not been utilized in the survey index calculation, but awaits a longer time-series and further evaluation. Catch rates from the additional areas in Skagerrak was lower than for the core survey area in Kattegat. Based on 72 successful hauls out of 74 planned hauls in 2018, 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 an increase in catch rates in 2018 and especially age group 1 had record high observations (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 2019 is named 'sole2024_2019' and is visible at stockassessment.org.

6.4.1 Model residuals

Model residuals 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). The survey is virtually the only calibration to the catch matrix (the other two ceased 10 years ago) and therefore the effect of removing the survey is significant and also of limited value. However, with only the catch matrix along with the two commercial series from back in time suggests a higher fishing mortality in periods and a similarly a lower SSB.

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 and in Table 6.11. The SSB in the past 5 years have increased slowly and is in 2018 estimated to be at 2850 t. This is above MSY $B_{trigger}$ for the first time since 2006. After two years of sharp increase fishing mortality is now decreasing and being at F_{MSY} in 2018. Recruitment calculated as age 1 has since 2010 been low but has increased since 2015 (Figure 6.10, Table 6.11).

6.4.4 Retrospective analysis

Retrospective pattern (Figure 6.11) of the SSB and F estimates show some patterns of bias where fishing mortality is slightly underestimated and SSB is slightly overestimated, but both within acceptable ranges. Mohns rho calculated for SSB, F and recruitment are in the range 0.13 to -0.14. This year's pattern is an improvement from last year most likely due to improved sampling from the fishery (see section 6.2.1).

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 2850 t in 2018 above MSY $B_{trigger}$. Fishing mortality has decreased continuously since 2005 with a sudden increase in 2017 but has decreased again in 2018 to 0.23 equal to F_{MSY}.

Recent recruitment (2014–2017 year classes at age 1) are estimated higher than previous year classes and are expected to contribute to a more robust SSB in the coming years (Tables 6.10–6.11).

6.5 Short-term forecast and management options

Basis for the intermediate year are provided in Table 6.12.

Discards are not included in the assessment but comprise 2% in weight in 2018 (Table 6.3). The average of the discard in the recent 5 years (4%) is added to landings to derive catches. Catch options are provided in Table 6.12.

Assumed recruitment ages 1 in 2019 and 2020 have changed basis this year; previously it was sampled by SAM from the recent 5 years due to low recruitment in that period, but since recruitment in 2014–2018 have increased slightly it no longer represent a low recruitment period. Therefore a longer period was used to sample representing a low productivity regime since 2004, i.e. 2004–2018. This resulted in assumed recruitment 2019–2020 of 2618 thousand individuals.

Due to the nearly full utilization of the TAC, catch constraint was assumed for the intermediate year of 2019 (502 t). This catch corresponds to a fishing mortality of 0.23. Given this scenario, SSB in the beginning of 2020 is estimated to 3065 t which is above MSY $B_{trigger}$. With this assumption the forecast predicts that fishing at F_{MSY} in 2020 will lead to yields of 518 t (Table 6.12). At this level of exploitation, spawning-stock-biomass is estimated at 3081 t in 2021. Catch in 2019–2020 and stock composition in 2020–2021, is estimated to be dominated by age 3 to 5 as indicated in Figure 6.13 under the assumed conditions in 2019.

EC has since 2018 requested advice for the sole stock in SD 20–24 based on F_{MSY} ranges. Catches in 2020 corresponding to F_{MSY} upper and lower range (F = 0.19–0.26) are 435–577 t.

A yield-per-recruit analysis was made with long-term averages (15 years) with unscaled exploitation pattern. The yield-per-recruit curve (Figure 6.14) indicates that maximal yield per recruit is poorly estimated at F4–8 around 0.87 and that F0.1 is estimated to 0.20.

6.6 Reference points

Reference points were redefined under the inter benchmark, IBPSOLKAT (ICES, 2015) in November 2015 as follows:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY Bt_{rigger}	2600 t	B_{pa}	ICES (2015)
	F_{MSY}	0.23	Equilibrium scenarios stochastic recruitment, short time-series 1992–2014, constrained by F_{pa}.	ICES (2015)
	F_{MSY} lower	0.19	F_{MSY} lower without AR from equilibrium scenarios	ICES (2015)
	F_{MSY} upper	0.26	F_{MSY} upper capped by Fp05 with AR from equilibrium scenarios	ICES (2015)
Precautionary approach	B_{lim}	1850 t	B_{loss} from 1992 (low productivity regime)	ICES (2015)
	B_{pa}	2600 t	B_{lim} × e 1.645σ, σ = 0.20	ICES (2015)
	F_{lim}	0.315	Equilibrium scenarios prob(SSB< B_{lim})< 50% with stochastic recruitment	ICES (2015)
	F_{pa}	0.23	F_{lim} × e -1.645σ, σ = 0.18	ICES (2015)
Management plan	SSB_{MGT}	Not defined.		
	F_{MGT}	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. Sampling since 2017 has improved partially due to a reference fleet of fishing vessels (2015–2016) and partially due to increased sampling effort from the Danish Institute DTU Aqua.

The enhanced sampling has likely caused the assessment to improve and to reduce the annual variation in stock and fishing pressure perception as evident from the retrospective plots with a minor overestimation of SSB and subsequent underestimation of F. Mohn’s rho for SSB, F and R retro’s are within the acceptable range of 0.13 to -0.14.

6.8 Comparison with previous assessment

This year’s assessment are conducted as in previous years and in accordance with the procedure described in the stock annex. The stock status in relation to reference points have changed so that fishing mortality is now at F_{MSY} and SSB is above MSY $B_{trigger}$.

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 landing obligation cod is potentially 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+, the true 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. 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 biological parameters for sole in the assessment.

6.10 Issues relevant to a forthcoming benchmark

DTU Aqua finalized the project "Improvement of the biological advice for Common Sole in Danish waters" in 2018. The project aimed to investigate stock structure of sole in SDs 20-24, improve biological parameters such as growth and recruitment monitoring, evaluate the sole surveys that is basis for the assessment, evaluate sampling strategies from the fishery and finally to estimate selectivity parameters for the most commonly used active gear types including SELTRA trawl. The project achieved many of its objectives but especially for the studies on the stock structure the results were not conclusive. Genetics and partly growth analyses pointed to a difference between the sole populations in Kattegat and Skagerrak, while recruitment patterns pointed to a common population. These inconclusive results have made a scheduled benchmark in 2020 redundant and any planned benchmark is postponed to after 2020.

Further work is however required in order to finalize conclusions on stock structure.

- The connection to the North Sea sole stock is an immediate task to investigate;
- and also recruitment areas that contribute to the adult sole stock in SDs 20-24 including validation of nursery grounds within SDs 20-24 and nursery grounds outside SDs 20-24 that contribute to the 20-24 stock.

These studies will include following methods/substudies:

1. Genetics; genotyping spawning fish from the North Sea adjacent to Skagerrak along with spawners from 20-24 in order to identify stock structure in SD 20–24 and adjacent waters to identify main self-reproducing units. In addition juveniles from both the North Sea and 20-24 should be examined for genetic differentiation to evaluate feeding migrations within SD 20-24 and Div 4;
2. Abundance and distribution of juveniles; identification of potential nursery grounds was done under the finalized DTU Aqua project however, validation of those identified areas needs to be done. That will include sampling/monitoring by various small gears in the potential coastal areas;
3. Otolith trace element analysis to identify the origin of sole sampled both in the North Sea and in SD 20-24;
4. Drift modelling of egg/larvae releases from potential spawning grounds and/or reverse modelling from known/potential nursery grounds;

5. Conventional tagging of mature/immature sole in SD 20-21 and in the North Sea adjacent to Skagerrak in order to verify migrations and mix.

In addition to the above research needs the assessment needs improvement for:

- Weight in stock is currently assumed equal to weight in catch due to lack of information. However, data from the sole survey can be utilized to establish WEST;
- Maturity-at-age is currently not known; the sole survey is late in the year (November-December) when sole is difficult to assess with respect to maturity and likelihood of spawning. An effort could be made in the sampling program from the fishery to achieve maturity data, however, establishing a few years maturity will only result in scaling of perception of the SSB development over time and requires more years to identify eventual changes in maturity-at-age.

Table 6.1. Sole 20-24. Landings (t) of sole in 2018 by area, nation, quarter and gear.

Skagerrak (SD20)	Quarter				Gear		Total
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	26	75	11	27	71	69	140
Germany	0	6	0	0	0	6	6
Sweden	1	0	0	0	1	0	1
Netherlands	0	2	15	30	46	2	47
Total	27	84	27	58	118	77	195

Kattegat (SD21)	Quarter				Gear		Total
Nation	1	2	3	4	Trawl	Gillnet	
DK	41	34	19	64	128	31	158
Germany	0	0	5	3	0	7	7
Sweden	2	5	3	3	5	8	13
Total	43	39	27	70	132	47	179

Belts and Baltic (SD22-24)	Quarter				Gear		Total
Nation	1	2	3	4	Trawl	Gillnet	
DK	11	15	9	22	31	26	57
Germany	0	0	0	0	1	0	1
Sweden	0	0	0	1	0	2	1
Total	0	0	1	0	32	28	60

Skagerrak (SD20)	Quarter				Gear		Total
Nation	1	2	3	4	Trawl	Gillnet	
Denmark	23	82	9	56	81	87	169
Germany	0	5	0	0	0	5	5
Sweden	1	0	0	0	1	0	1
Norway	1	1	0	1	1	1	2
Netherlands	0	1	15	25	40	1	41

Total	24	88	24	82	124	94	218

Kattegat (SD21)	**Quarter**				**Gear**		**Total**
Nation	**1**	**2**	**3**	**4**	**Trawl**	**Gillnet**	
DK	32	32	33	124	157	64	221
Germany	0	2	2	11	0	15	16
Sweden	2	3	6	7	9	8	18
Total	34	37	41	142	166	88	254

Belts and Baltic (SD22-24)	**Quarter**				**Gear**		**Total**
Nation	**1**	**2**	**3**	**4**	**Trawl**	**Gillnet**	
DK	6	8	8	25	20	26	47
Germany	0	0	0	0	1	0	2
Sweden	0	0	0	0	0	0	0
Total	6	8	8	26	21	27	49

Table 6.2. Sole 3a, 22-24. Catches (tons) in the Skagerrak, Kattegat and the Belts 1952–2018 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
2017	215	166	46	19	21	2	31		501
2018	158	140	57	16	15	0	47		434

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.

Discard in weight (kg)																	
Age	Year																
	1999	2000	2001	2002	2003	2004	2005	2006-2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	-	7,992	-	-	-	-	-	-	616	140	128	490	3,128	1,156	5,913	254	230
2	-	36,918	-	4,312	24,384	-	-	-	3,136	1,767	1,326	2,392	2,492	828	2,761	2,095	479
3	-	119,198	-	-	7,040	-	-	-	2,646	1,105	1,782	1,872	19,126	-	1,800	9,733	2,459
4	-	4,592	-	4,171	10,366	-	-	-	2,175	972	4,032	954	1,316	1,076	3,408	1,117	564
5	-	-	-	1,962	-	-	-	-	2,499	888	680	510	1,785	981	14	1,404	1,384
6	-	-	-	-	588	-	-	-	166	480	928	1,232	972	264	315	692	586
7	-	-	-	-	158	-	-	-	1,080	714	570	1,030	1,800	-	702	315	710
8	-	-	-	-	123	-	-	-	291	545	248	416	1,220	296	-	603	30
9	-	-	-	-	-	-	-	-	1,197	306	572	708	232	-	172	345	143
10	-	-	-	-	158	-	-	-	117	605	393	224	-	832	1,456	379	45
11	-	-	-	-	-	-	-	-	-	-	345			118	-	169	-
Total (t)	-	169	-	10	43	-	-	-	14	8	11	10	32	6	17	17	7
Landings(t)	637	645	478	862	618	826	994	706	538	552	359	332	335	224	348	520	434
Catches	637	814	478	872	661	826	994	706	552	560	370	342	367	230	365	537	441
Discard %	0%	21%	0%	1%	6%	0%	0%	0%	3%	1%	3%	3%	9%	2%	5%	3%	2%

Table 6.4. Sole 20-24. Sampling and ageing in 2018 from landings.

	Belts			**Skagerrak**			**Kattegat**			**Total**		
Quarter	Landings	Sampled catch (kg)	Aged	Landings	Sampled catch	Aged	Landings	Sampled catch	Aged	Landings	Sampled catch	Aged
1	11,603	-	-	26,796	23,036	33	42,559	37,647	226	80,959	60,683	259
2	15,631	5,671	53	83,854	75,075	29	39,345	19,468	143	138,830	100,214	225
3	10,378	2,031	41	26,688	9,554	54	27,006	8,433	3	64,071	20,018	98
4	22,443	11,964	17	57,662	25,035	-	70,074	62,069	87	150,179	99,068	104
Total	**60,055**	19,666	111	195,000	**132,700**	116	178,984	127,617	459	434,039	279,983	686

Table 6.5. Sole 20-24. Tuning fleets.

Fisherman-DTU Aqua survey meth 6									
2004	2018								
1	1	0.8	1						
1	9								
1	16.81675	55.63244	49.86173	31.46729	21.69616	9.002508	7.380025	4.444972	6.001396
1	12.93771	38.61357	67.95328	36.36597	18.02666	8.16397	2.848377	1.775283	1.420126
1	34.49954	38.78635	28.75918	51.29957	25.71245	13.9948	4.849805	1.591302	5.076621
1	32.0475	33.68539	24.55375	29.82973	31.05507	20.81031	11.94609	7.20201	12.66451
1	10.06202	46.30325	27.801	15.74882	13.38554	17.46229	7.388407	6.721877	7.692608
1	15.82009	13.8231	30.47798	12.87098	16.29397	15.52828	18.99879	7.125988	8.194522
1	13.92305	16.65361	19.71129	18.01859	7.321337	10.3888	8.675918	12.76415	14.76453
1	15.05429	30.23019	18.14685	17.38298	16.10598	10.18371	9.1238	4.181539	19.67623
1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1	22.3673	17.57118	19.50865	14.7055	12.53922	9.709523	4.090422	8.794353	12.48183
1	34.29962	29.30396	17.14458	15.57881	9.772076	17.79977	6.588998	4.828371	31.37076
1	18.24567	38.89483	27.62885	14.87994	14.22831	4.173854	7.880067	4.589344	27.06012
1	10.79649	50.54734	37.52496	24.32936	7.883941	12.43821	2.319349	2.338682	22.41587
1	41.78173	17.7488	39.93127	35.85389	15.6868	6.174575	7.157482	3.119242	21.6421

```
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.

Catch numbers at age Numbers*10**-3

YEAR,	1984,	1985,	1986,	1987,	1988,
AGE					
2,	64,	786,	258,	391,	516,
3,	638,	594,	1255,	857,	1035,
4,	240,	190,	671,	1018,	897,
5,	117,	55,	210,	434,	484,
6,	31,	60,	33,	174,	129,
7,	33,	16,	36,	64,	37,
8,	40,	8,	33,	31,	23,
+gp,	175,	69,	63,	87,	60,
0 TOTALNUM,	1338,	1778,	2559,	3056,	3181,
TONSLAND,	337,	397,	643,	722,	706,
SOPCOF %,	99,	100,	100,	100,	100,

Catch numbers at age Numbers*10**-3

YEAR,	1989,	1990,	1991,	1992,	1993,	1994,	1995,	1996,	1997,	1998,
AGE										
2,	863,	1209,	530,	506,	523,	127,	272,	316,	54,	303,
3,	613,	1300,	1301,	1178,	1804,	1037,	622,	1015,	251,	146,
4,	847,	651,	928,	939,	1251,	1451,	1359,	537,	440,	212,
5,	592,	564,	334,	493,	826,	752,	1226,	691,	365,	299,
6,	404,	310,	345,	320,	418,	444,	600,	440,	505,	267,
7,	83,	167,	302,	178,	117,	152,	385,	232,	360,	250,
8,	30,	27,	180,	166,	137,	45,	142,	148,	262,	218,
+gp,	52,	31,	76,	239,	157,	59,	104,	203,	263,	292,
0 TOTALNUM,	3484,	4259,	3996,	4019,	5233,	4067,	4710,	3582,	2500,	1987,
TONSLAND,	824,	1050,	1011,	1294,	1439,	1198,	1297,	1059,	814,	605,
SOPCOF %,	100,	100,	95,	93,	100,	99,	98,	98,	100,	100,

Numbers*10**-3

YEAR,	1999,	2000,	2001,	2002,	2003,	2004,	2005,	2006,	2007,	2008,
AGE										
2,	249,	142,	170,	655,	48,	195,	231,	122,	293,	313,
3,	826,	483,	369,	758,	431,	602,	1015,	400,	420,	330,
4,	150,	771,	360,	285,	480,	814,	1083,	857,	384,	354,
5,	228,	114,	354,	423,	280,	475,	583,	734,	583,	297,
6,	177,	130,	68,	472,	344,	257,	276,	505,	299,	489,
7,	165,	123,	84,	94,	197,	187,	117,	169,	135,	240,
8,	167,	135,	36,	85,	25,	86,	102,	67,	81,	179,
+gp,	233,	306,	205,	464,	210,	171,	91,	116,	108,	202,
0 TOTALNUM,	2195,	2204,	1646,	3236,	2015,	2787,	3498,	2970,	2303,	2404,
TONSLAND,	638,	646,	476,	862,	619,	824,	990,	836,	633,	656,
SOPCOF %,	100,	100,	99,	100,	100,	99,	98,	98,	97,	102,

Catch numbers at age Numbers*10**-3

YEAR,	2009,	2010,	2011,	2012,	2013,	2014,	2015,	2016,	2017,	2018,

	AGE										
	2,	554,	230,	138,	26,	48,	13,	37,	110,	137,	32,
	3,	683,	591,	558,	157,	226,	66,	81,	273,	181,	131,
	4,	445,	458,	613,	284,	286,	178,	95,	190,	347,	268,
	5,	285,	211,	246,	160,	194,	109,	109,	175,	195,	201,
	6,	139,	132,	65,	111,	137,	199,	89,	82,	186,	97,
	7,	92,	67,	28,	36,	62,	105,	81,	38,	163,	144,
	8,	29,	83,	14,	54,	23,	68,	18,	50,	120,	104,
	+gp,	88,	103,	106,	192,	96,	69,	93,	181,	301,	157,
0	TOTALNUM,	2315,	1875,	1768,	1020,	1072,	807,	603,	1099,	1630,	1134,
	TONSLAND,	640,	541,	507,	358,	332,	331,	215,	348,	520,	434,
	SOPCOF %,	98,	101,	100,	100,	109,	100,	100,	101,	100,	100,

1

Table 6.7. Sole 20-24. Weight at age (kg) in the catch and in the stock.

Catch weights at age (kg)

	YEAR,	1984,	1985,	1986,	1987,	1988,
	AGE					
	2,	.1830,	.1740,	.1650,	.1600,	.1590,
	3,	.2130,	.2340,	.2310,	.1940,	.1970,
	4,	.2570,	.2830,	.2870,	.2450,	.2350,
	5,	.2940,	.2910,	.2970,	.2740,	.2510,
	6,	.2970,	.3350,	.4090,	.3190,	.3350,
	7,	.2800,	.2920,	.2670,	.3600,	.3480,
	8,	.3210,	.2790,	.2620,	.4170,	.3630,
	+gp,	.3680,	.3640,	.3830,	.3610,	.3520,
0	SOPCOFAC,	.9930,	.9984,	.9995,	1.0027,	1.0032,

Catch weights at age (kg)

	YEAR,	1989,	1990,	1991,	1992,	1993,	1994,	1995,	1996,	1997,	1998,
	AGE										
	2,	.1760,	.1800,	.1740,	.2130,	.1780,	.1740,	.1870,	.1760,	.1980,	.1610,
	3,	.2210,	.2280,	.2290,	.2520,	.2240,	.2290,	.2000,	.2180,	.2720,	.2190,
	4,	.2550,	.2510,	.2750,	.3360,	.2740,	.2800,	.2480,	.2670,	.2960,	.3160,
	5,	.2660,	.3080,	.2920,	.4120,	.3280,	.3420,	.2910,	.3070,	.3080,	.3220,
	6,	.2710,	.3330,	.3460,	.4300,	.3740,	.3880,	.3510,	.3390,	.3450,	.3500,
	7,	.3520,	.4000,	.3090,	.4910,	.4030,	.4450,	.3820,	.4040,	.3590,	.3580,
	8,	.3000,	.5470,	.3860,	.5660,	.3880,	.4480,	.4320,	.4570,	.3640,	.3770,
	+gp,	.3550,	.5550,	.5030,	.6220,	.4740,	.3940,	.3830,	.6640,	.3610,	.3270,
0	SOPCOFAC,	.9964,	.9970,	.9508,	.9304,	.9980,	.9931,	.9767,	.9826,	.9983,	1.0006,

Catch weights at age (kg)

	YEAR,	1999,	2000,	2001,	2002,	2003,	2004,	2005,	2006,	2007,	2008,
	AGE										
	2,	.1620,	.1690,	.1840,	.1720,	.1740,	.2030,	.1920,	.2010,	.2110,	.2150,
	3,	.2320,	.2360,	.2420,	.2050,	.2100,	.2370,	.2230,	.2150,	.2280,	.2460,
	4,	.3040,	.3040,	.2900,	.2940,	.2460,	.2910,	.3000,	.2630,	.2950,	.2670,
	5,	.3680,	.3440,	.3780,	.3730,	.3600,	.3280,	.3240,	.3170,	.3020,	.2800,

```
     6,       .3600,  .3190,  .3460,  .3860,  .3820,  .3710,  .3670,  .3390,  .3540,  .2900,
     7,       .3780,  .3640,  .3080,  .2140,  .4310,  .4010,  .3710,  .3210,  .3390,  .2960,
     8,       .3970,  .3520,  .3620,  .2920,  .2610,  .3700,  .4210,  .2930,  .3800,  .3010,
   +gp,       .3500,  .3280,  .2810,  .2760,  .3820,  .3150,  .3720,  .3440,  .2440,  .2460,
0  SOPCOFAC, 1.0041, 1.0004,  .9941,  .9967,  .9971,  .9916,  .9841,  .9794,  .9654, 1.0209,


2  Catch weights at age (kg)
   YEAR,      2009,   2010,   2011,   2012,   2013,   2014,   2015,   2016,   2017,   2018,

   AGE
     2,       .2110,  .2580,  .2610,  .2850,  .2390,  .2270,  .2210,  .2340,  .2160,  .2100,
     3,       .2590,  .2700,  .2710,  .2790,  .2250,  .2830,  .2390,  .2670,  .2650,  .2280,
     4,       .3010,  .2830,  .2920,  .3170,  .2760,  .3720,  .2860,  .2680,  .2920,  .3130,
     5,       .3190,  .3240,  .2770,  .3750,  .3040,  .4210,  .3910,  .2830,  .2990,  .3680,
     6,       .4030,  .3110,  .3580,  .4060,  .3730,  .4430,  .4040,  .3410,  .3260,  .3570,
     7,       .4390,  .3690,  .4760,  .4060,  .3050,  .4860,  .3880,  .3300,  .3770,  .4630,
     8,       .4390,  .3100,  .2850,  .3500,  .3060,  .4540,  .5010,  .5440,  .3340,  .4750,
   +gp,       .2630,  .2630,  .3010,  .4060,  .2870,  .4060,  .4340,  .4390,  .3950,  .5640,
0  SOPCOFAC,  .9832, 1.0103, 1.0003, 1.0006, 1.0891,  .9976, 1.0043, 1.0051, 1.0034, 1.0007,
```

Table 6.8. Sole 20-24. SAM diagnostics. Standard deviation estimates of log observations. (fleet2: Survey, fleet3: PL gill-netters, fleet4: PL trawlers)

Index	Fleet number	Age	Catchability	Low	High
1	2	1	7.87706	5.90958	10.49958
2	2	2	13.97759	10.87531	17.96482
3	2	3	16.76268	13.10083	21.44808
4	2	4	18.34497	14.73190	22.84415
5	2	5	18.34497	14.73190	22.84415
6	2	6	18.34497	14.73190	22.84415
7	2	7	18.34497	14.73190	22.84415
8	2	8	18.34497	14.73190	22.84415
9	2	9	18.34497	14.73190	22.84415
10	3	2	0.06673	0.04753	0.09367
11	3	3	0.29161	0.23239	0.36592
12	3	4	0.32080	0.25554	0.40272
13	3	5	0.30460	0.25887	0.35841
14	3	6	0.30460	0.25887	0.35841
15	3	7	0.30460	0.25887	0.35841
16	3	8	0.30460	0.25887	0.35841

17	4	2	1.60923	1.27178	2.03622
18	4	3	2.96316	2.32732	3.77272
19	4	4	2.83617	2.22424	3.61646
20	4	5	2.86754	2.36767	3.47295
21	4	6	2.86754	2.36767	3.47295

Table 6.9. Sole 20-24. Fishing mortality-at-age (age 6-9 assumed constant).

Year\Age	2	3	4	5	6+
1984	0.084	0.401	0.49	0.405	0.383
1985	0.072	0.295	0.358	0.322	0.278
1986	0.084	0.313	0.41	0.389	0.342
1987	0.102	0.338	0.454	0.464	0.461
1988	0.099	0.31	0.413	0.408	0.4
1989	0.105	0.32	0.431	0.434	0.42
1990	0.098	0.301	0.412	0.415	0.372
1991	0.099	0.305	0.425	0.443	0.49
1992	0.098	0.305	0.426	0.468	0.6
1993	0.098	0.311	0.435	0.491	0.614
1994	0.081	0.26	0.362	0.415	0.453
1995	0.089	0.293	0.393	0.454	0.503
1996	0.085	0.289	0.36	0.409	0.437
1997	0.078	0.258	0.339	0.389	0.432
1998	0.074	0.239	0.318	0.382	0.412
1999	0.069	0.226	0.299	0.351	0.372
2000	0.065	0.218	0.297	0.336	0.367
2001	0.054	0.18	0.236	0.282	0.298
2002	0.062	0.199	0.264	0.329	0.427
2003	0.053	0.163	0.238	0.294	0.383
2004	0.064	0.194	0.291	0.349	0.445
2005	0.074	0.225	0.328	0.378	0.448
2006	0.076	0.232	0.325	0.383	0.381
2007	0.079	0.24	0.326	0.358	0.314
2008	0.092	0.282	0.387	0.392	0.342
2009	0.08	0.267	0.373	0.338	0.196
2010	0.073	0.27	0.377	0.331	0.176
2011	0.055	0.216	0.327	0.263	0.129
2012	0.044	0.164	0.273	0.228	0.149

Year\Age	2	3	4	5	6+
2013	0.039	0.144	0.253	0.218	0.155
2014	0.032	0.107	0.208	0.193	0.161
2015	0.029	0.094	0.171	0.187	0.139
2016	0.04	0.125	0.232	0.257	0.206
2017	0.056	0.159	0.32	0.374	0.389
2018	0.030	0.078	0.177	0.218	0.255

Table 6.10. Sole 20-24. Stock number-at-age from assessment.

Year\Age	1	2	3	4	5	6	7	8	9+
1984	6328	2613	1605	509	366	135	80	126	478
1985	5294	5912	2321	921	266	221	90	46	352
1986	4879	4708	4941	1640	592	174	145	70	267
1987	4410	4429	3923	3256	979	360	123	92	222
1988	5891	3719	3804	2715	1872	492	177	71	180
1989	7496	5378	2703	2578	1684	1162	268	102	149
1990	7555	7073	4413	1763	1578	1014	702	146	143
1991	8377	6720	5618	2861	1038	940	666	467	189
1992	6456	8093	5467	3536	1583	588	511	370	392
1993	3687	6166	6889	3672	2126	886	286	262	368
1994	3469	3049	5252	4829	2224	1221	418	141	296
1995	2295	3344	2650	3937	3131	1450	766	267	281
1996	1628	2051	2883	1874	2419	1747	860	432	370
1997	3550	1204	1459	1723	1248	1510	1120	618	541
1998	3649	3678	896	958	989	778	855	688	735
1999	3183	3401	3610	645	729	613	521	524	882
2000	4437	2647	2685	2515	435	504	372	362	954
2001	5780	4064	2200	1961	1590	297	371	214	891
2002	4574	5721	3759	1565	1492	1141	223	269	825
2003	4628	3960	4402	2714	1139	1035	626	119	627

Year\Age	1	2	3	4	5	6	7	8	9+
2004	3150	4498	3801	3296	1748	751	578	341	431
2005	2701	2874	4545	3338	2207	990	377	293	352
2006	3128	2476	2312	3438	2144	1413	561	230	412
2007	3381	2670	2005	1624	2184	1089	791	355	470
2008	2355	3164	1938	1434	1080	1393	670	537	575
2009	2283	2190	2623	1274	988	686	895	386	673
2010	2074	2103	2008	1765	758	655	450	677	804
2011	1797	1914	1916	1488	1143	490	461	282	1115
2012	1606	1576	1552	1433	943	812	343	371	1096
2013	1668	1414	1392	1224	1042	677	633	246	1002
2014	2618	1401	1200	1035	856	793	468	525	895
2015	3272	2399	1211	1040	719	664	566	315	1206
2016	2960	2949	2204	1019	931	513	460	410	1310
2017	2179	2852	2505	1763	740	763	405	339	1345
2018	3485	1824	2406	2058	1228	498	547	297	1122
2019*		3153	1603	2014	1559	894	349	384	995

***Estimated by simple forward projection of 2018 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	6328	3965	10098	1717	1411	2090	859	696	1061	0.404	0.305	0.535
1985	5294	3529	7944	2469	1990	3064	1122	903	1395	0.312	0.237	0.411
1986	4879	3307	7197	3087	2553	3733	2018	1619	2514	0.369	0.29	0.469
1987	4410	2891	6726	3078	2614	3625	2104	1751	2529	0.456	0.358	0.58
1988	5891	3987	8704	3118	2674	3635	2173	1835	2572	0.407	0.319	0.518
1989	7496	5059	11106	3592	3075	4196	2196	1873	2574	0.419	0.331	0.53
1990	7555	5127	11134	4439	3782	5209	2712	2313	3181	0.387	0.308	0.487
1991	8377	5515	12725	4855	4149	5681	3183	2696	3758	0.463	0.374	0.575
1992	6456	4325	9637	6286	5346	7392	4175	3553	4905	0.53	0.426	0.66
1993	3687	2505	5427	5289	4525	6181	3970	3357	4693	0.533	0.423	0.672
1994	3469	2373	5070	4893	4230	5660	4155	3555	4856	0.417	0.331	0.527
1995	2295	1531	3442	4205	3675	4811	3442	2985	3969	0.451	0.359	0.566
1996	1628	988	2682	3713	3253	4237	3254	2836	3734	0.404	0.326	0.502
1997	3550	2357	5348	3086	2710	3514	2635	2293	3027	0.399	0.322	0.494
1998	3649	2495	5338	2707	2348	3121	1896	1633	2200	0.378	0.302	0.473
1999	3183	2131	4754	2978	2554	3473	2236	1902	2628	0.346	0.278	0.432
2000	4437	3038	6481	2998	2592	3467	2284	1953	2672	0.339	0.271	0.423
2001	5780	3887	8597	3341	2883	3872	2247	1934	2611	0.286	0.226	0.362
2002	4574	3123	6701	3840	3259	4526	2582	2192	3040	0.375	0.297	0.473
2003	4628	3119	6868	3905	3386	4502	2938	2499	3453	0.348	0.269	0.451
2004	3150	2230	4451	4307	3743	4957	3205	2767	3712	0.398	0.313	0.506
2005	2701	1897	3844	4201	3621	4874	3487	2981	4079	0.405	0.32	0.511
2006	3128	2167	4514	3635	3107	4252	2949	2500	3479	0.365	0.29	0.459
2007	3381	2360	4845	3265	2811	3793	2499	2138	2921	0.319	0.248	0.409
2008	2355	1620	3426	2889	2455	3398	2067	1744	2449	0.342	0.262	0.445
2009	2283	1592	3273	2993	2512	3566	2394	1977	2899	0.249	0.189	0.33
2010	2074	1440	2985	2745	2290	3291	2078	1709	2527	0.235	0.177	0.312

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F48	Low	High
2011	1797	1218	2651	2689	2209	3274	2082	1691	2562	0.188	0.141	0.252
2012	1606	1057	2440	2830	2304	3476	2284	1839	2838	0.181	0.135	0.243
2013	1668	1096	2537	2214	1801	2721	1776	1427	2209	0.174	0.13	0.233
2014	2618	1800	3808	2741	2249	3340	2266	1837	2794	0.163	0.122	0.217
2015	3272	2199	4870	2763	2265	3371	2037	1647	2519	0.139	0.103	0.189
2016	2960	1988	4409	3473	2831	4261	2250	1822	2780	0.178	0.135	0.236
2017	2179	1353	3510	3454	2792	4273	2446	1972	3034	0.261	0.193	0.353
2018	3485	1732	7011	3860	3005	4959	2850	2229	3643	0.232	0.167	0.324

Table 6.12. Sole 20-24. Basis for forecasts and management options table for short-term predictions.

Variable	Value	Notes
F ages 4–8 (2019)	0.23	F corresponding to a TAC of 502 t in 2019
SSB (2020)	3065 tonnes	Fishing at F=0.23 in 2019
Rage1 (2019-2020)	2618 thousands	Resampled from recent recruitment (2004-2018)
Wanted catch (2019)	482 tonnes	Based on the TAC and mean discard rate
Unwanted catch (2019)	20 tonnes	Mean discard rate in weight (2014-2018) of 4%.
Total catch (2019)	502 tonnes	Corresponding to a TAC of 502 t.

Basis	Total catch * (2020)	Wanted catch ** (2020)	Unwanted catch ** (2020)	F_{wanted} (2020)	SSB (2021)	% SSB change ***	% TAC change ^	% Advice change ^^
ICES advice basis								
EU MAP#: F_{MSY}	539	518	21	0.23	3081	1%	3%	12%
EU MAP#: F_{lower}	452	435	17	0.19	3168	3%	-13%	11%
EU MAP#: F_{upper}	600	577	23	0.26	3019	-2%	15%	11%
Other scenarios								
F = 0	0	0	0	0	3631	18%	-100%	-100%
F_{pa}	539	518	21	0.23	3081	1%	3%	12%
F_{lim}	710	683	27	0.315	2902	-5%	36%	47%
SSB (2021) = B_{lim}	1758	1690	68	1.07	1848	-40%	237%	288%
SSB (2021) = B_{pa}	1015	976	39	0.49	2620	-15%	94%	110%
SSB (2021) = MSY $B_{trigger}$	1015	976	39	0.49	2620	-15%	94%	110%
F = F_{2019}	539	518	21	0.23	3081	1%	3%	12%

*** 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).**

**** “Wanted” and “unwanted” catch are used to describe fish that would be landed and discarded in the absence of the EU landing obligation, based on discard rate estimates for 2014–2018.**

***** SSB 2021 relative to SSB 2020.**

^ Wanted catch in 2020 relative to TAC in 2019 (502 t).

^^ Advice value 2020 relative to advice value 2019 (483 t).

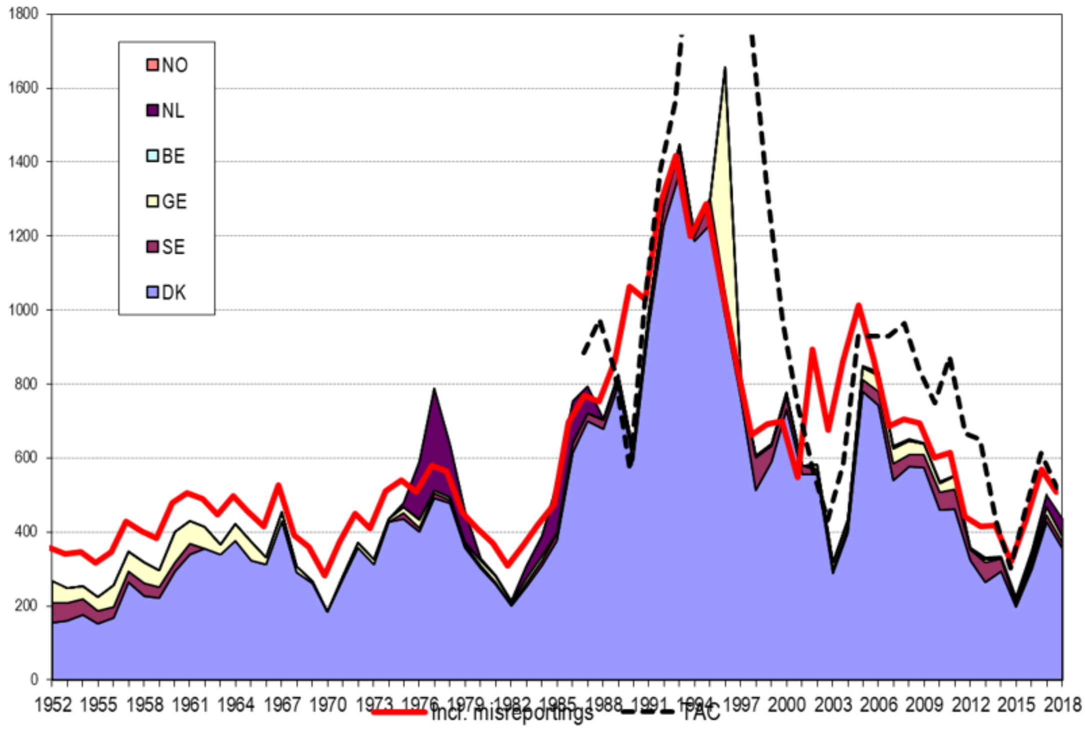


Figure 6.1. Sole 20-24. Landings of sole in Skagerrak and Kattegat (IIIa) by nation since 1952. Bold red line indicate estimated total landings including misreportings as estimated by the WG and dashed black-bold line is TAC.

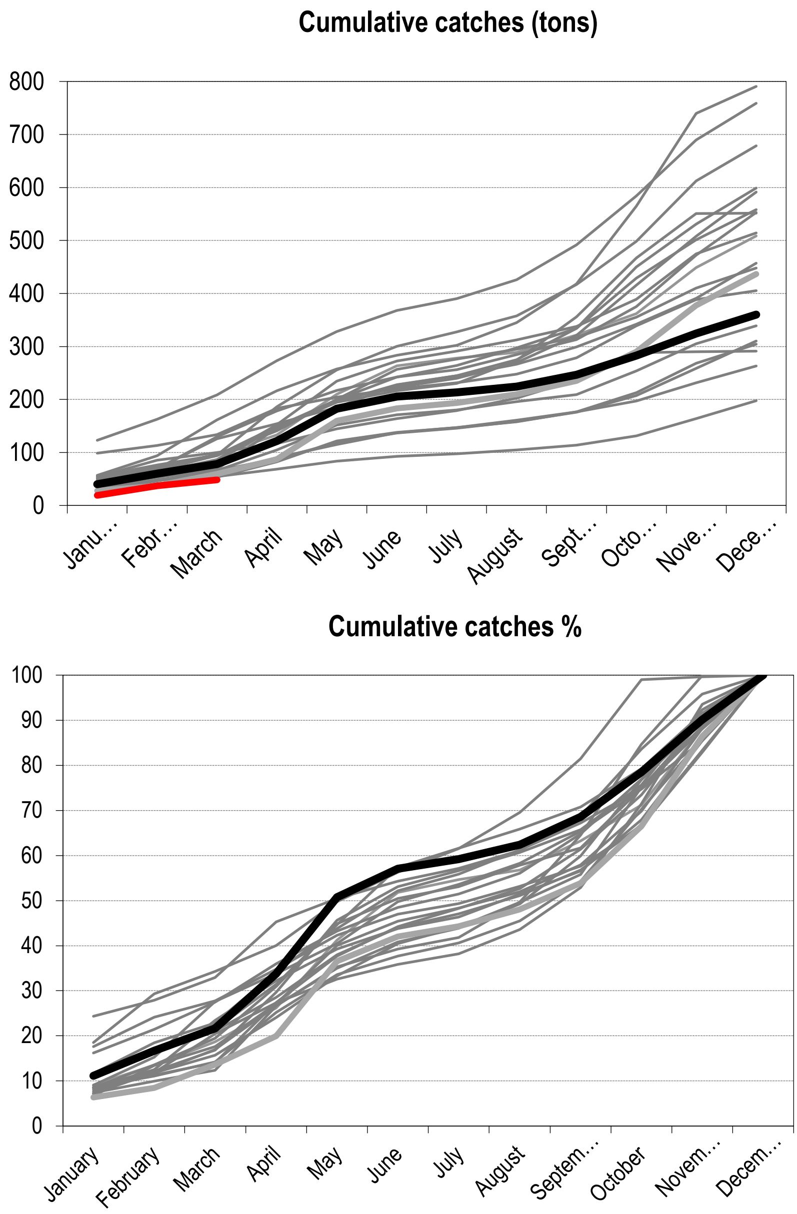


Figure 6.2. Sole 20-24. Cumulative Danish landings of sole by month. Black bold curve is 2017 and red bold curve is 2018 including March.

Figure 6.3. Sole 20-24. Standardized age aggregated CPUE indices of sole from private logbooks from trawlers , private logbooks gillnetters and Fisherman/DTU Aqua survey as used in the assessment.

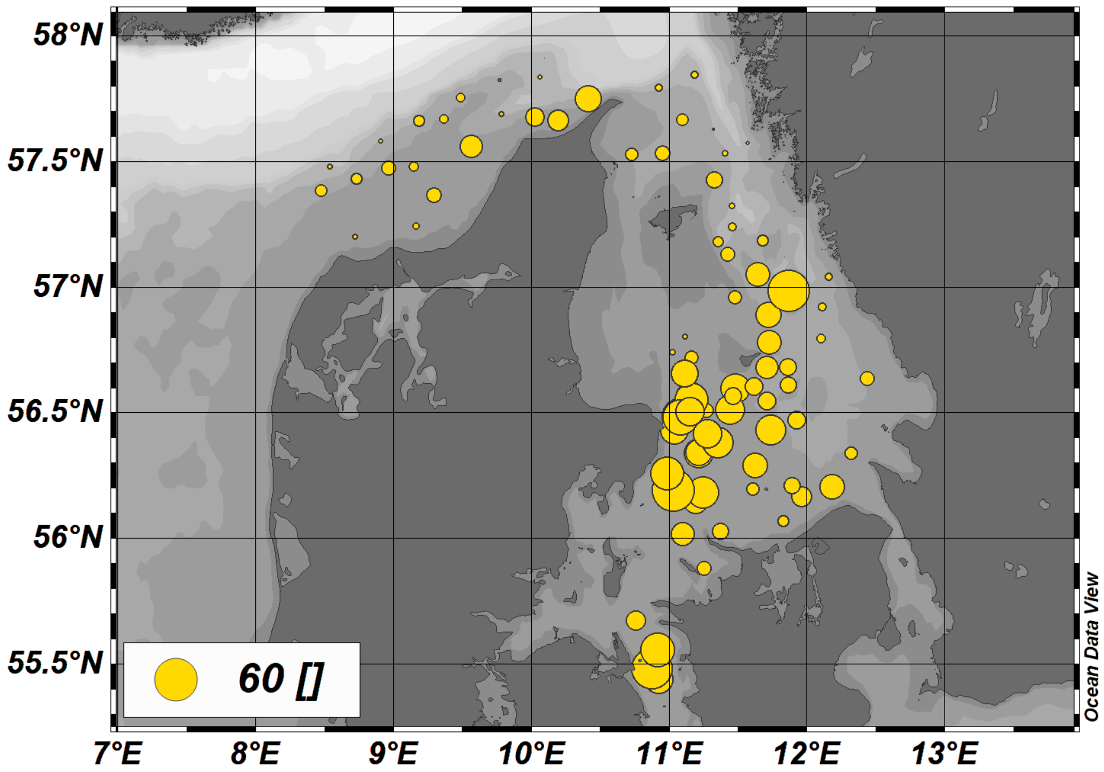


Figure 6.4. 20-24. Fisherman-DTU Aqua survey. Distribution and catch rates of stations in 2018.

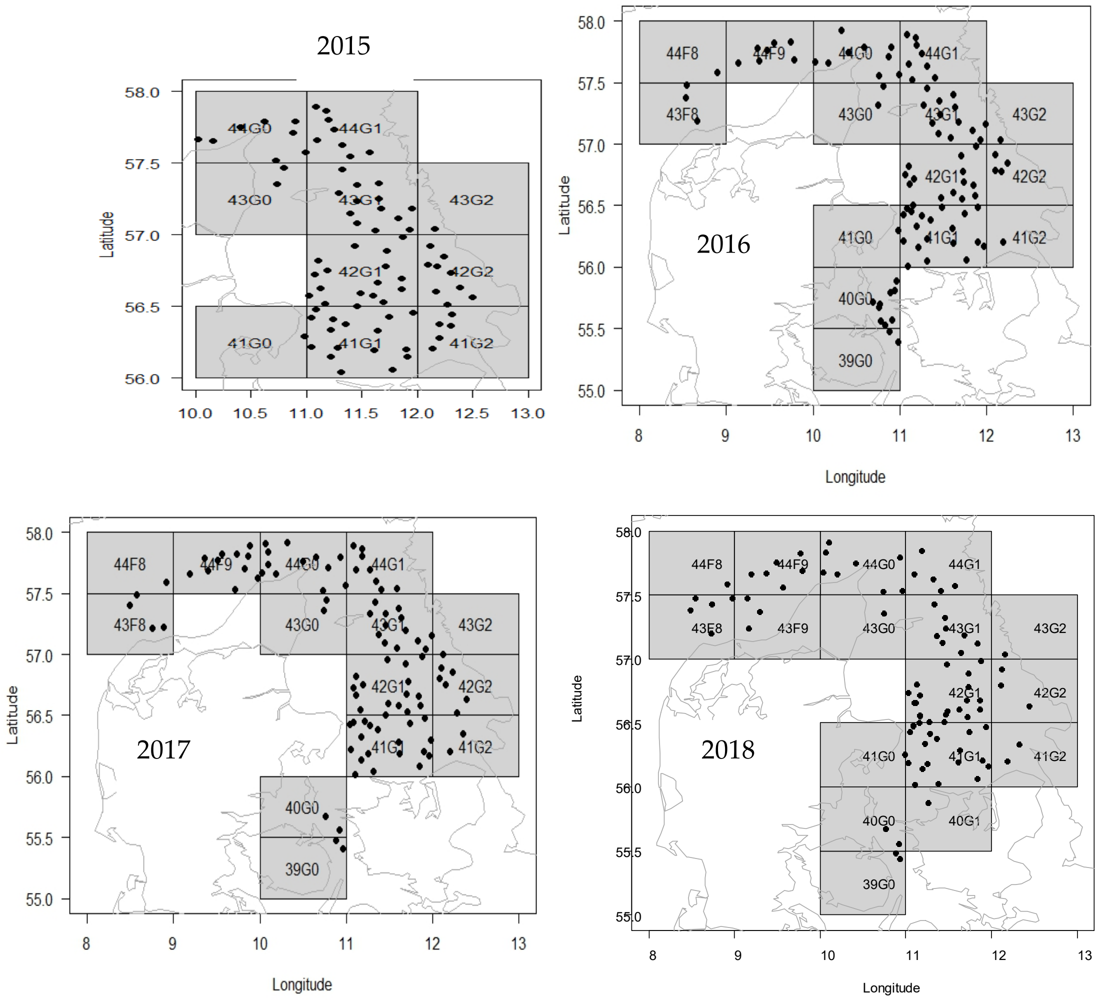


Figure 6.5. Sole 20-24. Map of sole survey station distribution in 2015–2018, illustrating the extended survey area (Subdivisions 20 and 22) since 2016.

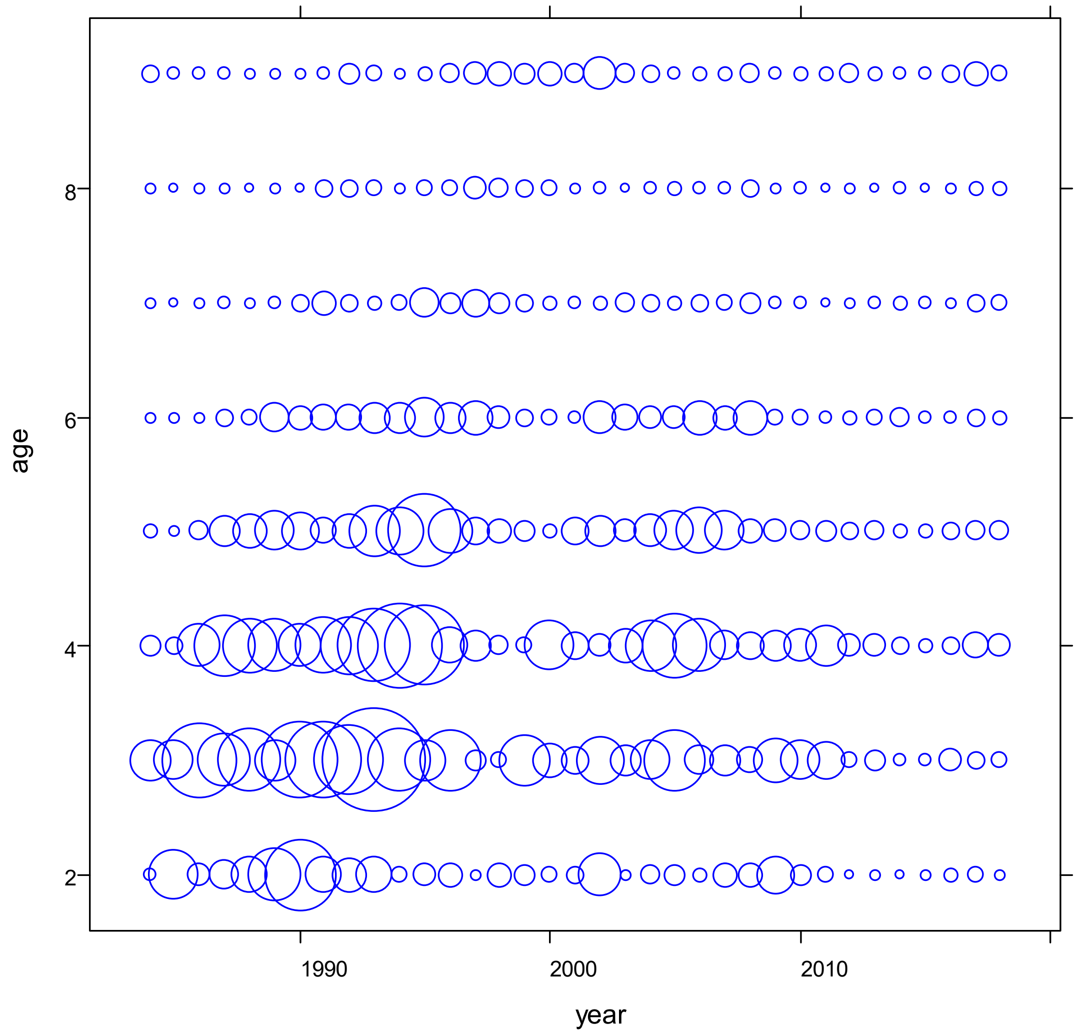


Figure 6.6. Sole 20-24. Catch numbers-at-age.

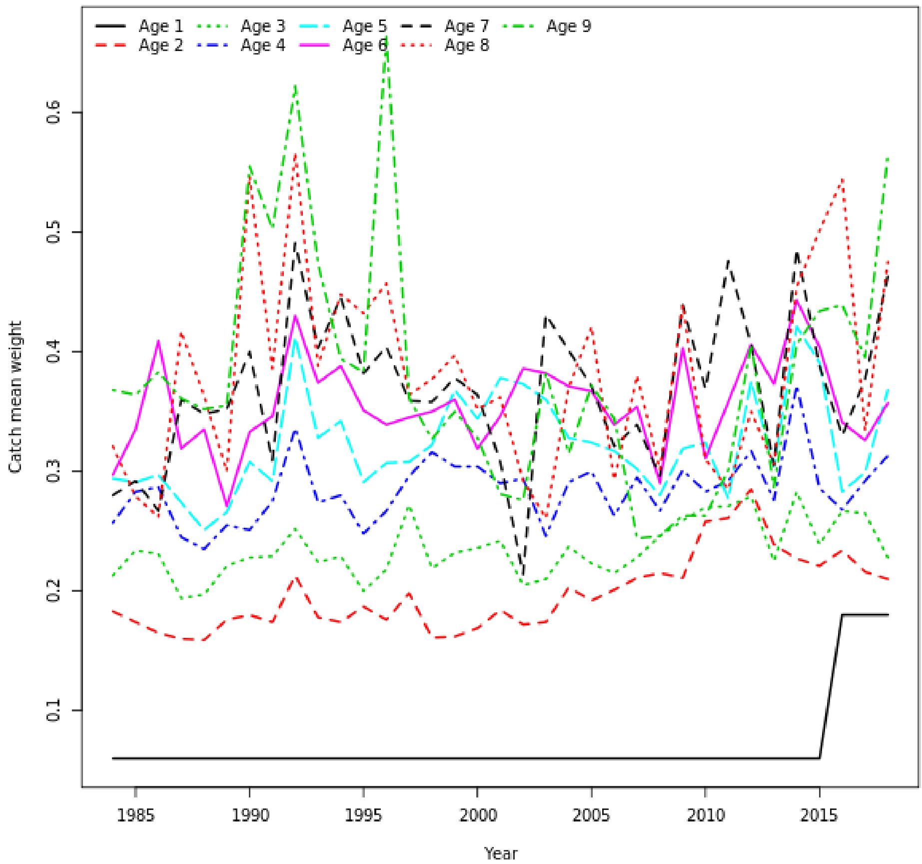


Figure 6.7. Sole in 20-24. Catch weight-at-age.

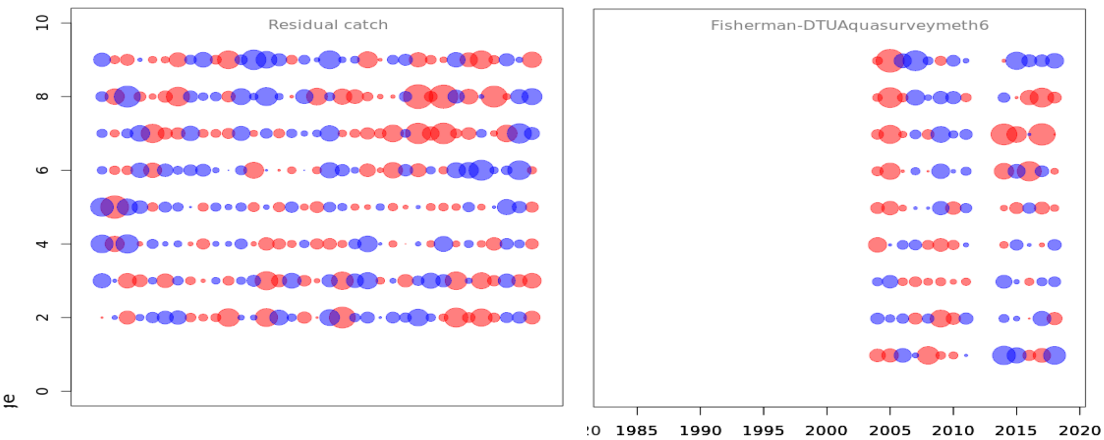


Figure 6.8. Sole 20-24. Model residuals for landings and survey.

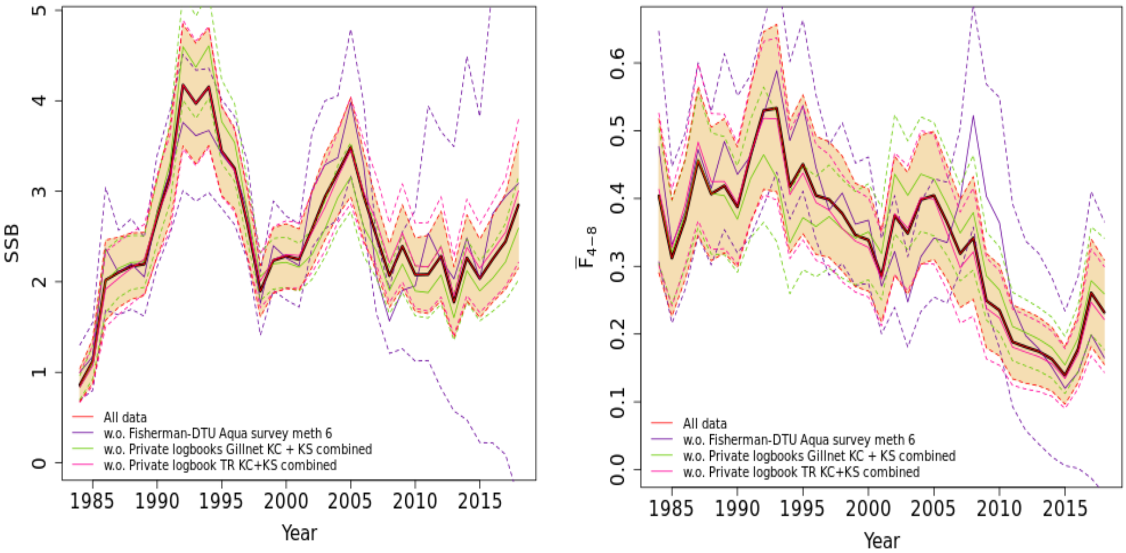


Figure 6.9. 20-24. Fleet sensitivity. Estimated SSB, and fishing mortality from runs leaving single fleets out. Recruitment (age 1) plot is not possible to provide since only the survey contains age 1 group.

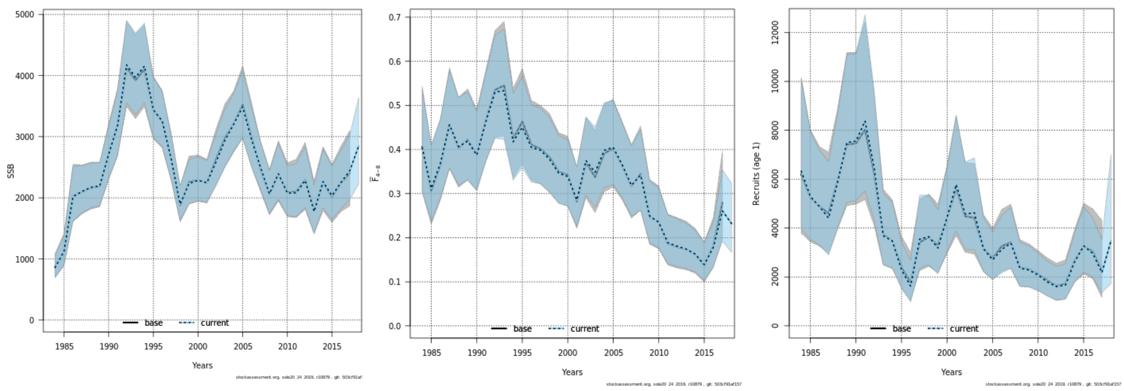


Figure 6.10. Sole 20-24. Stock summary; SSB, F(4-8) and R (age 1) compared to last year's assessment.

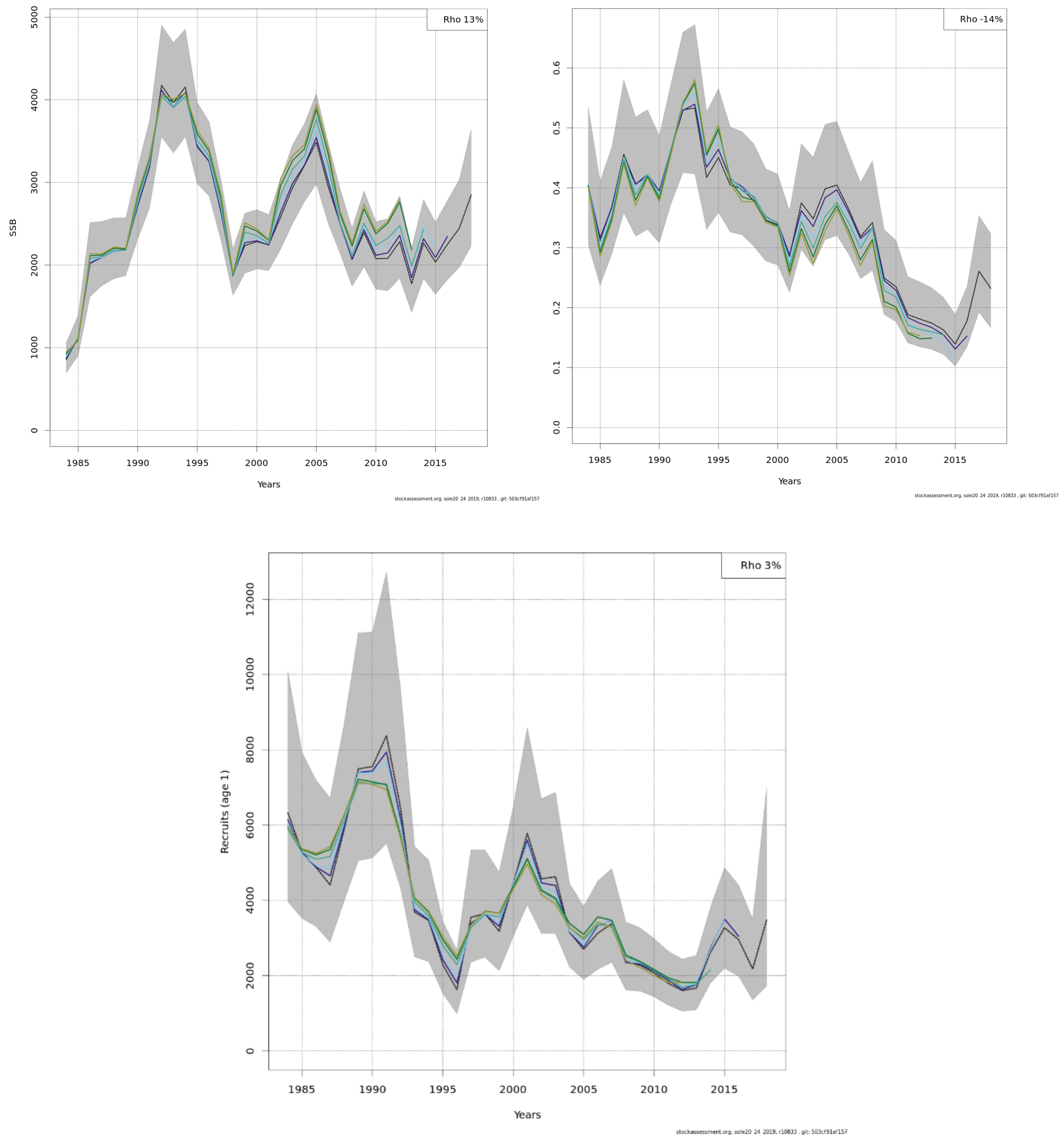


Figure 6.11. Sole 20-24. Retrospective analyses. Upper: SSB and F, lower: R. Confidence limits are provided for the 2018 scenario.

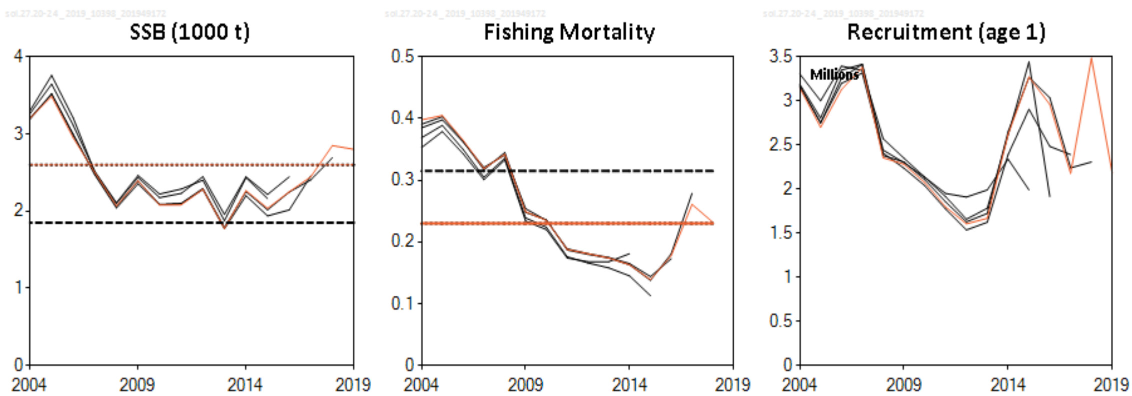


Figure 6.12. Sole 20-24. Historical performance of F, SSB and recruitment.

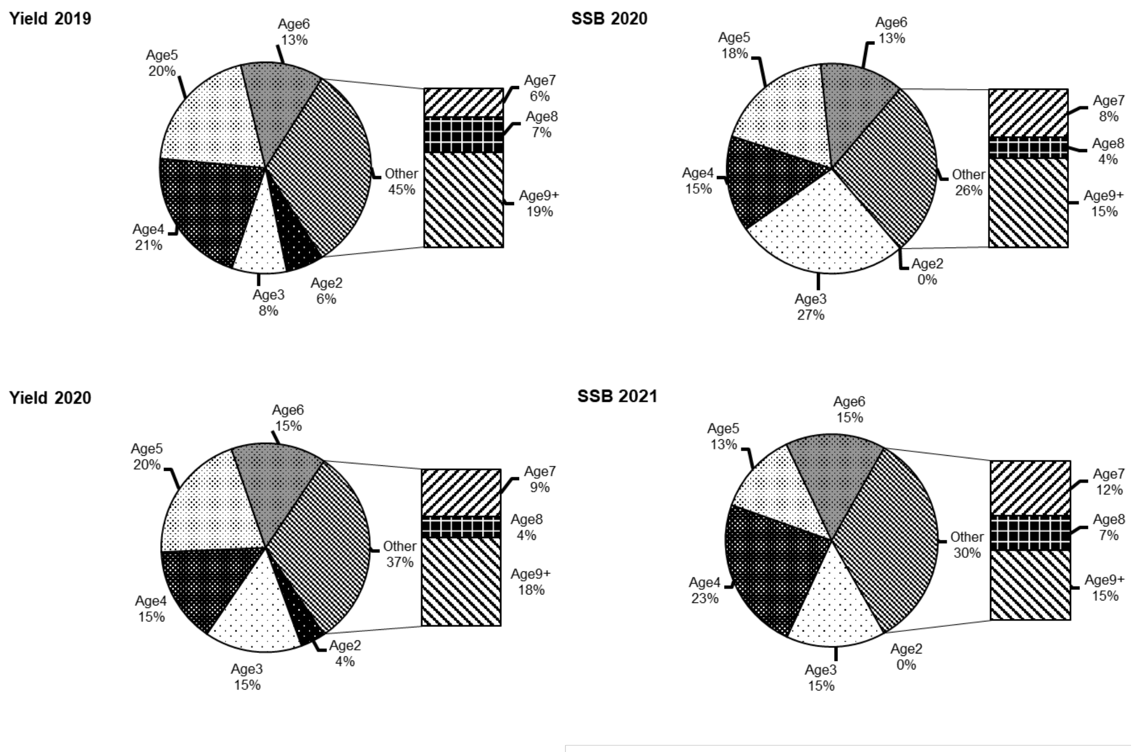


Figure 6.13. Sole 20-24. Short-term forecast for 2019-2021. Yield and SBB at age 2-9+ for TAC constrained fishing mortality in 2019.

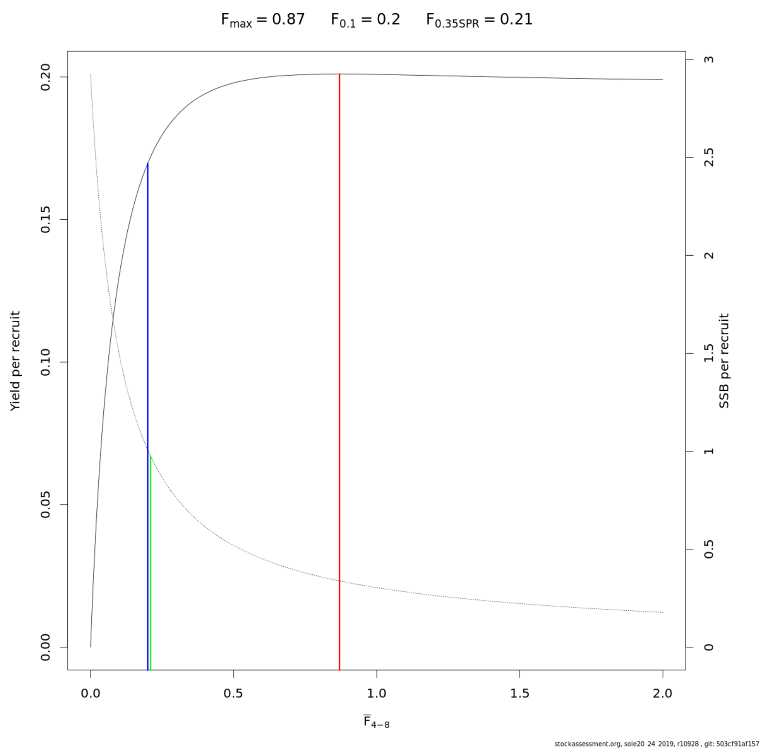


Figure 6.14. Sole 20-24 Yield-per-recruit curve and reference point estimates (red=F_{max}, green=F_{35}%SPR and blue=$F_{0.1}$)

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) was provided in the Report from WGBFAS meeting in 2017 (ICES, 2017).

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 2018 were 308 827 t, which is 8% more than in 2017 and 42% less than the record high value of 529 400 t in 1997. In 2018 total TAC set by the EU plus the Russian autonomous quota was 304 900 t, which was utilized in 101%. The largest increase in catches was observed for Lithuania (30%), followed by Estonia and Poland (16% for both). At the same time the Demarks catches decreased by 9% compared to 2017.

The spatial distribution (by subdivision) of sprat catches was similar to previous years. Subdivision 26 dominated the catches with a 39% share in the sprat catch. Other important areas are subdivisions 28, 25, and 29 (24, 17, and 9%, 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 2001–2018. 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 fishmeal 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 two 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, 2017, and 2018 into the InterCatch – 563, 482 and 335 kg, respectively from the 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, 2017, and 2018. Russia provided the updated data on fishing effort and CPUE for Subdivision 26 in 1995–2018 (Table 7.4). These data indicate increase in CPUE in 1995–2004 and stable CPUE in 2005–2011, followed by a stable CPUE at a higher level in 2012–2017. In 2018 the Russian effort was much higher compared to the previous years. At the same time the CPUE was somewhat lower again. The dynamics of this CPUE does not reflect the stock size estimates from the analytical models (XSA or SAM). 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 13% of the total. All German catches (100%) were landed in foreign ports but also these were very well sampled, resulting that 93% 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 fishmeal fishery. In some fisheries the catch species composition is not very precise.

The estimated catch-at-age in numbers is presented in Tables 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 (Tables 7.7a and 7.7b). The consistency of the weight-at-age estimates was explored and it is of the similar quality as consistency of catch-at-age data (the correlation between mean weight at a given age and the mean weight of the same generation 1 year later is high and exceeds 0.9 in most cases).

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 2012–2018 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 have not been 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 analytical estimates of cod SSB from last accepted assessment. 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.

This year new analytical assessment of cod stock have been performed and it is expected than in next years such assessments will form the basis for predation mortality estimates.

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 M and F 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 logbook 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 bycatches 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 2018 by quarter, ICES subdivision, and country is presented in Table 7.5. These data show that generally in 2018 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, number of length measurements, and number of age readings was 3-5 times higher than indicated in the directive.

7.3 Fishery-independent information

Two tuning datasets covering subdivisions 22–29 were available: from Baltic International Acoustic Survey (BIAS) in autumn in 1991–2018 and one covering subdivisions 24–26 and 28 from international Baltic Acoustic Spring Survey (BASS) in May in 2001–2018 (Tables 7.12–7.14). The survey data were corrected for area coverage (WGBIFS, ICES, 2019). 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 parameterization of XSA were the same as specified in the benchmark assessment:

1. tricubic time weightingm
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 residuals are moderately noisy and slightly lower for October fleet (SE of log q = 0.3-0.40) than for the May survey (SE's range of 0.35–0.5). 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 0.35). The correlations between XSA estimates and survey indices are quite 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 recent assessments (following exclusion of the 2016 data from this survey) the survivors estimated by May survey have bigger variance and the October survey gets higher weight (mostly 50–55%). The weight of estimates resulting from shrinkage is low (up to 6%) (Figure 7.7a). The survey estimates of survivors are quite consistent at most ages – consistency is somewhat lower at age 1, where estimate based on May survey diverge from estimate using October and Age0 surveys (Figure 7.7b). The estimates based on Age0 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 -0.22, 0.21, and 0.07 respectively for F, SSB, and recruitment.

The fishing mortalities, stock numbers and summary of assessment are presented in Tables 7.16–7.18. Fish stock summary plots and stock–recruitment relationship are presented in Figures 7.9 and 7.10.

Trends in the survey indices of stock size and XSA estimates of stock biomass are quite consistent (Figure 7.12).

7.4.2 Exploration of SAM

The SAM model was attempted at benchmark workshop as the second assessment model for sprat. This year SAM estimates have been updated. Results of SAM parameterised in similar way as XSA are compared with XSA estimates in Figure 7.11a. The XSA and SAM estimates of SSB, F, and recruitment for 2018 are very similar and the XSA estimates are contained within SAM confidence intervals. 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.

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 2018 year class was estimated at 60 billion individuals, ca. 30% below the average.

7.4.4 Historical stock trends

In the 1990s the SSB exceeded 1 million tonnes, being record high in 1996–1997 (about 1.9 million tonnes). These values were several times higher than the SSB estimates of 300 000 t in the early 1980s. Since 1997 the SSB has been generally decreasing, and reached 0.7 million tonnes in 2013-2014. The strong year class 2014 has led to marked increase of stock biomass in 2016–2018. The estimate of SSB for 2019 is 1.1 million tonnes. 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, 2018).

7.5 Short-term forecast and management options

The RCT3 program estimate of the 2018 year class at age 1 was used in the predictions. The 2019 and 2020 year classes were assumed as geometric mean of the recruitment-at-age 1 in 1991–2018 (period of recruitment fluctuations without clear trend, the 2018 value is well estimated in the assessment). The natural mortalities and mean weights-at-age were assumed as averages of 2016–2018 values. The fishing pattern was smoothed as the average F at-age in 2016–2018 scaled to the F consistent with TAC constraint in 2019 (TAC defined as EU quota of 270.8 kt and Russian quota of 42.3 kt). Input data for catch prediction are presented in Table 7.21.

Prediction results with TAC constraint are shown in Table 7.22a. In addition, prediction option with F_{sq} in 2019 was performed (Table 7.22b); that produced catches in 2019 at 291 kt, 7% lower than the TAC. The differences between two predictions are small, e.g. difference between total biomass in 2020 is below 1%. The group considers TAC constraint prediction as basis for the advice.

In Figure 7.13 the sensitivity of the projection to the assumed strength (GM) of the 2019 and 2020 year classes and the estimate of 2018 year class is presented. The assumed level of the 2019 year class contributes in 9% to the predicted catch in 2020 and with assumed level of the 2020 year class contributes in 42% to SSB in 2021.

7.6 Reference points

Up to 2012 the PA software (Cefas, Lowestoft) was used to estimate biological reference points. The estimated F_{med} (used by ACFM as a basis for 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.

During the benchmark assessment the BRPs were estimated 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 F_{MSY} 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 F_{lower}	F_{MSY}	MSY F_{upper} with AR	MSY $B_{trigger}$ (thousand t)	MSY F_{upper} with no AR
Sprat in subdivisions 22–32 (Baltic Sea)	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 (42%) 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.

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 2018 and 2019 assessments is presented in the text table below. The XSA settings were the same in both years.

Category	Parameter	Assessment 2018	Assessment 2019	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, M2012-2017 estimated from regression of M against cod SSB	M in 1974–2011 estimated in SMS, M2012- M2018 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	No
		Acoustic on age 0 (subdiv. 22–29)	Acoustic on age 0 (subdiv. 22–29)	No
XSA results	SSB 2017 (million t)	1.3	1.17	-10%
	TSB 2017 (million t)	1.98	1.77	-10%
	F(3-5) 2017	0.28	0.32	15%
	Recruitment (age 1) in 2017 (billions)	80.1	68.0	-15%

7.9 Management considerations

There is an 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 F_{MSY} 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. At 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, following high catches and varying recruitment, SSB declined to 0.7 million tonnes in 2013–2014. Very strong year class of 2014 has led to marked increase in stock size, SSB reached 1.2 million tonnes in 2016–

2017 and is predicted to stay above 1 million tonnes until 2021 if it is exploited at F_{MSY}. After 2000 fishing mortality increased and next fluctuated, exceeding F_{lim} in several years. In recent years F declined towards the F_{pa}. Among the year classes 2009–2018 only one (2014) was strong, which contributed to previous stock decline.

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
2017	27,1	25,3	16,1	13,6	35,7	12,5	68,4	38,7	48,3	285,7
2018	24,6	29,3	16,4	15,2	37,1	16,2	79,4	41,4	49,1	308,8

* 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**
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**

Continued

Table 7.2. Sprat landings in the Baltic Sea by country and Subdivision (thousand tonnes). (2/3)

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

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

Continued

Table 7.2. Sprat landings in the Baltic Sea by country and Subdivision (thousand tonnes). (3/3)

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			0,1
Estonia	**28,5**				0,00	0,0		1,1	9,9			17,5
Finland	**11,7**						0,2	0,1	2,8	2,80	0,001	5,8
Germany	**10,2**	0,60		0,04	2,62	2,2	0,6	1,5	2,6			
Latvia	**30,8**				0,27	2,9		27,6				
Lithuania	**9,6**				0,65	3,5	0,0	4,5	0,9			
Poland	**56,9**			1,49	21,83	31,2	0,2	2,1	0,1			
Russia	**23,4**					23,4						
Sweden	**46,0**			0,04	8,27	6,4	6,3	11,0	12,8	0,25		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		
Estonia	**24,0**				0,490		0,205	1,378	6,807			15,073
Finland	**12,0**				0,354		0,482	0,082	4,396	2,027	0,0003	4,619
Germany	**10,3**	0,657		0,071	2,680	0,851	0,294	4,671	1,068			
Latvia	**30,5**				0,527	2,716		27,067	0,182			
Lithuania	**11,0**				4,355	0,782		5,117	0,749			
Poland	**62,2**			2,715	26,122	33,004	0,001	0,387				
Russia	**30,7**					30,694						
Sweden	**44,1**			0,059	5,857	0,957	13,320	11,212	12,544	0,181		
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			
Estonia	**23,7**				0,535		0,104	4,780	4,702			13,566
Finland	**16,9**				0,274		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			
Latvia	**28,1**				1,390	1,789		24,922				
Lithuania	**11,6**				4,063	1,039	0,054	5,126	1,275			
Poland	**59,3**			3,703	24,620	28,475	0,313	1,587	0,560			
Russia	**34,6**					34,588						
Sweden	**42,4**			0,032	5,506	5,862	5,719	13,958	10,919	0,435		
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**

Year 2017

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	**27,1**	1,158		1,030	5,657	8,056	3,703	4,991	2,522			
Estonia	**25,3**							1,925	9,719			13,640
Finland	**16,1**				0,353	0,127	0,959	1,008	7,766	2,307	0,001	3,576
Germany	**13,6**	0,688		0,165	1,046	7,293		2,326	2,035			
Latvia	**35,7**				2,372	2,195		31,175				
Lithuania	**12,5**				3,107	3,444	0,526	4,406	0,996			
Poland	**68,4**			4,196	24,900	34,587	0,743	3,406	0,598			
Russia	**38,7**					38,683						
Sweden	**48,3**			0,150	6,013	12,369	11,553	11,894	6,284	0,052		
Total	**285,7**	**1,8**	**0,0**	**5,5**	**43,4**	**106,8**	**17,5**	**61,1**	**29,9**	**2,4**	**0,001**	**17,2**

Year 2018

Country	Total	22	23	24	25	26	27	28	29	30	31	32
Denmark	**24,6**	4,461		0,119	5,700	6,323	0,517	6,145	1,326			
Estonia	**29,3**							4,066	11,430			13,845
Finland	**16,4**			0,081	0,191	1,234	0,343	2,186	7,049	2,010	0,011	3,326
Germany	**15,2**	1,419		0,104	0,898	7,828	0,558	3,635	0,771			
Latvia	**37,1**				1,588	4,211		31,301				
Lithuania	**16,2**				3,410	8,201		4,246	0,392			
Poland	**79,4**			1,971	32,904	42,147		2,349	0,025			
Russia	**41,4**					41,374						
Sweden	**49,1**			0,116	6,506	9,471	5,938	19,007	7,869	0,057	0,170	
Total	**308,8**	**5,9**	**0,0**	**2,4**	**51,2**	**120,8**	**7,4**	**72,9**	**28,9**	**2,1**	**0,181**	**17,2**

Table 7.3. Sprat in SD 22–32. Catch in numbers and weight-at-age by quarter and Subdivision in 2018 (1/4)

Sub-division 22

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.5	5.6	6.0			6.1	6.1
1	110.9	0.0	0.2	2.1	113.1	6.2		8.3	8.3
2	265.8	0.0	0.4	4.3	270.5	13.2		12.6	12.6
3	41.2	0.0	0.5	5.7	47.4	15.1		14.9	14.9
4	36.7	0.0	0.4	5.2	42.3	15.9		15.6	15.6
5	7.6	0.0	0.1	1.3	9.0	17.5		16.8	16.8
6	1.9	0.0	0.0	0.2	2.1	17.6		17.2	17.2
7	0.0	0.0	0.0	0.1	0.1			18.5	18.5
8	0.0	0.0	0.0	0.0	0.0			18.5	18.5
9	0.0	0.0	0.0	0.0	0.0				
10	0.0	0.0	0.0	0.0	0.0				
Sum	464.2	0.0	2.1	24.4	490.7				
SOP	5570.1	0.0	25.2	298.2	5893.5				
Catch	5556.6	0.0	25.2	298.4	5880.2				

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	1.1	7.7	8.8			6.1	6.1
1	2.2	1.8	0.4	2.9	7.3	7.1	7.1	8.3	8.3
2	10.6	8.8	0.8	6.0	26.2	12.8	12.8	12.6	12.6
3	16.8	13.9	1.1	7.9	39.7	15.4	15.4	14.9	14.9
4	24.9	20.7	1.0	7.2	53.8	16.4	16.4	15.6	15.6
5	8.9	7.3	0.3	1.8	18.3	17.4	17.4	16.8	16.8
6	3.3	2.7	0.0	0.2	6.2	18.8	18.8	17.2	17.1
7	0.6	0.5	0.0	0.1	1.2	22.4	22.4	18.5	18.5
8	0.0	0.0	0.0	0.1	0.1			18.5	18.5
9	0.0	0.0	0.0	0.0	0.0				
10	0.0	0.0	0.0	0.0	0.0				
Sum	67.3	55.7	4.8	33.9	161.6				
SOP	1048.0	867.6	58.0	413.5	2387.1				
Catch	1049.6	868.9	58.0	413.7	2390.2				

Continued

Table 7.3. Sprat in SD 22–32. Catch in numbers and weight-at-age by quarter and Subdivision in 2018. (2/4)

Sub-division 25

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	14.8	110.6	125.5			5.4	5.2
1	227.3	168.2	15.5	50.1	461.0	4.7	4.1	10.6	10.1
2	222.9	215.9	19.7	92.3	550.8	10.0	9.1	12.5	12.0
3	410.6	291.0	34.0	133.4	868.9	11.4	10.3	13.5	13.1
4	917.4	918.5	50.8	168.8	2055.5	12.4	11.0	14.0	13.2
5	213.8	139.8	12.1	27.2	392.9	13.7	13.5	14.7	13.9
6	67.3	42.8	4.0	11.8	125.9	15.4	14.0	14.9	14.5
7	40.6	9.5	1.0	1.2	52.3	15.6	15.2	17.2	16.5
8	2.1	5.1	0.4	0.1	7.7	18.6	15.0	14.4	17.9
9	0.8	0.0	0.2	0.8	1.9	15.0		13.7	13.5
10	0.8	0.3	0.2	0.8	2.2	16.5	17.3	17.3	12.8
Sum	2103.6	1791.1	152.9	597.0	4644.5				
SOP	24016.0	18468.0	1929.1	6755.0	51168.0				
Catch	24037.2	18460.1	1928.6	6769.5	51195.5				

Sub-division 26

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	10.7	466.9	477.6			3.6	4.3
1	2035.6	494.6	22.7	340.8	2893.7	3.4	3.3	7.5	8.3
2	1801.0	987.2	20.1	360.8	3169.0	8.4	7.7	10.0	10.1
3	2013.1	928.7	27.5	253.9	3223.3	9.6	9.0	11.3	11.5
4	2755.6	1186.8	21.3	281.0	4244.8	10.0	9.3	12.4	12.2
5	318.0	164.5	1.9	16.6	501.0	11.2	10.2	12.8	13.1
6	68.2	48.7	1.5	12.7	131.1	12.5	10.7	13.0	13.7
7	17.0	9.6	1.0	0.0	27.6	11.7	11.2	11.4	
8	2.0	4.7	0.5	0.0	7.3	15.2	10.9	15.4	
9	2.4	1.6	0.0	0.0	4.0	9.5	8.9		
10	0.0	0.0	0.0	0.0	0.0				
Sum	9013.0	3826.4	107.2	1732.7	14679.3				
SOP	73598.0	31001.0	1048.0	15220.1	120867.0				
Catch	73573.1	30949.2	1049.7	15215.4	120787.5				

Sub-division 27

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.1	1.5	1.6			3.6	3.8
1	120.1	22.7	3.4	7.5	153.7	2.7	2.5	6.6	7.7
2	93.3	51.8	1.4	6.0	152.6	7.8	7.4	8.2	9.3
3	72.7	49.6	1.6	5.1	129.0	8.3	8.1	8.8	10.0
4	286.8	109.1	4.4	11.6	411.9	9.0	8.3	8.9	10.1
5	44.1	13.2	0.3	1.1	58.7	9.5	9.4	9.9	11.1
6	15.2	4.8	0.1	0.6	20.8	9.9	10.2	10.7	11.0
7	11.7	1.9	0.0	0.2	13.9	11.1	10.6	10.0	11.3
8	2.3	1.2	0.1	0.2	3.8	12.8	11.1	10.2	12.4
9	1.0	0.4	0.0	0.0	1.3	11.9	9.7		
10	1.9	0.4	0.0	0.0	2.3	8.2	8.0		
Sum	649.1	255.1	11.5	33.9	949.6				
SOP	4992.8	1961.0	93.7	311.7	7359.3				
Catch	4985.6	1965.5	93.5	311.9	7356.5				

Continued

Table 7.3. Sprat in SD 22–32. Catch in numbers and weight-at-age by quarter and Subdivision in 2018. (3/4)

Sub-division 28

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	2.5	114.1	116.5			3.6	3.8
1	494.6	122.9	106.7	570.6	1294.8	2.7	3.2	6.6	7.7
2	847.9	103.8	44.8	458.0	1454.4	7.3	7.8	8.2	9.3
3	904.5	112.9	51.4	388.4	1457.2	8.3	8.9	8.8	10.0
4	2249.1	370.3	136.9	881.9	3638.2	8.5	9.0	8.9	10.1
5	416.1	44.4	8.3	84.1	552.9	9.0	10.2	9.9	11.1
6	102.3	36.8	3.5	44.7	187.3	10.0	10.4	10.7	11.0
7	43.0	8.9	1.1	17.6	70.6	10.4	12.1	10.0	11.3
8	20.9	9.5	4.5	11.8	46.7	11.4	11.8	10.2	12.5
9	10.3	0.0	0.0	0.0	10.3	10.9			
10	0.0	0.0	0.0	0.0	0.0				
Sum	5088.7	809.6	359.5	2571.2	8829.0				
SOP	39715.2	6597.3	2926.1	23649.8	72888.4				
Catch	39766.2	6588.0	2919.1	23661.6	72935.0				

Sub-division 29

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.0	27.2	27.2				3.1
1	298.5	89.9	17.1	356.4	761.8	2.5	2.5	7.0	7.4
2	320.0	60.4	7.8	192.0	580.2	7.2	6.4	8.3	8.6
3	210.0	27.1	6.8	191.1	435.1	8.1	7.9	8.6	9.3
4	750.4	124.9	15.0	554.6	1444.9	8.4	8.3	9.4	9.9
5	127.3	16.4	5.5	53.3	202.5	9.5	9.8	10.4	11.0
6	43.0	5.8	0.9	21.4	71.2	10.6	9.6	10.9	10.9
7	19.3	8.5	3.1	8.6	39.4	10.3	9.5		12.0
8	27.7	5.5	3.2	36.7	73.1	10.5	9.7		11.6
9	0.0	0.0	0.0	0.0	0.0				
10	0.0	0.0	0.0	0.0	0.0				
Sum	1796.2	338.4	59.4	1441.4	3635.4				
SOP	13209.5	2211.9	450.5	12989.9	28861.9				
Catch	13230.1	2217.3	449.8	12965.5	28862.8				

Sub-division 30

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.0	0.1	0.1				3.3
1	18.5	3.2	0.0	10.2	31.9	2.8	2.8	7.0	9.3
2	1.9	3.0	0.0	4.6	9.5	6.1	5.9	8.2	11.2
3	6.7	9.5	0.1	2.4	18.7	6.9	6.4	8.3	12.1
4	26.9	40.8	0.1	7.6	75.4	9.4	7.8	9.9	12.1
5	16.6	15.1	0.1	22.4	54.2	9.9	9.3	10.7	13.0
6	6.4	3.2	0.0	1.2	10.8	10.7	10.0	10.9	14.0
7	3.4	9.7	0.2	1.7	15.0	10.5	9.6		14.9
8	5.1	6.8	0.0	3.3	15.2	10.3	8.8		14.9
9	0.0	0.0	0.0	0.0	0.0				
10	0.0	0.0	0.0	0.0	0.0				
Sum	85.6	91.3	0.5	53.4	230.8				
SOP	684.3	731.5	2.8	648.8	2067.4				
Catch	686.6	728.4	2.8	649.8	2067.6				

Continued

Table 7.3. Sprat in SD 22–32. Catch in numbers and weight-at-age by quarter and Subdivision in 2018. (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				3.3
1	0.0	0.0	0.0	2.7	2.7		2.8		9.3
2	0.0	0.0	0.0	1.2	1.2		5.9		11.2
3	0.0	0.1	0.0	0.6	0.8		6.4		12.1
4	0.0	0.6	0.0	2.0	2.6		7.8		12.1
5	0.0	0.2	0.0	5.9	6.1		9.3		13.0
6	0.0	0.0	0.0	0.3	0.4		10.0		14.0
7	0.0	0.1	0.0	0.4	0.6		9.6		14.9
8	0.0	0.1	0.0	0.9	1.0		8.8		14.9
9	0.0	0.0	0.0	0.0	0.0				
10	0.0	0.0	0.0	0.0	0.0				
Sum	0.0	1.4	0.000	14.0	15.3				
SOP	0.0	11.0	0.00	169.7	180.7				
Catch	0.0	10.9	0.0	170.0	180.9				

Sub-division 32

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	0.5	16.0	16.5			4.0	4.2
1	67.7	26.0	41.0	423.4	558.1	2.5	3.0	6.4	7.1
2	94.8	10.7	16.6	160.6	282.7	7.3	7.1	8.1	8.4
3	110.9	18.4	9.3	114.4	253.1	7.9	8.3	8.8	9.0
4	371.6	86.2	48.2	319.9	825.8	8.5	8.4	9.1	9.0
5	34.2	10.1	7.9	23.4	75.6	10.0	10.2	10.2	10.0
6	33.5	6.3	3.3	11.3	54.4	10.3	10.1	10.7	10.3
7	11.0	4.3	1.8	17.9	34.9	10.7	10.9	11.9	10.6
8	6.7	8.6	2.5	12.9	30.8	10.0	10.3	10.6	10.2
9	0.0	0.0	0.0	0.0	0.0				
10	0.0	0.0	0.0	0.0	0.0				
Sum	730.4	170.6	131.3	1099.7	2132.0				
SOP	5768.1	1332.8	1084.6	9002.0	17187.5				
Catch	5754.9	1332.3	1082.0	9001.3	17170.5				

Sub-divisions 22-32

	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0.0	0.0	30.1	749.6	779.8			4.3	4.3
1	3375.4	929.3	207.0	1766.6	6278.3	3.4	3.3	7.0	7.7
2	3658.2	1441.5	111.6	1285.8	6497.1	8.5	7.9	9.3	9.5
3	3786.6	1451.3	132.3	1103.0	6473.2	9.4	9.2	10.6	10.6
4	7419.4	2857.8	278.2	2239.7	12795.1	9.6	9.7	10.2	10.4
5	1186.7	411.2	36.4	237.0	1871.3	10.7	11.4	11.9	11.7
6	341.1	151.2	13.4	104.4	610.2	11.8	11.6	12.2	11.7
7	146.5	53.0	8.2	47.8	255.6	12.1	11.6	7.6	11.5
8	66.8	41.5	11.3	65.8	185.5	11.2	11.0	7.8	11.7
9	14.4	2.0	0.2	0.8	17.5	11.0	9.1	13.7	13.5
10	2.7	0.7	0.2	0.8	4.5	10.7	12.3	17.3	12.8
Sum	19998.0	7339.6	829.0	7601.5	35768.1				
SOP	168601.9	63182.0	7609.9	69458.6	308852.5				
Catch	168640.0	63120.7	7608.8	69457.2	308826.8				

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
2011			9373	1125
2012			13308	1877
2013			11988	1885
2014			11724	2000
2015			15822	1940
2016			19746	1752
2017			21092	1834
2018			30046	1377

*) - vessels withdrawn from exploitation in 2007

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Subdivision for 2018 available to the Working Group. (1/8)

Sub-division	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
22	Denmark	1	4 137,3	7	781	340
		2	-			
		3	25,2	0	0	0
		4	298,4	0	0	0
		Total	4 460,8	7	781	340
	Germany	1	1 419,4	2	536	109
		2	-	0	0	0
		3	-	0	0	0
		4	-	0	0	0
		Total	1 419,4	2	536	109
	Total	1	5 556,6	9	1317	449
		2	-	0	0	0
		3	25,2	0	0	0
		4	298,4	0	0	0
		Total	5 880,2	9	1317	449
Sub-division	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
23+24	Denmark	1	9,7	0	0	0
		2	-			
		3	-			
		4	108,8	0	0	0
		Total	118,6	0	0	0
	Finland	1	81,0	0	0	0
		2	-			
		3	-			
		4	-			
		Total	81,0	0	0	0
	Germany	1	98,3	0	0	0
		2	1,5	0	0	0
		3	-			
		4	4,1	0	0	0
		Total	103,9	0	0	0
	Latvia	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Lithuania	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Poland	1	747,0	0	0	0
		2	867,4	4	511	100
		3	58,0	0	0	0
		4	298,3	3	613	185
		Total	1 970,7	7	1124	285
	Sweden	1	113,5	0	0	0
		2	-			
		3	-			
		4	2,6	0	0	0
		Total	116,1	0	0	0
	Total	1	1 049,6	0	0	0
		2	868,9	4	511	100
		3	58,0	0	0	0
		4	413,7	3	613	185
		Total	2 390,2	7	1124	285

Continued

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Subdivision for 2018 available to the Working Group. (2/8)

Sub-division 25	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	4 678,9	5	440	285
		2	161,2	0	0	0
		3	-			
		4	859,6	1	107	54
		Total	5 699,6	6	547	339
	Estonia	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Finland	1	183,5	0	0	0
		2	-			
		3	1,4	0	0	0
		4	6,0	0	0	0
		Total	190,9	0	0	0
	Germany	1	109,4	0	0	0
		2	788,5	2	527	88
		3	-			
		4	-			
		Total	897,9	2	527	88
	Latvia	1	1 192,4	0	0	0
		2	384,2	0	0	0
		3	11,0	0	0	0
		4	-	0	0	0
		Total	1 587,6	0	0	0
	Lithuania	1	1 214,9	0	0	0
		2	2 150,3	0	0	0
		3	-			
		4	44,8	0	0	0
		Total	3 410,0	0	0	0
	Poland	1	13 112,9	19	3445	229
		2	14 237,1	25	5631	1089
		3	1 356,8	4	730	100
		4	4 197,0	40	7137	639
		Total	32 903,8	88	16943	2057
	Sweden	1	3 545,3	9	428	424
		2	738,9	0	0	0
		3	559,4	11	562	559
		4	1 662,2	4	293	292
		Total	6 505,8	24	1283	1275
	Total	1	24 037,2	33	4313	938
		2	18 460,1	27	6158	1177
		3	1 928,6	15	1292	659
		4	6 769,5	45	7537	985
		Total	51 195,5	120	19300	3759

Continued

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Subdivision for 2018 available to the Working Group. (3/8)

Sub-division 26	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	4 962,6	11	1155	597
		2	1 331,6	1	110	57
		3	-			
		4	28,7	0	0	0
		Total	6 322,9	12	1265	654
	Estonia	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Finland	1	598,4	0	0	0
		2	634,3	0	0	0
		3	0,9	0	0	0
		4	-	0	0	0
		Total	1 233,5	0	0	0
	Germany	1	4 859,1	4	1061	206
		2	2 968,8	3	994	139
		3	-			
		4	-			
		Total	7 827,9	7	2055	345
	Latvia	1	2 773,0	1	208	93
		2	876,7	1	204	94
		3	123,0	0	0	0
		4	438,2	1	212	97
		Total	4 210,9	3	624	284
	Lithuania	1	4 813,0	0	0	0
		2	3 102,8	0	0	0
		3	83,9	0	0	0
		4	201,4	0	0	0
		Total	8 201,0	0	0	0
	Poland	1	24 822,5	23	4844	1148
		2	11 700,0	15	3216	320
		3	352,7	7	1350	151
		4	5 271,3	30	5218	414
		Total	42 146,5	75	14628	2033
	Russia	1	23 716,6	14	3085	453
		2	7 947,6	18	3910	603
		3	478,9	14	2160	399
		4	9 230,9	14	2994	563
		Total	41 374,0	60	12149	2018
	Sweden	1	7 028,0	5	400	388
		2	2 387,5	3	449	448
		3	10,3	0	0	0
		4	45,0	0	0	0
		Total	9 470,8	8	849	836
	Total	1	73 573,1	58	10753	2885
		2	30 949,2	41	8883	1661
		3	1 049,7	21	3510	550
		4	15 215,4	45	8424	1074
		Total	120 787,5	165	31570	6170

Continued
Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Subdivision for 2018 available to the Working Group. (4/8)

Sub-division 27	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	362,7	0	0	0
		2	148,8	0	0	0
		3	-			
		4	5,7	0	0	0
		Total	517,3	0	0	0
	Estonia	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Finland	1	280,4	0	0	0
		2	40,3	0	0	0
		3	0,9	0	0	0
		4	21,2	0	0	0
		Total	342,9	0	0	0
	Germany	1	149,5	1	110	43
		2	408,4	1	306	52
		3	-			
		4	-			
		Total	557,9	2	416	95
	Latvia	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Lithuania	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Poland	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Sweden	1	4 192,9	8	647	646
		2	1 368,0	5	500	497
		3	92,6	0	0	0
		4	284,9	0	0	0
		Total	5 938,4	13	1147	1143
	Total	1	4 985,6	9	757	689
		2	1 965,5	6	806	549
		3	93,5	0	0	0
		4	311,9	0	0	0
		Total	7 356,5	15	1563	1238

Continued

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Subdivision for 2018 available to the Working Group. (5/8)

Sub-division 28	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	5 434,7	2	229	118
		2	97,8	0	0	0
		3	-			
		4	612,1	2	278	109
		Total	6 144,6	4	507	227
	Estonia	1	1 794,0	7	1222	633
		2	154,0	1	225	100
		3	-			
		4	2 118,0	7	1299	650
		Total	4 066,0	15	2746	1383
	Finland	1	1 699,4	0	0	0
		2	21,0	0	0	0
		3	5,6	0	0	0
		4	460,3	0	0	0
		Total	2 186,3	0	0	0
	Germany	1	3 496,5	1	274	55
		2	138,4	0	0	0
		3	-			
		4	-			
		Total	3634,9	1	274	55
	Latvia	1	12 752,7	5	1021	438
		2	4 398,4	5	892	460
		3	2 638,0	4	822	389
		4	11 511,5	13	2788	1213
		Total	31 300,7	27	5523	2500
	Lithuania	1	1 446,6	0	0	0
		2	110,5	0	0	0
		3	101,7	0	0	0
		4	2 587,6	0	0	0
		Total	4 246,4	0	0	0
	Poland	1	802,2	0	0	0
		2	-			
		3	53,2	0	0	0
		4	1 493,3	0	0	0
		Total	2 348,7	0	0	0
	Russia	1				
		2				
		3				
		4				
		Total	0,0	0	0	0
	Sweden	1	12 340,0	5	496	337
		2	1 667,9	0	0	0
		3	120,6	0	0	0
		4	4 878,8	0	0	0
		Total	19 007,3	5	496	337
	Total	1	39 766,2	20	3242	1581
		2	6 588,0	6	1117	560
		3	2 919,1	4	822	389
		4	23 661,6	22	4365	1972
		Total	72 935,0	52	9546	4502

Continued

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Subdivision for 2018 available to the Working Group. (6/8)

Sub-division 29	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Denmark	1	942,6	1	118	57
		2	133,3	0	0	0
		3	-			
		4	250,3	0	0	0
		Total	1326,2	1	118	57
	Estonia	1	5491,0	6	1276	676
		2	807,0	2	319	200
		3	176,0	2	434	200
		4	4956,0	7	1368	700
		Total	11430,0	17	3397	1776
	Finland	1	1691,7	3	47	0
		2	567,0	2	420	0
		3	273,8	2	450	82
		4	4516,7	4	765	71
		Total	7049,2	11	1682	153
	Germany	1	401,4	0	0	0
		2	-			
		3	-			
		4	369,8	0	0	0
		Total	771,1	0	0	0
	Latvia	1				
		2				
		3				
		4				
		Total	0,0	0	0	0
	Lithuania	1	392,0	0	0	0
		2	-			
		3	-			
		4	-			
		Total	392,0	0	0	0
	Poland	1	-			
		2	-			
		3	-			
		4	25,0	0	0	0
		Total	25,0	0	0	0
	Sweden	1	4311,5	3	272	271
		2	710,0	0	0	0
		3	-			
		4	2847,8	0	0	0
		Total	7869,3	3	272	271
	Total	1	13230,1	13	1713	1004
		2	2217,3	4	739	200
		3	449,8	4	884	282
		4	12965,5	11	2133	771
		Total	28862,8	32	5469	2257

Continued

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Subdivision for 2018 available to the Working Group. (7/8)

Sub-division 30	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	0	0
	Finland	1	677,3	12	1224	0
		2	691,0	9	755	0
		3	2,8	3	184	0
		4	639,1	8	998	695
		Total	2010,1	32	3161	695
	Sweden	1	9,3	0	0	0
		2	37,4	0	0	0
		3	-			
		4	10,7	0	0	0
		Total	57,5	0	0	0
	Total	1	686,6	12	1224	0
		2	728,4	9	755	0
		3	2,8	3	184	0
		4	649,8	8	998	695
		Total	2067,6	32	3161	695

Sub-division 31	Country	Quarter	Landings in tons	Number of samples	Number of fish measured	Number of fish aged
	Finland	1	-			
		2	10,9	0	0	0
		3	-			
		4	-			
		Total	10,9	0	0	0
	Sweden	1				
		2				
		3				
		4	170,0	0	0	0
		Total	170,0	0	0	0
	Total	1	0,0	0	0	0
		2	10,9	0	0	0
		3	0,0	0	0	0
		4	170,0	0	0	0
		Total	180,9	0	0	0

Continued

Table 7.5. Sprat in subdivisions 22–32. Samples of commercial catches by quarter, country and Subdivision for 2018 available to the Working Group. (8/8)

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	4 785,0	14	2760	1400
		2	1 221,0	7	1918	700
		3	753,0	6	1170	600
		4	7 086,0	8	1829	800
		Total	13 845,0	35	7677	3500
	Finland	1	969,9	3	1000	0
		2	111,3	2	92	0
		3	329,0	2	650	0
		4	1 915,3	3	1000	0
		Total	3 325,5	10	2742	0
	Sweden	1				
		2				
		3				
		4				
		Total	-	0	0	0
	Total	1	5 754,9	17	3760	1400
		2	1 332,3	9	2010	700
		3	1 082,0	8	1820	600
		4	9 001,3	11	2829	800
		Total	17 170,5	45	10419	3500
Sub-divisions 22-32	**Total**	**Quarter**	**Landings in tons**	**Number of samples**	**Number of fish measured**	**Number of fish aged**
		1	**168 640,0**	**171**	**27079**	**8946**
		2	**63 120,7**	**106**	**20979**	**4947**
		3	**7 608,8**	**55**	**8512**	**2480**
		4	**69 457,2**	**145**	**26899**	**6482**
		Total	**308 826,8**	**477**	**83469**	**22855**

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
2017	3579884	6141001	16543725	3195711	1563614	675502	241309	398356
2018	6278336	6497104	6473215	12795134	1871268	610191	255558	207540

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
2017	0,0054	0,0080	0,0088	0,0108	0,0118	0,0118	0,0115	0,0109
2018	0,0047	0,0086	0,0096	0,0098	0,0110	0,0117	0,0117	0,0111

Table 7.8. Sprat in SD 22–32. Natural Mortality.

NATMOR: 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
2017	0,28	0,28	0,28	0,28	0,28	0,28	0,27	0,27
2018	0,27	0,27	0,27	0,27	0,26	0,26	0,26	0,26

Table 7.9. Sprat in SD 22–32. Proportion mature at spawning time.

MATPROP: Proportion of Mature at Spawning Time

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2018	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.

MPROP: Proportion of M before Spawning

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2018	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.

FPROP: Proportion of F before Spawning

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1974-2018	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.

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
2017	1	30765
2018	1	78167

Table 7.13. Sprat in SD 22–32. Tuning Fleet/ International Acoustic 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+**
1991	1	46488	40299	43681	2743	8924	1851	1957	3117
1992	1	36519	26991	24051	9289	1921	2437	714	560
1993	1	-11	-11	-11	-11	-11	-11	-11	-11
1994	1	12532	44588	43274	17272	11925	5112	1029	1559
1995	1	-11	-11	-11	-11	-11	-11	-11	-11
1996	1	69994	130760	20797	23241	12778	6405	3697	1311
1997	1	-11	-11	-11	-11	-11	-11	-11	-11
1998	1	100615	21975	55422	36291	8056	4735	1623	1011
1999	1	4892	90050	15989	35717	38820	5231	3290	1738
2000	1	58703	5285	49635	5676	13933	15835	1554	2678
2001	1	12047	35687	6927	30237	4028	9606	6370	2407
2002	1	31209	14415	36763	5733	18735	2638	5037	4345
2003	1	99129	32270	24035	23198	8016	13163	4831	8536
2004	1	119497	47027	11638	7929	4876	2450	2389	3552
2005	1	7082	125148	48724	10035	5116	3011	2364	3325
2006	1	36531	11774	103289	32412	7937	4583	2111	2947
2007	1	51888	21665	8175	26102	9800	1067	470	1578
2008	1	28805	45118	20134	5350	18820	5678	1241	1917
2009	1	77343	25333	20840	6547	4667	7023	2011	1376
2010	1	11638	51321	10654	6663	1684	1958	2572	1168
2011	1	20620	11657	43357	9990	6747	2615	1795	2808
2012	1	40516	16525	7935	18413	3494	1733	606	1368
2013	1	19408	20364	11448	5684	11219	1771	759	1274
2014	1	10448	8623	9735	4695	2034	3779	681	774
2015	1	99618	17315	19728	11041	3426	3552	2772	1528
2016	1	20531	80822	24344	9305	3725	1475	1203	1250
2017	1	30171	33937	78088	13673	6372	2681	823	925
2018	1	26879	19204	14849	29575	9135	3134	1182	1336

Table 7.14. Sprat in SD 22–32. Tuning Fleet/ International Acoustic 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
2017	1	32701	36292	132939	20630	6790	2250	809	942
2018	1	27209	25642	38632	69259	7251	2086	1025	619

Table 7.15. Sprat in SD 22–32. Output from XSA.(1/7)

Lowestoft VPA Version 3.1

1/04/2019 23:08

Extended Survivors Analysis

Sprat 22 32

CPUE data from file d:\SprDat18\Fleet3xsa.txt

Catch data for 45 years. 1974 to 2018. Ages 1 to 8.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLT01: BIAS	1991	2018	1	7	0,75	0,85
FLT02: BASS	2001	2018	1	7	0,35	0,42
FLT03: Latvian/F	1992	2018	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 110 iterations

Total absolute residual between iterations
109 and 110 = .00025

Continued

Table 7.15. Sprat in SD 22–32. Output from XSA. (2/7)

Final year F values

Age	1	2	3	4	5	6	7
Iteration **	0,0856	0,1676	0,2763	0,3404	0,3396	0,2799	0,2804
Iteration **	0,0856	0,1676	0,2763	0,3405	0,3396	0,2798	0,2803

1

Regression weights

0,751	0,82	0,877	0,921	0,954	0,976	0,99	0,997	1	1

Fishing mortalities

Age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0,15	0,11	0,209	0,102	0,137	0,108	0,098	0,051	0,063	0,086
2	0,28	0,28	0,187	0,258	0,325	0,277	0,161	0,168	0,16	0,168
3	0,467	0,342	0,351	0,214	0,391	0,439	0,345	0,215	0,25	0,276
4	0,518	0,455	0,387	0,428	0,347	0,422	0,471	0,33	0,318	0,34
5	0,413	0,381	0,364	0,384	0,522	0,419	0,465	0,368	0,391	0,34
6	0,477	0,458	0,373	0,392	0,44	0,41	0,381	0,399	0,401	0,28
7	0,528	0,375	0,473	0,449	0,328	0,484	0,335	0,492	0,375	0,28

1

XSA population numbers (Thousands)

YEAR \ AGE	1	2	3	4	5	6	7
2009	182000	43800	32800	11600	6350	8960	2930
2010	54400	108000	22800	14200	4780	2930	3880
2011	58300	32000	53800	10700	5980	2190	1240
2012	64300	30200	16900	24200	4660	2700	980
2013	57400	40300	16200	9510	11000	2230	1290
2014	56000	36600	21300	8010	4940	4820	1060
2015	213000	37100	20500	10100	3890	2420	2380
2016	69900	142000	23200	10700	4670	1810	1220
2017	68000	47800	86200	13500	5550	2350	884
2018	87500	48100	30700	50600	7410	2850	1190

Estimated population abundance at 1st Jan 2019

0	61500	31100	17800	27600	4060	1660

Taper weighted geometric mean of the VPA populations:

80700	51000	28800	14700	6400	3020	1470

Standard error of the weighted Log(VPA populations) :

0,4769	0,5141	0,5434	0,5791	0,4576	0,4872	0,5146

1

Log catchability residuals.

Continued

Table 7.15. Sprat in SD 22–32. Output from XSA. (3/7)

Fleet : FLT01: International

Age	1991	1992	1993	1994	1995	1996	1997	1998
1	99,99	99,99	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	99,99	99,99
3	99,99	99,99	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	99,99	99,99
5	99,99	99,99	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	99,99	99,99
7	99,99	99,99	99,99	99,99	99,99	99,99	99,99	99,99

Age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	-0,97	0,29	-0,16	0,47	0,45	-0,03	-0,56	0,22	0,17	0,15
2	0,52	-1,38	0,15	-0,1	0,7	0,11	0,55	-0,43	0,01	0,45
3	-0,25	0,16	-1,07	0,51	0,63	-0,07	0,31	0,59	-0,69	0,25
4	0,36	-0,82	0,27	-0,73	0,67	0,13	0,41	0,45	-0,13	-0,57
5	0,38	-0,02	-0,69	0,38	0,15	-0,15	0,43	0,79	-0,19	0,17
6	0,06	0,19	0,38	-0,49	0,69	-0,28	0,08	1,16	-0,45	0,08
7	0,38	-0,5	0,02	0,43	0,85	-0,33	0,5	0,39	-0,24	0,5

Age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	-0,07	-0,21	0,2	0,48	0,05	-0,39	-0,1	-0,14	0,14	-0,19
2	0,24	0,08	-0,23	0,16	0,1	-0,71	-0,12	0,1	0,28	-0,3
3	0,06	-0,31	0,27	-0,45	0,06	-0,34	0,33	0,33	0,17	-0,44
4	-0,13	-0,33	0,33	0,09	-0,26	-0,22	0,44	0,12	0,23	-0,32
5	-0,11	-0,84	0,34	-0,12	0,26	-0,73	0,07	-0,09	0,25	0,27
6	0,01	-0,13	0,4	-0,27	-0,05	-0,1	0,51	-0,05	0,26	0,11
7	-0,09	-0,21	0,67	-0,26	-0,44	-0,24	0,24	0,21	0,03	0,01

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	-0,2682	0,1531	0,2659	0,4173	0,4173	0,4173
S.E(Log q)	0,3431	0,3783	0,3345	0,4147	0,3679	0,3564

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	0,72	1,61	3,65	0,77	20	0,28	-0,67

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	0,8	1,316	2,42	0,81	20	0,26	-0,27
3	0,78	1,386	2,12	0,8	20	0,28	0,15
4	1,1	-0,522	-1,29	0,72	20	0,38	0,27
5	0,85	0,617	0,94	0,63	20	0,36	0,42
6	1,13	-0,512	-1,63	0,6	20	0,42	0,51
7	1	0,011	-0,45	0,68	20	0,37	0,47
1							

Continued

Table 7.15. Sprat in SD 22–32. Output from XSA. (4/7)

Fleet : FLT02: International

Age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	99,99	99,99	-0,32	0,57	-0,27	0,43	-0,85	-0,38	0,42	-0,58
2	99,99	99,99	-0,03	0	-0,16	0,3	0,03	-0,95	0,07	0,11
3	99,99	99,99	-0,67	0,14	-0,73	-0,09	-0,7	-0,02	-1,2	-0,09
4	99,99	99,99	0,03	0,04	-0,18	0,01	-0,37	-0,41	-0,28	-0,95
5	99,99	99,99	-0,73	-0,23	-0,56	0,35	-0,39	0,08	-0,83	-0,1
6	99,99	99,99	-0,74	-0,86	-0,25	-0,38	-0,34	-0,09	-0,67	-0,64
7	99,99	99,99	-0,69	-0,23	-0,6	0,49	-0,17	-0,27	-0,55	-0,39

Age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	-0,33	-0,28	0,22	0,25	0,43	-0,28	-0,04	99,99	0,45	0,05
2	0,08	-0,02	-0,98	0,26	0,44	0,24	0,1	99,99	0,22	-0,13
3	0,23	-0,3	0,33	-0,37	0,21	0,03	0,44	99,99	0,45	0,25
4	-0,17	0,04	0,35	0,27	0,02	-0,21	0,51	99,99	0,24	0,13
5	-0,19	-0,12	0,39	0,28	0,14	0	0,54	99,99	-0,02	-0,27
6	0,29	-0,72	0,45	0,42	0,22	-0,45	0,3	99,99	-0,26	-0,59
7	0,46	0,18	0,52	0,16	0,28	-0,05	-0,16	99,99	-0,32	-0,43

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	-0,328	0,1884	0,4124	0,4827	0,4827	0,4827
S.E(Log q)	0,4112	0,4459	0,369	0,3491	0,4811	0,3632

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	0,81	0,73	3,03	0,63	17	0,41	-1,11

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	0,85	0,537	1,85	0,6	17	0,36	-0,33
3	0,8	1,017	1,93	0,74	17	0,36	0,19
4	1	-0,007	-0,43	0,72	17	0,39	0,41
5	1,52	-1,551	-5,32	0,49	17	0,5	0,48
6	1,22	-0,572	-2,15	0,44	17	0,57	0,33
7	0,81	1,105	1,02	0,79	17	0,29	0,44
1							

continued

Table 7.15. Sprat in SD 22–32. Output from XSA. (5/7)

Age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	-1,92	-0,36	-0,92	-0,42	0,05	-0,19	-1,09	0,04	0,04	-0,39
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	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	-0,13	-0,36	0,35	0,3	0,22	0,04	-0,06	0,08	-0,01	0,35
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	0,66	1,621	4,34	0,69	20	0,34	-0,69
1							

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 2017

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F	
FLT01:	50918	0,3	0	0	1	0,364	0,102	0,102
FLT02: Internati	64733	0,425	0	0	1	0,182	0,081	0,081
FLT03: Latvian/F	87121	0,359	0	0	1	0,255	0,061	0,061
P shrinkage me	50980	0,51				0,135	0,102	0,102
F shrinkage me	57154	0,75				0,064	0,092	0,092

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
61457	0,18	0,11	5	0,617	0,086

1

Age 2 Catchability constant w.r.t. time and dependent on age

continued

Table 7.15. Sprat in SD 22–32. Output from XSA. (6/7)

Year class = 2016

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F	
FLT01:	29669	0,23	0,22	0,96	2	0,474	0,175	0,175
FLT02: Internati	36200	0,303	0,293	0,97	2	0,274	0,146	0,146
FLT03: Latvian/F	30821	0,352	0	0	1	0,197	0,169	0,169
F shrinkage me	23127	0,75				0,055	0,22	0,22

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
31142	0,16	0,11	6	0,683	0,168

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2015

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	16072	0,199	0,199	1	3	0,549	0,302
FLT02: Internati	22573	0,317	0,014	0,04	2	0,229	0,224
FLT03: Latvian/F	19311	0,351	0	0	1	0,163	0,257
F shrinkage me	14445	0,75				0,058	0,331

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
17792	0,15	0,1	7	0,699	0,276

1

Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 2014

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	25628	0,18	0,116	0,64	4	0,554	0,363
FLT02: Internati	33189	0,256	0,126	0,49	3	0,298	0,291
FLT03: Latvian/F	26045	0,387	0	0	1	0,091	0,358
F shrinkage me	24157	0,75				0,057	0,381

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
27629	0,14	0,08	9	0,555	0,34

continued

Table 7.15. Sprat in SD 22–32. Output from XSA. (7/7)

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2013

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	4385	0,169	0,135	0,8	5	0,503	0,318
FLT02: Internati	3778	0,212	0,137	0,65	4	0,369	0,36
FLT03: Latvian/F	4222	0,359	0	0	1	0,074	0,328
F shrinkage me	2989	0,75				0,053	0,437

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4055	0,13	0,08	11	0,657	0,34

1

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2012

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	1787	0,171	0,12	0,7	6	0,549	0,262
FLT02: Internati	1547	0,222	0,19	0,86	5	0,344	0,297
FLT03: Latvian/F	2061	0,36	0	0	1	0,046	0,231
F shrinkage me	1055	0,75				0,061	0,41

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1657	0,13	0,1	13	0,732	0,28

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2011

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	779	0,177	0,089	0,5	7	0,542	0,253
FLT02: Internati	592	0,226	0,161	0,71	6	0,369	0,322
FLT03: Latvian/F	936	0,365	0	0	1	0,025	0,215
F shrinkage me	590	0,75				0,063	0,323

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
695	0,14	0,08	15	0,602	0,28

1
1

Table 7.16. Sprat in SD 22–32. Output from XSA. Fishing mortality (F) at age.

Run title : Sprat 22 32
At 1/04/2019 23:10

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAF	1974	1975	1976	1977	1978
AGE					
1	0,0685	0,0442	0,0309	0,0759	0,047
2	0,0996	0,0963	0,1021	0,0985	0,2274
3	0,299	0,1748	0,1896	0,2447	0,1181
4	0,3952	0,4765	0,2153	0,3735	0,2754
5	0,2916	0,3865	0,5619	0,216	0,4253
6	0,5657	0,2863	0,4071	0,5559	0,1833
7	0,426	0,3913	0,4021	0,3904	0,3025
+gp	0,426	0,3913	0,4021	0,3904	0,3025
FBAR 3-	**0,33**	**0,35**	**0,32**	**0,28**	**0,27**

YEAF	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
AGE										
1	0,067	0,0284	0,052	0,0157	0,0205	0,0277	0,0185	0,0421	0,0289	0,0072
2	0,1263	0,1883	0,1782	0,1372	0,0289	0,0552	0,0893	0,0643	0,0552	0,1693
3	0,1787	0,2115	0,1382	0,2264	0,0725	0,0798	0,1129	0,1387	0,1283	0,1763
4	0,1253	0,233	0,1397	0,2013	0,1503	0,1342	0,1865	0,1782	0,3549	0,2011
5	0,2829	0,1873	0,1062	0,249	0,1043	0,2574	0,1654	0,2922	0,3	0,3122
6	0,2121	0,308	0,1886	0,1677	0,1178	0,1867	0,2197	0,2253	0,4254	0,251
7	0,213	0,2515	0,1491	0,2128	0,1274	0,1969	0,1938	0,2353	0,3657	0,2583
+gp	0,213	0,2515	0,1491	0,2128	0,1274	0,1969	0,1938	0,2353	0,3657	0,2583
FBAR 3-	**0,20**	**0,21**	**0,13**	**0,23**	**0,11**	**0,16**	**0,16**	**0,20**	**0,26**	**0,23**

YEAF	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
AGE										
1	0,0659	0,0253	0,0223	0,0219	0,0247	0,0189	0,0287	0,059	0,033	0,0813
2	0,0413	0,1594	0,0917	0,0871	0,0985	0,1632	0,0574	0,1864	0,2559	0,1066
3	0,2018	0,0749	0,1989	0,1568	0,1434	0,2244	0,2165	0,1738	0,2647	0,3615
4	0,1743	0,1879	0,1325	0,2171	0,1511	0,255	0,3205	0,3811	0,4213	0,4255
5	0,2405	0,1343	0,1825	0,2263	0,1895	0,2915	0,4631	0,2898	0,4924	0,3537
6	0,3244	0,1803	0,1153	0,1547	0,2245	0,2819	0,4956	0,429	0,2512	0,4647
7	0,2493	0,1689	0,1443	0,2007	0,1897	0,2786	0,4312	0,3703	0,3924	0,4196
+gp	0,2493	0,1689	0,1443	0,2007	0,1897	0,2786	0,4312	0,3703	0,3924	0,4196
FBAR 3-	**0,21**	**0,13**	**0,17**	**0,20**	**0,16**	**0,26**	**0,33**	**0,28**	**0,39**	**0,38**

YEAF	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
AGE										
1	0,0443	0,131	0,0694	0,155	0,0947	0,1262	0,0699	0,1758	0,1655	0,1156
2	0,2393	0,0945	0,2417	0,2201	0,2835	0,2054	0,2752	0,1203	0,3472	0,3336
3	0,2745	0,3297	0,1341	0,4436	0,3568	0,409	0,3054	0,3485	0,2242	0,3942
4	0,4151	0,245	0,4179	0,3398	0,4456	0,4588	0,4549	0,3504	0,4705	0,3282
5	0,4013	0,3675	0,3114	0,4069	0,4226	0,646	0,6367	0,4582	0,3947	0,4309
6	0,3002	0,3812	0,4785	0,291	0,358	0,4901	0,3762	0,5025	0,4455	0,5005
7	0,3757	0,343	0,4382	0,3312	0,482	0,4187	0,537	0,3513	0,5773	0,4696
+gp	0,3757	0,343	0,4382	0,3312	0,482	0,4187	0,537	0,3513	0,5773	0,4696
FBAR 3-	**0,36**	**0,31**	**0,29**	**0,40**	**0,41**	**0,50**	**0,47**	**0,39**	**0,36**	**0,38**

YEAF	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	FBAR **-**
AGE											
1	0,1502	0,1097	0,2094	0,1025	0,1365	0,1077	0,0982	0,0515	0,0626	0,0856	0,0665
2	0,2802	0,2803	0,1869	0,2577	0,3251	0,2771	0,1607	0,1675	0,1603	0,1676	0,1651
3	0,4672	0,3419	0,3508	0,2144	0,3914	0,4386	0,3446	0,2146	0,2498	0,2763	0,2469
4	0,5185	0,4554	0,3874	0,428	0,3471	0,422	0,471	0,3295	0,3184	0,3405	0,3295
5	0,4135	0,381	0,3639	0,3839	0,5218	0,4193	0,4649	0,3683	0,3907	0,3396	0,3662
6	0,4767	0,4581	0,3728	0,3918	0,4395	0,4104	0,3811	0,3991	0,4013	0,2798	0,3601
7	0,5276	0,3752	0,4726	0,4489	0,328	0,4841	0,335	0,4922	0,375	0,2803	0,3825
+gp	0,5276	0,3752	0,4726	0,4489	0,328	0,4841	0,335	0,4922	0,375	0,2803	
FBAR 3-	**0,47**	**0,39**	**0,37**	**0,34**	**0,42**	**0,43**	**0,43**	**0,30**	**0,32**	**0,32**	

Table 7.17. Sprat in SD 22–32. Output from XSA. Stock number-at-age (Numbers*10^-6).

Run title : Sprat 22 32

At 1/04/2019 23:10

Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year)

YEAF	1974	1975	1976	1977	1978
AGE					
1	50439	18934	194499	42727	15222
2	83209	28854	10663	117861	22851
3	17887	46145	15425	6017	61620
4	7517	8126	22805	7975	2746
5	9600	3164	3030	11608	3231
6	2718	4528	1304	1102	5560
7	4401	975	2062	559	379
+gp	984	2099	1553	1550	953
TOTAL	176755	112824	251340	189399	112562

YEAF	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
AGE										
1	30536	20035	67767	35168	133305	50395	40552	15184	33953	13475
2	7432	13091	8407	28906	15248	61076	26107	23200	9099	21459
3	9314	3002	4682	3161	11099	6928	30782	13914	13597	5601
4	28300	3607	1060	1832	1110	4827	3407	16184	7569	7780
5	1099	11793	1271	427	680	456	2293	1681	8549	3488
6	1125	399	4438	540	154	298	195	1167	800	4203
7	2490	443	136	1753	214	67	139	95	594	350
+gp	899	1492	1002	373	1708	606	465	292	286	748
TOTAL	81194	53862	88763	72160	163517	124654	103940	71717	74448	57105

YEAF	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
AGE										
1	40039	49595	54540	94261	87190	67033	261404	169134	61556	165573
2	8703	25379	34765	40313	70400	63015	48730	188168	119300	44123
3	11785	5654	15557	23972	28206	47260	39652	34085	116859	68427
4	3055	6521	3771	9637	15644	18104	27974	23657	21436	66435
5	4181	1755	3924	2496	5921	10064	10497	15192	12214	10421
6	1694	2248	1114	2471	1535	3666	5627	4943	8593	5586
7	2170	846	1363	758	1632	918	2069	2565	2433	5002
+gp	737	1497	1287	1014	1705	979	1331	1480	981	1642
TOTAL	72363	93494	116321	174922	212234	211039	397285	439225	343372	367208

YEAF	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
AGE										
1	56918	101688	48810	55164	119795	226767	48934	78992	106699	69733
2	110842	38756	63491	32737	33293	81536	149557	33804	48113	65011
3	28799	62104	25098	35846	18512	18762	49684	84140	21764	24442
4	34615	15578	31788	15780	16210	9695	9327	27120	43121	12504
5	31525	16431	8766	15199	7996	7846	4585	4384	13872	19365
6	5366	15172	8180	4662	7274	3960	3108	1815	2034	6788
7	2574	2857	7451	3681	2505	3843	1834	1596	805	946
+gp	1902	3034	1695	5529	4100	4527	1683	2062	1414	1125
TOTAL	272542	255621	195279	168598	209686	356938	268712	233914	237821	199913

YEAF	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	GMST 74-**	AMST 74-**
AGE													
1	182471	54408	58322	64280	57417	55974	212928	69878	68011	87522	0	62720	80970
2	43775	108465	32033	30162	40318	36628	37122	141564	47764	48140	61457	38574	52269
3	32818	22848	53845	16943	16198	21300	20505	23185	86164	30661	31142	20481	28312
4	11613	14207	10665	24176	9511	8008	10147	10667	13475	50623	17792	10335	14786
5	6346	4776	5979	4662	11028	4940	3894	4670	5554	7415	27629	5030	7333
6	8958	2928	2187	2703	2231	4824	2416	1809	2347	2849	4055	2377	3545
7	2929	3880	1241	980	1289	1062	2385	1223	884	1193	1657	1170	1802
+gp	1005	1957	1817	1412	1302	1105	1180	1335	1443	961	1254		
TOTAL	289916	213470	166090	145318	139293	133842	290578	254330	225642	229363	144986		

Table 7.18. Sprat in SD 22–32. Output from XSA. Stock summary (recruitment in millions, weights in Kt)

Run title : Sprat 22 at 1/04/2019 23:10
Table 16 Summary (without SOP correction)
Terminal Fs derived using XSA (With F shrinkage)

Recruitment						
	age1	TSB	SSB	Yield	Yield/SSB	F(3- 5)
1974	50439	1777	1097	242	0.220	0.329
1975	18934	1288	867	201	0.232	0.346
1976	194499	2077	738	195	0.264	0.322
1977	42727	1938	1257	181	0.144	0.278
1978	15222	1283	866	132	0.153	0.273
1979	30536	859	498	77	0.155	0.196
1980	20035	604	311	58	0.187	0.211
1981	67767	750	268	49	0.184	0.128
1982	35168	779	340	49	0.143	0.226
1983	133305	1693	478	37	0.078	0.109
1984	50395	1365	691	53	0.076	0.157
1985	40552	1152	640	70	0.109	0.155
1986	15184	857	581	76	0.130	0.203
1987	33953	844	466	88	0.190	0.261
1988	13475	611	416	80	0.193	0.230
1989	40039	877	439	86	0.196	0.206
1990	49595	1137	571	86	0.150	0.132
1991	54540	1351	776	103	0.133	0.171
1992	94261	1927	1035	142	0.137	0.200
1993	87190	2144	1362	178	0.131	0.161
1994	67033	2211	1409	289	0.205	0.257
1995	261404	3276	1501	313	0.209	0.333
1996	169134	3056	1923	441	0.229	0.282
1997	61556	2797	1896	529	0.279	0.393
1998	165573	2497	1426	471	0.330	0.380

Recruitment						
1999	56918	2069	1410	421	0.299	0.364
2000	101688	2255	1340	389	0.290	0.314
2001	48810	1823	1196	342	0.286	0.288
2002	55164	1563	933	343	0.368	0.397
2003	119795	1548	801	308	0.385	0.408
2004	226767	2149	1010	374	0.370	0.505
2005	48934	1891	1277	405	0.317	0.466
2006	78992	1691	1053	352	0.334	0.386
2007	106699	1740	924	388	0.420	0.363
2008	69733	1736	982	381	0.388	0.384
2009	182471	2000	904	407	0.450	0.466
2010	54408	1678	1032	342	0.331	0.393
2011	58322	1286	791	268	0.339	0.367
2012	64280	1240	694	231	0.333	0.342
2013	57417	1186	699	272	0.390	0.420
2014	55974	1103	645	244	0.378	0.427
2015	212928	1716	756	247	0.327	0.427
2016	69878	1793	1174	247	0.210	0.304
2017	68011	1772	1171	286	0.244	0.320
2018	87522	1755	1121	309	0.276	0.319
Arith. Mean	**80827**	**1625**	**928**	**240**	**0.2487**	**0.302**

Table 7.19. Sprat in SD 22–32. Input for RCT3 analysis.

Sprat 22-32: Acoustic on age 0 in subdiv. 22-29, shifted to represent age1

Year	VPA, age 1	Acoustic, Age 0
1991	94261	59473
1992	87190	48035
1993	67033	-11
1994	261404	64092
1995	169134	-11
1996	61556	3842
1997	165573	-11
1998	56918	1279
1999	101688	33320
2000	48810	4601
2001	55164	12001
2002	119795	79551
2003	226767	146335
2004	48934	3562
2005	78992	41863
2006	106699	66125
2007	69733	17821
2008	182471	115698
2009	54408	12798
2010	58322	41158
2011	64280	45186
2012	57417	33653
2013	55974	24694
2014	212928	162715
2015	69878	36900
2016	68011	30765
2017	87522	78167
2018	-11	18542

Table 7.20. Sprat in SD 22–32. Output from RCT3 analysis. (1/3)

Analysis by RCT3 ver3.1 of data from file z:\recsprl1.txt
Sprat 22-32: YFS data from international acoustic survey on age 0

Data for 1 surveys over 27 years: 1991-2018
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 = 2007

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,42	7,24	0,38	0,7	13	9,79	11,33	0,443	0,606
				VPA	Mean	=	11,43	0,549	0,394

Yearclass = 2008

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,42	7,22	0,36	0,705	14	11,66	12,08	0,44	0,592
				VPA	Mean	=	11,4	0,53	0,408

Yearclass = 2009

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,42	7,22	0,33	0,754	15	9,46	11,16	0,382	0,671
				VPA	Mean	=	11,45	0,545	0,329

Yearclass = 2010

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,43	7,05	0,32	0,757	16	10,63	11,62	0,372	0,681
				VPA	Mean	=	11,4	0,543	0,319

continued

Table 7.20. Sprat in SD 22–32. Output from RCT3 analysis. (2/3)

Yearclass = 2011

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,47	6,62	0,38	0,678	17	10,72	11,61	0,439	0,594
			VPA	Mean	=		11,36	0,531	0,406

Yearclass = 2012

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,49	6,29	0,41	0,629	18	10,42	11,42	0,464	0,547
			VPA	Mean	=		11,33	0,51	0,453

Yearclass = 2013

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,53	5,84	0,42	0,593	19	10,11	11,2	0,485	0,51
			VPA	Mean	=		11,29	0,495	0,49

Yearclass = 2014

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,56	5,46	0,42	0,587	20	12	12,21	0,522	0,457
			VPA	Mean	=		11,26	0,479	0,543

Yearclass = 2015

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,59	5,13	0,4	0,67	21	10,52	11,36	0,451	0,588
			VPA	Mean	=		11,33	0,539	0,412

continued

Table 7.20. Sprat in SD 22–32. Output from RCT3 analysis. 3/3

Yearclass = 2016

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter-cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,62	4,81	0,38	0,679	22	10,33	11,21	0,428	0,596
				VPA	Mean	=	11,31	0,52	0,404

Yearclass = 2017

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter-cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,64	4,53	0,35	0,695	23	11,27	11,77	0,406	0,603
				VPA	Mean	=	11,3	0,5	0,397

Yearclass = 2018

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter-cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,65	4,35	0,34	0,69	24	9,83	10,79	0,394	0,594
				VPA	Mean	=	11,3	0,477	0,406

Year class (Age 1)	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2005	114801	11,65	0,37	0,16	0,19	78993	11,28
2006	122523	11,72	0,37	0,25	0,45	106700	11,58
2007	86552	11,37	0,34	0,05	0,02	69733	11,15
2008	134137	11,81	0,34	0,34	0,98	182472	12,11
2009	77402	11,26	0,31	0,14	0,19	54408	10,9
2010	104059	11,55	0,31	0,1	0,11	58323	10,97
2011	99979	11,51	0,34	0,12	0,13	64280	11,07
2012	87532	11,38	0,34	0,04	0,02	57417	10,96
2013	76616	11,25	0,35	0,05	0,02	55974	10,93
2014	119571	11,69	0,35	0,48	1,82	212928	12,27
2015	84643	11,35	0,35	0,01	0	69878	11,15
2016	76827	11,25	0,33	0,05	0,03	68012	11,13
2017	107281	11,58	0,32	0,23	0,55	87522	11,38
2018	**59567**	10,99	0,3	0,25	0,68		

Table 7.21. Sprat in SD 22–32. Input data for short-term prediction

MFDP version 1a
Run: runFsq
Time and date: 10:09 2019-04-03
Fbar age range: 3-5

2019

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	59567	0,293333	0,17	0,4	0,4	0,0049	0,0666	0,0049
2	61457	0,293333	0,93	0,4	0,4	0,0079	0,1651	0,0079
3	31142	0,292667	1	0,4	0,4	0,0094	0,2469	0,0094
4	17792	0,289	1	0,4	0,4	0,0106	0,3295	0,0106
5	27629	0,287	1	0,4	0,4	0,0115	0,3662	0,0115
6	4055	0,284667	1	0,4	0,4	0,0120	0,3601	0,0120
7	1657	0,283333	1	0,4	0,4	0,0118	0,3825	0,0118
8	1254	0,283333	1	0,4	0,4	0,0114	0,3825	0,0114

2020

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	86541	0,293333	0,17	0,4	0,4	0,0049	0,0666	0,0049
2	.	0,293333	0,93	0,4	0,4	0,0079	0,1651	0,0079
3	.	0,292667	1	0,4	0,4	0,0094	0,2469	0,0094
4	.	0,289	1	0,4	0,4	0,0106	0,3295	0,0106
5	.	0,287	1	0,4	0,4	0,0115	0,3662	0,0115
6	.	0,284667	1	0,4	0,4	0,0120	0,3601	0,0120
7	.	0,283333	1	0,4	0,4	0,0118	0,3825	0,0118
8	.	0,283333	1	0,4	0,4	0,0114	0,3825	0,0114

2021

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	86541	0,293333	0,17	0,4	0,4	0,0049	0,0666	0,0049
2	.	0,293333	0,93	0,4	0,4	0,0079	0,1651	0,0079
3	.	0,292667	1	0,4	0,4	0,0094	0,2469	0,0094
4	.	0,289	1	0,4	0,4	0,0106	0,3295	0,0106
5	.	0,287	1	0,4	0,4	0,0115	0,3662	0,0115
6	.	0,284667	1	0,4	0,4	0,0120	0,3601	0,0120
7	.	0,283333	1	0,4	0,4	0,0118	0,3825	0,0118
8	.	0,283333	1	0,4	0,4	0,0114	0,3825	0,0114

Input units are millions and grams - 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)

N_{2019} Age 1:	RCT3 estimate (Table 7.20)
N_{2019} Age 2-8+:	Survivors estimates from XSA (Table 7.16)
$N_{2020\text{-}2021}$ Age 1:	Geometric mean from XSA-estimates at age 1 for the years 1991-2018
Natural Mortality (M):	average 2016-2018
Weight in the Catch/Stock (C	average 2016-2018
Expoitation pattern (Sel):	average 2016-2018 scaled to TAC in 2019

Table 7.22a. Sprat in SD 22–32. Output from short-term prediction with management option table for TAC constrained fishery in 2019.

MFDP version 1a
Run: projTACconst
Sprat
Time and date: 11:56 2019-04-03
Fbar age range: 3-5

2019				
Biomass	**SSB**	**FMult**	**FBar**	**Landings**
1664	1103	1,0857	0,3411	313

2020					2021	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
1620	1106	0	0	0	1923	1365
.	1095	0,1	0,0314	30	1894	1326
.	1084	0,2	0,0628	59	1866	1288
.	1073	0,3	0,0943	88	1838	1251
.	1062	0,4	0,1257	115	1812	1216
.	1051	0,5	0,1571	142	1785	1181
.	1040	0,6	0,1885	169	1760	1149
.	1029	0,7	0,2199	194	1735	1117
.	1019	0,8	0,2514	219	1711	1086
.	1008	0,9	0,2828	244	1687	1057
.	998	1	0,3142	267	1664	1028
.	988	1,1	0,3456	291	1641	1001
.	978	1,2	0,377	313	1619	975
.	968	1,3	0,4084	335	1598	949
.	958	1,4	0,4399	357	1577	924
.	948	1,5	0,4713	378	1557	900
.	939	1,6	0,5027	398	1537	877
.	929	1,7	0,5341	418	1517	855
.	920	1,8	0,5655	438	1499	834
.	911	1,9	0,597	457	1480	813
.	902	2	0,6284	475	1462	793

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 status quo fishery in 2019.

MFDP version 1a
Run: runFsq
Sprat
Time and date: 10:09 2019-04-03
Fbar age range: 3-5

2019				
Biomass	**SSB**	**FMult**	**FBar**	**Landings**
1664	1113	1,0000	0,3142	291

2020					2021	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
1641	1125	0	0	0	1940	1380
-	1113	0,1	0,0314	30	1910	1340
-	1102	0,2	0,0628	60	1882	1301
-	1090	0,3	0,0943	89	1854	1264
-	1079	0,4	0,1257	117	1826	1228
-	1068	0,5	0,1571	145	1800	1193
-	1057	0,6	0,1885	172	1774	1160
-	1046	0,7	0,2199	198	1748	1128
-	1035	0,8	0,2514	223	1724	1097
-	1025	0,9	0,2828	248	1700	1067
-	1014	1	0,3142	272	1676	1038
-	1004	1,1	0,3456	296	1653	1010
-	994	1,2	0,377	319	1631	983
-	984	1,3	0,4084	341	1609	957
-	974	1,4	0,4399	363	1588	932
-	964	1,5	0,4713	385	1567	908
-	954	1,6	0,5027	405	1547	885
-	944	1,7	0,5341	426	1527	862
-	935	1,8	0,5655	446	1508	841
-	925	1,9	0,597	465	1489	819
-	916	2	0,6284	484	1471	799

Input units are millions and grams - output in tonnes

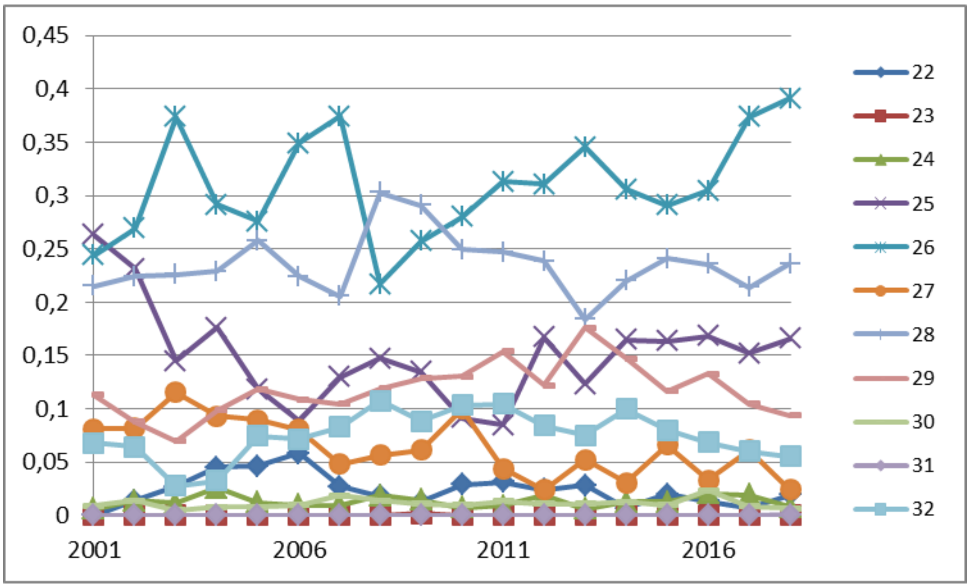


Figure 7.0 Sprat in Subdivisions 22-32. Share of catches by Subdivision in 2001-2018

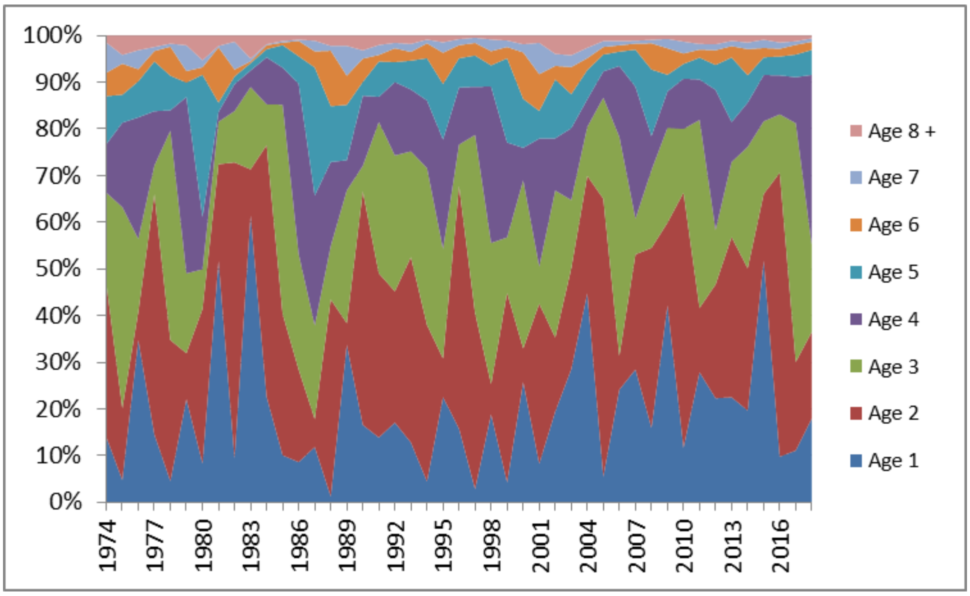
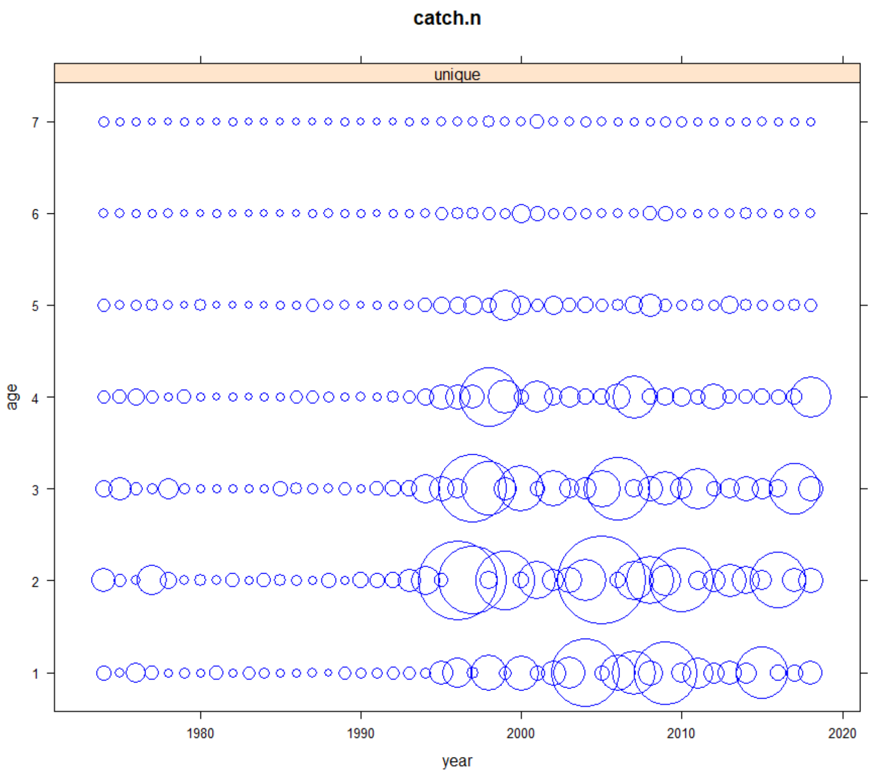


Figure 7.1. Sprat in SD 22-32. Relative catch-at-age in numbers.



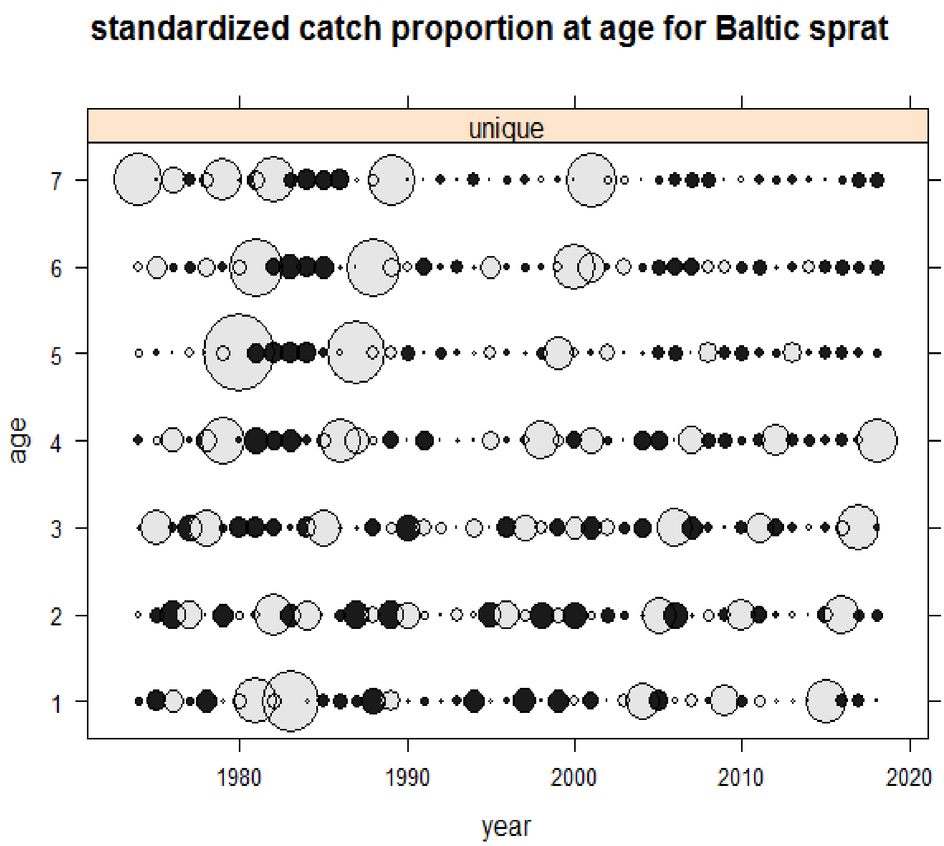
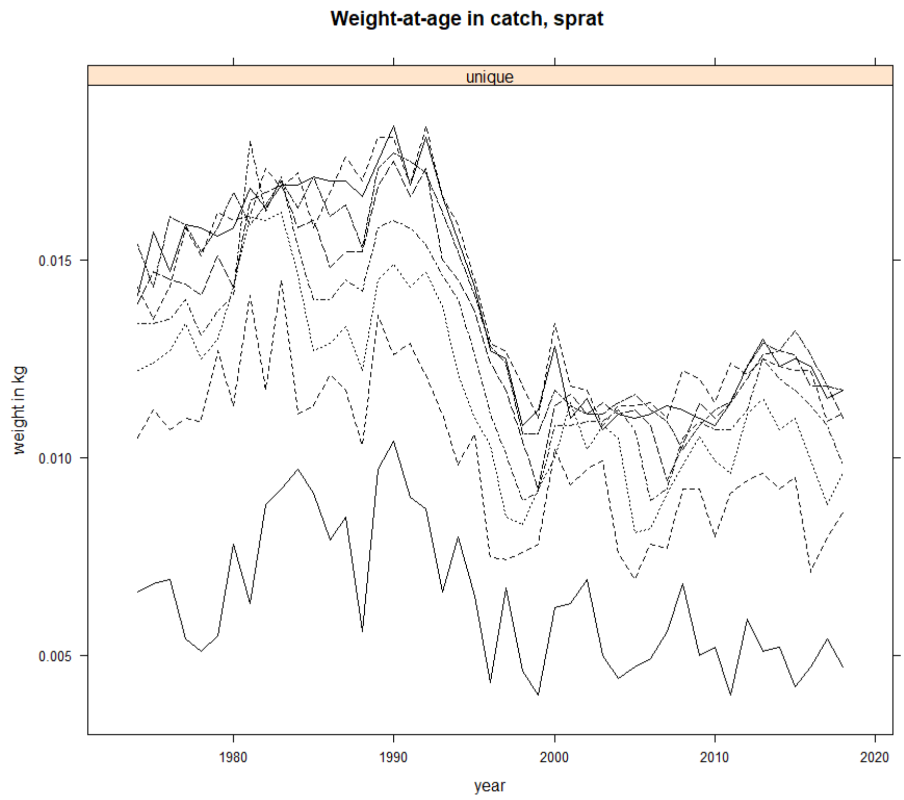


Figure. 7.2. Sprat in SD 22-32. CANUM consistency check.



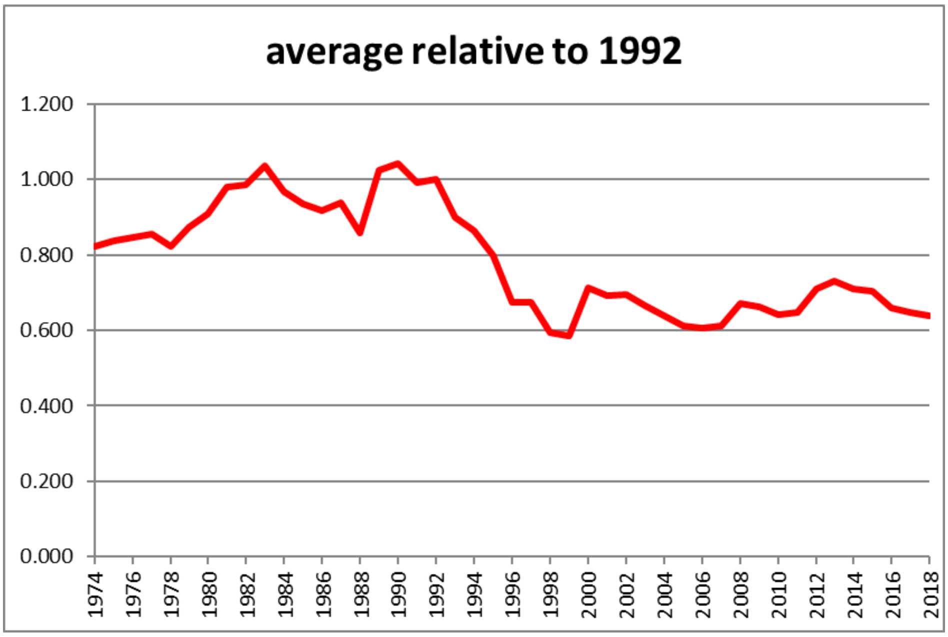


Figure 7.3. Sprat in SD 22-32: mean weight-at-age in the catches by ages and average of values relative to weights in 1992 (weight in the stock assumed as in the catches).

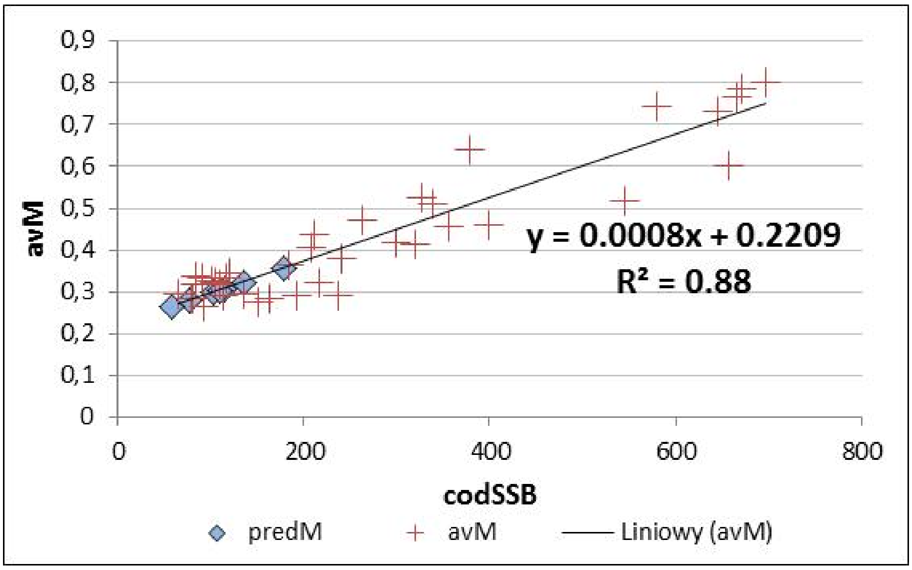


Figure 7.4a. The dependence of average M for sprat on cod SSB (diamonds show predicted values).

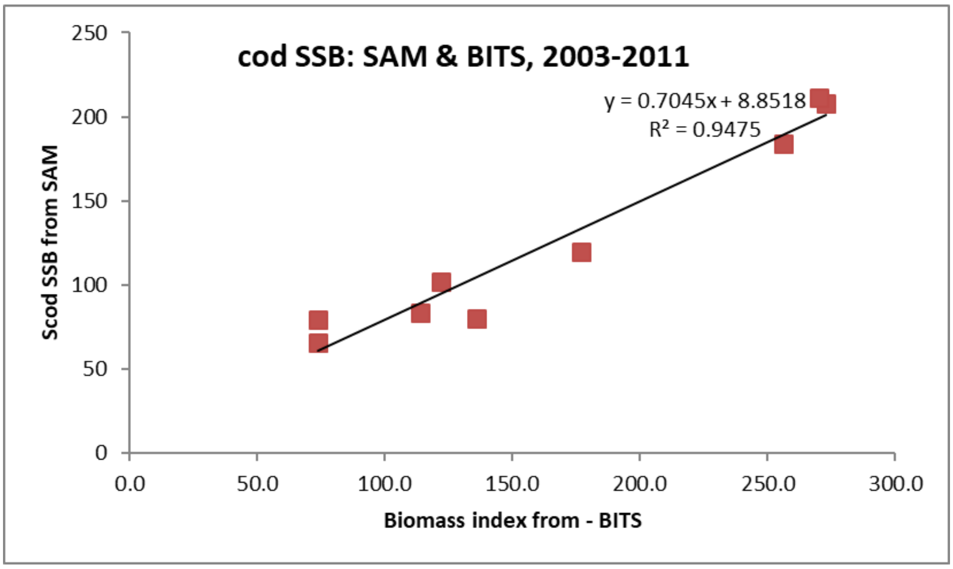


Figure 7.4b. The relationship between cod SSB and biomass index from BITS (years 2003 - 2011).

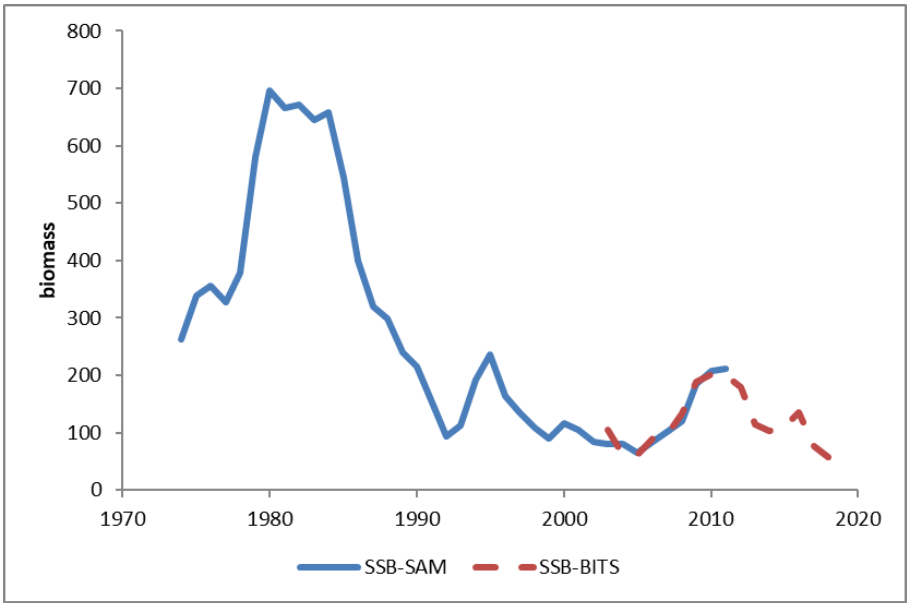


Figure 7.4c. The biomass index from BITS rescaled to level of cod SSB and cod SSB from last accepted assessment (2012).

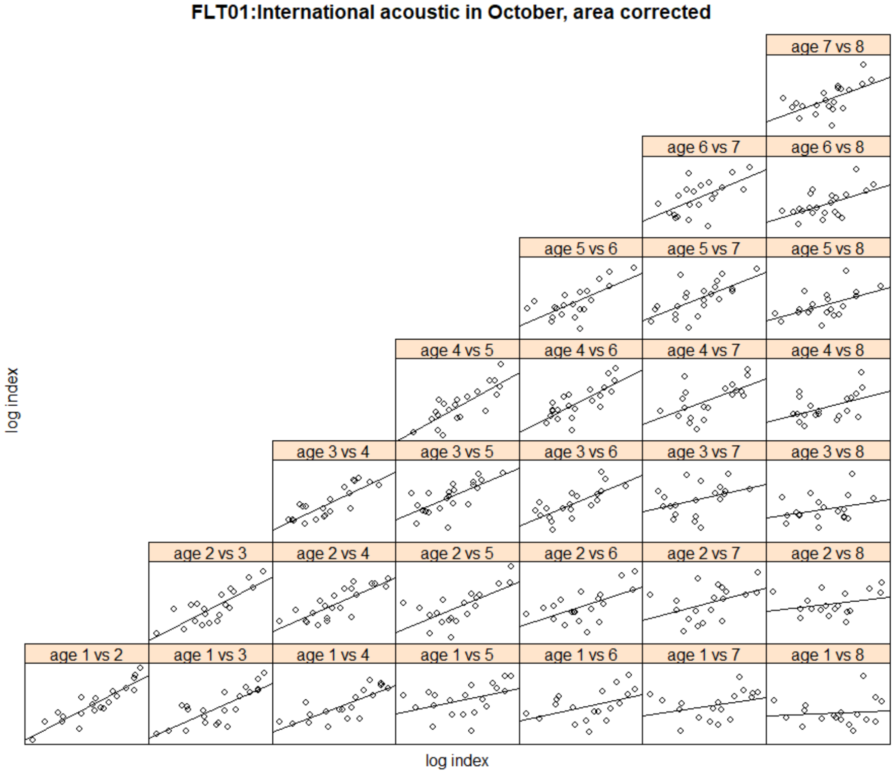


Figure 7.5a. Sprat in SD 22-32. Check for consistency in October acoustic survey estimates.

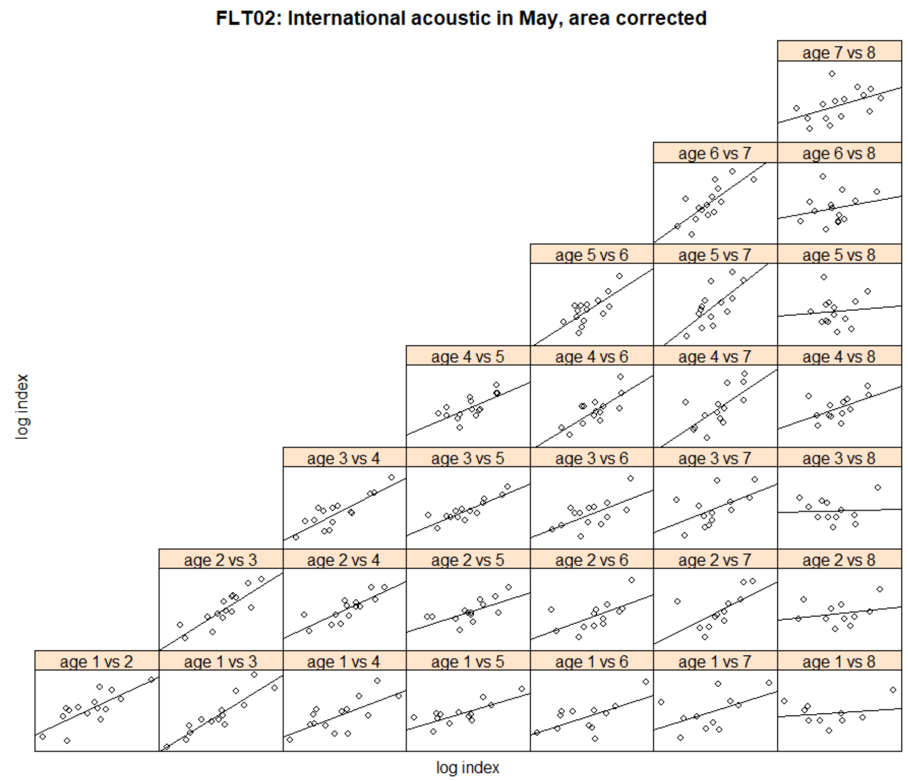


Figure 7.5b. Sprat in SD 22-32. Check for consistency in May acoustic survey estimates.

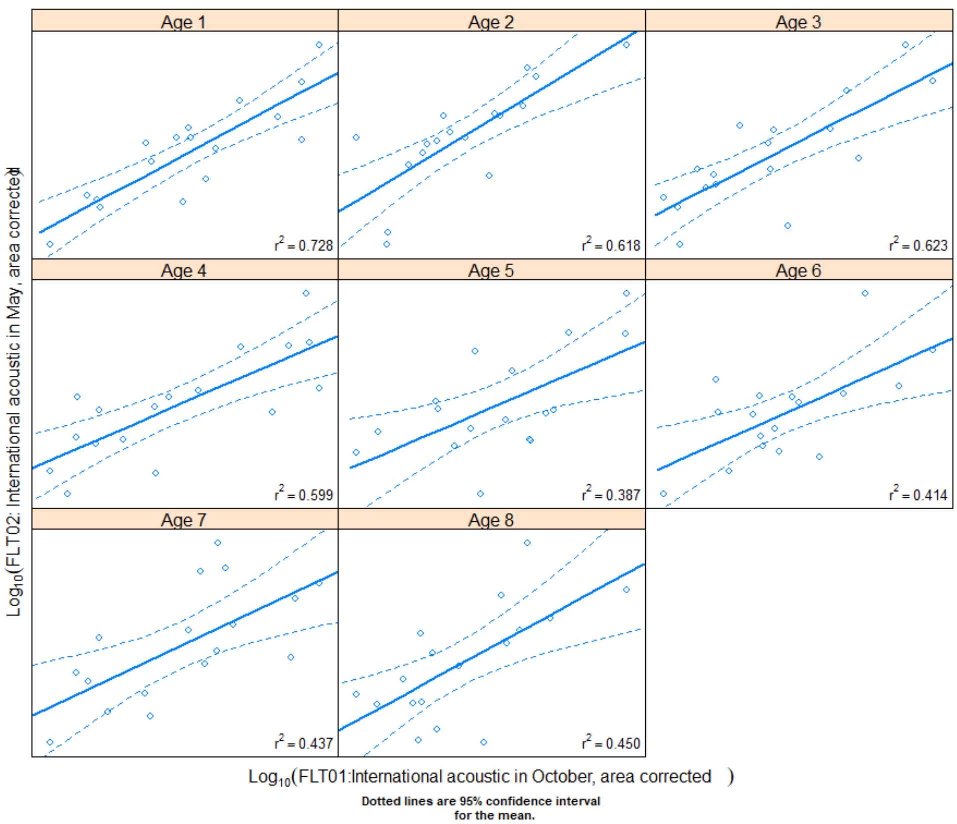


Figure 7.5c. Sprat in SD 22-32. Check for consistency between May and October surveys.

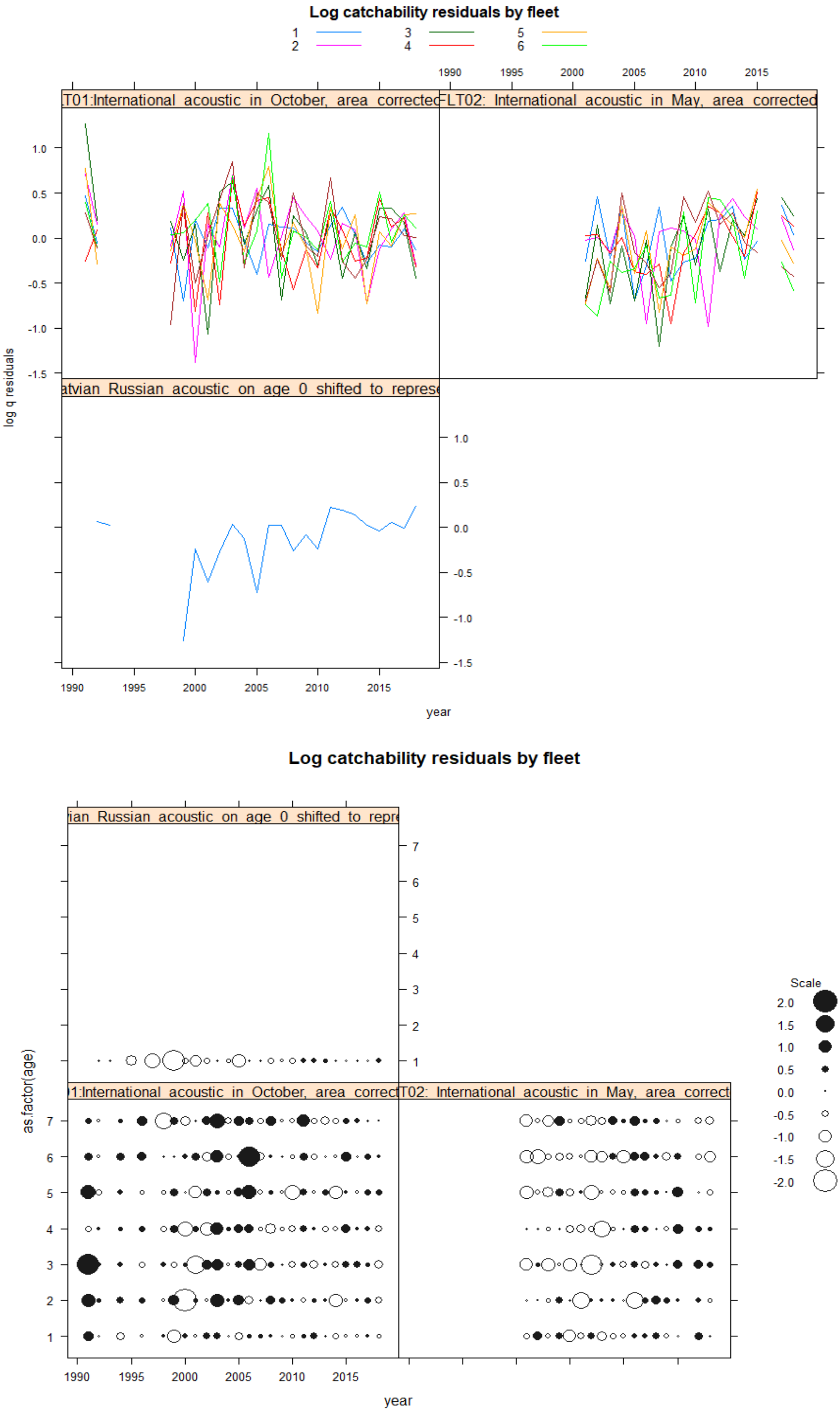


Figure 7.6. Sprat in SD 22-32. Log-catchability residuals by fleet presented in two ways.

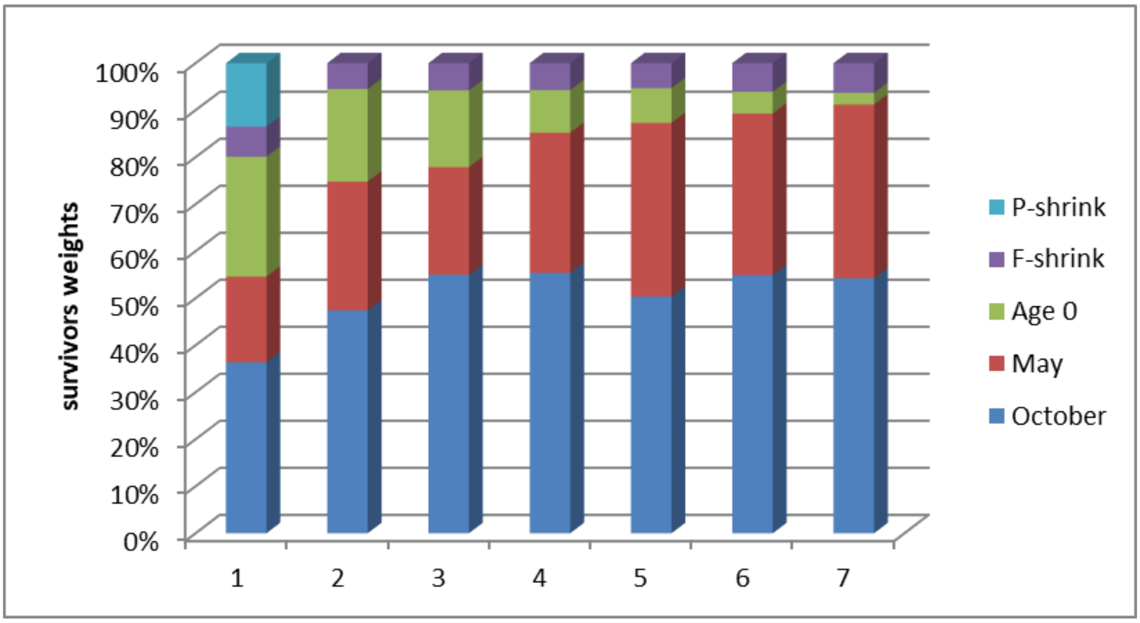


Figure 7.7a. Sprat In SD 22-32. Weights of survivors' estimates by fleet used to provide final survivors estimates.

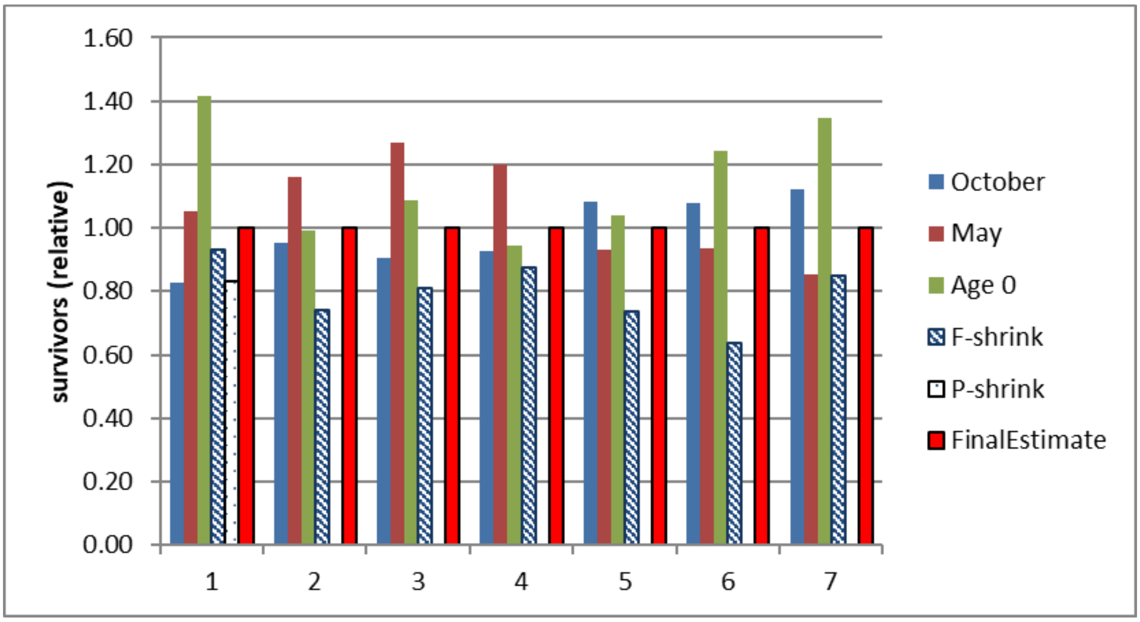


Figure 7.7b. Sprat in SD 22-32. Survivors estimates by fleet and age relative to final estimate.

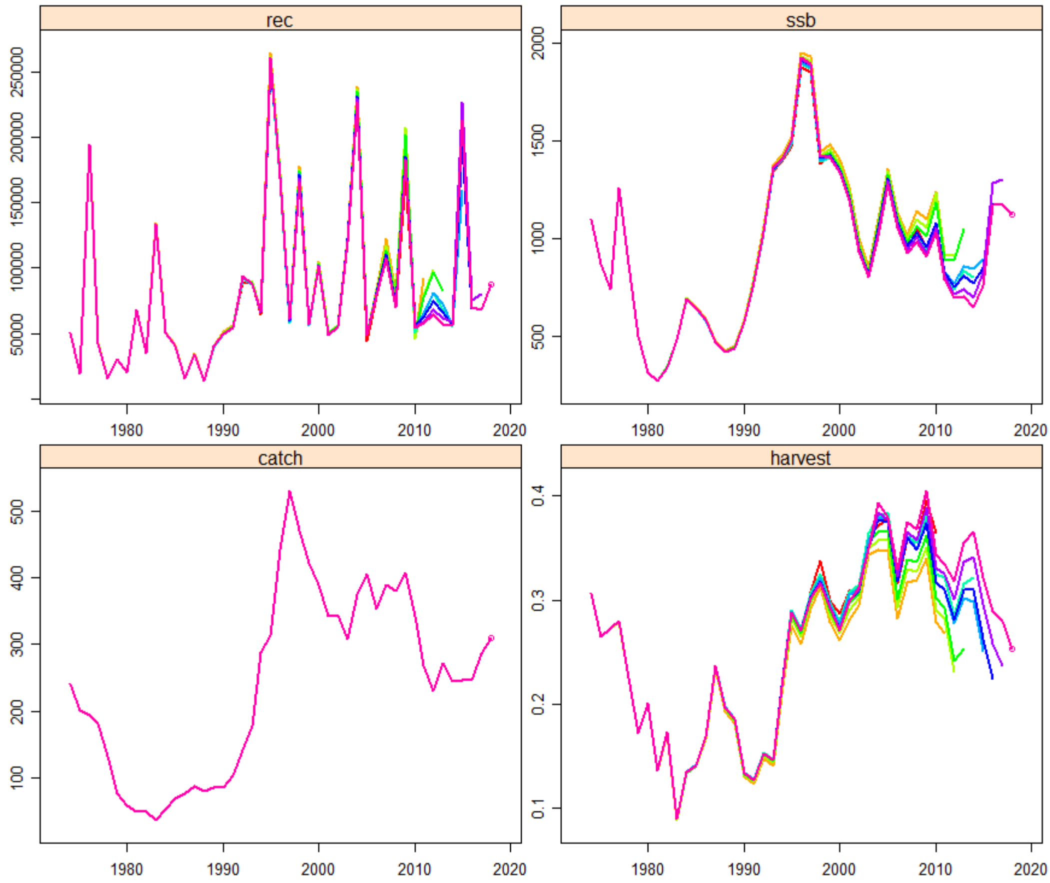


Figure 7.8. Sprat in SD 22-32. Retrospective analysis from XSA.

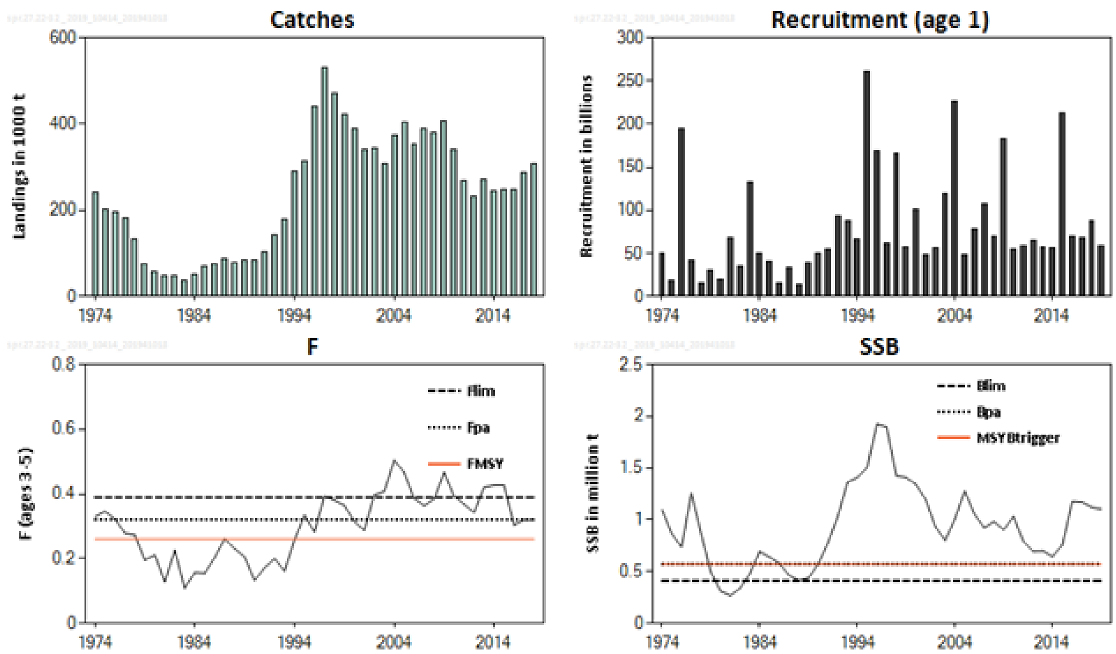


Figure 7.9. Sprat in SD 22–32. Summary sheet plots: landings, fishing mortality, recruitment (age 1) and spawning-stock biomass.

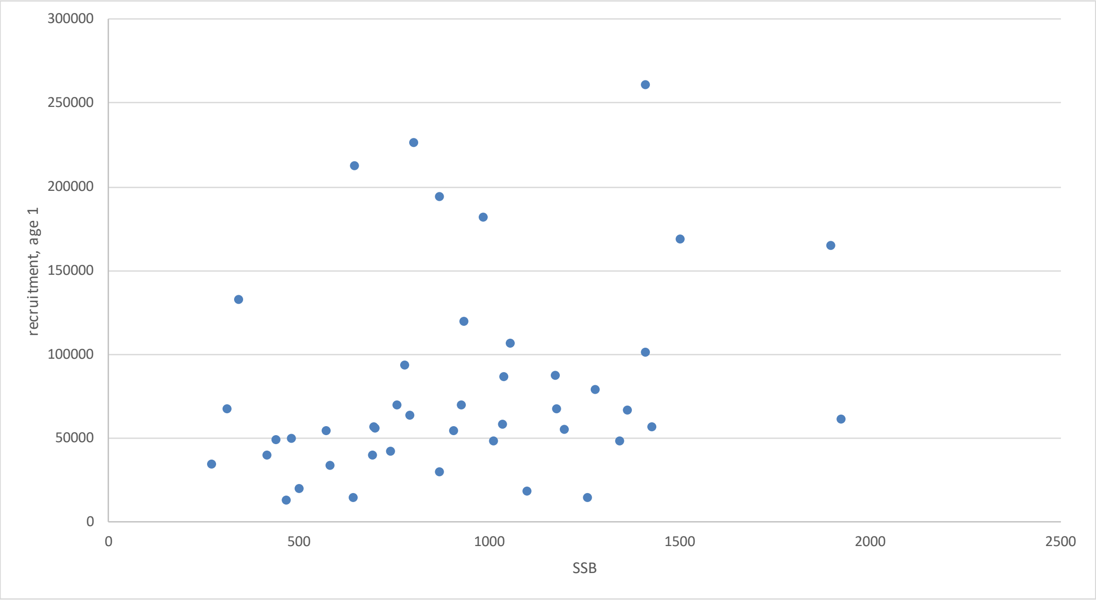


Figure 7.10. Sprat in SD 22–32. Stock - recruitment plot.

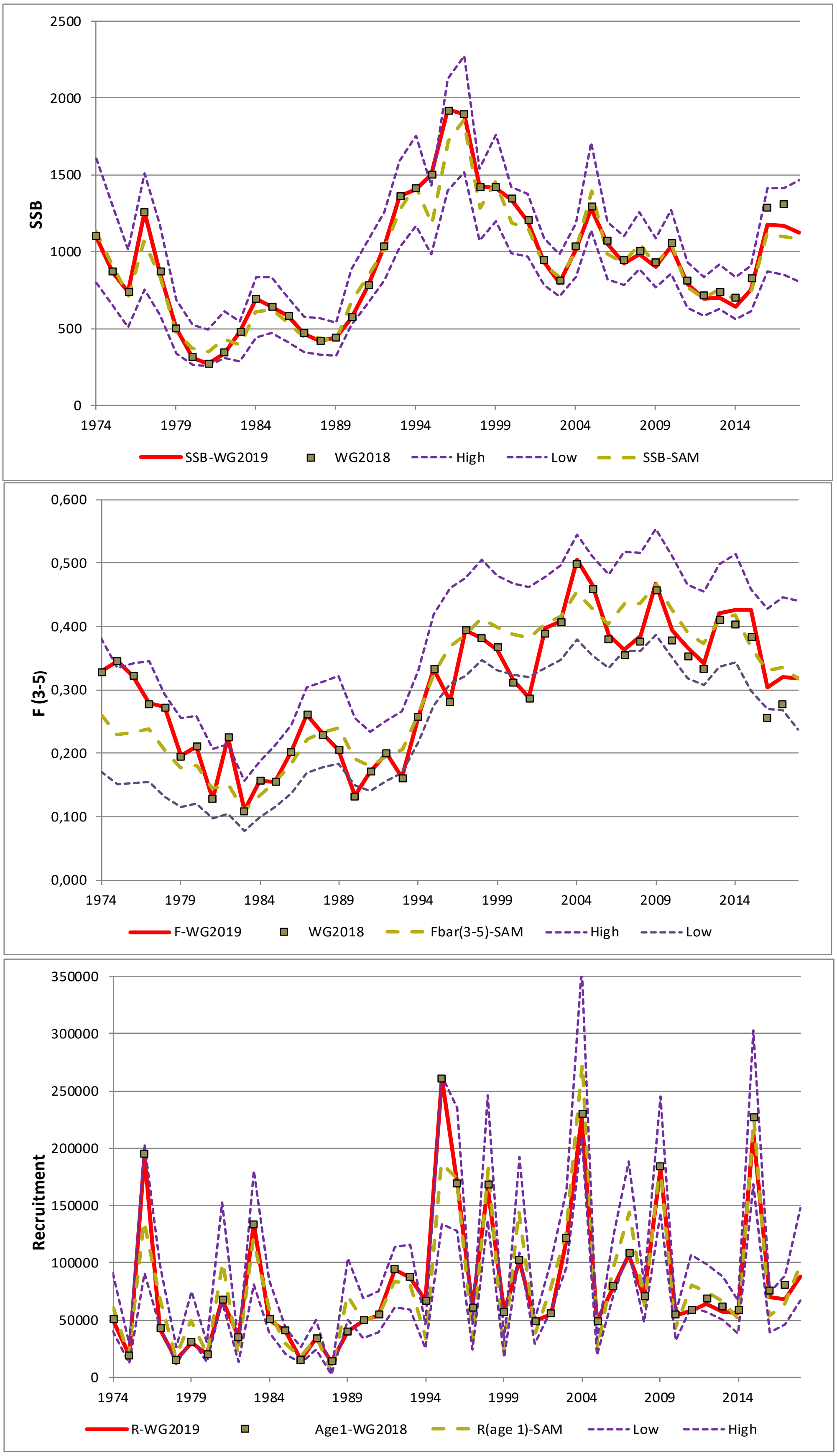


Figure 7.11a. Sprat in SD 22-32. Comparison of spawning-stock biomass, fishing mortality, and recruitment (age 1) from XSA (present and 2018) and SAM. Uncertainties of SAM estimates are shown.

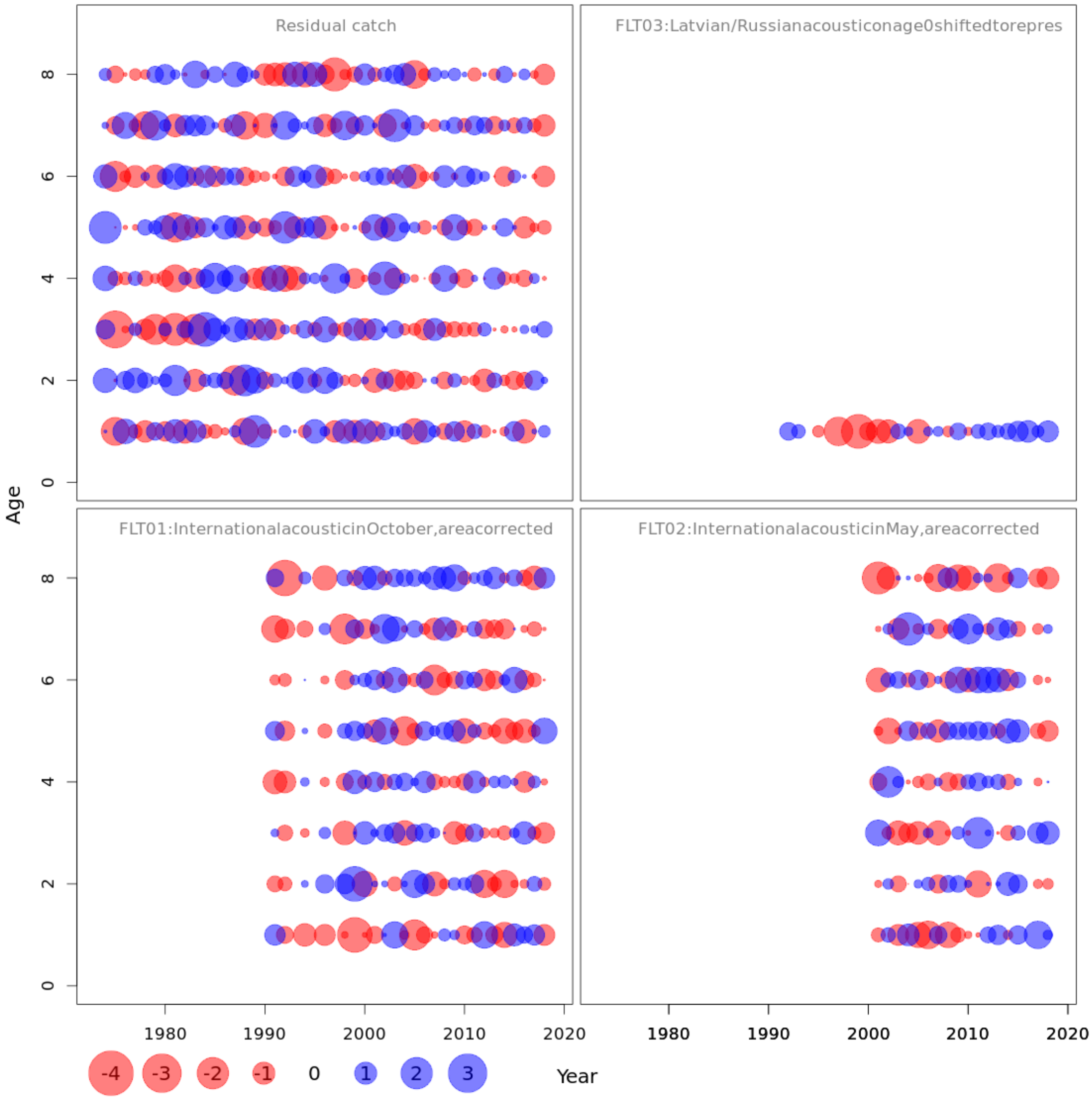


Figure 7.11b. Sprat In SD 22-32. Log-catchability residuals by fleet from SAM.

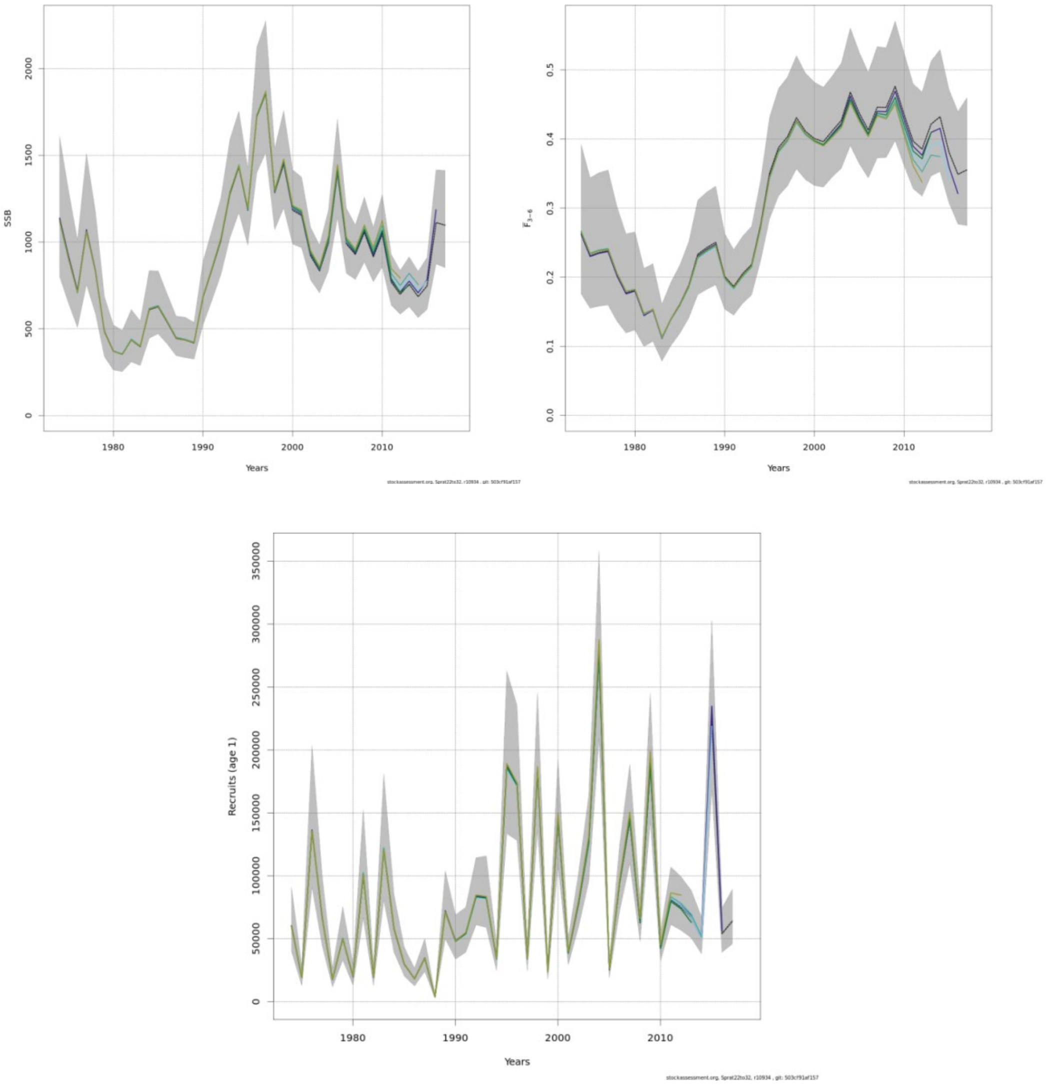

SSB
0
500
1000
1500
2000
1980
1990
2000
2010
Years
0.0
0.1
0.2
0.3
0.4
0.5
1980
1990
2000
2010
Years
Recruits (age 1)
0
50000
100000
150000
200000
250000
300000
350000
1980
1990
2000
2010
Years

Figure 7.11c. Sprat in SD 22-32. Retrospective analysis from SAM.

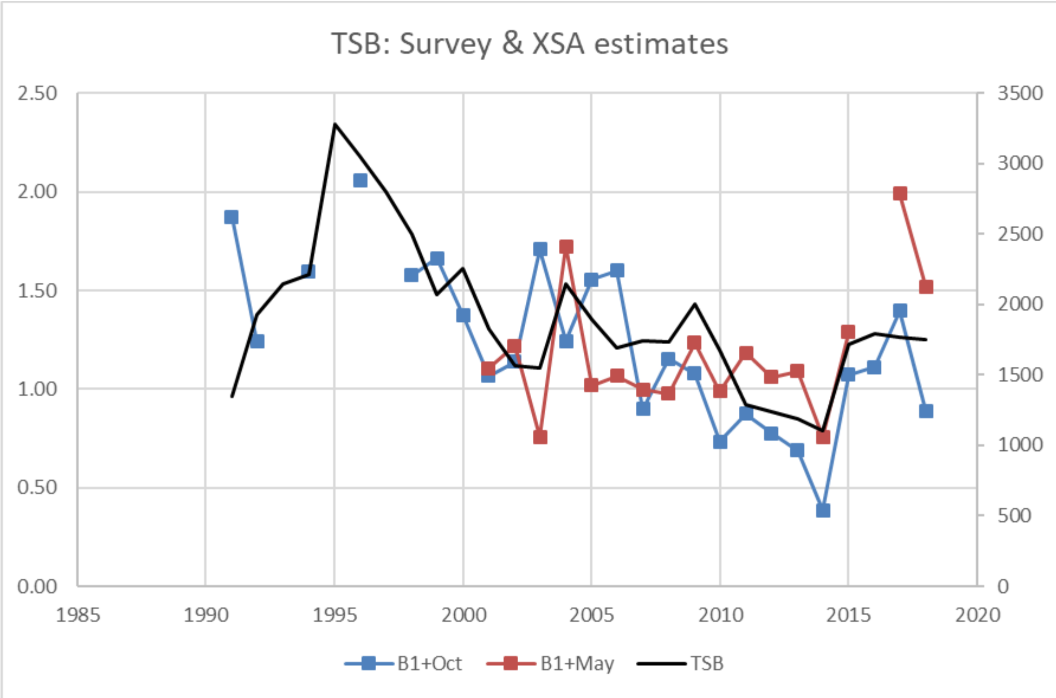


Figure 7.12. Sprat in SD 22-32. Comparison of survey (age 1+) stock size estimates with TSB.

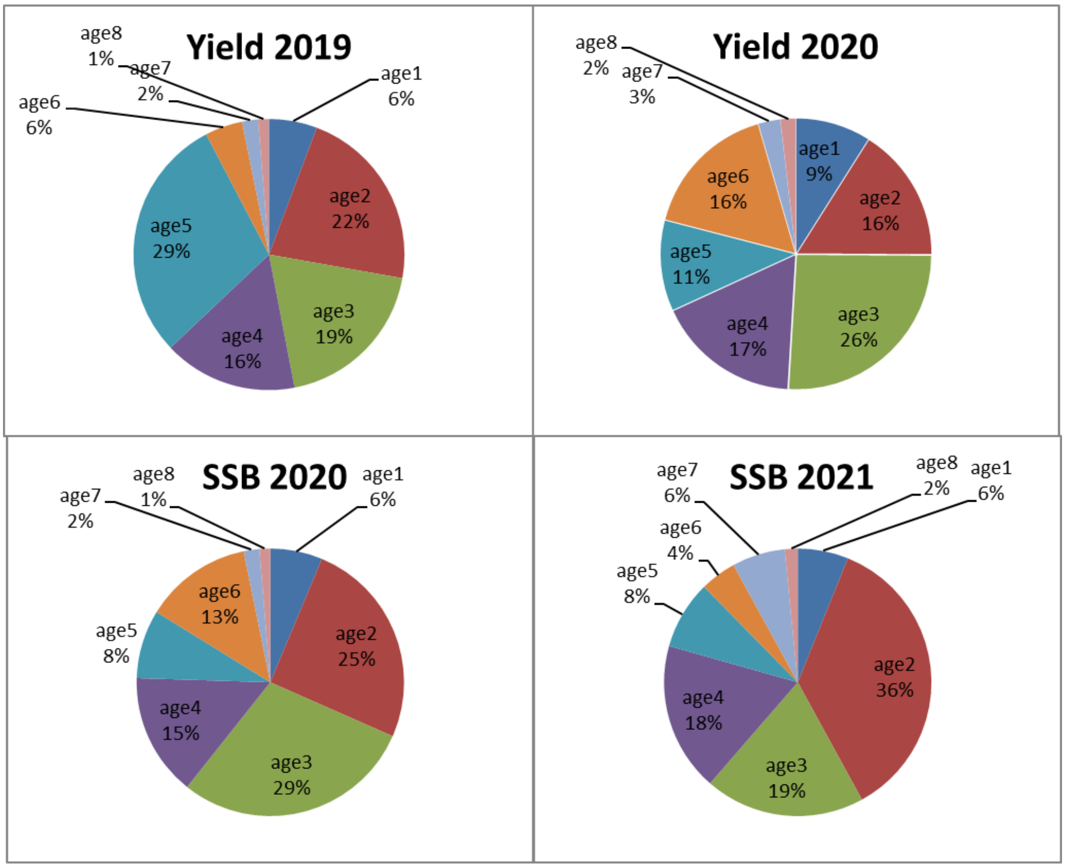


Figure 7.13. Sprat in SD 22-32. Short-term forecast for 2019-2021. Yield and SSB at age 1-8+ under the TAC constraint in 2019.

8 Turbot, dab, and brill in the Baltic Sea

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 1210 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 fishers 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 360 t 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 250 tonnes of turbot from subdivisions 22 and 24. Poland, Russia and Sweden are the main fishing countries in the Eastern and landed about 113 tonnes from subdivisions 25–28. Total landings in 2018 were about 370 tonnes. 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 2018. Due to the low sampling coverage of the discarded catch fraction, the estimates are considered too imprecise to be used for catch advice. The advice will be given for landings only.

Year	Landings (t)	Discards (t)
2012	221	139
2013	313	25
2014	253	85
2015	233	34
2016	252	100
2017	264	57
2018	370	147

8.1.2 Biological composition of the catch

Available age data were compared during the ICES/HELCOM Workshop on Flatfish in the Baltic SeaWKFLABA (2010) 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 2018 increases compared to the previous year, but is still on a low level (~5.08 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

No new advice was given in 2019. However, the report is giving an update on the stock status and the proxy reference points. The stock status is based on the data-limited approach of ICES. The mean abundance index of 2017 and 2018 were 45% higher than the mean of the abundance index from 2014–2016. 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 2018. 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 (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 Fifth Workshop on the Development of Quantitative Assessment Methodologies based on Life-history Traits, Exploitation Characteristics and other Relevant Parameters for Data-limited Stocks (WKLIFE V, 2015) (Table 8.1.2). CANUM and WECA of commercial catches from 2014–2018 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

- L_{inf}: average of 2002–2018, both quarter, only females→ L_{inf} = 46.2 cm
- L_{mat}: average of 2002–2018, quarter 1, only females → L_{mat} = 20.5 cm

The results of LBI (Figure 8.1.4) show that stock status of tur.27.22–32 is above possible reference points (Table 8.1.3). Some truncation in the length distribution in the catches might take place. Mega spawners seem to be lacking, as P_{mega} is smaller than 30% of the catch. This might very well be an artefact produced by a relative small L_{inf}, which would also explain the overfishing 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 yield/exploitation 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					Germ. Dem. Rep.[1]		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	0
2017	76	5	18	3	0			41	33	0		55	8	0	1	2	4	0	1	1	0	1	7	7	0	0	0	0	0	0	0	0
2018	103	9	41	3	0			37	55	0		72	4	0	1	14	11	0	1	2	1	5	0	7	0	0	0	0	0	0	0	0

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
2017	117	5	53	63	23	1	2	0	265
2018	141	10	111	87	13	1	7	0	370

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 Subdivision 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 subdivisions 24 and 25

In 2005 Lithuanian landings are reported for 1995 onwards

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
$L_{max5\%}$	Mean length of largest 5%	L_{inf}	$L_{max5\%} / L_{inf}$	> 0.8	Conservation (large individuals)
$L_{95\%}$	95th percentile		$L_{95\%} / L_{inf}$		
P_{mega}	Proportion of individuals above Lopt + 10%	0.3–0.4	P_{mega}	> 0.3	
$L_{25\%}$	25th percentile of length distribution	L_{mat}	$L_{25\%} / L_{mat}$	> 1	Conservation (immatures)
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c / L_{mat}	> 1	
L_{mean}	Mean length of individuals > L_c	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{maxy}	Length class with maximum biomass in catch	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals > L_c	$L_F = M = (0.75L_c+0.25L_{inf})$	$L_{mean} / L_{F=M}$	≥ 1	MSY

Table 8.1.3 Turbot in the Baltic Sea Indicator status for the most recent three years 2015-2017.

	Conservation				Optimizing Yield	MSY
Year	**L_c / L_{mat}**	**$L_{25\%} / L_{mat}$**	**L_{max5} / L_{inf}**	**P_{mega}**	**L_{mean} / L_{opt}**	**$L_{mean} / L_{F=M}$**
2016	1.05	1.10	0.88	0.12	0.89	0.99
2017	0.66	1.39	0.91	0.29	1.03	1.46
2018	0.66	1.34	0.85	0.18	0.98	1.39

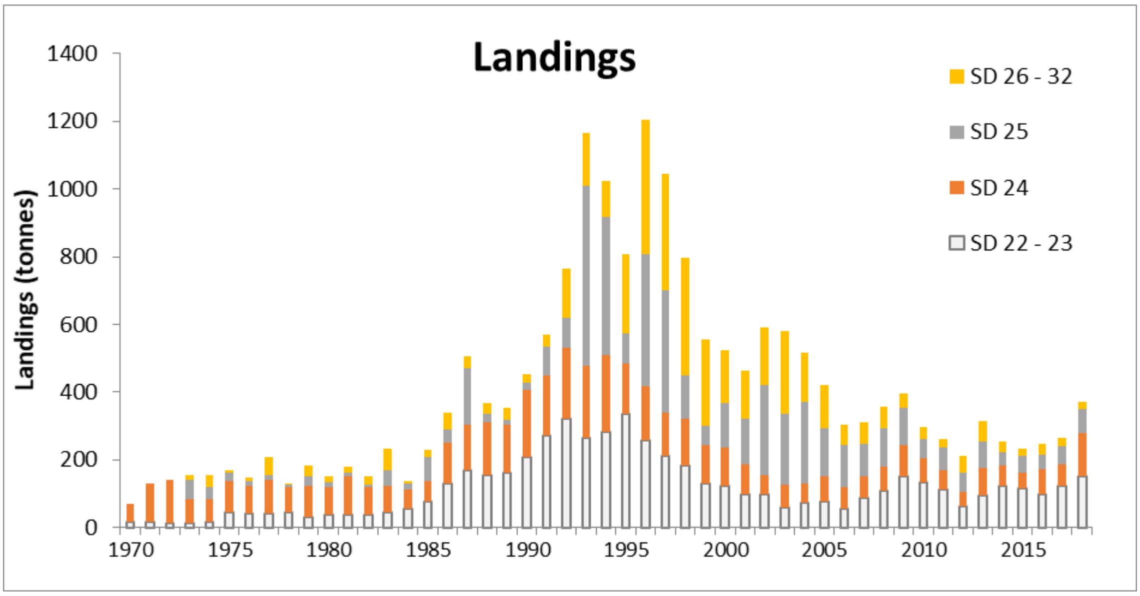


Figure 8.1.1. Turbot in the Baltic Sea. Development of turbot landings [t] from 1970 onwards by ICES subdivision (SD).

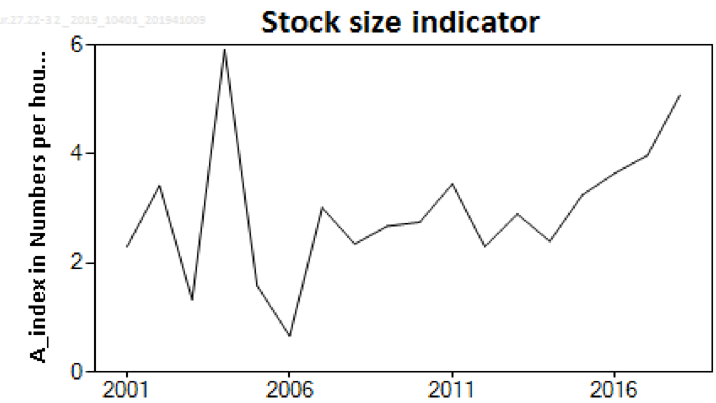


Figure 8.1.2. Turbot in the Baltic Sea. Mean CPUE (no. hr^{-1}) of turbot with L ≥20 cm based on arithmetic mean of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–28.

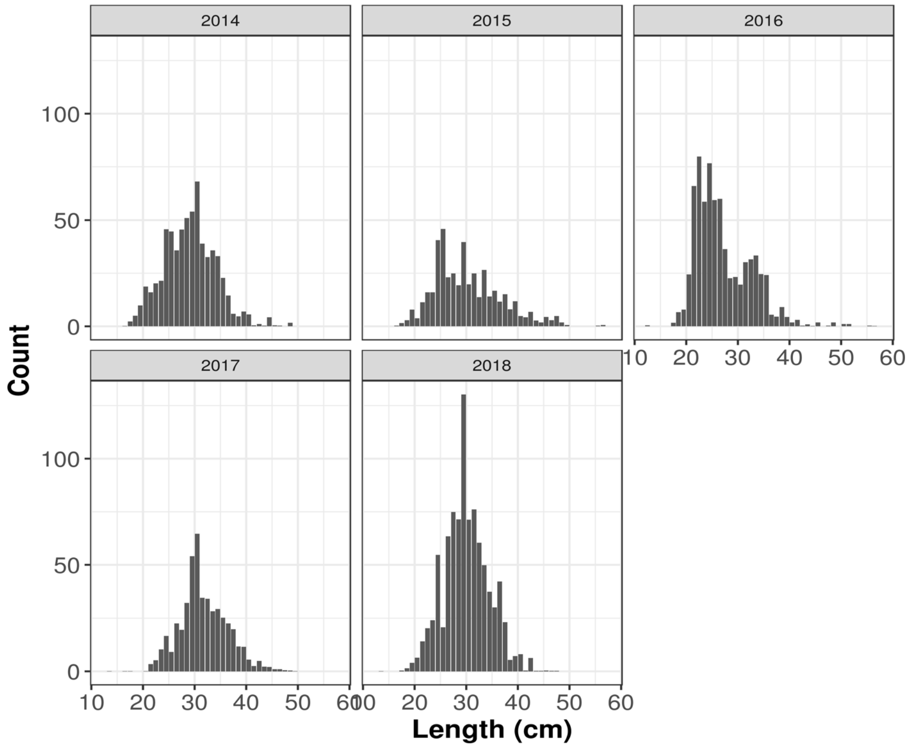


Figure 8.1.3. Turbot in subdivisions 22 to 32. Binned length frequency distributions.

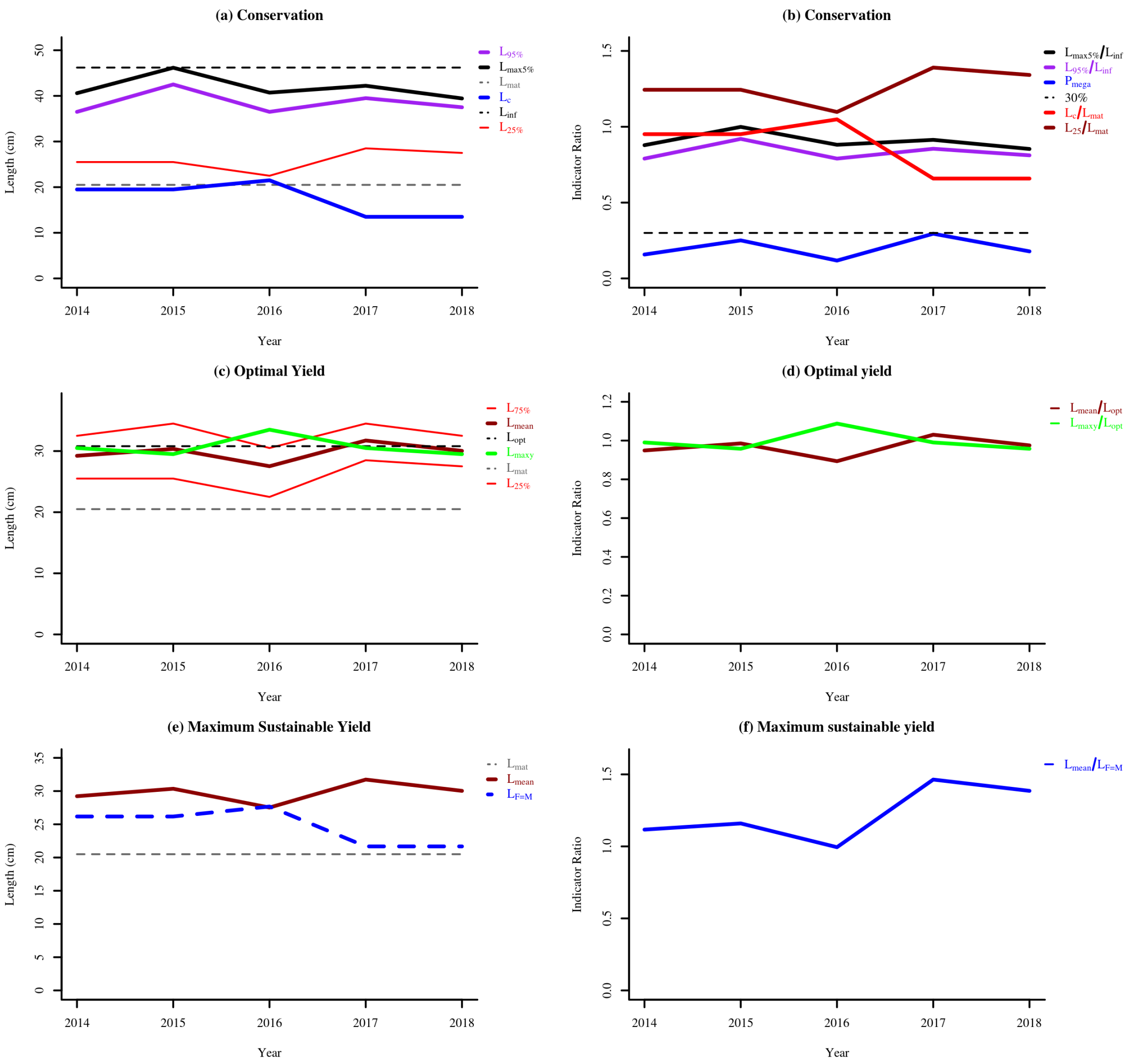


Figure 8.1.4. Turbot in subdivisions 22 to 32. Indicator trends

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 and SD 24W and SD 24E and SD 25. Analyses of BITS and IBTS data during the Benchmark Workshop on Baltic Flatfish Stocks (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 941 t (2018) and 1495 t (2005) without trend between 2005 and 2018.

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 and a mixed flatfish fisheries.

8.2.1.2 Discard

Estimates of discards were available from Denmark and Germany in 2012 to 2018.

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
2017	1227	905
2018	941	840

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

Advice on dab is given biennial assessment was conducted, but no new advice is given in 2019 for the stock. The update on the stock status is based on the data-limited approach of ICES. The advice based on landings has been changed to advice based on catch in 2018 based on estimate discards of the respective last three years. The intermediate advice for 2019 is also a catch advice. The mean biomass index of 2017 and 2018 was 11% higher than the mean of the mean biomass index from 2014–2016 (Figure 8.2.3). Therefore, no precautionary truncation was applied. The precautionary buffer was also not applied because the length based indicators are stating a good status of the stock. 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 2014–2018 were taken from InterCatch. Biological parameters were calculated using survey data from DATRAS:

- L_{inf}: average of 2002–2018, both quarter and sexes → L_{inf} = 35.61 cm
- L_{mat}: average of 2002–2018, quarter 1, only females → L_{mat} = 18 cm

The results of LBI (Figure 8.2.4) 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 lower than 30% of the catch. No overfishing on immatures is indicated ($L_c/L_{mat} < 1$). 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.

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	1011
1972	1110		30		9		63						23						1182	0	53	0	0	0	0	0	0	1235
1973	1087		58		18		118						30						1223	0	88	0	0	0	0	0	0	1311
1974	1178		51		18		118						34						1314	0	85	0	0	0	0	0	0	1399
1975	1273		74		20		131						32						1424	0	106	0	0	0	0	0	0	1530
1976	1238		60		17		114						27						1369	0	87	0	0	0	0	0	0	1456
1977	889		32		13		89						25						991	0	57	0	0	0	0	0	0	1048
1978	928		51		19	14	128	4											1075	0	69	0	0	0	0	0	0	1144
1979	1413		50		18	25	123	1					9						1554	0	85	0	0	0	0	0	0	1639
1980	1593		21		15	25	101						3						1709	0	49	0	0	0	0	0	0	1758
1981	1601		32		24	39	164						5						1789	0	76	0	0	0	0	0	0	1865
1982	1863		50		46	38	182	4					6	5	8	6		1	2091	0	98	5	0	8	6	0	1	2209
1983	1920		42		46	28	198						24	20	32	22		2	2164	0	94	20	0	32	22	0	2	2334
1984	1796		65		30	47	175	2					4	3	5	4		1	2001	0	118	3	0	5	4	0	1	2132
1985	1593		58		52	51	187	2					3	3	5	3		1	1832	0	114	3	0	5	3	0	1	1958
1986	1655		85		36	35	185	1					1	1	1	1			1876	0	122	1	0	1	1	0	0	2001
1987	1706		93		14	87	276	4					1	1	1	1			1996	0	185	1	0	1	1	0	0	2184
1988	1846		75		22	91	281	1					1	1	1	1			2149	0	168	1	0	1	1	0	0	2320
1989	1722		48		26	19	218	1					1	1	2	1			1966	0	69	1	0	2	1	0	0	2039
1990	1743		146		14	11	252	1					8						2009	0	166	0	0	0	0	0	0	2175
1991	1731		95				340	5					1						2071	0	101	0	0	0	0	0	0	2172
1992	1406		81				409	6						1	1		4		1815	0	87	1	0	1	0	4	0	1908
1993	996		155				556	10				7	1	1			1		1552	7	166	1	0	0	0	1	0	1727
1994	1621		163				1190	80	45			5	1	1					2811	5	244	46	0	0	0	0	0	3106
1995	1510	47	127	10			1185	49	3			5	1	5		1			2695	52	177	18	0	0	1	0	0	2943
1996	913	37	128				991	134	13	2	3		3	4	1				1907	37	265	17	2	1	0	0	0	2229
1997	728		60				413	21	2			5	5	10	3	1			1141	5	86	12	0	3	1	0	0	1248
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					1003	3	64	1	0	0	0	0	0	1071
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						1053	1	179	0						1233
2004	953		185				745	10	0			1	1	0					1698	1	196	0						1894
2005	752	34	163	16			474	45	9			1	1	0					1226	35	209	25	0	0	0	0	0	1495
2006	400	23	112	161			494	24	11			1	2	0		0			894	24	138	172						1228
2007	860	40	108	7			472	18	0			0	0	0	0	0			1332	40	126	7						1504
2008	757	36	86	222			507	33	0			3	0	1	1	2			1264	39	119	223		1	2			1648
2009	521	25	97	0			587	32	0			2	0	0	1	3			1108	27	129	1		1	3			1268
2010	552	18	51	0			398	17	2			1	0	0					950	19	69	2						1041
2011	544	20	39	0			647	15	0			1	0	1	0	0			1192	21	53	1						1268
2012	481	22	69	0			692	20	0	0	0	1	0	0	0	1	0	0	1173	23	89	0						1285
2013	445	18	69	0			834	17	0	0		0	0	1	0	0	1		1279	18	86	1						1384
2014	373	11	57	0			801	25	2	0		0	0	0	0	0			1174	11	82	2						1269
2015	268	9	21	0	0	0	955	14	0	0	0	0	0	0	1	0	0	0	1223	9	35	0	0	1	0	0	0	1268
2016	268	14	21				1027	23	1	0	0	0	0	0	1	1	0	0	1295	38	23	1	0	1	1	0	0	1358
2017	276	9	15				874	50			0.0	0.1	0	0.4	0	0.6	0.7	0	1150.7	59.3	15.1	0.4	0	0	0.6	0.7	0	1227
2018	273	18	20	0			560	66			0.0	1.3	0	0.1	0	0.0	0.0	0	833.2	86.1	19.9	0.2	0	0	0.0	0.0	0	940

1 From October-December 1990 landings of Germany, Fed. Rep. are included.

2 For the years 1970–1981 and 1990 the catches of subdivisions 25–28 are included in Subdivision 24.

3 For the years 1970–1981 and 1990 the Swedish catches of subdivisions 25–28 are included in Subdivision 24.

5 In 1995 Danish landings of subdivisions 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
$L_{max5\%}$	Mean length of largest 5%	L_{inf}	$L_{max5\%}$ / L_{inf}	> 0.8	Conservation (large individuals)
$L_{95\%}$	95th percentile		$L_{95\%}$ / L_{inf}		
P_{mega}	Proportion of individuals above L_{opt} + 10%	0.3–0.4	P_{mega}	> 0.3	
$L_{25\%}$	25th percentile of length distribution	L_{mat}	$L_{25\%}$ / L_{mat}	> 1	Conservation (immatures)
L_c	Length at first catch (length at 50% of mode)	L_{mat}	L_c/L_{mat}	> 1	
L_{mean}	Mean length of individuals > L_c	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	L_{mean}/L_{opt}	≈ 1	Optimal yield
L_{maxy}	Length class with maximum biomass in catch	$L_{opt} = \frac{3}{3+M/k} \times L_{inf}$	L_{maxy} / L_{opt}	≈1	
L_{mean}	Mean length of individuals > L_c	$L_{F=M}$ = $(0.75L_c+0.25L_{inf})$	L_{mean} / $L_{F=M}$	≥ 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	**L_c / L_{mat}**	**$L_{25\%}$ / L_{mat}**	**$L_{max 5}$ / L_{inf}**	**P_{mega}**	**L_{mean} / L_{opt}**	**L_{mean} / $L_{F=M}$**
2016	1.19	1.25	0.89	0.31	1.07	1.01
2017	1.08	1.14	0.89	0.23	1.02	1.03
2018	1.03	1.08	0.88	0.20	0.99	1.04

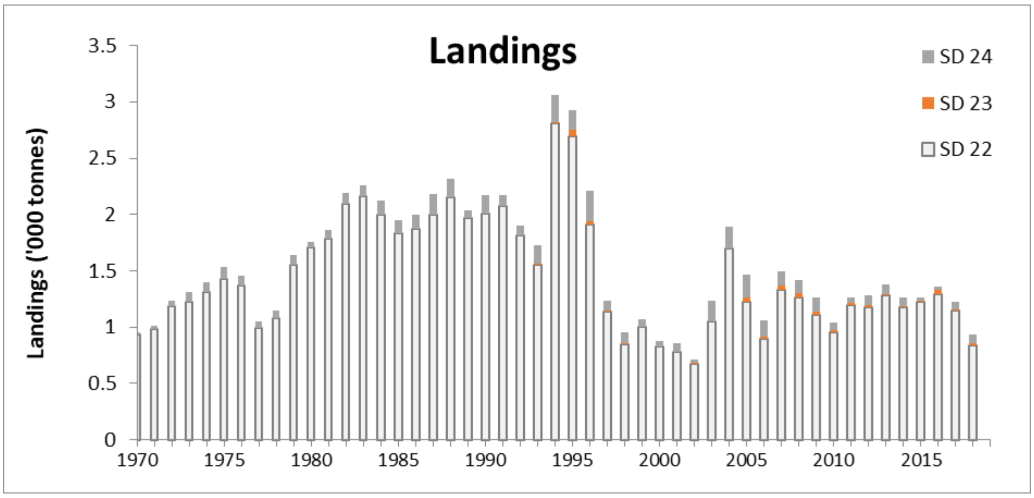


Figure 8.2.1. Dab in subdivisions 22 to 32. Development of dab landings [t] from 1970 onwards by ICES subdivision (SD).

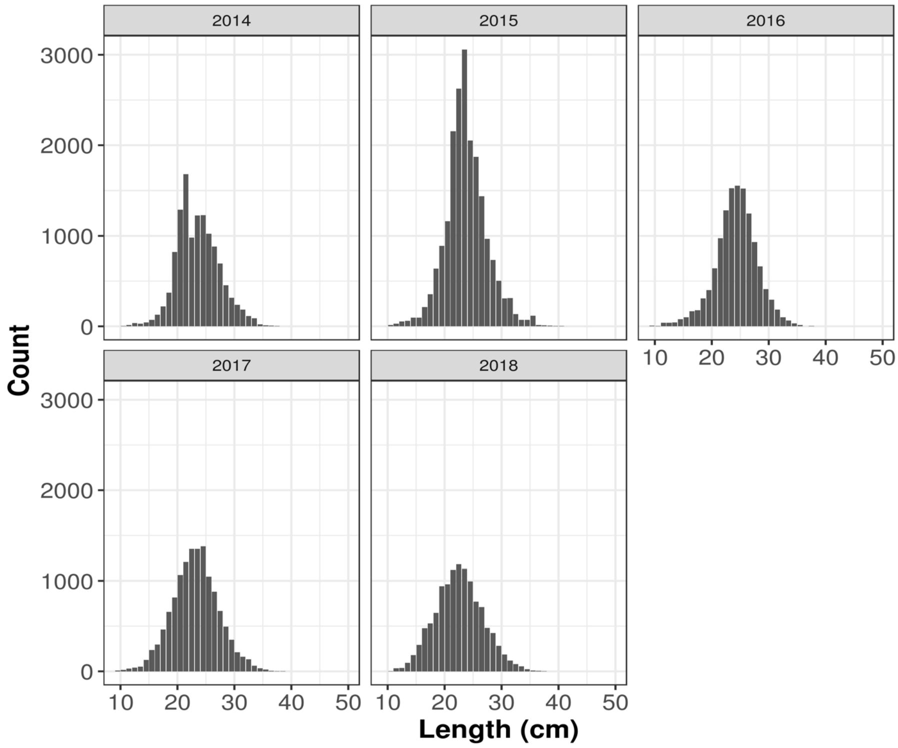


Figure 8.2.2. Dab in subdivisions 22 to 32. Catch in numbers per length for the three most recent years 2014–2018.

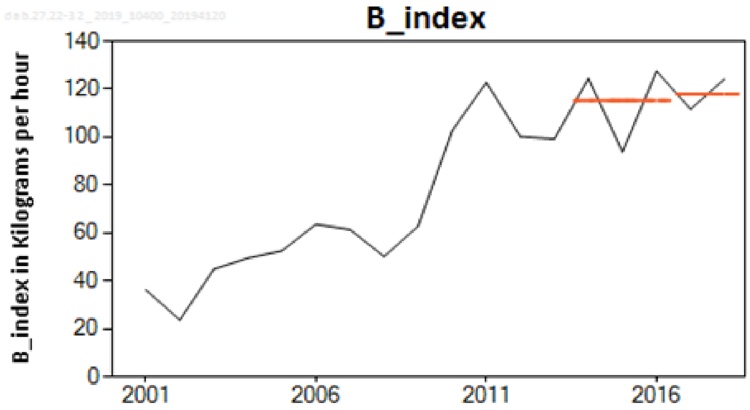


Figure 8.2.3. Dab in subdivisions 22 to 32. Mean biomass (kg hr⁻¹) of dab with L ≥15 cm based of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–24.

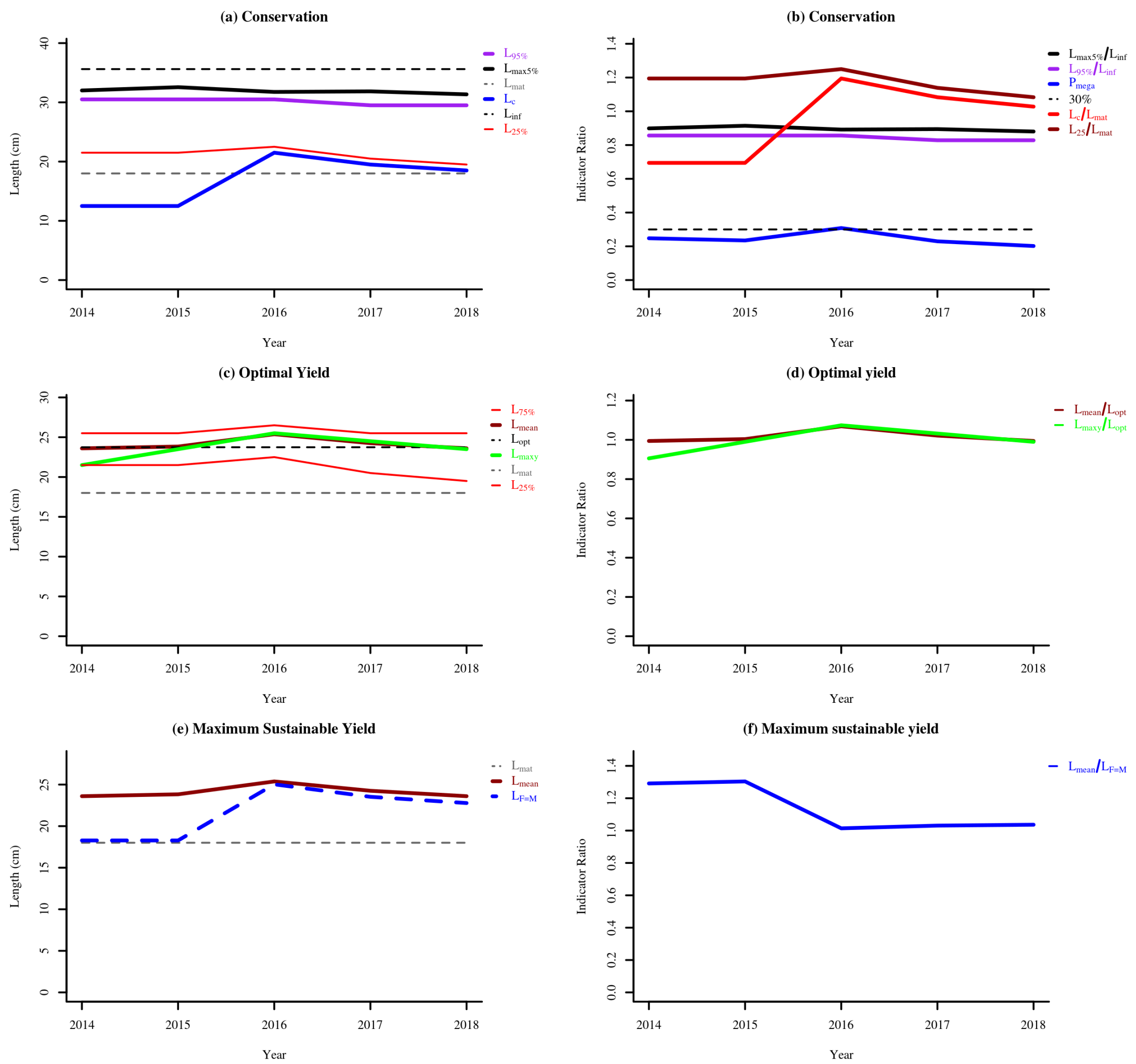


Figure 8.2.4. Dab in subdivisions 22 to 32. Indicator trends.

8.3 Brill

8.3.1 Fishery

8.3.1.1 Landings

Total landings of brill varied from 1 tonne to 160 tonnes between 1975 and 2004 (Table 5.3, Figure 5.6). 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, for 2016 and 2017with 39 t and finally at 53 t in 2018.

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 discard were reported. For 2017, 9.2 tonnes of discards have been reported. This is almost 25% of the landings. Most of these discards (7 t) have been generated in Subdivision 22, in proportion with the landings in Subdivision 22, which contribute to more than 80% of the total In 2018, discards had decreased to 3.2 t despite of an increase in landings.

8.3.2 Biological composition of the catch

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.

8.3.3 Fishery-independent information

Stock indices (CPUE) were estimated as weighted mean catch in number per hour for brill with a length of ≥20 cm. As weights applied were the sizes of the subareas sampled in the ICES subdivisions. The CPUE values of the small TV were multiplied with a conversion factor of 1.4 (Figure 5.7).

The area data are available at http://www.ices.dk/marine-data/data-portals/Pages/DATRAS-Docs.aspx . The CPUE data were derived from DATRAS (CPUE per length per haul per hour). It was not possible to match exactly the same data as in the assessments used so far. This is probably due to some selective weightings of subareas done in former assessments that has not been possible to reconstruct. However, the new and old calculation routine yield the same trends in CPUE and it is considered important from now on to derive the stock indices in a transparent and reproducible way.

Stable index with low fluctuations were observed between 2007 and 2017. CPUE values follow in general fisheries landings.

8.3.4 Assessment

ICES has not been requested to advice on fishing opportunities for this stock

8.3.5 Management considerations

Brill in ICES subdivisions 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 5.8). 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 Subdivision 22-32 with Brill in Subdivision 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
2017	29	6	0	4	0	0	0	33	6	0	39
2018	36	11	1	6	1	1	0	41	11	1	53

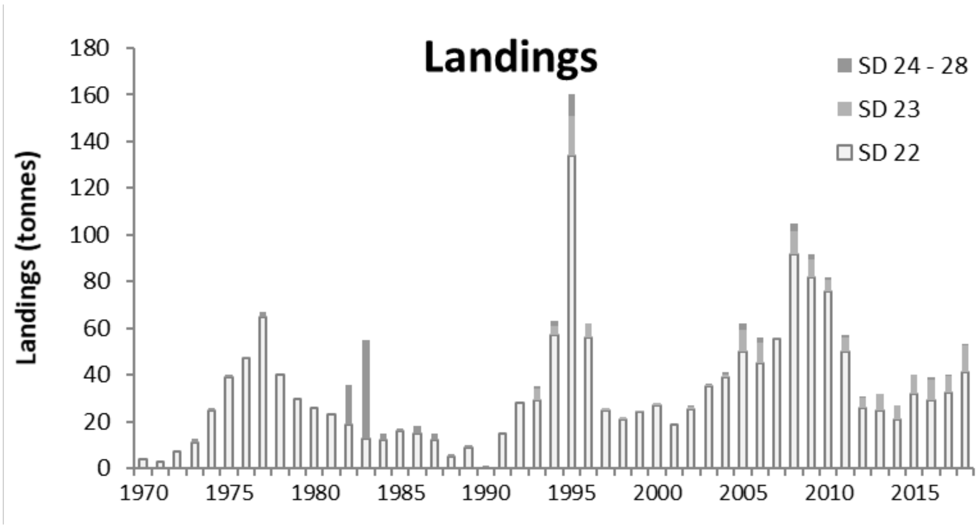


Figure 8.3.1. Development of brill landings [t] from 1970 onwards by ICES subdivision (SD).

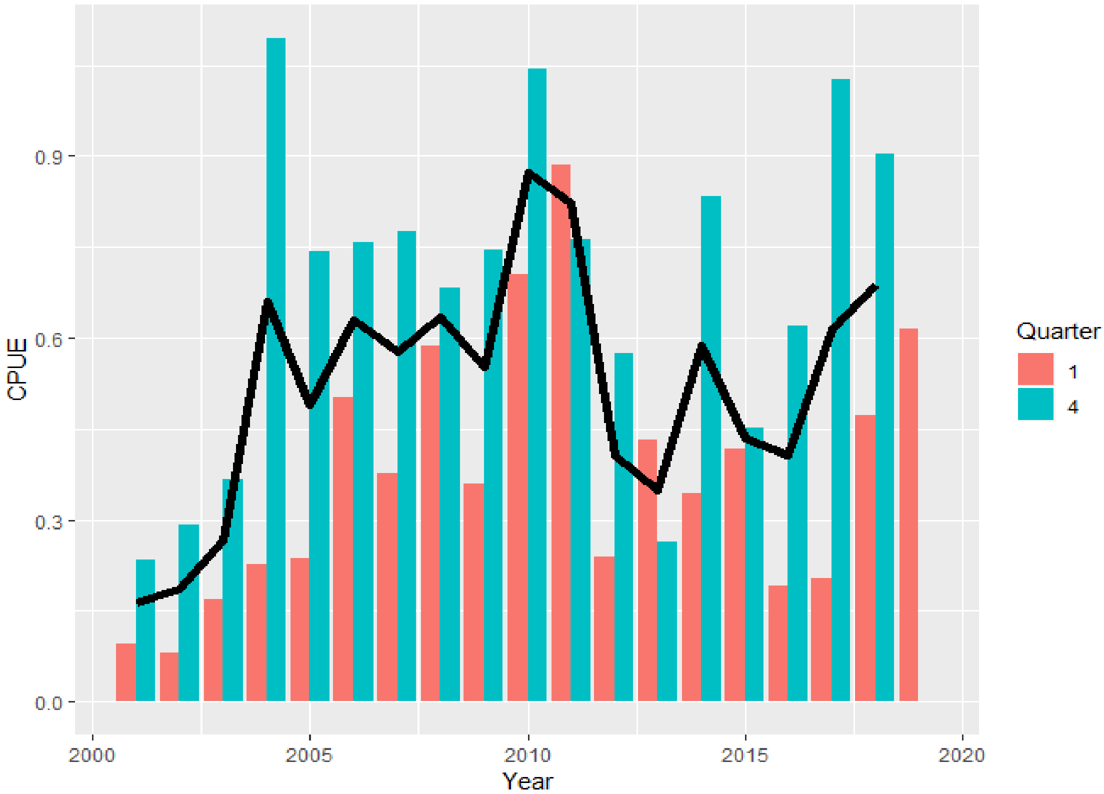


Figure 8.3.2. Mean CPUE (no. hr^{-1}) of brill with L ≥20 cm.

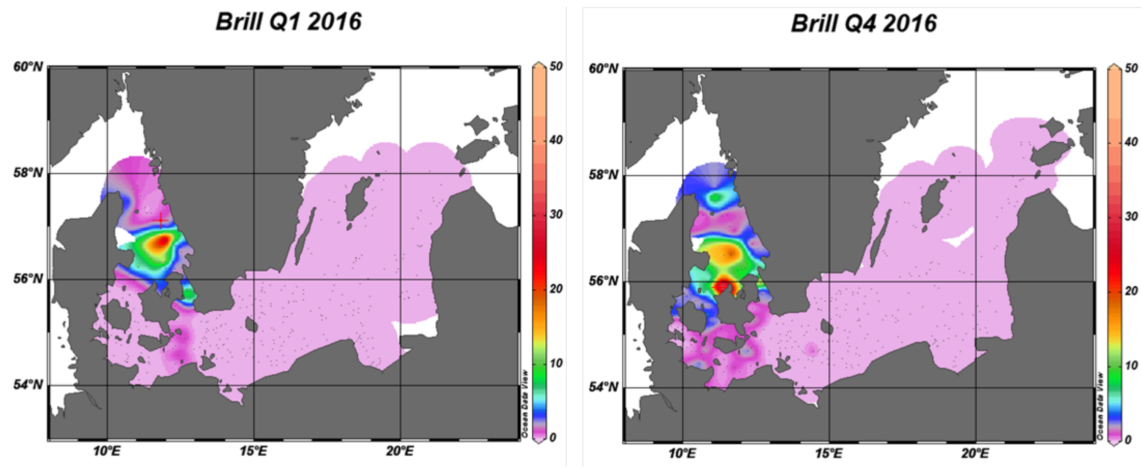


Figure 8.3.3. Brill distribution in the Baltic Sea, CPUE in numbers per hour indicated in colour bars.

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Annex 1: List of participants

Name	Email address
Amosova, Viktoriia	amosova@atlantniro.ru
Berg, Casper	cbe@aqua.dtu.dk
Bergenius, Mikaela (Chair)	mikaela.bergenius@slu.se
Boje, Jesper	jbo@aqua.dtu.dk
Carlshamre, Sofia	sofia.carlshamre@slu.se
Eero, Margit	mee@aqua.dtu.dk
Fernandez, Ruth	Ruth.Fernandez@ices.dk
Gröhsler, Tomas	tomas.groehsler@thuenen.de
Gutkowska, Julita	jgutkowska@mir.gdynia.pl
Hommik, Kristiina	kristiinahommik@gmail.com
Horbowy, Jan	horbowy@mir.gdynia.pl
Jounela, Pekka	pekka.jounela@luke.fi
Kaljuste, Olavi	olavi.kaljuste@slu.se
Karpushevskiy, Igor	karpushevskiy@atlantniro.ru
Klinger, Richard	richard.klinger@uni-hamburg.de
Krumme, Uwe	uwe.krumme@thuenen.de
Lövgren, Johan	johan.lovgren@slu.se
Mirny, Zuzanna	zuzanna.mirny@mir.gdynia.pl
Neuenfeldt, Stefan	stn@aqua.dtu.dk
Nielsen, Anders	an@aqua.dtu.dk
Öhman, Kristin	kristin.ohman@slu.se
Pekcan Hekim, Zeynep	zeynep.pekcan.hekim@slu.se
Plikshs, Maris	Maris.Plikss@bior.lv
Pönni, Jukka	jukka.ponni@luke.fi
Putnis, Ivars	Ivars.Putnis@bior.lv
Raid, Tiit	Tiit.Raid@ut.ee

Raitaniemi, Jari	jari.raitaniemi@luke.fi
Rodriguez-Tress, Paco	paco.rodriguez-tress@thuenen.de
Statkus, Romas	romas.statkus@zuv.lt
Stoetera, Sven	sven.stoetera@thuenen.de
Storr-Paulsen, Marie	msp@aqua.dtu.dk
Ulrich, Clara	clu@aqua.dtu.dk
Ustups, Didzis	Didzis.Ustups@bior.gov.lv
Zolubas, Tomas	tomas.zolubas@apc.ku.lt

Annex 2: Working documents

WD01: German Herring-Sprat Fisheries 2018.
T. Gröhsler

WD02: Cod survey in the Kattegatt 2019.
J. Lövgren

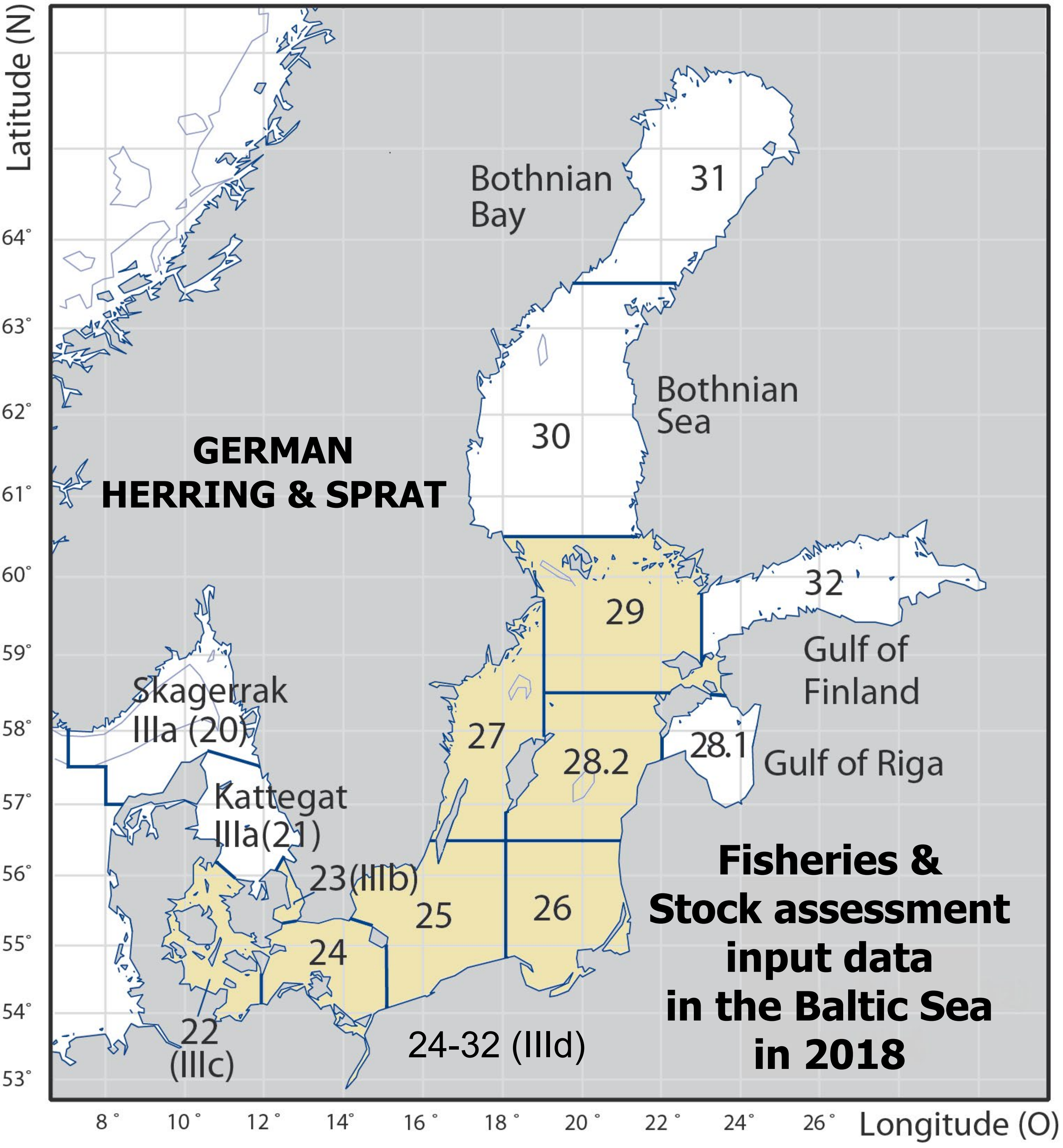
WD03: EBcod assessment using SPiCT.
C. W. Berg

WD04: Fisheries and ecosystem.
V. Amosova

WD05: Working document in response to EU special request on Eastern Baltic Cod (19_07 EBC)
M. Eero and M. Storr-Paulsen (DTU Aqua)

WD01:
German Herring-Sprat Fisheries 2018.

T. Gröhsler



compiled by
Tomas Gröhsler
Thünen Institute of Baltic Sea Fisheries (TI-OF)
Germany

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1 HERRING

1.1 Fisheries

In 2018 the total German herring landings from the Western Baltic Sea **in Subdivisions (SD) 22 and 24** amounted to 11,304, which represents a decrease of 23 % compared to the landings in 2017 (14,694 t). This decrease was caused by a decrease of the TAC/quota (German quota for SDs 22 and 24 in 2018: 9,551 t + quota-transfer of 2,434 t). The German quota in 2018 was only used by 94 % (2017: 88 %, 2016: 98). The fishing activities in one of the main fishing areas, the Greifswald Bay (SD 24), which started already in mid-February, had to be suspended at the end of February until mid-March due to a cold period with ice coverage. The main German fishery stopped their activities at the end of April.

Only a small part of the total German landings was taken **in Subdivisions 25-29** (2018: 3,951 t, 2017: 3,594 t). The landings taken in the herring fisheries exceeded the existing TAC/quota (2018: 1,338 t) by means of quota transfer (+2,696 t) with other countries around the Baltic Sea. The consequent total quota of 4,034 t was finally used by 98 %. All landings in this area were taken by the trawl fishery and landed in foreign ports (2018:100 %, 2017: 99.6 %).

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	114.932	7,521.311	48.000	1,555.669	130.000	936.231	150.329	2,820.229	27.0%	**10,456.472**	68.5%
	0.000	0.950	48.000	1,555.669	130.000	936.231	150.329	2,820.229	100.0%	2,821.179	71.3%
II	13.538	2,471.531	351.338	408.180	312.500	34.000	-	1,106.018	30.8%	**3,591.087**	23.5%
	0.000	1.500	351.338	408.180	312.500	34.000	-	1,106.018	99.9%	1,107.518	28.0%
III	0.477	0.145	-	-	-	-	-	0.000		**0.622**	0.0%
	0.000	0.000	-	-	-	-	-	0.000		0.000	0.0%
IV	7.375	1,174.924	-	-	-	-	24.999	24.999	2.1%	**1,207.298**	7.9%
	0.000	0.440	-	-	-	-	24.999	24.999	98.3%	25.439	0.6%
Total	**136.322**	**11,167.911**	**399.338**	**1,963.849**	**442.500**	**970.231**	**175.328**	**3,951.246**	**25.9%**	**15,255.479**	**100.0%**
	0.000	2.890	399.338	1,963.849	442.500	970.231	175.328	3,951.246	99.9%	3,954.136	100.0%

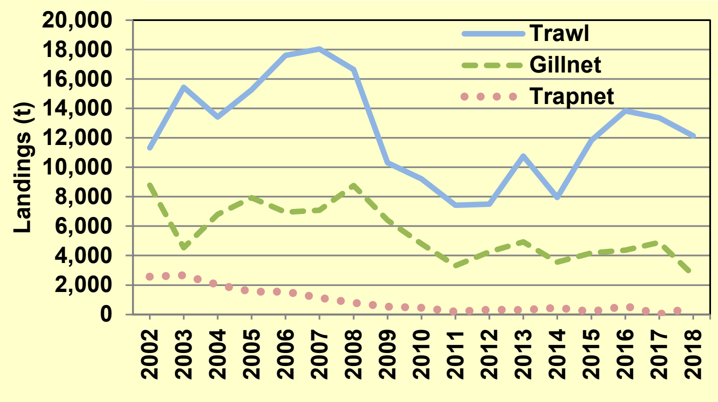
= Fraction of total landings (t) in foreign ports	100.0%	25.9%
	2018/2017:	**2018/2017:**
= Fraction of total landings (t)	109.9%	83.4%
= Fraction of total landings (t) in foreign ports	110.3%	96.1%

The main fishing season was during spring time as in former years. About 88 % of all herring (SDs 22-29) in 2018 was caught between January and April (2017: 86 %). The majority of the German herring landings (72 %) were taken in Subdivision 24 (2017: 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 before 2018.

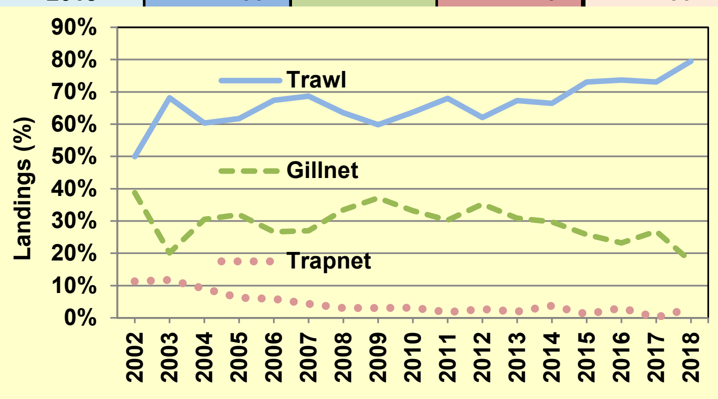
Logbook registered discards of 14.507 t have been recorded for the first in 2018 in the gillnet t fisheries in SD 24 (3.133 t in quarter 1 and of 11.374 t in quarter 2), which represent 0.1 % of the total German herring caught in SDs 20-24 of 11,510 t.

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 in SDs 22-29, reached 80 % in 2018 (2017: 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
2017	13,370.750	4,898.840	19.104	18,288.694
2018	12,136.988	2,663.317	455.174	15,255.479



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%
2017	73%	27%	0%	100%
2018	80%	17%	3%	100%



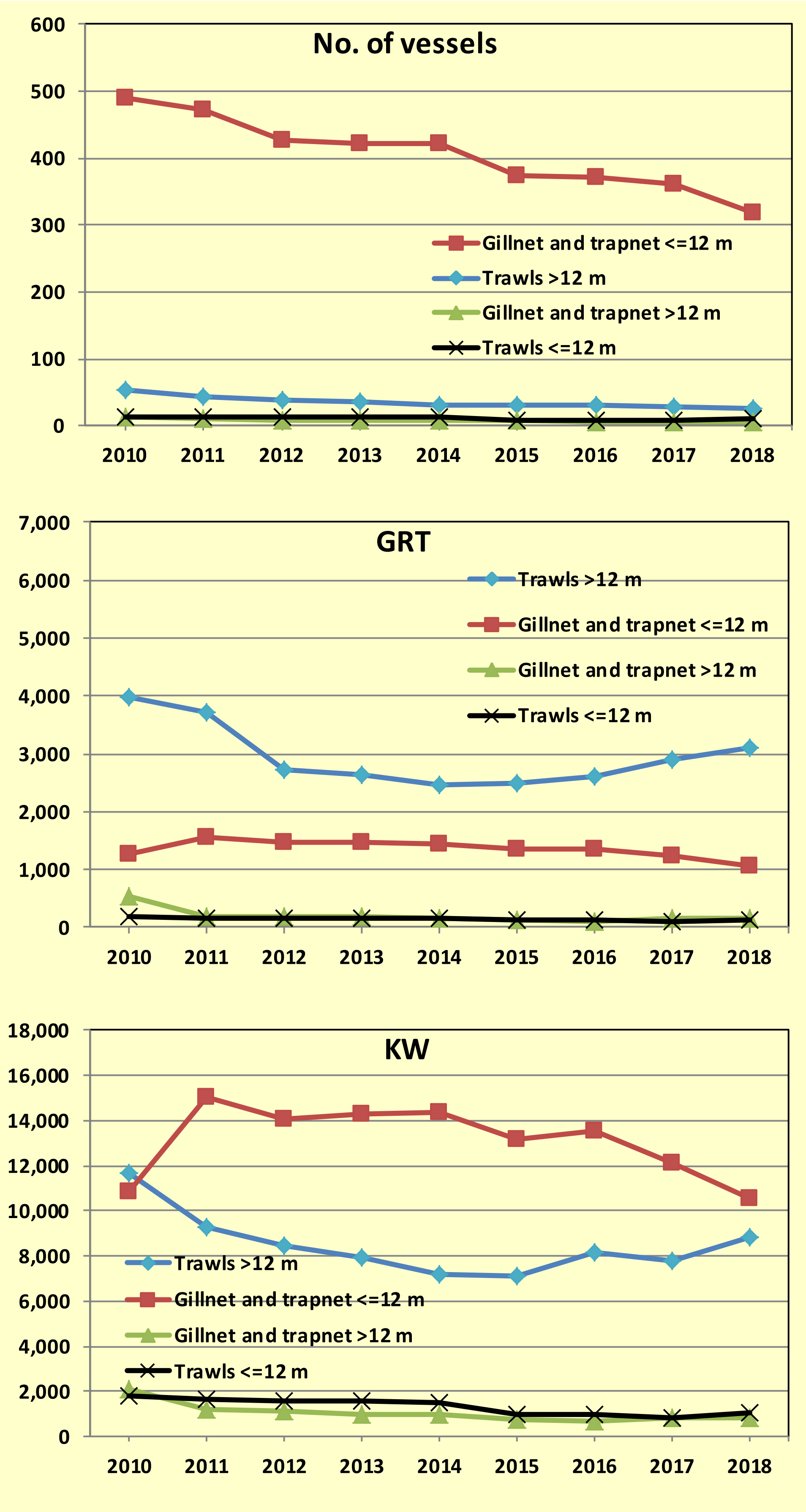
1.2 Fishing fleet

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 2010 until 2018 the following types of fishing vessels carried out the herring fishery in the Baltic (only referring to vessels, which are contributing to the overall total landings per year with more than 20 %):

Year	Type of gear	Vessel length (m)	No. of vessels	GRT	kW
2010	Fixed gears (gillnet and trapnet)	<=12	491	1,280	10,884
		>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 (gillnet and trapnet)	<=12	473	1,566	15,020
		>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 (gillnet and trapnet)	<=12	426	1,485	14,105
		>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 (gillnet and trapnet)	<=12	421	1,459	14,289
		>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 (gillnet and trapnet)	<=12	421	1,443	14,351
		>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 (gillnet and trapnet)	<=12	375	1,341	13,163
		>12	7	133	802
	Trawls	<=12	9	122	991
		>12	31	2,503	7,148
	TOTAL		**422**	**4,099**	**22,104**
2016	Fixed gears (gillnet and trapnet)	<=12	371	1,341	13,532
		>12	5	103	699
	Trawls	<=12	8	137	997
		>12	30	2,599	8,205
	TOTAL		**414**	**4,180**	**23,433**
2017	Fixed gears (gillnet and trapnet)	<=12	362	1,237	12,158
		>12	6	148	874
	Trawls	<=12	8	113	872
		>12	27	2,910	7,816
	TOTAL		**403**	**2,910**	**21,720**
2018	Fixed gears (gillnet and trapnet)	<=12	319	1,049	10,572
		>12	6	148	874
	Trawls	<=12	11	143	1,080
		>12	26	3,093	8,815
	TOTAL		**362**	**4,433**	**21,341**


No. of vessels
600
500
400
300
200
100
0
2010
2011
2012
2013
2014
2015
2016
2017
2018
Gillnet and trapnet <=12 m
Trawls >12 m
Gillnet and trapnet >12 m
Trawls <=12 m
GRT
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m
KW
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m

1.3 Species composition of landings

The catch composition from gillnet and trapnet consists of nearly 100 % of herring.

The results from the species composition of German trawl catches, which were sampled in Subdivision 24 of quarter 1 and 4 in 2018, are given below:

SD 24/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
January	1	57.4	0.0	0.0	0.0	57.4	100.0	0.0	0.0	0.0
	2	61.5	0.0	0.0	0.0	61.5	100.0	0.0	0.0	0.0
	3	53.6	0.0	0.0	0.0	53.6	100.0	0.0	0.0	0.0
	Mean	57.5	0.0	0.0	0.0	57.5	100.0	0.0	0.0	0.0
February	1	69.7	0.0	0.0	0.0	69.7	100.0	0.0	0.0	0.0
	2									
	3									
	Mean	69.7	0.0	0.0	0.0	69.7	100.0	0.0	0.0	0.0
March	1	43.7	0.0	0.0	0.0	43.8	100.0	0.0	0.0	0.0
	2	50.2	0.0	0.0	0.0	50.2	100.0	0.0	0.0	0.0
	3	56.9	0.1	0.0	0.0	56.9	99.9	0.1	0.0	0.0
	Mean	50.3	0.0	0.0	0.0	50.3	100.0	0.0	0.0	0.0
Q I	Mean	59.2	0.0	0.0	0.0	59.2	100.0	0.0	0.0	0.0

SD 24/Quarter IV		Weight (kg)					Weight (%)			
	Sample No.	Herring	Sprat	Cod	Other	Total	Herring	Sprat	Cod	Other
Octob.	1									
	2									
	3									
	Mean									
Novemb.	1									
	2									
	3									
	Mean									
Decemb.	1	60.580	0.419	0.000	0.000	60.999	99.3	0.7	0.0	0.0
	2									
	3									
	Mean	60.580	0.419	0.000	0.000	60.999	99.3	0.7	0.0	0.0
Q IV	Mean	60.580	0.419	0.000	0.000	60.999	99.3	0.7	0.0	0.0

The officially reported total trawl landings of herring in Subdivision 24 (see 2.1) in combination with the detected mean species composition in the samples (see above) results in the following differences:

Subdiv.	Quarter	Trawl landings (t)	Mean Contribution of Herring (%)	Total Herring corrected (t)	Difference (t)
24	I	**6,740**	100.0	6,740	0
	IV	**1,122**	99.3	1,115	-8

The officially reported trawl landings in Subdivision 24 (see 2.1) and the referring assessment input data (see 2.2 and 2.3) were as in last years not corrected since the results would only result in overall small changes of the official statistics (total trawl landings in Subdivision 22 and 24 of 8186 t – 8 t -> 0.1 % difference).

1.4 Logbook registered discards/BMS landings

No BMS landings (both new catch categories since 2015) of herring have been reported in the German herring fisheries in 2018 (no BMS landing have been reported since 2015). A total amount logbook registered discards of 14.507 t (quarter 1: 3.133 t; quarter 2: 11.374) were recorded by the German fisherman (as predation by seals?) in the gillnet fisheries in SD 24 in 2018. Neither discards nor logbook registered discards have been reported before 2018.

1.5 Central Baltic herring

In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring Spawning herring (WBSSH) and the Central Baltic herring (CBH) overlap. German autumn acoustic survey (GERAS) results indicated in the recent years that in SD 24, which is part of the WBSSH management area, a considerable fraction of CBH is present and correspondingly erroneously allocated to WBSSH stock indices (ICES, 2013). Accordingly, a stock separation function (SF) based on growth parameters in 2005 to 2010 has been developed to quantify the proportion of CBH and WBSSH in the area (Gröhsler et al., 2013, Gröhsler et al., 2016). The estimates of the growth parameters based on baseline samples of WBSSH and CBH support the applicability of SF in 2011-2018 (Oeberst et al., 2013, WD Oeberst et al., 2014, WD Oeberst et al., 2015; WD Oeberst et al., 2016; WD Oeberst et al., 2017; WD Gröhsler, T. and Schaber, M., 2018, WD Gröhsler, T. and Schaber, M., 2019). SF (slightly modified by commercial samples) was employed in the years 2005-2016 to identify the fraction of Central Baltic Herring in German commercial herring landings from SD 22 and 24 (WD Gröhsler et al., 2013; ICES, 2018). Results showed a rather low share of CBH in landings from all métiers but indicated that the actual degree of mixing might be underrepresented in commercial landings as German commercial fisheries target pre-spawning and spawning aggregations of WBSSH.

1.6 References

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1.7 Landings (tons) and sampling effort

1.7.1 Subdivisions 22 and 24

Gear	Quarter	SUBDIVISION 22				SUBDIVISION 24				TOTAL SUBDIVISIONS 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	102.877	0	0	0	6,739.938	7	2,924	726	6,842.815	7	2,924	726
	Q 2	0.201	0	0	0	220.305	0	0	0	220.506	0	0	0
	Q 3	0.000	-	-	-	0.000	-	-	-	no landings	0	0	0
	Q 4	0.000	-	-	-	1,122.421	1	349	119	1,122.421	1	349	119
	Total	103.078	0	0	0	8,082.664	8	3,273	845	8,185.742	8	3,273	845
GILLNET	Q 1	11.953	1	339	70	757.373	6	2,124	343	769.326	7	2,463	413
	Q 2	13.324	3	1,217	169	1,820.398	6	2,324	350	1,833.722	9	3,541	519
	Q 3	0.464	0	0	0	0.145	0	0	0	0.609	0	0	0
	Q 4	7.162	0	0	0	52.498	0	0	0	59.660	0	0	0
	Total	32.903	4	1,556	239	2,630.414	12	4,448	693	2,663.317	16	6,004	932
TRAPNET	Q 1	0.102	0	0	0	24.000	0	0	0	24.102	0	0	0
	Q 2	0.013	1	321	49	430.828	2	798	198	430.841	3	1,119	247
	Q 3	0.013	0	0	0	0.000	-	-	-	0.013	0	0	0
	Q 4	0.213	0	0	0	0.005	0	0	0	0.218	0	0	0
	Total	0.341	1	321	49	454.833	2	798	198	455.174	3	1,119	247
TOTAL	Q 1	114.932	1	339	70	7,521.311	13	5,048	1,069	7,636.243	14	5,387	1,139
	Q 2	13.538	4	1,538	218	2,471.531	8	3,122	548	2,485.069	12	4,660	766
	Q 3	0.477	0	0	0	0.145	0	0	0	0.622	0	0	0
	Q 4	7.375	0	0	0	1,174.924	1	349	119	1,182.299	1	349	119
	Total	136.322	5	1,877	288	11,167.911	22	8,519	1,736	11,304.233	27	10,396	2,024

1.7.2 Subdivisions 25-29

All herring was caught in this area by trawls. ***No samples could be taken since all herring was landed in foreign ports*.**

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	48.000	0	0	0	1,555.669	0	0	0	130.000	0	0	0
	Q 2	351.338	0	0	0	408.180	0	0	0	312.500	0	0	0
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Total	399.338	0	0	0	1,963.849	0	0	0	442.500	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	936.231	0	0	0	150.329	0	0	0	2,820.229	0	0	0
	Q 2	34.000				0.000	-	-	-	1,106.018	0	0	0
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	0	0	0
	Q 4	0.000	-	-	-	24.999	0	0	0	24.999	0	0	0
	Total	970.231	0	0	0	175.328	0	0	0	3,951.246	0	0	0

1.8 Catch in numbers (millions)

1.8.1 Subdivisions 22 and 24

Gear	W-rings	SUBDIVISION 22 Q1	Q2	Q3	Q4	SUBDIVISION 24 Q1	Q2	Q3	Q4	SUBDIVISIONS 22+24 Q1	Q2	Q3	Q4
TRAWL	0								0.126				0.126
	1	0.001	0.0000			0.069	0.002		0.272	0.070	0.002		0.272
	2	0.005	0.0000			0.302	0.010		1.928	0.307	0.010		1.928
	3	0.155	0.0003			10.133	0.331		2.465	10.288	0.332		2.465
	4	0.106	0.0002			6.934	0.227		0.613	7.040	0.227		0.613
	5	0.328	0.0006			21.496	0.703		2.481	21.824	0.703		2.481
	6	0.095	0.0002			6.220	0.203		0.538	6.315	0.204		0.538
	7	0.049	0.0001			3.221	0.105		0.341	3.271	0.105		0.341
	8+	0.026	0.0000			1.673	0.055			1.698	0.055		
	Sum	0.764	0.0015			50.048	1.636		8.763	50.812	1.637		8.763
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0												
	1												
	2												
	3	0.002	0.0005	0.0000	0.000		0.033	0.0000	0.001	0.002	0.033	0.000	0.001
	4	0.006	0.002	0.0001	0.001	**0.148**	0.433	0.0000	0.012	0.154	0.435	0.000	0.014
	5	0.006	0.021	0.0007	0.011	**2.082**	5.272	0.0004	0.152	2.089	5.293	0.001	0.163
	6	0.008	0.030	0.0011	0.016	**0.928**	2.491	0.0002	0.072	0.937	2.522	0.001	0.088
	7	0.027	0.020	0.0007	0.011	**0.878**	1.955	0.0002	0.056	0.905	1.975	0.001	0.067
	8+	0.017	0.009	0.0003	0.005	**0.301**	0.973	0.0001	0.028	0.319	0.982	0.000	0.033
	Sum	0.067	0.083	0.0029	0.045	**4.338**	11.157	0.0009	0.322	4.405	11.240	0.004	0.367
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0												
	1	0.000	0.000	0.0000	0.0004					0.000	0.000	0.0000	0.0004
	2	0.001	0.0002	0.0002	0.0025	0.002	0.036		0.00000	0.003	0.036	0.0002	0.0025
	3	0.0003	0.0000	0.0000	0.0006	0.070	1.264		0.00001	0.071	1.264	0.0000	0.0006
	4	0.0001	0.0000	0.0000	0.0003	0.044	0.788		0.00001	0.044	0.788	0.0000	0.0003
	5					0.087	1.568		0.00002	0.087	1.568		0.0000
	6					0.016	0.289		0.00000	0.016	0.289		0.0000
	7					0.013	0.235		0.00000	0.013	0.235		0.0000
	8+					0.004	0.074		0.00000	0.004	0.074		0.0000
	Sum	0.0018	0.000	0.0002	0.0038	0.237	4.253		0.00005	0.239	4.253	0.0002	0.0039
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								0.126				0.126
	1	0.001	0.000	0.000	0.0004	0.069	0.002		0.272	0.070	0.002	0.000	0.272
	2	0.0058	0.000	0.000	0.0025	0.304	0.046		1.928	0.310	0.046	0.000	1.931
	3	0.157	0.001	0.000	0.0009	10.204	1.628	0.000	2.466	10.361	1.628	0.000	2.467
	4	0.112	0.003	0.000	0.0016	7.126	1.447	0.000	0.625	7.238	1.450	0.000	0.627
	5	0.334	0.021	0.001	0.0112	23.665	7.543	0.000	2.633	24.000	7.564	0.001	2.644
	6	0.103	0.031	0.001	0.0164	7.165	2.984	0.000	0.609	7.268	3.014	0.001	0.626
	7	0.076	0.020	0.001	0.0107	4.112	2.295	0.000	0.398	4.189	2.315	0.001	0.408
	8+	0.043	0.009	0.000	0.0051	1.978	1.102	0.000	0.028	2.021	1.111	0.000	0.033
	Sum	0.833	0.085	0.003	0.0486	54.623	17.046	0.001	9.085	55.456	17.131	0.004	9.133

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22 Missing Gear	Quart.	Replacement by Area	Gear	Quart.	SUBDIVISION 24 Missing Gear	Quart.	Replacement by Area	Gear	Quart.
Trawl	1, 2	24	Trawl	1	Trawl	2	24	Trawl	1
Gillnet	3, 4	22	Gillnet	2	Gillnet	3, 4	24	Gillnet	2
Trapnet	1, 3, 4	22	Trapnet	2	Trapnet	1, 4	24	Trapnet	2

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			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0								17.9				17.9
	1	19.6	19.6			19.6	19.6		49.6	19.6	19.6		49.6
	2	49.1	49.1			49.1	49.1		79.7	49.1	49.1		79.7
	3	93.0	93.0			93.0	93.0		110.7	93.0	93.0		110.7
	4	112.7	112.7			112.7	112.7		142.9	112.7	112.7		142.9
	5	147.4	147.4			147.4	147.4		167.9	147.4	147.4		167.9
	6	157.3	157.3			157.3	157.3		196.2	157.3	157.3		196.2
	7	166.5	166.5			166.5	166.5		207.2	166.5	166.5		207.2
	8+	189.4	189.4			189.4	189.4			189.4	189.4		
	Sum	134.7	134.7			134.7	134.7		128.1	134.7	134.7		128.1
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0												
	1												
	2												
	3	153.5	101.9	101.9	101.9		111.1	111.1	111.1	153.5	111.0	103.1	109.0
	4	138.5	150.1	150.1	150.1	160.4	142.9	142.9	142.9	159.5	142.9	147.9	143.5
	5	149.5	149.6	149.6	149.6	167.6	158.7	158.7	158.7	167.6	158.6	153.0	158.1
	6	182.7	159.9	159.9	159.9	177.9	164.2	164.2	164.2	177.9	164.2	160.6	163.4
	7	185.1	165.4	165.4	165.4	182.7	168.4	168.4	168.4	182.8	168.3	166.0	167.9
	8+	190.0	176.3	176.3	176.3	196.0	185.0	185.0	185.0	195.7	185.0	178.0	183.7
	Sum	177.4	159.9	159.9	159.9	174.6	163.2	163.2	163.2	174.6	163.1	160.6	162.8
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0												
	1	45.5	45.5	45.5	45.5					45.5	45.5	45.5	45.5
	2	55.0	55.0	55.0	55.0	47.6	47.6		47.6	50.4	47.7	55.0	55.0
	3	62.5	62.5	62.5	62.5	74.9	74.9		74.9	74.9	74.9	62.5	62.8
	4	60.9	60.9	60.9	60.9	95.6	95.6		95.6	95.5	95.6	60.9	61.9
	5					117.8	117.8		117.8	117.8	117.8		117.8
	6					116.2	116.2		116.2	116.2	116.2		116.2
	7					128.4	128.4		128.4	128.4	128.4		128.4
	8+					145.4	145.4		145.4	145.4	145.4		145.4
	Sum	55.6	55.6	55.6	55.6	101.3	101.3		101.3	101.0	101.3	55.6	56.1
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0								17.9				17.9
	1	23.8	43.6	45.5	45.5	19.6	19.6		49.6	19.7	19.9	45.5	49.6
	2	50.3	54.6	55.0	55.0	49.1	47.9		79.7	49.1	48.0	55.0	79.7
	3	93.8	97.1	75.7	75.2	92.9	79.3	111.1	110.7	92.9	79.4	77.3	110.6
	4	114.1	146.4	133.0	132.2	113.6	112.4	142.9	142.9	113.6	112.5	135.6	142.8
	5	147.4	149.6	149.6	149.6	149.0	149.1	158.7	167.3	149.0	149.1	153.0	167.3
	6	159.4	159.9	159.9	159.9	159.9	159.1	164.2	192.5	159.9	159.1	160.6	191.6
	7	173.1	165.4	165.4	165.4	169.9	164.2	168.4	201.7	169.9	164.2	166.0	200.8
	8+	189.6	176.3	176.3	176.3	190.3	182.6	185.0	185.0	190.3	182.5	178.0	183.7
	Sum	138.0	159.1	152.1	151.7	137.7	145.0	163.2	129.3	137.7	145.1	154.5	129.5

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	1, 2	24	Trawl	1	Trawl	2	24	Trawl	1
Gillnet	3, 4	22	Gillnet	2	Gillnet	3, 4	24	Gillnet	2
Trapnet	1, 3, 4	22	Trapnet	2	Trapnet	1, 4	24	Trapnet	2

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								14.2				14.2
	1	14.6	14.6			14.6	14.6		19.6	14.6	14.6		19.6
	2	19.2	19.2			19.2	19.2		22.4	19.2	19.2		22.4
	3	23.5	23.5			23.5	23.5		24.5	23.5	23.5		24.5
	4	24.8	24.8			24.8	24.8		26.4	24.8	24.8		26.4
	5	27.0	27.0			27.0	27.0		27.7	27.0	27.0		27.7
	6	27.6	27.6			27.6	27.6		28.9	27.6	27.6		28.9
	7	28.2	28.2			28.2	28.2		29.6	28.2	28.2		29.6
	8+	29.6	29.6			29.6	29.6			29.6	29.6		
	Sum	26.1	26.1			26.1	26.1		25.2	26.1	26.1		25.2
GILLNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												
	1												
	2												
	3	26.9	24.6	24.6	24.6		24.1	24.1	24.1	26.9	24.1	24.6	24.2
	4	26.2	27.1	27.1	27.1	27.4	26.7	26.7	26.7	27.4	26.7	27.0	26.7
	5	26.8	26.9	26.9	26.9	28.0	27.8	27.8	27.8	28.0	27.8	27.3	27.8
	6	28.9	27.6	27.6	27.6	28.8	28.2	28.2	28.2	28.8	28.2	27.7	28.1
	7	29.0	28.0	28.0	28.0	29.2	28.5	28.5	28.5	29.2	28.5	28.1	28.4
	8+	29.4	28.8	28.8	28.8	30.3	29.6	29.6	29.6	30.2	29.6	29.0	29.5
	Sum	28.6	27.7	27.7	27.7	28.5	28.1	28.1	28.1	28.5	28.1	27.8	28.1
TRAPNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												
	1	18.6	18.6	18.6	18.6					18.6	18.6	18.6	18.6
	2	20.0	20.0	20.0	20.0	19.8	19.8		19.8	19.9	19.8	20.0	20.0
	3	20.8	20.8	20.8	20.8	23.1	23.1		23.1	23.1	23.1	20.8	20.9
	4	21.0	21.0	21.0	21.0	24.9	24.9		24.9	24.9	24.9	21.0	21.1
	5					26.7	26.7		26.7	26.7	26.7		26.7
	6					26.5	26.5		26.5	26.5	26.5		26.5
	7					27.6	27.6		27.6	27.6	27.6		27.6
	8+					28.9	28.9		28.9	28.9	28.9		28.9
	Sum	20.0	20.0	20.0	20.0	25.3	25.3		25.3	25.3	25.3	20.0	20.1
TOTAL	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0								14.2				14.2
	1	15.3	18.3	18.6	18.6	14.6	14.6		19.6	14.6	14.7	18.6	19.6
	2	19.3	19.9	20.0	20.0	19.2	19.7		22.4	19.2	19.7	20.0	22.4
	3	23.6	23.8	22.1	22.0	23.5	23.2	24.1	24.4	23.5	23.2	22.2	24.4
	4	24.8	26.5	25.9	25.8	24.8	25.4	26.7	26.4	24.8	25.4	26.1	26.4
	5	26.9	27.8	26.9	26.9	27.0	27.5	27.8	27.7	27.0	27.5	27.3	27.7
	6	27.7	28.2	27.6	27.6	27.7	28.0	28.2	28.8	27.7	28.0	27.7	28.8
	7	28.5	28.5	28.0	28.0	28.4	28.4	28.5	29.5	28.4	28.4	28.1	29.4
	8+	29.5	29.6	28.8	28.8	29.7	29.5	29.6	29.6	29.7	29.5	29.0	29.5
	Sum	26.3	28.1	27.1	27.0	26.3	27.2	28.1	25.3	26.3	27.2	27.3	25.3

REPLACEMENT OF MISSING SAMPLES:

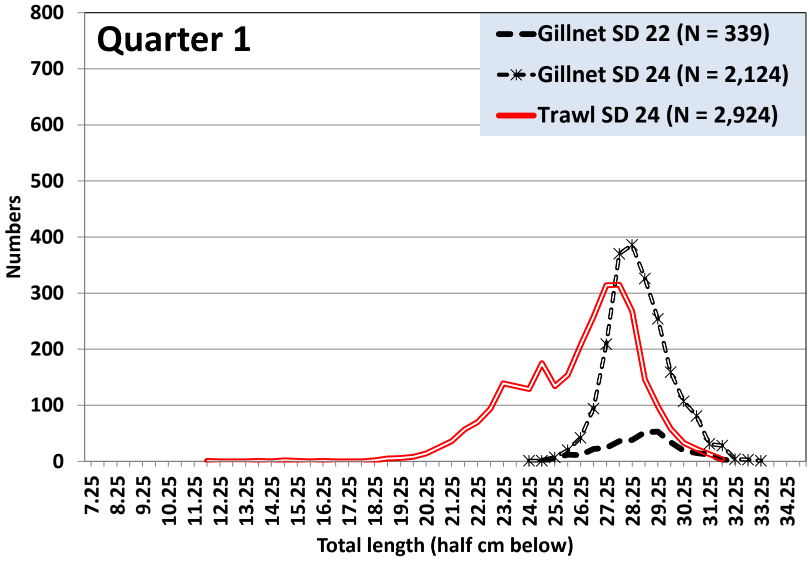
SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	1, 2	24	Trawl	1	Trawl	2	24	Trawl	1
Gillnet	3, 4	22	Gillnet	2	Gillnet	3, 4	24	Gillnet	2
Trapnet	1, 3, 4	22	Trapnet	2	Trapnet	1, 4	24	Trapnet	2

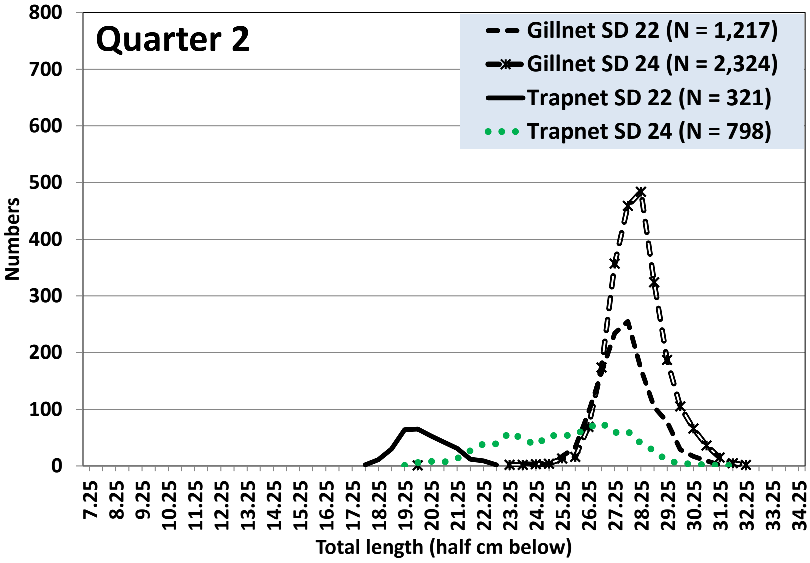
1.10.2 Subdivisions 25 and 29

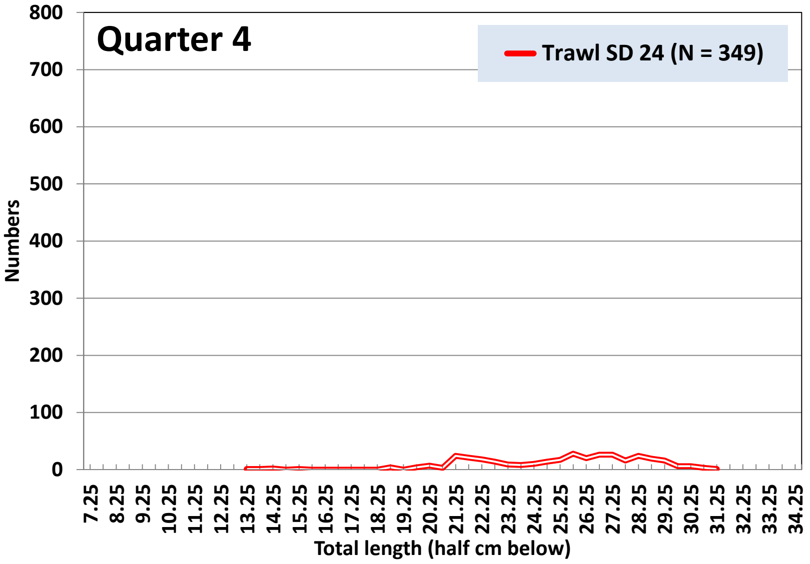
No sampling.

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 provisional sprat landings in Subdivisions 22-29 in 2018 reached according to the

(a) share of the EU quota (2018: 16,393 t) and

(b) further transfer of quota (overall 695 t were transferred to other Baltic countries)

15,213 t,

which represents a final utilization of the overall 2018 quota of 15,698 t of 96.9 % (2017: 13,553 t = 93.5 % of total quota of 14,495 t (16,310 t – quota transfer of 1,816 t)).

As in previous years most sprat was

- landed in foreign ports (2018: 90 %, 2017: 86 %)
- caught in the first quarter (2018: 69 %; 2017: 54 %),
- caught in Subdivisions 25-29 (2018: 90 %, 2017: 94 %). All catches in SDs 25-29 were landed in foreign ports (2018: 100 %, 2017: 91 %, 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	1,419.358	98.281	109.384	4,859.067	149.522	3,496.504	401.351	9,015.828	85.6%	10,533.467	69.2%
	0.000	0.000	109.384	4,859.067	149.522	3,496.504	401.351	9,015.828	100.0%	9,015.828	65.9%
II	-	1.496	788.487	2,968.813	408.383	138.383	-	4,304.066	100.0%	4,305.562	28.3%
	-	0.000	788.487	2,968.813	408.383	138.383	-	4,304.066	100.0%	4,304.066	31.4%
III	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
IV	-	4.082	-	-	-		369.761	369.761	98.9%	373.843	2.5%
	-	0.000	-	-	-	-	369.761	369.761	100.0%	369.761	2.7%
Total	**1,419.358**	**103.859**	**897.871**	**7,827.880**	**557.905**	**3,634.887**	**771.112**	**13,689.655**	**90.0%**	**15,212.872**	100.0%
	0.000	0.000	897.871	7,827.880	557.905	3,634.887	771.112	13,689.655	100.0%	13,689.655	90.0%
								2018/2017		**2018/2017**	
	Fraction of total landings (t) in foreign ports							**107.8%**		**112.2%**	
								118.1%		117.3%	
					Proportion landed in foreign ports in 2018					**90.0%**	

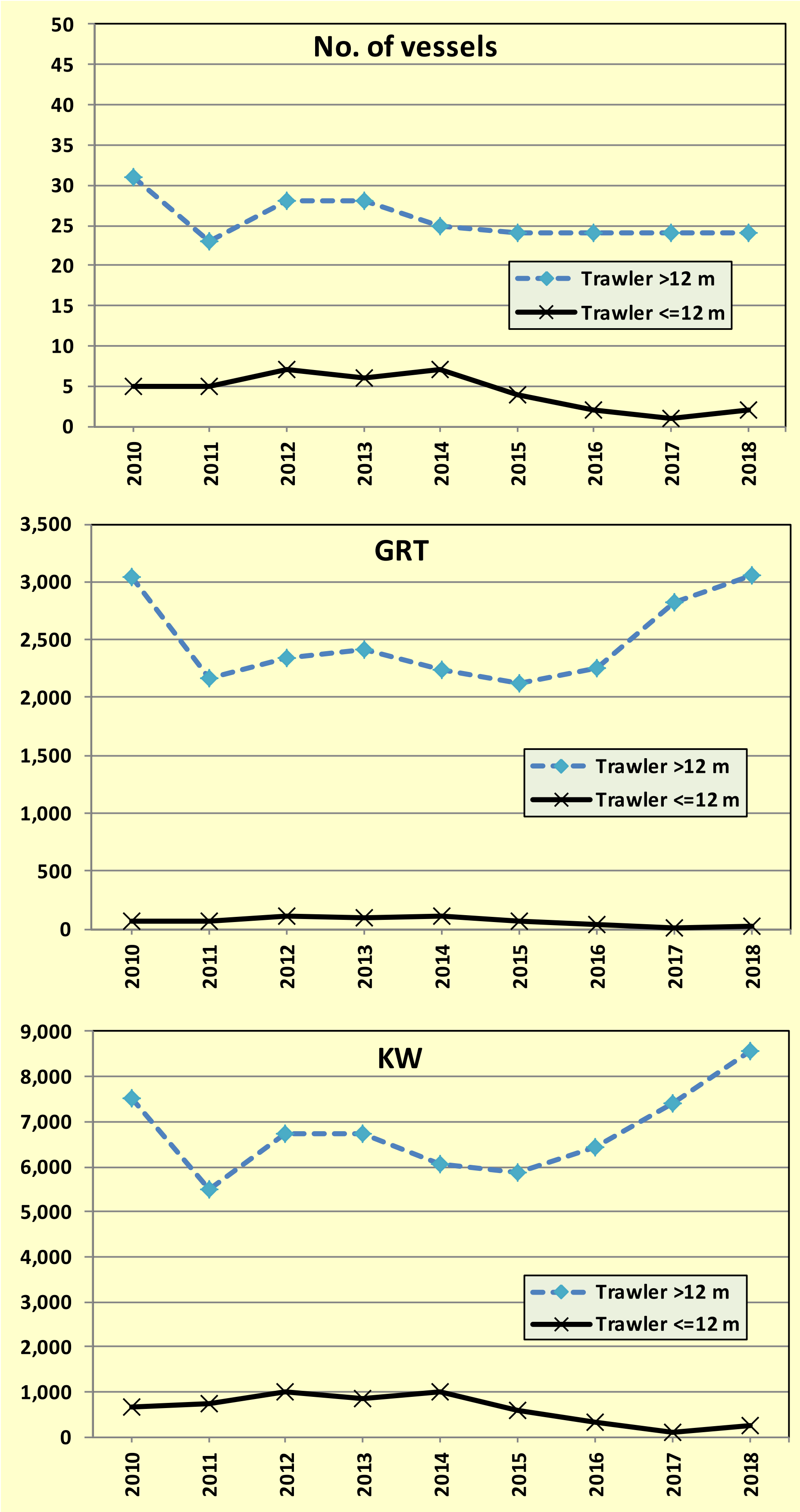
2.2 Fishing fleet

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 2010 – 2018 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
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
2017	<=12	1	17	100
	>12	24	2,821	7,396
2018	<=12	2	32	246
	>12	24	3,052	8,560


No. of vessels
50
45
40
35
30
25
20
15
10
5
0
2010
2011
2012
2013
2014
2015
2016
2017
2018
Trawler >12 m
Trawler <=12 m
GRT
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Trawler >12 m
Trawler <=12 m
KW
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
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 2018, are given below:

SD 25/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January										
	Mean									
February	1	7.4	0.7	0.0	0.0	8.1	91.7	8.3	0.0	0.0
	2	5.6	1.2	0.0	0.0	6.8	82.7	17.3	0.0	0.0
	Mean	6.5	0.9	0.0	0.0	7.4	87.2	12.8	0.0	0.0
March										
	Mean									
Q I	Mean	6.5	0.9	0.0	0.0	7.4	87.2	12.8	0.0	0.0

The results from the species composition of German trawl catches, which were sampled in **Subdivision 26 of quarter 1 and quarter 2** in 2018, are given below:

SD 26/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January	1	7.5	0.6	0.0	0.0	8.1	93.0	7.0	0.0	0.0
	Mean	7.5	0.6	0.0	0.0	8.1	93.0	7.0	0.0	0.0
February	2	5.8	1.2	0.0	0.0	7.0	82.7	17.3	0.0	0.0
	Mean	5.8	1.2	0.0	0.0	7.0	82.7	17.3	0.0	0.0
March		6.6	0.0	0.0	0.0	6.6	99.4	0.6	0.0	0.0
	Mean	6.6	0.0	0.0	0.0	6.6	99.4	0.6	0.0	0.0
Q I	Mean	6.6	0.6	0.0	0.0	7.2	91.7	8.3	0.0	0.0

SD 26/Quarter II		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
April	1	7.5	0.0	0.0	0.0	7.5	100.0	0.0	0.0	0.0
	2	7.0	0.0	0.0	0.0	7.0	99.9	0.1	0.0	0.0
	Mean	7.3	0.0	0.0	0.0	7.3	100.0	0.0	0.0	0.0
May										
	Mean									
June										
	Mean									
Q II	Mean	7.3	0.0	0.0	0.0	7.3	100.0	0.0	0.0	0.0

The results from the species composition of German trawl catches, which were sampled in **Subdivision 27 of quarter 1 and quarter 2** in 2018, are given below:

SD 28/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January	1	6.3	0.9	0.0	0.0	7.2	87.4	12.6	0.0	0.0
	Mean	6.3	0.9	0.0	0.0	7.2	87.4	12.6	0.0	0.0
February	1	8.1	0.0	0.0	0.0	8.1	99.6	0.4	0.0	0.0
	2	9.0	0.0	0.0	0.0	9.0	100.0	0.0	0.0	0.0
	Mean	8.5	0.0	0.0	0.0	8.5	99.8	0.2	0.0	0.0
March	1	7.8	0.3	0.0	0.0	8.2	96.0	4.0	0.0	0.0
	2									
	Mean	7.8	0.3	0.0	0.0	8.2	96.0	4.0	0.0	0.0
Q I	Mean	7.6	0.4	0.0	0.0	8.0	94.4	5.6	0.0	0.0

SD 28/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January	1	6.3	0.9	0.0	0.0	7.2	87.4	12.6	0.0	0.0
	Mean	6.3	0.9	0.0	0.0	7.2	87.4	12.6	0.0	0.0
February	1	8.1	0.0	0.0	0.0	8.1	99.6	0.4	0.0	0.0
	2	9.0	0.0	0.0	0.0	9.0	100.0	0.0	0.0	0.0
	Mean	8.5	0.0	0.0	0.0	8.5	99.8	0.2	0.0	0.0
March	1	7.8	0.3	0.0	0.0	8.2	96.0	4.0	0.0	0.0
	2									
	Mean	7.8	0.3	0.0	0.0	8.2	96.0	4.0	0.0	0.0
Q I	Mean	7.6	0.4	0.0	0.0	8.0	94.4	5.6	0.0	0.0

The results from the species composition of German trawl catches, which were sampled in **Subdivision 28 of quarter 1** in 2018, are given below:

SD 29/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January	1	7.8	0.8	0.0	0.0	8.6	90.6	9.4	0.0	0.0
	2	7.9	0.0	0.0	0.0	7.9	99.6	0.4	0.0	0.0
	Mean	7.8	0.4	0.0	0.0	8.2	95.1	4.9	0.0	0.0
February										
	Mean									
March										
	Mean									
Q I	Mean	7.8	0.4	0.0	0.0	8.2	95.1	4.9	0.0	0.0

The officially reported total trawl landings of sprat in Subdivisions 25-28 (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)
22	1	1,419	43.4	616	803
26	I	4,859	75.5	3,667	1,192
	II	2,969	97.1	2,882	87
27	I	150	20.7	31	119
	II	408	44.5	182	227
28	I	3,497	96.3	3,368	129

The overall difference amounted to -1,753 t, which would represent a change of the total landing value for Germany in 2017 of -12 % (total landings in SD 22-29 in 2018 of 15,213 t – 1,753 t -

>13,460 t; 2017: -4 %, 2016: -11 %, 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 these differences in 2018. However, an implementation error of about at least 4-14 % 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 or BMS landings (both new catch categories since 2015) of sprat have been reported in the German fisheries in 2018 (almost no BMS landing have been reported in 2015 - 2017 and no discards/logbook registered discards have been reported before 2018).

2.5 Landings (tons) and sampling effort

Even so most of the sprat was landed in foreign port in 2018 (90 %, 2017: 86 %), it was possible to sample 93 % (14,090 t, 2017: 80 %) 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	1,419.358	2	536	109	98.281	0	0	0	109.384	0	0	0
	Q 2	0.000	-	-	-	1.496	0	0	0	788.487	2	527	88
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.000	-	-	-	4.082	0	0	0	0.000	-	-	-
	Total	1,419.358	2	536	109	103.859	0	0	0	897.871	2	527	88

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	4,859.067	4	1,061	206	149.522	1	110	43	3,496.504	1	274	55
	Q 2	2,968.813	3	994	139	408.383	1	306	52	138.383	0	0	0
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Total	7,827.880	7	2,055	345	557.905	2	416	95	3,634.887	1	274	55

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	401.351	0	0	0	10,533.467	8	1,981	413
	Q 2	0.000	-	-	-	4,305.562	6	1,827	279
	Q 3	0.000	-	-	-	0.000	0	0	0
	Q 4	369.761	0	0	0	373.843	0	0	0
	Total	771.112	0	0	0	15,212.872	14	3,808	692

Fraction of landings in foreign ports:
[1]SD 22: 0 %
[2]SD 24: 0 %
[3]SD 25-29: 13,690 t (100 %)
[4]SD 22-29: 13.690 t (90 %)

2.6 Catch in numbers (millions)

	Age	SUBDIVISION 22 Q1	Q2	Q3	Q4	SUBDIVISION 24 *Q1	*Q2	Q3	Q4	SUBDIVISION 25 Q1	Q2	Q3	Q4	SUBDIVISION 26 Q1	Q2	Q3	Q4
TRAWL	0																
	1	31.674									0.573			85.614	14.684		
	2	69.584									13.959			97.259	56.298		
	3	6.799									18.139			165.805	52.515		
	4	12.357									38.568			205.887	150.839		
	5	0.837									3.236			40.339	27.545		
	6	1.065									0.143			5.519	7.710		
	7										0.143						
	8+										0.687						
	Sum	122.316									75.448			600.422	309.591		

	Age	SUBDIVISION 27 Q1	Q2	Q3	Q4	SUBDIVISION 28 Q1	Q2	Q3	Q4	SUBDIVISION 29 Q1	Q2	Q3	Q4	SUBDIVISIONS 22-29 Q1	Q2	Q3	Q4
TRAWL	0																
	1	18.375	11.817			60.436								196.099	27.073		
	2	2.486	5.946			53.122								222.451	76.203		
	3	3.621	19.860			121.826								298.051	90.515		
	4	4.342	15.476			169.540								392.126	204.884		
	5	0.270	5.032			27.675								69.120	35.812		
	6		0.191			3.182								9.766	8.044		
	7	0.270												0.270	0.143		
	8+	0.360												0.360	0.687		
	Sum	29.725	58.323			435.781								1188.244	443.362		

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																
	1	5.6									4.1			2.7	5.1		
	2	13.0									9.5			7.6	8.3		
	3	15.2									10.0			9.0	9.6		
	4	15.9									10.8			9.3	10.1		
	5	18.6									13.6			10.5	11.5		
	6	18.6									16.5			9.7	10.4		
	7										16.5						
	8+										12.6						
	Sum	11.6									10.5			8.1	9.6		

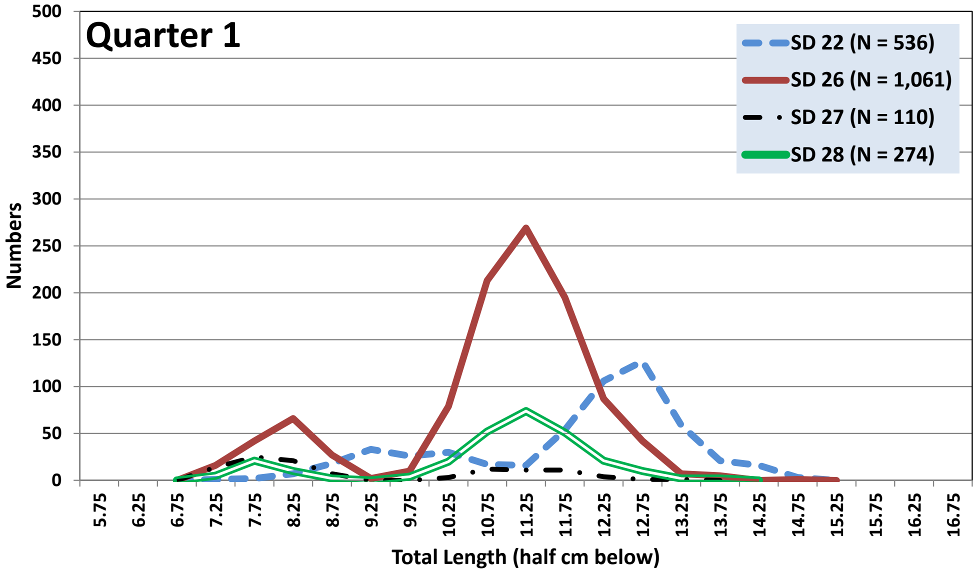
		SUBDIVISION 27				SUBDIVISION 28				SUBDIVISION 29				SUBDIVISIONS 22-29			
	Age	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0																
	1	2.6	2.5			2.7								3.1	3.9		
	2	7.7	6.8			7.3								9.2	8.4		
	3	9.0	8.2			8.8								9.1	9.4		
	4	9.2	8.2			9.2								9.5	10.1		
	5	12.1	9.4			10.1								10.4	11.4		
	6		10.7			11.0								11.1	10.5		
	7	12.1												12.1	16.5		
	8+	11.2												11.2	12.6		
	Sum	5.0	7.0			8.0								8.4	9.4		

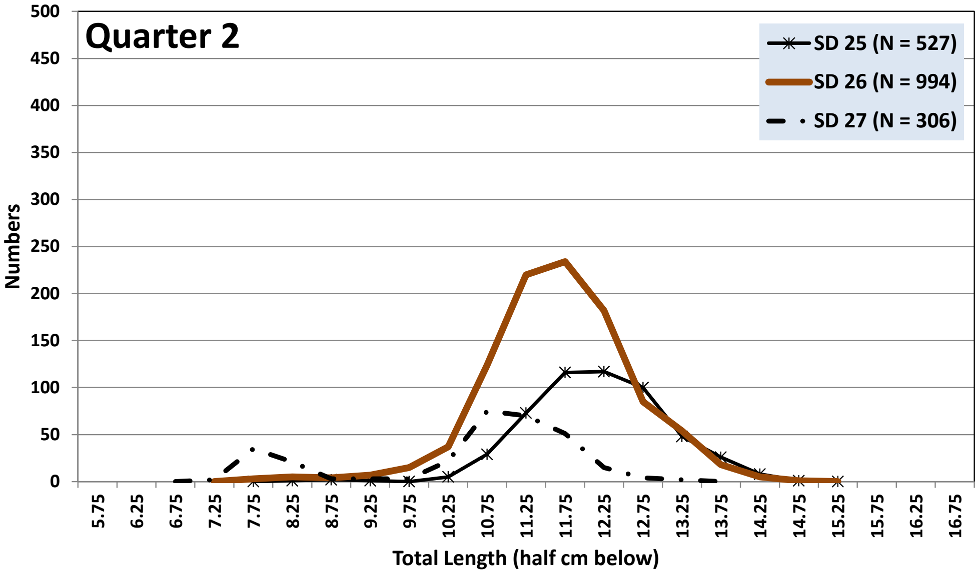
2.8 Mean length in the catch (cm)

		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																
	1	9.7									9.3			8.1	9.5		
	2	12.4									11.8			10.7	11.2		
	3	13.2									12.0			11.3	11.7		
	4	13.4									12.3			11.5	11.9		
	5	14.4									13.5			12.1	12.5		
	6	14.5									14.3			11.8	12.0		
	7										14.3						
	8+										13.3						
	Sum	11.9									12.2			10.9	11.7		

		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																
	1	7.9	8.0			7.9								8.3	8.8		
	2	10.6	10.4			10.4								11.1	11.2		
	3	11.4	11.2			11.3								11.4	11.7		
	4	11.5	11.2			11.5								11.6	11.9		
	5	12.8	11.9			12.1								12.1	12.5		
	6		13.3			12.8								12.4	12.1		
	7	13.3												13.3	14.3		
	8+	12.3												12.3	13.3		
	Sum	9.3	10.5			10.9								10.9	11.6		

2.9 Sampled length distributions of sprat by Subdivision and quarter





WD02:
Cod survey in the Kattegatt 2019.

J. Lövgren

Joint Swedish and Danish survey for cod in the Kattegat November-December 2018

O.A. Jorgensen and Marie Storr-Paulsen[1]
Katja Ringdahl, Johan Lövgren, Patrik Börjesson[2]

[1]DTU-Aqua Charlottenlund Slot, DK 2920 Charlottenlund, Denmark
[2]Havsfiskelaboratoriet, SLU, Turistgatan 5, 453 30, Lysekil, Sweden

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 in cooperation with commercial trawlers from Denmark and Sweden. The survey design has been largely unchanged during the years, but a fourth stratum representing the closed area in Southern Kattegat was added in 2013. The total swept area biomass of cod was estimated to 647 tonnes in 2018. This corresponds to a reduction of more than 90% compared to 2015 when the highest biomass was estimated and represents the lowest estimated biomass in the whole time series of the survey. The abundance decreased from an estimated 3.52 million individuals in 2017 to 0.88 million in 2018 which is also the lowest number ever estimated in the survey. The estimated numbers of fish five years and older is still higher than in 2009-2011, but the potential recruitment observed in 2017 data can no longer be detected in the survey.

Introduction

Cod fishermen in Kattegat have, 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 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 at the benchmark 2016 it was concluded that other factors, primarily migration of cod from the North Sea/Skagerrak was a major 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 the way they are designed, as well as limited coverage and sampling intensity. This also implies that 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 and distribution of cod. The results should be used to strengthen the scientific advice on the cod stock in Kattegat. Due to 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 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, parts of Laholmsbukten and Skælderviken 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 2008-2011 stratified in three strata based on information from commercial fishers on expected densities of cod: a stratum with expected high density of cod, a stratum with medium density and a stratum with low density. In 2010 and 2011 there was a minor re-stratification to adopt the areas to the catch information collected during the former years. In 2013 a fourth strata was 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-c) and table 1.

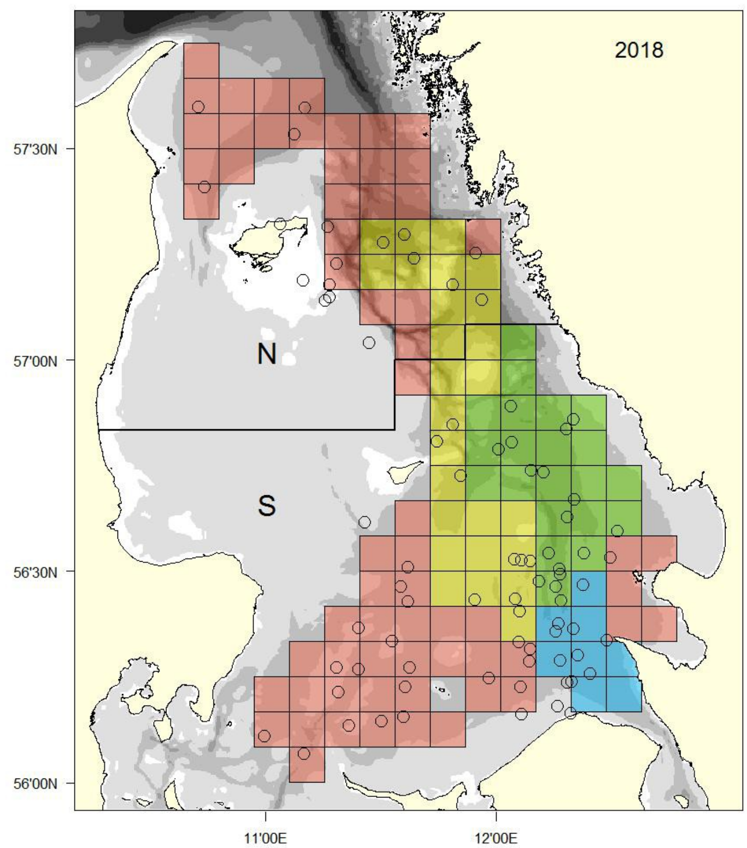


Figure 1. Survey stratification and sampled stations in 2018. Green represents high density areas; yellow medium density areas and red low density areas. From 2013 the fourth (blue) stratum was added to ensure sufficient sampling in the closed areas. N (north) and S (south) identifies the two domains used for age sampling.

Table 1: Showing number of survey squares by strata and year.

Year	High density	Medium density	Low density	Closed area	Total
2008			10		44
2009			10		44
2010			15		32
2011			18		31
2012					
2013			21		26
2014			21		26
2015			21		26
2016			21		26
2017			21		26
2018			21		26

Station (tow) location

The survey is planned with in average 3 to 4 trawl hauls per day in 6 days for each of the 4 vessels, i.e. in total 80 trawl hauls. Each vessel is assigned 20 randomly selected 5*5 nm survey squares. Probability for a square to be selected differ between strata (see table 1 and table 2). The skipper of the vessel decides on the best way to fish at the square and hence the exact position of the haul. 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 are 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 only Swedish vessels participated in the survey.

Year	Number of vessels	High density	Medium density	Low density	Closed area	Total
2008			4 6		8	
2009			4 6		8	
2010			4 6		8	
2011			4 9		6	
2012						
2013			2 15		10	
2014			4 6		5	
2015			4 6		5	
2016			3 6/12		5/10	
2017			3 6/12		5/10	
2018			3 6/12		5/10	

Target species

The survey design is optimised to get estimates on cod. All species are recorded and the survey can be used for other species as well.

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. From 2016 and onwards Denmark has used R/V Havfisken instead of chartered trawlers, thus 2 Swedish vessels and 1 Danish vessel participate in the survey. The Danish vessel fish twice as many hauls as the Swedish vessels keeping the total fished hauls at the same level as previous years. 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
2012				
2013			Cindy Wester	Tärnan
2014	Tiki	Stjerne	Cindy Wester	Tärnan
2015	Annie Holm	Stjerne	Cindy Wester	Tärnan
2016	Havfisken	Havfisken	Cindy Wester	Tärnan
2017	Havfisken	Havfisken	Cindy Wester	Tärnan
2018	Havfisken	Havfisken	Cindy Wester	Tärnan

Gear

The trawl is a commercial bottom trawl.

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 was 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 areas Laholmsbukten and Skælderviken). The survey area is stratified in four strata: HIGH, MEDIUM, LOW and CLOSED AREA. The total survey area is 10204 km2.

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:

$$Wing\ spread = \frac{\text{Ground gear length} \times \text{ Door spread}}{\text{Bridle length } + \text{Ground gear length}}$$

Door spread is estimated for the single hauls, using a warp divergence method (Anon. 2006) (Annex 1).

Swept area= (distance towed (nm) x 1.852) x (wing spread (m)/1000)

The catchability coefficient is assumed to be 1.0.

All catches are standardized to 1 km2 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).

Ref 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 2008-2018 is given in Figure 2ab. 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 in 2018 was estimated to 647 tons, compared to 2255 tons in 2017 and 4977 tons in 2016 (Table 4). This corresponds to a reduction in biomass with approximately 87% in two years. The trawlable abundance in 2018 was estimated to 0.88 million which corresponds to a 75% decrease compared to 2017 (3.52 million) and more than 90% decrease from the estimate of 8.73 million in 2014 (Table 4).

The highest densities in biomass (133 kg per km2) and numbers (112 specimens per km2) were found in high stratum (Table 5 and 6). This was also the case in 2016 & 2017 but differs from 2015 when the highest biomass was found in the mid-density stratum. Catch per unit effort, measured as weight per trawl hour and numbers per hour was highest in the high density area (Table 8).

Table 4: Biomass (t) and abundance of cod with Stdev together with weight and number km2 by year.

Year	Weight km2	Stdev	Biomass	Number km2	Stdev	Abundance
2008						129.20
2009						80.60
2010						75.70
2011						119.60
2013						232.80
2014						776.60
2015						919.10
2016						487.80
2017						221.00
2018						63.40

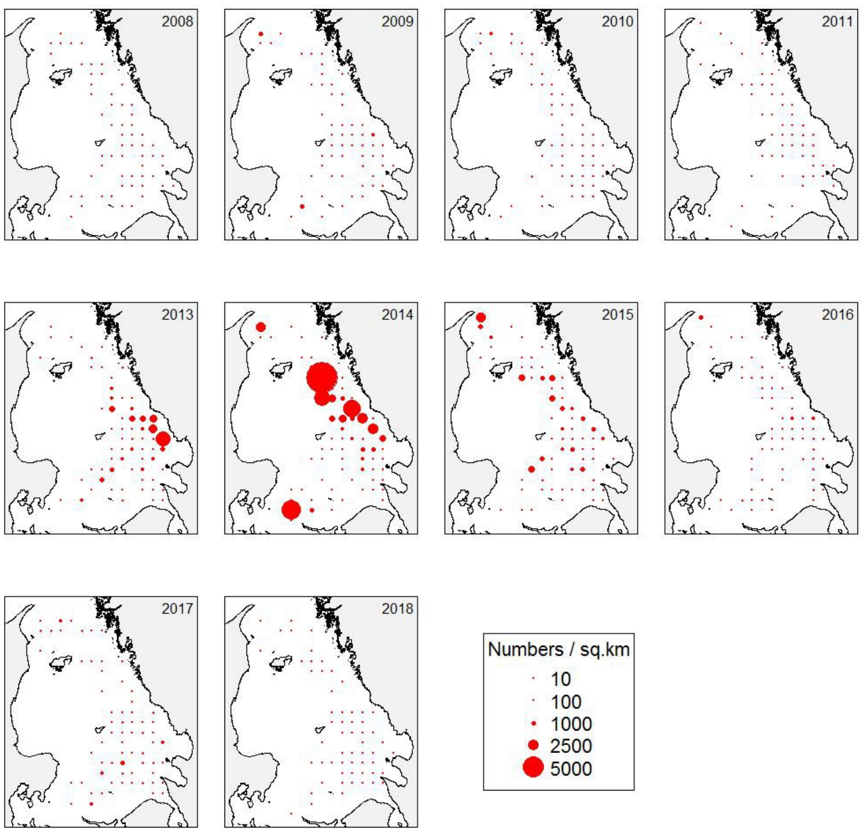


Figure 2a. Abundance of cod per km2, calculated as an average from all vessels per square.

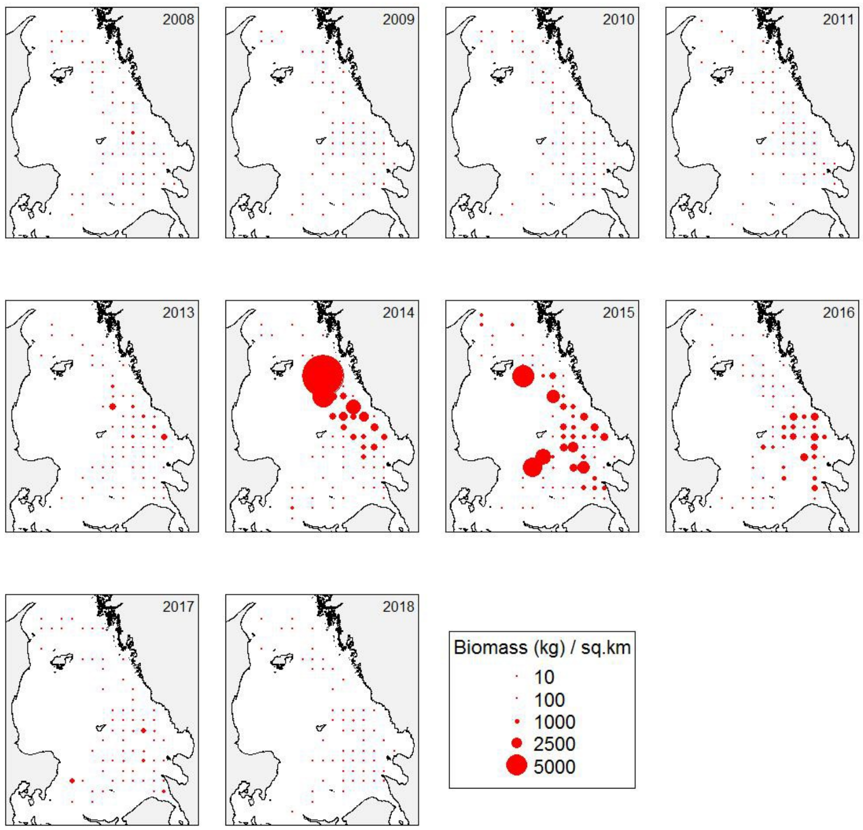


Figure 2b. Biomass of cod per km2, calculated as an average from all vessels per square.

Table 5: Stratum area (km), number of hauls, mean biomass per km2 (tons), Stdev and total biomass (tons).

Strata	Area	Hauls	Mean_biomass_km2	Stdev	Biomass
Closed					
High					
Medium					
Low					

Table 6: Cod 2018. Stratum area (km), number of hauls, number per km2 (tons), Stdev and abundance

Strata	Area	Hauls	Mean_number_km2	Stdev	Abundance
Closed					
High					
Medium					
Low					

Length distribution The length ranged from 10 to 85 cm. The overall length distribution (weighted by stratum area) showed modes at 18 and 30 cm in 2018 (Figure 5 and 6). Most small cod were found in the low and medium density areas, while large individuals (over 50 cm) were more common in the medium and high density areas (Figure 6).

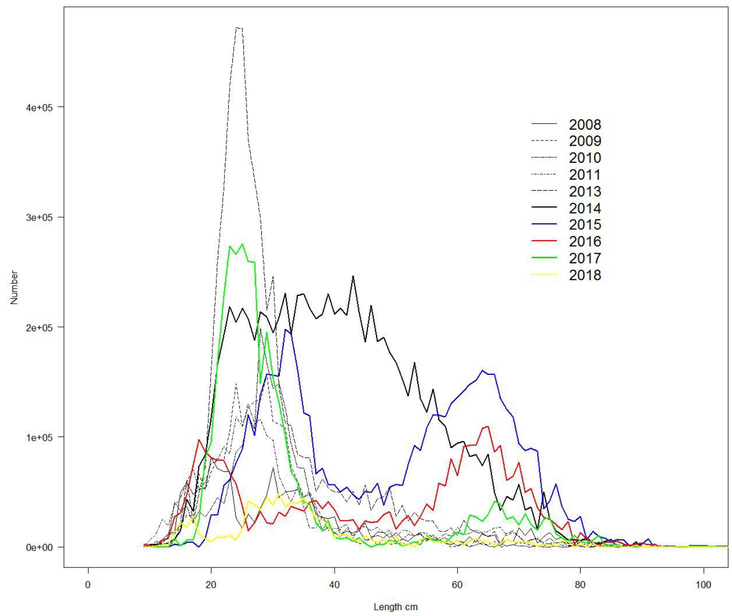


Figure 5. Length distribution in total number of cod weighted by stratum area by year in the total survey area.

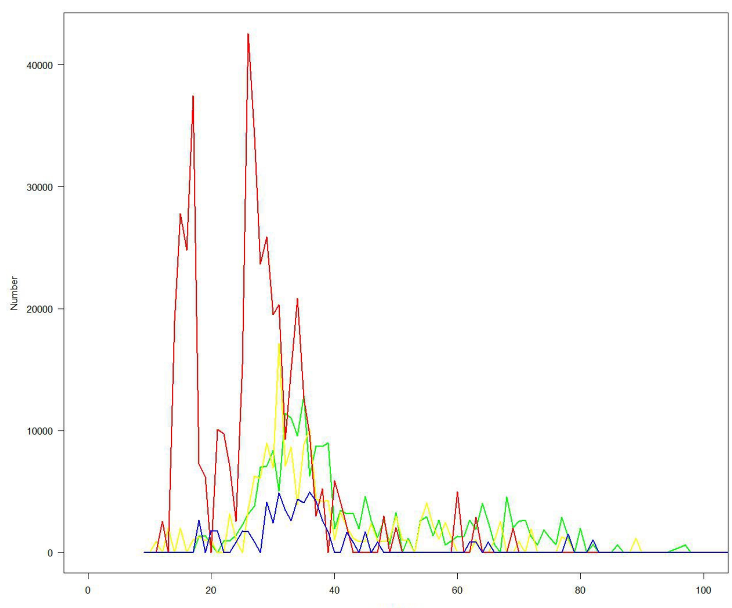


Figure 6. Length distribution of cod in 2018.

Age distribution

From 2008 to 2013 was the age distribution dominated by age class 1-4. In 2014 did the contribution of older fish (age 5 and 6) increase in the catches. This relatively higher contribution of older fish in the catches continued between 2015-2017. In 2018 were there however not many old fish left (table 7), even if they proportionally contributes to the biomass (table 8). The number of age 1 cod was in 2018 the lowest in the entire time series (table 7).

Table 7: Number at age of cod by year in the survey area.

yy	a0	a1	a2	a3	a4	a5	a6
2008				621.90			
2009				308.90			9.80
			2010				
			2011				
			2013				
			2014				
			2015				
			2016				
			2017				
			2018				

Table 8: WECA, weight at age in tonnes

yy	a0
2008	49.87
2009	22.97

CPUE

CPUE in both weight and number per hour was highest in the high density area (Table 8). The overall CPUE in 2018 was 9.0 individuals per hour (compared to 33.5 in 2017) and 5.8 kg per hour (compared to 18.7 kg in 2017).

Table 9: CPUE (h) in 2018. Number, Stdev Number, Weigh, Stdev weight, by Strata and overall.

Strata	Number	Stdev Number	weight	Stdev Weight
High				
Medium				
Low				
Closed				
All	9.00	9.00	5.80	10.40

Table 10: CPUE per age and km2 (swept area)

yy	a0
2008	60.94
2009	30.27
2010	30.85
2011	48.50
2013	23.56
2014	49.38
2015	5.57
2016	24.95
2017	3.09
2018	8.40

Annex 1. Survey stratification 2008 - 2018

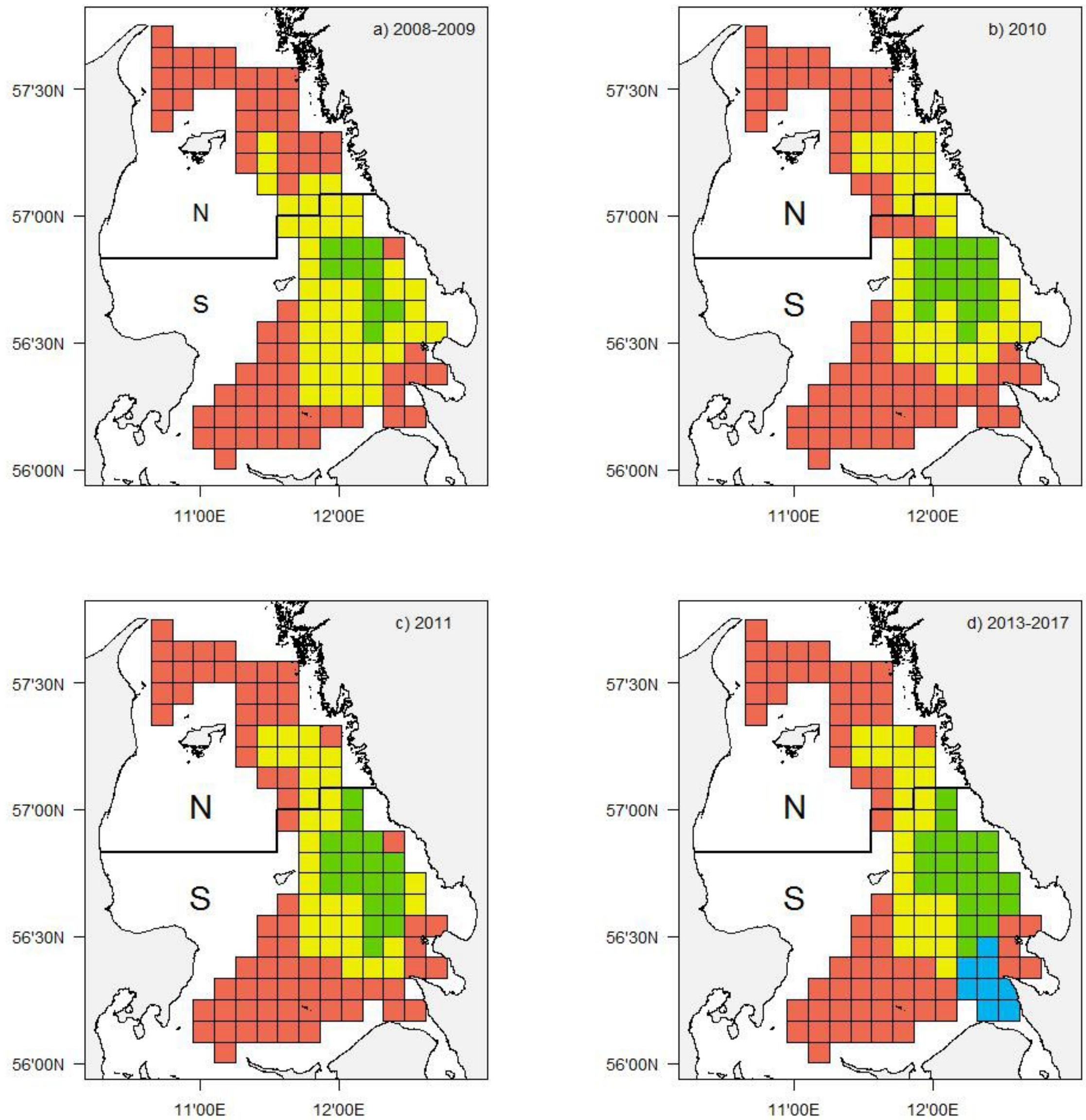
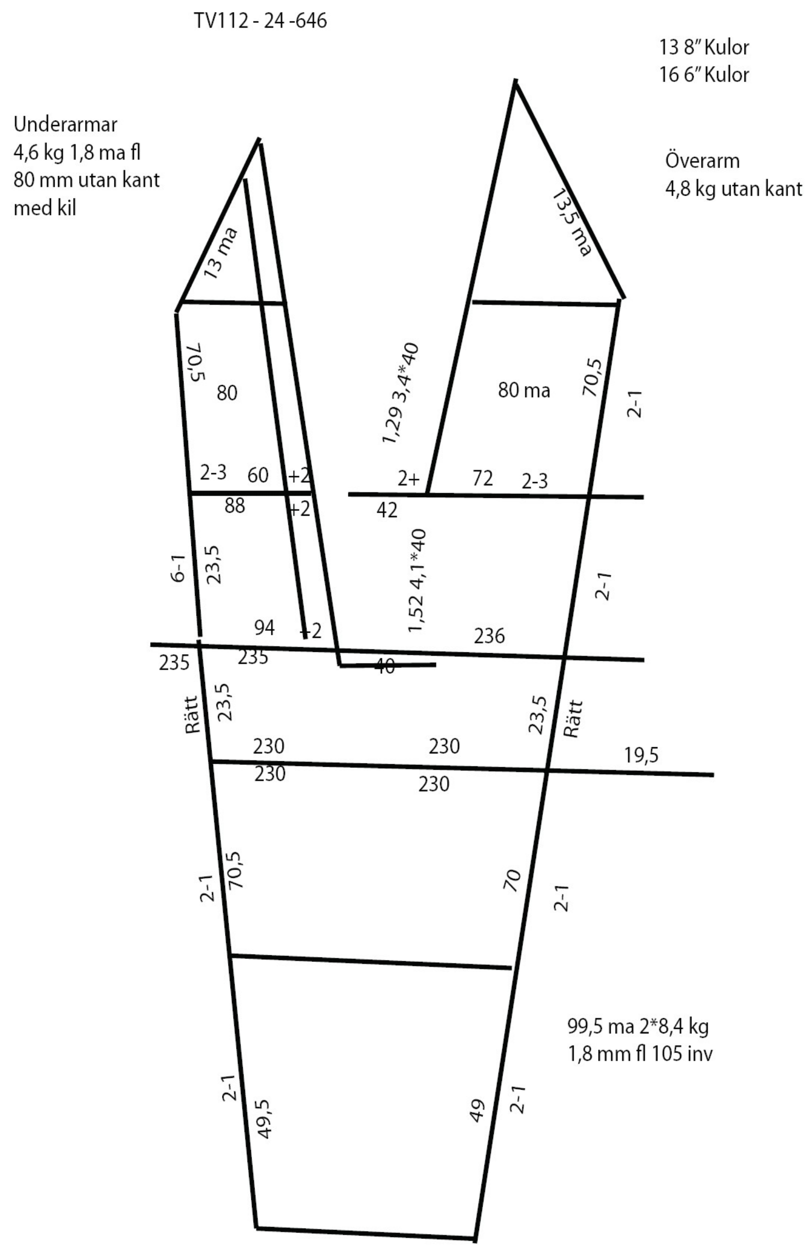
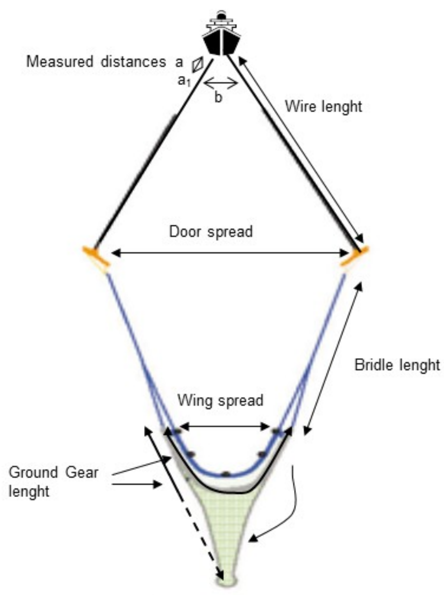


Figure 1a-d. The survey stratification 2008-2018. Green represents high density areas; yellow medium density areas and red low density areas. From 2013 the fourth (blue) stratum was added to ensure sufficient sampling in the closed areas.

Annex 2. TV112 trawl



Annex 3. 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

$$\text{Door spread} = \frac{\text{Wire length} \times \text{measured distance b}}{\text{measured distance a}}$$

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:

$$\text{Wing spread} = \frac{\text{Ground gear length} \times \text{Door spread}}{\text{Bridle length} + \text{Ground gear length}}$$

(Calculation from "Course in Trawl Gear Technology", May 2006, SeaFish Flume Tank, Hull, UK)

NOTE: Figure not according to scale

WD03:
EBcod assessment using SPiCT.

C. W. Berg

Eastern Baltic Cod assessment using seasonal data and SPiCT.

Casper W. Berg

April 9, 2019

1 Introduction

This document describes a new assessment of Eastern Baltic Cod using quarterly resolved commercial catch data using the production model called SPiCT [2], which was slightly extended, among other things to deal with changes in surplus production over time. 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. A third index (SSB from egg production model) is also used. It is assumed that SSB is proportional to exploitable stock biomass (ESB).

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.

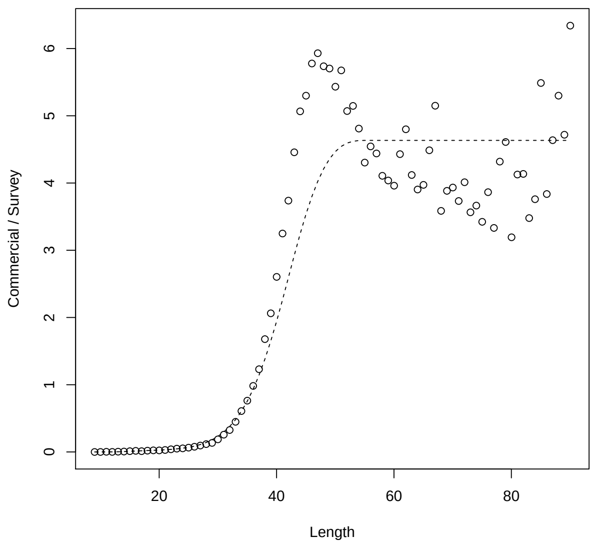


Figure 1: Ratio of commercial to survey total catch at length. Only data from quarters 1 and 4 are considered here.

2.2 Biomass conversion

The index standardization model provides survey indices by length, and is described in the 2019 benchmark reports. The ESB correction is applied to the standardized 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. This relationship is applied to the ESB corrected indices to provide biomass indices for SPiCT.

3 SPiCT assessment

Details about the SPiCT model can be found in [2]. Briefly, the model is based on a reparameterized version of the Pella-Tomlinson model [1] formulated as a stochastic differential equation such that it includes process noise:

$$dB_t = \left(\gamma m \frac{B_t}{K} - \gamma m \left[\frac{B_t}{K}\right]^n - F_t B_t\right) dt + \sigma_B B_t dW_t, \tag{1}$$

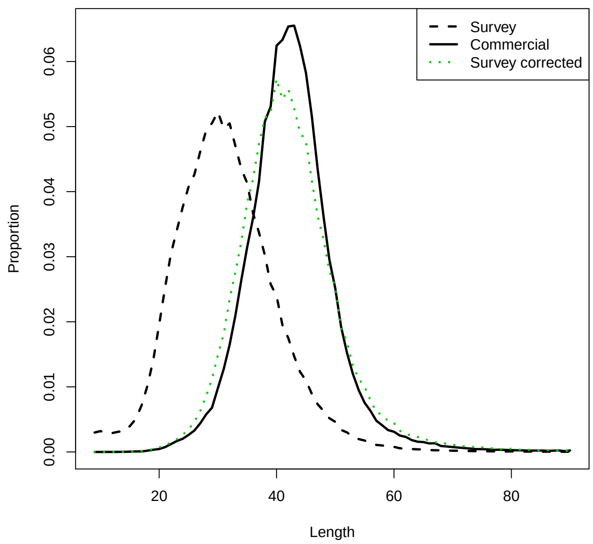


Figure 2: Length distributions in the survey and commercial data, and the ESB corrected survey length distribution obtained when using the correction factor shown in figure 1.

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

$$F_t = S_t G_t \tag{2}$$

$$d \log G_t = \sigma_F dV_t \tag{3}$$

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

$$F_t = \exp(D_{s(t)}) G_t \tag{4}$$

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

[2] 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,

$$F_t = S_t G_t \exp(A_{q(t)}) \tag{5}$$

$$d \log G_t = \sigma_F dV_t \tag{6}$$

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 Time-varying productivity

The SPiCT model is further extended to deal with changes in surplus production over time. This is implemented by replacing the fixed m parameter with a random process that varies over time m_t, which is assumed to be an Ornstein-Uhlenbeck process – the continuous time analogue of an AR(1) process. This process is stationary and mean-reverting, and has two extra parameters compared to fixed m (strength of mean reversion and a variance parameter).

3.3 Priors

The default SPiCT priors are replaced with a single prior on the production curve shape parameter $\log n \sim N\left(\log(1.729), \left(\frac{0.937}{1.729}\right)^2\right)$, which was taken from a published meta study [3].

3.4 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

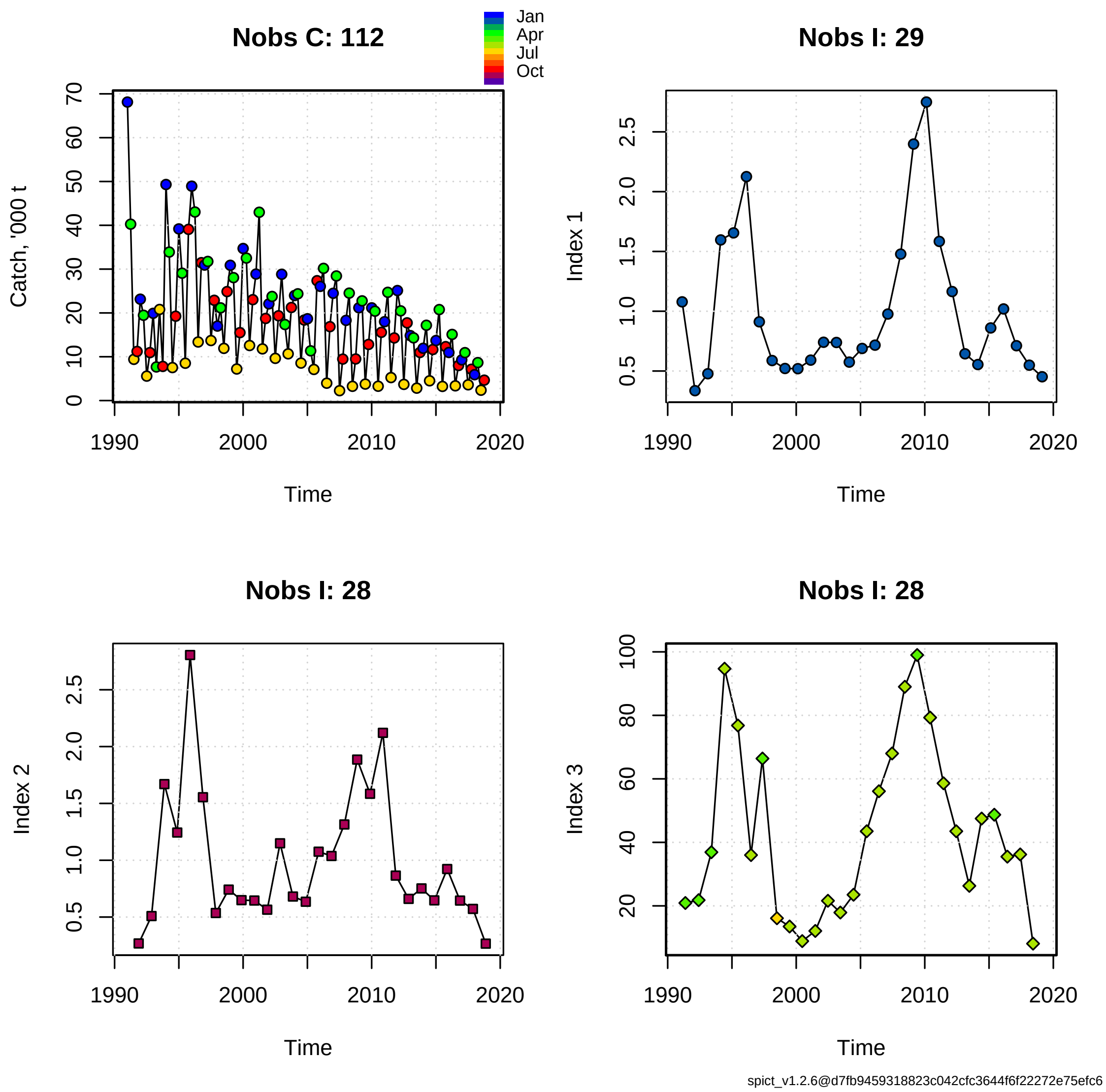


Figure 3: Input data.

Model summary:

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 90.3718017
Euler time step (years):  1/16 or 0.0625
Nobs C: 112,  Nobs I1: 29,  Nobs I2: 28,  Nobs I3: 28
Catch/biomass unit: '000 t

Residual diagnostics (p-values)
    shapiro   bias    acf   LBox shapiro bias acf LBox
 C   0.8404 0.6463 0.2083 0.3019       -    -   -    -
 I1  0.7755 0.9896 0.2899 0.5188       -    -   -    -
 I2  0.6365 0.8415 0.2839 0.6021       -    -   -    -
 I3  0.0953 0.7612 0.0819 0.1079       .    -   .    -

Priors
 logn  ~  dnorm[log(1.729), 0.542^2]

Model parameter estimates w 95% CI
           estimate      cilow       ciupp    log.est
 alpha1   2.1557956  0.0072176 643.9067018  0.7681598
 alpha2   2.7977877  0.0109299 716.1682773  1.0288290
 alpha3   3.6534644  0.0162118 823.3391521  1.2956759
 beta     0.5561108  0.3592437   0.8608621 -0.5867877
 r        0.8374983  0.2610139   2.6872266 -0.1773360
 rc       2.4199375  0.9267828   6.3187383  0.8837417
 rold     2.7206102  0.2442645  30.3020709  1.0008562
 m       54.1106025 24.2156389 120.9118336  3.9910301
 K      147.7699357 78.3639490 278.6479520  4.9956566
 q1       0.0269224  0.0171061   0.0423719 -3.6147953
 q2       0.0237738  0.0155469   0.0363540 -3.7391724
 q3       1.4659110  0.7879677   2.7271362  0.3824769
 n        0.6921653  0.3475805   1.3783650 -0.3679305
 sdb      0.0898612  0.0004059  19.8955287 -2.4094895
 sdf      0.2908857  0.2071401   0.4084890 -1.2348250
 sdi1     0.1937223  0.1173952   0.3196751 -1.6413296
 sdi2     0.2514124  0.1767088   0.3576970 -1.3806605
 sdi3     0.3283045  0.2305054   0.4675980 -1.1138136
 sdc      0.1617647  0.1267671   0.2064243 -1.8216127
 sdm      0.2080710  0.1001159   0.4324344 -1.5698758
 psi      0.0752181  0.0080002   0.7072035 -2.5873634
 phi1     0.8127278  0.3985523   1.6573146 -0.2073590
 phi2     2.0062469  1.2494659   3.2213976  0.6962657
 phi3     0.1635722  0.0779681   0.3431644 -1.8105007
 SARphi   0.8036577  0.5377579   0.9350698  1.4093137
 SdSAR    0.2008258  0.1286307   0.3135410 -1.6053175

Deterministic reference points (Drp)
        estimate      cilow      ciupp   log.est
 Bmsyd 44.720661 25.0076845  79.972917 3.8004356
 Fmsyd  1.209969  0.4633914   3.159369 0.1905945
 MSYd  54.110602 24.2156389 120.911834 3.9910301
Stochastic reference points (Srp)
        estimate      cilow      ciupp   log.est  rel.diff.Drp
 Bmsys 44.620826 25.0559150  79.462999 3.7982007 -0.0022373905
 Fmsys  1.209132  0.4654216   3.141241 0.1899032 -0.0006916236
 MSYs  53.952409 24.1945765 120.310536 3.9881023 -0.0029320873

States w 95% CI (inp$msytype: d)
                 estimate     cilow      ciupp    log.est
 B_2019.12      12.995287 6.9719324 24.2224788  2.5645868
 F_2019.12       1.570956 0.7729655  3.1927738  0.4516846
 B_2019.12/Bmsy  0.290588 0.1536914  0.5494215 -1.2358488
 F_2019.12/Fmsy  2.778002 1.3301976  5.8016156  1.0217320
```

```
Predictions w 95% CI (inp$msytype: d)
                prediction      cilow      ciupp    log.est
 B_2020.00      12.8310891  5.1024048 32.2665199  2.5518711
 F_2020.00       1.5709565  0.6468322  3.8153701  0.4516847
 B_2020.00/Bmsy  0.2869164  0.1088116  0.7565465 -1.2485645
 F_2020.00/Fmsy  2.6463229  0.9795789  7.1490158  0.9731711
 Catch_2019.00  18.5783033 11.9816331 28.8068706  2.9219944
 E(B_inf)       39.1456743         NA         NA  3.6672899
```

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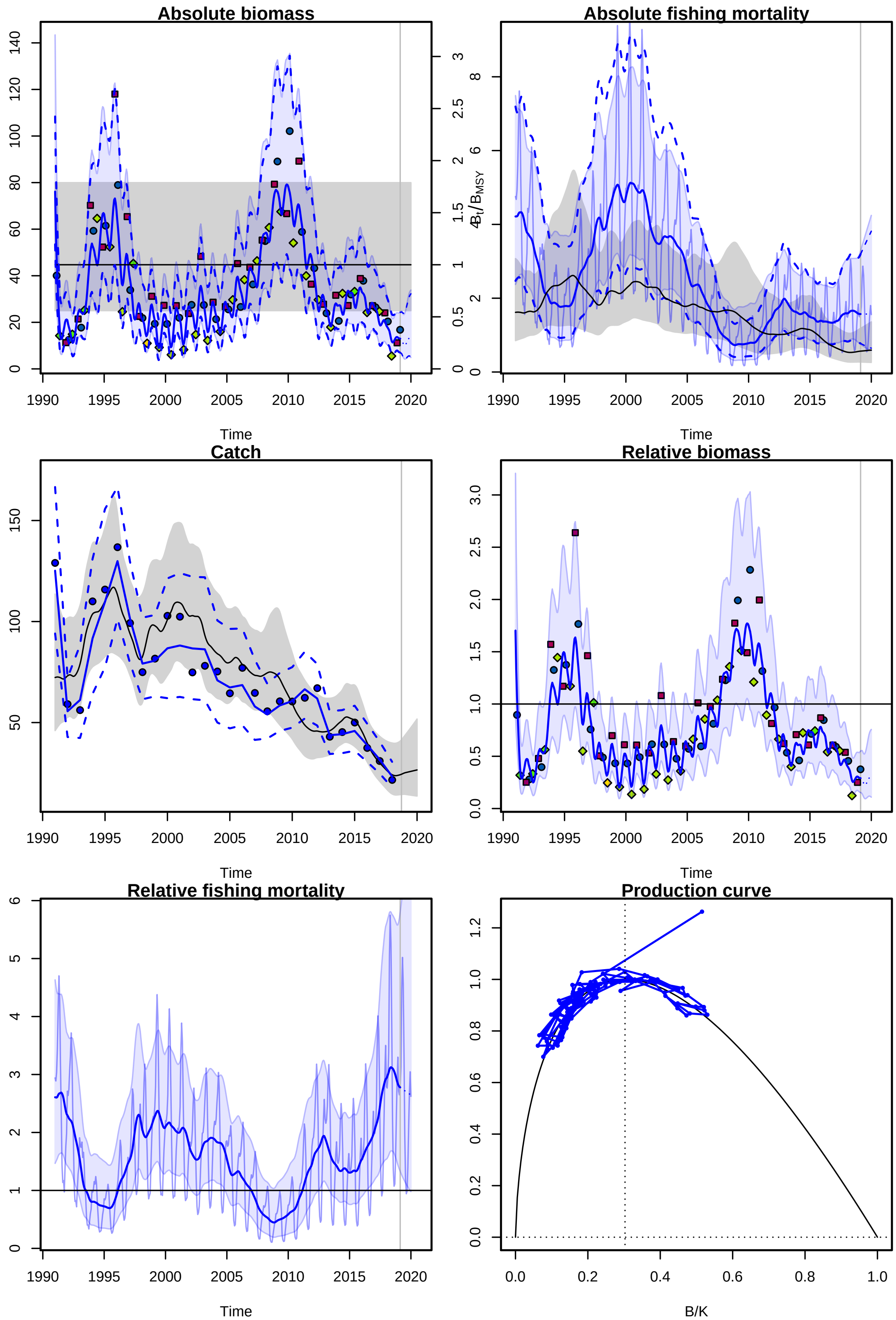

Figure 4: Results

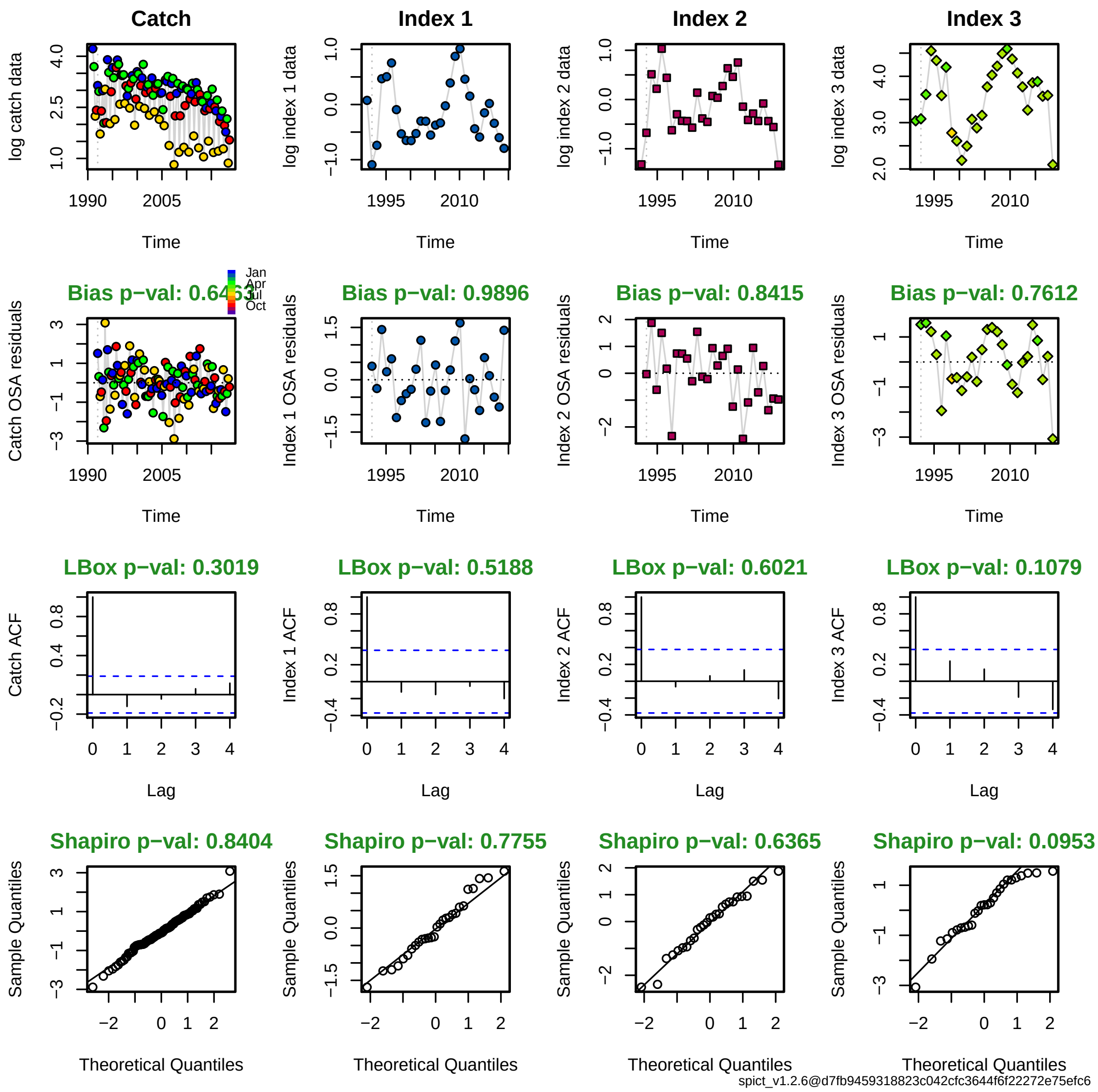

Figure 5: Diagnostics

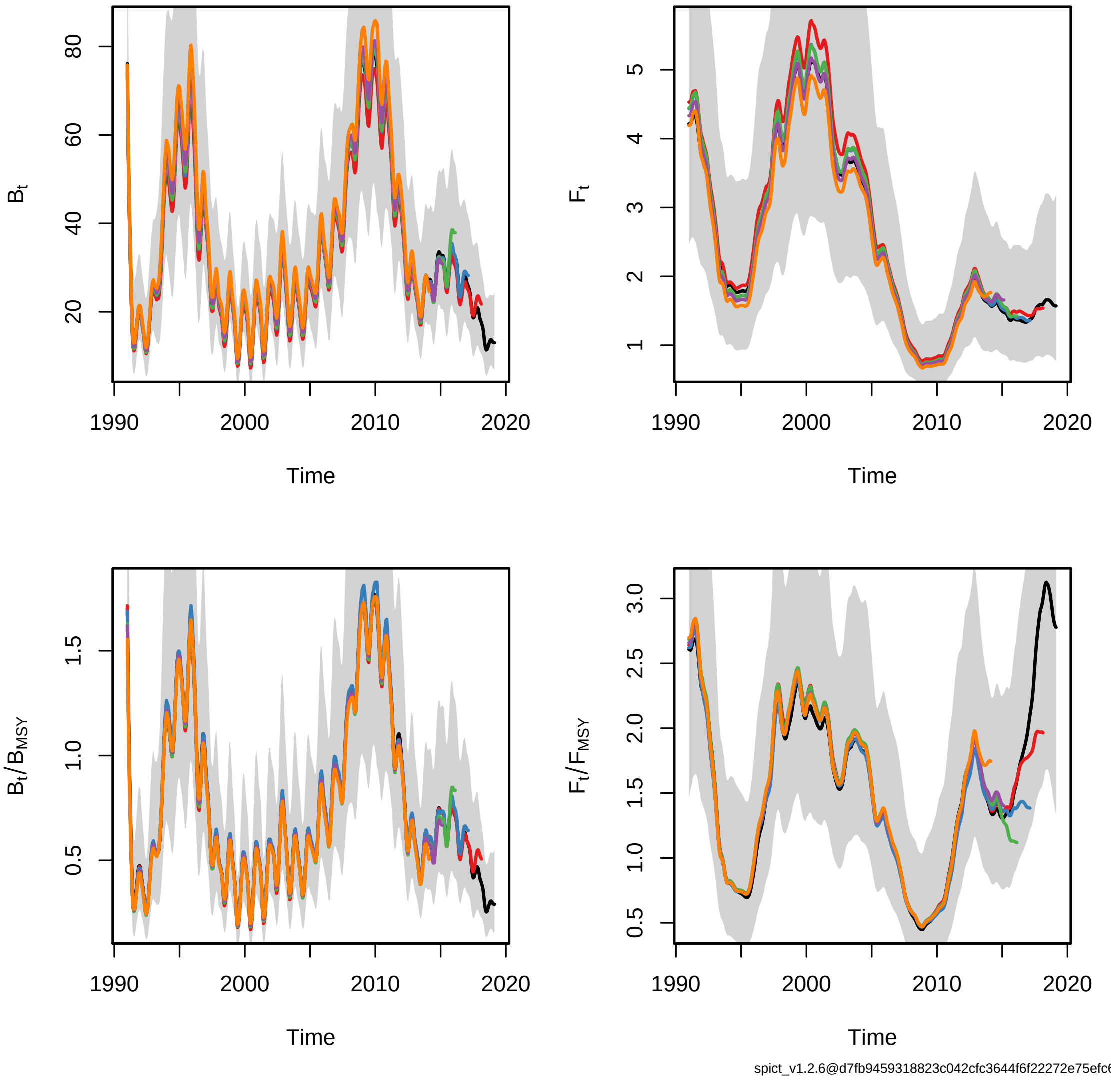

Figure 6: Retrospective analysis

	Year	F/F_{MSY}	B/B_{MSY}
1	1991	2.61	1.70
2	1992	2.30	0.47
3	1993	1.55	0.57
4	1994	0.80	1.20
5	1995	0.73	1.49
6	1996	0.91	1.53
7	1997	1.49	0.95
8	1998	2.17	0.51
9	1999	2.21	0.54
10	2000	2.10	0.51
11	2001	2.00	0.55
12	2002	1.72	0.58
13	2003	1.74	0.72
14	2004	1.88	0.58
15	2005	1.54	0.61
16	2006	1.32	0.82
17	2007	1.00	0.95
18	2008	0.58	1.29
19	2009	0.46	1.72
20	2010	0.59	1.75
21	2011	0.92	1.48
22	2012	1.51	1.00
23	2013	1.91	0.61
24	2014	1.40	0.61
25	2015	1.31	0.73
26	2016	1.54	0.74
27	2017	2.01	0.60
28	2018	2.93	0.42
29	2019	2.81	0.29

Table 1: 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.

WD04:
Fisheries and ecosystem.

V. Amosova

WD 04 Baltic Fisheries Assessment Working Group (WGBFAS) 08 - 15 April 2019

SOME SUGGESTIONS ON DESCRIPTION OF ECOSYSTEM IMPACT OF FISHERIES ON THE EXAMPLE OF ANALYZING THE BYCATCH SPECIES OCCURRENCE OF IN THE CENTRAL BALTIC SEA

V.M. Amosova, A.I. Karpushevskaya, A.S. Zezera, I.V. Karpushevskiy

(Russian Federal «Research Institute of Fisheries and Oceanography «VNIRO»

Atlantic branch of VNIRO («AtlantNIRO»), Russia)

This paper provides an example of assessing changes in the biodiversity of marine ecosystems based on an analysis of occurrence of by-catch fish species (during the cod fishery in the Baltic Sea) associated with the demersal fish fauna (the species that spends most of its life cycle in the bottom or near the bottom). "By-catch" species may have a direct or indirect impact on the commercial fish species; there are the one of the main indicators of the sea ecosystem and its particular areas [Карпушевская, 2014, 2018]. The approach considered in the work (the method of integrated analysis) as a tool for the functioning of ecosystems assessment used longtime and has proven to be useful in analyzing and studying of the fish by-catch.

Materials and methods. It was conducted an integrated analysis [ICES, 2011] of the space-time diversity of the Baltic bottom fish species on the basis of the data of the bottom trawl surveys carried out by the ICES program from 2002 to 2017 using a standard fishing gear (TV3). Investigation areas: 25, 26 and 28 ICES Subdivisions (DATRAS). The frequency of the by-catch fish species occurrence as the proportion of hauls with the presence of this species was calculated. The data from oceanological long-term observations at monitoring stations of the Baltic Sea were used to estimate the abiotic conditions (temperature, salinity, and oxygen dissolved in water) in the bottom and surface layers of the sea (BY5 for Bornholm basin (SD 25), P1 for Gdansk basin (SD 26) and BY15 for Gotland basin (SD 28) («AtlantNIRO», ICES Oceanography).

Results. Below this is a cod catch by ICES subdivisions (Fig. 1), the list of the demersal (by-catch) fish species, caught on bottom trawl surveys in ICES SDs 25, 26 and 28 (Table), the spatial distribution of the number of fish species from demersal ichthyocenosis for the period 2002 -2017 (Fig. 2).

The main catch of the Eastern cod stock taken from ICES SDs 25 and 26. Not considered the catch in the SDs 27-28 due to its insignificant. However, to compare similarities or differences in components with the SD 26, the SD 28 examined.

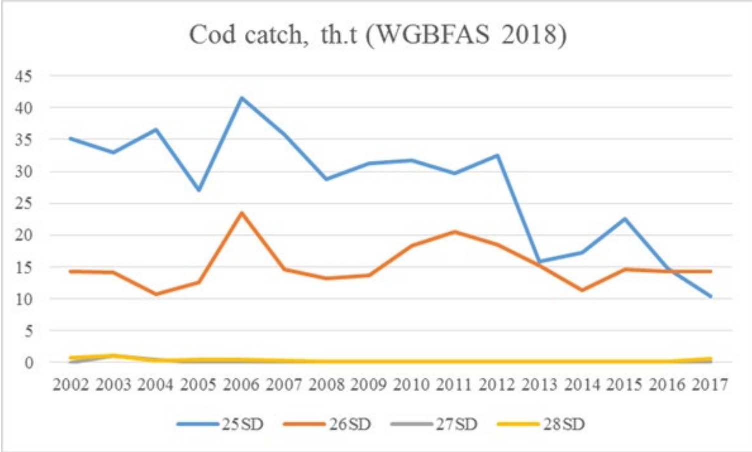

Fig. 1. Eastern Baltic cod catch by ICES SDs for 2002-2017

Table. The list of demersal (bycatch) species of fish, caught on bottom trawl surveys in 25, 26 and 28 ICES SDs for 2002-2017 (DATRAS)

lesser small sandeel	Ammodytes tobianus (L., 1758)
common eel	Anguilla anguilla (L., 1758)
lumpfish	Cyclopterus lumpus (L., 1758)
four-bearded rockling	Enchelyopus cimbrius (L., 1766)
pike	Esox lucius (L., 1758)
three-spined stickledack	Gasterosteus aculeatus (L., 1758)
two- spotted goby	Gobiusculus flavescens (Fabricius, 1779)
ruffe	Gymnocephalus cernuus (L., 1758)
limanda	Limanda limanda (L., 1758)
sea snail	Liparis liparis (L., 1766)
snake blenny	Lumpenus lampretaeformis (Walbaum, 1792)
four-horn sculpin	Myoxocephalus quadricornis (L., 1758)
shorthorn sculpin	Myoxocephalus scorpius (L., 1758)
round goby	Neogobius melanostomus (Pallas, 1771)
perch	Perca fluviatilis (L., 1758)
rock eel	Pholis gunnellus (L., 1758)
plaice	Pleuronectes platessa (L., 1758)
Gobies	Pomatoschistus (Gill, 1864) (Pomatoschistus microps, Pomatoschistus minutus)
turbout	Psetta maxima (L., 1758)
nine-spined stickledack	Pungitius pungitius (L., 1758)
brill	Scophthalmus rhombus (L., 1758)
sole	Solea solea (L., 1758)
fifteen-spined stickledack	Spinachia spinachia (L., 1758)
eelpout	Zoarces viviparus (L., 1758)

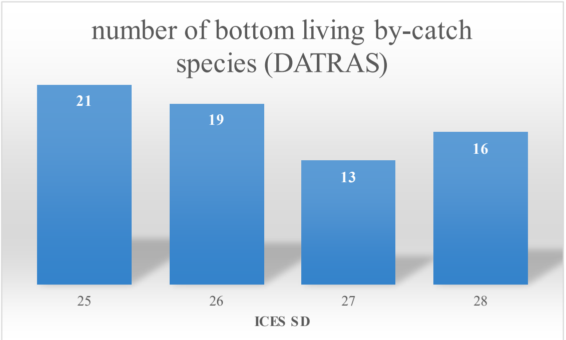

Fig. 2. The spatial distribution of the number of the demersal fish species (by-catch) for the period 2002 -2017

The calculation by the principal component method and the determination of shifts according to Rodionov [2004, 2005a] showed differences in the results by ICES SDs and the sign of changes in these SDs also differs. Therefore, changes took place in 25 SD ICES since 2012, and in 2010 and in SD 26 and 28 - from 2010 (Fig. 3).

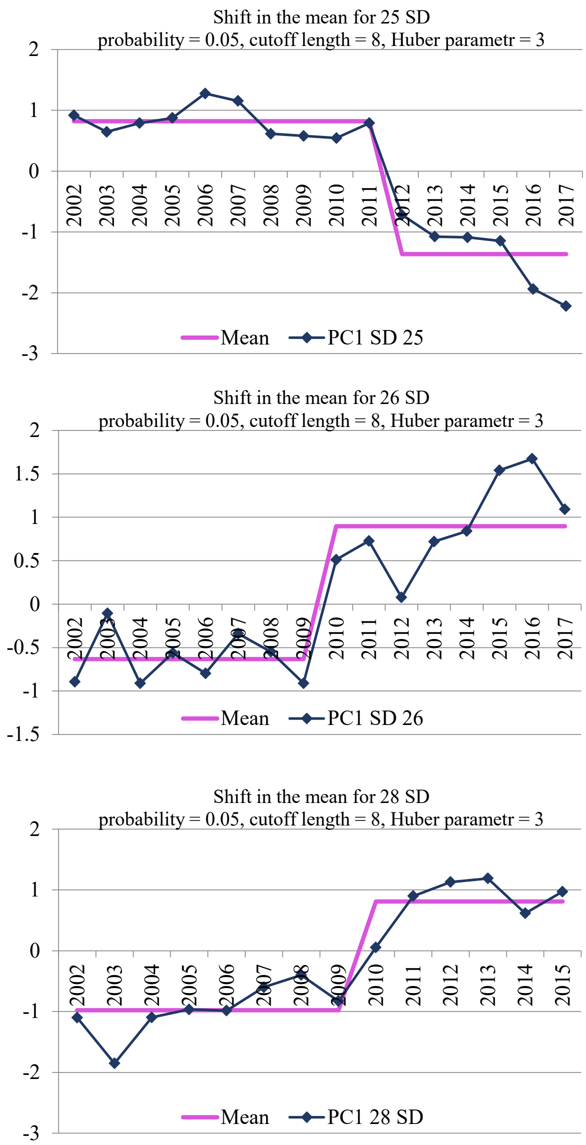

Рис. 3. Results of the analysis of the first principal component by ICES SDs (method STARS).

Below presented the variables and accounts of the PC1 component in the ICES subdivisions.

***25 SD ICES*: Species scores PC1 (31% proportion explained, changes from 2012)**

COD CATCH	⇩	-0.8
Scophthalmus.rhombus..L...1758.	⇩	-0.4
Anguilla.anguilla..L...1758.	⇩	-0.3
TEMPbot	⇨	-0.2
Esox.lucius..L...1758.	⇨	-0.2
Solea.solea..L...1758.	⇨	-0.1
Pholis.gunnellus..L...1758.	⇨	0.1
Psetta.maxima..L...1758.	⇨	0.1
Ammodytes.tobianus..L...1758.	⇨	0.1
Gobiusculus.flavescens..Fabricius..1779.	⇨	0.2
SALsur	⇨	0.3
Liparis.liparis..L...1766.	⇧	0.3
Pungitius.pungitius..L...1758.	⇧	0.3
Neogobius.melanostomus..Pallas..1771.	⇧	0.4
OXYbot	⇧	0.4
SALbot	⇧	0.4
Pomatoschistus..Gill..1864...Pomatoschistus.microps..Pomatoschistus.minutus.	⇧	0.5
Myoxocephalus.quadricornis..L...1758.	⇧	0.5
TEMPsur	⇧	0.5
Enchelyopus.cimbrius..L...1766.	⇧	0.6
Lumpenus.lampretaeformis..Walbaum..1792.	⇧	0.6
Limanda.limanda..L...1758.	⇧	0.6
Gasterosteus.aculeatus..L...1758.	⇧	0.7
Pleuronectes.platessa..L...1758.	⇧	0.7
Zoarces.viviparus..L...1758.	⇧	0.7
Cyclopterus.lumpus..L...1758.	⇧	0.7
Myoxocephalus.scorpius..L...1758.	⇧	0.8

The main characteristic feature for SD 25 of the period from 2012 (high and medium statistically significant component scores more than 0.5) were variables associated with an ***increase*** in the frequency of occurrence of typical representatives — indicators of bottom by-catch species (shorthorn sculpin, four-horn sculpin, lumpfish, eelpout, plaice, limanda, three-spined stickledack, snake blenny, four-bearded rockling, Gobies) against the background of a ***decrease in cod catch volumes*** and a small increase in surface temperature values.

***26 SD ICES**: Species scores PC1 (40% proportion explained, changes from 2010)*

Gymnocephalus.cernuus..L...1758.	⇩	-0.1
COD	⇩	-0.1
Pholis.gunnellus..L...1758.	⇩	0.0
Ammodytes.tobianus..L...1758.	⇩	0.1
TEMPbot	⇩	0.1
OXYbot	⇩	0.1
Lumpenus.lampretaeformis..Walbaum..1792.	⇩	0.2
TEMPsur	⇨	0.2
Pungitius.pungitius..L...1758.	⇨	0.3
SALsur	⇨	0.4
Limanda.limanda..L...1758.	⇨	0.4
Liparis.liparis..L...1766.	⇨	0.4
Spinachia.spinachia..L...1758.	⇨	0.4
SALbot	⇧	0.6
Psetta.maxima..L...1758.	⇧	0.7
Cyclopterus.lumpus..L...1758.	⇧	0.7
Pleuronectes.platessa..L...1758.	⇧	0.7
Perca.fluviatilis..L...1758.	⇧	0.7
Enchelyopus.cimbrius..L...1766.	⇧	0.7
Myoxocephalus.quadricornis..L...1758.	⇧	0.8
Gasterosteus.aculeatus..L...1758.	⇧	0.8
Pomatoschistus..Gill..1864...Pomatoschistus.microps..Pomatoschistus.minutus.	⇧	0.8
Zoarces.viviparus..L...1758.	⇧	0.8
Myoxocephalus.scorpius..L...1758.	⇧	0.8
Neogobius.melanostomus..Pallas..1771.	⇧	0.8

For SD 26 the main feature of the period from 2010 (high and medium statistically significant component scores more than 0.5) were variables associated also with an ***increase*** of the frequency of occurrence of typical representatives — indicators of bottom by-catch species (round goby, shorthorn sculpin, eelpout, Gobies, three-spined stickledack, four-horn sculpin, four-bearded rockling, perch, plaice, lumpfish, turbout) ***but against the background of rising values of bottom salinity***. *Not traced the relationship between the frequencies of occurrence of bycatch species with cod catch volumes.*

***28 SD ICES*: Species scores PC1 (38% proportion explained, changes from 2010)**

Enchelyopus.cimbrius..L...1766.	⇩	-0.6
COD	⇩	-0.2
OXYbot	⇩	-0.2
SALsur	⇩	-0.2
Limanda.limanda..L...1758.	⇨	0.1
SALbot	⇨	0.2
Liparis.liparis..L...1766.	⇨	0.3
Perca.fluviatilis..L...1758.	⇨	0.3
Psetta.maxima..L...1758.	⇨	0.3
Pleuronectes.platessa..L...1758.	⇧	0.4
Spinachia.spinachia..L...1758.	⇧	0.4
Cyclopterus.lumpus..L...1758.	⇧	0.5
Neogobius.melanostomus..Pallas..1771.	⇧	0.5
TEMPbot	⇧	0.6
TEMPsur	⇧	0.6
Pomatoschistus..Gill..1864...Pomatoschistus.microps..Pomatoschistus.minutus.	⇧	0.7
Lumpenus.lampretaeformis..Walbaum..1792.	⇧	0.7
Pungitius.pungitius..L...1758.	⇧	0.8
Zoarces.viviparus..L...1758.	⇧	0.8
Myoxocephalus.scorpius..L...1758.	⇧	0.8
Gasterosteus.aculeatus..L...1758.	⇧	0.8
Myoxocephalus.quadricornis..L...1758.	⇧	0.9

For SD 28 the main feature of the period from 2010 (high and medium statistically significant component scores more than 0.5) were variables associated also with an ***increase*** in the frequency of occurrence of typical representatives — indicators of bottom by-catch species (round goby, lumpfish, Gobies, snake blenny, nine-spined stickledack, three-spined stickledack, shorthorn sculpin, eelpout, four-horn sculpin) and a ***decrease*** in the frequency of occurrence of four-bearded rockling, which is an indicator of oxygen deficiency in the bottom layers of the sea. *These changes in the bottom ichthyocenosis occurred against the background of an increase in temperature, both in the surface and in the bottom layers. Not traced the relationship of the frequency of occurrence of bycatch species with cod catch volumes.*

CONCLUSIONS

1. In ICES SD 25 the increase in the frequency of occurrence of typical representatives - indicators of bottom by-catch species since 2012 has occurred against the background of a decrease in the Eastern cod catch cod in this area.
2. The increase in the frequency of the bottom by-catch species occurrence in ICES SDs 26 and 28 ICES SD since 2010 has occurred against the background of an increase in the

values of bottom salinity, and (for SD 28) the whole water column temperature. For the bottom ichthyocenosis in these subdivisions, the role of other factors (for example, abiotic) is more significant than the press of the bottom fishing.

3. The results of the presented analysis of the possible impact of the fishery on the marine ecosystem showed the need for such research in a spatial aspect (for example, by ICES subdivisions). It is also of interest to perform this analysis considering the depths, shallow waters and etc.

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WD05:
Working document in response to EU special request on Eastern Baltic Cod (19_07 EBC)

M. Eero and M. Storr-Paulsen (DTU Aqua)

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By Margit Eero and Marie Storr-Paulsen (DTU Aqua)

Summary

1.a. ICES considers that when total catches are constrained by TACs set at sustainable levels, closures do not contribute substantially to sustainable exploitation; closures can, however, be considered as a supplement in specific circumstances. Spawning closures in particular can have additional benefits for the stock that cannot be achieved by TAC alone (e.g. increased recruitment through undisturbed spawning), though these effects cannot be demonstrated or quantified for Eastern Baltic cod.

If spawning closures are chosen to be applied, a seasonal closure during peak spawning covering most of the distribution area of the stock should be preferred over smaller area closures. This is because area closures cause effort reallocation to other stock components during the closure, with the risk of having counterproductive effects on the stock. For Eastern Baltic cod, peak spawning is in May-August and most of the stock is distributed in ICES Subdivisions (SD) 25-26, and partly in SD 24.

1.b A zero catch from the Eastern Baltic cod stock in Q3-Q4 in 2019 is estimated to result in only a 4% higher spawning stock biomass in 2020 compared to the scenario with no additional catch restrictions in 2019. The limited effect is because presently fishing mortality is estimated to be much lower compared to natural mortality. However, fishing at any level targets the remaining few commercial sized (>=35cm) cod, and by that further deteriorates the stock structure and reduces its reproductive potential.

1.c Recreational catches of Eastern Baltic cod in SDs 25-32 were in the range of 465-763 t in the last 3 years, based on preliminary data available. This is around 2% from the total cod catch in SDs 25-32.

2. The commercial catch from the Eastern Baltic cod stock expected to be taken in SD 24 in Q3-Q4 in 2019 is relatively low and were estimated to result in only 1% lower spawning stock biomass of the Eastern Baltic cod in 2020 compared to the scenario when the catches in SD24 in Q3-Q4 in 2019 were set to zero. All recreational cod catches taken in SD 24 are considered to be from the Western Baltic cod stock.

3. Most of the altogether 68 métiers (gear groups) that were used in the Baltic Sea in SDs 24-28 in 2018 had no or very low amounts of cod in their landings.

Two métiers (bottom trawl with >105 mm mesh size with 120 mm Bacoma exit window and gillnets with 110-156 mm mesh size) contributed altogether 82% of the total cod landings in SDs 24-28 in 2018. These métiers are considered to target cod. Cod constituted approximately 40-50% of their annual landings, the other species landed were mostly flatfish.

The landings of a few métiers (bottom trawls with >115 mm mesh size and long lines) contributing approximately 15% of the total annual cod landing, consisted mostly of only cod. These métiers are also considered to target cod.

The other métiers landed a variety of different species, and cod constituted varying proportions of their landings, though the overall amounts of cod in these métiers were low (less than 1% of the total annual cod landings).

The request

Assuming that the ICES stock advice would confirm the current indications and the situation would hence require rapid action,

1) *ICES is requested to provide advice on effective measures for 2019 to safeguard eastern Baltic cod, and in particular on the options below:*
    a. *Extending the spawning closure period for commercial and recreational fishing of eastern Baltic cod in terms of time and/or geographic scope, whereby ICES is requested to advise on appropriate modalities*
    b. *Reducing the TAC for eastern Baltic cod, whereby ICES is requested to advise on the appropriate level*
    c. *Closing the recreational fishery of eastern Baltic cod, whereby ICES should advise on the appropriate period.*
2) *Should in such case specific measures be considered in 2019 for the area where eastern and western Baltic cod mix, and if so, which would ICES recommend? In case of option 1b and 1c, should the TAC for western Baltic cod and the bag limit for recreational fishing be reduced and by how much so as to avoid the potentially harmful effects of a possible effort reallocation of the fishing effort to other areas?*
3) *If ICES were to advise no or very low catches of eastern Baltic cod for 2020, ICES is asked to estimate the bycatch levels of eastern cod in other, non-cod targeting fisheries, where possible broken down by fishery and Member State – taking the 2019 measures and fisheries as the starting point for this estimation. In case ICES were to advise measures for 2019 to safeguard eastern Baltic cod, ICES is also asked to estimate the bycatch levels of eastern cod in other, non-cod targeting fisheries, where possible broken down by fishery and Member State – taking the 2019 measures and fisheries as the starting point for this estimation.*

1. Stock status of the Eastern Baltic cod

The spawning stock biomass (SSB) of the Eastern Baltic cod has been declining since 2015 and is estimated to be below Blim in the last 2 years. The biomass of commercial sized cod (>= 35 cm) is presently at the lowest level observed since the 1950s. Fishing mortality (F) has declined since 2012, the value estimated for 2018 is the lowest in record, and substantially lower than the estimated natural mortality.

The poor status of the Eastern Baltic cod is largely driven by biological changes in the stock during the last decades. Growth, condition (weight at length) and size at maturation have substantially declined. These developments indicate that the stock is distressed and is expected to have reduced reproductive potential. Natural mortality has increased, and is estimated to be considerably higher than the fishing mortality in recent years. Population size structure has continuously deteriorated during the last years, and the stock presently consists of relatively small individuals.

At the presently low productivity, the stock is estimated not to recover above Blim in long-term even at no fishing, with 95% probability. Furthermore, fishing at any level will target the remaining few commercial sized (>=35cm) cod, and by that further deteriorate the stock structure and reduce its reproductive potential.

The low growth, poor condition and high natural mortality of cod are related to changes in the ecosystem, which include: i) Poor oxygen conditions that can affect cod directly via altering metabolism and via shortage of benthic prey, and additionally affect the survival of offspring. ii) Low availability of fish prey in the main distribution area of cod, as sprat and herring are more northerly distributed with little overlap with cod. (iii) High infestation with parasites, which is related to increased abundance of grey seals. The relative impact of these drivers for the cod stock is unclear.

2. Effectiveness of spawning closures for the Eastern Baltic cod

ICES evaluated the effectiveness of spawning closures for the Eastern Baltic cod in 2018 (ICES, 2018). Here the main findings from this evaluation are summarised. Further details can be found in ICES (2018) and in Eero et al. (2019).

2.1 Methods

The specific biological objectives for cod spawning closures in the Eastern Baltic Sea addressed in this evaluation were i) increased recruitment via undisturbed spawning, taking into account survival probability of the offspring; ii) increased proportion of larger/older individuals in the stock, which may also increase recruitment; iii) reduced total catch.

It is recognized that reduced total catch should not be the main objective of spawning closures in the Eastern Baltic Sea, when catches are regulated by TAC. Thus, the potential objective of reduced total catch was only included for completeness.

The realized effects of spawning closures (e.g., increased recruitment, increased proportion of large cod in the population) on a fish stock are generally very difficult to demonstrate or quantify. This is because there is a large number of factors and processes that influence recruitment as well as size structure of the stock. Thus, it is not possible to separate out effects of the closures on Eastern Baltic cod stock from other factors, which are known to influence the stock at the same time.

For this reason, ICES evaluated potential effects of the closures. The key focus in this approach is on the overlap between the closure and the stock component intended to be protected. If such overlap is not present, this implies that the closure cannot be beneficial, but can possibly be counterproductive for the stock. If the overlap is present, the closure can potentially contribute to achieving a given objective. However, it can still not be verified that the closure actually has a positive effect on the Eastern Baltic cod stock.

The closures evaluated included:

i) the presently applied area closures in the three designated areas in the Eastern Baltic Sea (May 1- Oct 31), as specified in the Baltic MAP (2016), and potential modifications to there;

ii) the seasonal closure (July 1- Aug 31 in 2018; July only in 2019) in SDs 25-26 and potential expansion of this seasonal closure to SDs 27–32 and to SD 24.

ICES evaluated potential positive and negative effects of both area and seasonal closures. Potential positive effects were related to overlap between the closure and the stock component intended to be protected. Potential negative effects of the closures were generally associated with possible spatial and temporal effort reallocation.

The specific questions that ICES addressed for both the area and seasonal closures, were the following:

Objectives	Criteria
Increased recruitment (via undisturbed spawning)	Is there an overlap between the closure and cod spawning activity, in time and space? Is there an overlap between the closure and spawners whose offspring has a higher survival probability?
Increased proportion of larger cod	Is there an overlap between the closure and largest individuals of cod? Does the closure decrease the proportion of largest cod in fisheries catch?
Reduced total catch (F)	Is there an overlap between the closure and cod distribution? Could the same total amount of cod be caught regardless of the closure?

2.2 Results and conclusions on area closures

The existing area closure in the Bornholm Basin (1 May–31 October) has potentially both positive and negative effects for Eastern Baltic cod. The potential negative effects are associated with effort reallocation to areas in the Bornholm Basin where spawners may produce eggs and larvae with a higher rate of survival, and to areas where larger individuals of Eastern Baltic cod are relatively more abundant, at least in some years (i.e. in Subdivision 26). To eliminate these potential negative effects an extension of the closed area would be needed to include the area in the Bornholm Basin with water depths of 60 m or more, and additionally the entire SD 26. Additional benefits to cod may be obtained by including the Slupsk Furrow, where cod spawning also takes place.

The current closure includes May to October. Shortening the period of the closure to only cover the peak spawning (May-August) would not substantially reduce the potential benefits of the closure.
The present area closures in Gdansk and Gotland basins have little potential to contribute to improving the stock status given the present hydrographic conditions.

2.3 Results and conclusions on seasonal closures

The present seasonal closure (in July in 2019) in SDs 25-26 does not cover the period when most intensive spawning has been observed in years since 2010 (June), and the closure may therefore cause increased disturbance of peak spawning in June due to effort reallocation. This potential negative effect can be eliminated by including June in the period of the closure.

Potential expansion of the closure to SDs 27–32 would have only minor potential benefits to the Eastern Baltic cod stock, because cod abundance as well as catches are very low in this area.

A potential expansion of the closure to SD 24 may have some benefits to Eastern Baltic cod recruitment due to undisturbed spawning, though the survival of Eastern Baltic cod eggs spawned in this area is generally low. Quantitative analyses on the relative contribution of spawning in SD 24 to Eastern Baltic cod recruitment are currently lacking. Similarly to SD 25–26, a closure not covering June would potentially increase the disturbance of peak spawning (in June) due to effort reallocation. Thus, to avoid possible negative effects, if a closure in SD 24 is implemented, it should also cover June. Eastern and Western Baltic cod are mixed in the entire SD 24. Thus, a summer closure in SD 24 would have implications for Western Baltic cod due to effort reallocation to SDs 22–23.

2.4 Overall conclusions

Designing smaller area closures properly is associated with much greater complexity and data requirements compared to a closure covering most of the distribution area of the stock during its main spawning time. This is because small area closures cause fishing effort reallocation to other stock components with a risk of unintended negative effects via mechanisms that may not have been accounted for when designing the closure (Eero et al. 2019).

If spawning closures are chosen to be applied as a supplementary management measure, these should be designed in a way that allows their potential benefits to occur, while avoiding potential counteracting effects. The closures covering most of the distribution area of the stock during its peak spawning time are better suited for this purpose rather than those covering small areas (Eero et al. 2019). For Eastern Baltic cod, most of the spawning takes place during May-August and the stock is mainly distributed in SDs 25-26. Part of the stock is also distributed in SD 24, however the contribution of spawning in this area to overall recruitment of the Eastern Baltic cod stock is unclear.

3. Effect of a potential reduction of TAC in 2019 for the Eastern Baltic cod

3.1 Methods

Total catch from the Eastern Baltic cod stock in 2019 is assumed to be at 18 904 t, if no additional fishing restrictions are implemented in 2019. This is based on the assumption that fishing mortality in 2019 stays at the same level as estimated for 2018, and it corresponds to a 12 % lower catch in 2019 compared to 2018. This is considered to be the maximum likely catch level in 2019, given the declining biomass of the Eastern Baltic cod. The catch at 18 904 t was used as a starting point for the present analyses exploring the effect of a possible reduction of catch/TAC in 2019 on stock development in short-term.

In case the TAC for 2019 would be reduced, ICES assumes that this would only affect the cod catches in the 3rd and 4th quarter of the year 2019. This is because the fishery in Q1 and likely also in Q2 have already taken place before such a measure could potentially be enforced in practise. Thus, in the short-term forecast scenarios with alternative catch levels for 2019, the catch for Q1-Q2 was kept as assumed in the ICES latest stock assessment, and only the catches in Q3-Q4 were modified. The quarterly distribution of the assumed catches in 2019 was based on data from 2018 (67% in Q1-Q2 and 33% in Q3-Q4), which is similar to the average in the former 2 years (2016-2017).

Short-term forecast scenarios

The short-term forecast scenarios conducted represented the maximum possible effect that could be obtained by reducing the TAC for 2019 from Q3 onwards, i.e. setting the catches to zero in the last two quarters of the year 2019. Two scenarios were conducted, which differed in terms of whether the zero catch in Q3-Q4 applied for the entire Eastern Baltic cod stock (incl. SD24) (***Scenario 1***) or only for the Eastern Baltic management area (SDs 25-32) (***Scenario 2***) . These were compared with the run (***Scenario 0***) assuming no additional catch/TAC restrictions in 2019.

In ***Scenario 1***, total catch of the Eastern Baltic stock in 2019 was reduced from 18 904 t to 12754 t, which is the catch amount assumed to have been taken in Q1-Q2 (Table 2.1). This scenario corresponds to zero catch from the Eastern Baltic cod stock in Q3-Q4 in 2019 (incl. SD24).

In **Scenario 2**, zero catch in Q3-Q4 in 2019 was applied for SDs 25-32, but allowing for continued fishery in SD24 without any further restrictions. Eastern Baltic cod is caught in SD 24 together with the Western Baltic cod stock in a mixed fisheries. Given that the TAC of 9515 t established in the Western Baltic management area (SD 22-24) for 2019 will be taken, this is estimated to correspond to a catch of 3646 tons of the Eastern Baltic cod in SD 24 in 2019.

This is when assuming that the geographical distribution of cod catches in the Western Baltic management area in 2019 is the same as observed in 2016–2018 (52% in SD 24), implying that 4599 tonnes out of the TAC at 9515 t is expected to be taken in SDs 22–23 and 4916 tonnes in SD 24. Furthermore, the proportion of the Eastern Baltic cod in the commercial cod catch in SD 24 is assumed to be the same as observed on average during 2016–2018 (74%). This results in catch of 3646 t of the Eastern Baltic cod in SD 24, in 2019. About half of the annual commercial cod catch in SD 24 is expected to be taken in first two quarters of the year (based on 2018 data). This proportion could be higher in 2019, when no spawning closures in SD 22-24 have been implemented in the first quarter of the year. Thus, a maximum 1823 tons (0.5*3646 t) of Eastern Baltic cod is expected to be taken in SD 24 in the second half of the year 2019. Thus, in ***Scenario 2***, 1823 t of the Eastern Baltic cod was assumed to be taken in Q3-Q4 in 2019, which corresponds to the annual catch of the Eastern Baltic cod at 14577 t in 2019 (Table 3.1).

This calculation considers the TAC to be the maximum commercial cod catch taken in SDs 22-24, not including discards that may occur in addition. Recreational fishery in SD24 are considered to target western Baltic cod stock, as the recreational fishery is largely taking place in near-shore areas, where the western Baltic cod dominate.

The catch assumptions for 2019 in the short-term forecast scenarios are summarised in the table below.

Table 3.1. Catch of the Eastern Baltic cod stock in 2019 in short-term forecast scenarios.

Scenario	Total catch from the Eastern Baltic cod stock in 2019	Basis
Scenario 0	18 904 t	F 2019= F 2018
Scenario 1	12754 t	Catch in Q1-Q2, assuming the same quarterly distribution of catches (67 % in Q1-Q2) as in 2018 (0.67*18 904 =12754 t). Catch in Q3-Q4 set to zero.

Scenario 2	14577 t	Catch in SDs 25-32 in Q3-Q4 set to zero, allowing for continued fishery in SD 24. The expected catch amount of Eastern Baltic cod in SD 24 is 1823 t in Q3-Q4. (12754+1823=14577 t)

In all these scenarios, the same assumptions were applied for recruitment (average of 2013-2017) and other biological parameters (latest estimates). The catch for 2020 was set to zero in all scenarios.

3.2. Results and conclusions

The results show little difference in SSB between the three scenarios (Table 3.2). Applying zero catch in Q3-Q4 for the entire Eastern Baltic cod stock (*Scenario 1*) resulted in a 4% higher SSB in 2020 compared to *Scenario 0*. Applying zero catch in Q3-Q4 only in SDs 25-32 resulted in a 3% higher SSB in 2020 compared to *Scenario 0*.

TACs for the Eastern Baltic cod have not been utilized since 2010 (in 2018, only 55 % of the TAC was utilized). Therefore, a reduction in TAC needs to be large enough to limit the landings in practice and have a measurable effect on the stock.

Even the zero catch in Q3-Q4 in 2019 makes a little difference to the SSB because i) majority of the annual catch has already been taken in Q1-Q2, and ii) fishing mortality at these catch levels is low compared to the estimated natural mortality, implying that fishing is presently not the major driver for the stock dynamics. However, fishing at any level targets the remaining few commercial sized (>=35cm) cod, and by that further deteriorates the stock structure and reduces its reproductive potential.

Table 3.2. Results of the short-term forecast scenarios.

Scenario	Total catch (2019)	F (2019)	Total catch (2020)	F (2020)	SSB (2019)	SSB (2020)	SSB (2021)
Scenario 0	18904	0.21	0	0	66412	68942	77373
Scenario 1	12754	0.13	0	0	66353	71578	79122
Scenario 2	14577	0.15	0	0	66353	70773	78580

4. Recreational fishery for the Eastern Baltic cod

Several Member States provided information on recreational catches of cod in SDs 25-32, for the purpose of this request (Table 4.1). ICES has not evaluated the quality of these data, in stock assessment context. The provided recreational catch amounts of the Eastern Baltic cod, in total in the range of 465-763 t in the last 3 years, are considered to be a minimum estimate, since not all Member States were able to contribute with recreational fishery data (Table 4.1).

The available estimate of recreational catch constitutes approximately 2% of the total catch of Eastern Baltic cod in SDs 25-32, in the last 3 years (Table 4.2). All recreational cod catches taken in SD24 are considered to be from the Western Baltic cod stock.

There is presently no EU regulations for recreational cod fishery in SDs 25-32, however Member States can have implemented national regulations. The level of recreational cod catch is presently low compared to commercial catch. However, a severe reduction of commercial fishing opportunities for cod in the eastern Baltic management area could lead to an increased importance of the recreational fishery.

Table 4.1. The recreational cod catches (t) in the Eastern Baltic management area (SD 25-32) by Member State.

Year	Denmark	Sweden	Germany	Poland	Lithuania	Latvia	Estonia	Total
2016	40	NA	NA	695	26	1	1	763
2017	16	NA	NA	442	16	1	0	475
2018	8	NA	NA	400	56	0	0	465

Table 4.2. The total recreational cod catch compared to commercial catch in the Eastern Baltic management area (SDs 25-32).

Year	Recreational catch (t)	Commercial catch (t)	Total (t)	Percentage of recreational catch from total (%)
2016	763	32591	33354	2.3
2017	475	28734	29209	1.6
2018	465	19010	19475	2.4

5. Cod landings in different commercial fisheries

5.1 Methods

Data

The analyses presented here are based on landing data uploaded to the Regional Database (RDB) for the year 2018. The data are available by metier, quarter, ICES Subdivision, Member State and species. To analyse bycatch, data on a fishing trip level should ideally be used, to estimate the fractions of different species caught within a given fishing trip. This was however not possible due to time constraints, as data on trip level are presently not available in RDB. Therefore, the analyses presented here are only showing species compositions of landings on the level of metier, quarter, SD and Member State, however it is not saying to what extent these species are actually caught together during one single fishing operation.

Furthermore, the analyses presented here only include landing data, i.e. not including discards. This could have an effect on metiers where cod is not the target species. Species compositions of total catch could be analysed based on observer data, however this was not possible within the time frame available for these analyses.

The landing data used here are for the EU Member States, i.e. Russian data are not included.

Definition of a métier

Métier is the term used in the Data Collection Framework (DCF) to define a somewhat homogeneous group of fishing actions which share common physical features, e.g. gear type, mesh size range, main target species and discard pattern.

Each defined métier has its name expressed as a code (Fig. 5.1). The code consists of a combination of gear type, mesh size range, target species assemblage, the existence or non-existence of a selection device (including information of type) and the mesh size in the selection device (if existing). The gear code values follow FAO standards and the target species assemblage and selection device type are given in Table 5.1.

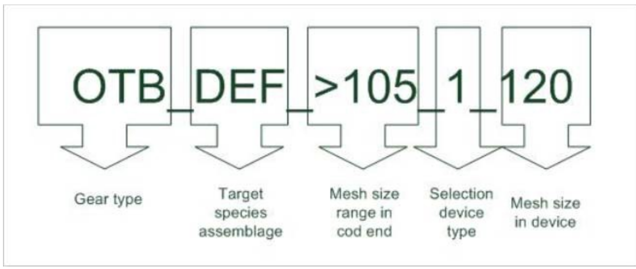

Figure. 5.1. Example of a métier code: bottom Otter board trawl targeting demersal fish and having >105 mm mesh size in cod end and Bacoma exit window with 120 mm mesh size.

Table 5.1 . Codes used for target species assemblage and Selection device in the métier names.

Gear code	***Gear***
FPN	*Fixed pound nets*
FPO	*Pots*
FYK	*Fykenet*
GNS	*Set gillnet*
LLS	*Longlines bottom*
OTB	*Otter trawl bottom*
OTM	*Otter trawl midwater*
OTT	*Otter twin trawl (midwater)*
PTM	*Pair trawl midwater*
PTB	*Pair trawl bottom*
PS	*Purse seine*
SDN	*Anchored seine*
SSC	*Flyshooter*
Target species assemblage code	***Target species assemblage***
ANA	*Anadromous species*
CAT	*Catadromous species*
DEF	*Demersal fish*

SPF	*Small pelagic species*
CRU	*Crustaceans*
Selection device code	***Selection device***
1	*Bacoma window*
2	*Fixed grid*

Analyses

The analyses were conducted for métiers that had fished in ICES SDs 24-28, i.e. in the distribution area of the Eastern Baltic cod. In the northern Baltic in SDs 29-32 cod abundance is very low, and less than 1% of the total annual landings of the Eastern Baltic cod have been taken in these areas in the last decades. Therefore, the métiers only fishing in these northern SDs were not included in the analyses.

Altogether 68 métiers had fished in SDs 24-28 in 2018. Large number of these métiers (40) had landed no or very little cod (below 0.1% of the total cod landings in 2018), and cod constituted less than 5% of the total landings of these métiers (Table 5.2). Additional 13 métiers had landed a similarly small fraction of the total cod landings (below 0.1% of the total cod landings in 2018), although cod constituted more than 5% of the landings of these métiers. This is due to generally low landings of these métiers (Table 5.3).

For the remaining 15 métiers (each contributing >0.1%of the total cod landings), further analyses were conducted, looking at:

- i) Species compositions of total annual landings and total amounts of cod landings
- ii) Species compositions by Subdivisions and distribution of cod landings between Subdivisions
- iii) Species compositions by quarter and distribution of cod landings between quarters
- iv) Species compositions by Member States and distributions of cod landings between the Member States

5.2 Results and conclusions

Métiers with no or very low bycatch of cod

Cod catches are very low in ICES SDs 29-32, because of very low cod abundance in this area. Thus, cod bycatch is not expected to become an issue for fisheries in these areas, regardless of the cod TAC level.

Furthermore, cod bycatch is very low for the métiers listed in Table 5.2, both in terms of the landed amount of cod and the fraction of cod in their landings.

For the métiers listed in Table 5.3, the amount of cod landings as well as total landings were low in 2018. However, as cod constituted a relatively high proportion of the landings of some of these métiers, cod bycatch could become an issue for these métiers if their effort would increase.

The landings of the remaining 15 métiers that contributed most of the cod landings in SDs 24-28 in 2018 are analysed in further detail in the sections below.

Overall species composition and total cod landings of the selected métiers

The majority (approximately 70%) of the cod landings in SDs 24-28 were taken by trawlers with a BACOMA/ T90 with a 120 mm escape window (OTB_DEF_>=105_1_120) and 15% of the cod landings were taken by gillnetters with a mesh size between 110-156 mm (GNS_DEF_110-156_0_0). These métiers are generally considered to target cod. Both of these two métiers also landed flatfish (mostly flounder and to a lesser degree plaice and turbot). Cod constituted about a half of the annual landings of OTB_DEF_>=105_1_120 and less than half for GNS_DEF_110-156_0_0.

The other métiers in the top 15 in terms of the amount of cod landings contributed to the total cod landings with less than 5% each (Fig. 5.2). The landings of the next métiers in terms of their contribution to total cod landings (OTB_DEF_>=115_0_0, OTB_DEF_>=120_0_0 and OTT_DEF_>=105_1_120, which were only used in Sweden) consisted mostly of cod, with little amounts or other species. Also, most of the landings with longliners targeting demersal fish (LLS_DEF_0_0_0) were cod.

The other métiers had variable proportions of cod in their landings and landed a variety of species. Some of these métiers had very low proportion of cod in their landings (e.g. pelagic trawls - OTM métiers fishing for sprat and herring). These métiers were among the top 15 in terms of the amount of landed cod due to their overall high catch levels (Fig. 5.2). However, it should be noted that 95% of the total cod landings were taken by the first five listed métiers, and the contribution of the other métiers to total cod landings was low (between 0.1 and 1%) (Fig. 5.2).

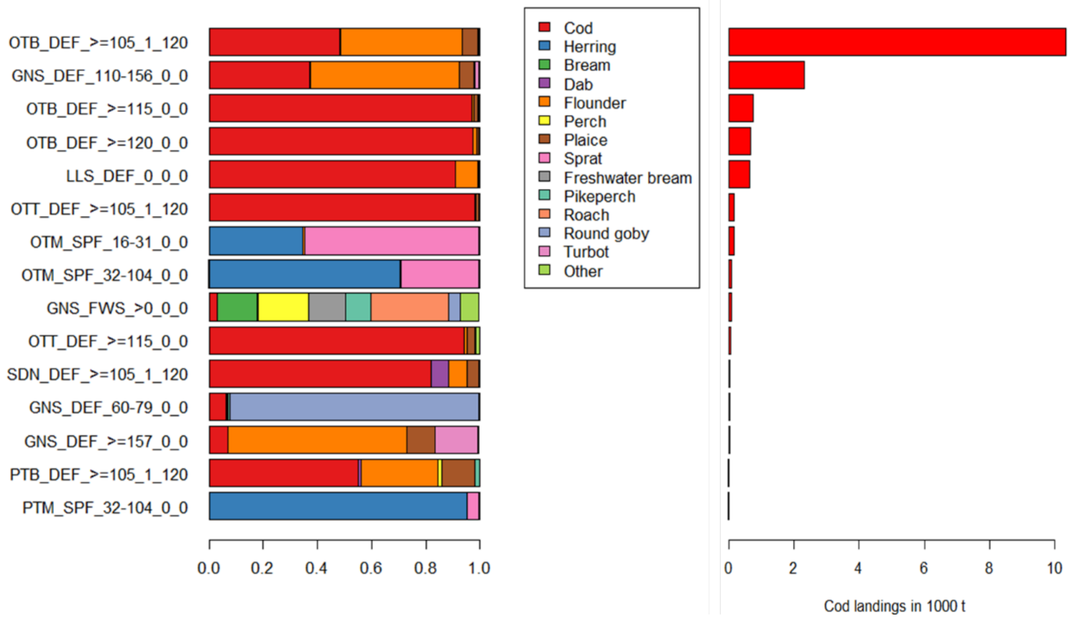

Figure 5.2. Left panel: Species composition of landings in SDs 24-28 in 2018, by métiers. Right panel: The amount of cod landings by the same métiers.

Species composition of landings of the selected métiers by Subdivisions

The Eastern Baltic cod is mostly caught in SDs 24-26. Most of the métiers that take larger part of the cod landings operate in all three of these SDs. There are also métiers that have only been fishing in one or two SDs, but these have taken smaller fractions of the total cod landings (Fig. 5.3).

Species compositions of the landings of a given métier were generally similar between SDs 24-26, though the proportions of the different species somewhat differed (Fig. 5.4). In the first two métiers that take most of the cod landings (OTB_DEF_>=105_1_120 and GNS_DEF_110-156_0_0), the proportion of cod in the landings was highest in SD 26, while flatfishes contributed larger shares to the total landings in SDs 24 and 25. In SDs 25-26, it is mostly flounder, while plaice and other species occur in higher fractions in SD 24.

In the other métiers, where cod landings were generally much lower, the species compositions depended on the gear type, and were generally relatively similar between the SDs 24-26 (Fig. 5.4).

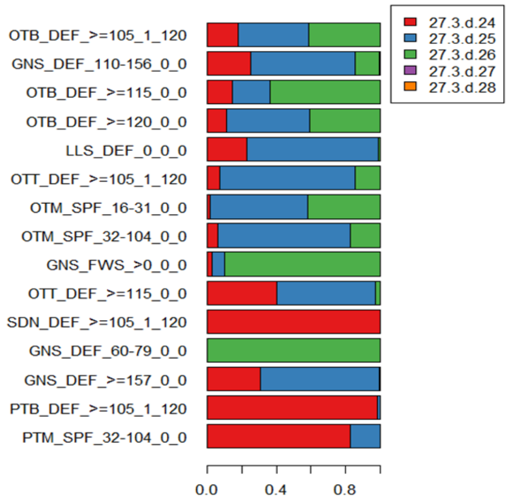

Figure 5.3. Distribution of cod landings between Subdivisions, in 2018, by métiers. Metiers are listed in the order of their contribution to total cod landings in SDs 24-28 in 2018.

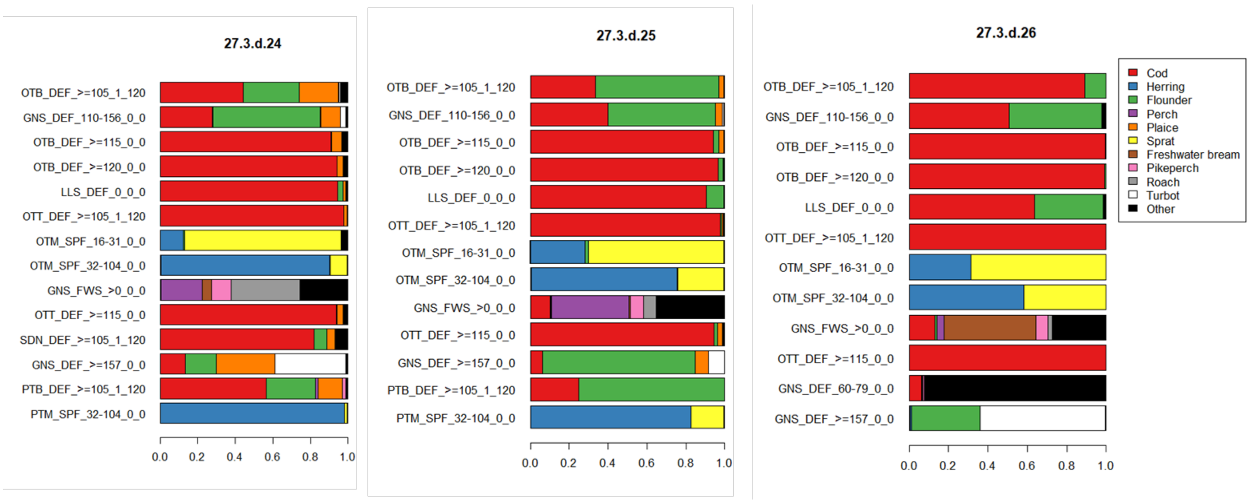

Figure 5.4. Species composition of landings in SDs 24-28 in 2018, by métier, and Subdivision. Note that not all métiers are present on all panels, as have not been fishing in all Subdivisions. Métiers are listed in the order of their contribution to total cod landings in SDs 24-28 in 2018.

Species composition of landings of the selected métiers by quarter

Quarterly distribution of cod landings in SDs 24-28 in 2018, by métier, is shown in Figure 5.5. The most important métiers in terms of total cod landings had generally a larger share of their cod landings in Q1-Q2. Some of the other métiers with lower total cod landings landed cod mostly in Q4.

Species compositions of the landings of a given métier were generaly similar between different quarters, though with some differences in the proportions of species in the landings (Fig. 5.6). The two métiers with the highest cod landings (OTB_DEF_>=105_1_120 and GNS_DEF_110-156_0_0) had a relatively low proportion (less than 30% of total landings) of cod in their landings in Q1, when flounder dominated in the landings. In Q2, when large part of the annual cod landings were taken, cod constituted at least half or more of the landings. For the other métiers with lower total cod landings, the proportion of cod in the landings was generally similar between quarters, if a métier had been fishing in all quarters. Some of the analysed métiers did not operate in all quarters of the year (Fig. 5.5, 5.6)

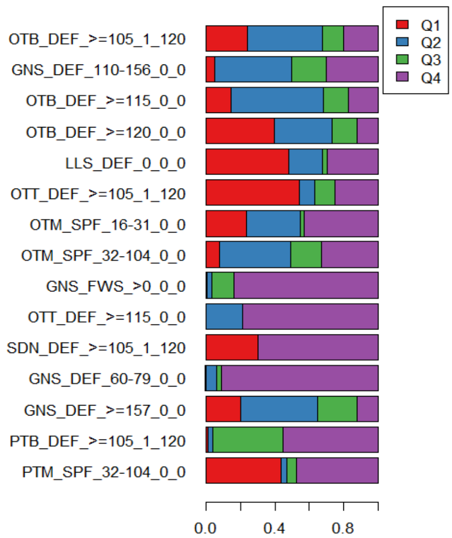

Figure 5.5. Distribution of cod landings in 2018 in SDs 24-28 between quarters, by métiers. Métiers are listed in the order of their contribution to total cod landings in SDs 24-28 in 2018.

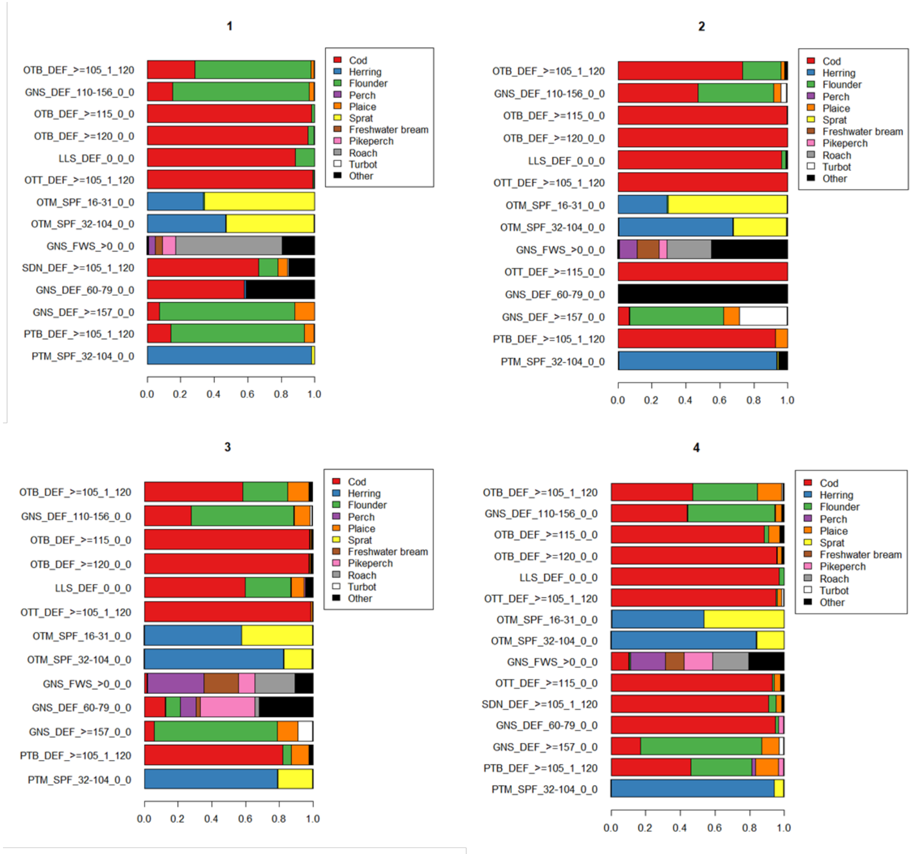

Figure 5.6 Species composition of landings in SDs 24-28 in 2018, by métier, and quarter. Note that not all métiers are present on all panels, as have not been fishing in all quarters. Métiers are listed in the order of their contribution to total cod landings in SDs 24-28 in 2018.

Species composition of landings of the selected métiers by Member State

The two métiers taking most of the cod landings (OTB_DEF_>=105_1_120 and GNS_DEF_110-156_0_0) are used by most Member States participating in cod fisheries. Although there are also métiers that are only used by one country. For example, OTB_DEF_>=115_0_0, OTB_DEF_>=120_0_0 and OTT_DEF_>=105_1_120, that altogether took 10% of the cod landings, were used by Sweden only (Fig. 5.7).

Consequently, in Sweden, the main métiers contributing to cod fishery landed mostly only cod (Fig. 5.8). In other countries, the métiers landing cod additionally landed flatfish and some other species. The share of other species in the landings of the main cod métiers (OTB_DEF_>=105_1_120 and GNS_DEF_110-156_0_0) was highest in Poland and Germany (more than 50%). In Denmark, Latvia and Lithuania, around 30% of the landings of the two main cod métiers (OTB_DEF_>=105_1_120 and GNS_DEF_110-156_0_0) consisted of species other than cod (mainly flatfish) (Fig. 5.8). In the other métiers with lower amounts of cod landings, cod constituted varying but mostly low proportions in all countries (Fig. 5.8).

The differences in landing patterns between Member States of course reflect also the available quota shares for different species. Although there is no TAC for flounder, the different landing patterns can be connected to marked prices. For example, Denmark and Sweden have less tradition for flounder fishery than is seen in other Baltic countries.

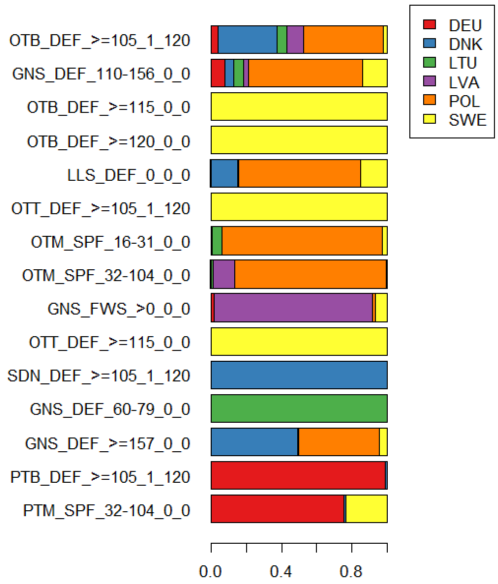

Figure 5.7 Distribution of cod landings in 2018 in SDs 24-28 between Member States, by métiers. Métiers are listed in the order of their contribution to total cod landings in SDs 24-28 in 2018.

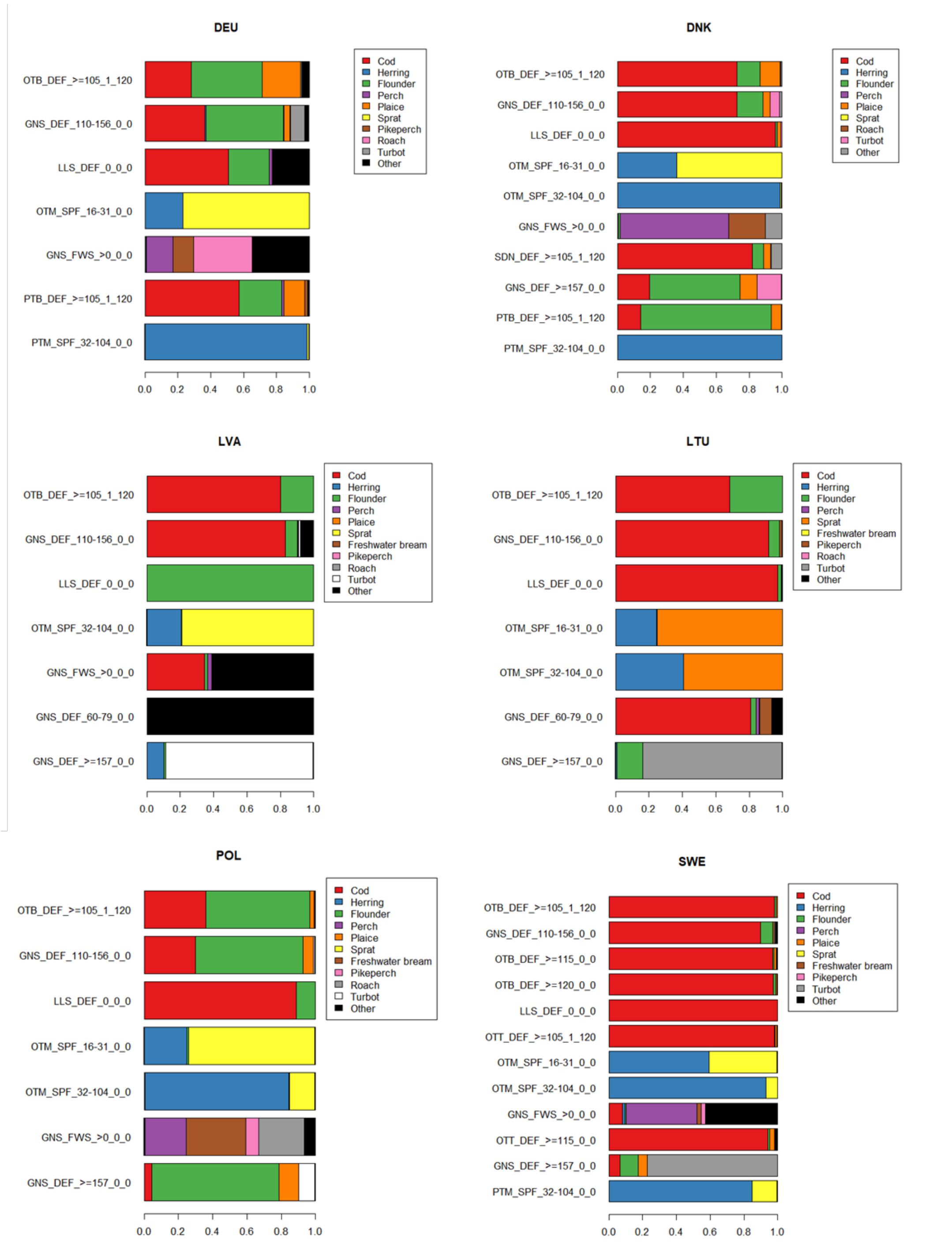

Figure 5.8 Species composition of landings in SDs 24-28 in 2018, by métier, and Member State. Note that not all métiers are present on all panels, as have not been used by all countries. Métiers are listed in the order of their contribution to total cod landings in SDs 24-28 in 2018.

Table 5.2. Métiers that contributed <0.1% of the total cod landings in SDs 24-28 in 2018, and cod constituted <5% of their landings.

Metier	Total landings of all species (kg)	Landings of cod (kg)	Proportion of cod in the total landings of all species	Proportion of total cod landings
GNS_SPF_32-109_0_0	3999011	7619	0.002	0.0005
OTM_DEF_<16_0_0	1261667	4788	0.004	0.0003
OTM_DEF_>=105_1_120	364598	4077	0.011	0.0003
FPN_SPF_>0_0_0	1645000	3456	0.002	0.0002
FPO_SPF_>0_0_0	1122361	2865	0.003	0.0002
OTB_FWS_>0_0_0	115525	2552	0.022	0.0002
PTM_SPF_16-31_0_0	16338819	2161	0.000	0.0001
OTB_SPF_32-104_0_0	124207	1368	0.011	0.0001
FPN_CAT_>0_0_0	95053	1219	0.013	0.0001
OTM_SPF_16-104_0_0	44567769	1135	0.000	0.0001
PTB_FWS_>0_0_0	16244	640	0.039	0.0000
PTM_DEF_<16_0_0	470359	379	0.001	0.0000
GNS_ANA_>=157_0_0	177191	270	0.002	0.0000
PTB_SPF_32-104_0_0	245298	224	0.001	0.0000
GNS_CAT_>0_0_0	58558	223	0.004	0.0000
LLD_ANA_0_0_0	205556	205	0.001	0.0000
OTB_SPF_16-104_0_0	3110710	170	0.000	0.0000
LLS_CAT_0_0_0	12428	141	0.011	0.0000
GNS_ANA_110-156_0_0	5063	88	0.017	0.0000
FYK_CAT_>0_0_0	33045	72	0.002	0.0000
OTB_SPF_16-31_0_0	3796464	57	0.000	0.0000
FPO_FWS_>0_0_0	2441076	50	0.000	0.0000
FPN_FWS_>0_0_0	147819	45	0.000	0.0000
LLS_FWS_0_0_0	3906	40	0.010	0.0000
OTB_DEF_90-104_0_0	2716	34	0.013	0.0000
GTR_SPF_32-109_0_0	21272	28	0.001	0.0000
FYK_FWS_>0_0_0	651	17	0.026	0.0000
FPO_ANA_>0_0_0	2928	0	0.000	0.0000
FPO_CAT_>0_0_0	13706	0	0.000	0.0000
GNS_CRU_>0_0_0	6699	0	0.000	0.0000
GNS_SPF_16-109_0_0	13403	0	0.000	0.0000
GTR_FWS_>0_0_0	279	0	0.000	0.0000
LLS_ANA_0_0_0	1286	0	0.000	0.0000
LLS_SPF_0_0_0	328	0	0.000	0.0000
PS_SPF_16-31_0_0	197761	0	0.000	0.0000
PS_SPF_32-104_0_0	125436	0	0.000	0.0000
PTB_SPF_>=105_1_120	6000	0	0.000	0.0000
PTB_SPF_16-31_0_0	59300	0	0.000	0.0000
SDN_DEF_>=105_1_110	73200	0	0.000	0.0000
SDN_SPF_32-104_0_0	6566	0	0.000	0.0000

Table 5.3. Métiers that contributed <0.1% of the total cod landings in SDs 24-28 in 2018, but cod constituted >5% of their landings.

Metier	Total landings of all species (kg)	Landings of cod (kg)	Proportion of cod in the total landings of all species	Proportion of total cod landings
OTB_DEF_<16_0_0	120202	10204	0.08	0.0007
FPO_DEF_>0_0_0	12173	9400	0.77	0.0006
FPN_DEF_>0_0_0	18203	8937	0.49	0.0006
LHP_FIF_0_0_0	1990	1987	1.00	0.0001
MIS_MIS_0_0_0	1598	1582	0.99	0.0001
GTR_DEF_110-156_0_0	17649	1574	0.09	0.0001
GNS_DEF_90-109_0_0	2839	1503	0.53	0.0001
OTT_DEF_>=120_0_0	934	902	0.97	0.0001
GTR_DEF_>=157_0_0	1239	503	0.41	0.0000
SSC_DEF_>=105_1_120	483	431	0.89	0.0000
FPN_ANA_>0_0_0	212	72	0.34	0.0000
PTB_DEF_90-104_0_0	124	64	0.52	0.0000
GNS_SPF_110-156_0_0	108	18	0.17	0.0000

References

Eero, M., Hinrichsen, H., Hjelm, J., Huwer, B., Hüssy, K., Köster, F. W., Margonski, P., Plikshs, M., Storr-Paulsen, M., Zimmermann, C. 2019. Designing spawning closures can be complicated: Experience from cod in the Baltic Sea. Ocean & Coastal Management, 169: 129-136, 10.1016/j.ocecoaman.2018.12.018

EU. 2016. Regulation (EU) 2016/1139 of the European Parliament and of the Council of 6 July 2016 establishing a multiannual plan for the stocks of cod, herring and sprat in the Baltic Sea and the fisheries exploiting those stocks, amending Council Regulation (EC) No 2187/2005 and repealing Council Regulation (EC) No 1098/2007. Official Journal of the European Union, L 191. 15 pp. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016R1139.

ICES 2018. Report of the WorKshop to evaluate the effect of CONservation measures on Eastern Baltic cod (GAdus morhua) (WKCONGA), 14–15 August 2018, Copenhagen, Denmark. ICES CM 2018/ACOM:51. 56 pp.

Annex 3: Resolution for the 2020 meeting

2019/X/ACOMXX The Baltic Fisheries Assessment Working Group (WGBFAS), chaired by Mikaela Bergenius, will meet at ICES, Denmark, 16 – 23 April 2020 to:

a) Address generic ToRs for Regional and Species Working Groups

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

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 on the dates specified in the 2020 ICES data call.

WGBFAS will report by xx April 2020 for the attention of ACOM.

Annex 4: List of stock annexes

The table below provides an overview of the WGBFAS Stock Annexes. Stock Annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the year, ecoregion, species, and acronym of the relevant ICES expert group.

Name	Title
cod.27.22-24	Western Baltic cod in Subdivisions 22-24
cod.27.2432	Cod (*Gadus morhua*) in Subdivisions 24–32, eastern Baltic stock
fle.27.2223	Flounder (*Platichthys flesus*) in subdivisions 22 and 23 (Belt Seas and the Sound)
fle.27.2425	Flounder (*Platichtys flesus*) in Subdivisions 24 and 25 (West of Bornholm and Southwestern Central Baltic)
her.27.25-2932	Herring (*Clupea harengus*) in subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea)
her.27.28	Herring (*Clupea harengus*) in Subdivision 28.1 (Gulf of Riga)
her.27.3031	Herring (*Clupea harengus*) in Subdivisions 30 and 31 (Gulf of Bothnia)
ple.27.2123	Plaice in subdivisions 21, 22 and 23 (Kattegat, Belt Sea, Sound)
tur.27.2232	Turbot (*Scophthalmus maximus*) in subdivisions 22–32 (Baltic Sea)

Annex 5: Audits reports

Audit of (Cod in subdivisions 24-32, eastern Baltic cod)

Date: 14.04.2019
Auditor: Jan Horbowy and Maris Pliksh

General

For single stock summary sheet advice:

Assessment type: new assessment following benchmark meeting

1) **Assessment**: analytical and fully stochastic model
2) **Forecast**: presented
3) **Assessment model**: Stock Synthesis – fitted to: 9 abundance indices (5 commercial, 2 BITS surveys, ichtioplankton survey (larvae & eggs-production)); length composition (passive &active gears, 2 BITS surveys); age composition
4) **Data issues:** the usage of data followed procedure agreed at benchmark
5) **Consistency**: data and model used are consistent with benchmark WK
6) **Stock status**: SSB<B_{lim}, situation is even worse as size at first maturation markedly declined and presently SSB contains smaller fish than previously; stock size in terms of biomass of fish exceeding 35 cm declined more than SSB and is lowest observed in 70 years.
   Fishing mortality declined but large increase in natural mortality is estimated
7) **Management Plan**: EU multiannual plan (MAP) that includes cod is in place for stocks in the Baltic Sea (EU, 2016). However, FMSY ranges are not presently available for the eastern Baltic cod stock.

General comments

Enormous amount of work has been done to assess the stock. Extensive data from several sources were used.

Technical comments

Assessment has been done following procedure agreed at benchmark meeting

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Assessment follows benchmark specifications
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Basis for advice is PA
- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock? Not relevant.
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? not relevant

Audit of (Her.27.25-2932, Central Baltic Herring stock)
Date: 11.4.2019
Auditor: Stefan Neuenfeldt, Jukka Pönni

General

The EG answered the TORs relevant to providing advice.

For single stock summary sheet advice:

8) **Assessment type: update**
9) **Assessment**: analytical
10) **Forecast**: presented
11) **Assessment model**: XSA + tuning with one survey (BIAS autumn survey)
12) **Data issues:** The data were uploaded by national laboratories and aggregated into international data in ICES InterCatch database.
13) **Consistency** The 2019 assessment is consistent with 2018 assessment and was accepted both years.
14) **Stock status** Fishing pressure on the stock is above F_{MSY} and below and F_{lim}; spawning stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}
15) **Management Plan** EU Multi-annual Management Plan (MAP)
16) **General comments**

The report is describing the assessment in a clear way.

Technical comments
No specific comments.

Conclusions
The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes
- Is the assessment according to the stock annex description?
  Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  Yes
- Have the data been used as specified in the stock annex?
  Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  Yes
- Is there any **major** reason to deviate from the standard procedure for this stock?
  No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  Yes

Audit of Plaice in subdivisions 24–32 (Ple27.24-32)

Date: 30.04.2019
Auditor: Julita Gutkowska

General

For single stock summary sheet advice:

1) **Assessment type:** update/SALY
2) **Assessment**: age-based analytical assessment, SAM, considered indicative of trends only
3) **Forecast**: not presented
4) **Assessment model**: SAM + 2 tuning fleets
5) **Data issues:** data available as described in stock annex
6) **Consistency**: Both last year's and this year's assessments were accepted
7) **Stock status**: The stock size indicator (relative SSB) and relative recruitment have been increasing significantly since 2013. The relative fishing mortality has been declining in recent years and relative F in 2018 is the second-lowest observed in the time-series. The stock status and exploitation status relative to MSY and PA reference points cannot be assessed because the reference points are undefined.
8) **Management Plan**: There is no management plan for this stock

General comments

In general this was a well documented, well ordered and considered section.

Technical comments

The author of the report for Plaice in SDs 24-32 has received the comments of the audit and has made the necessary corrections.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? **Yes**
- Is the assessment according to the stock annex description? **Yes**
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? **NA**
- Have the data been used as specified in the stock annex? **Yes**
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **Yes**
- Is there any **major** reason to deviate from the standard procedure for this stock? **No**
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **Yes**

Audit of sol.27.20-24

Date: 19.04.2019

Auditor: Kristiina Hommik and Zuzanna Mirny

General

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: Age structured analytical stochastic assessment (SAM) that uses landings only in the model. Discards are included afterwards in the forecast.
   3 tuning fleets: DTU Aqua-Fisherman survey (2004-2018); private logbooks from gillnetters (1994-2007) and private logbooks from trawlers (1987-2008). Fixed maturity(knife-edge maturity-at-age 3) and fixed natural mortality (0.1) for all age groups.
5) **Data issues:** The data are available as described in stock annex. Sampling since 2017 has improved
6) **Consistency**: The assessment of recent years including the 2019 assessment have been accepted.
7) **Stock status**: fishing pressure on the stock is at F_{MSY} and F_{pa} and below F_{lim}, and spawning stock size is above MSY $B_{trigger}$ and B_{lim}.
8) **Management Plan**: The EU multiannual plan (MAP) for stocks in the North Sea. The advice is based on F_{MSY} ranges used in the MAP and is considered precautionary.

General comments:

Report is well documented and possible to follow the assessment.

Technical comments

The assessment is performed according to the stock annex.

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes
- Is the assessment according to the stock annex description?
  Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  Yes
- Have the data been used as specified in the stock annex?
  Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  Yes
- Is there any **major** reason to deviate from the standard procedure for this stock?
  No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  Yes

Audit of (Spr.27.22-32, Baltic sprat)

Date: 16.4.2019

Auditors: 2nd reviewer Jukka Pönni, 1st reviewer Clara Ulrich

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: XSA– tuning by 3 surveys
5) **Data issues:** The data were uploaded by national laboratories and aggregated into international data in ICES InterCatch database.
6) **Consistency**: The 2019 assessment is consistent with 2018 assessment and was accepted both years.
7) **Stock status**: SSB decline in 2006-2015 ceased, in 2016-18 increase almost 30% above average. Average or low recruitment in 5 years in row but strong 2014 year class (41% of catch in 2018), yearclasses 2015-17 close to average; decline in F(0,43-0.30 in 2013-16 with a raise to 0,32 afterwards), above Fmsy (0,26) and at Fpa (0,32) in 2018).

   Management Plan: EU Baltic multiannual plan.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

No specific comments.

It is though suggested that using FLR would simplify the forecast procedures compared to MFDP, considering that the assessment does not include several fleets with different objectives and does not justify the need for MFDP. The FLR forecast would in particular help with scenarios based on the SSB target, this being an easy procedure with Flash.

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes
- Is the assessment according to the stock annex description?
  Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  Yes
- Have the data been used as specified in the stock annex?
  Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  Yes
- Is there any **major** reason to deviate from the standard procedure for this stock?
  No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  Yes

Audit of (Cod in subdivisions 22-24, Western Baltic cod, cod.27.22-24)

Date: 2019-04-26

Auditor: Zeynep Hekim, Tomas Gröhsler

General

Stock has been benchmarked this year. This stock exhibits mixing with the Eastern Baltic cod in subdivision 24. Catch separation has been applied for stock separation and is available for 19 of the 34 years in the present time-series (1985-1993 newly included this year). The recreational catches are considerable (30 % in 2018), and just recently incorporated for all countries into the assessment. The effects of recent changes in the management of the recreational fisheries is difficult to predict. The SSB development is very depended on a single year class.

For single stock summary sheet advice:

1) **Assessment type:** update (Benchmarked in 2019)
2) **Assessment**: Analytical (category 1)
3) **Forecast**: presented
4) **Assessment model**: Age-based analytical assessment SAM that uses catches (landings, discards, and recreational catch) in the model. Tunin by three survey indices (FEJUCS (age 0), BITS-Q1 and BITS-Q4).
5) **Data issues:** The data as described in stock annex are available.
6) **Consistency**: Benchmarked in 2019. Overestimation of the SSB and recruitment of the last strong year class 2016, wheres F constistent with last year's assessment. The SSB development is very depended on a single year class increasing the uncertenties in the assessment.
7) **Stock status**: The spawning-stock biomass (SSB) has been fluctuating around the limit reference point (B_{lim}) since 2009, but has increased in the last two years and is presently close to MSY Btrigger. The fishing mortality (F) is above F_{MSY}, although a large decrease in F has occured in later years. Recruitment (R) has been low since 1999; only recruitment in 2017 (the 2016 year class) is estimated to be above average. The recruitment in 2018 and 2019 (age 1) are historically low.
8) **Management Plan**: Agreed 2006: The stock was benchmarked in 2019 at which the reference points were updated. The advice based on the FMSY ranges used in the management plan are considered precautionary. The SSB in 2020 is predicted to be above MSY Btrigger. In this situation, catch scenarios applicable under the MAP correspond to fishing mortalities between Flower and Fupper. However, according to the MAP, catches corresponding to F higher than FMSY (i.e. column B of Annex I in the MAP) can only be taken under conditions specified in the MAP.

General comments

This was a well-documented, well ordered and considered advice sheet. Due the last benchmark in 2019 and the complexity of the input data and corresponding all necessary calculations (e.g stock separation) it was very difficult to conduct a review. If no stronger year classes will be seen in the coming years this will lead to severe decline of the stock.

Technical comments

The assessment and forecast has been undertaken according to the stock annex (SA, just updated following the procedure aggreed at the benchmark meeting in 2019).

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Yes
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes, however difficult to follow
- Is there any **major** reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Audit of Cod (Gadus morhua) in Subdivision 21 (Kattegat) cod.27.21

Date: 17.04.2019

Auditor: Margit Eero and Olavi Kaljuste

General

For single stock summary sheet advice:

1) **Assessment type: update/SALY**
2) **Assessment**: trends
3) **Forecast**: not presented
4) **Assessment model**: *SAM- tuning by 4 surveys*
5) **Data issues:** *no issues identified*
6) **Consistency**: *same procedure as last year*
7) **Stock status**: Ref points not defined, however as SSB is at the lowest level in record, it would be at or below possible Blim
8) **Management Plan**: *NA*

General comments

The assessment was performed correctly according to Stock Annex.

Technical comments

The following technical issues were identified during auditing, that were corrected in the final report:

- Report says discard in 2018 at 75 t (Table 2.2.2), advice says 72 t (Table 6 & 7). One of these needs to be corrected.
- In advice draft, the ICES landings for 2015 are shown as 103 t (Table 5 & 7), while it says 106 t in the report (Table 2.2.1).
- In the advice draft tables 5 & 7, the total landings for 2017 are given as 294 t, while it is written 293 t in the report (Table 2.2.1).
- Advice table 8, the landings in 2015-2017 do not match with the values in report (Table 2.2.1) or with the values in the other tables in the advice (Table 7).
- Discards given in Table 8 in advice in several years do not match with the values given in the report (Table 2.2.2)
- Report Table 2.2.7, mean weight for age 1 in 2018 should not show 0.
- The tuning indices shown for Havfisken Q1, and IBTS Q1 survey for 2017 in the report from WGBFAS 2018 differ from the values used by WGBFAS 2019, needs to be explained in the report.
- Figures 2.2.12-2.2.15 are missing in the report and also in the SharePoint holder for figures.
- It is written in the report: "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." And additionally: "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.". If we look at the Table 2.2.8 and 2.2.9, then it seems that these figures are not running mean of 3 years.
- There is a confusing table in the report under the chapter of survey data. The header of that table says: "The tuning series available for assessment" and there are listed all surveys with time span and ages. These ages for BITS-1Q and IBITS-3Q in that table are

different compared to the Table 2.2.10. (Header of that table is also missing.) Additionally, in the table called "The tuning series available for assessment" are ages for IBITS-1Q and CODS-1Q given as 1-6, but in the stock annex (in the tunin data table) they are given as 1-6+ instead.

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes
- Is the assessment according to the stock annex description?
  Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  NA
- Have the data been used as specified in the stock annex?
  Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
  Yes
- Is there any **major** reason to deviate from the standard procedure for this stock?
  For assessment no, for advice yes, as the stock is at the lowest level in record.
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
  Yes

Audit of Flounder in subdivisions 27.24-25

Date 16.04.2019

Reviewer: R. Statkus, O. Kaljuste and J. Raitaniemi

General

There is no advice on fishing opportunities for this stock. Information on stock status and occurrence of new flounder species has been provided in the document.

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: Survey trends-based assessment
3) **Forecast**: not presented
4) **Assessment model**: n/a
5) **Data issues**: the usage of data followed procedure. All data are made available and corresponding to stock annex.
6) **Consistency**: n/a
7) **Stock status**: below F_{MSY} proxy
8) **Man. Plan**: Bycatch of this species is taken into account in the EU Multiannual Plan for the Baltic Sea

General comments

In general this was a well-documented, well ordered and considered section.

Technical comments

The numbering of the figures and tables in the report text does not always correspond to the order of reference. Some references are missing.

Conclusions

The assessment has been performed correctly.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?

Yes

- Is the assessment according to the stock annex description?

Yes

- Is general ecosystem information provided and is it used in the individual stock sections.

Yes

- If a management plan has been agreed, has the plan been evaluated?

No management plan for this stock

For update assessments

- Have the data been used as specified in the stock annex?

  Yes

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

  Yes

- Is there any **major** reason to deviate from the standard procedure for this stock?

  No

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

  Update assessment gives a valid basis for advice

Audit of (FLE2223)

Date: 14.04.2019

Auditor: Uwe Krumme, Kristin Öhman

General

No remarks

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: Stock trend model based on scientific trawl surveys
3) **Forecast**: not presented
4) **Assessment model**: NA
5) **Data issues:** No obvious issues. Available data were used as described in a stock annex. Discard estimates from all countries are available since 2014.
6) **Consistency**: NA
7) **Stock status**: Unknown - Biological reference points not available
8) **Management Plan**: No management plan for this stock, however bycatch for this species is taken into account in the EU MAP for the Baltic Sea.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

In the stock annex the possibility of using discard survival rates is still mentioned. However, the precautionary assumption of 100% discard mortality is applied.

- Is the assessment according to the stock annex description? Yes
- Is there any **major** reason to deviate from the standard procedure for this stock? No.
- Does the update assessment give a valid basis for advice? Yes, it does.

Conclusions

The assessment has been performed correctly.

The survey index is quite similar to the flounder stock fle2425. In a future benchmark of the flounder stocks, stock identification of fle2223 and fle2425 may be re-considered.

Audit of Herring in 30-31 (her.27.3031)

Date: 12.04.2019.

Auditor: 2nd reviewer Tiit Raid

General

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model:** Space-State model SAM. Tuning fleets: 1 commercial trapnet fleet (for CPUE 1992-2006 (ages 3-9)) + acoustic survey 2007-2018 (ages 1-9) + trapnet CPUE survey
5) **Data issues**: Data well described and following the Stock Annex.
6) **Consistency** : A considerable downscaling of the biomass
7) **Stock status**: The SSB has been above MSY $B_{trigger}$ since 1987 and is decreasing since 2014. SSB in 2018 was just above MSY $B_{trigger}$. Fishing mortality (F) has been above F_{MSY} since 2012 and was just below Flim in 2018. Recruitment shows an overall increasing trend but is below average in 2018. ICES assesses that fishing pressure on the stock is above FMSY and between Fpa and Flim; and spawning stock size is at/above MSY Btrigger, Bpa and Blim.
8) **Management Plan**: No agreed management plan for that stock.

General comments:

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments:

All technical issues pointed out in draft audit have been addressed.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? **Yes**
- Is the assessment according to the stock annex description? **Yes**
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? **Yes**
- Have the data been used as specified in the stock annex? **Yes**
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **Yes**
- Is there any **major** reason to deviate from the standard procedure for this stock? **No**
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **Yes**

Audit of Plaice in 21-23 (ple.27.21-23)

Date: 14.04.2019

Auditor:: Olavi Kaljuste and Victoria Amosova

General

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: **analytical**
3) **Forecast**: **presented**
4) **Assessment model**: Age-based analytical assessment SAM; Commercial catches; two combined survey indices (NS-IBTSQ1 and BITS–Q1, NS-IBTSQ3 and BITS–Q4); mean maturity data for the modelled period (from commercial catch and surveys); natural mortalities are fixed and assumed to be 0.1 except for age 1, which has 0.2.
5) **Data issues:** All data are made available and corresponding to stock annex. Discard information is available from 1999 from the main fleets and is included.
6) **Consistency**: The quality of the assessment has improved in 2019, following a few adjustments aiming at reducing the large retrospective patterns observed with the previous settings. Age 6 is now included in the two surveys datasets, considering the increasing proportion of older fish observed both in the catches and in the surveys since 2012.
7) **Stock status**: The spawning-stock biomass (SSB) has increased significantly from 2009 and has been above MSY $B_{trigger}$ since 2013. Fishing mortality (F) has declined since 2008, but the reduction has levelled of since 2014 and F remains above Fmsy. Recruitment has fluctuated without trends between 1999 and 2016 and the last two year classes are the highest observed. Fishing pressure on the stock to be above F_{MSY}, but below F_{pa} and F_{lim}; and the size of the spawning stock to be above MSY $B_{trigger}$, B_{pa}, and B_{lim}.
8) **Management Plan**: The EU Multiannual Plan for the Baltic Sea takes bycatch of this species into account. No management plan covers Subdivision (SD) 21.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

No specific comments.

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? **Yes**
- Is the assessment according to the stock annex description? **Yes**
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? **No**
- Have the data been used as specified in the stock annex?**Yes**
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **Yes**
- Is there any **major** reason to deviate from the standard procedure for this stock? **No**
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **Yes**

Audit of GoR Herring 28

Date: 14.4.19
Auditor: Jesper Boje and Johan Lövgren

General

The assessment have been conducted according to the stock annex as an update assessment. Data is available and seems correct as do the reflections of the data in the report (figures and tables).

The assessment could benefit to be changed to a stochastic assessment avoiding to rely so precisely on catch at age for this stock that mix with adjacent herring stocks.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: Analytical
3) **Forecast**: presented
4) **Assessment model**: XSA – tuning by 1 comm trapnet + 1 acoustic survey
5) **Data issues:** Data available in data folder, SPALY use and according to annex.
6) **Consistency**: The assessment is consistent with last year's assessment (setup and assumptions); output shows a slight retrospective pattern (see technical comments).
7) **Stock status**: SSB>>MSY $B_{trigger}$ and $F<F_{MSY}$
8) **Management Plan**: advice according to man plan; F_{MSY} ranges (PA).

General comments

This was a well-documented, well-ordered and considered section. It was easy to follow and interpret.

Technical comments

The XSA did not converge after 30 iterations but total absolute residual between last iterations are minor (iterations 29 and 30 = .00026).

Retrospective pattern evident; underestimation of SSB and overestimation of F. Mohn's rho not provided.

Some year effects are evident from the residual plots of the tuning series.

Conclusions

The assessment has been performed correctly.
A stochastic assessment method could with benefit be introduced for this stock to replace the XSA. Exploratory SAM runs have been performed in parallel with the XSA and show same perception of SSB, F and R. However, median estimates from SAM are less variable than XSA estimates. XSA estimates within the confidence limits of the SAM.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Yes
- Have the data been used as specified in the stock annex? Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Yes
- Is there any **major** reason to deviate from the standard procedure for this stock? Yes
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Annex 6: New assessment her.27.3031

27 May 2019

ADGBS in May 2019 agreed that the advice for this stock should be based on an assessment accepted for trends and used as an indicator of stock size and fishing mortality. This is because the stock levels estimated by the model are sensitive to small changes in the acoustic survey index. The latest inter-benchmark failed to reduce the retrospective bias that has persisted in the stock for many years. There is a strong tendency for the assessment to overestimate SSB and underestimate F (the calculated Mohn's Rho on SSB was 37% and -27% on F). ICES considers that this bias renders the assessment unreliable.

Due to the strong retrospective bias in this assessment, it has been downgraded to a category 3 assessment which now uses the change in spawning stock biomass to calculate the advice. The trends in relative SSB from the exploratory assessment should be used as the index of stock development.

New catch scenarios Table

Index A (2017–2018)		1.01
Index B (2014–2016)		1.21
Index ratio (A/B)		0.83
Uncertainty cap	Not applied	-
Catch (2018)		97366 tonnes
Discard rate		Negligible
Precautionary buffer	Applied	0.8
Catch advice *		65018 tonnes
% advice change ^		−27%

The figures in the table are rounded. Calculations were made with unrounded inputs and computed values may not match exactly when calculated using the rounded figures in the table.

* [Catch 2018] × [index ratio] × [precautionary buffer].

^ Advice value 2020 relative to advice value 2019.

New summary of the assessment Table. Weights are in tonnes. High and low refers to 95% confidence intervals.

Year	Recruitment (Age 1)	Recruitment High	Recruitment Low	SSB	SSB High	SSB Low	Catches	F (ages 3–7)	F High	F Low
	Relative values			Relative values				Relative values		
1980	0.72	1.11	0.47	0.35	0.47	0.27	29809	1.32	1.78	0.98
1981	0.26	0.39	0.169	0.34	0.46	0.25	21526	1.00	1.37	0.73
1982	0.25	0.39	0.162	0.37	0.50	0.27	26499	1.12	1.54	0.82
1983	0.78	1.19	0.52	0.39	0.54	0.28	26208	1.04	1.45	0.75
1984	1.05	1.61	0.69	0.47	0.66	0.34	34545	1.09	1.54	0.78
1985	0.81	1.26	0.52	0.56	0.79	0.40	35432	0.95	1.37	0.66
1986	0.21	0.32	0.130	0.64	0.92	0.45	35579	0.86	1.26	0.59
1987	0.51	0.81	0.33	0.76	1.10	0.53	32628	0.75	1.11	0.51
1988	0.21	0.33	0.131	0.76	1.13	0.52	36418	0.71	1.06	0.48
1989	1.18	1.82	0.76	0.91	1.34	0.62	33086	0.59	0.88	0.40
1990	1.97	3.0	1.29	1.08	1.57	0.75	39180	0.55	0.82	0.37
1991	0.65	0.98	0.43	1.21	1.70	0.86	33419	0.46	0.68	0.32
1992	0.94	1.39	0.64	1.31	1.80	0.95	46610	0.56	0.79	0.40
1993	1.73	2.5	1.19	1.30	1.73	0.98	49314	0.57	0.78	0.43
1994	0.66	0.95	0.46	1.51	1.95	1.18	61986	0.69	0.91	0.53
1995	0.74	1.07	0.51	1.34	1.69	1.06	65547	0.82	1.04	0.64
1996	0.67	0.95	0.46	1.32	1.65	1.06	61303	0.83	1.04	0.65
1997	0.67	0.96	0.47	1.16	1.44	0.94	69808	1.02	1.27	0.81
1998	1.29	1.85	0.90	1.09	1.36	0.87	62474	0.99	1.24	0.79
1999	0.62	0.88	0.43	1.07	1.34	0.86	66502	1.10	1.38	0.87
2000	1.18	1.69	0.82	0.98	1.22	0.79	58852	1.04	1.30	0.83
2001	1.11	1.60	0.78	0.96	1.19	0.78	57806	0.99	1.23	0.79
2002	1.50	2.1	1.05	1.00	1.23	0.81	53969	0.82	1.02	0.66
2003	1.68	2.4	1.17	1.00	1.23	0.82	53644	0.79	0.98	0.64
2004	0.53	0.75	0.37	1.02	1.24	0.85	61423	0.84	1.04	0.68
2005	0.74	1.05	0.52	1.09	1.31	0.91	62911	0.86	1.06	0.70

Year	Recruitment (Age 1)	Recruitment High	Recruitment Low	SSB	SSB High	SSB Low	Catches	F (ages 3–7)	F High	F Low
	Relative values			Relative values				Relative values		
2006	0.81	1.15	0.56	1.07	1.28	0.89	71318	0.92	1.14	0.76
2007	1.70	2.4	1.21	1.03	1.23	0.86	78678	1.05	1.28	0.86
2008	0.97	1.36	0.69	0.98	1.17	0.81	67914	1.02	1.25	0.83
2009	1.04	1.47	0.74	1.11	1.33	0.92	71248	0.93	1.14	0.76
2010	1.09	1.54	0.78	1.31	1.58	1.10	72590	0.90	1.11	0.73
2011	0.87	1.21	0.62	1.23	1.46	1.03	81850	0.97	1.18	0.80
2012	1.52	2.1	1.08	1.30	1.54	1.09	106007	1.25	1.52	1.03
2013	1.15	1.62	0.82	1.32	1.56	1.11	114396	1.39	1.69	1.15
2014	1.18	1.66	0.84	1.31	1.56	1.10	115366	1.40	1.71	1.15
2015	2.6	3.8	1.84	1.22	1.45	1.02	114942	1.53	1.88	1.25
2016	1.30	1.88	0.89	1.10	1.33	0.91	130029	1.85	2.3	1.48
2017	1.36	2.0	0.91	1.05	1.31	0.84	104358	1.66	2.2	1.28
2018	0.74	1.21	0.45	0.97	1.28	0.73	97366	1.74	2.4	1.26

Annex 7: ADGNS work on Kattegat cod

The following work was developed during the Advice Drafting Group North Sea (ADGNS) 2019.

In the survey BITS Quarter 1, 2019, there was 0 catch of 1 year-old cod. Few days before ADGNS, it was found out that the assessment model used (SAM) was reading that 0 as Not Available data. When the 0 was changed to a small number such as 0.01, the resulting assessment time-series differed, particularly for recruitment and in a smaller degree for F and SSB.

ADGNS agreed to use 0.01 as age 1 fish abundance.

The table below includes the final assessment results.

Table A7.1. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), and average fishing mortality for ages 3 to 5 (F35), including 95% confidence intervals (Low and High). Weights in tonnes, Recruitment in thousands.

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F35	Low	High
1997	16559	11600	23639	12694	11160	14440	10554	9180	12135	1,125	0,971	1,304
1998	13259	9233	19039	10510	9352	11812	7937	6942	9075	1,26	1,103	1,439
1999	12630	8829	18066	9312	8339	10399	7497	6696	8393	1,294	1,136	1,474
2000	7030	4937	10012	7066	6349	7865	5716	5104	6402	1,393	1,23	1,578
2001	6587	4638	9353	6186	5567	6873	4920	4394	5509	1,486	1,308	1,687
2002	11732	8270	16645	6044	5419	6740	4828	4290	5432	1,226	1,068	1,408
2003	3076	2130	4442	5130	4614	5703	4224	3791	4708	1,081	0,927	1,261
2004	18228	12784	25989	5318	4708	6008	3839	3392	4345	1,051	0,908	1,217
2005	9118	6331	13131	7306	6453	8271	4782	4252	5378	1,114	0,963	1,287
2006	8744	5915	12926	6774	5970	7687	4993	4388	5682	1,104	0,959	1,271
2007	2309	1514	3521	4307	3842	4829	3478	3096	3908	1,305	1,141	1,492
2008	1398	949	2059	2379	2144	2640	2114	1890	2366	1,487	1,307	1,692
2009	4708	3237	6849	1223	1088	1373	858	768	958	1,388	1,212	1,591
2010	4392	3022	6383	1323	1158	1511	766	678	865	1,052	0,871	1,27
2011	5291	3576	7830	1641	1433	1879	1079	938	1241	0,713	0,575	0,884
2012	12207	8299	17957	2283	1952	2670	1422	1213	1666	0,608	0,486	0,761
2013	17443	11601	26226	4111	3543	4769	2494	2142	2905	0,478	0,377	0,606
2014	4970	3330	7418	6239	5420	7181	3450	2990	3982	0,458	0,367	0,57
2015	3122	2128	4579	7559	6446	8865	5451	4613	6441	0,637	0,518	0,783
2016	1066	692	1642	5249	4489	6137	4290	3620	5083	0,918	0,73	1,154

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F35	Low	High
2017	4388	2812	6847	2895	2464	3402	2359	1976	2816	0,781	0,613	0,995
2018	476	250	906	2065	1676	2544	1728	1379	2165	1,133	0,769	1,668
2019	247	31	1993	909	543	1522	807	476	1367			

Table A7.2. Results for Recruitment, SSB, and Total Mortality shown as relative to the time series as reflected in the advice sheet for the stock. Weights in tonnes.

Year	Relative Recruit-ment (age 1)	Rela-tive High	Rela-tive Low	Rela-tive SSB	Rela-tive High	Rela-tive Low	Land-ings	Dis-cards	Relative Mortal-ity (Z-0.2)	Rela-tive High	Rela-tive Low
1997	2.3	3.2	1.58	2.7	3.1	2.4	9500	880	1.07	1.24	0.93
1998	1.81	2.6	1.26	2.0	2.3	1.78	6800	660	1.20	1.37	1.05
1999	1.72	2.5	1.20	1.93	2.2	1.72	6600	760	1.23	1.40	1.08
2000	0.96	1.36	0.67	1.47	1.64	1.31	4900	650	1.33	1.50	1.17
2001	0.90	1.27	0.63	1.26	1.41	1.13	4000	660	1.42	1.61	1.25
2002	1.60	2.3	1.13	1.24	1.40	1.10	2500	820	1.17	1.34	1.02
2003	0.42	0.61	0.29	1.08	1.21	0.97	2000	620	1.03	1.20	0.88
2004	2.5	3.5	1.74	0.99	1.12	0.87	1400	1090	1.00	1.16	0.87
2005	1.24	1.79	0.86	1.23	1.38	1.09	1070	620	1.06	1.23	0.92
2006	1.19	1.76	0.81	1.28	1.46	1.13	880	860	1.05	1.21	0.91
2007	0.31	0.48	0.21	0.89	1.00	0.80	650	620	1.24	1.42	1.09
2008	0.190	0.28	0.129	0.54	0.61	0.49	450	156	1.42	1.61	1.25
2009	0.64	0.93	0.44	0.22	0.25	0.197	197	67	1.32	1.52	1.16
2010	0.60	0.87	0.41	0.197	0.22	0.174	155	170	1.00	1.21	0.83
2011	0.72	1.07	0.49	0.28	0.32	0.24	145	210	0.68	0.84	0.55
2012	1.66	2.4	1.13	0.37	0.43	0.31	94	157	0.58	0.73	0.46
2013	2.4	3.6	1.58	0.64	0.75	0.55	92	360	0.46	0.58	0.36
2014	0.68	1.01	0.45	0.89	1.02	0.77	108	350	0.44	0.54	0.35
2015	0.43	0.62	0.29	1.40	1.65	1.18	103	480	0.61	0.75	0.49
2016	0.145	0.22	0.094	1.10	1.30	0.93	300	220	0.87	1.10	0.70
2017	0.60	0.93	0.38	0.61	0.72	0.51	290	260	0.74	0.95	0.58
2018	0.065	0.123	0.034	0.44	0.56	0.35	212	72	1.08	1.59	0.73
2019	0.034	0.27	0.0040	0.21	0.35	0.122					