BALTIC FISHERIES ASSESSMENT WORKING GROUP (WGBFAS)

Please note: Tables 6.13 and 8.31 were updated on July 1 2020
Please note: Annex 8-10 were updated or added on July 1 2020

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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 (catch advice)
- Cod in Kattegat SD 21 (catch advice)
- Cod in SDs 22–24 (catch advice)
- Cod in SDs 24–32 (catch advice)
- Herring in SDs 25–27, 28.2, 29 and 32 (catch advice)
- Herring in SD 28.1 (Gulf of Riga) (catch advice)
- Herring in SDs 30-31 (Gulf of Bothnia; catch advice)
- Sprat in SDs 22–32 (catch advice)
- Plaice in SDs 21–23 (catch advice)
- Plaice in SDs 24–32 (catch advice)
- Flounder in SDs 24–25 (stock status advice)
- Flounder in SDs 26+28 (stock status advice)
- Flounder in SDs 27+29–32 (stock status advice)
- Brill in SDs 22–32 (stock status advice)
- Dab in SDs 22–32 (stock status advice)

The WG was not requested to produce an advice for Flounder in SDs 22–23 and Turbot in SDs 22–32. For these stocks, however, data were compile and updated, and update assessments were conducted. The group adhered to the ICES spring 2020 approach to advice, developed because of the COVID-19 disruption. The meeting was consequently conducted online and abbreviated advice were produced for all stocks (for which an advice was requested), except Herring in SDs 30-31, Herring in SDs 25–27, 28.2, 29 and 32, and Sprat in SDs 22-32, as these stocks have been benchmarked since the last advice in 2019.

In the introductory chapter of this report the Working Group (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 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 group thus completed all but one of the ToRs (to complete the productivity audit). This ToR will be completed intersessionally, before summer 2020.

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 Herring in SDs 30-31, a data input issue was discovered during the meeting and the new benchmark assessment declared invalid. Therefore, the stock was downgraded from a category 3 to 5, and the advice based on the previous advice, applying the ICES advice rule for category 5 stocks.

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	14-21 April, 2020 by correspondence (33 participants)

1 Introduction

1.1 ICES code of conduct

The ices code of conduct and the importance of identifying, reporting and dealing with any potential conflict of interest were discussed at the start of the meeting. Not conflict of interest was declared.

1.2 Consider and comment on Ecosystem and Fisheries overviews where available

1.2.1 Ecosystem overviews

WGBFAS was asked to comment on 'Baltic Sea Ecoregion – Ecosystem overview'. Comments and suggestions are presented below.

General comments: The structure of the overview needs still some editing. At present, e.g. phenomenon like Regime Shift is discussed in several parts of the text and already before it is actually described. As a phenomenon, regime shift should be described earlier. In the same time with the changes in the pelagic fish community and cod, changes took place at least in some areas in the coastal fish communities, as well, as the coastal fish communities changed from the dominance of marine species to the dominance of fresh water species.

In the discussion about nutrient flows or 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 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.

Other comments:

- 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
- Suggestion to edit text: "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. ***In addition, a number of both sea-spawning and river-spawning salmonid populations (Coregonus* sp.*, Salmo trutta, Thymallus thymallus) have severely suffered."***
- Suggestion: "Grey seal populations have had a high growth rate over the past few decades following the cessation of hunting in the 1980s ***and especially recovered reproduction as a consequence of decreased contaminants such as DDT and PCB:s,*** but this has levelled off in recent years. The growth rate of the southern Baltic harbour seal population has also been high."

- "The principal species targeted in the commercial fishery are cod *Gadus morhua*, herring *Clupea harengus*, and sprat *Sprattus sprattus* "*Should the order of these species be changed to the one with biggest landings first and smallest landings last?*
- *Coregonus clupeaformis* is commonly regarded a North American freshwater whitefish species. In European whitefish in e.g. Baltic Sea, there are different interpretations of nomenclature. Perhaps the easiest is to write *Coregonus sp*.
- Figure 6. The unit of Static/Gill net is not explained, possibly others neither except trawls. As these gears are very different, there is a comparability problem. It might be better to have trawls in one figure and the other gears in another.
- "A decrease in sprat landings in the late 1970s, followed by a decline in cod landings in the late 1980s, led to a marked decline in total landings. Pelagic landings increased in the early and mid-1990s, reflecting an increase in sprat abundance during this period." *There is a relationship between these changes that is blurry or even missing in the text. This could be also:* **"A decrease in sprat landings as the cod landings peaked in the late 1970s and the 1980s, was followed by a decline in cod landings in the late 1980s and an increase of sprat landings in the early and mid-1990s, reflecting an increase in sprat abundance during this period."**
- The abundance of sprat, herring and cod: in 2019 sprat more abundant in the south, as well (though several years the abundance like in the figure from 2018)?
- "Contaminants that degrade very slowly and are expected to be long-lasting in the ecosystem include mercury, flame retardants (PBDEs), dioxins, and PCBs. The latter two are of special concern for the fishing sector and for food provision." Despite the slowness dioxins and PCB:s have decreased remarkably, this is seen in recovered reproduction of grey seals and ringed seals and at least improved situation with white-tailed eagle, and reduced dioxin and PCB contents in especially herring
- Figure 11: WGBFAS: Bothnian Sea and Bothnian Bay: are they real bottom trawls or deep water pelagic trawls, aiming at herring and vendace?
- "For most of the pelagic stocks in the Baltic Sea, the spawning-stock biomass has increased since 2000 and is now above, or close to the biomass reference points used in stock assessments. An exception is the western Baltic cod stock, for which the biomass is below B_{lim} (Figure 17)."
- Figure 17: The names of species or taxons could be added in the caption to clarify the groups: herring and sprat (or clupeids), flatfishes, cod

1.2.2 Fisheries overviews*

WGBFAS was asked to consider and comment on 'Baltic Sea Ecoregion – Fisheries overview'. We decided to update the texts on 'who is fishing', with members of each country updating the text from respective countries.

Fishing vessels from nine nations operate in the Baltic Sea, with the highest 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). Total fishing effort has declined since 2003 (Figure 3). The following country paragraphs highlight features of the fleets and fisheries of each country and are not exhaustive descriptions.

**Updated in June 2020, please see Annex 8 for more information.*

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, flatfishes, 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 recreational 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 (18–42 m), while the coastal fishery consists of several hundred small boats of <12 m. The pelagic fleet consists of stern trawlers, mainly targeting herring and sprat in the subdivisions 28.1, 28.2, 29, and 32. Trawlers also occasionally catch cod in subdivisions 25 and 26. About 25–30% of the herring catch is taken by 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 56 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. 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 70:30. 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 trammel nets. 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 2019 comprised 19 offshore vessels (>18 m) and 63 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 152 active offshore vessels (12–35 m) and approximately 634 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 96% 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 42 vessels divided into offshore fisheries (36 vessels by 25–31 m size class) and coastal fisheries (six 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 pound net 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 flatfishes 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 Review progress on benchmark processes of relevance to the Expert Group

The group have no stocks for benchmark in 2021.

For 2022 or later sole in 20-24 and sprat are only candidates for benchmark processes.

Sole in SDs 20-24 was recently scheduled for benchmark. As many critical issues were not solved in time, however, the benchmark was postponed. Science work is ongoing, hopefully leading to a benchmark in 2022 at the earliest. The main issues to be solved are given in text table below.

The assessment of sprat in the Baltic has for many years been violated by the mixture of the catches (with herring) and associated misreporting problems, but also from population distribution and structure. Work is ongoing to solve these issues, and therefore the stock is aimed for a benchmark at the earliest in 2022.

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 could validate a benchmark.

Stock	Year for benchmark	Issues	Present/aimed category
Sprat	2022 or later	Mixture of sprat and herring in some fisheries, misreporting of sprat as herring Retrospective pattern, especially in F_{bar} Changing spatial distribution of sprat and its effect on assessment	1/1
Sole	2022 or later	Stock structure; connectivity to North Sea stock establish Stock weight-at-age	1/1

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

A data call subgroup discussed the ICES data call for 2021. No changes were made except for one country (Poland) that is no longer requested to submit catch data for Baltic brill. It was recommended that the deadlines for uploading selected survey data to DATRAS should be included in the WGBFAS section of the ICES data call. In addition, a sentence will be added to the WGBFAS section of the ICES data call highlighting that data submitters from the Baltic area are requested to submit data related to mixed fisheries.

1.5 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 role of WGBFAS to handle these knowledge 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 for stock assessment and management advice. This could possibly also affect other stocks but currently there is also a challenge related to mismatch between what is available from science and what is needed for stock assessment and management advice.

Below is list of the most important parameters 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 2020:

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	Elliot Brown	Elliot Brown
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	Julita Gutkowska	Tomas Gröhsler
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**	**Time-frame**	**Priority**
Stock identity	At the edge of its distributional area, with the centre 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 bench-mark**	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**	**Time-frame**	**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
Survey	Quarter 4 survey – shift in catchability	Maybe the increased warming in sea temperature and/ or lack of oxygen at the bottem the cod has shifted distribution at the time for the quarter 4 survey	Oxygen and temperature data from the survey should be analysed	WGBIFS	Before next WG	High
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	

<table>
<tr><th colspan="2">STOCK</th><th colspan="5">COD SD 24–32 (EASTERN BALTIC COD)</th></tr>
<tr><td colspan="2">Stock coordinator</td><td colspan="2">Sofia Carlshamre</td><td>Last benchmark</td><td colspan="2">2019 (ICES 2019b)</td></tr>
<tr><td colspan="2">Stock assessor</td><td colspan="2">Margit Eero</td><td>Stock category</td><td colspan="2">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>Time-frame</td><td>Priority</td></tr>
<tr><td>Growth</td><td>Validated quantitative information on growth in recent years and in future</td><td>Analyses of recent tagging, new method for growth monitoring in future (e.g., otolith microchemistry)</td><td>Ongoing TABA-COD project</td><td>Estimate recent growth from tagging and establish a method for future growth monitoring (e.g., otolith microchemistry) (TABA-COD)</td><td>Some years</td><td>high</td></tr>
<tr><td>Ageing error</td><td>Age error matrix</td><td>Developing an age-error matrix to account for past uncertainties in age information in Stock Synthesis model</td><td>Past otolith exchanges plus tagging information</td><td>Develop age error matirx</td><td>Some years</td><td>medium</td></tr>
<tr><td>Sample sizes</td><td>Sample size information associated with length distributions of commercial catches</td><td>The input to Stock Synthesis model could be improved, if a meaningful measure representing sample size of combined international commercial data could be developed.</td><td></td><td></td><td>some years</td><td>medium/low</td></tr>
</table>

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		Elliot Brown	**Last benchmark**	2015 (ICES 2015b) (reviewed in 2019)		
Stock assessor		Elliot Brown	**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	medium
Environmentally driven connectivity	Is there adult mediated connectivity between subareas? Under what conditions are adults more likely to move from one area to another?	Combined genetics and otolith chemistry, or large tag recapture studies	Independent Research Projects / Collaborative transnational research projects			medium
Environmentally driven connectivity	Recruitment may not be coherent across the whole stock area. Under what conditions does each area contribute more or less to the recruitment of themselves and neighbouring areas?	Combined genetics and otolith chemistry studies.	Independent Research Projects / Collaborative transnational research projects			medium
Age reading	Improve precision of the age reading based on age-validated material	Exchange of otolith images		Otolith exchange workshop		high
Age reading	Different methods used for otolith preparation	Assess if method can be standardized (whole and reflecting light; sliced and transmitted light)				high

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

<table>
<tr><th colspan="2">STOCK</th><th colspan="5">Flounder SD 24-25</th></tr>
<tr><td colspan="2">Stock coordinator</td><td colspan="2">Zuzanna Mirny</td><td>Last benchmark</td><td colspan="2">2014 (ICES 2014)</td></tr>
<tr><td colspan="2">Stock assessor</td><td colspan="2">Zuzanna Mirny</td><td>Stock category</td><td colspan="2">3</td></tr>
<tr><th>Issue</th><th>Problem/Aim</th><th>Work needed / possible direction of solution</th><th>Data needed / are these available / where should these come from?</th><th>Research/ WG input needed</th><th>Timeframe</th><th>Priority</th></tr>
<tr><td>Stock identity</td><td>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.</td><td>Genetic sampling</td><td>from commercial samples</td><td></td><td></td><td>Medium</td></tr>
<tr><td rowspan="2">Age reading</td><td>Collect age-validated otoliths</td><td>Mark-recapture study involving chemical tagging of otoliths</td><td>Age-validated otoliths</td><td></td><td>ongoing</td><td>High</td></tr>
<tr><td>Improve precision of the age reading based on age-validated material</td><td>Exchange of otolith images</td><td></td><td>Otolith exchange</td><td>After age validated otoliths are available</td><td>High</td></tr>
</table>

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**	**Time-frame**	**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**	**Time-frame**	**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 is available only partially	Data is partially available from Estonian ministry		Ongoing	Medium
Age/length data from commercial fishery (gillnets)	Data missing from commercial gillnetters.	Collecting samples from commercial gillnetters.	Data available for three years (2017,2018, 2019). Data collecting is ongoing work		Ongoing	High/medium

STOCK	Herring SD 25-27, 28.2, 29, 32 (CENTRAL BALTIC HERR.)					
Stock coordinator	Julita Gutkowska		**Last benchmark**	IBPBASH 2020 (ICES 2020), 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	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><td colspan="2">STOCK</td><td colspan="5">HERRING SD 28.1 (HERRING IN GULF OF RIGA)</td></tr>
<tr><td colspan="2">Stock coordinator</td><td>Tiit Raid</td><td>Last bench-mark</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>Time-frame</td><td>Priority</td></tr>
<tr><td>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 macro-structure</td><td>Data available from Latvia and Estonia</td><td>No</td><td>2019</td><td>High</td></tr>
<tr><td rowspan="2">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>2020</td><td>High</td></tr>
<tr><td>Commercial trawl cpue</td><td>Commercial trawl cpue as new tuning index for the assessment</td><td>Data available from Latvia and Estonia (need to see how long back in time is available)</td><td>No</td><td>2020</td><td>Medium</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**	1/5 for 2020		
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 for 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	**Next benchmark**	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.			**Next benchmark**	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 is 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.		**Next benchmark**	Medium
Tuning series	Acoustic survey use of different vessels during the time-series	Investigating the effects of usage of different vessels on the survey index	Data needed is available from WGBIFS			High
Sampling	Adaptation of a more balanced sampling covering all quarters, fishing métiers and the two subdivisions (SD 30 and 31) is recommended in order to estimate fish biological parameters (age, weight, etc.).	For historical catch data it is recommended to split the data by subdivision, fishery and quarter.			**Next benchmark**	Medium

Ageing	Two different age reading methods have been used for ageing. During 1980–2001 whole otoliths were used while from 2002 and onwards cut otoliths were used for ageing. The major concern is that older ages of herring are underestimated when ageing whole otoliths.	Recalibration of the age readings from the period when whole otoliths were used (1980–2001) should be performed.	Otoliths are archived and available for the years 1980-2001.		**Next benchmark**	High
Examining of taking the regime shift in account in recruitment estimates			Data are available		**Next benchmark**	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**	**Timeframe**	**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 & tagging information
Sole SD 20-24 Plaice SD 21-23/SD 24-32 Flounder SD 24-25 Flounder SD 26+28	Stock identity	Validation of stock identity	e.g. Genetics

Flounder SD 27, 29-32 Herring SD 25-27, 28.2, 29, 32 Herring SD 30-31			
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	Age reading	Age-validated otoliths	Tagging
Herring SD 25-27, 28.2, 29, 32		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 misreporting	Logbook data/VMS

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

1.6.1 Working group of integrated assessment of the Baltic Sea (WGIAB)

The ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (WGIAB) follows a 3-year workplan. This year's meeting was held online, and its content had to be adjusted accordingly. The main activity and aim of this meeting was to do an indicator analysis using a common framework across Baltic Sea subbasins. In addition to the main activity, the group discussed potential synergies with WGBFAS representatives and a subgroup discussed risk-assessment analysis in preparation of the next annual meeting. Preliminary indicator analysis for each subsystems were presented and methodological problems were identified. During a plenary session, WGIAB invited WGBFAS chair and members to discuss collaborations and expectations between the two groups. The WGs wish to strengthen their collaborations and agree that synergies will be beneficial for both groups. However, due to the intrinsic operational differences between the two groups (funded vs. voluntary), the WGs acknowledged that any future collaborations have to first and foremost be driven by scientific curiosity and interest. The WGs applied for funding to hold a meeting in 2021 to develop a common strategy (pending).

1.6.2 Working group on Multispecies Assessment Methods (WGSAM)

The ICES Working Group on Multispecies Assessment Methods (WGSAM) met on 14-18 October 2019 in Rome, Italy. This report details results related to ToR B, Update of key-runs (standardized model runs updated with recent data) of multispecies and ecosystem models for different ICES regions. Multispecies model key-runs are used in ICES advice processes, and WGSAM provides critical expert review of these key-runs to recommend appropriate use of results.

Although key-run reviews have been conducted in the past, requests for reviews are increasing. Therefore, WGSAM first formalized a consistent set of review criteria to conduct key-run reviews. These are outlined in the first section of this report and are posted online (https://ices-eg.github.io/wg_WGSAM/ReviewCriteria.html). WGSAM then applied these review criteria to three key-runs: two for the Baltic Sea ecosystem and one for the Irish Sea ecosystem. Each review is detailed in sections 2-4 of this report. As the review criteria were applied, WGSAM also noted any difficulties with the review process in order to further refine the review criteria and to make future key-run reviews more efficient and effective.

For the Baltic Sea, multispecies model key runs estimate predation mortality to provide time-series of natural mortality (M) for use in single species stock assessments for herring and sprat. Therefore, the review of key-runs from an SMS model (used in the previous 2012 key-run) and from a newly developed Gadget model focused on the ability of the models to provide M time-series for these species. Overall, both models provided consistent time-series of M for herring and sprat when using the same assumptions regarding residual natural mortality, despite different representations of cod population dynamics.

1.6.3 Workshop on the Ecosystem Based Management of the Baltic Sea (WKBALTIC)

The Workshop on the Ecosystem Based Management of the Baltic Sea (WKBALTIC) aimed at identifying issues necessary for management needs regarding mixed-fisheries interactions, ecosystem drivers of fisheries productivity and inter- and intra-specific interactions. Focus was put on how to develop a roadmap for the delivery of future research needs for EBM and mixed fisheries management of Baltic Sea fisheries. There is currently a discussion on follow-up meetings for the further development of the roadmap. WGBFAS will observe the development.

1.6.4 Working group on Mixed Fisheries (WGMIXFISH)

ICES Secretariat gave a brief overview to the group about the status of WGMIXFISH work in the Baltic Sea. Baltic mixed fisheries data were asked for as part of the annual data call for WGMIXFISH and provided by some member states, but in an aggregated form of passive and active gears (that may not be sufficient for the WGMIXFISH group to complete the work required). There are therefore ongoing discussions about this between WGMIXFISH, the ICES Secretariat and the relevant experts and data submitters from the Baltic countries about how best to submit the data.

WGBFAS was also informed about the special request by the EU for other catch scenarios for stocks on which ICES will advise zero catch in 2020 for 2021, which in the WGBFAS case concerns Kattegat cod (KCod) and Easter Baltic cod (EBC). No extra scenarios can currently be provided for the KCod as this is a category 3 stock. Some extra scenarios for the EBC were agreed on during the meeting. Further communications about this request will take place between ICES Secretariat and relevant experts after the WGBFAS meeting.

Attendance at the WGMIXFISH by Baltic experts was also discussed, as this will be necessary to begin working with the Baltic mixed fisheries data. It was agreed that two members of WGBFAS would attend the WGMIXFISH-METHODS meeting by webconference in June, and that ICES Secretariat and the chair of WGMIXFISH would be in touch before this meeting regarding preparatory work. This is particularly concerning work on Kattegat cod.

1.6.5 Working group on the Baltic International Fish Surveys (WGBIFS)

The presentation of WGBIFS 2020 was composed from two parts focussed on the:

- Baltic acoustic-trawl surveys (BIAS, BASS) in 2019,
- BITS surveys in 2019-Q4 and 2020-Q1,

BIAS

BIAS database was updated with the survey results from 2019.

Finland has corrected the calculation error in their BIAS data for 2013-2015.

Poland has updated the biological sampling data for 2016 BIAS and recalculated the survey results.

The Baltic International Acoustic Survey (BIAS) in September-October 2019 was completed according to the plan. It covered even the Russian EEZ. 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 2019 was demonstrated in consecutive graphs. In September-October 2019, the highest concentrations of herring (age 1+) were detected in the ICES SDs 29, 30 and 32. At the same time, the geographical distribution of age 0 herring abundance was limited mainly to the SDs 29 and 32. Sprat (age 1+) dense shoals were mostly distributed in the ICES SDs 26, 28 and 32. Total abundance of age 0 sprat was relatively high. Highest abundances of age 0 sprat were recorded in the northeaster part of the Baltic Proper. Cod was concentrated mostly in the south-western part of Baltic Proper. Highest concentrations were recorded in the Swedish EEZ in the SD 25.

WGBIFS recommended:

The updated and corrected BIAS index series can be used in the assessment of the herring (CBH) and sprat stocks in the Baltic Sea with the restriction that the years 1993, 1995, and 1997 are excluded from the index series.

The updated and corrected BIAS index series can be used in assessment of the Gulf of Bothnia herring stock size 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

BASS database was updated with the survey results from 2019.

The Baltic Acoustic Spring Survey (BASS) in May 2019 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 index series can be used in the assessment of 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-Q4/2019 and the BITS-Q1/2020 was on the level of 96% and 98% (by numbers), respectively and was considered by the WGBIFS-2020 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 due to problems with financing research vessel.

WGBIFS recommends that the data obtained and uploaded to DATRAS for both the 4th quarter 2019 and the 1st quarter 2020 BITS are used for calculating survey indices for the relevant cod and flatfish stocks.

1.7 Methods used by the working group

1.7.1 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) 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.

Herring in Subdivisions 30 and 31 was downgraded to a category 5 stock during the meeting due to unresolved data issues (See subsection 4.4). No assessment was therefore conducted and the advice based on trends in catches.

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 SDs 30 and 31 and sole 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 SDs 25—29 and 32, excluding Gulf of Riga, Herring in the Gulf of Riga (SD 28.1) and Sprat in the SDs 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.

No advice was requested for stocks j) and p), but update assessment were conducted and included in the report.

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 Stock annex

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

1.9 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.

1.9.1 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). However, Mohrholz (2018) concluded that "until today climate change has no obvious impact on the MBI related oxygen supply to the central Baltic Sea. The increased eutrophication during the last century is most probably the main driver for temporal and spatial spreading of suboxic and anoxic conditions in the deep layer of the Baltic Sea."

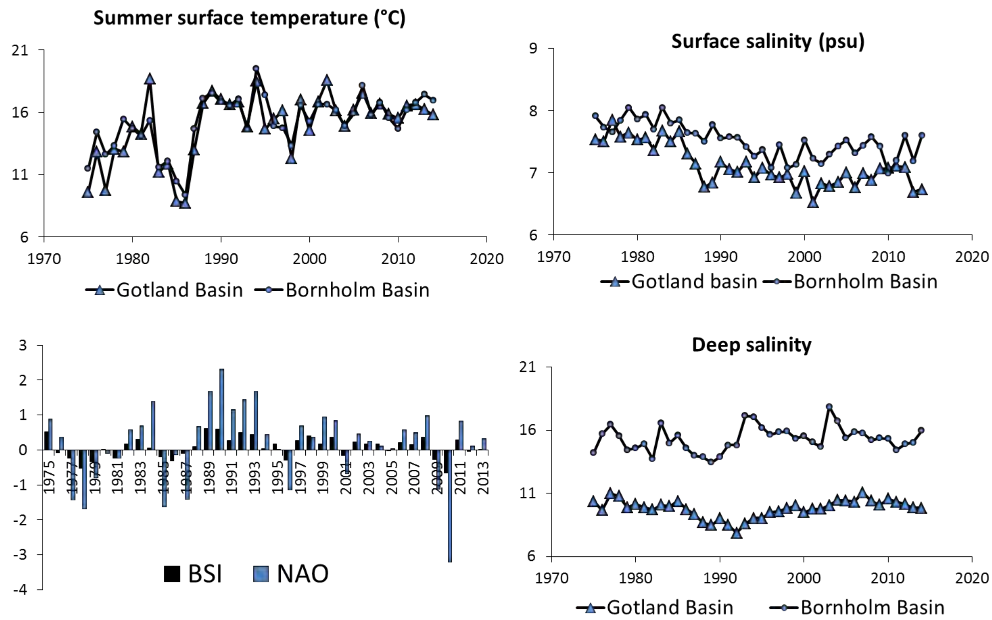


Figure 1.2. Time-series in summer surface temperature and surface salinity (top panels), BSI (Baltic Sea Index) and NAO (North Atlantic Oscillation index) and deep salinity (lower panel) in the Gotland Basin and Bornholm Basin.

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 in the surface layer 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 and potentially increased biological oxygen consumption on seafloor (Figure 1.3).

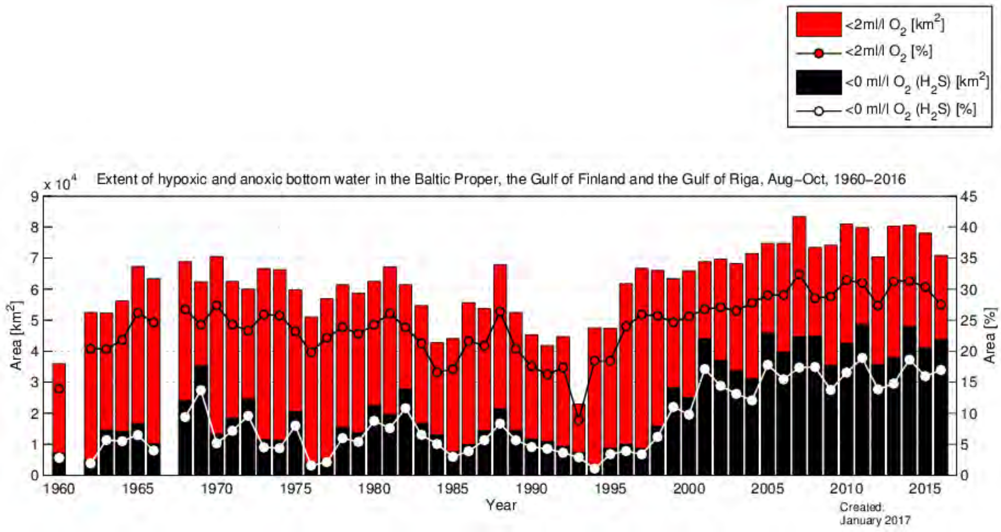


Figure 1.3. Time-series of anoxic and hypoxic seabed in the entire Baltic Proper. From the Swedish Meteorological and Hydrological Institute (SMHI) annual report.

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 fisheries. In order to take the ecosystem context into account in the management process and achieve consensus concerning fishing possibilities among stakeholders, it is important that the status of various drivers influencing fish stocks, and their relative impacts are broadly understood.

An overview of the dynamics of the eastern Baltic cod, sprat and central Baltic herring SSB and recruitment together with the dynamics of drivers influencing the dynamics of biomass and recruitment is presented in Figure 1.4.

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).

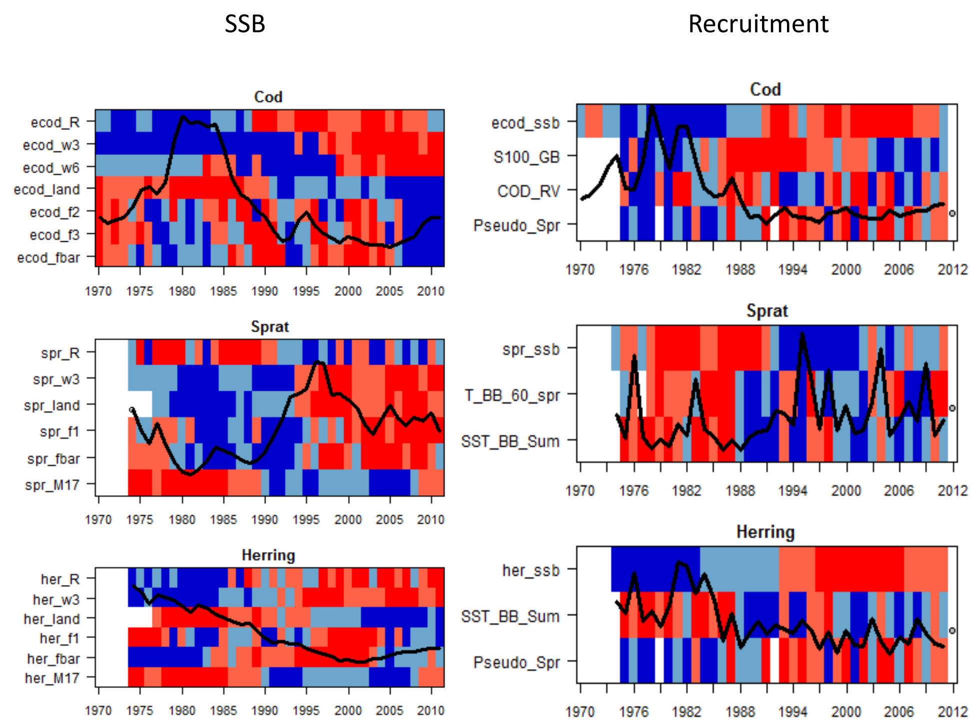


Figure 1.4. Temporal changes in indicators influencing the SSB and recruitment of the eastern Baltic cod, sprat and central Baltic herring. The colours refer to quartiles of the values observed in the time-series, high values are marked with blue and low values with red colours, except for mortality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

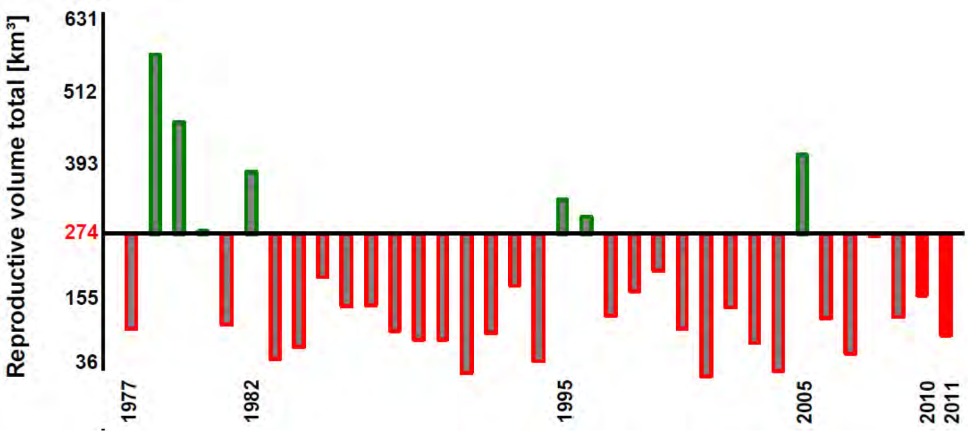


Figure 1.5. Time-series of reproductive volume for Eastern Baltic cod (summed across the three deep basins in the Baltic Sea), assembled by WGIAB 2013. Relationships between each variable and residuals from cod recruitment (back shifted) vs. cod SSB were derived during WGIAB 2013, using linear models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

1.9.2 Biotic factors

1.9.2.1 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 (>15 m water depth) and thus possibly mis-estimate abundances of species inhabiting coastal areas (e.g. Funk *et al.*, 2020 for potential bias in Western Baltic cod).

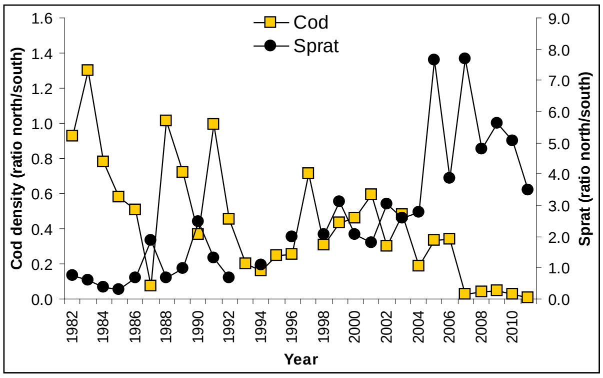


Figure 1.6. Ratio between sprat stock in northern Baltic Proper (SDs 27–29) and southern areas (SDs 25–26) as calculated by acoustic surveys, and ratio between cod stock in the northern Baltic Proper (SDs 27–28) and southern areas (SDs 25–26) from bottom-trawl surveys. Modified from Casini *et al.* (2011).

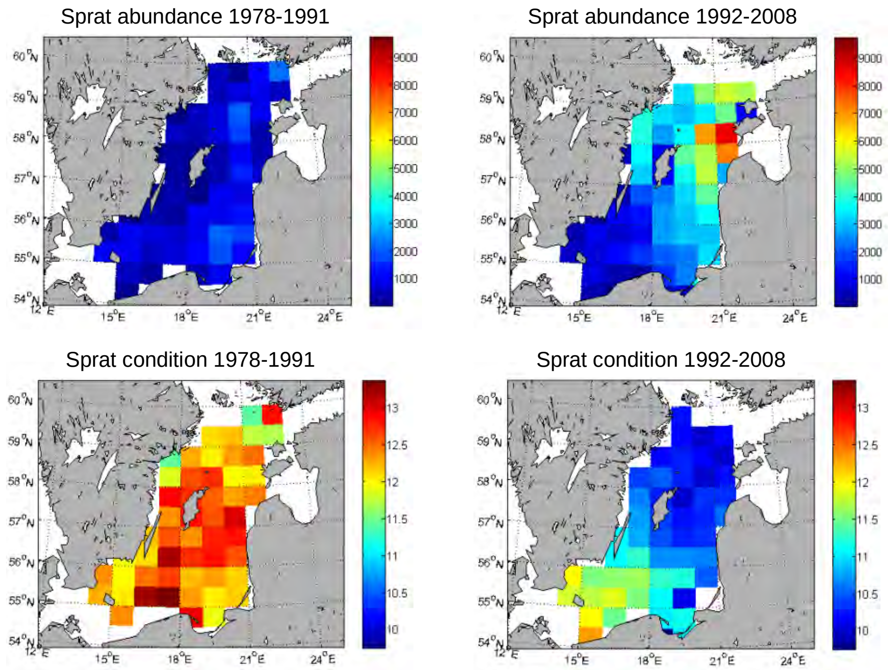


Figure 1.7. Spatial patterns in mean sprat abundance and clupeid condition in 1984–1991 and 1992–2008, from autumn acoustic survey. Only years with at least 10 individuals per rectangle were used in the condition calculation. From Casini *et al. (*2011).

1.9.2.2 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 in 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.

1.9.2.3 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. From neighbouring marine and tidally-influenced 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. Overall, less than 1% of the Baltic Sea seabed is assessed as potentially lost due to human activities.

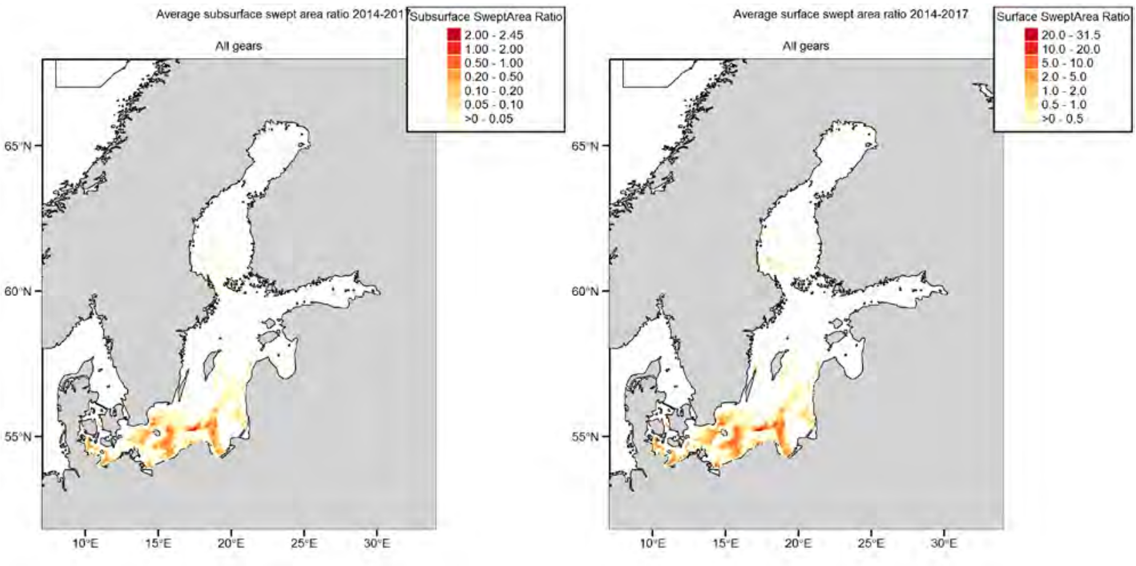


Figure 1.8. Average annual subsurface (left) and surface (right) disturbance by mobile bottom-contacting fishing gear (bottom otter trawls, bottom seines, beam trawls) in the Baltic Sea during 2014–2017, expressed as average swept-area ratios (SAR).

1.9.2.4 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 marinus)*. 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.

1.9.2.5 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).

1.9.2.6 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 and 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.

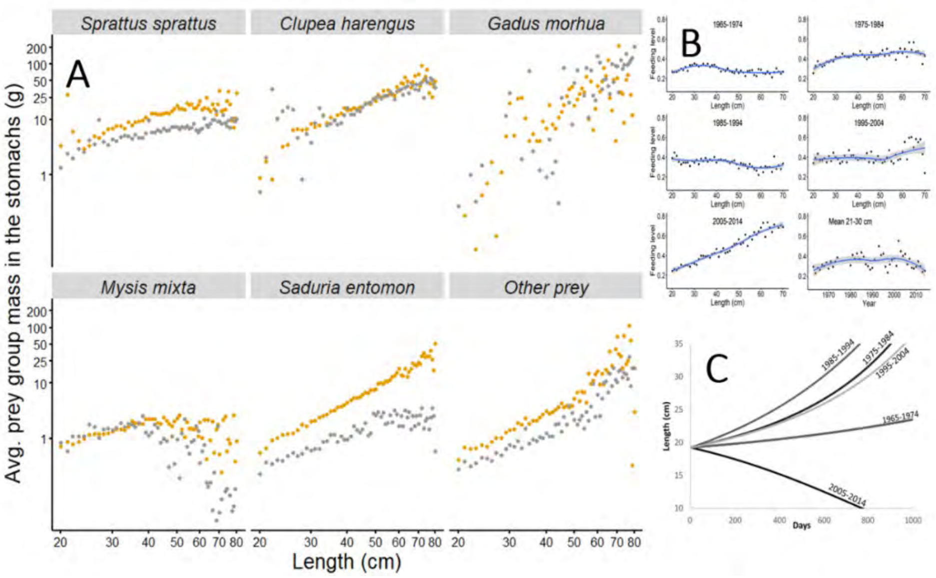


Figure 1.9. A Diet composition in *Gadus morhua* stomachs by mass before 1988 (orange) and after 1994 (grey). The transition period between ecological regimes from 1988 to 1993 (Moellmann *et al.*, 2009) is left out. B Feeding levels of *Gadus morhua* by length during the past five decades. LOESS-based 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.)

1.9.2.7 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 years. 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).

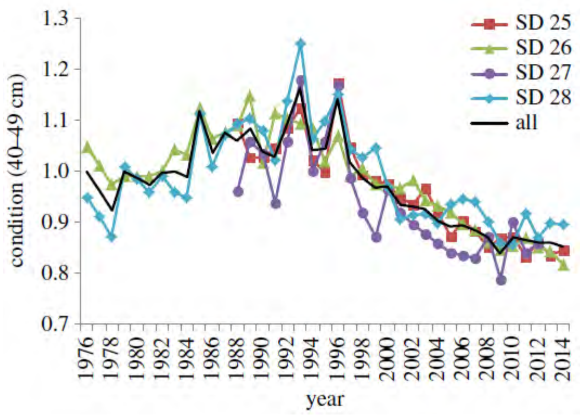


Figure 1.10. Temporal developments of mean cod condition in the different subdivisions (SDs) of the Central Baltic Sea for cod 40–49 cm. The black thick line is the average between the SDs. From Casini *et al.*, 2016.

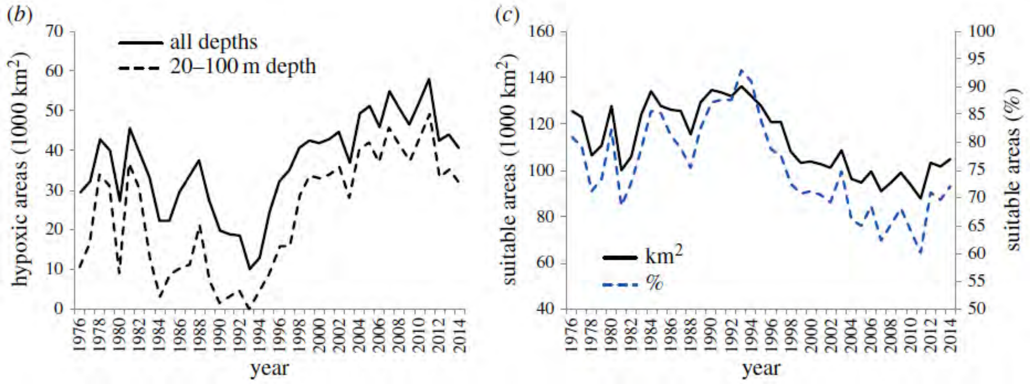


Figure 1.11. (b) time-series of total hypoxic areas (all depths), and hypoxic areas between 20–100 m depth, the latter used as predictors to explain cod condition in the GAMs; c) time-series of suitable areas for cod (> 1 ml/l oxygen concentration) between 20–100 m depth, in absolute values and in percentage.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

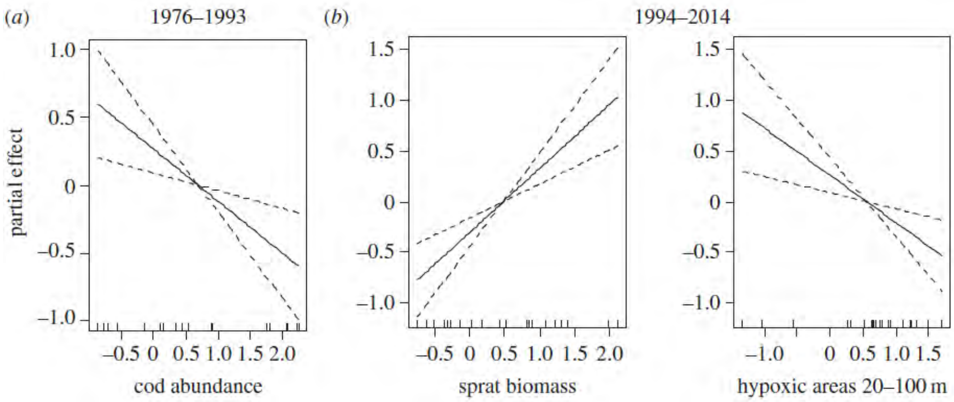


Figure 1.12. Results of the GAM (final model) for the two separated periods (1976–1993 and 1994–2014). The partial effects of each predictor on cod condition are shown. From Casini *et al.* 2016.

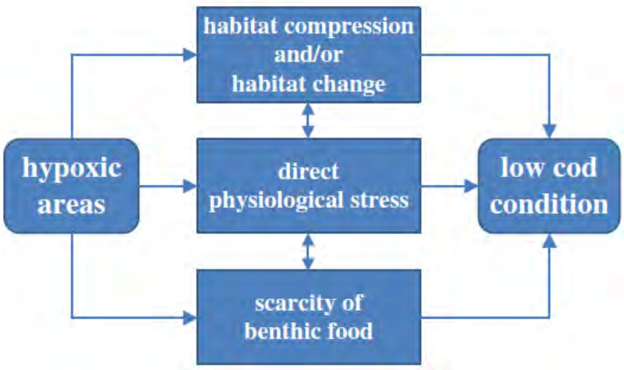


Figure 1.13. Schematic representation of the mechanisms potentially explaining the negative relationship between hypoxic areas and cod condition. From Casini *et al.*, 2016.

1.9.2.8 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.

1.9.2.9 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.

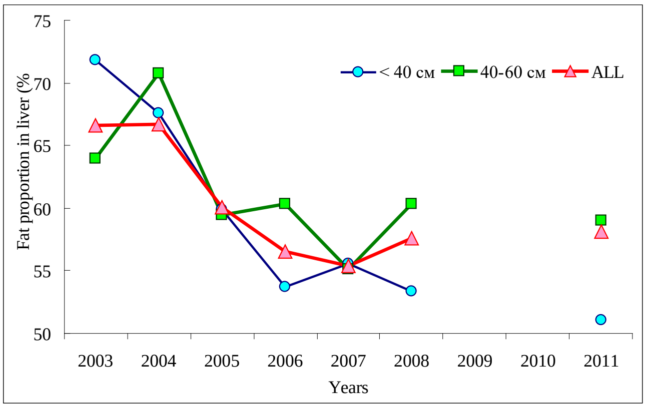


Figure 1.14. Fat proportion in liver of different cod size groups (in %) based on chemical analysis (data obtained by L.I. Perova and M.L. Vinokur, technological direction of AtlantNIRO: Reports on the research work "Investigation of nutrition and biological value of commercial and non-commercial fish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

1.9.3 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 1.10.1. 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.

There exist several trophic models for different areas in the Baltic Sea. In table 1.10.2, 27 food-web related models with different application areas in the Baltic Sea. We highlight the specific purpose for which each model was designed.

Table 1.10.2. Model applications by ICES subdivisions and purpose of the models (Neuenfeldt *et al.*, 2020).

#	Authors	Year	Subdivisions													Purpose
			21	22	23	24	25	26	27	28.1	28.2	29	30	31	32	
1	Elmgren	1984														Overview over main carbon flows
2	Wulff and Ulanowicz	1989														Comparison of structure and function Baltic/Chesapeake Bay
3	Rudstam *et al.*	1995														Top-down control in the pelagic ecosystem
4	Jarre-Teichmann	1995														Seasonal energy flows
5	Horbowy	1996														Production model for commercial fish stocks
6	Sandberg *et al.*	2000														Updated carbon flows
7	Harvey *et al.*	2003														Interactions between fisheries and food web
8	Sandberg *et al.*	2004														Terrigene dissolved organic carbon as structuring factor for secondary production

#	Authors	Year	Subdivisions													Purpose
			21	22	23	24	25	26	27	28.1	28.2	29	30	31	32	
9	Sandberg	2007														Comparison of pelagic food web structures in three main basins
10	Hansson *et al.*	2007														Management scenarios
11	Van Leeu-wen *et al.*	2008														Apparent Allee effect
12	Tomczak *et al.*	2009					Coastal systems									Compared carbon flows in five south-eastern Baltic coastal ecosystems
13	Lindegren *et al.*	2009														demonstrate that in hind-sight the cod collapse could only have been avoidable by adapting fishing pressure to envi-ronmental conditions and food-web interactions
14	Teschner *et al.*	2010														Impact of hypoxia on pe-lagic commercial fishes predation rates
15	Tomczak *et al.*	2013														simulated the regime shift in the Central Baltic Sea of the 1980s
16	Gårdmark *et al.*	2013														Biological ensemble model
17	Lindegren *et al.*	2014														Meta-commnity model for source-sink dynamics
18	Gårdmark *et al.*	2015														Detecting mechanisms un-derlying alternative table states
19	Norrström *et al.*	2017														Nash equilibrium for mul-tispecies fisheries man-agement reference points
20	Jacobsen *et al.*	2017														Ecosystem-level efficiency of fisheries in five large marine ecosystems (
21	Bauer *et al.*	2018														Simulating reduced eu-trophication
22	Bossier *et al.*	2018														End-to-end model imple-mentation
23	Uusitalo *et al.*	2018														Dynamic Bayes Network Implementation
24	Bauer *et al.*	2019														Food web and fisheries in the future Baltic

#	Authors	Year	Subdivisions													Purpose
			21	22	23	24	25	26	27	28.1	28.2	29	30	31	32	
25	Bauer *et al.*	2019														Model uncertainty and simulated fisheries advice
26	Kulatska *et al.*	2019														Implementing GADGET multispecies model for commercial fish species
27	Karlson *et al.*	2020														Linking consumer physiological status to food web structure and prey food value

1.9.4 Ecosystem considerations for the stock assessments

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

The changes in cod predation pressure on clupeids are accounted for in the assessments of herring in SD 25–27, 28.2, 29 and 32 and sprat SD 22-32 stocks by using SMS estimates of natural mortality up to 2018 (IVES 2018, WGSAM), and the 2018 values were assumed for 2019.

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.

1.9.5 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.

1.10 Stock Overviews

In WGBFAS, a total of 3 cod stocks, 3 herring stocks, 1 sprat stock and 10 flatfish stocks, are considered. In 2020 analytical assessments were carried out for cod in Kattegat, cod in SD 22–24 (western stock), cod in SD 24-32 (eastern stock), herring in SD 25–29, 32 (excl. GoR), herring in GoR, sole in SD 20-24, sprat in SD 22–32 and plaice in 21–23. Spawning stock trends are given for plaice in 24–32 and herring in SD's 30 and 31. ICES has not been requested to advice on fishing opportunities for dab, brill and turbot in 22–32 and the four flounder stocks. Results of the assessments are presented in the subsequent sections of the WG report.

1.10.1 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 2019, reported landings were 83 t. The SSB has decreased to historical low levels in 2020. The mortality has increased from historical low levels since 2014 to again approach the high mortality levels in the late 1990. The recruitment the last four years has been below average.

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

The cod stock in the Western Baltic has historically been much smaller than the neighbouring Eastern Baltic stock, from which it is biologically distinct. It appears to be a relatively 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 for this stock is a rather large and amounts to 1/3 of the total catches. Recruitment is variable and the stock is highly dependent upon the strength of incoming year-classes. The 2015, 2017, and 2018 year classes were estimated to be very low, however the 2016 class is presently dominating the catches. Fishing pressures has decreased in recent years and the 2020 spawning stock biomass was estimated around 20 800 t (which is slightly below $B_{trigger}$ 21 876 t).

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

The Eastern Baltic cod stock is biologically distinct from the adjacent Western Baltic (subdivisions 22–24) stock although there is mixing of the two stocks in SD 24 that is taken into account in present assessment. The biomass increased in the end of the 1970s to the historically highest level during 1982–1983 and thereafter declined to lower levels. The pronounced decline in size at maturation over time implies that the exploitable stock size is not consistently represented by SSB, especially in recent years. The SSB in recent years includes small cod that were not part of SSB in earlier years. The biomass of commercial sized cod (≥35 cm) is presently at the lowest level observed since the 1950s. Fishing mortality of the stock is presently at lowest level in the time-series since the 1950s. Recruitment has been declining in later year, with the 2018 year class estimated to be the weakest in the time-series. The poor status of the Eastern Baltic cod is largely driven by biological changes in the stock during the last decades, including poor nutritional condition, reduced growth and a high natural mortality.

1.10.4 Sole in Subdivisions 20-24

The landings of sole in SD20–24 reached a maximum of 1400 t in 1993 and have since then decreased to around 400 t in recent years. Sole is mainly been caught in a mixed fishery as a valuable bycatch; in the trawl fishery for *Nephrops* and in a gillnet fishery for cod and plaice. 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 regulations over time is poorly known. The closed area in Kattegat to protect spawning cod also restrict trawl fisheries for sole. Spawning stock biomass was between B_{pa}/$B_{trigger}$ (2600 t) and B_{lim} (1850 t) in the past decade but is in recent years increasing to above $B_{trigger}$. Fishing mortality has decreased continuously since the mid-1990s and is recently below F_{MSY} (0.23). The low fishing mortality might have caused the SSB to increase and produce some relatively good year classes in 2017-2018 even within the present regime with lower productivity (since 2004).

1.10.5 Plaice in 21–23

Plaice is caught all year round, mainly from winter to spring. Survey indices show variation in CPUE latitudinally in quarters 1, 3, and 4. Subdivision 22 plaice are mostly taken in mixed fisheries together with cod but also in a directed fisheries. In Subdivision 21 plaice is almost exclusively a bycatch in the combined *Nephrops*–sole fishery. Discard rates in area 22 have more than halved over the last decade. This combined with the increasing landings from this area may indicate that this stock is becoming a targeted fishery in area 22. The SSB in the plaice stock increased in the period from 2009 to 2018 but this increase has appeared to level off in recent years. At the same time the relative trend in F has begun to increase away from F_{MSY} toward F_{pa}. Discard information is considered reliable since 2001 and BMS landings are included in landings.

1.10.6 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 Poland, Denmark and Germany being the main fishing countries. Subdivision 25 is the second most important fishing area. Denmark, Sweden and Poland are the main fishing countries there. Minor catches occur in the rest of the Eastern Baltic. The stock size indicator from surveys has increased steadily since the early 2000s about five fold since the start of the survey time-series in 2001. Especially the years 2017 and 2018 (Q1) display a strong increase in plaice abundance. The average stock size indicator in the last two years (2020–202019) is 17% higher than the abundance indices in the three previous years (2016–2018). In 2014 discard data was for the first time included in the advice of the stock. Discard was estimated to be relatively high for this stock – close to 45% in 2014 and about 26% in 2019. Discards in 2016 were exceptional high (~67%). Since 2017, plaice is under a landing obligation, resulting in an additional landings of 17 tons of "unwanted catch" (BMS landings) in the most recent year.

1.10.7 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). Based on new genetic analysis, the currently described two sympatric populations (pelagic spawning *Platichthys flesus* and demersal spawning *Platichthys solemdali* flounder) are considered to be two different species. Flounder (*Platichthys flesus*) is the most widely distributed among all flatfish species in the Baltic Sea.

1.10.8 Flounder in 22–23

The stock size indicator from surveys has increased steadily since 2005 about four fold, but is decreasing since 2016. The average stock size indicator (biomass-index) in the last two years (2019–2018) is 44% lower than the biomass-indices in the three previous years (2015–2017), due to a weak abundance in the BITS Q4 surveys. 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.

1.10.9 Flounder in 24–25

This stock is the largest flounder stock in the Baltic. The biomass index from surveys has been increasing until 2016, then it was showing a decrease until 2018 followed by an increase in 2019. The average stock size indicator (biomass index) in the last two years (2018–2019) is 51% lower than the biomass-indices in the three previous years (2015–2017). Landings in SD 25 are substantially higher than in SD 24. The main fishing nations in SD 24 are Poland and Germany and in SD 25 – Poland and Denmark. The majority of landing is taken by Poland. The discard ratio in both subdivisions varies between countries, gear types, and quarters. Discarding practices are controlled by factors such as market price and cod catches. Despite the high variability in discard ratios, discard estimates since 2014 have been used in the advice because discards reporting has improved.

1.10.10 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 the years showing increasing trend. The results of LBI show that stock status is above possible reference points.

1.10.11 Flounder in 27, 29–32

Flounder is mainly taken in a directed fishery, and some extent as bycatch in demersal fisheries. Major part of the landings are taken in subdivisions 29 and 32, the role of subdivision 29 has been increasing year by year. The main landing country is Estonia (>80%), followed by Sweden and Finland. 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 survey, Estonia).

1.10.12 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. Survey data suggest that the Baltic dab is part of the larger dab stock in Kattegat, whose distribution is ranging into the western Baltic Sea. 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 but also from flatfish directed fisheries. Discards 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 varied around 106 kg hour-1 between 2010 and 2019 in SD 22– 24 and remains stable.

1.10.13 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 2019 in SD 22– 24.

1.10.14 Turbot in 22–32

Turbot is a coastal species commonly occurring from Skagerrak up to the Sea of Åland. Turbot spawns in shallow waters (10–40 m, 10–15 m in central Baltic) and the metamorphosing postlarvae migrate close to shore to shallow water (down to one meter depth). Turbot fishery is concentrated on the westerly parts of the Baltic Sea (SD 22– 26) and mean annual landings are around 200 tonnes since 2013. Biological and fishery data of turbot were available from all national fisheries. For turbot the genetic data show no structure within the Baltic Sea (Nielsen et al., 2004, Florin and Höglund, 2007), although the former discovered a difference between Baltic Sea and Kattegat with a hybrid zone in SD 22. Spatial distributions of turbot during BITS suggest that the turbot stock SD 22–32 is probably related with turbot in SD 21. The stock size indicator from surveys varied around 2-3 individuals/hour larger or equal to 20 cm total length in the last five year in SD 22–28 and increased to 4-6 individuals/hour in the two last recent years.

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

This stock, which is one of the largest herring stocks assessed by the WG, 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 recent interbenchmark assessment in March 2020, which introduced updated natural mortalities for 1974-2018, lead to a downward revision of SSB and upward revision of fishing mortality. The latest stronger year-classes were the 2002, 2007, 2011 and 2014 year class, respectively. Recruitment in 2020 is well above average. Spawning-stock biomass (SSB) has been above MSY $B_{trigger}$ since 2002. SBB shows a decreasing trend since 2014 and is just below MSY $B_{trigger}$ in 2020. 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. Fishing mortality has shown an increasing trend since 2014 and has been above F_{MSY} since 2015.

1.10.16 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 71 000–138 000 t. The year class abundance of this stock is significantly influenced by hydro- meteorological conditions (by the severity of winter, in particular). Mild winters in the second half of 1990s have supported the formation of series of rich year-classes and increase of SSB. Due to low and only occasional presence of sprat in the Gulf, there is no mixed pelagic fishery in the Gulf of Riga.

1.10.17 Herring in subdivisions 30 and 31

The spawning stock of Gulf of Bothnia herring was at relatively low level in the beginning of the 1980s, from which it started to increase and peaked in 1994. A new increasing development started in the first half of the 2000s with a peak in 2013-2014, after which the spawning stock has showed a decreasing trend between years 2015-2018. Recruitment has been on average much higher during the high biomass period, in addition, favourable environmental conditions have contributed to the production of especially abundant year classes in some years. The most abundant year classes have hatched in very warm summers like 2002, 2006, 2011, and 2014. SSB in 2018 is estimated to have decreased from its highest peak in 2014.

1.10.18 Sprat in subdivisions 22–32

The spawning stock biomass of sprat has been low in the first half of 1980s, when cod biomass was high. At the beginning of 1990s the stock started to increase rapidly and in 1996–1997 it reached the maximum observed SSB of 1.8 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) and decline in weight at age by about 40%. High catches in following years and five in row below average year-classes (2009-2013) led to stock decline to below 1 million t. in 2007-2015. Due to strong year class of 2014, the stock has increased in recent years and is predicted to stay above 1 million t. in 2022.

Spawning stock biomass for over 30 years was higher than precautionary levels, while fishing mortality has been higher than present F_{MSY} in most of years since late 1990s. During recent two decades the stock distribution has been changing with tendency to increase density in north-eastern Baltic, especially in autumn.

2 Cod in the Baltic Sea and the Kattegat

2.1 Cod in subdivisions 24-32 (eastern stock)

2.1.1 The fishery

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

2.1.1.1 Landings

In 2019, due to the poor state of the stock, emergency measures were adopted by the European Commission in order to reduce the fishing mortality. This resulted in a fishing ban for Eastern Baltic cod in the last two quarters of the year. All fishing targeting cod was prohibited in quarter three and four, with the exception of small scale coastal vessels fishing with passive gears in shallow waters.

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, Poland, and Sweden. 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 2017-2019.

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 2019 are shown in Table 2.1.2. The total provided landings in SD 25-32 in 2019 summed up to 8 383 t (Figure 2.1.1), whereof 99% were above MCRS and only 57 t were BMS landings (Tables 2.1.3 and 2.1.4). As a result of the closure of the cod fishery in quarter three and four, the landings in 2019 were reduced by 47% compared to 2018, with 83% of the landings taken in quarter one and two. The vast majority (86%) of the cod landings in the last two quarters were taken by Russia that was not affected by the closure of the cod fishery.

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). 16% of total landings of Eastern Baltic stock are estimated to have been taken in SD 24 in 2019 (Figure2.1.2; Table 2.1.4).

2.1.1.2 Unallocated landings

For 2019, similar to 2010–2018, 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 in 2009-2018, misreporting is considered a minor problem in recent years.

2.1.1.3 Discards

In addition to landings above MCRS and BMS landings, discard estimates were submitted from most countries. Even though there is a landing obligation in the Baltic Sea from 2015, discards were still estimated to occur, based onboard sampling by most countries. The total discards in 2019, in subdivision 25-32, were estimated to 1337 t (not including any BMS landings), which constituted 14% of the total catch in weight. This was rather similar to 2018, when the discard rate was estimated to 16%. 98% of the estimated discards in weight were caught by active gears.

Due to the closure of the directed cod fishery in quarter three and four in 2019, many countries had difficulties to obtain discard samples from the second half of the year. Even if the landings of cod for those quarters were small (see section 2.1.1.1), some countries still had a limited trawl fishery targeting flatfish that could potentially generate discards of cod. Different approaches were used in order to get discard estimates for quarter three and four. Denmark provided discard estimates based on sampled flatfish trips mainly from Subdivision 24. Poland provided a discard rate based on sampled flatfish trips from 2018-2019, collected in subdivisions 24 to 26. The Polish discard rate was calculated as discarded cod/landed flounder and applied to the Polish flounder landings in subdivision 25 and 26 in quarter three and four. Latvia provided discard estimates derived from onboard sampling for the last two quarters.

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 2019 was length class 30-34 cm (67% in numbers) followed by length classes 25-29 cm and 35-37 cm (19% and 11%, respectively) (Table 2.1.5).

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 621 tons of estimated discards of eastern Baltic stock in SD 24 in 2019 (Table 2.1.4). This results in estimated discard rate of 14 % in weight, for the entire eastern Baltic stock, including both the SDs 25-32 and the fraction of the stock in SD24.

2.1.1.4 Effort and CPUE data

No data on commercial CPUEs were 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 2019 was 38-44 cm (34% in numbers), followed by 35-37 cm (27%) and 30-34 cm (24%) (Table 2.1.5). Table 2.1.6 gives the estimated mean weight-per-length class and gear in the landings and discards 2019.

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

Numbers and mean weight-at-length were requested from commercial catches for the data year 2019. All countries biological data were estimated nationally before being uploaded and further processed in InterCatch. Numbers and mean weight-at-length were provided for 87% of the total landings (>MCRS) in weight, 78% of the BMS landings and 68% of the estimated discards. This was similar to 2018. 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 2013–2019 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 latest BITS surveys (Figure 2.1.3). Genetic analyses were conducted for juvenile cod caught in Q4 2019 BITS survey, which showed that a large fraction of these juvenile cod caught in SD25 belonged to the western cod stock (Figure 2.1.4).

Nutritional condition

Nutritional condition (Fulton K) of the eastern Baltic cod has substantially declined since the 1990s in SDs 24-28 and has been at a relatively stable low level since 2010, with some increase in Q1 in latest years in all length groups(Figure 2.1.5). 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 10-15% 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, with a slight improvement in 2019 (Figure 2.1.6).

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 L_{50} (50% percent mature) has been estimated at around 35-40 cm (males and females combined) in the early 1990s and has declined to around 20 cm since the late 2000s.

Recruitment

Larval abundances from ichthyoplankton surveys in 2018 were among the lowest observed, while 2019 value is similar to larval abundances in 2014-2015 (Figure 2.1.7). In WGBFAS 2020, data on larval abundances were updated since 2013. The main change is the inclusion of Polish data from BALTICA cruises in late August into the average larval abundance estimates, which only recently became available. Inclusion of these data is considered to improve the average larval abundance estimates and considerably improve the index used in stock assessment. This revision had only a very minor impact on recruitment estimates from the assessment.

Relative biomass trends and size distribution from surveys

Time-series of cod CPUE shows a decline in biomass in both Q1 and Q4 in later years, with the latest values being similar to the year before (Figure 2.1.8). 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, and a slight increase in 2019 (Figure 2.1.9).

2.1.4 Input data for stock assessment

Overview of the time-series included in stock assessment with Stock Synthesis model is provided in Table 2.1.7.

2.1.4.1 Catch data

The time-series of catch data used in stock assessment starts in 1946 (Figure 2.1.10). 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 2019 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 2019. However, to be able to use the survey information from 2020 Q1, the last data year in the Stock Synthesis model is set to 2020. This implies that catches for 2020 need be assumed. The catch in 2020 was set to 7500 tonnes (sum of EU TAC at 2000 t plus Russian quota at 5500 t).

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 2.1.11). Both ALKs from Q1 (1991-2019) and Q4 (1998-2019) were included. The average length at age in the individual fish data from BITS, used as basis for ALK, are presented in Figure 2.1.12.

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	1991-2020	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	1993-2019	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	1986-2019	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	1987-2019	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 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 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 2018, 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 2019 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). 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 2019 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, 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.

2.1.5.2 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 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.

2.1.5.3 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 and is estimated considerably higher than fishing mortality in later years (Figure 2.1.13). At the same time, growth has declined since around the year 2000 (Figure 2.1.14), which is in line with the available biological knowledge on the stock (WKBALTCOD2 2019). The estimated time invariant selectivity is shown in Figure 2.1.15.

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 2.1.16, 2.1.17), 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 2.1.18), besides the BITS surveys indices for 2008-2011, which were always underestimated in the model.

The retrospectives of the model were reasonable (Figure 2.1.19). The estimated Hurtado-Ferro (2014) variant of the Mohn´s index was 0.21 for SSB and -0.23 for F. The index was relatively large for recruitment at age 0 (-0.65). 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 2.1.19).

The spawning stock biomass is estimated to have declined since 2015 (Figure 2.1.20, 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. 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 2.1.21). Fishing mortality has declined over the last years and the value for 2019 is estimated to be at the lowest level in record (Figure 2.1.20). The 2018 year class is estimated to be the weakest in the entire time-series (Figure 2.1.20, 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 is 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 2.1.22).

SPICT estimates the fishing mortality of the stock to be above F_{MSY} Proxy in 2019 and the biomass below B_{MSY} trigger proxy since 2018 (Figure 2.1.23). The results are in line with the stock status estimates based on Stock Synthesis model.

At last benchmark (WKBALTCOD2 2019), is 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 forecast with MCMC. 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 2019. For maturity and weight-at-length, the values for the latest time-block were used.

Variable	Value	Notes
$F_{ages\ 4–6}$ (2020)	0.08	F based on catch constraint.
SSB (2020)	68 652	Stock Synthesis assessment estimate
R_{age0} (2019-2022)	2 052 590	Average of 2014-2018
Total catch (2020)	7500	EU TAC 2000 tonnes + Russian quota 5500 tonnes

In all explored catch scenarios, SSB in 2020 is estimated to increase compared to 2021 (Table 2.1.13). However, it should be noted that this increase is conditional of the recruitment assumption. It is because the assumption on recruitment in forecast has an impact on SSB in the forecast, as SSB presently largely consists of small individuals. Even at no fishing, the SSB is estimated to remain below B_{lim} in 2022, with very high probability.

2.1.8 Reference points

WKBALTCOD2 (2019) concluded that B_{lim} should presently not be set lower than the SSB in 2012 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). 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 (2020) estimated the B_{lim} to be at 102 702 t (SSB in 2012 in the present assessment).

B_{lim} at 102 702 t corresponds to B_{pa} at 114 723 t ($B_{lim} \times \exp(1.645 \times \sigma)$, where $\sigma = 0.07$).

2.1.9 Quality of the assessment

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 is consistent with the last years' assessment.

2.1.11 Management considerations

Reported BMS landings in 2019 were very low and discarding still occurs, with estimated discard rate at 14% for the Eastern Baltic cod stock.

At the presently low productivity, the stock is estimated not to recover above B_{lim} in medium-term even at no fishing. 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 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.

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, especially in autumn. (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.

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
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

Year	Denmark	Estonia	Finland	German Dem.Rep.**	Germany Fed. Rep.	Latvia	Lithuania	Poland	Russia	Sweden	USSR	Faroe Islands^	Norway	Unallocated***	Total
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
2019	1051	2	85		281	251	111	3180	2701	665					8326

*** 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 2019. (Wanted catch, i.e. BMS excluded).

Subdivision		25	26	27	28	29	30	31	32	Total 25-32
Fleet	Country									
Active	Denmark	689	350	0		0				1039
	Estonia	1	0		0	0			0	1
	Finland	24	22							47
	Germany	185	96							281
	Latvia	46	146		4					196
	Lithuania	10	79							90
	Poland	1147	1261	0	0	0				2408
	Russia		2388							2388
	Sweden	443	104	1			0	0		548
Total Active gears		2544	4447	1	4	0	0	0	0	6997
Passive	Denmark	12	0	0		0				12
	Estonia	0	0		0	0			1	1
	Finland					38	0		0	38
	Germany									0
	Latvia		9		46					55
	Lithuania	1	20							21
	Poland	695	77	0	0	0				772
	Russia		312							312
	Sweden	80		10	1	26	0			117
Total Passive gears		787	419	10	47	64	0		1	1329
Total All gears		3332	4866	11	52	64	0	0	1	8326

Table 2.1.3. Cod in SD 25-32. Total landings (tonnes) by country in 2019, separated between landings for human consumption (above MCRS) and the reported BMS landings.

Country	Landings for human consumption (t)	BMS landings (t)
Denmark	1051	7
Estonia	2	0
Finland	85	0
Germany	281	18
Latvia	251	9
Lithuania	111	1
Poland	3180	4
Russia	2701	0
Sweden	665	18
Total	8326	57

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 al-lo-cated*	Land-ings AMS	Land-ings BMS	Total land-ings	Dis-cards	Catch	Total land-ings	Dis-cards	Catch	Total land-ings	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
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

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 al-lo-cated*	Land-ings AMS	Land-ings BMS	Total land-ings	Dis-cards	Catch	Total land-ings	Dis-cards	Catch	Total land-ings	Dis-cards	Total catch
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
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

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 al-lo-cated*	Land-ings AMS	Land-ings BMS	Total land-ings	Dis-cards	Catch	Total land-ings	Dis-cards	Catch	Total land-ings	Dis-cards	Total catch
2018		15800	108	15907	3103	19010	2295	300	2595	18202	3403	21605
2019		8326	57	8383	1337	9720	1598	621	2219	9980	1958	11938

***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 2019.

Length class (cm)	Wanted catch	Unwanted catch	Total
<20		2	2
20-24	7	85	92
25-29	390	809	1198
30-34	1642	2892	4534
35-37	4763	458	5221
38-44	6524	70	6594
45-49	1157	23	1180
≥50	325		325
Total	14808	4338	19146

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 2019.

Fleet	Length class (cm)	Wanted catch	Unwanted catch
Active	<20		63
	20-24	113	113
	25-29	187	213
	25-37	328	336
	30-34	437	401
	38-44	606	557
	45-49	905	824
	>=50	1492	
Passive	<20		70
	20-24		108
	25-29	216	204
	25-37	361	322
	30-34	482	403
	38-44	746	472
	45-49	970	
	>=50	1279	

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	1946-2019	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,	2000-2019	5–120 cm	
Maturity ogives	Size at 50%maturity(L_{50}) and slope	1946-2019		Yes (1998-2019, L_{mat})
Growth	Von Bertalanffy growth parameters	1946-1990		No

Type	Name	Year range	Range	Time variant
Age length keys	Age length keys from BITS Q1 and Q4	1991-2019	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	1975-2020		
Length composition of survey catch	Length composition of BITS Q1 and Q4	1991-2020		
Commercial CPUE indices	Commercial CPUE 1-3	1948-1989		
SSB index	SSB index from egg production method	1986-2019		
Larval index	Larval abundance	1987-2019		

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 (2000-2019) of age class 5.5	20	Estimated using random walk annual deviations	(0.1,2.0)	no prior	0.35-0.67
Stock and recruitment					
$Ln(R_0)$	1	14.8	(13,16)	no prior	15.2
Steepness (h)		0.99			
Recruitment variability (σ_R)		0.60			
Ln (recruitment deviations): 1946-2018	73				
Recruitment autocorrelation		0			
Growth					
L_{inf} (cm) (1946-1990)		125.27			
L_{inf} (cm) (1991-2019)	29	Estimated using random walk annual deviations	(40-150)	no prior	122-52

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
k (1946-1990)		0.10			
k (1991-2019)	29	Estimated using random walk annual deviations	(0.07-0.45)	no prior	0.10-0.23
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			
Weight (kg) at length (cm)					
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, 2015-2017, 2018-2020)		6.58E-06, 8.05E-06, 6.81E-06, 6.78E-06 6.76E-06, 7.47E-06 6.70E-06, 7.73E-06, 8.78E-06, 7.56E-06			
b (1991-1993, 1994- 1996, 1997- 1999, 2000 -2002, 2003-2005, 2006-2008, 2009-2011, 2012-2014, 2015-2017,2018-2020)		3.1353, 3.0636, 3.1062 3.0992, 3.0972, 3.0637 3.0831, 3.0406, 3.0086,3.0586			
Maturity					
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, 2015-2020)		38, 36, 31, 26, 21			
Initial fishing mortality					
Active gears		0.60			
Selectivity (logistic)					
Active gears					
Time-invariant length based logistic selectivity	2	35; 12.68	(20,45; 0.01,50)	no prior	(39; 8.9)
Passive gears					

Parameter	**Number estimated**	**Initial value**	**Bounds (low,high)**	**Prior**	**Value (MLE)**
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	(27.2;9.7)
BITS Q4 survey					
Time-invariant length based logistic selectivity	2	25,10	(15,50; -12,15)	no prior	(27.8; 10.3)
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	0.29
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					
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			

Parameter	Number estimated	Initial value	Bounds (low,high)	Prior	Value (MLE)
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	0.34
SSBEggProd					
Ln(Q) – catchability		Float option used			
Extra variability added to input standard deviation	1	0.1	(0.0,1.2)	no prior	0.47
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	875	8043	14016	5798	3065	1587	661	792
1947	626	17063	27619	14721	3798	1763	877	789
1948	1087	11009	50428	23850	7640	1695	750	691
1949	1273	15658	27137	36708	10359	2836	597	495
1950	1349	19297	41153	21324	17318	4187	1089	409
1951	1062	19909	49012	30913	9536	6605	1515	528
1952	981	17612	55339	39599	14735	3861	2532	760
1953	824	10370	32574	30697	13037	4120	1021	844
1954	1308	12978	28373	27346	15860	5855	1769	781
1955	1131	17195	30405	20587	12179	6119	2156	915
1956	864	20744	54089	28738	11837	6053	2902	1419
1957	927	15748	62043	46294	14345	4988	2409	1665
1958	1270	11478	32932	37445	16007	4128	1346	1060
1959	1152	19399	29754	24967	16562	5960	1449	819

Year	a1	a2	a3	a4	a5	a6	a7	a8
1960	1662	21277	58182	24726	11662	6386	2149	789
1961	1158	18573	40049	29993	6896	2615	1323	583
1962	1180	16665	44453	26756	11282	2142	759	533
1963	1369	18358	42626	31538	10660	3707	658	382
1964	1573	14866	34416	22850	9568	2671	868	234
1965	1934	22465	36786	24981	9784	3475	918	367
1966	2641	43208	81050	36635	14247	4671	1563	558
1967	2585	37946	100404	49789	12051	3757	1138	495
1968	2553	39395	92071	63983	16976	3296	949	393
1969	1988	36506	90698	56082	20796	4413	790	308
1970	2040	28118	83250	54871	18130	5381	1053	250
1971	2247	25922	58794	47099	16787	4466	1225	284
1972	2610	28696	56028	35576	15905	4648	1153	375
1973	2673	32272	61258	34232	12431	4624	1268	402
1974	1339	31493	65807	36756	12149	3746	1320	461
1975	1204	20520	83373	52422	17840	5105	1504	696
1976	1436	15887	51124	64757	25012	7378	2018	847
1977	2606	18952	36143	34599	26845	9009	2543	959
1978	2275	38522	44256	25295	15220	10447	3378	1285
1979	1342	33581	105540	41078	15424	8338	5540	2423
1980	3092	26281	106204	105593	26309	8787	4577	4277
1981	2545	39823	62755	84536	53671	11772	3770	3710
1982	1814	39914	100975	47987	39995	22156	4653	2889
1983	1061	26425	102858	81053	23991	17520	9308	3097
1984	1099	19876	85554	103229	50560	13038	9109	6290
1985	1279	18482	55565	67350	47364	19622	4790	5481
1986	1934	20449	51975	44783	31470	18595	7271	3684
1987	1290	33016	57978	39534	19030	11034	6111	3474
1988	875	21322	89162	41101	15369	6043	3268	2731

Year	a1	a2	a3	a4	a5	a6	a7	a8
1989	860	13548	53956	59979	15176	4632	1695	1618
1990	818	16046	37637	39672	24271	5005	1419	977
1991	1236	10928	39877	25438	14260	6925	1311	599
1992	1129	10923	15705	15063	5074	2242	993	261
1993	542	11739	21672	9044	5026	1418	586	315
1994	582	11761	43822	29901	7699	3665	977	602
1995	865	10977	29296	32225	13922	3021	1345	558
1996	678	13297	32903	29257	20339	7719	1571	955
1997	1336	8491	30617	22393	10948	6214	2185	679
1998	1637	16333	20324	20394	7756	2912	1486	650
1999	1414	16855	41710	17430	8855	2481	810	553
2000	1134	21007	49302	34720	6971	2423	568	282
2001	1466	14412	48951	33058	11868	1697	487	153
2002	752	14206	26844	25729	9158	2458	298	101
2003	910	8853	35206	22093	11630	3235	766	114
2004	1702	10502	22849	29078	10032	3967	962	240
2005	1404	18354	22924	15512	10502	2725	920	254
2006	1085	11862	43513	21957	8755	4600	1049	416
2007	845	8556	24865	30709	8980	2723	1235	358
2008	775	8276	22130	19318	12966	2914	765	409
2009	833	8891	24595	23271	11084	5626	1108	409
2010	727	8504	22462	23049	13134	4756	2103	527
2011	833	7267	23747	23004	14472	6529	2058	1056
2012	1549	9072	23909	28992	16250	7857	3074	1325
2013	1231	8474	17356	17745	11975	4812	1946	966
2014	928	10154	23943	18885	10684	5126	1693	908
2015	851	7227	26405	25589	11565	4655	1811	791
2016	433	4611	13286	20580	12111	4038	1342	653
2017	699	3013	10695	12631	12086	5467	1554	683

Year	a1	a2	a3	a4	a5	a6	a7	a8
2018	289	3581	5709	8637	6310	4696	1850	685
2019	9	1040	5174	3758	3575	2044	1342	671

Table 2.1.10. Eastern Baltic cod in SDs 24-32. Spawning stock biomass (SSB, at the spawning time), recruitment at age 0 and fishing mortality (Fbar for ages 4-6). "High" and "low" values correspond to 90% confidence intervals.

Years	SSB	SSBhigh90	SSBlow90	F_{bar}	Fhigh90	Flow90	R	Rhigh90	Rlow90
1946	61104	67697	54511	0.408	0.449	0.367	2121700	2381953	1889883
1947	80460	87963	72957	0.53	0.576	0.484	3083430	3397443	2798440
1948	103496	112198	94794	0.598	0.644	0.552	3647870	3993712	3331977
1949	111881	121777	101985	0.577	0.623	0.531	3734020	4083400	3414534
1950	117596	127777	107415	0.605	0.651	0.559	2918160	3228164	2637926
1951	129241	139555	118927	0.611	0.655	0.567	2334190	2616851	2082060
1952	132384	142956	121812	0.682	0.73	0.634	2682560	2991359	2405638
1953	137908	149336	126480	0.501	0.539	0.463	3885230	4249901	3551850
1954	132019	143875	120163	0.542	0.585	0.499	3746480	4095539	3427171
1955	133137	144672	121602	0.504	0.543	0.465	2267440	2536891	2026608
1956	137334	147459	127209	0.63	0.671	0.589	1880490	2122784	1665852
1957	127961	136775	119147	0.775	0.821	0.729	2930820	3211722	2674486
1958	111976	120639	103313	0.677	0.721	0.633	2472010	2727821	2240188
1959	93023	101505	84541	0.741	0.799	0.683	2724370	2987891	2484091
1960	78529	84331	72727	0.971	1.01	0.932	2460990	2721856	2225126
1961	78880	84855	72905	0.781	0.834	0.728	2519200	2797443	2268632
1962	82265	88375	76155	0.773	0.824	0.722	2691080	3002934	2411612
1963	80550	87095	74005	0.828	0.887	0.769	4178300	4595227	3799201
1964	87482	94967	79997	0.635	0.683	0.587	5357260	5847919	4907769
1965	100522	108842	92202	0.625	0.671	0.579	4773510	5367374	4245353
1966	109504	116280	102728	0.931	0.961	0.901	4725570	5543227	4028522
1967	125250	132527	117973	0.919	0.947	0.891	4379750	4872120	3937138
1968	129940	140387	119493	0.951	0.994	0.908	3402100	3837222	3016318
1969	127506	143611	111401	0.949	1.015	0.883	3503860	3916800	3134455

Years	SSB	SSBhigh90	SSBlow90	F_{bar}	Fhigh90	Flow90	R	Rhigh90	Rlow90
1970	120599	139632	101566	0.939	1.051	0.827	4336760	4813106	3907557
1971	113719	131034	96404	0.839	0.956	0.722	5750870	6320434	5232632
1972	115754	130320	101188	0.76	0.846	0.674	7111350	7755097	6521041
1973	137581	151769	123393	0.655	0.718	0.592	4449970	4987323	3970513
1974	189358	205120	173596	0.514	0.555	0.473	3754460	4268040	3302680
1975	238145	256107	220183	0.521	0.557	0.485	5409470	6068077	4822346
1976	237914	258666	217162	0.511	0.55	0.472	11725200	12728157	10801274
1977	244151	267826	220476	0.419	0.455	0.383	9532210	10482528	8668045
1978	302127	328120	276134	0.349	0.377	0.321	5656850	6413229	4989679
1979	398005	425562	370448	0.386	0.411	0.361	9460860	10363964	8636451
1980	447717	477375	418059	0.485	0.515	0.455	9574980	10425491	8793854
1981	413034	443442	382626	0.491	0.522	0.46	6310890	6967388	5716250
1982	438851	467502	410200	0.469	0.497	0.441	3918480	4377934	3507245
1983	438149	461962	414336	0.47	0.493	0.447	3351990	3707428	3030629
1984	374175	392341	356009	0.611	0.637	0.585	3503470	3796147	3233358
1985	281607	295154	268060	0.647	0.673	0.621	5248970	5544798	4968926
1986	195008	206811	183205	0.721	0.762	0.68	3179640	3403524	2970483
1987	150848	157624	144072	0.779	0.794	0.764	1984940	2147326	1834834
1988	142784	148795	136773	0.808	0.843	0.773	2008720	2157886	1869865
1989	119434	124622	114246	0.811	0.841	0.781	1481330	1610206	1362769
1990	89758	94632	84884	0.936	0.979	0.893	2964900	3176673	2767245
1991	57757	61371	54143	1.044	1.082	1.006	3521850	3751231	3306495
1992	61420	67829	55011	0.556	0.605	0.507	2382010	2564734	2212304
1993	103428	113869	92987	0.351	0.382	0.32	2003650	2163237	1855836
1994	120209	130783	109635	0.544	0.582	0.506	1969950	2123750	1827288
1995	131609	141234	121984	0.553	0.584	0.522	1473190	1611956	1346369
1996	93180	100311	86049	0.855	0.904	0.806	2765110	2998141	2550191
1997	62740	68249	57231	0.919	0.985	0.853	2810900	3065591	2577369
1998	55725	60706	50744	0.89	0.962	0.818	2854730	3116788	2614706

Years	SSB	SSBhigh90	SSBlow90	F_{bar}	Fhigh90	Flow90	R	Rhigh90	Rlow90
1999	51891	56668	47114	0.957	1.038	0.876	2191670	2440845	1967932
2000	61631	66449	56813	1.04	1.116	0.964	2839640	3094429	2605830
2001	75266	80657	69875	1.015	1.087	0.943	1885830	2079278	1710379
2002	84111	89831	78391	0.73	0.783	0.677	2289100	2499220	2096646
2003	85225	90913	79537	0.747	0.8	0.694	3893320	4196135	3612358
2004	74205	79836	68574	0.766	0.824	0.708	3048680	3335112	2786848
2005	92100	98435	85765	0.604	0.648	0.56	3761230	4121903	3432117
2006	91452	98124	84780	0.678	0.727	0.629	3955220	4349370	3596789
2007	89606	96808	82404	0.547	0.59	0.504	3720100	4117847	3360772
2008	127427	137044	117810	0.414	0.447	0.381	3899100	4330245	3510883
2009	139592	150113	129071	0.393	0.424	0.362	3379590	3802748	3003520
2010	143031	153778	132284	0.372	0.402	0.342	3605750	4072888	3192190
2011	127333	137210	117456	0.417	0.45	0.384	4855190	5447818	4327030
2012	102702	111300	94104	0.562	0.611	0.513	4993910	5612196	4443740
2013	96851	105112	88590	0.414	0.453	0.375	3242640	3717697	2828287
2014	105503	114391	96615	0.408	0.446	0.37	2918140	3359716	2534601
2015	126145	136559	115731	0.401	0.437	0.365	2145850	2530387	1819750
2016	113509	122858	104160	0.303	0.331	0.275	3310880	3812158	2875518
2017	93161	100971	85351	0.285	0.311	0.259	1769730	2198230	1424757
2018	90045	97744	82346	0.217	0.238	0.196	118322	193664	72291
2019	84527	92110	76944	0.117	0.129	0.105	NA	NA	NA
2020	68652	76250	61054	NA	NA	NA	NA	NA	NA

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

Year	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8+
1946	2250270	443769	121847	25327	10251	4714	1890	2216
1947	1257260	731856	188751	51539	10309	4277	2054	1807
1948	1827150	408803	308746	76070	19032	3787	1618	1463
1949	2161620	593967	171357	120743	26569	6515	1326	1075

Year	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8+
1950	2212670	702700	249139	67473	42842	9293	2337	860
1951	1729210	719265	294255	97054	23419	14555	3227	1101
1952	1383170	562104	301089	114382	33534	7909	5021	1481
1953	1589600	449518	233792	113460	37292	10516	2515	2041
1954	2302270	516828	189546	94906	42783	14120	4119	1781
1955	2220050	748451	217169	75606	34616	15524	5277	2196
1956	1343620	721825	315711	88138	28457	13068	6058	2908
1957	1114320	436732	301589	121656	29972	9418	4409	2998
1958	1736710	362041	180138	109126	36754	8528	2691	2083
1959	1464840	564378	150416	67839	35666	11582	2728	1514
1960	1614380	475973	233490	55230	21073	10517	3442	1245
1961	1458300	524278	193509	77992	14259	4891	2398	1042
1962	1492800	473849	216650	70124	23496	4032	1386	960
1963	1594650	485063	195877	78729	21253	6698	1153	659
1964	2475930	518075	199577	69537	22830	5726	1800	477
1965	3174550	804798	216522	76839	23567	7518	1920	755
1966	2828640	1031950	336882	83828	26275	7843	2550	899
1967	2800220	918842	421983	114909	22392	6353	1869	800
1968	2595300	909629	376073	144682	30996	5482	1535	628
1969	2015970	842936	370854	126941	38004	7345	1278	491
1970	2076270	654770	343639	125213	33372	9017	1715	403
1971	2569820	674354	267055	116481	33192	8006	2131	487
1972	3407780	834860	277163	94332	33467	8838	2124	680
1973	4213960	1107370	345640	101352	28904	9671	2565	799
1974	2636920	1369760	462650	132244	33829	9319	3167	1089
1975	2224780	857369	577863	187400	49435	12638	3593	1632
1976	3205490	723304	360977	232746	69552	18330	4836	1991
1977	6948050	1042420	306001	146878	87322	26056	7083	2628
1978	5648520	2259820	443558	129052	59264	35986	11194	4173

Year	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8+
1979	3352090	1836940	961584	190898	54910	26316	16832	7226
1980	5606240	1090170	780678	408314	78894	23456	11788	10816
1981	5673850	1822620	458540	316453	155346	30390	9386	9059
1982	3739650	1845120	770961	187448	120459	59452	12038	7316
1983	2321980	1215970	779804	317150	72551	47174	24169	7885
1984	1986290	755078	514202	320302	122530	28380	19164	13016
1985	2076060	645781	317117	201056	110922	41324	9757	10971
1986	3110380	674863	270073	121829	67572	36062	13655	6795
1987	1884160	1011110	281799	101398	38719	20332	10915	6105
1988	1176220	612404	420514	103435	30765	10956	5746	4726
1989	1190310	382249	253625	151957	30618	8452	2999	2814
1990	877795	386864	158238	91244	44801	8390	2310	1561
1991	1756900	285136	158188	54046	24352	10775	1982	891
1992	2086940	571061	117586	53281	13432	5224	2220	570
1993	1411510	678486	242179	48022	19567	4791	1890	996
1994	1187310	459065	288575	105630	20613	8659	2214	1332
1995	1167340	386048	192801	114945	38994	7464	3189	1290
1996	872969	379278	160475	74970	41166	14063	2761	1643
1997	1638520	283640	156116	56867	21299	10774	3661	1114
1998	1665650	532335	117735	55885	15792	5184	2540	1088
1999	1691610	540890	220163	43424	16162	3970	1241	831
2000	1298710	549609	224825	81540	12406	3777	847	409
2001	1682680	421911	225531	78180	21516	2703	740	226
2002	1117490	546676	174466	78816	20715	4808	552	180
2003	1356450	363183	228721	67840	25767	6181	1385	199
2004	2307060	440841	152149	88518	22076	7455	1705	414
2005	1806550	749685	184744	59011	28324	6220	1960	521
2006	2228780	586913	312457	73620	20877	9300	1981	756
2007	2343750	724718	247202	122961	24762	6235	2600	718

Year	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8+
2008	2204430	762347	309098	103272	45160	8294	1974	993
2009	2310500	717016	324650	133127	41166	16873	3005	1035
2010	2002650	751483	303701	137239	52882	15342	6066	1409
2011	2136660	651336	317926	127122	53831	19740	5522	2617
2012	2877040	694896	275073	131527	47719	18707	6541	2580
2013	2959220	935356	291883	110522	45235	13992	4930	2208
2014	1921490	962363	395145	122066	41958	15293	4317	2058
2015	1729200	624791	404968	163806	46113	14125	4664	1788
2016	1271560	562255	262199	165979	61291	15476	4305	1805
2017	1961930	413599	237110	109637	65172	22460	5344	2003
2018	1048690	638121	174507	99560	43297	24086	7890	2477
2019	70114	341152	269944	74653	41110	17090	9210	3898
2020	1216310	22817	145017	118229	32783	17960	7470	5835

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	15
1946	0.001	0.029	0.164	0.326	0.425	0.472	0.491	0.498	0.5	0.5	0.501	0.501	0.501	0.506	0.506
1947	0.001	0.037	0.212	0.423	0.552	0.613	0.638	0.647	0.65	0.651	0.651	0.651	0.651	0.656	0.656
1948	0.001	0.043	0.242	0.479	0.623	0.691	0.718	0.729	0.732	0.733	0.733	0.733	0.733	0.738	0.738
1949	0.001	0.043	0.235	0.463	0.602	0.666	0.693	0.703	0.706	0.706	0.707	0.707	0.707	0.712	0.712
1950	0.001	0.044	0.246	0.485	0.631	0.699	0.727	0.737	0.74	0.741	0.741	0.741	0.741	0.746	0.746
1951	0.001	0.045	0.248	0.49	0.637	0.705	0.734	0.744	0.747	0.748	0.748	0.748	0.748	0.753	0.753
1952	0.002	0.051	0.279	0.548	0.711	0.787	0.818	0.829	0.833	0.834	0.834	0.834	0.834	0.839	0.839
1953	0.001	0.037	0.205	0.402	0.522	0.578	0.601	0.61	0.612	0.613	0.613	0.613	0.613	0.618	0.618
1954	0.001	0.041	0.222	0.436	0.565	0.625	0.65	0.659	0.662	0.663	0.663	0.663	0.663	0.669	0.669
1955	0.001	0.037	0.205	0.404	0.525	0.582	0.605	0.614	0.616	0.617	0.617	0.617	0.617	0.623	0.623
1956	0.001	0.046	0.257	0.506	0.657	0.727	0.756	0.767	0.77	0.771	0.771	0.771	0.771	0.778	0.778
1957	0.002	0.059	0.32	0.624	0.808	0.894	0.929	0.942	0.946	0.947	0.947	0.947	0.947	0.955	0.955
1958	0.002	0.052	0.28	0.545	0.706	0.781	0.811	0.823	0.826	0.827	0.827	0.827	0.827	0.834	0.834
1959	0.002	0.056	0.305	0.596	0.772	0.854	0.888	0.9	0.904	0.905	0.906	0.906	0.906	0.911	0.911

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1960	0.002	0.074	0.4	0.781	1.012	1.119	1.164	1.18	1.185	1.186	1.186	1.186	1.186	1.191	1.191
1961	0.002	0.057	0.318	0.627	0.814	0.902	0.938	0.951	0.955	0.956	0.956	0.956	0.956	0.962	0.962
1962	0.002	0.057	0.315	0.621	0.806	0.893	0.928	0.941	0.945	0.946	0.947	0.947	0.947	0.952	0.952
1963	0.002	0.062	0.339	0.665	0.863	0.955	0.993	1.007	1.011	1.012	1.012	1.013	1.013	1.018	1.018
1964	0.001	0.046	0.258	0.509	0.662	0.733	0.763	0.774	0.777	0.778	0.778	0.778	0.778	0.783	0.783
1965	0.001	0.045	0.252	0.5	0.651	0.722	0.751	0.762	0.765	0.766	0.766	0.766	0.766	0.771	0.771
1966	0.002	0.068	0.379	0.747	0.971	1.075	1.118	1.134	1.139	1.14	1.14	1.14	1.14	1.146	1.146
1967	0.002	0.067	0.374	0.737	0.958	1.062	1.104	1.12	1.124	1.126	1.126	1.126	1.126	1.132	1.132
1968	0.002	0.071	0.389	0.764	0.991	1.097	1.14	1.156	1.161	1.163	1.163	1.163	1.163	1.169	1.169
1969	0.002	0.071	0.389	0.763	0.99	1.096	1.139	1.155	1.16	1.161	1.161	1.161	1.161	1.167	1.167
1970	0.002	0.071	0.385	0.755	0.979	1.083	1.126	1.142	1.147	1.148	1.148	1.148	1.148	1.155	1.155
1971	0.002	0.063	0.344	0.674	0.874	0.968	1.006	1.02	1.025	1.026	1.026	1.026	1.026	1.034	1.034
1972	0.002	0.056	0.309	0.61	0.793	0.878	0.913	0.926	0.93	0.931	0.931	0.931	0.931	0.939	0.939
1973	0.001	0.046	0.264	0.524	0.683	0.757	0.788	0.799	0.803	0.804	0.804	0.804	0.804	0.811	0.811
1974	0.001	0.037	0.207	0.411	0.536	0.594	0.618	0.627	0.63	0.63	0.631	0.631	0.631	0.638	0.638
1975	0.001	0.039	0.213	0.418	0.543	0.602	0.626	0.634	0.637	0.638	0.638	0.638	0.638	0.645	0.645
1976	0.001	0.034	0.202	0.408	0.533	0.592	0.616	0.625	0.628	0.628	0.629	0.629	0.629	0.636	0.636
1977	0.001	0.028	0.167	0.335	0.438	0.486	0.506	0.513	0.515	0.516	0.516	0.516	0.516	0.523	0.523
1978	0.001	0.028	0.146	0.282	0.363	0.401	0.416	0.422	0.424	0.424	0.424	0.424	0.424	0.431	0.431
1979	0.001	0.029	0.16	0.311	0.402	0.444	0.461	0.468	0.47	0.47	0.47	0.47	0.47	0.477	0.477
1980	0.001	0.04	0.206	0.394	0.505	0.557	0.578	0.586	0.588	0.589	0.589	0.589	0.589	0.596	0.596
1981	0.001	0.034	0.198	0.393	0.512	0.567	0.59	0.598	0.601	0.602	0.602	0.602	0.602	0.609	0.609
1982	0.001	0.035	0.191	0.376	0.489	0.541	0.563	0.571	0.573	0.574	0.574	0.574	0.574	0.581	0.581
1983	0.001	0.034	0.193	0.378	0.49	0.542	0.563	0.571	0.573	0.574	0.574	0.574	0.574	0.581	0.581
1984	0.001	0.041	0.242	0.488	0.638	0.709	0.738	0.748	0.752	0.753	0.753	0.753	0.753	0.76	0.76
1985	0.001	0.045	0.26	0.518	0.675	0.748	0.779	0.79	0.793	0.794	0.794	0.794	0.794	0.801	0.801
1986	0.001	0.047	0.283	0.573	0.752	0.836	0.871	0.883	0.887	0.889	0.889	0.889	0.889	0.894	0.894
1987	0.001	0.051	0.305	0.62	0.814	0.905	0.942	0.956	0.961	0.962	0.962	0.962	0.962	0.966	0.966
1988	0.002	0.055	0.321	0.645	0.843	0.937	0.975	0.989	0.994	0.995	0.995	0.995	0.995	1	1
1989	0.002	0.056	0.325	0.649	0.846	0.938	0.977	0.991	0.995	0.996	0.996	0.996	0.996	1.002	1.002

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1990	0.002	0.068	0.377	0.748	0.976	1.084	1.129	1.146	1.151	1.152	1.153	1.153	1.153	1.158	1.158
1991	0.001	0.06	0.391	0.819	1.09	1.221	1.275	1.296	1.302	1.304	1.305	1.305	1.305	1.309	1.309
1992	0.001	0.032	0.199	0.429	0.582	0.658	0.69	0.703	0.707	0.708	0.708	0.708	0.708	0.712	0.712
1993	0.001	0.029	0.133	0.273	0.366	0.413	0.434	0.441	0.444	0.445	0.445	0.445	0.445	0.45	0.45
1994	0.001	0.041	0.224	0.424	0.567	0.64	0.672	0.684	0.689	0.69	0.69	0.69	0.69	0.695	0.695
1995	0.002	0.052	0.248	0.454	0.571	0.635	0.664	0.675	0.679	0.68	0.68	0.68	0.68	0.685	0.685
1996	0.002	0.061	0.341	0.686	0.892	0.987	1.033	1.052	1.058	1.06	1.06	1.06	1.06	1.066	1.066
1997	0.002	0.053	0.33	0.708	0.964	1.086	1.136	1.159	1.167	1.169	1.17	1.17	1.17	1.176	1.176
1998	0.002	0.057	0.301	0.668	0.932	1.071	1.13	1.153	1.162	1.164	1.165	1.165	1.165	1.173	1.173
1999	0.002	0.052	0.296	0.68	1.005	1.186	1.271	1.304	1.315	1.319	1.32	1.32	1.32	1.329	1.329
2000	0.002	0.065	0.361	0.763	1.08	1.277	1.372	1.412	1.426	1.43	1.432	1.432	1.432	1.439	1.439
2001	0.002	0.057	0.356	0.758	1.054	1.234	1.332	1.375	1.392	1.397	1.398	1.398	1.399	1.406	1.406
2002	0.002	0.045	0.247	0.545	0.76	0.884	0.952	0.986	1	1.004	1.005	1.006	1.006	1.014	1.014
2003	0.002	0.043	0.249	0.543	0.782	0.918	0.989	1.025	1.041	1.047	1.048	1.049	1.049	1.057	1.057
2004	0.002	0.041	0.242	0.552	0.796	0.952	1.032	1.071	1.089	1.096	1.099	1.099	1.099	1.109	1.109
2005	0.002	0.045	0.209	0.441	0.628	0.742	0.806	0.837	0.851	0.856	0.858	0.859	0.859	0.868	0.868
2006	0.001	0.033	0.214	0.478	0.704	0.851	0.932	0.974	0.994	1.002	1.004	1.005	1.006	1.015	1.015
2007	0.001	0.018	0.145	0.374	0.567	0.7	0.778	0.82	0.841	0.849	0.853	0.854	0.854	0.866	0.866
2008	0.001	0.017	0.105	0.275	0.432	0.535	0.599	0.636	0.654	0.662	0.666	0.667	0.667	0.684	0.684
2009	0.001	0.02	0.113	0.26	0.408	0.512	0.573	0.609	0.629	0.638	0.642	0.643	0.643	0.662	0.662
2010	0.001	0.019	0.113	0.255	0.381	0.481	0.544	0.58	0.6	0.611	0.615	0.617	0.617	0.64	0.64
2011	0.001	0.019	0.116	0.283	0.431	0.538	0.616	0.663	0.69	0.705	0.712	0.715	0.716	0.737	0.737
2012	0.001	0.023	0.138	0.358	0.582	0.745	0.857	0.937	0.986	1.012	1.027	1.033	1.036	1.059	1.059
2013	0.001	0.015	0.092	0.249	0.424	0.57	0.669	0.737	0.786	0.815	0.831	0.84	0.843	0.867	0.867
2014	0.001	0.018	0.095	0.244	0.415	0.565	0.679	0.756	0.809	0.846	0.868	0.88	0.887	0.914	0.914
2015	0.001	0.02	0.102	0.245	0.406	0.551	0.668	0.754	0.812	0.852	0.879	0.895	0.904	0.932	0.932
2016	0.001	0.014	0.078	0.189	0.307	0.414	0.503	0.573	0.624	0.659	0.683	0.7	0.709	0.741	0.741
2017	0.001	0.012	0.071	0.178	0.291	0.388	0.469	0.535	0.587	0.625	0.652	0.67	0.683	0.718	0.718
2018	0.001	0.009	0.05	0.131	0.221	0.298	0.361	0.412	0.454	0.488	0.513	0.53	0.543	0.578	0.578
2019	0	0.004	0.027	0.069	0.119	0.164	0.2	0.228	0.251	0.27	0.285	0.296	0.303	0.336	0.336

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

Basis	Total catch (2021)	F (2021)	SSB (2021)	SSB (2022)	Probability of SSB (2022) >B_{Lim} (%)	% SSB change	% Catch change**
F = 0	0	0	61169	67233	< 0.01	10	-100
F = 0.05	4133	0.050	59411	64082	< 0.01	8	-65
F =F (2019)	9390	0.117	57155	60033	< 0.01	5	-21
Catch=TAC(2020)	7500	0.097	57914	61204	< 0.01	6	-37
Catch=0.75*TAC(2020)	5625	0.072	58711	62717	< 0.01	7	-53
Catch in SD24*	1532	0.019	60504	66005	< 0.01	9	-87

*** Due to a mixed fisheries for eastern and western Baltic cod in SD 24 it would be expected that 1532 tonnes of eastern Baltic cod would be caught in SD 24 in 2021, when commercial catch of 4635 tonnes is taken from the western Baltic cod stock (corresponding to FMSY catch option for western Baltic cod). It is assumed that the geographical distribution of commercial catches from the western stock in 2021 is the same as observed in 2019 (26% in SD 24), and the ratio between eastern and western stock in the commercial cod catch in SD 24 is the same as observed in 2019 (1.27).**

****Catch in 2021 compared to catch in 2019 (11 938 tonnes)**

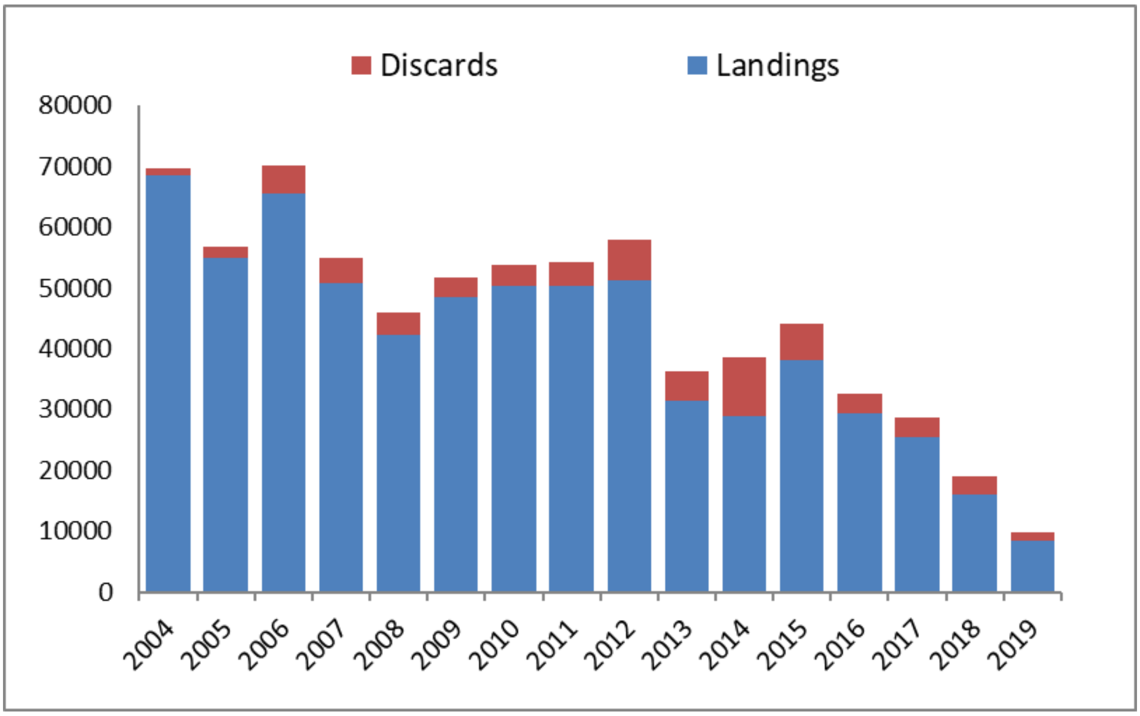


Figure 2.1.1. Eastern Baltic cod in SDs 24-32. Total landings (incl. unallocated for years before 2010) and estimated discards in management area of SD 25-32.

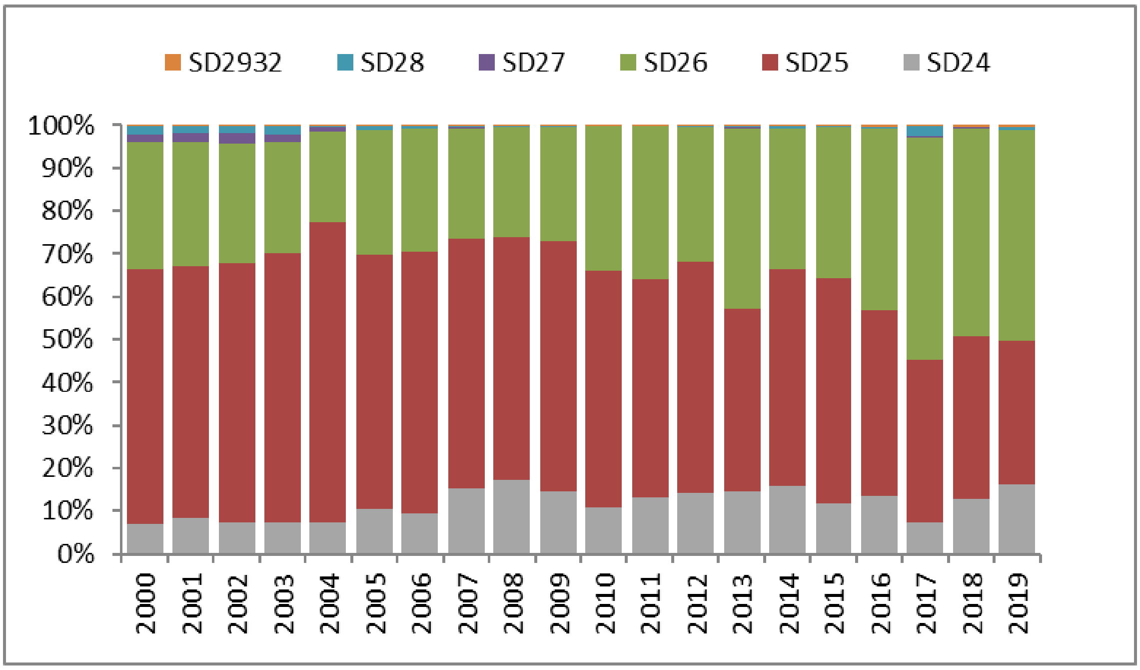


Figure 2.1.2. Eastern Baltic cod in SDs 24-32. Relative distribution of landings of the eastern Baltic cod stock by SD.

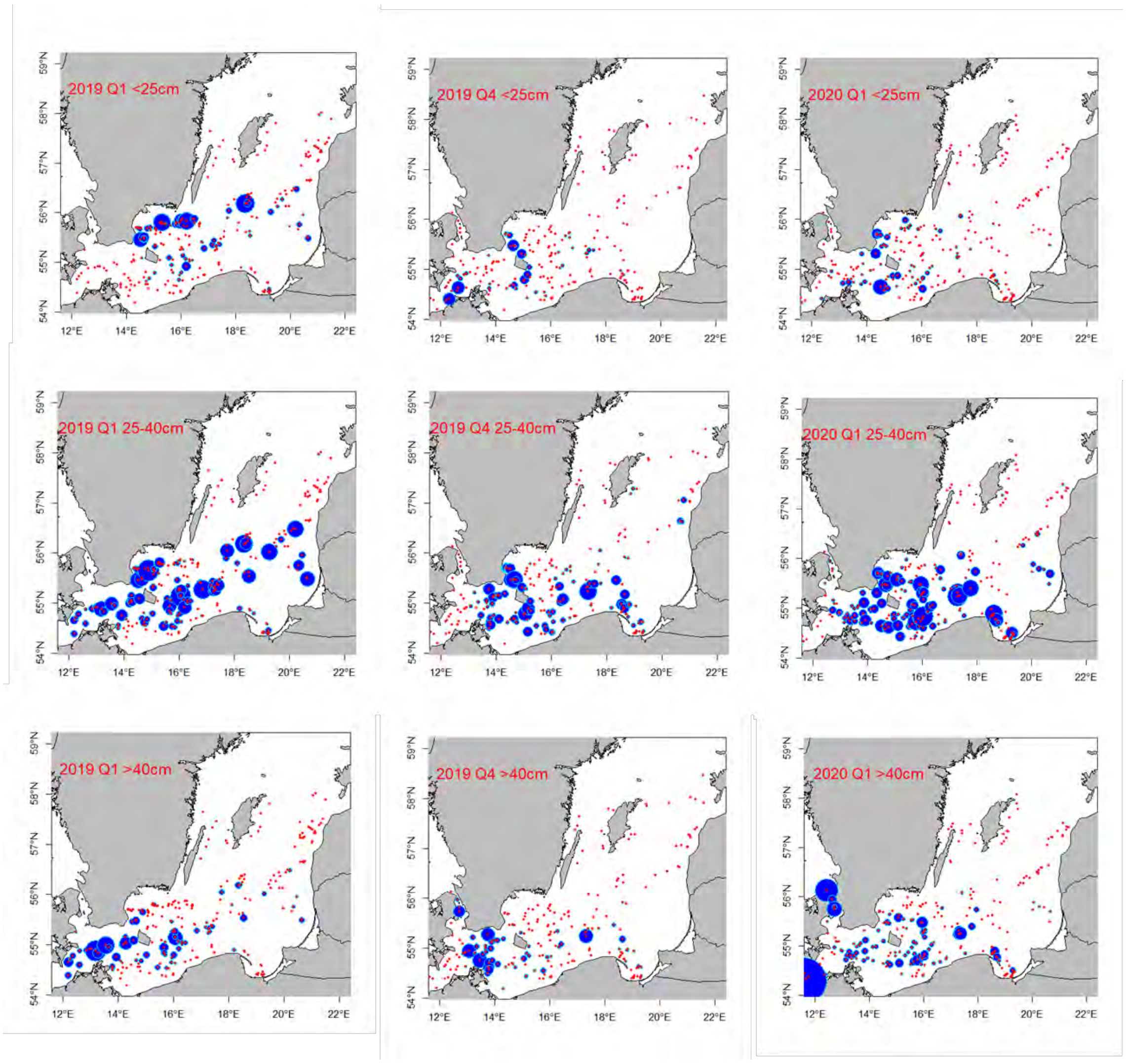


Figure 2.1.3. Eastern Baltic cod in SDs 24-32. Distribution of cod from BITS surveys in Q1 and Q4 in 2019 and Q1 in 2020, by 3 size-groups (<25 cm, 25-40 cm and >40 cm cod). The scale is comparable between surveys within a size group, but not between size-groups.

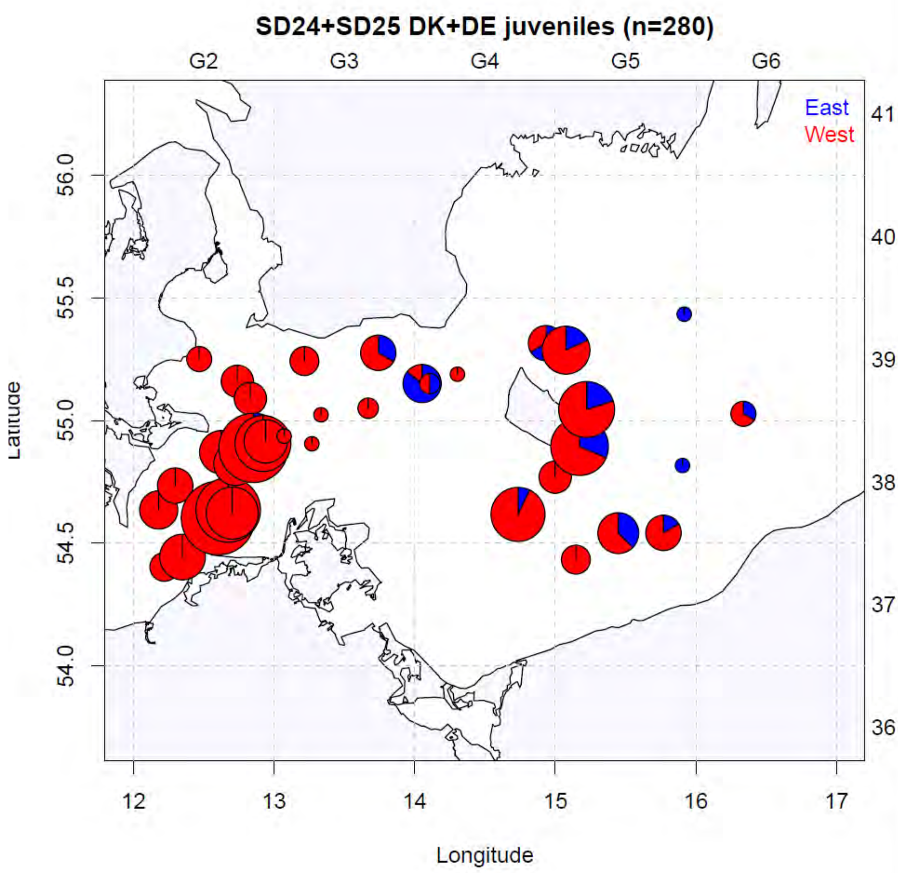


Figure 2.1.4. Eastern Baltic cod in SDs 24-32. Proportion of eastern and western juvenile cod in samples taken in BITS Q4 2019 survey, based on genetic analyses.

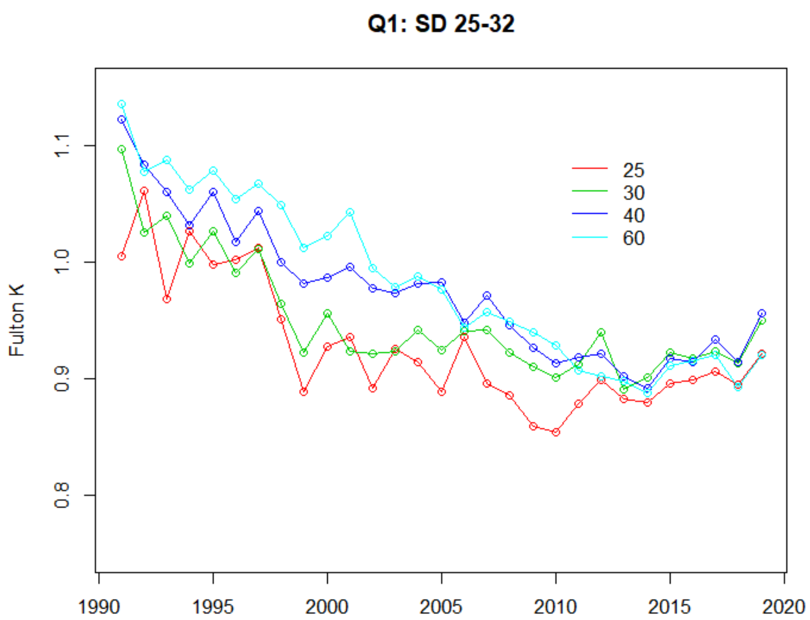


Figure 2.1.5. Eastern Baltic cod in SDs 24-32. Condition (Fulton K) of cod by length groups (<25 cm, 25-30 cm, 30-40 cm, 40-60 cm) in Q1 BITS survey.

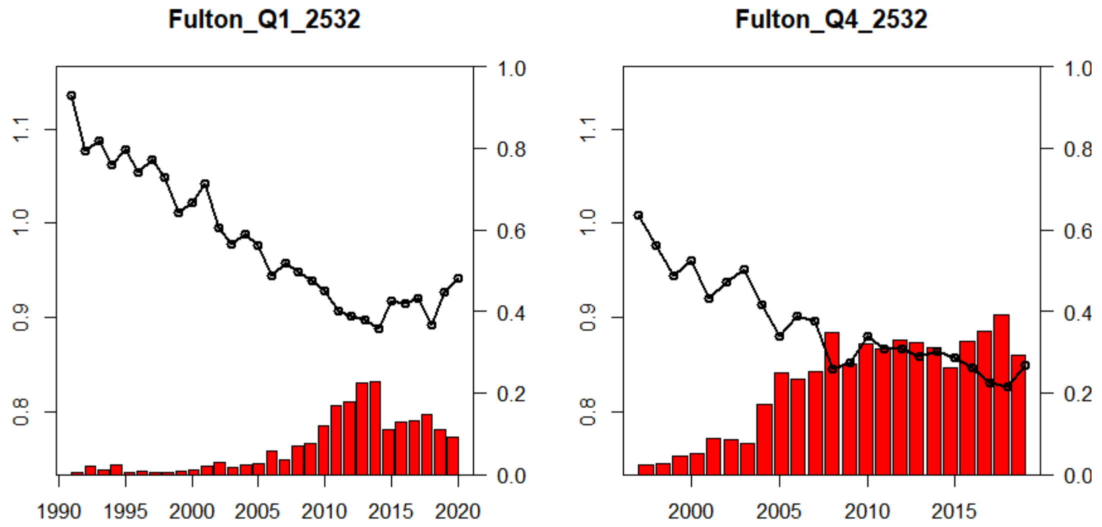


Figure 2.1.6. Eastern Baltic cod in SDs 24-32. Average condition (Fulton K) of cod at 40-60 cm in length in Q1 and Q4 BITS survey in SD 25-32. The lines show mean values for Fulton K, the bars show the proportion of cod at Fulton K <0.8.

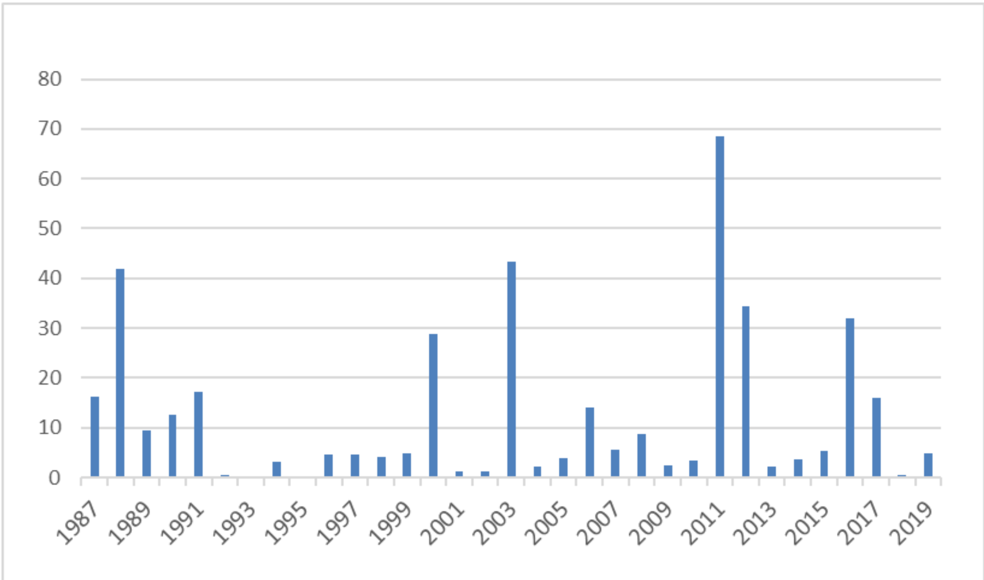


Figure 2.1.7. Eastern Baltic cod in SDs 24-32. Abundance of larvae in the main spawning area during peak spawning time.

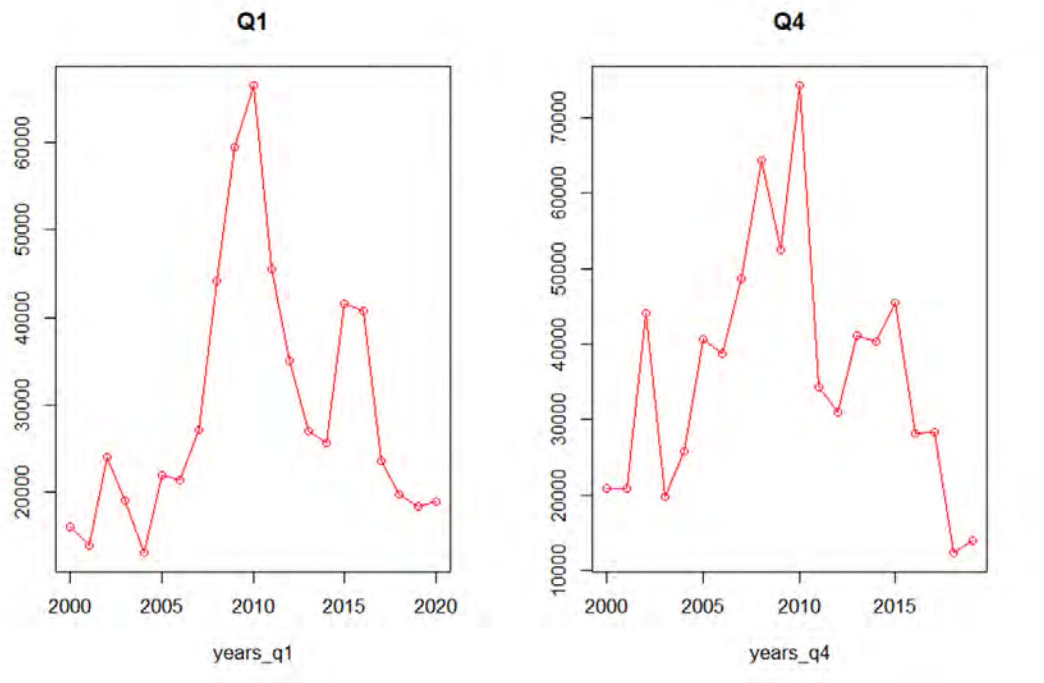


Figure 2.1.8. Eastern Baltic cod in SDs 24-32. Relative total biomass index, estimated from Q1 and Q4 BITS surveys.

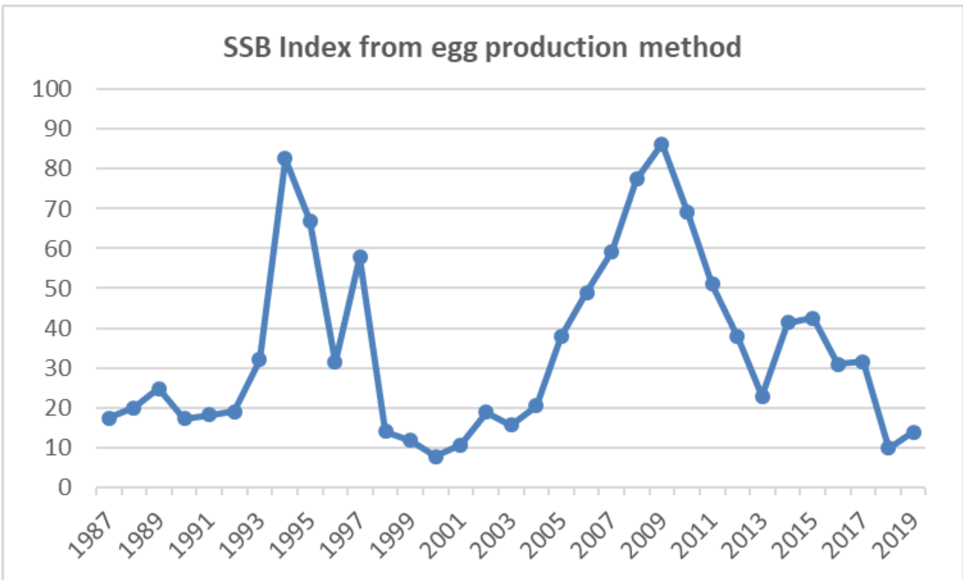


Figure 2.1.9. Eastern Baltic cod in SDs 24-32. Index of spawning stock biomass, calculated from egg production method. Data are from ichthyoplankton surveys.

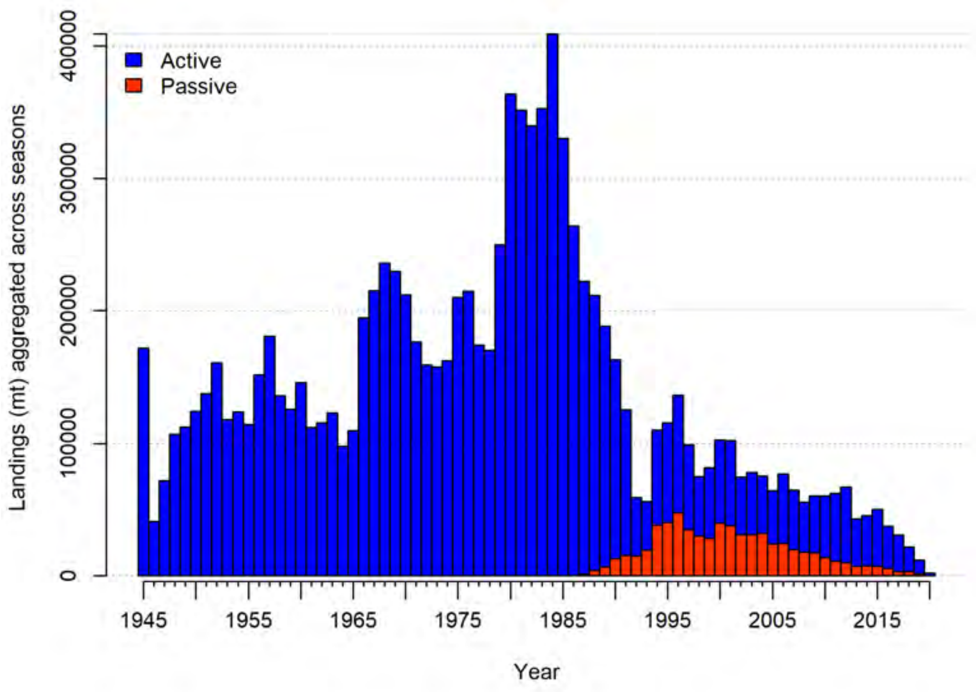


Figure 2.1.10. Eastern Baltic cod in SDs 24-32. Time-series of total catch used in the assessment, by fleets).

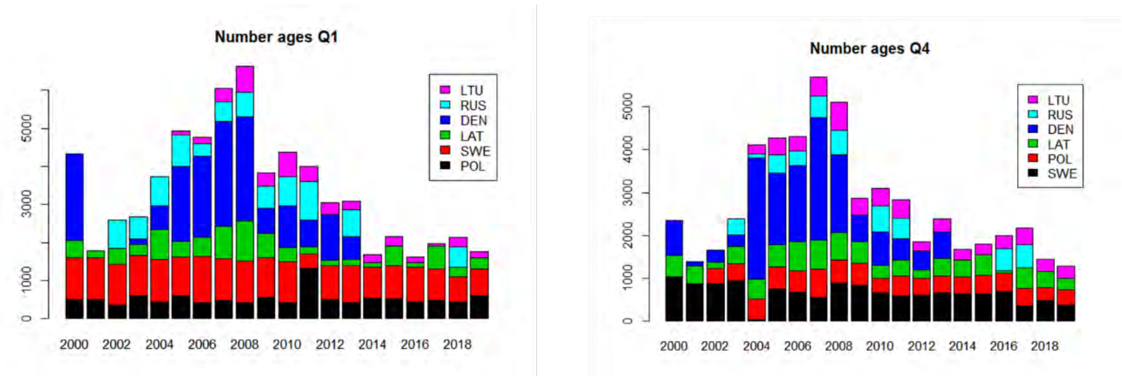


Figure 2.1.11. Eastern Baltic cod in SDs 24-32. Numbers of cod with age readings, for BITS Q1 and Q4, by country.

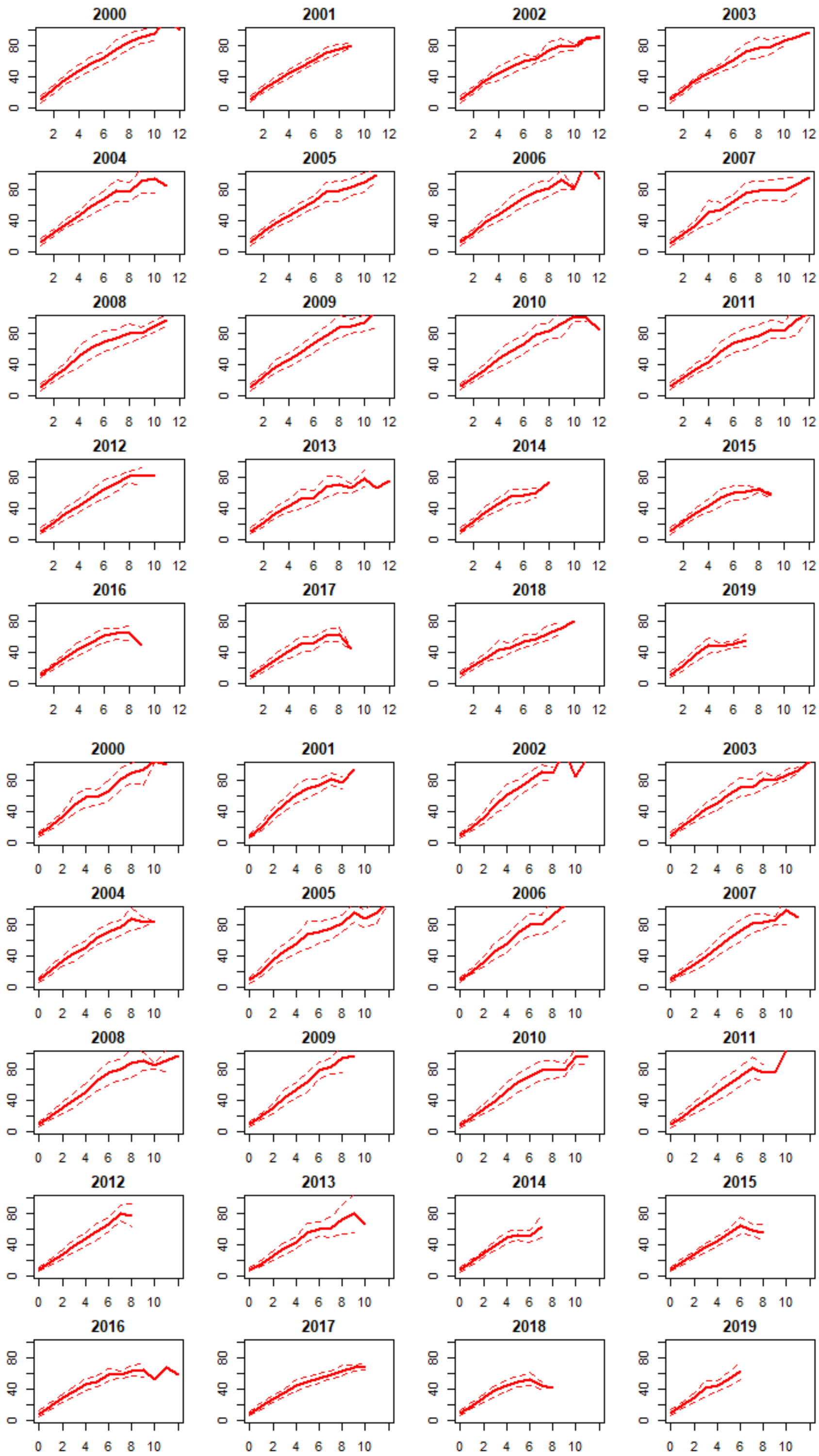


Figure 2.1.12. Eastern Baltic cod in SDs 24-32. Mean length at age (LAA) based on average annual ALKs of all countries included in DATRAS, for BITS Q1 (upper panels) and BITS Q4 (lower panels) (individual sample data only, not raised to the population).

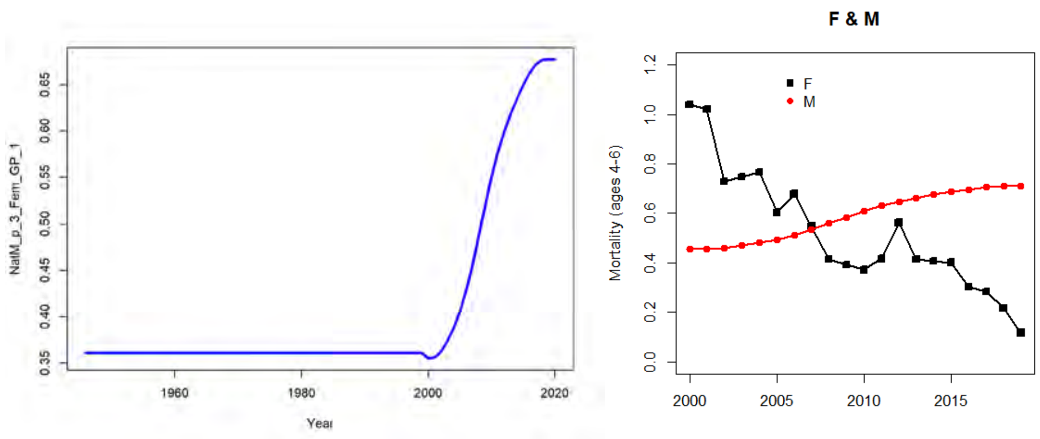


Figure 2.1.13. Eastern Baltic cod in SDs 24-32. Change in natural mortality for age-break 5.5, estimated in Stock Synthesis model (left panel). Fishing mortality (F) and natural mortality (M) for ages 4-6 (right panel).

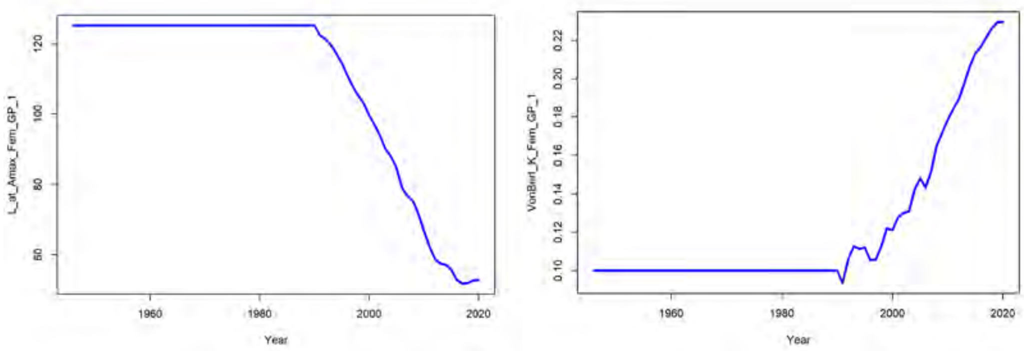


Figure 2.1.14. Eastern Baltic cod in SDs 24-32. Estimated change in von Bertalanffy growth parameters Linf (left panel) and K (right panel) from Stock Synthesis model.

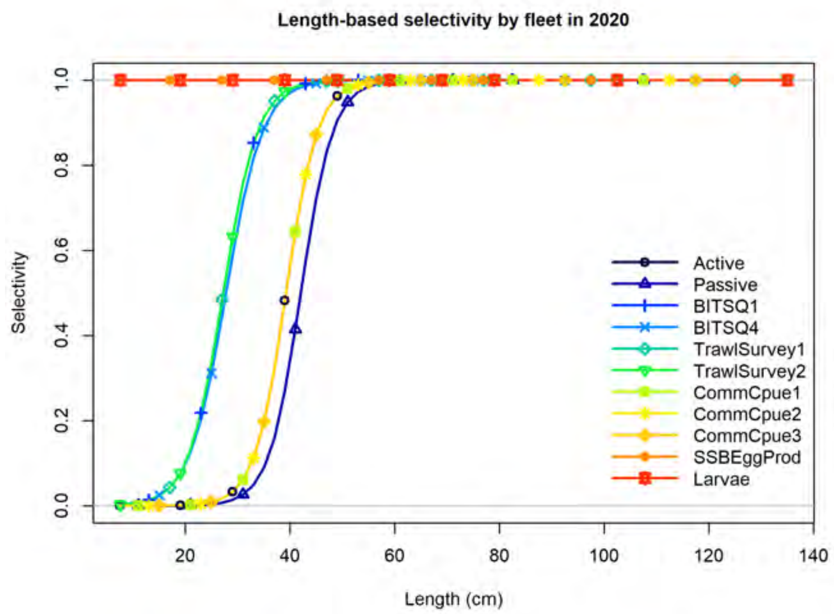


Figure 2.1.15. Eastern Baltic cod in SDs 24-32. Selectivity of different fleets.

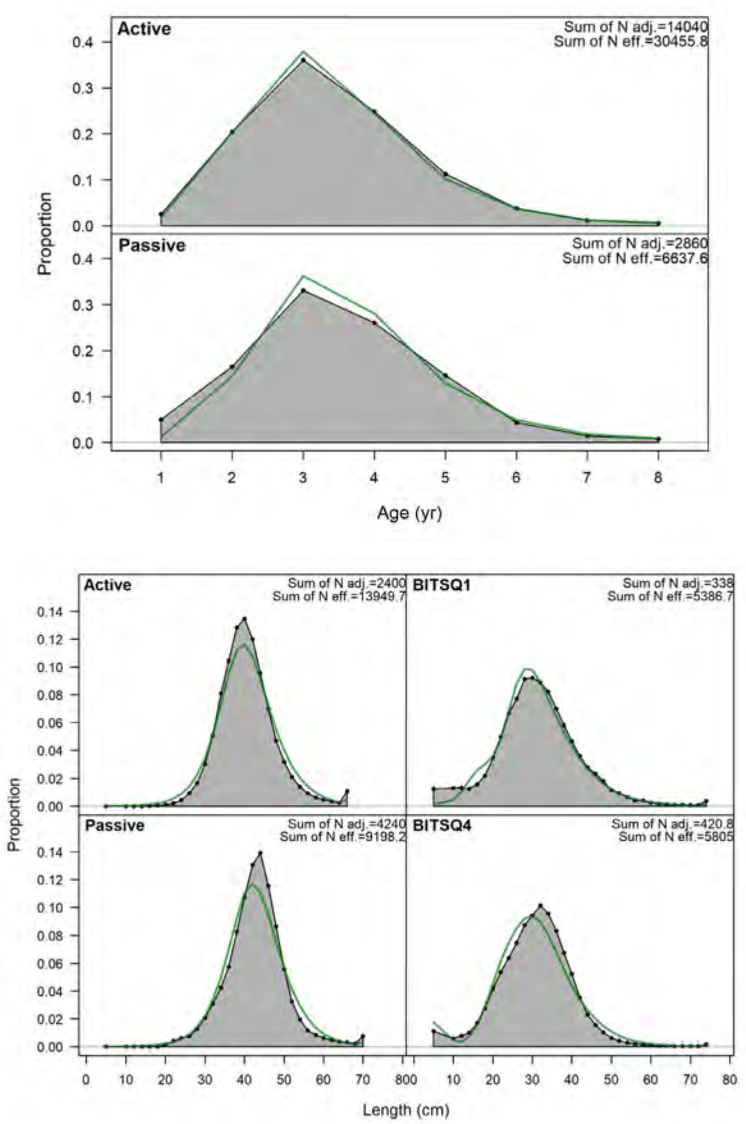
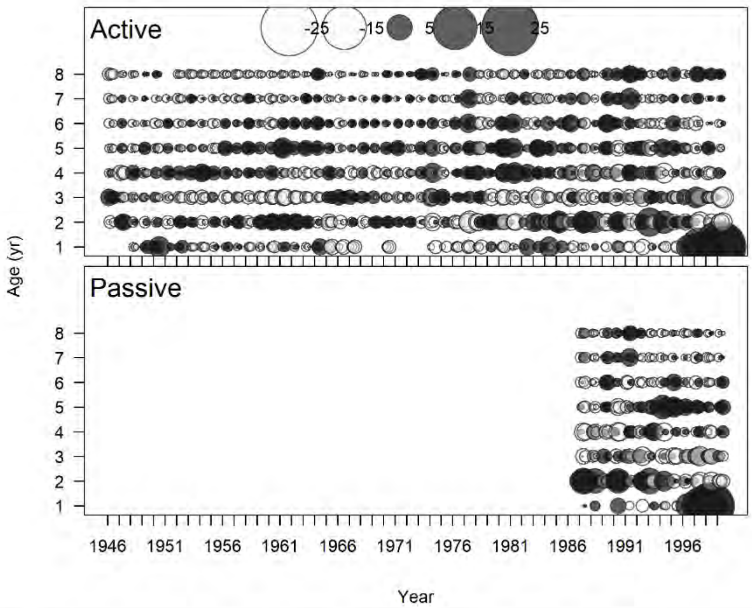


Figure 2.1.16. Eastern Baltic cod in SDs 24-32. Fits to age (upper panels) and length (lower panels) composition data, aggregated across years.


Active
-25
-15
5
15
25
Passive
Age (yr)
1946 1951 1956 1961 1966 1971 1976 1981 1986 1991 1996
Year

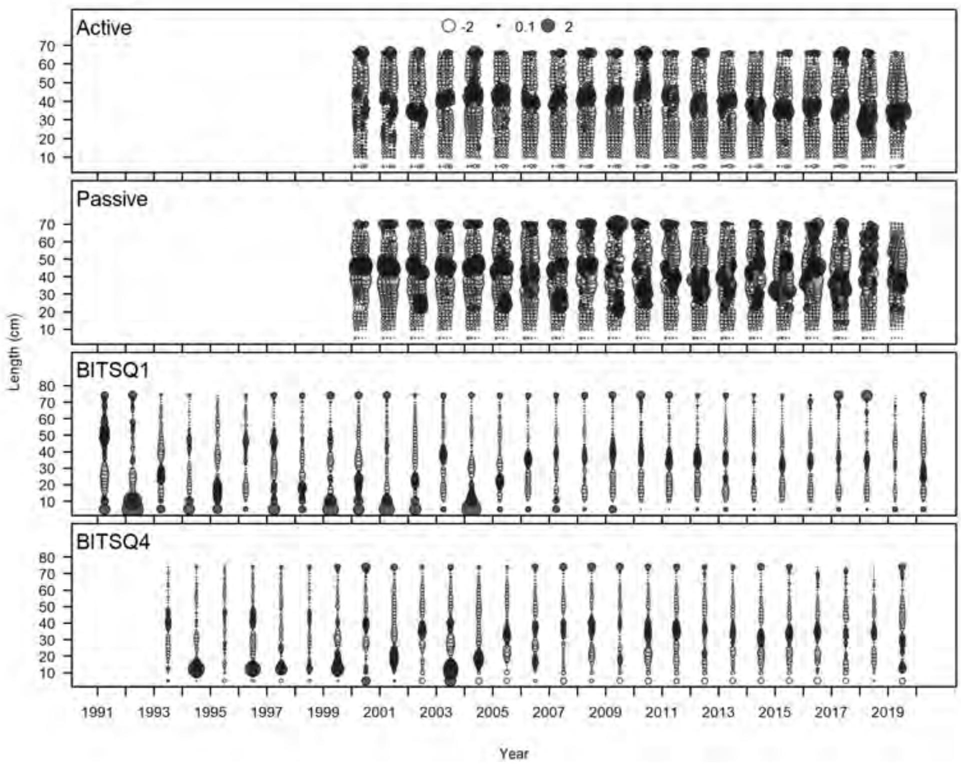

Active
-2
0.1
2
Passive
BITSQ1
BITSQ4
Length (cm)
1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019
Year

Figure 2.1.17. Eastern Baltic cod in SDs 24-32. Residuals of fits to age (upper panels) and length (lower panels) composition data for different fleets.

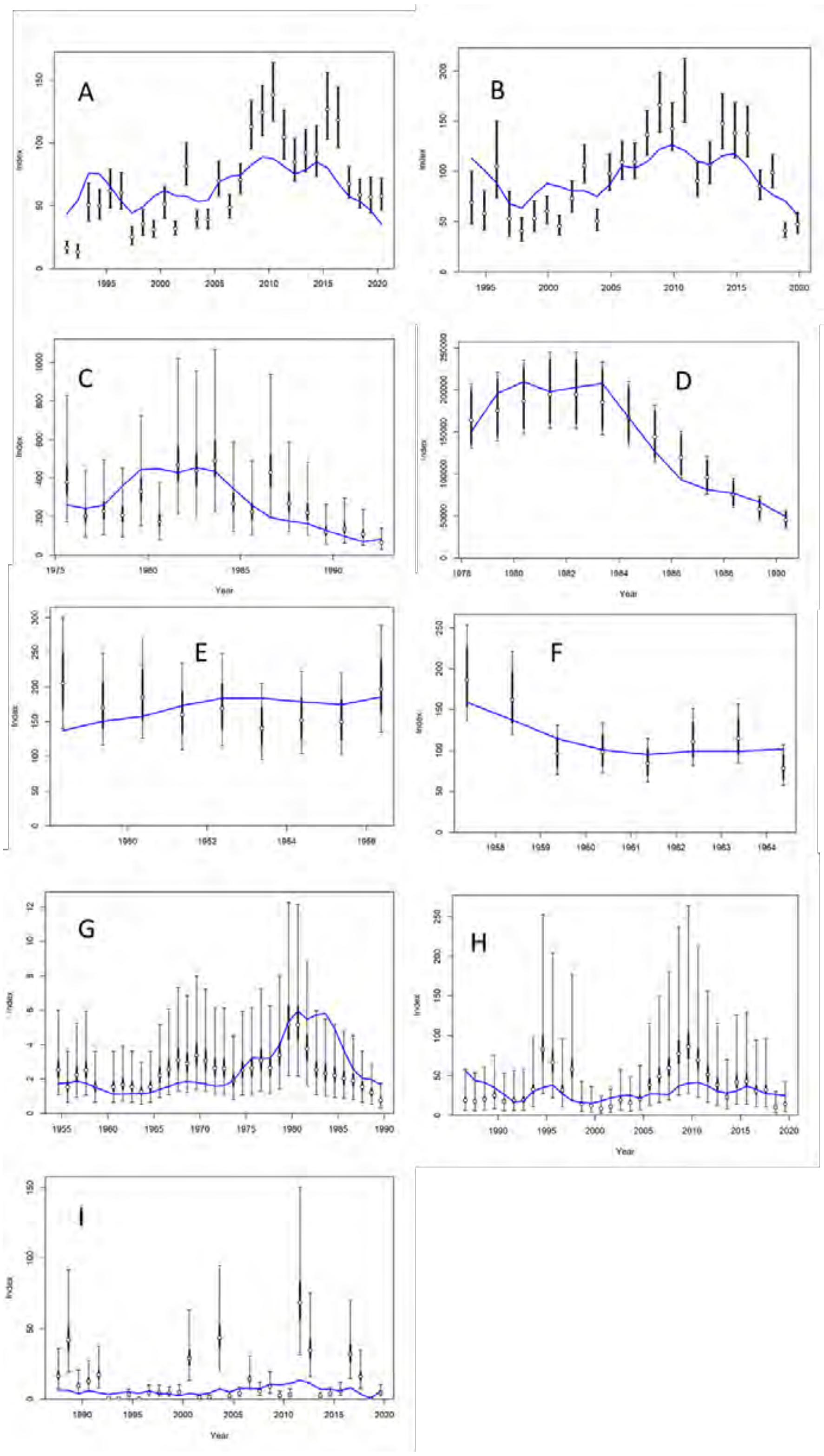


Figure 2.1.18. Eastern Baltic cod in SDs 24-32. Model fits to different tuning indices. A- BITSQ1; B-BITSQ4; C- TrawlSurvey1; D- TrawlSurvey2; E- CommCpue1; F- CommCpue2; G- CommCpue3; H- SSBEggProd; I- Larvae.

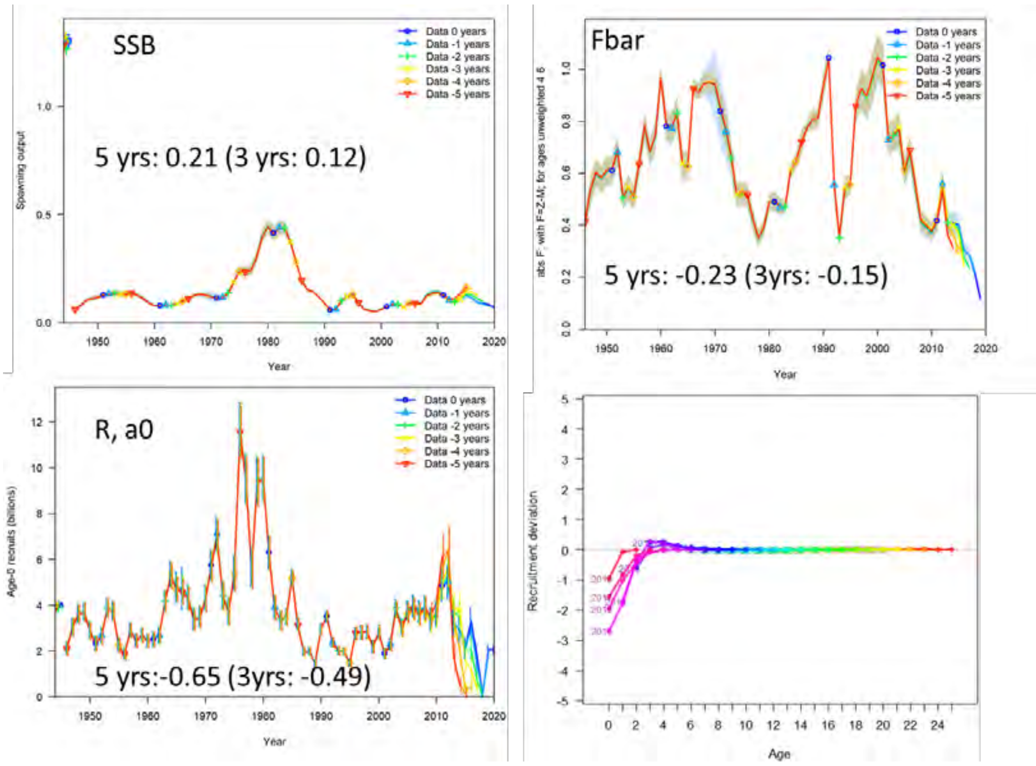


Figure 2.1.19. Eastern Baltic cod in SDs 24-32. Retrospective analyses, including Mohn's Rho values estimated for 5 years and 3 years (in brackets).

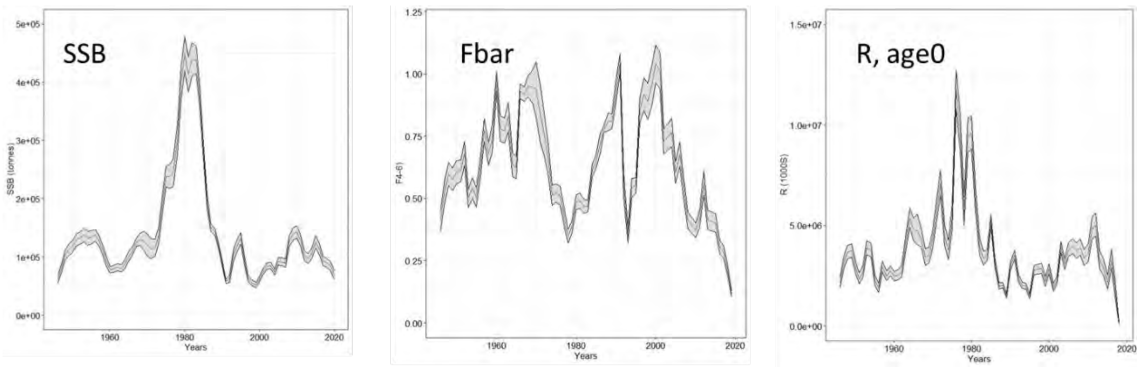
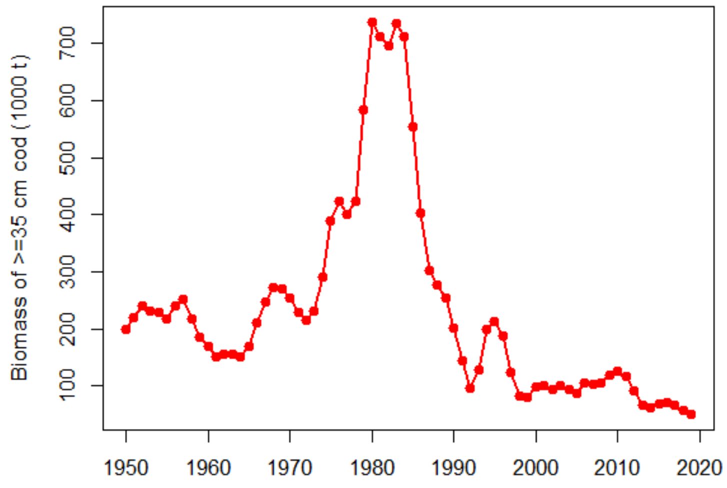


Figure 2.1.20. Eastern Baltic cod in SDs 24-32. Spawning stock biomass, fishing mortality (average of ages 4-6) and recruitment (age 0).


Biomass of >=35 cm cod (1000 t)
100
200
300
400
500
600
700
1950
1960
1970
1980
1990
2000
2010
2020

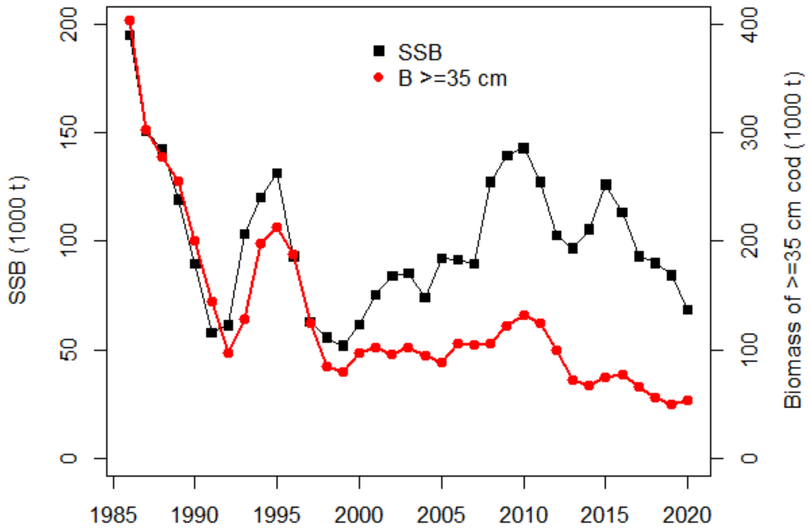

SSB
B >=35 cm
SSB (1000 t)
Biomass of >=35 cm cod (1000 t)
0
50
100
150
200
0
100
200
300
400
1985
1990
1995
2000
2005
2010
2015
2020

Figure 2.1.21. Eastern Baltic cod in SDs 24-32. Biomass of commercial sized cod (≥35 cm in length) (upper panel), compared to SSB in later years (lower panel).

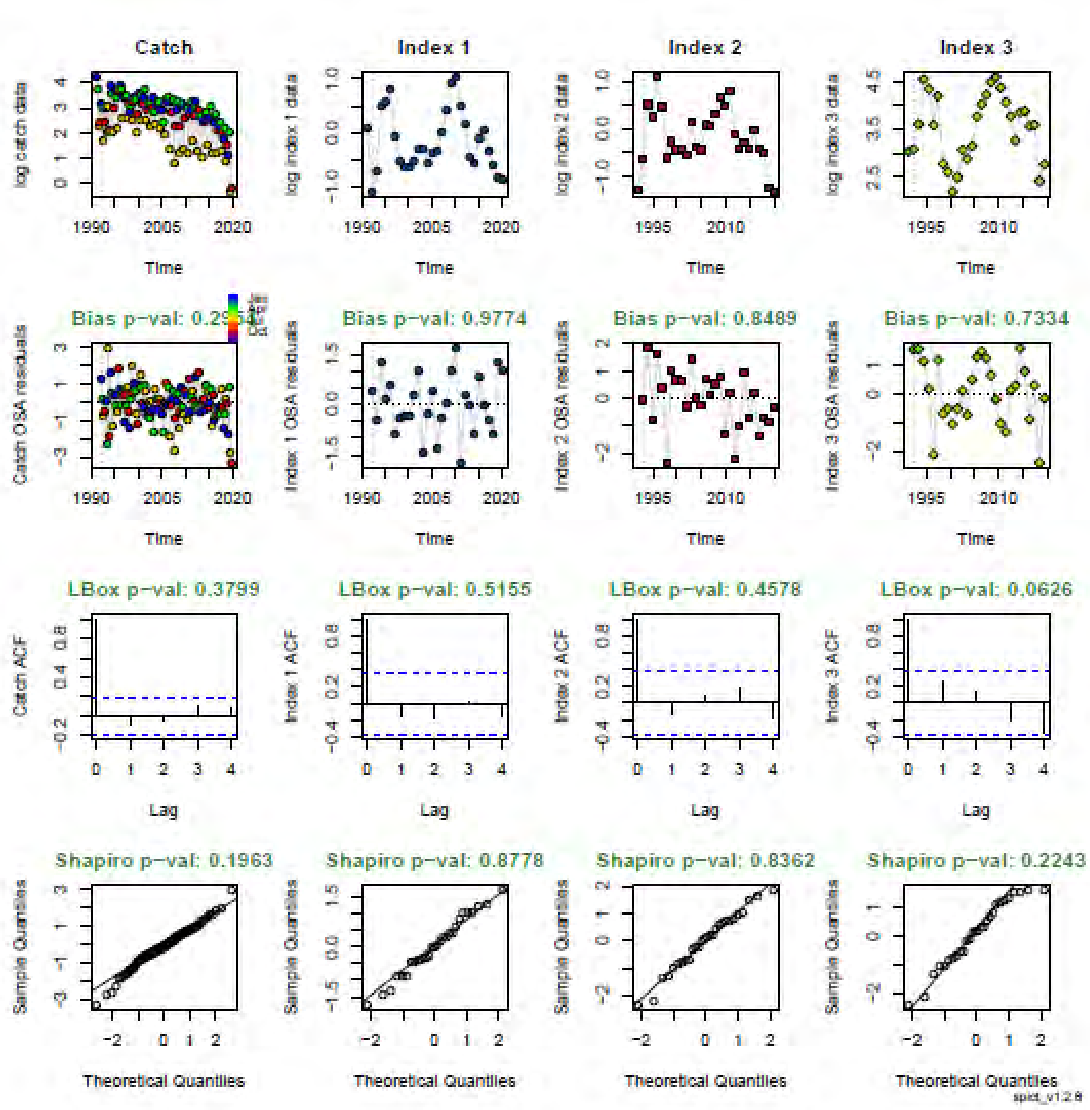


Figure 2.1.22. Eastern Baltic cod in SDs 24-32. Diagnostics of SPICT model.

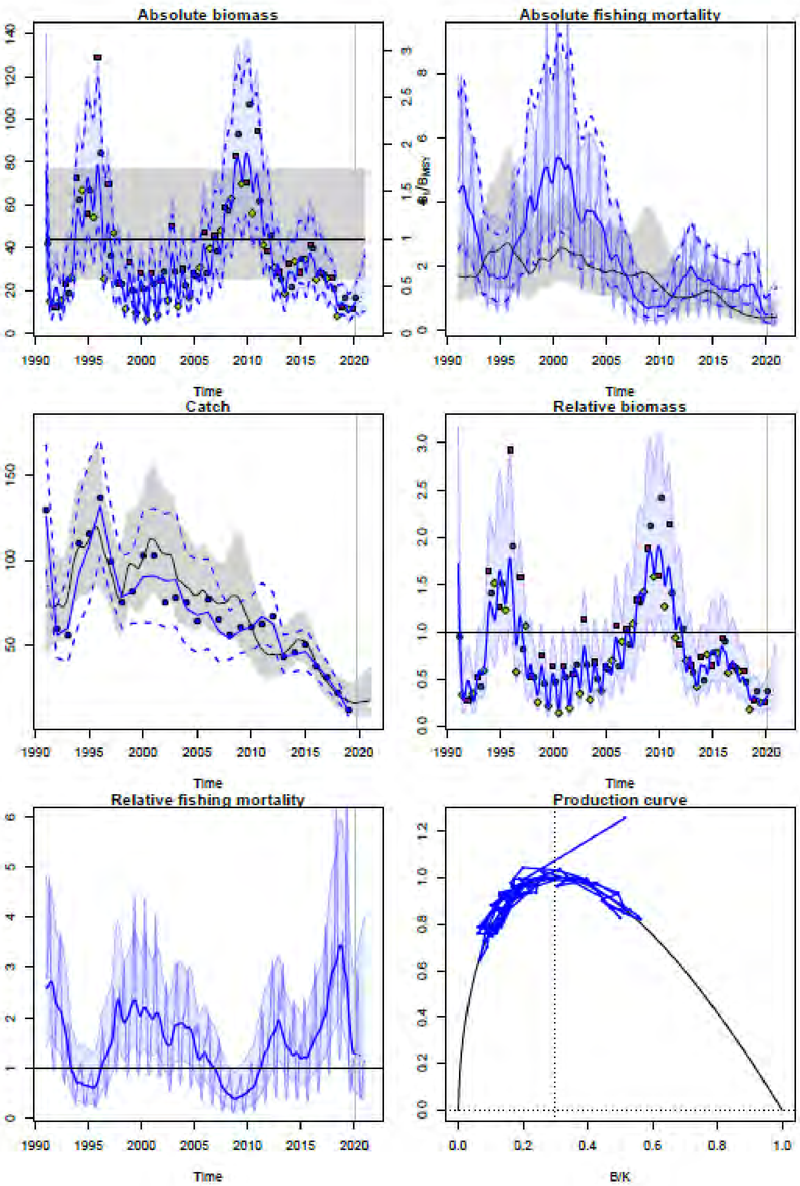


Figure 2.1.23. Eastern Baltic cod in SDs 24-32. Results of SPICT model.

2.2 Cod in Subdivision 21 (Kattegat)

2.2.1 The fishery

2.2.1.1 Recent changes in fisheries regulations

The TAC is mainly regulating the fishing of cod 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 the North Sea (incl. Kattegat), a new effort system was introduced. In this system each Member State was given kW days for different gear groups. It was then the MS responsibility to distribute the kW days among fishing vessels. MS could apply for derogation from the kW days 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 kW day 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 (mainly of the *Nephrops* fishery) where the landings of cod should constitute of 50% of the total landings.

In 2017 the cod in Kattegat came under the landing obligation. This has however not affected the discard rate of undersized cod which still remains at high levels.

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 to 32 mm carapace width) 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 also affect the Kattegat cod stock development.

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 Kattegatat in 2019 were 84 tonnes, lower levels than last years (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. In spite of that there has been a discard ban of Kattegat cod since 2017, there is no BMS landing reported so far.

Discard estimates were available from Sweden for 1997—2019 and from Denmark for 2000—2019. The estimated discard numbers by age and total discards in tons are presented in Figure 2.2.2 and in Table 2.2.2. The sampling levels are shown in Tables 2.2.3 and 2.2.4a,b.

In 2018, the estimated discards formed about 33% of the catch weight and the proportion of discards in the catches has increased slightly in the last year compared to the previous year (Figure 2.2.1). In numbers, the available data indicates that close to 59% of the cod caught in the Kattegat is discarded. Discarding has in 2019 as in previous years mostly affected ages 1-2

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. The 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 2019. 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 2019, presented in Table 2.2.7, 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 three 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 maturity based on visual inspections used in the assessment are presented in Table 2.2.9. The estimates are based on the 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 three 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 the IBTS 1st and 3rd quarter surveys, from the BITS 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) (1997-2020)
IBTS-3Q	International Bottom Trawl Survey, 3rd quarter, Kattegat (age 1-4) (1997-2019)
IBTS-1Q	International Bottom Trawl Survey, 1st quarter, Kattegat; (Ages 1-6) (1997-2020)
CODS-4Q	Cod survey, 4th Quarter, Kattegat, (ages 1-6). (2008-2019)

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. 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 were performed.

Catch (landings and discards) from 1997—2019 with estimating total removals from 2003—2019 within the model based on survey information. (SPALY _Scaling)

Catch (landings and discards) from 1997—2019 without estimating total removals (SPALY _)

Unallocated removals were estimated separately for the years 2003—2019, but common for all age-groups within a year. The scaling factors estimated for 2005—2019 were significant for all the years in the SAM run with landings and total removals estimated. 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 Figures 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 are shown in Fig 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 with cod from the Western Baltic Sea. Additionally, discards are associated with uncertainties, at least for part of the time series. There has not been a recruitment above the average since 2012, the year classes of 2014 and 2015 are the lowest in the times series (Figure 2.2.5 and 2.2.6). However, the year class of 2019 was higher than the year classes in 2017 and 2018 but still below average recruitment over the whole time period (Figures 2.2.5 and 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 were some signs of a recovery in the 2015 but the SSB level are at historical low level again in 2020.

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 continues due the lack of stronger 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 0.7 to 2.0. In contrast, the run without estimating total removals in the interval of 0.5 to 1.7. (Tables 2.2.11—2.2.12, Fig 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—2019, 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 mismatch.

Therefore, the current level of fishing mortality cannot be reliably estimated and is in the range of 0.5-2.0 in the SPALY runs. The exact estimates of SSB are considered uncertain, however all available information consistently indicates that SSB is at historically low levels in 2018, around 89 to 1092 tonnes.

2.2.8 Comparison with previous assessment

The assessment was performed using state-space assessment model (SAM) as 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 this 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 in the last years.
The removal of the effort system has led to a 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 may dramatically increase the fishing mortality of the Kattegat cod.
Furthermore, the substantial decrease in the fishing opportunities of the eastern Baltic cod fishery will potentially also lead to an increase in fishing pressure when fishing capacity is moved from the eastern Baltic cod fishery to the Norway lobster fishery in the Kattegat. The movement of capacity could 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. Obligatory use of devices that reduce cod bycatch appear to be a necessary requirement for recovery of the cod stock in the Kattegat when the current fishing patterns on *Nephrops* and flatfish fisheries are not changed.

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 the North Sea are needed, to be incorporated in the model, or used to validate the values estimated in the model. The first step would be to analyze historical samples to determine stock origin for individuals at age 1, for the last 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 analyze the samples back in time that would be needed 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.

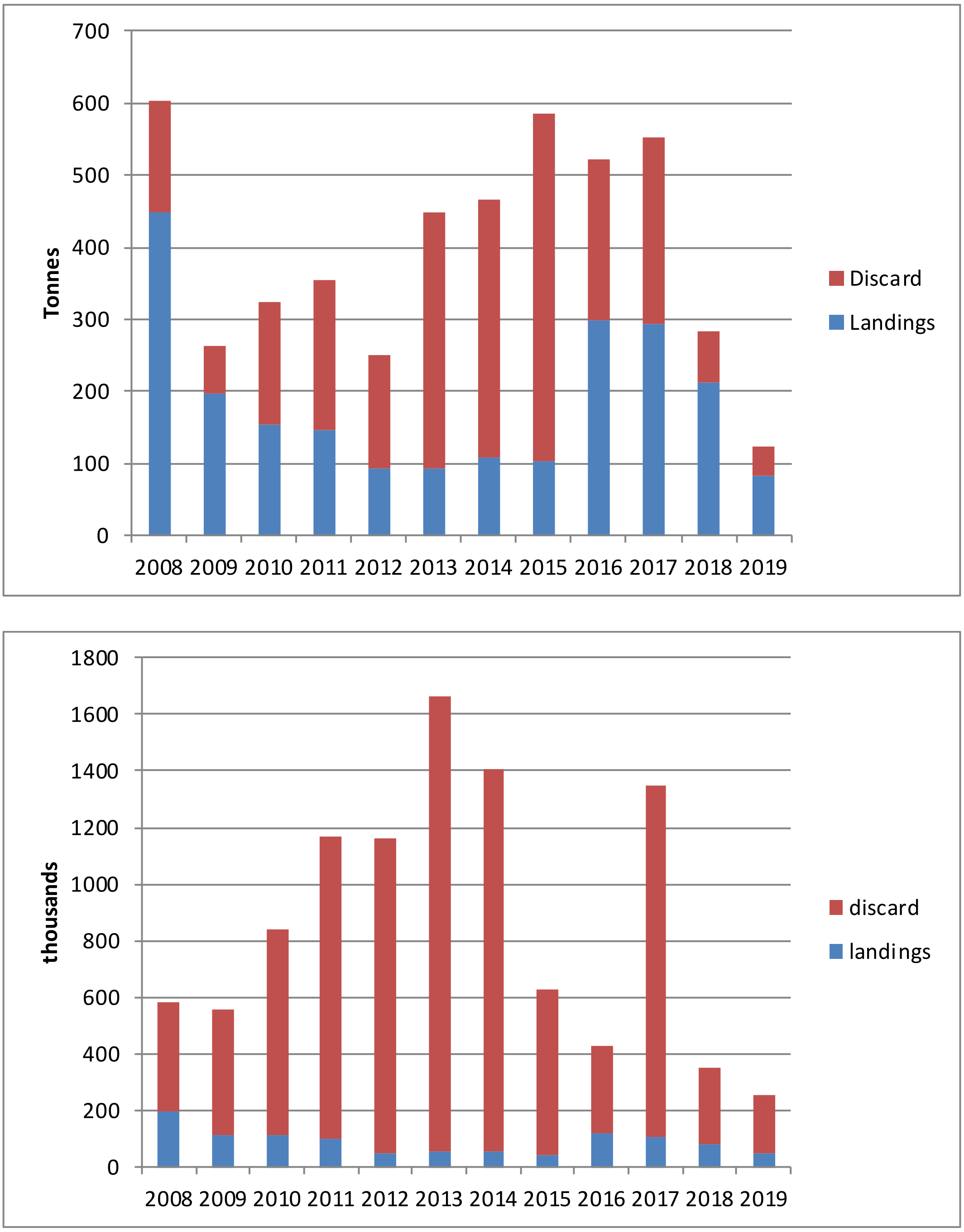


Figure. 2.2.1. Cod in the Kattegat. Estimates of discards (Denmark and Sweden combined) compared to reported landings, in tonnes (upper panel) and in numbers (lower panel).

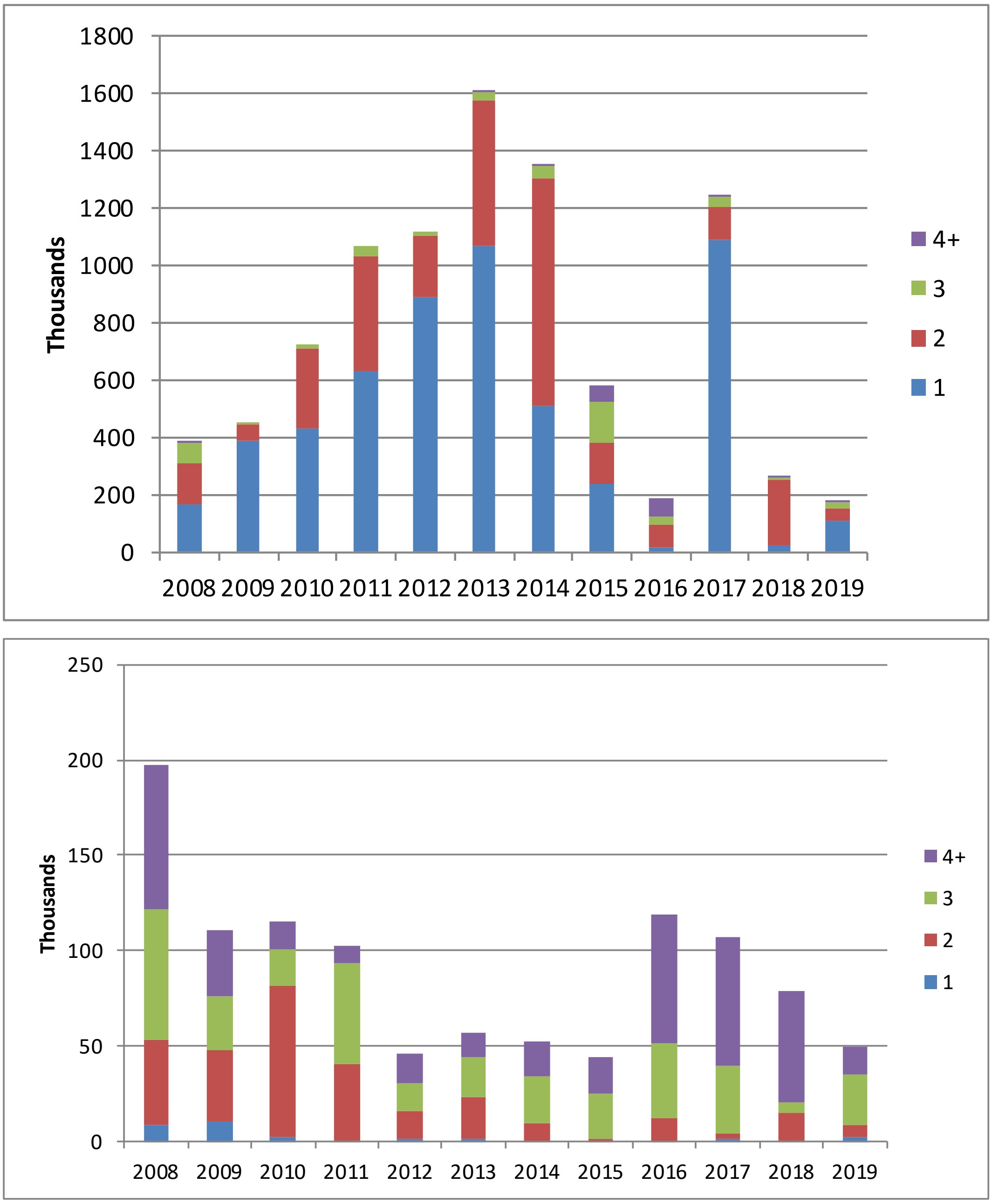
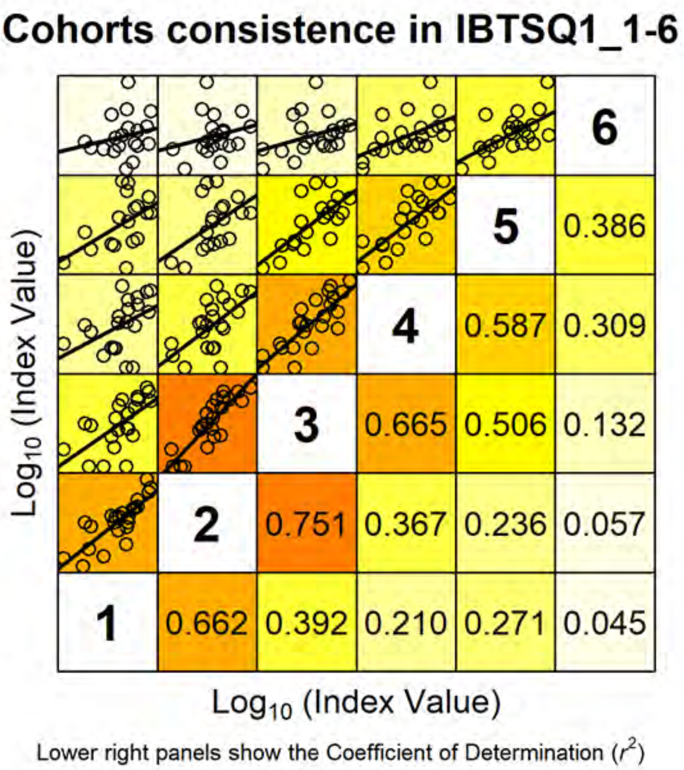
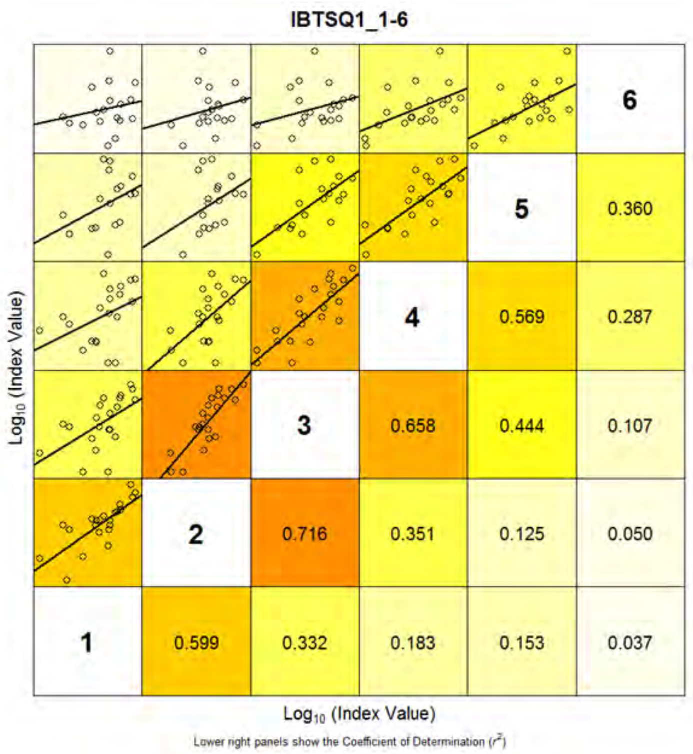


Figure. 2.2.2. Cod in the Kattegat. Estimates of discards in numbers-at-age in the upper panel. Landings in numbers by age in the lower panel (Sweden and Denmark combined).

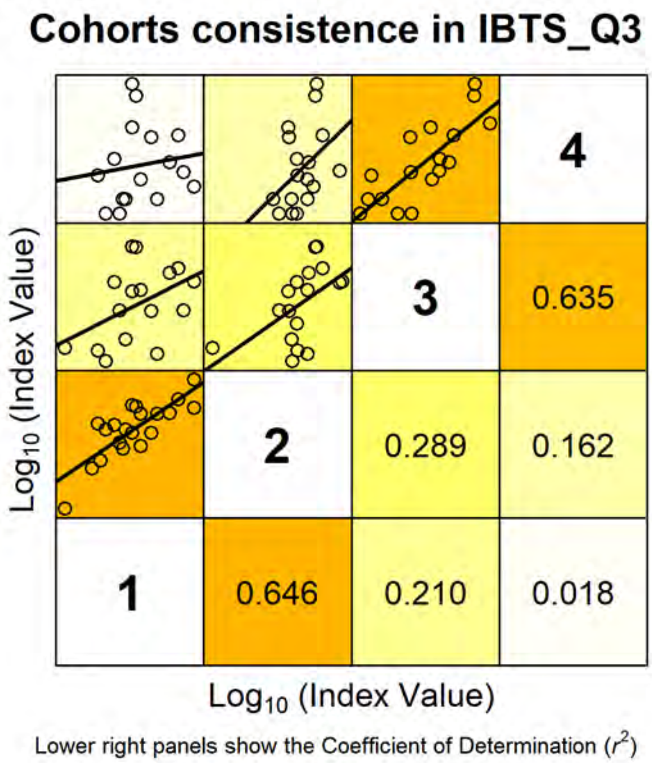


2019

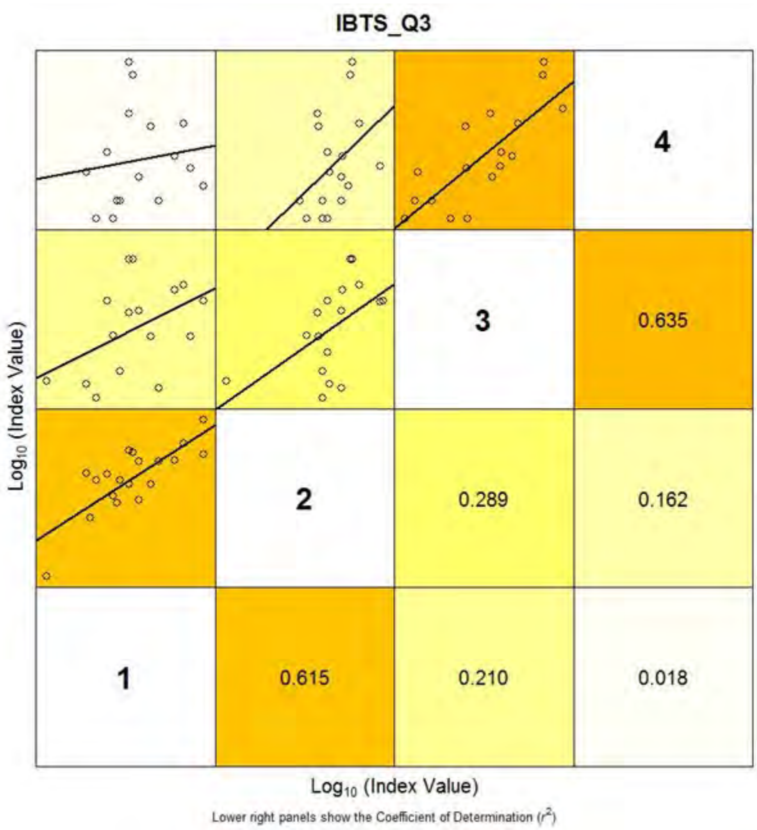


2018

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 2000-2019. Upper 2019 and lower 2018

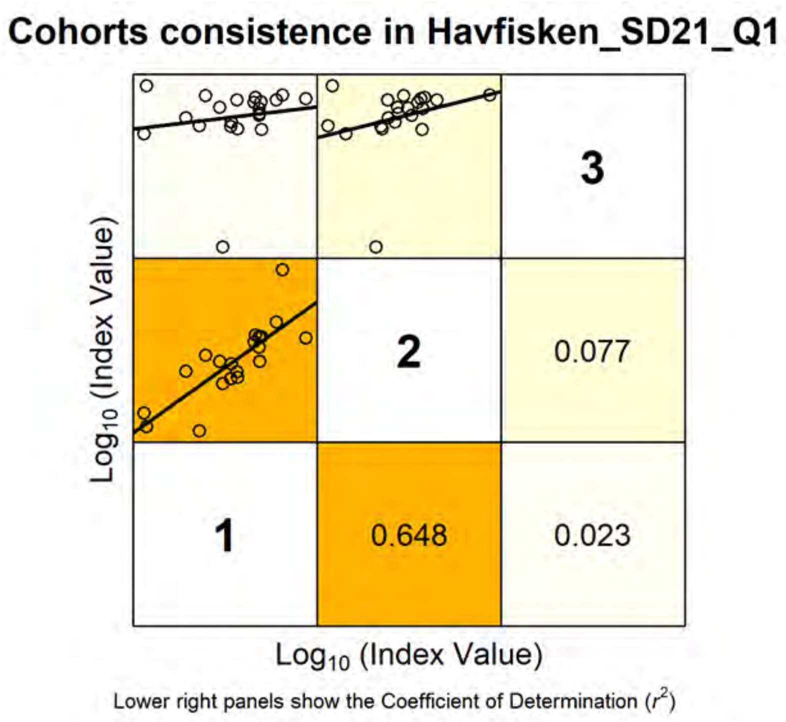


2019

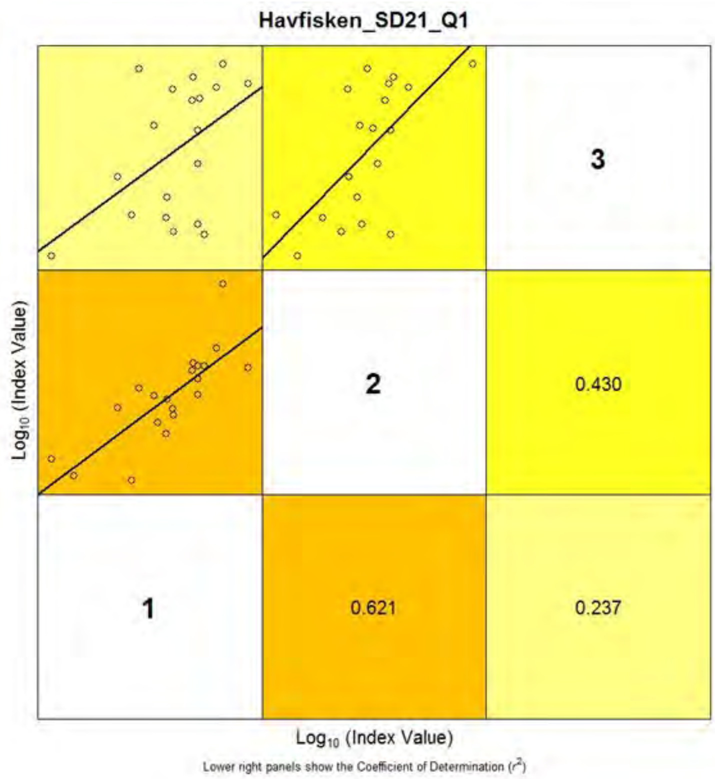


2018

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 2000-2019. Individual points are given by year-class. Upper plot 2019 and lower 2018.

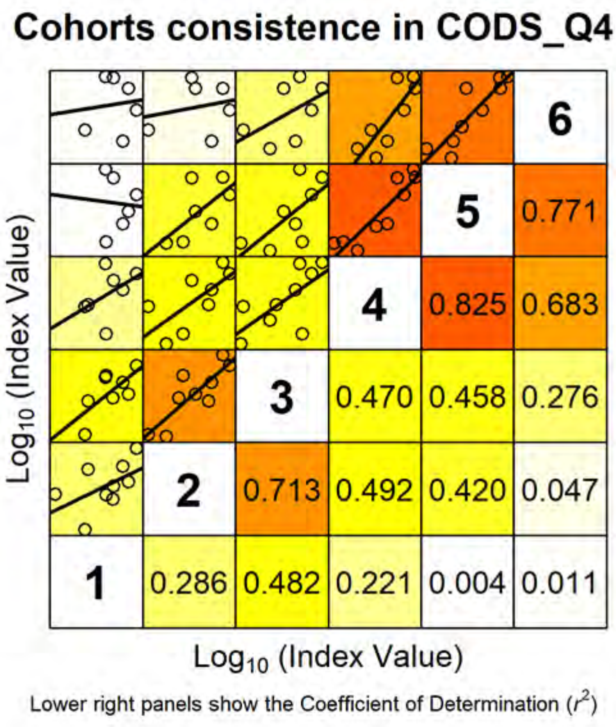


2019

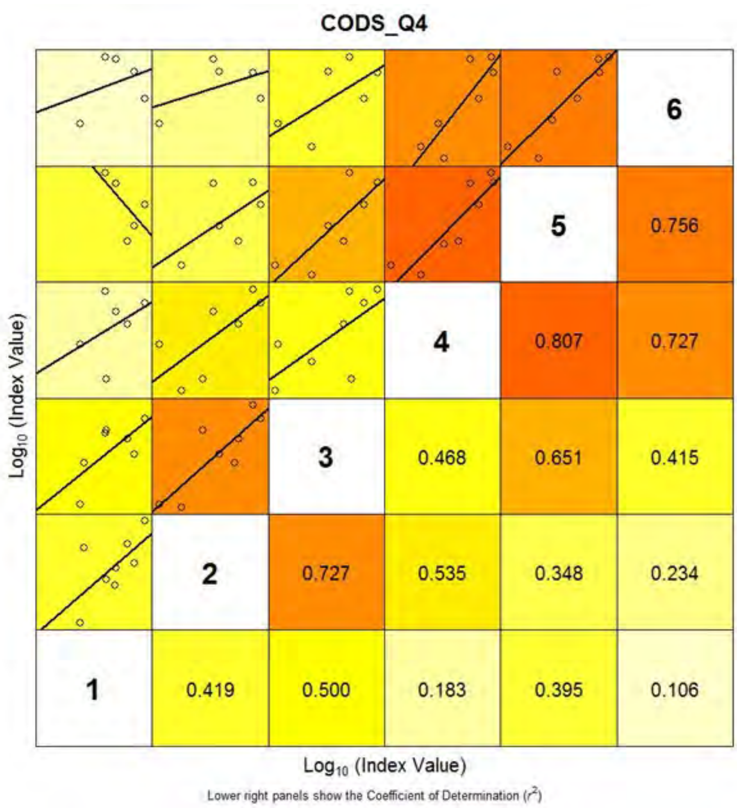


2018

Figure 2.2.3c. Cod in Kattegat. Havfisken 1st quarter survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2000-2019. Upper plot 2019, lower 2018.



2019



2018

Figure 2.2.3d. Cod in Kattegat. Cod survey quarter 4survey numbers at age vs numbers at age +1 of the same cohort in the following year in the period 2008-2019. Individual points are given by year-class. Red dots highlight the information from the latest year. Upper plot 2019, lower plot 2018

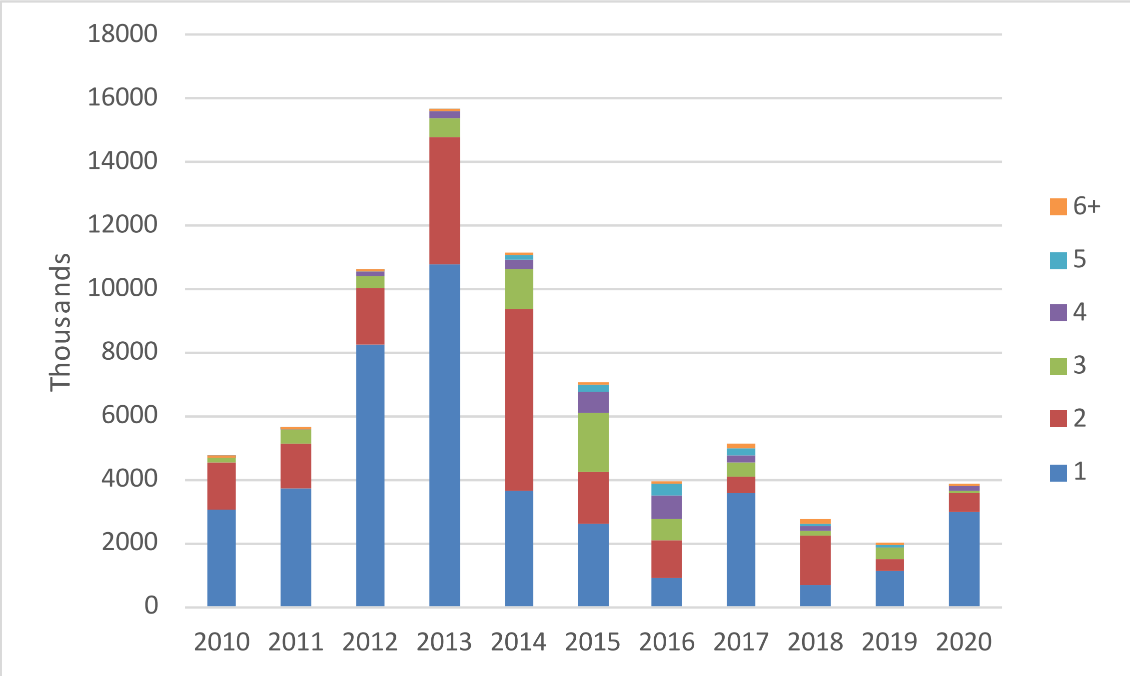


Figure 2.2.4. Stock numbers in numbers-at-age 2010-2020 from SAM output

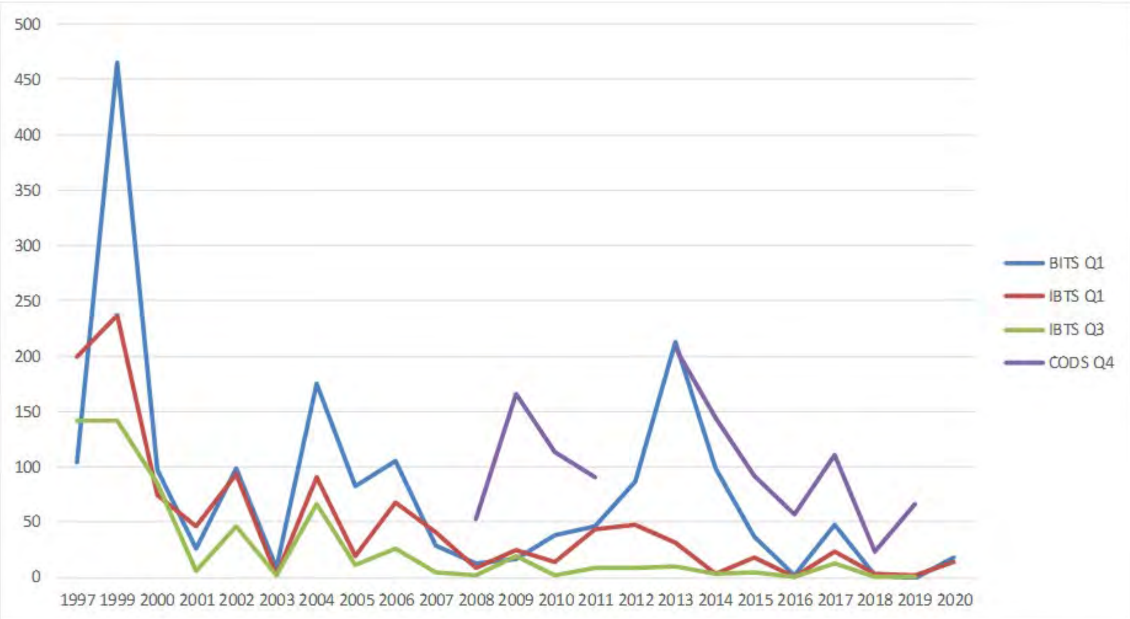


Figure 2.2.5. Cod in the Kattegat. Trends in recruitment index (Age 1) from different surveys.

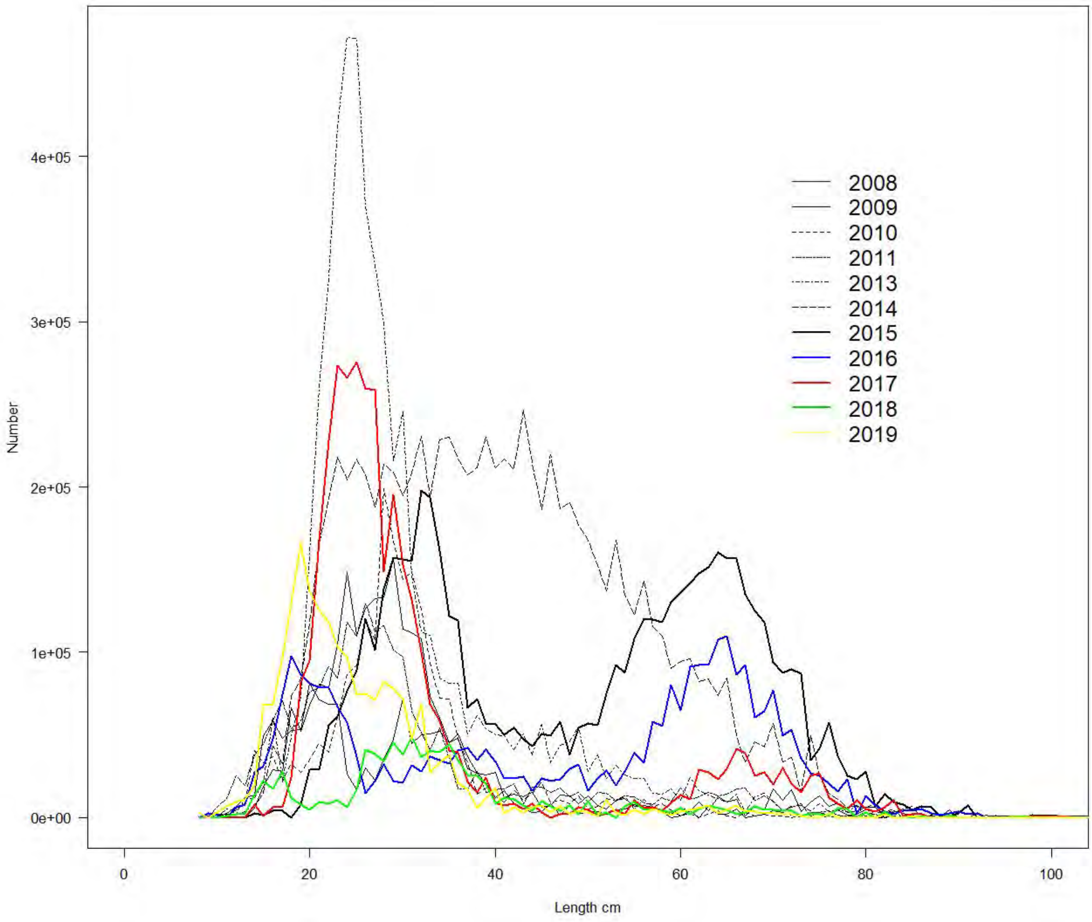


Figure 2.2.6. Length distributions from the Cod survey 2008-2019.

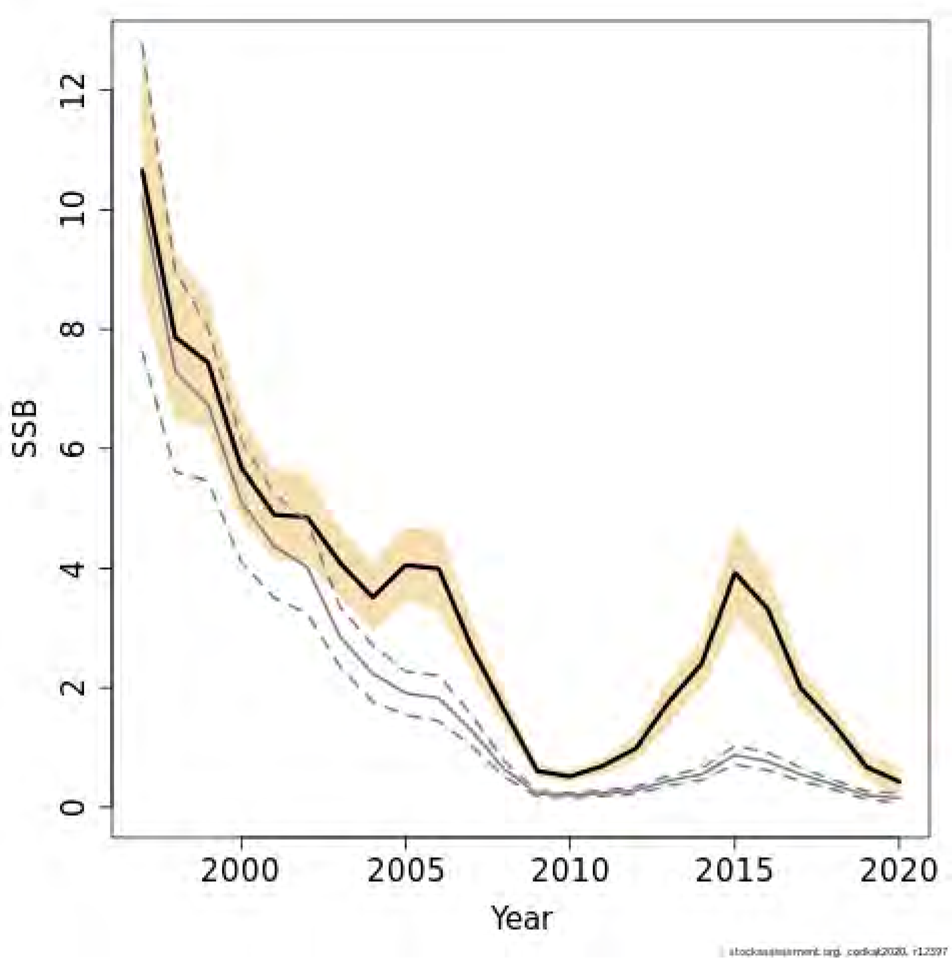


Figure 2.2.7. SSB. SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95% confidence interval).

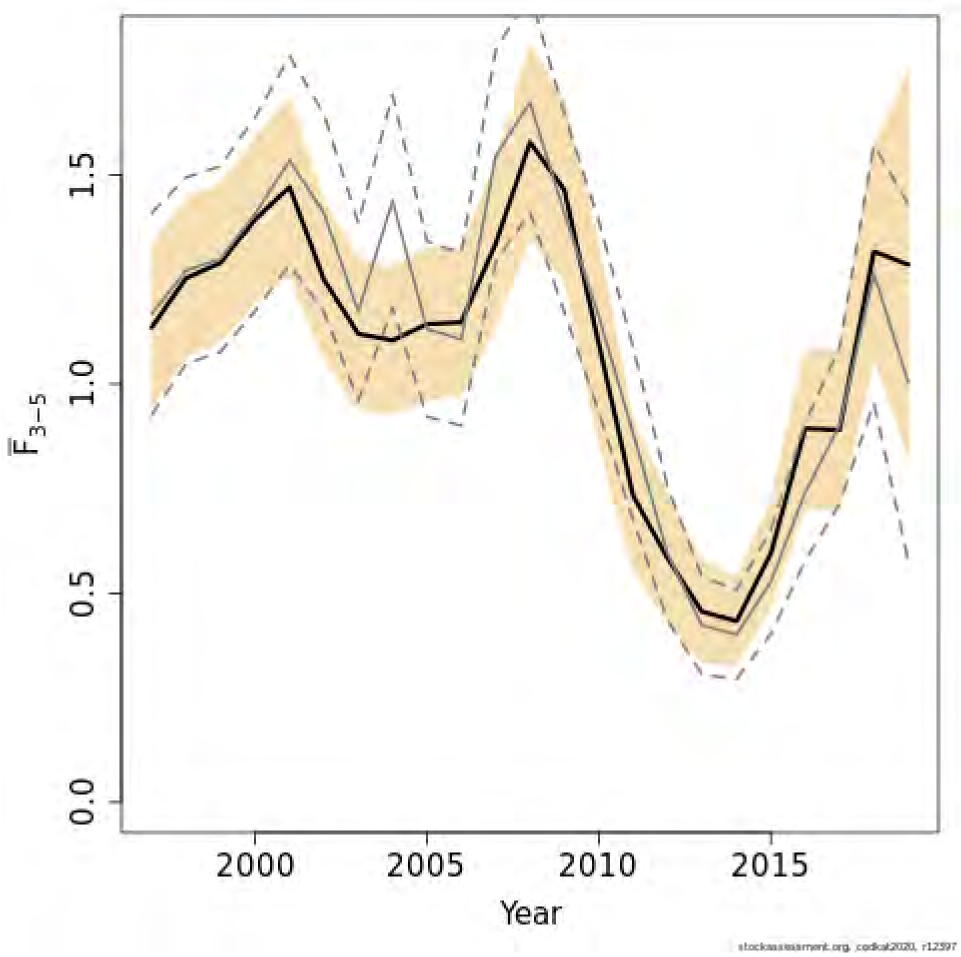


Figure 2.2.8. Unallocated mortality (Z-0.2) SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95% confidence interval).

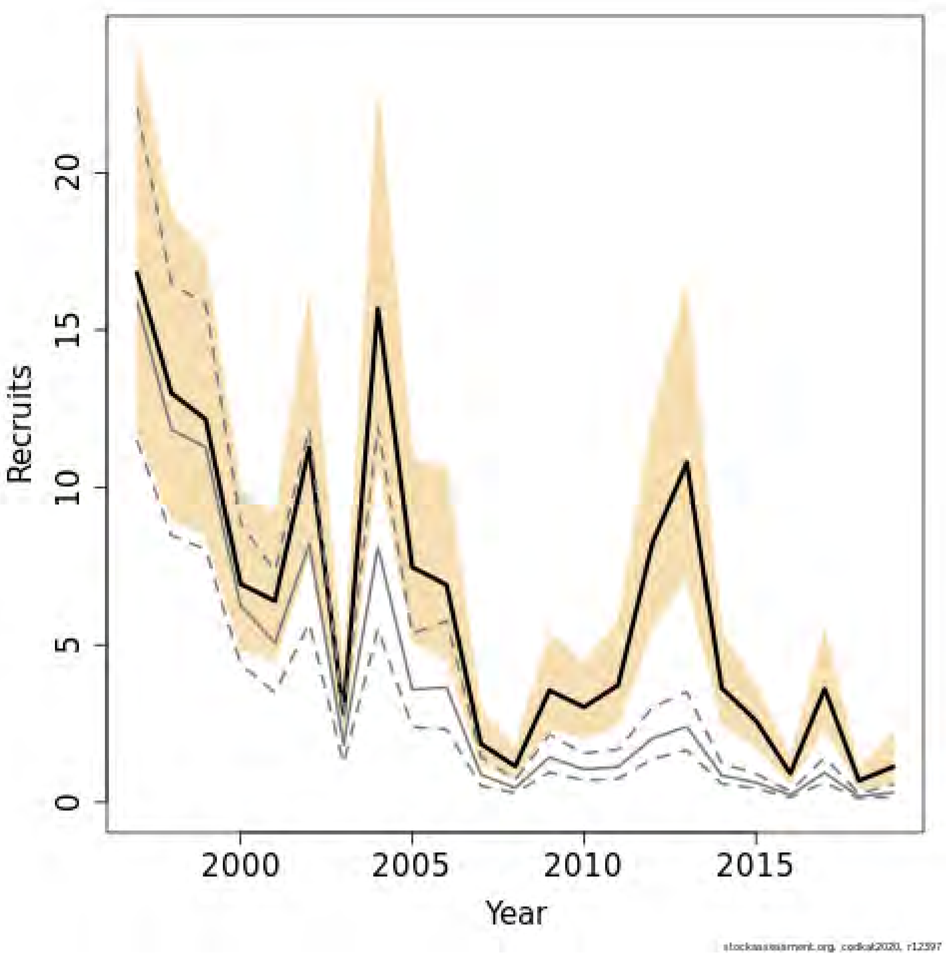
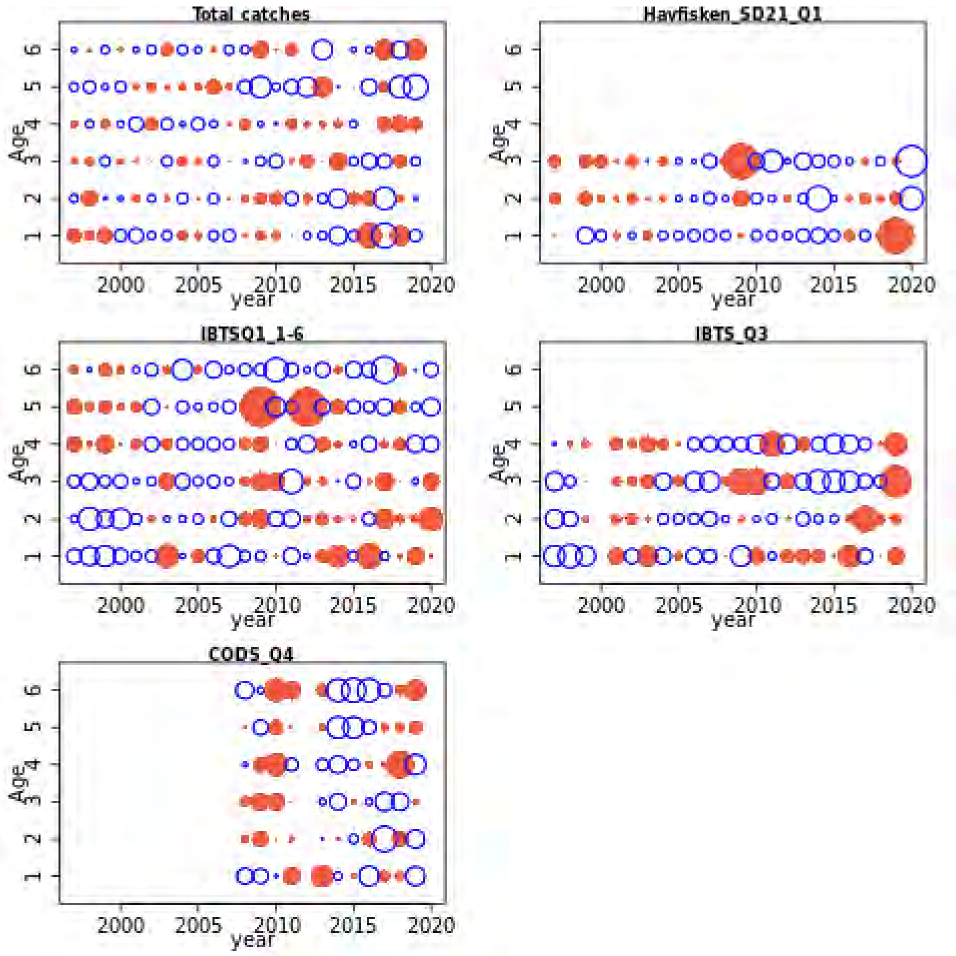


Figure 2.2.9. Recruitment. SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95% confidence interval).

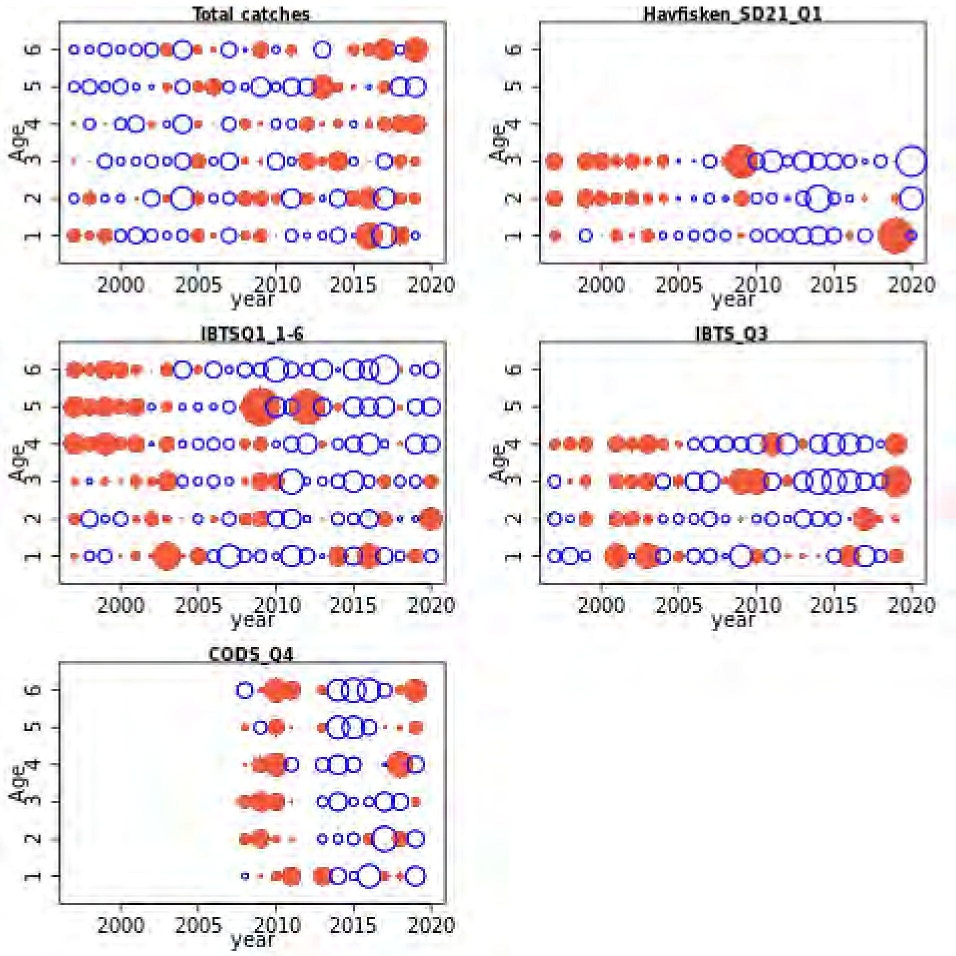
Year	Catch multiplier
2003	1,48
2004	1,08
2005	2,7
2006	2,46
2007	1,67
2008	2,68
2009	3,19
2010	2,79
2011	2,88
2012	5,03
2013	5,38
2014	5,67
2015	5,61
2016	5,89
2017	3,87
2018	3,95
2019	4,61

Figure 2.2.10. Catch multiplier. The scaling factor by year from the SAM run with scaling.



Total catches
Havfisken_SD21_Q1
IBTSQ1_1-6
IBTS_Q3
CODS_Q4
Age
year
1
2
3
4
5
6
2000
2005
2010
2015
2020

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).

Table 2.2.1 Cod in the Kattegat. Landings (in tonnes) 1971-2019.

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
2019	66	17	1,0	84

[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 tal

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
2019	85	26	19	0	0	0

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
2019	26	14	1	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
2019	111	40	20	0	0	0	171

Table 2.2.3. **Cod in the Kattegat.** Numbers of hauls in discard sampling by years and countries

Year/Country	Sweden	Denmark	Total
1997	45		45
1998	50		50
1999	55		55
2000	63	52	115
2001	40	68	108
2002	63	43	106
2003	38	30	68
2004	26	47	73
2005	48	33	81
2006	66	22	88
2007	72	10	82
2008	50	24	74
2009	49	38	87
2010	58	34	92
2011	48	43	91
2012	41	48	89
2013	44	58	102
2014	39	55	94
2015	40	46	86
2016	40	37	77
2017	51	61	112
2018	41	51	92
2019	75	61	136

Table 2.2.4 a Cod in the Kattegat. Sampling level of Danish landings, 2019

Quarter	n. of harbour days	n. of cod aged	n. of cod weighed	n. of cod measured
1	7	294	294	286
2	7	147	147	147
3	6	156	156	156
4	6	194	194	180
Total	26	791	791	769

Table 2.2.4 b Cod in the Kattegat. Sampling level of Swedish landings, 2019

Quarter	n. of size distributions sampled	n. of cod aged	n. of cod weighed	n. of cod measured
1	9	262	262	262
2	2	89	89	89
3	1	18	18	18
4	7	71	71	71
Total	19	440	440	440

Table 2.2.5. Cod in the Kattegat. Landings numbers and mean weight at age by quarter and country for 2019

Sub-div **21**

Year	**2019**	**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	0,129467	447,6145	0,039	742,95	0,17	515,98
3	14,42155	1681,388	1,278	995,85557	15,70	1625,58
4	0,722671	2673,77	0,983	1323,8851	1,71	1895,81
5	3,823796	2909,316	0,224	2148,2125	4,05	2867,20
6	0,608118	4037,98	0,13	3167,9859	0,74	3884,75
7	0,71	3791,28	0,112	3021,8347	0,82	3686,47
8	0,14	3533,40	0,045	4531,6024	0,18	3781,59
9			0,01	9430,20	0,01	9430,20
10						
SOP (t)	42,99			4,12	47,12	
Landings (t)	37,60			4,05	41,65	

Sub-div **21**

Year	**2019**	**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	0,164322	669,1508			0,16	669,15
3	2,488908	1665,206	1,935	1154,1145	4,42	1441,66
4	0,036309	3299,4	1,707	1973,3384	1,74	2000,96
5	2,159089	2522,631	0,308	2358,6514	2,47	2502,16
6	0,437826	3572,114	0,045	3620,5111	0,48	3576,62
7	0,37	2680,25	0,033	4362,54	0,41	2817,03
8	0,04	2886,39	0,006	5772,78	0,04	3295,72
9			0,01	8073,47	0,01	8073,47
10						
SOP (t)	12,49			6,73	19,22	
Landings (t)	12,31			6,73	19,04	

Sub-div	**21**					
Year	**2019**	**Quarter**		**3**		
Country	**Denmark**		**Sweden**		**Grand Total**	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1			0,045	643,5	0,05	643,50
2	0,872642	1064,579	0,338	755,31845	1,21	978,24
3	1,460422	2111,398	0,414	1603,3003	1,87	1999,18
4	0,110753	3249,089	0,348	2176,4404	0,46	2435,40
5	0,11734	3534,019	0	3510	0,12	3534,02
6	0,014079	1826,37	0,007	4322,8421	0,02	2655,40
7	0,02	5268,51	0,033	4219,3923	0,05	4561,97
8	0,01	3409,38	0,024	5264,15	0,04	4556,30
9			0,03	6041,35	0,03	6041,35
10						
SOP (t)	4,95			2,19	7,14	
Landings (t)	4,41			2,17	6,58	

Sub-div	**21**					
Year	**2019**	**Quarter**		**4**		
Country	**Denmark**		**Sweden**		**Grand Total**	
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1	1,88	514,58	0,198	643,500	2,08	526,87
2	3,213618	1188,596	1,359	865,697	4,57	1092,63
3	3,065243	2146,263	1,160	1892,476	4,23	2076,59
4	0,363487	3483,668	0,545	2035,544	0,91	2614,94
5	0,121038	4689,794			0,12	4689,79
6	0	0	0,001	4322,842	0,00	4322,84
7	0,03	4139,46	0,019	4173,154	0,05	4152,50
8						
9			0,002	9045,385	0,00	9045,38
10						
SOP (t)	13,32			4,71	18,03	
Landings (t)	11,28			3,86	15,14	

Sub-div	21						
Year	**2019**	**Quarter**	**all**				
Country	**Denmark**		**Sweden**		**Grand Total**		
Age	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)	Numbers *1000	Mean weight (g)
1	1,878964	514,5839	0,243	643,5	2,12	529,35
2	4,380049	1188,596	1,736	865,69667	6,12	1096,94
3	21,43612	2146,263	4,787	1892,4758	26,22	2099,93
4	1,23322	3483,668	3,583	2176,4404	4,82	2511,16
5	6,221264	4689,794	0,532	3510	6,75	4596,85
6	1,06	4037,98	0,183	4322,8421	1,24	4079,92
7	1,13	5268,51	0,197	4362,54	1,33	5133,94
8	0,187109	3533,4	0,075	5772,78	0,08	5772,78
9			0,05	9430,20	0,05	9430,20
10						
SOP (t)	96,54			22,95	118,83	
Landings (t)	65,60			16,80	82,40	

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

	Age					
Year	1	2	3	4	5	6
1997	1456	2540	5137	891	222	88
1998	1499	3587	1595	1908	283	76
1999	1201	3859	3972	455	409	77
2000	1819	3942	2346	1027	125	103
2001	2166	2012	2034	703	187	45
2002	3190	2161	1062	391	85	40
2003	628	2441	650	184	65	16
2004	3547	1077	1195	206	65	39
2005	854	2169	121	167	21	12
2006	1406	1305	796	36	33	9
2007	668	1446	383	190	16	26
2008	175	191	136	40	33	7
2009	400	92	30	22	9	4
2010	433	361	33	8	4	2
2011	631	445	84	6	2	1
2012	889	231	30	13	2	0
2013	1068	533	49	12	3	1
2014	510	804	66	20	6	0
2015	239	144	167	56	15	6
2016	16	95	68	75	38	13
2017	1090	119	68	28	30	14
2018	28	240	12	23	19	25
2019	114	46	46	5	7	3

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
2019	0.434	0.348	1.047	2.019	2.537	3.078	NA	NA

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

	Age							
Year	1	2	3	4	5	6	7	8+
1971	0,059	0,355	0,919	1,673	2,518	3,553	5,34	6,635
1972	0,059	0,355	0,919	1,673	2,518	3,553	5,34	6,635
1973	0,059	0,355	0,919	1,673	2,518	3,553	5,34	6,635
1974	0,059	0,355	0,919	1,673	2,518	3,553	5,34	6,635
1975	0,059	0,355	0,919	1,673	2,518	3,553	5,34	6,635
1976	0,059	0,355	0,919	1,673	2,518	3,553	5,34	6,635
1977	0,059	0,355	0,919	1,673	2,518	3,553	5,34	6,635
1978	0,059	0,355	1,006	1,69	2,86	4,12	5,18	6,9
1979	0,059	0,35	0,934	1,89	2,215	3,382	7,314	6,101
1980	0,058	0,361	0,817	1,44	2,478	3,157	3,526	6,903
1981	0,051	0,323	0,965	1,432	2,076	3,532	4,42	4,644
1982	0,05	0,317	1,06	1,391	2,078	2,911	3,698	6,48
1983	0,05	0,304	0,971	1,943	3,348	3,141	5,301	6,325
1984	0,06	0,301	0,974	1,687	2,798	3,022	5,273	7,442
1985	0,051	0,339	0,848	1,614	2,575	4,09	6,847	7,133
1986	0,056	0,285	1,077	1,955	2,956	4,038	7,1	7,29
1987	0,041	0,289	0,961	1,972	2,868	4,2	5,185	8,288
1988	0,045	0,317	0,945	1,792	2,88	4,283	5,852	7,073
1989	0,052	0,372	1,091	2,296	3,856	5,733	5,166	6,527
1990	0,052	0,393	1,362	2,323	3,288	5,383	6,412	10,337
1991	0,06	0,415	1,799	2,986	4,548	4,179	9,127	12,055
1992	0,052	0,34	1,191	2,662	4,048	5,888	7,067	7,895
1993	0,056	0,353	1,086	2,321	4,97	7,566	9,391	8,705
1994	0,035	0,269	1,225	2,652	3,526	7,279	9,793	10,13
1995	0,032	0,148	1,31	1,947	2,404	3,537	9,973	10,708
1996	0,027	0,22	0,496	1,771	2,638	3,773	4,677	7,871
1997	0,034	0,179	0,743	1,95	2,806	3,877	5,756	7,213
1998	0,049	0,213	0,442	1,68	2,497	4,317	6,669	8,948
1999	0,046	0,207	0,625	1,616	2,588	4,665	5,376	8,04
2000	0,046	0,176	0,624	1,332	2,779	3,944	5,069	9,02
2001	0,065	0,269	0,72	1,585	2,597	4,693	7,117	7,691
2002	0,045	0,29	1,334	2,052	3,539	4,814	6,915	7,833
2003	0,066	0,224	1,054	2,46	3,75	5,923	7,835	10,891
2004	0,052	0,407	1,007	1,63	2,7	3,916	6,181	9,423
2005	0,058	0,349	1,187	2,343	3,584	5,442	6,439	8,307
2006	0,064	0,280	1,083	3,130	3,995	4,222	5,264	6,713
2007	0,058	0,289	1,060	2,275	3,344	3,829	1,802	7,897
2008	0,045	0,335	1,010	3,210	4,097	4,437	5,552	5,827
2009	0,053	0,300	1,069	2,651	4,069	4,693	4,870	5,792
2010	0,052	0,285	1,171	3,081	4,038	3,592	4,252	6,404
2011	0,051	0,269	0,905	2,695	3,372	4,997	4,059	7,569
2012	0.044	0.251	0.923	3,174	4,004	5,224	4,305	6,921
2013	0.041	0.255	1.043	2.545	3.726	3.310	5,1	NA
2014	0.049	0.285	1.050	2.541	3.869	5.431	NA	NA
2015	0.055	0.311	1.036	2.023	3.385	2.873	NA	NA
2016	0,045	0,338	1,041	2,448	2,72	3,665	NA	NA
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
2019	0.036	0.206	1.067	2.020	2.537	3.078	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+

Year	Age 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
2019	0,00	0.48	0.80	0.96	1,00	1,00	1,00	1,00

Table 2.2.10 . Tuning data for the Kattegat cod assesment 2019

Tuning Data; Cod in the Kattegat (part of Division IIIa)_30/03/11
104
Havfisken_SD21_Q1
1997 2020
1 1 0 0.25
1 3

1	104.552146	24.105792	16.370021		
1	-9		-9		-9
1	464.863274	25.740582	8.849065		
1	97.616777	44.329151	5.524313		
1	25.789944	30.099006	11.121938		
1	98.272996	16.652928	3.154041		
1	8.341221	47.242161	5.778205		
1	175.055626	11.183467	5.333215		
1	83.149813	86.679327	2.545501		
1	105.175603	38.4632	10.578578		
1	28.874848	46.527365	8.608119		
1	13.097342	6.648041	1.012895		
1	16.212387	0.908864	0.001		
1	38.500591	21.422327	1.388748		
1	46.248519	15.004462	14.262675		
1	86.615477	10.825403	1.844459		
1	212.343689	51.341883	10.257821		
1	98.780392	781.879234	12.409109		
1	37.3475	16.909	15.1715		
1	2.06	8.22	3.59		
1	47.506	1.919	1.32		
1	2.20	8.58	0.71		
1	0.001	1.08	1.07		
1	18.7	53.97	31.58		

IBTSQ1_1-6
1997 2020
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	15.40	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	0.001	0.333
1	14.636	22.460	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	0.001	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	27.360	9.498	4.189	2.151
1	0.522	14.551	4.311	18.679	5.759	3.000
1	23.69	0.80	0.93	1.92	6.20	15.40
1	2.99	7.59	0.80	0.89	0.38	0.625
1	2.02	1.70	3.11	1.06	0.444	0.3
1	14.40	0.419	0.24	2.96	0.22	0.24

IBTS_Q3
1997 2019
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	0.20
1	-9	-9	-9	-9
1	6.03	2.11	0.46	0.12
1	46.53	1.56	0.26	0.19
1	1.70	4.50	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	4.20	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	0.001	0.08
1	2.50	1.28	0.001	0.08
1	8.35	1.59	0.45	0.001
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
1	0.91	0.13	0.001	0.001

CODS_Q4
2008 2019
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
1	66.0	38.01	19.5	5.68	0.86	0.34

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	16808	11759	24025	12786	10755	15201	10655	8829	12859	1.135	0.957	1.347
1998	12992	9007	18740	10456	9011	12133	7870	6599	9385	1.253	1.078	1.456
1999	12156	8512	17361	9215	8006	10606	7440	6424	8616	1.290	1.114	1.494
2000	6941	4859	9916	7004	6090	8055	5680	4884	6606	1.394	1.210	1.605
2001	6403	4479	9152	6157	5371	7059	4898	4218	5687	1.471	1.275	1.698
2002	11263	7878	16103	6043	5266	6935	4860	4178	5652	1.250	1.074	1.454
2003	2829	1914	4183	4960	4342	5665	4094	3571	4693	1.120	0.953	1.316
2004	15693	10861	22676	4815	4148	5589	3515	2997	4122	1.104	0.943	1.293
2005	7473	5081	10990	6168	5252	7243	4056	3487	4718	1.143	0.975	1.341
2006	6913	4541	10525	5403	4576	6380	3998	3370	4743	1.147	0.984	1.338
2007	1855	1176	2928	3335	2861	3886	2689	2302	3142	1.335	1.151	1.549
2008	1144	754	1735	1839	1594	2121	1628	1394	1901	1.578	1.364	1.826
2009	3556	2359	5361	883	762	1022	607	522	705	1.465	1.264	1.698
2010	3021	2046	4462	906	762	1077	515	439	605	1.097	0.885	1.360
2011	3724	2436	5693	1073	909	1267	694	584	824	0.734	0.577	0.934
2012	8249	5567	12225	1576	1291	1924	984	792	1223	0.585	0.450	0.760
2013	10784	7094	16393	2818	2345	3387	1761	1446	2145	0.457	0.349	0.597
2014	3637	2461	5376	4257	3623	5002	2403	2036	2835	0.433	0.340	0.553
2015	2590	1777	3776	5451	4525	6566	3923	3224	4773	0.596	0.483	0.735
2016	913	603	1381	4101	3420	4919	3322	2722	4055	0.894	0.722	1.106
2017	3601	2354	5509	2457	2108	2864	1997	1692	2358	0.890	0.719	1.101
2018	686	443	1062	1723	1456	2040	1396	1168	1668	1.317	1.084	1.600
2019	1127	574	2215	827	625	1094	675	508	897	1.286	0.900	1.837
2020	3011	738	12289	625	358	1092	429	239	769	1.260	0.758	2.093

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	15899	11462	22053	12207	9681	15393	10192	7924	13110	1.167	0.949	1.435
1998	11823	8486	16473	9725	8037	11769	7299	5793	9197	1.271	1.067	1.515
1999	11278	8039	15822	8364	7010	9980	6745	5582	8149	1.299	1.095	1.541
2000	6235	4381	8874	6319	5285	7555	5115	4201	6228	1.407	1.193	1.659
2001	5063	3494	7337	5454	4557	6528	4373	3589	5327	1.535	1.304	1.806
2002	8214	5690	11857	4915	4118	5866	4023	3315	4881	1.409	1.192	1.667
2003	1830	1231	2720	3447	2910	4084	2855	2394	3404	1.173	0.978	1.406
2004	8114	5518	11932	2962	2449	3583	2240	1815	2764	1.438	1.205	1.716
2005	3582	2394	5361	2903	2378	3544	1909	1578	2310	1.131	0.940	1.362
2006	3656	2318	5765	2490	2046	3030	1829	1485	2252	1.106	0.919	1.333
2007	876	527	1455	1600	1311	1953	1285	1048	1575	1.545	1.311	1.821
2008	456	294	707	730	607	878	640	523	783	1.673	1.431	1.957
2009	1432	953	2152	336	285	396	226	188	272	1.409	1.191	1.667
2010	1044	701	1555	348	289	419	200	168	238	1.163	0.955	1.416
2011	1121	750	1676	354	297	422	235	194	285	0.883	0.699	1.115
2012	2033	1369	3018	433	362	518	281	230	343	0.596	0.456	0.780
2013	2407	1653	3503	688	584	812	446	371	534	0.424	0.322	0.559
2014	852	589	1233	954	812	1119	554	466	659	0.401	0.307	0.523
2015	630	439	903	1204	1019	1423	872	728	1045	0.528	0.417	0.668
2016	231	153	348	951	796	1135	768	632	932	0.742	0.595	0.926
2017	938	623	1412	670	558	806	551	449	677	0.901	0.732	1.109
2018	182	119	279	471	387	572	379	308	466	1.264	0.990	1.613
2019	315	177	562	244	178	333	200	143	278	1.004	0.656	1.534
2020	732	198	2708	205	128	329	151	89	258	0.983	0.544	1.778

2.3 Western Baltic cod (update assessment)

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 2019 is estimated to be 0.52.
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; and 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, in previous years, 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 22 t in 2019, at the same level as the officially reported BMS landings in 2018 (24 t). Landings by SD, passive and active gear in 2019 are given in Table 2.3.2 (both include eastern Baltic cod landings in SD 24).

The total commercial human consumption landings in 2019 was 7679 t + 22 t BMS, 19% below the TAC for the area (9515 t). In the last 10 years slightly more than half of the total western Baltic area landings have been fished in SD 24, in 2019 this changed and only 36% of the total landings were from SD 24. This change is due to a temporary management regulation installed mid-2019 (see below), where a directed cod fishery in SD 24 was prohibited (Figure 2.3.1).

22 t of BMS (below minimum conservation reference size) cod was landed in 2019, or 0.3% of the total landings in the management area SD 22–24, the main part of BMS (15 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 (28%) 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 subareas 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.

Unlike the last couple of year, in 2019, there was no spawning closure in place in the western Baltic (SD 22–24). However in June, The European Commission issued an immediate measure to protect the cod stock of the eastern Baltic Sea (EU 2019/1248). It also prohibited a directed fishery for cod in SD 24 with special regulations for active and passive gear fisheries. The Danish fishing pattern in 2019 can be seen by VMS plots Figure 2.3.4

2.3.1.2 Discards

All relevant countries uploaded their discard data to InterCatch. Discard data from at-sea observer programs for 2019 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 2.3.3). Besides the sample level shown in table 2.3.4, 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 presently only used for stock ID and not for age reading.

The discard rate of the active and passive gear was estimated to be 1.4% for active and 1.2% for passive gear in SD 22 and 1.7% and 2.1% in SD 23, respectively. For cod in SD 24, the discard rate of the active and passive gear was estimated to be 25.7% and 1.0%, respectively. Discards per gear segment and quarter can be seen in table 2.3.5. Catches of long-liners (LLS) were minor in 2019 and therefore, this fleet was not considered separately in the raising process.

The discard weights at age for SD 22 and SD 23 for 2019 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 have been available since 2013 (WKBALTCOD 2015). The recreational catch included in the assessment has been just above 3000 t (average of the last 10 years) but was much lower in 2017 and 2018 due to the introduction of a bag limit and reduced resource availability. The recreational catches are mainly taken by private and charter boats and to a small degree by land-based fishing methods. The amount in 2019 is estimated to be 2573 t.

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 and unreported 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). For example in Germany, some passive gear fishers may still buy the same amount of ice at the fishing associations as in former years in spite of significantly reduced quotas. It is unlikely that this can be explained with higher temperatures or much higher catches of fish not regulated by a quota. Further, landings may occur at days, times and places when the control is known not to operate. The national quota is distributed over hundreds of vessels. Despite the TAC increase in 2019, the TAC for western Baltic cod is relatively low and unreported landings would be considered to ensure economic viability of the fishers′ activities. 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 2019, the estimate was 9.7 t.

Other unreported removals negatively affecting the data quality in the 2019 data involve increased discard in the active fleet, and the adverse consequences of the immediate measure to protect the cod stock of the eastern Baltic Sea (EU 2019/1248) for the fisheries in SD24:

In late July 2019 an immediate measure to protect eastern Baltic cod (EU 2019/1248) was introduces by the Commission. These measures provided that directed cod fishing should no longer be carried out in the areas SD24-26. However, fishing was not entirely prohibited, and bycatches of cod in trawling (which is then nominally a flatfish fishery using the same trawl gear) had to be discarded and caused an increased discard ratio from 4.2 to 9.7% in 2019. The at-sea observer trips suggested that the discard rate in SD24 increased significantly after the introduction of the EU 2019/1248.

In addition to the uncertainty in the latest discards estimates, the landings from SD24 in Q3 and Q4 are likely underestimates because official landings were restricted to 10% bycatch of cod. Consequently, there was a strong incentive to misreport landings (e.g. area-misreporting of cod caught in SD24 to SD22).

Overall, the new measure, increased the discards of cod (both of EBC and particularly of the only strong 2016 year class of Western Baltic cod which dominated the commercial catches in 2019 in SD24) and resulted in unreported landings of unknown amounts.

2.3.1.5 Total catch

Total catches of the western Baltic cod stock (SD 22–24), including commercial landings (and since 2017 including reported BMS), discards and recreational catches, were estimated to be 9331 t in 2019. Landings and discards of eastern Baltic cod in SD 24 is estimated to be 2219 t and are shown in Table 2.3.6. By management area, the total catch is estimated to be 11550 t in the western Baltic Sea.

2.3.1.6 Data quality

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

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 2019 (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 Sea 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 2019. Sweden had no active gear fishery in SD 22–24 in 2019 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. Denmark samples landings via harbour-sampling with harbour trips being the primary sampling unit and discard via at-sea observer sampling with a random selection of all active vessels above 10 m. Sampling levels of commercial catch in 2019 are given in Table 2.3.3.

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, 2017, and 2018 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 two 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 2019, 43% of cod in SD 24 was found to be WB based on otolith shape analysis and genetics, this is an increase compared to last year (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. This year, the German commercial split in ICES squre38G3, were applied for the Danish landings from this square because Danish samples mainly originated from the Bornholmsgatt while the catches mainly came from the area north of Rügen where Germany could collect reasonable samples sizes. The spilt is weighted with landings from Germany, Denmark, Sweden and Poland based on 2019 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 2019 was age-group 3 from the large 2016 year class amounting 88% of the total catch (Figure 2.3.5, Table 2.3.14). This year class was also large in both the discard and recreational catches, accounting for 84% and 82% of the total share, respectively. (Table 2.3.12 and 2.3.12).

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. In 2019 the weight estimate for age 3 in the Q 1 survey was unusually low (40% below average), probably due to the very wide length range of this age group (covering ~25-65 cm) which was not representatively covered by the samples. However, in the Q4 survey the weight for this age group was not measured as low. For this reason it was decided to use a mean weight of the last 3 years for age 3 in 2019. Weights at ages 4–7 in the stock were set equal to the annual mean weights in the catch (Table 2.3.18). For 2020 the survey weight was used for ages 1-3.

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.

For 2020 the maturity ogive is estimated as an average for the last 3 years.

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 Sea 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 WGBFAS 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, BITS Q4 and a pound net survey. 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 (longitude 13° to 15°) is not included in the index due to the uncertainties related to stock mixing in this area.

Funk *et al.* (2020) showed that cod in SD22 use areas deeper than 15 m from late December until March and again from July until August; shallower areas were favoured during the rest of the year. When cod tend to use shallower habitats in the fourth quarter, the trawl survey catchability is probably much lower (underestimation of true abundances) than in the first quarter when cod is aggregated at the spawning grounds. This effect could be problematic for the Q4 survey if the distribution is not constant in time, but differs in a non-systematic way with regards to age groups, sex or fish condition between quarters or years. In the last couple of years the internal consistency plot for the Q4 BITS has decreased for older age groups. Changed behaviour could be caused by a delayed cooling of the sea surface in fall giving cod forage opportunities in shallow-water habitats for a longer time period before seeking to the deeper areas were the survey is conducted. Also, increased areas with oxygen-depletion at the bottom could have changed the stock distribution encountered during the Q4 survey in recent years.

FLEET	YEAR RANGE	AGE RANGE
BITS, Q4, SD22–24W (12–13 degrees)	2001–2019	age 0–4
BITS, Q1, SD22–24W (12–13 degrees)	2001–2020	age 1–4
FEJUCS, SD22	2011-2019	age 0

2.3.3.1 Recruitment estimates

The 2015, 2017 and 2018 year class were estimated very weak and among the lowest in the time series (Figure 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 and 2.3.11) and reencountered in Q4 BITS 2017 and as age 2 cod in Q1 BITS 2018. However, in 2018 Q4 and 2019 Q4 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 3 cod (red dots) are below the trend line.

In 2019 there was indication of a moderate good year class. This year class was not detected in SD22 but in SD24 and even east of Bornholm genetic assignment showed that these age 0 were of western Baltic cod origin. However, due to this changed distribution, the year class was not detected in the German pound net survey in Fehmarn and it is not clear at this stage how much the 2019 year class will contribute to the western Baltic cod stock in the future.

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.

In this year's assessment the SSB was downscaled and F increased compared to the results from last year assessment. Further, the SSB retro in the final run had a Mohns Rho at 0.24. The main concerns was that the model did not trust the relatively high catch values in 2019 and that the Q4 survey showed a very low abundance of cod. Several exploratory runs were conducted to explore the effect of the low value for age 3 found in the 2019 Q4 survey and to investigate the reason for the models underestimate of the reported catch values.

1. Excluding Q4 survey in 2019
2. Excluding age 3 in Q4 survey
3. Higher trust in the Q1 survey
4. 20% CV coefficient of variation around the catch estimate (higher trust in catches)
5. 10% CV coefficient of variation around the catch estimate (higher trust in catches)
6. Final SPALY run

For all the different exploratory runs the Mohn Rho for SSB and F is given, the model catch estimate compared to the observed catch estimate and the estimate of SSB in 2020 compared to the value for SSB in 2020 from last year's assessment.

Exploratory runs	MohNs Rho (SSB/ F)	Catch estimate	SSB 2020
1 (-Q4 survey)	0.23 / -0.18	30% below observation	22807 / 29613 (77%)
2 (-age 3 Q4 survey)	0.16 / -0.06	33% below observation	33827 / 29613 (114%)
3 (Trust Q1)	0.18 / -0.10	32% below observation	30236/ 29613 (102%)
4 (20% cv catch)	0.21 / -0.19	26% below observation	23292 / 29613 (79%)
5 (10% cv catch)	0.19 / -0.22	7% below observation	27520 / 29613 (93%)
6. Final run (SPALY)	0.24 / -0.17	42% below observation	20800 / 29613 (70%)

None of the exploratory runs gave a perfect fit on all parameters, however, most of the alternative runs gave a better Mohns Rho and a model catch closer to the observed catch (Figure 2.3.12). Further, more of the exploratory runs were more in alignment with last year's assessment estimate of SSB in 2020.

Only if the model was forced to believe in catches was it possible to get a model catch estimate close to the observed. However, the retro was still relatively high.

It seemed that both some of the very strong year classes (2016) and the very weak year classes (2015, 2017, and 2018) has a much stronger signal in the catch data compared to the survey data (2.3.13, 2.3.14 and 2.3.15). The Q1 survey did find the strong 2016 year class, but the very low year classes were not reflected. In the Q4 survey the older age groups were lacking.

During the benchmark it was decided to use an annual effect estimate on the Q1 survey due to a pattern for all age groups in a given year. This setting has down-weighted the influence of the Q1 survey compared to the Q4 survey. However, as the year effect was still evident, the WGBFAS group found no reason to change this setting.

This indicates that the assessment is rather sensitive in terms of the uncertainties introduced from variable information coming from one large dominating year class and weak neighbouring year classes. It was discussed during the meeting if the effect was due to problems in cod catchability during the Q4 survey given seasonal changes in vertical distribution of cod (Funk et al. 2020) and of an increased area with hypoxia in fall 2019 during the Q4 survey. However, it was decided to use the assessment as in former years.

The model fit relatively well to the historic catch data (Figure 2.3.13) except for the historic low age 3 value in 2018 and the very high age 3 in 2019. For the surveys especially very low or very high values are not fitted to the model (2.3.14 and 2.3.15), 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 (Figure 2.3.16). This is also evident in the leaving out one-plots where one tuning series at a time is excluded (Figure 2.3.17).

The retrospective pattern for SSB and F was relatively poor (Mohn's Rho at 0.24 and -0.17, respectively), and 0.27 for the recruitment. (Figure 2.3.18).

The summaries for SSB, Recruitment and F from the final run are shown in Figure 2.3.19 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_2020_split".

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. As in last year's assessment a TAC (catch) constraint was used in the intermediate year. This was derived from the splitting factor (0.75) applied to the TAC (3806 t), including discard (9.7%) and recreational catches added (1315 t). This gives a total catch of 4488 t in 2020 and an F at 0.24, which is below F_{MSY}.

Given the lack of a valid estimation for the intermediate year, the recreational catch from 2017 (1315 t) was used as it reflects the catches from a year with similarly restrictive management regulations. (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, however, this is not included in this year's advice due to the abbreviated advice but the same information is included in this report. The assumption for this calculation is that the relative catch distribution between subdivisions is stable. In the most recent years the total commercial catch of WB cod stock have been on average quite stable between subdivisions 22–23 and Subdivision 24, amounting to 74% and 26% in 2019, respectively. The overall ratio EB cod /WB cod in the commercial catch in Subdivision 24 has been 1.3. This is an increase of western Baltic cod in SD24 compared to eastern Baltic cod, probably caused by the strong 2016 year class having an eastern distribution. The ratio of 1.3 means that every time one WB cod is caught in SD 24, 1.3 eastern Baltic cod is caught at the same time. The advice based on the management plan indicates that the total catch can be between 4275 t (Fmsy lower) and 9039 t (Fmsy higher) with F_{MSY} at 5950 t for the western Baltic cod stock in 2021.

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+1 compared to the MSY B-trigger level. These values were updated at the benchmark to 0.18 (lower) 0.26 (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 FMSY 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 quality of this assessment has in recent years become worse. The uncertainty on the catch matrix is relatively high in this assessment. For several years, the model seems to consistently overestimate the catches in the last year; however, in this year's assessment the model underestimated the catch by 42%. This seems to be caused by conflicting information from the surveys and the catch matrix.

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 introduce 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).

2.3.8 Comparison with previous assessment

The assessment this year has downscaled the 2020 SSB estimate by 30%.

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.

If the commercial catches are divided between SD 22, 23 and 24 in same proportion as in 2019, and if the relative amount of east and west cod in SD 24 are similar to 2019 then an estimate of the east Baltic cod catches can be calculated for 2021. If quota is sat to F_{MSY}, and the recreational catches subtracted (1315 t) then the amount of East Baltic cod caught in SD 24 would be 1532 t (Table 2.3.27). An alternative solution would be to allow the whole quota to be fished in SD 22-23, this would off course then not effect the eastern Baltic cod stock.

Given the poor recruitment in 2015, 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. The 2019 year class was only detectable in SD24 but with moderate strength; however, it is not clear at this stage how much this year class will contribute to the western Baltic cod stock.

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				
	22	23	22+24	24	22+24	22	22+24	22	24	24	24	24	22	23	22+24	22	23	24	Unalloc.	Grand total
1965			19457		9705		13350								2182	27867		17007		44874
1966			20500		8393		11448								2110	27864		14587		42451
1967			19181		10007		12884								1996	28875		15193		44068
1968			22593		12360		14815								2113	32911		18970		51881
1969			20602		7519		12717								1413	29082		13169		42251
1970			20085		7996		14589								1289	31363		12596		43959
1971			23715		8007		13482								1419	32119		14504		46623
1972			25645		9665		12313								1277	32808		16092		48900
1973			30595		8374		13733								1655	38237		16120		54357
1974			25782		8459		10393								1937	31326		15245		46571
1975			23481		6042		12912								1932	31867		12500		44367
1976		712	29446		4582		12893								1800	33368	712	15353		49433
1977		1166	27939		3448		11686							550	1516	29510	1716	15079		46305
1978		1177	19168		7085		10852							600	1730	24232	1777	14603		40612
1979		2029	23325		7594		9598							700	1800	26027	2729	16290		45046
1980		2425	23400		5580		6657							1300	2610	22881	3725	15366		41972
1981		1473	22654		11659		11260							900	5700	26340	2373	24933		53646
1982		1638	19138		10615		8060							140	7933	20971	1778	24775		47524
1983		1257	21961		9097		9260							120	6910	24478	1377	22750		48605
1984		1703	21909		8093		11548							228	6014	27058	1931	20506		49495
1985		1076	23024		5378		5523							263	4895	22063	1339	16757		40159
1986		748	16195		2998		2902							227	3622	11975	975	13742		26692
1987		1503	13460		4896		4256							137	4314	12105	1640	14821		28566
1988		1121	13185		4632		4217							155	5849	9680	1276	18203		29159
1989		636	8059		2144		2498							192	4987	5738	828	11950		18516
1990		722	8584		1629		3054							120	3671	5361	842	11577		17780
1991		1431	9383				2879							232	2768	7184	1663	7846		16693
1992		2449	9946				3656							290	1655	9887	2739	5370		17996
1993		1001	8666				4084							274	1675	7296	1275	7129	5528	21228
1994		1073	13831				4023							555	3711	8229	1628	13336	7502	30695
1995		2547	18762	132			9196				15			611	2632	16936	3158	13801		33895
1996		2999	27946	50			12018		50		32			1032	4418	21417	4031	23097	2300	50845
1997		1886	28887	11			9269		6			263		777	2525	21966	2663	18995		43624
1998		2467	19192	13			9722		8		13	623		607	1571	15093	3074	16049		34216
1999		2839	23074	116			13224		10		25	660		682	1525	20409	3521	18225		42155
2000		2451	19876	171			11572		5		84	926		698	2564	18934	3149	16264		38347
2001		2124	17446	191			10579		40		46	646		693	2479	14976	2817	16451		34244
2002		2055	11657	191			7322				71	782		354	1727	11968	2409	9781		24158
2003		1373	13275	59			6775				124	568		551	1899	9573	1925	13127		24624
2004		1927	11386				4651				221	538		393	1727	9091	2320	9430	13	20854
2005		1902	9867	2			7002	72	67		476	1093		720	835	8729	2621	10686	9	22045
2006		1899	9761	242			7516		91		586	801			1855	9979	1914	10858		22751
2007		2169	8975	220			6802		69		273	2371		534	2322	7840	2713	13183		23736
2008		1612	8582	159			5489		134		30	1361		525	2189	5687	2139	12256		20082
2009		567	7871	259			4020		194		23	529		269	1817	3451	839	11259		15549
2010		689	6849	203			4250			9	159	319		490	1151	3925	1179	9016		14120
2011		783	7799	149			4521				24	487		414	2153	5493	1198	9641		16332
2012		733	8381	260			4522		3		11	818		390	1955	4896	1123	11053		17072
2013		580	6566	50			3237				128	708		380	1317	4675	960	7333		12968
2014	2206	795	6804	7		2109	3243				39	854	1	565	1231	4316	1361	7862		13538
2015	2781	738	6623	28		2213	2915				7	755		493	1858	4994	1232	7193		13418
2016	1576	675	4881	29		1617	2390					657	1	448	1550	3193	1123	6313		10629
2017	1167	506	2352			1029	1281					926		435	352	2196	941	2714		5852
2018	1010	475	2235	0.5		1005	1373					886		395	462	2014	870	2942		5826
2019	2074	608	3194			1653	1992					991	2	559	334	3728	1167	2783		7679

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

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

Year: 2019		Gear: Active and passive gear combined		
Subdiv.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	2074	608	1120	3802
Germany	1653	0	340	1992
Sweden	2	559	333	894
Poland	0	0	991	991
Finland	0	0	0	0
Latvia	0	0	0	0
Estonia	0	0	0	0
Lithuania	0	0	0	0
Russia	0	0	0	0
Total	3728	1167	2783	7679

Year: 2019			Gear: Active gear	
Subdiv.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	2003	80	1036	3120
Germany	1084	0	131	1214
Sweden	0	0	256	256
Poland	0	0	763	763
Finland	0	0	0	0
Estonia	0	0	0	0
Lithuania	0	0	0	0
Russia	0	0	0	0
Latvia	0	0	0	0
Total	3087	80	2185	5353

Year: 2019			Gear: Passive gear	
Sub-div.	**22**	**23**	**24**	**22-24**
Country:				
Denmark	71	528	84	682
Germany	569	0	209	778
Sweden	2	559	77	638
Poland	0	0	228	228
Latvia	0	0	0	0
Estonia	0	0	0	0
Finland	0	0	0	0
Lithuania	0	0	0	0
Russia	0	0	0	0
Total	641	1087	598	2326

Table 2.3.3. Cod 22–23. Unsampled landing and discard strata and allocated sampled strata in 2019.

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

DE_27.3.c.22_Longline set_2_L,DK_27.3.b.23_Longline set_2_L,X
DE_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_1_L,X
DE_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_2_L,X
DE_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_3_L,X
DE_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_4_L,X
DE_27.3.c.22_Longline set_2_L,SE_27.3.b.23_Passive_1_L,X
DE_27.3.c.22_Longline set_2_L,SE_27.3.b.23_Passive_2_L,X
DE_27.3.c.22_Longline set_2_L,SE_27.3.b.23_Passive_3_L,X
DE_27.3.c.22_Longline set_2_L,SE_27.3.b.23_Passive_4_L,X
DE_27.3.c.22_Longline set_3_L,DE_27.3.c.22_Gillnets set_1_L,X
DE_27.3.c.22_Longline set_3_L,DE_27.3.c.22_Gillnets set_2_L,X
DE_27.3.c.22_Longline set_3_L,DE_27.3.c.22_Gillnets set_3_L,X
DE_27.3.c.22_Longline set_3_L,DE_27.3.c.22_Gillnets set_4_L,X
DE_27.3.c.22_Longline set_3_L,DK_27.3.b.23_Gillnets set_2_L,X
DE_27.3.c.22_Longline set_3_L,DK_27.3.b.23_Gillnets set_3_L,X
DE_27.3.c.22_Longline set_3_L,DK_27.3.b.23_Gillnets set_4_L,X
DE_27.3.c.22_Longline set_3_L,DK_27.3.b.23_Longline set_2_L,X
DE_27.3.c.22_Longline set_3_L,DK_27.3.c.22_Gillnets set_1_L,X
DE_27.3.c.22_Longline set_3_L,DK_27.3.c.22_Gillnets set_2_L,X
DE_27.3.c.22_Longline set_3_L,DK_27.3.c.22_Gillnets set_3_L,X
DE_27.3.c.22_Longline set_3_L,DK_27.3.c.22_Gillnets set_4_L,X
DE_27.3.c.22_Longline set_3_L,SE_27.3.b.23_Passive_1_L,X
DE_27.3.c.22_Longline set_3_L,SE_27.3.b.23_Passive_2_L,X
DE_27.3.c.22_Longline set_3_L,SE_27.3.b.23_Passive_3_L,X
DE_27.3.c.22_Longline set_3_L,SE_27.3.b.23_Passive_4_L,X
DK_27.3.b.23_Active_1_L,DK_27.3.b.23_Active_2_L,X
DK_27.3.b.23_Active_1_L,DK_27.3.b.23_Active_3_L,X
DK_27.3.b.23_Gillnets set_1_L,DK_27.3.b.23_Gillnets set_2_L,X
DK_27.3.b.23_Gillnets set_1_L,DK_27.3.b.23_Gillnets set_3_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_Longline set_1_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Longline set_1_L,DE_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Longline set_1_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Longline set_1_L,DE_27.3.c.22_Gillnets set_4_L,X
DK_27.3.b.23_Longline set_1_L,DK_27.3.b.23_Gillnets set_2_L,X
DK_27.3.b.23_Longline set_1_L,DK_27.3.b.23_Gillnets set_3_L,X
DK_27.3.b.23_Longline set_1_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.b.23_Longline set_1_L,DK_27.3.b.23_Longline set_2_L,X
DK_27.3.b.23_Longline set_1_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.b.23_Longline set_1_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Longline set_1_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Longline set_1_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.b.23_Longline set_1_L,SE_27.3.b.23_Passive_1_L,X
DK_27.3.b.23_Longline set_1_L,SE_27.3.b.23_Passive_2_L,X
DK_27.3.b.23_Longline set_1_L,SE_27.3.b.23_Passive_3_L,X
DK_27.3.b.23_Longline set_1_L,SE_27.3.b.23_Passive_4_L,X
DK_27.3.b.23_Longline set_3_L,DE_27.3.c.22_Gillnets set_1_L,X
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DK_27.3.b.23_Longline set_3_L,DE_27.3.c.22_Gillnets set_3_L,X
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DK_27.3.b.23_Longline set_3_L,DK_27.3.b.23_Gillnets set_2_L,X

DK_27.3.b.23_Longline set_3_L,DK_27.3.b.23_Gillnets set_3_L,X
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DK_27.3.b.23_Longline set_3_L,SE_27.3.b.23_Passive_3_L,X
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DK_27.3.c.22_Longline set_1_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_1_L,DE_27.3.c.22_Gillnets set_4_L,X
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DK_27.3.c.22_Longline set_1_L,DK_27.3.b.23_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.b.23_Longline set_2_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_1_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_1_L,SE_27.3.b.23_Passive_1_L,X
DK_27.3.c.22_Longline set_1_L,SE_27.3.b.23_Passive_2_L,X
DK_27.3.c.22_Longline set_1_L,SE_27.3.b.23_Passive_3_L,X
DK_27.3.c.22_Longline set_1_L,SE_27.3.b.23_Passive_4_L,X
DK_27.3.c.22_Longline set_2_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_2_L,DE_27.3.c.22_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_2_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_2_L,DE_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.b.23_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.b.23_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.b.23_Longline set_2_L,X

DK_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_2_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_2_L,SE_27.3.b.23_Passive_1_L,X
DK_27.3.c.22_Longline set_2_L,SE_27.3.b.23_Passive_2_L,X
DK_27.3.c.22_Longline set_2_L,SE_27.3.b.23_Passive_3_L,X
DK_27.3.c.22_Longline set_2_L,SE_27.3.b.23_Passive_4_L,X
DK_27.3.c.22_Longline set_3_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_3_L,DE_27.3.c.22_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_3_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_3_L,DE_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.b.23_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.b.23_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.b.23_Longline set_2_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_3_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_3_L,SE_27.3.b.23_Passive_1_L,X
DK_27.3.c.22_Longline set_3_L,SE_27.3.b.23_Passive_2_L,X
DK_27.3.c.22_Longline set_3_L,SE_27.3.b.23_Passive_3_L,X
DK_27.3.c.22_Longline set_3_L,SE_27.3.b.23_Passive_4_L,X
DK_27.3.c.22_Longline set_4_L,DE_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_4_L,DE_27.3.c.22_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_4_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_4_L,DE_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_4_L,DK_27.3.b.23_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_4_L,DK_27.3.b.23_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_4_L,DK_27.3.b.23_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_4_L,DK_27.3.b.23_Longline set_2_L,X
DK_27.3.c.22_Longline set_4_L,DK_27.3.c.22_Gillnets set_1_L,X
DK_27.3.c.22_Longline set_4_L,DK_27.3.c.22_Gillnets set_2_L,X
DK_27.3.c.22_Longline set_4_L,DK_27.3.c.22_Gillnets set_3_L,X
DK_27.3.c.22_Longline set_4_L,DK_27.3.c.22_Gillnets set_4_L,X
DK_27.3.c.22_Longline set_4_L,SE_27.3.b.23_Passive_1_L,X
DK_27.3.c.22_Longline set_4_L,SE_27.3.b.23_Passive_2_L,X
DK_27.3.c.22_Longline set_4_L,SE_27.3.b.23_Passive_3_L,X
DK_27.3.c.22_Longline set_4_L,SE_27.3.b.23_Passive_4_L,X
SE_27.3.c.22_Passive_1_L,DE_27.3.c.22_Gillnets set_1_L,X
SE_27.3.c.22_Passive_1_L,DE_27.3.c.22_Gillnets set_2_L,X
SE_27.3.c.22_Passive_1_L,DE_27.3.c.22_Gillnets set_3_L,X
SE_27.3.c.22_Passive_1_L,DE_27.3.c.22_Gillnets set_4_L,X
SE_27.3.c.22_Passive_1_L,DK_27.3.b.23_Gillnets set_2_L,X
SE_27.3.c.22_Passive_1_L,DK_27.3.b.23_Gillnets set_3_L,X
SE_27.3.c.22_Passive_1_L,DK_27.3.b.23_Gillnets set_4_L,X
SE_27.3.c.22_Passive_1_L,DK_27.3.b.23_Longline set_2_L,X
SE_27.3.c.22_Passive_1_L,DK_27.3.c.22_Gillnets set_1_L,X
SE_27.3.c.22_Passive_1_L,DK_27.3.c.22_Gillnets set_2_L,X
SE_27.3.c.22_Passive_1_L,DK_27.3.c.22_Gillnets set_3_L,X

SE_27.3.c.22_Passive_1_L,DK_27.3.c.22_Gillnets set_4_L,X
SE_27.3.c.22_Passive_1_L,SE_27.3.b.23_Passive_1_L,X
SE_27.3.c.22_Passive_1_L,SE_27.3.b.23_Passive_2_L,X
SE_27.3.c.22_Passive_1_L,SE_27.3.b.23_Passive_3_L,X
SE_27.3.c.22_Passive_1_L,SE_27.3.b.23_Passive_4_L,X

Table 2.3.4. 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 2019 (upper, middle and lower table, respectively). Colour codes indicate sampling coverage (see legend below). Also SD 24 has otolith and length samples.

Table.2.3.4. Cod 22-24. Number of samples by quarter for 2019 available to the Working Group (SD22-23 samples only).

SD2223		Area	27,3,c,22				27,3,b,23						
Number of samples			Season				Season				Total	Country sum	%
Country	Catch Category	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards *1	Active	15			4					19		
TAC 44%		Gillnets set										69	**36%**
		Longline set											
	Landings *2	Active	17	9	9	8		1	2	4	50		
		Gillnets set	17	9	9	8		1	2	4			
		Longline set						1					
Germany	Discards *1	Active	3		1						4		
TAC 21%		Gillnets set	3			1					4	38	**20%**
		Longline set											
	Landings *1	Active	5	2	4						11		
		Gillnets set	6	5	5	3					19		
		Longline set											
Sweden	BMS *3	Gillnets set					9	9	10	12			
TAC 16%	Discards *2	Gillnets set					9	9	10	12	40	87	**45%**
	Landings *2	Gillnets set					13	11	10	13	47		
			49	16	19	16	22	21	22	29	194		

*1: number of sampled trips; *2: harbor days; *3: Below Minimum Size (BMS) sampled in harbor

SD2223		Area	27,3,c,22				27,3,b,23						
Number of length measurements			Season				Season				Total	Country sum	%
Country	Catch Category	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards	Active	592			9					601		
TAC 44%		Gillnets set										1877	**19%**
		Longline set											
	Landings	Active	545	153	86	98		24	162	208	1276		
		Gillnets set	545	153	86	98		24	162	208			
		Longline set						24					
Germany	Discards	Active	64		9						73		
TAC 21%		Gillnets set	64			8					72	4952	**49%**
		Longline set											
	Landings	Active	780	41	226						1047		
		Gillnets set	2278	521	505	456					3760		
		Longline set											
Sweden	BMS	Gillnets set					394	365	402	473			
TAC 16%	Discards	Gillnets set					394	365	402	473	1634	3236	**32%**
	Landings	Gillnets set					484	342	333	443	1602		
Total			4323	715	826	571	878	731	897	1124	10065		

SD2223		Area	27,3,c,22				27,3,b,23						
Number of otoliths age-read			Season				Season				Total	Country sum	%
Country	Catch Category	Fleets	1	2	3	4	1	2	3	4			
Denmark	Discards	Active	127			9					136		
TAC 44%		Gillnets set										1412	**21%**
		Longline set											
	Landings	Active	545	153	86	98		24	162	208	1276		
		Gillnets set	545	153	86	98		24	162	208			
		Longline set						24					
Germany	Discards	Active	56		0						56		
TAC 21%		Gillnets set	56			0					56	2129	**31%**
		Longline set											
	Landings	Active	458	41	212						711		
		Gillnets set	695	173	193	245					1306		
		Longline set											
Sweden	BMS	Gillnets set					394	365	402	473			
TAC 16%	Discards	Gillnets set					394	365	402	473	1634	3236	**48%**
	Landings	Gillnets set					484	342	333	443	1602		
Total			1937	367	491	352	878	731	897	1124	6777		

Table 2.3.5. Cod 22–23. 2019. Discard (Number * 1000) by quarter and gear type.

Sum of DISCARD	Quarter				Grand Total
Gear type	1	2	3	4	
Passive gears	19	5	22	34	80
Active gears	167	8	5	24	204
Grand Total	186	14	27	57	284

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). Landings in 2017-2019 includes BMS.

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	2058	227	25496	3238	7	7642	0.64	2.86
2018	3555	157	1600	0.04	0.21	2295	300	15907	3103	12	7907	0.59	3.39
2019	6103	655	2573	0.10	0.26	1598	621	15907	3103	10	11550	0.75	1.27
3 avr.					0.22								2.50

Table 2.3.7. Cod in SD 22–23. Numbers at age (LANUM) and mean weight-at-age (WELA) in commercial landings for Sub-division 22 and 23 by quarter and gear in 2019.

Year:		Gear:	Trawl, gillnet and longlines combined			
Year:	**2019**	**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	0.001	618		624	0.001	620
2	7	722	0.2	948	8	816
3	1944	1428	185	1448	2129	1436
4	70	2524	11	2223	81	2403
5	57	3200	13	2687	71	2995
6	20	4816	3	5005	23	4891
7	6	5452	1	4451	6	4990
8	1	5818	0.1	3310	1	4815
9	0.5	9086		9293	0.5	9138
SOP [t]	2399		278		2677	
Landings (t)	2375		276		2651	

Year:	**2019**	**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	0.0004	620		632	0.0004	624
2	0.5	780	1	956	1	833
3	171	1585	94	1473	265	1537
4	5	2807	1	2401	6	2620
5	6	3567	6	2557	13	3062
6	3	5360	0.3	6186	3	5736
7	0.3	6216	1	4045	1	5130
8	0.3	5311	0.02	7130	0.4	5830
9	0.00004	9293		9293	0.00004	9293
SOP [t]	281		144		425	
Landings (t)	278		143		421	

Year:	**2019**	**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	0.00007	620		624	0.00007	622
2	2	761	1	901	3	831
3	190	1840	189	1510	379	1698
4	4	2990	8	2339	12	2711
5	3	3187	11	2671	14	2966
6	0.3	5016	0.6	5804	0.9	5410
7	0.9	5977	0.8	4541	2	5259
8	0.3	6234	0.1	4463	0.4	5570
9	0.05	10536		9293	0.1	10181
SOP [t]	287		297		584	
Landings (t)	284		294		578	

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 2019. 2/2

Year:	**2019**	**Quarter:**	**4**			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers *10-3	Mean weight [g]	Numbers *10-3	Mean weight [g]	Numbers *10-3	Mean weights [g]
1	4	617	1	633	5	626
2	4	976	8	1032	12	1007
3	330	2042	277	1578	607	1828
4	13	3256	5	2184	19	2761
5	13	3436	5	2707	19	3100
6	0.01	5932	0.2	5804	0.2	5855
7	1	5534	1	4024	2	4779
8		5047	0.03	4463	0.03	4697
9		9293		9293		9293
SOP [t]	799		460		1259	
Landings (t)	791		455		1246	

Year:	**2019**	**Quarter:**	**All**			
Sub-div.	Sub-div. 22		Sub-div. 23		Sub-div. 22-23	
Age	Numbers *10-3	Mean weight [g]	Numbers *10-3	Mean weight [g]	Numbers *10-3	Mean weights [g]
1	4	619	1	629	5	623
2	14	798	10	960	24	870
3	2635	1704	746	1502	3380	1618
4	93	2873	25	2287	118	2617
5	80	3325	36	2655	116	3027
6	23	5173	4	5678	27	5415
7	8	5781	3	4265	11	5039
8	2	5707	0.3	4523	2	5233
9	1	9604		9293	1	9509
SOP [t]	3765		1179		4944	
Landings (t)	3728		1167		4895	

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

	SD 22	SD 23	SD 24
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 (length, weight and age) 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
1977	63	52	56
1978	65	52	55
1979	65	48	52
1980	65	44	50
1981	65	40	45
1982	65	47	51
1983	65	55	57
1984	65	55	58
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

year	Area 1 _ W	Area 2 E	Percent WBC in landings for SD 24
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
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
2019	41	48	43

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

age	a1	a2	a3	a4	a5	a6	a7+
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
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
2019	6	28	4226	148	142	35	16

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
2013	903	666	500	469	52	0	0

age	a1	a2	a3	a4	a5	a6	a7+
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
2019	213	38	1345	10	1	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

age	a1	a2	a3	a4	a5	a6	a7+
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
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
2019	96	46	2107	243	46	13	3

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

age	a1	a2	a3	a4	a5	a6	a7+
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
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
2019	315	113	7677	401	190	47	19

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
2013	0.832	1.035	1.288	1.843	2.517	3.301	3.534

age	a1	a2	a3	a4	a5	a6	a7+
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
2019	0.588	0.816	1.202	2.598	3.271	4.033	6.386

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
2019	0.249	0.321	0.436	0.650	1.861

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

age	a1	a2	a3	a4	a5	a6	a7+
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
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
2019	0.257	0.542	1.010	1.975	3.163	3.739	5.940

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

age	a0	a1	a2	a3	a4	a5	a6	a7+
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	0.048	0.461	0.797	1.975	3.163	3.739	5.940
2020	0.005	0.046	0.324	0.832	2.153	3.319	4.187	5.769

Table 2.3.19. Western Baltic cod. Proportion mature at age (spawning probability). From 1985-2000 same value was used and from 2001 an annual value.

age	a1	a2	a3	a4	a5	a6	a7+
1985-2000	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
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

age	a1	a2	a3	a4	a5	a6	a7+
2018	0.07	0.64	0.87	0.88	1.0	1.0	1.0
2019	0.06	0.71	0.89	0.88	1.0	1.0	1.0
2020*	0.06	0.65	0.88	0.88	1.0	1.0	1.0
*3 years average							

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
1997-2019	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	12646	98538	12916	206
1997	12262	2219	11099	437
1998	26387	6657	533	463
1999	7250	12107	2345	55
2000	10594	5390	6171	1034
2001	4702	3962	843	445
2002	11501	2430	1275	89
2003	983	3469	379	123
2004	10128	1273	1592	47
2005	9121	26646	873	476
2006	13411	4869	4828	95
2007	2605	7502	1520	988
2008	118	813	748	206
2009	8525	566	573	196
2010	3304	8315	254	101
2011	12252	6119	8873	34
2012	2142	2748	1095	753
2013	8024	2381	1547	170
2014	4868	3812	413	146
2015	3213	4120	1269	104
2016	71	860	448	311
2017	17369	494	848	155
2018	390	20489	734	407
2019	307	1691	5962	270
2020	2593	1118	372	1606

To be continued

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

BITS Q4	a0	a1	a2	a3	a4
1999	9416	5314	2484	164	22
2000	3126	2920	742	128	23
2001	11639	689	347	42	61
2002	1271	1715	262	79	11
2003	12622	1093	659	32	30
2004	4500	9545	711	125	20
2005	3612	2067	1199	48	46
2006	2050	3180	261	296	52
2007	408	363	146	78	188
2008	17320	46	46	36	52
2009	2393	2015	52	49	15
2010	8420	756	448	13	9
2011	3041	1469	98	81	5
2012	14110	1365	322	44	37
2013	6271	3306	159	40	17
2014	5026	1482	612	63	45
2015	272	830	267	111	34
2016	34155	281	63	14	70
2017	194	12163	69	45	39
2018	1509	766	344	20	21
2019	4226	521	37	36	46

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
2016	164.2
2017	0.4
2018	2.2
2019	4.6

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	TSB	Low	High
1985	29009	15853	53081	29993	23512	38260	1.319	1.085	1.602	43109	34363	54080
1986	78631	43678	141558	19010	15533	23265	1.246	1.047	1.482	31578	25993	38364
1987	25969	14675	45953	17567	14395	21438	1.157	0.971	1.378	32376	25509	41092
1988	11383	6360	20372	21709	16761	28117	1.126	0.943	1.343	31086	24358	39673
1989	13787	7785	24416	15940	12686	20028	1.053	0.871	1.273	22604	18134	28175
1990	21350	12059	37802	12124	9886	14868	1.159	0.977	1.374	17545	14599	21086
1991	33402	18864	59141	9617	7995	11569	1.284	1.084	1.522	16598	13796	19969
1992	65814	36956	117206	9606	7803	11826	1.316	1.107	1.565	20089	16112	25048
1993	25729	14483	45708	14148	11081	18063	1.189	1.001	1.412	28058	21796	36118
1994	59886	33714	106376	25014	19078	32798	1.106	0.924	1.325	40112	31666	50812
1995	94217	52867	167909	28310	22655	35376	1.234	1.03	1.477	50095	40595	61817
1996	25898	14351	46737	35655	28544	44538	1.15	0.967	1.368	57603	46229	71777
1997	80922	47493	137881	40633	31035	53198	1.157	0.974	1.374	59353	46401	75921
1998	124123	73544	209488	28052	22658	34731	1.152	0.969	1.368	55627	45185	68481
1999	42343	25756	69613	33554	27321	41210	1.298	1.103	1.528	56687	45894	70019
2000	43222	26812	69676	34650	27512	43638	1.29	1.098	1.516	50775	41002	62878

Year	R(age 1)	Low	High	SSB	Low	High	F_{bar}(3-5)	Low	High	TSB	Low	High
2001	25895	15861	42278	28454	23478	34485	1.366	1.163	1.604	43646	36135	52719
2002	47301	28987	77186	24845	20327	30367	1.321	1.122	1.554	36744	30304	44553
2003	14617	8901	24002	20235	16853	24296	1.19	1.01	1.403	32427	26722	39350
2004	64204	39511	104329	22881	18258	28675	1.153	0.975	1.364	34568	28146	42454
2005	21539	13308	34859	25982	21280	31723	1.082	0.905	1.294	39948	32387	49273
2006	23741	14546	38749	27216	21698	34137	0.892	0.726	1.096	35783	28735	44559
2007	7886	4852	12819	27886	22505	34553	0.927	0.77	1.115	35615	29107	43577
2008	3839	2172	6786	20878	17346	25129	0.989	0.828	1.182	24856	20770	29745
2009	28498	17229	47137	15238	12741	18226	1.049	0.881	1.249	19282	16249	22880
2010	10530	6507	17041	14293	11773	17353	1.071	0.895	1.282	18377	15025	22478
2011	15635	9561	25566	13739	10833	17425	0.983	0.819	1.179	16960	13470	21354
2012	12264	7622	19732	16536	13408	20393	0.922	0.761	1.116	19531	15976	23876
2013	28818	17660	47027	13813	11481	16619	1.103	0.91	1.337	17182	14390	20516
2014	16354	10054	26600	15760	13100	18961	0.997	0.828	1.2	20137	16681	24310
2015	10255	6313	16658	16812	13754	20550	0.974	0.799	1.186	20446	16783	24908
2016	2733	1634	4570	12559	10177	15498	0.945	0.753	1.188	14915	12145	18317
2017	35586	20108	62977	9410	7525	11766	0.777	0.569	1.063	11403	9165	14186

Year	R(age 1)	Low	High	SSB	Low	High	F_{bar}(3-5)	Low	High	TSB	Low	High
2018	1777	972	3250	10975	8026	15007	0.605	0.374	0.977	14267	10324	19715
2019	3636	1739	7604	15542	9890	24422	0.523	0.284	0.966	17537	11207	27442
2020*	9076	2939	27316	19992	9329	40481						

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

Year Age	0	1	2	3	4	5	6	7
1985	166208	29009	19624	20843	4138	1131	357	200
1986	58521	78631	16913	7580	4433	814	274	127
1987	26547	25969	53918	6750	1800	932	199	101
1988	31090	11383	17141	20205	1854	455	249	90
1989	47582	13787	6453	7443	4940	503	130	92
1990	74883	21350	9347	3139	2210	1338	160	73
1991	136717	33402	15070	4004	807	500	352	74
1992	61800	65814	22306	5857	951	155	117	101
1993	130965	25729	45193	9558	1401	194	25	48
1994	194635	59886	17510	23825	3287	300	35	18
1995	63986	94217	45100	8323	8643	1166	92	9
1996	174723	25898	77702	22882	2027	2392	258	14
1997	258365	80922	11352	41499	5220	597	552	87
1998	98536	124123	53321	5521	9829	1241	174	152
1999	92769	42343	83477	24375	1812	2158	327	102
2000	55739	43222	27551	34087	5967	350	445	85
2001	97512	25895	31289	10961	8140	1445	79	122
2002	32286	47301	19491	13370	2416	1574	361	36
2003	125605	14617	39787	8053	2795	538	341	94
2004	48886	64204	10721	19781	2366	604	158	116
2005	47905	21539	52747	4930	5539	598	137	71
2006	17814	23741	14766	25666	1706	1369	154	41
2007	8743	7886	16668	7543	7984	754	451	62
2008	61453	3839	5978	7254	2782	1837	301	176
2009	24544	28498	4412	4204	2362	865	405	134
2010	36718	10530	23098	2945	1654	674	224	118
2011	29211	15635	7238	13243	1420	498	136	73
2012	64948	12264	10900	4447	4755	714	147	40

Year Age	0	1	2	3	4	5	6	7
2013	38090	28818	8287	6250	1752	1404	276	72
2014	24739	16354	19924	4163	2158	387	315	69
2015	6623	10255	10701	9508	1394	557	99	111
2016	78694	2733	6924	4358	3039	401	140	60
2017	3857	35586	2127	3650	1398	697	112	58
2018	8277	1777	22722	1336	1410	419	188	54
2019	19588	3636	1285	15156	981	540	142	70
2020		8916	2683	930	8674	465	241	94

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	0.161	0.74	1.313	1.383	1.26
1986	0.152	0.698	1.237	1.306	1.194
1987	0.141	0.647	1.146	1.21	1.113
1988	0.135	0.621	1.108	1.177	1.092
1989	0.124	0.569	1.025	1.101	1.033
1990	0.131	0.612	1.115	1.212	1.15
1991	0.14	0.658	1.214	1.341	1.297
1992	0.138	0.652	1.217	1.37	1.362
1993	0.121	0.574	1.082	1.232	1.252
1994	0.112	0.532	1.006	1.14	1.172
1995	0.123	0.59	1.127	1.271	1.304
1996	0.118	0.564	1.071	1.188	1.192
1997	0.118	0.567	1.079	1.2	1.191
1998	0.116	0.568	1.076	1.2	1.179
1999	0.127	0.634	1.209	1.357	1.328
2000	0.126	0.636	1.21	1.349	1.311
2001	0.131	0.672	1.282	1.431	1.385
2002	0.124	0.646	1.233	1.385	1.345

Year Age	age 1	age 2	age 3	age 4	age 5-7
2003	0.109	0.573	1.097	1.248	1.227
2004	0.101	0.536	1.038	1.207	1.214
2005	0.093	0.495	0.957	1.13	1.16
2006	0.077	0.409	0.786	0.927	0.963
2007	0.077	0.415	0.804	0.965	1.011
2008	0.078	0.423	0.835	1.028	1.104
2009	0.079	0.435	0.868	1.092	1.187
2010	0.078	0.429	0.869	1.118	1.227
2011	0.071	0.388	0.792	1.028	1.128
2012	0.067	0.365	0.747	0.967	1.051
2013	0.078	0.429	0.888	1.158	1.263
2014	0.072	0.39	0.808	1.046	1.137
2015	0.07	0.379	0.79	1.019	1.112
2016	0.067	0.363	0.763	0.99	1.084
2017	0.054	0.291	0.617	0.812	0.903
2018	0.042	0.223	0.475	0.631	0.708
2019	0.037	0.194	0.415	0.546	0.609

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

2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt***	**Sel**	**CWt**
1	9076	0.242	0.06	0	0	0.05	0.04	0.23
2		0.2	0.65	0	0	0.33	0.19	0.67
3		0.2	0.88	0	0	0.83	0.42	1.33
4		0.2	0.88	0	0	2.15	0.55	2.15
5		0.2	1.00	0	0	3.32	0.61	3.32
6		0.2	1.00	0	0	4.19	0.61	4.19
7		0.2	1.00	0	0	5.77	0.61	5.77

2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt***	**Sel**	**CWt**
1	9535	0.242	0.06	0	0	0.05	0.04	0.23
2		0.2	0.65	0	0	0.33	0.19	0.67
3		0.2	0.88	0	0	0.83	0.42	1.33
4		0.2	0.88	0	0	2.15	0.55	2.15
5		0.2	1.00	0	0	3.32	0.61	3.32
6		0.2	1.00	0	0	4.19	0.61	4.19
7		0.2	1.00	0	0	5.77	0.61	5.77

2022								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt***	**Sel**	**CWt**
1	9948	0.242	0.06	0	0	0.05	0.04	0.23
2		0.2	0.65	0	0	0.33	0.19	0.67
3		0.2	0.88	0	0	0.83	0.42	1.33
4		0.2	0.88	0	0	2.15	0.55	2.15
5		0.2	1.00	0	0	3.32	0.61	3.32
6		0.2	1.00	0	0	4.19	0.61	4.19
7		0.2	1.00	0	0	5.77	0.61	5.77

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 2017–2019
Weight in the stock (SWt): average of 2017–2019
Exploitation pattern (Sel.): average of 2019

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

Variable	Value	Notes
Fages 3–5 (2020)	0.52	Based on catch constrain in 2020
SSB (2021)	24488	Based on catch constrain in 2020
Rage 1 (2020)	9076	From the assessment
Rage 1 (2021)	9535	Sampled from the last 10 years*
Rage 1 (2022)	9948	Sampled from the last 10 years*
Total catch (2020)	4488	Commercial+ recreational catches
Commercial catches (2020)	3173	**
Recreational catches (2020)	1315	Same value as in 2017***

*** Recruitment is randomly resampled from the last ten years' assessment estimates and the median of these random draws is used. This will vary slightly every time this is done.**

**** Calculated as the 2020 TAC (3806 tonnes) plus an assumed discard ratio as in 2019 (9.7%), and accounting for the proportion of western Baltic cod in commercial catches in subdivisions 22–24 in 2019 (75%).**

***** Same management measures in 2020 as in 2017 for the recreational fishery.**

Table 2.3.27. Cod in subdivisions 22–24, western Baltic stock. The scenarios illustrate the implications of zero catch advice for eastern Baltic cod on the commercial catch by management area, assuming a recreational catch of 1315 tonnes in 2021. Weights are in tonnes.

Area	Commercial catch WB cod stock				Commercial catch EB cod stock		Commercial catch of cod by management area (TAC)			
	A	B	C	D	E	F	G		H	
	Advice Total	SDs 22–23	SD 24	Total	SD 24	SDs 25–32	SDs22–24	% TAC change (SDs 22–24)*	SDs 25–32	% TAC change (SDs 25–32)**
a. Status quo distribution, with no catch of EB cod in the Western Baltic management area										
Calculation		= A × 0.74^	= A × 0.26^		= C × 1.27 ^^	= D − E	= B + C + E		= F	
EU MAP: F_{MSY}	4635	4635	0	0	0	0	4635	22	0	−100
F=MAP F_{MSY} lower	2960	2960	0	0	0	0	2960	−22	0	−100
b. Status quo distribution, with catch of EB cod in the Western Baltic management area										
Calculation		= A × 0.76^	= A × 0.24^		= C × 1.27^^	= D − E	= B + C + E		= F	
EU MAP: F_{MSY}	4635	3430	1205	-	1532	-	6167	62	-	-
F=MAP F_{MSY} lower	2960	2190	770	-	979	-	3939	3	-	-

*** Compared to the 2020 TAC for subdivisions 22–24 (3806 tonnes).**

**** Compared to the 2020 TAC for subdivisions 25–32 (2000 tonnes).**

^ Same proportions of the WB cod stock commercial catch that has been caught in subdivisions 22–23 and Subdivision 24 in latest data year (2019).

^^ The EB cod catch / WB cod commercial catch ratio is similar to observed in Subdivision 24 in latest data year (2019).

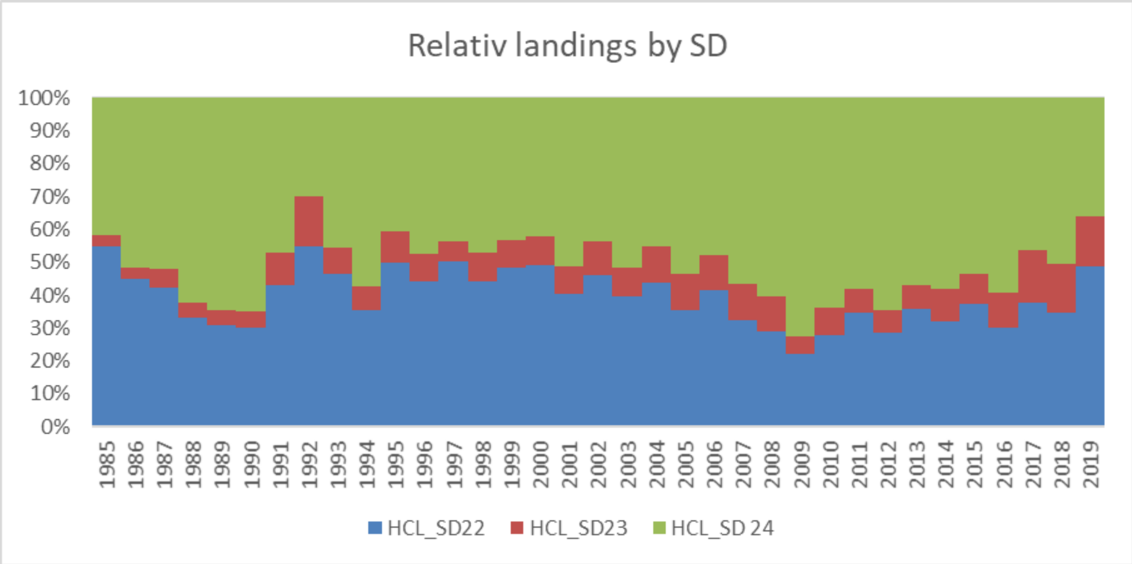

Figure 2.3.1. Western Baltic cod. Relative landings by SD (tonnes) for the western Baltic management area (both east and west cod included). HCL: human consumption landings.

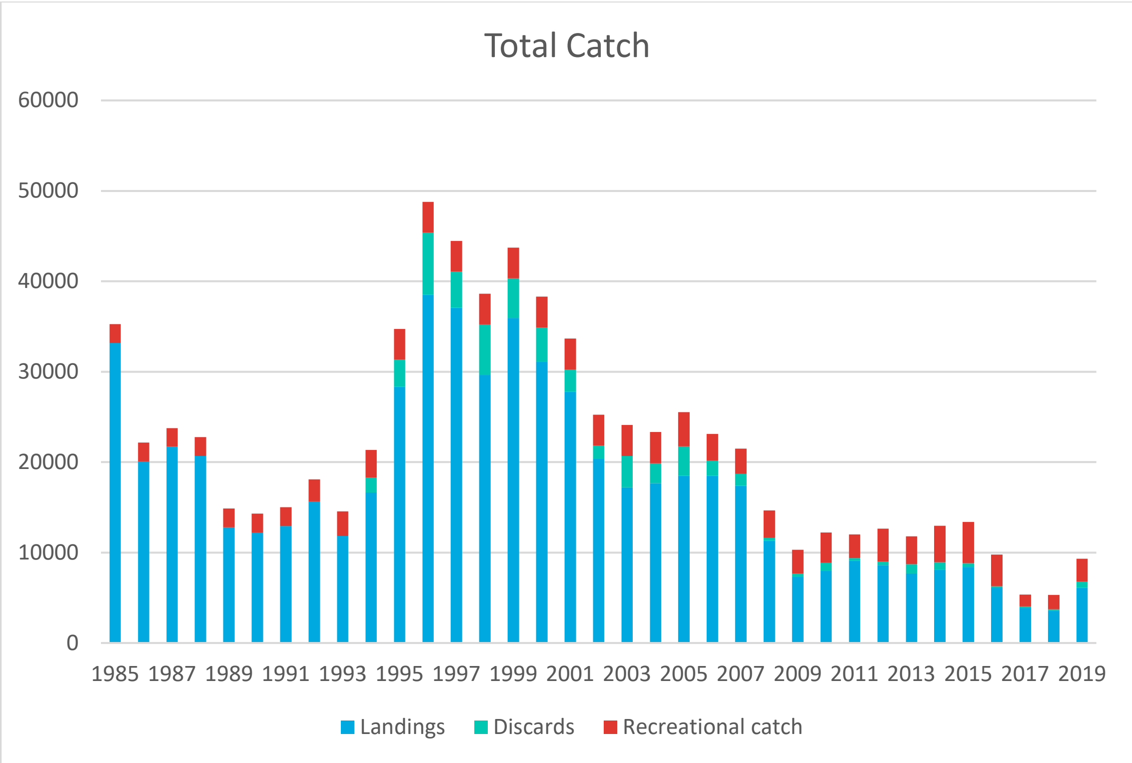

Figure 2.3.2. Western Baltic cod. Commercial landings, discard and recreational catch (tonnes) of the WBC stock.

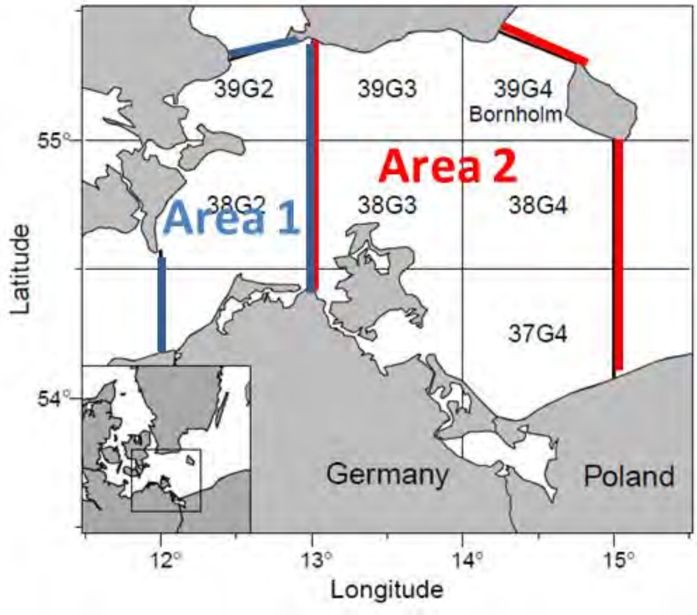

Figure 2.3.3. Western Baltic cod. Subareas (Area 1 and Area 2 within SD 24) for which different keys for splitting between eastern and western Baltic cod catches in SD 24 were applied.

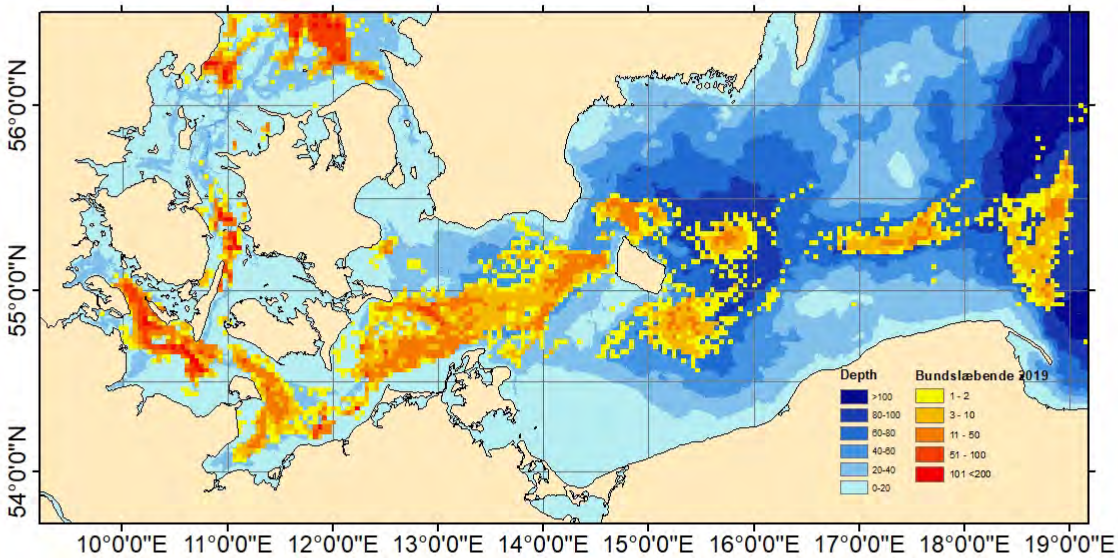

Figure 2.3.4. Danish VMS data from 2019 from OTB.

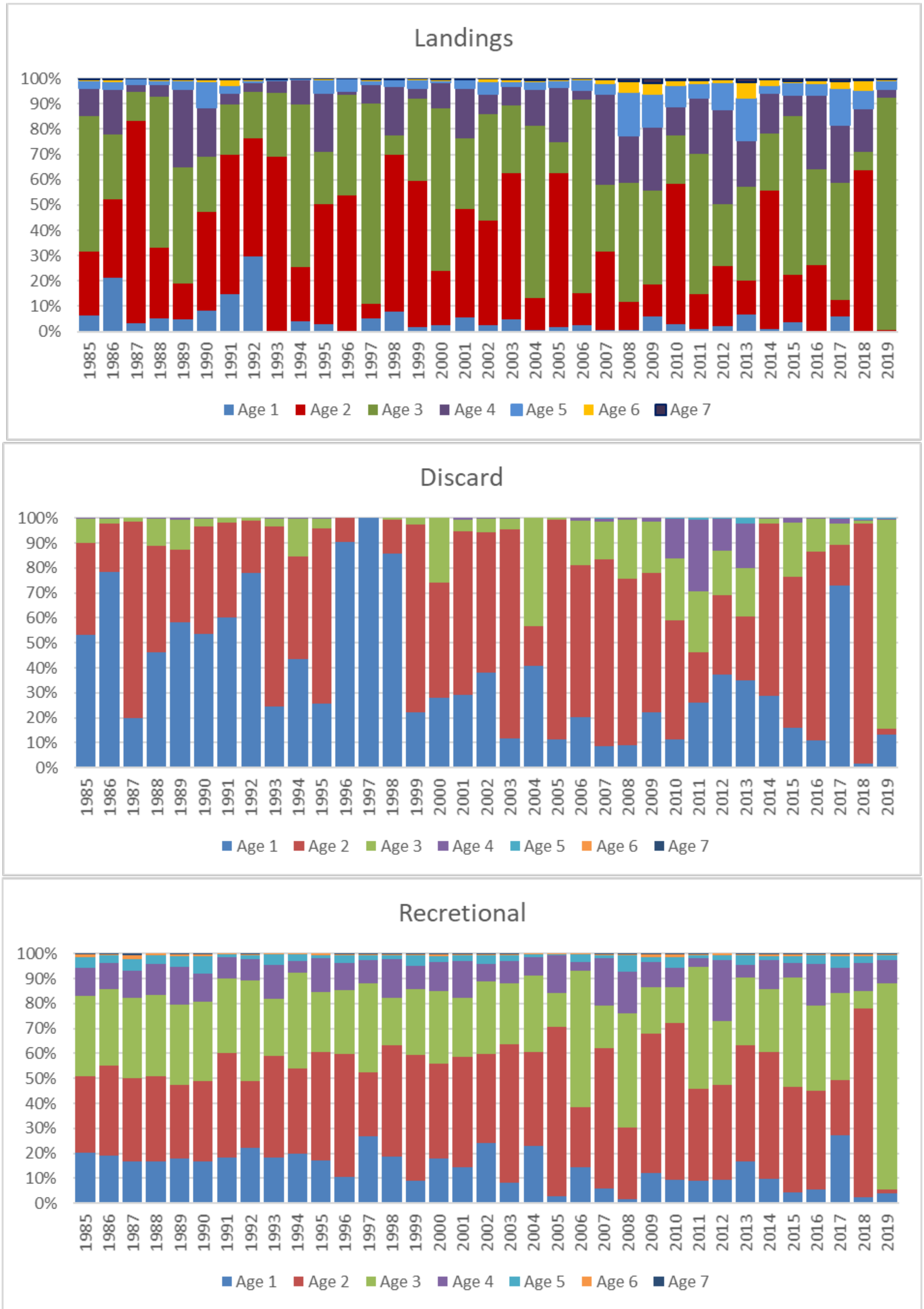

Figure 2.3.5. Western Baltic cod. Number at age distribution of cod in commercial landings, discards and recreational catch (relative proportions).

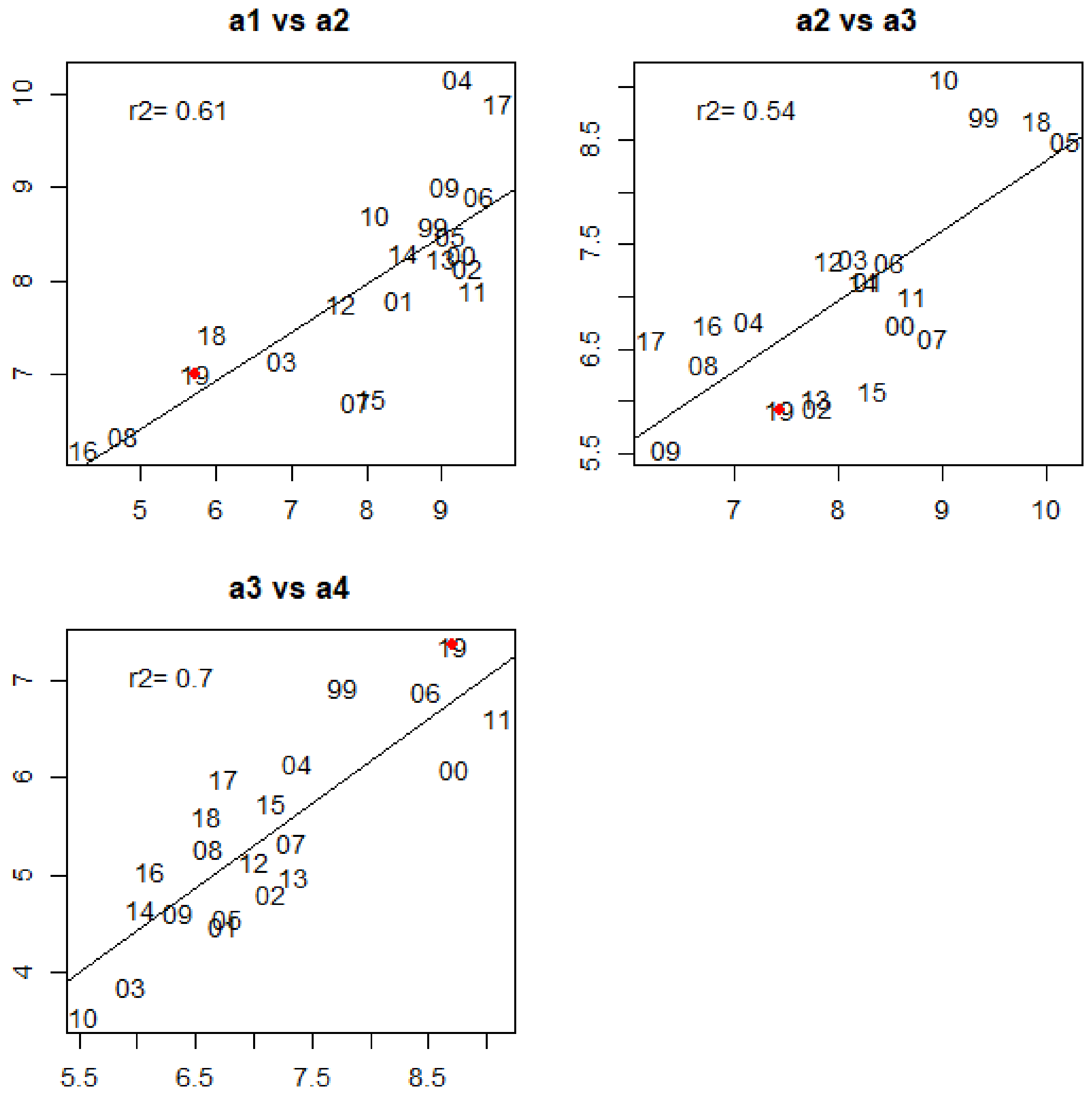

Figure 2.3.6. Western Baltic cod. CPUE at age i vs numbers at age i +1 in the following year, in BITS Q1 survey. Red dots highlight the information from the latest year.

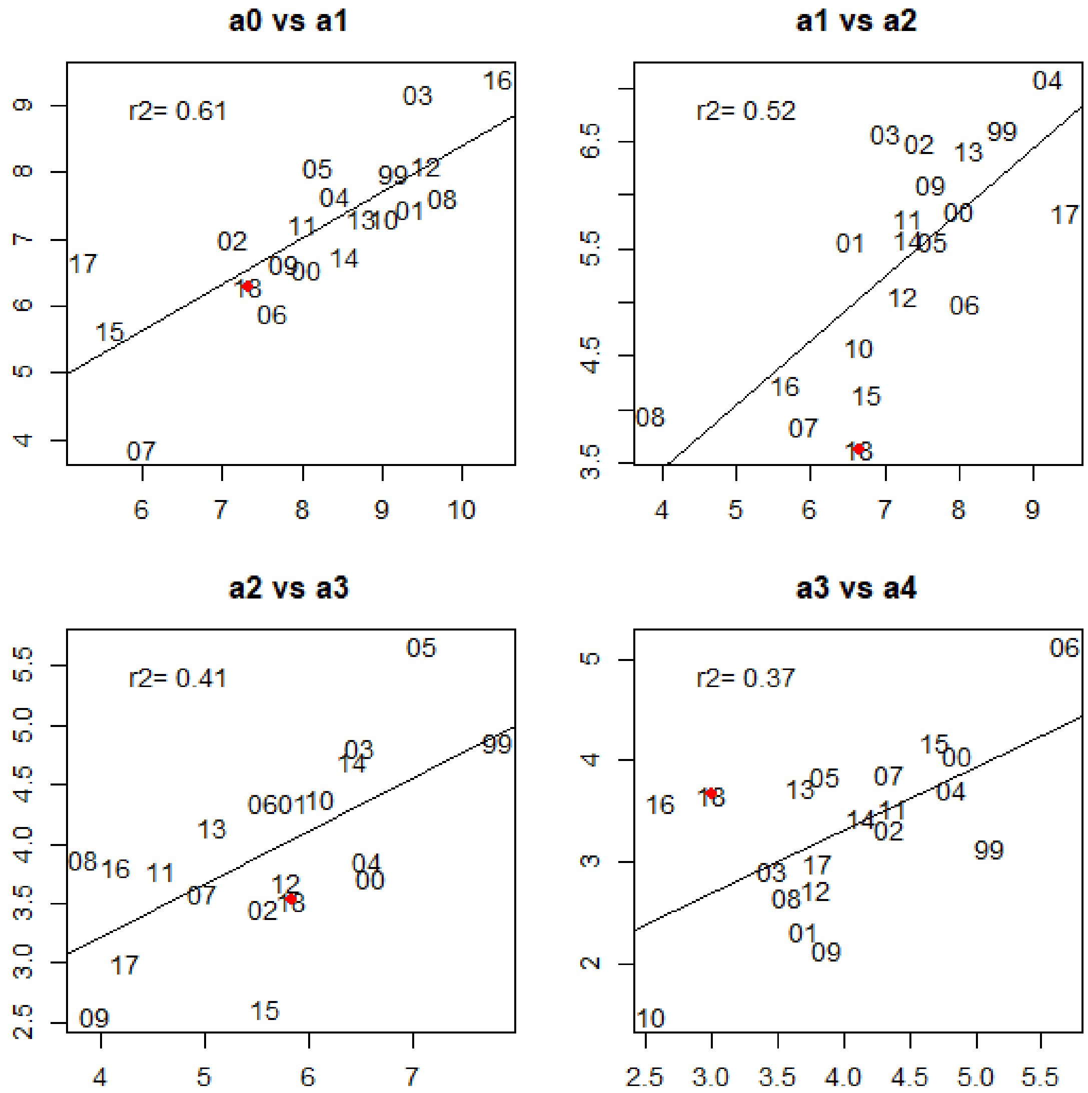

Figure 2.3.7. Western Baltic cod. CPUE at age i vs numbers at age i +1 in the following year, in BITS Q4 survey. Red dots highlight the information from the latest year.

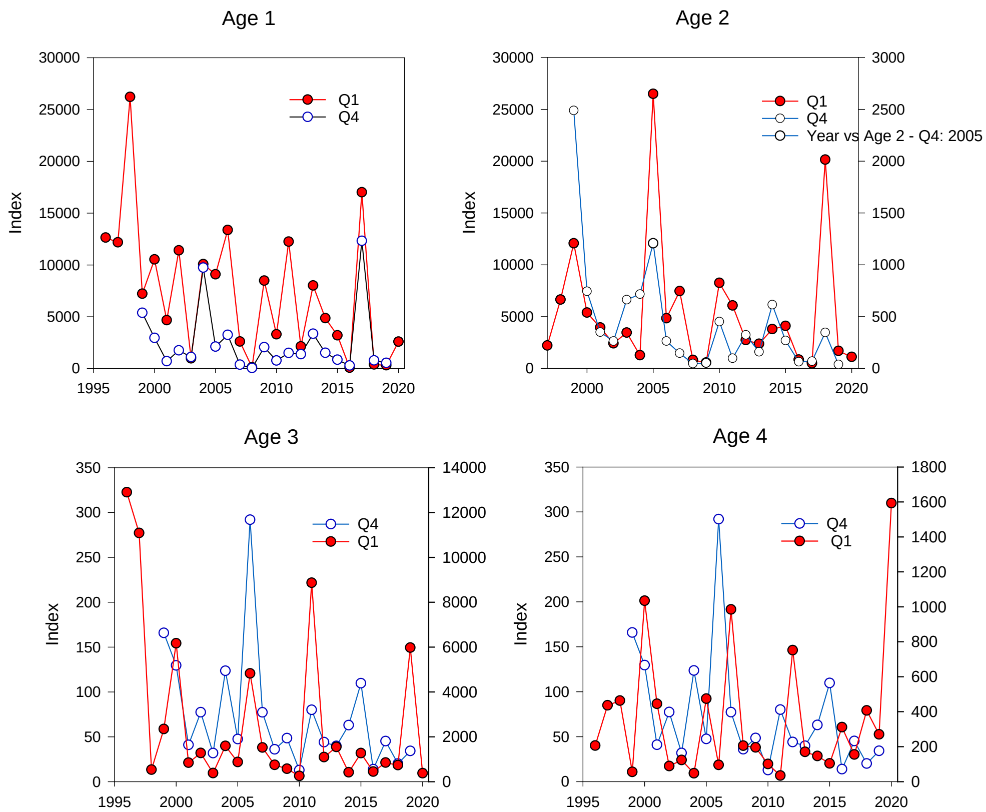

Figure 2.3.8. Western Baltic cod. Time series of BITS Q1 and BITS Q4 in numbers by age groups.

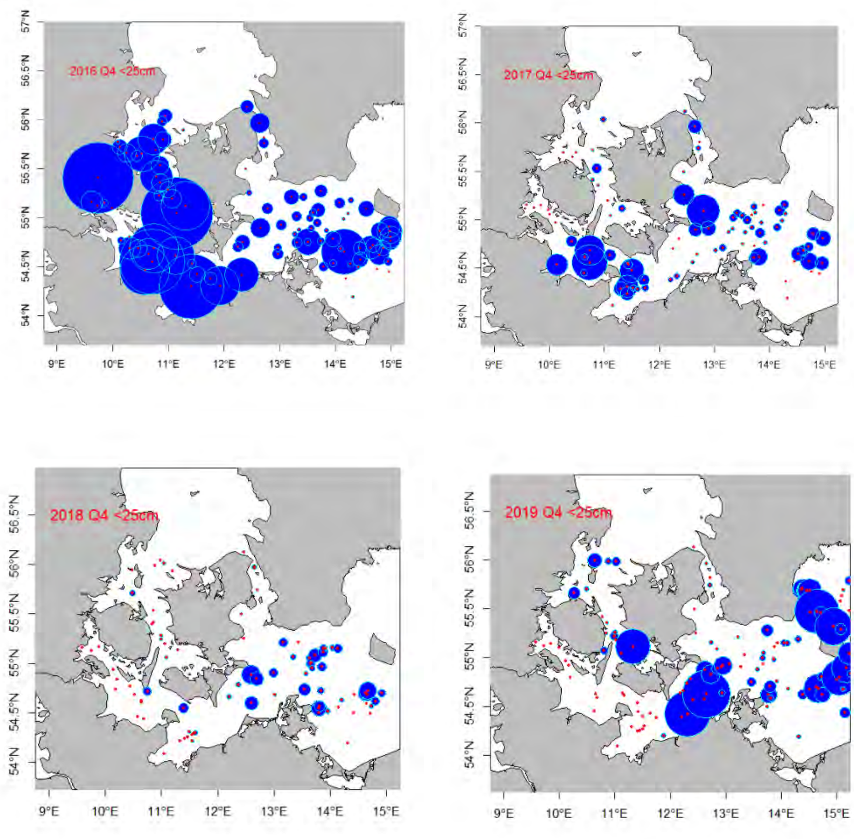

Figure 2.3.9. Western Baltic cod. Distribution of cod<25 cm from BITS Q4 2016, 2017, 2018 and 2019.

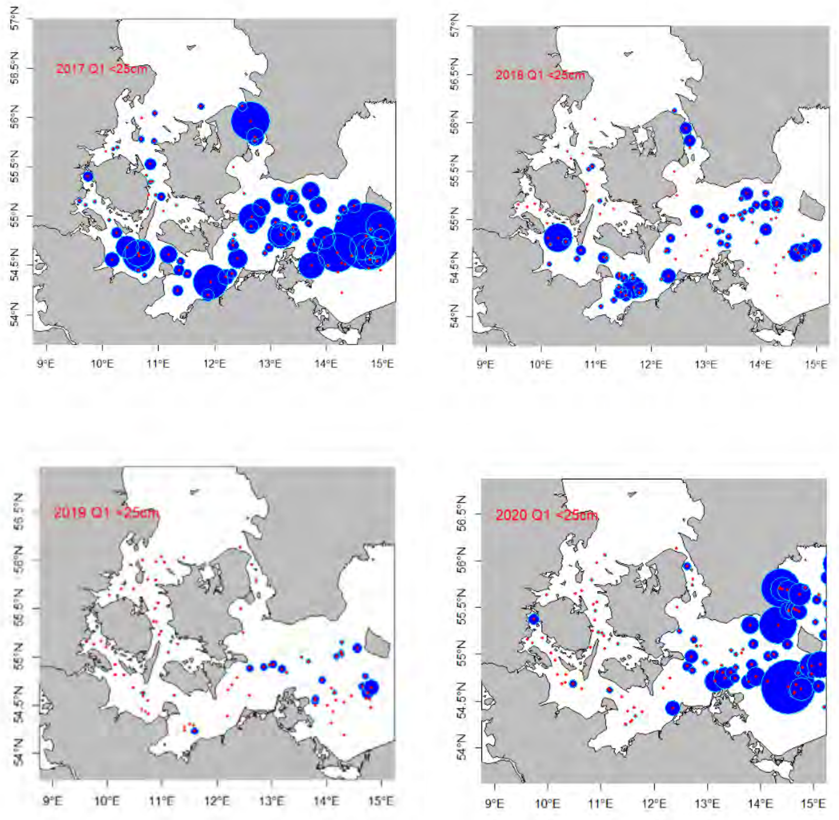

Figure 2.3.10. Western Baltic cod. Distribution of cod<25 cm from BITS Q4 2017, 2018, 2019 and 2020.

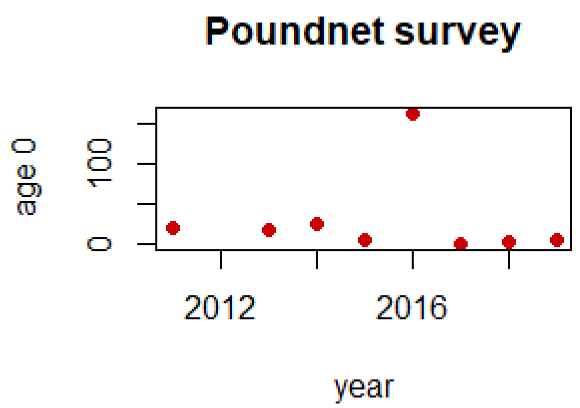

Figure 2.3.11. Western Baltic cod. Fejucs, German Pound net survey age 0.

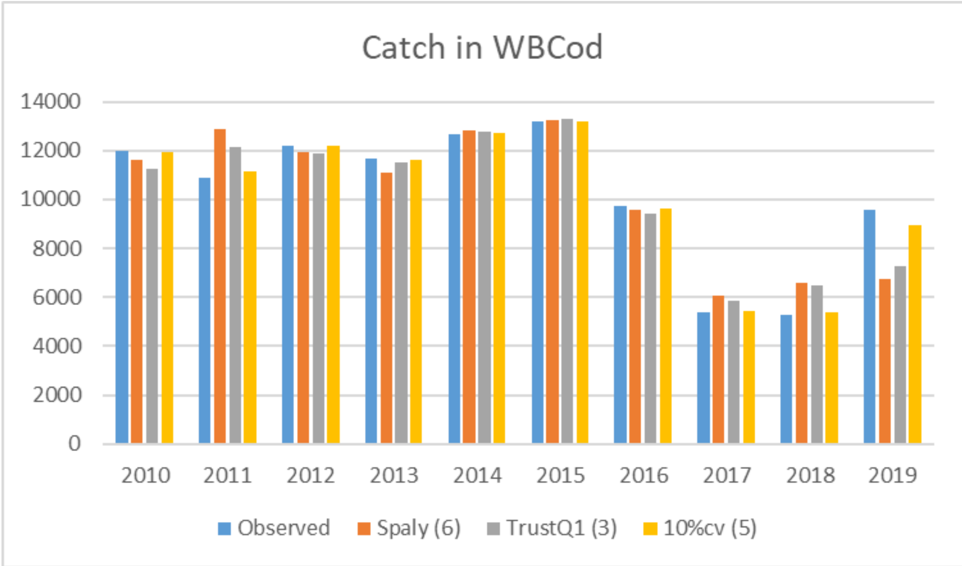

Figure 2.3.12. Western Baltic cod. The catch estimate from the model in 3 different runs compared with the observed estimate (blue).

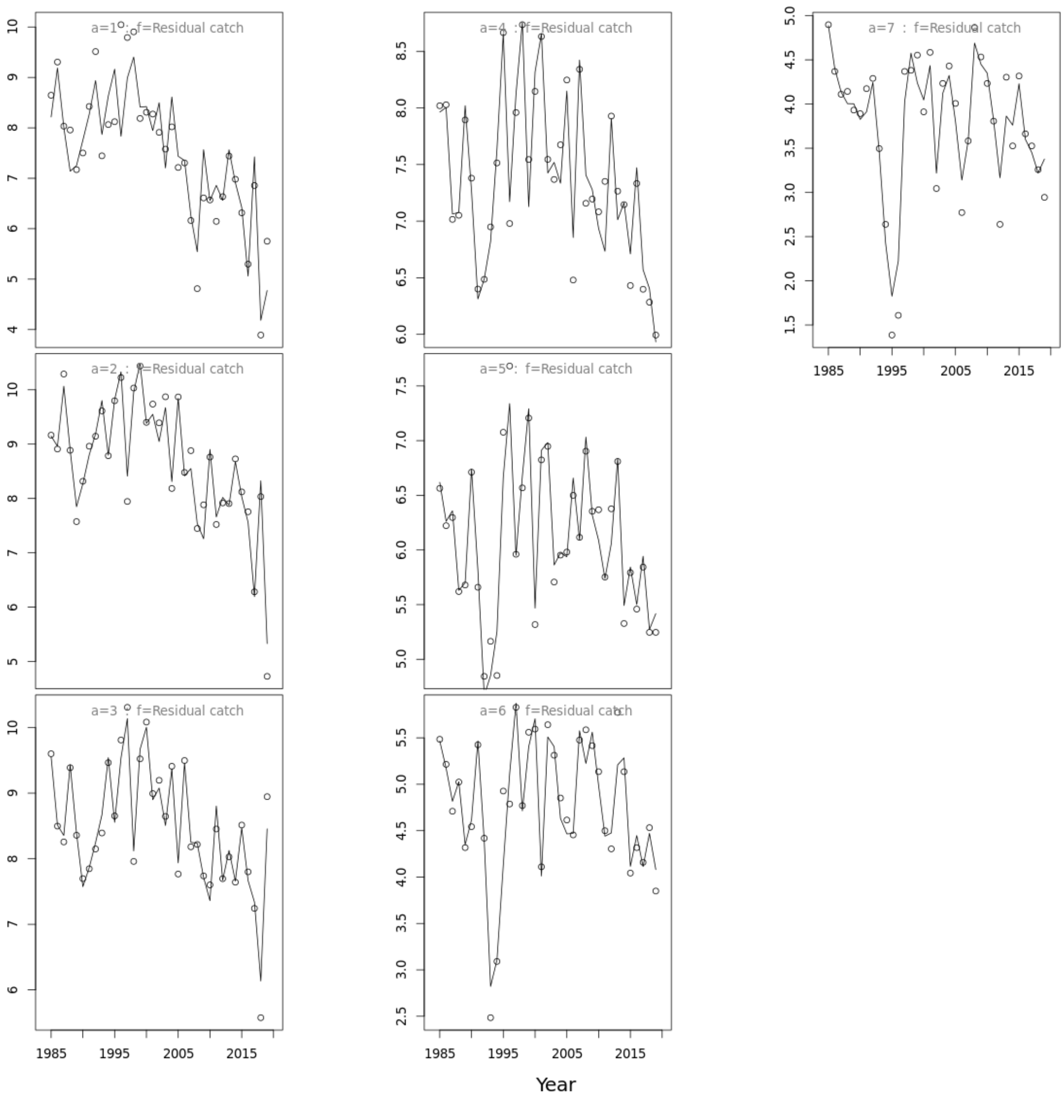

Figure 2.3.13. Western Baltic cod. Commercial catch data fit to the model by age and year.

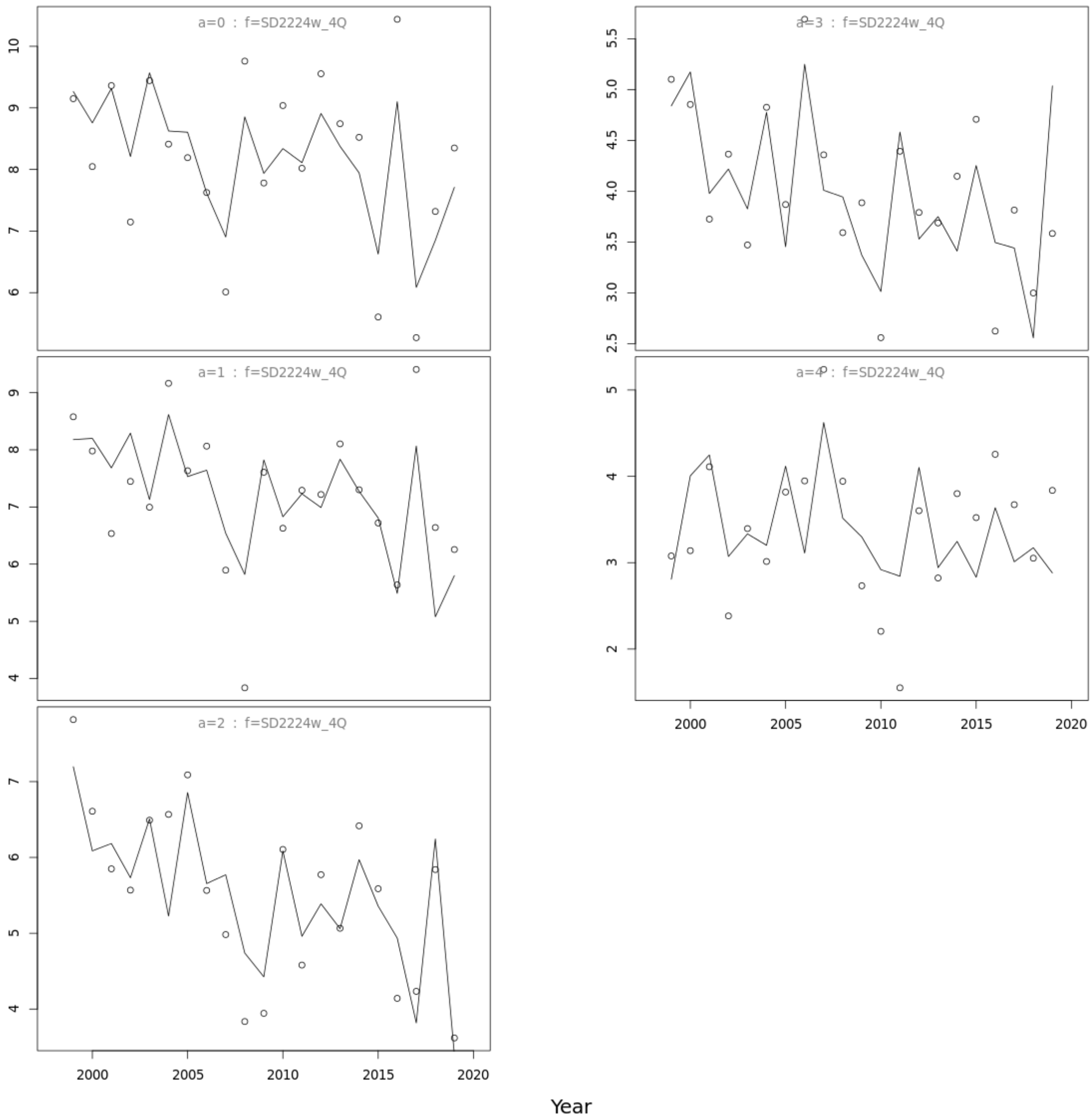

Figure 2.3.14. Western Baltic cod. BITS Q4 data fit to the model by age and year.

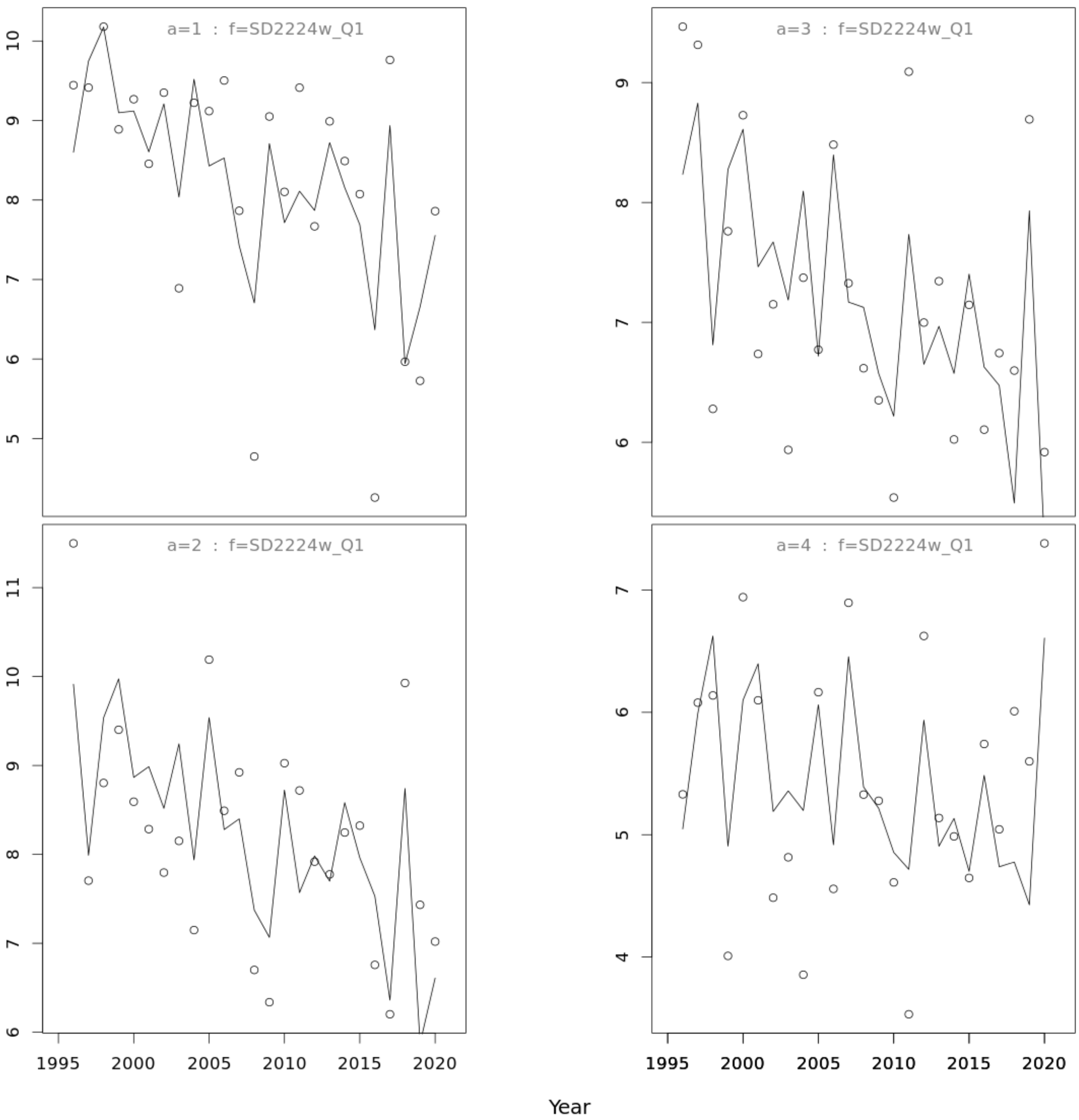

Figure 2.3.15. Western Baltic cod. BITS Q1 data fit to the model by age and year.

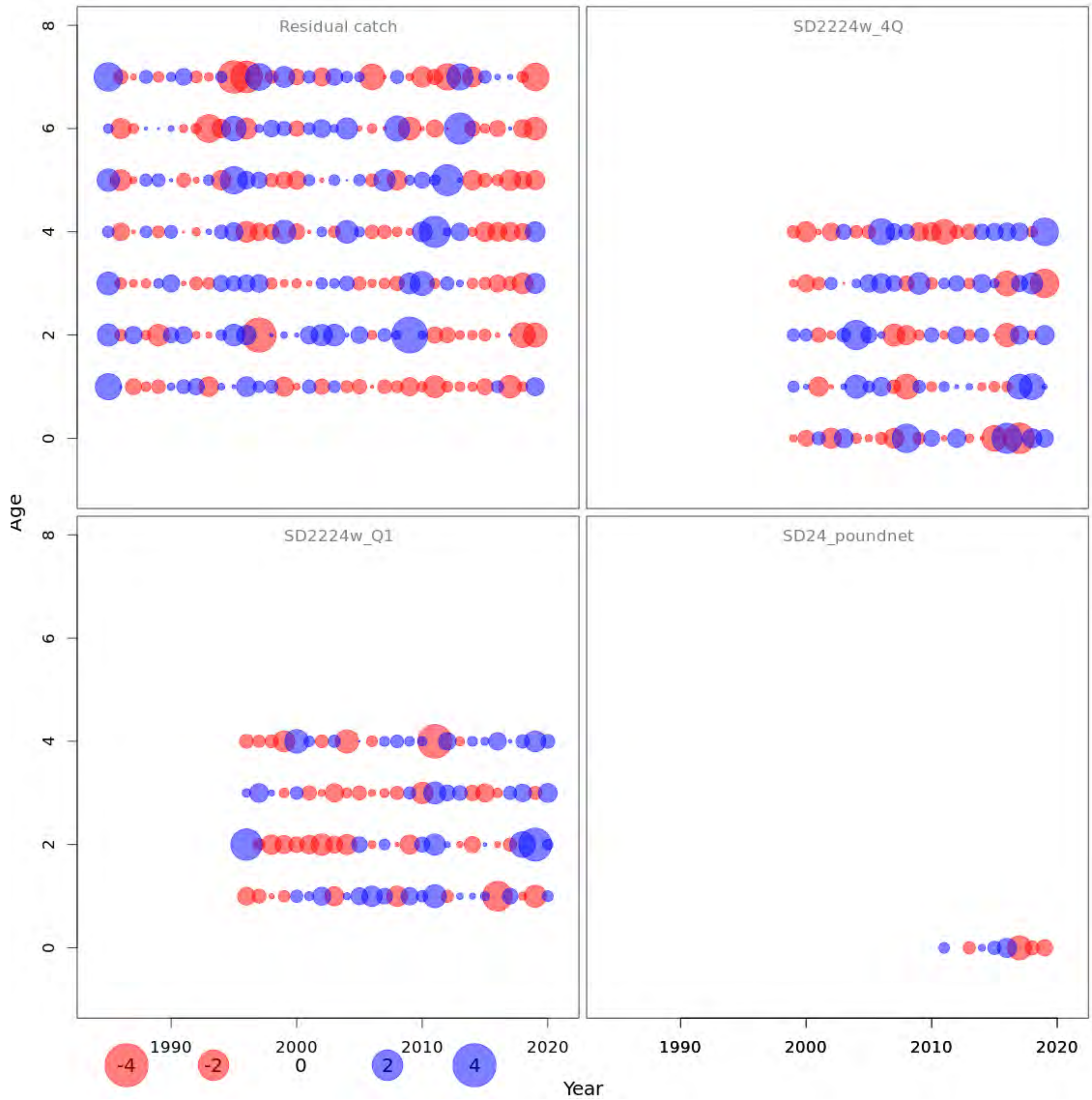

Figure 2.3.16. Western Baltic cod. Standardized residuals from the final SAM run where open circles are positive and filled circles are negative residuals.

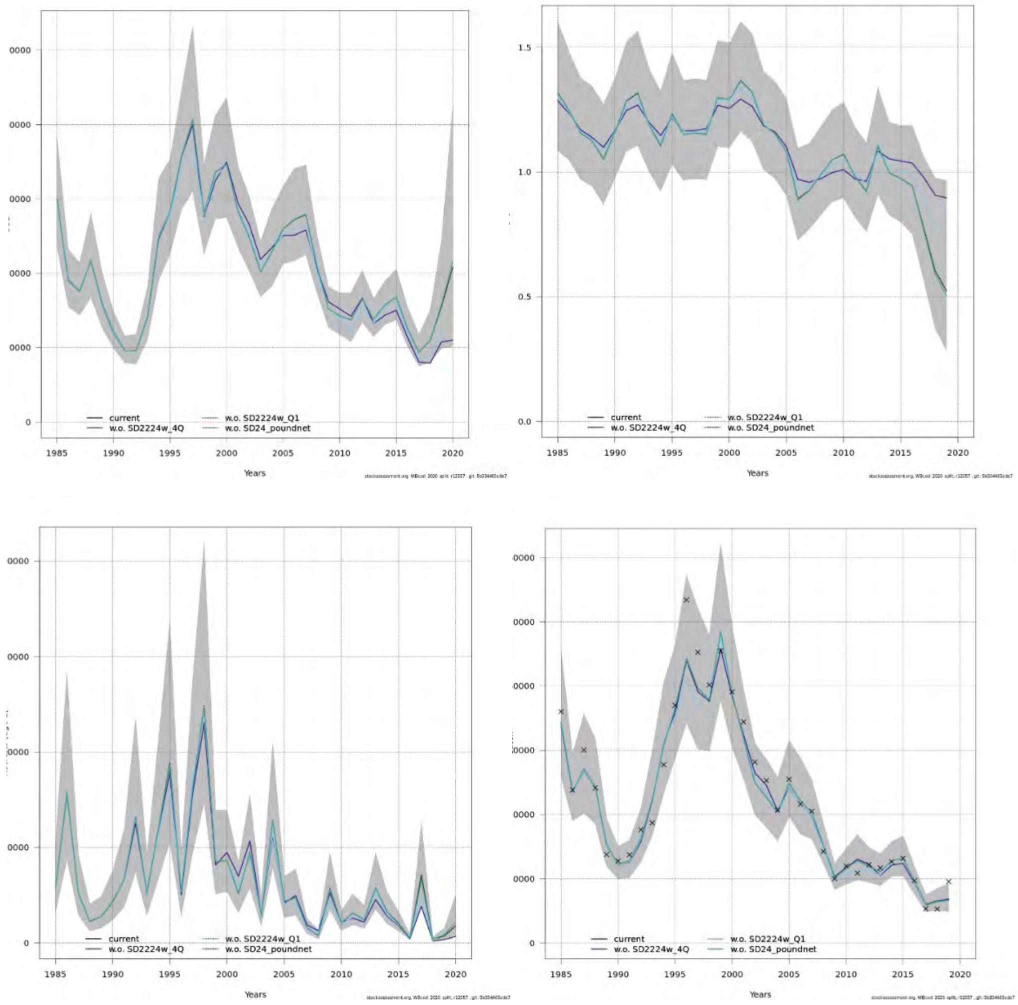
current
w.o. SD2224w_4Q
w.o. SD2224w_Q1
w.o. SD24_poundnet
Years

Figure 2.3.17. Western Baltic cod. Leave one out plots on SSB, F, Recruitment and catch.

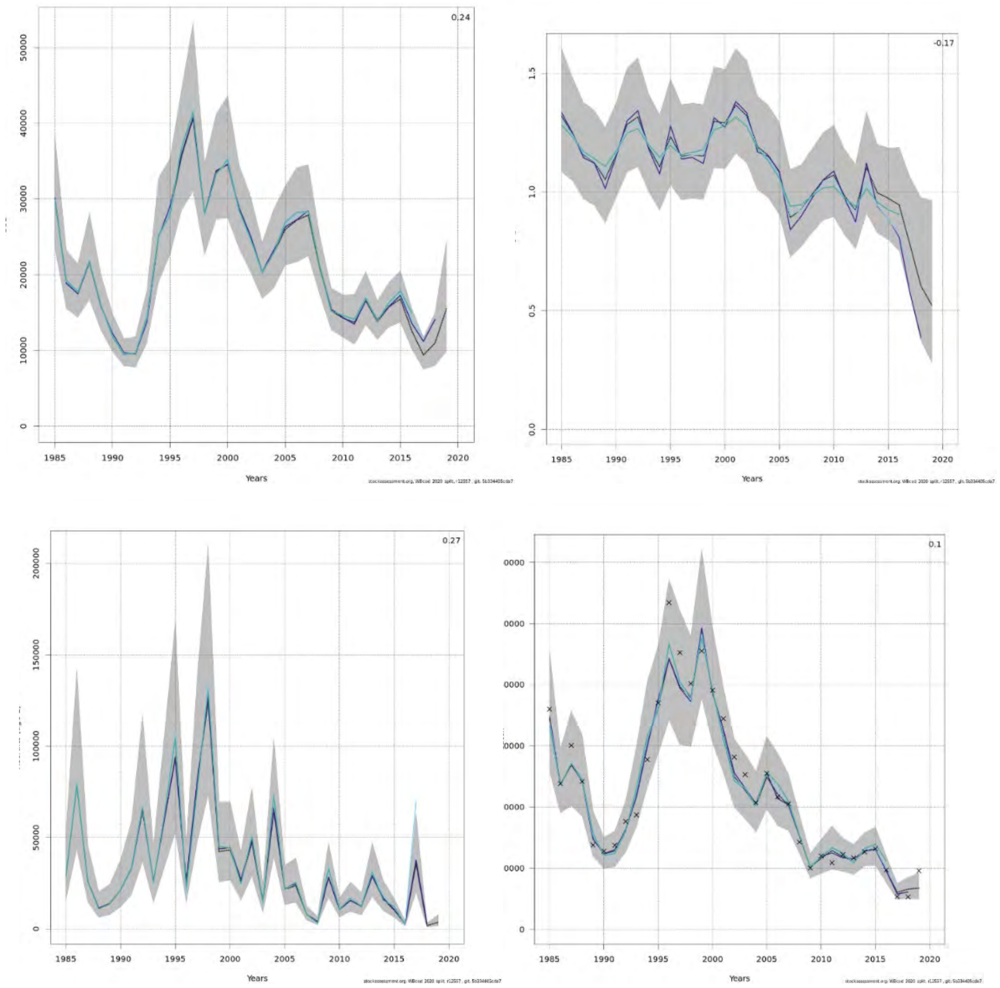

Figure 2.3.18. Western Baltic cod. Retrospective analyses of SSB, F(3–5), recruitment (age 1) and catch.

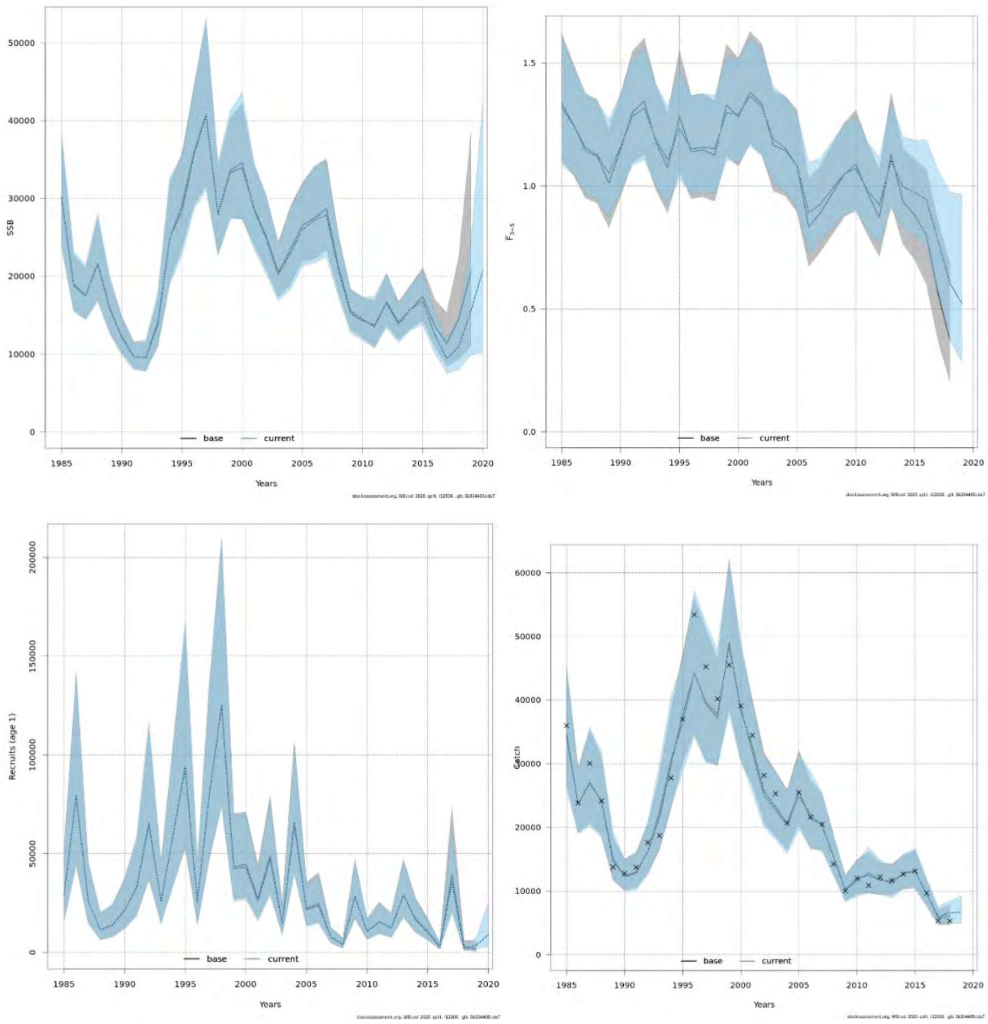

Figure 2.3.19. Western Baltic cod. SSB (upper left), F (3–5) (upper right) and stock numbers at age 1 (lower left) and catch (lower right) from the final assessment. Grey line is assessment results from last year's assessment and blue stippled line is the updated final assessment.

3 Flounder in the Baltic

3.1 Introduction

3.1.1 Stock identification

Previously, it was believed that European flounder in the Baltic Sea has two distinctively different ecotypes (sometimes also considered 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 these two sympatric flounder populations (which since 2018 are considered two separate species) in the Baltic Sea: pelagic and demersal spawners 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 SD 28 (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 fertilization 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 SD 23, 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.

In the 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 the proportion of pelagic ecotype per SD was calculated (Table 3.1). It revealed that the current management unit of SD 26+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 these two ecotypes are in fact different species (and therefore that the assessment unit SD 26+28 consists of two flounder species) complicates the matter even further.

Currently these two flounder species can only be separated through genetic analysis, and so at present there is no easy or inexpensive way to separate these species in commercial catches or in BITS-survey trawl. Accordingly, in the current state, it is acknowledged that there are two different flounder species in the Baltic, but that there is a mix of these two species in all of the management units (with no separation 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 variability of flounder discards, which exceed the landings or are sometimes 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 controlled by factors such as market price and cod catches.

According to the call for data submission for ICES WGBFAS, a new method for estimating discards was recommended and should be applied to all flounder stocks; here the main issue being 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 are recalculated by using a better approach which avoids 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 the 1st quarter and the 4th quarter.

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

3.1.5 Effort

Time-series from 2009–2019 was available from the ICES WGBFAS data call, where countries submitted flatfish effort data by fishing fleet and subdivision. Effort data were asked to be reported as days-at-sea. However, different calculation methods were used by different countries: some countries reported all of the fishing days when flounder were landed; some countries reported the number of fishing days where a significant amount of flounder were landed; and some countries reported fishing days for the whole demersal fleet. It was discussed at the time that in the future a more specific description about methodology should be given.

Standardisation and weighting factor was applied for the submitted effort data to calculate a common effort index for the whole population. First, every country data was standardised using the proportion for a given year from the national average. Standardised effort data were then weighted by demersal fish landings for every country and year, and the final effort for the 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 discarded flounder is unknown. However, a relatively wide range of survival rates was obtained from several studies conducted in the Baltic Sea (cf. WKBALFLAT 2014, WD 2.1). During WKBALFLAT, the precautionary level of survival rate was assumed to be 50% in the 1st and 4th quarter and 10% in the 2nd and 3rd 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 Q1 and females as distinguishing between mature and immature fish was only possible 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 number of 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 mixed flatfish fisheries (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 have slightly increased since 2006, and have varied between 1400 and 1000 tonnes since then. Landings in 2019 were at about 1114 tonnes.

3.2.2.1 Unallocated removals

Unallocated removals might take place but are considered minor, as there is no TAC on this stock, and are not reported on from the respective countries. Recreational fishery on flounder takes place, but removals are considered to be minor and not taken into account in 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 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 estimations. 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 past 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 past years; therefore fewer discard ratios were borrowed. Table 3.2.3 gives an overview of total landings and both 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 2019 are estimated to be around 243 tonnes, which would result in a discard ratio of 18% of the total catch—which is at around the same level as 2017 and 2018—but 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) covers the area of the flounder stock in SD 22–23. The survey is conducted twice a year (1st and 4th quarter) by the member states with a fishery in this area. Survey design and gear is standardised. 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.

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). Sampling data from the beginning of the time-period (2000–2006) in particular are considered 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" was 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 2019 was also a catch advice. The mean biomass index of 2018 and 2019 was 44% lower than the mean of the biomass index from 2015–2017 (Figure 3.2.7.). 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 last applied in 2014. Length-based indicators are used to assess the stock status in terms of over-exploitation of immatures and/or large individuals following the guidelines provided by WKLIFE V (2015). The 3 year average (2017–2019) absolute value of $L_{F=M}$ was used as an 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 2014–2019 were taken from InterCatch. Biological parameters were calculated using DATRAS survey data:

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

The results of LBI (Table 3.2.5) show that stock status of fle.27.2223 is above possible reference points, for most of the variables (Table 3.2.5). However, $L_{max5\%}$ is below the lower limit of 0.80 (i.e. 0.61 in 2019), some truncation in the length distribution in the catches might take place. Compared to last year's data, smaller amounts of mega spawners occur, P_{mega} accounts for 28% of the catch and is therefore below the optimum of >0.3. 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 (LF=M).

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

Year/SD	Denmark		DDR	BRD	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
2019	572	59		473	0	10

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
2019	1045	69	1114

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
2019	1114	243	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		$L_{95\%}$ / 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 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} / $L_{F=M}$
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
2019	0.61	1.34	0.89	0.28	1.02	1.47

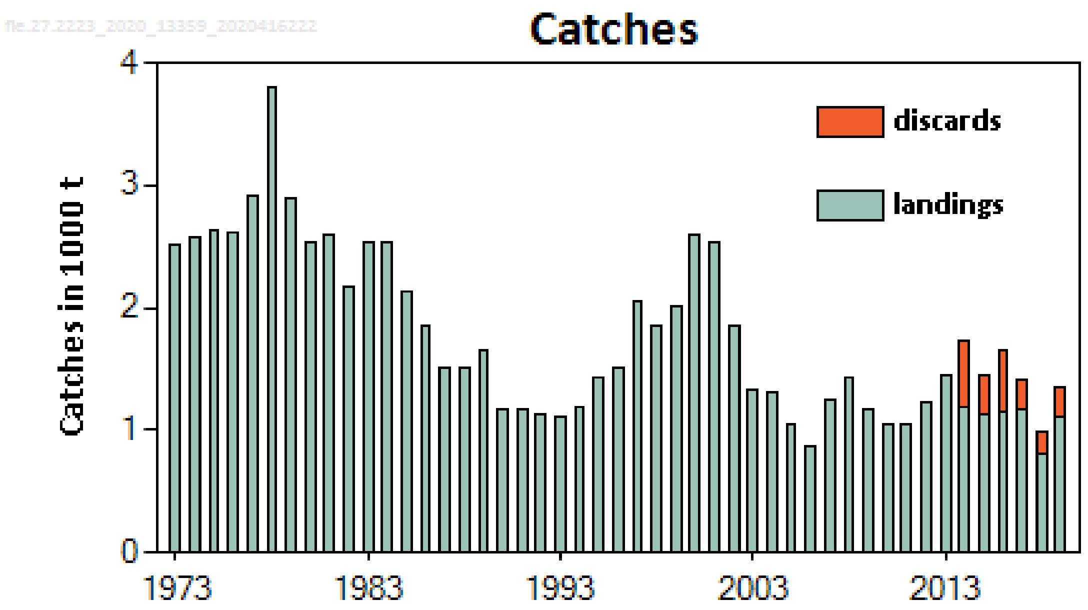

Figure 3.2.1. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings of flounder in tonnes for subdivisions SD 22–23 (Western Baltic Sea). ICES discard estimates are included from 2006 onwards.

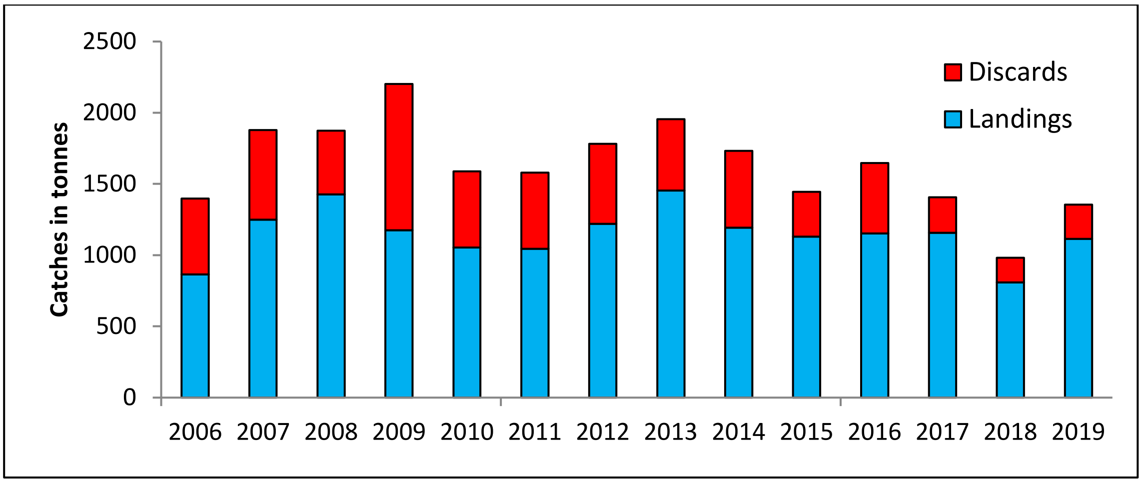

Figure 3.2.2. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings and calculated discards (in tonnes) of flounder for subdivisions SD 22–23 (Western Baltic Sea).

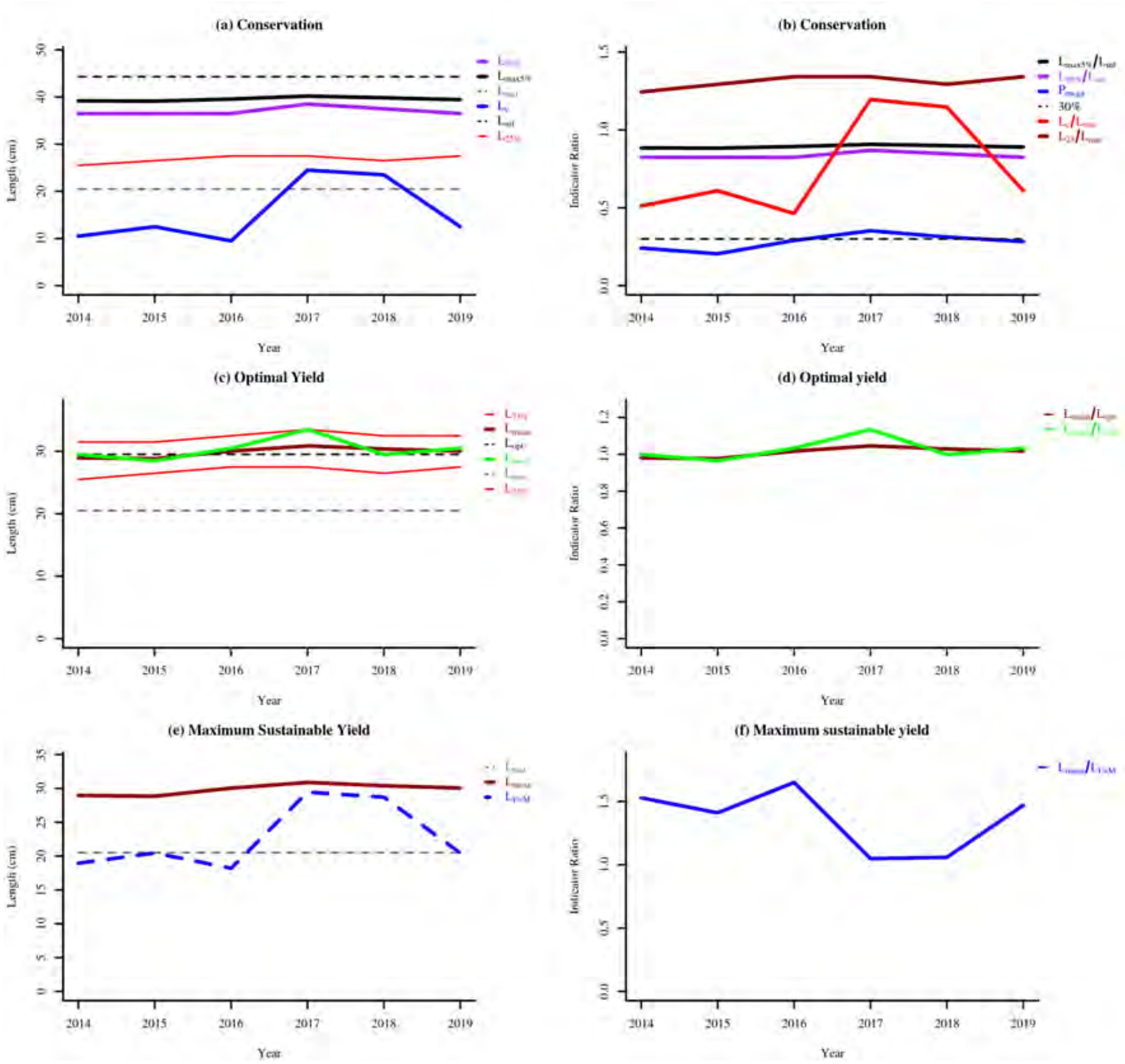

Figure 3.2.3. fle.27.2223. LBI indicator trends

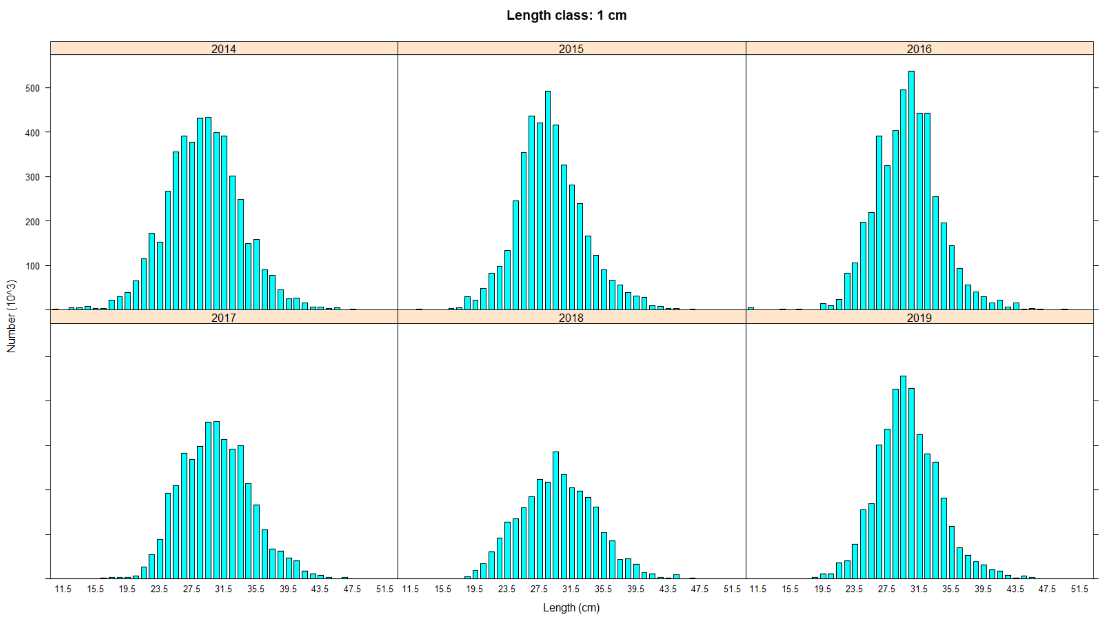

Figure 3.2.4. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Catch in numbers per length class in Subdivision 22 and 23 (Belts and Sound). All countries and fleets were combined.

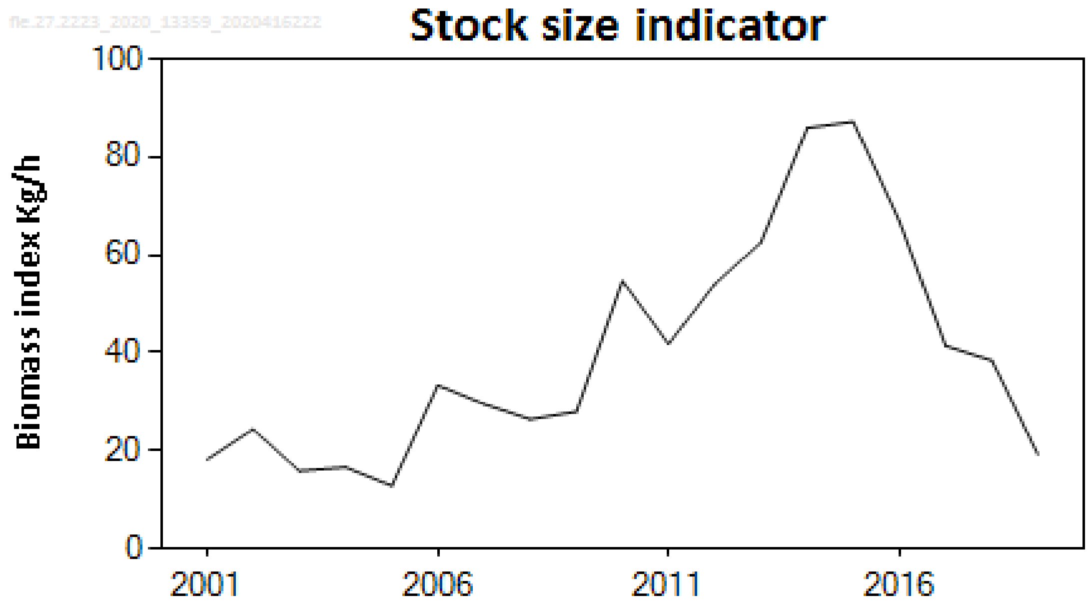

Figure 3.2.7. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Survey-biomass-index (BITS). Dashed lines indicate the average values used for advice (i.e. avg. of the last two years and the avg. of the three years before).

3.3 Flounder in subdivisions 24 and 25[1,2]

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

Taking into account contrasting reproductive flounder behaviours 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 SDs is taken by Poland. The other fishing nations which take significant landings are Germany in SD 24 and Denmark in SD 25 (Figure 3.3.2; Table 3.3.1a).

Flounder landings in both SDs are dominated by active gears, taking around 72% of total landings in 2019 (Figure 3.3.3).

In 2019 landings were 11 815 tonnes (3772 and 8043 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 14 657 tonnes in 2019 (Figure 3.3.4).

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[1] ADGBS edited the stock name due to species mixing (for 2425 and 2628).

[2] ADGBS edited the stock name that consists mainly in Baltic flounder (*P. solemdali*).

3.3.1.2 Discards

During WKBALFLAT (ICES, 2014) the quality of the estimated discards was questioned and a new method for discards estimation was recommended. Discard estimations in 2019 are available for 38% strata with landings, and reporting has decreased compared to last year (47%). For stratum with no discards estimates available, discard rate was borrowed from other strata according to an 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 was improving until 2018, as discard reporting was increasing. However, compared to last year, reporting in 2019 had a 9% decrease. The highest discards in subdivisions 24 and 25 can be assigned to Sweden and Denmark. Germany and Poland have moderate discards (Table 3.3.1b; Figure 3.3.5).

Mean discard rate for 2019 for both subdivisions is 0.12 with discard equal to 2842 tonnes, which is the lowest in the time series (since 2014).

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 standardised within each country and weighted by the national demersal fish (cod and flounder) landings from SD 24–25.

Standardised (SE) effort by average effort by country (se) was calculated from the equation:

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

where: f_c – effort by country c

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

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

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

The effort in 2019 has slightly decreased compared to 2018, and it was one of the lowest over the time series (Figure 3.3.6).

3.3.2 Biological information

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

Sampling coverage of discards differs between years and subdivisions, and in 2019 was slightly worse than those obtained in 2018. 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 the 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. The 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 0.66.

Stock trends from Baltic International Trawl Survey (BITS) for SD 24 and 25 were increasing until 2016, then they showed a decrease until 2018, followed by and an increase in 2019 (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 2014–2019 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 2012–2019 (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} = 329 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 (2017–2019) is equal to 24.1 cm and L_{mean} - 27.5 cm. Compared to last year's data only indicator ratio L_c / L_{mat} is below expected value, which indicates that some immature individuals were present in the catch. The overall 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.

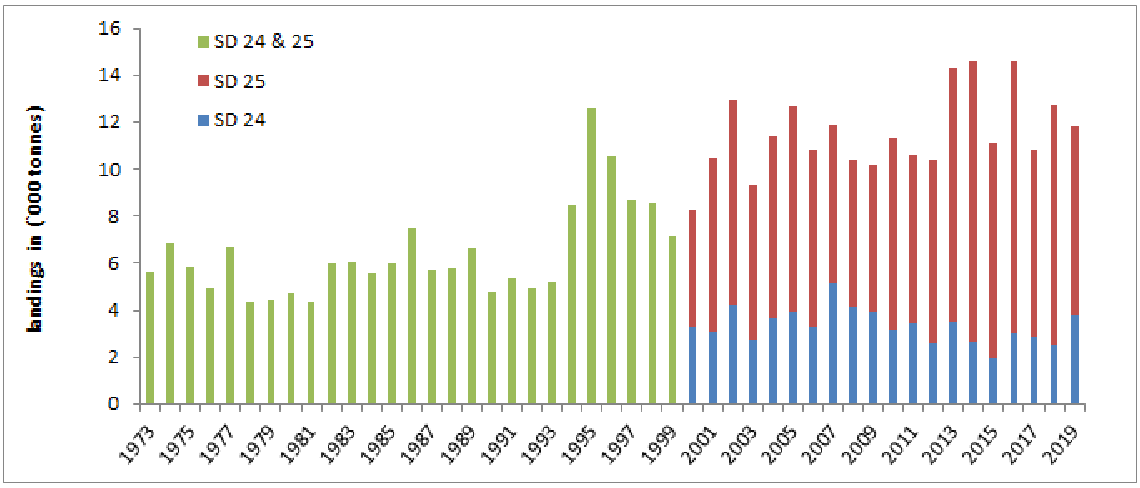

Figure 3.3.1. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Landings in thousand tonnes.

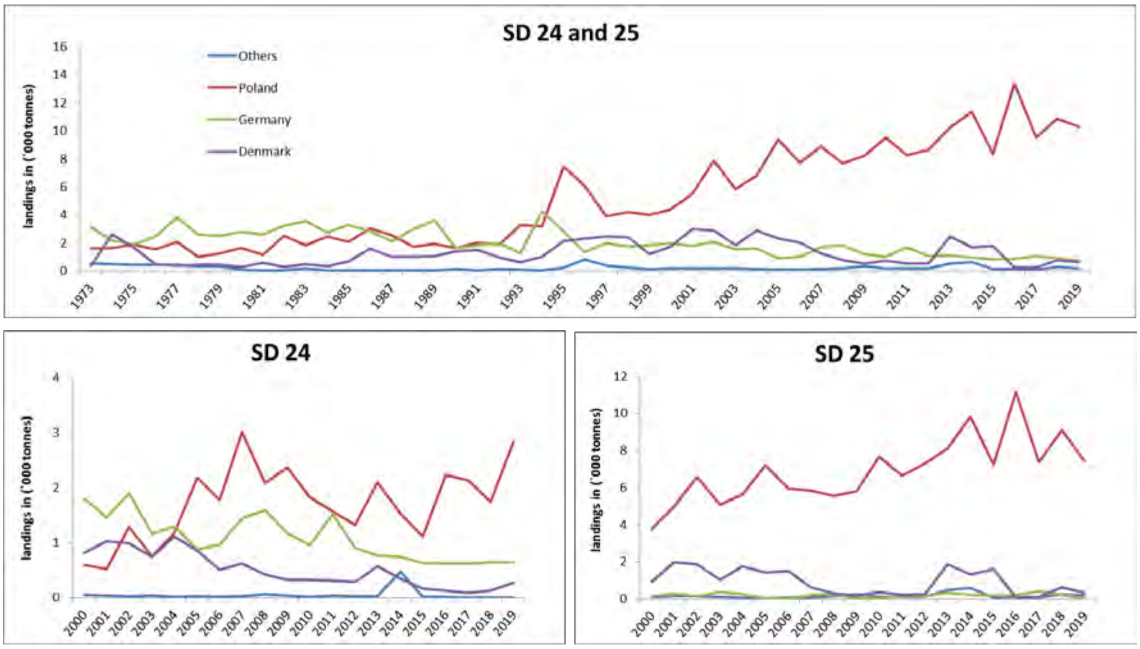

Figure 3.3.2. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Landings by country in thousand tonnes (merged SD 24–25 in upper plot, and separately for SD 24 and SD 25 in lower plots).

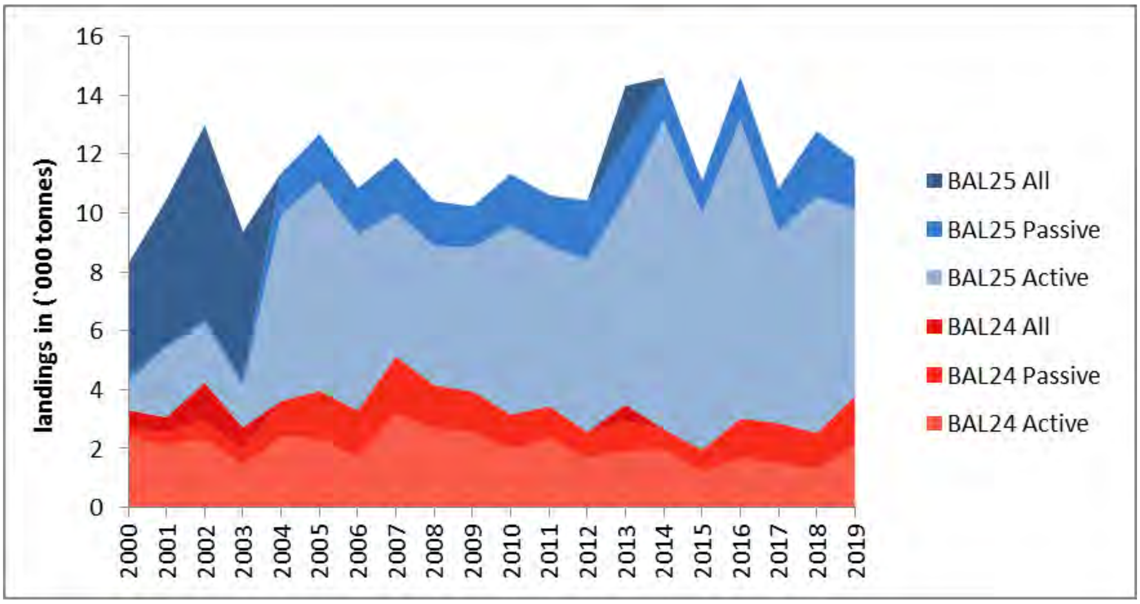

Figure 3.3.3. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Landings by fleet type in thousand tonnes (SD 24: red shades; SD 25: blue shades).

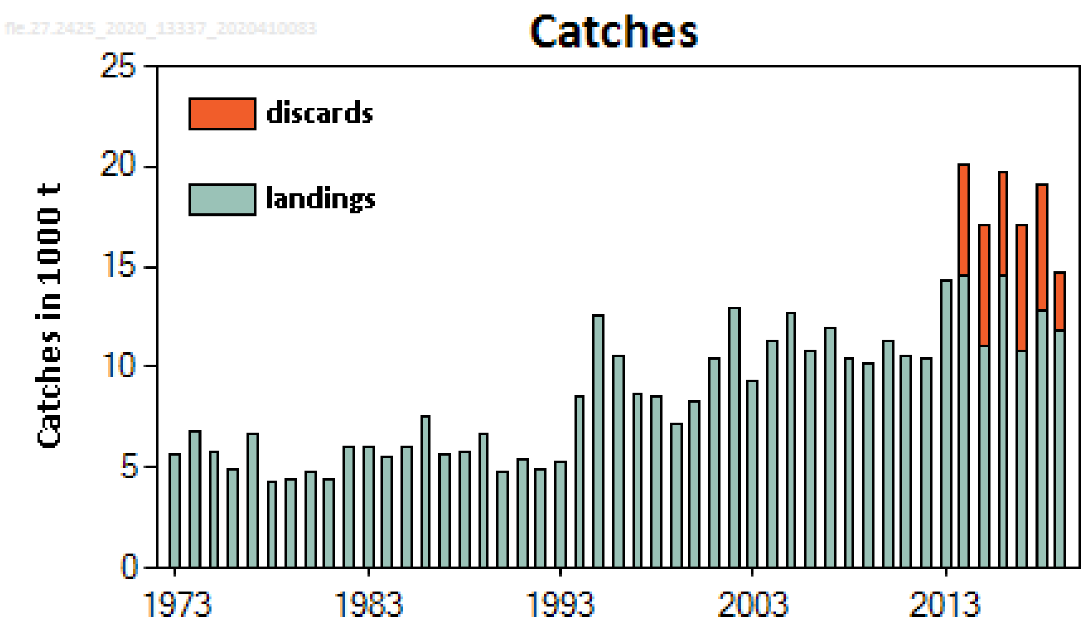

Figure 3.3.4. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Landings and catches in thousand tonnes (catch available since 2014).

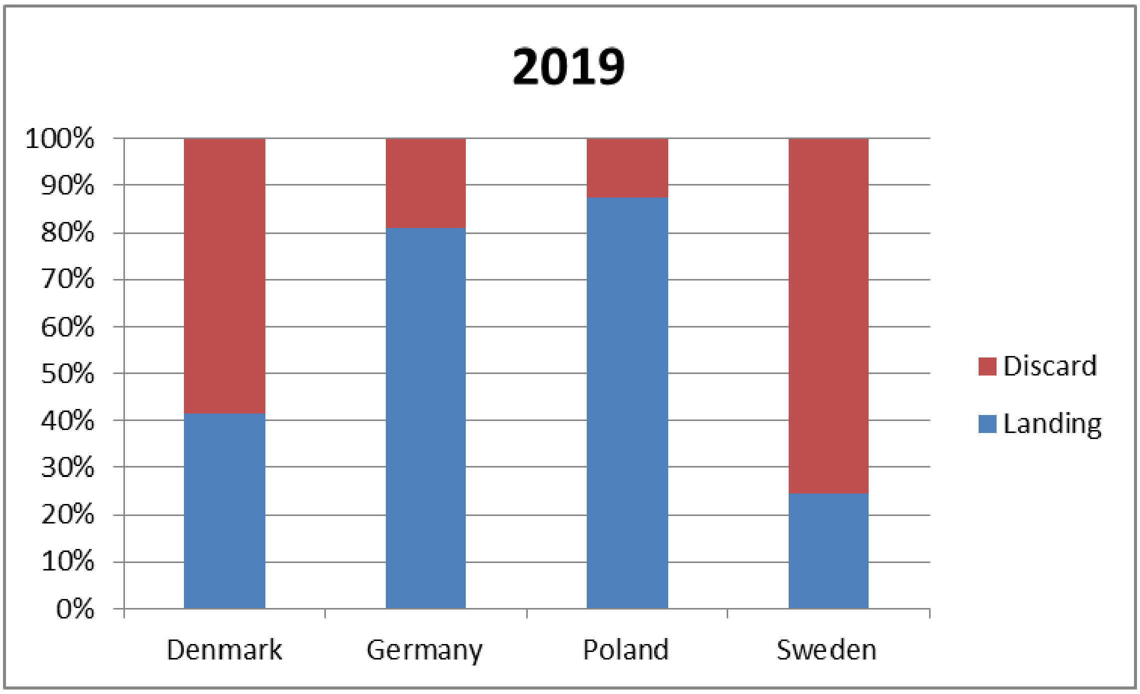

Figure 3.3.5. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Discard and landing proportion in 2018 catches in main fishing countries.

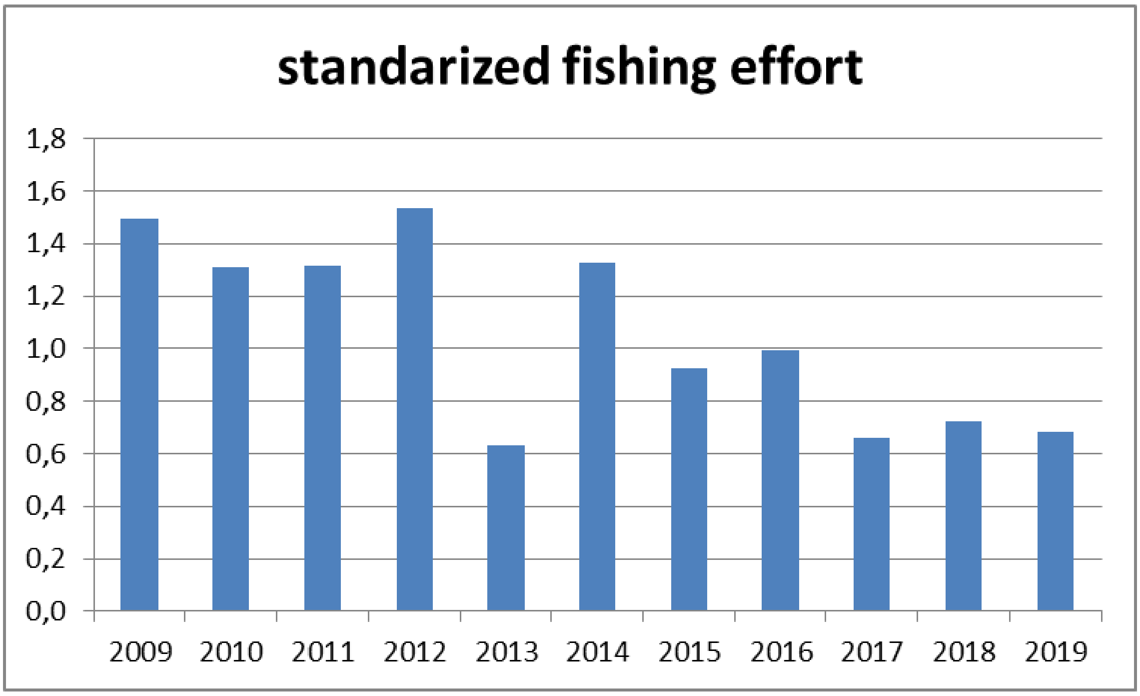

Figure 3.3.6. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Standardized fishing effort (days-at-sea standardised within each country, and weighted by the national demersal fish landings from SD 24–25).

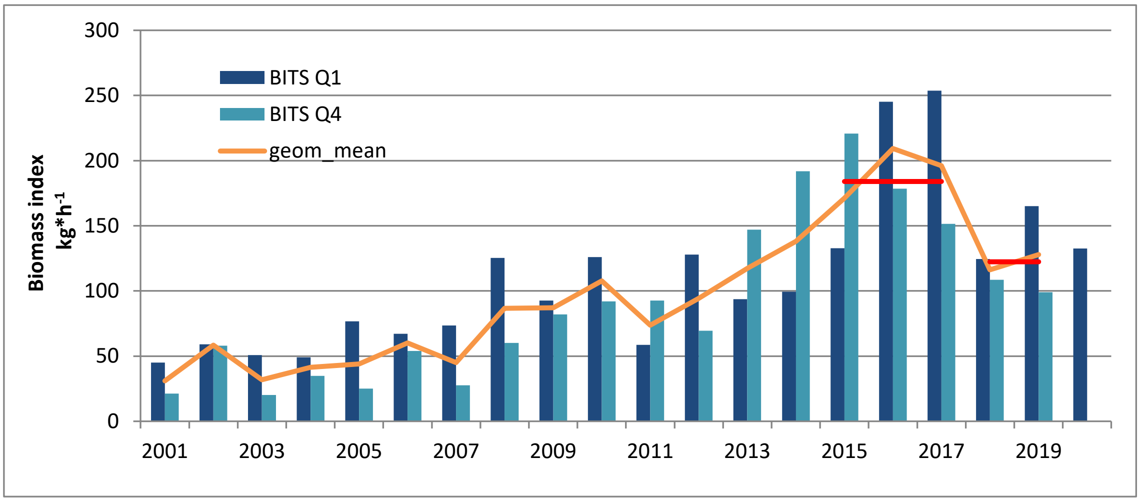

Figure 3.3.7. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Survey biomass index (BITS) Q1 and Q4 from 2001-2019 and geometric mean (line); stock trends from Baltic International Trawl Survey (BITS).

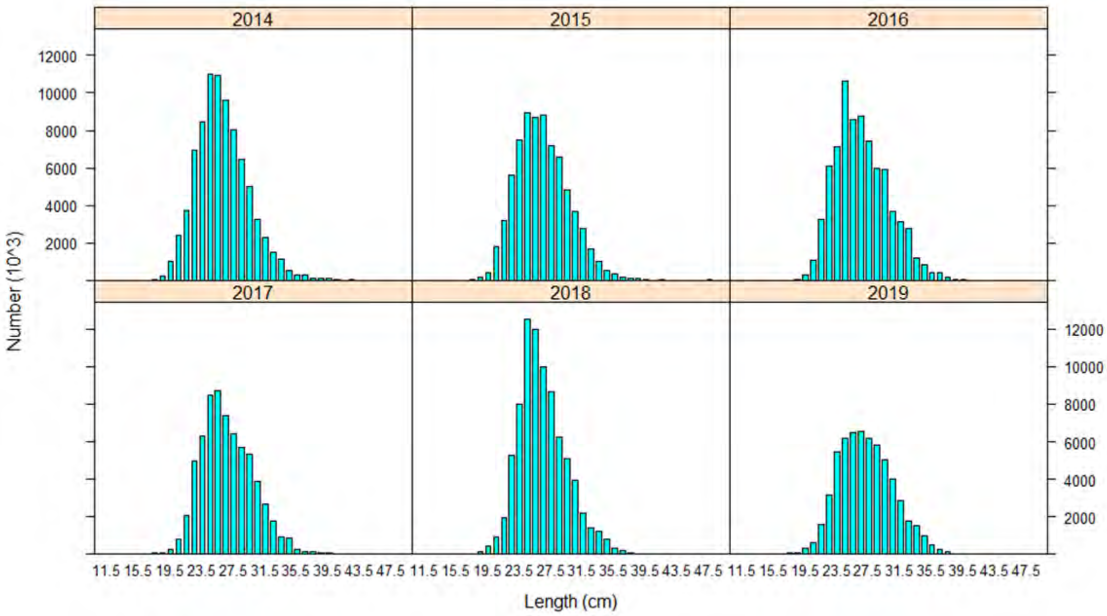

Figure 3.3.8. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Catch in numbers (CANUM) per length classes.

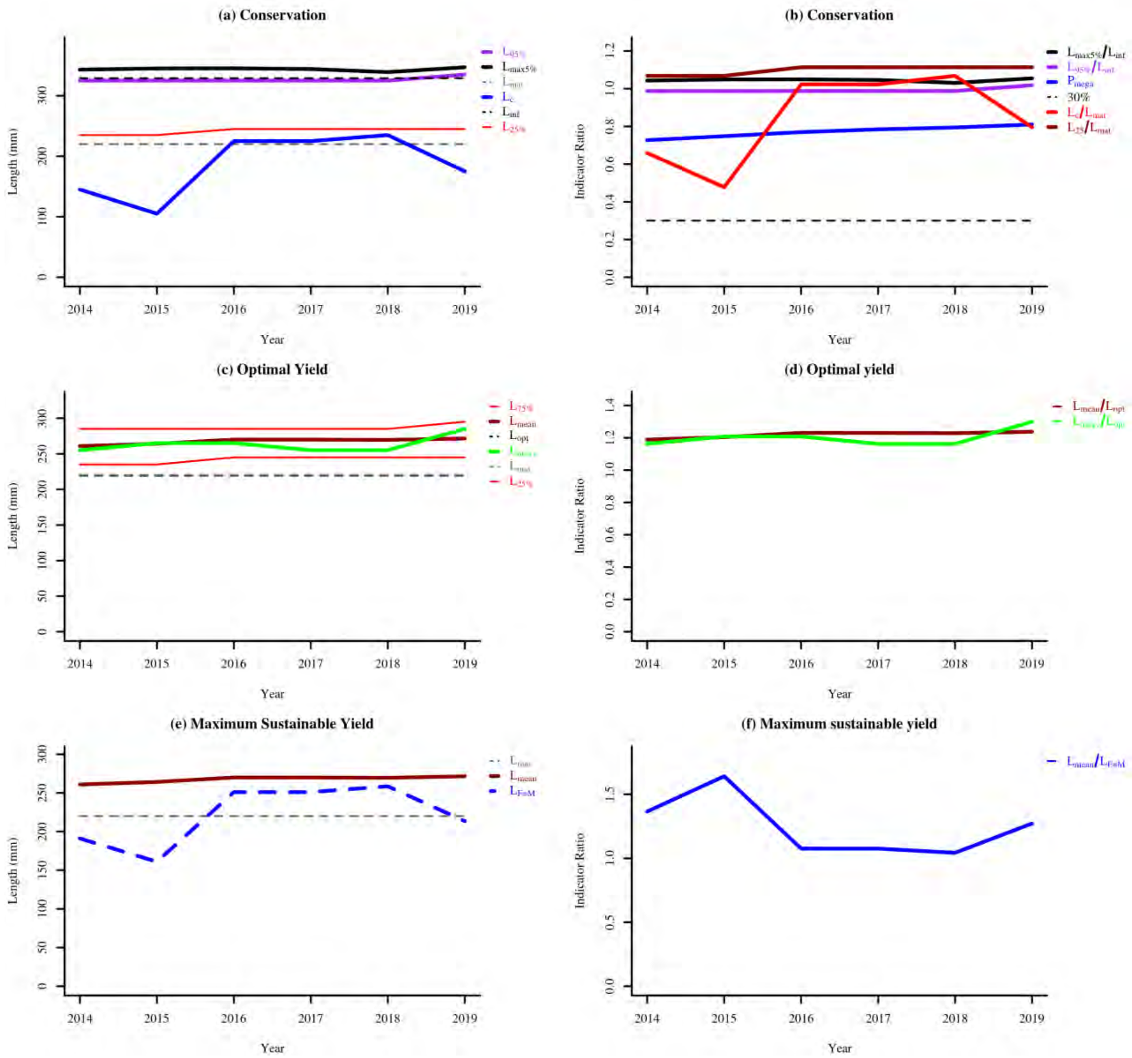

Figure 3.3.9. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). LBI indicator trends.

Table 3.3.1a. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Total landings (tonnes) 1973–2019 by Subdivision and country.

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	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	SD 25	SD 24–25	SD 24–25
1973			386									3144									1580			502	5612
1974			2578									2139									1635			470	6822
1975			1678									1876									1871			400	5825
1976			482									2459									1549			400	4890
1977			389									3808									2071			416	6684
1978			415									2573									996			346	4330
1979			405									2512									1230			315	4462
1980			286									2776									1613			62	4737
1981			548									2596									1151			51	4346
1982			257									3203									2484			55	5999
1983			450									3573									1828			180	6031
1984			306									2720									2471			45	5542
1985			649									3257									2063			40	6009
1986			1558									2848									3030			51	7487
1987			1007									2107									2530			43	5687

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	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	SD 25	SD 24–25	SD 24–25
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
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

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	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	SD 25	SD 24–25	SD 24–25
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
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
2019	276	350	626	0	0	0	0	44	44	650	38	687	0	36	36	0	16	16	2480	7459	10300	6	100	106	11815

Table 3.3.1b. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Estimated discards (tonnes) 2014–2019 by Subdivision and country.

	Denmark			Estonia			Finland			Germany			Latvia			Lithuania			Poland			Sweden			Total
Year	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	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
2019	167	729	896	0	0	0	0	0	0	104	16	123	0	4	4	0	0	0	82	1045	1127	6	226	232	2379

Table 3.3.2. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic –West). Discard allocation scheme for 2019.

24		2019						
fleet	quarter	Denmark	Germany	Poland	Sweden	Finland	Latvia	Lithuania
Active	1		DE_A_1_24		SE_A_1_25			
	2			PL_A_2_25	SE_A_2_25			
	3			DE_DK_A_3_24	DE_DK_A_3_25			
	4			DE_DK_A_4_24	DE_DK_A_4_25			
Passive	1	SE_P_1_25	SE_P_1_25	SE_P_1_25	SE_P_1_25			
	2	SE_P_2_24		PL_P_2_25				
	3	DE_P_3_24		DE_P_3_24	DE_P_3_24			
	4	DE_P_4_25		DE_P_4_25	DE_P_4_25			

25		2019						
fleet	quarter	Denmark	Germany	Poland	Sweden	Finland	Latvia	Lithuania
Active	1					LV_A_1_25		
	2		DE_A_2_24			LV_A_2_25		LV_A_2_25
	3	DK_A_3_24		DK_A_3_24	DK_A_3_24			
	4	DK_A_4_24		DK_A_4_24	DK_A_4_24			
Passive	1	SE_P_1_25		SE_P_1_25				
	2	SE_P_2_25						PL_P_2_25
	3	DE_P_3_24		DE_P_3_24	DE_P_3_24			
	4	DE_P_4_25		DE_P_4_25	DE_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 2019 in subdivisions 24 and 25.

	Country	Catch category	Catch t	No. of length samples in numbers	No. Measured in numbers
SD 24	Denmark	Landings	276	4	480
	Germany		650	18	4174
	Poland		2840	8	812
	Sweden		7	0	0
	Denmark	Discards	167	10	1000
	Germany		104	17	959
	Poland		82	1	97
	Sweden		6	8	544
		Total	4131	66	8066

	Country	Catch category	Catch t	No. of length samples in numbers	No. Measured in numbers
SD 25	Denmark	Landings	350	2	396
	Finland		44	0	0
	Germany		38	1	156
	Latvia		36	0	0
	Lithuania		16	0	0
	Poland		7459	14	1419
	Sweden		100	2	272
	Denmark	Discards	729	6	986
	Germany		16	1	91
	Latvia		4	0	0
	Poland		1045	7	672
	Sweden		226	12	1295
		Total	10063	45	5287

Table 3.3.3.3. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Number of BITS-stations in SD 24 and SD 25.

	SD 24		SD 25	
	Q1	Q4	Q1	Q4
2001	66	40	96	52
2002	55	46	57	75
2003	48	46	97	61
2004	50	47	112	63
2005	43	46	113	81
2006	43	44	95	72
2007	45	41	88	81
2008	35	47	97	62
2009	45	53	104	81
2010	50	31	80	77
2011	44	50	105	77
2012	52	47	102	74
2013	54	38	102	75
2014	52	49	97	73
2015	50	38	97	73
2016	53	47	85	81
2017	55	51	102	96
2018	56	43	107	99
2019	46	54	112	91
average	50	45	97	76

Table 3.3.3.4. 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	

Indicator	Calculation	Reference point	Indicator ratio	Expected value	Property
$L_{25\%}$	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	LF=M = $(0.75L_c+0.25L_{inf})$	L_{mean} / LF=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} = 32.9 cm and L_{mat} = 22.0 cm.

	Conservation				Optimizing Yield	MSY
Year	L_c / L_{mat}	$L_{25\%} / L_{mat}$	$L_{max\,5} / L_{inf}$	P_{mega}	L_{mean} / L_{opt}	$L_{mean} / L_{F=M}$
2017	1.02	1.11	1.05	0.78	1.23	1.08
2018	1.07	1.11	1.03	0.79	1.23	1.04
2019	0.80	1.11	1.05	0.81	1.24	1.27

3.4 Flounder in subdivisions 26–28 (Eastern Gotland and Gulf of Gdansk)[3,4]

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 behaviours in the Baltic Sea, namely 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 (newly described) coastal spawning 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 Latvia is the main fishing country in Subdivision 28 (Table 3.4.1). In previous years, Polish fishery

[3] ADGBS edited the stock name due to species mixing (for 2425 and 2628).

[4] ADGBS edited the stock name that consists mainly of Baltic flounder (*P. solemdali*).

consisted mainly of gillnet fishing targeting flounder along the coast, whereas Latvian, Russian and Lithuanian landings consisted mainly of 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 2019, and amounted to 2740 tonnes. Decrease of landings was observed since 2014 (Figures 3.4.1. and 3.4.2.). The highest landings were recorded in Russia (1325 tonnes), Latvia (753 tonnes), and Poland (565 tonnes). The major part of the landings was realised with active fishing gears (2112 tonnes).

The majority of landings were taken in Subdivision 26 (71%) and in trawl fishery (77%). The total landings in Subdivision 28 amounted to about 776, which was just below the long-term average. The highest landings in Subdivision 28 were observed in 2015-2016 after that gradual decrease could be observed. The majority of landings was realised by Latvian fishers (715 tonnes), whose landings were below 1000 tonnes for the first time in the last five years. The total landings in Subdivision 28 amounted to about 1963, which was the lowest amount in this century. The majority of the landings were realised by Russia (1325 tonnes) and Poland (565 tonnes).

Due to market limitation for sprat, in some countries (Latvia, Russia) specialized flounder fishery was performed, however effort decreased of this fishery in past years. Due to closure of cod fishing in the second part of the year, flounder fishing was limited in some countries.

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 the 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 of InterCatch.

Discard data of flounder from 2019 according to ICES Data Call were submitted in InterCatch. Discards rates from Germany, Latvia, Lithuania, Sweden 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 ratios varied significantly between countries, fleets and quarters. The highest discards (by weight) were observed in Poland (460 t), Sweden (123 t), and Lithuania (45 t) (Table 3.4.2), which was similar with averages from 2014. Significant decrease of discard was observed in Latvia over the last years, where the majority of flounder was landed. Weighted average of flounder discard in subdivisions 26 and 28 in 2019 was estimated at 19.2%, which is significantly lower than estimates for 2018 (26.6%).

3.4.1.4 Effort and CPUE data

Time-series from 2009–2019 were available from the 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 the fishing days when flounder were landed; some countries reported the number of fishing days where a significant amount of flounder were landed, while some countries reported fishing days for whole demersal fleet.

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

According to new effort estimates, a decreasing trend of effort was observed in previous years and in 2019 it was the lowest observed in a time-series since 2009 (Figure 3.4.3). Decrease of effort in 2019 was observed in all four main fishing countries (Latvia, Lithuania, Poland and Russia). This decrease could be related to the closure of cod fishery in EU countries, while flounder were often fished as bycatch in the 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 2019 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, 1196 otoliths were collected from the catch (1178 from landings and 18 from discards, (Table 3.4.3). Otoliths from Estonia and Russia covering landings, while otoliths from discards were available from Estonia.

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 the 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 the past years are that some increasing trend could be observed (Figure 3.4.6, Table 3.4.4). The stock abundance is estimated to have increased by 15.7% between 2015–2017 (average of the three years) and 2018–2019 (average of the two years). For this stock, scientific advice on stock status is provided for 2021, 2022, or 2022.

3.4.5 Reference points

The stock status was evaluated by calculating length-based indicators applying the LBI method developed by WKLIFE V (ICES, 2015). Commercial landing data from InterCatch in the period 2014–2019 were used to estimate CANUM and WECA (Figure 3.4.7, 3.4.8.). On the other hand, the biological parameters L_{inf} and L_{mat} were calculated using survey data from DATRAS.

In WGBFAS 2017, potential reference points were calculated first. However, later they were rejected in ADGBS. Results of LBI were green for fishing pressure, which was in contradiction with the decline in the survey index used as stock size indicator. The ADG or WG did not understand what creates this apparent inconsistency between the results of the LBI and the biomass indicator. Also noted were issues with age reading, which makes the estimate of L_{inf} very uncertain. The L_{inf} value used in the analysis was 28 cm, but it was unclear if this value is appropriate. The results from the presented LBI analysis for this stock did not appear reliable and were rejected by the ADG.

For estimating L_{inf}, data from 2014–2019 in Q4, and for both sexes, were taken. Only age data determined by recommended ageing technique was included in the analyses, as a result for Subdivision 26 data from Poland, Lithuania, and Latvia while for Subdivision 28–data from Latvia and Estonia were used. Age data with inadequate ageing technique (whole otoliths) were excluded from calculations. Preliminary analysis indicated different growth rate in subdivisions 26 and 28 therefore expert group decided to calculate separate L_{inf} for each subdivision and later calculate one weighted L_{inf} where landings of flounder by subdivisions were used as a weighting factor. For Subdivision 25 L_{inf} was 32.46 cm, while for Subdivision 28 it was 28.38 cm (Figure 3.4.9). Landing proportion between subdivisions in the last five years is 65% (for Subdivision 26) and 35% (for Subdivision 28). The final weighted L_{inf} was calculated to be 31.04 cm. Data from BITS Q4 only were used. In Q1, flounder is close to spawning time and both flounder species are separated at this time of the year. In BITS Q1 surveys, mainly European flounder (or pelagic flounder) are represented. In Q4, both species are mixing, and therefore those data better represent all flounder in subdivisions 26 and 28.

In the case of L_{mat}, data for females were derived from 2014–2019 (also Q4; the reasons for this are described in the previous paragraph). Like L_{inf}, the same approach was used to calculate weighted L_{mat}. L_{mat} for Subdivision 26 was 18.8 cm, for Subdivision 28 was 15.3 cm, while the weighted average for the stock is 17.6 cm (Figure 3.4.10).

Accepted biological parameters mentioned above are as follows:

L_{inf} = 31.04 mm

L_{mat} = 17.6 mm

The results were compared to standard length-based reference values to estimate the status of the stock (Table 3.4.5).

The results of LBI (Table 3.2.5, Figure 3.4.11.) show that the stock status of fle.27.2628 is above possible reference points (Table 3.4.6). $L_{max5\%}$ is well above the lower limit of 0.80 (i.e. 1.28 in 2019), while some truncation in the length distribution in the catches might take place. 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 is consistent with F_{MSY} proxy (LF = M).

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

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

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

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

Country	2011			2012			2013			2014			2015		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	1		1	0		0	22		22	0.872	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	1209.7379	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	1047.097	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			2019		
	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total	SD 26	SD 28	Total
Denmark	0	0	0			0	8		8	1	0	1
Finland			0			0			0	11	0	11
Germany	1	0	1			0			0	2	0	2
Poland	912	0	912	701		701	473		473	565	0	565
Sweden	3	14	16	2	10	12	4	16	20	1	18	19
Estonia	0	52	52		59	59		60	60	0	43	43
Latvia	161	1683	1,843	190	1386	1,576	171	1036	1,207	38	715	753
Lithuania	295	0	295	255		255	214		214	20	0	20
Russia	1133	0	1,133	1304		1,304	1493		1,493	1325	0	1325
Total	2503	1748	4,252	2452	1455	3,907	2363	1112	3,475	1963	776	2740

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

Country	Landings	Discards	Discard ratio
Denmark	1.0	0.6	38.2
Estonia	43.4	0.0	0.0
Finland	11.4	7.0	38.2
Germany	1.9	1.8	49.1
Latvia	753.0	12.6	1.6
Lithuania	20.1	45.4	69.3
Poland	565.0	459.7	44.9
Russia	1325.4	0.0	0.0
Sweden	18.7	123.1	86.8
Total	2739.9	650.3	19.2

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

Country	Discards	Landings	Total
Estonia	18	104	122
Russia		1074	1074
Total	18	1178	1196

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

Year	1st quarter	4th quarter	Combined index
1991	124.2		124.2
1992	51.1		51.1
1993	91.3	48.4	66.5
1994	60.5	30.2	42.8
1995	132.4	68.3	95.1
1996	127.8	30.2	62.1
1997	143.7	80.9	107.9
1998	96.4	67.9	80.9
1999	102.3	73.7	86.8

Year	1st quarter	4th quarter	Combined index
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	119.7	150.2	134.1
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	102.4	72.4	86.1
2016	132.6	55.7	85.9
2017	128.7	138.9	133.7
2018	87.9	72.7	79.9
2019	203.9	119.3	156.0
2020	120.3		120.3

Table 3.4.5. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). 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	LF=M = ($0.75L_c+0.25L_{inf}$)	L_{mean} / LF=M	≥ 1	MSY

Table 3.4.6. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). 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} / $L_{F=M}$
2017	1.16	1.22	0.99	0.58	1.17	1.04
2018	1.22	1.28	1.08	0.71	1.24	1.07
2019	1.28	1.28	1.06	0.74	1.26	1.06

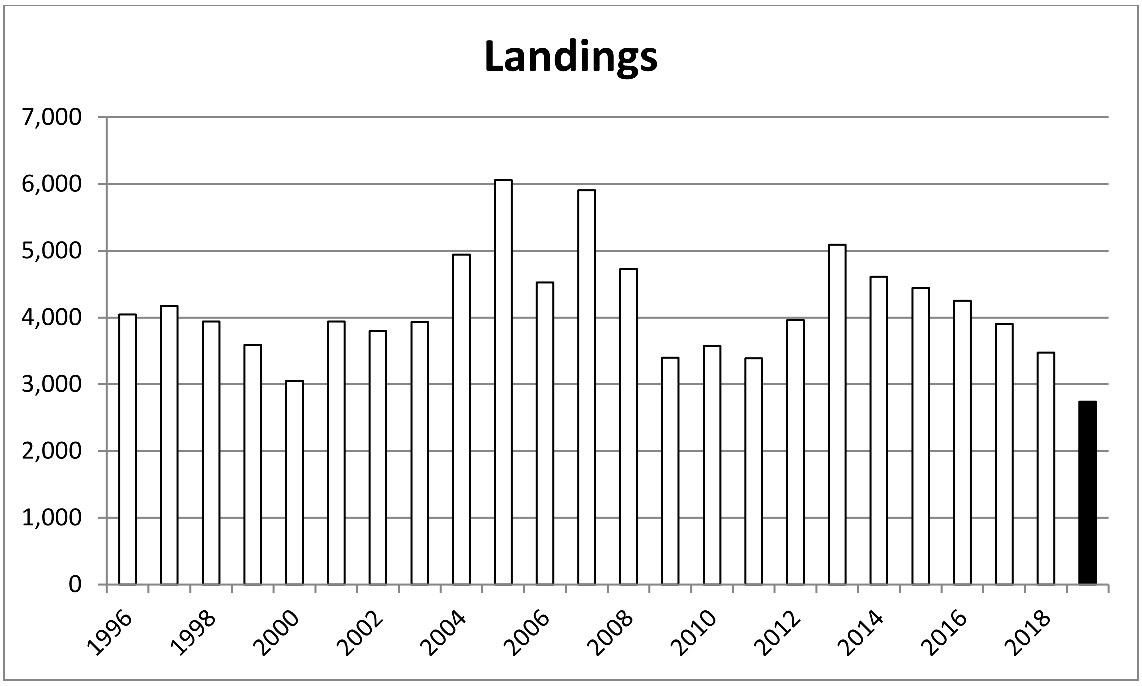

Figure 3.4.1. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder in subdivisions 26 and 28.

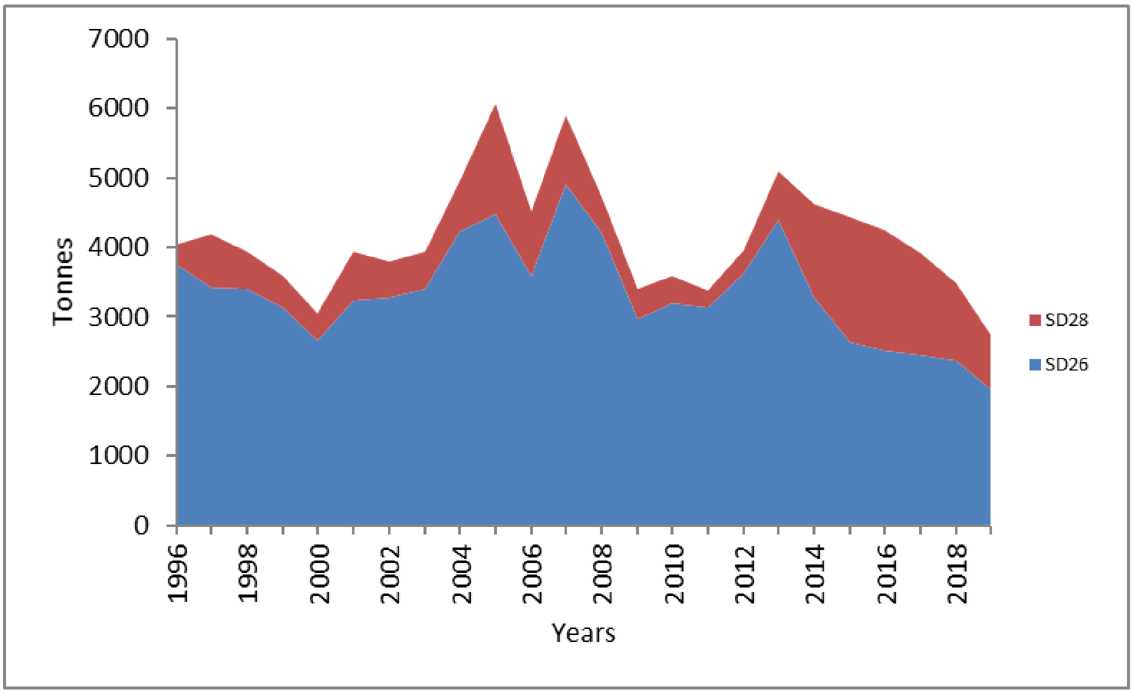

Figure 3.4.2. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder by subdivisions.

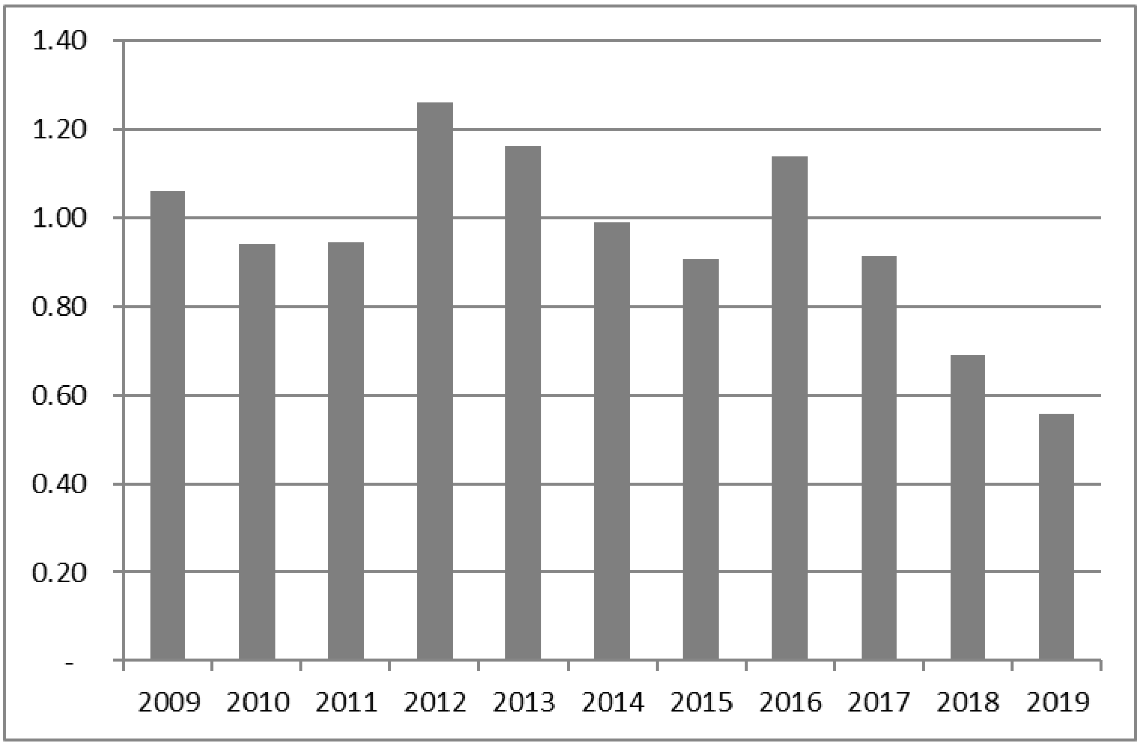

Figure 3.4.3. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Effort data (days-at-sea) of flounder in subdivisions 26 and 28 (days-at-sea).

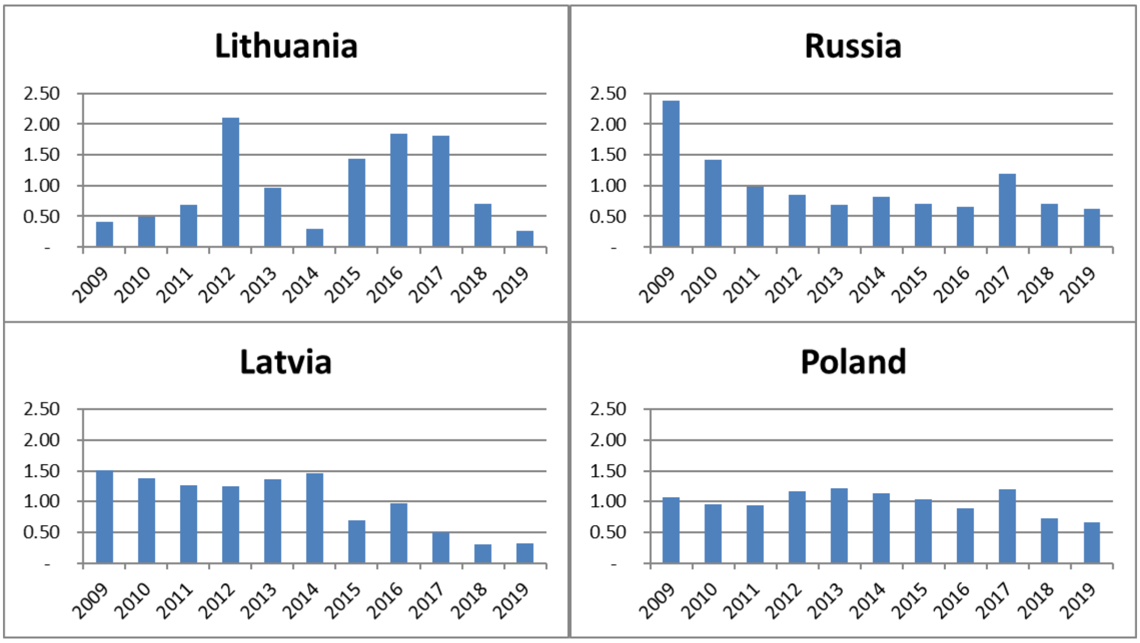

Figure 1 Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Effort data of flounder in subdivisions 26 and 28 by main fishing countries (days-at-sea).

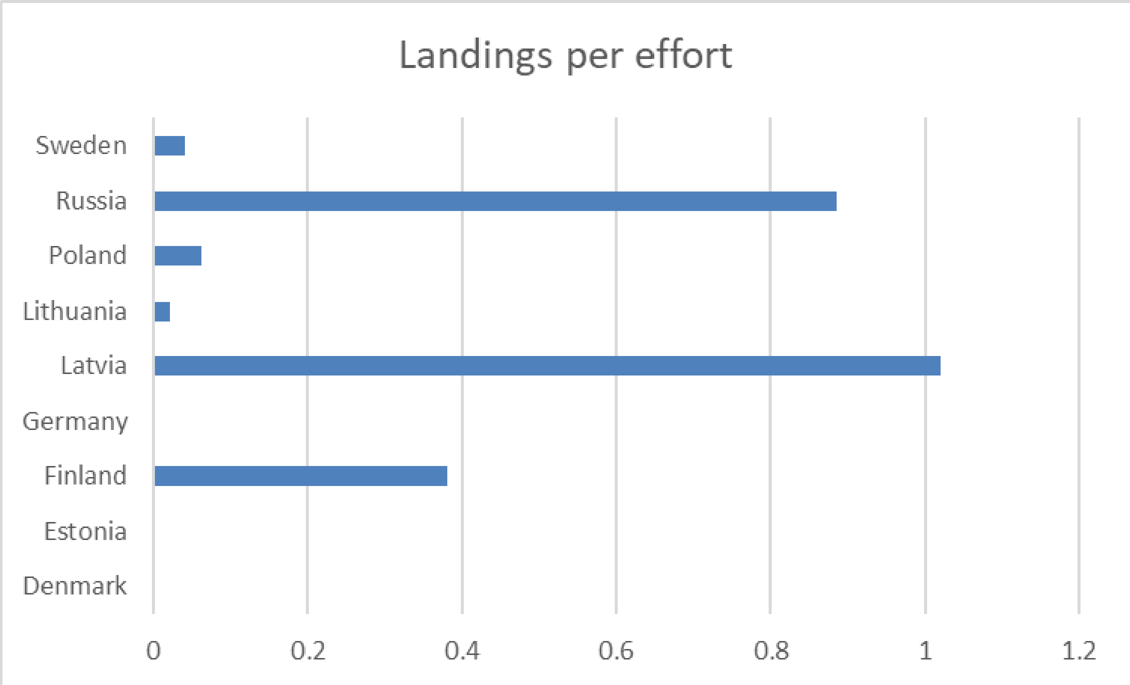

Figure 3.4.5. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Landings of flounder in tonnes per days-at-sea by country in subdivisions 26 and 28.

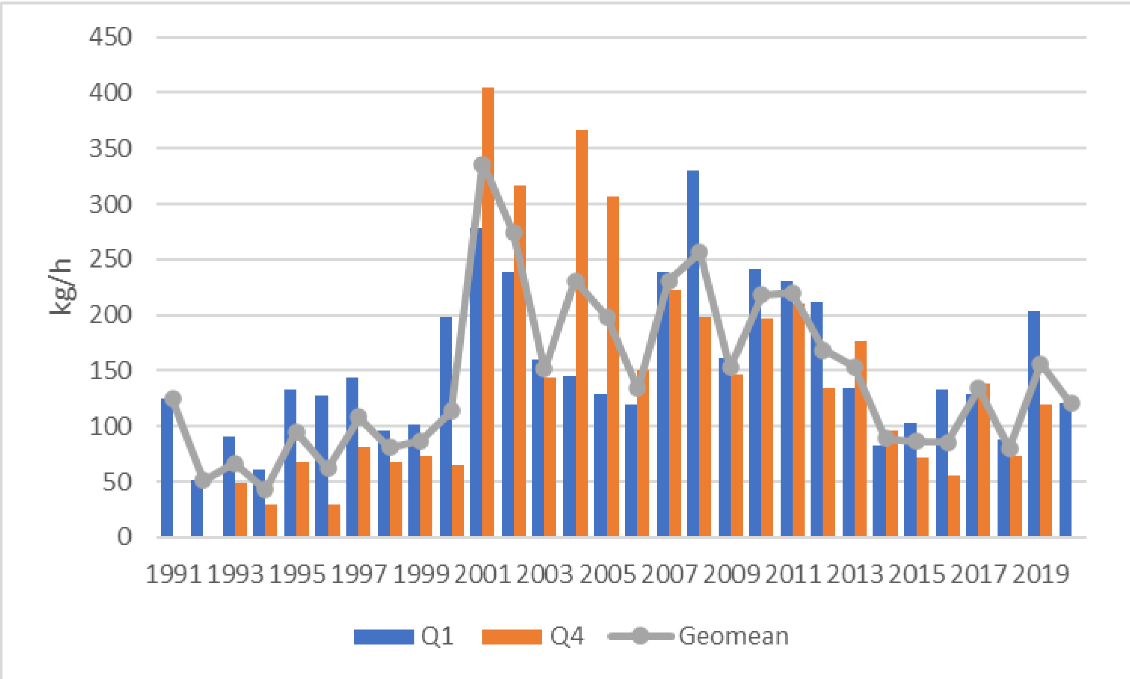

Figure 3.4.6. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch per unit of effort (kg per hour) from BIT Survey in 1st and 4th Quarters, subdivisions 26 and 28.

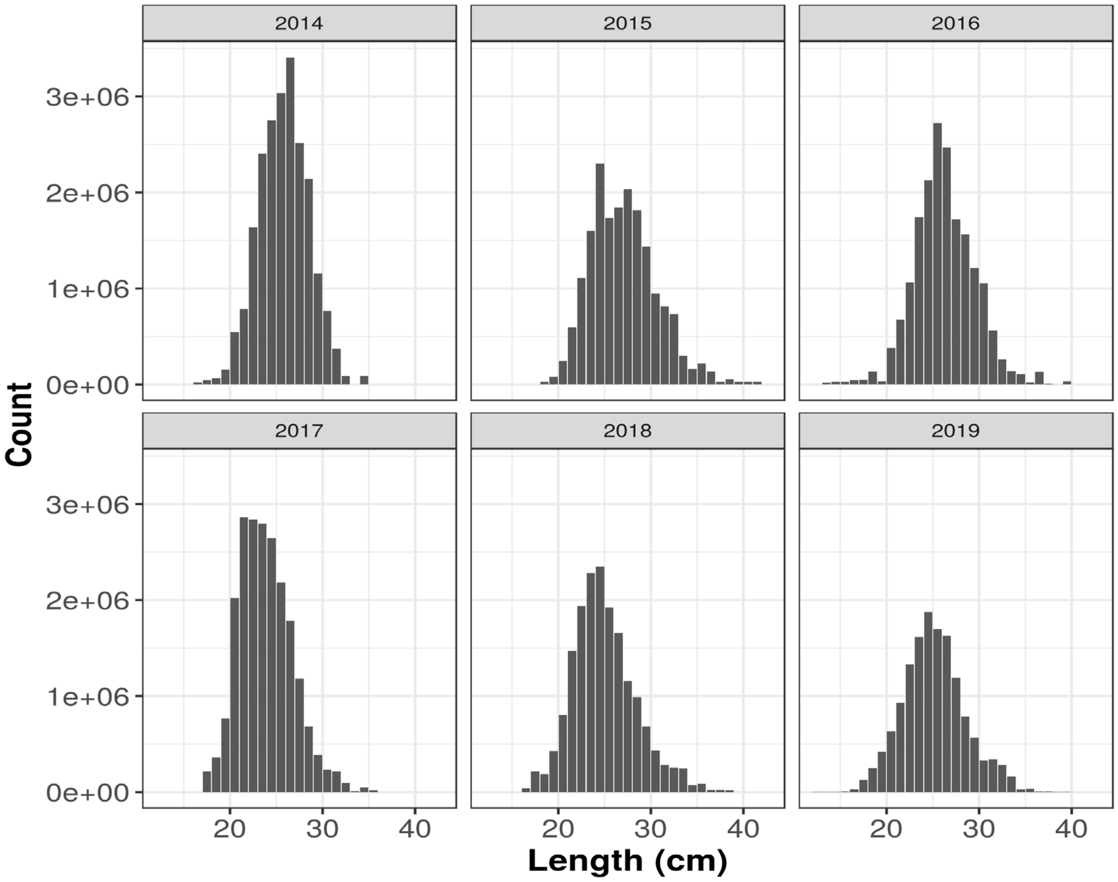

Figure 3.4.7. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch in numbers (CANUM) per length classes.

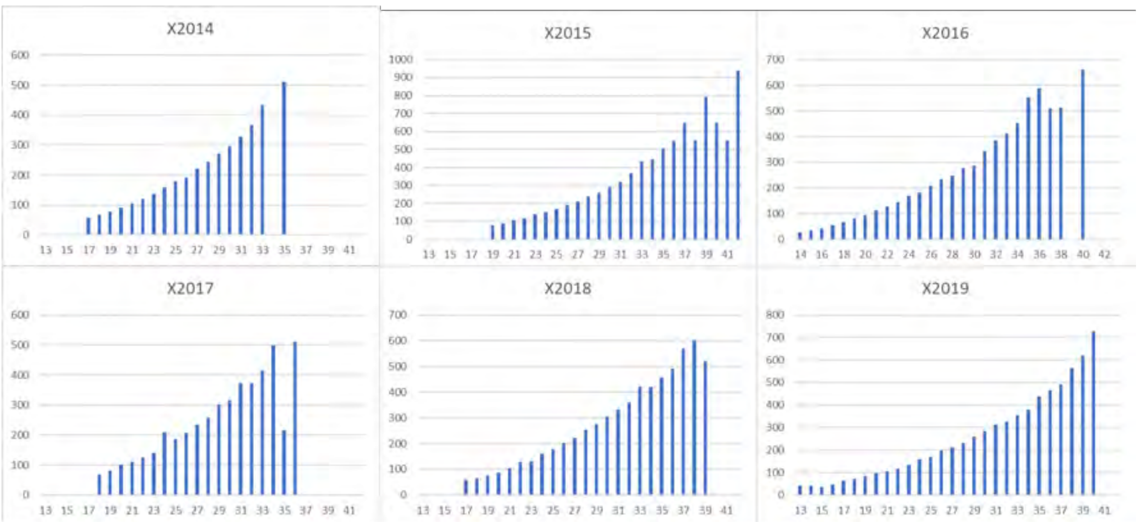

Figure 3.4.8. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Average weight (WECA) per length classes

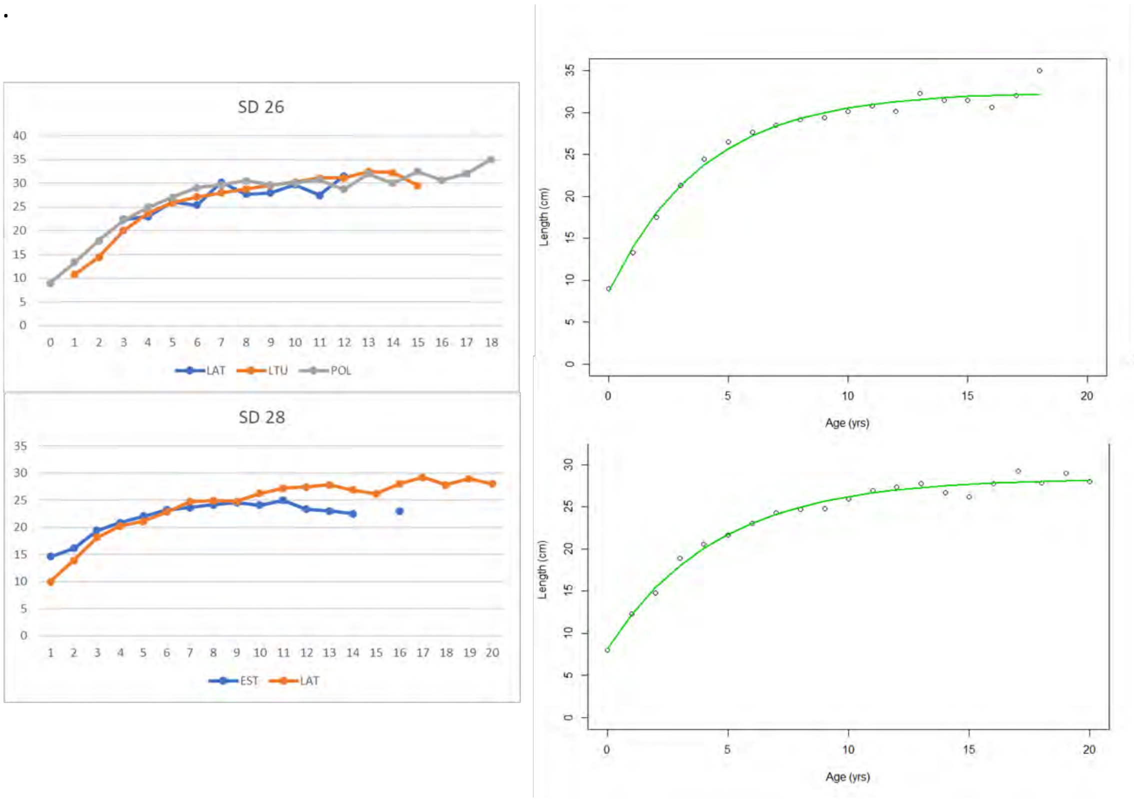

Figure 3.4.9. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Growth of flounder (Subdivision 26 – 1st line, Subdivision 28 – 2nd line) BIT Survey in 4th Quarters from 2014-2019.

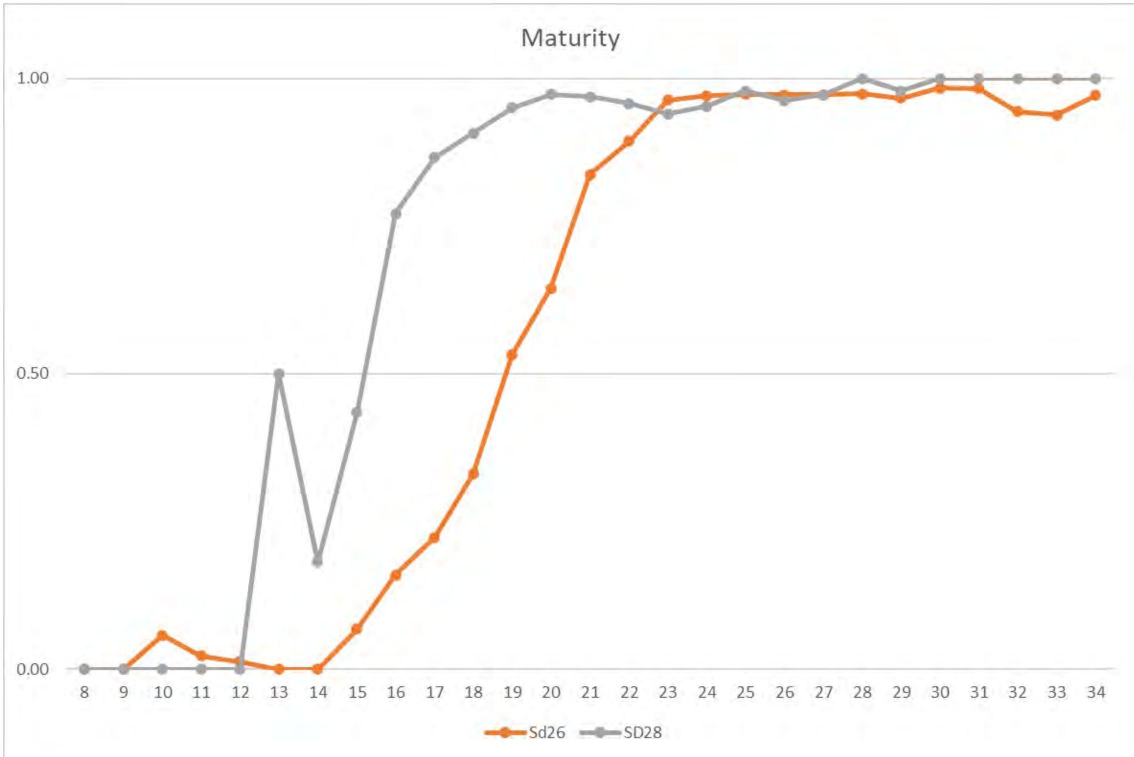

Figure 3.4.10. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Proportion of mature flounder females by Subdivisions, BIT Survey in 4th Quarters from 2014-2019.

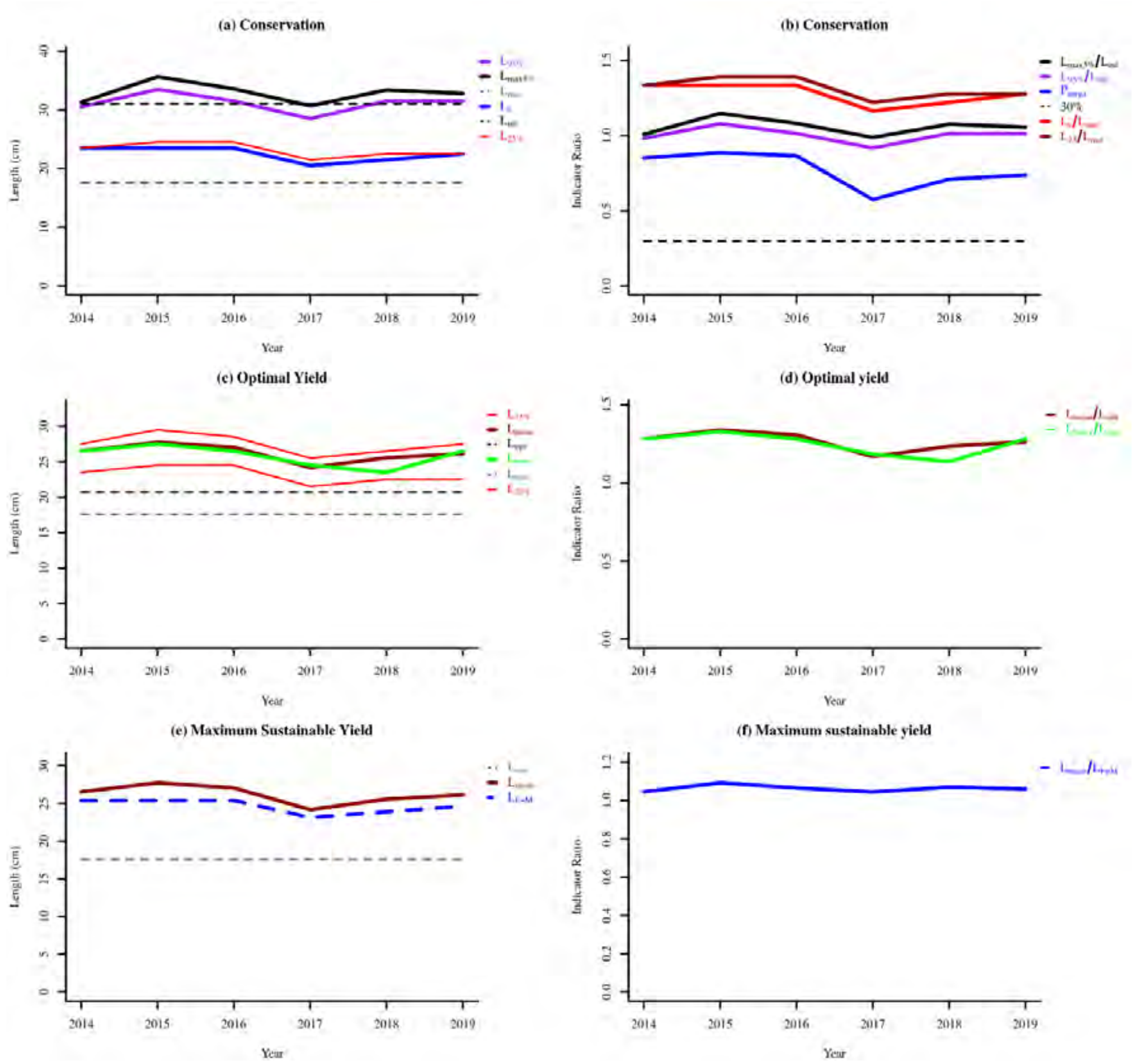

Figure 3.4.11. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Indicator trends.

3.5 Flounder in Subdivision 27, 29–32 (Northern flounder)[5,6]

Based on the decision by Benchmark Workshop on Baltic Flatfish Stocks (WKBALFLAT; 26–28 Nov 2013; 27–31 Jan 2014) flounder with demersal eggs inhabiting mainly the Northern Baltic Proper (SD 27, 29–32) is treated as a separate flounder stock. In the rest of the Baltic Sea, flounder with pelagic eggs dominate. Since 2018 these two ecotypes of flounder are considered to be two different species (Momigliano *et al.*, 2018), pelagic spawning flounder *Platichthys flesus* and demersal spawning flounder *P. solemdali*.

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.

[5] ADGBS edited the stock name due to species mixing (for 2425 and 2628).

[6] ADGBS edited the stock name that consists mainly of Baltic flounder (*P. solemdali*).

Flounder with demersal eggs also inhabit the Central Baltic Sea; however, it is not possible to separate the landings of the two spawning types, and in SD 28, presumably the pelagic spawning type dominates. Therefore SD 28 is not included in this stock.

At this stage it is not possible to separate these two species in either stock assessment or fisheries, as external morphological characters cannot discriminate between the two species. The two taxa can be clearly distinguished only based on gamete physiology or with genetic methods (Momigliano *et al.*, 2018). The work of Momigliano *et al.*, (2019) is based on Finland's historic catches from the Gulf of Finland (SD 32), and showed that in the beginning of the 1980s *P. flesus* dominated, but all but disappeared by 1993 and remained in low proportions (10-11%) thereafter. In the beginning of the 1980s, over 50% of catches were taken from SD 32; however, this dynamic has changed and currently >60% of catches are taken from SD 29. Unfortunately, SD 29 lacks any quantification of the possible proportions of these two species/ecotypes. However, based on work done by Momigliano *et al.*, (2019) and the INSPIRE BONUS project, it is plausible to assume that the proportion of *P. flesus* in SD 29 could be lower than 20%. Hence, this stock unit mainly consists of the new flounder species, *P. solemdali*.

3.5.1 The fishery

3.5.1.1 Landings

In subdivisions 27 and 29–32, flounder are caught mainly in the SDs 29 and 32 (Figure 3.5.1). The majority (>95% in the latest three years) of the catches are taken with passive gears, mostly gillnets. Yearly total landings were above 1000 tonnes at the beginning of 1980s, but have been decreasing since the late 1980s—reaching levels below 150 tonnes in the last two years. Estonia is the major fishing nation here, accounting for more than 80% of the catches, followed by Sweden (with a share of 15%)—the rest caught by Finland (in some years Poland as well) (Table 3.5.1).

3.5.1.2 Discards

Discards probably take place, but the amount is unknown (the extent depends on market price). In the major fishing country, Estonia, discard is not allowed. Survival rate of flounder in discards is unknown for passive gears, but can be presumed high under certain conditions. In Sweden, no discard sampling is made for this stock. Swedish discard rates are 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 2019, total discard was estimated at 13.9 tonnes. Estimated discard in Finland has been below 1 tonne for the past three years, but scaled up to the same level as landing in 2019 (2.8 tonnes).

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 other flatfishes, which complicates the catch estimates for recreational fishery. Although the species composition is unknown, the majority of this is presumed to be flounder. Rough calculations have shown that recreational fishery catches for Sweden can be three times higher than commercial landings; the same seems to be true for Finland. In Estonia, the reported recreational catch is on average equivalent to 20-40% of the commercial landings. Using the estimates from WKBALFLAT (2014), total recreational catches in this area are up to 40% of the commercial landings. However, the quality of the estimates is not well known, and the data is therefore not included in the advice.

3.5.1.4 Effort

The exploitation status of the stock is unknown, since effort data from the most important fishery, i.e. passive gears, is lacking from the dominating fishing country Estonia (Table 3.5.3). Also, there is no data on effort for the recreational fishery, which could roughly constitute up to 30% of the commercial landings. However, some improvement has been made, and starting from 2019 Estonia can provide the effort data on the passive gear.

3.5.2 Biological information

Age data are considered to be applicable only when ageing was conducted using a 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 weights-at-age data are available from Estonian commercial trap nets from 2011-2019 in SD 29 and 32. Age data was not sampled in commercial landings in Finland, and for Sweden, age data exists only for the years 2009-2010.

Estonian commercial landings length distribution data is only available from trap nets, and to some extent from Danish seine landings. Also, from 2017, gillnet catches from SD 29 and 32 were sampled during the main fishing months (the 2nd and 3rd quarter). Most of the fish (>90%) are 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 fishers use mainly 60-70 mm mesh sizes. For Estonia, the situation is more complicated, since the minimum legal size in SD 29-32 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 a smaller mesh size than 55 mm. It was decided that data from the Küdema survey (SD 29) that 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 trap nets, 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 non-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 trap net landings. The weight per age fluctuates strongly. 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 SD 29. 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 is gathered from four national gillnet surveys since the BITS survey was deemed inappropriate for this stock (not covering shallow areas, not covering Northern Baltic Sea). From Estonia two surveys were available, one in Muuga bay near Tallinn (mesh size 40 –60 mm bar length) in SD 32 ongoing since 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 was 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. In 2018 Sweden modified their survey protocol and since 2018 are fishing only during one night instead of six (Appelberg *et al.*, 2020). It was shown that the change of fishing one night instead of six nights does not have a statistically significant effect on the survey's CPUE (Leonardsson *et al.*, 2016, Appelberg *et al.*, 2020).

Cpue in biomass (kg per fishing station and fishing day) was used as a 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 the year 2000 onwards. For this, the indices from these SDs 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. Since 2019, ICES has been requested to provide information on stock status but has not been requested to provide advice on fishing opportunities for this stock.

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 a 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 a slightly increasing trend from 2012 onwards, but was decreasing in 2017 and has been stable for the past two years.

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 to be 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 slightly from 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 estimate this indicator independent of L_c, which tends to be more variable. The reference point $L_{F=M}$ is calculated using the formula:

$$L_{F=M} = \frac{L_\infty + 2\frac{M}{K}L_c}{2\frac{M}{K} + 1}$$

And L_{opt} is calculated:

$$L_{opt} = L_{\infty}\left(\frac{3}{3 + {}^{M}/_{K}}\right)$$

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 also includes 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

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	USSR		265			806	1 071
	Total	47	288	9	0	813	1 157
1986	Finland*		36	11		5	52
	Sweden	60	3				63
	USSR		281			556	837
	Total	60	320	11	0	561	952
1987	Denmark	1					1
	Finland*		37	18		3	58
	Sweden	51	2				53
	USSR		279			397	676
	Total	52	318	18	0	400	788
1988	Finland*		43	21		5	69
	Sweden	68	3				71
	USSR		257			331	588
	Total	68	303	21	0	336	728
1989	Finland*		39	24		6	69
	Sweden	66	3				69
	USSR		214			214	428
	Total	66	256	24	0	220	566
1990	Finland*		35	19		4	58
	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

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Total	86	98	10	0	51	245
1993	Finland*		52	26		5	83
	Sweden	83					83
	Estonia		86			55	141
	Total	83	138	26	0	60	307
1994	Denmark	9					9
	Finland*		47	24		8	79
	Sweden	33	10				43
	Estonia		3			4	7
	Total	42	60	24	0	12	138
1995	Denmark		1				1
	Finland*		54	29		6	89
	Sweden	81					81
	Estonia		52			35	87
	Total	81	107	29	0	41	258
1996	Finland*		47	36		9	92
	Sweden	114					114
	Estonia		99			145	244
	Total	114	146	36	0	154	450
1997	Finland*		35	32		13	80
	Sweden	105					105
	Estonia		96			125	221
	Total	105	131	32	0	138	406
1998	Finland*		36	21		14	71
	Sweden	70					70
	Estonia		79			87	166
	Total	70	115	21	0	101	307
1999	Denmark	0	1				1
	Finland*		43	22	2	9	76

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Sweden	15					15
	Estonia		150			164	314
	Total	15	194	22	2	173	406
2000	Denmark	1					1
	Finland*		34	13	0	9	56
	Sweden	73					73
	Estonia**		166			126	292
	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

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Total	47	157	10	0	117	330
2006	Finland*		11	4.166	0	2	17
	Sweden	33					33
	Estonia		165			129	294
	Total	33	176	4	0	131	344
2007	Finland*		6	1	0	2	9
	Sweden	39	0	0	0		39
	Estonia**		110			104	214
	Total	39	116	1	0	107	263
2008	Finland		5	1	0	5	11
	Sweden	49	0	0			49
	Estonia**		103			86	189
	Total	49	108	1	0	89	249
2009	Finland		6	1	0	3	10
	Sweden	41	0	0			41
	Estonia**		109			102	210
	Total	41	115	1	0	105	262
2010	Finland	0	6	1	0	3	10
	Sweden	36	0	0			36
	Estonia**		85			96	180
	Total	36	91	1	0	99	227
2011	Finland	0	5	1	0	2	9
	Sweden	34	0	0	1		35
	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

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Total	36	85	0	0	69	190
2013	Finland		3	1	0	1	5
	Poland		3				3
	Sweden	31	0				31
	Estonia		123			75	198
	Total	31	129	1	0	77	237
2014	Finland		2	0	0	1	4
	Poland		0				
	Sweden	29	0				29
	Estonia		85			65	150
	Total	29	87	0	0	67	183
2015	Finland		3	0	0	1	4
	Poland		0				0
	Sweden	26	0	0			27
	Estonia		81			64	145
	Total	26	85	0	0	64	176
2016	Finland		2	0	0	1	3
	Poland						0
	Sweden	22	0				22
	Estonia		96			52	148
	Total	22	98	0	0	53	173
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

Year	Country	SD 27	SD 29	SD 30	SD 31	SD 32	Total
	Total	14	80	0	0	32	127
2019	Finland		2	0	0	0	3
	Estonia		76			30	106
	Sweden	12	0				12
	Total	12	79	0	0	31	121

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

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

***** Poland 2012 corrected**

Zero values equal to landings under 0.5 tonnes

Table 3.5.2. Flounder SD 27, 29-32 (Northern Baltic Sea). Recreational fishery catch estimates for Estonia and Finland.

	Estonia		Finland			
	SD32	SD 29	SD32	SD 29	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
2019	13.2	11.2	1	4	0	0

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

	SWE Active	SWE Passive	EE Active	EE Passive	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
2019	25	1106	2	18741	2696.0

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**			**Combined[3)]**
Survey	**Muuga-Q4**	**Kudema-Q4**	**Kvädöfjärden-Q4[1)]**	**Muskö-Q4[1)]**	**Combined for SD 27[2)]**	
	(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			

SD	32	29	27			Combined[3)]
Survey	Muuga-Q4	Kudema-Q4	Kvädöfjärden-Q4[1)]	Muskö-Q4[1)]	Combined for SD 27[2)]	
	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	kg gear-night-1)
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
2001	0.65	2.32	1.42	1.17	1.29	1.34
2002	0.172	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	0.096	2.24	0.60	2.61	1.60	1.27
2008	0.108	2.68	1.33	4.67	3.00	1.80
2009	0.36	0.86	0.20	2.19	1.19	0.71
2010	0.136	0.79	0.45	1.04	0.75	0.50
2011	0.24	0.97	0.163	0.50	0.33	0.59
2012	0.126	1.03	0.136	0.48	0.31	0.56
2013	0.128	2.03	0.32	0.95	0.63	1.22
2014	0.090	2.35	0.43	0.98	0.70	1.26
2015	0.070	8.70	0.53	1.32	0.92	4.36
2016	0.111	1.90	0.43	0.76	0.60	1.18

SD	32	29	27			Combined[3)]
Survey	Muuga-Q4	Kudema-Q4	Kvädöfjärden-Q4[1)]	Muskö-Q4[1)]	Combined for SD 27[2)]	
	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	(kg gear-night-1)	kg gear-night-1)
2017	0.164	2.72	0.57	0.50	0.54	1.88
2018	0.151	1.57	0.088	0.08	0.083	1.04
2019	0.071	1.60	0.075	0.147	0.111	1.07

[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 SD 27, 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	2000-2019	
L_{inf}	Commercial trapnet data SD 29+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 SD 27, 29-32 (Northern Baltic Sea). Length-based indicators analysis results.

	Conservation	Optimizing Yield	MSY		
Year	L_c/L_{mat}	L_{mean}/L_{opt}	$L_{mean}/L_{f=m}$	L_{mean}	$L_{f=m}$
Ref	**>1**	**~1(>0.9)**	**≥1**	**cm**	**cm**
2000	1.07	1.06	1.03	21.9	21.2
2001	1.01	1.04	1.05	21.5	20.5
2002	1.10	1.06	1.02	21.8	21.5
2003	1.07	1.12	1.09	23.1	21.2

	Conservation	Optimizing Yield	MSY		
Year	L_c/L_{mat}	L_{mean}/L_{opt}	$L_{mean}/L_{f=m}$	L_{mean}	$L_{f=m}$
Ref	**>1**	**~1(>0.9)**	**≥1**	**cm**	**cm**
2004	0.95	1.04	1.08	21.3	19.8
2005	1.09	1.08	1.04	22.3	21.4
2006	1.13	1.12	1.06	23.1	21.8
2007	1.13	1.12	1.06	23.1	21.8
2008	1.19	1.13	1.04	23.3	22.5
2009	1.10	1.12	1.07	23.1	21.5
2010	1.01	1.06	1.07	21.8	20.5
2011	1.12	1.09	1.04	22.4	21.7
2012	1.13	1.13	1.07	23.3	21.8
2013	1.13	1.11	1.05	22.8	21.8
2014	1.07	1.05	1.02	21.5	21.2
2015	1.01	1.02	1.03	21.1	20.5
2016	1.11	1.08	1.03	22.2	21.6
2017	0.95	1.01	1.05	20.7	19.8
2018	1.07	1.07	1.04	21.9	21.2
2019	1.00	1.00	1.01	20.5	20.4

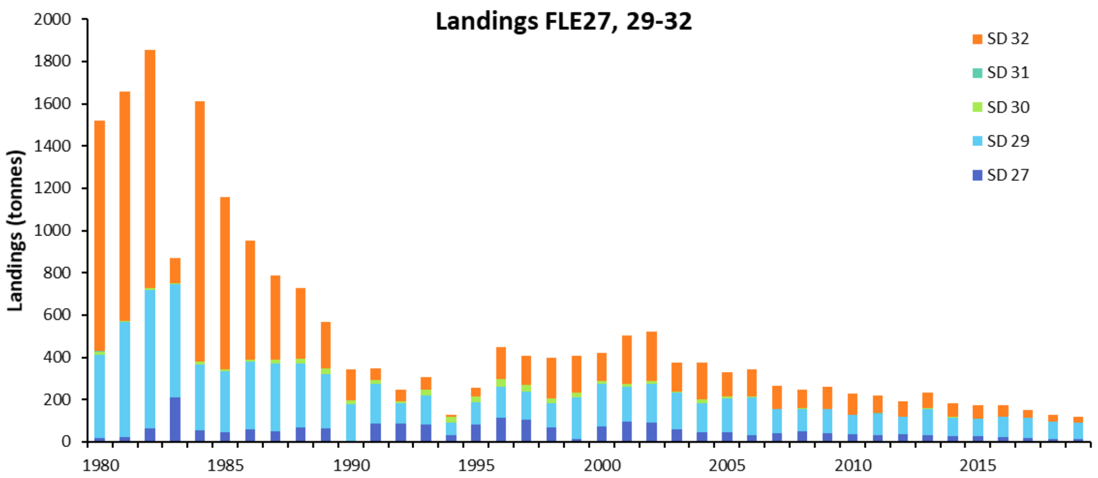

Figure 3.5.1. Flounder SD 27, 29-32 (Northern Baltic Sea). Landings (tonnes) in subdivisions (SDs) 27 and 29-32 from 1980-2019.

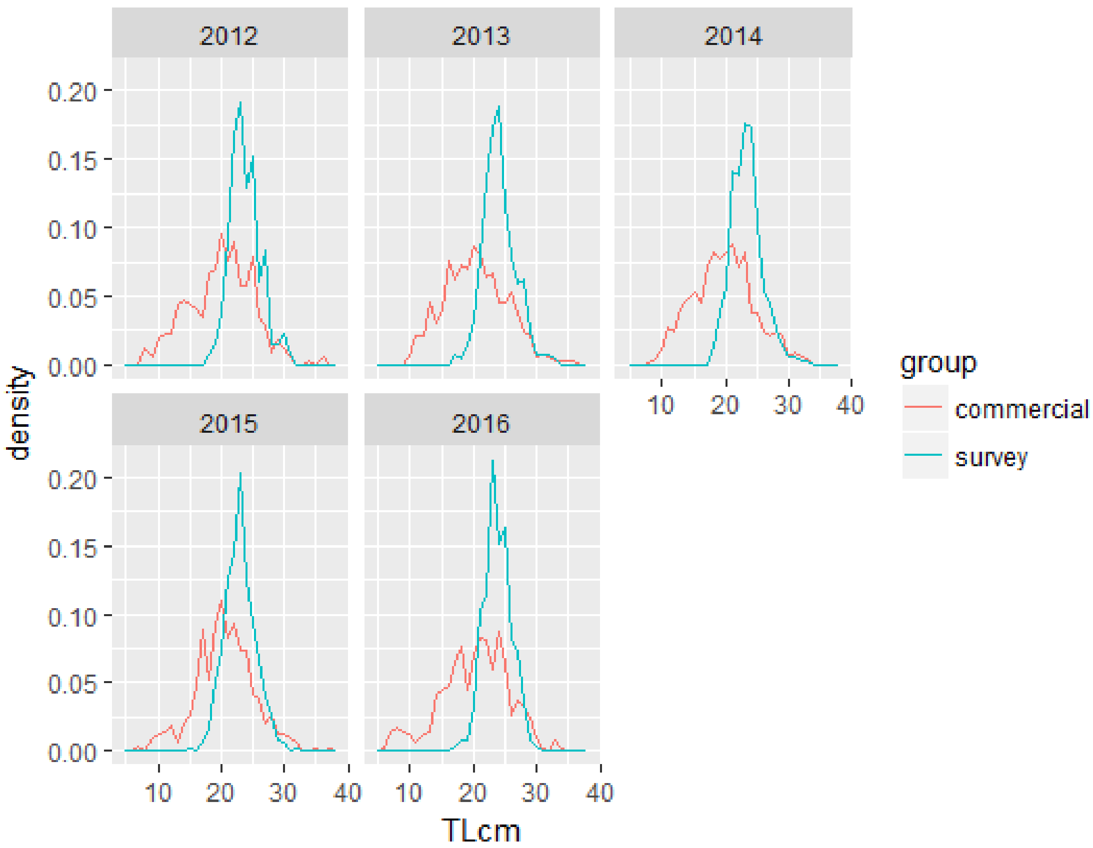

Figure 3.5.2. Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Comparison of commercial trap net length distribution with SD 29 survey length distribution (mesh sizes 50 & 60 mm).

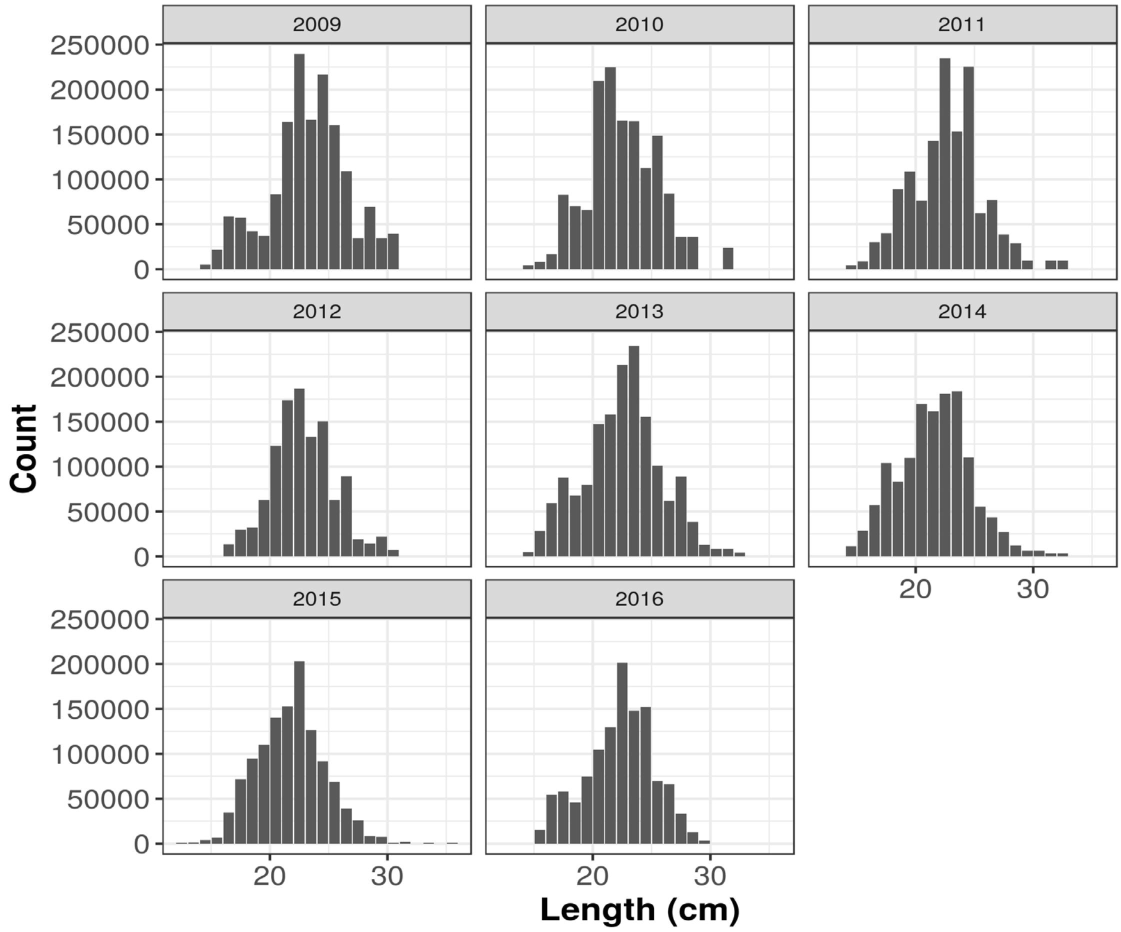

Figure 3.5.3. Flounder in Subdivisions 27 and 29-32 (Norther Baltic Sea). Representative catch in numbers by length class for flounder commercial landings in subdivisions 27 and 29-32.

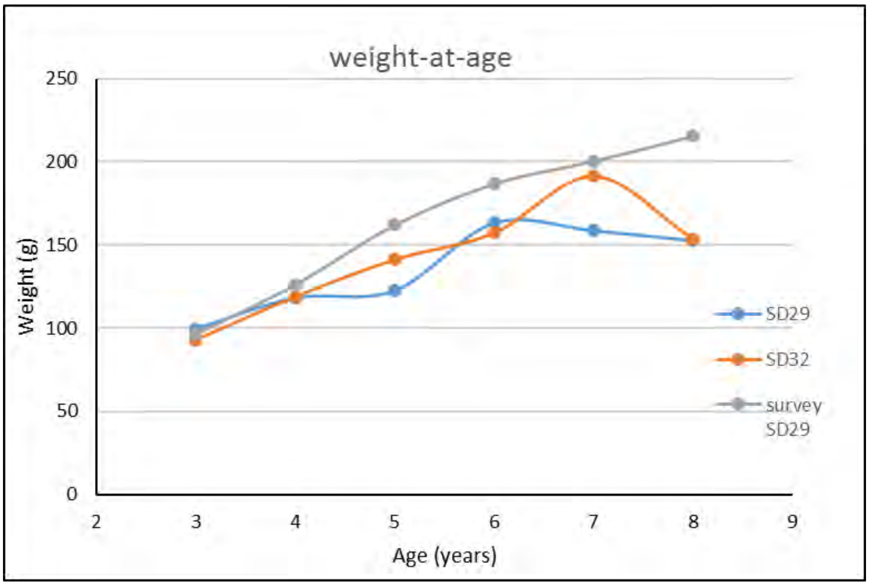

Figure 3.5.4. Flounder in Subdivisions 27 and 29–32 (Northern Baltic Sea). Mean weights per age for Estonian commercial trap net landings per Subdivision (Q3+4) and for survey in SD 29 (Küdema bay).

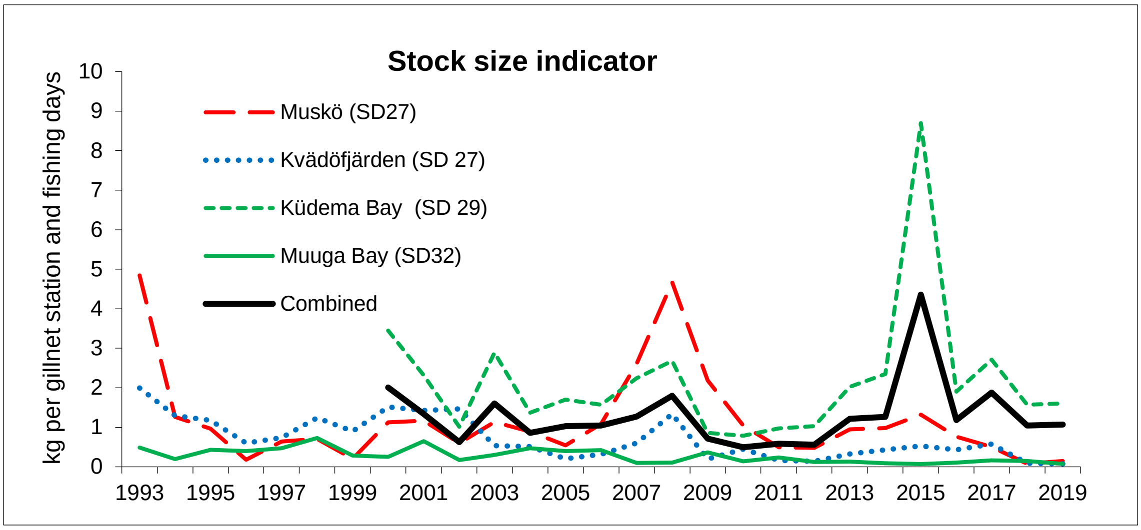

Figure 3.5.5. Flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Biomass indices of Muuga Bay (SD 32) (solid green line), Küdema Bay (SD 29) (dashed green line), Muskö (SD 27) (red dash line), Kvädöfjärden (SD 27) (dotted blue line) surveys and combined index (kg per gillnet station and fishing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

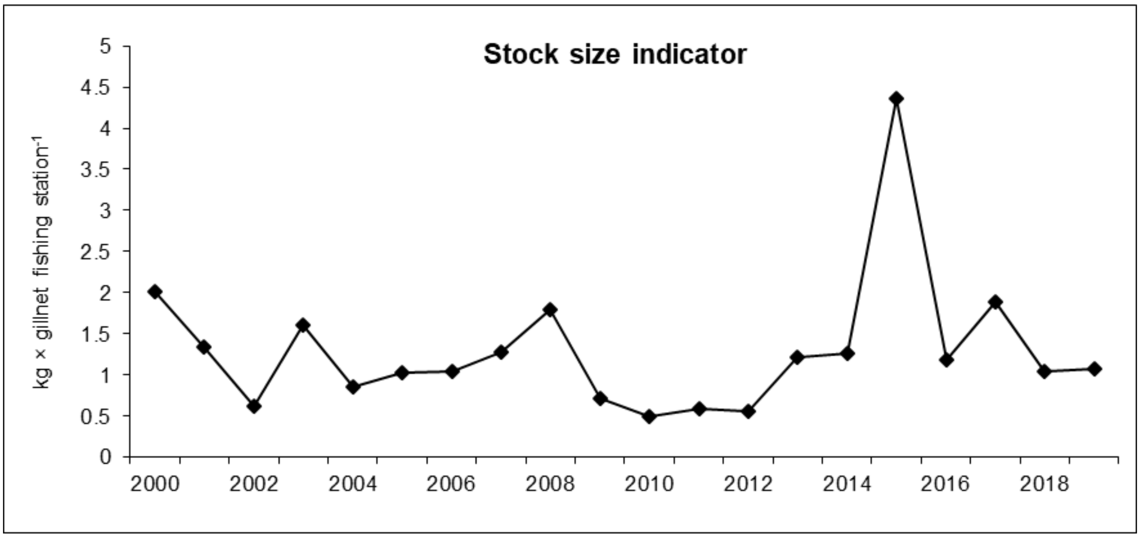

Figure 3.5.6. Flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea) Combined biomass index of four surveys (Muuga Bay (SD 32), Küdema Bay (SD 29), Muskö (SD 27), and Kvädöfjärden (SD 27)) (kg × gillnet fishing station−1)

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 2019 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 2019, 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 to 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 2019, 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 is 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 quota and one Russian quota.

Herring was formerly managed by three TAC's:

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

The units were changed in 2005 to be:

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

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

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

Management 2018 and 2019 herring – sprat

Stock	Stock status ACOM 2019		ICES Advice for 2020 (Basis) (t)	TAC 2020 (t)
	in relation to SSB_{2018}	in relation to F_{2018}		
SPRAT				
SD 22-32	Above trigger & Full reproductivity	Above & harvested sustainably Above range	169 965– 233 704 (MAP applied)	*256 700
HERRING				
SD 25–29&32 (excl. GOR)	Above trigger & Full reproductivity	Above & harvested sustainably Above range	130 546– 214 553 (MAP applied)	*182 484
SD 28.1 (Gulf of Riga)	Above trigger & Full reproductivity	Appropriate and harvested sustainably and within ranges	23 395 – 35 094 (MAP applied)	34 445
SD 30–31 (Bothnian Sea)	Unknown	Unknown	65 018 (MSY approach)	65 018

***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%
2019	9.8	25.4	38.6%
Mean	32.7	62.6	51.9%

***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 Gulf of Riga (SD 28.1)
2000	4.6	175.6	2.6%
2001	2.9	148.4	2.0%
2002	3.5	129.2	2.7%
2003	4.3	113.6	3.8%
2004	3.3	93.0	3.5%
2005	2.3	91.6	2.5%
2006	3.2	110.4	2.9%
2007	1.5	116.0	1.3%
2008	6.1	126.2	4.8%
2009	4.9	134.1	3.7%
2010	5.2	136.7	3.8%
2011	5.5	116.8	4.7%
2012	3.8	101.0	3.8%
2013	4.1	101.0	4.1%
2014	4.5	132.7	3.4%

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 Gulf of Riga (SD 28.1)
2015	5.0	174.4	2.8%
2016	4.3	192.1	2.2%
2017	3.9	202.5	1.9%
2018	4.2	244.4	1.7%
2019	3.6	204.4	1.8%
Mean	4.0	142.2	3.0%

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%

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
2018	0.5	*25.7	2.0%
2019	1.2	28.9	4.4%
Mean	0.5	32.1	1.4%

***corrected at WGBFAS 2020**

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 2019 by subdivision and quarter.

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
SD 25	Landings ('000 t)	40.49	41.12	6.95	17.87	**106.42**
	Herring (%)	27.03	26.86	80.76	68.78	**37.48**
	Sprat (%)	72.97	73.14	19.24	31.22	**62.52**
SD 26	Landings ('000 t)	90.75	54.16	4.97	14.95	**164.83**
	Herring (%)	25.04	26.04	86.33	48.10	**29.30**
	Sprat (%)	74.96	73.96	13.67	51.90	**70.70**
SD 27	Landings ('000 t)	27.33	6.51	0.11	2.93	**36.88**
	Herring (%)	55.41	64.33	75.29	84.44	**59.35**
	Sprat (%)	44.59	35.67	24.71	15.56	**40.65**
SD 28*	Landings ('000 t)	48.28	27.94	12.71	55.49	**144.42**
	Herring (%)	44.76	70.86	35.99	62.09	**55.70**
	Sprat (%)	55.24	29.14	64.01	37.91	**44.30**
SD 29	Landings ('000 t)	31.10	6.06	2.94	17.80	**57.91**
	Herring (%)	55.83	97.20	59.84	51.31	**58.97**
	Sprat (%)	44.17	2.80	40.16	48.69	**41.03**
SD 30	Landings ('000 t)	26.52	41.36	5.46	14.17	**87.50**
	Herring (%)	98.51	99.28	99.76	98.51	**98.95**
	Sprat (%)	1.49	0.72	0.24	1.49	**1.05**
SD 31	Landings ('000 t)	0.00	1.58	0.58	0.18	**2.35**
	Herring (%)	0.00	97.64	99.59	100.00	**98.31**
	Sprat (%)	0.00	2.36	0.41	0.00	**1.69**
SD 32	Landings ('000 t)	17.20	8.02	4.34	24.29	**53.85**
	Herring (%)	60.84	73.13	42.08	45.65	**54.31**
	Sprat (%)	39.16	26.87	57.92	54.35	**45.69**
Total	Landings ('000 t)	**281.68**	**186.74**	**38.05**	**147.69**	**654.16**
	Herring (%)	**44.16**	**55.42**	**63.51**	**61.47**	**52.40**
	Sprat (%)	**55.84**	**44.58**	**36.49**	**38.53**	**47.60**

* Gulf of Riga included

Table 4.1.2. Proportion of herring in landings 2019.

COUNTRY	QUARTER	SUBDIVISION							
		25	26	27	28*	29	30	31	32
DEN	1	0.14	0.12	0.49	0.23	0.29			
	2	0.08	0.02						
	3	0.47							
	4	0.47	0.67		0.38	0.03			
EST*	1				0.80	0.42			0.44
	2				0.95	1.00			0.63
	3				0.25	0.36			0.29
	4				0.30	0.28			0.33
FIN	1	0.81	0.86	0.89	0.00	0.85	0.98		0.72
	2	0.92	0.68	0.85	0.00	0.97	0.99	0.98	0.84
	3			0.97	0.00	0.76	1.00	1.00	0.58
	4	0.20			0.00	0.67	0.98	1.00	0.39
GER	1	0.12	0.15		0.15	0.09			
	2	0.03	0.07		0.06				
	3								
	4	0.04							
LAT*	1	0.01	0.06		0.44				
	2	0.01	0.11		0.53				
	3		0.70		0.33				
	4		0.37		0.40				
LIT	1	0.06	0.28	0.18	0.21	0.30			
	2	0.20	0.39		0.27				
	3		0.99						
	4		0.80		0.19	0.15			
POL	1	0.21	0.25		0.14				
	2	0.26	0.27		0.08				
	3	0.80	0.81		0.18				
	4	0.70	0.51		0.39				
RUS	1		0.24						0.89
	2		0.23						0.90
	3		0.93						
	4		0.41						0.83
SWE	1	0.39	0.29	0.56	0.48	0.53	1.00		
	2	0.48	0.36	0.64	0.59	1.00	1.00	1.00	
	3	0.87		0.68	0.80	1.00	1.00	1.00	
	4	0.82	0.77	0.84	0.63	1.00	1.00	1.00	
Total	1	0.27	0.25	0.55	0.45	0.56	0.99		0.61
	2	0.27	0.26	0.64	0.68	0.97	0.99	0.98	0.73
	3	0.81	0.86	0.75	0.36	0.60	1.00	1.00	0.42
	4	0.69	0.48	0.84	0.44	0.51	0.99	1.00	0.46
Acoust. Stock**	4	0.53	0.49	0.41	0.36	0.56	0.96		0.49

* 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 2019 available to the Working Group.

	Quarter	Landings in tons	Number of samples	Number of fish meas.	Number of fish aged
Subdivision 25	1	10,943	37	1,971	1,302
	2	11,045	13	1,092	964
	3	5,612	18	1,885	879
	4	12,290	11	1,434	720
	Total	39,889	79	6,382	3,865
Subdivision 26	1	22,722	34	4,571	1,880
	2	14,101	28	3,293	1,832
	3	4,288	11	2,863	525
	4	7,191	25	4,957	648
	Total	48,302	98	15,684	4,885
Subdivision 27	1	15,144	12	842	840
	2	4,188	8	504	502
	3	82	0	0	0
	4	2,474	0	0	0
	Total	21,887	20	1,346	1,342
Subdivision 28*	1	21,613	47	4,740	3,551
	2	17,412	59	6,593	5,879
	3	4,574	13	2,331	1,045
	4	16,288	32	3,704	2,392
	Total	59,887	151	17,368	12,867
Subdivision 29	1	17,366	27	3,028	1,409
	2	5,887	27	7,261	742
	3	1,762	16	1,248	510
	4	9,135	27	2,942	1,183
	Total	34,150	97	14,479	3,844
Subdivision 30	1	26,122	14	4,791	268
	2	41,029	30	10,928	561
	3	5,436	13	3,477	3,139
	4	13,956	20	6,289	256
	Total	86,543	77	25,485	4,224
Subdivision 31	1	0	0	0	0
	2	1,546	14	4262	523
	3	571	8	2053	377
	4	182	5	700	108
	Total	2,298	27	7,015	1,008
Subdivision 32	1	10,467	18	2,486	1,639
	2	5,867	36	6,661	2,428
	3	1,825	14	1,941	678
	4	11,087	20	2,266	1,096
	Total	29,245	88	13,354	5,841
Subdivisions 25-32	**1**	**124,377**	**189**	**22,429**	**10,889**
	2	**101,075**	**215**	**40,594**	**13,431**
	3	**24,148**	**93**	**15,798**	**7,153**
	4	**72,602**	**140**	**22,292**	**6,403**
	Total	**322,202**	**637**	**101,113**	**37,876**

* Gulf of Riga included

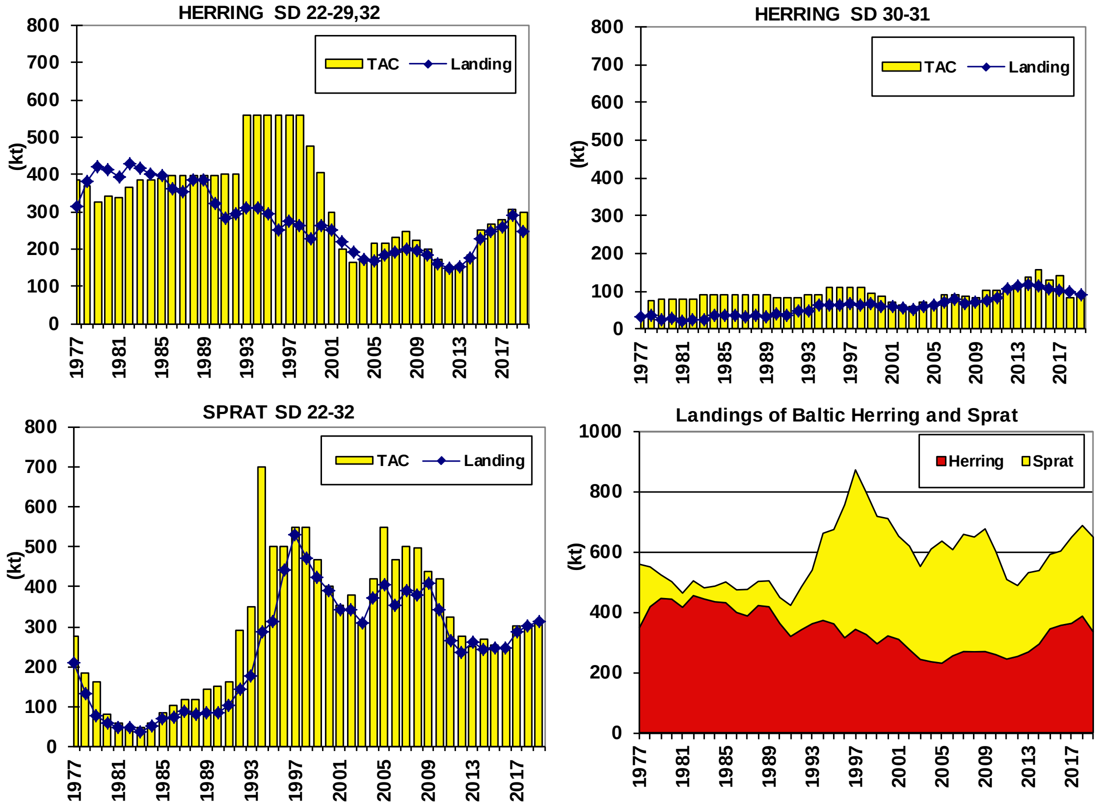

Figure 4.1.1. Reported landings of herring and sprat and agreed TACs in the Baltic Sea (since 2007 TACs for herring and sprat: EC quota + Russian TAC).

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 2019 amounted to 204 438 t, which is 16% lower than last year. Catches decreased for all countries (Denmark (-22%), Estonia (-11%), Finland (-18%), Germany (-56%), Latvia (-32%), Lithuania (-7%), Poland (-18%) and Sweden (-17%) except for Russia (+1%). The largest part of the catches in 2019 was taken by Sweden (27%), followed by Poland (20%) and then Finland (18%).

Catches by country and subdivision are presented in tables 4.2.2–4.2.3 (incl. Central Baltic Herring caught in SD 28.1; see Section 4.1.3). The spatial distribution of catches shows that in the last few years most catches were taken in 25, 26, 28.2 and 29. In 2019, the distribution of catches was as follows: 24% in SD 26, 20% in SD 25, 17% in SD 29 and 15% in SD 28.2.

4.2.1.2 Discards

There was only one country, Finland, reporting logbook registered discards of 30 t (0.01% of total catch) in 2019. 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 in recent years (in the years after the benchmark) can 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 the age composition of their major catches (caught in their waters by quarter and subdivision). The catches for which age composition was missing represented about 23% of the total catches in 2019. All German catches, which only represent a minor part (0.9%) of the total catches, were landed in foreign ports and therefore no age composition of catches could be provided from Germany.

The compilation of 2019 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 1–5 in 2018 and 2019 constitute 84% of the catches in numbers (Figure 4.2.1). The strong year class of 2014 is now 5 years old, and is still the main contributor to the fishery with 28% 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 or even slightly better 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 2019 (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 particularly strong year class occurs (e.g. 2002, 2007 or 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 not only to a real decrease in growth, but also where the larger proportion of herring is 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 not used, however, due to inconsistencies in some parts of the data; namely a very high maturity at age 1 with a notable year and country effect. The new maturity ogive was also, apart from the inconsistencies mentioned, similar to the old ogive and therefore it was decided to keep the old maturity ogive static from 1974-2018 (Table 4.2.8).

4.2.2.4 Natural mortality

New natural mortality estimates (1974-2018) obtained from a new SMS run in November 2019 (ICES 2019/ICES Scientific Reports. 1:91) were used in the inter-benchmark assessment of CBH in March 2020 (ICES 2020/ICES Scientific Reports. 2:34). The comparison of new estimates of predation mortality (1974-2018) with estimates used in the previous assessment in 2019 (Figure 4.2.5) showed the following overall differences:

- The new estimates of age 1 are in most years far higher and positive.
- In general, the new M values of age 2-8+ give higher and positive estimates at the beginning of the time-series till around the mid-1980s where they all become more or less negative.
- The new estimates of M show a decreasing trend in the last years.

Compared with the results obtained at WGBFAS in 2019 (ICES 2919/ ICES Scientific Reports. 1:20), the results of an assessment with the updated M values for the years 1974-2018 led to a downward revision of SSB and upward revision of fishing mortality.

As the SMS will not be updated every year, IBPBASH (ICES 2020/ICES Scientific Reports. 2:34) concluded that the further estimates of M will be set in the following way:

- M2019 = M2018 (WGBFAS 2020)
- M2020 and onwards = natural mortality values estimated from the regression of mean M values taken from SMS against Eastern Baltic cod SSB in 1974–2020 onwards (WGBFAS 2021 onwards).

The difference between last years' values compared to the updated new M values is illustrated in Figure 4.2.5. The updated new M values 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 2019 is given in Table 4.2.2. The overall frequency was 2.6 samples, 328 fishes measured and 153 fishes aged per 1000 tonnes landed. In 2019, sampling was most frequent in SD 26 followed by SD 29 and SD 32. Compared to 2018 the sampling has increased in all subdivisions, except SD 32.

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 a measure (Gröhsler *et al.*, 2013). It is recommended to estimate the degree of 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 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 nearshore 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 the 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 this should be investigated further.

4.2.3 Fishery independent information

As in the previous 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 parts 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 incomplete coverage of the standard survey area. The years 2013–2016 of the BIAS index were updated in 2020 by the WGBIFS working group. Running the assessment with and without these updates (using all data from 1991–2019 and the same XSA settings as last year), resulted in differences not exceeding 2.6% (SSB = 2.1%, F (ages 3-6) = 1.6% and recruitment (age 1) =2.6%). Due to these relatively small differences, it was decided to include the updates for the years 2013–2016 when conducting this year's final assessment. 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 2019 data, it did not have major impacts on the strength of the internal consistency compared to last year.

4.2.4 Assessment

4.2.4.1 Recruitment estimates

The data series of 0 group herring from the acoustic surveys in subdivisions 25–27, 28.2 and 29 (including southern and northern data) in 1991–2019 was used in an RCT3 analysis to estimate the year class 2019 at age 1 for 2020. As for the BIAS Index covering the age groups 1-8+ (see 4.2.3), also 0 group values were revised for the years 2013–2016. The RCT3 input and result are presented in tables 4.2.17 and 4.2.18. The estimate of the year class 2019 (age 1 in 2020: 20 523 billion) is well above average recruitment of the whole time-series (1974–2019: 17 741 billion).

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_2020. Results of SAM compared to XSA are presented in figure 4.2.11. In general, SAM has produced similar results since the year 2000. For the earlier period, 1974–1999, SAM gives lower estimates of SSB and recruitment (age 1), whereas it shows higher fishing mortality (F3–6). The retrospective pattern of SAM 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

An inter-benchmark assessment was carried out before this year's WGBFAS meeting in March 2020 (ICES 2020/ICES Scientific Reports. 2:34). New natural mortality estimates (1974–2018) obtained from a new SMS run in November 2019 (ICES 2019/ICES Scientific Reports. 1:91) were used in this inter-benchmark assessment (see 4.2.2.4).

Compared with the results obtained at WGBFAS in 2019 (ICES 2919/ ICES Scientific Reports. 1:20), the inter-benchmark results led to a downward revision of SSB and an upward revision of fishing mortality (ICES 2020/ICES Scientific Reports. 2:34).

The assessment performed at this year's WGBFAS meeting is an updated 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 the stock, tuning fleet and natural mortality by age and year, the 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 not converged after 80 iterations, are shown in Table 4.2.12. Further iterations of the XSA showed no difference in the assessment results. Including the latest acoustic estimates for 2019 and the data updates for the years 2013-2016 (see 4.2.3) 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, respectively. The summary is presented in Table 4.2.15.

The development of herring biomass as estimated by the acoustic surveys and by XSA is illustrated in Figure 4.2.7. The 2019 acoustic SSB and total biomass show a higher increase in biomass compared to the XSA estimates. The acoustic estimates in 2019 reached again lower levels compared to the very high values in 2018.

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

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 0.5–0.9, which is rather similar compared to last year's estimates.

4.2.4.4 Historical stock trend

Spawning-stock biomass (SSB) has been above MSY-Btrigger since 2002. SBB shows a decreasing trend since 2014 and is just below MSY-Btrigger in 2020. Fishing mortality has shown an increasing trend since 2014 and has been above F_{MSY} since 2015 (Figure 4.2.13). The present SSB estimate of 502 kt for 2019 is 41% below the long-term average (1974–2019: 856 kt). The historical decrease in SSB is believed to be partly caused by a shift in the 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 an 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 is higher in SD 25 than in SD 26 can influence the estimation of SSB. In numbers, the metrics show a spawning stock that decreased from 42 billion fish in 1974 to 19 billion fish in 1990. The spawning stock then varies around 21–24 billion fish in the period 1991–1997. The stock starts to decrease in 1998, to reach a value of 13 billion fish in 2003, which is the lowest value of the whole time-series. Since then the spawning stock numbers increased to 32 billion fish in 2016. Since 2017 the numbers start to decrease again and reached 21 billion fish in 2019 (Figure 4.2.14).

A major cause for decreasing trends in stock development is the drastic decrease in mean weight (size) at-age during the period of assessment (Figure 4.2.3). One of the reasons is that slow-growing herring, emanating from the north-eastern parts of the Baltic, has 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 afterward (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 63 percent higher than the last strong 2007 year class, and is one of the largest year classes in the time-series (34.4 billion). This year class is still the main contributor in the catches in 2019. The strong year class 2014 was followed by four years of below or on average recruitment. The 2019 year class is well above average. The stock status in the next years will depend on the further development of the incoming stronger year class 2019.

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 2017-2019. The estimate of recruitment of age 1 for 2020 was taken from the RCT3 analysis (Tables 4.2.17 and 4.2.18: 20.5 billions), whereas recruits in 2021 and 2022 were the GM for 1988–2018, 12.3 billions). The natural mortalities at age were assumed as the average of 2017–2019. The exploitation pattern was taken as the average over 2017–2019. The TAC constraint of 186 564 tonnes (EU share 153 384 tonnes + Russian quota 29 100 tonnes + central Baltic herring stock caught in Gulf of Riga 4 380 tonnes (mean 2014–2018) − Gulf of Riga herring stock caught in central Baltic Sea 300 tonnes (mean 2014 – 2018)) was used in the predictions in the intermediate year 2020 since the total TAC in 2019 was fully exploited (and status quo F resulted in 201 kt, which is above this TAC constraint). This resulted in a fishing mortality of 0.37 (Table 4.2.20), which lies below the present estimated F in 2019 of 0.45 but above FMSY (0.21). The SSB is expected to decrease to 449 702 t in 2020, which lies below MSY-Btrigger (460 000 t).

It should be noted that the large 2014 year class will still be the main contributor to the yields in 2020. The stock status in the next years will depend on the further development of the incoming stronger year class 2019. It is predicted that this year class will already contribute to a larger extent to the yield in 2021 and to the SSB in 2021 and 2022.

4.2.6 Reference points

Both MSY and PA reference points were re-estimated during an Inter-Benchmark Process (**IBP**) on **BA**ltic **S**prat (Sprattus sprattus) and **H**erring (Clupea harengus) (IBPBASH) in March 2020 (ICES 2020/ICES Scientific Reports. 2:34). For herring the biomass reference points were lowered by about 25%. F_{MSY} and the corresponding range were practically unchanged, while F_{lim} and F_{pa} increased slightly. Old ***and updated reference points*** are provided in the text table below:

Reference Points	Old Values	*Updated Values*	*Rationale*
B_{lim}	430 000 t	***330 000 t***	*The lowest SSB that has given rise to above average recruitment, i.e. year 2002. (The SSB in 2002 happens to correspond to Bloss)*
B_{pa}	600 000 t	***460 000 t***	*1.4* B_{lim}*

MSY-Btrigger	600 000 t	***460 000 t***	*B_{pa}*
F_{MSY}	0.22	***0.21***	*Estimated by EqSim*
$F_{MSYUpper}$	0.28	***0.26***	*Estimated by EqSim as the upper value of F at 95% of the landings of F_{MSY}*
$F_{MSYLower}$	0.16	***0.15***	*Estimated by EqSim as the lower value of F at 95% of the landings of F_{MSY}*
F_{lim}	0.52	***0.59***	*Estimated by EqSim as the F with 50% probability of SSB being less than B_{lim}*
F_{pa}	0.41	***0.43***	*F_{lim} *(exp(-1.645*0.2))*

4.2.7 Quality of assessment

The assessment has been benchmarked in 2013 (ICES CM 2013/ACOM:43). An Inter-Benchmark Process (IBP) on BAltic Sprat (Sprattus sprattus) and Herring (Clupea harengus) (IBPBASH) was carried out in March 2020 (ICES 2020/ICES Scientific Reports. 2:34).

The natural mortality was provided from multi-species models for the years 1974–2018 (ICES 2019/ICES Scientific Reports. 1:91), M for 2019 was set equal to 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. The 2013-2016 values were revised by WGBFIS in 2020.

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 as 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 (however, inter-benchmarked in March 2020, which lead to a substantial downward revision of SSB and recruitment-at-age 1 and upward revision $F_{(3-6)}$), the present assessment resulted in 33% less SSB for 2018. $F_{(3-6)}$ in 2018 was estimated to be 48% higher compared to last year's assessment and recruitment-at-age 1 in 2018 was estimated to be 40% less in this year's assessment.

Category	Parameter	Assessment WGBFAS 2019	Assessment WGBFAS 2020	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_{2018} = regression of M against cod SSB	$M_{1974–2028}$ = SMS, M_{2018} = M_{2019}	Yes
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, 2013-2016 revised	Yes
XSA results	SSB 2018 (1000 t)	938	628	-33.0%
	TSB 2018 (1000 t)	1380	922	-33.2%
	F(3–5) 2018	0.29	0.43	+48.3%
	Recruitment (age 1) 2018 (billions)	17.7	10.7	-39.5%

4.2.9 Management considerations

SBB shows a decreasing trend since 2014 and is just below MSY-Btrigger in 2020. The present SSB estimate for 2018 is above the long-term average (1974–2018). Fishing mortality (F3–6; 0.45) is far higher than the adopted F_{MSY} of 0.21 (ICES CM 2014/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 2020 (Figure 4.2.15). It is uncommon to see such still large contribution of one year class to the SSB as seen in the short term prediction for 2021 (15%) and 2022 (10%). This makes the stock more vulnerable to overexploitation. The strong year class 2014 was followed by four years of below or on average recruitment. The 2019 year class is well above average. The stock status in the next years will depend on the further development of this incoming stronger year class 2019.

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 the low abundance of herring in this area (WGBIFS 2016). New M values from WGSAM in 2019 (ICES 2019/ICES Scientific Reports. 1:91) were used in the present assessment and by this taking into account the predation by the cod stock.

Table 4.2.1. Herring in SD 25–29, 32 (excl. GoR). Catches by country (1000 t) (incl. central Baltic herring caught in GoR, see Section 4.1.3).

Year	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia**	Sweden	Total
1977	11.9		33.7				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
*2019	8.9	21.5	37.0	1.8	7.6	6.1	40.3	25.8	55.6	204.4

*** 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 2019 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	1 250	7	131	75
		2	229	0	0	0
		3	152	0	0	0
		4	1 042	0	0	0
		Total	2 673	7	131	75
	Finland	1	2 029	0	0	0
		2	515	0	0	0
		3				
		4	10	0	0	0
		Total	2 554	0	0	0
	Germany	1	103	0	0	0
		2	27	0	0	0
		3				
		4	10	0	0	0
		Total	140	0	0	0
	Latvia	1	0.2	0	0	0
		2	16	0	0	0
		3	0	0	0	0
		4	0	0	0	0
		Total	16	0	0	0
	Lithuania	1	40	0	0	0
		2	496	0	0	0
		3				
		4				
		Total	536	0	0	0
	Poland	1	3 878	16	968	358
		2	6 742	3	208	86
		3	3 414	6	1 245	242
		4	7 719	4	878	165
		Total	21 753	29	3 299	851
	Sweden	1	3 643	14	872	869
		2	3 021	10	884	878
		3	2 046	12	640	637
		4	3 509	7	556	555
		Total	12 218	43	2 952	2 939
	Total	1	10 943	37	1 971	1 302
		2	11 045	13	1 092	964
		3	5 612	18	1 885	879
		4	12 290	11	1 434	720
		Total	39 889	79	6 382	3 865

continued

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2019 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	949	6	21	21
		2	20	0	0	0
		3				
		4	31	0	0	0
		Total	1 001	6	21	21
	Finland	1	2 615	0	0	0
		2	1 830	0	0	0
		3				
		4				
		Total	4 444	0	0	0
	Germany	1	959	0	0	0
		2	317	0	0	0
		3				
		4				
		Total	1 275	0	0	0
	Latvia	1	123	1	183	100
		2	225	0	0	0
		3	344	0	0	0
		4	213	0	0	0
		Total	905	1	183	100
	Lithuania	1	1 745	3	585	485
		2	1 914	3	708	366
		3	72	0	0	0
		4	240	3	483	311
		Total	3 971	9	1 776	1 162
	Poland	1	8 177	8	564	224
		2	4 675	4	39	34
		3	1 663	3	621	175
		4	3 307	2	491	132
		Total	17 822	17	1 715	565
	Russia	1	6 106	15	3 068	900
		2	4 631	21	2 546	1 432
		3	2 209	8	2 242	350
		4	2 750	20	3 983	205
		Total	15 697	64	11 839	2 887
	Sweden	1	2 048	1	150	150
		2	490	0	0	0
		3	0	0	0	0
		4	649	0	0	0
		Total	3 187	1	150	150
	Total	1	22 722	34	4 571	1 880
		2	14 101	28	3 293	1 832
		3	4 288	11	2 863	525
		4	7 191	25	4 957	648
		Total	48 302	98	15 684	4 885

continued

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2019 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	2 332	0	0	0
		2				
		3				
		4				
		Total	2 332	0	0	0
	Finland	1	333	0	0	0
		2	28	0	0	0
		3	26	0	0	0
		4				
		Total	386	0	0	0
	Lithuania	1	4	0	0	0
		2				
		3				
		4				
		Total	4	0	0	0
	Sweden	1	12 476	12	842	840
		2	4 160	8	504	502
		3	56	0	0	0
		4	2 474	0	0	0
		Total	19 166	20	1 346	1 342
	Total	1	15 144	12	842	840
		2	4 188	8	504	502
		3	82	0	0	0
		4	2 474	0	0	0
		Total	21 887	20	1 346	1 342

continued

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2019 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	1 374	11	205	166
	2				
	3				
	4	317	0	0	0
	Total	1 692	11	205	166
Estonia	1	621	14	791	791
	2	2 954	5	401	401
	3	213	4	270	270
	4	615	13	854	853
	Total	4 404	36	2 316	2 315
Germany	1	182	0	0	0
	2	10	0	0	0
	3				
	4				
	Total	192	0	0	0
Latvia	1	1 765	3	598	320
	2	2 384	2	408	228
	3	210	1	202	91
	4	2 341	4	727	351
	Total	6 700	10	1 935	990
Lithuania	1	523	0	0	0
	2	54	0	0	0
	3				
	4	885	0	0	0
	Total	1 461	0	0	0
Poland	1	89	0	0	0
	2	8	0	0	0
	3	37	0	0	0
	4	562	0	0	0
	Total	696	0	0	0
Sweden	1	5 775	7	592	587
	2	1 173	3	400	394
	3	797	0	0	0
	4	8 075	13	754	749
	Total	15 820	23	1 746	1 730
Total	1	10 329	35	2 186	1 864
	2	6 583	10	1 209	1 023
	3	1 258	5	472	361
	4	12 795	30	2 335	1 953
	Total	30 965	80	6 202	5 201

continued

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2019 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	1 137	5	38	16
		2				
		3				
		4	18	0	0	0
		Total	1 155	5	38	16
	Estonia	1	2 440	14	791	791
		2	529	6	550	400
		3	431	4	270	270
		4	1 690	13	854	853
		Total	5 091	37	2 465	2 314
	Finland	1	8 358	6	1 936	340
		2	5 347	21	6 711	342
		3	1 330	12	978	240
		4	7 424	14	2 088	330
		Total	22 460	53	11 713	1 252
	Germany	1	144	0	0	0
		2				
		3				
		4				
		Total	144	0	0	0
	Lithuania	1	112	0	0	0
		2				
		3				
		4	2	0	0	0
		Total	114	0	0	0
	Sweden	1	5 174	2	263	262
		2	11	0	0	0
		3	1	0	0	0
		4	1	0	0	0
		Total	5 186	2	263	262
	Total	1	17 366	27	3 028	1 409
		2	5 887	27	7 261	742
		3	1 762	16	1 248	510
		4	9 135	27	2 942	1 183
		Total	34 150	97	14 479	3 844

continued

Table 4.2.2. Herring in SD 25–29, 32 (excl. GoR). Samples of commercial catches by quarter and subdivision for 2019 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	4 092	15	1 490	1 490
		2	3 103	18	1 750	1 750
		3	700	5	309	309
		4	4 095	11	832	832
		Total	11 990	49	4 381	4 381
	Finland	1	3 259	3	996	149
		2	142	18	4 911	678
		3	1 125	9	1 632	369
		4	2 667	9	1 434	264
		Total	7 192	39	8 973	1 460
	Russia	1	3 116	0	0	0
		2	2 622	0	0	0
		3				
		4	4 325	0	0	0
		Total	10 063	0	0	0
	Total	1	10 467	18	2 486	1 639
		2	5 867	36	6 661	2 428
		3	1 825	14	1 941	678
		4	11 087	20	2 266	1 096
		Total	29 245	88	13 354	5 841
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	**86 971**	**172**	**17 030**	**10 012**
		2	**47 671**	**158**	**24 105**	**11 047**
		3	**14 826**	**73**	**10 238**	**3 707**
		4	**54 971**	**121**	**15 749**	**6 485**
		Total	**204 438**	**524**	**67 122**	**31 251**

Table 4.2.3. Herring in SD 25–29, 32 (excl. GoR). Catch by country and SD and mean weight by SD in 2019.

CATCH (1000 T) BY COUNTRY AND SD							
Country	**Total**	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
Denmark	8.852	2.673	1.001	2.332	1.692	1.155	0.000
Estonia	21.485	0.000	0.000	0.000	4.404	5.091	11.990
Finland	37.037	2.554	4.444	0.386	0.000	22.460	7.192
Germany	1.752	0.140	1.275	0.000	0.192	0.144	0.000
Latvia*	7.620	0.016	0.905	0.000	6.700	0.000	0.000
Lithuania	6.085	0.536	3.971	0.004	1.461	0.114	0.000
Poland	40.271	21.753	17.822	0.000	0.696	0.000	0.000
Russia	25.759	0.000	15.697	0.000	0.000	0.000	10.063
Sweden	55.577	12.218	3.187	19.166	15.820	5.186	0.000
Total	**204.438**	**39.889**	**48.302**	**21.887**	**30.965**	**34.150**	**29.245**

*Catches in SD 28.2 include 1 177 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	328394	1287	37477	20812	42061	101241	125517
1	416846	29582	20705	72046	18206	194896	81412
2	1561422	121799	291234	194114	92921	457099	404255
3	1127576	80803	122418	141753	107692	370558	304352
4	891782	100072	196362	95048	144410	186097	169793
5	1957135	240278	336158	371221	378371	314745	316361
6	485302	86679	138554	44853	98823	47040	69354
7	396557	95614	90811	16833	80122	50608	62569
8	161987	29753	41487	3665	28885	17503	40693
9	43000	9851	19556	3481	9410	202	500
10+	34370	4358	14907	1327	11767	1610	400
Total N	**7404372**	**800076**	**1309667**	**965154**	**1012671**	**1741598**	**1575206**
CATON	**204.438**	**39.889**	**48.302**	**21.887**	**30.965**	**34.150**	**29.245**
Mean weight (g)							
AGE	Mean	**SD 25**	**SD 26**	**SD 27**	**SD 28.2**	**SD 29**	**SD 32**
0	5.9	15.8	11.6	5.8	5.8	5.7	4.4
1	11.8	19.2	17.8	9.1	17.1	10.2	12.7
2	20.3	40.9	28.9	16.2	22.9	15.3	14.8
3	24.2	47.6	33.5	21.7	26.0	20.9	18.9
4	31.2	54.0	38.3	24.8	30.3	23.7	22.0
5	31.4	48.5	38.8	27.0	31.4	24.8	22.5
6	40.4	60.1	44.4	32.8	37.9	29.0	24.0
7	44.1	56.1	48.7	38.2	40.2	32.1	35.5
8	45.0	65.0	51.6	40.5	43.9	35.2	29.0
9	55.0	64.7	55.8	44.3	48.9	29.5	32.6
10+	60.2	100.7	62.5	54.8	48.3	27.9	32.4

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. (CATON in 100o 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	175.903	24.513	13.369	40.240	0.946	77.576	19.259
2	705.925	38.678	152.557	113.763	15.916	264.228	120.783
3	486.500	26.460	54.538	87.459	19.412	195.874	102.757
4	370.155	28.960	70.789	68.875	32.422	99.647	69.463
5	1045.710	67.239	183.624	284.032	138.536	225.893	146.387
6	231.921	26.931	60.466	36.380	49.387	27.175	31.584
7	165.172	21.611	38.319	13.935	31.093	27.408	32.806
8	73.283	8.713	21.651	2.318	11.150	6.695	22.755
9	21.886	2.231	11.867	2.318	5.168	0.102	0.200
10+	14.973	1.305	8.583	0.777	3.498	0.610	0.200
Total N	3291.429	246.640	615.764	650.097	307.527	925.206	546.195
CATON	86.971	10.943	22.722	15.144	10.329	17.366	10.467
Quarter:	**2**						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	45.150	0.108	0.505	12.754	1.083	23.107	7.593
2	375.697	23.874	103.262	52.175	8.380	74.909	113.097
3	264.060	15.576	35.140	32.847	15.032	82.583	82.881
4	222.622	18.645	70.078	17.395	25.746	47.109	43.648
5	383.812	68.238	79.894	69.952	73.781	21.444	70.504
6	121.410	25.287	40.794	6.573	20.877	12.214	15.663
7	131.798	43.326	31.350	0.775	33.982	13.846	8.518
8	45.084	9.062	9.846	0.000	11.513	5.363	9.300
9	10.361	3.031	3.905	1.158	1.967	0.000	0.300
10+	13.146	1.730	3.583	0.383	6.950	0.301	0.200
Total N	1613.140	208.878	378.357	194.011	199.312	280.876	351.705
CATON	47.671	11.045	14.101	4.188	6.583	5.887	5.867
Quarter:	**3**						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	104.217	0.228	6.170	1.350	1.562	29.328	65.579
1	46.046	2.333	1.413	1.324	4.952	28.717	7.306
2	80.954	22.404	9.816	0.777	11.092	16.760	20.105
3	67.045	12.170	12.195	0.720	13.441	15.540	12.978
4	55.536	16.342	19.026	0.388	4.891	8.371	6.518
5	80.427	25.217	30.928	0.216	9.157	4.566	10.344
6	32.591	9.080	16.380	0.035	1.120	0.764	5.212
7	28.487	9.660	10.177	0.086	1.926	1.840	4.798
8	14.463	3.210	4.836	0.027	0.972	0.575	4.843
9	2.649	0.736	1.643	0.005	0.165	0.100	0.000
10+	2.061	0.287	1.192	0.005	0.477	0.100	0.000
Total N	514.477	101.667	113.777	4.934	49.756	106.661	137.684
CATON	14.826	5.612	4.288	0.082	1.258	1.762	1.825
Quarter:	**4**						
AGE	Sum	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	224.177	1.059	31.307	19.462	40.499	71.913	59.938
1	149.747	2.628	5.417	17.728	11.225	65.496	47.253
2	398.846	36.844	25.599	27.398	57.533	101.202	150.270
3	309.971	26.596	20.545	20.727	59.807	76.561	105.735
4	243.469	36.124	36.468	8.391	81.352	30.970	50.163
5	447.185	79.584	41.712	17.022	156.898	62.843	89.127
6	99.380	25.382	20.914	1.864	27.439	6.887	16.895
7	71.100	21.017	10.965	2.037	13.121	7.513	16.447
8	29.156	8.769	5.153	1.320	5.250	4.871	3.794
9	8.103	3.852	2.141	0.000	2.110	0.000	0.000
10+	4.190	1.036	1.548	0.163	0.842	0.600	0.000
Total N	1985.326	242.892	201.769	116.111	456.077	428.856	539.622
CATON	54.971	12.290	7.191	2.474	12.795	9.135	11.087

contiuned

Table 4.2.4. Herring in SD 25–29, 32 (excl. GoR). Mean weight -at-age (g) per SD. 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	7.8	16.4	14.2	6.4	4.3	5.5	4.6
2	17.4	35.7	27.1	14.9	17.3	13.0	11.4
3	22.2	43.9	33.0	20.7	23.9	19.9	16.2
4	28.6	48.5	40.9	24.9	29.9	22.5	19.6
5	29.3	44.0	38.7	27.0	31.8	23.7	21.4
6	38.6	61.0	44.2	32.8	39.2	28.0	23.9
7	44.3	55.0	51.4	39.4	41.8	32.0	43.9
8	42.9	66.4	50.4	45.2	46.4	33.5	27.7
9	54.3	65.1	57.0	44.6	49.1	27.3	31.1
10+	61.6	107.0	61.1	53.3	55.8	26.1	30.7
Quarter:	**2**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	NA	NA	NA	NA	NA	NA	NA
1	5.6	37.6	11.1	6.5	4.9	5.1	4.9
2	18.6	33.6	28.7	15.7	18.7	12.8	11.4
3	21.8	41.8	33.1	21.3	23.9	18.3	16.7
4	29.5	50.9	35.7	23.1	28.8	23.5	19.6
5	34.0	54.2	40.3	26.6	31.2	26.0	20.0
6	41.7	61.1	44.0	33.8	38.0	30.0	22.1
7	45.5	57.4	46.6	37.7	39.3	33.3	25.6
8	46.5	64.1	51.9	NA	41.4	40.1	33.7
9	58.1	71.2	57.7	43.6	50.9	NA	33.6
10+	60.6	120.6	64.9	67.7	45.4	22.4	34.0
Quarter:	**3**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	4.7	15.8	9.8	5.2	4.5	5.4	3.8
1	14.2	35.4	26.9	12.1	17.5	11.3	14.6
2	29.9	50.5	34.6	18.1	23.0	18.2	18.5
3	31.6	56.0	35.1	23.4	25.4	23.4	22.2
4	39.8	61.6	35.8	25.8	28.3	25.8	24.0
5	38.8	51.8	37.0	32.2	30.1	27.6	25.6
6	45.8	62.9	43.8	36.2	30.4	36.1	26.8
7	44.4	57.2	45.5	31.4	35.8	31.0	25.2
8	45.2	64.0	53.1	35.4	42.9	33.0	26.9
9	53.6	68.7	49.1	31.8	44.2	31.8	NA
10+	60.2	79.8	64.8	31.8	43.3	31.8	NA
Quarter:	**4**						
AGE	Mean	SD 25	SD 26	SD 27	SD 28.2	SD 29	SD 32
O	6.6	15.8	12.0	5.9	5.9	5.9	5.1
1	17.7	30.0	25.1	17.1	19.2	17.1	16.9
2	24.9	45.3	37.6	22.7	25.1	22.7	19.5
3	27.8	50.8	34.4	26.0	27.3	26.0	22.8
4	34.7	56.6	39.5	27.2	31.0	27.4	27.3
5	32.9	46.2	37.9	28.4	31.2	28.4	25.8
6	41.1	57.0	46.3	30.5	35.6	30.5	25.1
7	41.1	54.3	48.8	30.3	39.1	30.3	26.9
8	47.6	64.8	54.4	32.4	44.1	32.4	28.2
9	53.5	58.6	50.9	NA	46.9	NA	NA
10+	53.7	65.2	62.4	31.8	43.4	31.8	NA

Table 4.2.5. Herring in SD 25–29, 32 (excl. GoR). XSA input: Catch in numbers (CANUM, 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
2019	416846	1561422	1127576	891782	1957135	485302	396557	239356	98.8

Table 4.2.6. Herring in SD 25–29, 32 (excl. GoR). XSA input: Mean weight in the Catch (WECA, kg) and in the Stock (WEST, kg).

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
2019	0.0118	0.0203	0.0242	0.0312	0.0314	0.0404	0.0441	0.0490

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	0.4330	0.3070	0.2510	0.2330	0.2200	0.2190	0.2050	0.1760
1975	0.4760	0.3400	0.2780	0.2570	0.2430	0.2440	0.2290	0.1950
1976	0.4120	0.3030	0.2580	0.2400	0.2290	0.2280	0.2160	0.1870
1977	0.4650	0.3200	0.2700	0.2510	0.2380	0.2370	0.2220	0.1910
1978	0.6760	0.3850	0.3420	0.3220	0.3020	0.2780	0.2620	0.2330
1979	0.8480	0.4200	0.3580	0.3500	0.3350	0.3250	0.2910	0.2440
1980	0.8690	0.5340	0.4320	0.3860	0.3940	0.3440	0.3170	0.2830
1981	0.7930	0.5210	0.4090	0.3560	0.3250	0.3270	0.2900	0.2520
1982	0.8210	0.5140	0.4230	0.3580	0.3200	0.3010	0.3010	0.2420
1983	0.7310	0.5560	0.3960	0.3750	0.3310	0.2990	0.2830	0.2510
1984	0.6160	0.4880	0.3860	0.3130	0.3120	0.2810	0.2580	0.2330
1985	0.5190	0.4240	0.3240	0.2800	0.2500	0.2460	0.2320	0.2110
1986	0.4830	0.3780	0.3360	0.2670	0.2450	0.2270	0.2130	0.1900
1987	0.4910	0.3180	0.2710	0.2560	0.2230	0.2070	0.1950	0.1770
1988	0.4980	0.3740	0.2700	0.2590	0.2440	0.2190	0.2020	0.1800
1989	0.4150	0.2900	0.2900	0.2430	0.2190	0.2080	0.1900	0.1710
1990	0.2810	0.2090	0.1890	0.1950	0.1700	0.1630	0.1570	0.1490
1991	0.2290	0.1930	0.1680	0.1520	0.1620	0.1440	0.1470	0.1380
1992	0.2400	0.1970	0.1750	0.1490	0.1410	0.1500	0.1370	0.1340
1993	0.2980	0.2470	0.2120	0.1960	0.1780	0.1680	0.1760	0.1550
1994	0.3080	0.2570	0.2300	0.2010	0.1900	0.1780	0.1640	0.1630
1995	0.2710	0.2340	0.2180	0.2010	0.1900	0.1850	0.1730	0.1700
1996	0.2350	0.2140	0.1950	0.1860	0.1790	0.1710	0.1660	0.1550
1997	0.2150	0.2000	0.1820	0.1730	0.1650	0.1590	0.1550	0.1500
1998	0.2220	0.1930	0.1800	0.1660	0.1580	0.1510	0.1500	0.1390
1999	0.2530	0.2140	0.1910	0.1820	0.1690	0.1580	0.1550	0.1440
2000	0.3060	0.2300	0.2170	0.2070	0.1960	0.1830	0.1740	0.1740
2001	0.3180	0.2410	0.2140	0.2080	0.1940	0.1890	0.1810	0.1800
2002	0.3310	0.2490	0.2200	0.1990	0.1910	0.1830	0.1770	0.1760
2003	0.2910	0.2050	0.1900	0.1790	0.1720	0.1660	0.1590	0.1550
2004	0.2700	0.2460	0.1910	0.1800	0.1640	0.1590	0.1540	0.1470
2005	0.3230	0.2760	0.2480	0.2070	0.1860	0.1720	0.1650	0.1550
2006	0.3420	0.2390	0.2350	0.2240	0.2020	0.1770	0.1690	0.1600
2007	0.3440	0.2430	0.2280	0.2100	0.2040	0.1790	0.1690	0.1540
2008	0.3640	0.2590	0.2410	0.2210	0.1970	0.2060	0.1830	0.1720
2009	0.3740	0.2790	0.2410	0.2320	0.2080	0.1910	0.2040	0.1830
2010	0.4030	0.3080	0.2580	0.2290	0.2250	0.2100	0.1950	0.1930
2011	0.4000	0.2810	0.2550	0.2240	0.2040	0.1990	0.1850	0.1860
2012	0.3630	0.2110	0.2170	0.1950	0.1740	0.1680	0.1590	0.1490
2013	0.3550	0.2310	0.1810	0.1880	0.1690	0.1560	0.1530	0.1460
2014	0.3530	0.2340	0.1960	0.1650	0.1710	0.1560	0.1500	0.1440
2015	0.2980	0.2030	0.1850	0.1670	0.1550	0.1550	0.1480	0.1420
2016	0.2880	0.2540	0.1850	0.1740	0.1640	0.1560	0.1510	0.1440
2017	0.2680	0.2070	0.1950	0.1640	0.1580	0.1480	0.1390	0.1360
2018	0.2440	0.1880	0.1620	0.1600	0.1420	0.1410	0.1390	0.1330
*2019	0.2440	0.1880	0.1620	0.1600	0.1420	0.1410	0.1390	0.1330

1974-2018 based on the latest SM-data provided by WGSAM 2019 (ICES 2019/ICES Scientific Reports. 1:91),
***M in 2019 = M in 2018.**

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+
1974-2019	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+
1974-2019	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+
1974-2019	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	5749	8664	3553	6384	6987	7040	2127	3395
**2014	1	3675	8563	13770	5861	6585	5993	4619	3561
**2015	1	31108	9401	15006	15430	5440	4799	3600	4252
**2016	1	6885	27705	7260	7311	4046	2003	1460	1464
2017	1	4454	5362	20367	3945	3663	1824	628	1210
2018	1	6306	9085	8408	26663	5606	4625	2016	1311
2019	1	3209	4878	4676	3949	9016	1344	1178	765

*not used due to incomplete coverage **revised by WGBIFS 2020

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
6/04/2020 12:39
Extended Survivors Analysis
-Herring in Sub-div. 25 to 29 and 32 (excl. Gulf of Riga)
CPUE data from file BIAS_CBH_WGBFAS 2020 rev 13-16.tun

Catch data for 46 years. 1974 to 2019. Ages 1 to 8.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
BIAS SD 25-27&28.2&29S&N	1991	2019	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 had not converged after 80 iterations
Total absolute residual between iterations
79 and 80 = .00027
Final year F values

Age	1	2	3	4	5	6	7
Iteration 79	0.0575	0.2876	0.3135	0.3811	0.3759	0.7207	0.6855
Iteration 80	0.0575	0.2876	0.3135	0.3811	0.376	0.7206	0.6856

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	0.062	0.058	0.029	0.038	0.055	0.049	0.073	0.118	0.202	0.057
2	0.079	0.099	0.092	0.081	0.105	0.127	0.152	0.142	0.228	0.288
3	0.18	0.139	0.102	0.101	0.174	0.213	0.23	0.219	0.304	0.313
4	0.253	0.234	0.134	0.139	0.209	0.334	0.311	0.325	0.31	0.381
5	0.339	0.254	0.202	0.169	0.239	0.31	0.376	0.407	0.545	0.376
6	0.397	0.285	0.219	0.181	0.211	0.289	0.467	0.409	0.544	0.721
7	0.407	0.315	0.226	0.238	0.179	0.284	0.64	0.726	0.581	0.686

XSA population numbers (Thousands)

	AGE						
YEAR	1	2	3	4	5	6	7
2010	1.11E+07	9.91E+06	9.39E+06	3.32E+06	2.45E+06	9.61E+05	9.35E+05
2011	6.32E+06	6.97E+06	6.73E+06	6.06E+06	2.05E+06	1.39E+06	5.24E+05
2012	1.40E+07	4.00E+06	4.77E+06	4.54E+06	3.83E+06	1.30E+06	8.60E+05
2013	1.50E+07	9.48E+06	2.95E+06	3.47E+06	3.26E+06	2.63E+06	8.81E+05
2014	1.04E+07	1.01E+07	6.94E+06	2.23E+06	2.50E+06	2.33E+06	1.88E+06
2015	3.44E+07	6.93E+06	7.23E+06	4.80E+06	1.53E+06	1.66E+06	1.61E+06
2016	9.88E+06	2.43E+07	4.98E+06	4.85E+06	2.91E+06	9.62E+05	1.06E+06
2017	1.01E+07	6.89E+06	1.62E+07	3.29E+06	2.99E+06	1.69E+06	5.16E+05
2018	1.07E+07	6.89E+06	4.86E+06	1.07E+07	2.02E+06	1.70E+06	9.71E+05
2019	8.43E+06	6.86E+06	4.54E+06	3.05E+06	6.70E+06	1.01E+06	8.57E+05

Estimated population abundance at 1st Jan 2020

0.00E+00	6.24E+06	4.27E+06	2.82E+06	1.77E+06	3.99E+06	4.28E+05

Taper weighted geometric mean of the VPA populations:

1.22E+07	8.41E+06	5.91E+06	4.01E+06	2.58E+06	1.43E+06	8.68E+05

Standard error of the weighted Log(VPA populations) :

0.4283	0.4444	0.4373	0.4296	0.4334	0.3771	0.4466

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 : BIAS SD 25-27&28.2&29S&N

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	99.99	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	99.99
3	99.99	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	99.99
5	99.99	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	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.31	0.01	-0.22	0.28	-0.1	-0.35	0.05	0.04	-0.44	-0.15
2	-0.47	0.15	-0.23	0.53	0.06	0.08	0.45	-0.27	-0.02	-0.07
3	0.41	-0.2	0.03	0.65	0.17	0.14	0.45	-0.58	-0.16	-0.07
4	0.34	0.08	-0.11	0.28	0.01	0.4	0.63	-0.5	-0.21	-0.26
5	0.4	-0.25	-0.03	0.05	-0.38	0.3	0.83	-0.11	-0.01	-0.43
6	0.16	-0.33	-0.28	0.28	-0.24	0.02	0.43	-0.13	-0.25	-0.08
7	1.17	-0.44	-0.16	0.1	-0.23	0.15	0.05	-0.34	-0.21	-0.06

Age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	-0.17	0.04	0.51	-0.23	-0.17	0.1	0.29	-0.02	0.2	-0.12
2	-0.12	-0.15	-0.1	-0.09	-0.15	0.32	0.21	-0.22	0.36	-0.2
3	-0.1	0.1	0	-0.3	0.27	0.34	0	-0.15	0.22	-0.29
4	-0.18	0.12	0	-0.11	0.28	0.59	-0.18	-0.4	0.31	-0.28
5	-0.28	0.26	0.07	-0.08	0.19	0.54	-0.34	-0.44	0.48	-0.39
6	-0.09	0.1	-0.11	0.11	0.09	0.28	0.1	-0.62	0.42	-0.15
7	0.06	0.28	0.13	0.05	0.02	0.01	-0.17	-0.23	0.18	-0.15

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	2	3	4	5	6	7
Mean Log q	-6.6421	-6.1814	-5.9051	-5.7823	-5.7435	-5.7435
S.E(Log q)	0.2299	0.262	0.3345	0.3774	0.2771	0.1734

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	0.7	1.651	9.96	0.76	20	0.26	-7.29

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	0.96	0.244	7	0.8	20	0.23	-6.64
3	0.89	0.648	7.19	0.78	20	0.24	-6.18
4	0.78	1.226	7.94	0.76	20	0.26	-5.91
5	1.81	-1.897	-1.47	0.35	20	0.61	-5.78
6	0.96	0.192	6.1	0.67	20	0.28	-5.74
7	0.95	0.422	6.15	0.88	20	0.17	-5.76

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 2018

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD 25-27&28.2&29S&N	5530577	0.30	0	0	1	0.656	0.065
P shrinkage mean	8412326	0.44				0.317	0.043
F shrinkage mean	3514281	1.50				0.028	0.100

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
6236628	0.25	0.18	3	0.714	0.057

Age 2 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
BIAS SD 25-27&28.2&29S&N	4176805	0.213	0.201	0.94	2	0.971	0.293
F shrinkage mean	8696185	1.50				0.029	0.151

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4265079	0.21	0.17	3	0.782	0.288

continued

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

Age 3 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 SD 25-27&28.2&29S&N	2802458	0.175	0.196	1.12	3	0.979	0.316
F shrinkage mean	4041684	1.5				0.021	0.229

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2824515	0.17	0.16	4	0.925	0.313

Age 4 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 SD 25-27&28.2&29S&N	1763644	0.158	0.147	0.93	4	0.979	0.383
F shrinkage mean	2362542	1.5				0.021	0.299

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1774594	0.16	0.13	5	0.809	0.381

Age 5 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 SD 25-27&28.2&29S&N	3993159	0.152	0.13	0.86	5	0.978	0.376
F shrinkage mean	3979536	1.5				0.022	0.377

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3992867	0.15	0.12	6	0.756	0.376

Age 6 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 SD 25-27&28.2&29S&N	417324	0.15	0.122	0.81	6	0.968	0.734
F shrinkage mean	961619	1.5				0.032	0.385

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
428443	0.15	0.12	7	0.819	0.721

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

Year class = 2012

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BIAS SD 25-27&28.2&29S&N	370739	0.146	0.117	0.8	7	0.971	0.692
F shrinkage mean	577408	1.5				0.029	0.495

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
375609	0.15	0.11	8	0.745	0.686

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	0.1338	0.1376	0.0725	0.0790	0.0566	0.0269	0.0522	0.0430	0.0308	0.0369	0.0306	0.0646
Age 2	0.1097	0.1124	0.1397	0.0994	0.1390	0.1226	0.1297	0.1717	0.1567	0.1299	0.1158	0.1452
Age 3	0.1474	0.1515	0.1450	0.1491	0.1341	0.1571	0.1783	0.1820	0.1740	0.2488	0.1837	0.1842
Age 4	0.1971	0.1694	0.1471	0.1260	0.1302	0.1618	0.1605	0.2010	0.1554	0.2466	0.2824	0.2110
Age 5	0.1465	0.1967	0.1453	0.1484	0.1091	0.1623	0.1553	0.1776	0.1724	0.1810	0.2693	0.3104
Age 6	0.1503	0.1624	0.1942	0.1639	0.1317	0.1322	0.1431	0.1750	0.1572	0.2255	0.2123	0.3041
Age 7	0.1653	0.1771	0.1629	0.1468	0.1243	0.1531	0.1541	0.1859	0.1629	0.2194	0.2565	0.2770
Age 8+	0.1653	0.1771	0.1629	0.1468	0.1243	0.1531	0.1541	0.1859	0.1629	0.2194	0.2565	0.2770
FBAR 3-6	**0.1603**	**0.1700**	**0.1579**	**0.1469**	**0.1263**	**0.1533**	**0.1593**	**0.1839**	**0.1648**	**0.2255**	**0.2369**	**0.2524**

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Age 1	0.0599	0.0495	0.0674	0.0776	0.0470	0.0352	0.0817	0.0656	0.0492	0.0585	0.0854	0.0832
Age 2	0.1583	0.1290	0.1955	0.1256	0.1817	0.1612	0.1458	0.1995	0.1315	0.1399	0.1450	0.1646
Age 3	0.1891	0.2203	0.2105	0.3371	0.2035	0.2997	0.2575	0.2930	0.2692	0.3185	0.2387	0.2606
Age 4	0.2382	0.2435	0.2542	0.2684	0.3858	0.2670	0.2533	0.3667	0.3533	0.4814	0.3863	0.4262
Age 5	0.2439	0.2858	0.2785	0.3654	0.3197	0.4539	0.2536	0.3529	0.4871	0.3729	0.4840	0.5413
Age 6	0.2347	0.3007	0.2756	0.3997	0.4210	0.3462	0.4324	0.3352	0.5224	0.3787	0.5319	0.6070
Age 7	0.2402	0.2781	0.2709	0.3465	0.3774	0.3573	0.3143	0.3535	0.4569	0.4134	0.4703	0.5280
Age 8+	0.2402	0.2781	0.2709	0.3465	0.3774	0.3573	0.3143	0.3535	0.4569	0.4134	0.4703	0.5280
FBAR 3-6	**0.2265**	**0.2626**	**0.2547**	**0.3426**	**0.3325**	**0.3417**	**0.2992**	**0.3369**	**0.4080**	**0.3879**	**0.4102**	**0.4588**

YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Age 1	0.1782	0.1107	0.1699	0.1387	0.1439	0.0857	0.0679	0.0509	0.0729	0.0507	0.0459	0.0532
Age 2	0.2026	0.2422	0.2521	0.2944	0.2109	0.1661	0.1142	0.1121	0.1135	0.1226	0.1200	0.1216
Age 3	0.3427	0.3185	0.4221	0.2620	0.3557	0.2212	0.2103	0.1601	0.1663	0.2097	0.1922	0.1816
Age 4	0.4510	0.4367	0.5022	0.4947	0.3257	0.3109	0.2825	0.2694	0.2289	0.2367	0.2406	0.2705
Age 5	0.5698	0.4452	0.5750	0.4554	0.5174	0.3080	0.2777	0.3027	0.3264	0.2712	0.2563	0.2496
Age 6	0.5940	0.4723	0.5095	0.5555	0.4050	0.4334	0.3072	0.2437	0.3519	0.3663	0.4005	0.2859
Age 7	0.5414	0.4539	0.5118	0.5553	0.4900	0.3516	0.4094	0.2420	0.2616	0.2976	0.3965	0.5334
Age 8+	0.5414	0.4539	0.5118	0.5553	0.4900	0.3516	0.4094	0.2420	0.2616	0.2976	0.3965	0.5334
FBAR 3-6	**0.4894**	**0.4182**	**0.5022**	**0.4419**	**0.4009**	**0.3184**	**0.2694**	**0.2440**	**0.2684**	**0.2710**	**0.2724**	**0.2469**

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	FBAR 17-19
Age 1	0.0621	0.0583	0.0289	0.0381	0.0553	0.0489	0.0730	0.1177	0.2022	0.0575	0.1258
Age 2	0.0790	0.0986	0.0923	0.0808	0.1053	0.1268	0.1515	0.1423	0.2283	0.2876	0.2194
Age 3	0.1798	0.1394	0.1024	0.1014	0.1737	0.2131	0.2305	0.2193	0.3039	0.3135	0.2789
Age 4	0.2530	0.2341	0.1344	0.1395	0.2085	0.3340	0.3108	0.3251	0.3098	0.3811	0.3387
Age 5	0.3392	0.2541	0.2019	0.1694	0.2394	0.3102	0.3757	0.4071	0.5451	0.3760	0.4427
Age 6	0.3972	0.2847	0.2189	0.1813	0.2112	0.2890	0.4666	0.4085	0.5436	0.7206	0.5576
Age 7	0.4071	0.3146	0.2261	0.2381	0.1789	0.2839	0.6401	0.7258	0.5805	0.6856	0.6640
Age 8+	0.4071	0.3146	0.2261	0.2381	0.1789	0.2839	0.6401	0.7258	0.5805	0.6856	
FBAR 3-6	**0.2923**	**0.2281**	**0.1644**	**0.1479**	**0.2082**	**0.2866**	**0.3459**	**0.3400**	**0.4256**	**0.4478**	

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	2415210	1837779	3676307	2089755	2659274	2335519	3148258	4682897	4314991	2964122	3709500	2564413
Age 2	1743301	1370206	994997	2264564	1212906	1278175	973710	1253132	2029779	1841049	1375366	1943093
Age 3	902138	1149191	871569	639096	1488818	718194	742916	501389	626857	1037912	927197	751985
Age 4	846386	605687	747959	582484	420282	924827	429061	403555	277656	345074	544645	524508
Age 5	395701	550501	395436	507895	399530	267393	554379	248411	231207	166159	185326	300299
Age 6	274681	274280	354634	271980	345130	264855	162613	320068	150277	141304	99582	103632
Age 7	450034	189870	182676	232500	182142	229106	167675	99915	193747	95035	83627	60806
Age 8+	203537	369785	359676	437941	457518	378679	440899	350453	314127	247653	207623	158274
TOTAL	**7230989**	**6347299**	**7583255**	**7026215**	**7165600**	**6396747**	**6619511**	**7859819**	**8138641**	**6838307**	**7132865**	**6407010**

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Age 1	1210620	2437434	932276	1306720	1613858	1207309	1598664	1511423	1182095	1652696	1354520	766359
Age 2	1430633	703446	1419771	529634	798447	1162611	926951	1158874	1050740	827002	1188721	983193
Age 3	1099774	836807	449902	803308	349542	540232	815840	657952	741507	712483	569040	830207
Age 4	452358	650506	511974	278240	429094	236076	338439	529389	397076	450105	416652	368816
Age 5	321015	272957	394746	306456	166852	240057	155269	226345	301579	228104	227479	235079
Age 6	171463	196877	164101	234094	170833	102244	129669	104645	133111	153236	129914	117219
Age 7	59783	108056	118497	100071	127489	95263	62626	72429	63270	66074	87206	64326
Age 8+	107001	86821	96347	124432	104289	84542	86314	50560	82942	67715	64010	48535
TOTAL	**4852647**	**5292902**	**4087614**	**3682955**	**3760404**	**3668334**	**4113772**	**4311619**	**3952321**	**4157415**	**4037543**	**3413734**

YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Age 1	1282075	680785	1373922	952718	910823	1898207	1144114	772086	1363856	1098329	2110753	1519425
Age 2	568778	859186	473198	853656	603426	566475	1302448	816022	531209	900680	740109	1400940
Age 3	682790	382926	544478	292183	499743	380979	390841	908504	553571	373417	624878	506616
Age 4	533316	404819	230064	287346	181528	281024	252537	261659	604096	370594	241051	405207
Age 5	202563	287769	218056	113202	142301	107414	172178	159020	162497	384073	237089	151933
Age 6	116007	97827	155707	100862	59131	70074	66468	110702	97546	95799	238805	150672
Age 7	54492	55075	52089	77906	47907	32843	38481	41703	73047	57479	55532	130205
Age 8+	47382	35113	49954	50774	64334	73355	41364	79773	69191	46773	71290	62845
TOTAL	**3487403**	**2803501**	**3097468**	**2728648**	**2509192**	**3410372**	**3408431**	**3149470**	**3455014**	**3327145**	**4319507**	**4327845**

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	GMST 74-17	AMST 74-17
Age 1	1110027	632102	1403037	1503494	1042003	3443970	988283	1013286	1072213	843069	0	1581944	1804893
Age 2	991163	697180	399712	948131	1014827	692687	2434502	688838	689034	686259	623663	996469	1089624
Age 3	938524	673104	476958	295150	694153	722797	498104	1622887	485775	454394	426508	649905	700601
Age 4	331995	605795	453747	346538	222529	479602	485430	328760	1072457	304849	282452	404145	432238
Age 5	245167	205031	383146	326394	249761	153168	290598	298937	201579	670424	177459	247660	267465
Age 6	96140	139453	129673	263106	232686	165696	96191	169398	169895	101401	399287	148683	164145
Age 7	93527	52382	85974	88066	187772	161176	106293	51612	97098	85673	42844	90682	107632
Age 8+	118381	95076	110541	113350	164052	204775	141777	84660	80782	51132	60114		
TOTAL	**3924924**	**3100123**	**3442789**	**3884230**	**3807784**	**6023871**	**5041179**	**4258379**	**3868833**	**3197199**	**2012326**		

Geometric mean 1988-2018: 12 261 737 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	24152094	3136103	1932027	368652	0.1908	0.1603
1975	18377788	2883921	1864333	354851	0.1903	0.1700
1976	36763072	2890026	1672256	305420	0.1826	0.1579
1977	20897550	3047714	1944666	301952	0.1553	0.1469
1978	26592734	3130439	1904976	278966	0.1464	0.1263
1979	23355188	2880501	1814652	278182	0.1533	0.1533
1980	31482578	2831847	1626575	270282	0.1662	0.1593
1981	46828968	3083451	1438109	293615	0.2042	0.1839
1982	43149904	3025527	1520865	273134	0.1796	0.1648
1983	29641216	2481533	1421013	307601	0.2165	0.2255
1984	37095000	2276612	1266452	277926	0.2195	0.2369
1985	25644124	1969315	1177076	275760	0.2343	0.2524
1986	12106196	1642907	1090850	240516	0.2205	0.2265
1987	24374340	1652107	1011629	248653	0.2458	0.2626
1988	9322755	1514882	1013582	255734	0.2523	0.2547
1989	13067196	1415000	856182	275501	0.3218	0.3426
1990	16138581	1220090	714472	228572	0.3199	0.3325
1991	12073085	1132917	647044	197676	0.3055	0.3417
1992	15986635	1072660	675163	189781	0.2811	0.2992
1993	15114234	1058225	648737	209094	0.3223	0.3369
1994	11820953	1055860	650756	218260	0.3354	0.4080
1995	16526964	897321	538960	188181	0.3492	0.3879
1996	13545201	794976	481664	162578	0.3375	0.4102
1997	7663587	688616	449074	160002	0.3563	0.4588
1998	12820751	677208	413290	185780	0.4495	0.4894
1999	6807848	570531	358538	145922	0.4070	0.4182
2000	13739224	661415	350553	175646	0.5011	0.5022
2001	9527183	600462	333980	148404	0.4443	0.4419
2002	9108228	572266	329925	129222	0.3917	0.4009
2003	18982074	658470	368214	113584	0.3085	0.3184
2004	11441135	600325	379278	93006	0.2452	0.2694
2005	7720860	639443	427551	91592	0.2142	0.2440
2006	13638559	749322	464669	110372	0.2375	0.2684
2007	10983285	759189	482162	116030	0.2406	0.2710
2008	21107532	906029	480765	126155	0.2624	0.2724
2009	15194254	896681	539398	134127	0.2487	0.2469
2010	11100269	877396	569179	136706	0.2402	0.2923
2011	6321021	787790	561919	116785	0.2078	0.2281
2012	14030369	921744	602935	100893	0.1673	0.1644
2013	15034940	956311	634260	100954	0.1592	0.1479
2014	10420032	992103	700958	132700	0.1893	0.2082
2015	34439700	1058832	651058	174433	0.2679	0.2866
2016	9882828	898567	600877	192056	0.3196	0.3459
2017	10132864	926527	631373	202517	0.3208	0.3400
2018	10722132	921553	627942	244365	0.3892	0.4256
2019	8430689	758184	501973	204438	0.4073	0.4478
Arith. Mean	17680559	1416802	855911	202969	0.2719	0.2876
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 is modified accordingly)							
1							
# Max Age (should not be modified unless data is modified accordingly)							
8							
# Max Age considered a plus group (0=No, 1=Yes)							
1							
# The following matrix describes the coupling							
# of fishing mortality STATES							
# Rows represent fleets.							
# Columns represent ages.							
1	2	3	4	5	6	7	7
0	0	0	0	0	0	0	0
# Use correlated random walks for the fishing mortalities							
# (0 = independent, 1 = correlation estimated)							
1							
# Coupling of catchability PARAMETERS							
0	0	0	0	0	0	0	0
1	2	3	4	5	6	7	8
# Coupling of power law model EXPONENTS (if used)							
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
# Coupling of fishing mortality RW VARIANCES							
1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0
# Coupling of log N RW VARIANCES							
1	2	2	2	2	2	2	2
# Coupling of OBSERVATION VARIANCES							
1	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
# Stock recruitment model code (0=RW, 1=Ricker, 3=BH, ... more in time)							
0							
# Years in which catch data are to be scaled by an estimated parameter							
0							
# first the number of years							
# Then the actual years							
# Them the model config lines years cols ages							
# Define Fbar range							
3		6					

Table 4.2.17. Herring in SD 25–29, 32 (excl. GoR). Input for RCT3 analysis.

Yearclass	VPA Age 1 (millions)	Acoustic (SD 25-29S+N) Age 0 (millions)
1991	15987	13733
1992	15114	1608
1993	11821	-11
1994	16527	6122
1995	13545	-11
1996	7664	336
1997	12821	-11
1998	6808	508
1999	13739	2591
2000	9527	1319
2001	9108	2123
2002	18982	16046
2003	11441	9067
2004	7721	1587
2005	13639	5568
2006	10983	1990
2007	21108	12197
2008	15194	8673
2009	11100	3366
2010	6321	1178
2011	14030	10098
2012	15035	11141
2013	10420	**2582**
2014	34440	**30301**
2015	9883	**7175 revised by WGBIFS 2020**
2016	10133	**2956**
2017	10722	7184
2018	-11	2052
2019	-11	22620

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 - 2019
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 2013

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.40	6.07	0.19	0.79	19	7.86	9.19	0.222	0.714
					VPA	Mean =	9.39	0.351	0.286

Yearclass 2014

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.4	6.02	0.18	0.800	20	10.32	10.17	0.238	0.671
					VPA	Mean =	9.38	0.34	0.329

Yearclass = 2015

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.47	5.50	0.2	0.846	21	8.88	9.63	0.229	0.791
					VPA	Mean =	9.48	0.446	0.209

Yearclass = 2016

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.5	5.16	0.24	0.793	22	7.99	9.15	0.274	0.721
					VPA	Mean =	9.46	0.441	0.279

Yearclass = 2017

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.5	5.12	0.22	0.804	23	8.88	9.6	0.257	0.741
					VPA	Mean =	9.45	0.435	0.259

Yearclass = 2018

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.53	4.91	0.24	0.776	24	7.63	8.91	0.287	0.688
					VPA	Mean =	9.44	0.425	0.312

Yearclass = 2019

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index value	Predicted value	Std Error	WAP Weights
BIAS 0	0.53	4.84	0.24	0.778	24	10.03	10.17	0.307	0.664
					VPA	Mean =	9.44	0.432	0.336

Year Class	**Weighted Average Prediction**	**Log WAP**	**Int Std Error**	**Ext Std Error**	**Var Ratio**	**VPA**	**Log VPA**
2013	10339	9.24	0.19	0.09	0.24	10421	9.25
2014	20160	9.91	0.20	0.37	3.58	34441	10.45
2015	14701	9.60	0.20	0.06	0.09	9883	9.20
2016	10291	9.24	0.23	0.14	0.36	10133	9.22
2017	14161	9.56	0.22	0.06	0.08	10723	9.28
2018	8752	9.08	0.24	0.25	1.07		
2019	20523	9.93	0.25	0.34	1.90		

Table 4.2.19. Herring in SD 25–29, 32 (excl. GoR). Input data for short-term predictions.

MFDP version 1a
Run: WGBFAS 20_TAC constraint FINAL
Time and date: 18:27 09/04/2020
Fbar age range: 3-6

2020

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	20523000	0.2520	0	0.35	0.3	0.0113	0.1258	0.0113
2	6236630	0.1943	0.7	0.35	0.3	0.0194	0.2194	0.0194
3	4265080	0.1730	0.9	0.35	0.3	0.0243	0.2789	0.0243
4	2824520	0.1613	1	0.35	0.3	0.0306	0.3387	0.0306
5	1774590	0.1473	1	0.35	0.3	0.0353	0.4427	0.0353
6	3992870	0.1433	1	0.35	0.3	0.0405	0.5576	0.0405
7	428440	0.1390	1	0.35	0.3	0.0452	0.6640	0.0452
8	601140	0.1340	1	0.35	0.3	0.0510	0.6640	0.0510

2021

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	12261737	0.2520	0	0.35	0.3	0.0113	0.1258	0.0113
2		0.1943	0.7	0.35	0.3	0.0194	0.2194	0.0194
3		0.1730	0.9	0.35	0.3	0.0243	0.2789	0.0243
4		0.1613	1	0.35	0.3	0.0306	0.3387	0.0306
5		0.1473	1	0.35	0.3	0.0353	0.4427	0.0353
6		0.1433	1	0.35	0.3	0.0405	0.5576	0.0405
7		0.1390	1	0.35	0.3	0.0452	0.6640	0.0452
8		0.1340	1	0.35	0.3	0.0510	0.6640	0.0510

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	12261737	0.2520	0	0.35	0.3	0.0113	0.1258	0.0113
2		0.1943	0.7	0.35	0.3	0.0194	0.2194	0.0194
3		0.1730	0.9	0.35	0.3	0.0243	0.2789	0.0243
4		0.1613	1	0.35	0.3	0.0306	0.3387	0.0306
5		0.1473	1	0.35	0.3	0.0353	0.4427	0.0353
6		0.1433	1	0.35	0.3	0.0405	0.5576	0.0405
7		0.1390	1	0.35	0.3	0.0452	0.6640	0.0452
8		0.1340	1	0.35	0.3	0.0510	0.6640	0.0510

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_{2020} Age 1:	Output form RCT3 Analysis (Table 6.2.17)
N_{2020} Age 2-8+:	Output from VPA (Table 6.2.14)
$N_{2021/2022}$ Age 1:	Geometric Mean from VPA-Output of age 1 (Table 6.2.14) for the years **1988-2018**
Natural Mortality (M):	Average of 2017-2019
Weight in the Catch/Stock (CWt/SWt)	Average of 2017-2019
Expoitation pattern (Sel):	Average of 2017-2019

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 2020.

MFDP version 1a
Run: WGBFAS 20_TAC constraint FINAL
Herring in Sd 25-32 (excl. GOR).
Time and date: 18:27 09/04/2020
Fbar age range: 3-6

2020

Biomass	SSB	FMult	FBar	Landings
816538	449702	0.9143	0.3698	186564

2021					2022	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
823511	563554	0	0	0	1014684	754907
	556697	0.1	0.0370	21886	990509	723892
	549940	0.2	0.0740	42975	967207	694456
	543281	0.3	0.1109	63301	944741	666505
	536718	0.4	0.1479	82898	923072	639951
	530250	0.5	0.1849	101799	902168	614709
	523875	0.6	0.2219	120034	881993	590703
	517592	0.7	0.2588	137632	862517	567861
	511400	0.8	0.2958	154620	843710	546115
	505295	0.9	0.3328	171025	825543	525403
	499279	1.0	0.3698	186871	807989	505665
	493348	1.1	0.4067	202183	791023	486846
	487501	1.2	0.4437	216983	774619	468895
	481737	1.3	0.4807	231292	758755	451764
	476055	1.4	0.5177	245130	743408	435406
	470454	1.5	0.5547	258518	728558	419781
	464931	1.6	0.5916	271473	714183	404847
	459486	1.7	0.6286	284014	700266	390569
	454117	1.8	0.6656	296156	686786	376910
	448823	1.9	0.7026	307917	673728	363839
	443604	2.0	0.7395	319311	661074	351324

Input units are thousands and kg - output in tonnes

*'TAC constraint' in 2020:		
EU	153 384	t
+ EU/Russia	29 100	t
+ CBH in GOR	4 380	t (= mean catches 13-17)
- GORH	300	t (= mean catches 13-17)
Total	186 564	t

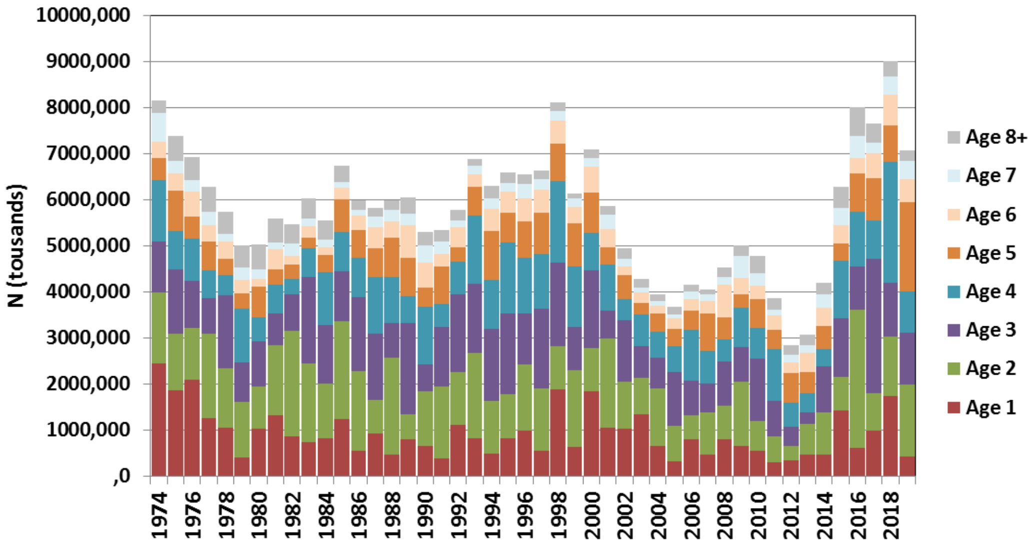

Figure 4.2.1 **Herring in SD 25–29, 32 (excl. GoR). Proportions of age groups (numbers) in total catch (CANUM).**

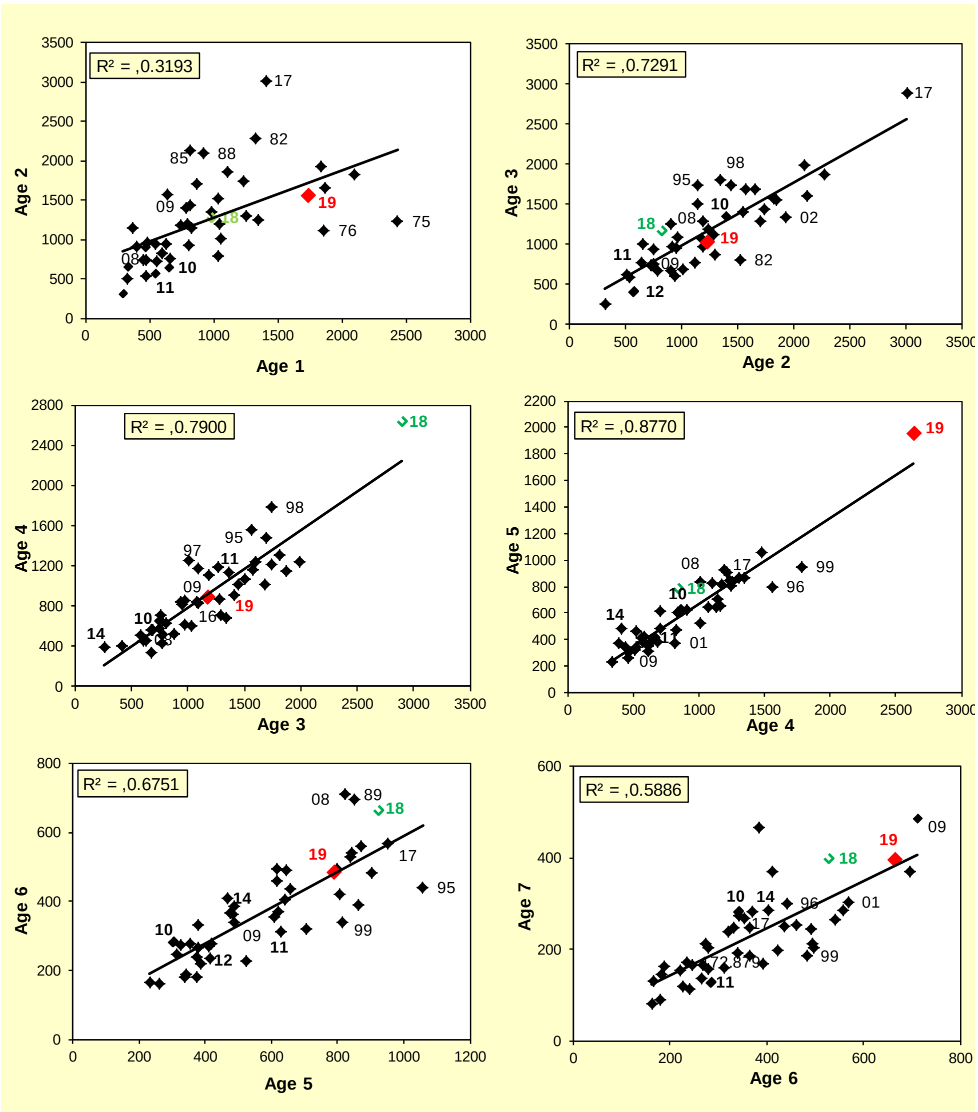

Figure 4.2.2 **Herring in SD 25–29, 32 (excl. GoR). Catch in numbers (thousands) at age vs. numbers-at-age +1 of the same cohort in the following year in the period 1974–2019.**

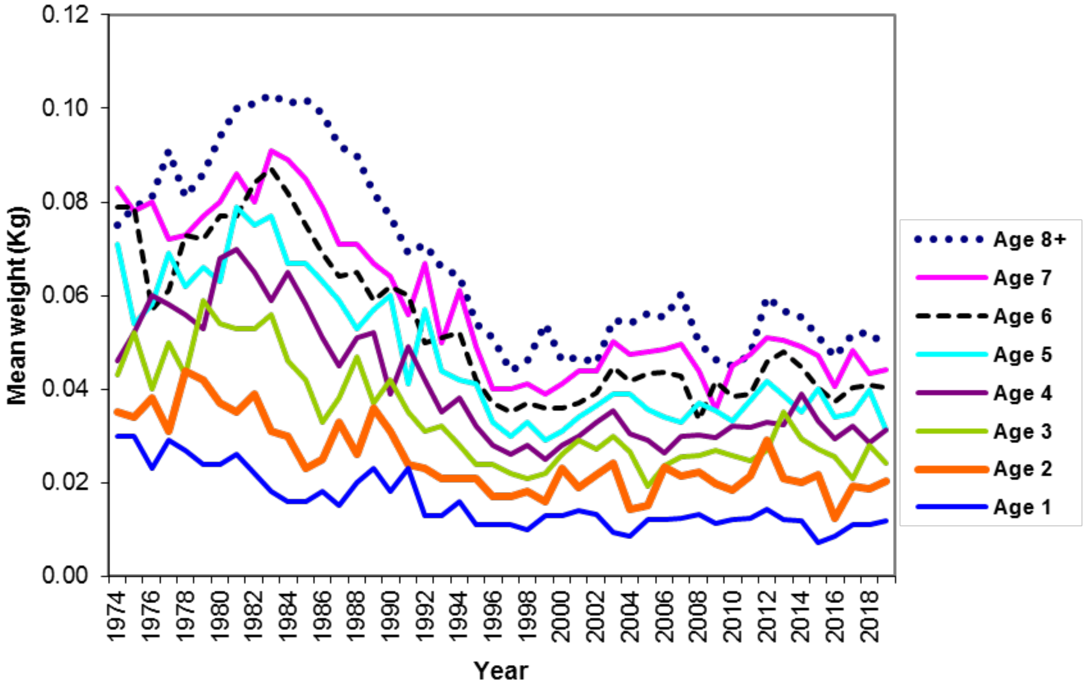

Figure 4.2.3 **Herring in SD 25–29, 32 (excl. GoR). Trends in the mean weights at age (kg) in the catch (WECA).**

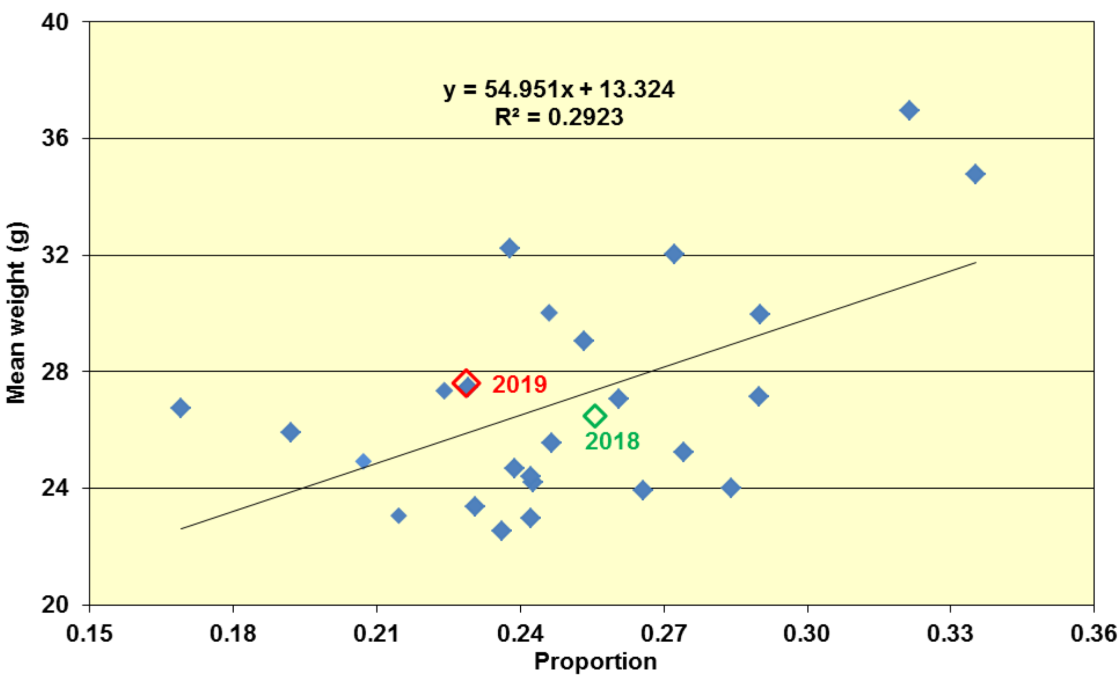

Figure 4.2.4 **Herring in SD 25–29, 32 (excl. GoR).Average individual weight in catches vs. the proportion of catches taken in SD 25 and 26 (1993–2019).**

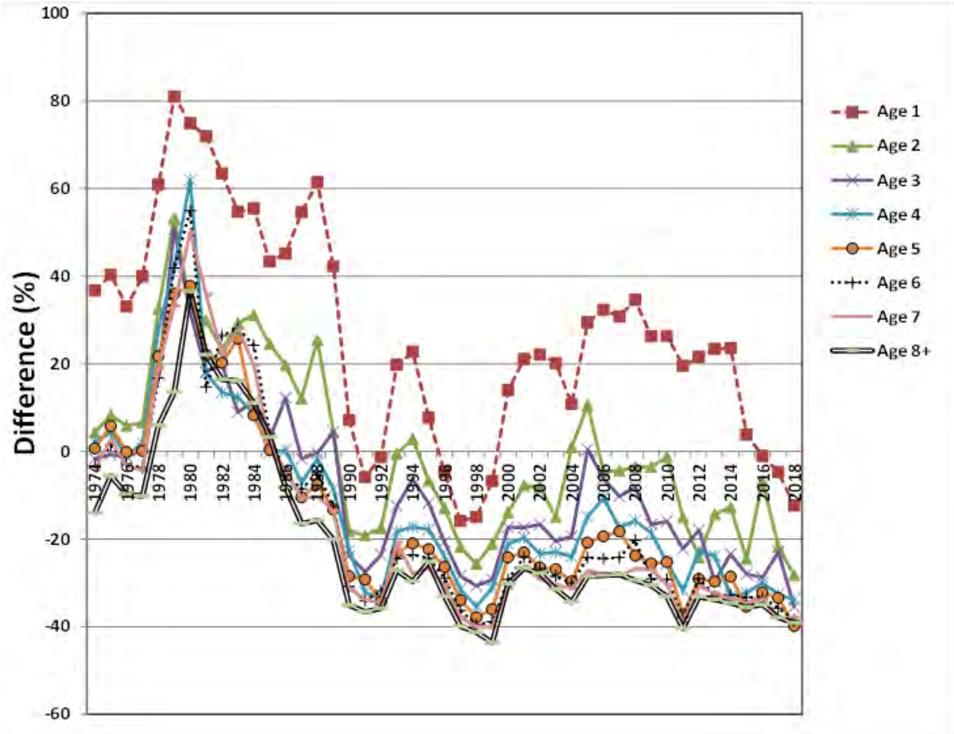

Figure 4.2.5 **Herring in SD 25-29, 32 (excl. GOR). Difference (%) of new M (WGSAM 2019) versus old M (WGBFAS 2019).**

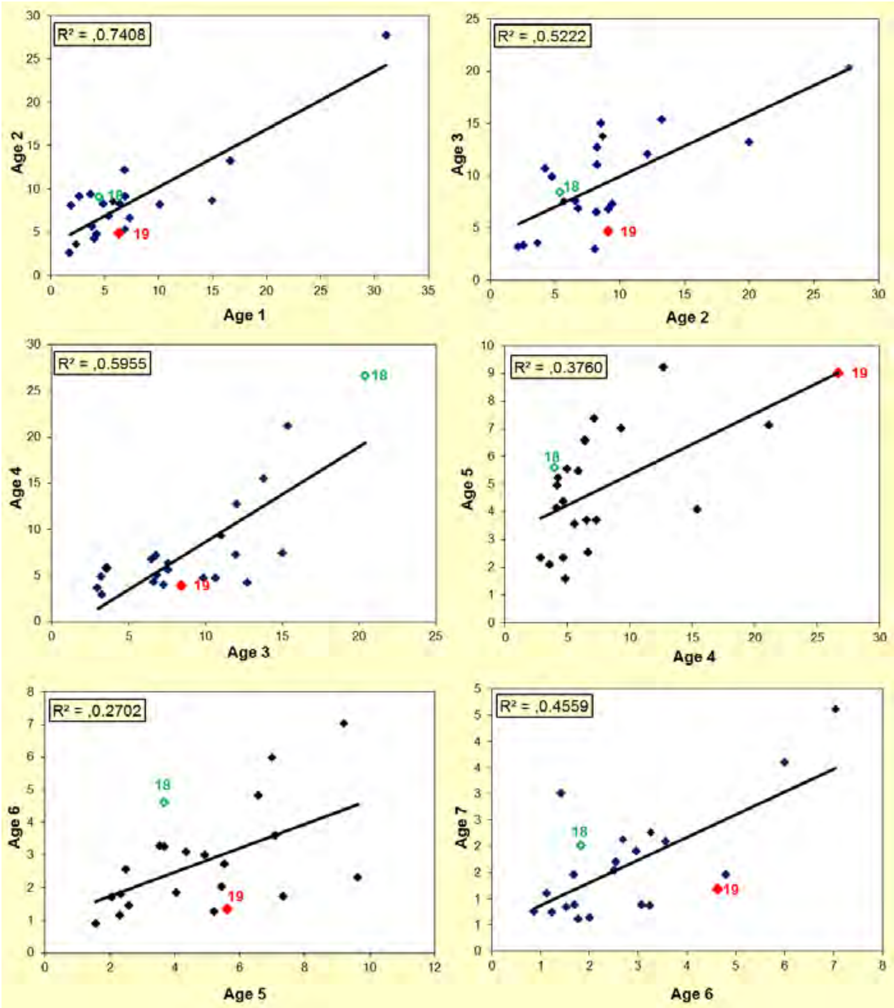

Figure 4.2.6 **Herring in SD 25–29, 32 (excl. GoR). Acoustic survey numbers-at-age vs. numbers-at-age +1 of the same cohort in the following year in the period 1991–2019 (STANDARD INDEX). Years 1993, 1995, and 1997 were excluded.**

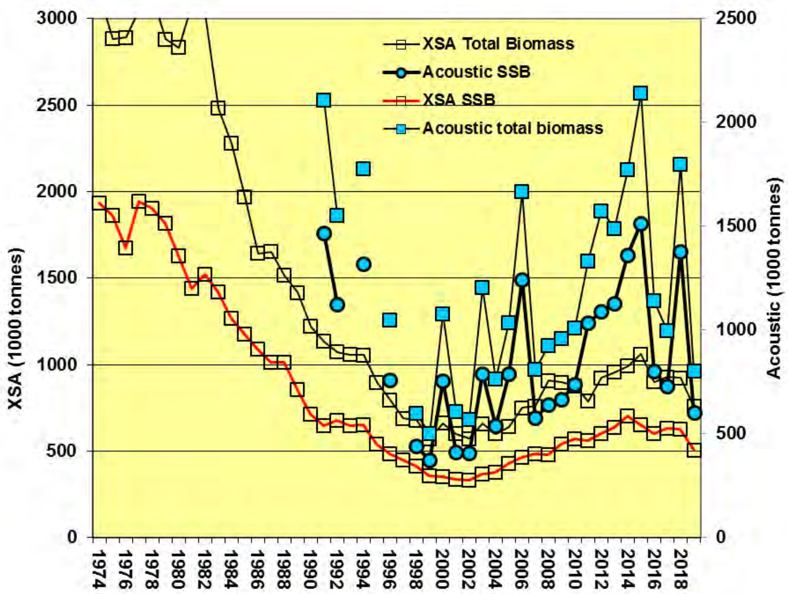

Figure 4.2.7 **Herring in SD 25–29, 32 (excl. GoR). Estimates of biomass and SSB from acoustic surveys (BIAS) and from XSA. Acoustic biomasses = Acoustic abundance x WECA; Acoustic SSB = Acoustic abundance x WECA x MATPROP**

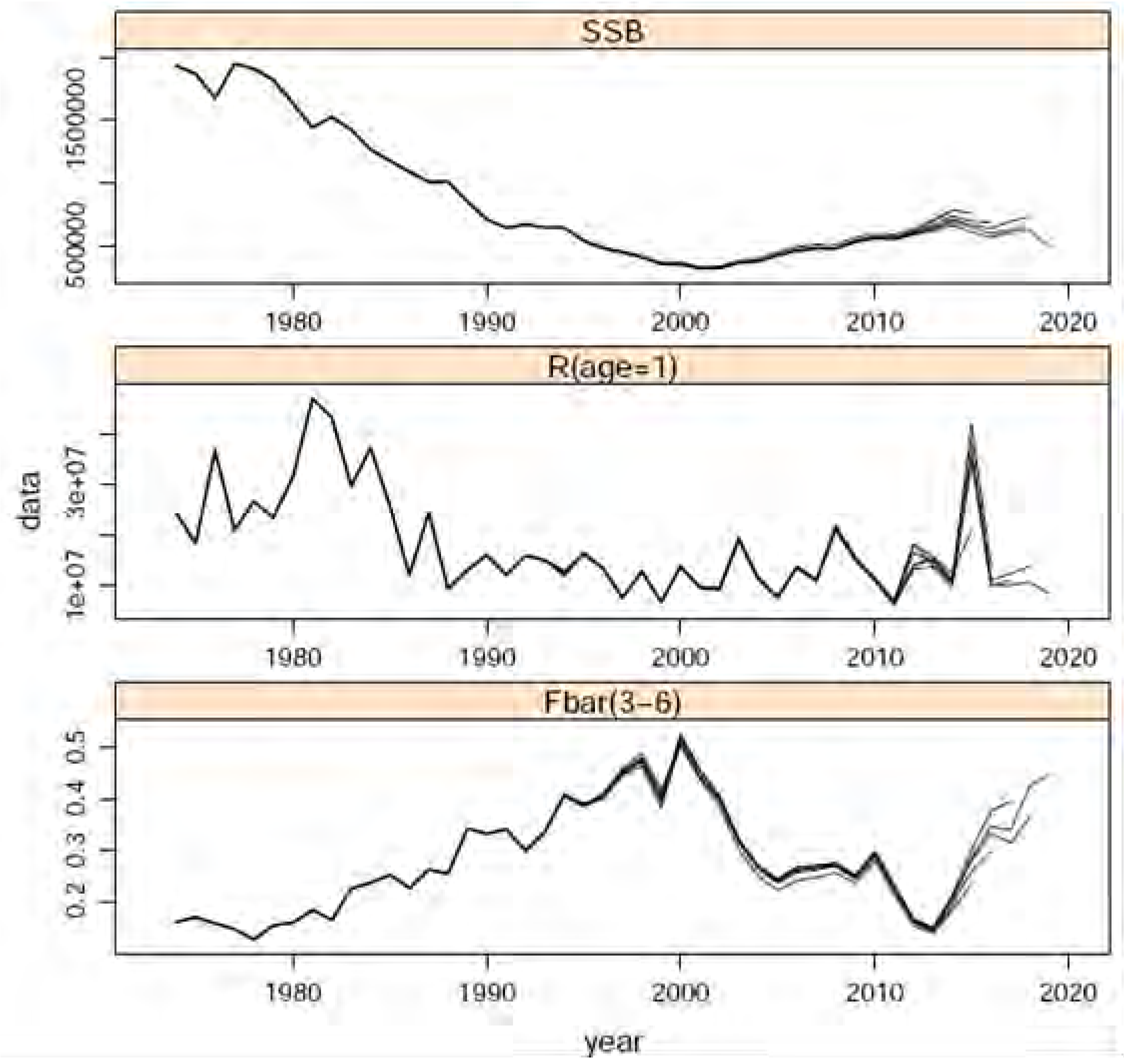

Figure 4.2.8 Herring in SD 25–29, 32 (excl. GoR). Retrospective Analysis.

Mohn's rho:

SSB:	0.1131893
Fbar:	-0.07456628
Recruitment:	.0.1009735

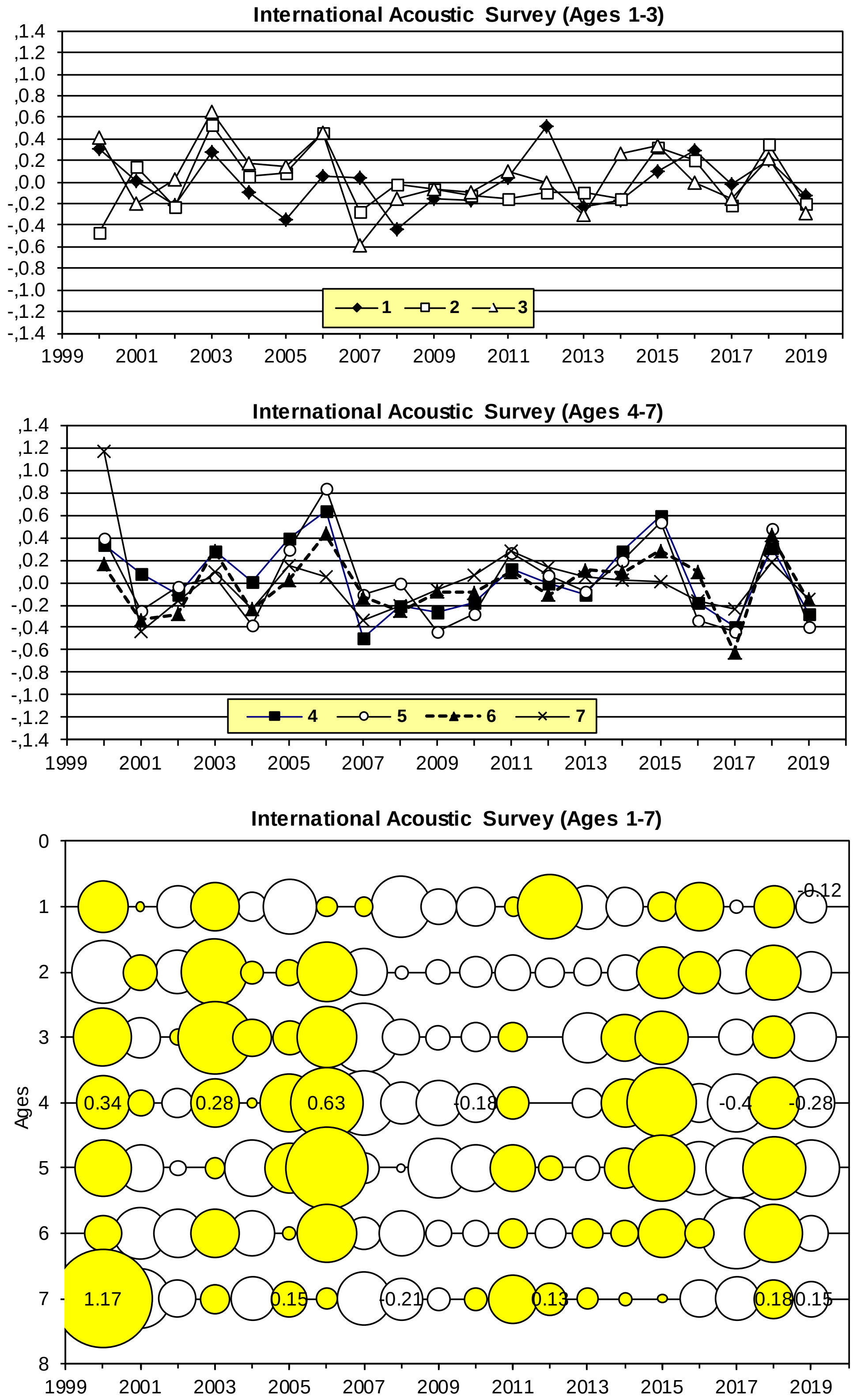

Figure 4.2.9 **Herring in SD 25–29, 32 (excl. GoR). International Acoustic Survey (Ages 1–7): Log Catchability residuals. Standardized log catchability residuals (top figure). Observed (circles) vs predicted (line) numbers (bottom figure).**

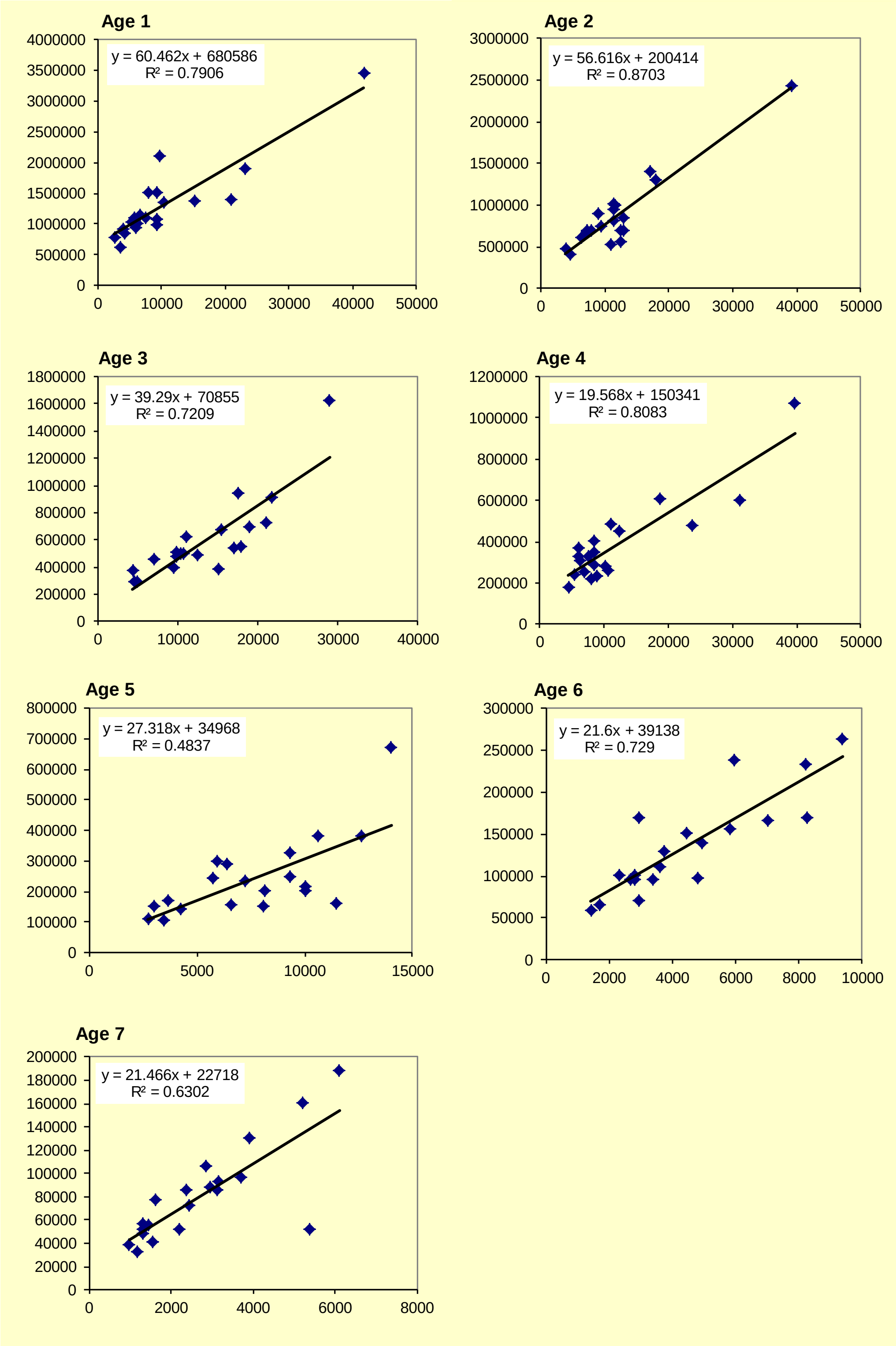

Figure 4.2.10 **Herring in SD 25–29, 32 (excl. GoR). Regression of XSA population vs. acoustic survey population numbers. x-axis = Acoustic estimates; y-axis = XSA.**

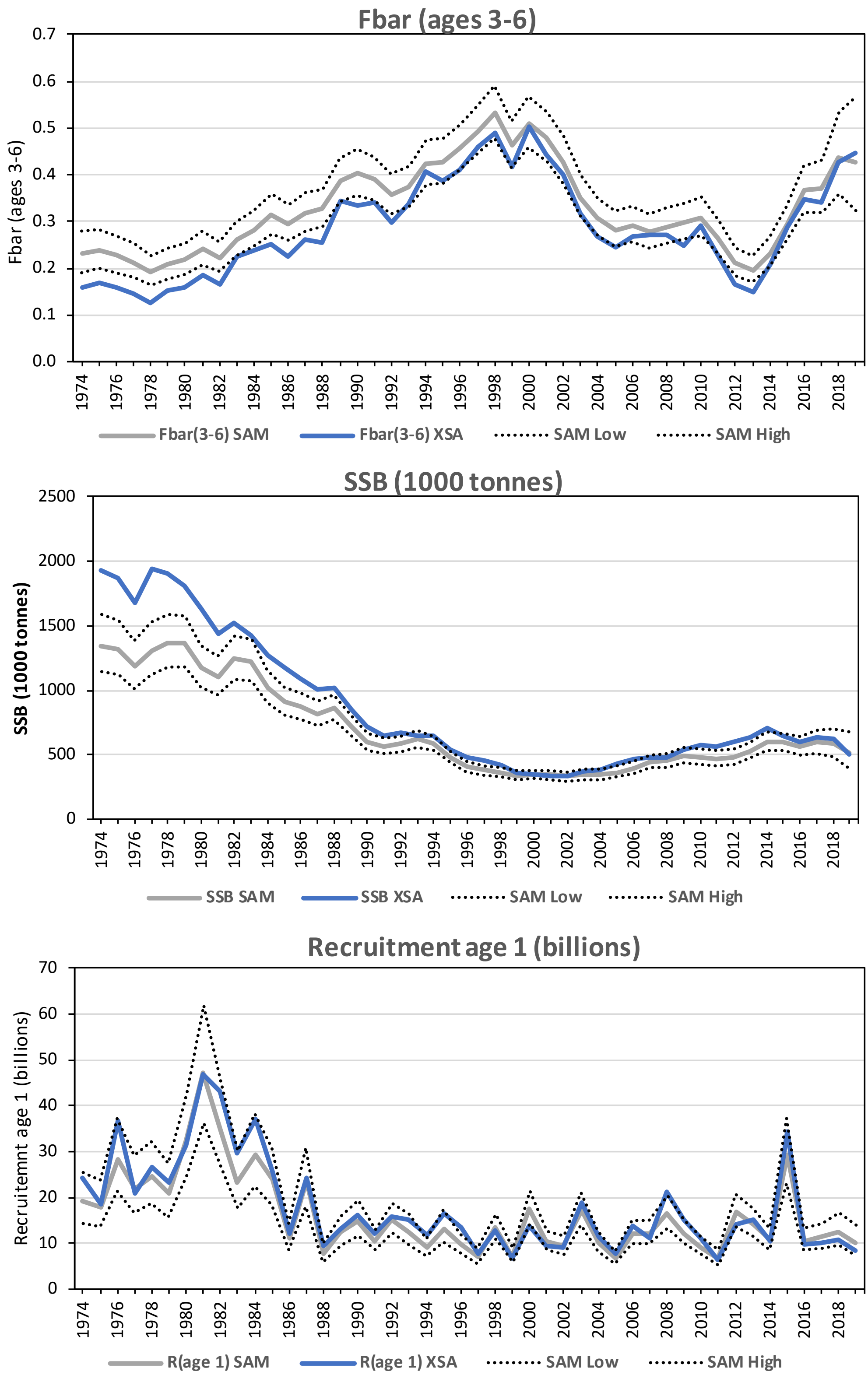

Figure 4.2.11 **Herring in SD 25–29, 32 (excl. GoR). Comparison of fishing mortality (F_{3-6}), spawning stock biomass (SSB) and recruitment (age 1) from XSA and SAM (the dotted line represents the 95% confidence intervals of the SAM results).**

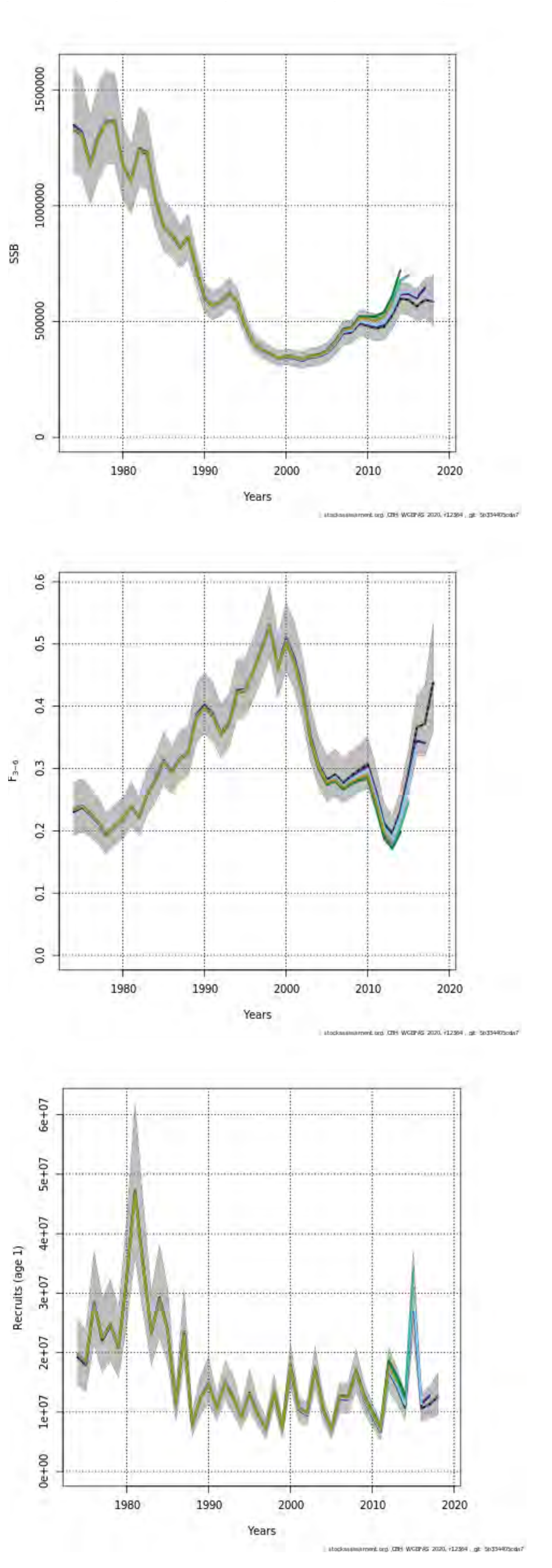

Figure 4.2.12 Herring in SD 25–29, 32 (excl. GoR). Retrospective analysis of SAM.

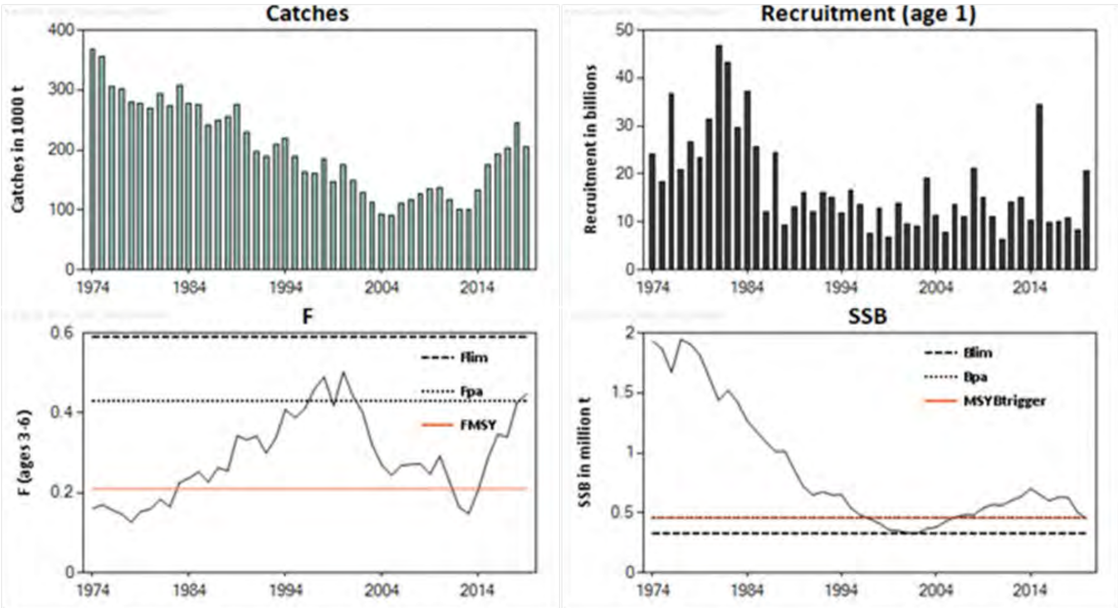

Figure 4.2.13 **Herring in SD 25–29, 32 (excl. GoR). Summary sheet plots: Catches, fishing mortality, recruitment (age 1) and SSB. (Recruitment in 2020 from RCT3 & SSB in 2020 predicted)**

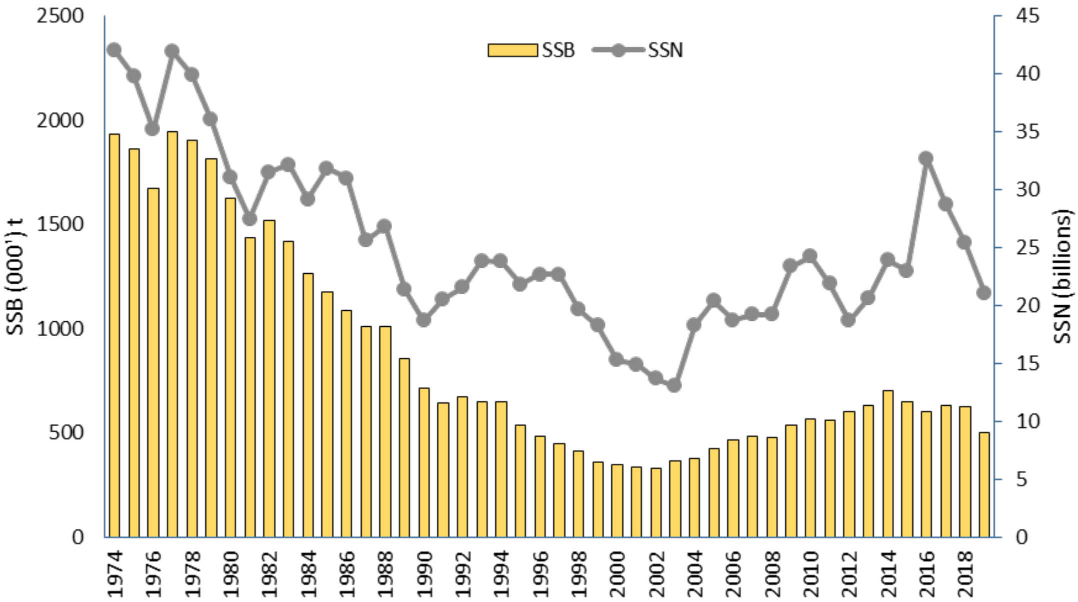

Figure 4.2.14 **Herring in SD 25–29, 32 (excl. GoR). SSB (000' t) and Spawning Stock in Numbers (SSN) (billions).**

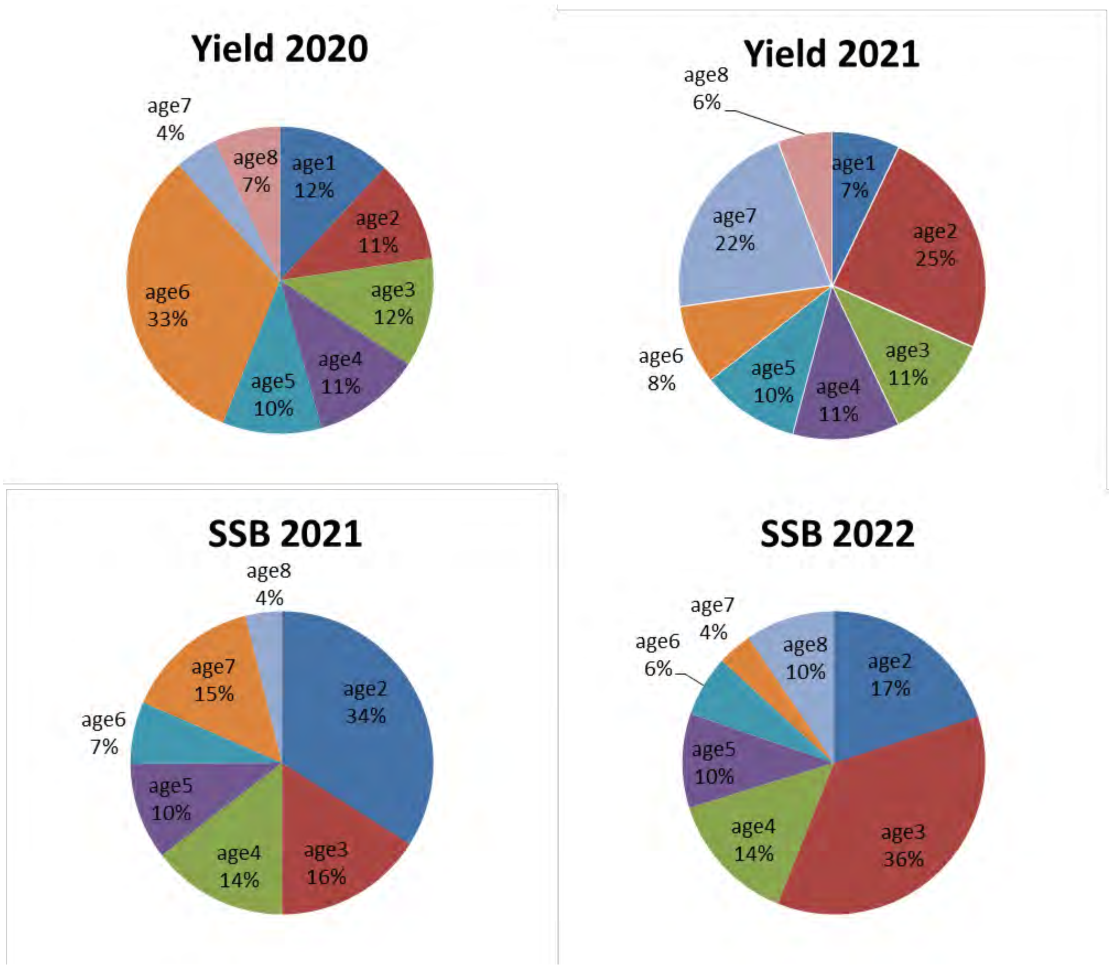

Figure 4.2.15 **Herring in SD 25–29, 32 (excl. GoR). Yield and SSB at age 1-8+ as estimated in the short-term forecast for 2020-2022 under the TAC constraint 2020.**

4.3 Gulf of Riga herring (Subdivision 28.1)

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 fishes are aged they are also assigned their population belonging. The stock does not migrate into the Baltic Proper; only minor part of the older herring leaves the gulf after spawning season in summer –autumn period but afterwards returns to the gulf. There is evidence, that the migrating fishes mainly stay close to the Irbe Strait region in Subdivision 28.2 and do not perform longer trips. The extent of this migration depends on the stock size and the feeding conditions in the Gulf of Riga. In 1970s and 1980s when the stock was on a low level the amount of migrating fishes was considered negligible. Since the beginning of 1990s when the stock size increased also the number of migrating fishes increased and the catches of the Gulf of Riga herring outside the Gulf of Riga in Subdivision 28.2 are taken into account in the assessments.

4.3.1 The fishery

Herring fishery in the Gulf of Riga is performed by Estonia and Latvia, using both trawls and trap-nets. Herring catches in the Gulf of Riga include the local Gulf herring and the open-sea herring, entering the Gulf of Riga for spawning. Discrimination between the two stocks is based on the different otolith structure due to different feeding conditions and growth of herring in the Gulf of Riga and the Baltic Proper (ICES, 2005). The Latvian fleet also takes gulf herring outside the Gulf of Riga in Subdivision 28.2. In 2019 these catches were 1200 t, while the average catches in the last five years were 514 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 utilised. In 2015 the catches considerably increased to 37 519 t being the highest in the last 11 years. In 2019 the total catches of herring in the Gulf of Riga were 31 281 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 in the beginning of 2000s and then gradually decreased. In 2018 and 2019 the catches of the Gulf of Riga herring stock were 25 747 t and 28 922 t respectively (Table 4.3.1b).

The landings of open-sea herring in the Gulf of Riga were 3560 t in 2019 (Table 4.3.1b). The average catch of open-sea herring in the last five years was 4189 t.

The trap-net catches of Gulf herring were 6017 t or 3% lower than in 2018. The fishing effort in trap-net fishery remained the same as in 2018. The trap-net catches comprised 21% of the total catches of Gulf of Riga herring in 2019.

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 is currently almost three times smaller than it used to be, and, 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 2011–2019. The level of misreporting in Estonian herring fishery has been low in 1995–2019 and therefore the official catch figures were used in the assessment.

4.3.1.3 Discards

The discards of herring in the Gulf of Riga are assumed very rare and have not been recorded by observers working on the fishing vessels.

4.3.1.4 Effort and CPUE data

The number of trap-nets used in herring fishery increased up to 2001 and slightly decreased since then, however in 2005 the decrease was more substantial especially in the Estonian coastal fishery. In 2019 the number of trap-nets remained at the same level as in the previous year (Table 4.3.8). Until the beginning of 2000s 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 2002–2004 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 2019. 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 trap-net fishery were compiled to get the annual catch in numbers (Table 4.3.3, Figure 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 trap-net catches was performed by Estonia and Latvia on monthly basis (from trap-nets on weekly basis). The sampling intensity of both countries is described in Table 4.3.2. In 2019 the sample number per 1000 t was as follows: in Estonia 2.3 samples and in Latvia 3.5 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 trap-net 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 in comparison with the previous year and stayed low also in 2010. In 2011–2013 the feeding conditions in the Gulf of Riga were favourable for herring and the mean weight-at-age increased in all age groups while the average Fulton's condition factor of herring in autumn of 2011 was the highest in the last 20 years (Putnis *et al.*, 2011). In 2019 the mean weight-at age was lower than in 2018 in most age groups but still 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 Tuning Fleets

[Two tuning fleets were available: from trap-net fishery (1996–present) and from fishery independent joint Estonian-Latvian hydro-acoustic survey in the Gulf of Riga which has been carried out in the end of July-beginning of August since 1999. The tuning data are given in Tables 4.3.8 and 4.3.9. The check of internal consistency of tuning data is shown in figures 4.3.5 and 4.3.6.

In trap-net fleet (Figure 4.3.5) the internal consistencies between age groups in 2019 correlated well with those in earlier years. In acoustic fleet the correlation did not change significantly, however the survey results of 2018 indicated a strong year effect (Figures 4.3.7 and 4.3.8b). Due to exceptional environment situation (very warm summer) of 2018, the 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 represented in control catches (e.g. some scatters in the water may not be represented in the hauls). Thus, the total acoustic estimate of 2018 was elevated. The acoustic estimates from the 2019 survey confirmed that the abundance of 2017 year-class is well above the average.

4.3.4 Assessment

4.3.4.1 Recruitment estimates

The historical dynamics of the recruitment (age 1) reveal a trend rather similar to that of the spawning stock biomass. The recruitment fluctuated between 500−3000 millions in the 1970s and 1980s mainly having the values at the lower end. In the 1990s the reproduction of Gulf of Riga herring improved and recruitment had values above long-term average in most of the years (Table 4.3.13). In 2000s three record high year classes appeared reaching values over 6000 million at age 1 in the beginning of the year.

Till 2011 the values of mean water temperature of 0−20 m water layer and the biomass of *Eurytemora affinis* in May (factors which significantly influence the year class strength of Gulf herring, ICES 1995/J:10) were regressed to the 1-group from the XSA using the RCT3 program. It was considered that year-class strength of the Gulf of Riga herring was strongly influenced by the severity of winter, which determines the water temperature, and abundance of zooplankton in spring. The higher water temperature in spring favours a longer spawning period and more even distribution of herring spawning activity. After mild winters the abundance of zooplankton is higher thus ensuring better conditions for the feeding of herring larvae. However, it was found in the previous years that RCT3 poorly predicts the rich year classes. In 2011 the analysis of factors determining year-class strength was performed and a paper at ICES Annual science conference in Gdansk was presented (Putnis *et al.*, 2011). Two additional significant relationships were found for the herring year-class strength. It was shown that since 2000 the year-class strength strongly depends on the feeding conditions during the feeding season of the adult (1+) herring. The feeding conditions were characterised as the average Fulton's condition factor for ages 2–5. In 2012 RCT3 analysis was done for the prediction of recruitment using the biomass of *Eurytemora affinis* in May and average Fulton's condition factor. However, this estimate was not accepted due to high variation ratio. In 2012 it was decided to use for the short-term forecast geometric mean of year classes over the period from 1989 corresponding to period of improved reproduction conditions and prevalence of mild winters. Hence, since 2012 the estimate of recruitment (age 1) for short-term forecast is calculated as geometric mean of year-classes 1989 – present-1 (excluding the latest year-class). The corresponding estimate for this year short-term forecast is 3212.1 million of age group 1 in the beginning of 2020. The same value for recruitment was used also for year-classes 2020 and 2021.

4.3.4.2 Assessment

The assessment was performed with the same settings in XSA as in the previous year and in accordance with the stock annex. The tuning used in the assessment were the effort in the commercial trap-nets directed at the Gulf herring in the Estonian and Latvian trap-net fishery and the corresponding abundance of Gulf herring in trap-net catches and the data from the 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 trap-net 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 2010–2011 and on 2018-2019 (Figure 4.3.8b). The retrospective analysis is shown in Figure 4.3.10. The overall trend is that fishing mortality has been overestimated, whereas the spawning stock biomass has been underestimated comparing to previous years.

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, GoRH_2020. Log catchability residuals of SAM run by fleets are shown in Figure 4.3.11. Results of SAM and its comparison with updated XSA run are presented in Figure 4.3.12. In general SAM produces lower estimates of SSB and recruitment (age 1), and for previous years SAM has produced higher fishing mortality ($F_{3\text{–}7}$), however for the latest year the opposite is seen. The Mohn's Rho index (average for last 5 years) for fishing mortality, SSB and recruitment is 0.07, -0.07 and -0.10 respectively and it is lower than in XSA. 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 124 922 t in 1994. The increase of SSB was connected with the regime shift which started in 1989 and manifested itself as a row of mild winters that was very favourable for the reproduction of Gulf of Riga herring. After mild winters the abundance of zooplankton in spring is usually higher thus ensuring better feeding conditions for herring larvae and evidently higher survival of them. Beginning with 1989, most of the year-classes were abundant or above the long-term average and only in few years when the winters were severe (1996, 2003, 2006, 2010, 2013) the recruitment was poor. Afterwards due to rather high fishing mortality SSB decreased and was fluctuating at the level below 100 000 t. In 2005–2006 SSB decreased to the level of 70 000 t that is below the long-term average, and increased since then. After appearance of very rich year classes in 2011 and 2012 the SSB reached 138 637 t in 2014 but has decreased since then. In 2016–2019 the SSB increased again, reaching 136 095 t in 2019. The mean fishing mortality in age groups 3–7 has been rather high in 1970s and 1980s fluctuating between 0.35 and 0.71. It has decreased below 0.4 in 1989 and stayed on this level till 1996. Afterwards the fishing mortality increased above 0.4 that was regarded as F_{pa} then. Since 2008 the fishing mortality has decreased below 0.4. In 2017-2019 the fishing mortality was in the range of 0.23-0.28 that is below the F_{MSY} (0.32). The estimate for 2019 was 0.284.

4.3.5 Short-term forecast and management options

The input data and summary of short-term 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 2017−2019. The exploitation pattern was taken equal to the average of 2017–2019 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 2020–2022 (year-classes of 2019, 2020, 2021) were taken to be equal to the geometric mean of year classes over the period 1989–2017.

Taking into account that the herring TAC for the Gulf of Riga is usually almost utilised the catch constraint of 30 382 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 2020 would be 136.0 thousand t (according to the 2019 prediction 109.2 thousand t). Under MSY scenario, SSB in 2021–2022 will remain on high level of 130 and 120 thousand tons, respectively. The catch corresponding to F_{MSY} (0.32) would be 35.8 thousand t in 2021. In 2020 the catches will be dominated by year-class of 2015-17 by 62%. The SSB in 2021 will be dominated by year classes of 2017–2019 (74%). SSB in 2022 will be dominated by age groups of 2, 3 and 5 (70%) (Figure 4.3.14). The share of younger age groups (1–3) in the yield of 2020–2021 will be 53% and 40% 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 about fisheries and stock development of the Gulf of Riga herring. It was considered that Gulf of Riga herring belongs to the stocks with no evidence that recruitment has been impaired or that a relation exists between stock and recruitment for which B_{lim}=Bloss 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 Fpa 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 trap-nets directed at the Gulf herring in the Estonian and Latvian trap-net fishery and the corresponding abundance of Gulf herring in trap-net catches are used for tuning VPA. These data could be very sensitive to changes in market demand and could be affected by fishery regulation. Therefore, the joint Estonian-Latvian hydro-acoustic surveys were started in 1999 to obtain the additional tuning data, which were implemented for the first time in 2004 assessment. The Mohn's Rho index (average for last 5 years) for fishing mortality, SSB and recruitment is 0.24, -0.17 and -0.17 respectively. If index is obtained as average for last 3 years then for fishing mortality, SSB and recruitment it is 0.16, -0.12 and -0.17 respectively.

4.3.8 Comparison with the previous assessment

Compared to last year, the present assessment resulted in 7.3% increase in SSB for 2018, and 11% increase for 2017 year-class estimate. $F_{(3-7)}$ estimate in 2018 was lowered by 10.4% in this year's assessment.

Comparison of XSA settings from assessments performed in 2019 and 2020

Category	Parameter	Assessment 2019	Assessment 2020	Diff.
XSA Setting	Catchability dependent on stock	Independent for all ages	Independent for all ages	No
	Catchability independent of age	>=5	>=5	No
	Survivor estimates shrinkage towards mean F of	Final 5 years, 3 oldest ages	Final 5 years, 3 oldest ages	No
	S.E. of the mean for shrinkage	0.5	0.5	No
Tuning fleet	Trap-nets	1996–2018	1996–2019	No
	Acoustic survey	1999–2018	1999–2019	No

Comparison of SSB and F estimates from assessments performed in 2019 and 2020

Assessment year	**Tuning fleet**	**SSB (2018) (t)**	**FBAR3-7 (2018)**	**Recruitment (age1)**
2019 (update)	Trap-nets+acoustics	110 182	0.2536	5 382 282
2020 (update)	Trap-nets+acoustics	118 237	0.2271	5 974 504
Diff. (+/-)%		+7.3%	-10.4%	+ 11%
Comparison of predictions	Prediction in 2019	Prediction in 2020	Actual yield 2019 (t)	Diff. (+/-)%
Yield 2019 (t)	26 932		28922	+7.3

SSB 2020 (t)	108 505	136 024	+25.4
Yield 2020 (t)	30 382	30 382	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 Central Baltic herring stock component is taken in the Gulf of Riga (Subdivision 28.1) and some amount of Gulf of Riga herring is taken in Subdivision 28.2. This is taken into account when setting TAC for the Gulf of Riga herring and herring in Sub-divisions 25–27, 28.2, 29, 32.

The TAC proposed for the Gulf of Riga area is based on the advised catch for the Gulf of Riga herring stock, plus the assumed catch of herring from the central Baltic stock taken in the Gulf of Riga, minus the assumed catch of the Gulf of Riga herring taken outside the Gulf of Riga. The values of the two latter are given by the average over the last five years.

1. Central Baltic herring assumed to be taken in the Gulf of Riga in 2020 (Subdivision 28.1) is 4189 tonnes (average 2015–2019);
2. Gulf of Riga herring assumed to be taken in Subdivision 28.2 in 2020 is 514 tonnes (average 2015–2019).

As an example, following the ICES MSY approach (here identical to the MAP F_{MSY}), catches from the Gulf of Riga herring stock in 2021 should be no more than 35 771 tonnes. The corresponding TAC in the Gulf of Riga management area for 2021 would be calculated as 35 771 tonnes – 514 tonnes + 4189 tonnes = 39 446 tonnes.

Table 4.3.1a. Total catches of herring in the Gulf of Riga by nation (official + unallocated landings). All weights 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

Year	Estonia	Latvia	Unallocated landings	Total
2017	13772	17948	-	31720
2018	12521	16904	-	29424
2019	13320	17961	-	31281

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

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
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
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
2019	27721	3560	31281	1200	28922

Table 4.3.2. Sampling of herring landings in the Gulf of Riga in 2019

Country	Quarter	Landings	Samples	Measured	Aged
Estonia	I	4889	13	1300	1300
	II	8426	16	1500	1500
	III	5	2	200	100
	IV	1	0	0	0
	Total	13320	31	3000	2900
Latvia	I	6255	9	1946	1079
	II	5417	36	4085	3557
	III	3225	9	1829	754
	IV	3064	8	1815	885
	Total	17961	62	9675	6275
Total	I	11144	22	3246	2379
	II	13843	52	5585	5057
	III	3229	11	2029	854
	IV	3065	8	1815	885
Grand total	Total	31281	93	12675	9175

Table 4.3.3. Gulf of Riga herring. Catch in numbers 1977-2019 in thousands.

Year	1	2	3	4	5	6	7	8+
1977	69500	885100	141400	109700	35300	15700	16000	600
1978	112000	97300	403900	39200	35900	9300	3200	5700
1979	76700	176500	103800	342500	22100	19300	6800	5500
1980	101000	125900	99600	55400	133100	10500	8600	2500
1981	62500	172500	112000	83000	51400	71700	7400	3500
1982	80000	96000	116900	68800	43000	29900	24500	3300
1983	49700	225300	138300	77700	38900	23300	15500	9600
1984	44000	152100	255100	96300	56700	32500	14700	11900
1985	23200	283900	203900	121700	31800	23700	8000	6100
1986	9200	106700	246900	110600	66500	19600	8000	5800
1987	70000	49000	110000	205000	75000	32000	5000	2000
1988	6000	197700	112700	112400	144600	38700	27800	5900
1989	61100	47400	492700	143000	76300	53900	6500	5400
1990	88100	83100	67100	263500	66800	27600	14600	4100
1991	119500	234000	94500	40800	180500	40500	35400	40800
1992	150300	339100	369300	91300	33200	157400	19000	47600
1993	192200	381400	298100	224400	66800	19000	78800	26900
1994	164230	288440	368870	263500	192700	46080	9410	56150
1995	232400	316900	363000	426900	277200	170900	39300	51500
1996	428800	450100	281400	247600	291000	183800	105600	57000
1997	204200	930700	559700	345400	242800	186700	90600	61100
1998	239360	282060	505410	274890	172470	114020	90230	67650
1999	361890	446500	157050	316480	157200	83650	60670	81050
2000	259030	552300	359430	123730	258070	83980	35120	53370
2001	819480	461570	378160	261040	81170	120980	56040	70710
2002	304160	1182680	360540	202120	118950	36310	48060	44940
2003	596730	396180	922840	231180	107440	70510	19990	58640
2004	166760	1342020	306210	505770	129160	64390	33200	62270
2005	383307	197546	873585	171434	186054	50952	27898	28826

Year	1	2	3	4	5	6	7	8+
2006	787870	600120	113610	467380	100900	70420	16470	20010
2007	305070	1145970	441270	83890	303940	59690	33710	24170
2008	599430	340150	707460	166050	21870	112520	11600	26250
2009	284970	787100	206390	505640	109220	20860	101490	29430
2010	469190	407890	515480	109990	275720	55630	7760	75000
2011	94610	346460	325910	398850	86030	168030	35030	44130
2012	458920	123970	276010	196090	245430	39330	90650	33980
2013	435220	596630	95600	143650	86850	128500	21350	57920
2014	76960	553760	443440	68530	115750	62060	80660	58830
2015	277380	141080	575230	394950	68160	82500	63190	117450
2016	467310	287890	110350	427240	291430	43770	50850	94760
2017	291780	449000	219830	59410	251400	183300	24030	94910
2018	357867	295664	329437	150533	46463	149032	88866	36412
2019	174379	629505	255381	267814	117162	48007	116436	60657

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

Year	Catch
1989	16783
1990	14931
1991	14791
1992	20000
1993	22200
1994	24300
1995	32656
1996	32584
1997	39843
1998	29443
1999	31403
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

Year	Catch
2018	25747
2019	28922

Table 4.3.5. Gulf of Riga herring. Proportion of mature at beginning the year in 1977-2019.

Period	1	2	3	4	5	6	7	8+
1977-2019	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 1977-2019.

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

Year	Age 1	2	3	4	5	6	7	8+
1998	0.0101	0.0133	0.0169	0.0182	0.0203	0.0213	0.0225	0.024
1999	0.0131	0.0155	0.0189	0.0221	0.0231	0.0245	0.0265	0.0289
2000	0.0125	0.0165	0.0201	0.0229	0.0254	0.0264	0.0282	0.0296
2001	0.0102	0.0160	0.0205	0.0230	0.0245	0.0277	0.0283	0.0307
2002	0.0100	0.0153	0.0193	0.0236	0.0250	0.0271	0.0280	0.0309
2003	0.0075	0.0153	0.0199	0.0223	0.0248	0.0263	0.0268	0.0276
2004	0.0086	0.0101	0.0165	0.0210	0.0242	0.0268	0.0271	0.0331
2005	0.0120	0.0142	0.0159	0.0204	0.0244	0.0260	0.0298	0.0308
2006	0.0086	0.0132	0.0178	0.0191	0.0228	0.0266	0.0275	0.0296
2007	0.0089	0.0117	0.0154	0.0202	0.0196	0.0237	0.0271	0.0278
2008	0.0098	0.0148	0.0173	0.0204	0.0238	0.0233	0.0286	0.0327
2009	0.0092	0.0140	0.0176	0.0191	0.0218	0.0207	0.0244	0.0294
2010	0.0091	0.0138	0.0169	0.0194	0.0209	0.0237	0.0231	0.026
2011	0.0118	0.0153	0.0184	0.0211	0.023	0.0255	0.0262	0.0324
2012	0.0094	0.0159	0.0203	0.0232	0.0258	0.0277	0.0299	0.0334
2013	0.0097	0.0146	0.0197	0.0227	0.0257	0.0282	0.0295	0.0319
2014	0.0098	0.0138	0.0176	0.0216	0.0236	0.0253	0.0271	0.0302
2015	0.0089	0.0150	0.0182	0.0211	0.0230	0.0252	0.0272	0.0295
2016	0.0086	0.0152	0.0181	0.0204	0.0223	0.0239	0.0260	0.0283
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
2019	0.0087	0.0136	0.0181	0.0207	0.0232	0.0237	0.0248	0.0262

Table 4.3.7. Gulf of Riga herring. Natural mortality.

Year	1	2	3	4	5	6	7	8+
1977-1978	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
1980	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

Year	1	2	3	4	5	6	7	8+
1982	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
1984-2019	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Table 4.3.8. Gulf of Riga herring. Tuning fleet: trap-nets (effort number of trap-nets).

Year	Effort	Age2	Age3	Age4	Age5	Age6	Age7	Age8*
1996	94.0	84.40	87.40	88.80	95.60	67.90	33.40	8.70
1997	101.0	115.50	115.70	85.10	68.20	46.70	18.80	12.40
1998	70.0	65.38	122.80	65.70	36.40	20.80	20.20	6.60
1999	78.0	34.56	21.36	101.42	51.14	25.81	18.47	18.49
2000	84.0	91.12	89.00	27.79	114.19	31.05	5.96	5.12
2001	100.0	124.13	149.34	118.20	37.23	59.59	27.53	10.40
2002	90.0	207.06	107.78	61.26	39.47	8.93	12.12	6.11
2003	86.0	77.79	265.91	72.98	23.36	25.15	3.17	6.07
2004	68.0	109.49	79.51	114.20	29.77	15.85	7.43	1.68
2005	51.0	23.01	162.65	31.30	51.30	13.68	6.04	4.31
2006	49.0	81.76	27.33	101.11	34.88	23.22	6.76	3.77
2007	57.0	126.63	108.24	24.53	91.65	16.98	9.91	2.59
2008	50.0	64.97	179.19	48.29	7.15	37.46	1.92	6.85
2009	60.0	159.17	45.13	165.51	40.41	7.13	35.53	4.37
2010	45.0	44.1	98.18	21.26	67.95	15.61	2.1	13.44
2011	45.0	40.8	62.4	96.73	15.04	44.65	7.68	3.3
2012	43.0	19.42	49.24	47.99	54.99	7.76	21.69	3.78
2013	45.0	107.13	26.36	37.23	26.01	35.77	4.71	11.23
2014	45.0	148.61	119.84	17.15	22.46	8.66	15.28	1.82
2015	43.0	15.96	128.17	76.97	9.93	11.83	8.64	19.22
2016	43.0	50.18	25.23	117.5	92.86	10.77	12.14	6.08
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

Year	Effort	Age2	Age3	Age4	Age5	Age6	Age7	Age8*
2019	43.0	93.15	59.61	75.4	30.14	8.13	29.05	11.53

*Age 8 is true age group

Table 4.3.9. Gulf of Riga herring. Tuning fleet: hydro-acoustics 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
2019	1	4912	7007	2237	1335	475	228	681	148

*Age 8 is true age group

Table 4.3.10. Gulf of Riga herring. XSA diagnostics.

Lowes+A1:B48toft VPA Version 3.1

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Extended Survivors Analysis

Index File; Gulf of Riga herring

CPUE data from file Tuning.dat

Catch data for 43 years. 1977 to 2019. Ages 1 to 8.

Fleet	First year	Last year	First age	Last age	Alpha
Trap-nets	1996	2019	2	7	0.33
Acoustics	1999	2019	1	7	0.55

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 converged after 40 iterations

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99
	0.997	1				

Fishing mortalities

Age	2010	2011	2012	2013	2014	2015
	2016	2017	2018	2019		
1	0.2	0.094	0.095	0.085	0.08	0.131
	0.129	0.111	0.068	0.077		
2	0.246	0.222	0.171	0.171	0.148	0.206
	0.196	0.177	0.157	0.165		
3	0.249	0.317	0.277	0.193	0.186	0.226
	0.247	0.226	0.19	0.198		
4	0.281	0.311	0.321	0.227	0.207	0.252
	0.262	0.204	0.238	0.234		
5	0.325	0.372	0.321	0.229	0.289	0.327
	0.298	0.242	0.243	0.295		
6	0.306	0.337	0.289	0.277	0.254	0.345
	0.362	0.31	0.221	0.427		
7	0.318	0.322	0.307	0.252	0.281	0.446
	0.371	0.346	0.243	0.269		

XSA population numbers (Thousands)

Age/Year	1	2	3	4	5	6	7
2010	2860000	2070000	2580000	496000	1100000	233000	31500
2011	1170000	1920000	1320000	1650000	306000	649000	141000
2012	5620000	871000	1260000	790000	988000	173000	379000
2013	5920000	4190000	601000	781000	469000	587000	106000
2014	1110000	4450000	2890000	405000	510000	306000	364000
2015	2490000	836000	3140000	1960000	270000	313000	194000
2016	4250000	1790000	557000	2050000	1250000	159000	181000
2017	3070000	3060000	1200000	356000	1290000	759000	90800
2018	5970000	2250000	2100000	786000	238000	831000	456000
2019	2610000	4570000	1570000	1420000	507000	153000	546000

Estimated population abundance at 1st Jan 2020

0	1980000	3170000	1060000	921000	309000	81500

Taper weighted geometric mean of the VPA populations:

3130000	2310000	1430000	879000	502000	288000	168000

Standard error of the weighted Log(VPA populations) :

0.599 0.6343 0.6415 0.6899 0.7233 0.7783 0.8874

Log catchability residuals.

Fleet : Trap-nets

Age	1996	1997	1998	1999
1	No data for this fleet at this age			
2	99.99	99.99	99.99	99.99
3	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99

Age	2000	2001	2002	2003	2004	2005
	2006	2007	2008	2009		
1	No data for this fleet at this age					
2	0.02	0.19	0.05	0.07	-0.54	0.24
	0.34	-0.19	0.57	0.19		
3	-0.15	0.3	0.08	0.36	0.28	0.06
	0.41	0.44	0.14	-0.09		
4	-0.32	0.41	-0.02	0.22	0.38	0.11
	0	0.64	0.18	0.22		
5	0.55	0.36	0	-0.4	0.22	0.59
	0.87	0.21	0.06	0.24		
6	0.06	0.5	-0.25	0.31	0.15	0.54
	0.56	0.91	-0.01	0.44		
7	-0.59	0.44	-0.26	-0.51	0.1	0.2
	0.54	0.18	-0.29	0.26		

Age	2010	2011	2012	2013	2014	2015
	2016	2017	2018	2019		
1	No data for this fleet at this age					
2	-0.14	-0.16	-0.09	0.01	0.26	-0.23
	0.16	-0.22	0.05	-0.18		
3	-0.19	0.05	-0.11	-0.08	-0.13	-0.09
	0.03	0.07	0.05	-0.18		
4	-0.24	0.09	0.17	-0.16	-0.29	-0.3
	0.09	-0.28	0.16	0		
5	0.03	-0.18	-0.03	-0.12	-0.32	-0.44
	0.25	0.11	-0.2	0.03		
6	0.1	0.15	-0.26	0	-0.78	-0.4
	0.18	0.26	-0.12	-0.02		
7	0.1	-0.09	-0.01	-0.33	-0.37	-0.2
	0.18	-0.01	0.05	-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	-14.2171	-13.586	-13.4055	-13.2925	-13.2925	-13.2925
S.E(Log q)	0.2353	0.1695	0.2444	0.2896	0.3913	0.2337

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	1.02	-0.132	14.21	0.88	20	0.25	-14.22
3	1.08	-0.879	13.54	0.93	20	0.18	-13.59
4	0.99	0.115	13.41	0.89	20	0.25	-13.41
5	0.91	0.778	13.28	0.89	20	0.27	-13.29
6	1.16	-0.898	13.38	0.76	20	0.46	-13.27
7	1.02	-0.266	13.36	0.93	20	0.25	-13.33

Fleet : Acoustics

Age	1996	1997	1998	1999
1	99.99	99.99	99.99	99.99
2	99.99	99.99	99.99	99.99
3	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99

Age	2000	2001	2002	2003	2004	2005
	2006	2007	2008	2009		
1	0.12	-0.16	0.18	0.15	0.77	0.55
	0.15	-0.68	0.11	0.41		
2	0.61	-0.06	0.29	-0.07	0.62	0.77
	-0.21	-0.42	0.33	0.03		
3	0.39	0.3	-0.01	0.09	-0.25	0.43
	-0.54	0.06	0.36	0.06		
4	0.61	0.31	0.04	-0.17	0.52	-0.16
	-0.48	-0.12	0.32	0.05		
5	0.2	0.1	-0.36	-0.11	-0.13	0.55
	-0.64	0.02	0.3	-0.32		
6	0.28	0.14	-0.05	0.57	0.3	-0.2
	0.13	0.34	-0.47	-0.68		
7	0.49	-0.78	0.27	0.04	0.29	0.07
	-0.5	-0.02	-0.85	-0.4		

Age	2010	2011	2012	2013	2014	2015
	2016	2017	2018	2019		
1	0.27	0.58	-0.36	0.05	-0.42	-0.14
	-0.33	-0.36	0.2	0.21		
2	0.03	0.87	-0.31	0.11	-0.34	-0.59
	-0.66	-0.05	0.52	0.25		
3	-0.38	0.65	0.19	-0.07	-0.31	-0.54
	-0.12	-0.36	0.48	0.3		
4	-0.55	0.71	0.11	0.54	-0.32	-0.48
	-0.3	0.19	0.07	0.02		
5	-0.55	0.71	0.06	-0.01	0.11	-0.03
	-0.59	0.21	0.33	-0.06		
6	-0.73	0.31	0.77	0.34	0.35	0.13
	0	0.27	0.51	0.48		
7	-0.87	0.17	-0.2	0.55	0.24	0.02
	-0.43	0.44	0.48	0.21		

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	-6.323	-6.5211	-6.6265	-6.7412	-6.6263	-6.6263	-6.6263
S.E(Log q)	0.3694	0.4605	0.3789	0.3789	0.3723	0.4631	0.4521

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	-0.2	5.98	0.71	20	0.4	-6.32
2	0.9	0.482	7.32	0.7	20	0.43	-6.52
3	0.98	0.13	6.8	0.75	20	0.39	-6.63
4	1.01	-0.039	6.69	0.77	20	0.4	-6.74
5	1.26	-1.368	4.96	0.74	20	0.45	-6.63
6	0.86	0.964	7.31	0.83	20	0.37	-6.46
7	0.82	1.544	7.62	0.88	20	0.35	-6.64

Terminal year survivor and F summaries :

Age 1 Catchability constant w.r.t. time and dependent on age

Year class = 2018

Fleet	Estimated survivors	Int s.e	Ext s.e	Var ratio	N	Scaled weights	Estimated F
Trap-nets	1	0	0	0	0	0	0
Acoustics	2433601	0.384	0	0	1	0.61	0.063
F shrinkage mean	1433959	0.5				0.39	0.104

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
1980476	0.3	0.33	2	1.083	0.077

Age 2 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
Trap-nets	2651801	0.3	0	0	1	0.419	0.195
Acoustics	3952563	0.3	0.025	0.08	2	0.403	0.135
F shrinkage mean	2930827	0.5				0.178	0.178

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
3170181	0.2	0.11	4	0.548	0.165

Age 3 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	982613	0.213	0.111	0.52	2	0.505	0.211
Acoustics	1206917	0.24	0.253	1.05	3	0.375	0.175
F shrinkage mean	957879	0.5				0.119	0.216

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
1058244	0.15	0.11	6	0.746	0.198

Age 4 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
Trap-nets	882290	0.175	0.077	0.44	3	0.539	0.243
Acoustics	981731	0.208	0.17	0.81	4	0.363	0.221
F shrinkage mean	921322	0.5				0.097	0.234

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
921064	0.13	0.08	8	0.581	0.234

Age 5 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
Trap-nets	339982	0.155	0.035	0.23	4	0.552	0.271
Acoustics	263363	0.189	0.112	0.59	5	0.357	0.338
F shrinkage mean	326074	0.5				0.091	0.282

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
309172	0.12	0.06	10	0.524	0.295

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5
Year class = 2013

Fleet	Estimated survivors	Int s.e	Ext s.e	Var ratio	N	Scaled weights	Estimated F
Trap-nets	70277	0.148	0.058	0.39	5	0.539	0.481
Acoustics	90077	0.18	0.156	0.87	6	0.357	0.394
F shrinkage mean	124065	0.5				0.104	0.3

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
81480	0.11	0.09	12	0.775	0.427

Age 7 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
Trap-nets	342741	0.138	0.056	0.41	6	0.578	0.268
Acoustics	357240	0.175	0.137	0.79	7	0.337	0.258
F shrinkage mean	278872	0.5				0.084	0.32

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var ratio	F
341580	0.11	0.06	14	0.585	0.269

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	0.1117
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	0.4467	0.6948	0.552	0.4124
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	0.5645	0.5673
8 +	0.7027	0.384	0.474	0.3678	0.4815	0.4411	0.4727	0.7755	0.5645	0.5673
FBAR 3- 7	0.6903	0.3751	0.431	0.3498	0.4525	0.4198	0.4679	0.7068	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	0.0392	0.0675	0.0673	0.0769	0.1072
2	0.0614	0.0718	0.1227	0.0961	0.0933	0.1377	0.1324	0.1369	0.1794	0.2097
3	0.1612	0.196	0.257	0.2557	0.1509	0.2088	0.1727	0.183	0.2555	0.2396
4	0.4268	0.2463	0.4088	0.2125	0.2439	0.2134	0.1891	0.2275	0.3338	0.2778
5	0.6778	0.6137	0.2633	0.3399	0.2208	0.3209	0.239	0.2463	0.3978	0.4004
6	0.3567	0.9444	0.4873	0.1428	0.3563	0.3053	0.3071	0.2581	0.3603	0.5037
7	0.4909	0.6067	0.3891	0.2329	0.2751	0.2814	0.2463	0.2452	0.3664	0.3966
8+	0.4909	0.6067	0.3891	0.2329	0.2751	0.2814	0.2463	0.2452	0.3664	0.3966
FBAR 3- 7	0.4227	0.5214	0.3611	0.2368	0.2494	0.266	0.2308	0.232	0.3428	0.3636

YEAR/AGE	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.1527	0.1005	0.1487	0.1146	0.1611	0.1595	0.0975	0.1978	0.1423	0.1324
2	0.3564	0.3261	0.2757	0.3549	0.3069	0.3685	0.3217	0.3301	0.3804	0.346
3	0.4376	0.3341	0.3041	0.3741	0.4406	0.4196	0.5527	0.4434	0.3725	0.3932
4	0.5208	0.3994	0.3616	0.4184	0.515	0.4484	0.5248	0.6813	0.4806	0.3495
5	0.4838	0.5391	0.42	0.5689	0.5384	0.4698	0.4579	0.6366	0.5775	0.5862
6	0.4875	0.4414	0.5504	0.4164	0.5776	0.4939	0.5695	0.5536	0.5601	0.4484
7	0.5012	0.4634	0.4472	0.4722	0.5463	0.4769	0.5611	0.5822	0.4965	0.3516

8+	0.5012	0.4634	0.4472	0.4722	0.5463	0.4769	0.5611	0.5822	0.4965	0.3516
FBAR 3- 7	0.4862	0.4355	0.4166	0.45	0.5236	0.4617	0.5332	0.5794	0.4974	0.4258

YEAR/AGE	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.1816	0.1272	0.1133	0.1997	0.0938	0.0946	0.0848	0.08	0.1314	0.1294
2	0.2896	0.3164	0.2376	0.2458	0.2223	0.1712	0.1714	0.148	0.2064	0.1961
3	0.464	0.2921	0.3119	0.2493	0.3173	0.2774	0.1935	0.186	0.2261	0.2472
4	0.5699	0.3166	0.3421	0.2814	0.3114	0.3208	0.2271	0.2069	0.2516	0.2615
5	0.4039	0.2805	0.3483	0.3253	0.3717	0.3209	0.2289	0.289	0.3274	0.2982
6	0.8581	0.2549	0.4625	0.3061	0.3371	0.2895	0.2771	0.2542	0.3449	0.3621
7	0.4016	0.3893	0.3786	0.3177	0.3221	0.3067	0.2518	0.2807	0.4462	0.3711
8 +	0.4016	0.3893	0.3786	0.3177	0.3221	0.3067	0.2518	0.2807	0.4462	0.3711
FBAR 3- 7	0.5395	0.3067	0.3687	0.2959	0.3319	0.3031	0.2357	0.2434	0.3192	0.308

YEAR/AGE	2017	2018	2019	FBAR
1	0.1109	0.0685	0.0767	0.0854
2	0.1769	0.1569	0.1652	0.1663
3	0.2257	0.1904	0.1975	0.2045
4	0.2039	0.2379	0.2336	0.2251
5	0.2418	0.2434	0.2948	0.26
6	0.3105	0.2208	0.4273	0.3195
7	0.3462	0.2428	0.2688	0.2859
8+	0.3462	0.2428	0.2688	
FBAR 3- 7	0.2656	0.2271	0.2844	

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	168899	125365	202719	138798	112029
2	283694	70936	78001	69316	77560	65232	124479	93248	161991	111539
3	32331	152182	49273	45171	42872	45181	42331	77062	62583	106938
4	26299	13676	88050	29214	26389	23505	24870	20762	40010	32789
5	8202	11606	7650	38348	17863	13227	12234	12512	8285	21746
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	301168	276865	334240	343301	417812	420376	392454
Year	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
1	392831	56092	129220	364481	368916	431812	325593	278668	346822	466389
2	90889	315289	45381	100268	290441	291230	339938	249182	213294	262926
3	81666	69980	240248	32866	74573	216619	207756	243807	177914	145956
4	65213	56909	47097	152117	20837	52505	143937	143123	166236	112818
5	16838	34843	36423	25621	100701	13368	34726	97541	93337	97475
6	11787	6999	15443	22917	14932	66114	7941	22387	62424	51336
7	1424	6755	2229	7767	16265	8561	39888	4782	14159	35645
8+	564	1417	1837	2169	18630	21312	13538	28373	18412	19082
TOTAL	661213	548284	517879	708206	905296	1101522	1113318	1067865	1092599	1191627
Year	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1	159404	276593	289526	264391	608523	228049	710247	102715	319355	702242
2	343048	112032	204797	204298	193027	424067	159189	527506	69007	226782
3	174539	196651	66202	127272	117291	116272	240183	94485	310455	38623
4	94037	92256	115272	39991	71679	61813	62573	113143	49651	175133
5	69964	45738	50660	65741	21547	35066	32319	30312	46870	25139
6	53475	35312	21841	27253	30473	10296	17947	16739	13131	21539
7	25399	26888	18594	10313	14714	14002	5144	8313	7879	6140
8+	16959	19972	24616	15524	18368	12969	14927	18179	8061	7404
TOTAL	936824	805442	791508	754784	1075621	902534	1242528	911393	824408	1203003

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	203008	554761	283014	286492	116799	561907	591562	110607	248929	425480
2	503658	138605	399961	206893	192106	87067	418526	444950	83594	178707
3	131372	308668	82702	258200	132482	125934	60067	288675	314188	55675
4	21342	67631	188703	49566	164754	78978	78132	40528	196223	205186
5	101097	9883	40347	109732	30629	98799	46918	50971	26981	124917
6	11452	55269	6112	23319	64892	17293	58683	30555	31258	15923
7	11263	3975	35069	3151	14058	37925	10599	36418	19401	18127
8+	8009	8927	10085	30541	17590	14116	28587	26394	35735	33517
TOTAL	991201	1147719	1045994	967893	733311	1022020	1293074	1029098	956308	1057532
Year	**2017**	**2018**	**2019**	**2020**	**GMST**	**AMST**				
1	307081	597450	261163	0	234812	286850				
2	306069	225016	456770	198048	174709	213627				
3	120264	209961	157474	317018	108179	134330				
4	35598	78573	142093	105824	62320	80208				
5	129334	23770	50709	92106	33883	46232				
6	75904	83142	15257	30917	16664	24072				
7	9076	45559	54586	8148	7992	12329				
8+	35582	18561	28263	51842						
TOTAL										

Table 4.3.13. Gulf of Riga herring. XSA output: Summary.

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR(3-7)
	Age 1					
1977	943222	76734	54522	24186	0.4436	0.6903
1978	1076482	66256	49356	16728	0.3389	0.3751
1979	976944	66130	46739	17142	0.3668	0.431
1980	1110340	69530	46712	14998	0.3211	0.3498
1981	908420	65532	47221	16769	0.3551	0.4525
1982	1688991	72906	42758	12777	0.2988	0.4198

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR(3-7)
1983	1253648	76284	50858	15541	0.3056	0.4679
1984	2027187	66158	39914	15843	0.3969	0.7068
1985	1387985	77480	51936	15575	0.2999	0.5381
1986	1120294	86762	64282	16927	0.2633	0.5099
1987	3928311	97606	51521	12884	0.2501	0.4227
1988	560920	116319	96695	16791	0.1736	0.5214
1989	1292204	86097	63287	16783	0.2652	0.3611
1990	3644814	139170	77323	14931	0.1931	0.2368
1991	3689164	141594	87262	14791	0.1695	0.2494
1992	4318119	167195	106119	20000	0.1885	0.266
1993	3255933	175711	120755	22200	0.1838	0.2308
1994	2786684	170378	124922	24300	0.1945	0.232
1995	3468223	166896	116652	32656	0.2799	0.3428
1996	4663893	167900	105732	32584	0.3082	0.3636
1997	1594037	134078	103482	39843	0.385	0.4862
1998	2765927	120510	81998	29443	0.3591	0.4355
1999	2895256	136754	84066	31403	0.3736	0.4166
2000	2643906	132894	83881	34069	0.4062	0.45
2001	6085227	157008	79309	38785	0.489	0.5236
2002	2280487	144228	100849	39701	0.3937	0.4617
2003	7102467	157608	86577	40803	0.4713	0.5332
2004	1027151	121553	92782	39115	0.4216	0.5794
2005	3193548	126249	74442	32225	0.4329	0.4974
2006	7022420	145995	72259	31232	0.4322	0.4258
2007	2030081	129346	93228	33742	0.3619	0.5395
2008	5547611	161493	92565	31137	0.3364	0.3067
2009	2830143	154172	109289	32554	0.2979	0.3687
2010	2864924	145003	103305	30174	0.2921	0.2959
2011	1167994	135289	104897	29639	0.2826	0.3319

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR(3-7)
2012	5619073	156885	90888	28115	0.3093	0.3031
2013	5915620	188908	114422	26511	0.2317	0.2357
2014	1106071	169403	138637	26253	0.1894	0.2434
2015	2489287	163180	123340	32851	0.2663	0.3192
2016	4254796	161550	108855	30865	0.2835	0.308
2017	3070813	160862	117166	28058	0.2395	0.2656
2018	5974504	192226	118237	25747	0.2178	0.2271
2019	2611633	179080	136095	28921	0.2125	0.2844
Arith. Mean	2934761	130858	87329	25944	0.3089	0.3955

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
  2  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) distri-
bution used in the distribution of that fleet
 0 0 0
$constRecBreaks
# Vector of break years between which recruitment is at constant level. The break year is included
in the left interval. (This option is only used in combination with stock-recruitment code 3)
$predVarObsLink
# Coupling of parameters used in a prediction-variance link for observations.
 -1  -1  -1  -1  -1  -1  -1  -1
 NA  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1
```

Table 4.3.15. Gulf of Riga herring. Short-term forecast input.

2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	3212088	0.2	0	0.2	0.3	0.0090	0.0854	0.0090
2	1980480	0.2	0.93	0.2	0.3	0.0145	0.1663	0.0145
3	3170180	0.2	0.98	0.2	0.3	0.0186	0.2045	0.0186
4	1058240	0.2	0.98	0.2	0.3	0.0211	0.2251	0.0211
5	921060	0.2	1	0.2	0.3	0.0229	0.2600	0.0229
6	309170	0.2	1	0.2	0.3	0.0241	0.3195	0.0241
7	81480	0.2	1	0.2	0.3	0.0251	0.2859	0.0251
8	518420	0.2	1	0.2	0.3	0.0274	0.2859	0.0274
2021								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	3212088	0.2	0	0.2	0.3	0.0090	0.0854	0.0090
2	.	0.2	0.93	0.2	0.3	0.0145	0.1663	0.0145
3	.	0.2	0.98	0.2	0.3	0.0186	0.2045	0.0186
4	.	0.2	0.98	0.2	0.3	0.0211	0.2251	0.0211
5	.	0.2	1	0.2	0.3	0.0229	0.2600	0.0229
6	.	0.2	1	0.2	0.3	0.0241	0.3195	0.0241
7	.	0.2	1	0.2	0.3	0.0251	0.2859	0.0251
8	.	0.2	1	0.2	0.3	0.0274	0.2859	0.0274

2022								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	3212088	0.2	0	0.2	0.3	0.0090	0.0854	0.0090
2	.	0.2	0.93	0.2	0.3	0.0145	0.1663	0.0145
3	.	0.2	0.98	0.2	0.3	0.0186	0.2045	0.0186
4	.	0.2	0.98	0.2	0.3	0.0211	0.2251	0.0211
5	.	0.2	1	0.2	0.3	0.0229	0.2600	0.0229
6	.	0.2	1	0.2	0.3	0.0241	0.3195	0.0241
7	.	0.2	1	0.2	0.3	0.0251	0.2859	0.0251

8	.	0.2	1	0.2	0.3	0.0274	0.2859	0.0274

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)

$N_{2020-2022}$ Age1: geometric mean from XSA-estimates at age 1 for the year classes 1989-2017
N_{2020} Age 3-8+: survivors estimates from XSA
Natural mortality (M): average 2017-2019
CWt/SWt=average 2017-2019
Sel=average 2017-2019

Table 4.3.16. Gulf of Riga herring. Short-term prediction results.

2020						
Biomass	SSB	FMult	FBar	Landings		
183743	136024	1.011	0.2619	30382		
2021					2022	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
178434	137089	0	0	0	204996	162076
.	136460	0.1	0.0262	3290	201597	158173
.	135834	0.2	0.0524	6508	198273	154373
.	135211	0.3	0.0786	9656	195021	150674
.	134591	0.4	0.1048	12736	191840	147073
.	133974	0.5	0.131	15749	188727	143567
.	133360	0.6	0.1572	18697	185683	140154
.	132749	0.7	0.1833	21581	182704	136831
.	132141	0.8	0.2095	24404	179789	133595
.	131535	0.9	0.2357	27165	176937	130444
.	130933	1.0	0.2619	29868	174147	127375
.	130333	1.1	0.2881	32512	171417	124387
.	129736	1.2	0.3143	35100	168745	121476
.	129143	1.3	0.3405	37633	166130	118641
.	128552	1.4	0.3667	40113	163571	115880
.	127963	1.5	0.3929	42539	161066	113190
.	127378	1.6	0.4191	44914	158615	110570
.	126795	1.7	0.4453	47239	156216	108018
.	126216	1.8	0.4715	49515	153867	105531
.	125639	1.9	0.4977	51743	151569	103108
.	125064	2.0	0.5239	53924	149318	100748

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 (2021)	F (2021)	SSB (2021)	SSB (2022)	%SSB change**	%Advice change***
ICES advice basis						
EU MAP: F_{MSY} *	35 771	0.32	129 580	120 724	-6.8%	17.7%
EU MAP: F_{MSY} lower^	27 702	0.24	131 416	129 832	-1.21%	18.4%
EU MAP: F_{MSY} upper^^	41423	0.38	128 235	114 426	-10.8%	18.0%
Other options						
ICES MSY approach: F_{MSY}	35 771	0.32	129 580	120 724	-6.8%	17.7%
F= 0	0	0	137 089	162 076	18.2%	-100%
F_{pa}	62 303	0.63	122 766	91 786	-25%	105%
F_{lim}	79 500	0.88	117 507	73 959	-37%	162%
SSB (2022) = B_{lim}	114 130	1.61	103 508	40 800	-61%	276%
SSB (2022) = B_{pa}	96 575	1.19	111 332	57 100	-49%	218%
SSB (2022) = MSY $B_{trigger}$	93 521	1.13	112 523	60 000	-47%	208%
F=F_{2020}	29 868	0.26	130 933	127 375	-2.7%	-1.69%

*** MAP Multiannual plan (EU, 2016)**

**** SSB 2022 relative to SSB 2021.**

*****Total catch in 2021 relative to ICES advice for 2020 (30 382 t) for the Gulf of Riga herring stock**

^ ICES advice for F_{lower} in 2021 relative to ICES advice F_{lower} in 2020 (23 395 tonnes).

^^ ICES advice for F_{upper} in 2021 relative to ICES advice F_{upper} in 2020 (35 094 tonnes).

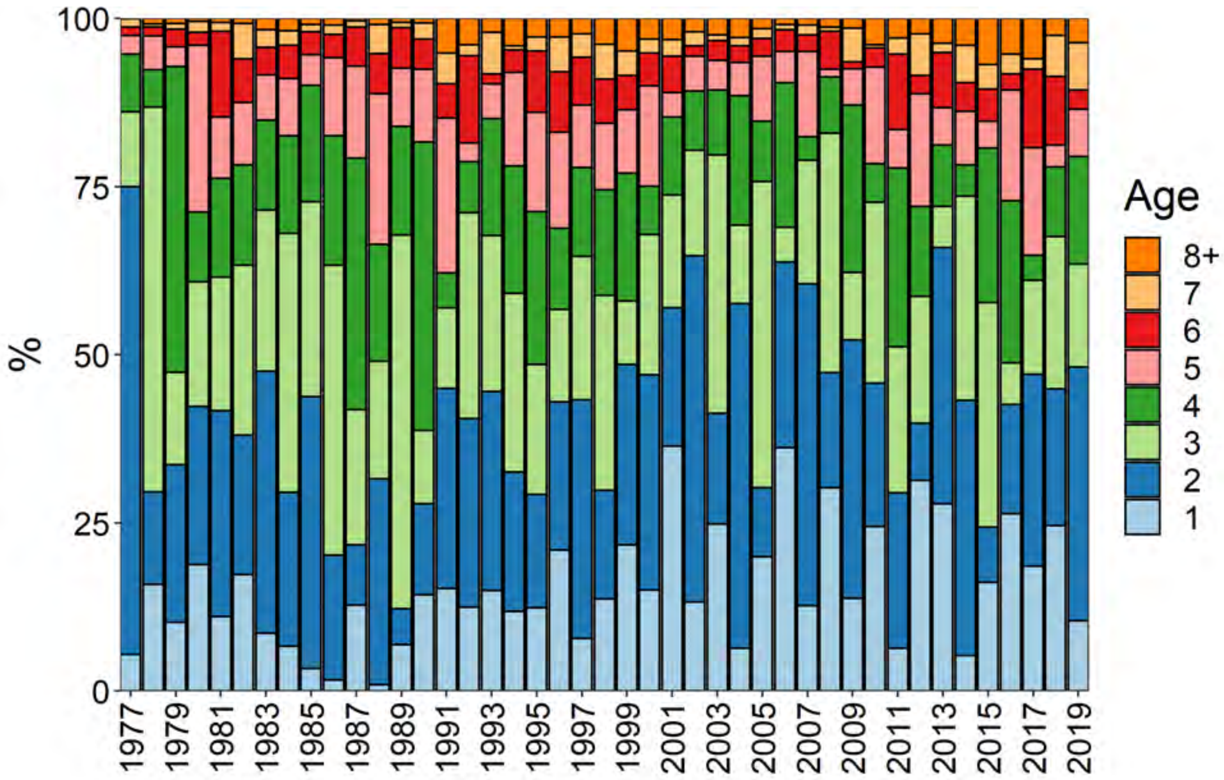


Figure 4.3.1. Gulf of Riga herring. Relative catch at age in numbers in 1977-2019.

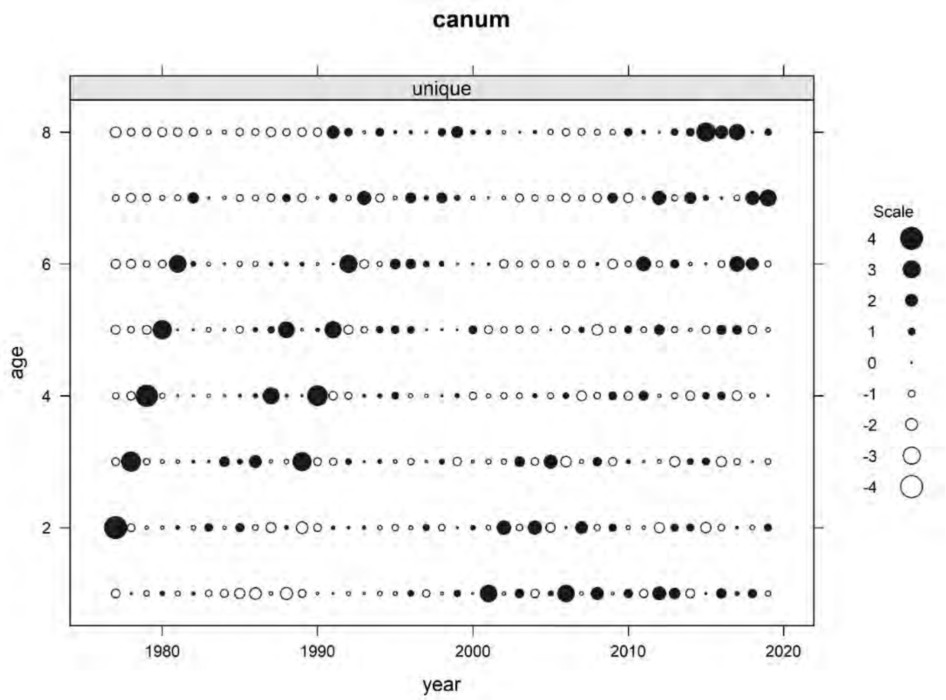


Figure 4.3.2. Gulf of Riga herring. Catch proportion at age.

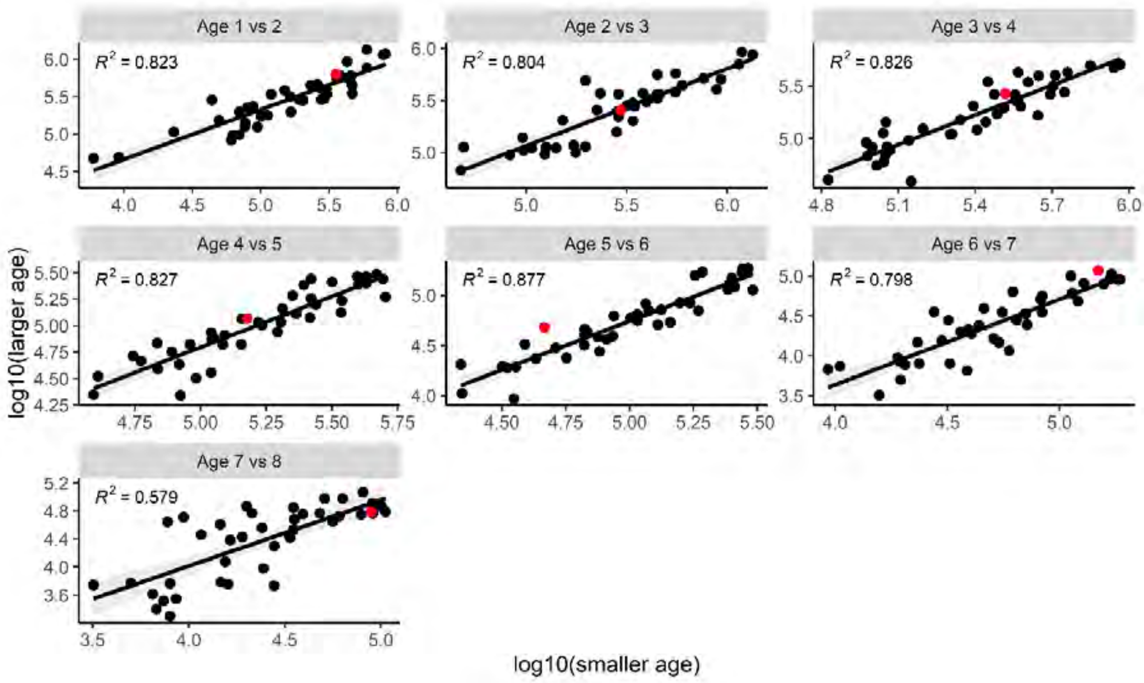


Figure 4.3.3. Gulf of Riga herring. Internal consistency in catch-at-age. Latest year is shown in red.

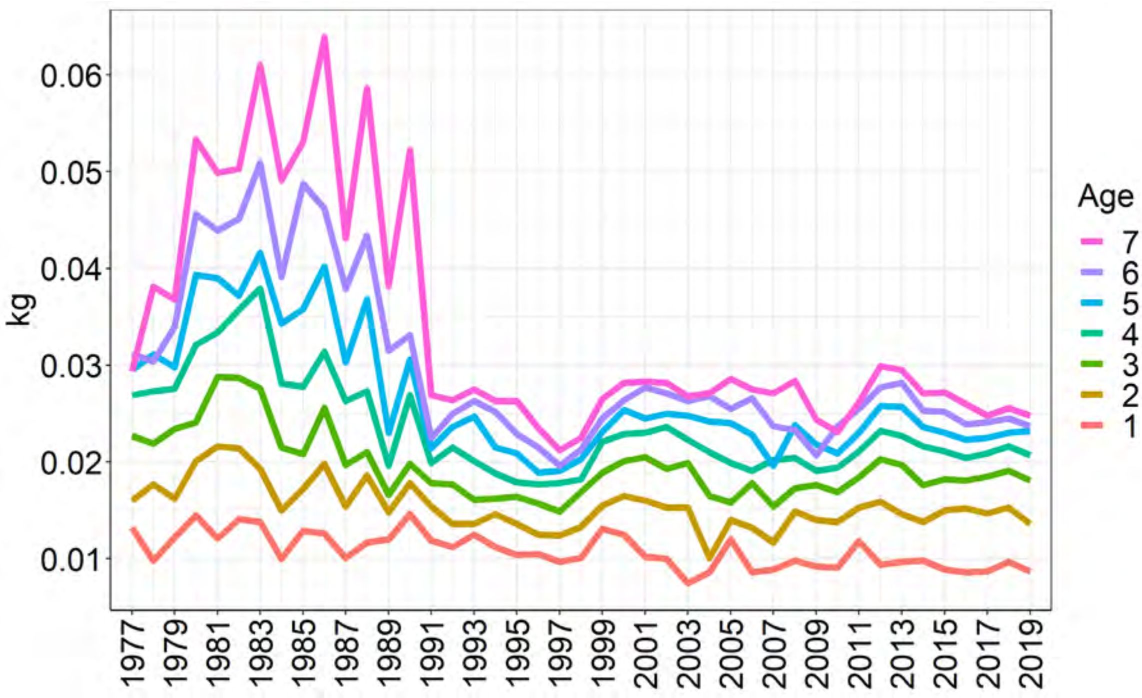


Figure 4.3.4. Gulf of Riga herring. Mean weight at age in the catches.

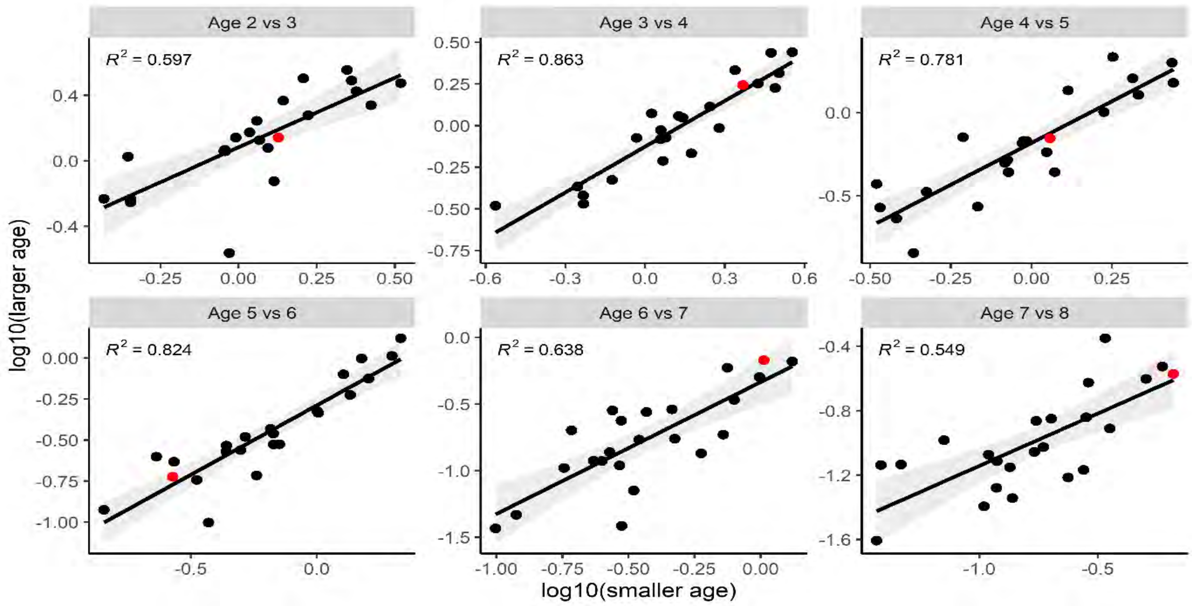


Figure 4.3.5. Gulf of Riga herring. Internal consistency in trap-net tuning fleet. Latest year is shown in red.

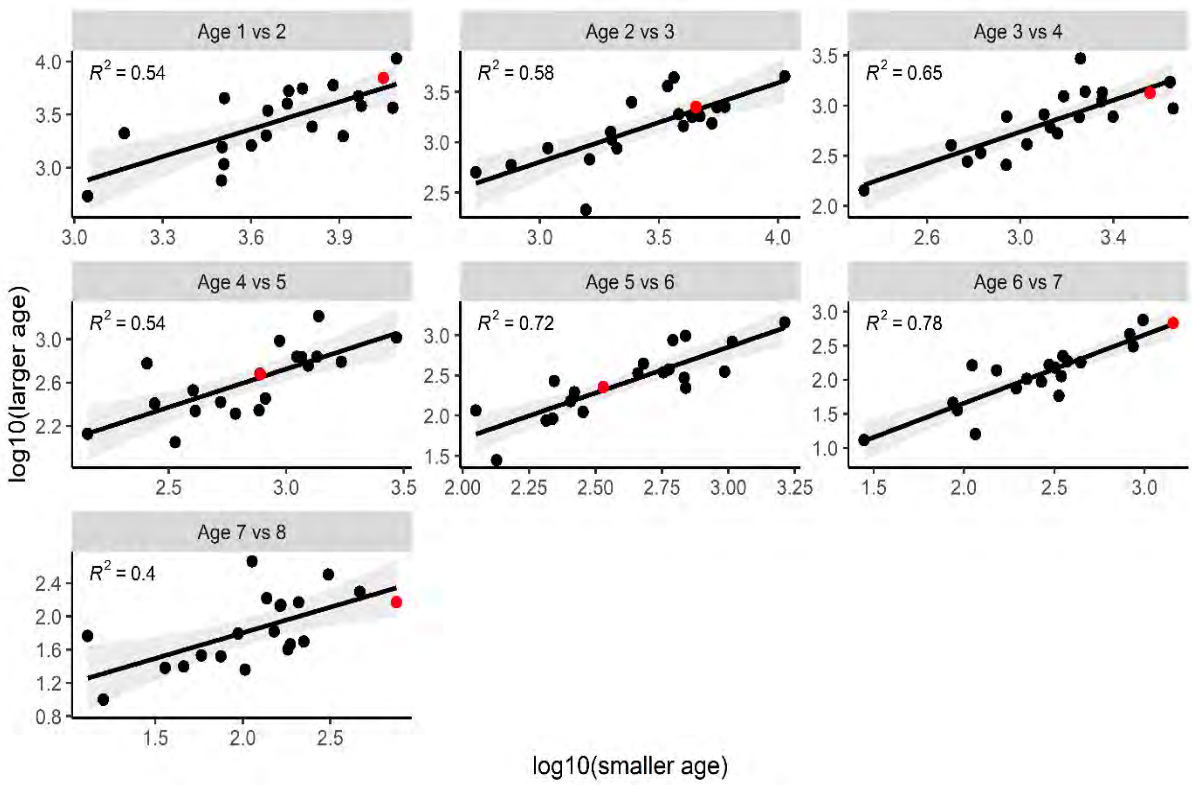


Figure 4.3.6. Gulf of Riga herring. Internal consistency in hydro-acoustics tuning fleet. Latest year is shown in red.

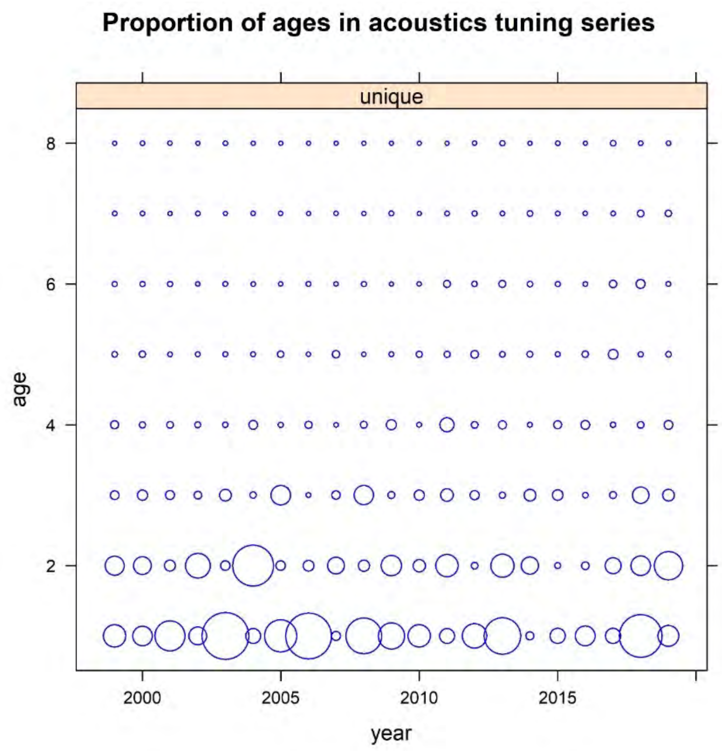


Figure 4.3.7. Gulf of Riga herring. Proportion of ages in hydro-acoustics tuning fleet.

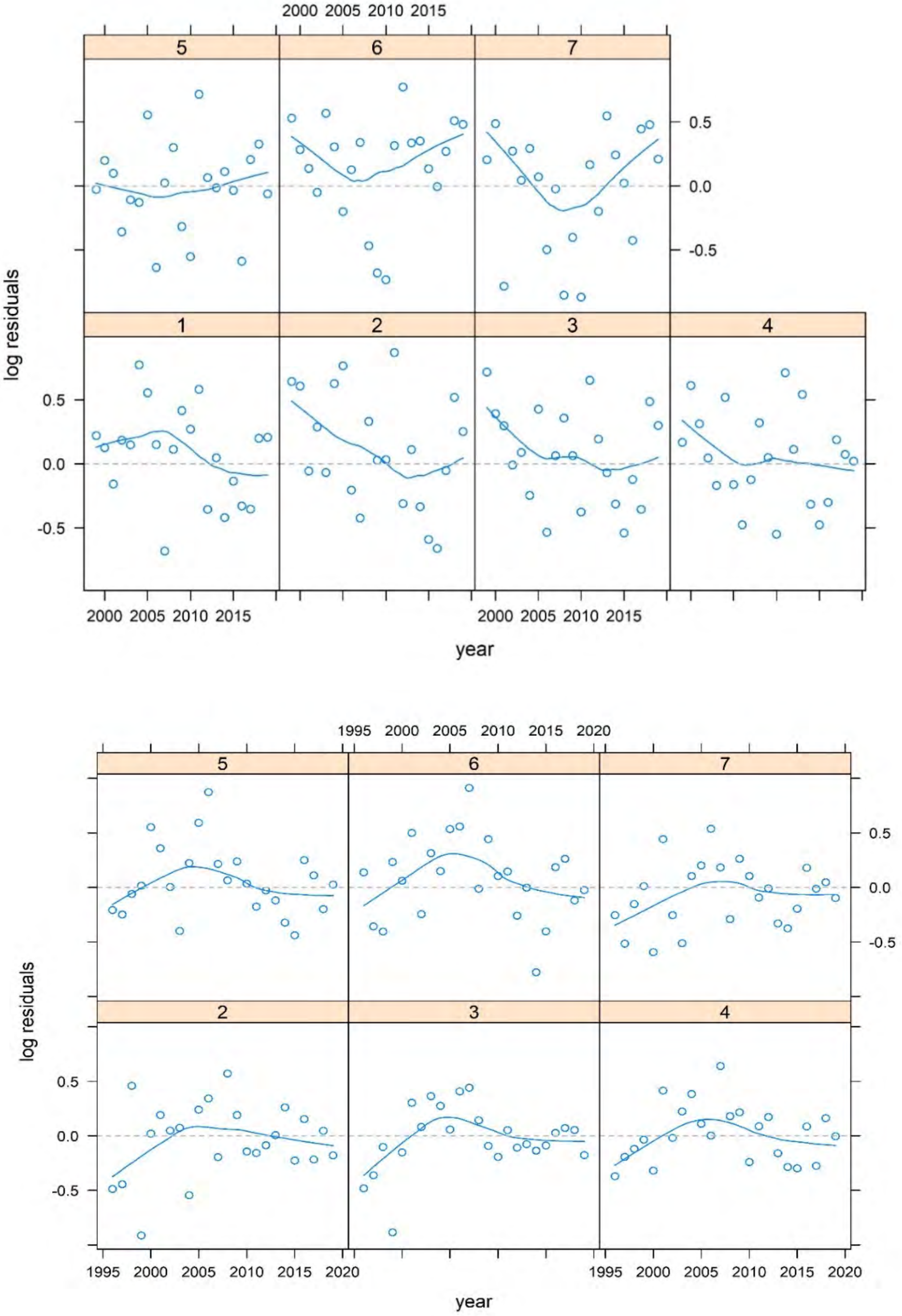


Figure 4.3.8a. Gulf of Riga herring. Log catchability residuals for acoustics survey (top) and trap-nets (bottom).

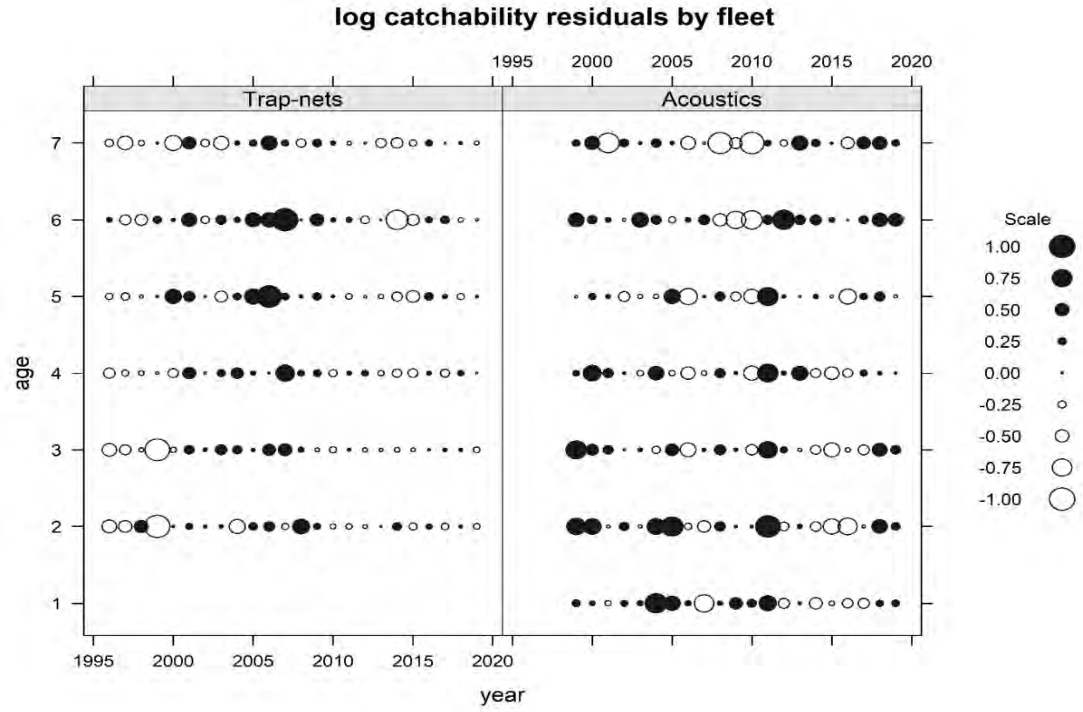


Figure 4.3.8b. Gulf of Riga herring. Log catchability residuals of trap-net fleet (left) and hydro-acoustics fleet (right).

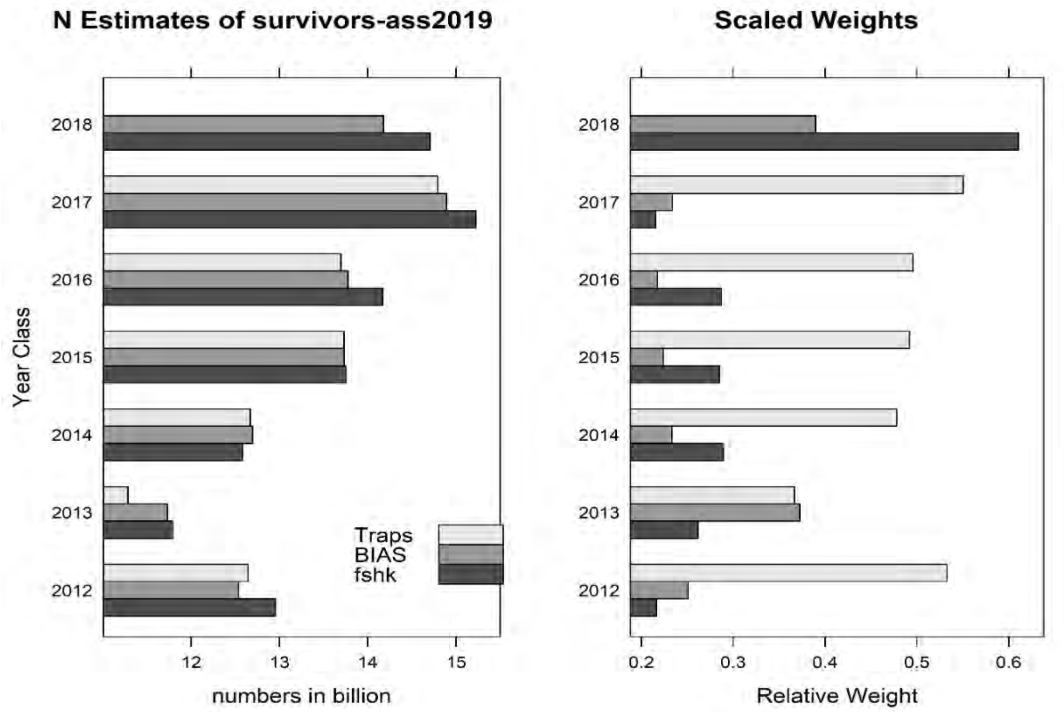


Figure 4.3.9. Gulf of Riga herring. Survivors estimates and scaled weights for both tuning fleets.

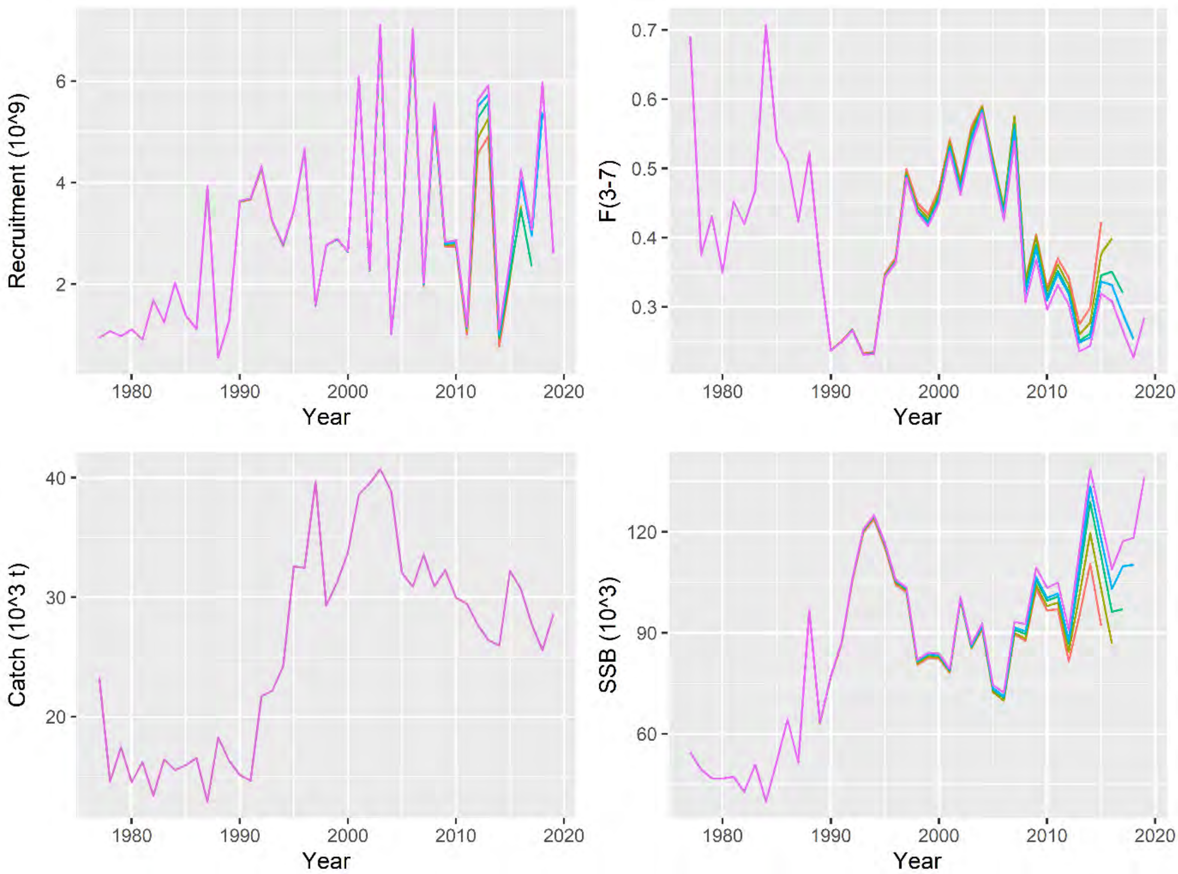


Figure 4.3.10. Gulf of Riga herring. Retrospective analysis (5 years).

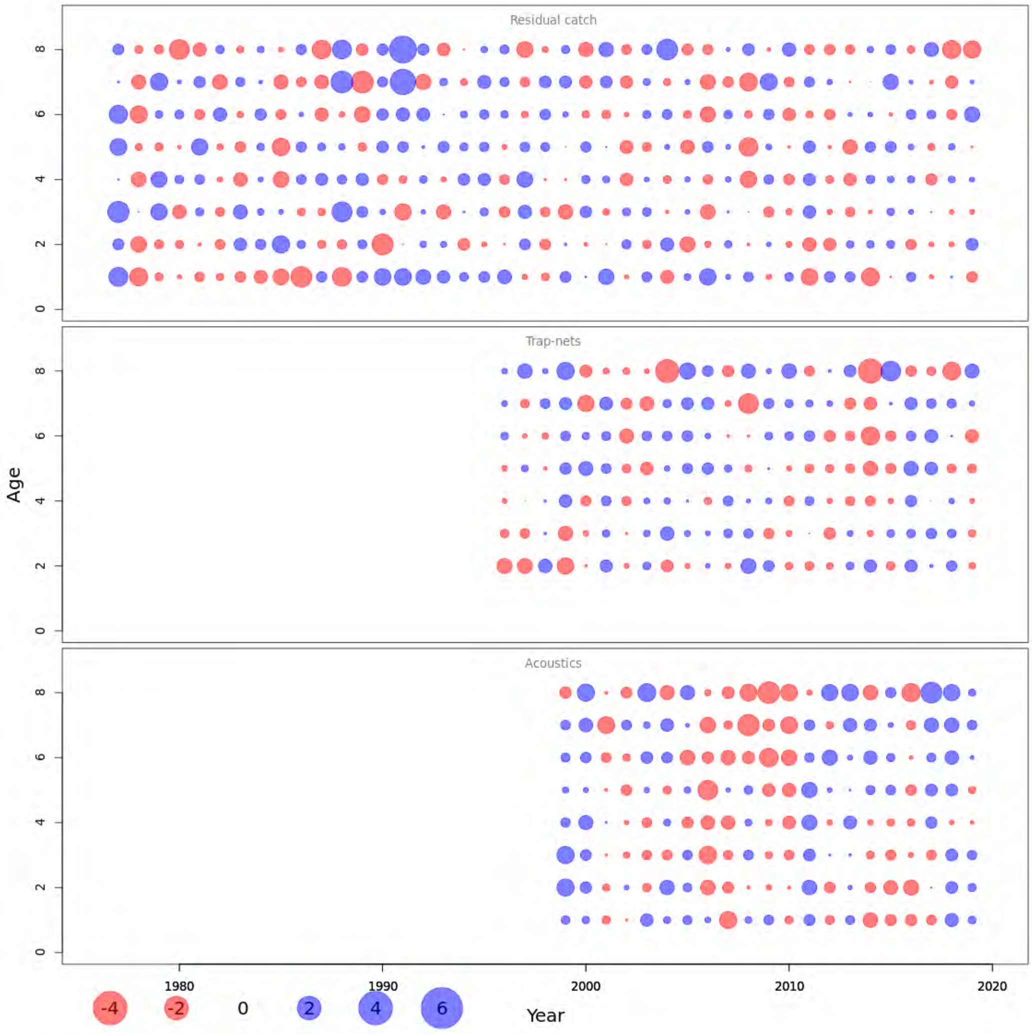


Figure 4.3.11. Gulf of Riga herring. Log catchability residuals from SAM run by fleet and catch.

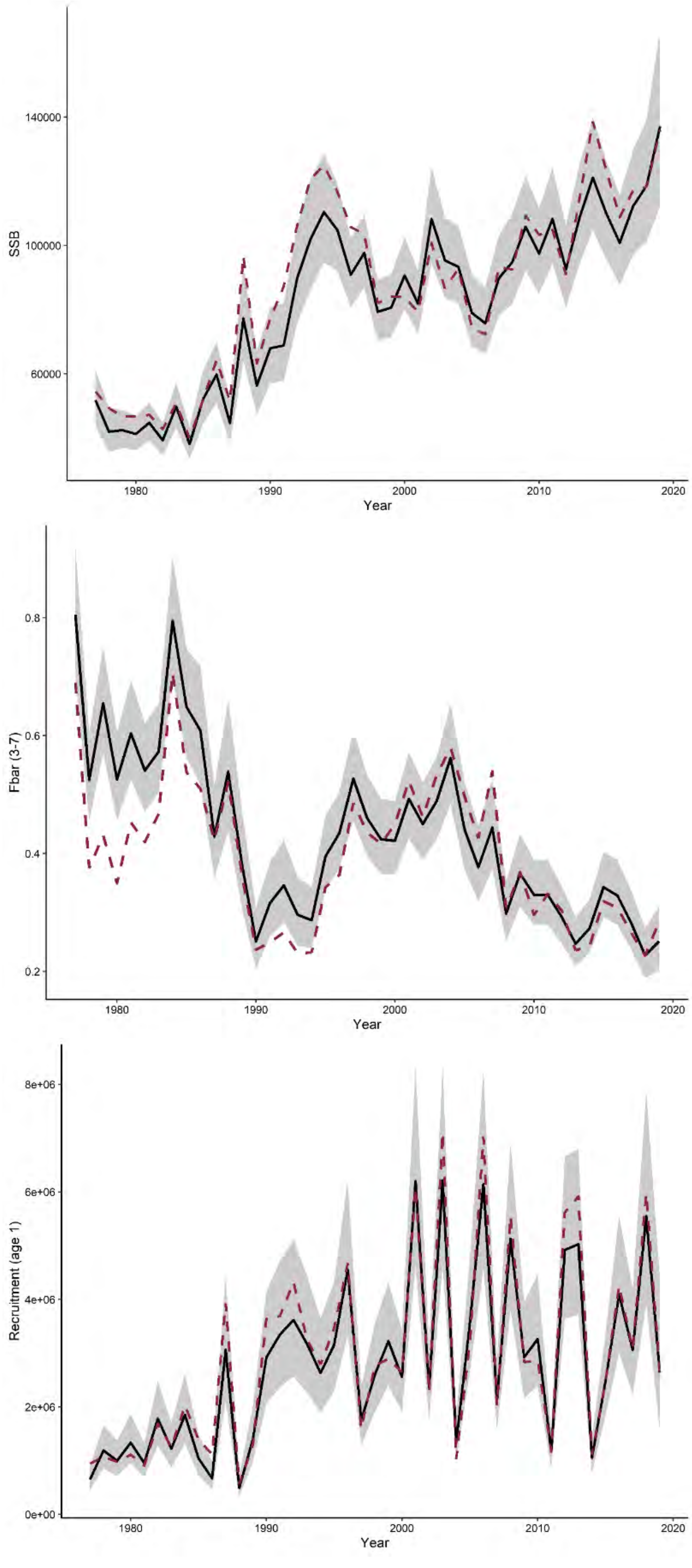
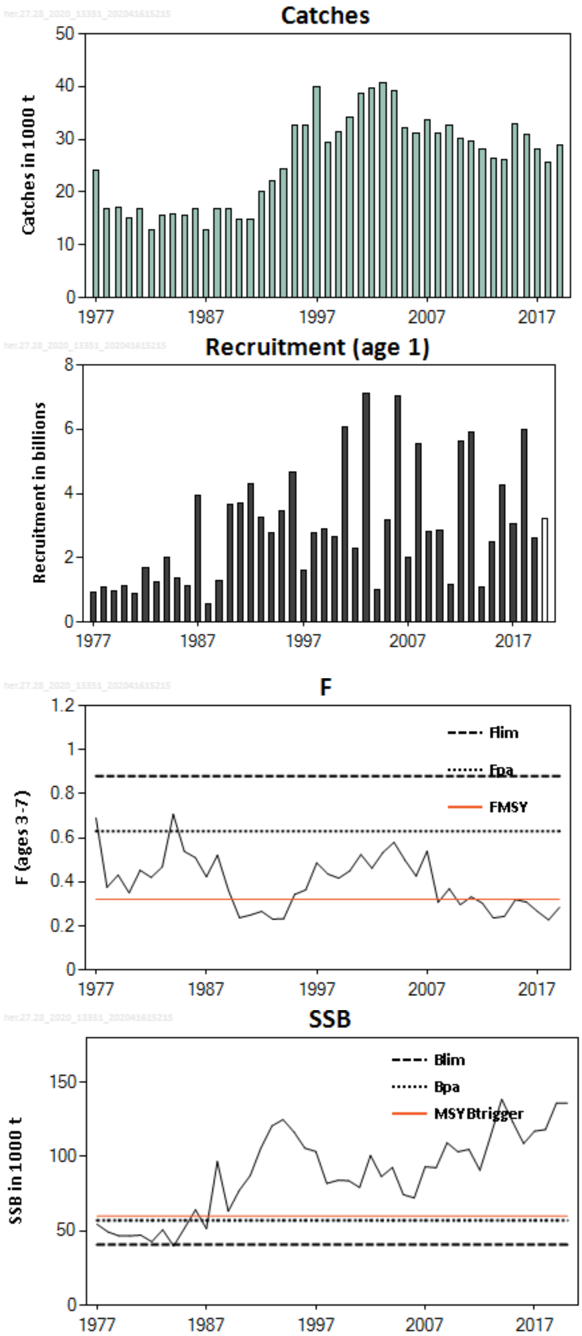


Figure 4.3.12. Gulf of Riga herring. Comparison of spawning stock biomass (SSB in tonnes), fishing mortality ($F_{3\text{-}7}$) and recruitment (age 1 in thousands) from XSA (dashed purple line) and SAM (back, grey shading represents the 95% confidence intervals of the SAM results).


Catches
Catches in 1000 t
50
40
30
20
10
0
1977
1987
1997
2007
2017
Recruitment (age 1)
Recruitment in billions
8
6
4
2
0
F
F (ages 3-7)
Flim
Fpa
FMSY
1.2
1
0.8
0.6
0.4
0.2
SSB
SSB in 1000 t
Blim
Bpa
MSY Btrigger
150
100
50

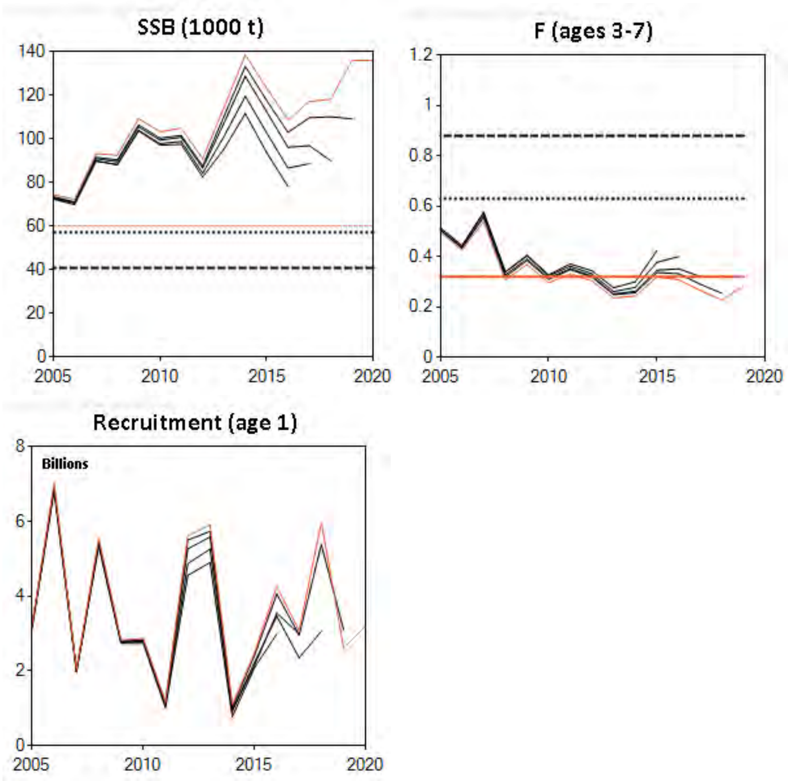


Figure 4.3.13. Gulf of Riga herring. Summary sheet plots: Catches, fishing mortality, recruitment (age 1) and SSB. (Recruitment and SSB in 2020 is predicted). Historical assessment results.

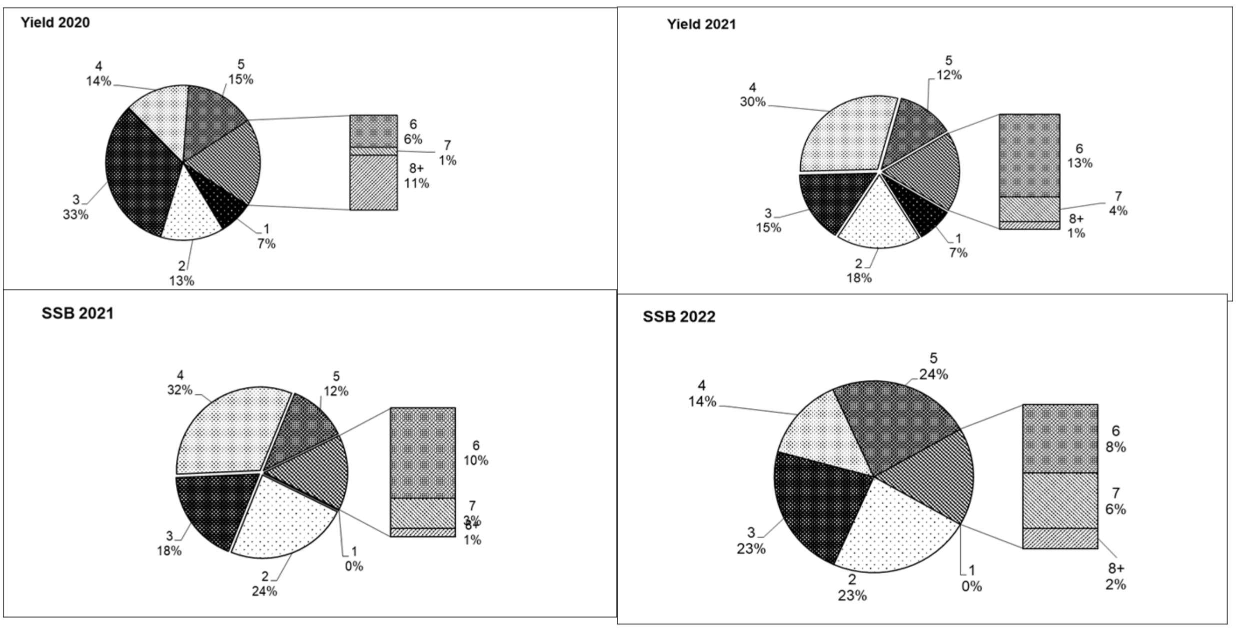


Figure 4.3.14. Gulf of Riga herring. Short term prediction. Age composition of catches and SSB.

4.4 Herring in Subdivisions 30 and 31 (Gulf of Bothnia)

4.4.1 The fishery

The three main fleets operating in Baltic herring fisheries in the Gulf of Bothnia are:

- Pelagic trawling (single and pair trawling)
- Demersal trawling
- Trapnet fisheries (spawning fishery)

In the Finnish trawl fishery, the same trawls are often used in the pelagic trawling near the surface and in deeper mid-water. In 2019, 96.4% of the Finnish landings came from trawl fishery, 3.4% with trapnets, and 0.2% with gill-nets. In 2019, 96.1% of the Swedish catches came from trawls: 94.3% from pelagic trawls, 1.8% from demersal trawls and 3.8% were caught with gill-nets and 0.1% with other passive gears.

4.4.1.1 Landings

The total catch in Gulf of Bothnia decreased by 8 459 tonnes (9%) from 2018 to 88 907 tonnes in 2019 (Figure 4.4.1), of which 82% (73 243 tonnes) was Finnish catch and 17% (15 496 tonnes) was Swedish catch (Table 4.4.1). The Finnish catch decreased by 9% (7 627 tonnes) while the Swedish catch decreased by 5% (832 tonnes) compared to 2018.

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 0.1% of total catches) but 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 fishermen indicated that they estimated the discard rate to be about 10% for the entire year.

Based on the Swedish official statistics and informal interviews 6–12% of Swedish herring catches taken from SD 30 have been discarded in the recent years. This 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

Not used in the assessment in 2020.

4.4.2 Biological information

In 2020, the stock was downgraded to category 5, thus biological information was not used. The aim is to undertake a benchmark of the stock before next year's advice in which the biological information will be validated for incorporation in an analytic assessment

4.4.2.1 Catch in numbers

During the WKCluB meeting in 2020 the age- matrix was expanded from age 10+ to 15+. (Figure 4.4.2). 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. For the catch in numbers calculations in 2019 Finnish and 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. When merging the SD 30 and SD 31 in 2017 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 catches (both in numbers and in terms of biomass) during 2019 catches was age-group 3, and the 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

The average weight at age has decreased for all ages since about the end of 1990's Table 4.4.5 and Figure 4.4.3), but stabilized in the beginning of the 2000. During recent years weights at age have been stable for all age-groups (1 through to 15+, but has clearly decreased in age-groups 6 and 11 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 4.4.4. The annual maturation variation in age-group 2 is usually quite large. The sensitivity of the variability in maturity ogives from year to year was evaluated during the benchmark working group in 2012 and it was concluded to continue the annual determination of maturity ogives (ICES 2012).

4.4.2.4 Quality of catch and biological information

From Finnish commercial catches, 86 length-samples and 65 age-samples were taken during 2019, as well as 18 length-samples and 11 age-samples from the Swedish fisheries. In total, during 2018, 32 519 herring were length-measured, besides 2 462 individuals were aged from commercial catches and 2 770 from acoustic survey (Table 4.4.3).

4.4.3 Fishery independent information

In 2020, the stock was temporarily downgraded in category 5, thus no assessment was conducted and no fishery independent information was used.

4.4.4 Assessment

The assessment for the Gulf of Bothnia herring (SD 3031) in 2019 was not accepted by the Advice Drafting Group and was downgraded from category 1 to 3. The assessment was not accepted based on the poor retrospective diagnostics where the Mohn's rho values were above 20% for SSB, F and recruitment. The Benchmark conducted in 2020 evaluated a new model, Stock Synthesis (SS3) as a candidate for the assessment of Gulf of Bothnia Herring SD30-31 in order to minimize the retrospective pattern previously observed.

A mistake in the input data in the 2019 assessment was detected; the acoustic survey indices were calculated to be higher for the years 2013 to 2015. This was corrected before the data evaluation meeting for the benchmark. A number of model runs were conducted for evaluation at this benchmark. The analysis presented extensive diagnostic tests including the standard ICES criterion related to retrospective patterns. It was noted that the final retrospective pattern had low and acceptable values of Mohn's rho. However, after the benchmark and right before the assessment in April 2020 it was discovered that the survey input data was incorrect which caused the benchmark and the assessment conducted to be invalid. Therefore, the stock was downgraded from category 3 to 5. The advice is now based on the previous advice applying the ICES advice rule for category 5 stocks.

No short-term forecast was performed.

4.4.5 Quality of the assessment

In 2020, the stock was downgraded in category 5, thus no assessment was conducted.

4.4.6 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	16 496	97 366
2019	73243	15664	88 907

Table 4.4.2. Herring in GoB. Allocation of unsampled 2019 catches.

Allocation of 2019 unsampled catches

Unsampled catches						Allocated according to catches					
Country	**Q**	**SD**	**Fleet**	**Cat**	**t**	**Country**	**Q**	**SD**	**Fleet**	**Cat**	**t**
SE	1	30	Gillnet	L	2	<<FI	1	30	Gillnet	L	0.1
SE	2	30	Gillnet	R	30	<<FI	2	30	Pelagic trawl	L	30893
SE	2	30	Pelagic trawl	L	7195	<<FI	2	30	Pelagic trawl	L	30893
SE	2	30	Gillnet	BMS	2	<<FI	2	30	Gillnet	L	96
SE	3	30	Gillnet	R	9	<<FI	3	30	Pelagic trawl	L	3919
FI	3	30	Longline	L	0.02	<<FI	3	30	Pelagic trawl	L	3919
SE	3	30	Passive gears	L	0.2	<<FI	3	30	Trapnet	L	77
SE	3	30	Pelagic trawl	L	1341	<<FI	3	30	Pelagic trawl	L	3919
SE	4	30	Gillnet	R	4	<<FI	4	30	Pelagic trawl	L	12569
FI	4	30	Longline	L	0.01	<<FI	4	30	Pelagic trawl	L	12569
SE	4	30	Passive gears	L	2	<<FI	4	30	Trapnet	L	0.4
SE	4	30	Gillnet	L	26	<<FI	4	30	Gillnet	L	5
SE	4	30	Pelagic trawl	L	1324	<<FI	4	30	Pelagic trawl	L	12569
FI	2	31	Trapnet	R	10	<<FI	2	31	Trapnet	L	44
FI	2	31	Gillnet	R	0.04	<<FI	2	31	Pelagic trawl	L	1473
SE	2	31	Passive gears	R	1	<<FI	2	31	Pelagic trawl	L	1473
SE	2	31	Gillnet	R	0.4	<<FI	2	31	Pelagic trawl	L	1473
SE	2	31	Passive gears	L	7	<<FI	2	31	Trapnet	L	44
FI	3	31	Trapnet	R	1	<<FI	3	31	Trapnet	L	12
FI	3	31	Gillnet	R	1	<<FI	3	31	Pelagic trawl	L	520
SE	3	31	Gillnet	R	0.1	<<FI	3	31	Pelagic trawl	L	520
SE	3	31	Passive gears	L	1	<<FI	3	31	Trapnet	L	12
SE	3	31	Bottom trawl	L	32	<<FI	3	31	Pelagic trawl	L	520
SE	3	31	Gillnet	BMS	0.01	<<FI	3	31	Gillnet	L	3.82
SE	3	31	Bottom trawl	BMS	8	<<FI	3	31	Pelagic trawl	L	520
FI	4	31	Trapnet	R	0.004	<<FI	4	31	Trapnet	L	0.7
FI	4	31	Gillnet	R	0.4	<<FI	4	31	Pelagic trawl	L	59
SE	4	31	Gillnet	R	0.3	<<FI	4	31	Pelagic trawl	L	59
SE	4	31	Bottom trawl	L	107	<<FI	4	31	Pelagic trawl	L	59
SE	4	31	Passive gears	L	0.1	<<FI	4	31	Trapnet	L	0.7
SE	4	31	Gillnet	L	1	<<FI	4	31	Gillnet	L	4
SE	4	31	Bottom trawl	BMS	10	<<FI	4	31	Pelagic trawl	L	59
Total					**10115**	**Total**					**118288**

Table 4.4.3 Herring in GoB. Landings and sampling by country in 2019

Table 4.4.3 Herring in SD´s 30 and 31. Landings and sampling by country in 2019

Country	ICES Sub Division	Landing	Quarter	Number of length samples	Number of fish measured	Number of age samples	Number of fish aged
Finland	30	21206	1	13	4011	13	268
		33317	2	23	7090	14	351
		4016	3	10	2467	8	1536
		12574	4	18	4922	15	256
		71113	**Total**	64	18490	50	2411
Sweden	30	4916	1	1	780		
		7712	2	7	3838	3	210
		1420	3	3	1010	2	1603
		1382	4	2	1367		
		15430	**Total**	13	6995	5	1813
Finland	31		1				
		1519	2	11	3032	7	281
		536	3	6	1806	6	234
		64	4	5	700	2	108
		2118	**Total**	22	5538	15	623
Sweden	31		1				
		27	2	3	1230	3	242
		35	3	2	247	2	143
		118	4				
		180	**Total**	5	1477	5	385
Finland & Sweden	30 + 31	26149	1	14	4791	13	268
		42583	2	44	15190	27	1084
		6006	3	21	5530	18	3516
		14138	4	25	6989	17	364
		88877	**Total**	104	32500	75	5232

SD 30 Q3 and Q 4 age sampling has in addition 28 age samples with 2770 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	11	12	13	14	15+
1980	124930	112920	61920	66620	262270	90230	96830	57120	21975	30323	5895	2811	1183	247	286
1981	27570	124000	59130	48010	57110	136920	54220	40650	22597	11658	13766	2519	795	1474	322
1982	26810	107840	270020	60380	49410	73080	114910	32730	32040	11800	7946	7603	1062	232	636
1983	102120	191340	104320	178520	23900	32000	48610	86810	21824	19309	9494	3865	1078	350	90
1984	142210	291180	209560	109520	132580	25450	25350	35000	57350	16341	18625	6698	1858	2977	410
1985	95150	373640	319790	144620	50160	88430	17750	15850	18317	40024	9750	8678	4106	1398	1406
1986	19100	406380	354920	217790	100740	47350	56500	9160	11426	17052	19772	5067	4659	1316	3128
1987	49170	77260	232130	254920	143520	69250	43370	21590	10706	11158	11786	8275	1000	1565	1280
1988	16480	226490	86310	203000	213910	122760	52930	26270	15435	10315	9527	6402	4451	1191	1119
1989	99380	79740	181120	70520	127840	133340	71910	28950	14631	8078	5861	5109	1719	2117	1157
1990	199890	511580	63700	131380	47270	99210	114320	47820	17975	16514	5758	3026	2325	1822	3729
1991	44190	224870	341910	48990	92540	58850	71890	46920	27505	10661	7624	4912	1813	1578	2707
1992	89540	232470	463390	358030	67780	81820	74790	55710	28937	14405	6138	6295	4256	1466	733
1993	222810	391710	211390	348550	317940	53970	62080	40350	25885	12762	7927	3603	628	954	1411
1994	84500	404060	361710	221140	347250	311050	48400	78140	34470	20947	10128	3331	906	525	323
1995	109660	249730	515960	325460	230160	287240	205880	41230	61001	19404	19283	4994	2791	2140	819
1996	109490	519790	247930	337900	258500	165210	203360	129180	18462	21710	8082	8768	1266	516	2865
1997	141310	407600	490200	274540	317290	230680	187540	150140	91849	13440	22691	6617	3811	1860	623
1998	296540	259230	337110	363200	238600	180210	160460	67120	53018	90747	34401	34744	16180	6027	3392
1999	147710	694270	312710	373660	278140	163180	216350	79080	57399	78561	27613	16886	10011	5538	1523
2000	289776	211673	433968	326427	200555	209571	118562	76728	62365	105656	46388	45821	27266	13185	11348
2001	266243	450302	203894	460811	167923	140134	139361	92518	68976	40305	103933	27796	18453	13735	10904
2002	308482	270574	404072	159300	216521	101917	58483	90625	82209	38414	41400	38165	29161	30350	19603
2003	305396	425299	267888	246267	177145	185773	67146	57477	49827	48923	49420	31533	25123	28618	27325
2004	104393	1021965	490316	243896	200519	143971	136323	65848	59707	39436	34104	25166	25094	25338	16658
2005	172165	238898	1189611	337559	182116	161536	87738	95355	76075	48573	35780	26610	16502	23875	12096
2006	176592	292909	132105	1061307	379704	161606	94974	128742	90335	57131	87244	24995	31028	18760	11643
2007	552847	660118	357542	168654	1017283	275806	92438	127731	87818	43966	51214	28743	19447	22977	13137
2008	266434	873384	327757	318645	218789	404664	186749	126807	94630	57204	51571	23608	17948	9705	16501
2009	268319	446210	586402	414737	128103	131399	355613	143488	82792	56912	33126	35109	18479	13428	21903
2010	297532	820306	481726	418950	286816	105453	82757	234997	86170	75015	19577	27325	21106	13041	16423
2011	251376	634214	569108	374424	369070	174016	92440	81609	247597	95550	82767	41832	22936	15236	49513
2012	512943	429102	696213	573553	364869	348220	183169	148802	82567	242740	120868	52298	48163	21863	25420
2013	486237	894795	530634	396023	567340	299623	294588	182312	95551	105273	109550	60420	50663	20657	48283
2014	434458	701891	753506	267860	427997	284267	225170	212795	118943	71664	65706	76491	63442	46905	61302
2015	1378190	913322	725069	450623	325361	247165	222505	150439	112138	55306	26751	47904	91521	21057	45589
2016	821289	1663093	811016	466569	337671	225412	268940	147995	125977	92024	44509	34376	31239	70054	90905
2017	742230	859392	1172496	435129	294949	133535	101620	128330	87524	58511	56329	62840	24453	23704	71325
2018	380824	1153984	573476	737474	299807	184310	104430	100232	60145	62283	29064	56602	24736	14416	53408
2019	460671	610074	792040	410444	59170	216637	134556	108043	44082	42040	24349	22425	25410	5233	39223

Table 4.4.5 Herring in SD's 30 and 31 Weights at age (g) in catches

	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12	AGE 13	AGE 14	AGE 15+
1980	11	21	26	32	35	38	40	45	50	56	58	57	77	62	93
1981	12	20	27	34	41	42	46	49	54	59	68	68	65	110	75
1982	10	19	28	35	39	43	45	50	52	60	61	67	80	73	84
1983	12	21	32	38	44	50	52	56	63	63	70	81	92	103	106
1984	13	22	32	40	45	51	58	61	59	63	67	82	74	72	115
1985	10	20	30	38	42	47	52	56	58	60	64	72	76	71	80
1986	12	18	27	35	40	45	48	50	59	58	63	63	68	81	63
1987	10	22	29	35	42	46	51	57	60	61	66	67	66	74	90
1988	11	21	32	37	42	48	54	61	62	70	72	78	77	84	90
1989	12	24	33	42	47	52	56	61	67	65	71	76	81	82	117
1990	10	19	32	39	45	51	57	60	69	72	75	93	85	79	94
1991	12	22	28	36	41	48	53	55	59	64	67	71	72	80	80
1992	12	20	27	30	40	44	50	54	58	65	64	72	65	87	72
1993	11	19	27	31	34	44	50	55	60	64	67	71	79	93	95
1994	12	21	28	33	36	40	49	56	62	69	74	70	77	46	85
1995	9	19	27	30	35	39	43	52	62	68	76	94	87	104	102
1996	11	17	26	32	34	40	44	49	58	64	69	76	70	98	87
1997	9	16	23	29	34	37	43	47	54	64	69	71	91	86	92
1998	8	14	21	28	34	41	44	56	58	67	82	83	112	97	110
1999	8	13	21	26	33	41	46	54	57	63	74	79	86	103	121
2000	8	14	20	25	29	34	39	41	46	56	55	65	71	69	78
2001	9	15	22	27	29	33	40	42	47	48	58	62	62	68	78
2002	8	16	23	27	31	35	39	44	48	54	58	58	66	75	88
2003	8	16	23	27	31	35	40	42	49	57	61	62	62	71	85
2004	7	14	20	26	30	37	39	43	49	53	60	59	64	73	63
2005	8	13	20	25	30	32	39	39	43	45	48	50	45	57	55
2006	8	15	19	23	27	33	35	38	40	43	43	45	51	54	51
2007	7	15	21	25	27	31	36	39	43	44	48	50	52	52	64
2008	9	15	21	23	28	29	33	38	40	46	54	47	54	62	51
2009	10	16	21	24	30	31	35	37	41	44	52	51	57	56	56
2010	8	17	23	26	29	35	33	39	44	43	50	58	55	55	67
2011	9	16	23	27	29	33	36	39	42	43	48	50	50	60	53
2012	9	17	24	27	30	36	39	41	46	49	50	53	57	57	68
2013	13	20	25	29	32	35	37	39	44	46	46	47	52	53	57
2014	10	18	26	29	33	40	43	46	48	49	49	60	56	59	70
2015	13	19	25	29	32	37	39	43	44	47	52	51	55	53	54
2016	12	17	23	28	32	35	38	45	48	52	53	54	65	66	62
2017	10	18	23	27	32	38	39	42	48	53	56	55	59	62	67
2018	10	18	24	28	32	37	37	41	47	50	61	49	58	65	62
2019	10	17	24	30	32	34	39	43	47	51	51	53	56	64	64

Table 4.4.6 Herring in Gulf of Bothnia. Maturity ogive.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1980	0.00	0.31	0.92	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1981	0.00	0.31	0.93	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1982	0.00	0.29	0.93	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1983	0.00	0.21	0.92	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1984	0.00	0.23	0.93	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1985	0.00	0.20	0.92	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1986	0.00	0.28	0.91	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1987	0.00	0.32	0.89	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1988	0.00	0.10	0.85	0.96	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1989	0.00	0.23	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1990	0.00	0.59	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1991	0.00	0.59	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1992	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1993	0.00	0.44	0.82	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1994	0.00	0.63	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1995	0.00	0.35	0.91	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1996	0.00	0.66	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1997	0.00	0.32	0.84	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1998	0.03	0.33	0.72	0.96	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1999	0.01	0.38	0.88	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2000	0.11	0.65	0.93	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2001	0.01	0.61	0.97	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2002	0.03	0.58	0.96	0.97	0.99	0.96	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2003	0.00	0.56	0.94	0.97	0.96	1.00	1.00	0.89	0.89	1.00	1.00	1.00	1.00	1.00	1.00
2004	0.02	0.34	0.91	0.97	1.00	1.00	1.00	1.00	1.00	0.96	1.00	1.00	1.00	1.00	1.00
2005	0.02	0.28	0.86	0.96	0.94	0.97	1.00	1.00	1.00	0.96	1.00	1.00	1.00	1.00	1.00
2006	0.02	0.37	0.92	0.91	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2007	0.02	0.56	0.87	1.00	0.96	1.00	1.00	0.90	1.00	0.97	1.00	1.00	1.00	1.00	1.00
2008	0.00	0.50	0.91	1.00	0.93	1.00	1.00	1.00	1.00	0.94	1.00	1.00	1.00	1.00	1.00
2009	0.00	0.51	0.91	0.95	0.95	0.91	0.97	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2010	0.05	0.87	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2011	0.01	0.46	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.00	1.00	1.00	1.00	1.00
2012	0.01	0.75	0.97	0.98	1.00	1.00	0.94	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00
2013	0.11	0.78	0.98	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00	1.00
2014	0.16	0.71	1.00	1.00	1.00	1.00	0.94	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2015	0.13	0.80	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2016	0.05	0.72	0.90	1.00	1.00	1.00	1.00	1.00	1.00	0.92	1.00	1.00	1.00	1.00	1.00
2017	0.11	0.76	0.98	0.99	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00	1.00
2018	0.16	0.88	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00	1.00
2019	0.08	0.83	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.94

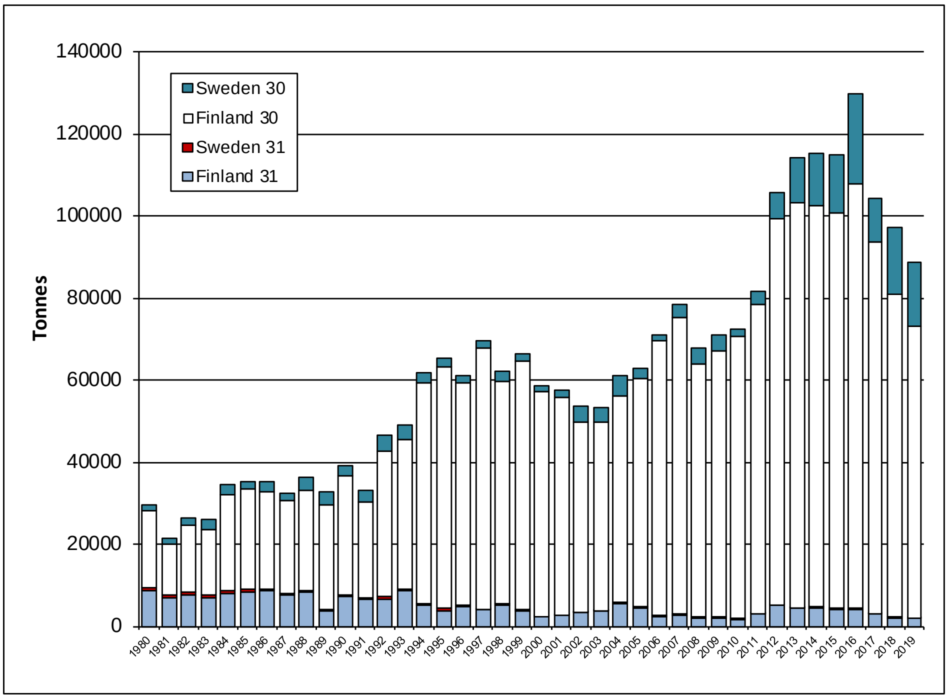


Figure 4.4.1 Herring in SD's 30 and 31. Catches by country

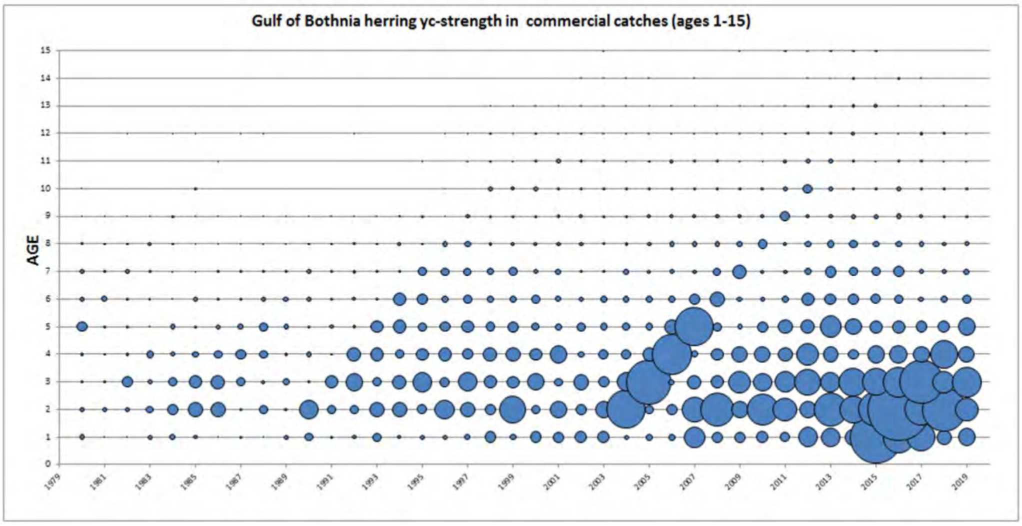


Figure 4.4.2. Herring in SD's 30 and 31 Age composition in commercial catch

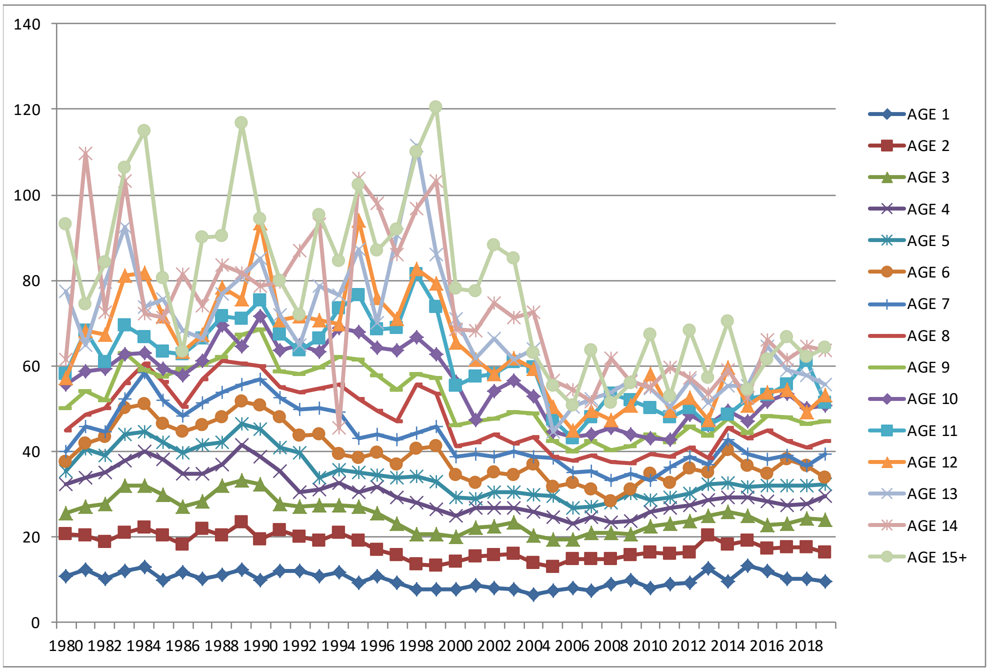


Figure 4.4.3 Herring in SD's 30 and 31 Weights at age in catches

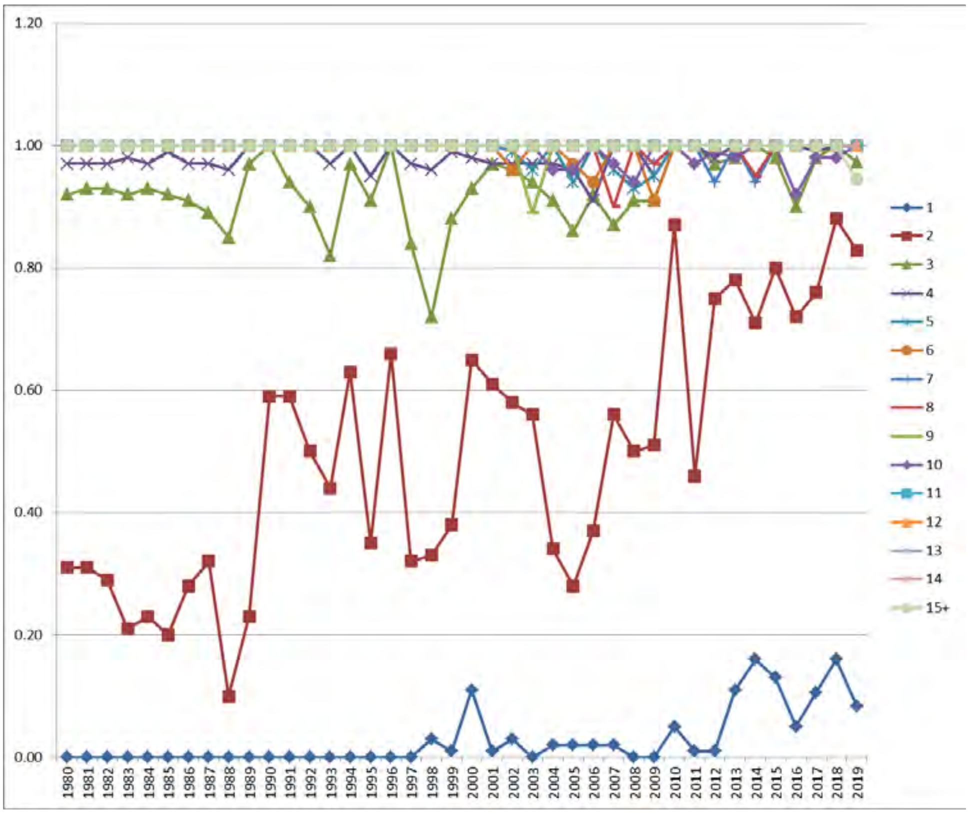


Figure 4.4.4. Herring in SD’s 30 and 31. Maturity ogive 1980-2019

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 consist of two stocks. One stock (ple.27.21–23) is defined by the Subdivision 21 (i.e. Kattegat), Subdivision 23 (i.e. the Sound) and Subdivision 22 (i.e. the 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 a 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-sixties 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 cod-end. 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 the cod stock in Kattegat, Denmark and Sweden, introduced protected areas on historically important spawning grounds in South-East Kattegat. The protected zone consists of three different areas in which the fisheries are either completely forbidden or limited to certain selective gears (Swedish grid and Danish SELTRA 300 trawl) during all or different periods of the year.

From 1st of January 2017, 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 for each subdivision is given in Figure 5.2.3.

5.2.1.3 Unallocated removals

No significant misreporting is believed to take place.

5.2.1.4 Discards

Discard data are only available back to 2002. SAM can handle if minor gaps exist the data series but cannot handle long periods of missing data. As discard information are only available back to 2002, the discard time-series is extended three years back to 1999 (based on average discards from 2002–2004) to provide a time-series sufficiently long for the assessment. The discard estimates are processed in InterCatch and consistent throughout the whole time-series (2002–2019).

Discard and landings (2019) by gear type and quarter is given in Table 5.2.2 and Figure 5.2.4a.

After raising, the discard ratio across the whole stock was 20% in 2019, which is lower than in 2018 follows a decreasing trend over the last five years (Figure 5.2.4b)

In 2019, the discards ratio was estimated as 51% in Kattegat (SD 21), 18% in SD 22 and 14% in SD 23 (Figure 5.2.4c).

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, the 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. Germany is continuing to investigate methods for SW Baltic plaice but so far there is no solution proposed to solve the age-reading discrepancies. In parallel, Denmark reports a North Sea / Skagerrak plaice otolith exchange programme underway which may help inform methodology for this stock.

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 97% of the total landings, and 94% 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), Table 5.2.4e (discards) and Table 5.2.4g (catch). Mean weight at age in catch over the entire time-series and for 2019 is presented in Figure 5.2.6.

Mean weight in stock is obtained from Combined 1 quarter surveys but is used as an average from 2002–2019. The procedure for calculating this average was updated in 2019 (the same procedure as used for Western Baltic cod) (Table 5.2.4f and 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 (Table 5.2.4d).

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 good except for Subdivision 23 where low numbers of samples are taken by Denmark and none by Sweden (Table 5.2.3). The low sampling for area 23 should be considered in the context of the relatively limited catches from that area (2.8% 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.

The BITS Q4 survey indices for all age groups was very low in 2019. This decrease in the tuning indices (especially for ages 2-4) was investigated in the raw data and checked with national survey operators, who determined that the reported low survey catches in 2019 were real observations, not erroneous. A potential explanation may be the abnormally low oxygen conditions in the basins where the majority of survey hauls take place (2019 compared to 2018 and 2017) (Velasco, 2019; 2018; and 2017). Plaice may have been excluded from these areas and hence the population was not properly surveyed.

A major change was introduced during WGBFAS 2019, in an attempt to reduce the large retrospective patterns observed with the previous model setup. Age 6 are now included in the survey tuning indices. 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).

Another change in the survey data was introduced in 2019. In 2019, it was determined, that at the time when 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 (see 2019 WGBFAS report).

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 2020 followed this method and only survey data until 2019 have been included in this assessment. After the WGBFAS meeting Denmark has stated that they can now reliably provide age reading of Q1 survey samples before the WGBFAS meeting, therefore, the decision to exclude the Q1 survey data from the year of assessment should be revisited in 2022 (after 3 years of data being provided on time).

5.2.4 Assessment

The stock is a Category 1 (Full annual age-based analytical assessment). The State-based Assessment Model (SAM) is used. In addition to the changes to the data introduced to the model, that were made in the 2019 assessment review, one further change was made in the model setup. The fishing mortality of ages 6-7+ were decoupled from age 5. This change, along with the other data changes, were carried forward into the 2020 SPALY assessment.

The SPALY assessment deviated substantially from last year (Figure 5.2.11), and performed sub-optimally. This is observed in retrospective patterns, with a Mohn's rho estimate of 26% for the SSB and -26% for F (Figure 5.2.12).

Investigation of the residuals revealed large negative residuals in the combined Q3 IBTS and Q4BITS survey indices across all ages (Figure 5.2.13). These residuals were traced back to the low catches that were reported (and confirmed observed) in the Q4 BITS survey of 2019.

The "Leave-one-out analysis" shows that the combined Q3-Q4 survey is what drives the decrease in SSB and increase in F relative to the 2019 assessment (Figure 5.2.14).

This SPALY run in SAM is named: ple.27.21-23_WGBFAS_2020_v6. The assessment is 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

In addition to this SPALY assessment a secondary assessment was made with a single change; the 2019 Q3-Q4 combined indices were set to "missing" in the input data (actual values: -9) for all ages. The exclusion of this one year's survey index brought the 2020 assessment in line with the 2019 assessment (Figure 5.2.15) and substantially reduced the patterns in the retrospective analyses (Figure 5.2.16). This secondary assessment is named ple.27.21-23_WGBFAS_2020_v5 and is also visible for everybody on "stockassessment.org".

5.2.4.1 Recruitment estimates

The high recruitment estimates for 2017 and 2018 from earlier assessments have been reduced in the 2020 assessment, although they remain relatively high compared to the time-series. The estimates for 2019 are very low at ~17 million, which is the lowest in the time-series.

5.2.4.2 Historical stock trends

The stock is in good condition, and remains above MSY Btrigger since 2014. The result shows that after an increase in biomass early in the last decade, from a lowest observed SSB at 3.6 kt in 2009, that the SSB has levelled off around 7-8 kt in the last four years.

After a reduction in fishing mortality early in the decade (2008-2014), F appears to be again steadily increasing and is currently above FMSY and approaching F_{pa}.

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 currently not utilised, the forecasts use 2019 as the base year and project until 2022. Intermediate year (2020) assumption is status quo F (0.0.586 in 2020, = F_{2019}). Recruitment for 2020 and 2021 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 (2017-2019).

In 2020, advice for this stock was requested according to the MSY approach, a change from 2019 where advice according to the precautionary approach was requested. This change in the basis for advice is responsible for a large portion of the decrease in the advised catch. (See Annex 9)*.

5.2.6 Reference points

Reference points were reviewed, together with assessment changes, in 2019. The 2020 assessment uses these same reference point values which are available in Table 5.2.8.

5.2.7 Quality of assessment

The quality of the assessment has declined in 2020, probably due to anomalous conditions during the Q4 BITS survey leading to large reductions in the tuning indices. Because of these anomalous conditions a secondary assessment, with the relevant survey indices removed, has been presented to and accepted by WGBFAS.

The large decrease in the 2019 Q4 survey index in the SPALY assessment has led to a revision of the recent history of the stock status. Therefore, the perception of the stock differs significantly from last year, with a downward estimation of SSB and of 2017 and 2018 recruitment, as well as an upward estimation of fishing mortality. This assessment has retrospective fit issues.

The secondary assessment, with the anomalous survey indices removed, matches more closely past views of the stock. This assessment continues the increase in SSB observed in recent history, maintains the high recruitment estimated for 2017 and 2018, and estimates that fishing mortality approaches FMSY. The retrospective analyses of this assessment are much more acceptable, however, the exclusion of confirmed real survey data requires substantial justification.

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 2019. This procedure was adopted in 2016 and used since then.

The catch ratio between SD 21 and SDs 22–23 in 2019 was used to calculate a split of the advised catches for 2021, and a similar calculation was done for the landings only. The advised catch for the stock in SDs 24–32 Figure 2.5.4 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. Using the secondary assessment results for ple.27.21-23, this results in catches of no more than 719 tonnes in SD 21 and 7754 tonnes in SDs 22–32 (See Annex 9).

Updated in June 2020, for additional information please refer to Annex 9.

Table 5.2.1. Plaice in SD 27.21–23. Official landings (t) by Subdivision and country. 1970–2019.

	SD 21			SD 22			SD 23		Total
Year	Denmark	Germany	Sweden	Denmark	Germany	Sweden	Denmark	Sweden	
1970				3757	202				3959
1971				3435	160				3595
1972	15504	77	348	2726	154				18809
1973	10021	48	231	2399	165				12864
1974	11401	52	255	3440	202				15350
1975	10158	39	296	2814	313				13620
1976	9487	32	177	3328	313				13337
1977	11611	32	300	3452	353				15748
1978	12685	100	312	3848	379				17324
1979	9721	38	333	3554	205				13851
1980	5582	40	313	2216	89				8240
1981	3803	42	256	1193	80				5374
1982	2717	19	238	716	45				3735
1983	3280	36	334	901	42				4593
1984	3252	31	388	803	30				4504
1985	2979	4	403	648	94				4128
1986	2470	2	202	570	59				3303
1987	2846	3	307	414	18				3588
1988	1820	0	210	234	10				2274
1989	1609	0	135	167	7				1918
1990	1830	2	202	236	9				2279
1991	1737	19	265	328	15				2364
1992	2068	101	208	316	11				2704
1993	1294	0	175	171	16			2	1658
1994	1547	0	227	355	1			6	2130
1995	1254	0	133	601	75		64	12	2127
1996	2337	0	205	859	43	1	81	13	3526
1997	2198	25	255	902	51			13	3431

	SD 21			SD 22			SD 23		Total
Year	Denmark	Germany	Sweden	Denmark	Germany	Sweden	Denmark	Sweden	
1998	1786	10	185	642	213			13	2836
1999	1510	20	161	1456	244	1		13	3392
2000	1644	10	184	1932	140			26	3910
2001	2069		260	1627	58			39	4014
2002	1806	26	198	1759	46			42	3835
2003	2037	6	253	1024	35	0		26	3355
2004	1395	77	137	911	60			35	2580
2005	1104	47	100	908	51		145	35	2355
2006	1355	20	175	600	46		166	39	2362
2007	1198	10	172	894	63		193	69	2531
2008	866	6	136	750	92	0	116	45	1966
2009	570	5	84	633	194	0	139	42	1626
2010	428	3	66	748	221	0	57	17	1524
2011	328	0	40	851	310		46	11	1575
2012	196	0	30	1189	365	7	54	12	1841
2013	232	0	60	1253	319	0	14	76	1955
2014	343	1	68	1097	320	0	57	45	1931
2015	807	0	87	1103	560	0	26	103	2687
2016	984	1	121	1108	680	0	107	20	3020
2017	703	1	97	1424	939	0	70	13	3247
2018	482	1	51	1708	1080	0	111	13	3474
2019	332	4	28	2342	1504	0	102	24	3700

Table 5.1.2. Plaice in SD 27.21–23. Landings (tonnes) and discard (tonnes) in 2019 by Subdivision, fleet, and quarter.

	1	**2**	**3**	**4**	**Total**
27.3.a.21	142.7595	153.7877	208.2056	243.4135	748.1664
Discards	60.14201	80.44669	135.6335	108.7022	384.9245
Active	59.44921	76.59996	132.9643	105.1206	374.1341
Passive	0.6928	3.84673	2.6692	3.58161	10.79034
Landings	82.6175	73.341	72.5721	134.7113	363.2419
Active	73.4684	58.1055	64.812	119.0583	315.4442
Passive	9.1491	15.2355	7.7601	15.653	47.7977
27.3.b.23	25.47387	49.91493	50.85596	26.79062	153.0354
Discards	7.64527	8.93613	5.02366	6.15382	27.75888
Active	4.85185	5.92967	3.01781	2.64615	16.44548
Passive	2.79342	3.00646	2.00585	3.50767	11.3134
Landings	17.8286	40.9788	45.8323	20.6368	125.2765
Active	5.996	4.498	1.471	2.997	14.962
Passive	11.8326	36.4808	44.3613	17.6398	110.3145
27.3.c.22	2318.745	611.3755	410.301	1146.396	4486.817
Discards	480.796	30.51348	43.28503	86.31366	640.9081
Active	471.206	29.394	41.613	79.198	621.411
Passive	9.58997	1.11948	1.67203	7.11566	19.49714
Landings	1837.949	580.862	367.016	1060.082	3845.909
Active	1667.695	463.172	307.598	911.336	3349.801
Passive	170.254	117.69	59.418	148.746	496.108
Total	**2486.978**	**815.0781**	**669.3626**	**1416.6**	**5388.019**

Table 5.2.5.2. Plaice in SD 27.21–23. Sampling effort 2019 by country, gear type and area.

	Sum of Catch (t)	Length Samples	Lengths Measured	Age Samples	Age Readings
27.3.a.21	748.16636	137	13039	127	3018
Discards	384.92446	91	4403	81	1150
Denmark	351.6999	61	3334	61	729
Active	343.338	61	3334	61	729
Passive	8.3619	0	0	0	0
Germany	3.72605	0	0	0	0
Active	3.47162	0	0	0	0
Passive	0.25443	0	0	0	0
Sweden	29.49851	30	1069	20	421
Active	27.3245	20	586	20	421
Passive	2.17401	10	483	0	0
Landings	363.2419	46	8636	46	1868
Denmark	331.626	46	8636	46	1868
Active	289.808	23	4318	23	934
Passive	41.818	23	4318	23	934
Germany	3.573	0	0	0	0
Active	2.763	0	0	0	0
Passive	0.81	0	0	0	0
Sweden	28.0429	0	0	0	0
Active	22.8732	0	0	0	0
Passive	5.1697	0	0	0	0
27.3.b.23	153.03538	4	334	4	92
Discards	27.75888	0	0	0	0
Denmark	24.11161	0	0	0	0
Active	16.44548	0	0	0	0
Passive	7.66613	0	0	0	0
Sweden	3.64727	0	0	0	0
Passive	3.64727	0	0	0	0
Landings	125.2765	4	334	4	92

	Sum of Catch (t)	Length Samples	Lengths Measured	Age Samples	Age Readings
Denmark	101.68	4	334	4	92
Active	14.962	2	167	2	46
Passive	86.718	2	167	2	46
Sweden	23.5965	0	0	0	0
Passive	23.5965	0	0	0	0
27.3.c.22	4486.81714	133	21634	133	4863
Discards	640.90814	51	3402	51	868
Denmark	478.91026	30	2149	30	307
Active	471.991	30	2149	30	307
Passive	6.91926	0	0	0	0
Germany	161.99675	21	1253	21	561
Active	149.42	13	1175	13	556
Passive	12.57675	8	78	8	5
Sweden	0.00113	0	0	0	0
Passive	0.00113	0	0	0	0
Landings	3845.909	82	18232	82	3995
Denmark	2341.628	58	10538	58	2316
Active	2172.454	29	5269	29	1158
Passive	169.174	29	5269	29	1158
Germany	1504.261	24	7694	24	1679
Active	1177.347	11	3739	11	1009
Passive	326.914	13	3955	13	670
Sweden	0.02	0	0	0	0
Passive	0.02	0	0	0	0
Grand Total	**5388.01888**	**274**	**35007**	**264**	**7973**

Table 5.2.5.3a. 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
2019	0.00	0.18	0.57	0.74	0.89	0.85	0.93	0.99	1.00	0.98

Table 5.2.4b. Plaice in SD 27.21–23. Maturity ogive.

	age1	age2	age3	age4	age5	age6	age7	age8	age9	age10
Mean (1999-2019)	0.17	0.58	0.75	0.87	0.95	0.97	0.98	0.99	0.99	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

Year	1	2	3	4	5	6	7	8	9	10+
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
2019	NA	0.248	0.270	0.296	0.361	0.378	0.448	0.528	0.479	0.701

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

Year	1	2	3	4	5	6	7	8	9	10+
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
2019	0.065	0.102	0.126	0.135	0.156	0.136	0.167	0.354	0.170	0.350

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(1999–2019)	0.031	0.077	0.131	0.201	0.248	0.285	0.302	0.336	0.461	0.462

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

Year	1	2	3	4	5	6	7	8	9	10+
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
2019	0.065	0.128	0.208	0.255	0.338	0.341	0.427	0.526	0.478	0.695

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

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
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
2019	302677	2950727	10360430	4532742	1998352	1247147	578394	262947	194713	140809

Table 5.2.4i. Plaice in SD 27.21–23. Survey indices NS-IBTS and BITS combined.

Q1	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1999	1190.9011	9250.2853	4072.5737	992.8679	508.8323	48.932
2000	2968.6652	23750.4863	10235.8911	1570.9987	470.0777	281.1228
2001	1005.2716	13526.2269	13129.4061	2905.1497	404.8263	169.1991
2002	1578.1131	3882.2584	9832.714	4805.525	964.7235	227.7353
2003	1506.755	16280.2099	6861.7229	6963.9776	3519.2481	505.3465
2004	1009.7844	5833.8563	11254.6221	4763.2531	2926.9197	1864.9708
2005	1197.9634	13008.3037	10917.7219	5392.1003	1823.818	1652.1062
2006	307.2169	7988.017	16403.7417	6171.9341	2439.4982	499.1365
2007	1049.0005	7135.1884	12078.946	8697.5635	2131.8399	914.7072
2008	1486.9311	5484.9601	6676.854	3298.8506	1064.8186	368.8642
2009	902.3793	4555.6905	7301.3709	3355.4476	1184.6321	438.6503
2010	3400.1059	8849.2712	10780.1843	5297.3968	1945.1303	460.3469
2011	1405.574	13652.9298	10977.182	5050.2781	2222.558	900.2737
2012	2345.8272	11705.7213	11974.0053	4529.048	1121.4196	400.0609
2013	467.633	6783.4863	17502.9286	8371.6	4634.2617	1063.919
2014	243.7957	8261.3901	12919.4656	11542.6194	5319.2524	1915.0788
2015	879.9445	11897.4617	14587.9213	9915.2114	6498.468	3131.3013
2016	1063.9791	17769.0099	20998.5824	10786.7065	5834.529	3011.1754
2017	4005.5804	14731.8125	18955.6724	9093.8867	4501.8118	2157.6823

Q1	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
2018	4281.6251	26199.6541	25176.0207	13814.0641	8233.8506	2321.6205
2019	672.7239	21800.0076	28087.3339	10996.4435	3076.3029	2383.1139

Q3+Q4	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1999	26241.7404	16438.3286	2785.6566	298.0997	372.3387	82.3285
2000	11650.256	19666.4445	6434.6246	112.743	87.6744	145.211
2001	4578.0611	12097.2222	5072.8993	1234.5586	136.1018	184.3917
2002	9313.7637	4718.4982	5137.3704	3434.4634	705.5444	133.7539
2003	4081.416	12514.4045	3163.9634	2394.2471	1221.4332	220.8525
2004	7857.1533	7132.2325	10719.8747	3113.1096	1837.7926	1413.5666
2005	7643.2473	9986.705	2646.3356	1366.0031	387.7365	498.7665
2006	6933.7954	9163.6559	7600.8895	1786.8006	863.0065	551.0399
2007	5843.213	9562.5913	3433.8339	2144.1326	575.7971	289.968
2008	2618.082	9520.0653	7282.9663	2821.8102	747.2792	183.3242
2009	4918.9789	9320.3908	9063.8711	1704.6933	340.6324	205.8489
2010	5245.655	7086.348	4246.2986	3300.0631	1000.7596	558.9289
2011	12556.1817	12628.4361	7126.5392	2352.8866	519.6731	250.4323
2012	10627.4919	13146.7643	9602.5039	4818.9242	1069.4676	288.7688
2013	5253.5502	9842.86	9230.0535	4105.6052	1938.5144	796.8999
2014	10915.0782	10629.9804	8815.2254	5224.1575	2899.4024	808.1937
2015	6964.217	14970.0358	10459.3197	7728.2773	4141.4863	1162.365
2016	12690.7432	12875.5897	9623.3134	4321.0043	2228.8705	1247.2461
2017	32566.6727	13488.1051	6996.816	4371.5404	1948.1693	1364.8213
2018	19747.6234	23085.4633	8865.6323	3147.1608	1300.3431	1135.0608
2019	6000.1023	5942.8912	4437.6578	1176.0524	708.5477	631.6888

Table 5.2.5 Plaice in SD 27.21–23. SAM results from the final assessment (SPALY). Estimated recruitment (000s), total stock biomass (TBS in tonnes), spawning stock biomass (SSB in tonnes), and avg. fishing mortality for ages 3 to 5 (F35).

Year	$R_{(age\ 1)}$	Low	High	SSB	Low	High	$Fbar_{(3-5)}$	Low	High	TSB	Low
1999	51884	38158	70549	4529	3646	5626	1.013	0.83	1.236	7308	5997
2000	44833	34219	58737	5231	4354	6285	1.012	0.859	1.193	8440	7044

Year	$R_{(age\ 1)}$	Low	High	SSB	Low	High	$Fbar_{(3-5)}$	Low	High	TSB	Low
2001	25177	19020	33327	6098	5082	7317	0.959	0.819	1.122	8974	7513
2002	35355	25929	48208	6094	5099	7283	0.906	0.77	1.066	8695	7328
2003	22700	17319	29751	5522	4674	6524	0.818	0.695	0.963	7675	6527
2004	27860	21384	36298	4960	4227	5819	0.775	0.654	0.919	6966	5970
2005	23530	18085	30614	4697	3997	5520	0.776	0.653	0.922	6628	5666
2006	17586	12827	24110	4568	3872	5390	0.81	0.685	0.958	6309	5374
2007	18766	14368	24509	4165	3533	4911	0.809	0.683	0.957	5733	4889
2008	21508	16294	28390	3827	3252	4503	0.819	0.693	0.968	5387	4603
2009	23575	18136	30645	3604	3061	4243	0.773	0.653	0.915	5220	4461
2010	32943	25155	43143	3735	3183	4382	0.712	0.597	0.851	5668	4857
2011	35198	27136	45656	4364	3718	5121	0.692	0.567	0.844	6683	5715
2012	33318	25456	43608	5202	4399	6151	0.556	0.453	0.683	7710	6562
2013	28626	22126	37036	6276	5322	7401	0.498	0.401	0.617	8799	7518
2014	24488	18237	32883	7087	6015	8350	0.465	0.371	0.582	9471	8108
2015	24323	18640	31740	7480	6337	8829	0.466	0.374	0.581	9747	8331
2016	27349	20716	36106	7647	6441	9077	0.507	0.411	0.625	9928	8444
2017	41124	29799	56754	7539	6303	9017	0.524	0.417	0.658	10138	8551
2018	34654	24031	49973	7739	6329	9464	0.558	0.425	0.733	10492	8611
2019	17281	10176	29346	7848	6057	10169	0.582	0.412	0.822	10227	7921
2020	27349	17281	51884	7559	10589	5195					

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

Year Age	1	2	3	4	5	6	7
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
2019	0.032	0.236	0.468	0.654	0.623	0.545	0.545

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

Year Age	1	2	3	4	5	6	7
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
2019	0.032	0.236	0.468	0.654	0.623	0.545	0.545

Table 5.2.8. Plaice in SD 27.21–23. Reference points for 2020, retained from 2019 review.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	4 730	= B_{pa}
	F_{MSY}	0.31	Equilibrium scenarios stochastic recruitment.
	Fp=0.5	0.68	Without advice rule
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

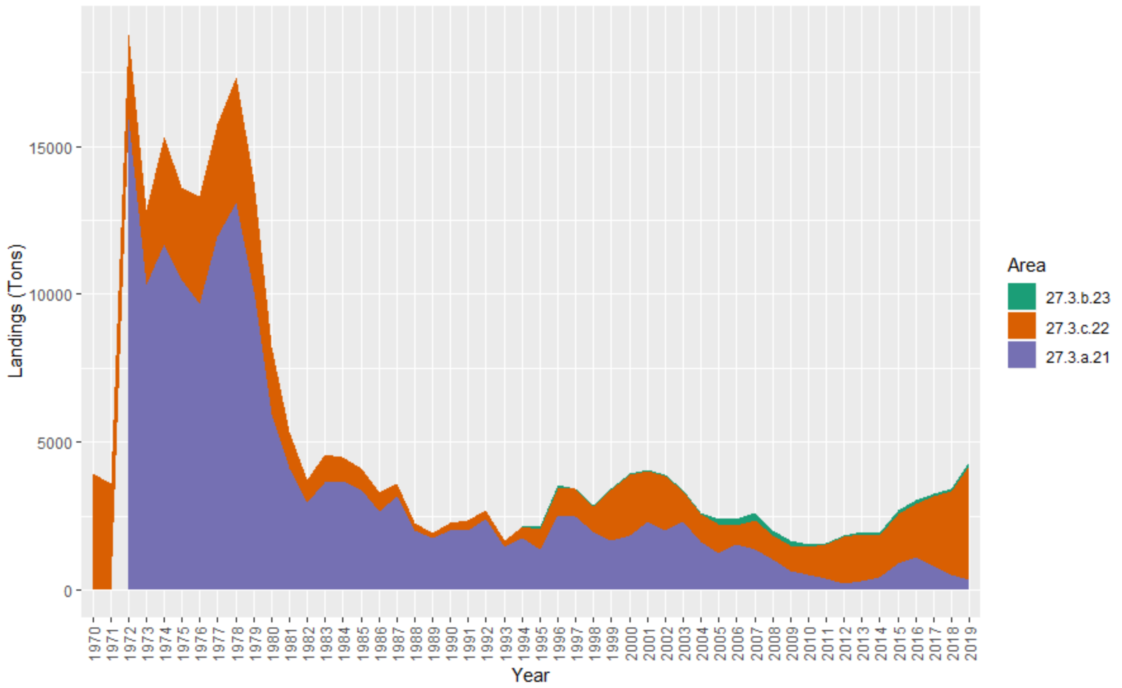


Figure 5.2.1. Plaice in SD 27.21–23. Landings by subdivision by year.

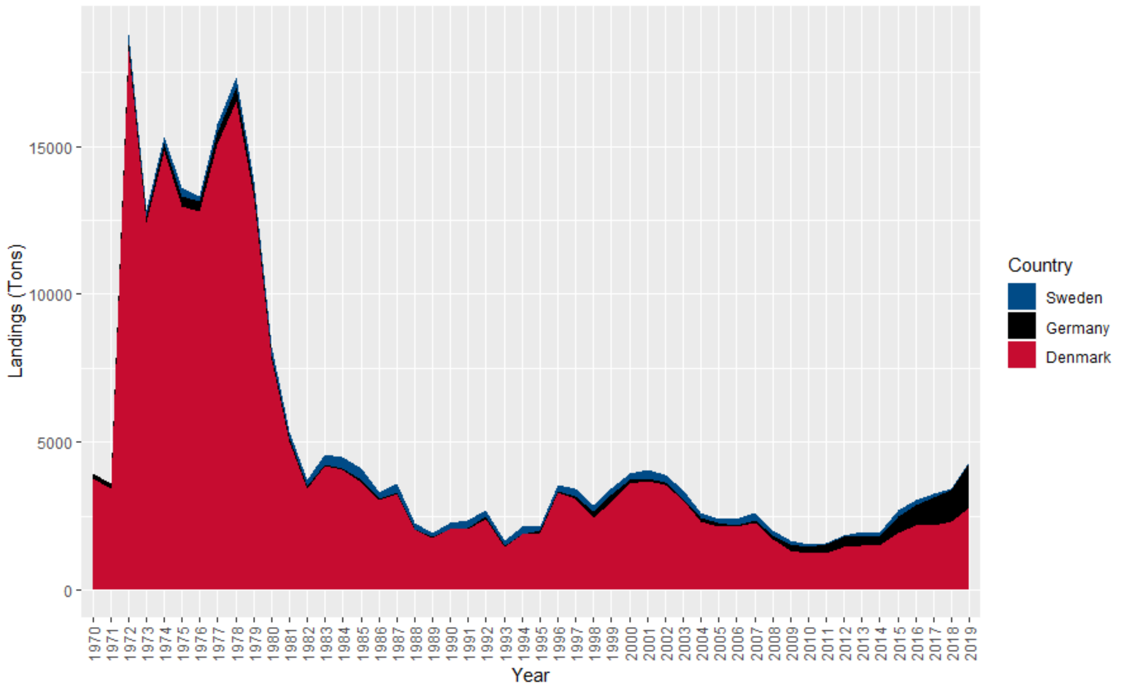


Figure 5.2.2. Plaice in SD 27.21–23. Landings (t) by country by year.

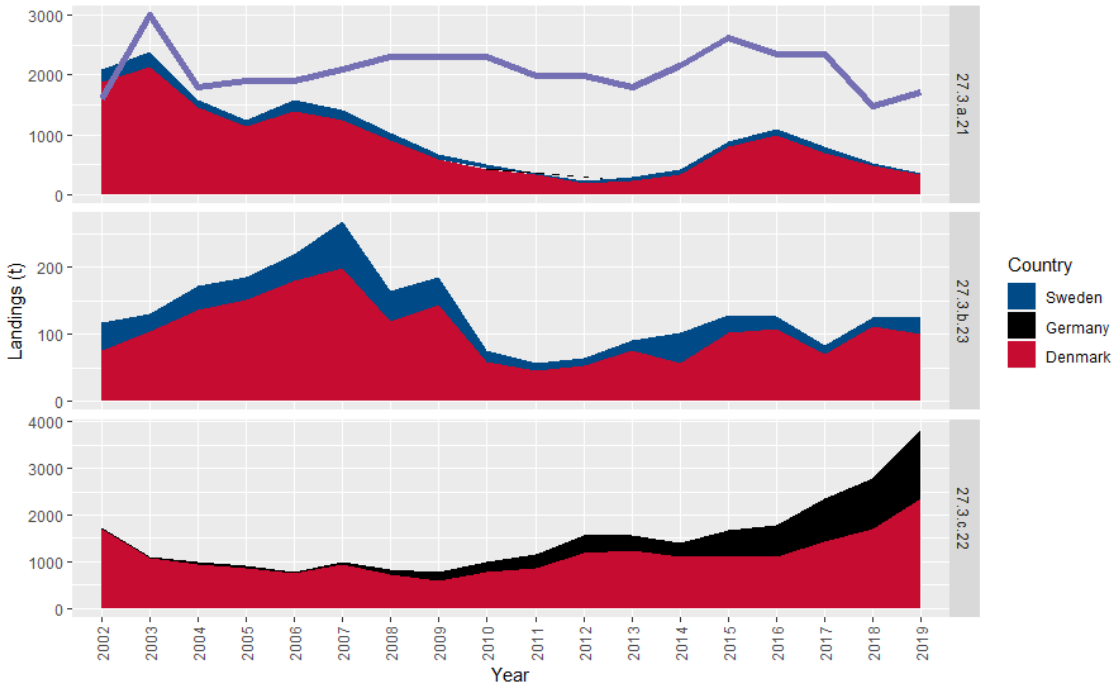


Figure 5.2.3. Plaice in SD 27.21–23. Landings (t) by country by year across areas. Advised TAC for SD 21 is the purple line.

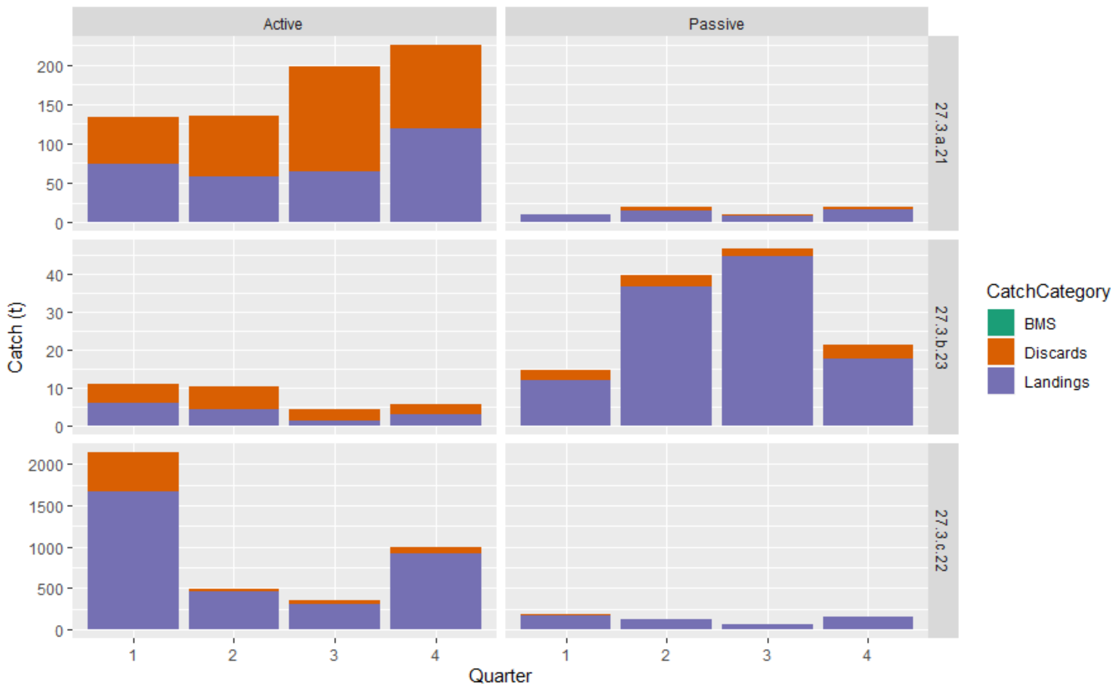


Figure 5.2.4a. Plaice in SD 27.21–23. Catches (t) in 2019 by gear type, area, quarter and catch category. Note varying y-axis values by area.

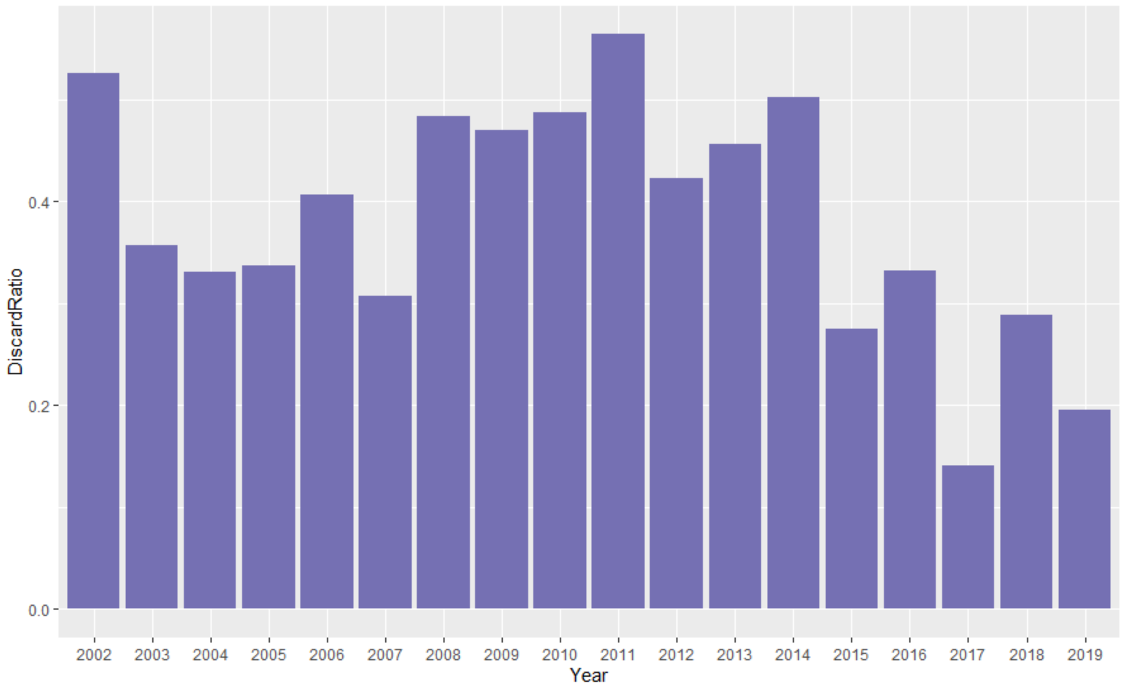


Figure 5.2.4b. Plaice in SD 27.21–23. Discard ratio over time.

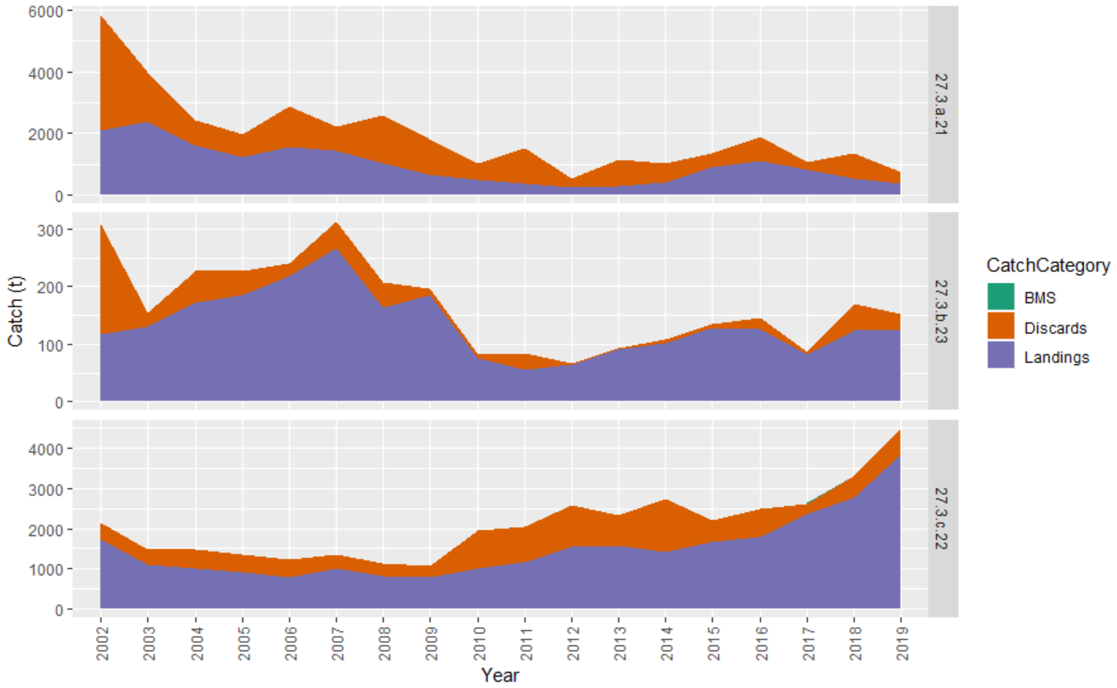


Figure 5.2.4c. Plaice in SD 27.21–23. Catch components over time by Subdivision. Note varying y-axes by subdivision.

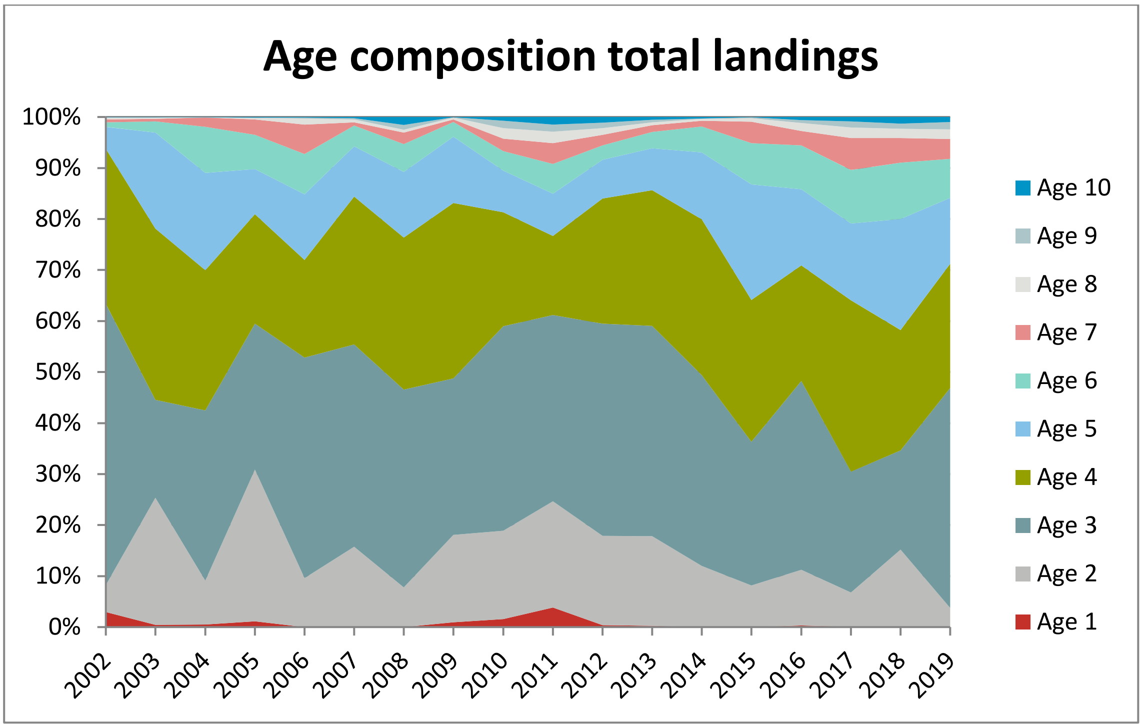


Figure 5.2.5a. Plaice in SD 27.21–23. Age composition for landings from 2002 to 2019.

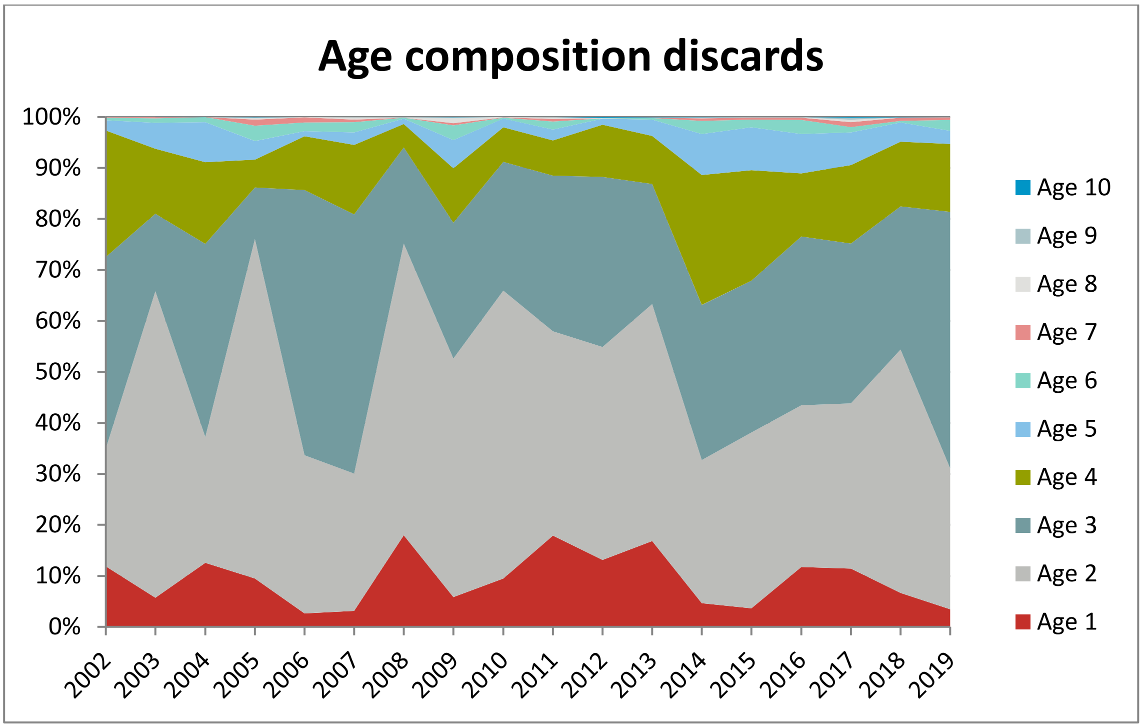


Figure 5.2.5b. Plaice in SD 27.21–23. Age composition for discards from 2002 to 2019.

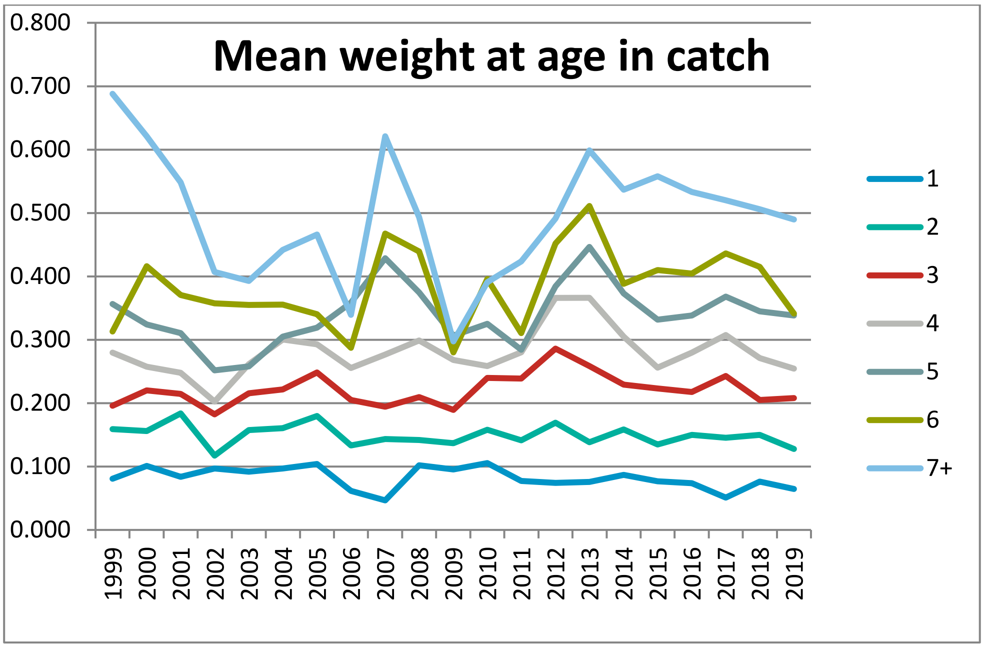


Figure 5.2.6. Plaice in SD 27.21–23. Mean weight (kg) at-age in catch.

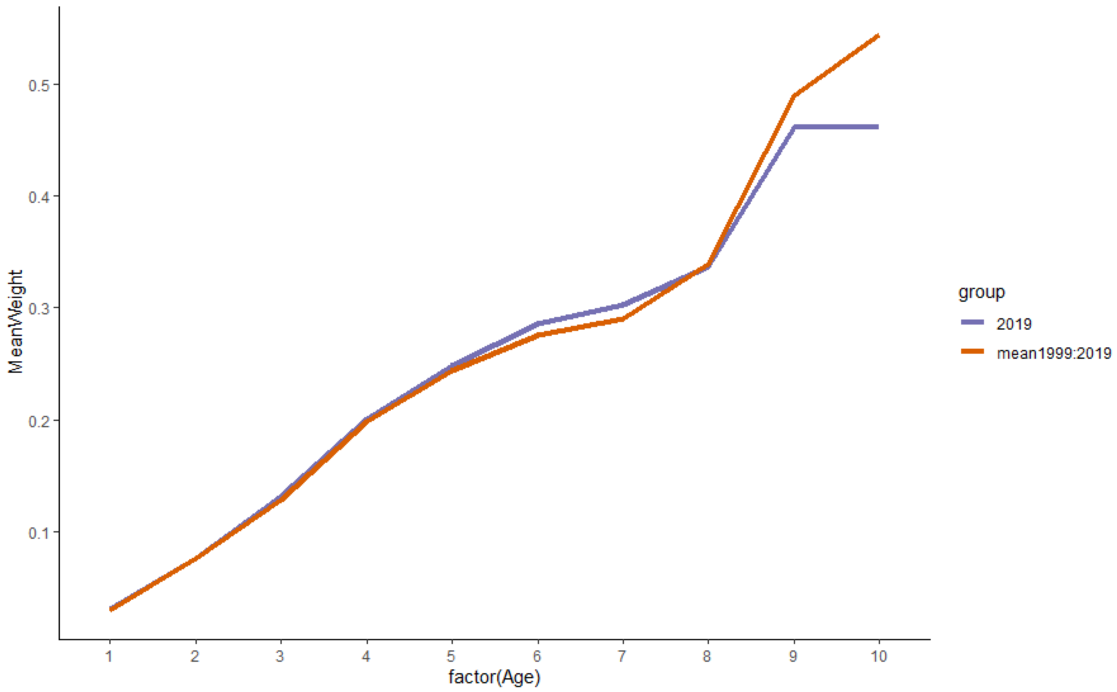


Figure 5.2.7. Plaice in SD 27.21–23. Mean weight (kg) at-age in stock.

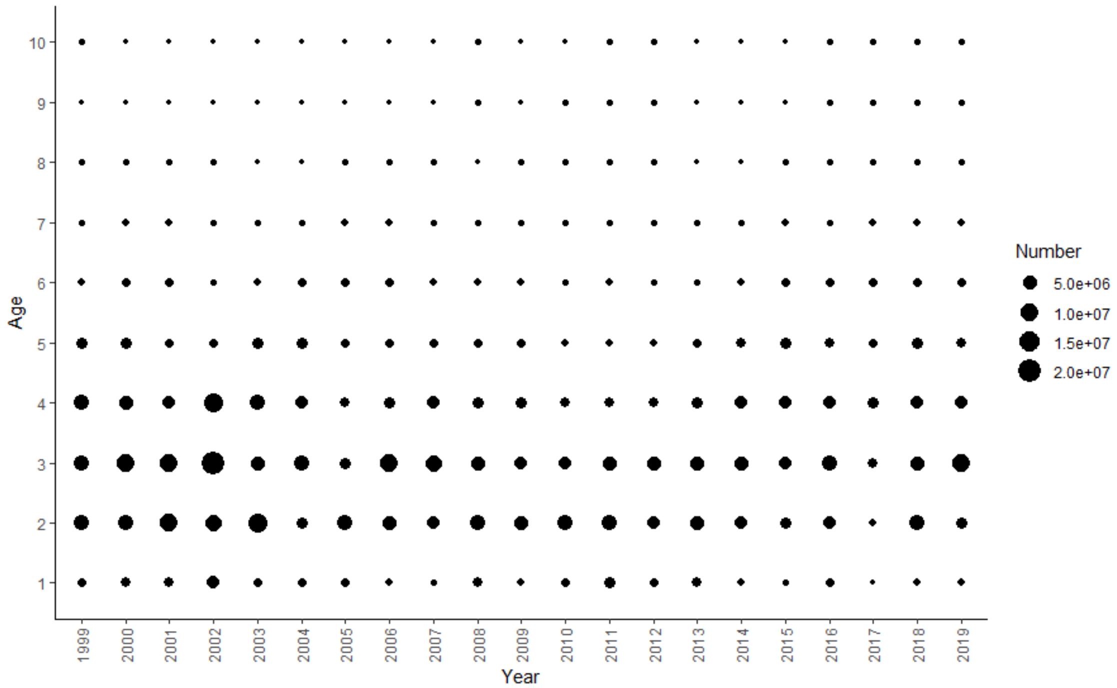


Figure 5.2.8. Plaice in SD 27.21–23. Cohort tracking of the catch-at-age matrix.

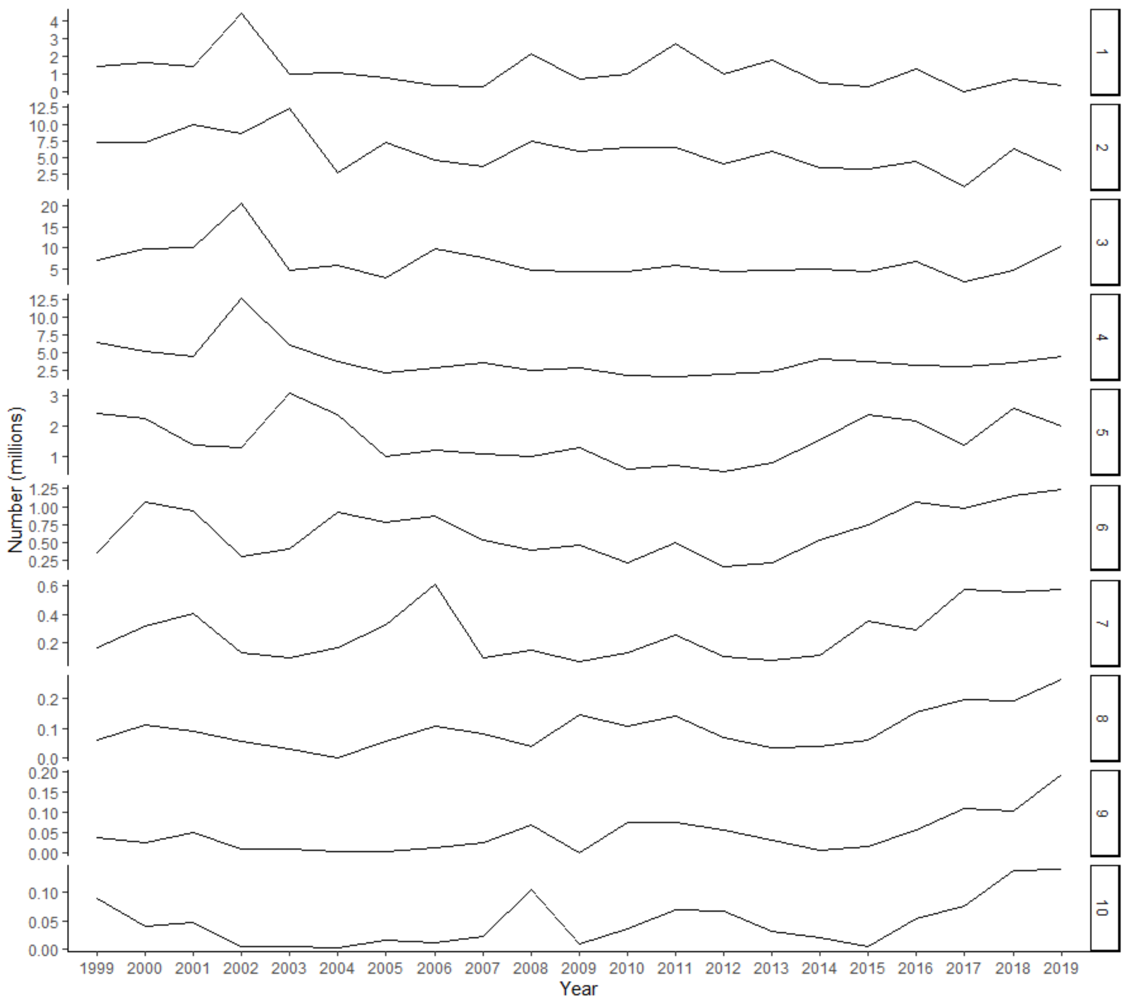


Figure 5.2.9. Plaice in SD 27.21–23. Catch-at-age 1999-2019.

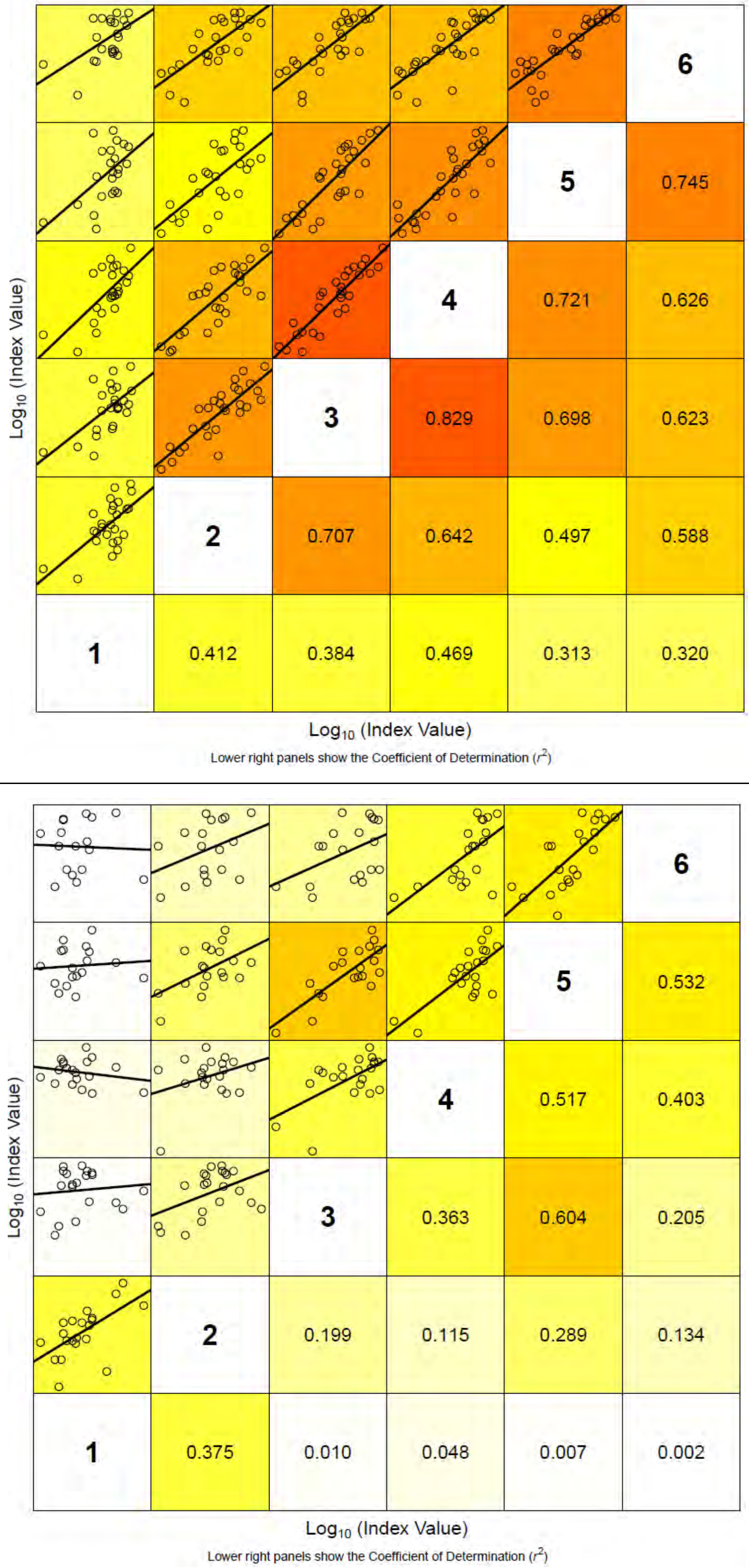


Figure 5.2.10. Plaice in SD 27.21–23. Internal consistency of the two survey indices. Top: Q1 survey. Bottom: Q3-4 survey.

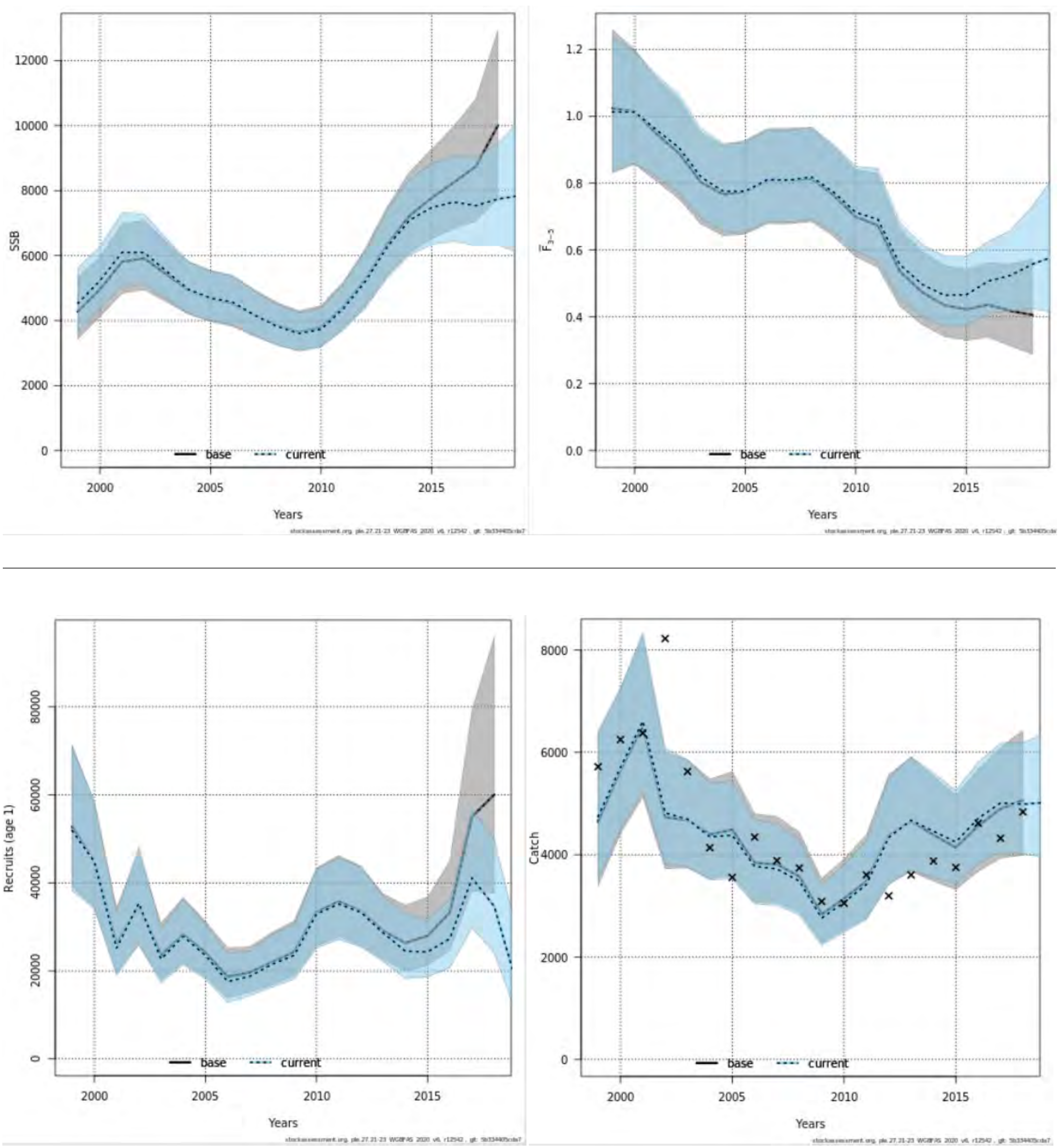


Figure 5.2.11. Plaice in SD 27.21–23. SPALY SAM run (in blue) in comparison with the 2019 assessment (in grey).

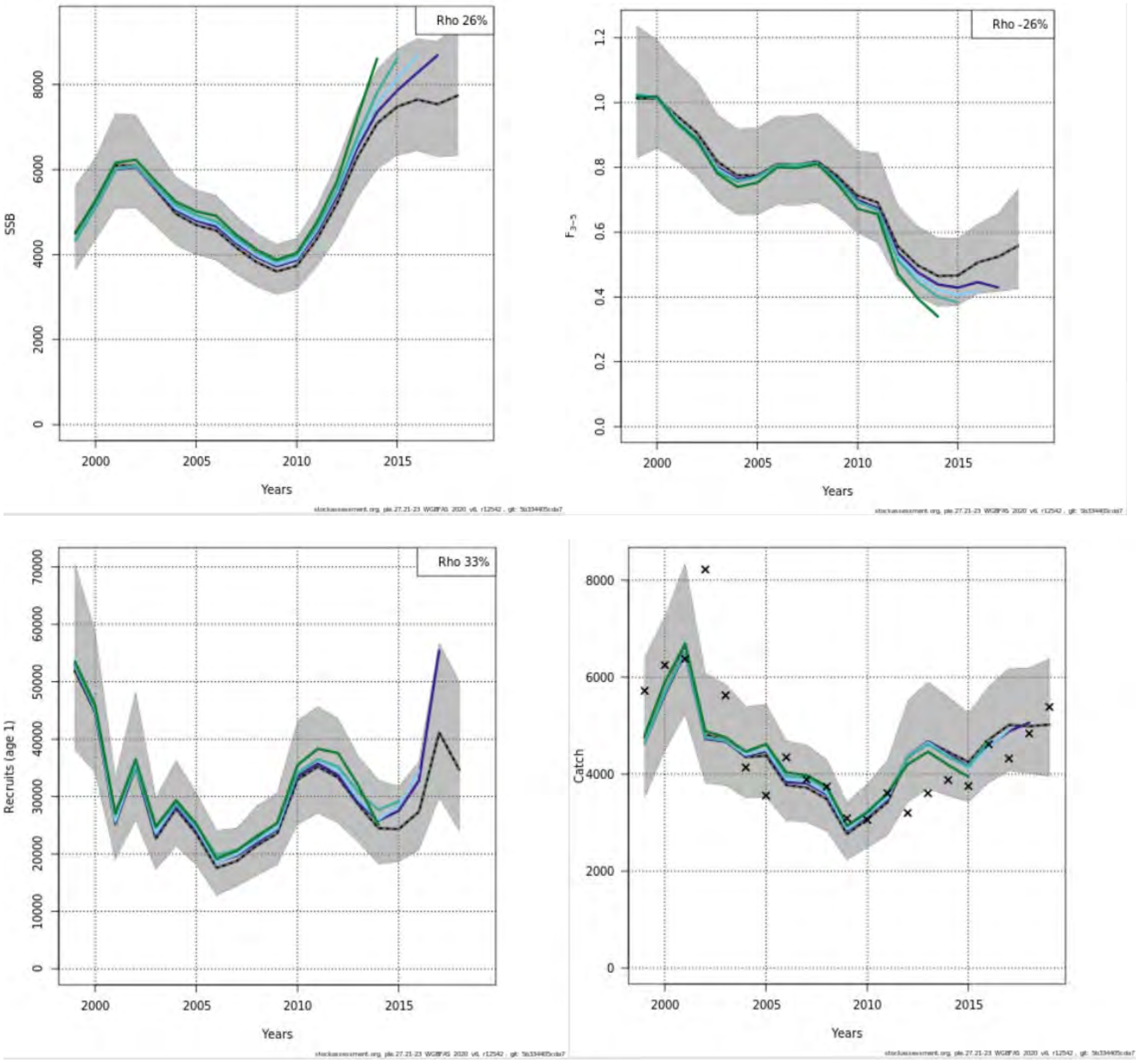
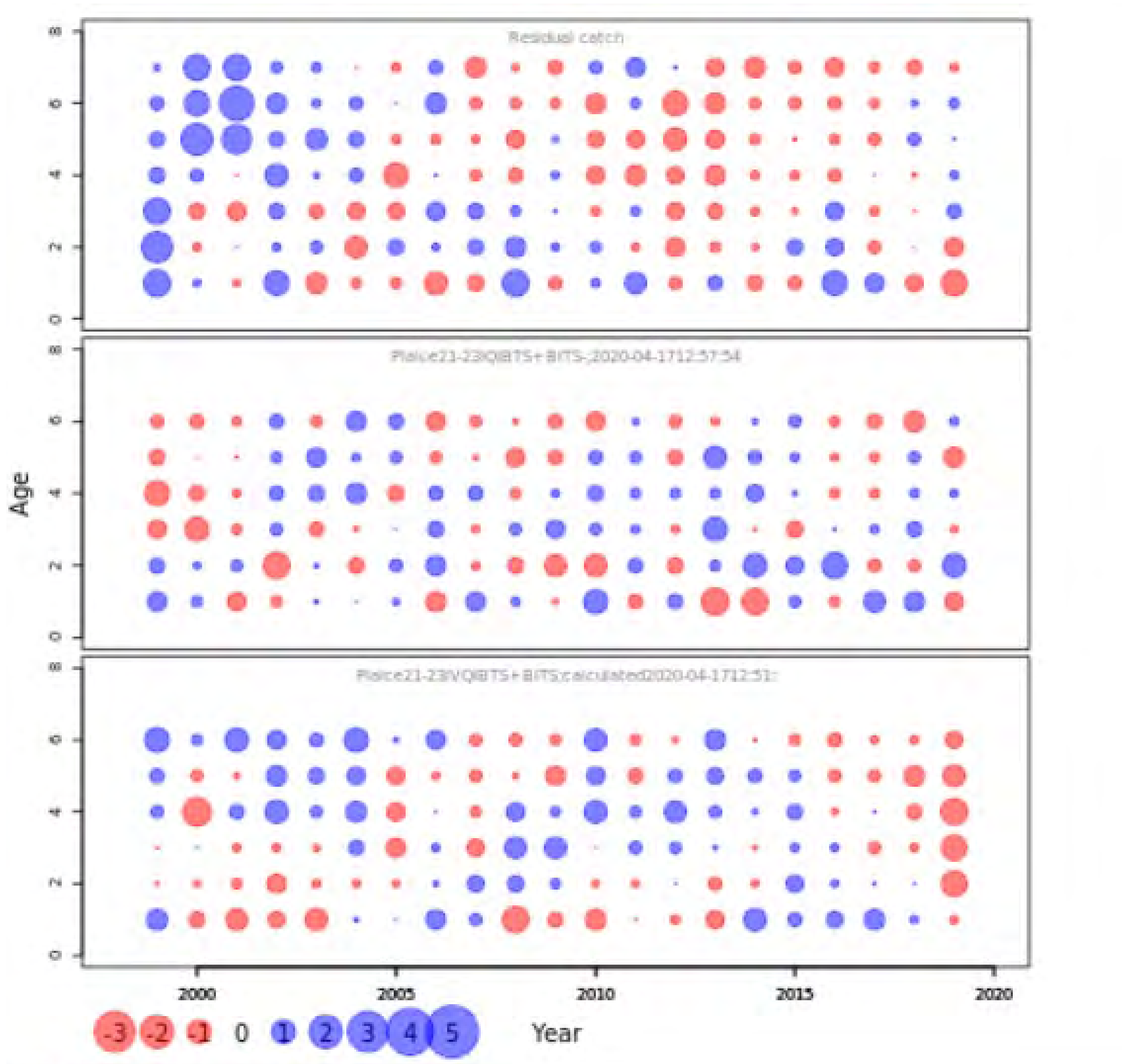


Figure 5.2.12. Plaice in SD 27.21–23. SPALY SAM run. Retrospective pattern.



Standardized one-observation-ahead residuals.

Figure 5.2.13. Plaice in SD 27.21–23. SPALY SAM Residuals by Fleet, Age and Year. The top panel represents catches, the middle the combined Q1 survey indices and the bottom the combined Q3-Q4 survey indices.

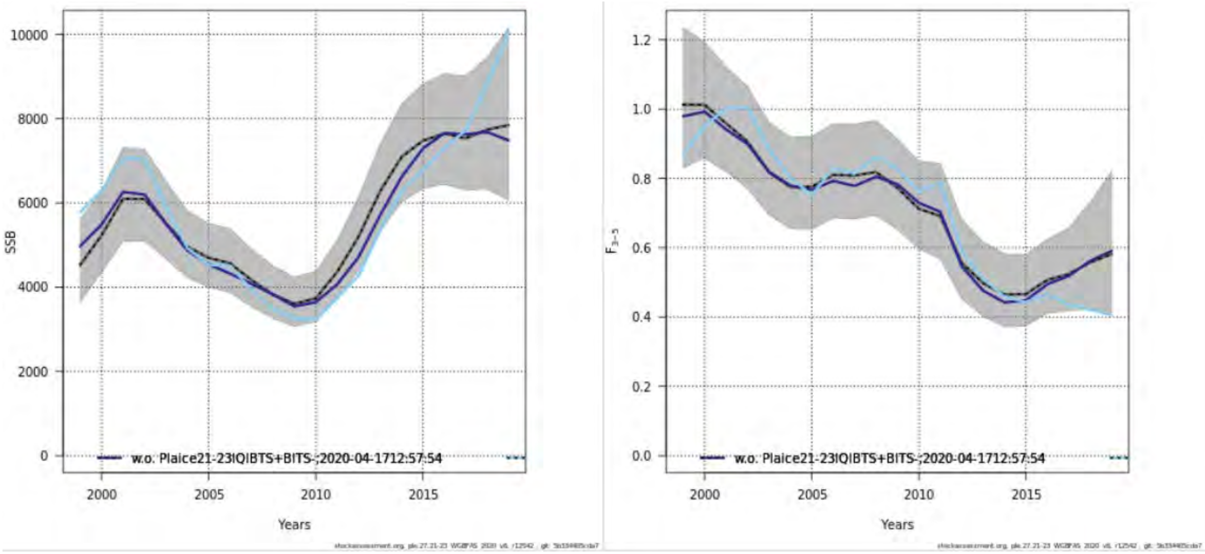


Figure 5.2.14. Plaice in SD 27.21–23. SPALY SAM run. Leave-one-out analysis of surveys in SSB (left) and F(right) with the full model (black), without the Q1 combined indices (dark blue), and without the Q3/4 combined indices (light blue).

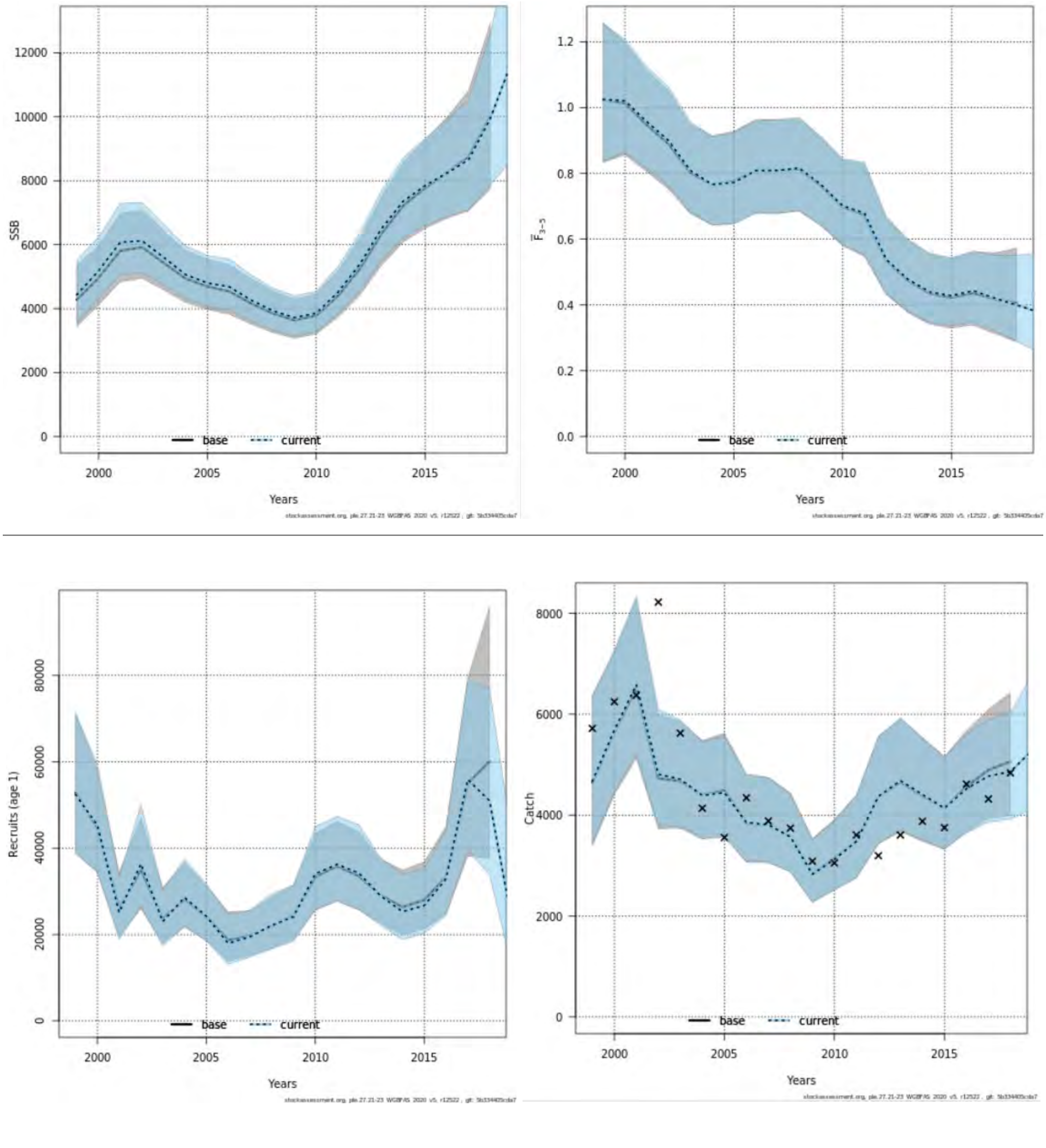


Figure 5.2.15. Plaice in SD 27.21–23. Secondary SAM run (without Q3-Q4 survey indices). Grey lines and ribbons are the 2019 assessment and the dashed lines and blue ribbons are the secondary SAM run from 2020.

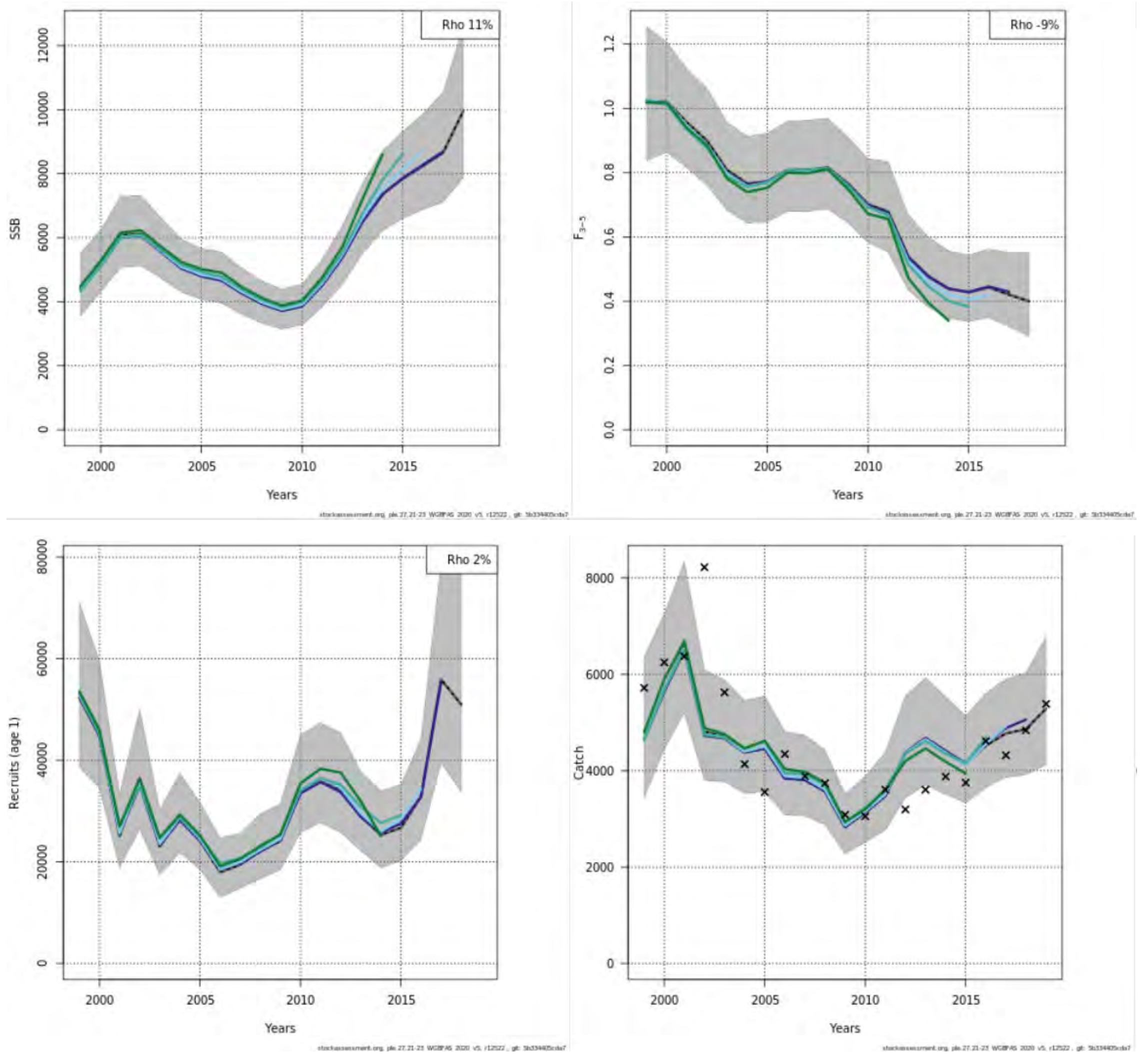


Figure 5.2.16. Plaice in SD 27.21–23. Secondary SAM run (without Q3-Q4 survey indices). Retrospective patterns

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 10772 tonnes for 2019 and decreased to 6894 tonnes for 2020. 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 Gdansk 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 2019, active gears provide most of the landings in SD 24 (ca. 77%) and SD 25 (ca. 65%) while passive gears provided most of the landings in SD 26 (ca. 79%); passive gears provided on average 25% of total plaice landings in 2019.

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 SDs 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 2019 was at the same level as in 2018 and about three times higher than in 2017 with about 1741 tonnes. Since 2017, a landing obligation is in place, resulting in an additional 17.4 tonnes of "BMS landings" (i.e. landings of plaice below the minimum conservation reference size of 25 cm) in 2019, which accounted for 0.74% 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 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 exceptionally 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 (2019) were around 617 tonnes (i.e. 26.2% 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 (2018, 2019) ages classes 3 and 4 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). The age classes above 7 are usually not very well sampled, causing some fluctuations in the average weight. Passive gears often catch larger fishes and have a lower discard-rate.

5.3.2.3 Natural mortality

No further information or studies on natural mortality are available. The average natural mortality for age classes 1 and 2 is set at 0.2, age classes 3+ are set at 0.1 as a default.

5.3.2.4 Maturity-at-age

The maturity ogive was taken from the BITS from SD 22 and SD 24 (since they are more reliable and consistent than SD 24+, see WKPLE 2015 report). Both quarters from the period 2002 to 2018 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 SD 24–32. 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 altogether covers the area covered by the stock. (Figure 5.3.4).

The internal consistency plots of the surveys (Figure 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 preliminary 2020 Q1 survey shows an increased number of smaller plaice (age 1).

The internal consistency in the commercial catches is also quite good (Figure 5.3.6). Only the medium-aged fish show a lesser consistency.

5.3.4 Assessment

The stock was as a result of the WKPLE in February 2015 upgraded to Category 3.2.0 (DLS; exploratory assessment with SSB trends). The State-based Assessment Model (SAM) is used. The assessment is an update of the benchmark assessment (ICES WKPLE) and the settings are according to the stock annex (ple.27.24-32).

The final run in SAM is named: ple.27.2432_2020_v2

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 2020, 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 SPiCT is named: ple.27.2432_2020_spict

5.3.4.1 Exploration of SAM

The stock is in a very good condition. The result shows (Figures 5.3.8a-c and Table 5.3.3) an increase in SSB from < 3 000 tonnes in 2010 to >5 600 tonnes in 2015 and estimated to 16 650 tonnes in 2020. 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 and

2019. The F in 2019 is at a similar level than last year (0.262 in 2019, 0.259 in 2018), 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 2019 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 2019 is estimated to 44.4 million, which is the highest value since 2002.

The normalized residuals show some year effects for the commercial catches in the last two years (Figure. 5.3.10). Year effects also occur in the CPUE of BITS, especially for the latest surveys, which have high numbers of smaller 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 (2020–2019) divided with the relative SSB average of the preceding three years (2016–2018) - This estimate gives an increase of 17%, The most recent survey indices, however, stating a decrease in abundance in late 2019 and early 2020. An uncertainty cap is not applied as the calculated trend does not exceed the limit of 20% change.

No F_{MSY} is available for the stock; however, an exploratory SPiCT model conducted on the stock states a $F_{MSY\ proxy}$ of 1.53.

After a period of decreasing total landings (and catch) until 2017, the most recent year (2019) showed a very strong increase in total catch and follows the trend of 2018. Advice will be given based on the taken catch of the last year (2019). Following that approach, the advised total catch for 2021 is 2753 tonnes. A pa buffer was not applied, as both proxy reference points are stating a good stock status (a pa buffer is applied, if $B < B_{trigger}$ or $F > F_{MSY}$).

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 advise the total catch in 2020. This exemplary 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 2021.

When applying the harvest control rule to the results of the LBI model (described in 5.1.7.1), the total advised catch for 2021 would be 2572 tonnes.

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.

5.3.4.2 Historical stock trends

Before the benchmark in 2015, trends in the stock were evaluated by survey-indices only. The survey indices are shown in Figure 5.3.4. See section 5.3.1 under "Description of the fishery" for historical trend details.

5.3.4.3 Recruitment estimates

The recruitment in 2019 is estimated to around 44.4 mills. This is an increase since 2013 and can be considered as a stable recruitment in the whole time-series (2002–2019). 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 2014–2019 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 coloured 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). $L_{max5\%}$ decreased and is no longer close to the lower limit of 0.80 (i.e. 0.55 in 2019), 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 the 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 Bertalanffy 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 before 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 $I_{y-1}/(1.4 \times I_{trigger})$. 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 = **2359**t (total catch), 1644t (total landings)

r = **1.167** (last 2-y index of *2.45* vs. last 3-y index of *2.1*)

f = **1.1** (avg L_{CAT} = *27.4 cm* L_{target} = *25 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 as L_{mean}/L_{opt}:

f = 0.78 (L_{mean}/L_{opt} of the LBI results)

b = **1** ($I_{trigger}$ = 0.23 I_{y-1} = 2.4 → $I_{y-1} > 1.4 \times I_{trigger}$)

m = **0.85** (v.B. growth rate k = 0.131)

Using these values, the advised catch for 2020 would be:

$Advice_{catch}$ 2020 = **2572 tonnes total catch**,

,

If using the alternative f value (L_{mean}/L_{opt}):

$Advice_{catch}$ 2020 = **1825 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 16 years combined with continuously increasing data quality (in terms of spatiotemporal 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, auto-correlation 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 values
- 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 data set 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 determine 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_ 2020_spict

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 an index for estimating the stock trend. The calculated trend was used for calculating the catch in 2021 by applying the "2 over 3 rule" in the same way as the previous year. Even though the SAM assessment is premature, the assessment shows surprisingly robustness despite the relatively short time-series available. This is expressed in the retrospective analysis which looks acceptable (Figure 5.3.10), although the rel. SSB shows a consistent overestimation. The F looks good, while the recruitment is poorly estimated. The F by-age group is shown in Figure 5.3.8. 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 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 2019 (0.77) decreased slightly compared to 2018 (0.0.82), which resulted out of a more plaice-targeted fisheries since 2018; the relative recruitment estimates (1.34) decreased compared to the previous assessment (2.4). The relative SSB remains at the same level (2.4 to 2.6 in the three years). 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			Germany, 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				
1984	166			2	8		106		23	3		4	1				
1985	771			593	40		119	49	25	4		5	1				

Year/SD	**Denmark**			**Germany, 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**
1986	1019			372	7		171	59	48	7		9	1				
1987	794			142	16		188	5	68	10		12	1				
1988	323			16	1		9	1	49	7		9	1				
1989	149			5			10		34	5		6	1				
1990	100			1	1		6		50								
1991	112				9		2	1	5	2		2					
1992	74				4		6		3	1		1					
1993	66				6		4		4								
1994	159						43	4	4	7							
1995	343				91		233	2	13	10	1						
1996	263				77		183	5	28	23	10	1					
1997	201				56		308	3	7	8		1					
1998	278				41		101	14	6	17		1					
1999	183				46		145	1	5	10							
2000	161				37		408	3	9	12							
2001	173				43		549	3	9	13							
2002***	153	159	0		137	7	429	3	10	15							

Year/SD	Denmark			Germany, 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
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		
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
2019	611	51	0		331	0	728	1	13	6	0	<1	<1	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 5.3.5.4. ple.27.24–32. Landings (tonnes), BMS landings (tonnes) and discard (tonnes) in 2019 by Subdivision, catch category, country and quarter.

Area	Country	Catch Category	1	2	3	4	Total*
27.3.d.24	**Denmark**	Landings	34.25	119.69	188.12	268.89	610.95
		Discards	50.59	3.72	24.34	45.16	123.80
		BMS landing	0.19	0.23	0.64	1.41	2.47
	Germany	Landings	5.31	73.22	87.21	164.70	330.45
		Discards	3.69	66.60	22.16	11.78	104.23
		BMS landing	6.00	2.00	1.00	4.00	13.00
	Poland	Landings	216.62	67.30	108.47	157.01	549.40
		Discards	48.48	87.19	72.72	23.15	231.54
		BMS landing	0.30	0.21	0.02	0.28	0.80
	Sweden	Landings	0.76	1.77	3.45	6.55	12.54
		Discards	0.78	1.55	0.60	0.79	3.72
		BMS landing	0.00	0.00	0.00	0.00	0.00
27.3.d.25	**Denmark**	Landings	35.48	0.39	1.22	13.73	50.81
		Discards	29.07	3.68	0.25	1.67	34.67
		BMS landing	0.20	0.00	0.00	0.25	0.44
	Germany	Landings	0.85	0.02			0.87
		Discards	0.93	0.11			1.04
	Latvia	Discards	2.62				2.62
	Lithuania	Landings	0.00	0.00			0.00
	Poland	Landings	54.82	42.21	36.55	45.44	179.01
		Discards	9.35	54.68	20.42	2.78	87.22
		BMS landing	0.42	0.00			0.00
	Sweden	Landings	3.96	0.47	0.30	1.24	5.97
		Discards	11.73	14.66	0.25	0.18	26.83
		BMS landing	0.00	0.00	0.00	0.00	0.00

Area	Country	Catch Category	1	2	3	4	Total*
27.3.d.26	Denmark	Landings	0.00	0.00	0.00	0.00	0.00
		BMS landing	0.00	0.00	0.00	0.00	0.00
	Latvia	Discards	0.31				0.31
	Lithuania	Landings	0.00	0.00	0.00	0.00	0.00
		Discards	0.00	0.00			0.00
	Poland	Landings	0.00	0.38	0.35	0.56	1.30
		Discards	0.00	0.70	0.30	0.11	1.11
		BMS landing	0.00				0.00
	Sweden	Landings	0.00	0.00	0.00		0.00
		BMS landing	0.00	0.00	0.00		0.00
27.3.d.27	Denmark	Landings	0.00	0.00	0.00	0.00	0.00
		BMS landing	0.00	0.00	0.00	0.00	0.00
	Sweden	Landings	0.04	0.00	0.00	0.00	0.04
		Discards	0.00				0.00
		BMS landing	0.00	0.00	0.00	0.00	0.00
27.3.d.28	Sweden	Landings	0.00	0.00	0.06	0.00	0.06
		Discards			0.05		0.05
		BMS landing	0.00	0.00	0.00	0.00	0.00
27.3.d.29	Denmark	Landings	0.00	0.00	0.00	0.00	0.00
		BMS landing	0.00	0.00	0.00	0.00	0.00
	Sweden	Landings	0.00	0.00	0.00	0.00	0.00
		BMS landing	0.00	0.00	0.00	0.00	0.00
27.3.d.30	Sweden	Landings			0.00	0.00	0.00
		BMS landing			0.00	0.00	0.00
027.3.d.31	Sweden	Landings			0.00	0.00	0.00
		BMS landing			0.00	0.00	0.00

*BMS landings are included in the discards and need to be subtracted 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	3679	1980	6839	1122	736	1711	2240	1520	3303	0.867	0.573	1.313
2003	5222	3096	8810	1075	769	1502	2269	1623	3172	1.106	0.757	1.617
2004	8336	4754	14617	1223	903	1654	2969	2104	4190	0.698	0.490	0.994
2005	6109	3569	10458	1797	1314	2456	3625	2613	5028	0.416	0.270	0.639
2006	3044	1403	6603	2336	1714	3183	3746	2783	5041	0.521	0.346	0.783
2007	2371	901	6238	2340	1745	3138	3399	2524	4577	0.626	0.423	0.927
2008	3194	1521	6707	2121	1612	2790	3174	2378	4236	0.567	0.391	0.824
2009	7889	4505	13815	2335	1755	3106	4068	3046	5434	0.550	0.385	0.787
2010	17548	9628	31982	2898	2161	3886	6302	4381	9066	0.636	0.447	0.904
2011	18734	9872	35553	3984	2795	5680	8549	5668	12894	0.694	0.483	0.997
2012	12177	6375	23262	4418	3150	6197	8320	5763	12010	0.649	0.435	0.971
2013	13344	7801	22825	4012	3007	5353	7380	5492	9916	0.615	0.369	1.025
2014	18744	10330	34014	4294	3117	5916	8755	6025	12722	0.270	0.144	0.507
2015	30023	14687	61371	6129	4440	8460	12661	8402	19078	0.228	0.129	0.401
2016	38086	19507	74359	8713	6317	12016	17289	11671	25610	0.244	0.141	0.423
2017	35540	19283	65506	11236	8349	15121	20491	14586	28786	0.186	0.100	0.346
2018	30502	15979	58224	14224	10673	18957	23401	17050	32119	0.295	0.160	0.546
2019	11024	4951	24548	15002	10873	20698	21450	15451	29777	0.259	0.132	0.508
2020	44410	10601	186034	16650	10839	25576	26213	15047	45666	0.262	0.092	0.746

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	0.40	0.23	915	353	1.64
2003	0.46	0.25	1281	271	2.1
2004	0.55	0.27	1081	214	1.20
2005	0.49	0.35	1081	166	0.68
2006	0.40	0.46	1012	818	0.81
2007	0.38	0.50	1167	491	1.00
2008	0.41	0.48	1102	294	0.92
2009	0.66	0.49	1226	418	0.95
2010	1.06	0.57	903	998	1.15
2011	1.09	0.70	748	1377	1.26
2012	0.81	0.78	848	917	1.21
2013	1.09	0.80	738	781	1.31
2014	1.30	0.84	534	481	0.63
2015	1.67	1.15	427	220	0.51
2016	2.1	1.60	521	1058	0.54
2017	2.0	2.1	650	408	0.45
2018	1.80	2.6	1644	710	0.82
2019	1.34	2.5	1741	617	0.77
2020		2.4			

Table 5.3.5. ple.27.24-32. Selected indicators for LBI screening plots. Indicator ratios in bold used for stock status assessment with the 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} / $L_{F=M}$
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
2019	0.55	0.92	0.73	0.02	0.78	1.13

Table 5.3.7. ple.27.24-32. Overview of SPiCT result values on catch and survey data 2002–2018.

Deterministic reference points (Drp)					
		estimate	cilow	ciupp	log.est
	B_{msyd}	1208.6399	600.0896	2434.3204	7.0973
	F_{msyd}	1.5320	0.8094	2.8997	0.4265
	MSY_d	1851.5883	1636.1527	2095.3907	7.5238
Stochastic reference points (SRP)					
		estimate	cilow	ciupp	log.est
	B_{MSYS}	1256.3086	856.1959	1843.3997	7.1359
	F_{MSYS}	1.4335	1.1248	1.8270	0.3601
	MSY_s	1805.6455	1549.3126	2104.3887	7.4987
States	w	0.95	CI	(inp$msytype:	s)
		estimate	cilow	ciupp	log.est
	B_2019.88	2412.1699	1396.9838	4165.0904	7.7883
	F_2019.88	1.0207	0.4921	2.1170	0.0205
	B_2019.88/B_{MSY}	1.9200	1.2966	2.8432	0.6523
	F_2019.88/F_{MSY}	0.7120	0.3673	1.3803	-0.3397
Predictions	w	0.950	CI	(inp$msytype:	s)
		prediction	cilow	ciupp	log.est
	B_2020.00	2296.8366	1252.2547	4212.7679	7.7393
	F_2020.00	1.0262	0.4506	2.3373	0.0259
	B_2020.00/B_{MSY}	1.8282	1.1808	2.8307	0.6034
	F_2020.00/F_{MSY}	0.7159	0.3339	1.5348	-0.3342
	Catch_2020.00	2082.7296	1105.2761	3924.5963	7.6414
	E(B_inf)	1620.6578			7.3906

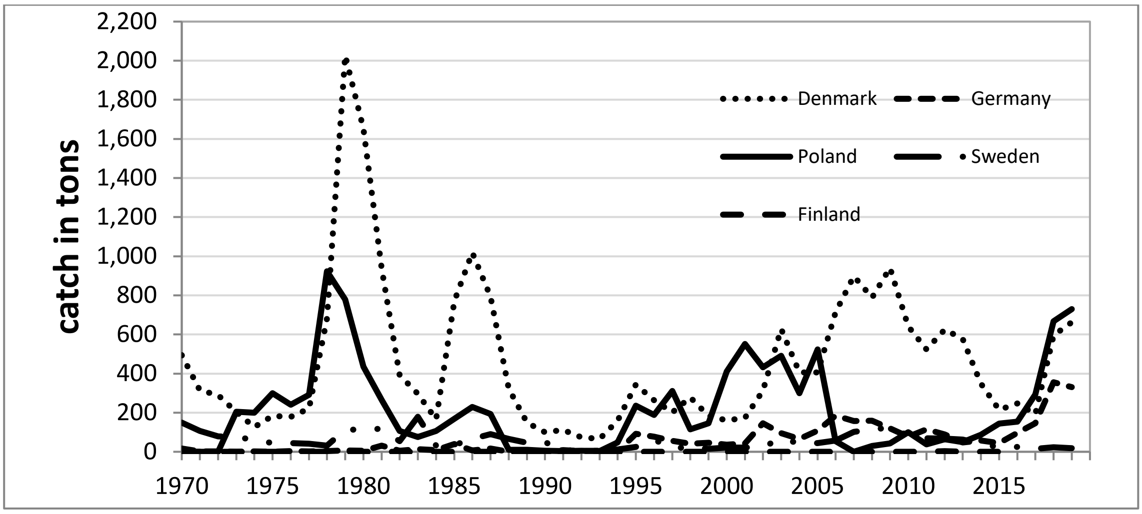


Figure 5.3.1. ple.27.24-32. Historical landings per country (in tonnes).

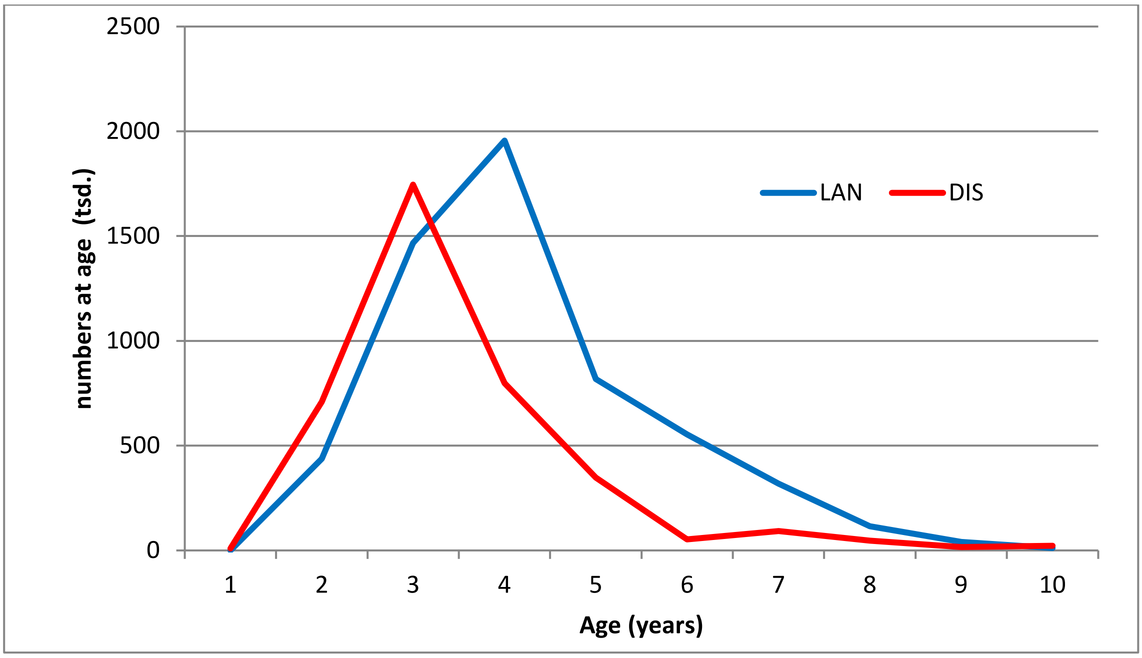


Figure 5.3.2. ple.27.24-32. Catch in numbers per age class and catch category in Subdivision 24 and 25. All countries and fleets were combined.

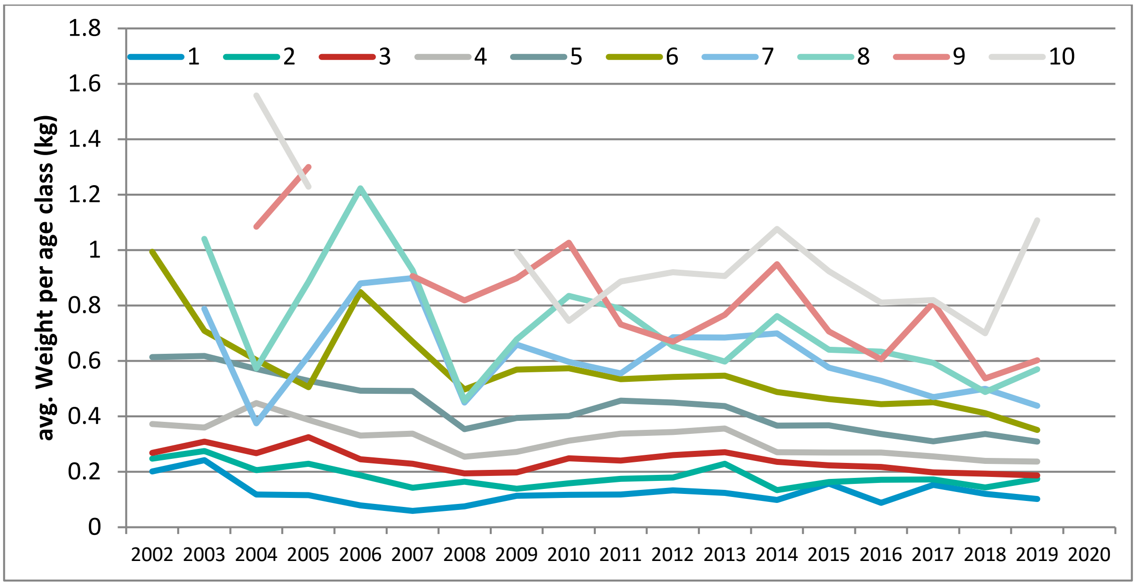


Figure 5.3.3. ple.27.24-32. Average weight-at-age for the age classes 1 to 10 in subdivisions 24 and 25. All countries and fleets were combined.

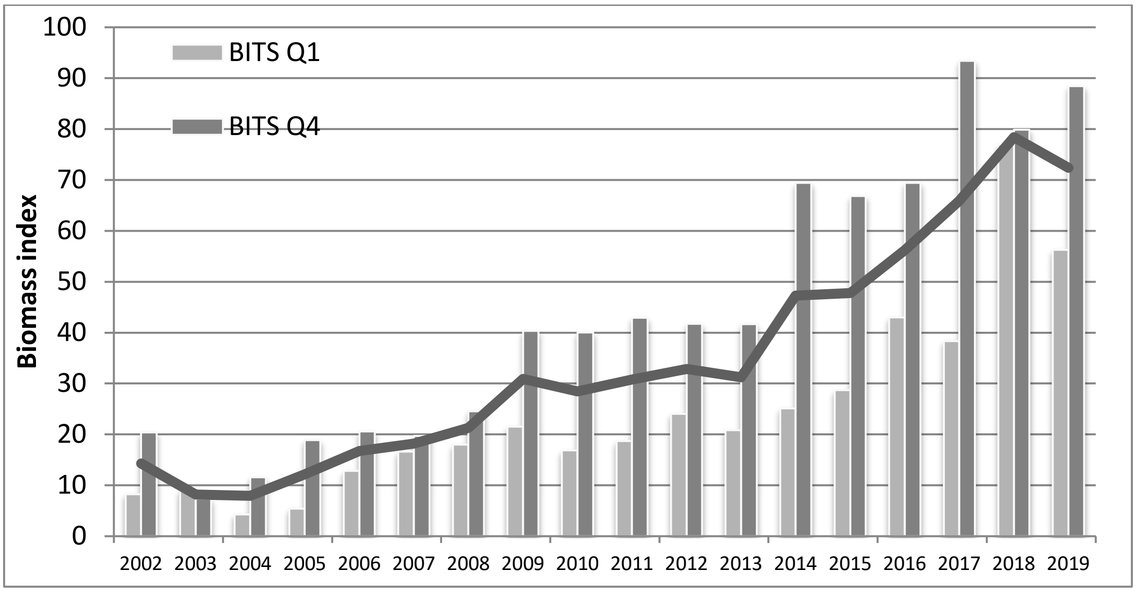


Figure 5.3.4. ple.27.24-32. Average CPUE index from Q1 and Q4 BITS from SD 24-SD 26 (no plaice catches in SD 27+). 2019 data (Q1) are preliminary.

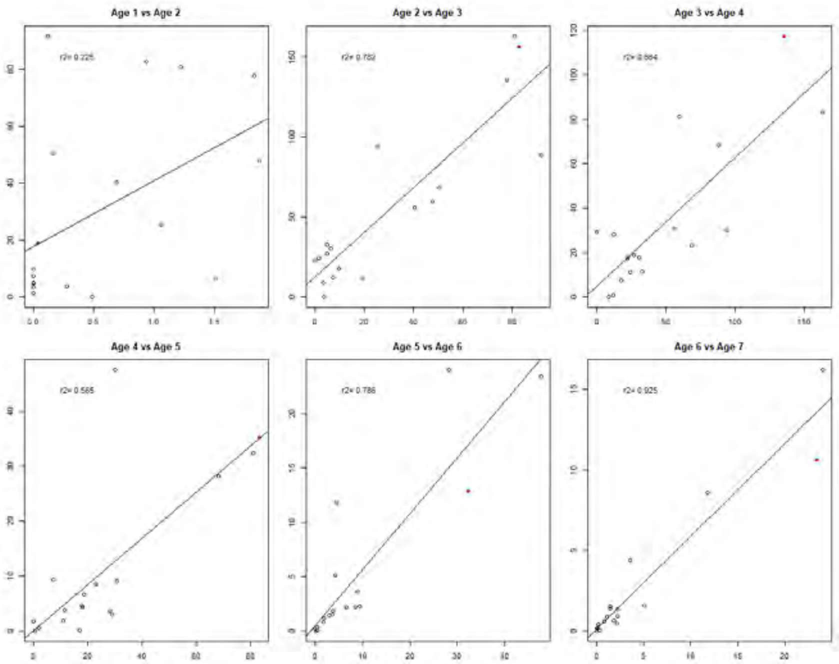


Figure 5.3.5a. ple.27.24-32. Internal consistency of age classes 1–7 from Q1 BITS.

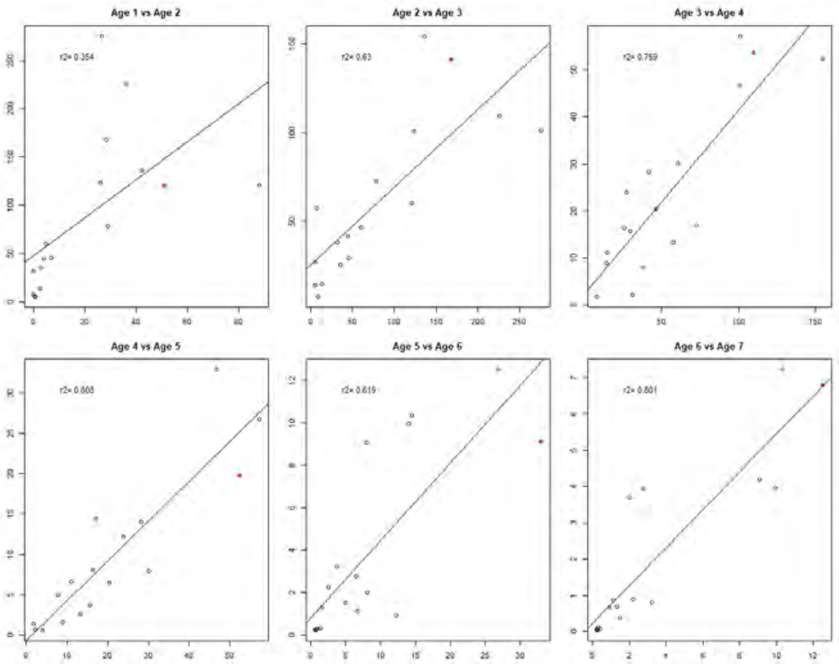


Figure 5.3.5b. ple.27.24-32. Internal consistency of age classes 1–7 from Q4 BITS.

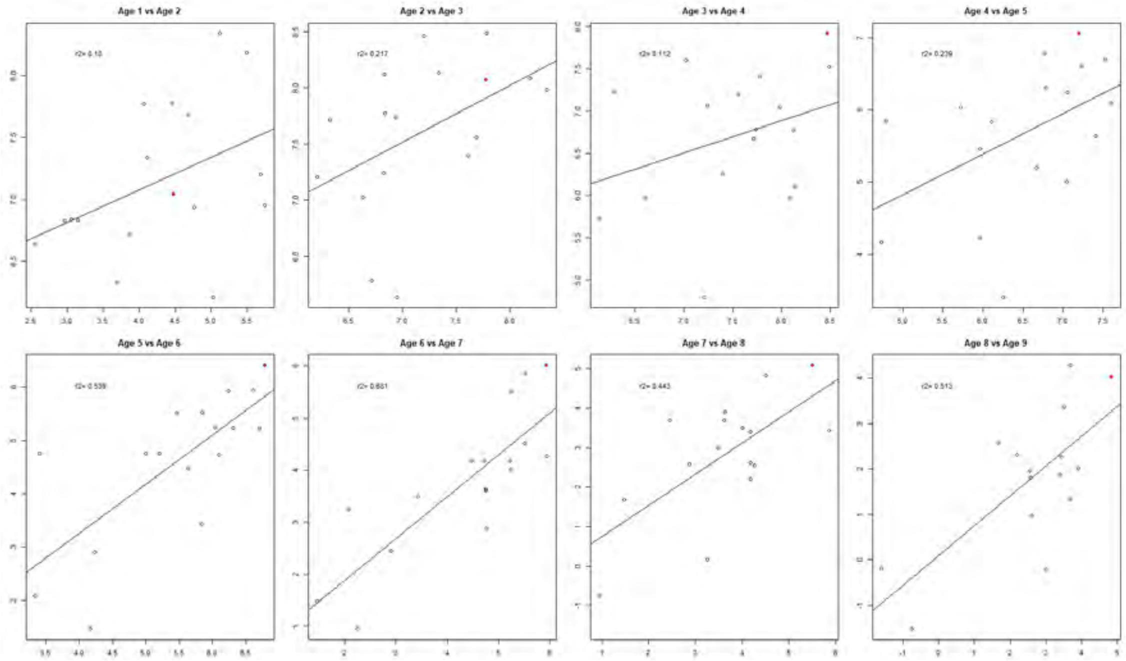


Figure 5.3.6. ple.27.24-32. Internal consistency of age classes 1–7 from commercial catches. All fleets and countries were combined.

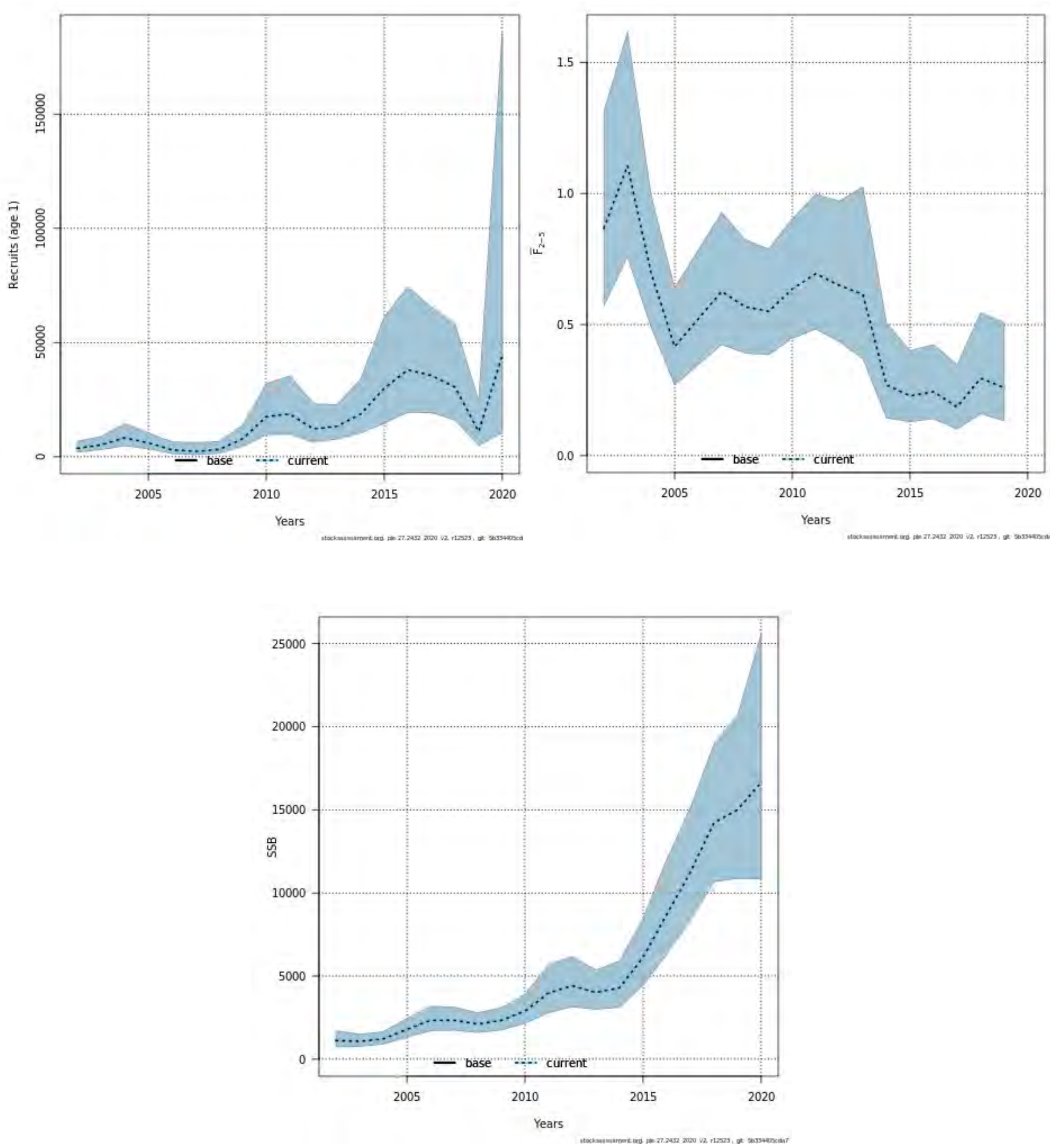


Figure 5.3.7. ple.27.24-32. Results from the exploratory SAM assessment: a) total SSB, b) F (age2–5,) and c) recruitment.

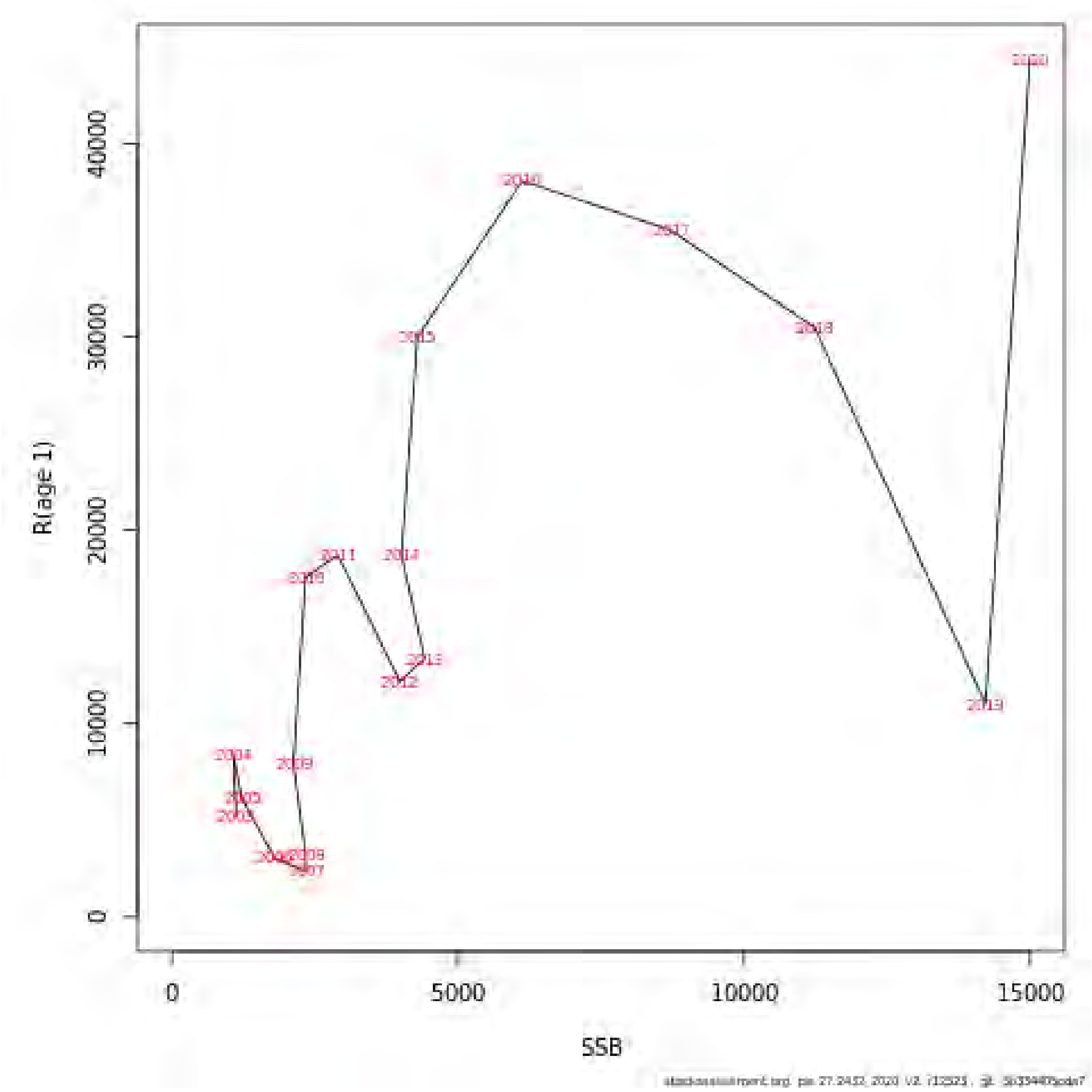


Figure 5.3.8. ple.27.24-32. Estimated recruitment as a function of spawning stock biomass.

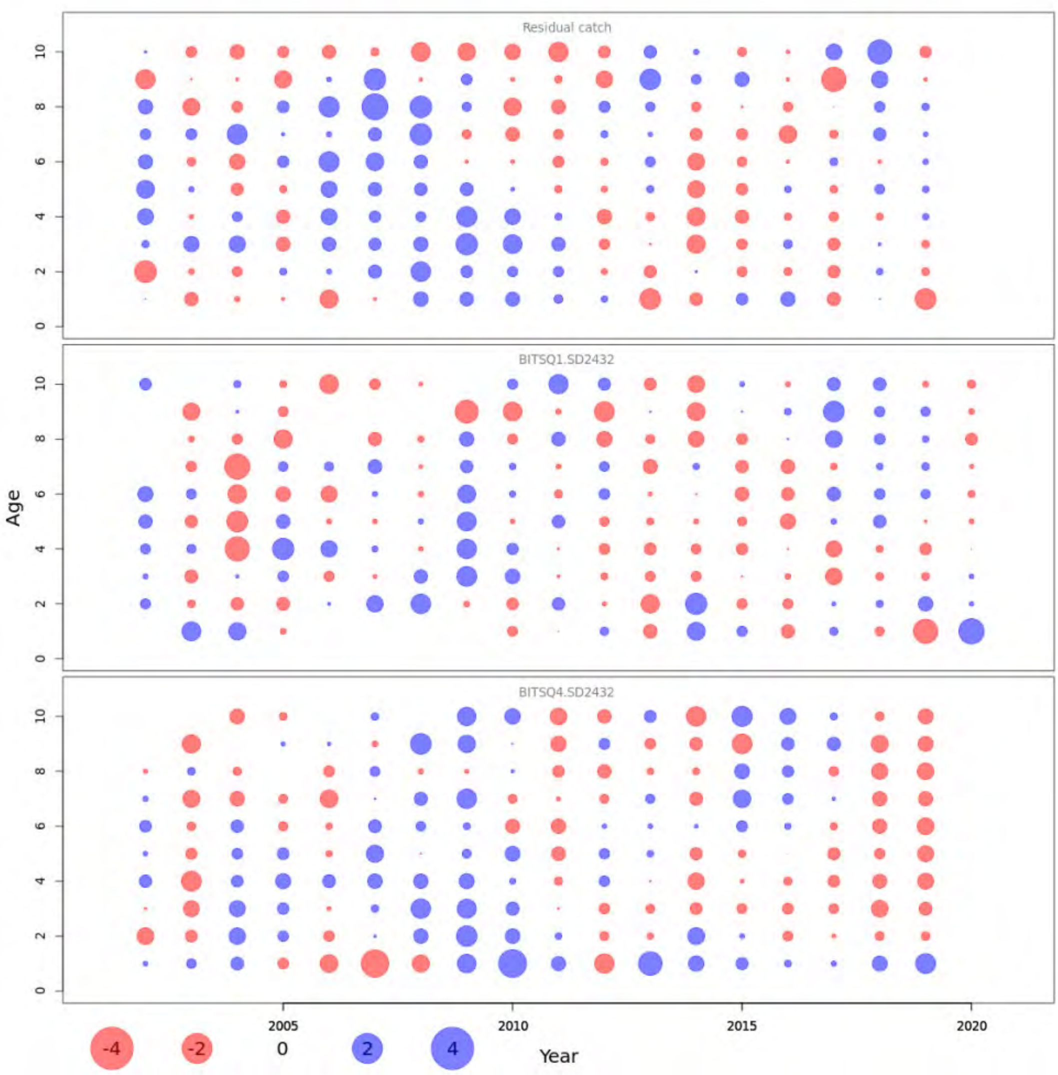


Figure 5.3.9. Normalized residuals for the current run. Blue circles indicate positive residuals (observations larger than predicted) and filled circles indicate negative residuals.

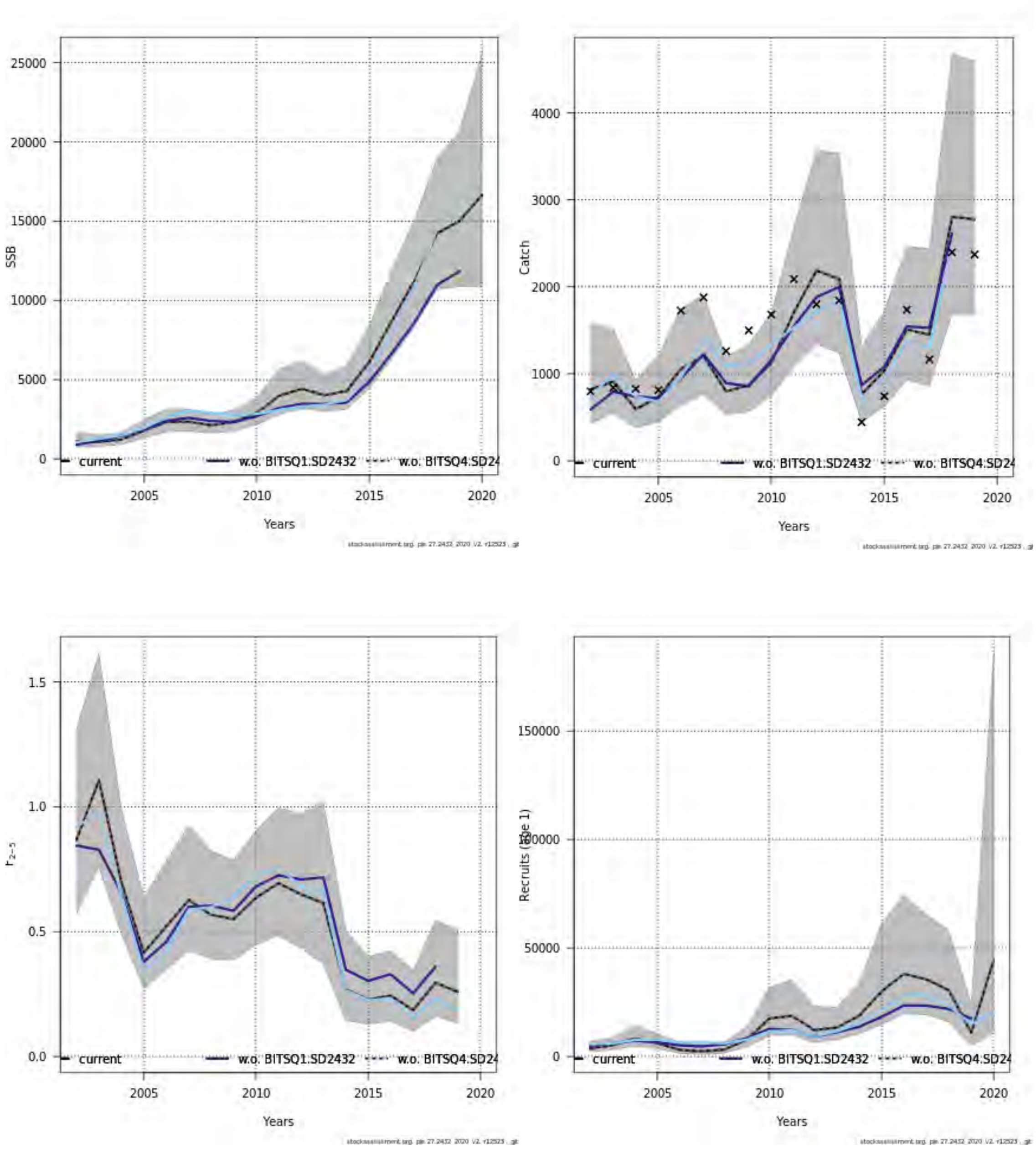


Figure 5.3.10. ple.27.24-32. The results of the retrospective analysis showing SSB, total catch, F (3–5) and recruitment.

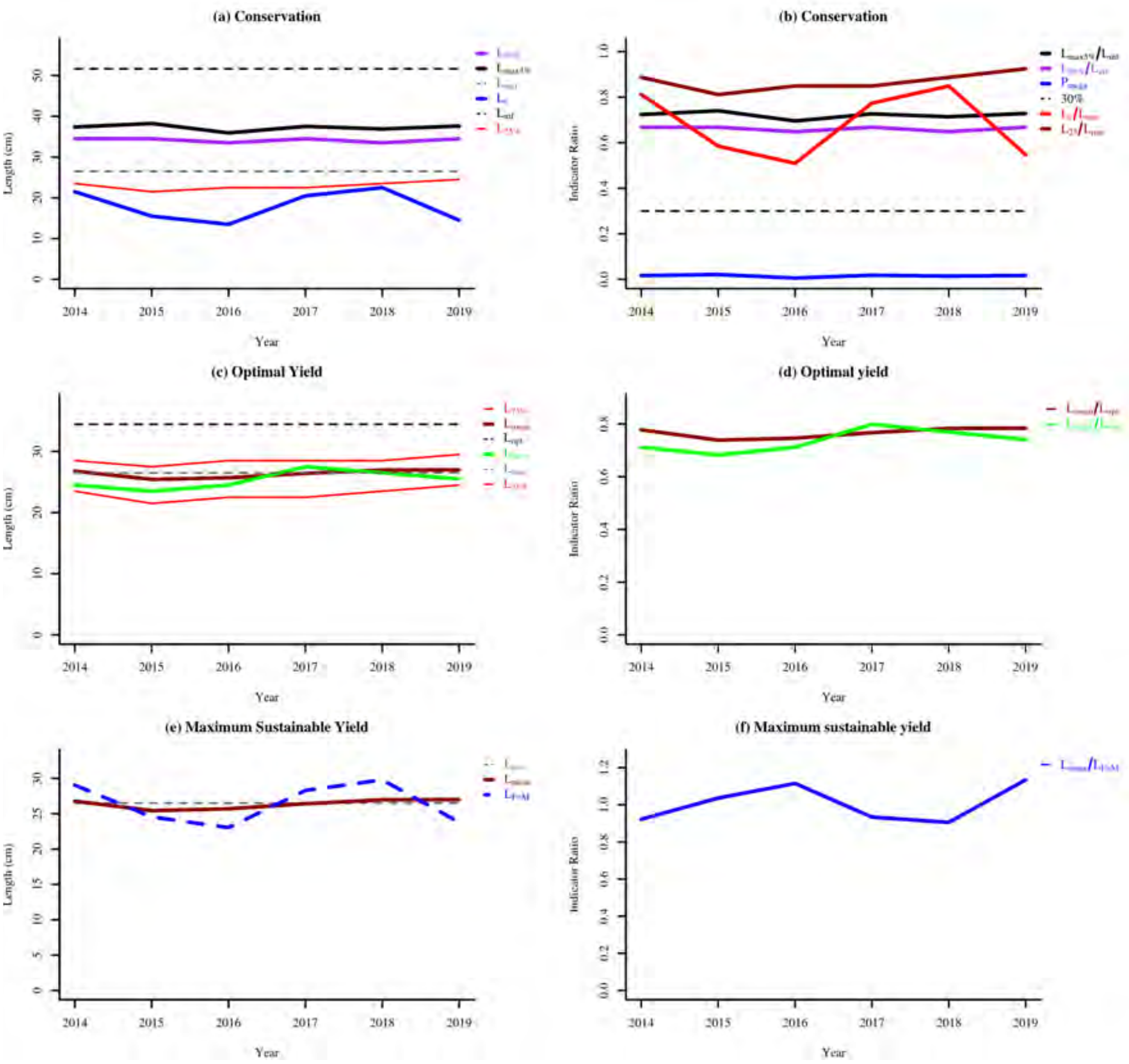


Figure 5.3.11. ple.27.24-32. Indicator trends of the Length-Based Indicator calculations.

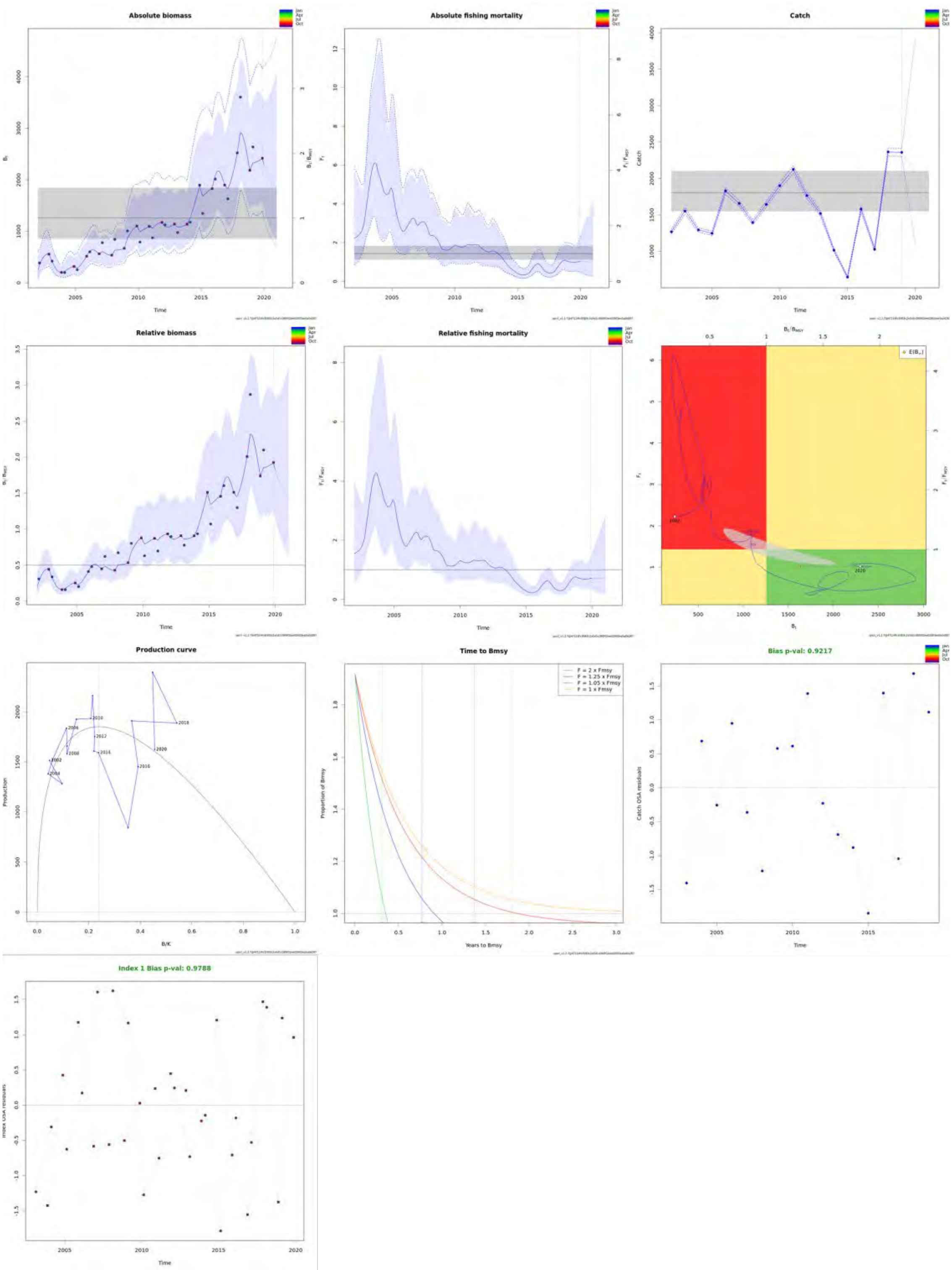


Figure 5.3.12. ple.27.24-32. Overview of the results of the surplus production model (SPiCT) on catch and survey data 2002–2019.

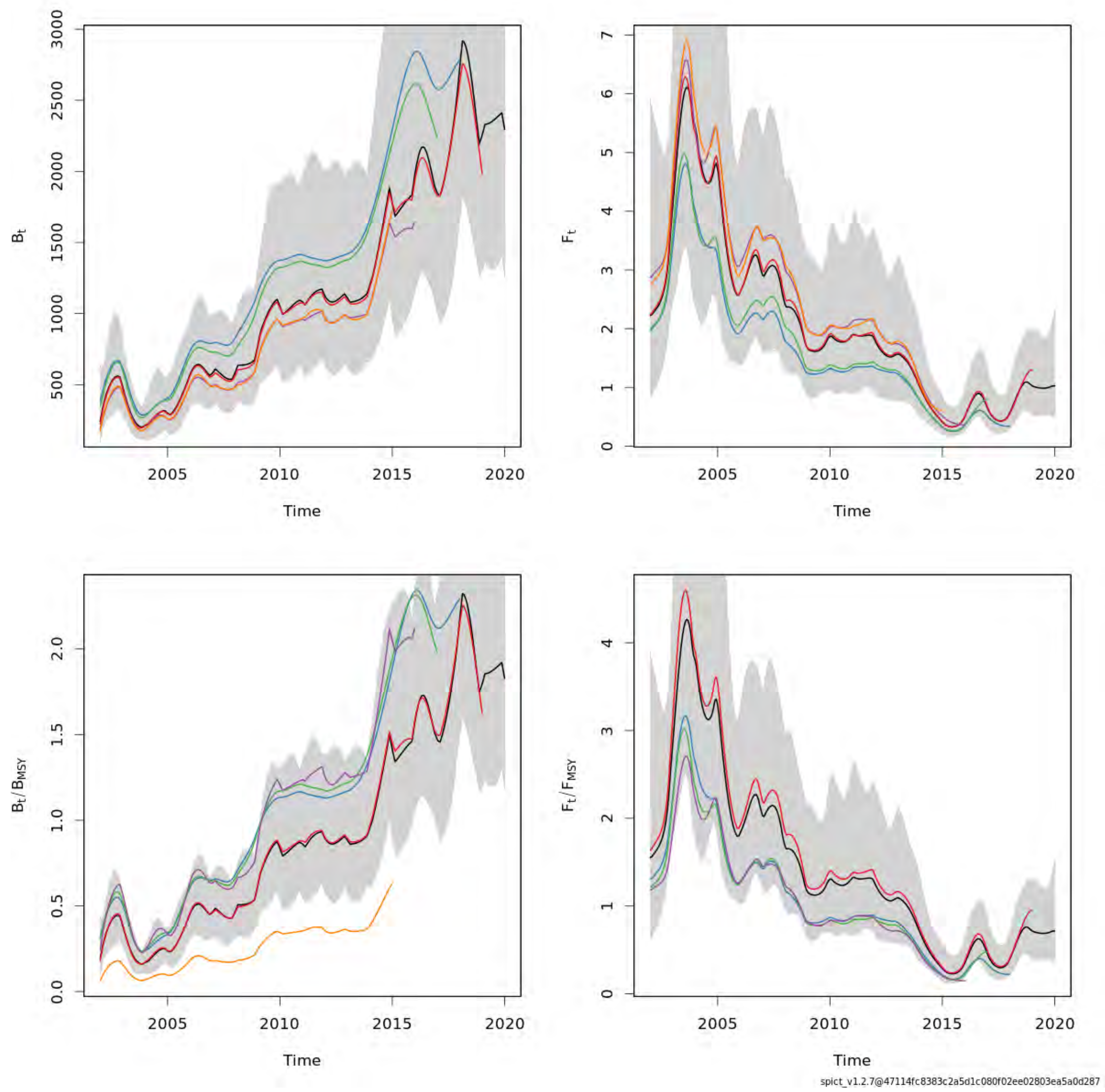


Figure 5.3.13. ple.27.24-32. Overview of the retrospective analysis of the surplus production model (SPiCT) on catch and survey data 2002–2019.

6 Sole in Subdivisions 20–24 (Skagerrak, Kattegat, the Belts and Western Baltic)

6.1 The Fishery

Sole is economically an important species 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 gill net 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 2019 are given in Table 6.1. Denmark took 77% of the total catch in 2019. Kattegat has traditionally been the most important area, but in recent years the proportion between the three areas are rather equal.

Historical catches, including the working group corrections, are provided in Figure 6.1 and Table 6.2. 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 to about 400-500 t along with decreasing TACs. Figure 6.2 provides the Danish catches cumulated by month since 1998 including preliminary 1st quarter catches of 2020, 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 2019 amounts to 2% of the catches by weight based on sampling from trawlers (Table 6.3) and the average of the recent five years are 3% 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

Presently 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 in 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). Overall the sampling has continued to improve (850 specimens from the catches) except for the Belts and the Baltic where no sampling was conducted. 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 higher 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 scattered sampling, ageing problems and/or sex differentiated growth. No trends are obvious for 2019 vs. 2018 mean weights.

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 and years.

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 2019 continued to improve. Thus, gillnetters for the first time in many years sampled both in Skagerrak and Kattegat. The Belts and the Baltic was not sampled in 2019. The small and scattered catches in the fishery for sole mainly caught as bycatch requires a huge effort in port sampling. The improved sampling effort in recent two years 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 the National Institute of Aquatic Resources - 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 shows the progressive expansion of the survey. 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 90 successful hauls out of 90 planned hauls in 2019, 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 that the survey coverage have been reduced over time (see stock annex). The aggregated index shows a stable tendency in catch rates in 2019 and confirmed of the good 2017 year class. (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 2020 is named 'sole20_24_2020' 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 2007/2008) and therefore the effect of removing the survey is visible. 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 five years have increased slowly and is in 2019 estimated to be at 2561 t. Fishing mortality continue to decrease and is below F_{MSY} in 2019. Recruitment calculated as age 1 has since 2010 been low but has increased since 2015 (Figure 6.10, Table 6.11). The good 2017 year class is confirmed in the survey and also shows up in the catch matrix.

6.4.4 Retrospective analysis

Retrospective pattern (Figure 6.11) of the SSB and F estimates a nearly non-existent for the past three years. Mohns rho calculated for SSB, F and recruitment are in the range 0.03 to -0.06. The assessment consistency has most likely improved from more representative 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 2561 t in 2019. Fishing mortality has decreased continuously since 2005 with a sudden increase in 2017 but has decreased again since 2018 to 0.20.

Recent recruitment 2017 and 2018 year classes) are estimated higher than previous year classes and 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

Input data to short-term prediction are provided in Table 6.12.

Discards are not included in the assessment but comprise 2% in weight in 2019 (Table 6.3). The average of the discard in the recent five years (3%) is added to landings to derive catches. Catch options are provided in Table 6.13.

Assumed recruitment ages 1 averaged for 2004-2019 led to an assumed recruitment 2020-2021 of 2647 thousands and 2595 thousands, respectively.

TAC has not been utilized in 2019 and preliminary information on Danish catches in the first quarter of 2020 are lowest in the time-series. In addition, the Covid-19 disruption in 2020 might likely cause some limitations for the fishery. Therefore, the TAC of 533 t for 2020 is assumed unlikely to be caught and the recently used TAC constraint assumption for 2020 is not applied. An Fsq ($F = F_{2019}$) assumption was chosen and leads to a more likely catch of 445 t in 2020. The basis for Fsq (F_{2019}) is not an average of recent Fs (e.g. 3 years) but the final estimate in 2019. Should the recent average be chosen, this average will be higher and consequently produce catches around the TAC, e.g. same scenario as the TAC constraint.

Given the Fsq scenario, SSB in the beginning of 2021 is estimated to 3554 t which is above MSY $B_{trigger}$ (Table 6.13). With this assumption the forecast predicts that fishing at F_{MSY} in 2021 will lead to a total yield of 597 t. At this level of exploitation, spawning stock biomass is estimated at 3540 t in 2022. Catch in 2020-2021 and stock composition in 2021-2022, is estimated to be dominated by age 4 to 6 as indicated in Figure 6.13 under the assumed conditions in 2020.

The European Commission has since 2018 requested advice for the sole stock in SD 20–24 based on F_{MSY} ranges. Landings in 2021 corresponding to F_{MSY} upper and lower range (F = 0.19–0.26) are 488–648 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 $F_{4\text{–}8}$ around 0.82 and that $F_{0.1}$ is estimated to 0.19.

6.6 Reference points

Reference points were redefined under the interbenchmark, IBPSOLKAT (ICES, 2015) in November 2015 as follows:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY 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) but mainly due to increased sampling effort from the National Institute of Aquatic Resources - 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. Mohn's rho for SSB, F and R retro's are within the range of 0.03 to -0.06, which is well within the acceptable range'

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 sur-vey will have implications on perception of present stock biomass. Work is ongoing to improve the biological parameters for sole in the assessment.

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 are unchanged from last year. The historical performance of the assessment is provided in Figure 6.12.

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 uncoupling could be achieved by selective gears and area restrictions.

6.10 Issues relevant for a forthcoming benchmark

DTU Aqua finalized a project in 2018 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. The project achieved many of its objectives but 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. DTU Aqua has therefore initiated a continuation of the study aiming to investigate stock structure further. The main bullets in this study are:

- The connection between the sole stock in SD 20-24 and the North Sea stock Division 4.
- 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.

To achieve these goals the studies will include following methods:

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 will be examined for genetic differentiation to evaluate feeding migrations within SD 20-24 and Division 4.
2. Abundance and distribution of juveniles; identification of potential nursery grounds was done under the previous project, however, validation of those identified areas needs to be done. That will include sampling/monitoring by various small and operational gears in the potential coastal and shallow waters.
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. This method is not included in present project scheme but aimed for future studies.

In addition to the above research items, the assessment needs improvement of:

- Weight in stock is presently 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 presently 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 2019 by area, nation, quarter and gear .

Skagerrak (SD20)	**Quarter**				**Gear**		**Total**
Nation	**1**	**2**	**3**	**4**	**Trawl**	**Gillnet**	
Denmark	11	43	12	23	55	33	88
Germany	0	0	0	0	0	0	0
Sweden	1	0	0	1	1	0	2
Netherlands	11	3	14	40	69	0	69
Norway	0	1	0	1	1	1	
Total	22	46	26	63	126	34	158

Kattegat (SD21)	**Quarter**				**Gear**		**Total**
Nation	**1**	**2**	**3**	**4**	**Trawl**	**Gillnet**	
DK	28	24	25	72	112	38	150
Germany	0	0	8	5	1	12	13
Sweden	1	3	2	3	5	4	9
Total	31	27	35	80	119	54	172

Belts and Baltic (SD22-24)	**Quarter**				**Gear**		**Total**
Nation	**1**	**2**	**3**	**4**	**Trawl**	**Gillnet**	
DK	12	17	10	43	57	24	82
Germany	0	0	0	0	1	1	3
Sweden	0	1	1	0	0	2	2
Total	0	0	1	0	58	27	87

Table 6.2. Sole 3a, 22-24. Landings (tons) in the Skagerrak, Kattegat and the Belts 1952–2019. 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
2019	150	88	82	13	15	2	69		417

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	2019
1	-	7,992	-	-	-	-	-	-	616	140	128	490	3,128	1,156	5,913	254	230	219
2	-	36,918	-	4,312	24,384	-	-	-	3,136	1,767	1,326	2,392	2,492	828	2,761	2,095	476	1,415
3	-	119,198	-	-	7,040	-	-	-	2,646	1,105	1,782	1,872	19,126	-	1,800	9,733	2,457	1,281
4	-	4,592	-	4,171	10,366	-	-	-	2,175	972	4,032	954	1,316	1,076	3,408	1,117	568	2,465
5	-	-	-	1,962	-	-	-	-	2,499	888	680	510	1,785	981	14	1,404	1,379	1,306
6	-	-	-	-	588	-	-	-	166	480	928	1,232	972	264	315	692	588	518
7	-	-	-	-	158	-	-	-	1,080	714	570	1,030	1,800	-	702	315	716	155
8	-	-	-	-	123	-	-	-	291	545	248	416	1,220	296	-	603	30	441
9	-	-	-	-	-	-	-	-	1,197	306	572	708	232	-	172	345	143	103
10	-	-	-	-	158	-	-	-	117	605	393	224	-	832	1,456	379	45	182
11	-	-	-	-	-	-	-	-	-	-	345			118	-	169	-	211
Total (t)	-	169	-	10	43	-	-	-	14	8	11	10	32	6	17	17	7	8
Landings(	637	645	478	862	618	826	994	706	538	552	359	332	335	224	348	520	348	417
Catches	637	814	478	872	661	826	994	706	552	560	370	342	367	230	365	537	355	425
Discard %	0%	21%	0%	1%	6%	0%	0%	0%	3%	1%	3%	3%	9%	2%	5%	3%	2%	2%

Table 6.4. Sole 20-24. Sampling and ageing in 2019 from landings.

	Belts and Baltic			Skagerrak			Kattegat			Total		
Quarter	Landings	Sampled catch	Aged	Landings	Sampled catch	Aged	Landings	Sampled catch	Aged	Landings	Sampled catch	Aged
1	12,164	-	-	22,806	11,242	306	29,672	28,244	164	64,642	39,486	470
2	18,494	-	-	46,841	42,562	70	26,992	-	-	92,327	42,562	70
3	10,664	-	-	26,412	11,654	12	35,179	25,227	38	72,256	36,881	50
4	43,799	-	-	63,871	22,549	120	80,433	72,214	140	188,103	94,763	260
Total	85,122	0	0	159,930	88,007	508	172,276	125,685	342	417,328	213,692	850

Table 6.5. Sole 20-24. Tuning fleets.

```
103
Fisherman-DTU Aqua survey meth 6
2004       2019
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
1          26.39153   69.97627   14.57185   31.64473   18.97451   15.03203   4.046981   3.637353   18.04592
```

```
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.

Numbers*10**-3

YEAR,	1984,	1985,	1986,	1987,	1988,	1989,
AGE						
2,	64,	786,	258,	391,	516,	863,
3,	638,	594,	1255,	857,	1035,	613,
4,	240,	190,	671,	1018,	897,	847,
5,	117,	55,	210,	434,	484,	592,
6,	31,	60,	33,	174,	129,	404,
7,	33,	16,	36,	64,	37,	83,
8,	40,	8,	33,	31,	23,	30,
+gp,	175,	69,	63,	87,	60,	52,
0 TOTALNUM,	1338,	1778,	2559,	3056,	3181,	3484,
TONSLAND,	337,	397,	643,	722,	706,	824,
SOPCOF %,	99,	100,	100,	100,	100,	100,

Numbers*10**-3

YEAR,	1990,	1991,	1992,	1993,	1994,	1995,	1996,	1997,	1998,	1999,
AGE										
2,	1209,	530,	506,	523,	127,	272,	316,	54,	303,	249,
3,	1300,	1301,	1178,	1804,	1037,	622,	1015,	251,	146,	826,
4,	651,	928,	939,	1251,	1451,	1359,	537,	440,	212,	150,
5,	564,	334,	493,	826,	752,	1226,	691,	365,	299,	228,
6,	310,	345,	320,	418,	444,	600,	440,	505,	267,	177,
7,	167,	302,	178,	117,	152,	385,	232,	360,	250,	165,
8,	27,	180,	166,	137,	45,	142,	148,	262,	218,	167,
+gp,	31,	76,	239,	157,	59,	104,	203,	263,	292,	233,
0 TOTALNUM,	4259,	3996,	4019,	5233,	4067,	4710,	3582,	2500,	1987,	2195,
TONSLAND,	1050,	1011,	1294,	1439,	1198,	1297,	1059,	814,	605,	638,
SOPCOF %,	100,	95,	93,	100,	99,	98,	98,	100,	100,	100,

Numbers*10**-3

YEAR,	2000,	2001,	2002,	2003,	2004,	2005,	2006,	2007,	2008,	2009,
AGE										
2,	142,	170,	655,	48,	195,	231,	122,	293,	313,	554,
3,	483,	369,	758,	431,	602,	1015,	400,	420,	330,	683,
4,	771,	360,	285,	480,	814,	1083,	857,	384,	354,	445,
5,	114,	354,	423,	280,	475,	583,	734,	583,	297,	285,
6,	130,	68,	472,	344,	257,	276,	505,	299,	489,	139,
7,	123,	84,	94,	197,	187,	117,	169,	135,	240,	92,
8,	135,	36,	85,	25,	86,	102,	67,	81,	179,	29,
+gp,	306,	205,	464,	210,	171,	91,	116,	108,	202,	88,
0 TOTALNUM,	2204,	1646,	3236,	2015,	2787,	3498,	2970,	2303,	2404,	2315,
TONSLAND,	646,	476,	862,	619,	824,	990,	836,	633,	656,	640,
SOPCOF %,	100,	99,	100,	100,	99,	98,	98,	97,	102,	98,

Numbers*10**-3

YEAR,	2010,	2011,	2012,	2013,	2014,	2015,	2016,	2017,	2018,	2019,
AGE										
2,	230,	138,	26,	48,	13,	37,	110,	137,	32,	163,
3,	591,	558,	157,	226,	66,	81,	273,	181,	131,	59,
4,	458,	613,	284,	286,	178,	95,	190,	347,	268,	309,
5,	211,	246,	160,	194,	109,	109,	175,	195,	201,	268,
6,	132,	65,	111,	137,	199,	89,	82,	186,	97,	93,
7,	67,	28,	36,	62,	105,	81,	38,	163,	144,	54,
8,	83,	14,	54,	23,	68,	18,	50,	120,	104,	83,
+gp,	103,	106,	192,	96,	69,	93,	181,	301,	157,	235,
0 TOTALNUM,	1875,	1768,	1020,	1072,	807,	603,	1099,	1630,	1134,	1264,
TONSLAND,	541,	507,	358,	332,	331,	215,	348,	520,	434,	417,
SOPCOF %,	101,	100,	100,	109,	100,	100,	101,	100,	100,	99,

Table 6.7. Sole 20-24. Weight at age (kg) in the catch and in the stock.

```
Mean Weight in Catch (kilograms)
1 3
1984 2019
1 9
1
0.06          0.183         0.213         0.257         0.294         0.297         0.28
              0.321         0.368
0.06          0.174         0.234         0.283         0.291         0.335         0.292
              0.279         0.364
0.06          0.165         0.231         0.287         0.297         0.409         0.267
              0.262         0.383
0.06          0.16          0.194         0.245         0.274         0.319         0.36
              0.417         0.361
0.06          0.159         0.197         0.235         0.251         0.335         0.348
              0.363         0.352
0.06          0.176         0.221         0.255         0.266         0.271         0.352
              0.3                         0.355
0.06          0.18          0.228         0.251         0.308         0.333         0.4
                            0.547         0.555
0.06          0.174         0.229         0.275         0.292         0.346         0.309
              0.386         0.503
0.06          0.213         0.252         0.336         0.412         0.43          0.491
              0.566         0.622
0.06          0.178         0.224         0.274         0.328         0.374         0.403
              0.388         0.474
0.06          0.174         0.229         0.28          0.342         0.388         0.445
              0.448         0.394
```

0.06	0.187	0.2		0.248	0.291	0.351
	0.382	0.432	0.383			
0.06	0.176	0.218	0.267	0.307	0.339	0.404
	0.457	0.664				
0.06	0.198	0.272	0.296	0.308	0.345	0.359
	0.364	0.361				
0.06	0.161	0.219	0.316	0.322	0.35	0.358
	0.377	0.327				
0.06	0.162	0.232	0.304	0.368	0.36	0.378
	0.397	0.35				
0.06	0.169	0.236	0.304	0.344	0.319	0.364
	0.352	0.328				
0.06	0.184	0.242	0.29	0.378	0.346	0.308
	0.362	0.281				
0.06	0.172	0.205	0.294	0.373	0.386	0.214
	0.292	0.276				
0.06	0.174	0.21	0.246	0.36	0.382	0.431
	0.261	0.382				
0.06	0.203	0.237	0.291	0.328	0.371	0.401
	0.37	0.315				
0.06	0.192	0.223	0.3		0.324	0.367
	0.371	0.421	0.372			
0.06	0.201	0.215	0.263	0.317	0.339	0.321
	0.293	0.344				
0.06	0.211	0.228	0.295	0.302	0.354	0.339
	0.38	0.244				
0.06	0.215	0.246	0.267	0.28	0.29	0.296
	0.301	0.246				
0.06	0.211	0.259	0.301	0.319	0.403	0.439
	0.439	0.263				
0.06	0.258	0.27	0.283	0.324	0.311	0.369
	0.31	0.263				
0.06	0.261	0.271	0.292	0.277	0.358	0.476
	0.285	0.301				
0.06	0.285	0.279	0.317	0.375	0.406	0.406
	0.35	0.406				
0.06	0.239	0.225	0.276	0.304	0.373	0.305
	0.306	0.287				
0.06	0.227	0.283	0.372	0.421	0.443	0.486
	0.454	0.406				
0.06	0.221	0.239	0.286	0.391	0.404	0.388
	0.501	0.434				

0.18	0.234	0.267	0.268	0.283	0.341	0.330	0.544	0.439
0.18	0.216	0.265	0.292	0.299	0.326	0.377	0.334	0.395

0.18	0.210	0.228	0.313	0.368	0.357	0.463
	0.475	0.564				
0.129	0.200	0.288	0.290	0.384	0.423	0.459
	0.386	0.344				

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	7.80571	6.07775	10.02493
2	2	2	14.56549	11.50124	18.44614
3	2	3	16.55114	13.13362	20.85795
4	2	4	18.26808	14.84251	22.48425
5	2	5	18.26808	14.84251	22.48425
6	2	6	18.26808	14.84251	22.48425
7	2	7	18.26808	14.84251	22.48425
8	2	8	18.26808	14.84251	22.48425
9	2	9	18.26808	14.84251	22.48425
10	3	2	0.06703	0.04781	0.09398
11	3	3	0.29210	0.23299	0.36622
12	3	4	0.32077	0.25574	0.40233
13	3	5	0.30436	0.25932	0.35722
14	3	6	0.30436	0.25932	0.35722
15	3	7	0.30436	0.25932	0.35722

Index	Fleet number	Age	Catchability	Low	High
16	3	8	0.30436	0.25932	0.35722
17	4	2	1.61132	1.27785	2.03183
18	4	3	2.96316	2.32936	3.76940
19	4	4	2.83447	2.22504	3.61082
20	4	5	2.86496	2.36996	3.46336
21	4	6	2.86496	2.36996	3.46336

Table 6.9. Sole 20-24. Fishing mortality at age (age 6-9 assumed constant).

Year Age	2	3	4	5	6
1984	0.081	0.394	0.485	0.401	0.377
1985	0.074	0.305	0.373	0.336	0.286
1986	0.084	0.314	0.416	0.397	0.345
1987	0.100	0.329	0.446	0.461	0.457
1988	0.100	0.310	0.412	0.411	0.405
1989	0.104	0.317	0.425	0.429	0.413
1990	0.098	0.303	0.414	0.418	0.369
1991	0.098	0.304	0.424	0.442	0.482
1992	0.096	0.300	0.419	0.462	0.587
1993	0.094	0.300	0.419	0.471	0.587
1994	0.080	0.258	0.358	0.407	0.437
1995	0.087	0.285	0.380	0.436	0.474
1996	0.084	0.288	0.354	0.400	0.421
1997	0.078	0.258	0.337	0.382	0.423
1998	0.073	0.237	0.310	0.372	0.401
1999	0.068	0.226	0.293	0.341	0.365
2000	0.064	0.215	0.291	0.326	0.358
2001	0.055	0.184	0.239	0.285	0.303
2002	0.061	0.198	0.262	0.325	0.430
2003	0.053	0.167	0.246	0.304	0.401
2004	0.062	0.191	0.292	0.352	0.453

Year Age	2	3	4	5	6
2005	0.072	0.218	0.323	0.376	0.445
2006	0.074	0.226	0.319	0.382	0.373
2007	0.077	0.235	0.318	0.354	0.304
2008	0.087	0.267	0.365	0.372	0.319
2009	0.078	0.258	0.361	0.326	0.185
2010	0.070	0.257	0.360	0.317	0.164
2011	0.053	0.207	0.318	0.256	0.121
2012	0.041	0.155	0.263	0.223	0.138
2013	0.036	0.131	0.237	0.207	0.141
2014	0.029	0.095	0.192	0.180	0.147
2015	0.026	0.080	0.154	0.171	0.124
2016	0.031	0.091	0.187	0.209	0.166
2017	0.038	0.093	0.219	0.265	0.271
2018	0.033	0.072	0.181	0.228	0.243
2019	0.031	0.064	0.168	0.211	0.213

Table 6.10. Sole 20-24. Stock number-at-age from assessment.

Year Age	1	2	3	4	5	6	7	8	9
1984	6444	2610	1599	508	365	136	80	126	476
1985	5285	5984	2311	922	267	220	90	46	353
1986	4857	4712	4981	1627	590	174	145	69	267
1987	4280	4420	3932	3275	971	358	122	92	221
1988	5886	3654	3794	2714	1882	492	178	70	180
1989	7620	5368	2688	2573	1682	1165	269	103	149
1990	7590	7135	4399	1756	1574	1013	704	148	144
1991	8650	6748	5652	2856	1036	939	663	467	190
1992	6609	8247	5489	3561	1586	587	512	369	391
1993	3599	6250	6959	3686	2136	887	287	263	369
1994	3510	3018	5289	4848	2234	1226	421	142	300
1995	2256	3353	2636	3940	3136	1453	767	267	283

Year Age	1	2	3	4	5	6	7	8	9
1996	1517	2029	2870	1870	2424	1758	864	434	368
1997	3687	1161	1462	1724	1246	1510	1123	615	537
1998	3689	3745	885	966	993	780	859	689	729
1999	3092	3416	3613	641	730	614	520	526	880
2000	4446	2607	2700	2517	434	505	373	360	951
2001	5945	4062	2182	1969	1595	297	369	215	885
2002	4560	5784	3736	1563	1491	1138	221	267	815
2003	4707	3969	4435	2700	1134	1030	625	119	622
2004	3047	4527	3803	3299	1745	748	577	341	428
2005	2595	2815	4547	3310	2203	993	377	293	353
2006	3209	2421	2300	3443	2131	1407	562	229	413
2007	3496	2696	1992	1630	2196	1096	795	358	471
2008	2229	3210	1959	1435	1085	1402	676	539	576
2009	2250	2101	2644	1282	990	690	908	394	679
2010	2064	2068	1953	1780	762	658	456	687	814
2011	1807	1902	1888	1459	1152	494	468	289	1130
2012	1586	1579	1553	1420	931	820	349	375	1110
2013	1605	1409	1387	1225	1032	669	643	252	1024
2014	2647	1362	1206	1033	861	784	467	533	921
2015	3391	2384	1190	1044	717	668	564	319	1238
2016	2948	2988	2170	999	926	511	466	413	1348
2017	1885	2865	2518	1716	719	753	404	343	1399
2018	4427	1511	2468	2039	1165	475	536	300	1208
2019	3955	4272	1220	2100	1504	807	323	371	1134

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	R(age 1)	Low	High	SSB	Low	High	Fbar(4-8)	Low	High	TSB	Low	High
1984	6444	4038	10284	857	696	1055	0.404	0.305	0.533	1721	1417	2090
1985	5285	3495	7993	1121	905	1389	0.314	0.239	0.411	2479	2002	3071
1986	4857	3267	7222	2023	1625	2519	0.370	0.292	0.469	3092	2561	3732
1987	4280	2813	6510	2108	1756	2530	0.456	0.359	0.579	3072	2613	3612
1988	5886	3953	8762	2173	1838	2569	0.407	0.320	0.518	3107	2671	3614
1989	7620	5112	11358	2192	1873	2565	0.419	0.331	0.529	3594	3081	4192
1990	7590	5117	11257	2708	2313	3171	0.388	0.309	0.487	4448	3795	5213
1991	8650	5734	13051	3188	2703	3759	0.463	0.374	0.573	4881	4180	5698
1992	6609	4431	9857	4189	3572	4913	0.528	0.425	0.657	6342	5413	7431
1993	3599	2434	5320	3994	3386	4712	0.530	0.422	0.666	5323	4565	6205
1994	3510	2384	5166	4178	3581	4873	0.416	0.330	0.523	4913	4256	5672
1995	2256	1511	3367	3444	2991	3965	0.448	0.358	0.560	4206	3683	4804
1996	1517	958	2405	3257	2843	3731	0.403	0.326	0.499	3705	3255	4218
1997	3687	2447	5554	2633	2297	3019	0.398	0.322	0.492	3085	2714	3505
1998	3689	2508	5426	1897	1638	2197	0.377	0.302	0.471	2722	2364	3133
1999	3092	2073	4610	2237	1910	2619	0.346	0.278	0.430	2975	2563	3455
2000	4446	3026	6534	2287	1961	2668	0.338	0.271	0.421	2994	2596	3454
2001	5945	4000	8836	2245	1937	2603	0.286	0.227	0.362	3350	2897	3873
2002	4560	3094	6721	2571	2195	3011	0.376	0.299	0.472	3839	3271	4506
2003	4707	3175	6979	2935	2509	3433	0.350	0.273	0.449	3908	3400	4493
2004	3047	2173	4273	3204	2775	3699	0.400	0.317	0.505	4305	3751	4941
2005	2595	1840	3659	3479	2992	4047	0.407	0.324	0.511	4176	3622	4814
2006	3209	2216	4646	2942	2511	3447	0.364	0.291	0.455	3621	3116	4208
2007	3496	2461	4967	2506	2153	2917	0.317	0.249	0.404	3285	2840	3800
2008	2229	1533	3240	2080	1765	2450	0.339	0.262	0.438	2903	2482	3397
2009	2250	1584	3196	2415	2011	2900	0.248	0.189	0.325	2993	2531	3540
2010	2064	1448	2941	2078	1724	2505	0.234	0.177	0.308	2735	2300	3253
2011	1807	1237	2639	2079	1706	2533	0.188	0.142	0.248	2684	2227	3235

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(4-8)	Low	High	TSB	Low	High
2012	1586	1044	2408	2289	1862	2815	0.180	0.135	0.240	2835	2332	3446
2013	1605	1063	2422	1780	1447	2190	0.174	0.131	0.230	2213	1821	2690
2014	2647	1842	3802	2278	1866	2780	0.162	0.123	0.214	2746	2276	3313
2015	3391	2318	4960	2049	1676	2506	0.139	0.104	0.187	2780	2304	3354
2016	2948	2045	4250	2254	1849	2747	0.179	0.137	0.233	3484	2883	4209
2017	1885	1227	2895	2448	2012	2978	0.260	0.196	0.345	3406	2812	4126
2018	4427	2794	7013	2871	2325	3544	0.228	0.171	0.303	3985	3240	4901
2019	3955	2251	6947	2561	2024	3240	0.203	0.147	0.282	3925	3096	4977

Table 6.12. Sole 20-24. Input to short term prediction.

2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	2647	0.1	0	0	0	0.163	0.000	0.163
2	3598	0.1	0	0	0	0.209	0.162	0.209
3	3715	0.1	1	0	0	0.260	0.498	0.260
4	1041	0.1	1	0	0	0.298	0.968	0.298
5	1614	0.1	1	0	0	0.350	1.100	0.350
6	1135	0.1	1	0	0	0.369	0.977	0.369
7	598	0.1	1	0	0	0.433	0.977	0.433
8	235	0.1	1	0	0	0.398	0.977	0.398
9	1112	0.1	1	0	0	0.434	0.977	0.434

2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	2595	0.1	0	0	0	0.163	0.000	0.163
2	2430	0.1	0	0	0	0.209	0.162	0.209
3	3214	0.1	1	0	0	0.260	0.498	0.260
4	3173	0.1	1	0	0	0.298	0.968	0.298
5	794	0.1	1	0	0	0.350	1.100	0.350
6	1177	0.1	1	0	0	0.369	0.977	0.369

2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
7	822	0.1	1	0	0	0.433	0.977	0.433
8	447	0.1	1	0	0	0.398	0.977	0.398
9	1000	0.1	1	0	0	0.434	0.977	0.434

2022								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWt**	**Sel**	**CWt**
1	2595	0.1	0	0	0	0.163	0.000	0.163
2	2328	0.1	0	0	0	0.209	0.162	0.209
3	1952	0.1	1	0	0	0.260	0.498	0.260
4	2267	0.1	1	0	0	0.298	0.968	0.298
5	1614	0.1	1	0	0	0.350	1.100	0.350
6	335	0.1	1	0	0	0.369	0.977	0.369
7	511	0.1	1	0	0	0.433	0.977	0.433
8	350	0.1	1	0	0	0.398	0.977	0.398
9	648	0.1	1	0	0	0.434	0.977	0.434

Input units are thousands and kg.

Table 6.13. Sole 20-24. Basis for forecasts and management options table for short term predictions[1].

Variable	Value	Notes
F ages 4–8 (2020)	0.196	Fsq (=F2019)
SSB (2021)	3554 tonnes	When fishing at F=0.196
Rage1 (2020)	2647 thousands	Resampled from recruitment (2004-2019)
Rage1 (2021)	2595 thousands	Resampled from recruitment (2004-2019)
Wanted catch (2020)	457 tonnes	Based on fishing at Fsq and mean discard rate
Unwanted catch (2020)	13 tonnes	Mean discard rate in weight (2015-2019) of 3%.
Total catch (2020)	445 tonnes	Fishing at Fsq in 2020

[1] *See Annex 10 for revised numbers regarding the basis for the short term forecasts and catch scenario for sole 20-24. Updated in June 2020 after correcting the value for F2020 as decided at ADGNS*.

Basis	Total catch * (2021)	Projected landings** (2021)	Projected discards ** (2021)	F projected landings (4–8) (2021)	SSB (2022)	% SSB change ***	% TAC change ^	% Advice change ^^
ICES advice basis								
EU MAP#: FMSY	597	581	16	0.23	3540	2.67	9.01	11
EU MAP#: Flower	502	488	14	0.190	3629	5.25	-8.44	11
EU MAP#: Fupper	666	648	18	0.26	3460	0.35	22	11
Other scenarios								
F = 0	0	0	0	0	4164	21	-100	-100
Fpa	597	581	16	0.23	3540	2.67	9.01	11
Flim	786	765	21	0.315	3330	-3.42	44	46
SSB (2022) = Blim	2216	2156	60	1.32	1859	-46	305	389
SSB (2022) = Bpa	1494	1453	41	0.67	2614	-24	173	177
SSB (2022) = MSY Btrigger	1494	1453	41	0.67	2614	-24	173	177
F = F2020	526	512	14	0.20	3435	0	-3.94	-2.35

 # EU multiannual plan (MAP) for the North Sea (EU, 2018).

*** Total catch is calculated based on projected landings (fish that would be landed in the absence of the EU landing obligation) and 2.8% discard ratio (in weight).**

**** "Projected landings" and "projected discards" are used to describe fish that would be landed and discarded in the absence of the EU landing obligation, based on discard ratio estimates for 2015–2019.**

***** SSB 2022 relative to SSB 2021.**

^ Total catch in 2021 relative to TAC in 2020 (533 tonnes).

^^ Advice value 2021 relative to advice value 2020 (539 tonnes).

 # ICES advice for F_{lower} in 2021 relative to ICES advice F_{lower} in 2020 (452 tonnes).

ICES advice for F_{upper} in 2021 relative to ICES advice F_{upper} in 2020 (600 tonnes).

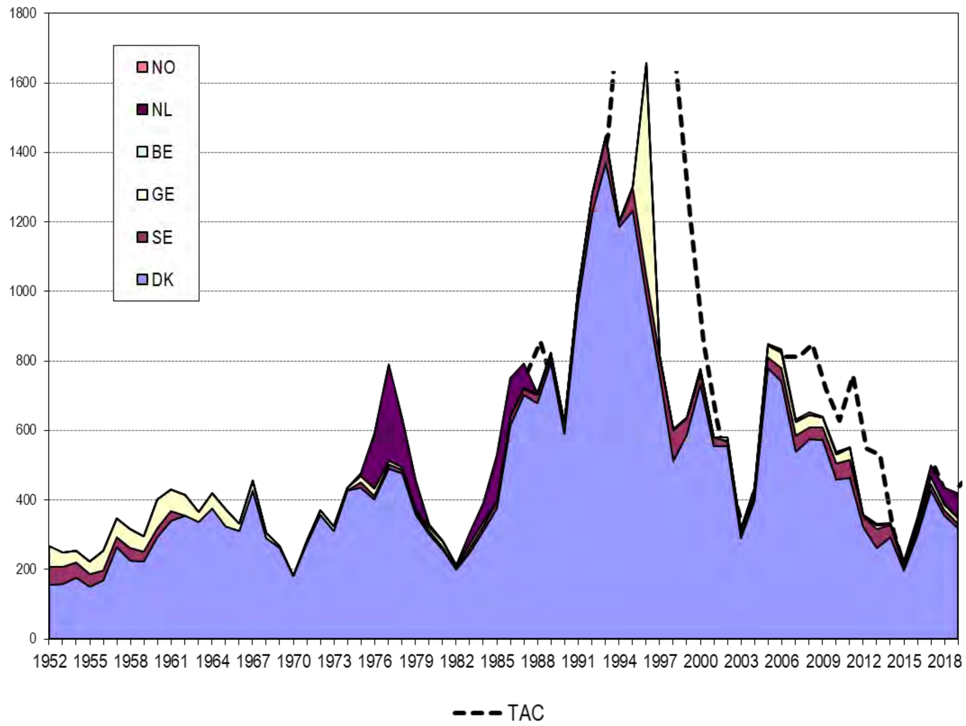
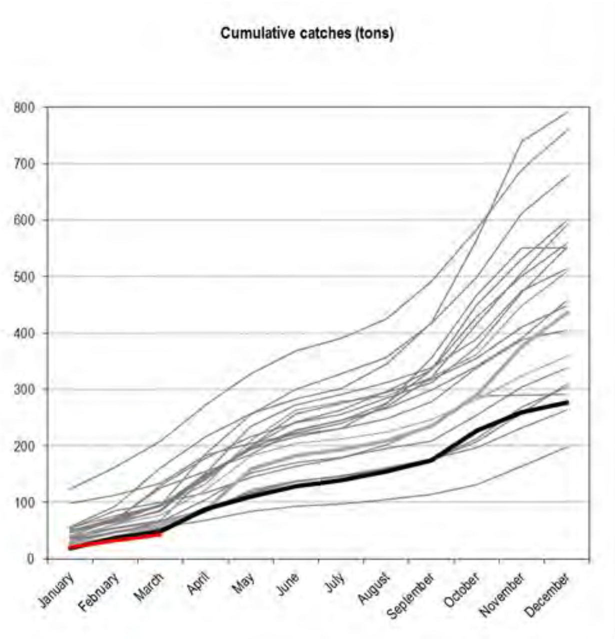


Figure 6.1. Sole 20-24. Landings of sole in divisions 20-24 by nation since 1952 (tonnes/kg).


Cumulative catches (tons)
800
700
600
500
400
300
200
100
0
January
February
March
April
May
June
July
August
September
October
November
December

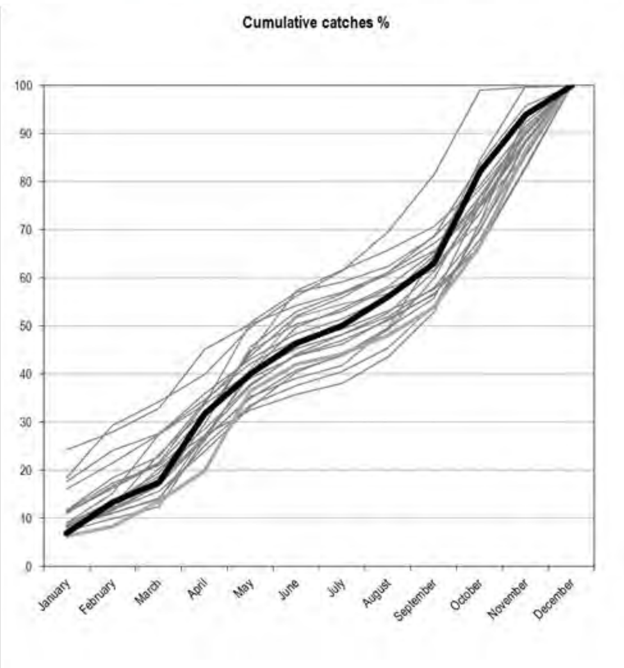

Cumulative catches %
100
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December

Figure 6.2. Sole 20-24. Cumulative Danish landings of sole by month. Black bold curve is 2019 and red bold curve is 2019 including March.

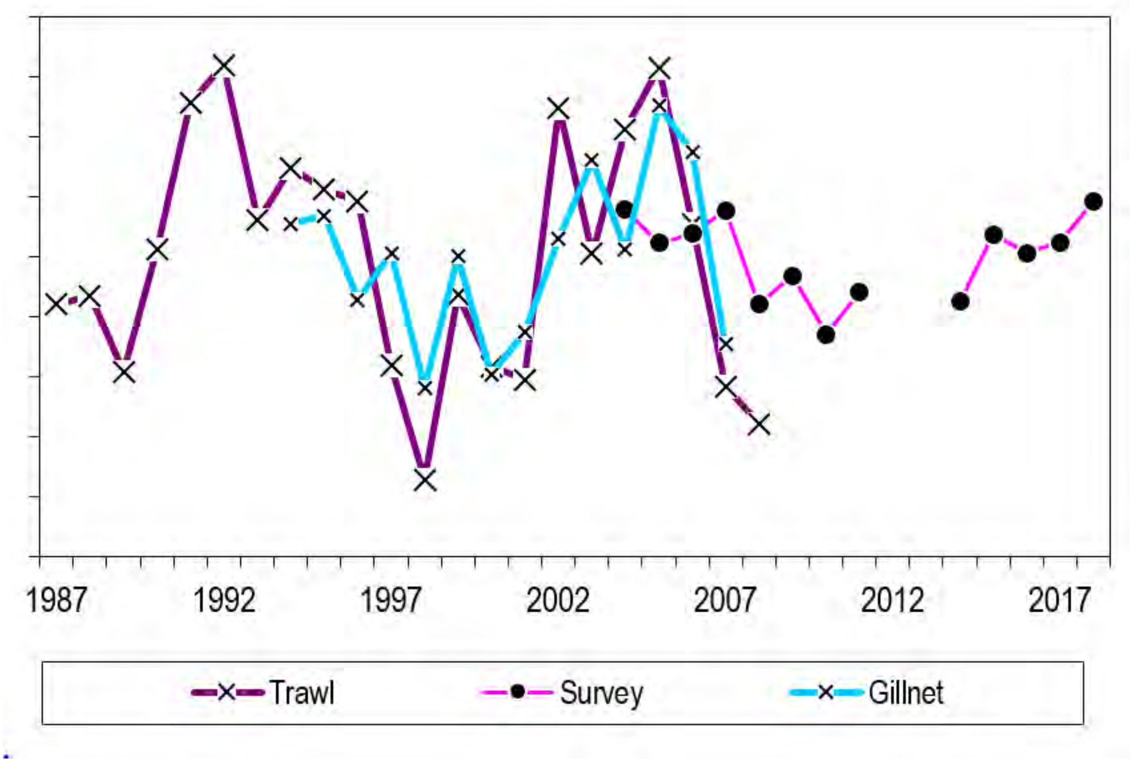


Figure 6.3. Sole 20-24. Standardised age aggregated CPUE indices of sole from private logbooks from trawlers, private logbooks gillnetters and Fisherman/DTU Aqua survey as used in the assessment.

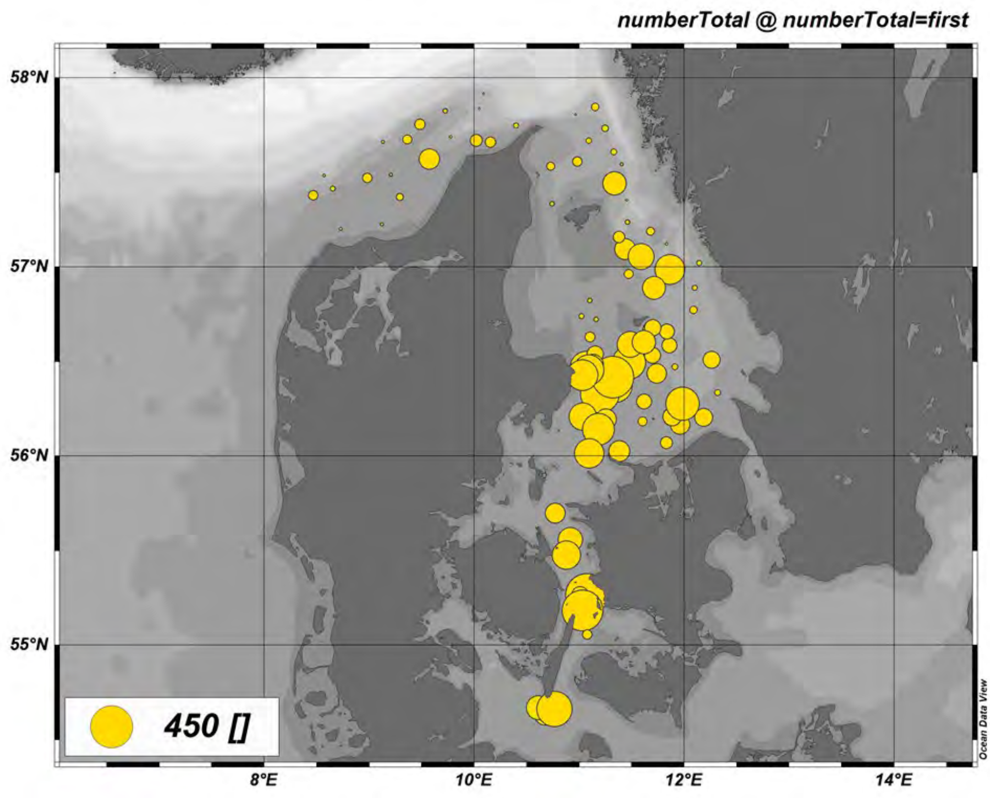


Figure 6.4. 20-24. Fisherman-DTU Aqua survey. Catch rate distribution of stations in 2019.

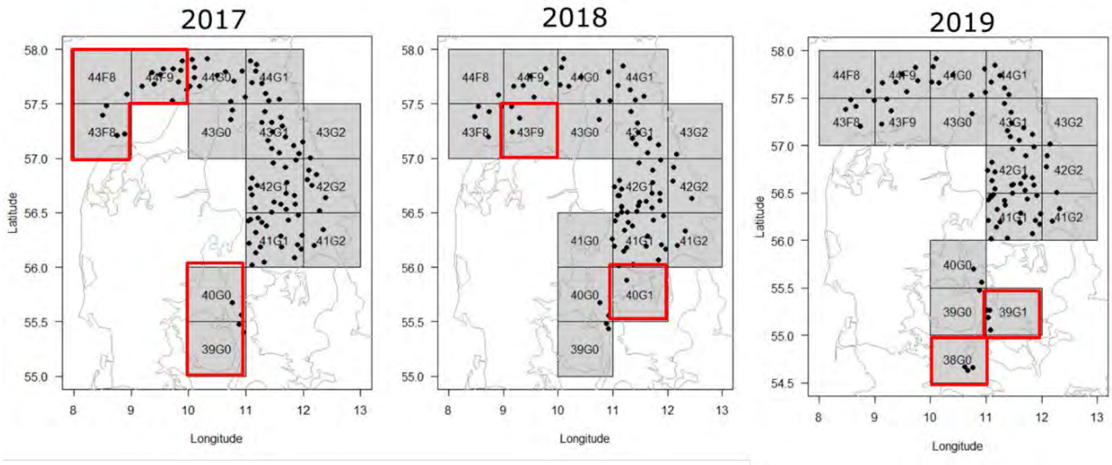


Figure 6.5. Sole 20-24. Map of sole survey station distribution in 2017-2019, red boxes illustrating the successively extended survey area (subdivisions 20 and 22).

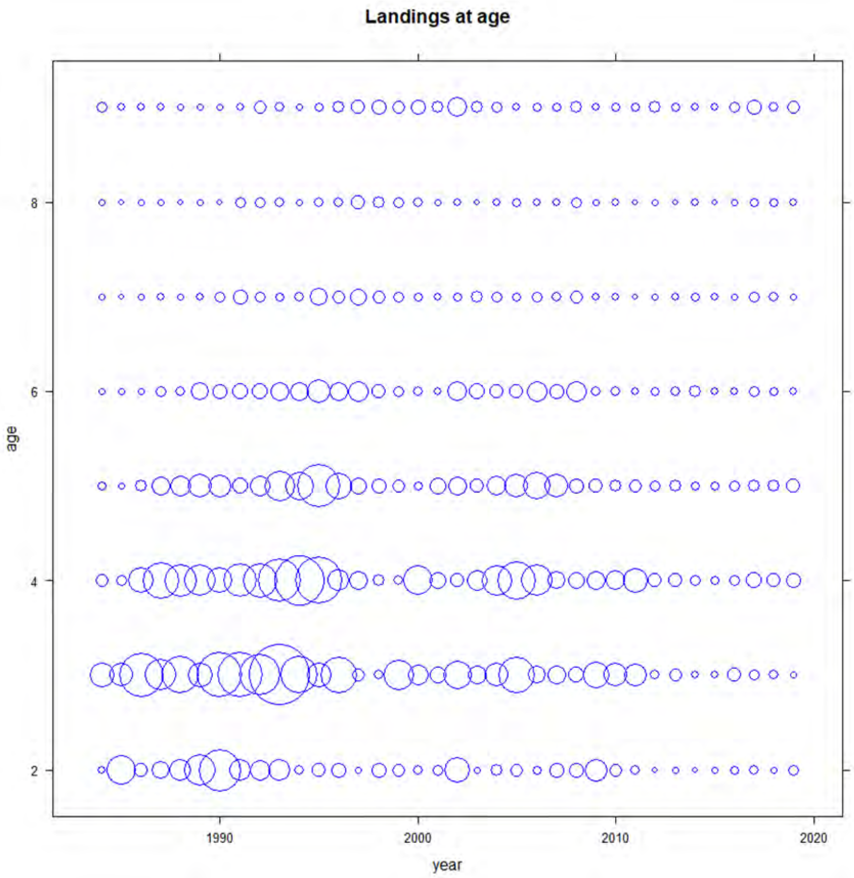


Figure 6.6. Sole 20-24. Landing number- at-age.

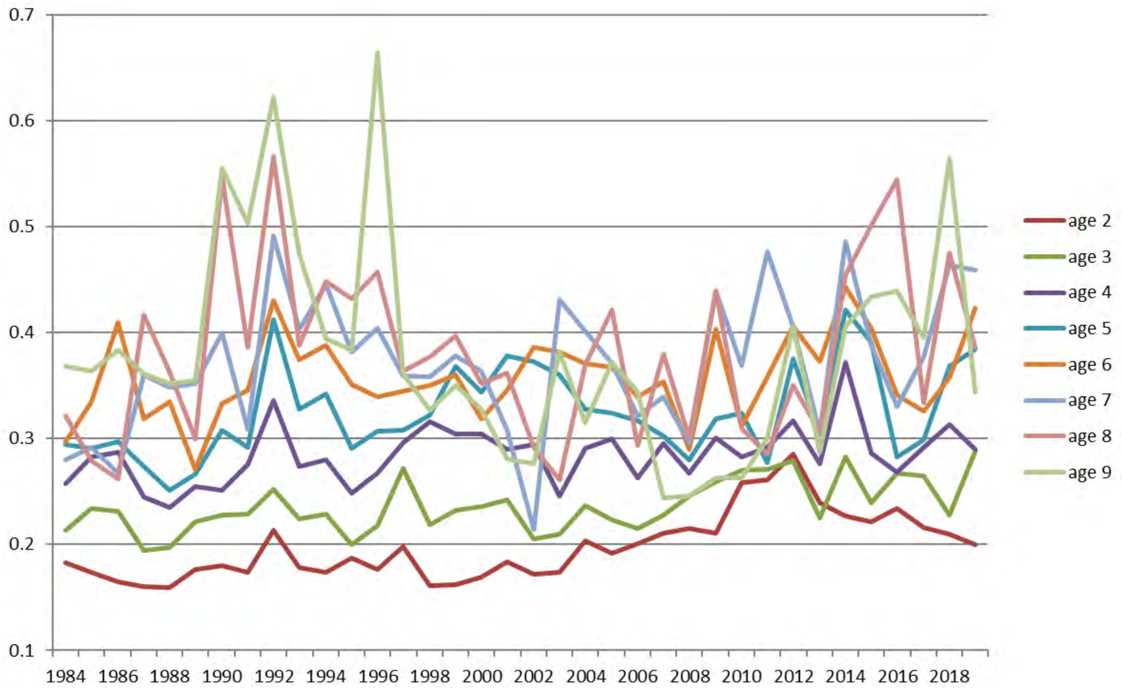


Figure 6.7. Sole in 20-24. Landings weight-at-age (tonnes/kg).

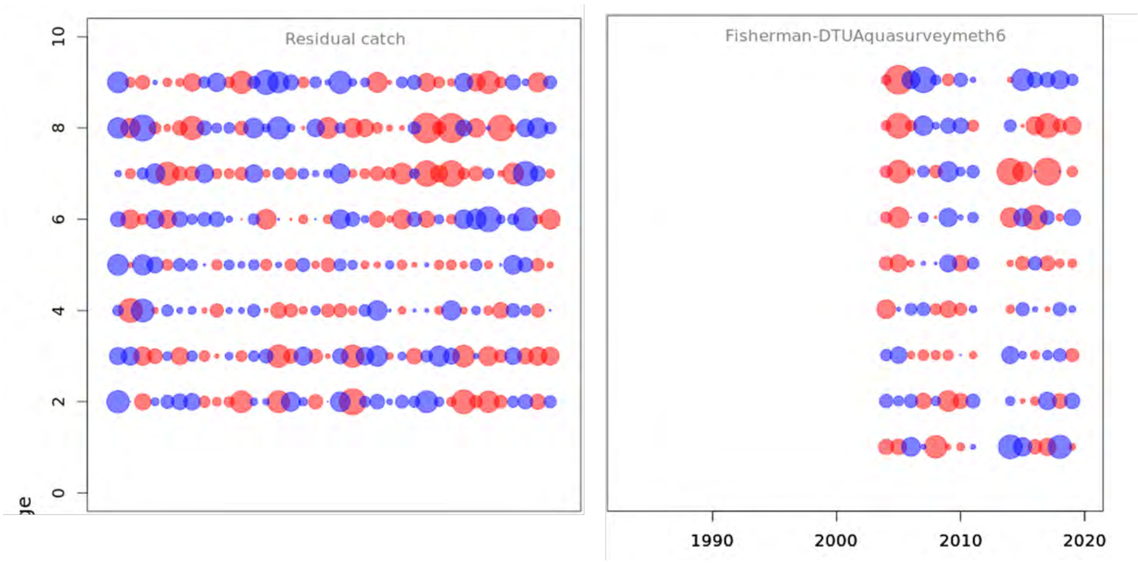


Figure 6.8. Sole 20-24. Model residuals for landings and survey.

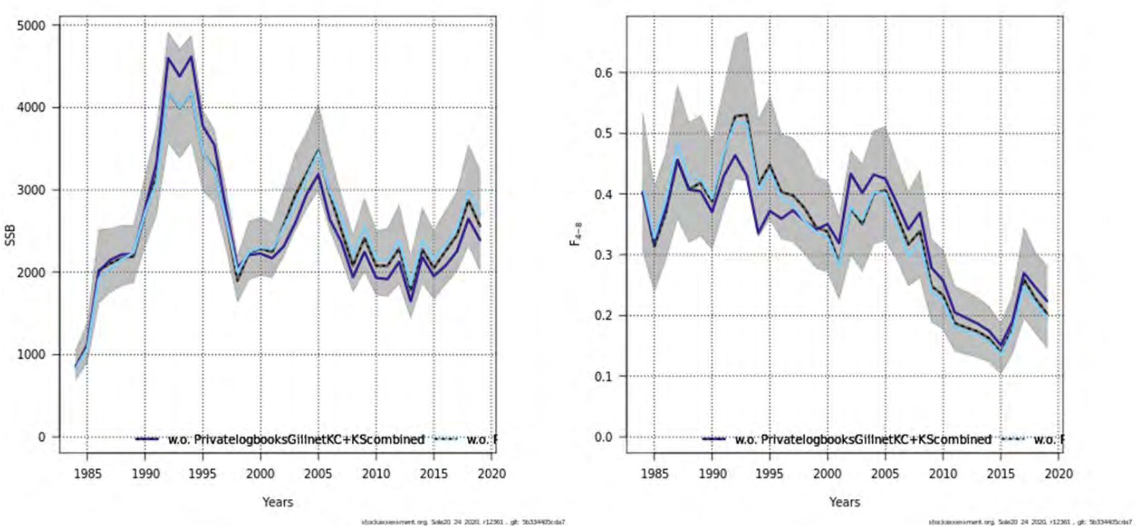


Figure 6.9. 20-24. Fleet sensitivity. Estimated SSB, and fishing mortality from runs leaving single fleets out. Recruitment (age 1) plot is not possible to provide since only the survey contains age 1 group.

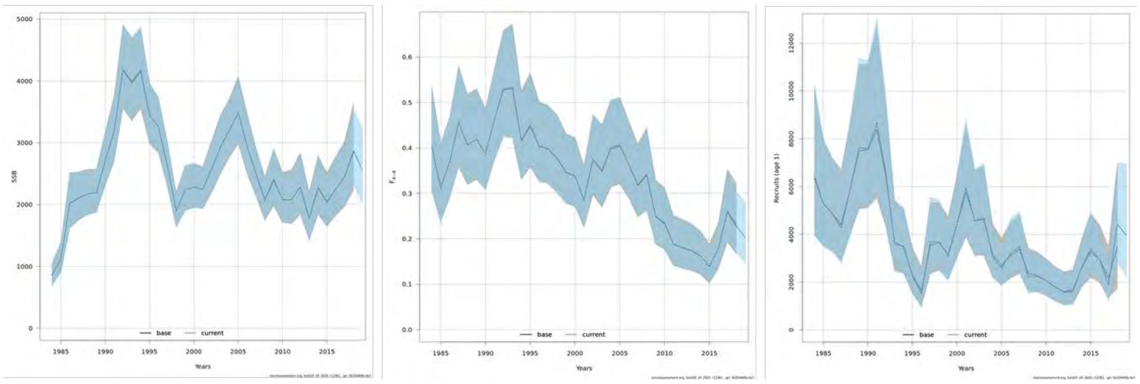


Figure 6.10. Sole 20-24. Stock summary; SSB, F(4-8) and R (age 1) compared to last year's assessment.

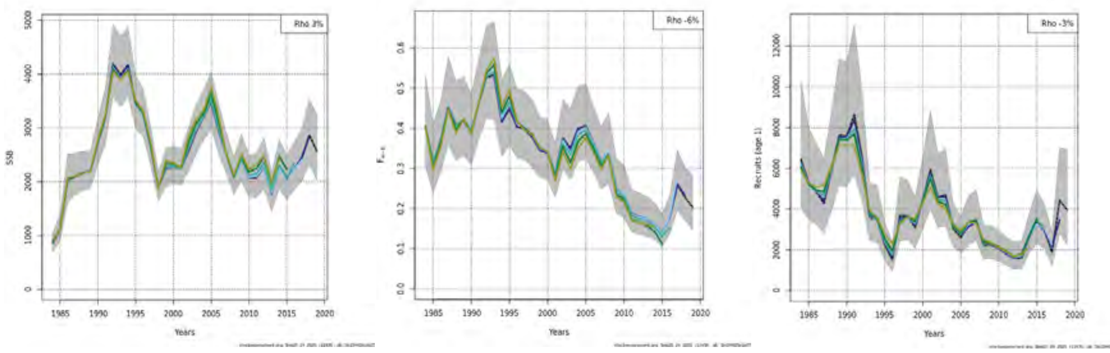


Figure 6.11. Sole 20-24. Retrospective analyses for SSB, F, and recruitment. Confidence limits are provided for the 2019 scenario.

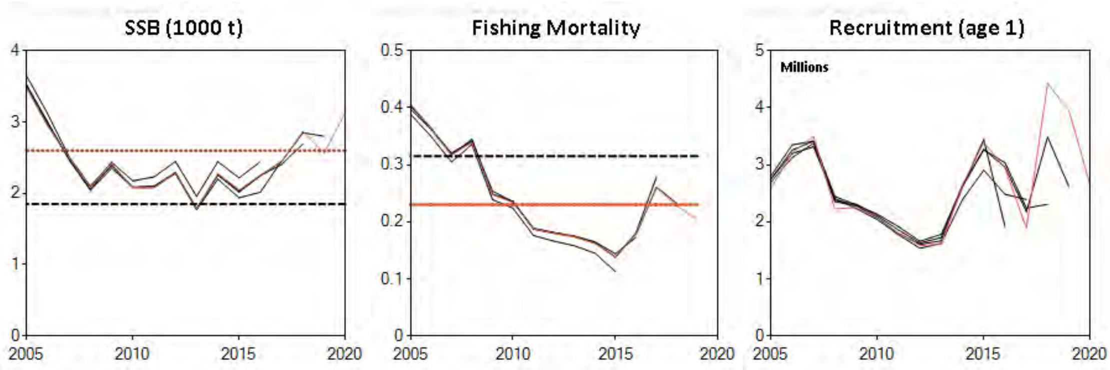


Figure 6.12. Sole 20-24. Historical performance of F, SSB and recruitment.

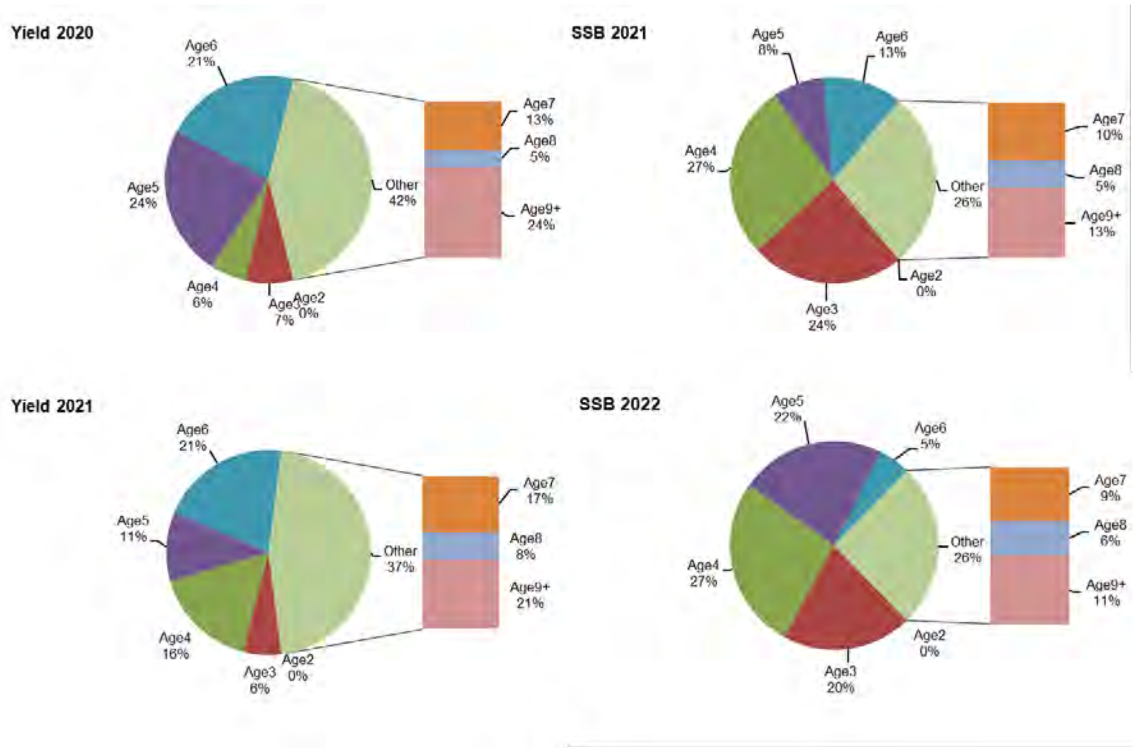


Figure 6.13. Sole 20-24. Short-term forecast for 2020-2022. Yield and SSB at age 2-9+ assuming fishery at F_{sq} in 2020.

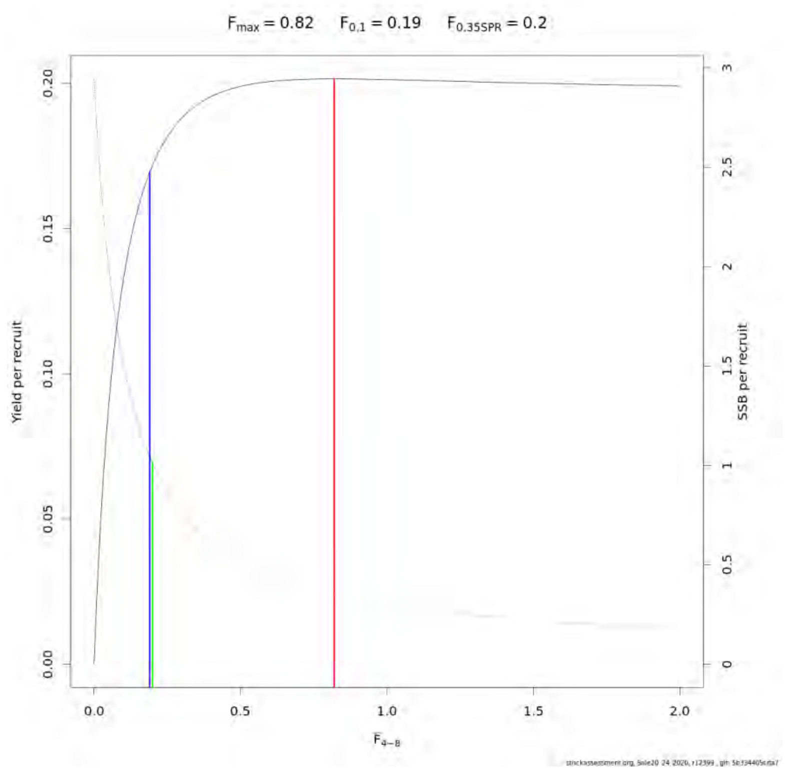


Figure 6.14. Sole 20-24. Yield per recruit curve and reference point estimates (red = F_{max}, green = $F_{35\%SPR}$ and blue = $F_{0.1}$).

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 at benchmark 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.

Natural mortality of sprat depends on cod stock and estimates of this mortality are used the assessment. In previous assessments they were available from multispecies model SMS up to year 2011, and from regression between cod biomass and predation mortality in next years. In 2019, the SMS model was updated and new estimates of M have been available (WGSAM 2019). The effects of these estimates on sprat assessment and BRPs was investigated through Inter-benchmark Process on BAltic Sprat (*Sprattus sprattus*) and Herring (*Clupea harengus*) (IBPBASH 2020). The ToRs of the inter-benchmark were to: a) Evaluate the appropriateness of the use of the natural Mortality estimates derived from the multispecies SMS key-run for the Baltic in the stock assessments for herring and sprat; b) Update the stock annex as appropriate; c) Re-examine and update MSY and PA reference points according to ICES guidelines (see Technical document on reference points).

7.1 The Fishery

7.1.1 Landings

According to the data uploaded to the InterCatch, sprat catches in 2019 were 314 147 t, which is 2% more than in 2018 and 41% less than the record high value of 529 400 t in 1997. In 2019 total TAC set by the EU plus the Russian autonomous quota was 313 072 t, which was utilized in 100.3%. The largest increase in catches was observed for Denmark (26%). At the same time the Swedish catches decreased by 8% compared to 2018.

The spatial distribution (by subdivision) of sprat catches was similar to previous years. Subdivision 26 dominated the catches with a 37% share in the sprat catch. Other important areas are subdivisions 25 and 28 (21% and 20%, respectively). Landings by country and subdivision are presented in tables 7.1–7.2. Figure 7.1 presents the shares of catches by subdivision in 2001–2019. Table 7.3 contains landings, catch numbers, and weight-at-age by subdivision and quarter.

7.1.2 Unallocated removals

No information on unallocated catches was presented to the group. It is expected, however, that misreporting of catches occurs, as the estimates of species composition of the clupeid catches are imprecise in some mixed pelagic fisheries.

7.1.3 Discards

According to the EC Common Fisheries Policy (adopted in 2014) in 2015, the landing obligation began to cover small and large pelagic species, industrial fisheries and the main fisheries in the Baltic. Historically, discards in most countries have probably been small because the undersized and lower quality fish can be used for production of fish meal and feeding in animal farms. In fisheries directed for human consumption, however, young fish (0 and 1 age groups) were discarded with higher rates in years when strong year classes recruit to the fishery. Recruitment to the fishery takes place in the 4th (age 0) and 1st (age 1) quarters. The amount of discarding of these age-groups was unknown. In the 2015 data call (L.27/ACB/HSL in 2015), ICES requested landings, discards, biological sample and effort data from 2014 in support of the ICES fisheries advice in 2015. Only Estonia and Germany provided the requested discard data for Baltic sprat. However, these 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 1995–2019 (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 and 2019 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 11% of the total. Most of the German catches (89%) were landed in foreign ports but also these were very well sampled, resulting that 90% of German total landings were sampled. The unsampled catches were distributed to ages according to overall age composition in a given Subdivision and quarter using "Allocation scheme" with CATON values as weighting keys in

InterCatch. A large part of the sprat catches is taken as part of the fish meal fishery. In some fisheries the catch species composition is not very precise.

The estimated catch-at-age in numbers is presented in tables 7.3 and 7.6 and the age composition of the catches is shown in Figure 7.2. The consistency of the catch-at-age estimates was checked in bubbles-plot (Figure 7.3). The correlation between catch at a given age and the catch of the same generation one 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 7.4). In 1999–2005 the weights have fluctuated without a clear trend. Although, the mean weights-at-age of the year class 2003 are significantly lower compared to other year classes in the last decade. Since 2006 the mean weights increased somewhat, but have dropped again in last years. The mean weight of the year class 2014 is very low; it could be a result of density dependent effect as this year class was very abundant. Mean weights in the stock were assumed the same as mean weights in the catch (Table 7.7). The consistency of the weight-at-age estimates was explored 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 one 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.

In the benchmark workshop new estimates of predation mortality (covering 1974–2011) were provided from SMS model (WKMULTBAL, ICES, 2013b). At next WGBFAS the M values for 2012–2018 were estimated from the regression of M values taken from SMS against cod SSB in 1974–2011. In years when analytical estimates of cod SSB have not been available the index of cod SSB obtained from BITS surveys (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

In 2019 new estimates of M were available from updated SMS (WGSAM 2019), using analytical estimates of cod stock as external variable. The 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 Working Group (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 2019 by quarter, ICES subdivision, and country is presented in Table 7.5. These data show that generally in 2019 the sampling activity by ICES subdivision exceeded much the levels indicated in the EC regulation No. 1639/2001, i.e. at least one 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 3-6 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 1991–2019 and one dataset covering subdivisions 24–26 and 28 from international Baltic Acoustic Spring Survey (BASS) in May in 2001–2019 (Tables 7.12–7.14). The survey data were corrected for area coverage (WGBIFS, ICES, 2020). 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).

Compared to the previous year, small corrections and updates were made in the two tuning datasets from BIAS (WGBIFS, 2020), and therefore also the values for the years 2013-2016 slightly increased accordingly in the assessment input datasets.

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 one year later is high ranging between 0.7–0.9.

7.4 Assessment

7.4.1 XSA

The input data for the catch-at-age analysis are presented in tables 7.6–7.14. The settings for the parameterisation of XSA were the same as specified in the benchmark assessment:

1) tricubic time weightin;
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 0.3–0.5). 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 0.3). The correlations between XSA estimates and survey indices are quite high (R^2 mostly at level of 0.6–0.8).

October survey gets somewhat higher weight in survivors estimates (mostly 35–55%) than the May survey (weight of 20–40%). The weight of estimates resulting from the F shrinkage is low (up to 6%) and the P-shrinkage gets 14% weight in survivors estimates at age 1 (Figure 7.7a). The survey estimates of survivors are quite consistent at most ages – consistency is somewhat lower at age 2, where estimate based on Age0 survey diverge from estimate using October and May surveys (Figure 7.7b). The estimates based on Age0 acoustic fleet are down-weighted with increasing age.

Retrospective analysis (Figure 7.8a) shows quite scattered estimates for F_{bar} defined as average F at ages 3-5 (Mohn's rho of -0.23). The $F_{(3–5)}$ estimates may be 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. To inspect the effect of short age range on stability of average F, the retrospective estimates were repeated with average F based on ages 1-7. However, this only slightly improved retrospective pattern of fishing mortality, reducing Mohn's rho to -0.21. Further analysis of stability of estimates of fishing mortality were conducted by performing retrospective estimates of Mohn's rho (retrospective assessments with present data were conducted, for each assessment Mohn's rho was calculated with retrospective assessments being reference assessment for calculation, Figure 7.8b). Red dots in the Figure represent retrospective estimates of Mohn's rho in given assessment year, and lines represent individual years deviations of F from fishing mortality in reference assessment (subsequent dots are averages of five deviations showed by subsequent lines). The analysis shows gradual change of retrospective pattern in F from being overestimation to underestimation of fishing mortality. However, the retrospective values of Mohn's rho slightly exceed the preferred bounds only in recent two years.

The retrospective estimates of SSB (Mohn's rho of 0.15) and recruitment (Mohn's rho = 0.04) are relatively consistent in most years.

The fishing mortalities, stock numbers and summary of assessment are presented in tables 7.16–7.18. Fish stock summary plots are presented in Figure 7.9. Trends in the survey indices of stock size and XSA estimates of stock biomass are quite consistent (Figure 7.10a).

The sum of absolute differences between fishing mortalities-at-age in subsequent iterations was at level of 0.00027 and increasing the number of iterations did not lead to this value lower than 0.0001, which is criterion set to define convergence of XSA (see text table below). With increase of number of iterations the "Total absolute residual between iterations" fluctuated along 0.00027.

Total absolute residual between iterations

59 and 60 = 0.00027 should be <0.0001

Final year F values							
Age	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Iteration 59	0.1325	0.248	0.2646	0.4208	0.4519	0.3829	0.3695
Iteration 60	0.1325	0.248	0.2645	0.4208	0.4520	0.3829	0.3695
difference	**0.0000**	**0.0000**	**-0.0001**	**0.0000**	**0.0001**	**0.0000**	**0.0000**

The convergence of the method was investigated further and in FLR series of runs were performed with number of iterations ranging from 5 to 1000 and estimates of SSB and F_{bar} in terminal year were recorded. Both SSB and F_{bar} converged to constant values after approximately 60 iterations (Figure 7.10b).

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 7.11. The XSA and SAM estimates of SSB, F, and recruitment are 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 7.12a). The retrospective analysis is somewhat better for SAM than for XSA, especially for fishing mortality (Figure 7.12b). 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). 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 2019 year class was estimated at 114 billion individuals, ca. 30% above the average from years 1991 onwards.

7.4.4 Historical stock trends

In the 1990s the SSB exceeded 1 million t, being record high in 1996–1997 (about 1.8 million t). These values were several times higher than the SSB estimates of 200 000 t in the early 1980s. Since 1997 the SSB has been generally decreasing, and reached 0.6-0.7 million tonnes in 2012-2015. The strong year class 2014 has led to marked increase of stock biomass in 2016-2018. The estimate of SSB for 2020 is 931 000 tonnes. Weight-at-age has decreased since the early 1990s, and has remained low since then. This is likely due to density-dependent effects. Acoustic surveys show that in recent years in autumn the stock has been mainly concentrated in subdivisions 27–29 and 32 (Casini *et al.*, 2011, WGBIFS, 2020).

7.5 Short-term forecast and management options

The RCT3 program estimate of the 2019 year class at age 1 was used in the predictions. The 2020 and 2021 year classes were assumed as geometric mean of the recruitment at age 1 in 1991–2019 (period of recruitment fluctuations without clear trend, the 2019 value is well estimated in the assessment). The natural mortalities, mean weights, and fishing pattern were assumed as averages of 2017–2019 values. Fishing mortality in intermediate years was estimated consistent with TAC in 2020 (TAC defined as EU quota of 210.2 kt and Russian quota of 46.5 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 2020 was performed (unscaled F, Table 7.22b); that produced catches in 2020 at 278 kt, 8% higher than the TAC. The differences between two predictions are small, e.g. difference between total biomass in 2021 is about 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 2020 and 2021 year classes and the estimate of 2019 year class is presented. The assumed level of the 2020 year class contributes in 12% to the predicted catch in 2021 and with assumed level of the 2021 year class contributes in 44% to SSB in 2022. The level of these sensitivities is similar to levels in previous years.

7.6 Reference points

Below recent history of estimates of BRPs is presented and at the end of section new BRPs are shown.

During the benchmark assessment (ICES, 2013) 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).

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} was 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

The biological reference points derived based on the replacement lines depend on the natural mortality, weight-at-age, and maturity data used. The changes in these data may have large impact on estimates of the fishing mortality reference points. Both natural mortalities and weights were variable historically. In 2019 new estimates of natural mortality from SMS were provided and BRPs were updated (ICES, 2020, IBPBASH report).

New estimates and their basis is given below.

Reference Point	Value	Rationale
B_{lim}	410 000 t	The average SSB producing 50% of maximal recruitment from the Beverton and Holt S-R function (470 000 t) and from the Ricker S-R function (345 000 t).
B_{pa}	570 000 t	1.4* B_{lim}
MSY $B_{trigger}$	570 000 t	B_{pa}
F_{MSY}	0.31	Estimated by EqSim
$F_{MSYUpper}$	0.41	$F_{p0.5}$
$F_{MSYLower}$	0.22	Estimated by EqSim as the F at 95% of the landings of F_{MSY}
F_{lim}	0.63	Estimated by EqSim as the F with 50% probability of SSB being less than B_{lim}
F_{pa}	0.45	F_{lim} * (exp(-1.645*0.2))

The biomass reference points are the same as previous, but fishing mortality reference points changed markedly. That is mainly due to low cod stock size and thus lower predation mortality of cod on sprat stock.

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. If strong year class goes through the stock (as e.g. recently 2014 y-c) , this contribution is smaller, close to 40%.

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 2019 and 2020 assessments is presented in the text table below. The XSA settings were the same in both years.

Category	Parameter	Assessment 2019	Assessment 2020	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, M2012-2018 estimated from regression of M against cod SSB	M in 1974–2018 estimated in updated SMS, M2019=M2018	yes
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 2018 (million t)	1.1	1.02	-9%
	TSB 2018 (million t)	1.75	1.63	-7%
	F(3-5) 2018	0.32	0.37	16%
	Recruitment (age 1) in 2018 (billions)	87.5	81.8	-6%

7.9 Management considerations

There is a EU multiannual plan for sprat in the Baltic Sea (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R1139&from=EN). In the plan F_{MSY} ranges are defined as 0.19 – 0.26 and 0.26–0.27. During the inter-benchmark process the F_{MSY} and ranges were redefined as 0.22-0.31 and 0.31-0.41 (ICES, 2020, IBPBASH).

As in previous years, sprat in Baltic subdivisions 22–32 was assessed as a single unit, and this procedure shows relatively good assessment quality.

The spawning stock biomass has been low in the first half of 1980s. In the beginning of 1990s the stock started to increase rapidly and in 1996–1997 it reached the maximum observed spawning stock biomass of 1.8 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 0.6 - 0.7 million tonnes in 2012–2015. Very strong year class of 2014 has led to marked increase in stock size, SSB reached 1.1 million tonnes in 2016–2018 and is predicted to stay above 1 million tonnes in 2022 if it is exploited at F_{MSY}. After 2000 fishing mortality increased and next fluctuated, exceeding F_{MSY} in most years. Among the year classes 2009–2018 only one (2014) was strong, which contributed to previous stock decline. The 2019 year class is above average.

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

Year	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden	Total
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
2019	30,9	29,2	16,1	14,6	38,9	16,2	82,4	40,7	45,1	314,1

*** Sum of landings by Estonia, Latvia, Lithuania, and Russia**

Table 7.2. Sprat landings in the Baltic Sea by country and Subdivision (thousand tonnes)

Year 2018

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	-	-	-	-

Country	Total	22	24	25	26	27	28	29	30	31	32
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

Year2004

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	-	-	-

Country	Total	22	24	25	26	27	28	29	30	31	32
Latvia	54,6	-	-	1,1	6,0	-	47,5	-	-	-	-
Lithuania	7,5	-	-	-	7,5	-	-	-	-	-	-
Poland	54,3	-	0,8	16,7	36,8	-	-	-	-	-	-
Russia	28,2	-	-	-	27,9	-	-	-	-	-	0,3
Sweden	68,7	0,0	0,7	4,6	25,3	13,7	16,6	7,6	0,0	0,0	0,2
Total	352,1	20,5	3,4	31,3	122,8	28,3	78,9	38,3	3,5	0,007	25,1

Year 2007

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	37,6	9,6	0,7	6,4	17,0	-	3,0	0,8	-	-	-
Estonia	51,0	-	-	2,2	0,8	0,1	4,3	15,3	-	-	28,3
Finland	24,6	0,0	0,0	1,9	4,2	0,3	2,6	4,5	7,2	0,002	3,8
Germany	30,8	0,8	0,46	1,8	12,2	5,8	4,8	4,9	-	-	-
Latvia	60,5	-	-	5,1	7,4	1,4	46,5	-	-	-	-
Lithuania	20,3	-	-	1,7	11,8	-	3,6	3,2	-	-	-
Poland	58,7	-	0,8	21,4	36,4	0,04	0,06	-	-	-	-
Russia	24,8	-	-	-	24,8	-	-	-	-	-	-
Sweden	80,7	-	1,8	10,0	30,8	11,0	14,9	11,9	0,1	-	0,2
Total	388,9	10,4	3,8	50,5	145,4	18,7	79,8	40,6	7,3	0,002	32,4

Year 2008

Country	Total	22	24	25	26	27	28	29	30	31	32
Denmark	45,9	5,6	1,0	5,6	4,0	7,1	13,2	0,3	-	-	9,2
Estonia	48,6	-	-	0,3	0,0	-	5,3	15,6	-	-	27,3
Finland	24,3	-	-	2,1	2,1	0,2	2,3	8,6	5,2	0,0002	3,8
Germany	30,4	1,3	0,07	1,8	6,0	4,0	13,7	3,6	-	-	-
Latvia	57,2	-	-	2,1	6,3	0,2	48,6	0,005	-	-	-
Lithuania	18,7	-	0,01	5,5	6,0	0,7	4,6	1,8	-	-	-
Poland	53,3	-	3,9	25,4	23,8	0,02	0,15	-	-	-	-
Russia	21,0	-	-	-	21,0	-	-	-	-	-	-
Sweden	81,1	-	2,0	13,3	13,2	9,1	27,4	15,4	0,00005	-	0,7

Country	Total	22	24	25	26	27	28	29	30	31	32
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

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			

Country	Total	22	23	24	25	26	27	28	29	30	31	32
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		

Country	Total	22	23	24	25	26	27	28	29	30	31	32
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

Year 2019

Country	**Total**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
Denmark	30,9	0,001		0,008	11,701	8,081	2,410	5,224	3,464			
Estonia	29,2							3,949	8,386			16,843
Finland	16,1				0,550	1,265	0,046	1,424	5,713	0,875	0,040	6,223
Germany	14,6	0,396		0,088	1,998	9,596		1,180	1,388			
Latvia	38,9				1,887	4,232		32,795				
Lithuania	16,2				2,503	7,597	0,017	5,838	0,273			
Poland	82,4			2,298	37,967	40,443		1,690				
Russia	40,7					39,153						1,541
Sweden	45,1			0,005	9,925	6,159	12,520	11,881	4,533	0,041		
Total	314,1	0,4	0,0	2,4	66,5	116,5	15,0	64,0	23,8	0,9	0,040	24,6

Table 7.3. SPRAT in SD 22-32. Catch in numbers and weight-at-age by quarter and Subdivision in 2018.

Subdivision 22									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0,0	0,0	0,0	0,0	0,0				
1	0,1	0,0	0,0	0,0	0,1	5,0	5,0		11,9
2	5,0	0,0	0,0	0,0	5,0	13,4	13,4		12,5
3	13,9	0,1	0,0	0,0	14,0	14,7	14,7		13,5
4	1,8	0,0	0,0	0,0	1,8	15,8	15,8		13,9
5	6,0	0,0	0,0	0,0	6,0	15,7	15,7		14,3
6	0,0	0,0	0,0	0,0	0,0				15,3
7	0,0	0,0	0,0	0,0	0,0				15,8
8	0,0	0,0	0,0	0,0	0,0				
9	0,0	0,0	0,0	0,0	0,0				
10	0,0	0,0	0,0	0,0	0,0				
Sum	26,8	0,1	0,0	0,0	27,0				
SOP	394,8	1,7	0,0	0,2	396,7				
Catch	394,8	1,7	0,0	0,2	396,7				

Subdivision 23									
	Numbers (millions)					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				

Subdivision 23									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
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				

Subdivision 24									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0,0	0,0	0,0	0,0	0,0				
1	3,8	4,0	1,1	1,4	10,3	5,6	8,9	11,9	11,9
2	2,3	8,2	1,8	2,2	14,5	12,5	12,2	12,5	12,5
3	10,3	16,3	2,2	2,7	31,6	13,4	15,4	13,5	13,5
4	9,0	29,6	9,2	11,3	59,0	14,6	16,3	13,9	13,9
5	14,7	16,5	4,6	5,7	41,4	14,3	16,6	14,3	14,3
6	2,2	0,0	1,7	2,1	6,0	16,5	0,0	15,3	15,3
7	0,3	0,5	0,3	0,3	1,5	15,8	24,6	15,8	15,8
8	1,0	0,5	0,0	0,0	1,5	14,6	24,6		
9	0,0	0,0	0,0	0,0	0,0				
10	0,0	0,0	0,0	0,0	0,0				
Sum	43,6	75,6	20,9	25,7	165,8				
SOP	584,9	1168,1	289,5	356,6	2399,1				
Catch	584,6	1167,7	289,4	356,5	2398,3				

Subdivision 25									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0,0	0,0	1,1	78,5	79,6			4,5	5,6
1	259,2	83,7	6,9	50,2	400,0	5,2	5,3	10,6	9,7
2	395,1	299,6	11,9	63,5	770,1	8,8	8,1	12,0	11,5
3	596,1	670,3	18,3	60,8	1345,5	10,6	9,5	12,7	12,4
4	631,6	620,8	36,4	96,3	1385,2	11,9	11,0	13,3	13,1
5	671,1	1002,8	23,4	105,4	1802,7	12,6	11,6	13,4	13,8
6	117,4	125,2	4,2	23,7	270,6	14,2	14,1	14,6	14,7
7	35,5	32,3	0,9	5,6	74,3	14,6	15,0	15,1	15,4
8	11,9	9,8	0,4	0,4	22,5	15,7	13,6	14,3	13,2
9	1,7	1,0	0,1	0,2	3,1	16,3	10,4	18,3	18,0
10	2,6	1,0	0,1	0,2	4,0	15,1	8,7	14,4	10,0
Sum	2722,1	2846,6	103,9	484,9	6157,5				
SOP	29553,9	30102,3	1337,3	5573,5	66567,0				
Catch	29541,9	30074,7	1336,6	5578,3	66531,4				

Subdivision 26									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0,0	0,0	2,8	314,0	316,8			3,3	3,7
1	2613,1	1026,7	8,0	114,5	3762,3	3,8	4,6	8,4	8,1
2	2250,1	2060,4	11,2	244,8	4566,5	7,8	7,1	9,4	9,4
3	1462,8	906,1	14,9	138,0	2521,7	9,2	8,7	10,6	10,4
4	1393,9	737,9	17,1	77,9	2226,7	10,1	9,6	11,5	11,2
5	1130,4	555,8	10,4	73,8	1770,5	10,2	9,6	11,8	11,6
6	89,6	35,8	1,0	14,8	141,3	10,9	11,3	14,1	13,5
7	23,8	9,2	0,4	0,4	33,8	12,2	12,3	13,9	13,3
8	18,2	3,9	0,1	0,0	22,2	11,8	12,2	14,7	15,1

Subdivision 26									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
9	0,0	0,0	0,0	0,0	0,0				
10	0,6	0,0	0,0	0,0	0,6	17,0			
Sum	8982,7	5335,8	65,8	978,2	15362,4				
SOP	68040,8	40219,0	678,9	7759,3	116698,0				
Catch	68033,0	40053,9	679,1	7760,4	116526,4				

Subdivision 27									
	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0,0	0,0	0,0	4,7	4,7			2,8	2,8
1	235,2	28,2	0,9	5,8	270,0	4,0	3,8	7,9	9,0
2	324,7	81,3	0,8	13,2	419,9	7,8	7,2	9,0	9,7
3	174,8	42,2	0,2	4,1	221,4	9,1	8,4	9,3	11,0
4	193,6	38,1	0,1	2,6	234,4	9,3	9,1	10,8	11,2
5	453,7	86,3	0,6	13,1	553,7	9,8	9,1	10,2	11,1
6	39,5	7,7	0,1	1,7	49,1	10,5	9,7	11,5	11,8
7	25,0	4,5	0,0	1,2	30,8	10,9	10,4	11,5	12,2
8	4,2	0,5	0,1	0,8	5,5	13,8	9,5	12,5	12,3
9	6,2	0,9	0,0	0,0	7,2	9,7	9,3		
10	4,2	0,5	0,0	0,0	4,6	10,4	10,1		
Sum	1461,1	290,2	2,9	47,1	1801,3				
SOP	12160,1	2318,7	26,8	457,2	14962,8				
Catch	12188,0	2322,3	26,8	455,8	14992,9				

Subdivision 28									
	Numbers (milions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0,0	0,0	0,0	247,5	247,5				3,1
1	274,8	64,3	215,7	371,7	926,5	3,9	3,9	7,4	8,2
2	1069,6	321,2	430,2	598,9	2419,8	7,1	7,1	8,5	9,2
3	420,0	119,4	71,5	300,9	911,8	8,5	8,6	9,6	9,9
4	584,0	154,0	56,8	301,6	1096,4	8,9	9,1	9,9	10,0
5	902,1	294,8	149,7	489,7	1836,4	9,0	8,9	9,8	10,1
6	55,7	35,1	6,0	33,9	130,6	10,0	10,6	12,3	11,0
7	24,1	11,6	5,2	17,2	58,1	10,9	11,3	11,0	11,7
8	26,4	6,3	1,7	17,0	51,4	11,6	11,1	11,9	12,4
9	0,0	0,0	0,0	1,6	1,6				9,9
10	0,0	0,0	0,0	0,0	0,0				
Sum	3356,7	1006,7	936,8	2380,0	7680,1				
SOP	26678,1	8156,1	8119,4	21066,4	64019,9				
Catch	26670,9	8141,4	8133,6	21035,1	63981,0				

Subdivision 29									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0,0	0,0	0,4	88,9	89,3			2,8	2,8
1	135,2	1,2	41,4	109,5	287,3	3,5	4,1	8,1	8,9
2	732,8	1,0	33,9	251,0	1018,7	6,8	7,0	8,9	9,7
3	191,3	0,6	8,6	78,4	278,8	8,3	9,0	9,5	11,0
4	280,2	1,6	5,7	49,0	336,5	8,7	9,3	10,6	11,2
5	395,1	5,4	26,9	248,3	675,7	8,8	9,1	10,1	11,2
6	38,6	2,5	6,2	32,6	79,8	10,1	11,1	11,4	11,9
7	22,2	0,9	0,8	23,2	47,1	9,2	10,6	11,5	12,2
8	9,3	4,6	4,3	15,5	33,7	10,6	11,2	11,9	12,4

Subdivision 29									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
9	0,0	0,0	0,0	0,0	0,0				
10	6,2	0,0	0,0	0,0	6,2	11,1			
Sum	1810,8	17,8	128,1	896,3	2853,1				
SOP	13719,9	169,8	1182,3	8712,5	23784,5				
Catch	13737,4	169,8	1182,6	8668,3	23758,0				

Subdivision 30									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0,0	0,0	0,0	0,0	0,0			4,0	2,5
1	1,1	0,6	0,2	0,3	2,2	3,5	4,1	10,0	10,7
2	7,9	5,4	0,2	2,0	15,4	6,8	7,0	11,3	11,9
3	3,3	1,6	0,1	1,2	6,2	8,4	9,0	13,3	13,4
4	6,7	3,8	0,1	1,2	11,8	9,1	9,3	14,4	14,2
5	16,0	12,7	0,4	7,1	36,2	8,7	9,1	14,8	14,4
6	5,7	2,6	0,0	1,1	9,5	10,2	11,1	13,7	14,9
7	1,6	1,5	0,0	0,7	3,8	10,3	10,6	16,4	16,3
8	3,3	4,2	0,0	1,3	8,8	10,6	11,2	16,8	15,7
9	0,0	0,0	0,0	0,0	0,0				
10	0,0	0,0	0,0	0,0	0,0				
Sum	45,6	32,4	1,0	14,9	93,9				
SOP	394,6	297,2	13,1	210,9	915,8				
Catch	394,4	297,3	13,1	210,9	915,7				

Subdivision 31									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0,0	0,0	0,0	0,0	0,0			4,0	
1	0,0	0,1	0,0	0,0	0,1		4,1	10,0	
2	0,0	0,7	0,0	0,0	0,7		7,0	11,3	
3	0,0	0,2	0,0	0,0	0,2		9,0	13,3	
4	0,0	0,5	0,0	0,0	0,5		9,3	14,4	
5	0,0	1,6	0,1	0,0	1,7		9,1	14,8	
6	0,0	0,3	0,0	0,0	0,3		11,1	13,7	
7	0,0	0,2	0,0	0,0	0,2		10,6	16,4	
8	0,0	0,5	0,0	0,0	0,5		11,2	16,8	
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	4,1	0,182	0,0	4,3				
SOP	0,0	37,4	2,41	0,0	39,8				
Catch	0,0	37,4	2,4	0,0	39,8				

Subdivision 32									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0,0	0,0	2,0	102,7	104,7			2,8	2,9
1	29,4	14,1	38,4	221,3	303,2	3,5	4,1	9,0	9,1
2	360,7	85,8	91,9	494,2	1032,7	6,8	7,0	9,6	9,6
3	80,5	12,5	21,1	115,0	229,0	8,1	9,0	10,2	10,7
4	93,3	27,9	12,7	57,3	191,2	8,5	9,3	10,4	11,2
5	263,1	91,9	60,2	306,2	721,4	8,5	9,1	10,5	10,6
6	20,0	8,0	15,9	45,9	89,9	9,5	11,1	11,1	11,9
7	13,9	5,2	3,3	18,8	41,2	9,9	10,6	11,0	12,4
8	19,0	12,8	7,7	22,3	61,8	10,2	11,2	11,7	12,1

Subdivision 32									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
9	0,0	0,0	0,0	0,0	0,0				
10	0,0	0,0	0,0	0,0	0,0				
Sum	880,0	258,3	253,1	1383,8	2775,2				
SOP	6759,0	2155,1	2514,5	13224,2	24652,8				
Catch	6737,5	2155,7	2512,3	13201,9	24607,3				

Subdivisions 22-32									
	Numbers (millions)					Weight (g)			
Age	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4
0	0,0	0,0	6,4	836,3	842,7			3,3	3,5
1	3551,9	1222,9	312,6	874,7	5962,1	3,9	4,6	7,8	8,6
2	5148,2	2863,6	581,8	1669,7	10263,4	7,5	7,2	8,8	9,5
3	2953,0	1769,2	136,8	701,0	5560,1	9,3	9,1	10,3	10,5
4	3194,2	1614,1	138,1	597,2	5543,5	10,0	10,2	11,3	11,0
5	3852,2	2067,9	276,3	1249,2	7445,7	10,0	10,5	10,4	10,9
6	368,8	217,3	35,2	156,0	777,2	11,6	12,7	12,1	12,3
7	146,5	65,9	10,8	67,5	290,7	11,7	13,2	11,6	12,5
8	93,1	43,2	14,3	57,3	207,9	11,9	12,0	11,9	12,4
9	7,9	1,9	0,1	1,8	11,8	11,1	9,9	18,3	10,9
10	13,6	1,5	0,1	0,2	15,5	11,9	9,1	14,4	10,0
Sum	19329,4	9867,5	1512,7	6211,0	36920,5				
SOP	158286,1	84625,4	14164,2	57360,7	314436,4				
Catch	158282,4	84421,9	14176,0	57267,3	314147,5				

Table 7.4. SPRAT in SD 22-32. Fishing effort and CPUE data.

	Russia - Subdivision 26			
	Type of vessels			
Year	*)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
2019			32184	1209

***) - vessels withdrawn from exploitation in 2007**

Table 7.5. Sprat in Subdivisions 22-32. Samples of commercial catches by quarter, country and Subdivision for 2019 available to the Working Group.

Subdivision 22

Country	**Quarter**	**Landings**	**Number of**	**Number of fish**	
		in tonnes	samples	measured	aged
Denmark	1				
	2	1,0	0	0	0
	3				
	4				
	Total	1,0	0	0	0
Germany	1	394,8	1	228	57
	2	0,7	0	0	0
	3				
	4	0,2	0	0	0
	Total	395,7	1	228	57
Total	1	394,8	1	228	57
	2	1,7	0	0	0
	3	0,0	0	0	0
	4	0,2	0	0	0
	Total	396,7	1	228	57

Subdivision 23+24

Country	**Quarter**	**Landings**	**Number of**	**Number of fish**	
		in tonnes	samples	measured	aged
Denmark	1	8,3	0	0	0
	2				
	3				
	4				
	Total	8,3	0	0	0
Finland	1				
	2				
	3				

Country	Quarter	Landings	Number of	Number of fish	
		in tonnes	samples	measured	aged
	4				
	Total	0,0	0	0	0
Germany	1	61,3	0	0	0
	2				
	3				
	4	26,5	0	0	0
	Total	87,9	0	0	0
Latvia	1				
	2				
	3				
	4				
	Total	0,0	0	0	0
Lithuania	1				
	2				
	3				
	4				
	Total	0,0	0	0	0
Poland	1	515,0	2	366	144
	2	1.167,7	2	345	52
	3	289,4	1	216	63
	4	325,4	0	0	0
	Total	2.297,5	5	927	259
Sweden	1				
	2				
	3				
	4	4,6	0	0	0
	Total	4,6	0	0	0
Total	1	584,6	2	366	144

Country	Quarter	Landings	Number of	Number of fish	
		in tonnes	samples	measured	aged
	2	1.167,7	2	345	52
	3	289,4	1	216	63
	4	356,5	0	0	0
	Total	2.398,3	5	927	259

Subdivision 25

Country	Quarter	Landings	Number of	Number of fish	
		in tonnes	samples	measured	aged
Denmark	1	7720,2	10	1180	373
	2	2649,7	5	605	212
	3	168,6	1	93	47
	4	1162,6	0	0	0
	Total	11701,0	16	1878	632
Estonia	1				
	2				
	3				
	4				
	Total	0,0	0	0	0
Finland	1	468,1	0	0	0
	2	42,3	0	0	0
	3				
	4	39,8	0	0	0
	Total	550,2	0	0	0
Germany	1	738,8	1	264	57
	2	1008,1	0	0	0
	3				
	4	250,9	0	0	0
	Total	1997,8	1	264	57
Latvia	1	23,5	0	0	0

Country	Quarter	Landings	Number of	Number of fish	
		in tonnes	samples	measured	aged
	2	1863,7	0	0	0
	3				
	4				
	Total	1887,2	0	0	0
Lithuania	1	580,3	0	0	0
	2	1923,1	0	0	0
	3				
	4				
	Total	2503,3	0	0	0
Poland	1	14375,4	32	6281	1523
	2	19376,1	29	5061	941
	3	849,7	16	3284	318
	4	3366,1	30	4691	624
	Total	37967,3	107	19317	3406
Sweden	1	5635,6	14	746	742
	2	3211,8	4	393	392
	3	318,4	6	281	281
	4	759,0	4	400	399
	Total	9924,7	28	1820	1814
Total	1	29541,9	57	8471	2695
	2	30074,7	38	6059	1545
	3	1336,6	23	3658	646
	4	5578,3	34	5091	1023
	Total	66531,4	152	23279	5909

Subdivision 26

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
Denmark	1	6881,3	16	2198	711
	2	1184,1	0	0	0
	3				
	4	15,2	0	0	0
	Total	8080,6	16	2198	711
Estonia	1				
	2				
	3				
	4				
	Total	0,0	0	0	0
Finland	1	416,4	0	0	0
	2	849,0	0	0	0
	3				
	4				
	Total	1265,4	0	0	0
Germany	1	5509,6	7	2129	361
	2	4086,0	6	2208	300
	3				
	4				
	Total	9595,6	13	4337	661
Latvia	1	1967,6	3	618	339
	2	1751,6	0	0	0
	3	144,4	0	0	0
	4	368,8	1	170	94
	Total	4232,5	4	788	433
Lithuania	1	4532,2	0	0	0
	2	3003,1	0	0	0
	3	0,8	0	0	0

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
	4	60,7	3	683	207
	Total	7596,8	3	683	207
Poland	1	24342,4	26	5525	757
	2	12544,4	18	3998	481
	3	377,6	14	2825	270
	4	3178,9	24	4829	257
	Total	40443,3	82	17177	1765
Russia	1	19290,5	11	2139	586
	2	15767,7	17	3707	737
	3	156,3	8	1331	230
	4	3938,8	20	3444	340
	Total	39153,3	56	10621	1893
Sweden	1	5093,0	2	300	299
	2	868,0	1	150	150
	3				
	4	198,0	0	0	0
	Total	6159,0	3	450	449
Total	1	68033,0	65	12909	3053
	2	40053,9	42	10063	1668
	3	679,1	22	4156	500
	4	7760,4	48	9126	898
	Total	116526,4	177	36254	6119

Subdivision 27

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
Denmark	1	2410,1	0	0	0
	2				
	3				

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
	4				
	Total	2410,1	0	0	0
Estonia	1				
	2				
	3				
	4				
	Total	0,0	0	0	0
Finland	1	40,5	0	0	0
	2	5,0	0	0	0
	3	0,8	0	0	0
	4				
	Total	46,3	0	0	0
Germany	1				
	2				
	3				
	4				
	Total	0,0	0	0	0
Latvia	1				
	2				
	3				
	4				
	Total	0,0	0	0	0
Lithuania	1	17,0	0	0	0
	2				
	3				
	4				
	Total	17,0	0	0	0
Poland	1				

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
	2				
	3				
	4				
	Total	0,0	0	0	0
Sweden	1	9720,4	10	703	702
	2	2317,3	9	647	639
	3	26,0	0	0	0
	4	455,8	0	0	0
	Total	12519,5	19	1350	1341
Total	1	12188,0	10	703	702
	2	2322,3	9	647	639
	3	26,8	0	0	0
	4	455,8	0	0	0
	Total	14992,9	19	1350	1341

Subdivision 28

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
Denmark	1	4708,8	14	1579	468
	2				
	3				
	4	515,0	1	132	43
	Total	5223,8	15	1711	511
Estonia	1	1392,0	7	963	526
	2	459,0	4	365	284
	3	649,0	1	234	100
	4	1449,0	7	1253	663
	Total	3949,0	19	2815	1573
Finland	1	460,2	0	0	0

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
	2	6,7	0	0	0
	3	7,5	0	0	0
	4	949,0	0	0	0
	Total	1423,5	0	0	0
Germany	1	1011,1	1	265	48
	2	168,9	0	0	0
	3				
	4				
	Total	1180,0	1	265	48
Latvia	1	10446,0	5	1066	506
	2	6442,8	7	1412	677
	3	7106,9	7	1489	649
	4	8799,7	6	1176	566
	Total	32795,4	25	5143	2398
Lithuania	1	1929,8	0	0	0
	2	147,2	0	0	0
	3				
	4	3761,2	0	0	0
	Total	5838,1	0	0	0
Poland	1	539,0	0	0	0
	2	97,0	0	0	0
	3	165,8	0	0	0
	4	888,4	0	0	0
	Total	1690,2	0	0	0
Russia	1				
	2				
	3				
	4				

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
	Total	0,0	0	0	0
Sweden	1	6184,0	4	510	484
	2	819,9	0	0	0
	3	204,3	0	0	0
	4	4672,7	12	482	479
	Total	11881,0	16	992	963
Total	1	26670,9	31	4383	2032
	2	8141,4	11	1777	961
	3	8133,6	8	1723	749
	4	21035,1	26	3043	1751
	Total	63981,0	76	10926	5493

Subdivision 29

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
Denmark	1	2774,3	5	613	142
	2				
	3				
	4	689,9	0	0	0
	Total	3464,2	5	613	142
Estonia	1	3354,0	10	1663	913
	2				
	3	768,0	3	600	300
	4	4264,0	8	1603	800
	Total	8386,0	21	3866	2013
Finland	1	1422,7	3	337	0
	2	169,8	3	19	0
	3	414,6	1	58	54
	4	3705,8	4	793	200

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
	Total	5712,9	11	1207	254
Germany	1	1388,0	1	370	51
	2				
	3				
	4				
	Total	1388,0	1	370	51
Latvia	1				
	2				
	3				
	4				
	Total	0,0	0	0	0
Lithuania	1	264,8	0	0	0
	2				
	3				
	4	8,5	0	0	0
	Total	273,3	0	0	0
Poland	1				
	2				
	3				
	4				
	Total	0,0	0	0	0
Sweden	1	4533,5	1	189	188
	2				
	3				
	4				
	Total	4533,5	1	189	188
Total	1	13737,4	20	3172	1294
	2	169,8	3	19	0

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
	3	1182,6	4	658	354
	4	8668,3	12	2396	1000
	Total	23758,0	39	6245	2648

Subdivision 30

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
Denmark	1				
	2				
	3				
	4				
	Total	0,0	0	0	0
Finland	1	372,6	12	800	0
	2	280,2	17	837	0
	3	12,5	6	150	95
	4	209,8	16	735	294
	Total	875,0	51	2522	389
Sweden	1	21,8	0	0	0
	2	17,1	0	0	0
	3	0,6	0	0	0
	4	1,1	0	0	0
	Total	40,7	0	0	0
Total	1	394,4	12	800	0
	2	297,3	17	837	0
	3	13,1	6	150	95
	4	210,9	16	735	294
	Total	915,7	51	2522	389

Subdivision 31

Country	Quarter	Landings in tonnes	Number of samples	Number of fish measured	aged
Finland	1				
	2	37,4	0	0	0
	3	2,4	0	0	0
	4				
	Total	39,8	0	0	0
Sweden	1				
	2				
	3				
	4				
	Total	0,0	0	0	0
Total	1	0,0	0	0	0
	2	37,4	0	0	0
	3	2,4	0	0	0
	4	0,0	0	0	0
	Total	39,8	0	0	0

Subdivision 32

Country	Quarter	Landings in tonnes	Number of samples	Number of fish measured	aged
Denmark	1				
	2				
	3				
	4				
	Total	0,0	0	0	0
Estonia	1	5130,0	13	2580	1145
	2	1836,0	9	985	777
	3	1686,0	5	758	469
	4	8191,0	11	2045	811

Country	Quarter	Landings	Number of samples	Number of fish	
		in tonnes		measured	aged
	Total	16843,0	38	6368	3202
Finland	1	1236,8	3	916	0
	2	26,3	3	550	0
	3	826,3	2	617	63
	4	4133,6	3	916	0
	Total	6223,0	11	2999	63
Russia	1	370,7	0	0	0
	2	293,4	0	0	0
	3				
	4	877,3	0	0	0
	Total	1541,3	0	0	0
Total	1	6737,5	16	3496	1145
	2	2155,7	12	1535	777
	3	2512,3	7	1375	532
	4	13201,9	14	2961	811
	Total	24607,3	49	9367	3265

Subdivisions 22-32

Quarter	Landings	Number of samples	Number of fish	
	in tonnes		measured	aged
1	158 282,4	214	34 528	11 122
2	84 421,9	134	21 282	5642
3	14 176,0	71	11 936	2939
4	57 267,3	150	23 352	5777
Total	314 147,5	569	91 098	25 480

Table 7.6. SPRAT in SD 22-32. Catch in Numbers (Thousands)
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

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
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
2019	5962092	10263401	5560056	5543538	7445687	777196	290655	235195

Table 7.7. SPRAT in SD 22-32. Mean weight in the Catch and in the Stock (Kilogrammes)
WECA (=WEST): Mean weight in Catch (Kilogrammes)

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

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
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

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
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
2019	0,0049	0,0078	0,0094	0,0102	0,0103	0,0121	0,0122	0,0119

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	0,69	0,51	0,46	0,44	0,44	0,42	0,44	0,44
1975	0,70	0,53	0,49	0,46	0,46	0,44	0,46	0,46
1976	0,59	0,46	0,43	0,41	0,41	0,40	0,41	0,41
1977	0,78	0,54	0,49	0,47	0,47	0,44	0,46	0,46
1978	1,07	0,74	0,68	0,63	0,62	0,61	0,61	0,61
1979	1,14	0,79	0,74	0,75	0,69	0,69	0,71	0,71
1980	1,17	0,84	0,75	0,73	0,74	0,70	0,72	0,72
1981	1,06	0,71	0,68	0,62	0,62	0,67	0,60	0,60
1982	1,06	0,75	0,69	0,67	0,63	0,67	0,68	0,68
1983	0,83	0,66	0,61	0,60	0,58	0,57	0,57	0,57
1984	0,69	0,58	0,52	0,52	0,50	0,49	0,49	0,49
1985	0,60	0,50	0,47	0,46	0,44	0,42	0,44	0,44
1986	0,63	0,48	0,46	0,44	0,42	0,42	0,41	0,41
1987	0,63	0,47	0,44	0,42	0,42	0,41	0,40	0,40
1988	0,59	0,47	0,45	0,43	0,41	0,41	0,40	0,40
1989	0,50	0,40	0,38	0,37	0,36	0,35	0,35	0,35
1990	0,35	0,30	0,30	0,29	0,29	0,29	0,28	0,28
1991	0,32	0,27	0,27	0,26	0,26	0,26	0,26	0,26
1992	0,34	0,28	0,27	0,27	0,26	0,26	0,26	0,26

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1993	0,37	0,33	0,32	0,31	0,31	0,30	0,30	0,30
1994	0,37	0,33	0,31	0,31	0,30	0,30	0,30	0,30
1995	0,33	0,30	0,30	0,29	0,29	0,29	0,28	0,28
1996	0,30	0,29	0,28	0,27	0,27	0,27	0,27	0,27
1997	0,30	0,28	0,27	0,27	0,26	0,26	0,26	0,26
1998	0,31	0,28	0,28	0,28	0,27	0,27	0,27	0,27
1999	0,34	0,30	0,29	0,29	0,29	0,28	0,28	0,28
2000	0,36	0,31	0,31	0,31	0,31	0,30	0,30	0,30
2001	0,37	0,32	0,31	0,31	0,31	0,31	0,31	0,31
2002	0,39	0,33	0,33	0,32	0,32	0,32	0,32	0,32
2003	0,35	0,31	0,30	0,30	0,30	0,30	0,30	0,30
2004	0,34	0,31	0,29	0,29	0,29	0,29	0,29	0,29
2005	0,39	0,35	0,34	0,32	0,32	0,32	0,32	0,32
2006	0,41	0,36	0,36	0,35	0,33	0,33	0,33	0,33
2007	0,41	0,36	0,35	0,35	0,35	0,33	0,33	0,33
2008	0,43	0,36	0,36	0,35	0,35	0,36	0,34	0,34
2009	0,43	0,36	0,35	0,35	0,35	0,35	0,35	0,35
2010	0,46	0,40	0,38	0,37	0,37	0,37	0,37	0,37
2011	0,46	0,38	0,38	0,37	0,36	0,36	0,36	0,36
2012	0,45	0,36	0,34	0,34	0,33	0,33	0,33	0,33
2013	0,46	0,36	0,34	0,33	0,33	0,33	0,33	0,33
2014	0,45	0,36	0,34	0,33	0,32	0,32	0,33	0,33
2015	0,38	0,32	0,30	0,30	0,29	0,29	0,30	0,30
2016	0,37	0,33	0,30	0,29	0,29	0,29	0,29	0,29
2017	0,35	0,31	0,30	0,29	0,28	0,28	0,28	0,28
2018	0,32	0,29	0,28	0,28	0,27	0,27	0,27	0,27
2019	0,32	0,29	0,28	0,28	0,27	0,27	0,27	0,27

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+
1974-2019	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+
1974-2019	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+
1974-2019	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/Baltic International Acoustic Survey (SD 22-29).
Fleet 03. Age 0 shifted to represent age 1 from international acoustic survey (BIAS) in October corrected by area surveyed (Abundance: Millions)

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

Year	Fish. Effort	Age 1
2008	1	17821
2009	1	115698
2010	1	12798
2011	1	41916
2012	1	45186
2013	1	33653
2014	1	24921
2015	1	168125
2016	1	42251
2017	1	30848
2018	1	78167
2019	1	18542

Table 7.13. SPRAT in SD 22-32. Tuning Fleet/Baltic International Acoustic Survey (SD 22-29).
Fleet 01. International acoustic survey (BIAS) in October corrected by area surveyed (Abundance: Millions)

Year	Fish. Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+	total
1991	1	46488	40299	43681	2743	8924	1851	1957	3117	149060
1992	1	36519	26991	24051	9289	1921	2437	714	560	102482
1993	1	-11	-11	-11	-11	-11	-11	-11	-11	-11
1994	1	12532	44588	43274	17272	11925	5112	1029	1559	137291
1995	1	-11	-11	-11	-11	-11	-11	-11	-11	-11
1996	1	69994	130760	20797	23241	12778	6405	3697	1311	268983
1997	1	-11	-11	-11	-11	-11	-11	-11	-11	-11
1998	1	100615	21975	55422	36291	8056	4735	1623	1011	229728
1999	1	4892	90050	15989	35717	38820	5231	3290	1738	195727
2000	1	58703	5285	49635	5676	13933	15835	1554	2678	153299
2001	1	12047	35687	6927	30237	4028	9606	6370	2407	107309
2002	1	31209	14415	36763	5733	18735	2638	5037	4345	118875
2003	1	99129	32270	24035	23198	8016	13163	4831	8536	213178
2004	1	119497	47027	11638	7929	4876	2450	2389	3552	199358
2005	1	7082	125148	48724	10035	5116	3011	2364	3325	204805

Year	Fish. Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+	total
2006	1	36531	11774	103289	32412	7937	4583	2111	2947	201584
2007	1	51888	21665	8175	26102	9800	1067	470	1578	120745
2008	1	28805	45118	20134	5350	18820	5678	1241	1917	127063
2009	1	77343	25333	20840	6547	4667	7023	2011	1376	145140
2010	1	11638	51321	10654	6663	1684	1958	2572	1168	87658
2011	1	20620	11657	43357	9990	6747	2615	1795	2808	99589
2012	1	40516	16525	7935	18413	3494	1733	606	1368	90590
2013	1	19703	20486	11243	6040	10792	1882	766	1161	72073
2014	1	10665	8623	9735	4933	2034	3779	681	774	41224
2015	1	102247	17406	19932	11138	3456	3574	2795	1548	162096
2016	1	20629	81157	24161	9343	3771	1492	1195	1253	143002
2017	1	30171	33937	78088	13673	6372	2681	823	925	166670
2018	1	26879	19204	14849	29575	9135	3134	1182	1336	105294
2019	1	13510	18518	13046	11131	19904	1747	1119	837	79813

Table 7.14. SPRAT in SD 22-32. Tuning Fleet/Baltic Acoustic Spring Survey in SD 24-28 excl. 27.
Fleet 02. International Acoustic Survey (BASS) in May corrected by area surveyed (Abundance: 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
2019	1	15958	28778	32532	49495	30131	3384	487	647

Table 7.15. SPRAT Output from XSA DIAGNOSTICS 2020.

Lowestoft VPA Version 3.1

7/04/2020 20:14

Extended Survivors Analysis

Sprat 22 32

CPUE data from file z:\SprDat19\Fleet3xsa.txt

Catch data for 46 years. 1974 to 2019. Ages 1 to 8.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLT01: Internatioı	1991	2019	1	7	0,75	0,85
FLT02: Internatioı	2001	2019	1	7	0,35	0,42
FLT03: Latvian/Rı	1992	2019	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
59 and 60 = .00027

Final year F values

Age	1	2	3	4	5	6	7
Iteration **	0,1325	0,248	0,2646	0,4208	0,4519	0,3829	0,3695
Iteration **	0,1325	0,248	0,2645	0,4208	0,452	0,3829	0,3695

1

Regression weights

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

Fishing mortalities

Age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	0,115	0,206	0,095	0,132	0,113	0,1	0,048	0,066	0,094	0,132
2	0,299	0,195	0,254	0,317	0,298	0,184	0,178	0,152	0,186	0,248
3	0,373	0,363	0,215	0,387	0,445	0,393	0,251	0,271	0,265	0,265
4	0,512	0,409	0,427	0,347	0,428	0,491	0,391	0,389	0,388	0,421
5	0,429	0,408	0,394	0,521	0,432	0,482	0,385	0,497	0,46	0,452
6	0,483	0,418	0,44	0,458	0,422	0,402	0,413	0,423	0,402	0,383
7	0,443	0,483	0,509	0,39	0,538	0,355	0,523	0,391	0,305	0,369

1

XSA population numbers (Thousands)

	AGE						
YEAR	1	2	3	4	5	6	7
2010	52900	101000	20800	12700	4270	2760	3330
2011	59500	29900	50400	9840	5260	1930	1180
2012	72300	30500	16800	24000	4520	2440	882
2013	63500	42000	16500	9600	11200	2180	1130
2014	57800	35300	21400	8020	4890	4780	997
2015	217000	32900	18300	9800	3770	2300	2270
2016	76800	134000	19900	9130	4450	1740	1150
2017	67000	50800	81000	11500	4600	2260	859
2018	81800	44200	32100	45800	5820	2110	1110
2019	56500	54000	27500	18600	23500	2800	1080

Estimated population abundance at 1st Jan 2020

0	35800	31600	15900	9210	11400	1460

Taper weighted geometric mean of the VPA populations:

80400	49600	27600	14100	6580	2760	1320

Standard error of the weighted Log(VPA populations) :

0,4583	0,4916	0,5228	0,5638	0,591	0,4541	0,461

1

Log catchability residuals.

Fleet : FLT01: International

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	99,99	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	99,99
3	99,99	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	99,99
5	99,99	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	99,99
7	99,99	99,99	99,99	99,99	99,99	99,99	99,99	99,99	99,99

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0,27	-0,14	0,42	0,35	-0,14	-0,57	0,19	0,17	0,2	-0,05
2	-1,37	0,14	-0,11	0,66	0,07	0,52	-0,43	0,05	0,52	0,33
3	0,2	-1,08	0,48	0,61	-0,11	0,3	0,6	-0,66	0,32	0,17
4	-0,92	0,26	-0,83	0,59	0,05	0,32	0,4	-0,14	-0,59	-0,08
5	-0,09	-0,84	0,37	0,03	-0,26	0,35	0,68	-0,22	0,18	-0,13
6	0,08	0,31	-0,68	0,73	-0,41	-0,01	1,11	-0,55	0,11	0,07
7	-0,61	-0,11	0,34	0,63	-0,21	0,37	0,32	-0,26	0,4	0,04

Age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	-0,13	0,2	0,4	0,06	-0,28	-0,09	-0,19	0,2	-0,07	-0,16
2	0,14	-0,21	0,14	0,08	-0,62	0,03	0,17	0,23	-0,19	-0,38
3	-0,23	0,29	-0,46	0,04	-0,32	0,49	0,48	0,26	-0,49	-0,47
4	-0,27	0,31	0,02	-0,25	-0,21	0,43	0,24	0,39	-0,23	-0,28
5	-0,79	0,36	-0,17	0,15	-0,77	0,04	-0,12	0,45	0,54	-0,08
6	-0,16	0,43	-0,22	-0,02	-0,14	0,49	-0,09	0,24	0,43	-0,45
7	-0,11	0,59	-0,2	-0,31	-0,19	0,23	0,19	0	0,02	0,05

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	-0,2643	0,1555	0,3271	0,4983	0,4983	0,4983
S.E(Log q)	0,3209	0,4144	0,3219	0,4265	0,3886	0,2701

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0,69	2,013	3,97	0,81	20	0,24	-0,68

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	0,8	1,335	2,4	0,81	20	0,25	-0,26
3	0,82	0,924	1,73	0,72	20	0,34	0,16
4	1,16	-0,779	-1,88	0,71	20	0,38	0,33
5	0,96	0,163	-0,17	0,67	20	0,43	0,5
6	1,19	-0,604	-2,15	0,51	20	0,47	0,56
7	0,91	0,541	0,13	0,79	20	0,25	0,55
1							

Fleet : FLT02: International

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	99,99	-0,39	0,5	-0,37	0,37	-0,98	-0,45	0,41	-0,6	-0,31
2	99,99	-0,06	-0,03	-0,22	0,22	-0,05	-0,99	0,06	0,14	0,14
3	99,99	-0,74	0,06	-0,81	-0,2	-0,8	-0,1	-1,25	-0,11	0,26
4	99,99	-0,07	-0,13	-0,35	-0,15	-0,55	-0,55	-0,4	-1,05	-0,22
5	99,99	-0,88	-0,26	-0,69	0,23	-0,5	-0,05	-0,88	-0,12	-0,23
6	99,99	-0,83	-1,05	-0,25	-0,51	-0,45	-0,17	-0,78	-0,64	0,32
7	99,99	-0,83	-0,33	-0,82	0,57	-0,31	-0,37	-0,6	-0,51	0,53

Age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	-0,28	0,19	0,14	0,36	-0,3	-0,03	99,99	0,48	0,13	0,07
2	0,02	-0,96	0,21	0,38	0,28	0,2	99,99	0,14	-0,07	-0,13
3	-0,29	0,3	-0,44	0,12	-0,04	0,49	99,99	0,45	0,14	0,12
4	0,01	0,27	0,13	-0,13	-0,34	0,41	99,99	0,29	0,11	0,69
5	-0,1	0,41	0,21	0,04	-0,07	0,48	99,99	0,11	-0,08	-0,05
6	-0,77	0,47	0,44	0,16	-0,52	0,26	99,99	-0,31	-0,33	-0,14
7	0,25	0,45	0,18	0,35	-0,05	-0,2	99,99	-0,38	-0,44	-1,13

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	-0,2972	0,2608	0,5574	0,5783	0,5783	0,5783
S.E(Log q)	0,3858	0,4321	0,4353	0,3174	0,4636	0,5227

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	0,83	0,662	2,79	0,64	18	0,38	-1,1

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	0,87	0,475	1,66	0,59	18	0,35	-0,3
3	0,8	0,954	1,79	0,72	18	0,35	0,26
4	0,95	0,212	-0,04	0,66	18	0,43	0,56
5	1,26	-1,294	-3,03	0,73	18	0,39	0,58
6	1,25	-0,632	-2,53	0,41	18	0,56	0,43
7	0,74	1,066	1,53	0,65	18	0,37	0,43
1							

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	0,8	1,335	2,4	0,81	20	0,25	-0,26
3	0,82	0,924	1,73	0,72	20	0,34	0,16
4	1,16	-0,779	-1,88	0,71	20	0,38	0,33
5	0,96	0,163	-0,17	0,67	20	0,43	0,5
6	1,19	-0,604	-2,15	0,51	20	0,47	0,56
7	0,91	0,541	0,13	0,79	20	0,25	0,55
1							

Fleet : FLT03: Latvian/Russi

Age		1991	1992	1993	1994	1995	1996	1997	1998	1999
	1	99,99	99,99	99,99	99,99	99,99	99,99	99,99	99,99	99,99
	2	No data for this fleet at this age								
	3	No data for this fleet at this age								
	4	No data for this fleet at this age								
	5	No data for this fleet at this age								
	6	No data for this fleet at this age								
	7	No data for this fleet at this age								

Age		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	1	-0,35	-0,93	-0,45	-0,04	-0,27	-1,17	0	0,03	-0,37	-0,1
	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		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	1	-0,3	0,35	0,21	0,14	0,04	-0,06	0,01	0,03	0,44	-0,13
	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	0,65	1,721	4,41	0,71	20	0,31	-0,73
	1							

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 2018

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	30640	0,3	0	0	1	0,335	0,153
FLT02: Internatio	38267	0,403	0	0	1	0,186	0,125
FLT03: Latvian/Ru	31552	0,332	0	0	1	0,275	0,149
P shrinkage mea	49633	0,49				0,143	0,097
F shrinkage mea	57478	0,75				0,061	0,085

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
35839	0,18	0,11	5	0,642	0,132

1

Age 2 Catchability constant w.r.t. time and dependent on age

Year class = 2017

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	25427	0,223	0,151	0,67	2	0,459	0,3
FLT02: Internatioı	31447	0,284	0,126	0,44	2	0,285	0,249
FLT03: Latvian/Rι	48968	0,331	0	0	1	0,2	0,167
F shrinkage mea	39900	0,75				0,055	0,201

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
31581	0,15	0,13	6	0,822	0,248

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2016

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	14412	0,199	0,192	0,96	3	0,466	0,289
FLT02: Internatioı	18910	0,242	0,16	0,66	3	0,322	0,227
FLT03: Latvian/Rι	16442	0,323	0	0	1	0,162	0,257
F shrinkage mea	12444	0,75				0,05	0,328

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
15949	0,14	0,1	8	0,719	0,265

1

Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 2015

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	7742	0,174	0,137	0,79	4	0,547	0,484
FLT02: Internatioı	13068	0,255	0,191	0,75	3	0,268	0,314
FLT03: Latvian/Rι	9332	0,323	0	0	1	0,128	0,416
F shrinkage mea	9186	0,75				0,057	0,422

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
9213	0,13	0,11	9	0,849	0,421

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2014

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	10945	0,17	0,086	0,51	5	0,493	0,466
FLT02: Internatio	12074	0,217	0,102	0,47	4	0,378	0,43
FLT03: Latvian/Ru	10741	0,363	0	0	1	0,067	0,473
F shrinkage mea	11251	0,75				0,063	0,456

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
11364	0,13	0,05	11	0,418	0,452

1

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2013

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	1505	0,171	0,183	1,07	6	0,5	0,372
FLT02: Internatio	1409	0,205	0,088	0,43	5	0,378	0,393
FLT03: Latvian/Ru	1508	0,333	0	0	1	0,056	0,372
F shrinkage mea	1314	0,75				0,065	0,416

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1455	0,13	0,09	13	0,708	0,383

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 5

Year class = 2012

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01:	666	0,172	0,103	0,6	7	0,591	0,323
FLT02: Internatio	431	0,217	0,256	1,18	6	0,315	0,463
FLT03: Latvian/Ru	656	0,335	0	0	1	0,028	0,327
F shrinkage mea	483	0,75				0,066	0,423

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
568	0,13	0,11	15	0,861	0,369

1
1

Table 7.16. SPRAT IN SD 22-32. Output from XSA. Fishing mortality (F) at age
Run title : Sprat 22 32
At 7/04/2020 20:16

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR		1974	1975	1976	1977	1978	1979
AGE							
	1	0,0725	0,0487	0,0349	0,081	0,0534	0,0757
	2	0,1209	0,1137	0,1232	0,119	0,2914	0,181
	3	0,3316	0,2161	0,2251	0,2975	0,1474	0,2493
	4	0,4425	0,5313	0,2662	0,443	0,3458	0,1631
	5	0,3345	0,4406	0,6418	0,2675	0,5291	0,3757
	6	0,6266	0,3304	0,4736	0,6583	0,2312	0,2828
	7	0,4772	0,443	0,4689	0,466	0,3793	0,2828
+gp		0,4772	0,443	0,4689	0,466	0,3793	0,2828
FBAR 3- 5		**0,37**	**0,40**	**0,38**	**0,34**	**0,34**	**0,26**

YEAR		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE											
	1	0,0337	0,0629	0,0182	0,0227	0,0288	0,0181	0,0381	0,0264	0,0069	0,065
	2	0,266	0,2473	0,1882	0,0364	0,0618	0,0939	0,0653	0,0551	0,1744	0,0431
	3	0,3161	0,1967	0,3028	0,0925	0,0914	0,1203	0,1424	0,1319	0,1822	0,2116
	4	0,3357	0,2027	0,2706	0,1856	0,1547	0,1985	0,1839	0,3644	0,2102	0,1827
	5	0,2496	0,149	0,3365	0,1292	0,2928	0,179	0,301	0,3105	0,325	0,2525
	6	0,4305	0,2528	0,2214	0,1464	0,2115	0,2362	0,2344	0,4395	0,2631	0,3403
	7	0,3507	0,2061	0,2846	0,1567	0,2234	0,2074	0,243	0,3773	0,2697	0,2614
+gp		0,3507	0,2061	0,2846	0,1567	0,2234	0,2074	0,243	0,3773	0,2697	0,2614
FBAR 3- 5		**0,30**	**0,18**	**0,30**	**0,14**	**0,18**	**0,17**	**0,21**	**0,27**	**0,24**	**0,22**

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	0,0251	0,0215	0,021	0,0241	0,0195	0,0301	0,0632	0,035	0,088	0,0459
2	0,1637	0,0918	0,0865	0,0993	0,1673	0,0615	0,1986	0,2748	0,1115	0,2551
3	0,0775	0,2009	0,1563	0,1442	0,232	0,2261	0,1859	0,2818	0,3835	0,2758
4	0,1947	0,1341	0,218	0,152	0,2611	0,3378	0,4016	0,4477	0,4445	0,4315
5	0,1387	0,1853	0,2273	0,1917	0,2989	0,4829	0,3094	0,522	0,3697	0,4071
6	0,1861	0,1166	0,1556	0,2271	0,2903	0,5175	0,454	0,2675	0,4876	0,3033
7	0,1743	0,1462	0,2016	0,1917	0,2861	0,4511	0,3921	0,4163	0,4384	0,3845
+gp	0,1743	0,1462	0,2016	0,1917	0,2861	0,4511	0,3921	0,4163	0,4384	0,3845
FBAR 3- 5	**0,14**	**0,17**	**0,20**	**0,16**	**0,26**	**0,35**	**0,30**	**0,42**	**0,40**	**0,37**

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
1	0,1301	0,0681	0,1473	0,0876	0,1168	0,0653	0,1701	0,1664	0,1194	0,1555
2	0,0963	0,2418	0,2184	0,2745	0,1962	0,2649	0,1195	0,3569	0,3556	0,3047
3	0,3455	0,1334	0,4361	0,352	0,3959	0,2982	0,3489	0,2299	0,4203	0,5142
4	0,237	0,438	0,3307	0,4345	0,4528	0,4394	0,3533	0,4878	0,3427	0,57
5	0,3746	0,2923	0,4334	0,4068	0,6324	0,6334	0,4458	0,4127	0,4649	0,436
6	0,3738	0,4819	0,2643	0,3968	0,4698	0,3709	0,5127	0,4367	0,5518	0,5396
7	0,334	0,4187	0,3312	0,4233	0,4995	0,5126	0,3531	0,6076	0,4593	0,6299
+gp	0,334	0,4187	0,3312	0,4233	0,4995	0,5126	0,3531	0,6076	0,4593	0,6299
FBAR 3- 5	**0,32**	**0,29**	**0,40**	**0,40**	**0,49**	**0,46**	**0,38**	**0,38**	**0,41**	**0,51**

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	FBAR **-**
AGE											
1	0,1152	0,2062	0,0946	0,1322	0,1126	0,1001	0,0476	0,0657	0,0944	0,1325	0,0975
2	0,2994	0,1946	0,2537	0,3174	0,2984	0,1841	0,1775	0,1521	0,1858	0,248	0,1953
3	0,3726	0,3634	0,2146	0,387	0,4447	0,3933	0,2509	0,2709	0,2645	0,2645	0,2666
4	0,5123	0,4093	0,4267	0,3473	0,4283	0,4909	0,3906	0,3891	0,3879	0,4208	0,3993
5	0,4287	0,4076	0,394	0,5209	0,4315	0,4821	0,3846	0,4966	0,4599	0,452	0,4695
6	0,4825	0,4181	0,4398	0,458	0,4223	0,4017	0,4132	0,4229	0,4015	0,3829	0,4025
7	0,4434	0,4828	0,5088	0,3903	0,5375	0,3547	0,523	0,3907	0,3052	0,3695	0,3551
+gp	0,4434	0,4828	0,5088	0,3903	0,5375	0,3547	0,523	0,3907	0,3052	0,3695	
FBAR 3- 5	**0,44**	**0,39**	**0,35**	**0,42**	**0,43**	**0,46**	**0,34**	**0,39**	**0,37**	**0,38**	

Table 7.17. SPRAT IN SD 22-32. Output from XSA. Stock number at age (Numbers*10^-6)
Run title : Sprat 22 32
At 7/04/2020 20:16

Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year)

YEAR	1974	1975	1976	1977	1978	1979
AGE						
1	52788	18704	182880	45092	16404	32557
2	69815	24625	8891	98289	19005	5350
3	16150	37260	12949	4952	50650	6803
4	6764	7303	18465	6733	2251	22099
5	8458	2796	2699	9362	2707	847
6	2472	3894	1131	940	4487	861
7	3975	868	1797	474	314	1937
+gp	889	1871	1353	1315	785	696
TOTAL	161312	97321	230166	167156	96603	71150

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	20054	64214	34159	124723	49912	42725	18167	40813	15295	42777
2	9614	5994	20870	11586	53270	24372	22959	9305	21254	8387
3	2028	3185	2297	8159	5757	28151	13485	13309	5493	11214
4	2529	699	1327	851	4037	3127	15585	7412	7512	2913
5	8913	869	306	518	389	2065	1617	8334	3376	3964
6	292	3300	401	117	255	176	1107	783	4022	1614
7	325	94	1310	165	57	126	91	578	335	2062
+gp	1092	701	279	1326	519	425	280	278	716	701
TOTAL	44848	79055	60949	147444	114197	101168	73291	80813	58004	73632

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	50547	57637	101823	92552	67209	253458	159151	57947	152411	54901
2	24434	34599	40798	70900	62469	45573	177353	110796	41534	102779
3	5390	15322	24047	28280	46200	38067	31812	109130	63805	27995
4	6231	3699	9587	15701	17867	26762	22585	20064	62721	32927
5	1674	3826	2487	5903	9912	10144	14285	11504	9837	30543
6	2148	1095	2456	1527	3592	5429	4697	8011	5263	5199
7	806	1339	754	1622	901	1991	2434	2282	4727	2477
+gp	1429	1264	1008	1695	960	1280	1405	921	1555	1834
TOTAL	92660	118782	182960	218179	209110	382704	413720	320653	341853	258656

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
1	103463	50832	58830	133019	249429	54518	84927	110536	70417	181929
2	37474	63249	32668	34547	85785	158750	34752	47782	62051	40609
3	58876	24986	35957	18841	19295	51762	85577	21472	23284	30215
4	15866	30506	16005	16730	9786	9689	27316	42287	12047	10702
5	15972	9200	14396	8324	8002	4665	4529	13547	18352	6038
6	15211	8095	5047	6757	4110	3185	1804	2081	6350	8100
7	2890	7731	3667	2808	3359	1926	1604	778	963	2564
+gp	3074	1760	5511	4596	3947	1766	2070	1365	1145	878
TOTAL	252825	196358	172081	225622	383713	286261	242578	239848	194608	281035

YEAR		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	GMST 74-**	AMST 74-**
AGE														
	1	52950	59527	72290	63516	57837	216611	76828	67046	81847	56455	0	64932	82123
	2	101402	29879	30485	42016	35307	32852	134027	50752	44241	53970	35839	35963	49527
	3	20807	50434	16753	16535	21448	18333	19943	81006	32069	27545	31581	19359	27896
	4	12695	9843	24029	9602	8024	9795	9128	11450	45771	18567	15949	9548	13938
	5	4269	5264	4520	11163	4887	3770	4446	4604	5818	23470	9213	4643	6893
	6	2762	1927	2441	2185	4781	2303	1735	2258	2111	2795	11364	2194	3327
	7	3331	1184	882	1129	997	2271	1153	859	1115	1079	1455	1070	1680
+gp		1680	1739	1270	1138	1034	1124	1260	1401	897	861	1022		
TOTAL		199897	159796	152669	147284	134316	287060	248521	219375	213868	184741	106425		

Table 7.18. Sprat in SD 22-32. Output from XSA. Stock summary.
At 7/04/2020 20:16

Table 16 Summary (without SOP correction)
Run title : Sprat 22 32

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 5
	Age 1					
1974	52788	1594	940	242	0,257	0,370
1975	18704	1099	726	201	0,278	0,396
1976	182880	1874	625	195	0,312	0,378
1977	45092	1663	1044	181	0,173	0,336
1978	16404	1077	695	132	0,190	0,341
1979	32557	706	377	77	0,204	0,263
1980	20054	485	227	58	0,256	0,301
1981	64214	633	199	49	0,248	0,183
1982	34159	641	254	49	0,191	0,303
1983	124723	1498	394	37	0,095	0,136
1984	49912	1241	616	53	0,085	0,180
1985	42725	1110	604	70	0,115	0,166
1986	18167	861	570	76	0,133	0,209
1987	40813	895	461	88	0,191	0,269
1988	15295	609	403	80	0,200	0,239
1989	42777	881	422	86	0,203	0,216
1990	50547	1122	556	86	0,154	0,137
1991	57637	1369	774	103	0,133	0,173
1992	101823	1998	1044	142	0,136	0,201
1993	92552	2186	1359	178	0,131	0,163
1994	67209	2187	1373	289	0,210	0,264
1995	253458	3149	1427	313	0,219	0,349
1996	159151	2879	1806	441	0,244	0,299
1997	57947	2613	1774	529	0,298	0,417
1998	152411	2332	1350	471	0,349	0,399
1999	54901	1962	1351	421	0,312	0,372
2000	103463	2220	1316	389	0,296	0,319
2001	50832	1827	1194	342	0,287	0,288
2002	58830	1586	941	343	0,365	0,400
2003	133019	1643	827	308	0,373	0,398
2004	249429	2279	1042	374	0,359	0,494
2005	54518	2005	1326	405	0,306	0,457
2006	84927	1743	1059	352	0,333	0,383
2007	110536	1745	901	388	0,431	0,377
2008	70417	1683	926	381	0,411	0,409
2009	181929	1913	832	407	0,490	0,507
2010	52950	1561	952	342	0,359	0,438
2011	59527	1217	754	268	0,355	0,393
2012	72290	1279	695	231	0,332	0,345
2013	63516	1235	707	272	0,386	0,418
2014	57837	1099	621	244	0,393	0,435
2015	216611	1658	692	247	0,357	0,455
2016	76828	1717	1090	247	0,226	0,342
2017	67046	1711	1107	286	0,258	0,386
2018	81847	1633	1024	309	0,302	0,371
2019	56455	1445	931	314	0,337	0,379
Arith. Mean	**81559**	**1562**	**876**	**241**	**0,267**	**0,327**
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 7.19. Sprat in SD 22-32. Input data for RCT3 analysis.
Sprat 22-32: Acoustic on age 0 in subdivisions 22-29, shifted to represent age1

Year	VPA, age 1	Acoustic, Age 0
1991	101823	59473
1992	92552	48035
1993	67209	-11
1994	253458	64092
1995	159151	-11
1996	57947	3842
1997	152411	-11
1998	54901	1279
1999	103463	33320
2000	50832	4601
2001	58830	12001
2002	133019	79551
2003	249429	146335
2004	54518	3562
2005	84927	41863
2006	110536	66125
2007	70417	17821
2008	181929	115698
2009	52950	12798
2010	59527	41158
2011	72290	45186
2012	63516	33653
2013	57837	24921
2014	216611	168125
2015	76828	42251
2016	67046	30848
2017	81847	78167
2018	56455	18542
2019	-11	95603

Table 7.20. Sprat in SD 22-32. Output from RCT3 analysis.

Analysis by RCT3 ver3.1 of data from file z:\recsprI1.txt

Sprat 22-32: YFS data from international acoustic survey on age 0

Data for 1 surveys over 29 years: 1991-2019

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	0,41	7,36	0,34	0,75	13	9,79	11,37	0,397	0,652
				VPA	Mean	=	11,46	0,543	0,348

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	0,41	7,3	0,33	0,747	14	11,66	12,12	0,404	0,629
				VPA	Mean	=	11,44	0,527	0,371

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	0,41	7,33	0,3	0,787	15	9,46	11,21	0,35	0,703
				VPA	Mean	=	11,49	0,539	0,297

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	7,07	0,31	0,775	16	10,63	11,66	0,36	0,695
				VPA	Mean	=	11,43	0,543	0,305

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	6,6	0,38	0,685	17	10,72	11,66	0,439	0,596
				VPA	Mean	=	11,39	0,534	0,404

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	6,35	0,39	0,649	18	10,42	11,46	0,451	0,563
				VPA	Mean	=	11,37	0,511	0,437

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	0,52	5,97	0,4	0,618	19	10,12	11,26	0,462	0,532
				VPA	Mean	=	11,34	0,493	0,468

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	5,56	0,4	0,605	20	12,03	12,27	0,508	0,471
				VPA	Mean	=	11,3	0,479	0,529

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	0,58	5,31	0,38	0,685	21	10,65	11,48	0,434	0,603
				VPA	Mean	=	11,38	0,535	0,397

Yearclass = 2016

|-----------Regression---------| |-----------Prediction---------|

Survey/ Series	Slope	Inter-cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,6	5,01	0,36	0,689	22	10,34	11,25	0,412	0,608
				VPA	Mean	=	11,36	0,513	0,392

Yearclass = 2017

|-----------Regression---------| |-----------Prediction---------|

Survey/ Series	Slope	Inter-cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,63	4,71	0,34	0,704	23	11,27	11,8	0,393	0,613
				VPA	Mean	=	11,34	0,495	0,387

Yearclass = 2018

|-----------Regression---------| |-----------Prediction---------|

Survey/ Series	Slope	Inter-cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,65	4,44	0,34	0,679	24	9,83	10,82	0,4	0,581
				VPA	Mean	=	11,33	0,47	0,419

Yearclass = 2019

|-----------Regression---------| |-----------Prediction---------|

Survey/ Series	Slope	Inter-cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
Acoust	0,65	4,45	0,31	0,711	25	11,47	11,87	0,365	0,612
				VPA	Mean	=	11,3	0,458	0,388

Year class (Age 1)	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2005	120479	11,7	0,34	0,16	0,23	84927	11,35
2006	129889	11,77	0,34	0,25	0,51	110537	11,61
2007	89819	11,41	0,32	0,04	0,02	70417	11,16
2008	142629	11,87	0,32	0,33	1,07	181930	12,11
2009	79942	11,29	0,29	0,13	0,19	52950	10,88
2010	108219	11,59	0,3	0,1	0,12	59527	10,99
2011	103786	11,55	0,34	0,13	0,14	72290	11,19
2012	91452	11,42	0,34	0,05	0,02	63517	11,06
2013	80531	11,3	0,34	0,04	0,02	57838	10,97
2014	127714	11,76	0,35	0,48	1,91	216611	12,29
2015	92855	11,44	0,34	0,05	0,02	76828	11,25
2016	80472	11,3	0,32	0,06	0,03	67046	11,11
2017	111418	11,62	0,31	0,22	0,52	81848	11,31
2018	61924	11,03	0,3	0,25	0,7	56455	10,94
2019	**114319**	11,65	0,29	0,28	0,96		

Table 7.21. Sprat in SD 22-32. Input data for short-term prediction.
MFDP version 1a
Run: rSQ
Time and date: 12:33 2020-04-10
Fbar age range: 3-5

2020

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	114319	0,331333	0,17	0,4	0,4	0,0050	0,0975	0,0050
2	35839	0,294333	0,93	0,4	0,4	0,0081	0,1953	0,0081
3	31581	0,288	1	0,4	0,4	0,0093	0,2666	0,0093
4	15949	0,282667	1	0,4	0,4	0,0103	0,3993	0,0103
5	9213	0,276333	1	0,4	0,4	0,0110	0,4695	0,0110
6	11364	0,274333	1	0,4	0,4	0,0119	0,4024	0,0119
7	1455	0,275333	1	0,4	0,4	0,0118	0,3551	0,0118
8	1022	0,275333	1	0,4	0,4	0,0113	0,3551	0,0113

2021

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	87490	0,331333	0,17	0,4	0,4	0,0050	0,0975	0,0050
2	.	0,294333	0,93	0,4	0,4	0,0081	0,1953	0,0081
3	.	0,288	1	0,4	0,4	0,0093	0,2666	0,0093
4	.	0,282667	1	0,4	0,4	0,0103	0,3993	0,0103
5	.	0,276333	1	0,4	0,4	0,0110	0,4695	0,0110
6	.	0,274333	1	0,4	0,4	0,0119	0,4024	0,0119
7	.	0,275333	1	0,4	0,4	0,0118	0,3551	0,0118
8	.	0,275333	1	0,4	0,4	0,0113	0,3551	0,0113

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	87490	0,331333	0,17	0,4	0,4	0,0050	0,0975	0,0050
2	.	0,294333	0,93	0,4	0,4	0,0081	0,1953	0,0081
3	.	0,288	1	0,4	0,4	0,0093	0,2666	0,0093
4	.	0,282667	1	0,4	0,4	0,0103	0,3993	0,0103
5	.	0,276333	1	0,4	0,4	0,0110	0,4695	0,0110
6	.	0,274333	1	0,4	0,4	0,0119	0,4024	0,0119
7	.	0,275333	1	0,4	0,4	0,0118	0,3551	0,0118
8	.	0,275333	1	0,4	0,4	0,0113	0,3551	0,0113

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)
$N_{2020-2021}$ Age 1:	Geometric mean from XSA-estimates at age 1 for the years 1991-2020
Natural Mortality (M):	average 2017-2019
Weight in the Catch/Stock (CWt/SWt):	average 2017-2020
Expoitation pattern (Sel):	average 2017-2019 scaled to TAC in 2021

Table 7.22a. Sprat in SD 22-32. Output from short-term prediction -TAC constraint in 2020.
MFDP version 1a
Run: projTACconst
Sprat
Time and date: 13:59 2020-04-10
Fbar age range: 3-5

2020				
Biomass	SSB	F_{Mult}	F_{Bar}	Landings
1585	873	0,9117	0,345	257

2021					**2021**	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
1678	1133	0	0	0	1972	1402
.	1121	0,1	0,0378	33	1939	1357
.	1109	0,2	0,0757	66	1908	1315
.	1097	0,3	0,1135	97	1877	1274
.	1085	0,4	0,1514	128	1846	1234
.	1073	0,5	0,1892	158	1817	1196
.	1062	0,6	0,2271	187	1788	1160
.	1050	0,7	0,2649	215	1760	1125
.	1039	0,8	0,3028	243	1733	1091
.	1028	0,9	0,3406	269	1707	1058
.	1017	1	0,3785	296	1681	1027
.	1006	1,1	0,4163	321	1656	997
.	996	1,2	0,4542	346	1632	968
.	985	1,3	0,492	370	1608	940
.	975	1,4	0,5299	394	1585	913
.	964	1,5	0,5677	416	1562	887
.	954	1,6	0,6055	439	1540	862
.	944	1,7	0,6434	461	1519	838
.	934	1,8	0,6812	482	1498	815
.	924	1,9	0,7191	503	1478	792
.	915	2	0,7569	523	1458	771

Input units are millions and kg - output in kilotonnes

Table 7.22b. Sprat in SD 22-32. Output from short-term prediction; F-status quo in 2020.
MFDP version 1a
Run: runFsq
Sprat
Time and date: 12:33 2020-04-10
Fbar age range: 3-5

2020				
Biomass	SSB	F_{Mult}	F_{Bar}	Landings
1585	864	1,0000	0,3785	278

2021					**2021**	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
1657	1114	0	0	0	1955	1386
.	1102	0,1	0,0378	33	1923	1343
.	1090	0,2	0,0757	64	1891	1301
.	1078	0,3	0,1135	95	1861	1260
.	1067	0,4	0,1514	126	1831	1221
.	1055	0,5	0,1892	155	1802	1184
.	1044	0,6	0,2271	183	1774	1148
.	1033	0,7	0,2649	211	1747	1114
.	1022	0,8	0,3028	238	1720	1080
.	1011	0,9	0,3406	265	1694	1048
.	1001	1	0,3785	290	1669	1017
.	990	1,1	0,4163	315	1644	988
.	979	1,2	0,4542	340	1620	959
.	969	1,3	0,492	363	1597	932
.	959	1,4	0,5299	387	1574	905
.	949	1,5	0,5677	409	1552	879
.	939	1,6	0,6055	431	1530	855
.	929	1,7	0,6434	453	1509	831
.	919	1,8	0,6812	474	1488	808
.	910	1,9	0,7191	494	1468	786
.	900	2	0,7569	514	1448	764

Input units are millions and grams - output in tonnes

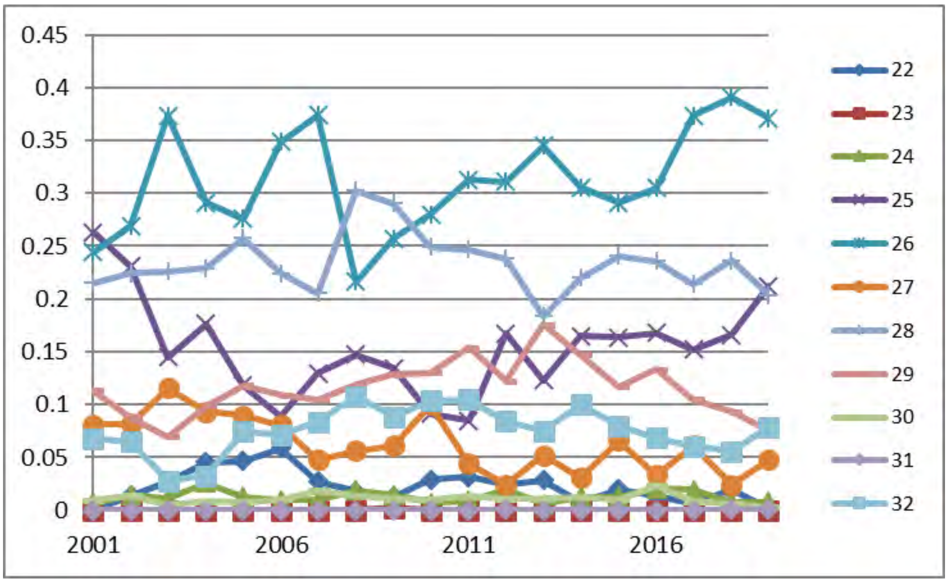


Figure 7.1. Sprat in subdivisions 22-32. Share of catches by Subdivision in 2001-2019

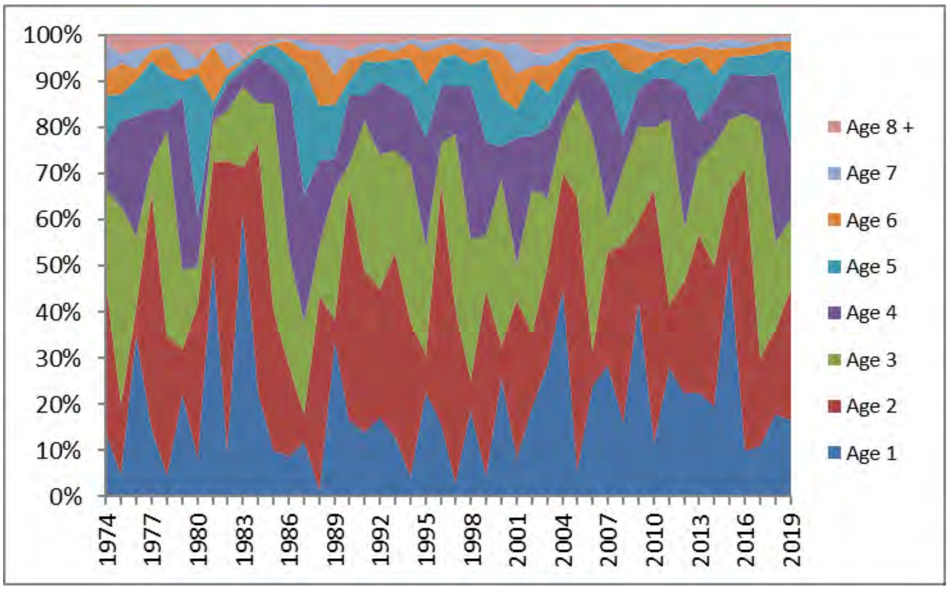


Figure 7.2. Sprat in SD 22-32. Relative catch-at-age in numbers.

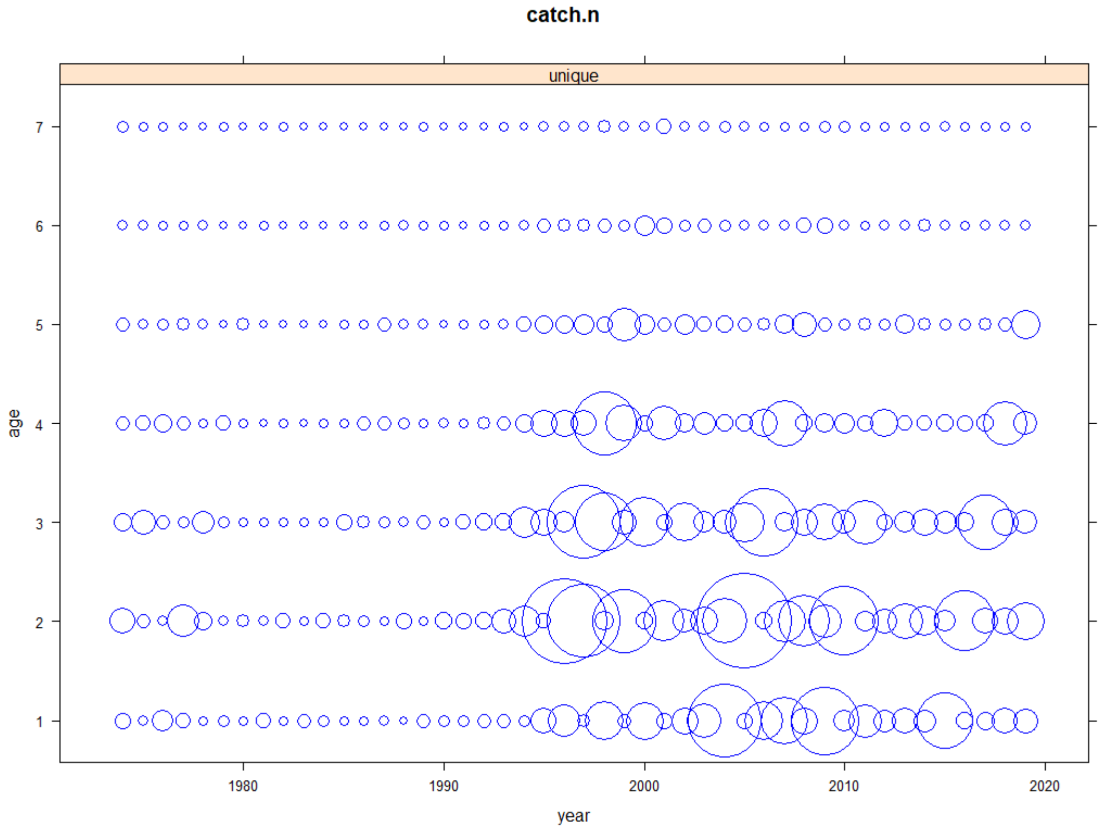
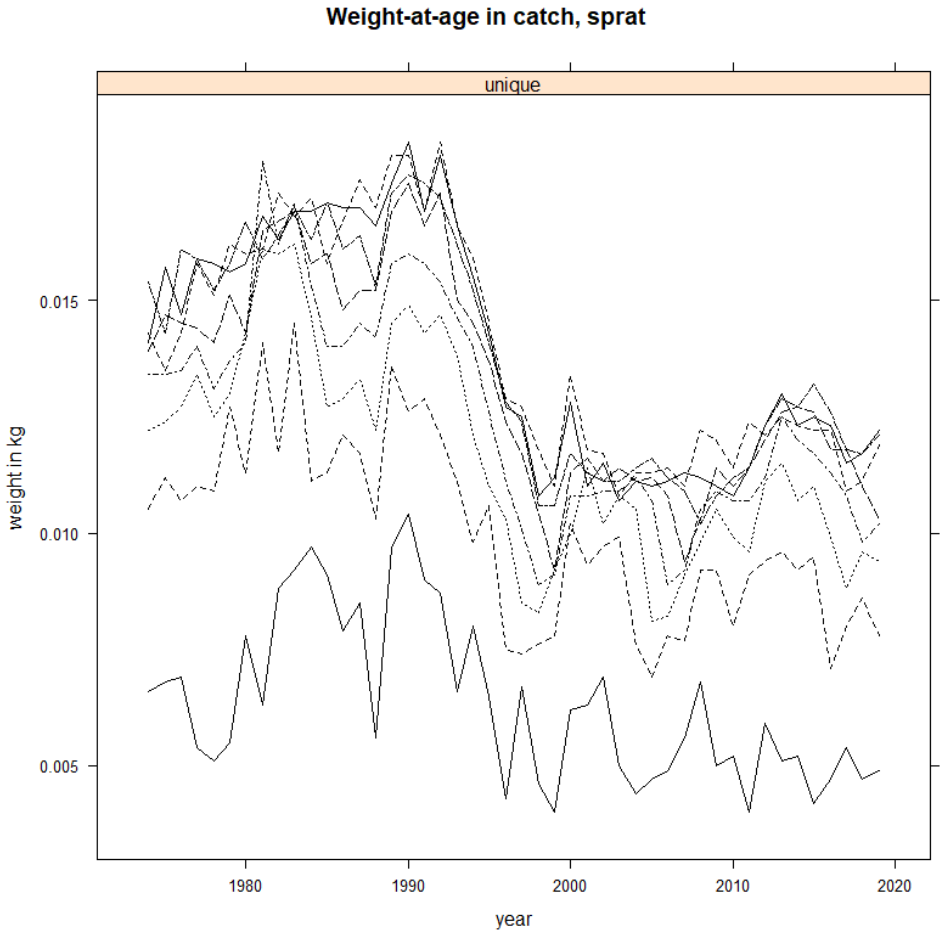


Figure 7.3. Sprat in SD 22-32. CANUM consistency check.



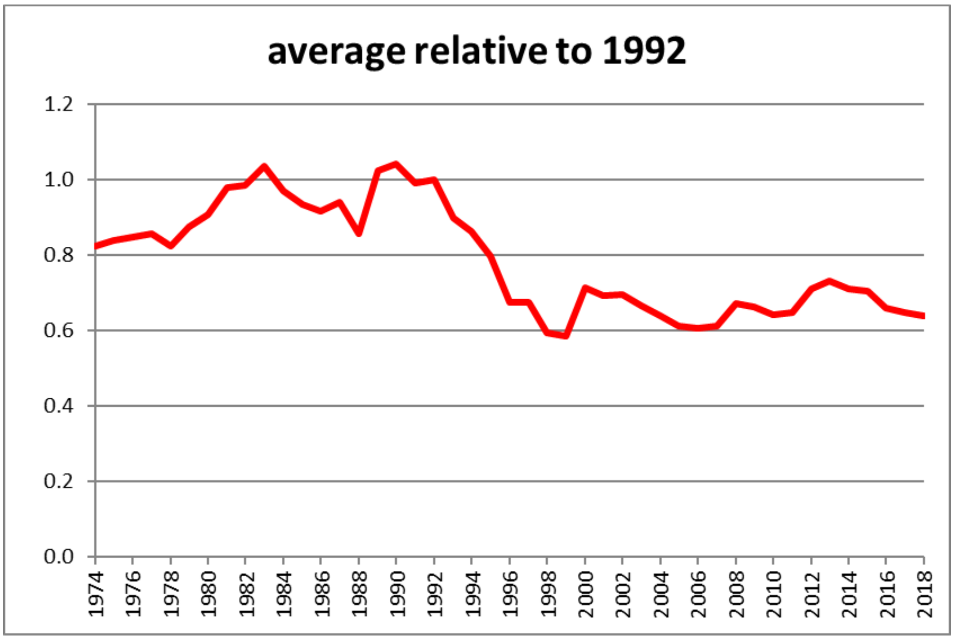


Figure 7.4. Sprat in SD 22-32: mean weight-at-age in the catches by ages and average of values relative to weights in 1992 (weight in the stock assumed as in the catches).

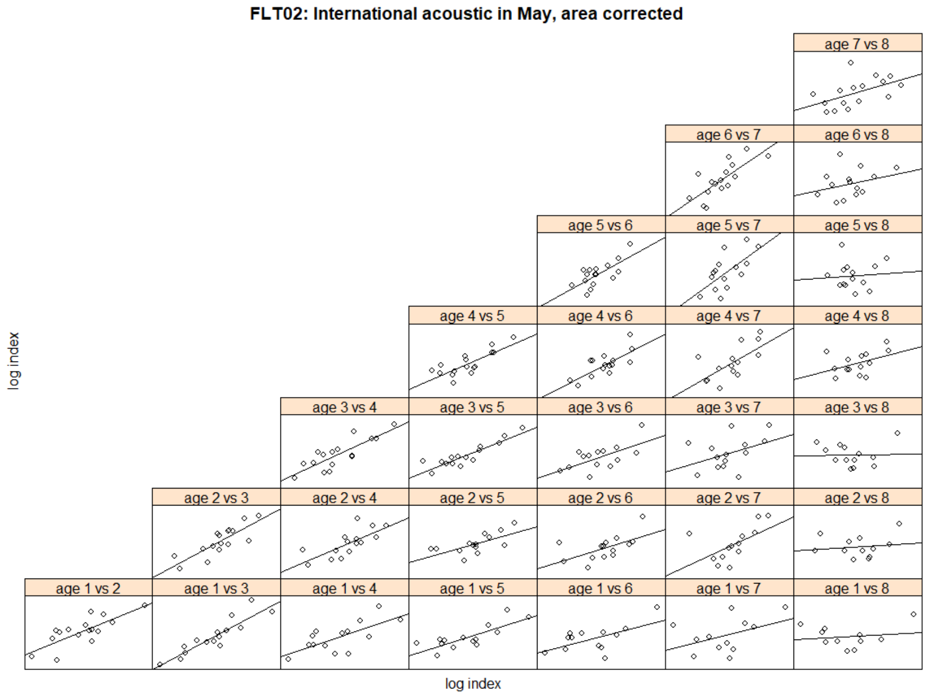


Figure 7.5a. Sprat in SD 22-32. Check for consistency in October acoustic survey estimates.

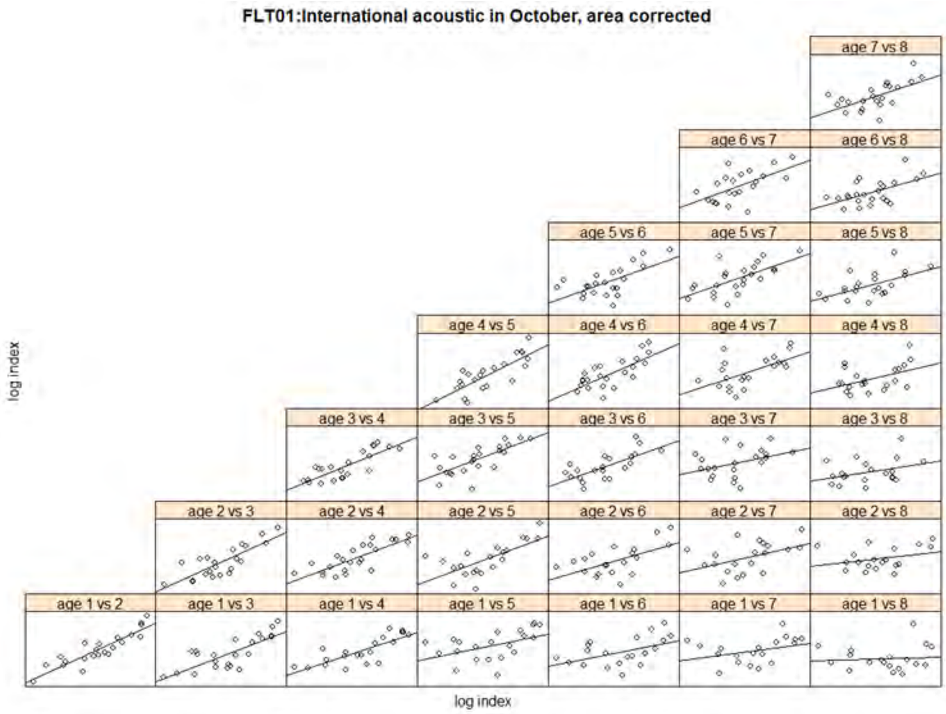


Figure 7.5b. Sprat in SD 22-32. Check for consistency in May acoustic survey estimates.

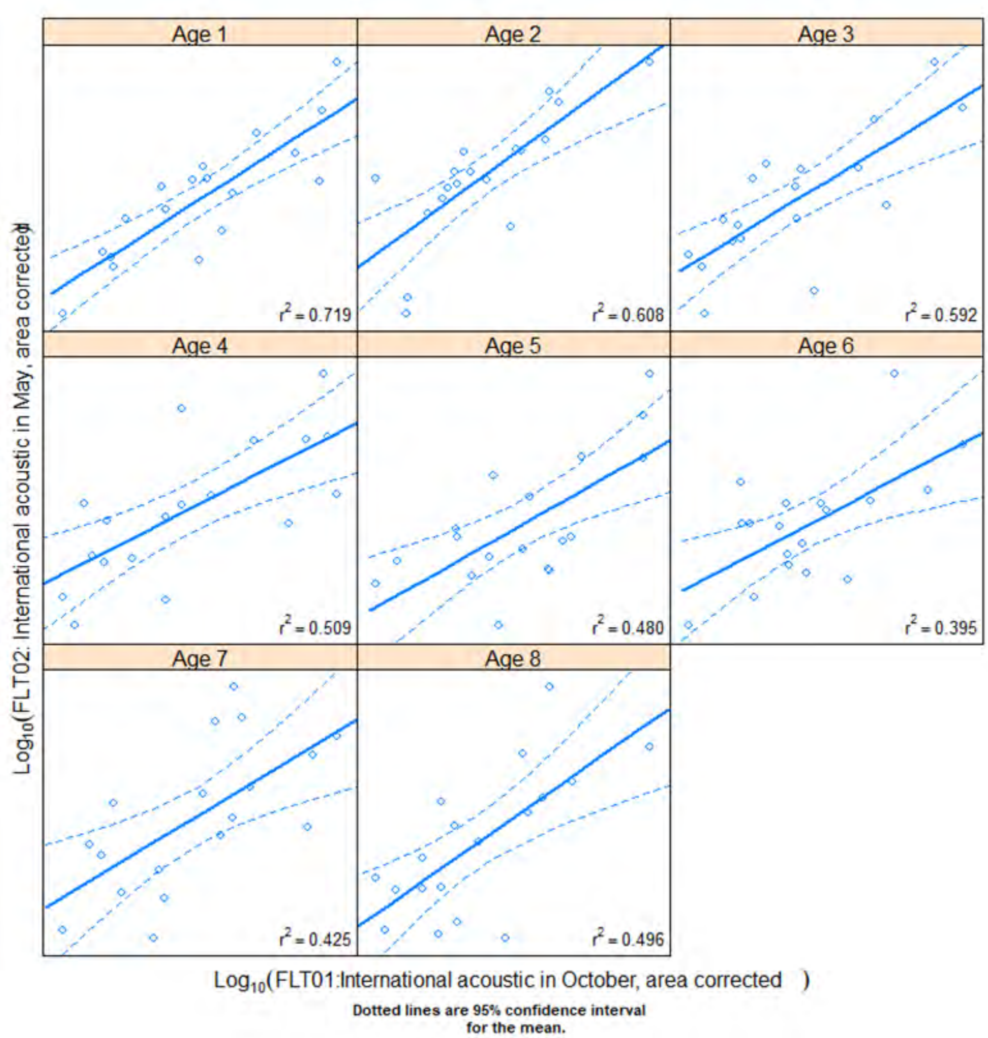
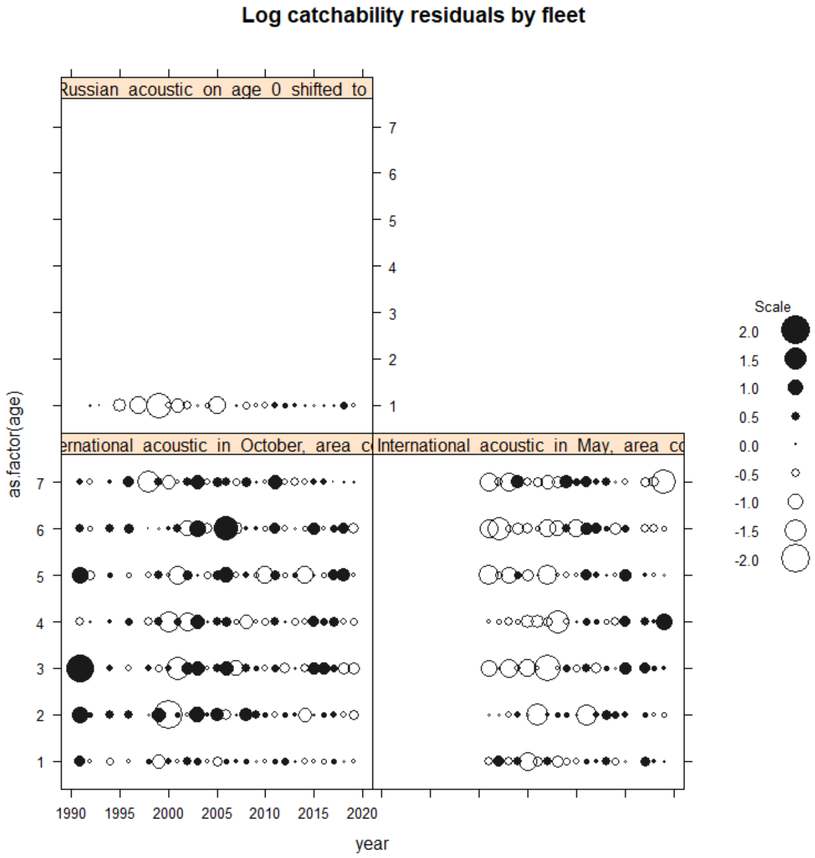


Figure 7.5c. Sprat in SD 22-32. Check for consistency between May and October surveys.



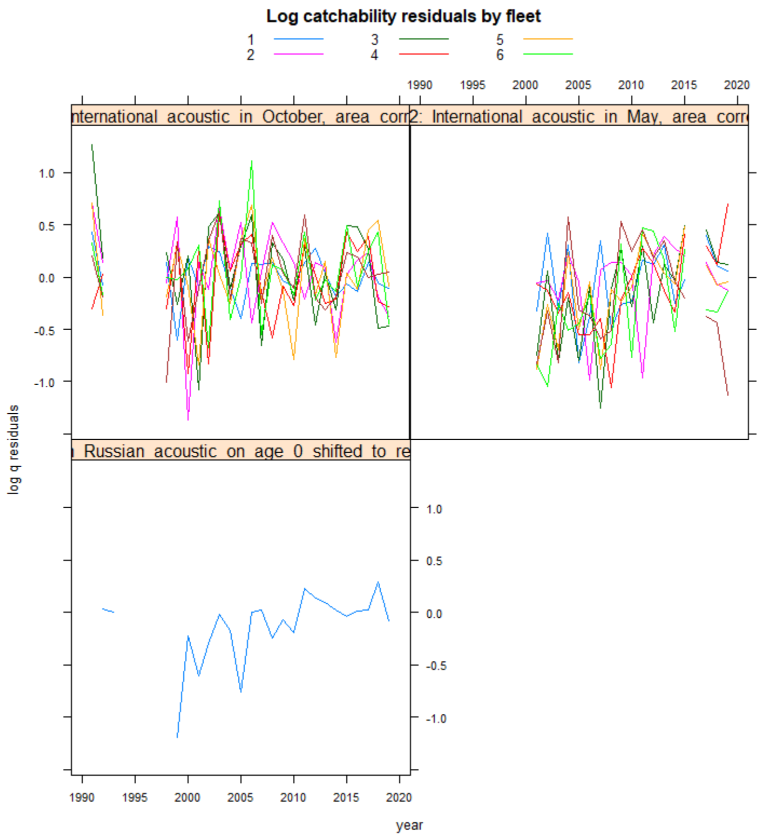


Figure 7.6. Sprat in SD 22-32. Log catchability residuals by fleet presented in two ways.

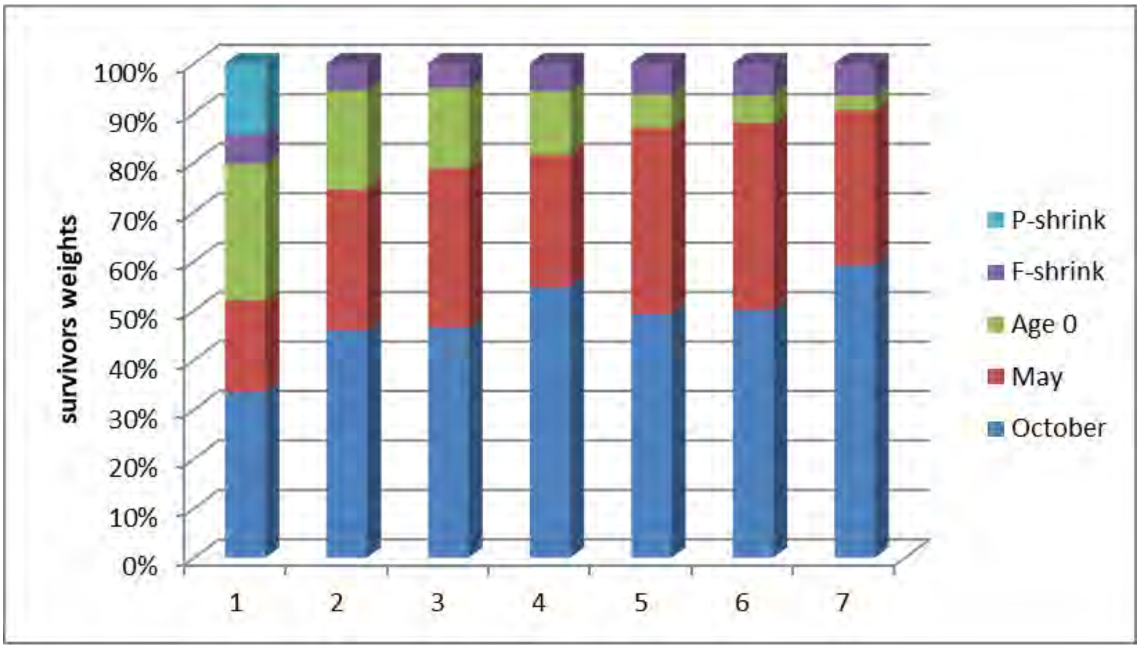


Figure 7.7a. Sprat In SD 22-32. Weights of survivors' estimates by fleet used to provide final survivors estimates.

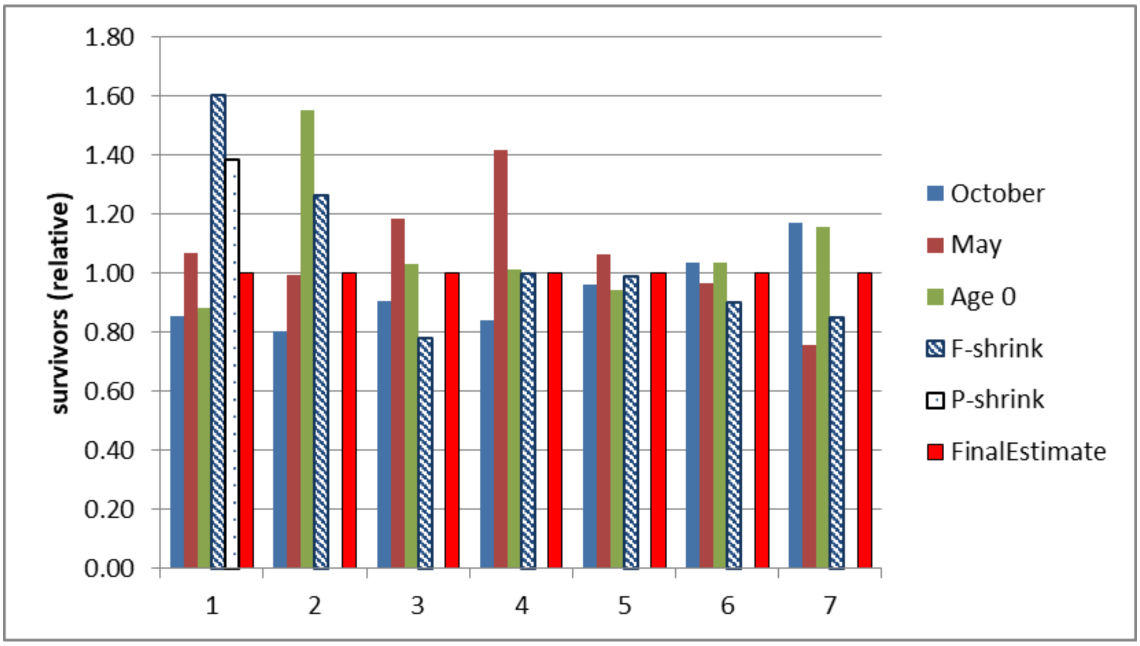


Figure 7.7b. Sprat in SD 22-32. Survivors' estimates by fleet and age relative to final estimate.

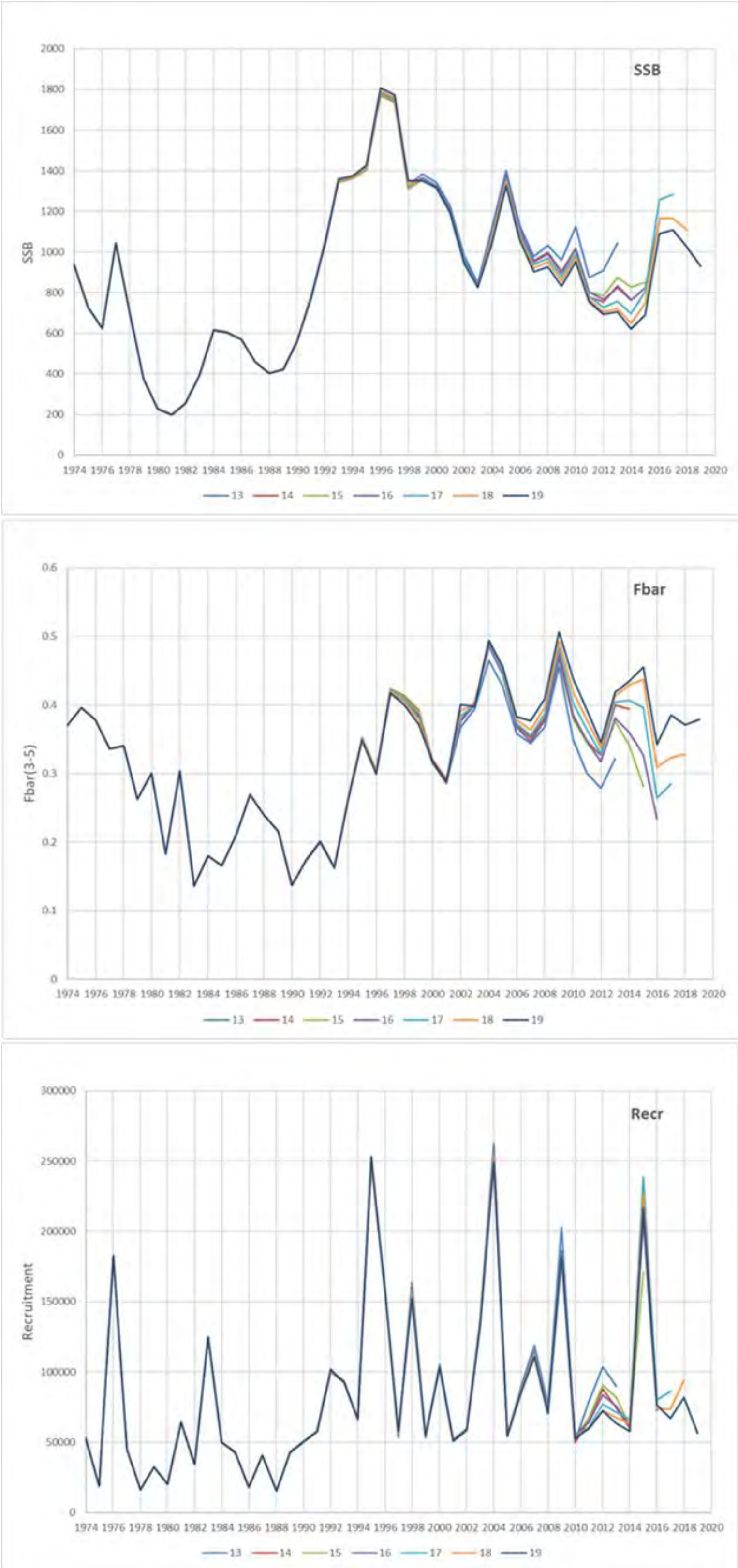


Figure 7.8a. Sprat in SD 22-32. Retrospective analysis from XSA.

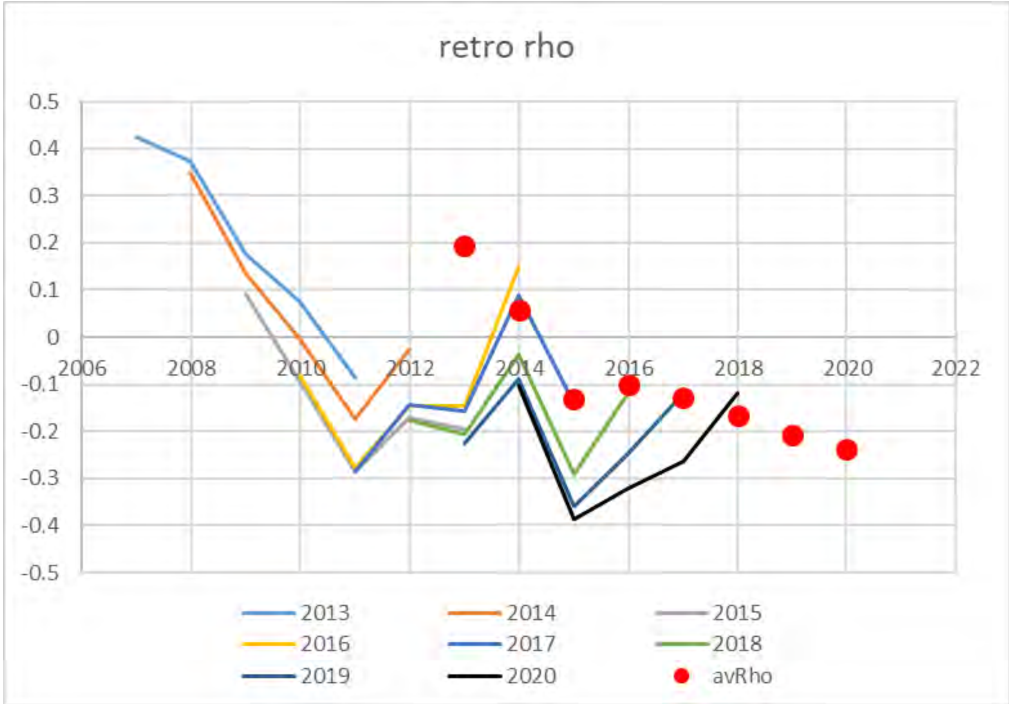


Figure 7.8b. Retrospective estimates of Mohn's rho for fishing mortality. Red dots represent the rho for given assessment year and lines represent deviations of retrospective estimates of F from F in reference assessment (dots are averages of five deviations represented in the lines).

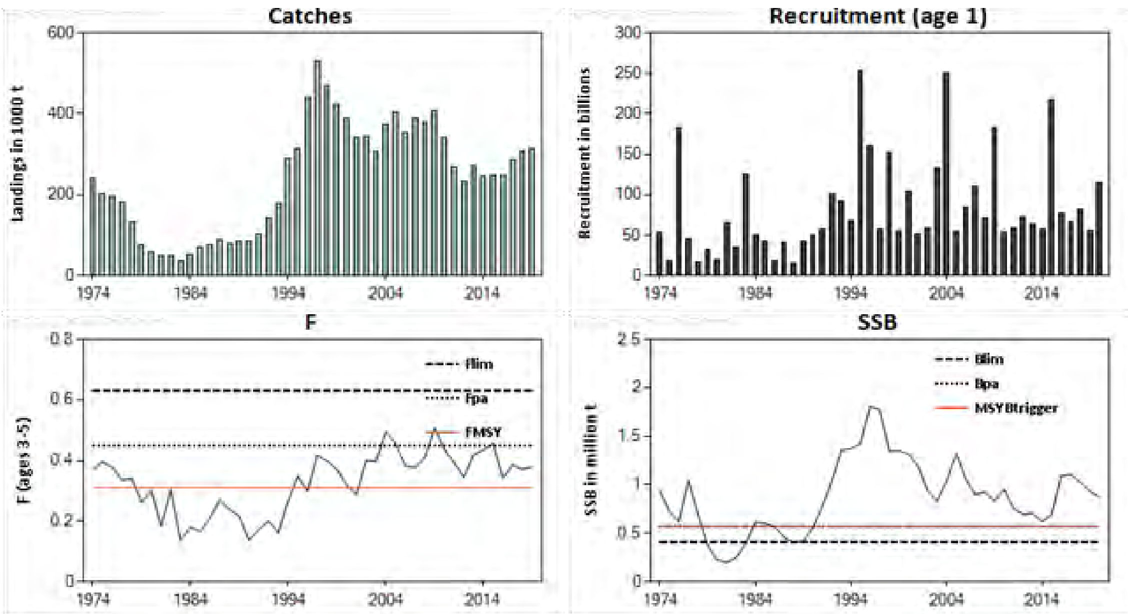


Figure 7.9. Sprat in SD 22–32. Summary sheet plots: landings, fishing mortality, recruitment (age 1) and spawning stock biomass.

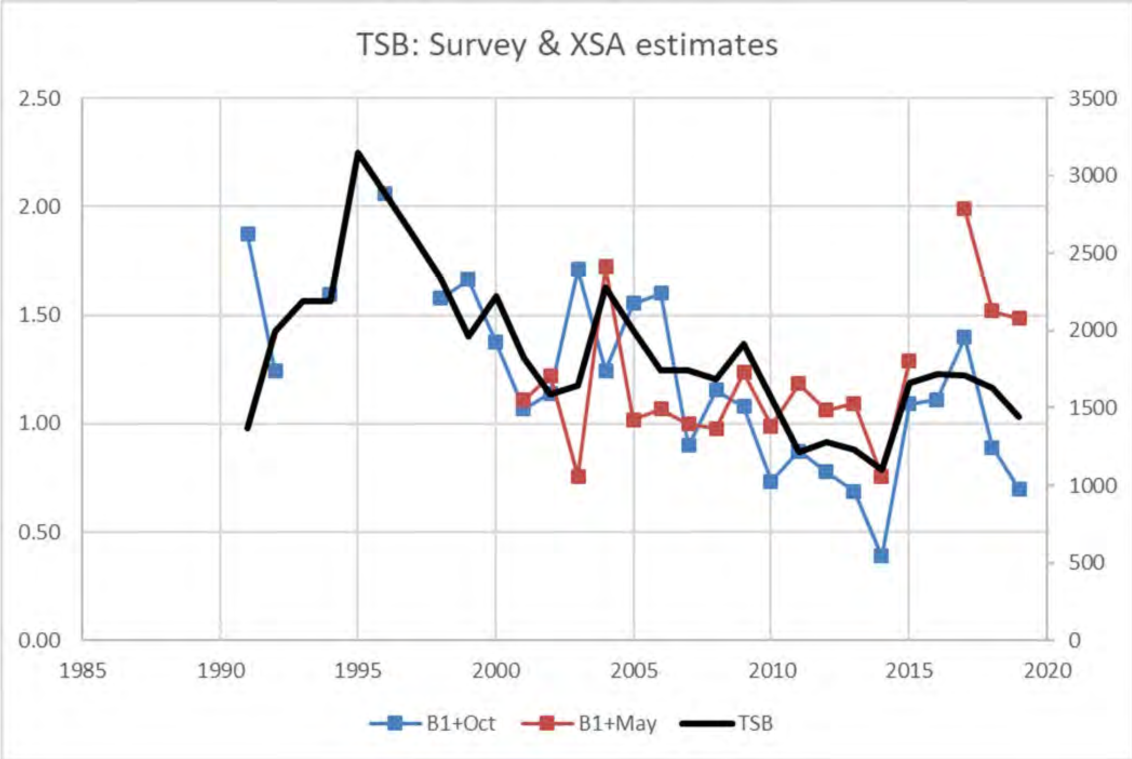


Figure 7.10a. Sprat in SD 22-32. Comparison of survey (age 1+) stock size estimates with TSB.

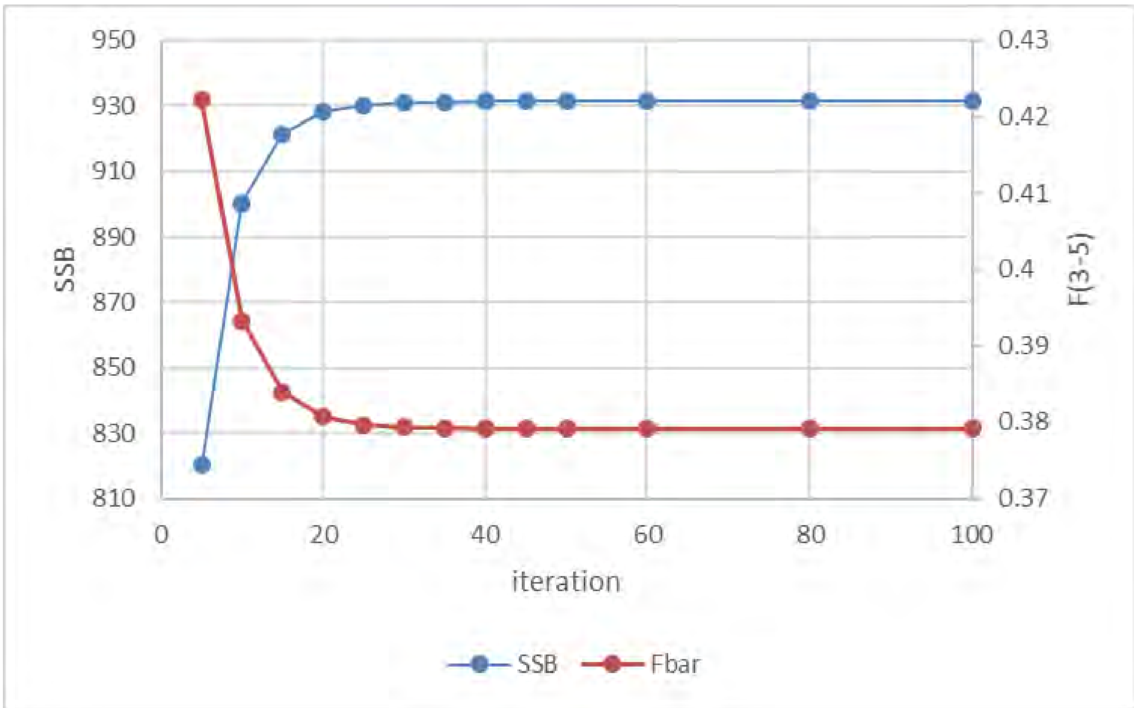


Figure 7.10b Sprat in SD 22-32. Convergence of the method: the dependence of SSB and Fbar estimates in terminal year on number of iterations.

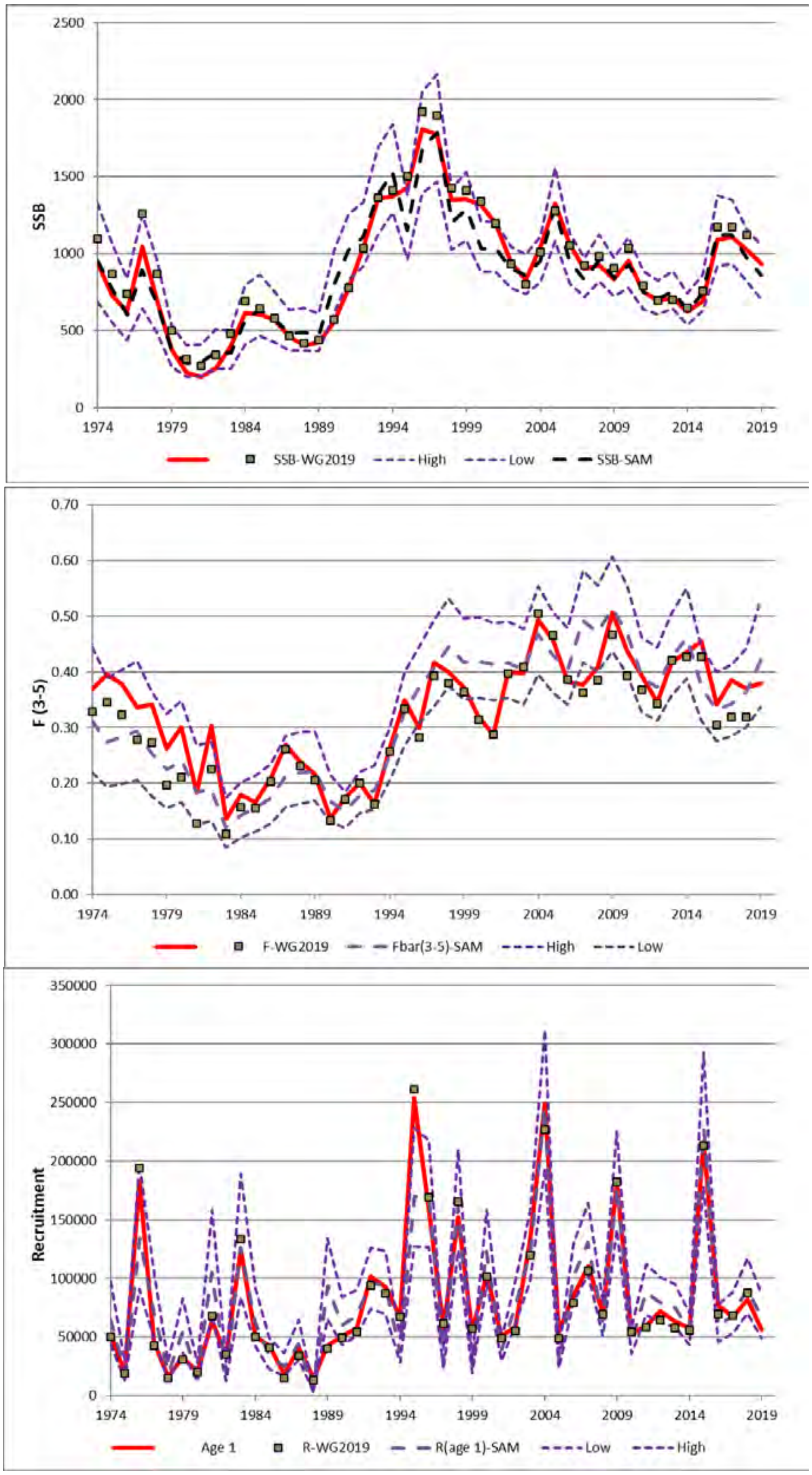


Figure 7.11. Sprat in SD 22-32. Comparison of spawning stock biomass, fishing mortality, and recruitment (age 1) from XSA (present and 2019) and SAM. Uncertainties of SAM estimates are shown (thin, broken lines).

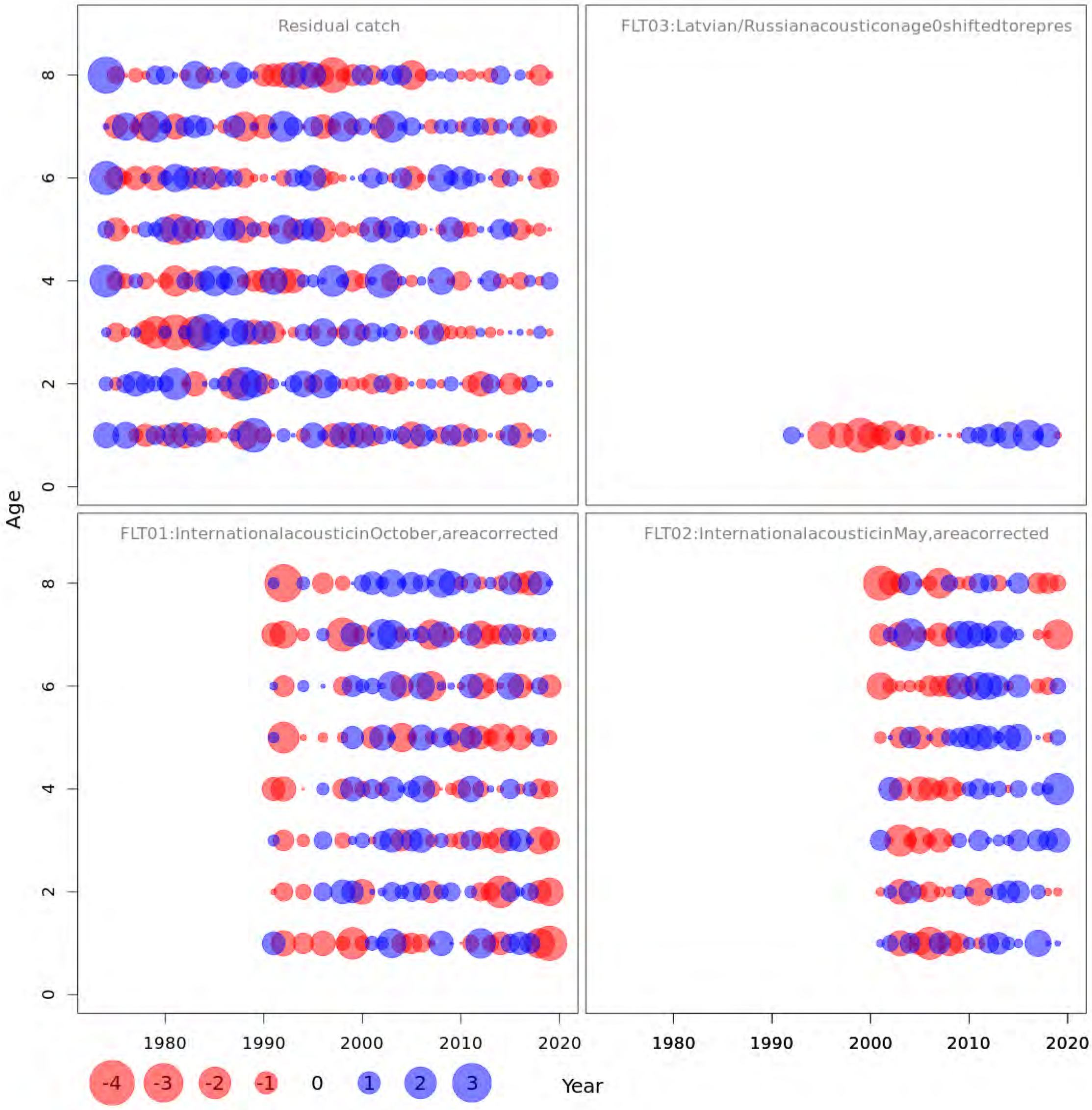


Figure 7.12a. Sprat in SD 22-32. Log catchability residuals by fleet from SAM.

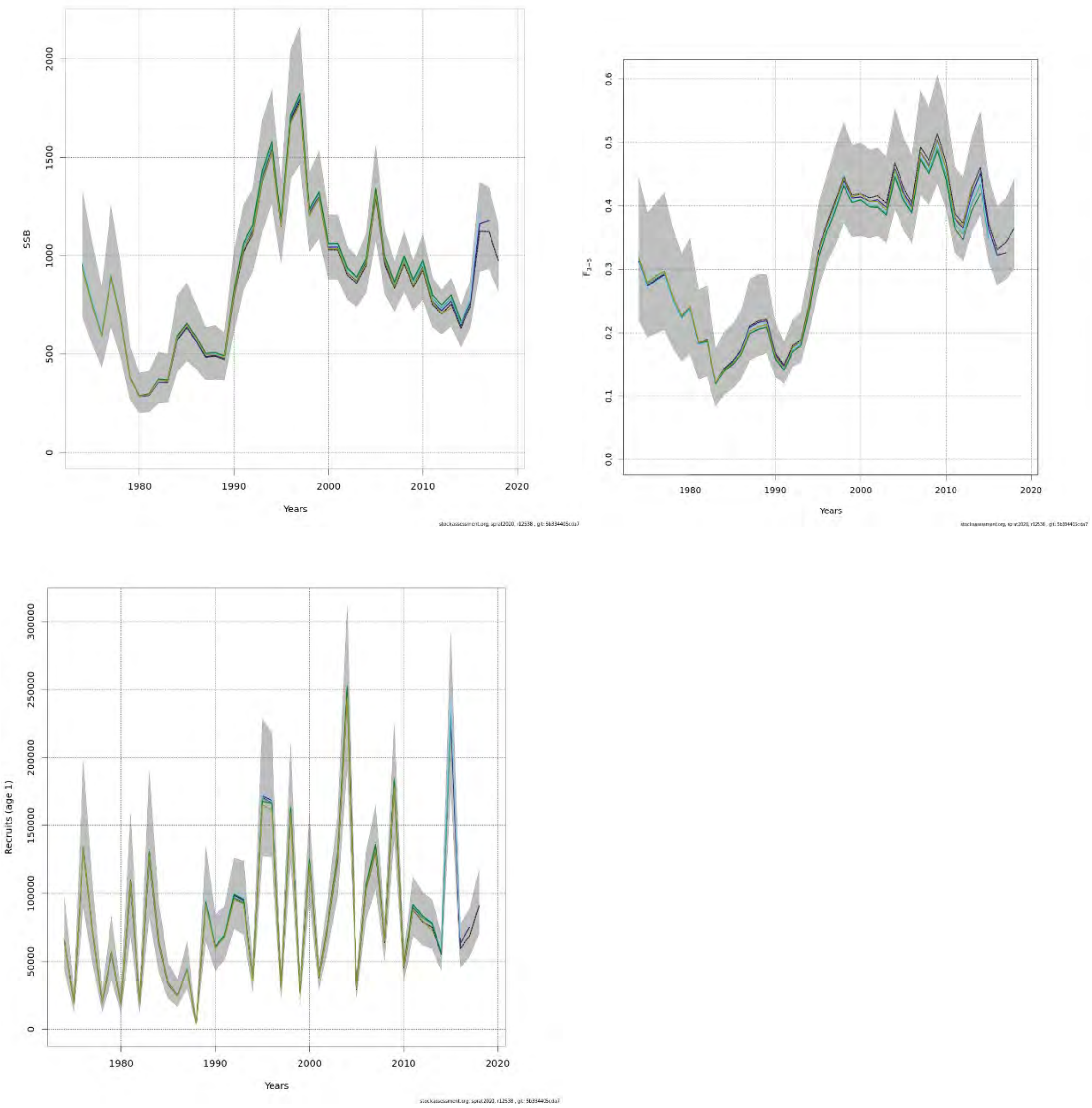


Figure 7.12b. Sprat in SD 22-32. Retrospective analysis from SAM.

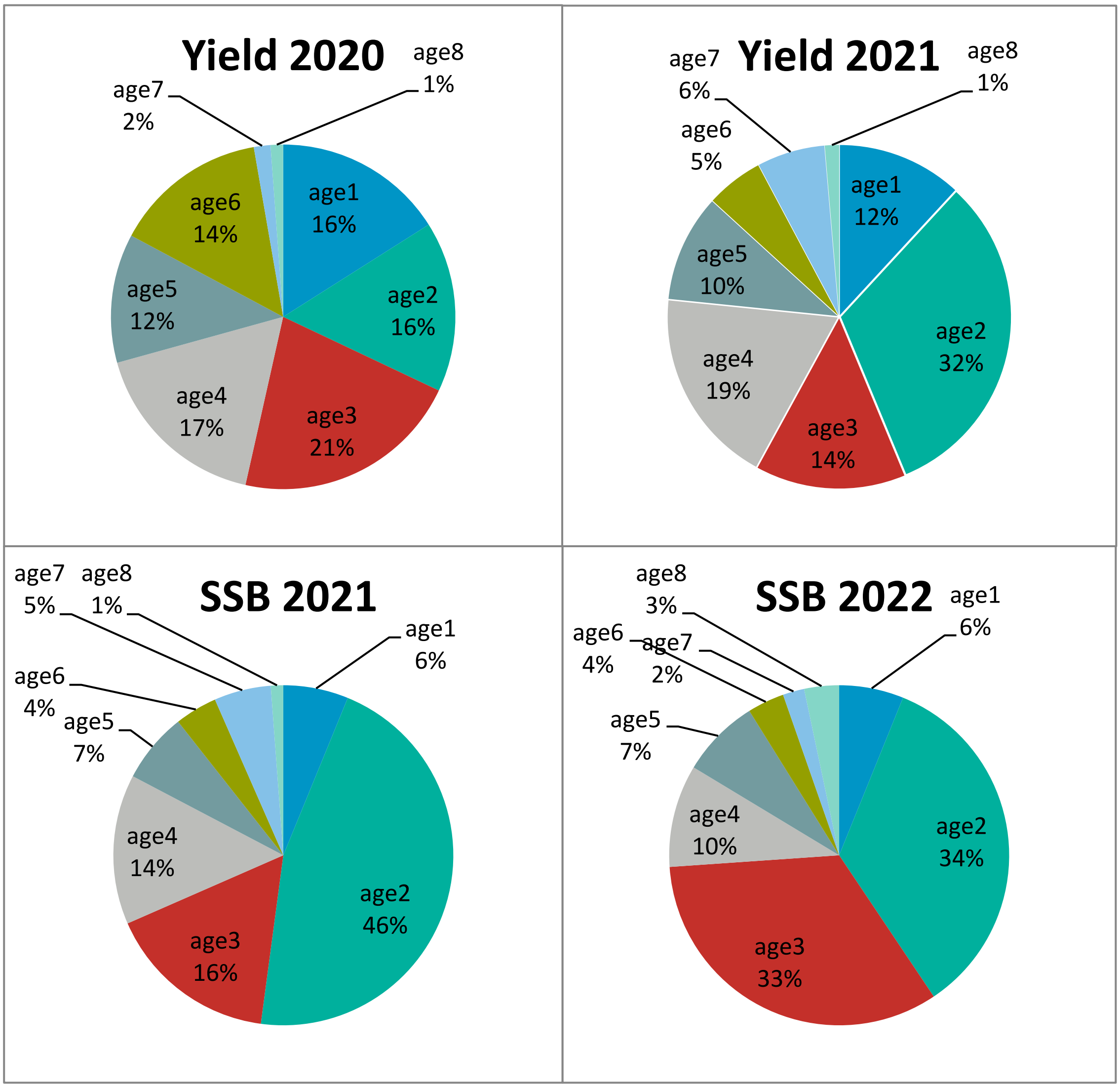


Figure 7.13. Sprat in SD 22-32. Short-term forecast for 2020-2022. Yield and SSB by age 1-8+ under the TAC constraint in 2020

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 fishermen having more interest in turbot. Since 1990 in all eastern Baltic countries turbot was sorted out from the flatfish catches due to the better price. For example, the Polish landings of turbot increased from 33 t to 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 Baltic and landed about 113 tonnes from subdivisions 25–28. Total landings in 2019 were about 201 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 22% for the years 2012 to 2019. 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
2019	201	95

8.1.2 Biological composition of the catch

Available age data were compared during WKFLABA (2012) meeting. Results using sliced otoliths were remarkably better than using whole otoliths. These two ageing methods showed sig-nificantly 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 rec-ommended.

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 2019 decreased compared to the previous year, but is still on a low level (~3.43 tur-bot/hour) compared to earlier years.

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 2020. 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 2019 and 2018 were 31% higher than the mean of the abundance index from 2015–2017. Therefore, precautionary truncation was applied with a factor of 1.2. Ex-ploitation is consistent with F_{MSY} proxy ($L_{F=M}$) and optimal yield in 2019. 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 WKLIFE V (2015) (Table 8.1.2). CANUM and WECA of commercial catches from 2014–2019 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} = 54.7 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 much 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 overfish-ing 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
2019	**53**	2	25	1	0			20	26	0		50	5.1	0	0.7	2.7	2.2	0	1.1	1.8	0.6	3.6	4.9	0.6			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
2019	73	3	69	38	11	1	6	0	201

[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 > 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 = (0.75Lc+0.25Linf)	L_{mean} / LF=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}	$L_{max\ 5}$ / L_{inf}	P_{mega}	L_{mean} / L_{opt}	L_{mean} / $L_{F=M}$
2017	0.66	1.39	0.77	0.04	0.87	1.33
2018	0.66	1.34	0.72	0.02	0.82	1.26
2019	0.80	1.20	0.84	0.08	0.79	1.10

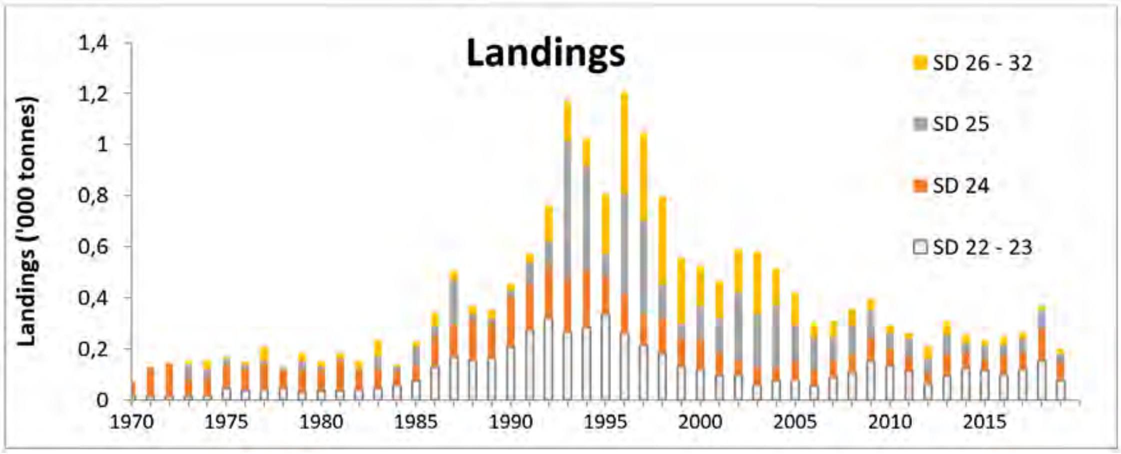


Figure 8.1.1. Turbot in the Baltic Sea. Development of turbot landings (t) from 1970 onwards by ICES subdivision (SD).

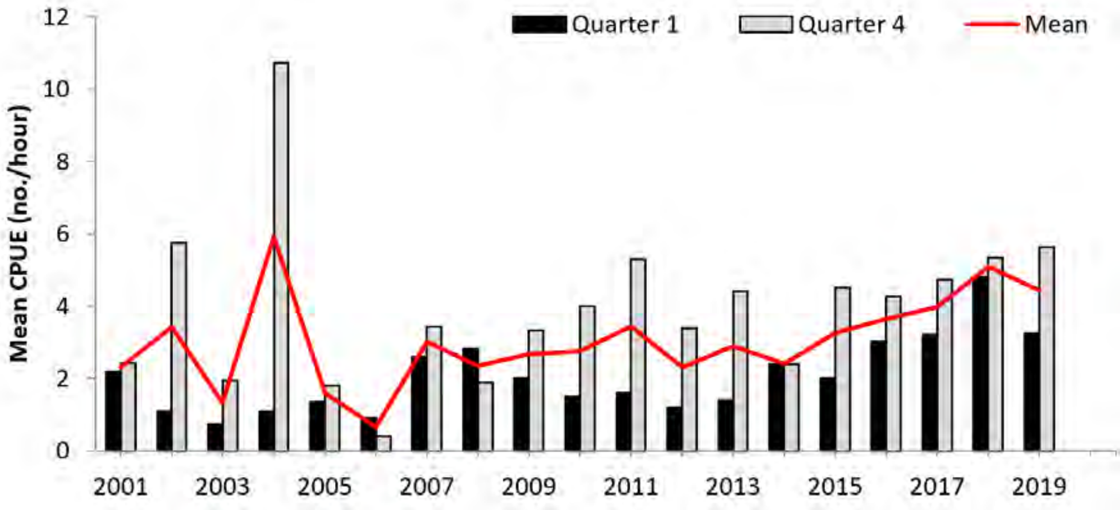


Figure 8.1.2. Turbot in the Baltic Sea. Mean CPUE (no.hr[-1]) of turbot with L ≥20 cm based on arithmetic mean of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22-28.

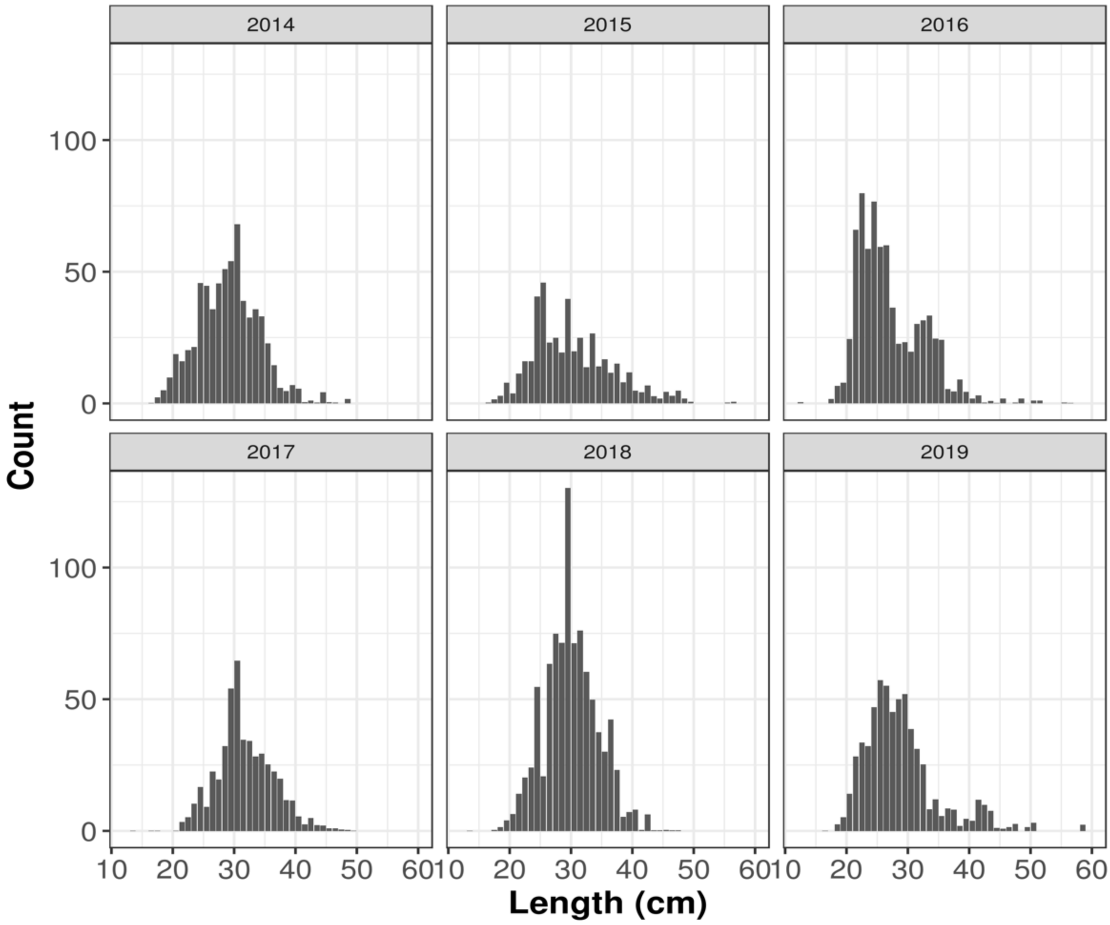


Figure 8.1.3. Turbot in subdivisions 22-32. Binned length frequency distributions.

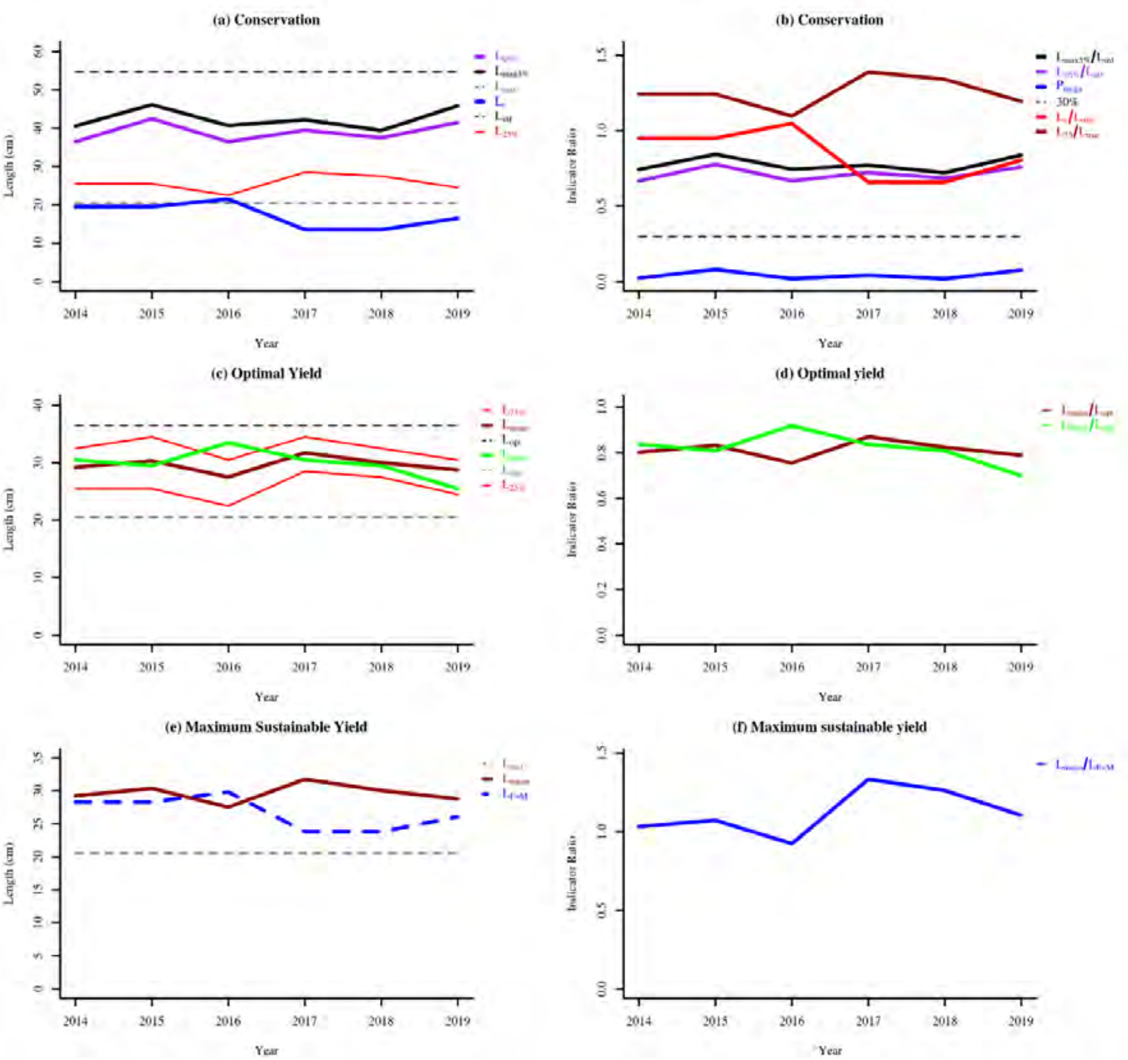


Figure 8.1.4. Turbot in subdivisions 22 to 32. Indicator trends.

8.2 Dab

8.2.1 Fishery

8.2.1.1 Landings

Dab (*Limanda limanda*) is distributed mainly in the western part of the Baltic Sea. The eastern border of its occurrence is not clearly identified. 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 the cod fishery. Less than 1000 t were landed in 1997 and from 1999 to 2002. Since 2003 landings fluctuated around 1300 t with a maximum of 1894 t in 2004. Landings varied between 941 t (2018) and 1648 t (2008) without a trend between 2005 and 2019.

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 the target of a mixed flatfish fisheries.

8.2.1.2 Discard

Estimates of discards are available from Denmark and Germany since 2012.

The data illustrate the high variability of the relation between landings and discards and support the conclusion of the benchmark workshop (WKBALFLAT 2014) that the application of the relation between landings and discards of one year in another year results in uncertain estimates.

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
2019	1102	801

8.2.2 Biological composition of the catch

Age samples were realized from 2008 onwards by Germany and Denmark during the Baltic International Trawl Survey (BITS) and commercial fishery. 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 the benchmark that a 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 was chosen because more than 50% of dab >14 cm of both sexes were maturing during Quarter 1, however with large fluctuations between years. 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 were caught.

8.2.3 Fishery independent information

The 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 every two years. A stock status update is given in 2020, which is based on the data-limited approach of ICES. In 2018 the advice based on landings has been changed to advice based on catches; and the estimated discards consider the respective last three years. The intermediate advice for 2019 is also a catch advice.

The mean biomass index of 2019 and 2018 was 1% lower than the mean of the mean biomass index from 2015–2017 (Figure 8.2.3). Therefore, no precautionary truncation was applied. The precautionary buffer was also not applied because the length-based indicators (proxy reference points) 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 2014–2019 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 only → 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, indicating the lack of large individuals. In the most recent year, an overfishing on immatures is indicated ($L_c/L_{mat} < 1$). Catch is close to the the-oretical length of L_{opt} and L_{mean} is stable over time and close to 1, indicating fishing close to the optimal yield. Exploitation is consistent with F_{MSY} proxy ($L_{F=M}$) and is used as proxy reference point to evaluate the stock status.

8.2.6 Data Quality

To improve the stock status analysis 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 stock definition needs further validation. Distributional maps from the BITS Survey suggest that the Baltic Sea dab is part of the larger stock of the Kattegat, ranging southwards into the western Baltic. More information about spatio-temporal distribution, spawning grounds and ideally genetic stock information should be gained before a benchmark.

Table 8.2.1 Dab in the Baltic Sea: total landings (tonnes) of by Subdivision and country.

Year/SD	Denmark				r. Dem. Re		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			0.3	0.0	0.0	0.0	0.0			1332	40	126	7						1504
2008	757	36	86	222			507	33	0			3.1	0.3	0.6	1.1	2.4			1264	39	119	223		1	2			1648
2009	521	25	97	0			587	32	0			1.9	0.5	0.2	0.7	2.6			1108	27	129	1		1	3			1268
2010	552	18	51	0			398	17	2			1.0	0.2	0.2					950	19	69	2						1041
2011	544	20	39	0			647	15	0			0.7	0.1	1.1	0.1	0.4			1192	21	53	1						1268
2012	481	22	69	0			692	20	0	0	0	1.0	0	0	0	1.0	0	0	1173	23	89	0						1285
2013	445	18	69	0			834	17	0	0		0	0	1.0	0	0	1.0		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	0.0	1223	9	35	0	0	1.0	0	0	0	1268
2016	268	14	21				1027	23	1	0	0	0.4	0	0	0.9	0.6	0	0	1295	38	23	1	0	0.9	0.6	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	0.2	0	0	0	940
2019	388	15	68	0			592	37			0.2	2.4	0	0.0	0	0.0	0.0	0	979.6	54.3	67.8	0.0	0	0.3	0	0	0	1102

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 > 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	$L_{opt} = \frac{3}{3+ M/k} \times L_{inf}$	Lmaxy / 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 8.2.3. Dab in subdivisions 22 to 32. Indicator status for the most recent three years. Indicator values above the expected value (i.e. signalling a good stock status) are given in green; values below the expected value are given in red.

	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} / $L_{F = M}$
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
2019	0.53	1.14	0.87	0.25	0.98	1.45

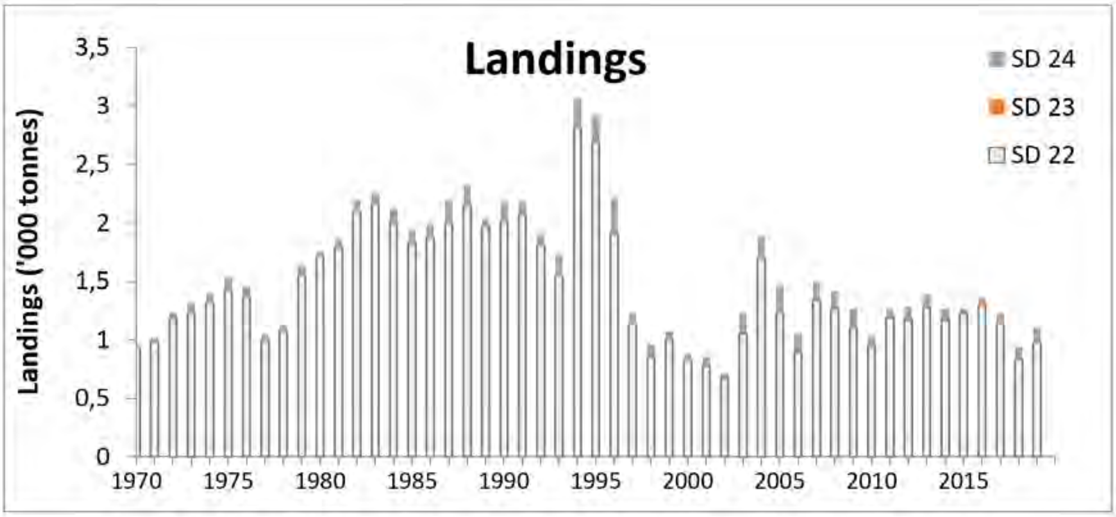


Figure 8.2.1. Dab in subdivisions 22 to 32. Development of dab landings (t) from 1970 onwards by ICES subdivision (SD).

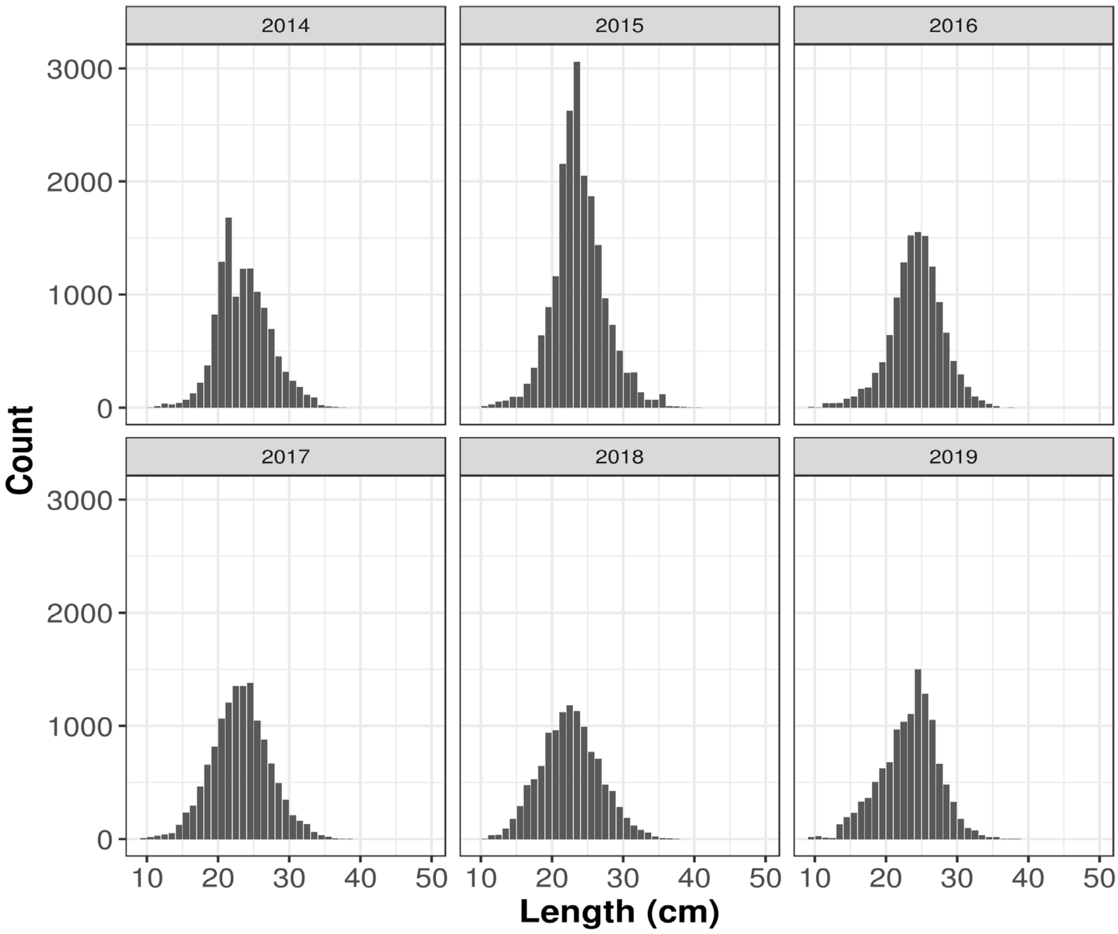


Figure 8.2.2. Dab in subdivisions 22 to 32. Catch in numbers per length for the three most recent years 2014–2019.

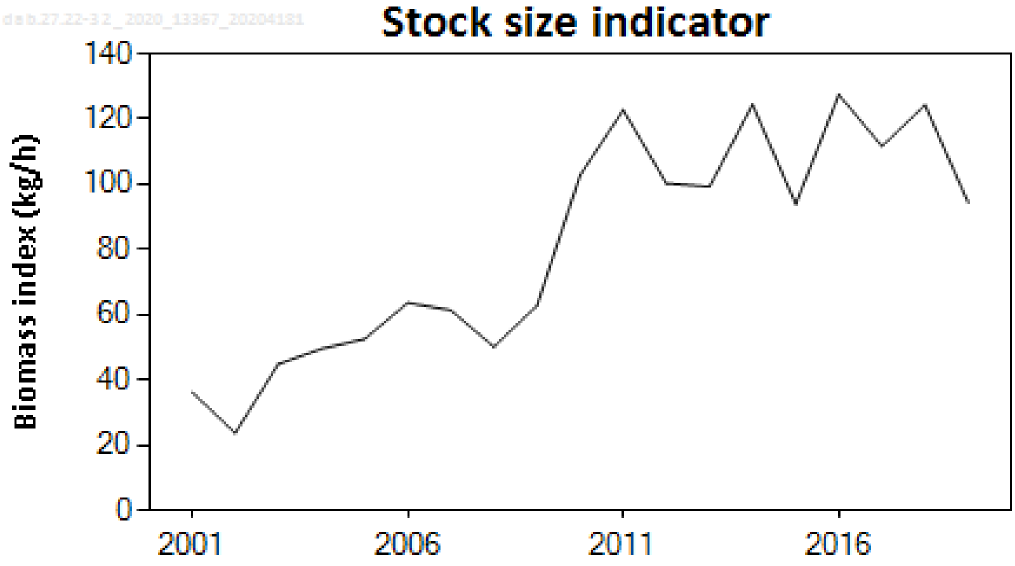


Figure 8.2.3. Dab in subdivisions 22 to 32. Mean biomass (kg hr^{-1}) of dab with L ≥ 15 cm based of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–24.

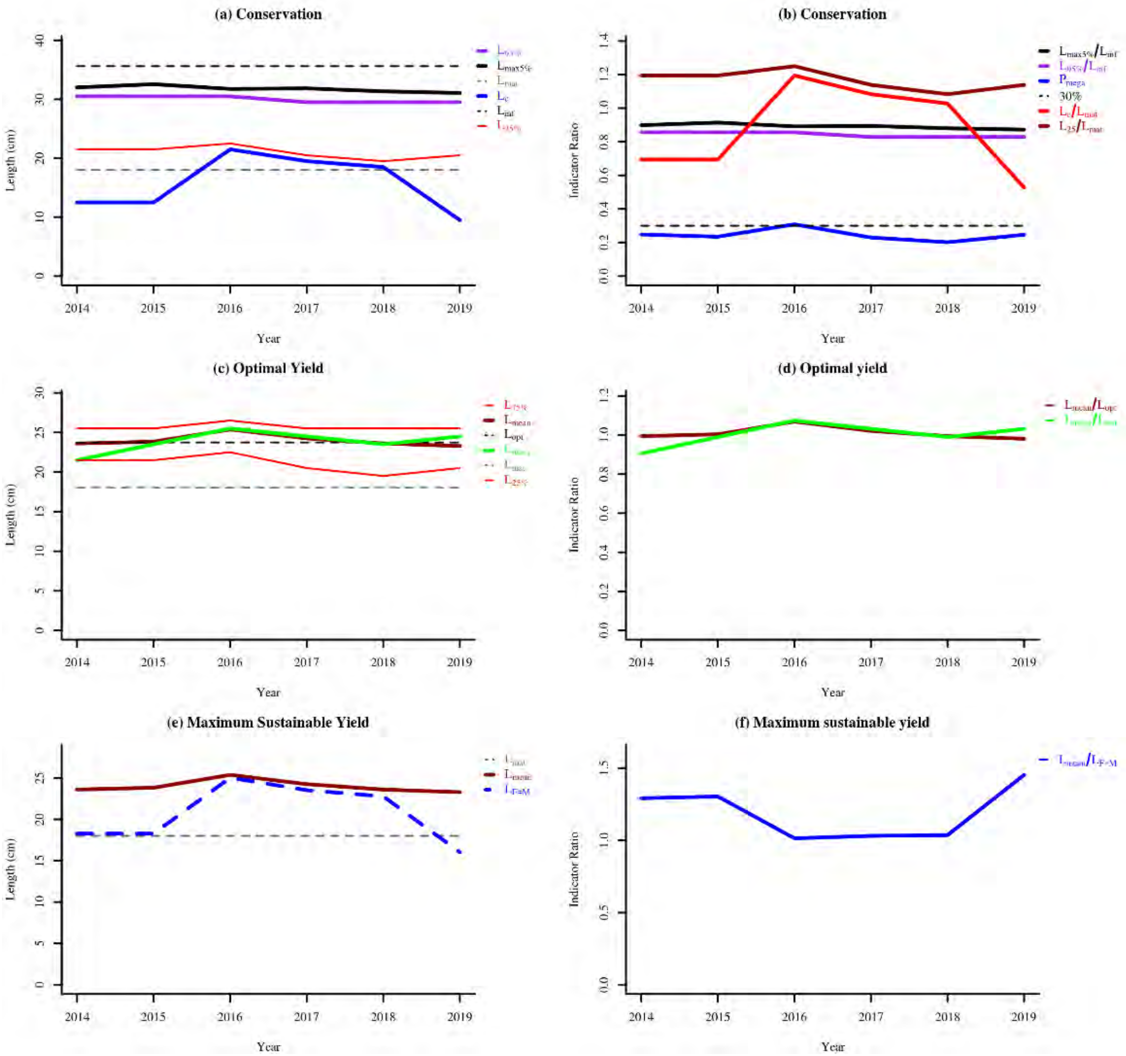


Figure 8.2.4. Dab in subdivisions 22 to 32. LBI F_{MSY} Proxy reference points

8.3 Brill

8.3.1 Fishery

8.3.1.1 Landings

Total landings of brill varied from 1 t to 160 t between 1975 and 2004 (Table 8.3.1, Figure 8.3.1). It can be assumed that the total landings of brill reported for 1994–1996 are overestimated due to species-misreporting in the landings of the directed cod fishery. The landings averaged about 25 t if the years 1994–1996 are excluded. Moderate increase of the landings was observed from 19 t in 2001 to 56 t in 2007 followed by landings of 105 t in the following year. Decreasing trend has been observed since 2009 which is continued with landings of 30 t in 2012, 31 t in 2013 and 28 t in 2014. Slightly increase of landings was reported for 2015 with 40 t, for 2016, 2017 with 39 t and 53 t in 2018. Landings in 2019 decreased slightly to 48 t.

8.3.1.2 Discards*

Less than 100 kg of brill was discarded in 2012. The amount of discards increased to 299 kg in 2013 and further increased to 4200 kg in 2014. Discards of brill were not reported in 2015. For 2016, 400 kg discard were reported. For 2019, 8.8 tonnes of discards have been reported. This is almost 25% of the landings. Most of these discards have been generated in Subdivision 22, in proportion with the landings in Subdivision 22, which contribute to more than 80% of the total.

Year	Landings (t)	Discards (t)
2013	31	1
2014	28	4
2015	40	0
2016	39	0
2017	39	9
2018	53	3
2019	48	9

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 8.3.2).

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).

* *Updated in June 2020.*

It was not possible to match exactly the same data as in the assessments used before 2018. This is probably due to some selective weightings of sub-areas 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. Since 2018 the index increased. 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 8.3.2). 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 worth-while considering to combine Brill in ICES Sub-division 22-32 with Brill in Sub-division 21.

Table 8.3.1. Brill in the Baltic Sea: total landings (tonnes) by Subdivision and country[1].

Year	Denmark			Germany, FRG		Sweden		Total			Total	Total discards
	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	1
2014	19	5	0	2	0	1	0	21	6	0	28	4
2015	29	7	0	3	0	1	0	32	8	0	40	0
2016	28	8	0	2	0	1	0	29	9	1	39	0
2017	29	6	0	4	0	0	0	33	6	0	39	9
2018	36	11	1	6	1	1	0	41	11	1	53	3
2019	35	6	1	5	0	1	0	40	7	1	48	9

[1] *Updated table: discards column added in June 2020*

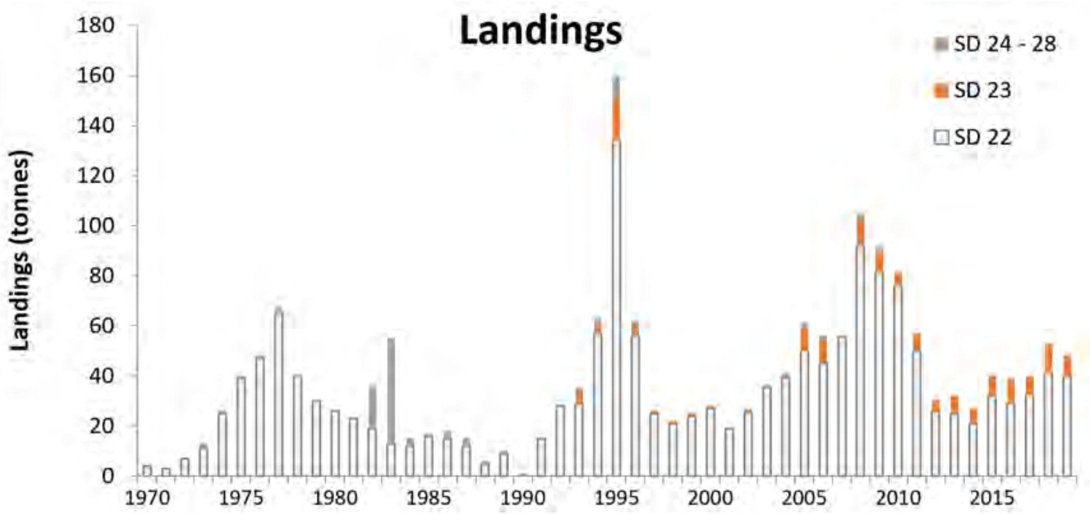


Figure 8.3.1. Development of brill landings (t) from 1970 onwards by ICES Subdivision (SD).

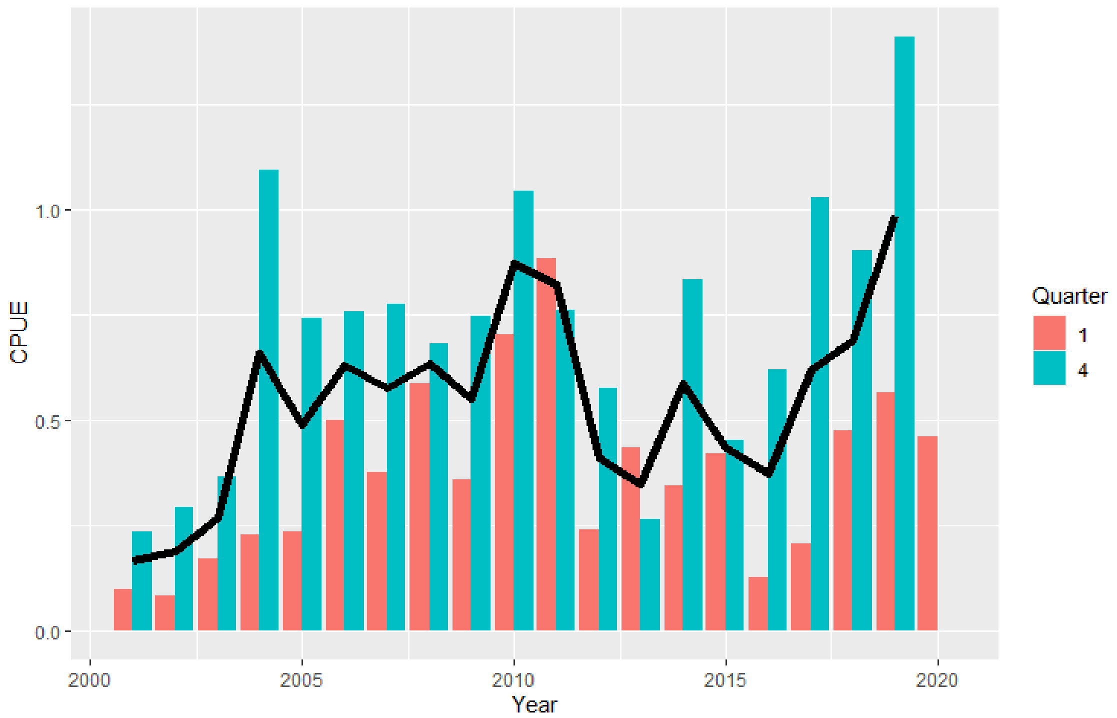


Figure 8.3.2. Mean CPUE (no. hr^{-1}) of brill with L ≥20 cm.

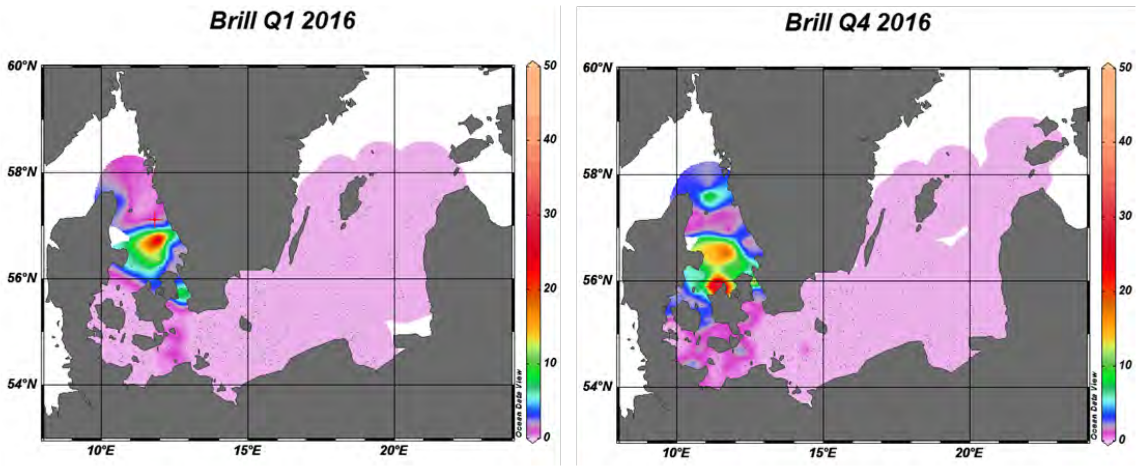


Figure 8.3.3. Brill distribution in the Baltic Sea, CPUE in numbers per hour indicated in colour bars.

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Annex 1: List of participants

NAME	COUNTRY
Amosova, Viktoriia	Russia
Bergenius, Mikaela (Chair)	Sweden
Boje, Jesper	Denmark
Brown, Elliot	Denmark
Carlshamre, Sofia	Sweden
Eero, Margit	Denmark
Gröhsler, Tomas	Germany
Gutkowska, Julita	Poland
Haase, Stefanie	Germany
Hjelm, Joakim	Sweden, part-time
Holmgren, Noel	Sweden, part-time
Hommik, Kristiina	Estonia
Horbowy, Jan	Poland
Jounela, Pekka	Finland
Kaljuste, Olavi	Sweden
Karpushevskaia, Anastasiia	Russia
Krumme, Uwe	Germany
Lövgren, Johan	Sweden
Mirny, Zuzanna	Poland
Neuenfeldt, Stefan	Denmark
Nielsen, Anders	Denmark, part-time
Pekcan Hekim, Zeynep	Sweden
Plikshs, Maris	Latvia
Putnis, Ivars	Latvia
Pönni, Jukka	Finland
Raid, Tiit	Estonia
Raitaniemi, Jari	Finland

NAME	COUNTRY
Schade, Franziska	Germany, part-time
Stoetera, Sven	Germany
Storr-Paulsen, Marie	Denmark
Strehlow, Harry	Germany, part-time
Ustups, Didzis	Latvia, part-time
Zolubas, Tomas	Lithuania

Annex 2: Resolution

This resolution was approved 1 October 2019

2019/2/FRSG07 The **Baltic Fisheries Assessment Working Group (WGBFAS)**, chaired by Mikaela Bergenius, will meet at ICES, Denmark, on 14–21 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 5 May 2020 for the attention of ACOM

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

Due to the COVID-19 disruption that started early 2020, ACOM drafted a "spring 2020 approach" for recurring fishing opportunities advice. The generic Terms of Reference have been adjusted as described in the letter to ICES chairs below.

Chairs of Expert Groups

Our Ref: C 4.e/MDC/mo 13 March 2020

Subject: **Spring 2020 approach to advice production**

Dear Expert Group Chair,

I am writing this letter to keep you up to date about the approach of ACOM to the COVID-19 disruption. Many of our institutes now have travel bans and/or working from home policies. ACOM has developed a "spring 2020 approach" to this year's spring advice season. This letter covers the recurrent fishing opportunities advice. Any special request processes and non-fisheries advice will be dealt with separately. The expert groups effected are listed in Annex 1.

ACOM is encouraging all expert groups to keep working, and stick broadly to the time line, but clearly this needs to be through virtual meetings. ICES secretariat will support your efforts and make WebEx available. They will also produce a broad training document on WebEx. We know that the use of virtual meetings will result in an increased burden on the Chairs and members of the expert groups, therefore we have made changes to the generic terms of reference (see Annex 2 below) categorizing them as high, medium and low priority for this year's work. We also suggest that the expert group works virtually through smaller subgroups, and only hold larger virtual meetings when necessary.

The requesters of advice have been informed that there will be disruption/change to the delivery of advice for the spring 2020 season.

ACOM will also change the way that ICES gives advice for the spring 2020 season. There will be three types of advice:

- **Standard advice** sheet (the advice sheet following the January 2020 guidelines)
- **Abbreviated advice** sheet (a shortened advice sheet)
- **Rollover advice** (the same advice as in 2019)

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The choice of which type of advice to apply to a stock is based on criteria determined by ACOM:

a. **Standard advice** - stocks with 2020 benchmarked methods
b. **Abbreviated advice** – most stocks, including management plan and MSY advice stocks, and some Cat 3 stocks. The abbreviated advice will contain the advice of the headline advice, catch scenario tables, plots and automated tables (last years' advice will be added as an annex to each sheet). The guidance for abbreviated advice is being written now and you should receive it in a few days.
c. **Rollover advice** – same as 2019 advice. This will be provided for stocks in the following categories:
    - zero TAC has been advised in recent years and no change likely,
    - category 3 or greater roll over advice, except if due to be reviewed in 2020
    - long lived stable stocks, with no strong trends in dynamics in recent years
    - some non-standard stocks (e.g. North Atlantic salmon)

We need to consult both you and the requesters of advice about which type of advice to apply to each stock. Today the ACOM criteria are being used by the secretariat to allocate advice types to stocks. This is the first version. We would like you to consider this list and comment if you think that the allocation needs changing. Please remember that the abbreviated advice is being developed to help your processes and also the ACOM processes during the disruption. The list of allocated advice type for each stock will hopefully be sent to you today or Monday. Please reply with your comments by 19th March so that we can start the dialogue with requesters. ACOM hopes that we could have a definitive list by 25th March. (This is too late for HAWG, so we suggest that HAWG use the list compiled in cooperation with Secretariat expecting requesters of advice to agree).

ACOM is recommending that for North Sea stocks with re-opening of advice in the autumn, the stock assessments be carried out in the spring but not the forecasts (postponed until early autumn). The advice would be delivered in the autumn of 2020.

You will shortly receive the first version of the **list of advice types allocated to stocks** and the **guidelines for abbreviated advice**. Please respond by 19th March with your comments on the first version of the list.
Your professional officer has been briefed about these changes. The changes are designed to reduce both expert group and ACOM workload. Lotte, your professional officer, the ACOM leadership and the FRSG Chair are available for further explanation.

Best regards

Mark Dickey-Collas
ACOM Chair

Annex 1. Expert groups associated with 2020 spring advice season

Herring Assessment Working Group for the Area South of 62°N
Working Group on North Atlantic Salmon*
Assessment Working Group on Baltic Salmon and Trout*
Baltic Fisheries Assessment Working Group
Arctic Fisheries Working Group
Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak
North-Western Working Group
Working Group on the Biology and Assessment of Deep-sea Fisheries Resources
Working Group for the Bay of Biscay and the Iberian Waters Ecoregion
Working Group for the Celtic Seas Ecoregion
Working Group on Southern Horse Mackerel, Anchovy, and Sardine
Working Group on Elasmobranch Fishes

* These groups already have different approaches.

Annex 2. Spring 2020 adapted generic terms of reference. [Agreed by ACOM 12 March 2020]

In light of the disruptions caused by COVID-19 in 2020, the generic terms of reference for the FRSG stock assessment groups have been re-prioritised. This applies to expert groups that feed into the spring advice season process[1]. ACOM is encouraging expert groups to use virtual meetings (e.g. WebEx) and subgroups to deliver the high priority terms of reference. See letter from the ACOM Chair to expert groups.

High Priority for spring 2020 advice season

c) Conduct an assessment on the stock(s) to be addressed in 2020 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarising where the item is relevant. **Check the list of the stocks to be done in detail and those to roll over.**
   - i) Input data and examination of data quality;
   - ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;
   - iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.
   - v) The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;
   - vi) The state of the stocks against relevant reference points;
   - vii) Catch scenarios for next year(s) for the stocks for which ICES has been requested to provide advice on fishing opportunities;
   - viii) Historical and analytical performance of the assessment and catch options with a succinct description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

d) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines. Check list to confirm whether the stock requires a concise advice sheet or a traditional advice sheet.

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

j) Audit all data and methods used to produce stock assessments and projections.

[1] These do not apply to Assessment Working Group on Baltic Salmon and Trout and Working Group on North Atlantic Salmon.

Medium Priority for spring 2020 advice season

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

b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:
   i) descriptions of ecosystem impacts of fisheries
   ii) descriptions of developments and recent changes to the fisheries
   iii) mixed fisheries considerations, and
   iv) emerging issues of relevance for the management of the fisheries;

e) Review progress on benchmark processes of relevance to the Expert Group; High for application;

Low Priority for spring 2020 advice season

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

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

h) Review and update information regarding operational issues and research priorities and the Fisheries Resources Steering Group SharePoint site.

i) Take 15 minutes, and fill a line in the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity'; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice. ACOM would encourage expert groups to carry out this term of reference later in the year through a webex.

Annex 3: Resolution for 2021 meeting

WGBFAS suggest the following draft ToRs for 2021.

2021/X/ACOMXX The Baltic Fisheries Assessment Working Group (WGBFAS), chaired by Mikaela Bergenius, will meet by correspondence on the 19th and 29th March 2021 and at ICES HQ, Denmark, 13-20 April 2021.

a) Address generic ToRs for Regional and Species Working Groups

b) Review the main result from WGMIXFISH, WGIAB, WGSAM, WGBIFS and WKBALTIC, 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 2021 ICES data call.

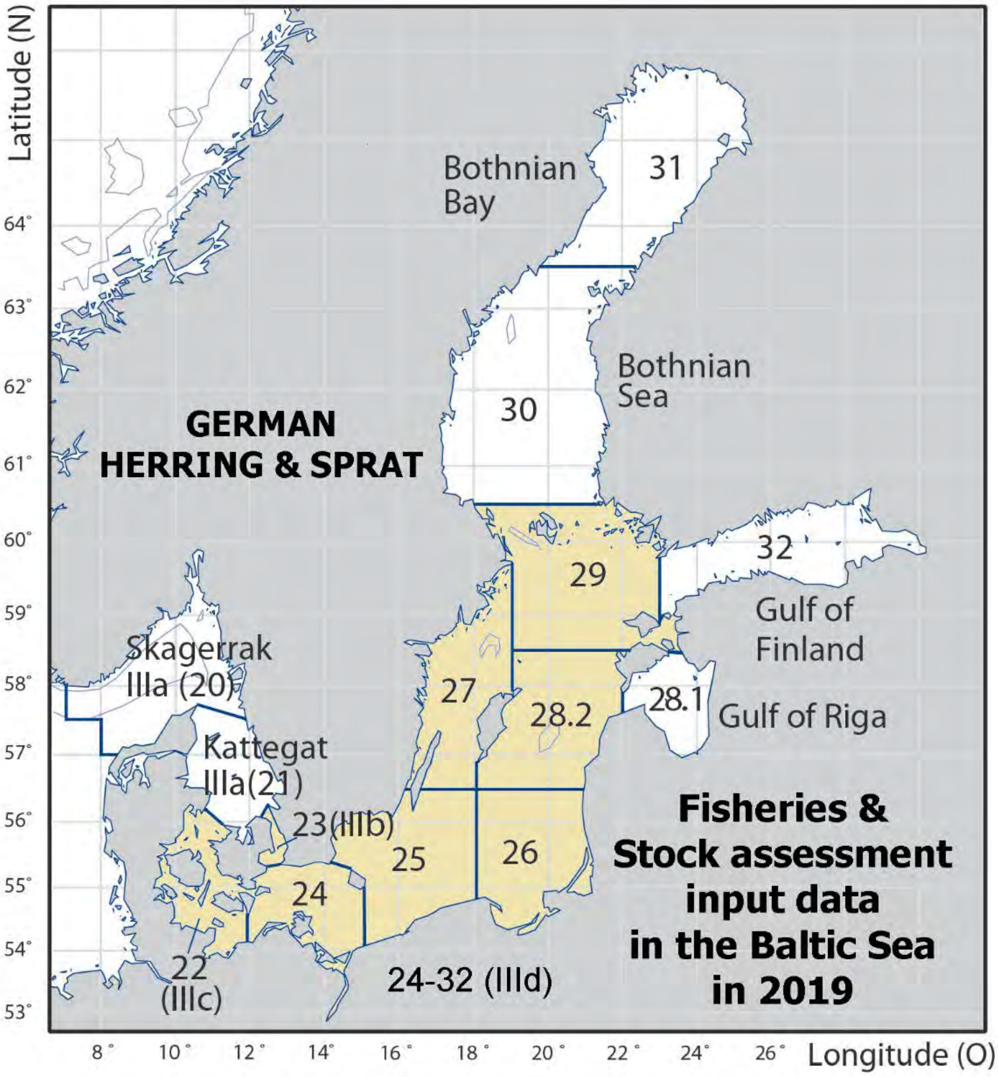
WGBFAS will report by xx April 2021 for the attention of ACOM.

Annex 4: Working documents

- **WD01**: German Herring and Sprat Fisheries and Stock assessment input data in the Baltic Sea. In 2019 (*Tomas Gröhsler*)
- **WD02**: Mixed Baltic Herring and Sprat fisheries in Estonia in 2019
- **WD03**: Joint Swedish and Danish survey for cod in the Kattegat, November-December 2019 (*O.A. Jørgensen, Marie Storr-Paulsen, Katja Ringdahl, Johan Lövgren, and Patrik Börjesson*)

Working document 01

Baltic Fisheries Assessment Working Group (WGBFAS)
14 - 21 April 2020



compiled by
Tomas Gröhsler
Thünen Institute of Baltic Sea Fisheries (TI-OF)
Germany

Working document 01

Baltic Fisheries Assessment Working Group (WGBFAS)
14 - 21 April 2020

TABLE OF CONTENTS

1 HERRING

1.1 Fisheries

In 2019 the total German herring landings from the Western Baltic Sea in **Subdivisions (SD) 22 and 24** amounted to 5,571 t, which represents a decrease of 51 % compared to the landings in 2018 (11,304 t). This decrease was caused by a decrease of the TAC/quota (German quota for SDs 22 and 24 in 2019: 4,966 t + quota-transfer of 808 t). The German quota in 2019 was used by 97 % (2018: 94 %, 2017: 88 %). The fishing activities in one of the main fishing areas, the Greifswald Bay (SD 24), started already in mid-Januray. The main German fishery stopped their activities at the beginning of April.
Only a small part of the total German landings was taken **in Subdivisions 25-29** (2019: 1,752 t, 2018: 3,951 t). The landings taken in the herring fisheries exceeded the existing TAC/quota (2019: 994 t) by means of quota transfer (+ 763 t) with other countries around the Baltic Sea. The consequent total quota of 1,757 t was finally used by 99.7 %. All landings in this area were taken by the trawl fishery and then mostly landed in foreign ports (2019: 95 %, 2018:100 %).

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	39.780	4,340.962	103.380	958.612	-	182.230	144.148	1,388.370	24.1%	**5,769.112**	78.8%
	0.000	3.174	103.380	913.569		167.243	144.148	1,328.340	99.8%	1,331.514	80.0%
II	3,670	108.134	26.717	316.769	-	10.000	-	353,486	76.0%	**465,290**	6.4%
	0.000	0.215	16.254	295.843	-	10.000	-	322.097	99.9%	322.312	19.4%
III	0.377	0.911	-	-	-	-	-	0.000		**1.288**	0.0%
	0.000	0.000	-	-	-	-	-	0.000		0.000	0.0%
IV	9.862	1,066.835	10.000	-	-	-		10.000	0.9%	**1,086.697**	14.8%
	0.000	0.000	10.000	-	-	-		10.000	100.0%	10.000	0.8%
Total	**53.689**	**5,516.842**	**140.097**	**1,275.381**	**0.000**	**192.230**	**144.148**	**1,751.856**	**23.9%**	**7,322.387**	**100.0%**
	0.000	3.389	129.634	1,209.412	0.000	177.243	144.148	1,660.437	99.8%	1,663.826	100.0%

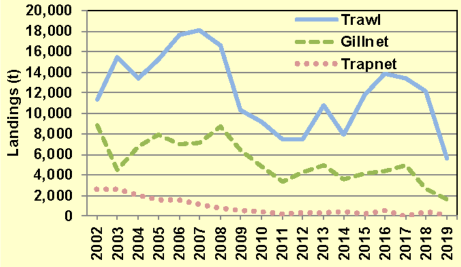
= Fraction of total landings (t) in foreign ports	94.8%	22.7%
	2019/2018:	**2019/2018:**
= Fraction of total landings (t)	44.3%	48.0%
= Fraction of total landings (t) in foreign ports	42.0%	42.1%

The main fishing season was during spring time as in former years. About 85 % of all herring (SDs 22-29) in 2019 was caught between January and April (2018: 88 %). The majority of the German herring landings (75 %) were taken in Subdivision 24 (2018: 72 %). 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.

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 77 % in 2019 (2018: 80 %). 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.

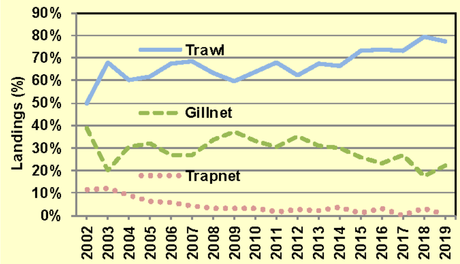
Landings in Subdivisions 22-29 (t)

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
2019	5,664.366	1,615.909	42.112	7,322.387



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%
2019	77%	22%	1%	100%



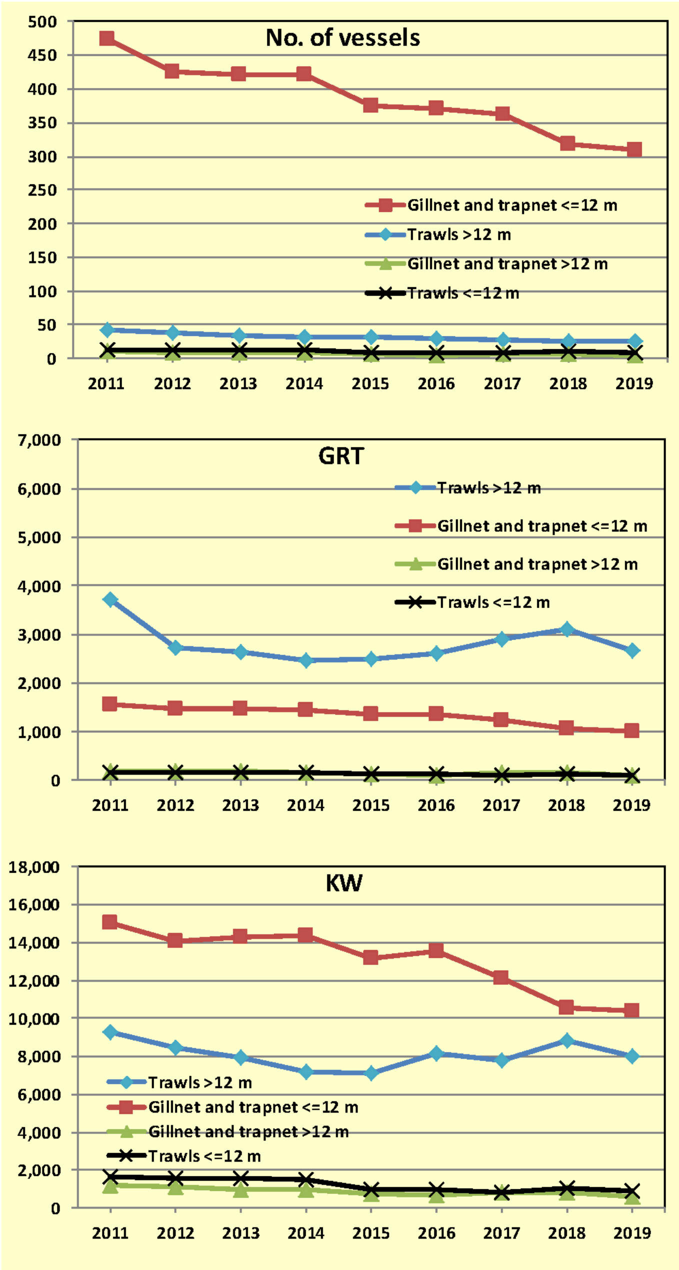
1.2 Fishing fleet

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 2011 until 2019 the following types of fishing vessels carried out the herring fishery in the Baltic (only referring to vessels, which are contributing to the overall total landings per year with more than 20 %):

	Type of gear	Vessel length (m)	No. of vessels	GRT	kW
2011	Fixed gears	<=12	473	1,566	15,020
	(gillnet and trapnet)	>12	10	185	1,215
	Trawls	<=12	12	171	1,666
		>12	43	3,710	9,325
	TOTAL		**538**	**5,632**	**27,226**
2012	Fixed gears	<=12	426	1,485	14,105
	(gillnet and trapnet)	>12	9	184	1,125
	Trawls	<=12	12	170	1,573
		>12	38	2,712	8,480
	TOTAL		**485**	**4,551**	**25,283**
2013	Fixed gears	<=12	421	1,459	14,289
	(gillnet and trapnet)	>12	9	186	1,005
	Trawls	<=12	14	173	1,557
		>12	35	2,638	7,960
	TOTAL		**479**	**4,456**	**24,811**
2014	Fixed gears	<=12	421	1,443	14,351
	(gillnet and trapnet)	>12	8	149	970
	Trawls	<=12	13	170	1,502
		>12	31	2,469	7,205
	TOTAL		**473**	**4,231**	**24,028**
2015	Fixed gears	<=12	375	1,341	13,163
	(gillnet and trapnet)	>12	7	133	802
	Trawls	<=12	9	122	991
		>12	31	2,503	7,148
	TOTAL		**422**	**4,099**	**22,104**
2016	Fixed gears	<=12	371	1,341	13,532
	(gillnet and trapnet)	>12	5	103	699
	Trawls	<=12	8	137	997
		>12	30	2,599	8,205
	TOTAL		**414**	**4,180**	**23,433**
2017	Fixed gears	<=12	362	1,237	12,158
	(gillnet and trapnet)	>12	6	148	874
	Trawls	<=12	8	113	872
		>12	27	2,910	7,816
	TOTAL		**403**	**2,910**	**21,720**
2018	Fixed gears	<=12	319	1,049	10,572
	(gillnet and trapnet)	>12	6	148	874
	Trawls	<=12	11	143	1,080
		>12	26	3,093	8,815
	TOTAL		**362**	**4,433**	**21,341**
2019	Fixed gears	<=12	309	1,008	10,374
	(gillnet and trapnet)	>12	4	100	598
	Trawls	<=12	8	114	897
		>12	25	2,655	8,025
	TOTAL		**846**	**3,877**	**19,894**


No. of vessels
Gillnet and trapnet <=12 m
Trawls >12 m
Gillnet and trapnet >12 m
Trawls <=12 m
GRT
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m
KW
Trawls >12 m
Gillnet and trapnet <=12 m
Gillnet and trapnet >12 m
Trawls <=12 m

1.3 Species composition of landings

The catch composition from gillnet and trapnet consists of nearly 100 % of herring.

The results from the species composition of German trawl catches, which were sampled in **Subdivision 24** of quarter 1, 2 and 4 in 2019, are given below:

SD 24/Quarter I	Sample No.	Weight (kg) Herring	Sprat	Cod	Other	Total	Weight (%) Herring	Sprat	Cod	Other
January	1	55.9	0.0	0.0	0.0	55.9	100.0	0.0	0.0	0.0
	2									
	3									
	Mean	55.9	0.0	0.0	0.0	55.9	100.0	0.0	0.0	0.0
February	1	47.2	0.0	0.0	0.0	47.2	99.9	0.1	0.0	0.0
	2	69.4	0.0	0.0	0.0	69.4	100.0	0.0	0.0	0.0
	3									
	Mean	58.3	0.0	0.0	0.0	58.3	99.9	0.1	0.0	0.0
March	1	75.7	0.0	0.0	0.0	75.7	100.0	0.0	0.0	0.0
	2									
	3									
	Mean	75.7	0.0	0.0	0.0	75.7	100.0	0.0	0.0	0.0
Q I	Mean	63.3	0.0	0.0	0.0	63.3	100.0	0.0	0.0	0.0

SD 24/Quarter II	Sample No.	Weight (kg) Herring	Sprat	Cod	Other	Total	Weight (%) Herring	Sprat	Cod	Other
April	1	49.4	0.1	0.0	0.0	49.6	99.7	0.3	0.0	0.0
	2									
	3									
	Mean	49.4	0.1	0.0	0.0	49.6	99.7	0.3	0.0	0.0
May	1									
	2									
	Mean									
June	1									
	2									
	Mean									
Q II	Mean	49.4	0.1	0.0	0.0	49.6	99.7	0.3	0.0	0.0

SD 24/Quarter IV	Sample No.	Weight (kg) Herring	Sprat	Cod	Other	Total	Weight (%) Herring	Sprat	Cod	Other
Octob.	1									
	2									
	3									
	Mean									
Novemb.	1	42.0	0.2	0.0	0.0	42.2	99.6	0.4	0.0	0.0
	2									
	3									
	Mean	42.0	0.2	0.0	0.0	42.2	99.6	0.4	0.0	0.0
Decemb.	1	73.5	0.0	0.0	0.0	73.5	100.0	0.0	0.0	0.0
	2	67.3	0.0	0.0	0.0	67.3	100.0	0.0	0.0	0.0
	3									
	Mean	70.4	0.0	0.0	0.0	70.4	100.0	0.0	0.0	0.0
Q IV	Mean	56.2	0.1	0.0	0.0	56.3	99.8	0.2	0.0	0.0

The officially reported total trawl landings of herring in Subdivision 24 (see 2.1) in combination with the detected mean species composition in the samples (see above) results in the following differences:

Quarter	Trawl landings (t)	Mean Contribution of Herring (%)	Total Herring corrected (t)	Difference (t)
I	**2,842.608**	100.0	2,842.608	0.000
II	**12.646**	99.7	12.613	-0.033
IV	**1,026.750**	99.8	1,024.925	-1.825

The officially reported trawl landings in Subdivision 24 (see 2.1) and the referring assessment input data (see 2.2 and 2.3) were as in last years not corrected since the results would only result in overall small changes of the official statistics (total trawl landings in Subdivision 22 and 24 of 3,913 t – 2 t: <0.1 % difference).

1.4 Logbook registered discards/BMS landings

No BMS landings (new catch categories since 2015) of herring have been reported in the German herring fisheries in 2019 (no BMS landing have been reported since 2015). A total amount logbook registered discards (new catch categories since 2015) of 21.882 t were recorded by the German fisherman (as predation by seals?) in the gillnet/trapnet fisheries in SDs 22/24 in 2019 (2018/SD 24/gillnet fisheries: 14.510 t). Neither discards nor logbook registered discards have been reported before 2018.

Logbook registered discards in 2019										
		Trapnet			Gillnet			Total		
		27.3.c.22	27.3.d.24	Total	27.3.c.22	27.3.d.24	Total	27.3.c.22	27.3.d.24	Total
Month	1	0.000	0.000	0.000	0.000	0.050	0.050	0.000	0.050	0.050
	2	0.000	0.000	0.000	0.000	3.945	3.945	0.000	3.945	3.945
	3	0.000	0.000	0.000	0.000	11.667	11.667	0.000	11.667	11.667
	4	0.000	0.000	0.000	0.100	2.845	2.945	0.100	2.845	2.945
	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	9	0.010	0.000	0.010	0.000	0.000	0.000	0.010	0.000	0.010
	10	0.005	0.090	0.095	0.000	0.050	0.050	0.005	0.140	0.145
	11	0.000	0.415	0.415	0.000	0.870	0.870	0.000	1.285	1.285
	12	0.000	0.285	0.285	0.000	1.550	1.550	0.000	1.835	1.835
Quarter	1	0.000	0.000	0.000	0.000	15.662	15.662	0.000	15.662	15.662
	2	0.000	0.000	0.000	0.100	2.845	2.945	0.100	2.845	2.945
	3	0.010	0.000	0.010	0.000	0.000	0.000	0.010	0.000	0.010
	4	0.005	0.790	0.795	0.000	2.470	2.470	0.005	3.260	3.265
Total		0.015	0.790	0.805	0.100	20.977	21.077	0.115	21.767	21.882

1.5 Central Baltic herring

In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring Spawning herring (WBSSH) and the Central Baltic herring (CBH) overlap. German autumn acoustic survey (GERAS) results indicated in the recent years that in SD 24, which is part of the WBSSH management area, a considerable fraction of CBH is present and correspondingly erroneously allocated to WBSSH stock indices (ICES, 2013). Accordingly, a stock separation function (SF) based on growth parameters in 2005 to 2010 has been developed to quantify the proportion of CBH and WBSSH in the area (Gröhsler et al., 2013, Gröhsler et al., 2016). The estimates of the growth parameters based on baseline samples of WBSSH and CBH support the applicability of SF in 2011-2018 (no update for 2019, due CBH occurring in baseline samples in SD 21 and SD 23, Oeberst et al., 2013, WD Oeberst et al., 2014; WD Oeberst et al., 2015; WD Oeberst et al., 2016; WD Oeberst et al., 2017; WD Gröhsler, T. and Schaber, M., 2018, WD Gröhsler, T. and Schaber, M., 2019). SF (slightly modified by commercial samples) was employed in the years 2005-2016 to identify the fraction of Central Baltic Herring in German commercial herring landings from SD 22 and 24 (WD Gröhsler et al., 2013; ICES, 2018). Results showed a rather low share of CBH in landings from all métiers but indicated that the actual degree of mixing might be underrepresented in commercial landings as German commercial fisheries target pre-spawning and spawning aggregations of WBSSH.

1.6 References

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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	30.218	0	0	0	2,842.608	4	1,809	455	2,872.826	4	1,809	455
	Q 2	0.203	0	0	0	12.646	1	591	105	12.849	1	591	105
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.085	0	0	0	1,026.750	3	1,430	369	1,026.835	3	1,430	369
	Total	30.506	0	0	0	3,882.004	8	3,830	929	3,912.510	8	3,830	929
GILLNET	Q 1	9.562	2	859	137	1,459.079	10	3,519	554	1,468.641	12	4,378	691
	Q 2	3.381	1	465	62	92.818	0	0	0	96.199	1	465	62
	Q 3	0.357	0	0	0	0.909	0	0	0	1.266	0	0	0
	Q 4	9.752	0	0	0	40.051	0	0	0	49.803	0	0	0
	Total	23.052	3	1,324	199	1,592.857	10	3,519	554	1,615.909	13	4,843	753
TRAPNET	Q 1	0.000	-	-	-	39.275	2	731	203	39.275	-	-	-
	Q 2	0.086	1	401	77	2.670	0	0	0	2.756	1	401	77
	Q 3	0.020	0	0	0	0.002	0	0	0	0.022	0	0	0
	Q 4	0.025	0	0	0	0.034	0	0	0	0.059	0	0	0
	Total	0.131	1	401	77	41.981	2	731	203	42.112	1	401	77
TOTAL	Q 1	39.780	2	859	137	4,340.962	16	6,059	1,212	4,380.742	18	6,918	1,349
	Q 2	3.670	2	866	139	108.134	1	591	105	111.804	3	1,457	244
	Q 3	0.377	0	0	0	0.911	0	0	0	1.288	0	0	0
	Q 4	9.862	0	0	0	1,066.835	3	1,430	369	1,076.697	3	1,430	369
	Total	53.689	4	1,725	276	5,516.842	20	8,080	1,686	5,570.531	24	9,805	1,962

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	103.380	0	0	0	958.612	0	0	0	0.000	-	-	-
	Q 2	26.717	0	0	0	316.769	0	0	0	0.000	-	-	-
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	10.000	0	0	0	0.000	-	-	-	0.000	-	-	-
	Total	140.097	0	0	0	1,275.381	0	0	0	0.000	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	182.230	0	0	0	144.148	0	0	0	1,388.370	0	0	0
	Q 2	10.000	0	0	0	0.000	-	-	-	353.486	0	0	0
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	0	0	0
	Q 4	0.000	-	-	-	0.000	-	-	-	10.000	0	0	0
	Total	192.230	0	0	0	144.148	0	0	0	1,751.856	0	0	0

1.8 Catch in numbers (millions)

1.8.1 Subdivisions 22 and 24

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0				0.000				0.047				0.047
	1	0.002			0.000	0.195			0.401	0.197			0.401
	2	0.008	0.001		0.000	0.798	0.032		2.099	0.806	0.032		2.100
	3	0.026	0.001		0.000	2.481	0.068		1.699	2.507	0.069		1.699
	4	0.059	0.000		0.000	5.560	0.028		1.676	5.619	0.029		1.676
	5	0.026	0.000		0.000	2.490	0.013		0.965	2.516	0.014		0.965
	6	0.066	0.000		0.000	6.254	0.006		1.256	6.320	0.006		1.256
	7	0.015	0.000		0.000	1.429	0.002		0.174	1.445	0.002		0.174
	8+	0.016	0.000		0.000	1.519	0.002		0.151	1.535	0.002		0.151
	Sum	0.220	0.002		0.001	20.725	0.151		8.468	20.945	0.154		8.469
GILLNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												
	1												
	2												
	3	0.003	0.0000	0.000	0.000	0.023	0.001	0.000	0.001	0.026	0.001	0.000	0.001
	4	0.008	0.001	0.000	0.002	**0.615**	0.016	0.000	0.007	0.622	0.017	0.000	0.009
	5	0.004	0.006	0.001	0.018	**1.505**	0.171	0.002	0.074	1.509	0.178	0.002	0.092
	6	0.026	0.006	0.001	0.017	**3.924**	0.166	0.002	0.072	3.950	0.172	0.002	0.089
	7	0.013	0.006	0.001	0.018	**1.192**	0.170	0.002	0.073	1.205	0.176	0.002	0.091
	8+	0.006	0.002	0.000	0.005	**0.780**	0.046	0.000	0.020	0.786	0.048	0.001	0.025
	Sum	0.059	0.021	0.002	0.060	**8.039**	0.571	0.006	0.246	8.098	0.591	0.008	0.306
TRAPNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												
	1												
	2		0.0001	0.000	0.0000	0.020	0.004	0.0000	0.000	0.020	0.004	0.000	0.0001
	3		0.0008	0.000	0.0002	0.079	0.023	0.0000	0.000	0.079	0.024	0.000	0.0005
	4		0.0003	0.000	0.0001	0.157	0.008	0.0000	0.000	0.157	0.009	0.000	0.0002
	5		0.0000	0.000	0.0000	0.034	0.001	0.0000	0.000	0.034	0.001	0.000	0.0000
	6		0.0000	0.000	0.0000	0.062	0.001	0.0000	0.000	0.062	0.001	0.000	0.0000
	7		0.0000	0.000	0.0000	0.014	0.000	0.0000	0.000	0.014	0.000	0.000	0.0000
	8+		0.000	0.000	0.0000	0.013	0.000	0.0000	0.000	0.013	0.000	0.000	0.0000
	Sum		0.001	0.000	0.0003	0.378	0.037	0.0000	0.000	0.378	0.038	0.000	0.0008
TOTAL	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0				0.000				0.047				0.047
	1	0.002			0.0000	0.195			0.401	0.197			0.401
	2	0.0085	0.001	0.000	0.0002	0.818	0.036	0.000	2.099	0.826	0.036	0.000	2.100
	3	0.029	0.002	0.000	0.0005	2.583	0.093	0.000	1.699	2.612	0.095	0.000	1.700
	4	0.067	0.001	0.000	0.0019	6.331	0.052	0.000	1.683	6.398	0.054	0.000	1.685
	5	0.031	0.006	0.001	0.0181	4.029	0.185	0.002	1.039	4.059	0.192	0.002	1.057
	6	0.092	0.006	0.001	0.0175	10.240	0.172	0.002	1.327	10.332	0.179	0.002	1.345
	7	0.028	0.006	0.001	0.0179	2.635	0.172	0.002	0.247	2.664	0.178	0.002	0.265
	8+	0.022	0.002	0.000	0.0049	2.312	0.048	0.000	0.171	2.334	0.050	0.001	0.176
	Sum	0.279	0.024	0.002	0.0610	29.142	0.759	0.006	8.715	29.421	0.783	0.008	8.776

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	1	24	Trawl	1	Gillnet	2, 3, 4	22	Gillnet	2
Trawl	2	24	Trawl	2	Trapn	2, 3, 4	22	Trapn	2
Trawl	4	24	Trawl	4					
Gillnet	3, 4	22	Gillnet	2					
Trapn	3, 4	22	Trapn	2					

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				16.0				16.0				16.0
	1	17.0			46.7	17.0			46.7	17.0			46.7
	2	53.1	60.4		80.2	53.1	60.4		80.2	53.1	60.4		80.2
	3	79.6	76.4		98.4	79.6	76.4		98.4	79.6	76.4		98.4
	4	122.5	87.1		143.9	122.5	87.1		143.9	122.5	87.1		143.9
	5	136.3	123.1		154.8	136.3	123.1		154.8	136.3	123.1		154.8
	6	166.3	140.8		178.1	166.3	140.8		178.1	166.3	140.8		178.1
	7	178.7	147.5		176.0	178.7	147.5		176.0	178.7	147.5		176.0
	8+	186.5	155.8		177.7	186.5	155.8		177.7	186.5	155.8		177.7
	Sum	137.2	83.7		121.3	137.2	83.7		121.3	137.2	83.7		121.3
GILLNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												
	1												
	2												
	3	125.9	88.9	88.9	88.9	140.4	88.9	88.9	88.9	138.9	88.9	88.9	88.9
	4	145.9	134.3	134.3	134.3	156.4	134.3	134.3	134.3	156.2	134.3	134.3	134.3
	5	146.9	160.9	160.9	160.9	172.9	160.9	160.9	160.9	172.9	160.9	160.9	160.9
	6	165.4	161.9	161.9	161.9	182.2	161.9	161.9	161.9	182.1	161.9	161.9	161.9
	7	169.2	164.8	164.8	164.8	190.4	164.8	164.8	164.8	190.1	164.8	164.8	164.8
	8+	181.7	176.3	176.3	176.3	201.9	176.3	176.3	176.3	201.8	176.3	176.3	176.3
	Sum	162.1	162.7	162.7	162.7	181.5	162.7	162.7	162.7	181.4	162.7	162.7	162.7
TRAPNET	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0												
	1												
	2		54.1	54.1	54.1	58.0	54.1	54.1	54.1	58.0	54.1	54.1	54.1
	3		68.0	68.0	68.0	81.3	68.0	68.0	68.0	81.3	68.0	68.0	68.0
	4		81.0	81.0	81.0	101.0	81.0	81.0	81.0	101.0	81.0	81.0	81.0
	5		104.9	104.9	104.9	109.2	104.9	104.9	104.9	109.2	104.9	104.9	104.9
	6		126.8	126.8	126.8	136.3	126.8	126.8	126.8	136.3	126.8	126.8	126.8
	7		118.9	118.9	118.9	123.8	118.9	118.9	118.9	123.8	118.9	118.9	118.9
	8+		117.3	117.3	117.3	153.5	117.3	117.3	117.3	153.5	117.3	117.3	117.3
	Sum		71.7	71.7	71.7	103.8	71.7	71.7	71.7	103.8	71.7	71.7	71.7
TOTAL	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	0				16.0				16.0				16.0
	1	17.0			46.7	17.0			46.7	17.0			46.7
	2	53.1	59.2	54.1	75.8	53.2	59.8	54.1	80.2	53.2	59.8	54.1	80.2
	3	83.9	73.3	68.6	82.2	80.2	74.4	76.5	98.3	80.3	74.4	69.7	98.3
	4	125.3	106.9	107.5	132.8	125.3	100.5	132.2	143.8	125.3	100.6	121.6	143.8
	5	137.7	159.5	160.4	160.9	149.8	158.0	160.9	155.3	149.7	158.0	160.8	155.4
	6	166.1	161.4	161.6	162.0	172.2	161.0	161.9	177.3	172.2	161.0	161.8	177.1
	7	174.3	164.6	164.7	164.8	183.7	164.5	164.7	172.6	183.6	164.5	164.7	172.1
	8+	185.3	175.9	176.1	176.3	191.5	175.4	176.3	177.5	191.5	175.5	176.3	177.5
	Sum	142.4	150.4	152.4	161.7	149.0	142.5	162.2	122.4	148.9	142.7	159.2	122.7

REPLACEMENT OF MISSING SAMPLES:

SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	1	24	Trawl	1	Gillnet	2, 3, 4	22	Gillnet	2
Trawl	2	24	Trawl	2	Trapn	2, 3, 4	22	Trapn	2
Trawl	4	24	Trawl	4					
Gillnet	3, 4	22	Gillnet	2					
Trapn	3, 4	22	Trapn	2					

1.9.2 Subdivisions 25 and 29

No sampling.

1.10 Mean length in the catch (cm)

1.10.1 Subdivisions 22 and 24

		SUBDIVISION 22				SUBDIVISION 24				SUBDIVISIONS 22+24			
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0				13.6				13.6				13.6
	1	14.3			19.3	14.3			19.3	14.3			19.3
	2	20.3	21.0		22.7	20.3	21.0		22.7	20.3	21.0		22.7
	3	22.7	22.6		24.0	22.7	22.6		24.0	22.7	22.6		24.0
	4	25.5	23.4		26.5	25.5	23.4		26.5	25.5	23.4		26.5
	5	26.3	26.0		27.0	26.3	26.0		27.0	26.3	26.0		27.0
	6	28.0	27.2		28.3	28.0	27.2		28.3	28.0	27.2		28.3
	7	28.7	28.2		28.2	28.7	28.2		28.2	28.7	28.2		28.2
	8+	29.1	28.7		28.1	29.1	28.7		28.1	29.1	28.7		28.1
	Sum	26.2	23.1		25.0	26.2	23.1		25.0	26.2	23.1		25.0
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GILLNET	0												
	1												
	2												
	3	25.3	22.8	22.8	22.8	26.0	22.8	22.8	22.8	26.0	22.8	22.8	22.8
	4	26.5	25.9	25.9	25.9	27.0	25.9	25.9	25.9	27.0	25.9	25.9	25.9
	5	26.6	27.7	27.7	27.7	28.1	27.7	27.7	27.7	28.0	27.7	27.7	27.7
	6	27.8	27.8	27.8	27.8	28.7	27.8	27.8	27.8	28.6	27.8	27.8	27.8
	7	28.1	27.9	27.9	27.9	29.2	27.9	27.9	27.9	29.2	27.9	27.9	27.9
	8+	29.1	28.9	28.9	28.9	29.9	28.9	28.9	28.9	29.9	28.9	28.9	28.9
	Sum	27.7	27.8	27.8	27.8	28.6	27.8	27.8	27.8	28.6	27.8	27.8	27.8
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAPNET	0												
	1												
	2		20.3	20.3	20.3	20.9	20.3	20.3	20.3	20.9	20.3	20.3	20.3
	3		21.9	21.9	21.9	23.3	21.9	21.9	21.9	23.3	21.9	21.9	21.9
	4		23.1	23.1	23.1	24.8	23.1	23.1	23.1	24.8	23.1	23.1	23.1
	5		24.9	24.9	24.9	25.5	24.9	24.9	24.9	25.5	24.9	24.9	24.9
	6		26.4	26.4	26.4	27.5	26.4	26.4	26.4	27.5	26.4	26.4	26.4
	7		26.3	26.3	26.3	26.5	26.3	26.3	26.3	26.5	26.3	26.3	26.3
	8+		26.3	26.3	26.3	28.9	26.3	26.3	26.3	28.9	26.3	26.3	26.3
	Sum		22.2	22.2	22.2	25.0	22.2	22.2	22.2	25.0	22.2	22.2	22.2
	W-rings	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TOTAL	0				13.6				13.6				13.6
	1	14.3			19.3	14.3			19.3	14.3			19.3
	2	20.3	20.9	20.3	22.3	20.3	21.0	20.3	22.7	20.3	20.9	20.3	22.7
	3	23.0	22.3	22.0	22.7	22.8	22.4	22.3	24.0	22.8	22.4	22.0	24.0
	4	25.6	24.5	24.5	25.9	25.7	24.1	25.8	26.5	25.7	24.1	25.2	26.5
	5	26.3	27.6	27.7	27.7	26.9	27.5	27.7	27.0	26.9	27.5	27.7	27.1
	6	27.9	27.8	27.8	27.8	28.2	27.8	27.8	28.3	28.2	27.8	27.8	28.2
	7	28.4	27.9	27.9	27.9	28.9	27.9	27.9	28.1	28.9	27.9	27.9	28.1
	8+	29.1	28.9	28.9	28.9	29.4	28.9	28.9	28.2	29.4	28.9	28.9	28.3
	Sum	26.5	27.1	27.2	27.8	26.8	26.6	27.8	25.1	26.8	26.6	27.6	25.1

REPLACEMENT OF MISSING SAMPLES:

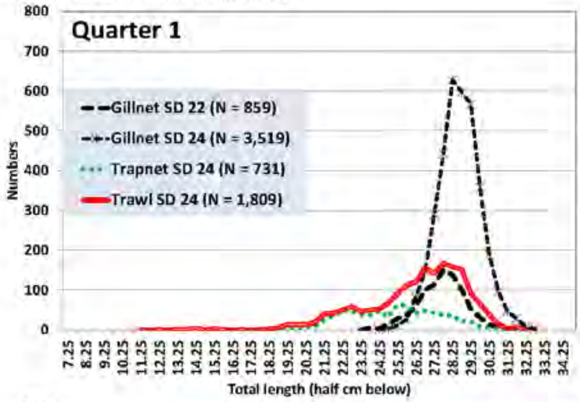
SUBDIVISION 22					SUBDIVISION 24				
Missing		Replacement by			Missing		Replacement by		
Gear	Quart.	Area	Gear	Quart.	Gear	Quart.	Area	Gear	Quart.
Trawl	1	24	Trawl	1	Gillnet	2, 3, 4	22	Gillnet	2
Trawl	2	24	Trawl	2	Trapn	2, 3, 4	22	Trapn	2
Trawl	4	24	Trawl	4					
Gillnet	3, 4	22	Gillnet	2					
Trapn	3, 4	22	Trapn	2					

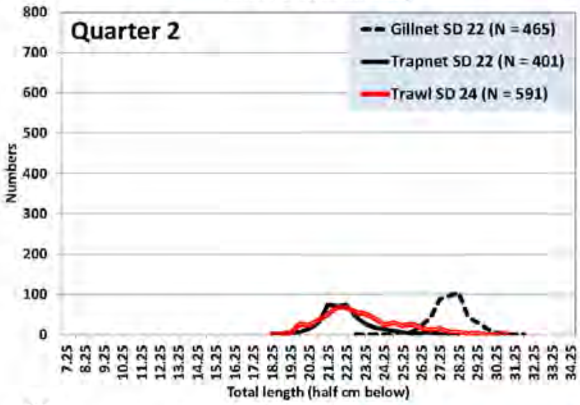
1.10.2 Subdivisions 25 and 29

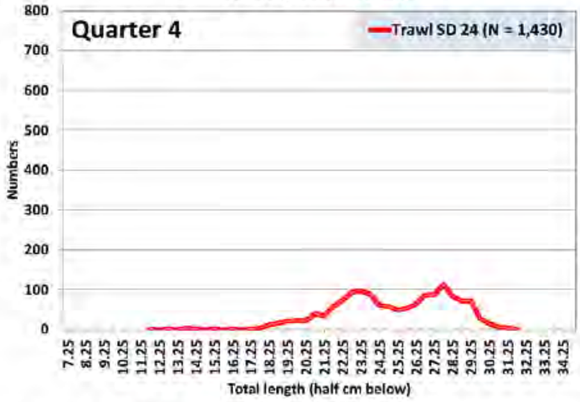
No sampling.

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 2019** reached according to the
(a) share of the EU quota (2019: 16,921 t) and
(b) further transfer of quota (overall 2,103 t were transferred to other Baltic countries)

14,645 t,

which represents a final utilization of the overall 2019 quota of 14,818 t of 99 % (2018: 15,213 t = 91 % of total quota of 16,698 t (16,393 t + quota transfer of 305 t)).

As in previous years most sprat was

- landed in foreign ports (2019: 89 %, 2018: 90 %),
- caught in the first quarter (2019: 62 %, 2018: 69 %),
- caught in Subdivisions 25-29 (2019: 97 %, 2018: 90 %)

Most catches in SDs 25-29 were landed in foreign ports (2019: 95 %, 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	394.789	61.348	738.836	5,509.612	-	1,011.117	1,388.038	8,647.603	95.0%	9,103.740	62.2%
	-	-	738.836	5,236.733	-	946.381	1,388.038	8,309.988	100.0%	8,309.988	63.8%
II	0.713	-	1,008.075	4,085.956	-	168.876	-	5,262.907	100.0%	5,263.620	35.9%
	-		803.693	3,483.028	-	168.876	-	4,455.597	100.0%	4,455.597	34.2%
III	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
IV	0.150	28.540	250.870	-	-	-	-	250.870	90.4%	277.560	1.9%
	-		250.870	-	-	-	-	250.870	100.0%	250.870	1.9%
Total	395.652	87.888	1,997.781	9,595.568	-	1,179.993	1,388.038	14,161.380	96.7%	14,644.920	100.0%
	-	-	1,793.399	6,719.761	-	1,115.257	1,388.038	13,016.455	100.0%	13,016.455	88.9%

	(1)	(2)
	2019/2018	2019/2018
Fraction of total landings (t) in foreign ports	103.4%	96.3%
	95.1%	95.1%
Proportion landed in foreign ports in 2019:		88.9%

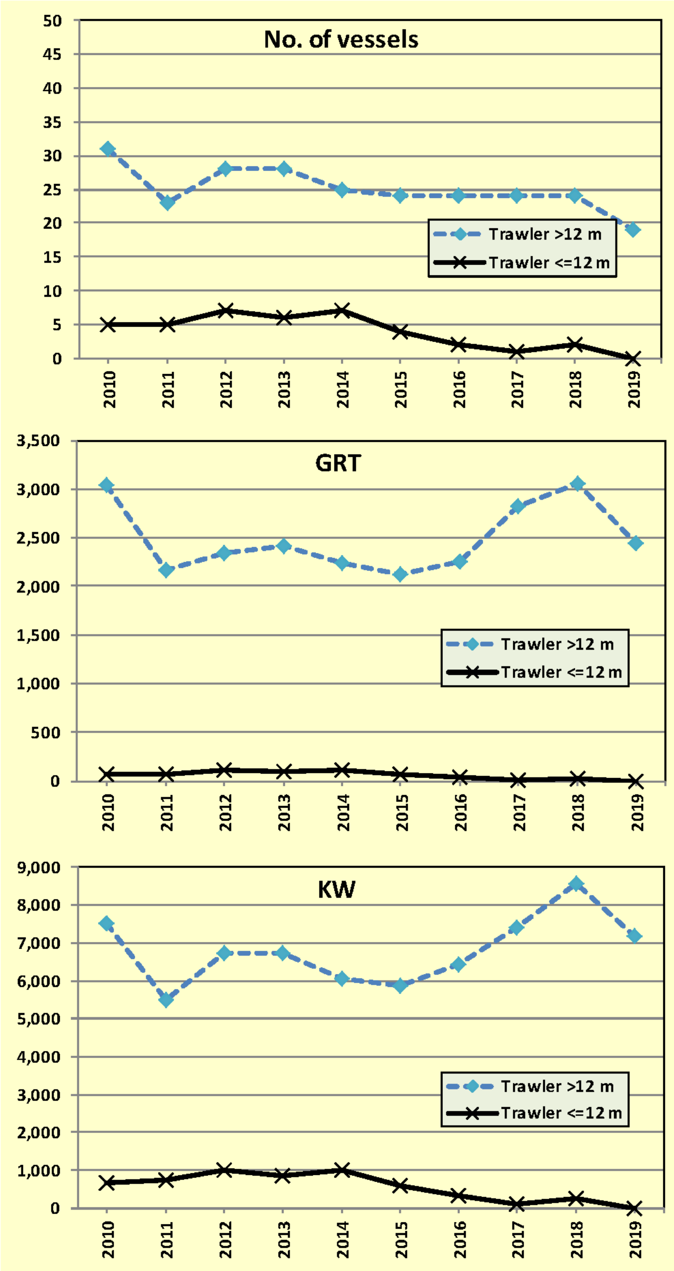
2.2 Fishing fleet

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 – 2019 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
2019	<=12	0	0	0
	>12	19	2,445	7,179


No. of vessels
GRT
KW
Trawler >12 m
Trawler <=12 m
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019

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 2019, are given below:

SD 22/Quartal 1		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January										
	Mean									
February	1	13.4	2.2	0.0	0.6	16.2	82.7	13.8	0.0	3.5
	Mean	13.4	2.2	0.0	0.6	16.2	82.7	13.8	0.0	3.5
March										
	Mean									
Q I	Mean	13.4	2.2	0.0	0.6	16.2	82.7	13.8	0.0	3.5

The results from the species composition of German trawl catches, which were sampled in **Subdivision 25 of quarter 1** in 2019, are given below:

SD 25/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January										
	Mean									
February										
	Mean									
March	1	8.8	0.0	0.0	0.0	8.9	99.5	0.5	0.0	0.0
	Mean	8.8	0.0	0.0	0.0	8.9	99.5	0.5	0.0	0.0
Q I	Mean	8.8	0.0	0.0	0.0	8.9	99.5	0.5	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 2019 are given below:

SD 26/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January										
	Mean									
February	1	7.5	0.0	0.0	0.0	7.5	100.0	0.0	0.0	0.0
	2	4.0	0.0	0.0	0.0	4.0	100.0	0.0	0.0	0.0
	Mean	5.8	0.0	0.0	0.0	5.8	100.0	0.0	0.0	0.0
March	1	7.7	0.1	0.0	0.0	7.8	98.5	1.5	0.0	0.0
	2	8.5	0.1	0.0	0.0	8.6	99.4	0.6	0.0	0.0
	3	7.2	0.0	0.0	0.0	7.2	100.0	0.0	0.0	0.0
	4	7.6	0.0	0.0	0.0	7.6	100.0	0.0	0.0	0.0
	5	8.1	0.2	0.0	0.0	8.3	97.7	2.3	0.0	0.0
	6	8.1	0.0	0.0	0.0	8.1	100.0	0.0	0.0	0.0
	Mean	7.9	0.1	0.0	0.0	7.9	99.3	0.7	0.0	0.0
Q I	Mean	6.8	0.0	0.0	0.0	6.8	99.6	0.4	0.0	0.0

SD 26/Quarter II		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
April	1	7.9	0.7	0.0	0.0	8.6	92.0	8.0	0.0	0.0
	2	7.7	0.0	0.0	0.0	7.7	99.5	0.5	0.0	0.0
	3	9.1	0.0	0.0	0.0	9.2	99.6	0.4	0.0	0.0
	4	8.7	0.0	0.0	0.0	8.7	100.0	0.0	0.0	0.0
	5	5.4	1.1	0.0	0.1	6.5	82.0	16.4	0.0	1.6
	6	6.1	0.2	0.0	0.0	6.3	97.3	2.7	0.0	0.0
	Mean	7.5	0.3	0.0	0.0	7.9	95.1	4.7	0.0	0.3
May										
	Mean									
June										
	Mean									
Q II	Mean	7.5	0.3	0.0	0.0	7.9	95.1	4.7	0.0	0.3

The results from the species composition of German trawl catches, which were sampled in **Subdivision 28 of quarter 1** in 2019, are given below:

SD 28/Quarter I		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January										
	Mean									
February										
	Mean									
March	1	7.3	0.0	0.0	0.0	7.3	100.0	0.0	0.0	0.0
	Mean	7.3	0.0	0.0	0.0	7.3	100.0	0.0	0.0	0.0
Q I	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 29 of quarter 1** in 2019, are given below:

SD 29/Quartal 1		Weight (kg)					Weight (%)			
	Sample No.	Sprat	Herring	Cod	Other	Total	Sprat	Herring	Cod	Other
January										
	Mean									
February	1	2.7	0.3	0.0	0.0	3.1	89.2	10.7	0.0	0.1
	Mean	2.7	0.3	0.0	0.0	3.1	89.2	10.7	0.0	0.1
March										
	Mean									
Q I	Mean	2.7	0.3	0.0	0.0	3.1	89.2	10.7	0.0	0.1

The officially reported total trawl landings of sprat in Subdivisions 25-29 (see 2.1) in combination with the noticed mean species composition in the samples (see above) would result in the following differences:

Subdiv.	Quarter	Trawl landings (t)	Mean Contribution of Sprat (%)	Total Sprat corrected (t)	Difference (t)
22	I	395	82.7	326	68
25	I	739	99.5	735	4
26	I	5,510	99.6	5,489	20
	II	4,086	95.1	3,884	202
28	I	1,011	100.0	1,011	0
29	I	1,388	89.2	1,238	150

The overall difference amounted to -443 t, which would represent a change of the total landing value for Germany in 2019 of -3 % (total landings in SD 22-29 in 2019 of 14,645 t – 443 t ->14,202 t; 2018: -12 %, 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 small differences in 2019. However, an implementation error of about at least 3-14 % regarding the total landing figure for Germany could 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 2019 (almost no BMS landing have been reported in 2015 - 2018 and no discards/logbook registered discards have been reported before 2019).

2.5 Landings (tons) and sampling effort

Even so most of the sprat was landed in foreign port in 2019 (89 %, 2018: 90 %), it was possible to sample 90 % (13,128 t, 2018: 93 %) 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	394.789	1	228	57	61.348	0	0	0	738.836	1	264	57
	Q 2	0.713	0	0	0	0.000	-	-	-	1,008.075	0	0	0
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.150	0	0	0	26.540	0	0	0	250.870	0	0	0
	Total	395.652	1	228	57	87.888	0	0	0	1,997.781	1	264	57

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	5,509.612	7	2,129	361	0.000	-	-	-	1,011.117	1	265	48
	Q 2	4,085.956	6	2,208	300	0.000	-	-	-	168.876	0	0	0
	Q 3	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Q 4	0.000	-	-	-	0.000	-	-	-	0.000	-	-	-
	Total	9,595.568	13	4,337	661	0.000	0	0	0	1,179.993	1	265	48

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	1,388.038	1	370	51	9,103.740	11	3,256	574
	Q 2	0.000	-	-	-	5,263.620	6	2,208	300
	Q 3	0.000	-	-	-	0.000	0	0	0
	Q 4	0.000	-	-	-	277.560	0	0	0
	Total	1,388.038	1	370	51	14,644.920	17	5,464	874

Fraction of landings in foreign ports:

[1]SD 22: 0 %
[2]SD 24: 0 %
[3]SD 25-29: 13,016 t (92 %)
[4]SD 22-29: 13.016 t (89 %)

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	0.118								7.831				69.778	26.146		
	2	4.966								34.719				230.204	190.215		
	3	13.933								19.643				90.001	101.685		
	4	1.800								16.119				185.303	123.194		
	5	6.013								7.179				91.672	79.427		
	6									0.326				6.374	2.957		
	7														1.293		
	8+									0.326							
	Sum	26.831								86.144				673.332	524.917		

	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					8.572				9.957				96.255	26.146		
	2					37.604				92.970				400.463	190.215		
	3					27.742				17.375				168.694	101.685		
	4					18.710				53.852				275.785	123.194		
	5					29.494				12.396				146.754	79.427		
	6									1.422				8.123	2.957		
	7														1.293		
	8+													0.326			
	Sum					122.122				187.972				1096.401	524.917		

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	5.0								3.5				3.9	3.6		
	2	13.4								7.9				7.5	6.9		
	3	14.7								9.1				8.8	8.0		
	4	15.8								10.4				9.5	8.9		
	5	15.7								11.2				9.9	9.1		
	6									13.7				9.5	12.6		
	7														11.6		
	8+									15.0							
	Sum	14.7								8.6				8.2	7.8		

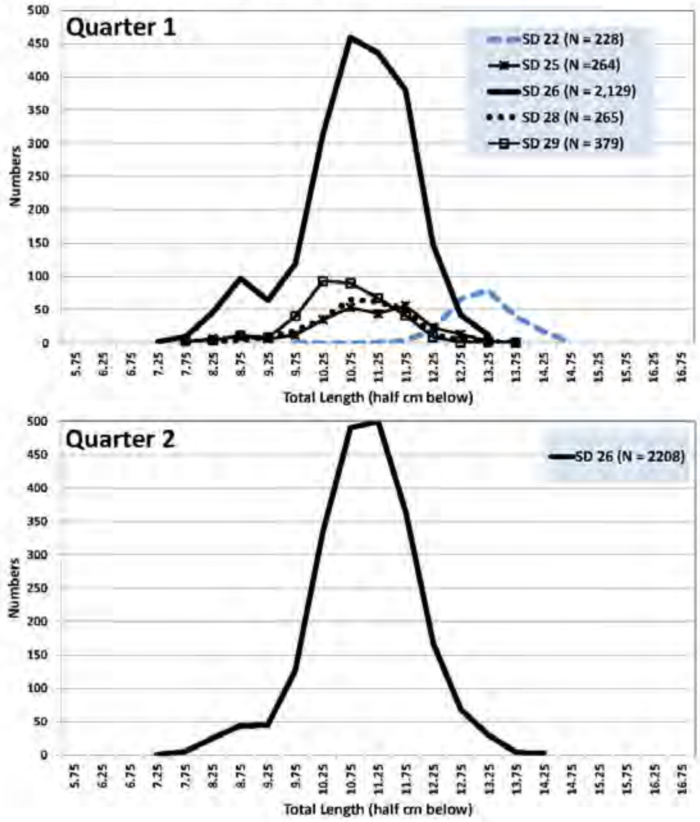
		SUBDIVISION 27				SUBDIVISION 28				SUBDIVISION 29				SUBDIVISIONS 22-29			
	Age	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TRAWL	0																
	1					4.5				3.4				3.9	3.6		
	2					7.4				6.9				7.5	6.9		
	3					8.9				8.2				9.3	8.0		
	4					9.4				8.3				9.3	8.9		
	5					9.2				8.9				10.0	9.1		
	6									10.6				9.9	12.6		
	7														11.6		
	8+													15.0			
	Sum					8.3				7.4				8.2	7.8		

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	9.8								8.6				8.8	8.8		
	2	12.6								10.7				10.5	10.5		
	3	13.1								11.3				11.1	11.1		
	4	13.6								11.8				11.5	11.6		
	5	13.6								12.2				11.7	11.7		
	6									13.3				11.6	13.1		
	7														12.8		
	8+									13.8							
	Sum	13.1								11.0				10.9	11.0		

		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					9.1				8.5				8.8	8.8		
	2					10.5				10.3				10.5	10.5		
	3					11.2				11.1				11.3	11.1		
	4					11.5				11.2				11.5	11.6		
	5					11.4				11.6				11.7	11.7		
	6									12.8				11.8	13.1		
	7														12.8		
	8+													13.8			
	Sum					11.0				10.6				10.9	11.0		

2.9 Sampled length distributions of sprat by Subdivision and quarter



WD02: Mixed Baltic Herring and Sprat fisheries in Estonia in 2019

ESTONIA:

Development of landing figures in relation to the TAC, fleets operating, gears used, usage of landings, spatial and temporal distribution of the landings (2016-2019)

From 2015 to 2019 the herring total landings in SD 28.1, 28.2, 29 and 32 have been in the range from 19 to 24 000 t depending on TAC limitations. The catches of the Gulf of Riga herring decreased at the same time due to the TAC reductions by 20% to 13 300 t in 2019.

The Estonian fishing fleet in the Baltic consists of two parts:

- Coastal fleet with undecked vessels (boats ≤ 10 m and engine power ≤ 100 HP). The fishing is mostly conducted with passive gears (gillnet and trapnet, which are exclusively catching herring.
- Trawlers with total length between 12 m and 40 m. The fishing is mainly carried out with pelagic trawls (single or pair trawlers) catching herring mixture of herring and sprat (minimum mesh-size 17-20 mm). The Estonian fishing fleet decreased substantially in 2004-2012 as a result of the EU scrapping program, and stabilized since then. At present most of the Baltic trawl fleet consists stern trawlers >=300 HP

On average, 25 % of herring catches was taken with coastal fixed gears and 75% with trawls in 2015-2019.

The main fishing season for herring was in spring (quarter 1: 40 % and quarter 2: 30-35 %), but also the 4th quarter- 20-25%. The fishery in 1st quarter can be hampered by ice.

Most herring catches originated from SD 28.1 (40-52 %), and from SD 32 (25%) in 2015-2019.

Sprat catches have shown slight increase since 2015 due to increase in TAC. Like in case of herring, the most of the sprat catches are taken in first half-year and in the 4th quarter in mixed trawl fishery. Main areas of sprat fishery were the SD 32 (53-66%) and SD 29 (20-40%) in 2015-2019.

No discarding takes place in Estonian herring and sprat fishery.

The allocated quota for herring and sprat were almost fully exploited (88 - 96% for herring and 86-99% for sprat).

Both herring and sprat are mostly used for human consumption, only a minor part ofsprat is used for industrial purposes (fish meal).

Official national monitoring system of the herring and sprat landing statistics

Information on the Estonian fishery is derived from logbooks and sales slips. This information is sent to the Ministry of Rural Affairs which is compiling the annual catch information and makes it open on its website. The data are compiled according to the type of fishery, fish species, and the fishing area and are submitted monthly, quarterly and annually to the EU Commission .

In the Baltic region, German fishing vessels ≥ 8 m are obliged to fill in a logbook. The logbooks contain fishing information on quoted fish species (date, gear used, rectangle, and landings in kg). Catches of fishing vessels < 8 m are required to provide monthly sales slips, which are submitted to the respective fishery department.

Catches and landings of trawlers are permanently monitored (incl. the species composition), in all landing harbors by inspectors of Environmental Inspectorate. This information is compared with the logbooks.

Data source

Estonian Ministry of Rural Affairs. The data correspond to Estonian landings in SD 28.1, 28.2, 29 and 32.

Does species misreporting occur in the Estonian pelagic fishery?

All catches taken with gillnet and trapnet are exclusively catching herring with no by-catch of sprat. Therefore some misreporting can occur in trawl fishery only (with exception of the Gulf of Riga (SD 28.1) with very low abundance of sprat.

The logbooks information are cross-checked and, when necessary, corrected on the basis of information from fisheries inspectors and the corresponding sales slips. Landing data based on sales slips are fairly reliable because it is based on the sorting and weighing process carried out in the factories with standardized equipment.

The scientific sampling programme for herring and sprat, which covers the all pelagic trawlers, (randomly chosen) catching herring and sprat in SDs 28.1, 28.2, 29 and 32- 1 unsorted catch sample (10 kg) per trip. Altogether about 3-5 trips are sampled per month and SD.

The above allow to conclude that species misreporting is not a big issue at the moment when both sprat and herring quotas are big enough to use full capacity of the fleet.

WD03: Joint Swedish and Danish survey for cod in the Kattegat, November-December 2019

Joint Swedish and Danish survey for cod in the Kattegat November-December 2019

O.A. Jørgensen and Marie Storr-Paulsen*
Katja Ringdahl, Johan Lövgren, Patrik Börjesson†

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 551 tonnes in 2019. This corresponds to a reduction of more than 94% compared to 2015 when the highest biomass was estimated and represents the lowest estimated biomass in the whole time series of the survey. At the same time the abundance increased from an estimated 0.88 million individuals in 2018 to 2.04 million in 2019. The length distribution was dominated by young individuals, around 20 cm and the number of age class zero cod was the highest observed since the start of the survey in 2008.

Introduction

Cod fishermen operating in the Kattegat has been restricted by steadily decreasing quotas since 2003 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 poor 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 monitoring trends in 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 survey improves the knowledge of spatial distribution of cod by size/age-groups and provides valuable information for monitoring the effect of the closed areas established in the Kattegat from January 1st 2009. Furthermore, although the survey is primarily designed for cod, data for all species is collected and survey products can be generated for other species and/or purposes.

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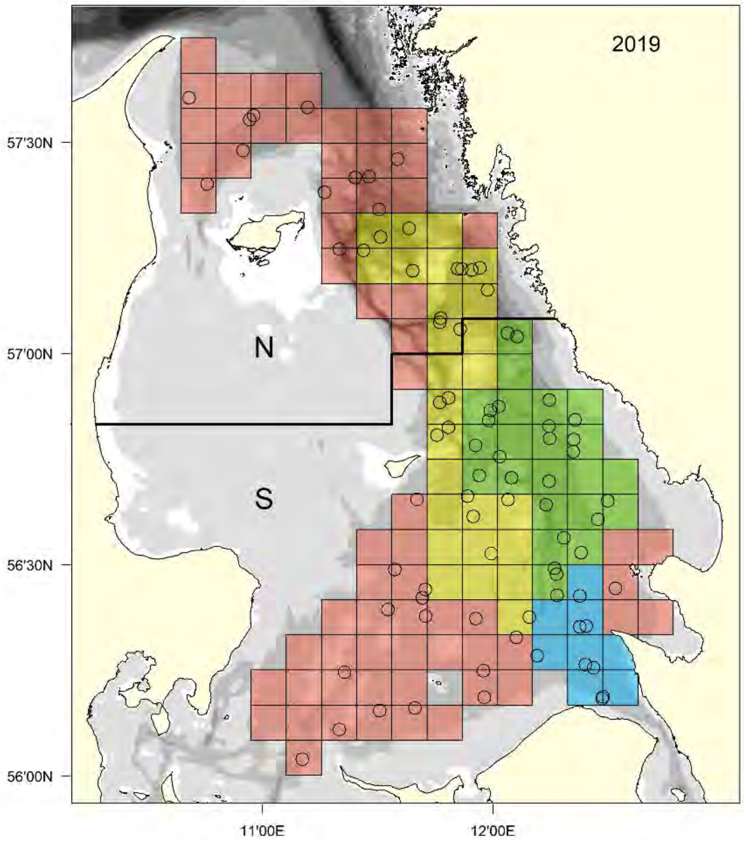
Materials and Methods

Survey area

The survey area cover depths exceeding 20 m in the Kattegat Sea (FAO area 27.3.a.21); bounded to the north by a line from Skagen to Tistlarna; to the southeast by a line between Gilleleje and Kullen; and to the southwest by a line between Gniben and Hassensør on Djursland. The total survey area is 10204 km^2 (Figure 1).



Figur 1. Survey stratification and sampled stations in 2019. Green represents the high-density stratum; yellow the medium-density stratum and red the low-density stratum. In 2013 a fourth stratum was added (marked in blue) to ensure sufficient sampling in the closed area. N (north) and S (south) identifies the two domaines used for biological sampling.

Survey method and stratification
The survey has a stratified random design with 80 hauls distributed within a survey grid of 5×5 nm squares. The grid was initially stratified into three geographical strata based on the information from commercial fishers on expected densities of cod; one stratum with expected high density of cod, one stratum with medium density and one stratum with low density. In 2010 and 2011, changes were made to align the stratification with the catch information collected during the earlier years. A fourth stratum was added in 2013 to ensure the collection of data from the closed area in southeastern Kattegat (Figure 1 and Annex 1).

The effort allocation varies between strata with relatively more hauls allocated to the high-density, the medium-density and the closed area strata than to the low-density stratum (table 1 & 2).

Table 1: Number of survey squares by strata and year.

Year	High density	Medium density	Low density	Closed area	Total
2008-2009	10	44	65		119
2010	15	32	72		119
2011	18	31	70		119
2012					
2013-2017	21	26	65	8	120
2018-2019	21	26	64	8	119

Table 2: Number of squares by vessel and strata. In 2013 only Swedish vessels participated in the survey.

Year	N vessels	High density	Medium density	Low density	Closed area	Total
2008-2010	4	6	8	6		20
2011	4	9	6	5		20
2012						
2013	2	15	10	10	5	40
2014-2015	4	6	5	7	2	20
2016-2019	3	6/12	5/10	7/14	2/4	20/40

Survey period
The survey takes place during second half of November - first half of December.

Vessels and Fishing gear
The original design was to be conducted by four chartered commercial trawlers, two covering the northern part and two covering the southern part of the survey area. The vessels were selected based on similarity in engine power, length and applicability for scientific investigations; two Swedish and two Danish vessels were chartered for each survey. In 2013 however, only Swedish vessels participated in the survey, and from 2016 and onwards Denmark has used R/V Havfisken instead of chartered trawlers, thus two Swedish vessels and one Danish vessel currently participate in the survey. R/V Havfisken fish twice as many hauls as the Swedish vessels keeping the total number of hauls at the same level as previous years. Participating vessels are shown in table 3. Each vessel is assigned 20 or 40 stratified randomly selected survey squares, i.e., all vessels are assigned the same proportion of hauls from each strata. In the closed area, and the high and medium density strata, several vessels are allowed to fish in the same survey square resulting in an overlap between vessels. In the low-density stratum, only one vessel is allowed in each square.

Within each survey square, the skipper decides on the best way to fish at the location, e.g. set position and tow direction. The survey gear is a 112 feet commercial bottom trawl with 70 mm liner in the cod-end (see Annex 2). The ground gear is of rockhopper type with 4 thumps rubber discs at 10 cm. The otter boards are 64-66" Thyborøn with a warp diameter of 15 mm. The sweep lengths have varied over time, but since 2016 been consistent within vessel (90 m, 108 m and 135.5 m). The hauls starts when the trawl is considered stable on the bottom, roughly 5-7 minutes after wires are connected. The tow duration is 1 hour

Table 3: Vessels participating in the survey.

Year	DK1	DK2	SWE1	SWE2
2008	Søren Kanne	Susanne H	Otseco	Yvonne II
2009	H210	Susanne H	Otseco	Yvonne II
2010	Havfisken	Susanne H	Ganler	Tärnan
2011	H292	Susanne H	Cindy Vester	Tärnan
2012				
2013			Cindy Vester	Tärnan
2014	Tiki	Stjerne	Cindy Vester	Tärnan
2015	Annie Holm	Stjerne	Cindy Vester	Tärnan
2016-2019	Havfisken		Cindy Vester	Tärnan

(down to 20 minutes accepted) at a speed of 3 knots over ground (2.7 to 3.4 knots accepted but should not vary within station). The haul ends when hauling the net back in starts. The trawled distance is estimated from GPS-positions or from the mean towing speed, recorded every 10 minutes and the tow duration. A maximum of 5 minutes of the tow duration are allowed outside the assigned survey square. If the 5 minutes are exceeded the haul should be terminated. Trawling is only carried out during daylight (15 minutes before sunrise to 15 minutes after sun set). 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.

Sampling of catch

Two technicians/scientists from DTU-Aqua (Danish vessels) or SLU-Aqua (Swedish vessels), on board each vessel are responsible for processing the catch. The catch is processed in accordance with IBTS standard operating procedures (ICES 2020). After each haul the catch is sorted by species and weighted to nearest 0.1 kg and the number of specimens is recorded. All fish species are measured as total length (TL) to 1.0 cm below. Norwegian lobster is measured to 0.1 mm below. Biological sampling is presently only carried out for cod. Two otoliths per 1-cm length class and domain (north and south) are to be collected. The Swedish protocol for biological sampling changed in 2016 and otoliths are collected from every haul. The number of age samples samples by haul is one per length class for cod sizes 10-40 cm, two per length class for cod sizes 41-60 cm and three per length class for cod larger than 60 cm. Individual weights are measured for all specimens for which age data are collected, but sex and maturity is not routinely reported. Besides the biological sampling of cod have campaigns for other purposes been conducted; for example genetic sampling of cod, thorny skate and thornback ray; and sampling of individual weights for establishing local weight-length relations for some species.

Data management

All trawl data (set/haul positions, doorspread, towing speed etc.) and catch and length frequency data on cod is screened for unrealistic figures before further estimations. Data is stored in national data bases but could be uploaded to the ICES DATRAS system.

Biomass and abundance

The catch in each tow (in kg and numbers) is standardized by swept area (in km^2) prior to further calculations. Swept area is calculated using recorded tow distance and estimated wingspread based on door spread and trawl dimensions (Anon. 2006) (Annex 1). Weight-at-length is estimated from calculated weight-length regressions and age-at-length from an age-length-key generated from the sample data. Missing age-length data is imputed using the multinomial approach by Gerritsen et al (2006). To date, the age-length-key have been based on Swedish samples only and age samples have been pooled from the entire area.

Estimation of stock indices

The calculations of biomass and abundance indices are based on the stratified random design, using inverse probability weighting. The probability for a square to be included in the sample depends primarily on the proportion sampled squares to strata size, but also on whether overlapping is allowed and the number of overlapping vessels. From 2013 to 2017 the survey grid contained 120 5×5 Nm survey squares, but for consistency, biomass and abundance was estimated for 119 squares throughout the period. The catchability coefficient is assumed to be 1.0. All calculations were carried out in R, using the R-survey package for the design based index estimation (Lumley 2020).

Results

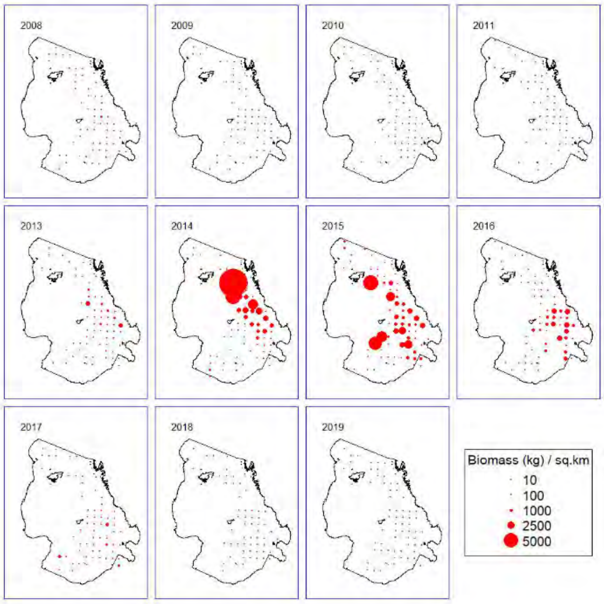
Biomass and abundance

Annual distribution of cod biomass and abundance 2008-2019 is presented in Figure 2 a & b. For biomass, 2014 and 2015 stands out with quantities high above the levels before and after. 2014 is also the year with the highest abundance in the time series.

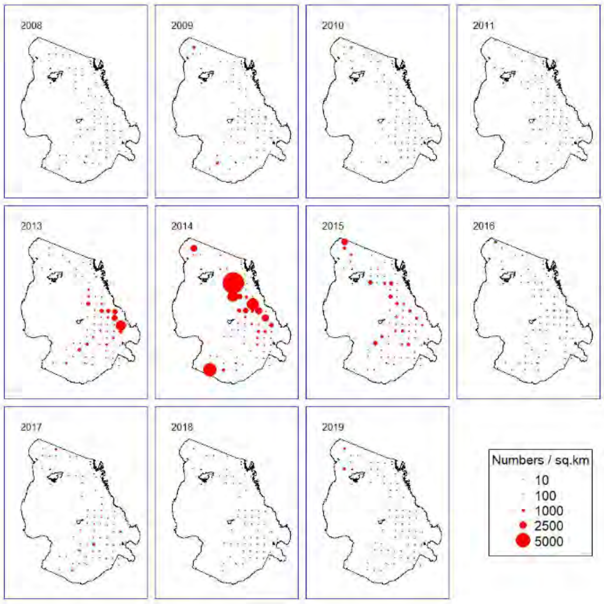
The trawlable biomass of cod in 2019 was estimated to 551 tons, compared to 649 tons in 2018 and 2255 tons in 2017 (Table 4). This corresponds to a reduction in biomass with 16% the last year and approximately 87% in two years. The estimated biomass 2019 is the lowest since the survey started in 2008. The trawlable abundance in 2019 was estimated to 2.08 million, which is a significant increase from last year, albeit from very low numbers (0.88 million in 2018) (Table 4).

Table 4: Weight in kg/km^2 and total biomass in tonnes. Numbers per km^2 and total abundance in 1000's.

Year	Weight_km2	Stdev	Biomass	Number_km2	Stdev	Abundance
2008	129.2	216.1	1318.1	156.8	94.0	1600.1
2009	80.6	78.3	822.4	212.0	203.0	2162.9
2010	75.7	84.1	772.2	211.7	193.6	2160.1
2011	119.6	187.2	1220.0	224.1	175.9	2287.0
2013	232.8	330.8	2375.0	540.7	493.4	5517.1
2014	776.6	1450.1	7924.5	855.6	1299.1	8730.4
2015	919.1	1119.5	9378.6	563.3	495.8	5747.4
2016	487.8	562.3	4977.0	303.4	250.1	3095.6
2017	221.0	290.9	2255.0	344.9	244.9	3519.1
2018	63.4	99.6	646.8	86.3	86.0	880.2
2019	54.0	69.6	550.9	199.5	190.4	2035.9



Figur 2a. Biomass of cod per km^2, calculated as an average from all vessels per square.



Figur 2b. Abundance of cod per km^2, calculated as an average from all vessels per square.

Table 5: Stratum area (km^2), hauls, mean biomass and Stdev (kg/km^2) and total biomass (t).

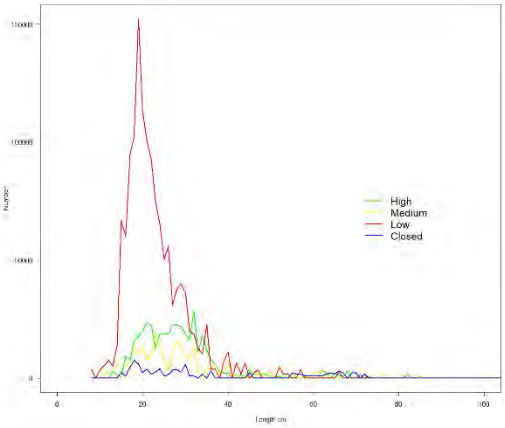
Strata	Area	Hauls	Mean_biomass_km2	Stdev	Biomass
Closed	686.00	8	116.50	168.00	79.90
High	1801.00	24	77.90	75.90	140.30
Medium	2229.00	21	42.50	47.60	94.60
Low	5488.00	28	37.00	30.40	203.20

Table 6: Stratum area (km^2), hauls, mean number and Stdev (N/km^2), and total abundance (1000's).

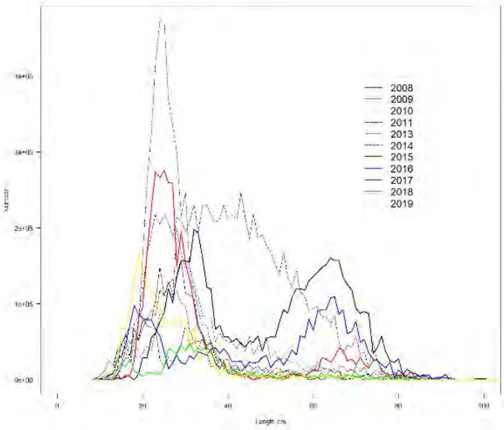
Strata	Area	Hauls	Mean_number_km2	Stdev	Abundance
Closed	686.00	8	128.30	120.00	88.00
High	1801.00	24	227.10	143.50	409.00
Medium	2229.00	21	114.40	82.10	255.10
Low	5488.00	28	247.20	243.70	1356.50

Length distribution

In 2019, the overall length distribution (weighted by stratum area) ranged from 8 to 85 cm with a distinct peak around 20 cm (young of the year cod). The highest densities of cod were found in the low density stratum (Figure 5). Raised length distributions for the entire survey period are shown in figure 6.



Figur 5. Cod length distribution by strata in 2019.



Figur 6. Cod length distributions in the total survey area by year, 2008-2019.

Age distribution

From 2008 to 2013 was the age distribution dominated by age class 1-4. The proportion of older fish (age 5 and 6+) increased in the catches from 2013 and peaked in 2015. Older fish continued to make up a relatively high proportion of the catches during 2016-2017 but decreased in 2018 even though they still made up a significant proportion of the biomass. In 2019 the older fish was virtually absent from the catches, decreasing to the lowest observed values since 2011. The number of recruits (age 0 and 1) which in 2018 was the lowest in the entire time series increased in 2019 and the number of age 0 cod is the highest observed since the start of the survey (table 7 & 8).

Table 7: Estimated numbers at age (in 1000's) in the survey area by year.

yy	a0	a1	a2	a3	a4	a5	a6
2008	621.9	538.7	181.7	115.5	74.6	44.3	23.5
2009	308.9	1696.8	83.6	20.9	20.1	22.7	9.8
2010	314.8	1155.1	655.7	24.2	4.4	4.6	1.2
2011	494.9	930.0	550.6	249.0	51.9	8.3	2.2
2013	240.4	2121.4	2138.2	643.9	309.8	54.8	8.6
2014	503.9	1474.7	2829.8	2364.2	955.4	421.6	180.8
2015	56.8	944.4	1293.3	1278.0	1077.3	702.9	394.7
2016	254.6	587.1	378.6	498.5	497.0	437.8	442.0
2017	31.5	1128.3	1138.3	732.8	160.5	149.7	178.0
2018	85.7	247.4	311.2	166.1	8.0	25.8	36.1
2019	704.5	673.8	387.9	199.3	58.1	8.8	3.5

Table 8: Estimated biomass at age (in tonnes) in the survey area by year.

yy	a0	a1	a2	a3	a4	a5	a6	total
2008	49.87	198.18	164.66	294.44	245.03	230.74	135.18	1318.10
2009	22.97	426.67	90.84	57.46	66.21	99.32	58.93	822.40
2010	17.97	277.30	380.30	51.92	25.28	14.99	4.43	772.19
2011	27.14	171.47	293.74	499.70	180.62	37.10	10.20	1219.96
2013	14.59	404.84	728.35	529.89	448.51	207.39	41.41	2374.99
2014	41.42	370.45	2039.16	2312.11	1616.10	1040.36	504.93	7924.54
2015	5.22	268.62	1106.28	2146.13	2416.09	2123.87	1312.39	9378.61
2016	12.32	84.53	290.55	761.84	1213.49	1253.85	1360.47	4977.05
2017	1.34	209.92	238.67	306.83	396.91	470.62	630.68	2254.97
2018	4.14	58.14	182.79	131.18	20.87	85.29	164.41	646.83
2019	51.56	133.49	127.82	148.01	56.53	24.66	8.81	550.87

CPUE
The survey swept area index from 2008 to 2019, estimated as the weighted mean catch in numbers at age per km^2 are shown in table 9.

Table 9: CPUE at age (N/km^2)

yy	a0	a1	a2	a3	a4	a5	a6	total
2008	60.94	52.79	17.80	11.32	7.31	4.34	2.31	156.81
2009	30.27	166.29	8.19	2.05	1.97	2.23	0.96	211.96
2010	30.85	113.20	64.26	2.37	0.43	0.45	0.11	211.69
2011	48.50	91.14	53.96	24.40	5.09	0.81	0.22	224.12
2013	23.56	207.90	209.55	63.10	30.36	5.37	0.85	540.68
2014	49.38	144.52	277.32	231.69	93.63	41.31	17.72	855.59
2015	5.57	92.55	126.74	125.25	105.57	68.88	38.69	563.25
2016	24.95	57.53	37.10	48.85	48.70	42.91	43.32	303.37
2017	3.09	110.58	111.55	71.82	15.73	14.67	17.44	344.88
2018	8.40	24.24	30.50	16.28	0.78	2.53	3.54	86.26
2019	69.04	66.03	38.02	19.53	5.69	0.86	0.34	199.52

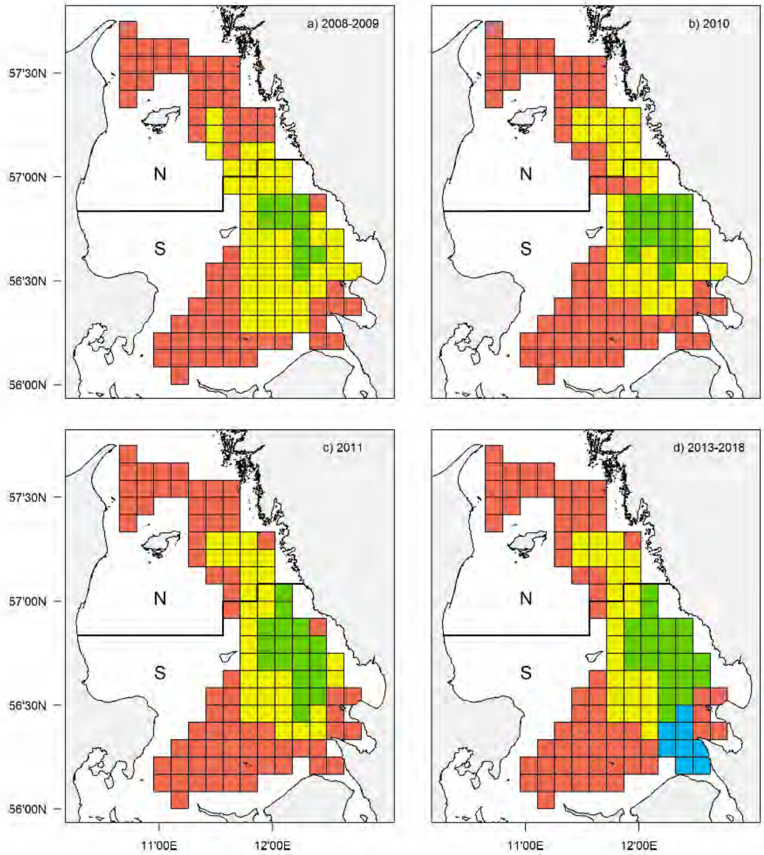
References

Gerritsen H, Mcgrath D, Lordan C, 2006. A simple method for comparing age - length keys reveals significant regional differences within a single stock of haddock (*Melanogrammus aeglefinus*). ICES J Mar Sci. 63:6 1096-1100.

ICES 2020. Manual for the North Sea International Bottom Trawl Surveys. Series of ICES Survey Protocols SISP x-IBTS X. 84 pp

Lumley T, 2020. Survey: analysis of complex survey samples. R package version 4.0.

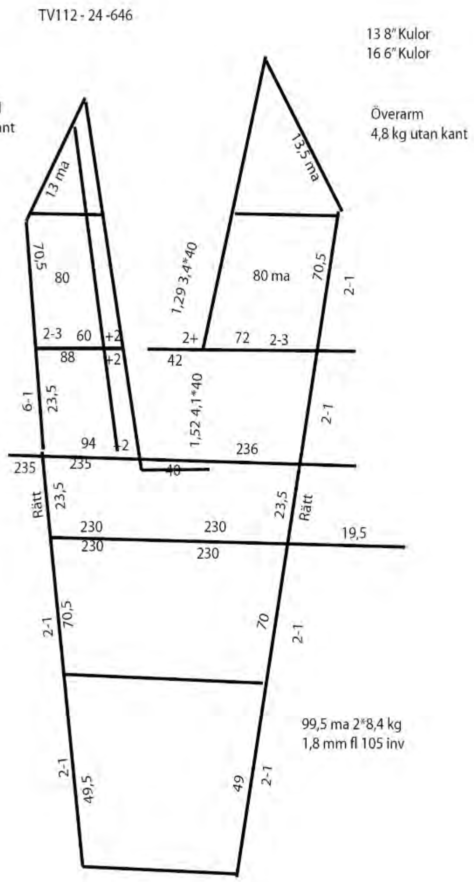
Annex 1. Survey stratification 2008 - 2019



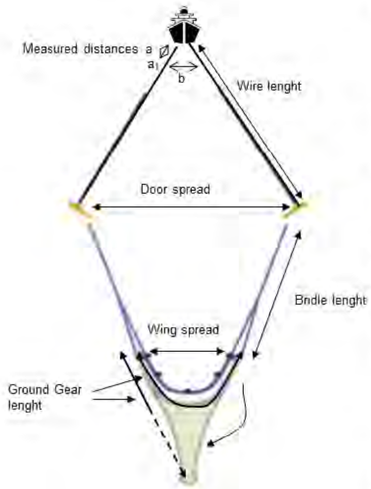
Figur 1a-d. The survey stratification 2008-2019. Green represents the high-density stratum; yellow the medium-density stratum and red the low-density stratum. In 2013 a fourth (blue) stratum was added to ensure sufficient sampling in the closed areas.

clearpage

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

$$\text{Door spread} = \frac{\text{Wire length x measured distance b}}{\text{measured distance a}}$$

For every haul, a length on the wire (distance a) and the length between the wires measured at a_1 (distance b) have been recorded.

Wing spread is estimated as:

$$\text{Wing spread} = \frac{\text{Ground gear length x Door spread}}{\text{Bridle length + Ground gear length}}$$

(Calculation from "Course in Trawl Gear Technology", May 2006, SeaFish Flume Tank, Hull, UK)

NOTE: Figure not according to scale

Annex 5: 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, 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.

	Title	Name
1	bwp.27.2729-32	Baltic flounder (*Platichthys solemdali*) in subdivisions 27 and 29–32 (northern central and northern Baltic Sea)
2	bwq.27.2425	Flounder (*Platichthys spp*) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic)
3	bwq.27.2628	Flounder (*Platichthys spp*) in subdivisions 26 and 28 (east of Gotland and Gulf of Gdansk)
4	dab.27.22-32	Dab (*Limanda limanda*) in subdivisions 22-32 (Baltic Sea)
5	her.27.25-2932	Herring (*Clupea harengus*) in subdivisions 25-29 and 32, excluding the Gulf of Riga (central Baltic Sea)
6	her27.28	Herring (Clupea harengus) in Subdivision 28.1 (Gulf of Riga)
7	her.27.3031	Herring (*Clupea harengus*) in subdivisions 30 and 31 (Gulf of Bothnia)
8	sol.27.20-24	Sole (*Solea solea*) in subdivisions 20-24 (Skagerrak and Kattegat, western Baltic Sea)
9	spr.27.22-32	Sprat (*Sprattus sprattus*) in subdivisions 22-32 (Baltic Sea)

Annex 6: Audit reports

Audit of Cod (*Gadus morhua*) in Subdivision 21 (Kattegat), cod.27.21

Date: 27.04.2020

Auditor: Tomas Zolubas, Uwe Krumme

General

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: survey trends based assessment
3) **Forecast**: not presented
4) **Assessment model**: SAM running by 4 surveys
5) **Data issues:** data available as described in stock annex
6) **Consistency:** the same procedure as last year
7) **Stock status:** Ref points are not defined but the SSB has declined since 2015 being at a historically low level in 2020.
8) **Management Plan:** NA

General comments

The advice sheet was well documented and ordered. It was easy to follow and interpret.

Technical comments

No specific comments. There were some smaller mistakes in the report. Observations and comments were sent to the assessor.

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 Dab (*Limanda limanda*) in subdivisions 22-32 (Baltic Sea), dab.27.22-32

Date: 19.04.2020

Auditor: S. Haase, U. Krumme

General

Information on stock status and historical trends have been provided.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: Survey trend-based assessment (biomass index)
3) **Forecast:** not presented since ICES has only been requested to provide stock status but not fishing opportunities for this stock.
4) **Assessment model:** NA
5) **Data issues:** Stock size indicator uncertain because mixing with dab in SD21 is unclear but significant seasonal movements are known
6) **Consistency**: NA
7) **Stock status**: Length based indicators (LBI) as developed by WKLIFE (2015) indicate that large dabs are still missing from the stock (P_{mega}=0.25, expected >0.3). In the most recent year overfishing of immature individuals is indicated (L_c/L_{mat}=0.53, expected >1).
8) **Management Plan**: No management plan for this stock

General comments

This was a well-documented, well-ordered and considered section. It was easy to follow and interpret.

Technical comments

The assessment is performed according to the stock annex.

Conclusions

The assessment has been performed correctly. Stock separation between dab2232 and dab in the Kattegat may be evaluated.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  Yes
- Is the assessment according to the stock annex description?
  Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
  No management plan for this stock
- 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 Flounder (*Platichthys flesus*) in subdivisions 27 and 29-32 (northern central and northern Baltic Sea), fle.27.2729-32

Date: 18.04.2020

Auditor: Didzis Ustups, Victoria Amosova

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) **Management 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 correspond to the order of reference.

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 management plan for this stock
- 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 Flounder (*Platichthys flesus*) in subdivisions 22 and 23 (Belt Seas and the Sound), fle.27.2223

Date: 21.04.2020

Auditor: Marie Storr-Paulsen

General

For single stock summary sheet advice:

1) **Assessment type:** update/SALY
2) **Assessment**: trends
3) **Forecast**: not presented
4) **Assessment model**: tuning by 3 comm + 2 surveys
5) **Data issues:** Due to a coding problem in DATRAS survey data were first available during the meeting.
6) **Consistency**
7) **Stock status**: shows stock being above possible reference points
8) **Management Plan**: There is no management plan for this stock

General comments

This stock is not having an advice but an update on stock status. This was a well-documented, well-ordered and considered section. It was easy to follow and interpret. The survey index showed a decrease since 2016 and is at a low level. However, most of the possible reference points (LBI) show that stock status of fle.27.2223 is above these and in a good status.

Technical comments

Some minor typing errors were detected in the report and corrected accordingly.

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 management plan
- Have the data been used as specified in the stock annex? yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? Survey trend only
- 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? No advice this year

Audit of Herring (*Clupea harengus*) in Subdivision 28.1 (Gulf of Riga), her.27.28

Date: 24.04.2020

Auditor: Olavi Kaljuste, Pekka Jounela

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 relying 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 (category 1)
3) **Forecast**: presented
4) **Assessment model**: XSA – tuning by 1 commercial CPUE (trapnet) + 1 acoustic survey indices
5) **Data issues:** Data available in data folder of SharePoint, SPALY done in accordance of stock annex.
6) **Consistency**: The assessment is consistent with last year's assessment (setup and assumptions). Retrospective pattern shows clear underestimation of SSB and overestimation of F. In certain years, even underestimation of R. Some year effects are evident from the residual plots of the tuning series.
7) **Stock status**: SSB is well above MSY $B_{trigger}$, B_{PA} and B_{lim}, F is below F_{msy} and well below F_{PA} and F_{lim}.
8) **Management Plan**: advice according to the MAP.

General comments

This was a well-documented, well-ordered and considered section. It was easy to follow and interpret.

Technical comments

Advice looks fine – no comments there.

There a couple of smaller mistakes in the report (have added my comments to the text file in the SharePoint).

Have checked even stock annex and added my comments there as well (SA is attached to my mail).

Found one serious contradiction between stock annex, report and forecast. Namely, the F_{PA} and F_{lim} values are much lower in the stock annex compared to report and forecast.

Additionally, it is not very clearly described in the stock annex, that the last year is excluded from the calculation of geometric mean of recruitment.

A few comments and suggestions about the wording in the text were added to the report

Conclusions

The assessment has been performed correctly.

Exploratory SAM runs have been performed in parallel with the XSA and show similar results. XSA estimates are 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?

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 (Pleuronectes platessa) in subdivisions 21-23 (Kattegat, Belt Seas, and the Sound), ple.27.21-23

Date: 22.04.2020

Auditor: Jari Raitaniemi

General

For single stock summary sheet advice:

The advice has been reduced for 2021 mainly due to a change in the basis for the advice (from precautionary approach to MSY approach). The assessment is based on two surveys (Q1 and Q4), which gave very different abundances for the stock in 2019. The common opinion in the group was that Q4 did not show the real situation because of anoxic conditions in the area at the time of survey, i.e. the plaice had probably migrated to better areas. Thus, the stock may be more abundant than advice draft shows. However, there is also uncertainty in Q1 survey index because of some age readings lacking. The "Leave one-out analysis" (SAM) shows that the combined Q3-Q4 survey is what drives the decrease in SSB and increase in F relative to the 2019 assessment.

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: SAM
5) **Data issues:** Stock annex not available at the time of auditing
6) **Consistency**: SAM used like in the previous year. The large decrease in the 2019 Q4 survey index in the SPALY assessment has led to a revision of the recent history of the stock status. Therefore, the perception of the stock differs significantly from last year, with a downward estimation of SSB and of 2017 and 2018 recruitment, as well as an upward estimation of fishing mortality. This assessment has retrospective fit issues.
7) **Stock status**: B>MSY$B_{trigger}$, F_{MSY}<F<F_{pa}, R good in recent years except in 2019 lower than average
8) **Management Plan**: MAP applied.

General comments

This was a well-documented, well-ordered and considered section. It was easy to follow and interpret.

Technical comments

Conclusions

The assessment has been performed correctly; however, a choice needs to be made concerning the Q4 survey results.

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? No stock annex available
- 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 (and corresponding to F_{MSY})
- Have the data been used as specified in the stock annex? No stock annex available.
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? No stock annex available.
- 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 (*Pleuronectes platessa*) in subdivisions 24-32 (Baltic Sea, excluding the Sound and Belt Seas), ple.27.24-32

Date: 21.04.2020

Auditor: Anastasiia Karpushevskaia, Maris Plikshs

General

For single stock summary sheet advice:

1) **Assessment type:** analytical/update
2) **Assessment**: SAM and additionally the surplus production model (SPiCT)
3) **Forecast**: not presented
4) **Assessment model**: SAM + 2 tuning fleets
5) **Data issues:** The data are available as described in stock annex. Some DATRAS data were updated since 2017.
6) **Consistency**: assessment is consistent with previous year's assessment. Additionally, SAM and SPiCT reveals similar stock trends.
7) **Stock status**: The recruitment and SSB is an increasing since 2013. The relative fishing mortality has been declining in recent years although it increased in 2019.
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

Some problems from DATRAS data were detect at the beginning. The numbering of the figures and tables in the report text correspond to the order of reference.

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 management plan for this stock**
- 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 Plaice (*Pleuronectes platessa*) in subdivisions 21-23 (Kattegat, Belt Seas, and the Sound), ple.27.21-23

Date: 01.05.2020

Auditor: Jesper Boje

General

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented, now based on MSY, previously F_{pa}
4) **Assessment model**: SAM
5) **Data issues:** maturity at age yr. avg changed from SA (see below). New method to calculate weight at age (applied in 2019) not in accordance with SA.
6) **Consistency**. No change in methodology. Large retro pattern are resident for this stock, under est. of F and over est. of SSB. Mohn's rho outside +-20% range.
7) **Stock status**: SSB>$B_{trigger}$ and F_{pa}>F>F_{msy}
8) **Management Plan**:

General comments

This was a well-documented, well-ordered and considered section. Modifications in assessment input and settings made in 2019 and 2020 should be inserted into the SA.

Technical comments

Maturity at age: Check with SA, where there B.2.1 notes that 2020 to present is used. All other places it is 199-present.

The huge retro pattern is partially caused by the Q3-4 IBTS survey. The inclusion of this index should be evaluated.

F_{msy} lower and upper are defined by other values in SA than provided in catch option table in advice sheet. (lower 0.18 vs 0.19 and upper 0.31 vs 0.50).

Catch option table: (Table 3): something is wrong with options F_{MSY} upper and lower ranges: the F_{msy} lower gives a lower SSB in 2022 than F_{msy} and similar opposite for F_{msy} upper. Should have been opposite. Either the code in SAM or output interpretation is not correct. Guess the forecast code need unique options for upper and lower.

Conclusions

The assessment has been performed correctly; however, the catch option table should be checked for F_{msy} upper/lower options.

SA should be checked for 2019 updates in assumptions etc. made for the assessment. Present available SA is from April 2019 by C.Ulrich.

Future benchmarks should include validity of biomass indices input

Audit of Sole (*Solea solea*) in subdivisions 20-24 (Skagerrak and Kattegat, western Baltic Sea), sol.27.20-24

Date: 23.04.2020

Auditor: Kristiina Hommik, 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. Three tuning fleets: DTU Aqua-Fisherman survey (2004-2011, 2014-2019); 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 below F_{MSY}, F_{pa} and 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 enables 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 Turbot (*Scophthalmus maximus*) in subdivisions 22-32 (Baltic Sea), tur.27.22-32

Date: 20.04.2020

Auditor: Jari Raitaniemi

General

For single stock summary sheet advice:

No advice in 2020.

1) **Assessment type:** update of stock status (no advice)
2) **Assessment:** trends
3) **Forecast**: not presented
4) **Assessment model**: mean abundance index, data limited approach
5) **Data issues:** Stock Annex not available at the time of auditing
6) **Consistency**: Consistent
7) **Stock status**: above possible reference points
8) **Management Plan**: None

General comments

This was a well-documented, well-ordered and considered section.

Technical comments

- 8.1.1 Something missing: "Poland, Russia and Sweden are the main fishing countries in the Eastern and landed about…"
- 8.1.2 were remarkable better… should be remarkably better
- 8.1.3: *The index of 2019 decreased compared to the previous year, but is still on a low level (~3.43 turbot/hour)*. Could you clarify this? (decreased, but is still at a low level)

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? No stock annex available.
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
- Have the data been used as specified in the stock annex? No stock annex available.
- 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? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? No advice.

Audit of Brill (*Scophthalmus rhombus*) in subdivisions 22-32 (Baltic Sea), bll.27.22-32

Date: 20.04.2020.

Auditors: A. Karpusshevskaia, T. Raid

General

Information on stock status and historical trends have been provided.

For single stock summary sheet advice:

1) **Assessment type:** update assessment
2) **Assessment:** Survey trends-based assessment
3) **Forecast**: not presented since ICES has not been requested to provide fishing opportunities for this stock.
4) **Data issues:** Data well described and following the Stock Annex.
5) **Consistency : A considerable downscaling of the biomass**
6) **Stock status:** Stock size index has shown increasing trend since 2016. The biomass and fishing pressure reference points have not been defined for that stock.
7) **Management Plan**: No agreed management plan for that stock.

General comments

This is a well-documented, well-ordered and considered section. It was easy to follow and interpret.

Technical comments

None

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 (*Gadus morhua*) in subdivisions 22-24, western Baltic stock (western Baltic Sea), cod.27.22-24

Date: 20.04.2020

Auditor: Jan Horbowy, Victoriia Amosova

General

The major problem encountered in the assessment performed according to the stock annex (SPALY assessment) was much lower estimate of catches in terminal year than reported by fishery (fishery reported 42% higher catches then estimated in the assessment model). Stock assessors extensively investigated the problem by both alternative data configurations and parameterization of assessments. The option in which CV of the catches was assumed at 10% gave more realistic fit of the model catches to observation in terminal year; however, that option deviated somewhat from parameterization specified in the stock annex. The group after long discussions decided to keep SPALY assessment as the basis for advice, although 42% "overeporting" of cod catches compared to the model is difficult to explain.

For single stock summary sheet advice:

1) **Assessment type:** update (Benchmarked in 2019)
2) **Assessment**: analytical (category 1 stock)
3) **Forecast**: presented
4) **Assessment model**: Age-based analytical assessment SAM that uses catches (landings, discards, and recreational catch) in the model and in the forecast. Three survey indices: FEJUCS (age 0), BITS-Q1, and BITS-Q4.
5) **Data issues:** the usage of data followed procedure described in SA. All data were made available and corresponding to data indicated in SA.
6) **Consistency**: data and model used are consistent with benchmark 2019 and assessment performed in 2019. The SSB development is heavily depended on a single strong year class increasing the uncertainties in the assessment.
7) **Stock status**: The SSB is driven by strong 2016 y-c, next y-c are week. Under F_{msy} the SSB in 2021-22 is predicted to be above Bpa (= MSY Btrigger). F in recent years was above F_{msy} but below F_{pa}.
8) **Management Plan**: The EU multiannual plan (MAP) that includes cod is in place for stocks in the Baltic Sea (EU, 2016). The F_{MSY} ranges, specified in the Plan are considered precautionary.

General comments

This was a well-documented, well-ordered and considered section. Extensive data from several sources were used.

Technical comments

The assessment and forecast has been done following procedure agreed at benchmark 2019.

Conclusions

The assessment has been performed according to the stock annex.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? 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? The discrepancy between catches in 2019 reported and estimated by the model could give the reason for some deviation, but finally assessment was performed as described in SA.
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes, although advice may be conservative.

Audit of Flounder (*Platichthys flesus*) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic), fle.27.2425

Date 19.04.2020
Reviewer: S. Haase, T.Raid

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 for individuals ≥20 cm
3) **Forecast:** not presented since ICES has not been requested to provide fishing opportunities for this stock.
4) **Assessment model:** n/a
5) **Data issues:** Sampling coverage of discards differs between years and subdivisions and in 2019 was slightly worse than those obtained in 2018. However, the usage of data followed procedure. All data are made available and the information is corresponding to Stock Annex.
6) **Consistency:** n/a
7) **Stock status:** below F_{MSY} proxy; in the most recent year overfishing of immature individuals is indicated (L_c/L_{mat}=0.8, expected >1).
8) **Management 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

NA

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

- 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 Flounder (*Platichthys flesus*) in subdivisions 26 and 28 (east of Gotland and Gulf of Gdansk), fle.27.2628

Date: 27.04.2020
Auditor: Ivars Putnis, Jukka Pönni

Prepared for: ADG, ACOM, benchmark groups and EG next year.

General

The assessment has been conducted according to the updated stock annex. The assessment could benefit if all countries would use recommended ageing methods.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment:** Category 3. Stock trend model based on scientific surveys (Baltic International Trawl Survey BITS–Q1 and Q4). The stock status was evaluated by calculating length-based indicators
3) **Forecast**: not presented
4) **Assessment model:** n/a
5) **Data issues:** Data were available as tables and figures in the report. Part of the age data was rejected due to non-accepted age-reading method used in SD 26
6) **Consistency**: n/a
7) **Stock status:** F below F_{MSY}, F_{pa} and F_{lim}. The survey stock size indicator indicates that the stock abundance is estimated to have increase between 2015–2017 (average of the three years) and 2018–2019 (average of the two years)
8) **Management Plan**: Bycatch of this species is taken into account in the EU Multiannual Plan 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

According to WG presentation, there was a significant increase in flatfish effort in Estonia in 2019 and it was suggested to exclude this country-specific data from the analysis. However, this is not described and justified in the report.

According to stock annex, weight at length was estimated as an average weight at length for data from 1991-2013 (calculation of Biomass Index from BITS surveys). The calculation would benefit by including data from the recent years available in DATRAS.

There are some smaller mistakes in the report and stock annex – have sent our comments to the stock assessor.

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?
  n/a

- 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 Herring (*Clupea harengus*) in subdivisions 30 and 31 (Gulf of Bothnia) (Gulf of Bothnia), her.27.3031

Date: 24.04.2020

Auditors: T. Zolubas and S.Neuenfeldt

General

Information on stock status and historical trends has been provided.

For single stock summary sheet advice:

1) **Assessment type:** In 2020, the stock was temporarily downgraded in category 5, thus no assessment was conducted
2) **Assessment**: None.
3) **Forecast**: not presented since no assessment was conducted.
4) **Data issues:** Data well described and following the Stock Annex.
5) **Consistency**: In 2020, the stock was temporarily downgraded in category 5, thus biological information was not used.
6) **Stock status**: Catches have been declining since 2017. Biomass and fishing pressure reference points have not been defined for that stock.
7) **Management Plan**: No agreed management plan for that stock. The advice was based on the one provided in 2019.

General comments

This is a well-documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

None

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 Sprat (*Sprattus sprattus*) in subdivisions 22-32 (Baltic Sea), spr.27.22-32

Date: 27.04.2020

Auditor: Margit Eero, Ivars Putnis

Prepared for: ADG, ACOM, benchmark groups and EG next year.

General

The assessment has been conducted according to the stock annex as an update assessment. The present assessment is based on new natural mortality data from the multispecies model (SMS) and updated reference points, introduced at interbenchmark in March 2020.

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: Age-based analytical assessment (XSA-tuning by 2 acoustic surveys)
5) **Data issues:** Data provided as tables and figures in the SharePoint Report folder.
6) **Consistency**: The 2020 assessment is consistent with 2019 assessment and was accepted both years.
7) **Stock status**: The spawning-stock biomass (SSB) is well above MSY $B_{trigger}$. The increase in SSB in 2016-2017 is was attributable to the strong year class of 2014. The 2015–2018 year classes are at below or close to average, and 2019 year class is above average. Fishing mortality (F) has remained above F_{MSY} since 2002.
8) **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. There are some smaller mistakes in the report – comments were sent to the stock assessor.

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 (*Gadus morhua*) in subdivisions 24-32, eastern Baltic stock (eastern Baltic Sea), cod.27.24-32
Date: 24.04.2020
Auditor: Zeynep Hekim and Johan Lövgren

Prepared for: ADG, ACOM, benchmark groups and EG next year.

General
The main features of this (stock change in growth and large natural mortality) is captured well by the Stock Synthesis model applied as assessment model to this stock. The implemented approach uses several types of data ranging from ichtioplankton, egg surveys and traditional stock assessment input data.

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical and fully stochastic model
3) **Forecast**: presented
4) **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
5) **Data issues:** the usage of data followed the Stock Annex
6) **Consistency**: The 2020 assessment is accepted and is consistent with 2019 assessment.
7) **Stock status**: SSB<Blim, 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 remains at historical low levels. Fishing mortality is low but natural mortality remains at high levels. Larval abundances from ichthyoplankton surveys in 2018 were among the lowest observed, while 2019 value is similar to larval abundances in 2014-2015.
8) **Management Plan**: EU multiannual plan (MAP) that includes cod is in place for stocks in the Baltic Sea (EU, 2016). However, F_{MSY} 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 performed following the procedure in 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

Audit of Central Baltic Herring (*Clupea harengus*) in subdivisions 25-29 and 32, excluding the Gulf of Riga (central Baltic Sea), her.27.25-2932

Date: 24.04.2020

Auditor: Zeynep Hekim and Maris Plikshs

Prepared for: ADG, ACOM, benchmark groups and EG next year.

General

The assessment have been conducted according to the stock annex as an update assessment. The inter-benchmark provided updated natural mortalities by SMS that were included in the assessment run. The interbenchmark results lead to a downward revision of SSB and upward revision of fishing mortality.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: XSA + tuning with one survey (BIAS autumn survey); an exploratory SAM.
5) **Data issues:** Data available in data folder of SharePoint, assessment done in accordance of stock annex.
6) **Consistency**: New natural mortality estimates (1974-2018) obtained from a new SMS run in November 2019. The assessment in 2020 was run with the new natural mortalities and accepted. XSA and SAM results are consistent for period since year 2000.
7) **Stock status**: The spawning stock biomass is above B_{lim} and B_{pa} but just below MSY $B_{trigger}$. Fishing pressure on the stock is above F_{MSY} and F_{pa} but below and F_{lim}
8) **Management Plan**: EU Multi-annual Management Plan (MAP).

General comments

Species misreporting of herring has occurred in the past and there are again indications of sprat being misreported as herring. These effects have not been quantified but may affect the quality of the assessment.

Technical comments

No specific comments.

Conclusions

The assessment has been performed correctly and described in a clear way.

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

Annex 7: WGBFAS 2020 Recommendations

Target Group	Recommendation
WGBIFS	WGBGFAS recommends WGBIFS to thoroughly scrutinize the acoustic survey index calculation for herring in SDs 30-31. Ultimately, the relevant survey data must be uploaded into the ICES database for acoustic-trawl surveys and the StoX software should be applied for the calculation of estimates for a transparent reproducible pathway in TAF.
WGDG	WGBGFAS recommends WGDG (Working Group DATRAS Governance) to make it possible for member states to include oxygen concentration into the DATRAS database. As of now, there is only possibility to upload salinity and temperature into the DATRAS database.
WGBIFS and WGIBTS	WGBGFAS recommends the survey working groups, WGBIFS and WGIBTS, to include abiotic conditions when they evaluate the survey quality and comment if/or there are any abiotic abnormalities compared to the previous year's survey.
ICES Data Centre	WGBFAS recommends that surveys conducted one year before the assessment year, be uploaded to the ICES databases (DATRAS/acoustic-trawl survey) with **1 February** as deadline. Data from these surveys, which are presently not incorporated in an ICES databases, should be sent to the stock coordinator/assessor due with the same deadline. This will ensure data quality checking by WGBIFS and WGBFAS in good time before the assessment period starts. This deadline is recommended to be included in the data call sent by ICES. ICES Data Centre should provide WGBIFS and WGIBTS with the indices for the assessment of cod (Cod in SD 22-24, Cod in SD 24-32, Cod in Kattegat) and flatfish (Flounder in SDs 22–23, Flounder in SDs 24–25, 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, Plaice in SDs 21–23, Plaice in SDs 24–32, Sole in Division 3.a, SDs 20–24) stocks, which are based on the data from BITS and IBTS surveys conducted in the previous year, by **1 March**. This would allow the survey working groups to perform a verification of the indices to detect potential irregularities and avoid late detection of errors in the index calculations. Surveys to be sent by the **1 February** includes: BASS IBTS Q3 FFS: Sole survey CodS_Q4: Cod survey FEJUCS: poundnet survey- BITS Q4
ACOM	*Several of the assessments presented at WGBFAS had retrospective patterns and calculated Mohn's rhos at or exceeding the ICES defined limit of 20%. This comment is intended to summarize the discussions that took place at the meeting. Concerns were raised about both the definition of Mohn's rho and the general application of the 20% rule of thumb, but the main concern is that including a quantitative threshold only for retrospective pattern is unbalanced, and could likely lead assessments where the model's description of the observations (model fit) has been sacrificed or deteriorated to get less retrospective pattern.* Mohn's rho is defined and calculated by taking the final assessment using all data available, and then successively dropping the most recent 1, 2, 3, 4, and 5 years and re-running the model with the reduced data. For each of the five reduced runs, their final year's estimate is compared to the corresponding estimate from the assessment using all data. Finally, the average of these five relative biases is computed. Concerns were raised about both the definition of Mohn's rho and the general application of the 20% rule of thumb, but the main concern is that including a quantitative threshold only for retrospective pattern is unbalanced and could likely lead assessments where the models description of the observations (model fit) has been sacrificed or deteriorated to get less retrospective pattern. The first thing we notice about this definition is that it is computed completely from the model output, by comparing model output to model output. A consequence of this is that it is simple to construct a model to get a Mohn's rho of 0%. A model that returns the same estimate always—independent of

Target Group	Recommendation
	data—has Mohn's rho of 0%. A slightly less obvious consequence is that if a model is modified such that the influence of data on the results is reduced, then Mohn's rho will generally be reduced, as the model becomes less responsive. Retrospective analysis is not a standard technique, especially not in the analysis of time-series, where normal practice would be to compare models based on their prediction performance. Many assessment models are either deterministic or require year-specific model parameters, which prohibit forward projection or require additional assumptions to do forward projections. Hence, this practice of retrospective performance evaluation was introduced. A standard validation measure for statistical models is model residuals. Model residuals measure the difference between observations and model predictions. Often the residuals are standardised to simplify validation against a standard normal distribution. If a model is modified such that the influence of data is improperly reduced, then the residuals will reveal that the model is no longer correctly describing data. Quantitative testing and thresholds exist for the analysis of the residuals of any model and have been recently used in stock assessment models to evaluate randomness in time-series residuals, and they should be used routinely in addition to retrospective and others diagnostics. The introduction of the 20% rule of thumb limit is based on Hurtado-Ferro *et al*. (2014), and within the paper are listed some limitations to its utility, one of which is for uncertain survey information. This may be particularly relevant for WGBFAS as reasonable doubts expressed about the IBTS quarter 4 survey in particular for the stocks using it. In addition, it is important to notice that the analysis in the paper was carried out for SSB and not for F and R, while ICES has the tradition to apply the 20% rule of thumb limit also to the F and R. Finally, the limits reported in Hurtado-Ferro *et al*. (2014) are different from the 20% ICES rule of thumb rule across stock typology and direction of the bias. A related issue raised is if the last year is extreme, then the retrospective measure (Mohn's rho) is—possibly unduly—influenced by that because it measures the differences from the reduced fits to the one using all years. However, having one extreme should be qualitatively different from having a systematically biased assessment. Even assuming Mohn's rho was measuring systematic bias in an optimal way—and even assuming the 20% was exactly the correct limit to identify significant bias—it would be unbalanced to put a quantitative limit on the retrospective distance, but leave the model misfit as a qualitative judgment. This simply shifts the assessment scientists' focus to reducing retrospective bias, possibly at the cost of poorer fit to the observations. As explained above, it is simple to sacrifice model fit and to reduce retrospective bias. Residual diagnostics is better understood, and it would be simpler to construct valid quantitative boundaries for the residual misfit; so if ICES is confident in setting up limits for retrospective patterns, then it should be more confident in setting up limits for residual summaries. This would be more balanced and strengthen confidence in the model validation put forward. Carvalho *et al*. (2017) tested several new and existing diagnostics and they found that no single diagnostic worked well in all cases. Instead, they recommended the use of a carefully selected range of diagnostics, which can increase the ability to detect model misspecification. Maunder and Piner (2017) developed a methodology based on several diagnostic tests to guide the construction of stock assessment models and reduce model misspecification evidenced by data conflicts. The recommendation is that retrospective is not used in a prescriptive way to validate or invalidate a model, but that a toolbox of diagnostics is developed and agreed by ICES, which would guide working groups in the model construction and model validation in the future. **References** Carvalho, F., Punt, A. E., Chang, Y. J., Maunder, M. N., & Piner, K. R. (2017). Can diagnostic tests help identify model misspecification in integrated stock assessments?. Fisheries Research, 192: 28-40. Hurtado-Ferro, F., Szuwalski, C. S., Valero, J. L., Anderson, S. C., Cunningham, C. J., Johnson, K. F., & Ono, K. (2014). Looking in the rear-view mirror: bias and retrospective patterns in integrated, age-structured stock assessment models. ICES Journal of Marine Science, 72(1): 99-110. Maunder, M. N., & Piner, K. R, 2015. Contemporary fisheries stock assessment: many issues still remain. ICES Journal of Marine Science, 72(1): 7-18.

Target Group	Recommendation
ICES Data Centre	Survey data of the BITS are uploaded in mid-February to the DATRAS database. However, MS are permanently re-uploading data throughout the year, which includes not only the most recent data sets, but also historical data. So far, changes in the DATRAS database are only visible via an unspecified upload log (Fig. 1), which does not give information if a stock coordinator needs to download these data to re-calculate survey indices or biological parameters. DATRAS data submitter can fill out a comment section, but this is not always used or comments are too unspecified.

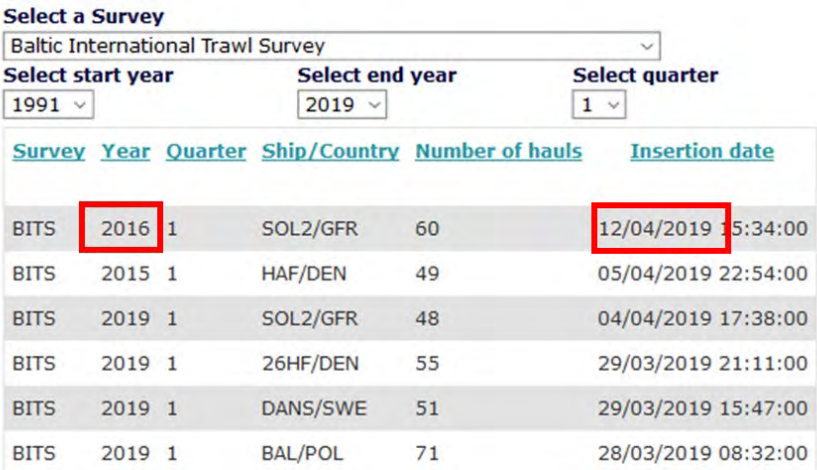


Figure 1. Example of a re-submission of a BITS dataset (2016 data uploaded in 2019), with no specification on what has been changed within the data

To make it easier for stock coordinators and assessors, the working group suggests that DATRAS should feature a designated area for stock coordinators and stock assessors (e.g. via ICES username login) on the webpage, which holds information of relevant changes to the respective stock.

Changes should only be listed if they have a direct effect on the data that are used for the assessment for the specific stock (e.g. the stock assessor and coordinator of flounder in SDs 22-23 should only see changes made to data that in the end influence the stock. Changes made for e.g. dab in SDs 22-23 or flounder in S D24 should not be listed for these persons). This can be the case if either relevant data (in HH, HL or CA) or the underlying method of calculation (for CPUE) has been changed.

Changes made by data submitter

Table	Field	Change/Threshold	Comment / notification
HH	Quarter	Added / removed	only notify, if HL/CA information for the stock are affected
HH	Gear	changed	TVS/TVL changes. Only notify, if HL/CA information for the stock are affected
HH	StNo	Added/removed	only notify, if HL/CA information for the stock are affected
HH	HaulNo	Added/removed	only notify, if HL/CA information for the stock are affected
HH	Year	Added/removed/changed	only notify, if HL/CA information for the stock are affected
HH	Month	Added/removed/changed	only notify, if HL/CA information for the stock are affected
HH	StatRec	Added/removed/changed	only notify, if HL/CA information for the stock are affected

Target Group	Recommendation			
	Table	**Field**	**Change/Threshold**	**Comment / notification**
	HH	HaulVal	Valid/Invalid	only notify, if HL/CA information for the stock are affected
	HL	SpecCode	Added/removed	Respective species has been added/removed from this stratum
	HL	LngtClass	Added/re-moved/changed	Additional lengths or lengths has been removed
	HL	HLNoAtLngt	Increased/decreased	Sampled numbers changed
	CA	SpecCode	Added / removed	Species has been added/removed from that dataset
	CA	AreaCode	changed	Rectangle changed
	CA	LngtCode	Unit change	Unit for the length has been changed
	CA	LngtClass	Increased/decreased	Ind sampled weight changed
	CA	Sex	Changed	Additionally: Codes should be unified here (M/F or 1/2, not a mix)
	CA	Maturity	Changed	Additionally: codes/scales should be unified here (I-X, 1-8, 1-10, not a mix)
	CA	AgeRings	Changed /added/re-moved	Age has been changed (ne wage reading) or a data point has been re-moved (or replaced by -9) or added (-9 into a real age)
	CA	CANoAtLngt	Increased/decreased	Sampled numbers changed
	CA	IndWgt	Increased/decreased	Ind sampled weight changed

Changes made by DATRAS data centre

Any changes made to the system or in the calculation (of abundance, CPUE, bootstrap, etc.) should be shortly reported and explained (if it concerns the respective stock.). Whenever the „DateofCalcula-tion“ field in the data products changes, it should be given a short explanation.

If these updated or re-calculations concern all stocks, this can also be a general information for every stock coordinator and assessor, (e.g. “new ICES rounding rules [ICES, 2018a.] have been applied to the calculation of the ALK for all stocks and years. This may results in minor changes [<1% change] in the output“).

Annex 8: Ecosystem and fisheries overviews

The Baltic Fisheries Assessment Working Group (WGBFAS) addressed the Generic Terms of Reference (ToRs) for Regional and Species Working Groups a) and b) and these overviews will be sent to and reviewed by the ICES Secretariat.

June 2020 update:

Further input to the Fisheries overviews.

In the generic ToRs, WGBFAS 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.

Fisheries overview (updated in June 2020)

Small pelagics

In the Baltic Sea the small pelagic fisheries are targeting sprat and herring. When the landings for the two species are combined the main part of the landings is in SD 25 and 26 and is mainly sprat. The third most important SD is 30 and this fishery is mainly the Bothnian Bay herring (Fig. A). In figure B, the importance of landings by area and country are shown.

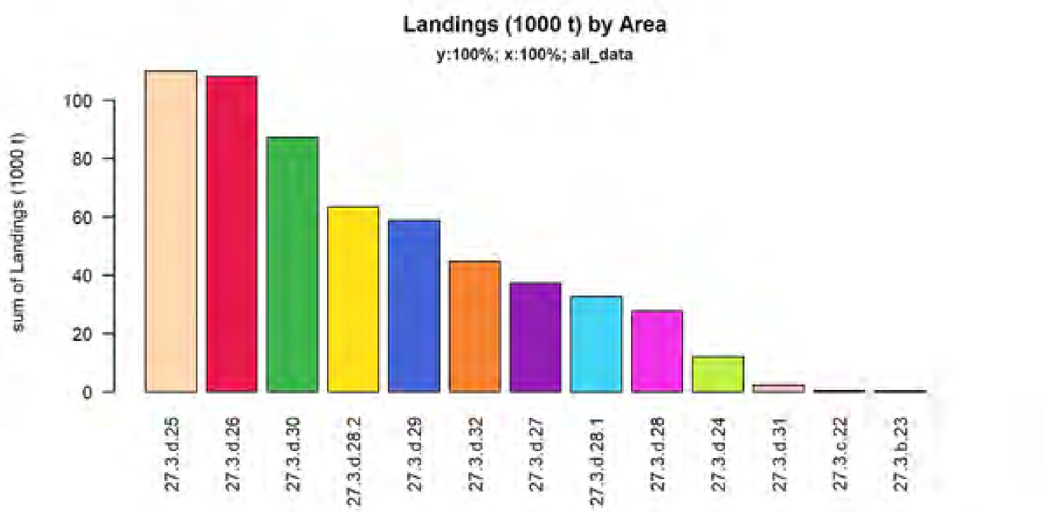


Figure A. Landings of small pelagics (in 1000t) by SD. Ref. RCG 20201.

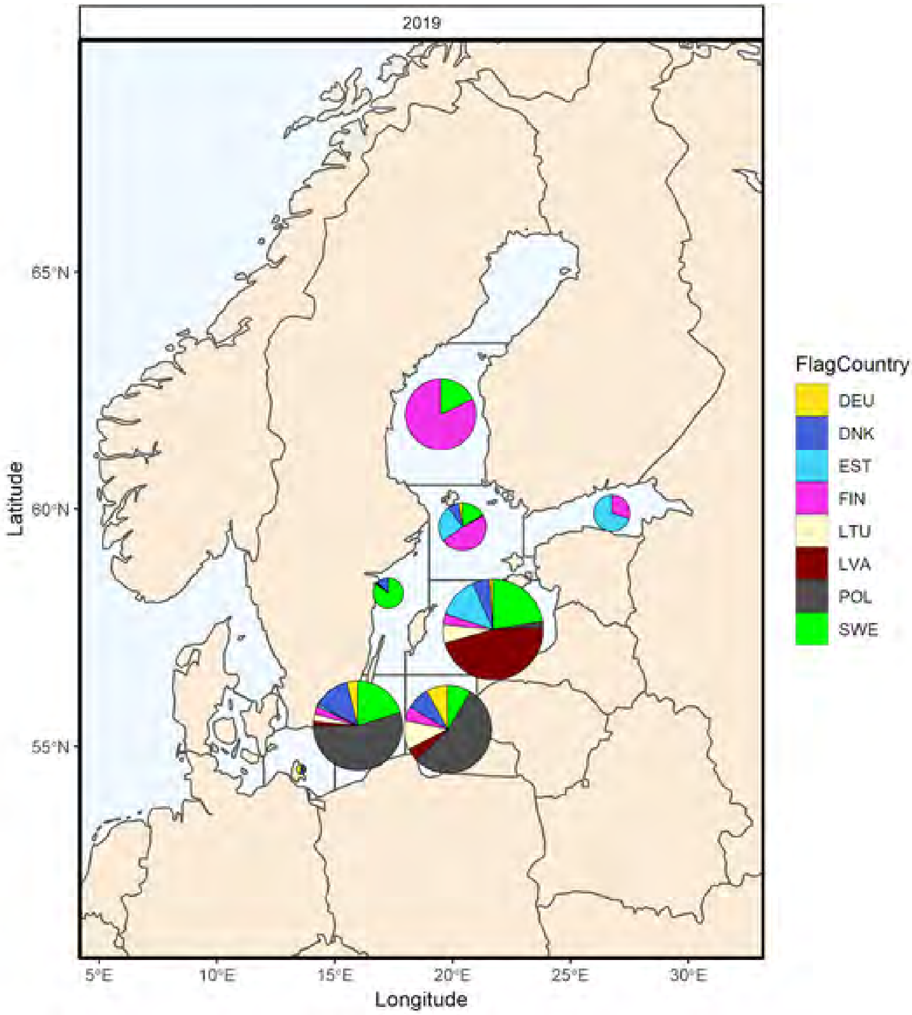


Figure B. Proportion of Landings by Country for each Subdivision (small pelagics). The size of the circles is proportional to total landings in the area. Ref. RCG 2020.

Landings by area, demersal

Landings of demersal fish in the Baltic Sea come mainly from the cod fishery. The cod fishery is mainly conducted in the southern part of the Baltic Sea SD 22-26 (Fig C). Landings by area and country are shown in figure D. and indicate that Denmark and Germany have the main part of the landings in the western Baltic and Poland has the main part of the landings in the eastern Baltic Sea.

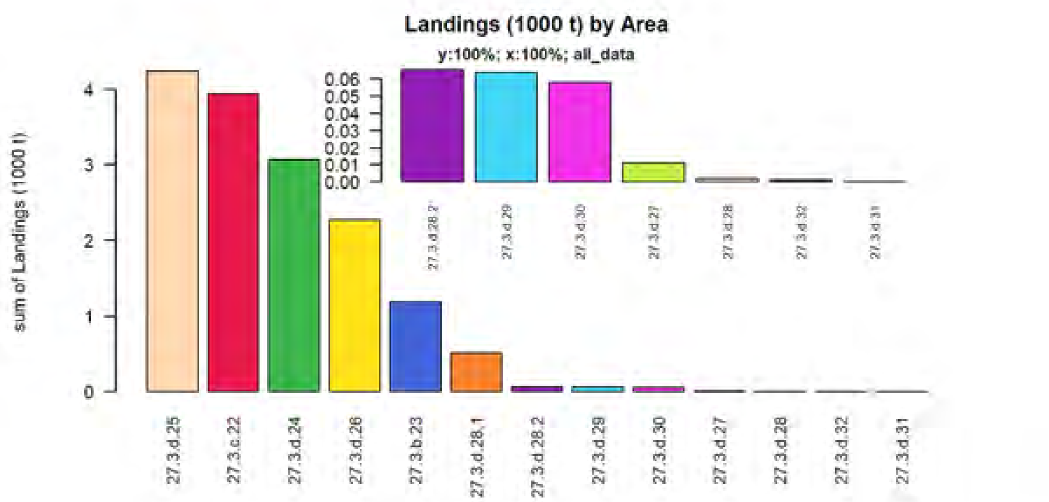


Figure C. Demersal landings (in 1000 t) by Area (SD). Ref. RCG 2020.

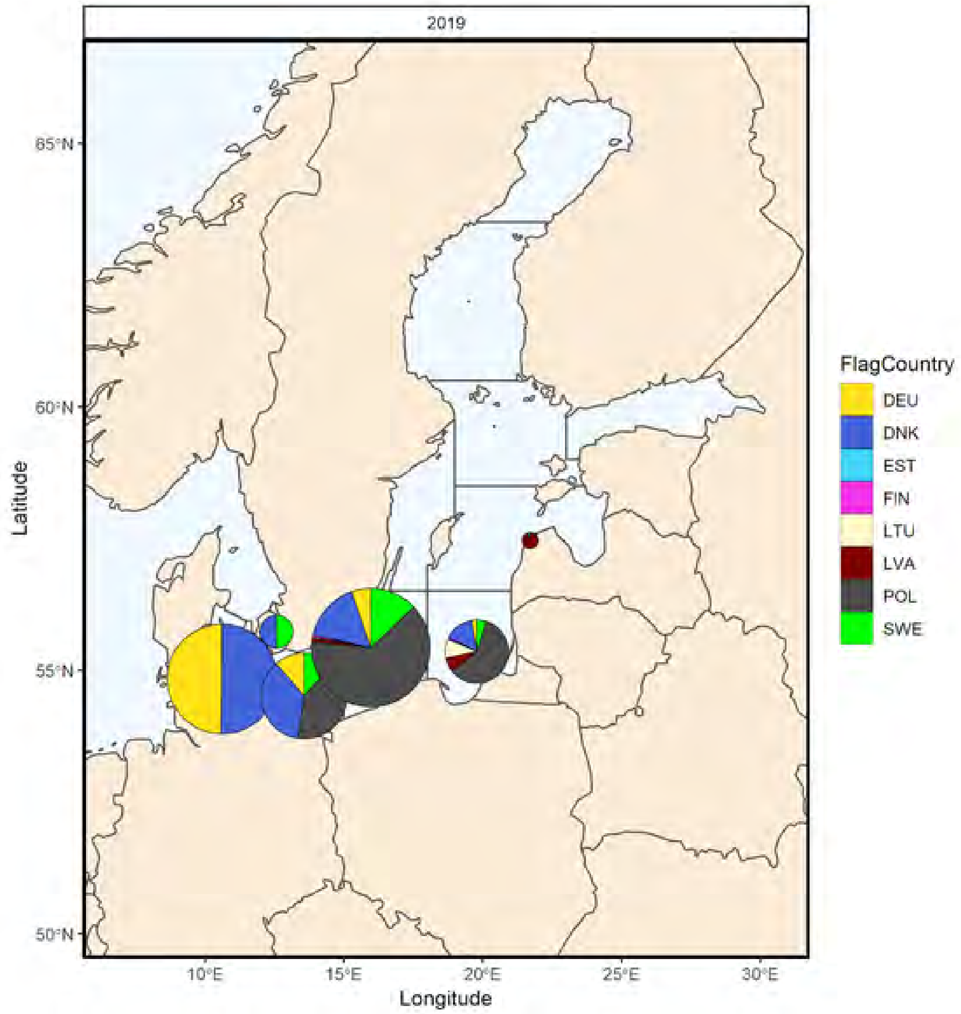


Figure D. Proportion of landings by Country for each Subdivision (demersal). The size of the circles is proportional to total landings in the area. Ref. RCG 2020.

Landings by area, flatfish

Several species of flatfishes are landed in the Baltic Sea including flounder, plaice, turbot, brill and dab. The main part of the landings of flat fishes are conducted in the western Baltic Sea by mainly Denmark and Germany but especially flounders are landed in most of the Baltic (Figure E and F). Poland is the main fishing nation for flatfish in the Eastern Baltic Sea.

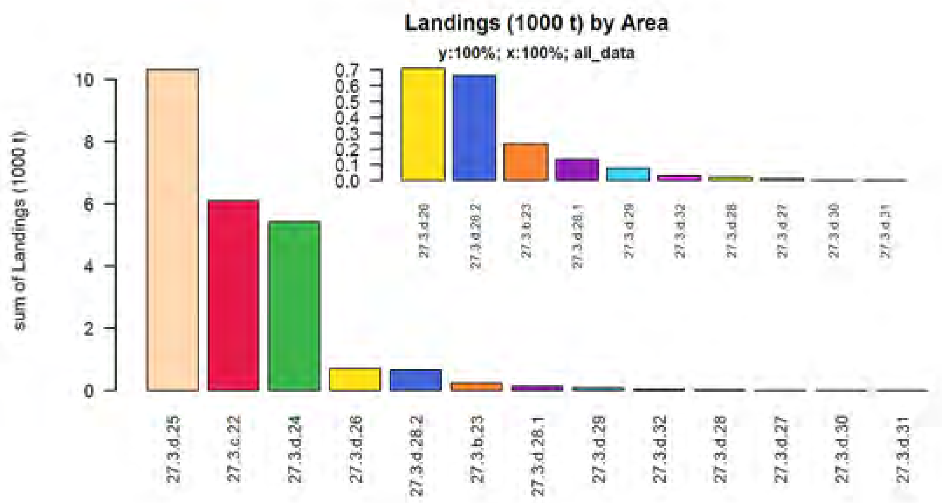


Figure E. Landings of flatfish (in 1000 t) by Area (SD). Ref. RCG 2020.

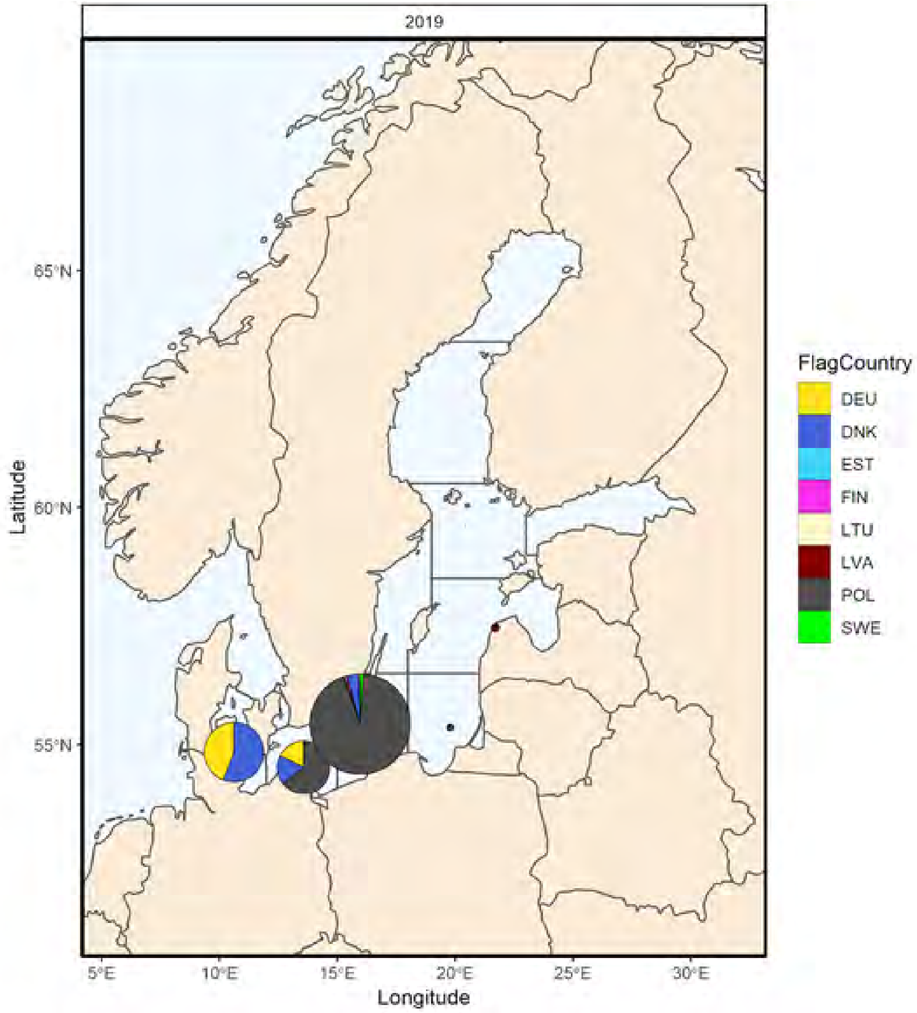


Figure F. Proportion of Landings by Country for each Subdivision (flatfish). The size of the circles is proportional to total landings in the area. Ref. RCG 2020.

Data source for figures in this annex:
RCG (2020). Regional Coordination Meeting BANANSEA - Report of the ISSG on fisheries and sampling overview. Preliminary data. (https://datacollection.jrc.ec.europa.eu/docs/rcg)

Annex 9: ple.27.21-23 Alternative assessment

ADGBS (12-15 May 2020) agreed on selecting the secondary assessment for this stock as provided by WGBFAS as basis for the advice (see report section 5.2). In this assessment the 2019 Q3-Q4 combined indices were set to “missing” in the input data (actual values: -9) for all ages. This substantially reduced the patterns in the retrospective analyses.

Table 1 Assessment summary used as basis for the advice. Weights are in tonnes, recruitment is in thousands. High and low refers to 95% confidence intervals.

Year	Recruitment			SSB			Landings	Discards	Fishing mortality		
	Age1	High	Low	SSB	High	Low			ages 3–5	High	Low
1999	52413	71040	38671	4434	5525	3559	3406	2313	1.02	1.25	0.8
2000	45327	59488	34536	5184	6235	4310	3935	2313	1.02	1.21	0.8
2001	25110	33362	18898	6081	7300	5066	4054	2313	0.96	1.12	0.8
2002	36380	50081	26427	6121	7318	5119	3939	4357	0.90	1.06	0.7
2003	23004	30341	17441	5598	6619	4735	3618	2004	0.81	0.96	0.6
2004	28584	37447	21819	5063	5955	4304	2766	1369	0.77	0.91	0.6
2005	24239	31723	18520	4801	5661	4072	2354	1197	0.77	0.92	0.6
2006	17970	24750	13047	4686	5553	3954	2580	1770	0.81	0.96	0.6
2007	19445	25547	14801	4272	5056	3609	2691	1191	0.81	0.96	0.6
2008	22159	29453	16672	3936	4651	3330	2028	1902	0.82	0.97	0.6
2009	24071	31442	18429	3718	4397	3144	1635	1448	0.77	0.91	0.6
2010	34055	44998	25773	3857	4542	3274	1570	1489	0.70	0.84	0.5
2011	36238	47368	27723	4516	5319	3834	1584	2045	0.68	0.84	0.5
2012	34243	45457	25795	5387	6378	4549	1845	1351	0.54	0.67	0.4
2013	28948	37758	22194	6505	7693	5501	1956	1638	0.48	0.60	0.3
2014	25305	34027	18819	7361	8715	6218	1931	1946	0.44	0.56	0.3
2015	26707	35210	20257	7845	9319	6605	2687	1021	0.43	0.54	0.3
2016	32897	44211	24479	8240	9872	6877	3020	1501	0.44	0.56	0.3
2017	55885	79114	39476	8655	1054	7105	3247	778	0.42	0.55	0.3
2018	50983	76970	33770	9954	1259	7869	3446	1400	0.40	0.55	0.2
2019	23707	43570	12900	1176	1593	8677	4334	1054	0.38	0.56	0.2
2020	28584 *	55885 *	17970 *	1305	1884	8665					

* Median of the time-series.

Table 2 Assumptions made for the interim year and in the forecast. Weights are in tonnes. Recruitment is in thousand individuals.

Variable	Value	Notes
$F_{ages\ 3–5}$ (2020)	0.38	$F_{ages\ 3–5}$ in 2019.
SSB (2021)	13083	From the F_{2020} assumption.
$R_{age\ 1}$ (2020)	28584	Median resampled from the entire time-series.
$R_{age\ 1}$ (2021)	28584	Median resampled from the entire time-series.
Total catch (2020)	6319	From the F_{2020} assumption.
Projected landings (2020)	4944	Based on the observed discard rate by age in 2017–2019.
Projected discards (2020)	1375	Based on the observed discard rate by age in 2017–2019.

Table 3 Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2021)	F (2021)	SSB (2022)
MSY approach: (F = F_{MSY})	5176	0.31	13423
F = 0	0	0	17338
F = F_{2019}	6174	0.382	12651
F = F_{p05}	9643	0.68	10000
F_{pa}	10258	0.74	9551
F = F_{lim}	12478	1	7868
SSB (2022) = B_{pa}	16826	1.775	4732
SSB (2022) = MSY $B_{trigger}$	16826	1.775	4732
SSB (2022) = B_{lim}	18399	2.253	3630
MSY approach: (F = F_{MSY}) Lower	3194	0.18	14909
MSY approach: (F = F_{MSY}) Upper	8704	0.59	10729

Table 4 Potential allocation of catches by management area. Weights are in tonnes. Landings including BMS.

Basis		Catch 2019	Landings 2019	ICES stock advice 2021 (catch)
Stock area-based	SDs 21–23	5388	4334	5176
	SDs 24–32	2359	1741	3297
Total advised catch, 2021 (SDs 21–32)				8473
Management area-based	SD 21	748	363	
	SDs 22–23	4640	3971	
	SDs 22–32	6999	5712	

	Calculation	Result
Share of SD 21 of the total catch in SDs 21–23 in 2019	748 / 5388 (catch in 2019 SD 21 / catch in 2019 SDs 21–23)	0.139
Catch in 2021 for SD 21	5176 x 0.139 (ICES stock advice in 2021 [catch] for SDs 21–23 × share)	719
Catch in 2021 for SDs 22–32	8473 - 719 (total advised catch in 2021 SDs 21−32 − catch SD 21)	7754
Share of SD 21 of the total landings in SDs 21–23 in 2019	363 / 4334 (landings in 2019 SD 21 / landings in 2019 SDs 21–23)	0.084

Annex 10: sol.27.20-24 New short term forecast

ADGNS (2-5 June 2020) F in 2020 was corrected at the third decimal (from 0.196 to 0.197) resulting in slight changes in the basis of the forecast and catch scenario tables (report section 6.5) as specified below.

Table 1 Sole 20-24. Basis for the short term forecasts and catch scenario table..

Variable	Value	Notes
$F_{ages\ 4–8}$ (2020)	0.197	$F_{ages\ 4–8}$ (2020); F_{sq} (average F_{2017}–F_{2019} rescaled to F_{2019})
SSB (2021)	3549	Tonnes; when fishing at F_{sq}
$R_{age\ 1}$ (2020)	2647	Thousands; resampled from recruitment (2004–2019)
$R_{age\ 1}$ (2021)	2595	Thousands; resampled from recruitment (2004–2019)
Projected landings (2020)	447	Tonnes; fishing at *status quo* (F_{sq}) in 2020
Projected discards (2020)	13	Tonnes; mean discard rate in weight (2015–2019): 2.8%.
Total catch (2020)	460	Tonnes; based on fishing at F_{sq} and mean discard rate

Basis	Total catch * (2021)	Projected landings ** (2021)	Projected discards ** (2021)	$F_{projected\ landings}$ (4–8) (2021)	SSB (2022)	% SSB change ***	% TAC change ^	% advice change ^^
ICES advice basis								
EU MAP #: F_{MSY}	596	580	16	0.23	3537	−0.34	12	11
EU MAP #: F_{lower}	502	488	14	0.190	3626	2.2	−5.8	−11 §
EU MAP #: F_{upper}	665	647	18	0.26	3457	−2.6	25	11 §§
Other scenarios								
F = 0	0	0	0	0	4160	17	−100	−100
F_{pa}	596	580	16	0.23	3537	−0.34	12	11
F_{lim}	785	764	21	0.315	3330	−6.2	47	46
SSB (2022) = B_{lim}	2153	2156	60	1.31	1859	−48	304	299
SSB (2022) = B_{pa}	1490	1449	41	0.71	2614	−26	180	176
SSB (2022) = MSY $B_{trigger}$	1490	1449	41	0.71	2614	−26	180	176
F = F_{2020}	525	511	14	0.20	3602	1.49	−1.50	−2.6

EU multiannual plan (MAP) for the North Sea (EU, 2018).

* Total catch is calculated based on projected landings (fish that would be landed in the absence of the EU landing obligation) and 2.8% discard ratio (in weight).
** "Projected landings" and "projected discards" are used to describe fish that would be landed and discarded in the absence of the EU landing obligation, based on discard ratio estimates for 2015–2019.
*** SSB 2022 relative to SSB 2021.
^ Total catch in 2021 relative to the TAC in 2020 (533 tonnes).
^^ Advice value 2021 relative to the advice value 2020 (539 tonnes).

§ ICES advice for F_{lower} in 2021 relative to ICES advice F_{lower} in 2020 (452 tonnes).
§§ ICES advice for F_{upper} in 2021 relative to ICES advice F_{upper} in 2020 (600 tonnes).