



Baltic Fisheries Assessment Working Group (WGBFAS)

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BALTIC FISHERIES ASSESSMENT WORKING GROUP (WGBFAS)

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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 compiled 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} , $MSY_{trigger}$ 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 exist, 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 | <u>Tomas Gröhsler</u> |
| her-riga | Tiit Raid | Maris Plikshts |
| 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? | Re-search/ 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 | Time-frame | 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 | Time-frame | Priority |
| Biological parameter | Young fish are poorly covered covered/caught by BITS, high uncertainty in biological parameters (used for LBI, e.g. Lmat, Linf) | Better coverage of younger age classes/smaller turbot in the survey | Biological data (age, Length, sex, maturity) from smaller/younger turbot | WGBIFS | Starting with the next BITS (autumn 2019) | Low |
| Survey data quality | Units in the HL and CA differ, working with DATRAS data requires beforehand corrections | A unified scale would be beneficial, e.g. for length units, maturity scales and weights | DATRAS database | WGBIFS | To be discussed at the next WGBIFS in 2020? | Medium |

| STOCK | | COD SD 21 (COD IN KATTEGAT) | | | | |
|--------------------------|---|---|--|-----------------------------------|---------------------------------------|------------------|
| Stock coordinator | | Johan Lövgren | Last benchmark | 2017 (ICES 2017) | | |
| Stock assessor | | Johan Lövgren | Stock category | 3 | | |
| Issue | Problem/Aim | Work needed / possible direction of solution | Data needed / are these available / where should these come from? | Re-search/ WG input needed | Time-frame | Prior-ity |
| Stock id | data on the proportion of North sea cod in the Kattegat. | Analyses of data sampled in future surveys and analyses of otoliths 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 | me- dium |
| Assess- ment model | Formulation of a Stock synthesis model (SS3). | modelling | National institutes, Danish/ Swedish | WGBFAS | Start- ing 2020- end 2021 | me- dium |

| 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? | Re-search/ WG input needed | Time-frame | 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 bottom 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 | |

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

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

| STOCK | | PLAICE SD 21-23 | | | | |
|-------------------------------------|--|---|---|---|------------|----------|
| Stock coordinator | | 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? | Re-search/ 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 | Time-frame | Priority |
| Stock identification | How many stocks are there in the Baltic Sea? | Genetics | Genetic samples | | ongoing | |
| Age reading | Collect age-validated otoliths | Mark-recapture study involving chemical tagging of otoliths | Age-validated otoliths | | ongoing | |
| Age reading | Improve precision of the age reading based on age-validated material | Exchange of otolith images | | Otolith exchange workshop | | |
| Age reading | Different methods used for otolith preparation | Assess if method can be standardized (whole and reflecting light; sliced and transmitted light) | | | | |
| 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 | Time-frame | Priority |
| Biological parameter | Young fish are poorly covered covered/caught by BITS, high uncertainty in biological parameters (used for LBI, e.g. Lmat, Linf) | Better coverage of younger age classes/smaller flounder in the survey | Biological data (age, Length, sex, maturity) from smaller/younger flounder | WGBIFS | Starting with the next BITS (autumn 2019) | Low |
| Survey data quality | Units in the HL and CA differ, working with DATRAS data requires beforehand corrections | A unified scale would be beneficial, e.g. for length units, maturity scales and weights | DATRAS database | WGBIFS | To be discussed at the next WGBIFS in 2020? | Medium |

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

| 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 bench- mark | IBPBASH 2020 (ICES 2020), 2013 (ICES 2013) | | |
| Stock assessor | | Tomas Gröhsler | Stock category | 1 | | |
| Issue | Problem/Aim | Work needed / possible direc- tion of solu- tion | Data needed / are these avail- able / where should these come from? | Re- search/ WG in- put needed | Time- frame | Prior- ity |
| Stock iden- tity | Mixing of Western Baltic spring spawners and CBH components in SD 24–26. | Test the of differ- ent of methods | Genetic samples, morphometrics, otolith shapes etc. | Project | | high |
| Tuning se- ries | 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 mem- bers | 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 quar- ter. | | | me- dium |
| 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, mortal- ity, etc | DTU aqua | | me- dium |
| Misreport- ing of her- ring 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 read- ing WK | | me- dium |

| STOCK | | HERRING SD 28.1 (HERRING IN GULF OF RIGA) | | | | |
|--------------------------|--|---|---|-----------------------------------|-------------------|------------------|
| Stock coordinator | | Tiit Raid | Last benchmark | 2008 (ICES 2008) | | |
| Stock assessor | | MarisPlikshs | Stock category | 1 | | |
| Issue | Problem/Aim | Work needed / possible direction of solution | Data needed / are these available / where should these come from? | Re-search/ WG input needed | Time-frame | Prior-ity |
| Stock ID and Age reading | Taken outside the SD28.1 in SD 28. 2. Additionally CBH fished in the Gulf of Riga (Sd28.1) | Separation of herring stocks based on otolith macro-structure | Data available from Latvia and Estonia | No | 2019 | High |
| Tuning series | Trapnet fleet | Estimation of trapnet fleet effort | Data available in national laboratories | No | 2020 | High |
| | Commercial trawl cpue | Commercial trawl cpue as new tuning index for the assessment | Data available from Latvia and Estonia (need to see how long back in time is available) | No | 2020 | Me-dium |
| Recruit-ment | Estimation of recruitment in the forecast basing it on environmental factors | Recruitment modelling | Data available in national laboratories | No | 2020 | Me-dium |

| STOCK | | HERRING SD 30-31 (HERRING IN GULF OF BOTH-NIA) | | | | |
|---|---|--|---|-----------------------------|-----------------------|----------|
| 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? | Re-search/ WG input needed | Time-frame | 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 | <u>Next benchmark</u> | Low |
| Possible extension of acoustic survey to SD 31 | Aiming for better coverage for the whole stock | Most probably not possible due to limited funds and vessel time. | | | <u>Next benchmark</u> | Low |
| Analysing maturity ogive (suggestion by 2019 WGBFAS; last examined for 2012 WKPELA benchmark) | Reduction of annual variation | 1) Examining the correlation of maturity@age to temperature and other environmental aspects. 2) Testing ogive with e.g. 3-year running averages | Mat data 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. | | <u>Next benchmark</u> | 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. | | | <u>Next benchmark</u> | 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. | | <u>Next benchmark</u> | High |
| Examining of taking the regime shift in account in recruitment estimates | | | Data are available | | <u>Next benchmark</u> | Medium |

| STOCK | | SPRAT SD 22-32 (BALTIC SPRAT) | | | | |
|------------------------------------|--|--|---|---------------------------|-----------|----------|
| Stock coordinator | | Olavi Kaljuste | Last benchmark | 2013 (ICES 2013) | | |
| Stock assessor | | Jan Horbowy | Stock category | 1 | | |
| Issue | Problem/Aim | Work needed / possible direction of solution | Data needed / are these available / where should these come from? | Research/ WG input needed | 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 | Stock identity | Validation of stock identity | e.g. Genetics |
| Plaice SD 21-23/SD 24-32 | | | |
| Flounder SD 24-25 | | | |
| Flounder SD 26+28 | | | |

| | | | |
|--------------------------------|------------------------------------|--------------------------------|---------------------------------------|
| Flounder SD 27, 29-32 | | | |
| Herring SD 25-27, 28.2, 29, 32 | | | |
| Herring SD 30-31 | | | |
| 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 | Age reading | Age-validated otoliths | Tagging |
| Flounder SD 24-25 | | | |
| Herring SD 25-27, 28.2, 29, 32 | | Precision of age reading | Otolith exchange/WK |
| Herring SD 25-27, 28.2, 29, 32 | Mixed fishery on herring and sprat | Quantification of misreporting | Logbook data/VMS |
| Sprat SD 22-32 | | | |

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 | Output for further assessment |
| XSA | Historical assessment |
| RETVPA | Retrospective analysis |
| RCT3 | Recruitment estimates |
| MFDP | Short-term prediction |
| SAM | Historical and exploratory assessment |
| SS3 | Historical assessment 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.”

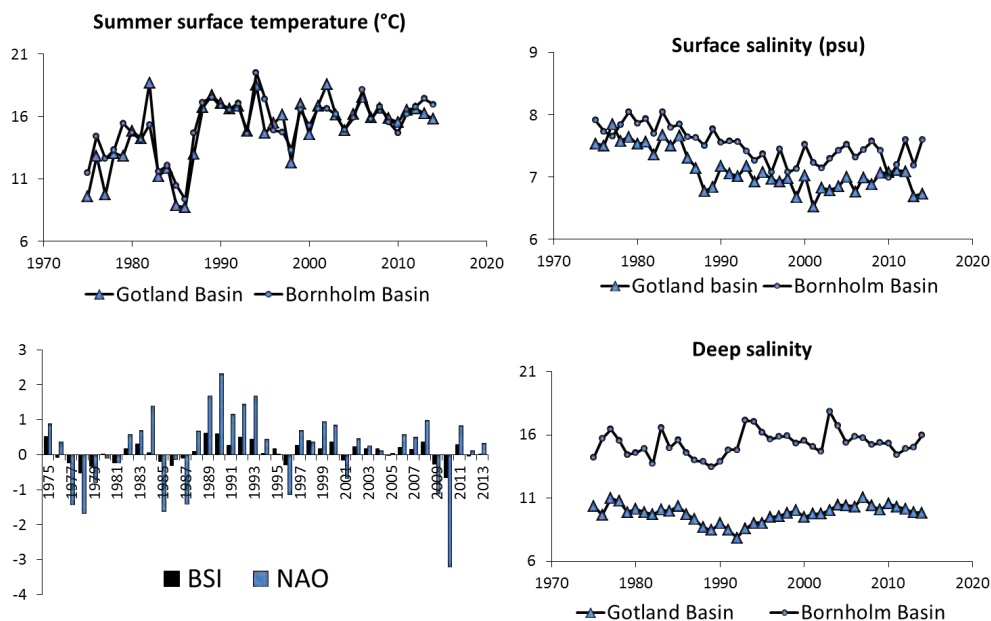


Figure 1.2. Time-series in summer surface temperature and surface salinity (top panels), BSI (Baltic Sea Index) and NAO (North Atlantic Oscillation index) and deep salinity (lower panel) in the Gotland Basin and Bornholm Basin.

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).

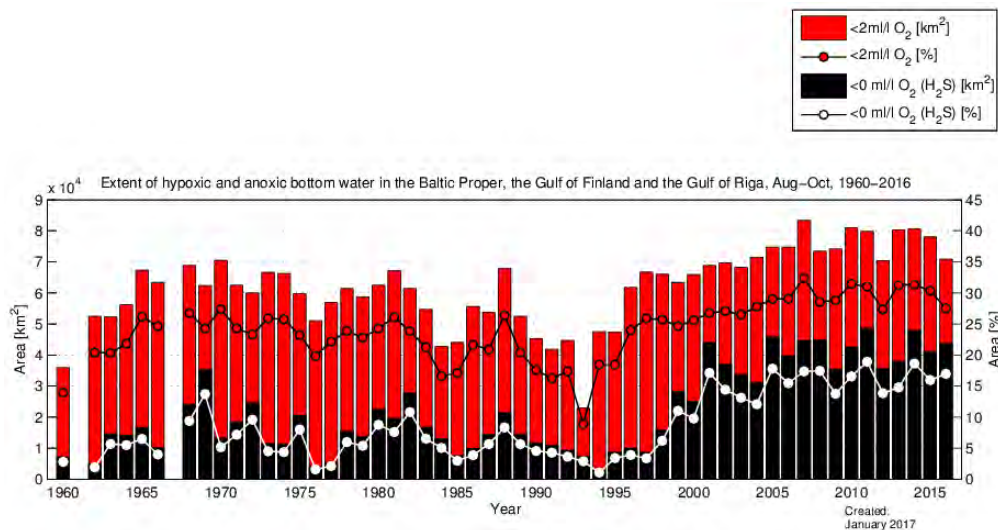


Figure 1.3. Time-series of anoxic and hypoxic seabed in the entire Baltic Proper. From the Swedish Meteorological and Hydrological Institute (SMHI) annual report.

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).

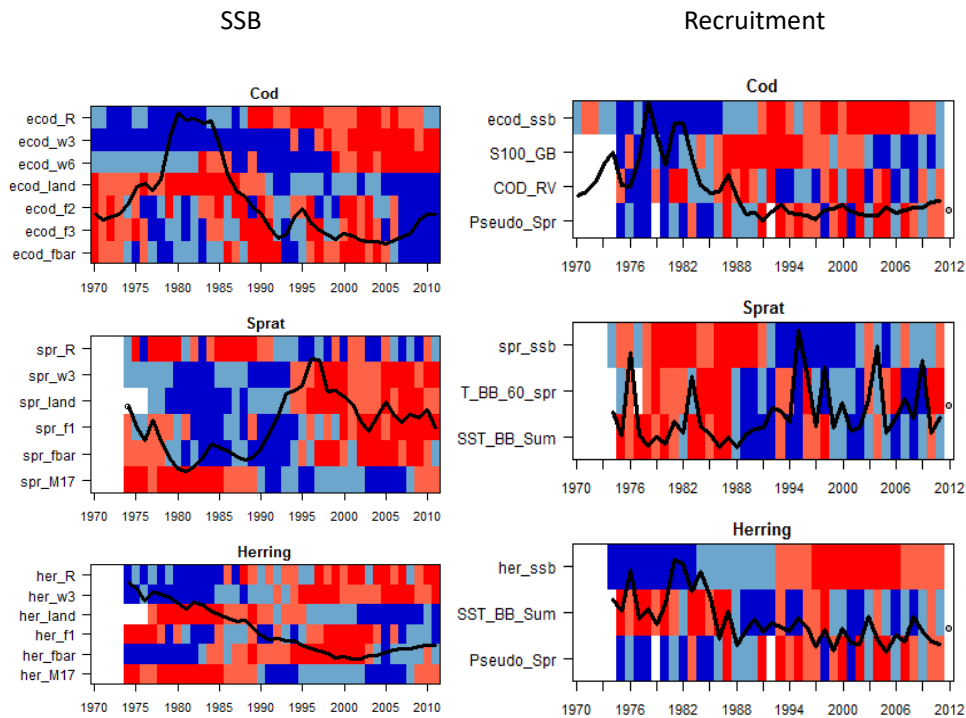


Figure 1.4. Temporal changes in indicators influencing the SSB and recruitment of the eastern Baltic cod, sprat and central Baltic herring. The colours refer to quartiles of the values observed in the time-series, high values are marked with blue and low values with red colours, except for mortality where the colours are inverted. The lines show the trends in SSB and Recruitment of the stocks, the dots for recruitment in the final years show the values used in short-term forecast (R-recruitment; 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).

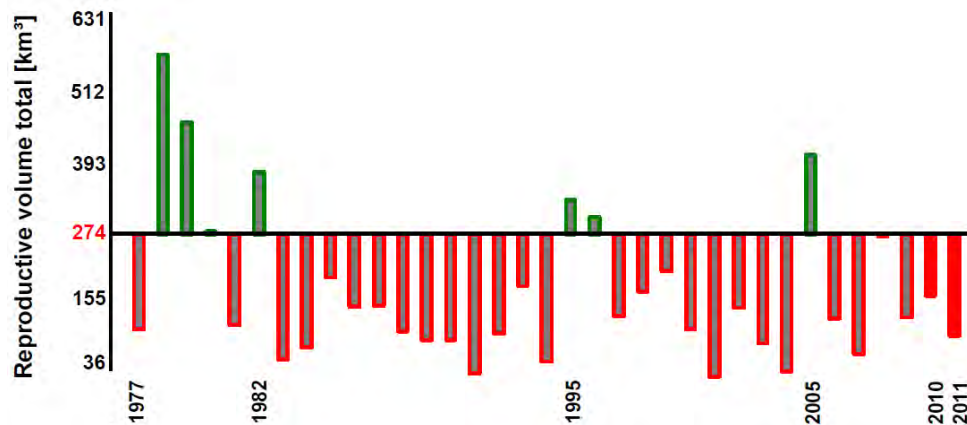


Figure 1.5. Time-series of reproductive volume for Eastern Baltic cod (summed across the three deep basins in the Baltic Sea), assembled by WGIAB 2013. Relationships between each variable and residuals from cod recruitment (back shifted) vs. cod SSB were derived during WGIAB 2013, using linear models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

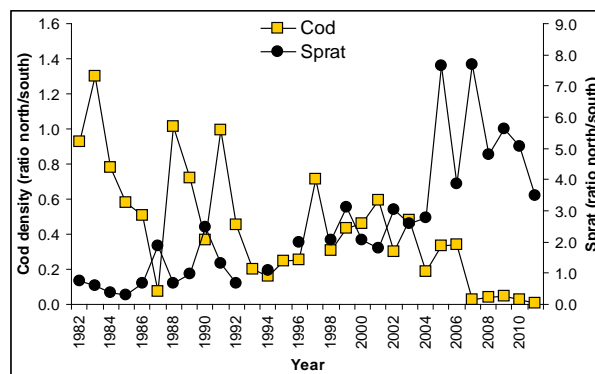


Figure 1.6. Ratio between sprat stock in northern Baltic Proper (SDs 27–29) and southern areas (SDs 25–26) as calculated by acoustic surveys, and ratio between cod stock in the northern Baltic Proper (SDs 27–28) and southern areas (SDs 25–26) from bottom-trawl surveys. Modified from Casini *et al.* (2011).

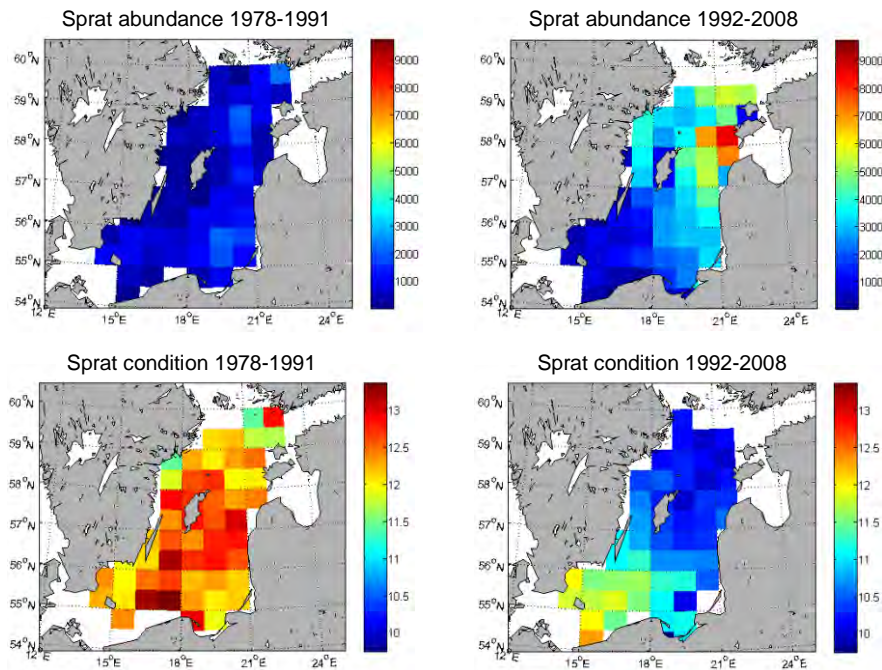


Figure 1.7. Spatial patterns in mean sprat abundance and clupeid condition in 1984–1991 and 1992–2008, from autumn acoustic survey. Only years with at least 10 individuals per rectangle were used in the condition calculation. From Casini *et al.* (2011).

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 fresh-water 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.

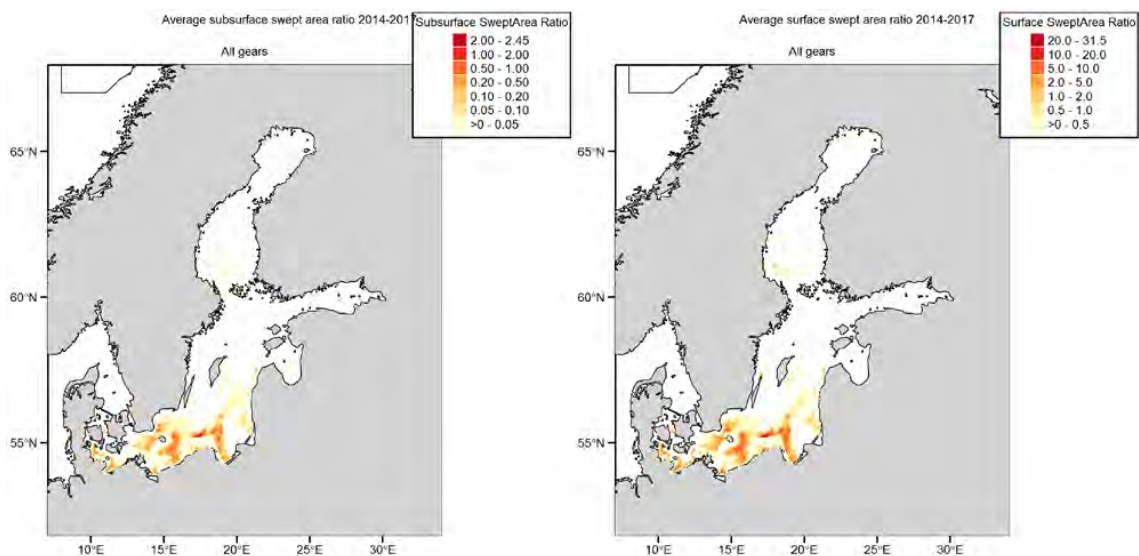


Figure 1.8. Average annual subsurface (left) and surface (right) disturbance by mobile bottom-contacting fishing gear (bottom otter trawls, bottom seines, beam trawls) in the Baltic Sea during 2014–2017, expressed as average swept-area ratios (SAR).

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 mollissima*) 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 (Huwert *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.

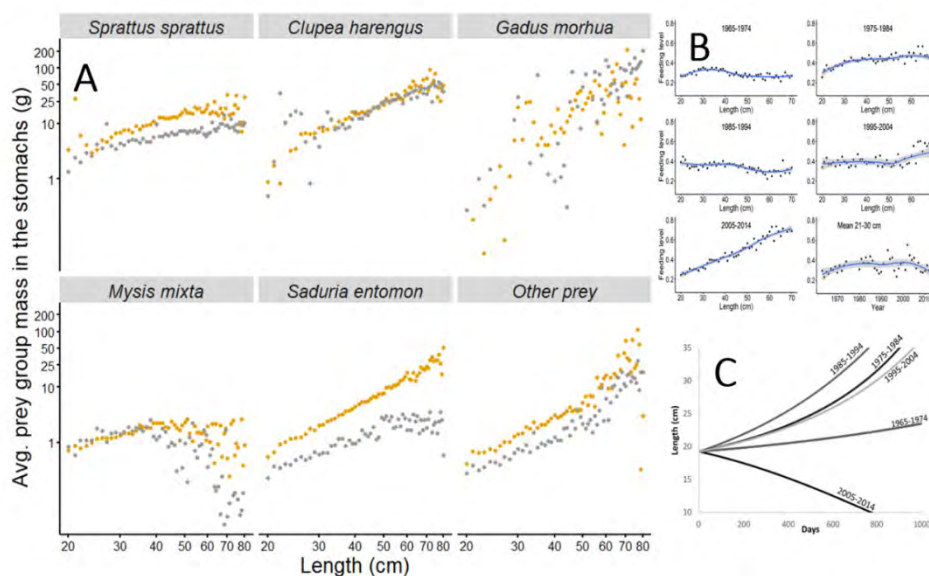


Figure 1.9. A Diet composition in *Gadus morhua* stomachs by mass before 1988 (orange) and after 1994 (grey). The transition period between ecological regimes from 1988 to 1993 (Moellmann *et al.*, 2009) is left out. B Feeding levels of *Gadus morhua* by length during the past five decades. LOESS-based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

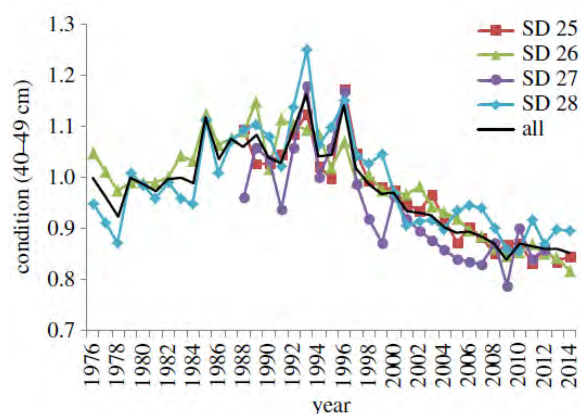


Figure 1.10. Temporal developments of mean cod condition in the different subdivisions (SDs) of the Central Baltic Sea for cod 40–49 cm. The black thick line is the average between the SDs. From Casini *et al.*, 2016.

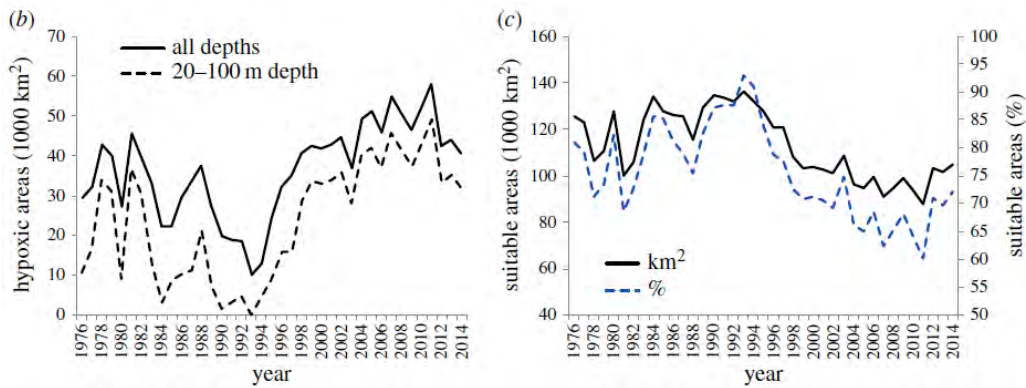


Figure 1.11. (b) time-series of total hypoxic areas (all depths), and hypoxic areas between 20–100 m depth, the latter used as predictors to explain cod condition in the GAMs; c) time-series of suitable areas for cod (> 1 ml/l oxygen concentration) between 20–100 m depth, in absolute values and in percentage.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

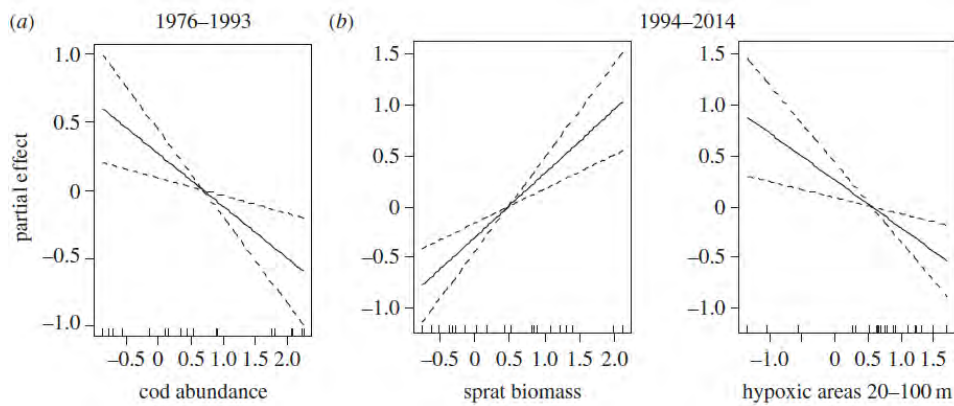


Figure 1.12. Results of the GAM (final model) for the two separated periods (1976–1993 and 1994–2014). The partial effects of each predictor on cod condition are shown. From Casini *et al.*, 2016.

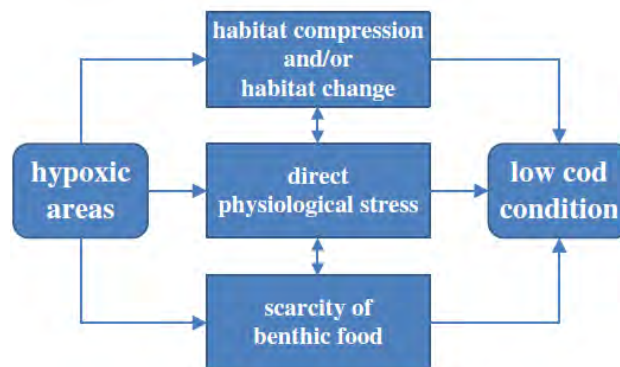


Figure 1.13. Schematic representation of the mechanisms potentially explaining the negative relationship between hypoxic areas and cod condition. From Casini *et al.*, 2016.

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.

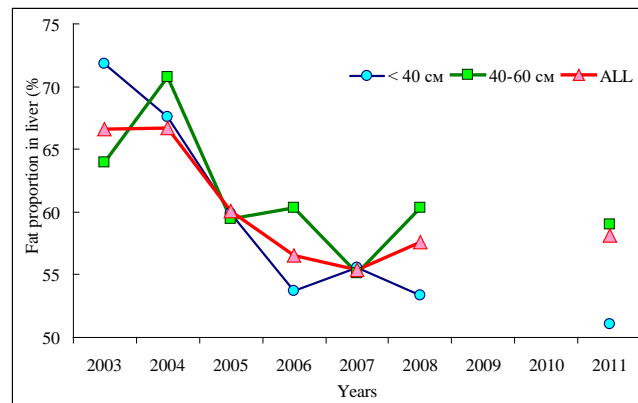


Figure 1.14. Fat proportion in liver of different cod size groups (in %) based on chemical analysis (data obtained by L.I. Perova and M.L. Vinokur, technological direction of AtlantNIRO: Reports on the research work “Investigation of nutrition and biological value of commercial and non-commercial fish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

| | FMSY | | Ranges | | | BMSY | | Blim | Bpa | MSY | |
|---------|------|------|--------|---------|---------|------|-----|------|-----|-----|-----|
| | P | U | ICES | U | ICES | P | U | | | 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 F_s 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 <i>et al.</i> | 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 <i>et al.</i> | 2000 | | | | | | | | | | | | | | | Updated carbon flows |
| 7 | Harvey <i>et al.</i> | 2003 | | | | | | | | | | | | | | | Interactions between fisheries and food web |
| 8 | Sandberg <i>et al.</i> | 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 <i>et al.</i> | 2007 | | | | | | | | | | | | | | | | Management scenarios |
| 11 | Van Leeuwen <i>et al.</i> | 2008 | | | | | | | | | | | | | | | | Apparent Allee effect |
| 12 | Tomczak <i>et al.</i> | 2009 | | | | | | | | Coastal systems | | | | | | | | Compared carbon flows in five south-eastern Baltic coastal ecosystems |
| 13 | Lindegren <i>et al.</i> | 2009 | | | | | | | | | | | | | | | | demonstrate that in hindsight the cod collapse could only have been avoidable by adapting fishing pressure to environmental conditions and food-web interactions |
| 14 | Teschner <i>et al.</i> | 2010 | | | | | | | | | | | | | | | | Impact of hypoxia on pelagic commercial fishes predation rates |
| 15 | Tomczak <i>et al.</i> | 2013 | | | | | | | | | | | | | | | | simulated the regime shift in the Central Baltic Sea of the 1980s |
| 16 | Gårdmark <i>et al.</i> | 2013 | | | | | | | | | | | | | | | | Biological ensemble model |
| 17 | Lindegren <i>et al.</i> | 2014 | | | | | | | | | | | | | | | | Meta-community model for source-sink dynamics |
| 18 | Gårdmark <i>et al.</i> | 2015 | | | | | | | | | | | | | | | | Detecting mechanisms underlying alternative stable states |
| 19 | Norrström <i>et al.</i> | 2017 | | | | | | | | | | | | | | | | Nash equilibrium for multispecies fisheries management reference points |
| 20 | Jacobsen <i>et al.</i> | 2017 | | | | | | | | | | | | | | | | Ecosystem-level efficiency of fisheries in five large marine ecosystems (|
| 21 | Bauer <i>et al.</i> | 2018 | | | | | | | | | | | | | | | | Simulating reduced eutrophication |
| 22 | Bossier <i>et al.</i> | 2018 | | | | | | | | | | | | | | | | End-to-end model implementation |
| 23 | Uusitalo <i>et al.</i> | 2018 | | | | | | | | | | | | | | | | Dynamic Bayes Network Implementation |
| 24 | Bauer <i>et al.</i> | 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 <i>et al.</i> | 2019 | | | | | | | | | | | | | | | Model uncertainty and simulated fisheries advice |
| 26 | Kulatska <i>et al.</i> | 2019 | | | | | | | | | | | | | | | Implementing GADGET multispecies model for commercial fish species |
| 27 | Karlson <i>et al.</i> | 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 $B_{\text{pa}}/B_{\text{trigger}}$ (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 (Figure 2.1.2; 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 on board 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 (BaltNIRH), SDs 25–28, yearly average. The index refers to total CPUE in biomass of all length groups caught in the survey (Orio <i>et al.</i> , 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 <i>et al.</i> , 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 deviations were assumed to have a standard deviation (σ_R 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), it was decided to maintain SPICT as an exploratory model in WGBFAS, while Stock Synthesis is used as the basis for fisheries management advice.

2.1.7 Short term forecast and management options

The short-term projections were done with Stock Synthesis, using probabilistic 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 |
|-------------------------------|-----------|--|
| $F_{\text{ages 4-6}}$ (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 ($B_{\text{lim}} \times \exp(1.645 \times \sigma)$, 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 (≥ 35 cm) cod, and by that further deteriorate the stock structure and reduce its reproductive potential.

The poor status of the Eastern Baltic cod is largely driven by biological changes in the stock during the last decades. Growth, condition (weight-at-length) and size at maturation have substantially declined. 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 allocated* | Landings AMS | Landings BMS | Total landings | Discards | Catch | Total landings | Discards | Catch | Total landings | Discards | 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 allocated* | Landings AMS | Landings BMS | Total landings | Discards | Catch | Total landings | Discards | Catch | Total landings | Discards | 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 allocated* | Landings AMS | Landings BMS | Total landings | Discards | Catch | Total landings | Discards | Catch | Total landings | Discards | 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) |
|--|------------------|---|-------------------|----------|-------------|
| <u>Natural mortality</u> (age classes 0.5, 1.5, 5.5, 15.5) | | 1.243, 0.857, 0.361, 0.215 | | | |
| <i>M</i> (2000-2019) of age class 5.5 | 20 | Estimated using random walk annual deviations | (0.1,2.0) | no prior | 0.35-0.67 |
| <u>Stock and recruitment</u> | | | | | |
| <i>Ln</i> (R_0) | 1 | 14.8 | (13,16) | no prior | 15.2 |
| <i>Steepness</i> (<i>h</i>) | | 0.99 | | | |
| <i>Recruitment variability</i> (σ_R) | | 0.60 | | | |
| <i>Ln</i> (recruitment deviations): 1946-2018 | 73 | | | | |
| <i>Recruitment autocorrelation</i> | | 0 | | | |
| <u>Growth</u> | | | | | |
| <i>L_{inf}</i> (cm) (1946-1990) | | 125.27 | | | |
| <i>L_{inf}</i> (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) |
|--|------------------|--|-------------------|----------|-------------|
| <i>k (1946-1990)</i> | | 0.10 | | | |
| <i>k (1991-2019)</i> | 29 | Estimated using random walk annual deviations | (0.07-0.45) | no prior | 0.10-0.23 |
| <i>L at minimum age (0.5 years) t₀</i> | | 12 | | | |
| <i>CV of young individuals</i> | 1 | 0.290 | (0.05-0.8) | no prior | 0.26 |
| <i>CV of old individuals</i> | | 0.05 | | | |
| <u>Weight (kg) at length (cm)</u> | | | | | |
| <i>a (1946-1990)</i> | | 6.58e-06 | | | |
| <i>b (1946-1990)</i> | | 3.1353 | | | |
| <i>a (1991-1993, 1994- 1996, 1997- 1999, 2000 -2002, 2003-2005, 2006-2008, 2009-2011, 2012-2014, 2015-2017, 2018-2020)</i> | | 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 | | | |
| <i>b (1991-1993, 1994- 1996, 1997- 1999, 2000 -2002, 2003-2005, 2006-2008, 2009-2011, 2012-2014, 2015-2017,2018-2020)</i> | | 3.1353, 3.0636, 3.1062 3.0992, 3.0972, 3.0637 3.0831, 3.0406, 3.0086,3.0586 | | | |
| <u>Maturity</u> | | | | | |
| <i>Length (cm) at 50% mature (1946-1990)</i> | | 38 | | | |
| <i>Slope of the length at maturity ogive</i> | | -0.23 | | | |
| <i>Length (cm) at 50% mature (1991-1997, 1998-2000, 2001-2007, 2008-2014, 2015-2020)</i> | | 38, 36, 31, 26, 21 | | | |
| <u>Initial fishing mortality</u> | | | | | |
| <i>Active gears</i> | | 0.60 | | | |
| <u>Selectivity (logistic)</u> | | | | | |
| <i>Active gears</i> | | | | | |
| <i>Time-invariant length based logistic selectivity</i> | 2 | 35; 12.68 | (20,45; 0.01,50) | no prior | (39; 8.9) |
| <i>Passive gears</i> | | | | | |

| Parameter | Number estimated | Initial value | Bounds (low,high) | Prior | Value (MLE) |
|--|------------------|---------------------|-------------------|----------|--------------|
| <i>Time-invariant length based logistic selectivity</i> | 2 | 35; 10 | (20,65; -12,15) | no prior | (42.1; 9.0) |
| BITS Q1 survey | | | | | |
| <i>Time-invariant length based logistic selectivity</i> | 2 | 25,10 | (15,50; -12,15) | no prior | (27.2;9.7) |
| BITS Q4 survey | | | | | |
| <i>Time-invariant length based logistic selectivity</i> | 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 | | | |
| <u>Catchability</u> | | | | | |
| BITSQ1 | | | | | |
| <i>Ln(Q) – catchability</i> | | Float option used | | | |
| <i>Extra variability added to input standard deviation</i> | | 0.001 | | | |
| BITSQ4 | | | | | |
| <i>Ln(Q) – catchability</i> | | Float option used | | | |
| <i>Extra variability added to input standard deviation</i> | | 0.001 | | | |
| Trawl survey 1 | | | | | |
| <i>Ln(Q) – catchability</i> | | Float option used | | | |
| <i>Extra variability added to input standard deviation</i> | 1 | 0.1 | (0.0,0.8) | no prior | 0.29 |
| Trawl survey 2 | | | | | |
| <i>Ln(Q) – catchability</i> | | Float option used | | | |
| <i>Extra variability added to input standard deviation</i> | 1 | 0.1 | (0.0,0.8) | no prior | 0.02 |
| Commercial CPUE 1 | | | | | |
| <i>Ln(Q) – catchability</i> | | Float option used | | | |
| <i>Extra variability added to input standard deviation</i> | 1 | 0.1 | (0.0,0.8) | no prior | 0.10 |
| Commercial CPUE 2 | | | | | |
| <i>Ln(Q) – catchability</i> | | Float option used | | | |

| Parameter | Number estimated | Initial value | Bounds (low,high) | Prior | Value (MLE) |
|--|------------------|-------------------|-------------------|----------|-------------|
| <i>Extra variability added to input standard deviation</i> | 1 | 0.1 | (0.0,0.8) | no prior | 0.06 |
| Commercial CPUE 3 | | | | | |
| <i>Ln(Q) – catchability</i> | | Float option used | | | |
| <i>Extra variability added to input standard deviation</i> | 1 | 0.1 | (0.0,0.8) | no prior | 0.34 |
| SSBEggProd | | | | | |
| <i>Ln(Q) – catchability</i> | | Float option used | | | |
| <i>Extra variability added to input standard deviation</i> | 1 | 0.1 | (0.0,1.2) | no prior | 0.47 |
| Larvae index | | | | | |
| <i>Ln(Q) – catchability</i> | | Float option used | | | |
| <i>Extra variability added to input standard deviation</i> | | 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 | F _{low} 90 | 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)

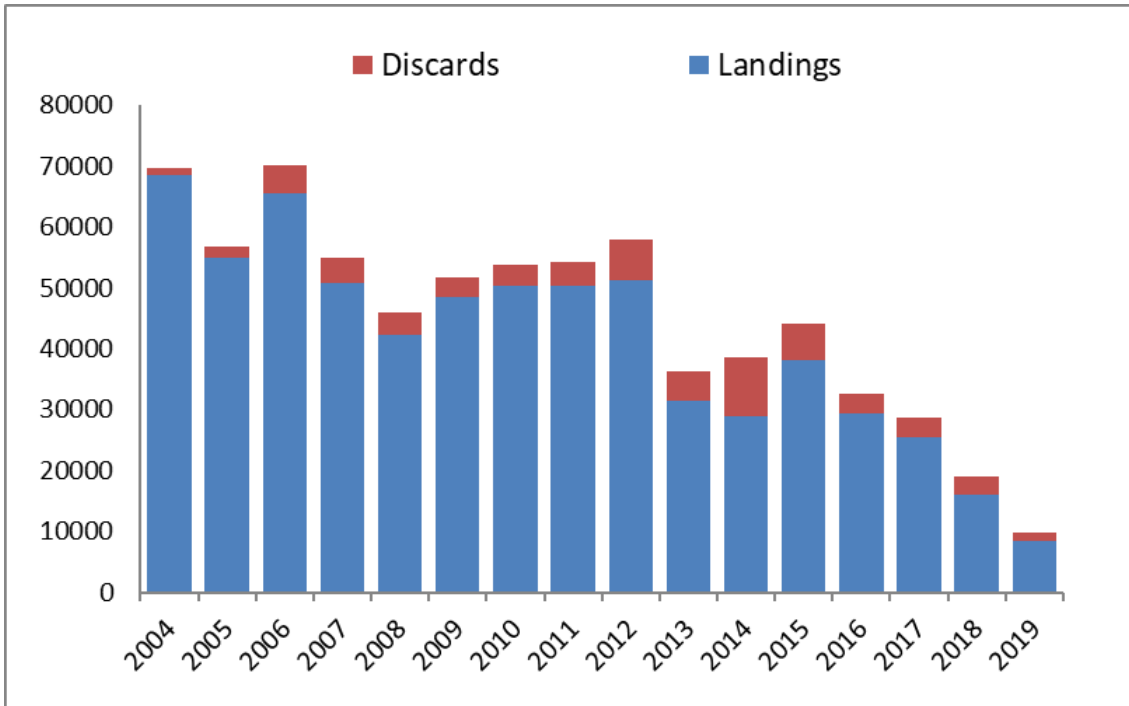


Figure 2.1.1. Eastern Baltic cod in SDs 24-32. Total landings (incl. unallocated for years before 2010) and estimated discards in management area of SD 25-32.

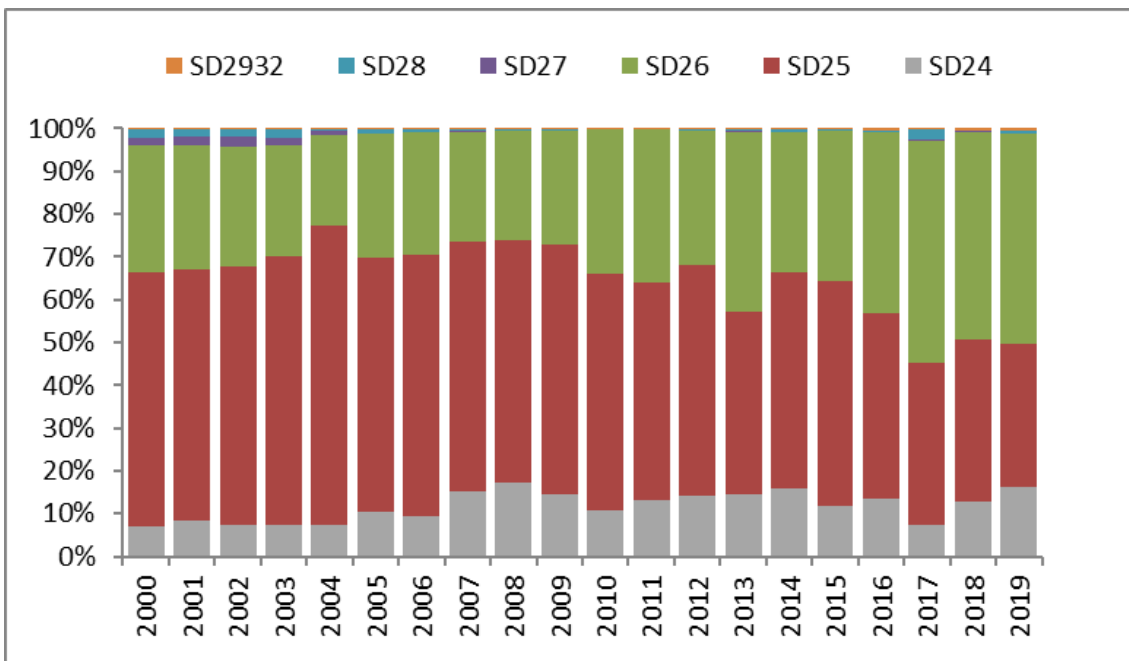


Figure 2.1.2. Eastern Baltic cod in SDs 24-32. Relative distribution of landings of the eastern Baltic cod stock by SD.

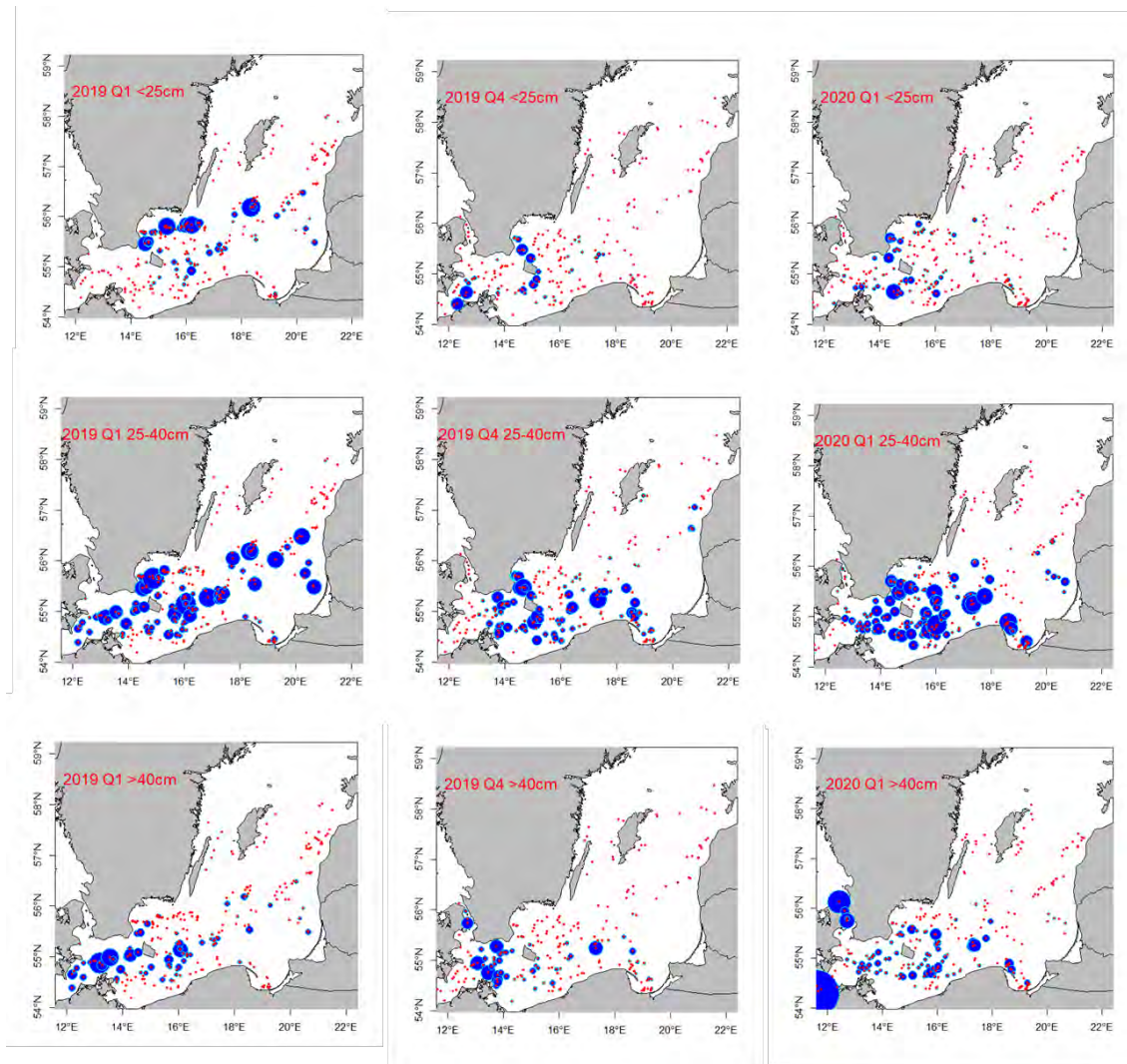


Figure 2.1.3. Eastern Baltic cod in SDs 24-32. Distribution of cod from BITS surveys in Q1 and Q4 in 2019 and Q1 in 2020, by 3 size-groups (<25 cm, 25-40 cm and >40 cm cod). The scale is comparable between surveys within a size group, but not between size-groups.

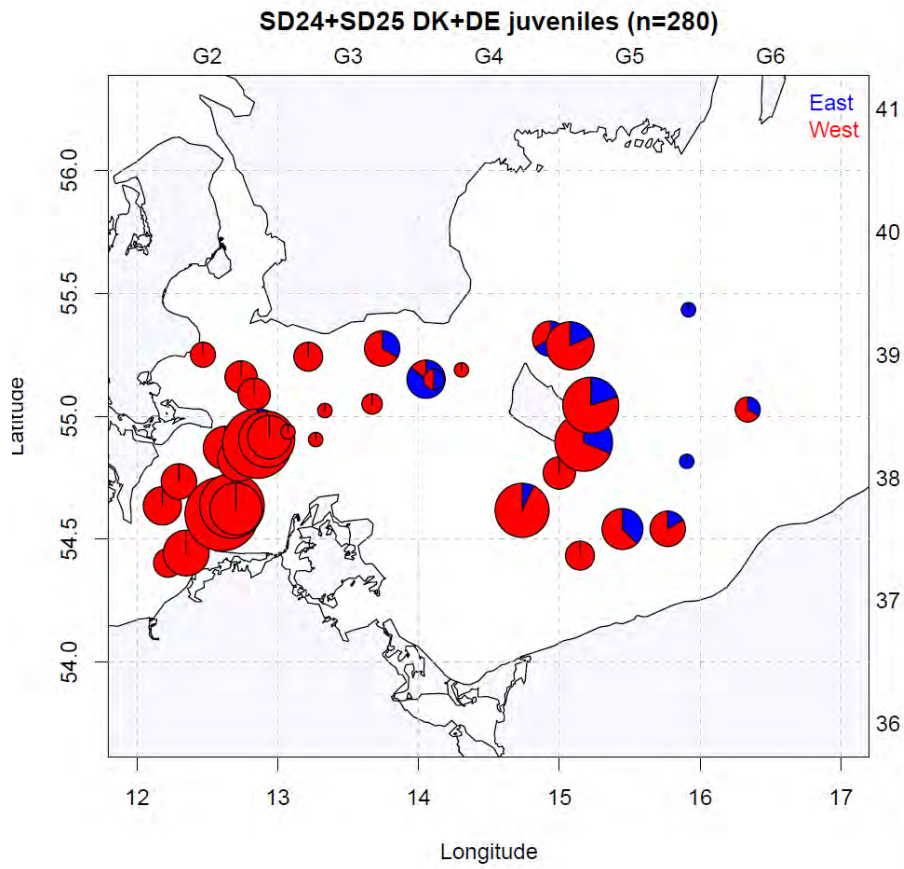


Figure 2.1.4. Eastern Baltic cod in SDs 24-32. Proportion of eastern and western juvenile cod in samples taken in BITS Q4 2019 survey, based on genetic analyses.

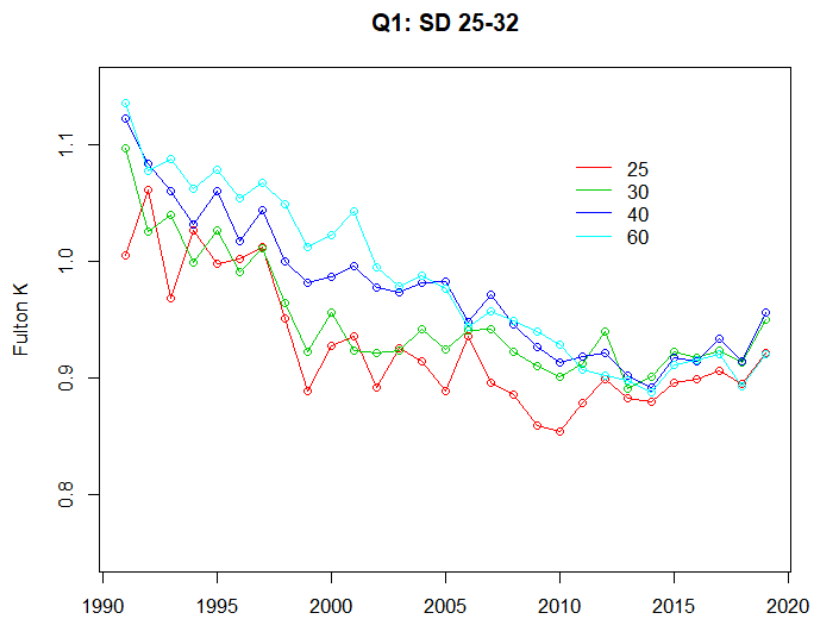


Figure 2.1.5. Eastern Baltic cod in SDs 24-32. Condition (Fulton K) of cod by length groups (<25 cm, 25-30 cm, 30-40 cm, 40-60 cm) in Q1 BITS survey.

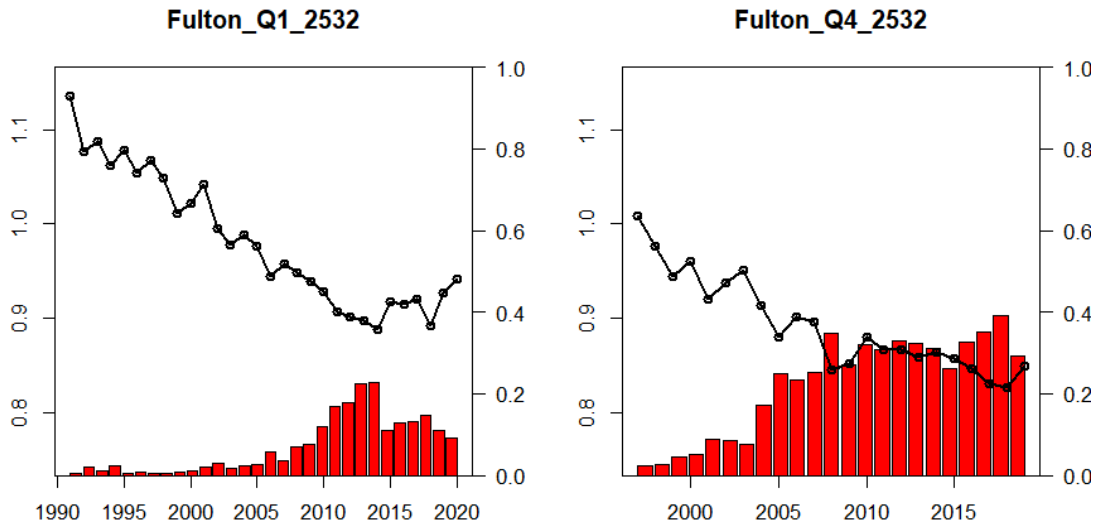


Figure 2.1.6. Eastern Baltic cod in SDs 24-32. Average condition (Fulton K) of cod at 40-60 cm in length in Q1 and Q4 BITS survey in SD 25-32. The lines show mean values for Fulton K, the bars show the proportion of cod at Fulton K < 0.8.

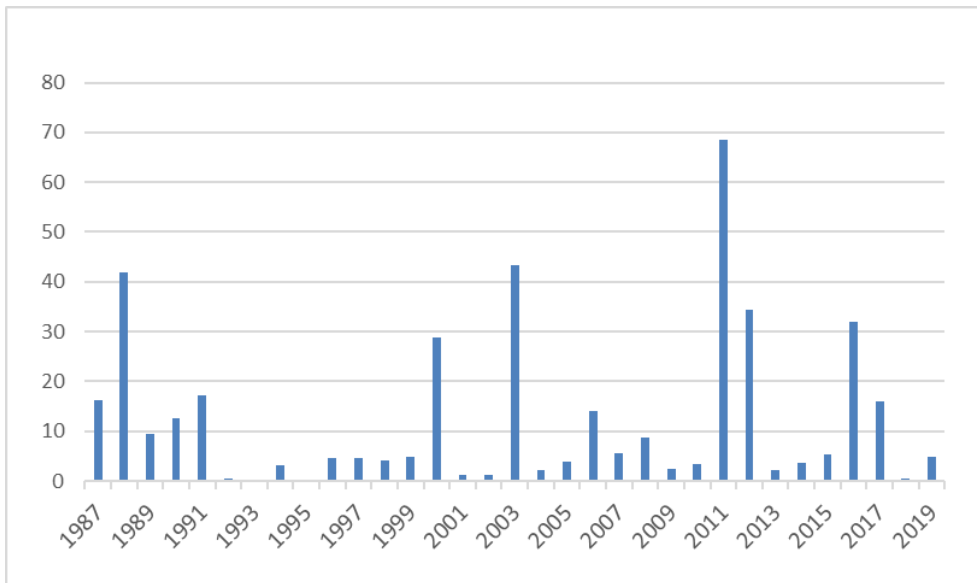


Figure 2.1.7. Eastern Baltic cod in SDs 24-32. Abundance of larvae in the main spawning area during peak spawning time.

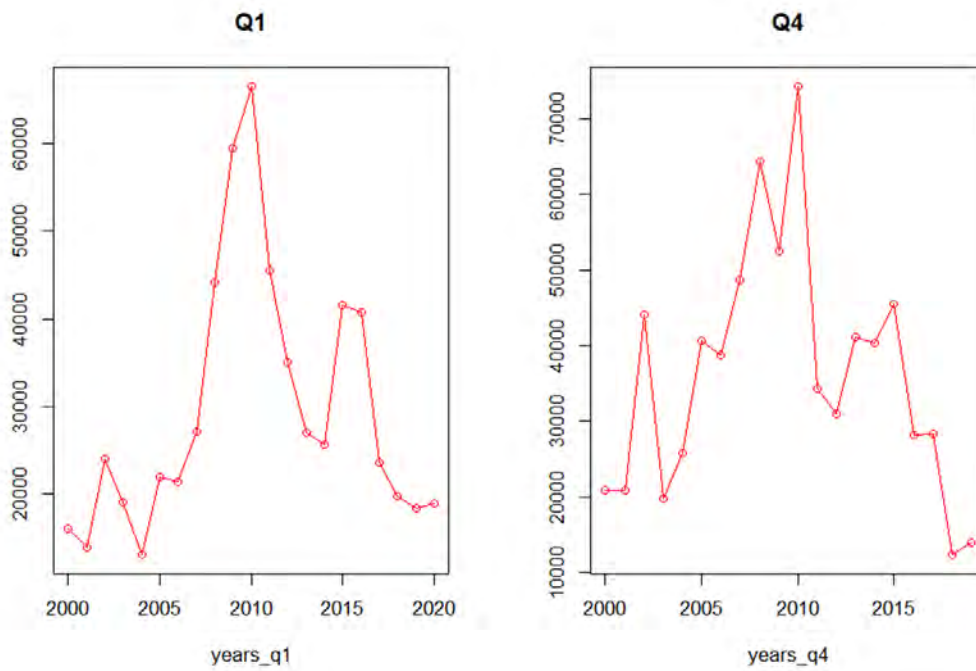


Figure 2.1.8. Eastern Baltic cod in SDs 24-32. Relative total biomass index, estimated from Q1 and Q4 BITS surveys.

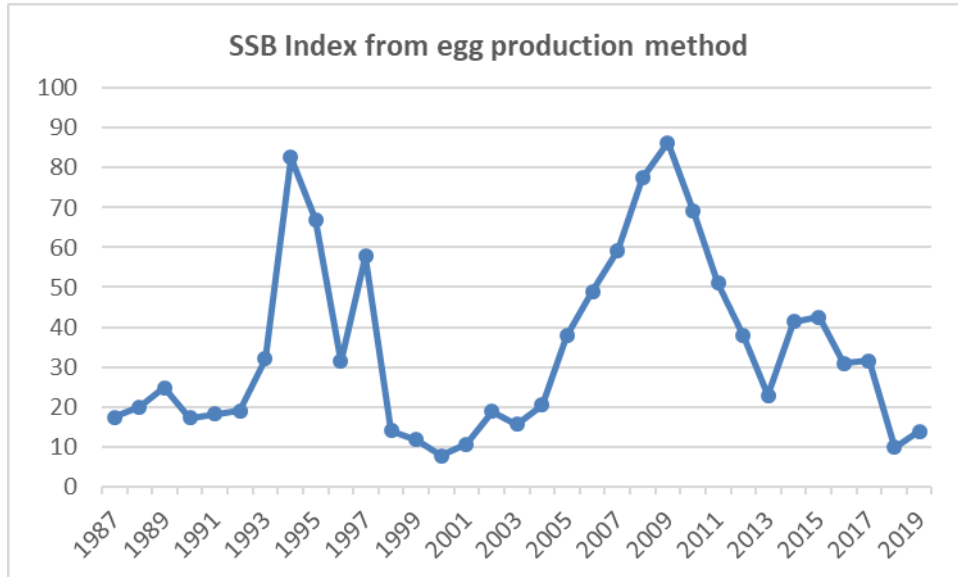


Figure 2.1.9. Eastern Baltic cod in SDs 24-32. Index of spawning stock biomass, calculated from egg production method. Data are from ichthyoplankton surveys.

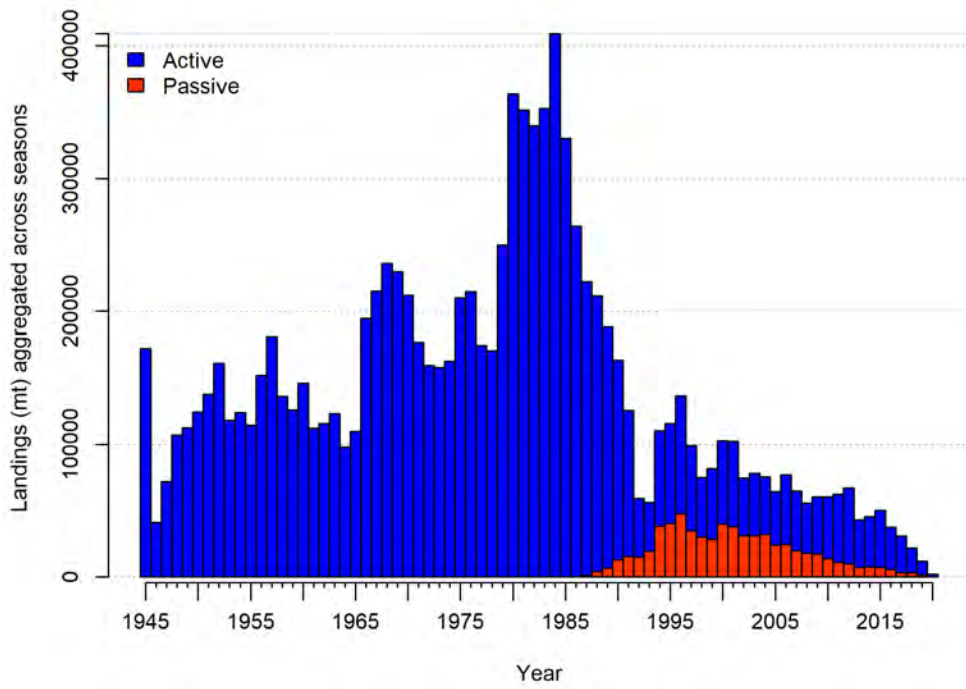


Figure 2.1.10. Eastern Baltic cod in SDs 24-32. Time-series of total catch used in the assessment, by fleets).

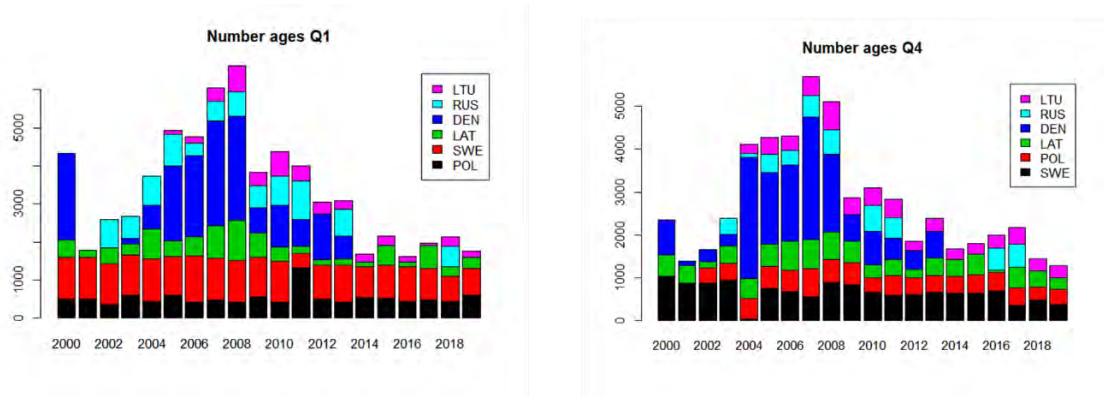


Figure 2.1.11. Eastern Baltic cod in SDs 24-32. Numbers of cod with age readings, for BITS Q1 and Q4, by country.

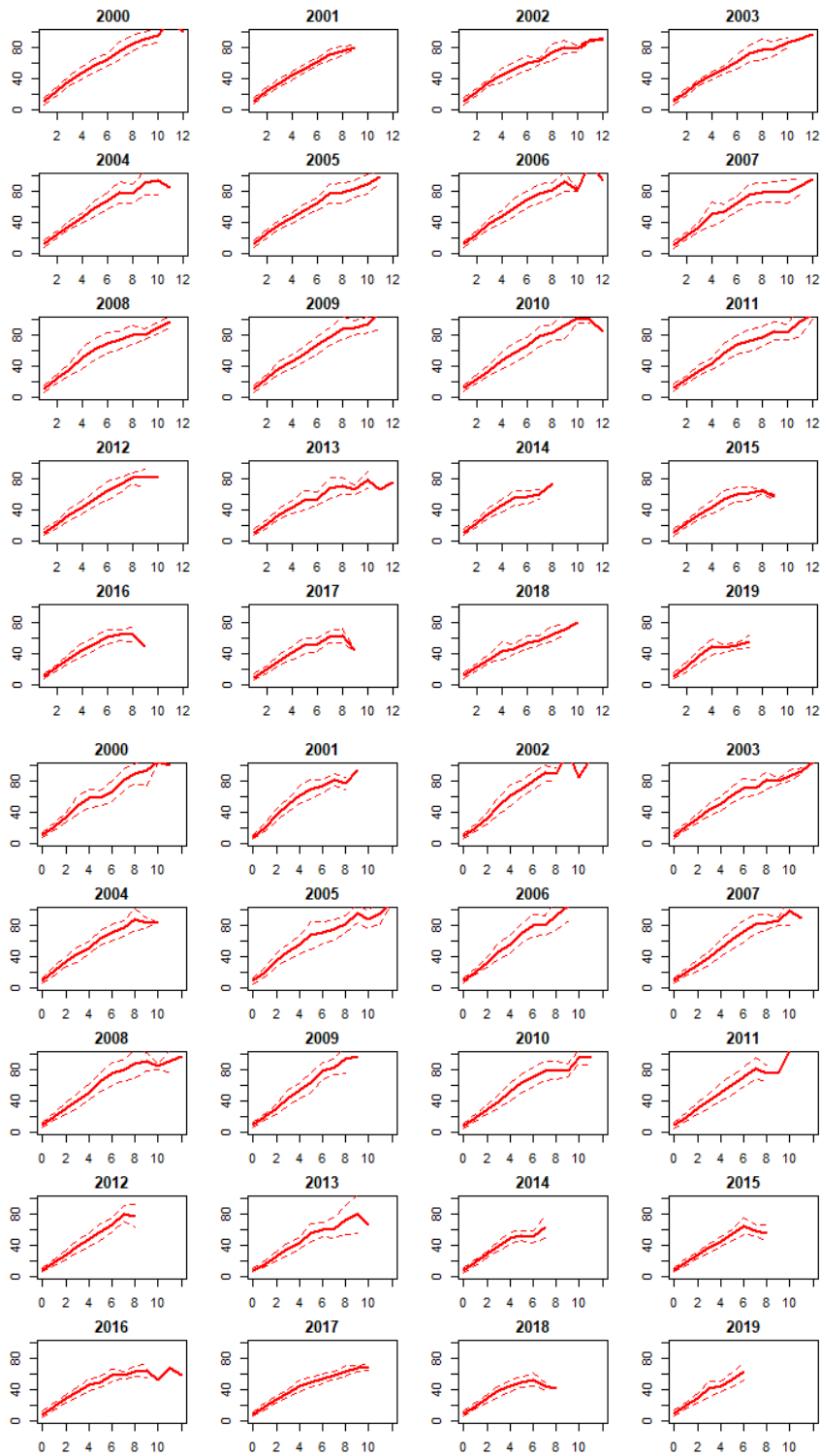


Figure 2.1.12. Eastern Baltic cod in SDs 24-32. Mean length at age (LAA) based on average annual ALKs of all countries included in DATRAS, for BITS Q1 (upper panels) and BITS Q4 (lower panels) (individual sample data only, not raised to the population).

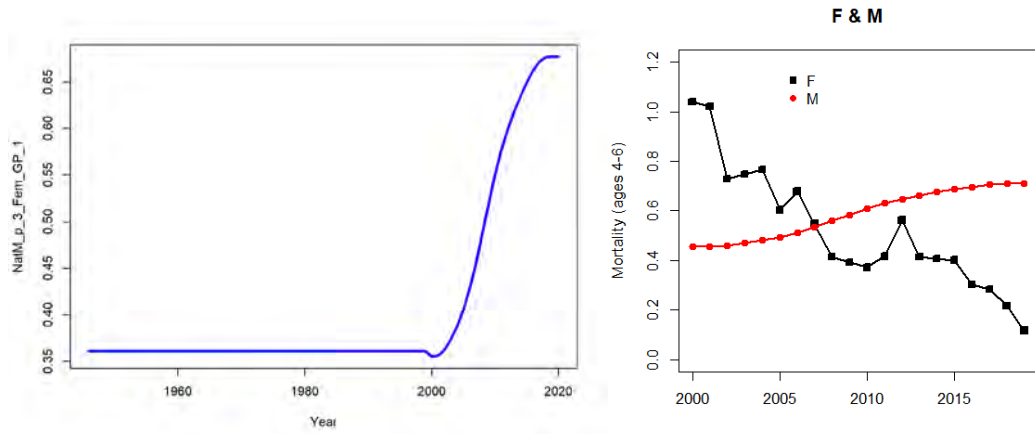


Figure 2.1.13. Eastern Baltic cod in SDs 24-32. Change in natural mortality for age-break 5.5, estimated in Stock Synthesis model (left panel). Fishing mortality (F) and natural mortality (M) for ages 4-6 (right panel).

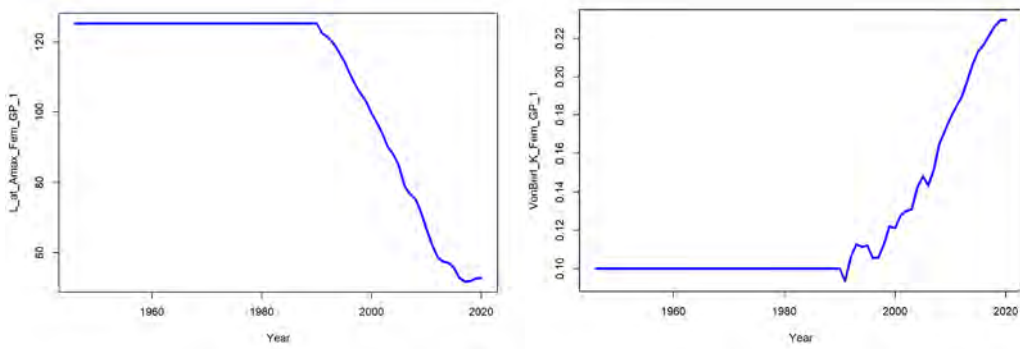


Figure 2.1.14. Eastern Baltic cod in SDs 24-32. Estimated change in von Bertalanffy growth parameters Linf (left panel) and K (right panel) from Stock Synthesis model.

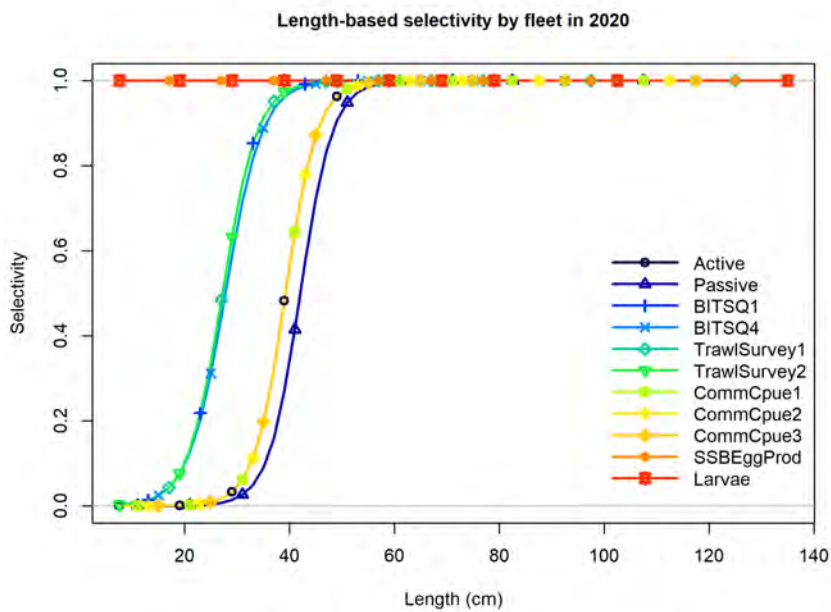


Figure 2.1.15. Eastern Baltic cod in SDs 24-32. Selectivity of different fleets.

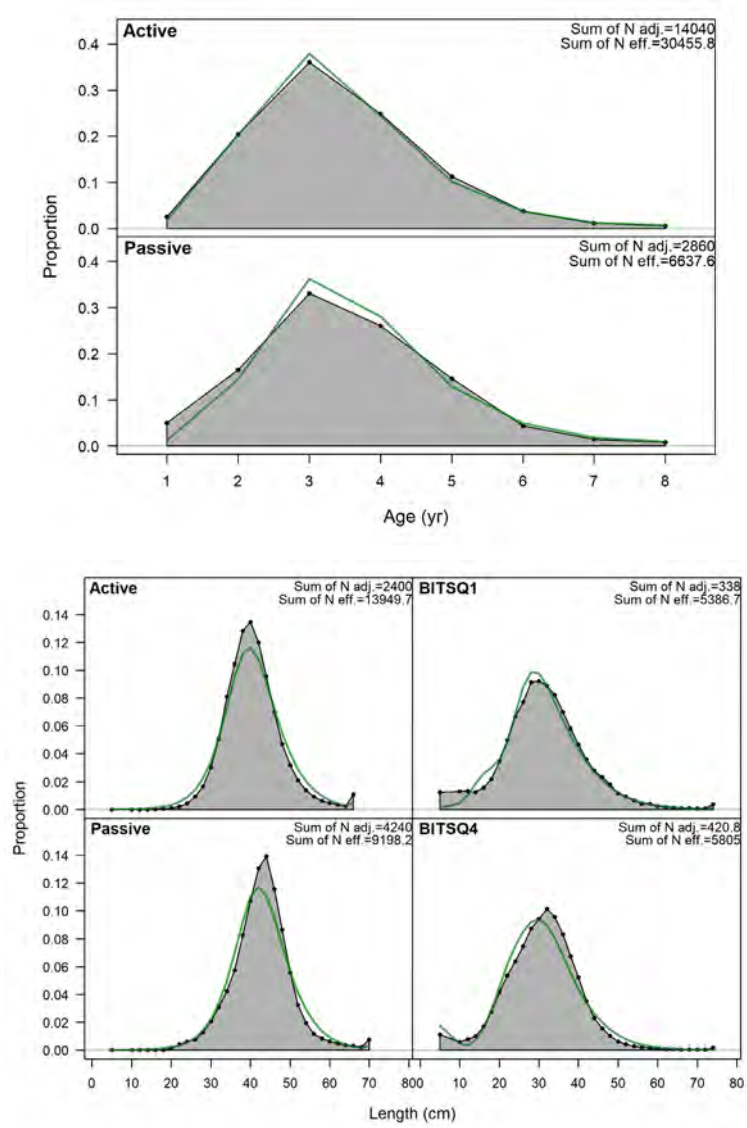


Figure 2.1.16. Eastern Baltic cod in SDs 24-32. Fits to age (upper panels) and length (lower panels) composition data, aggregated across years.

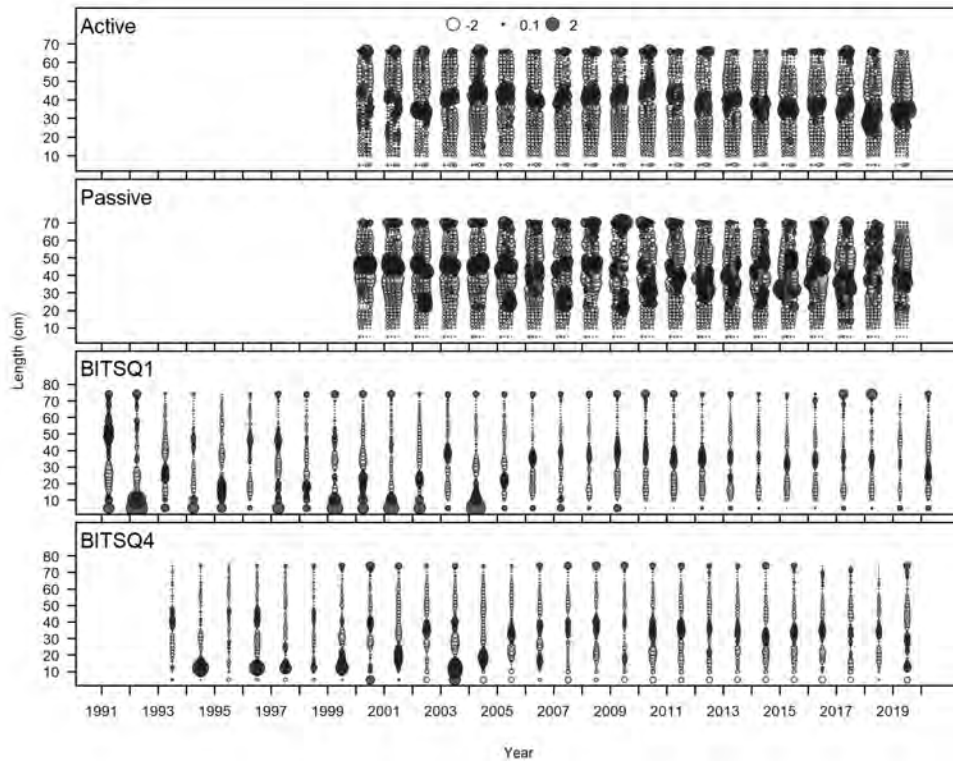
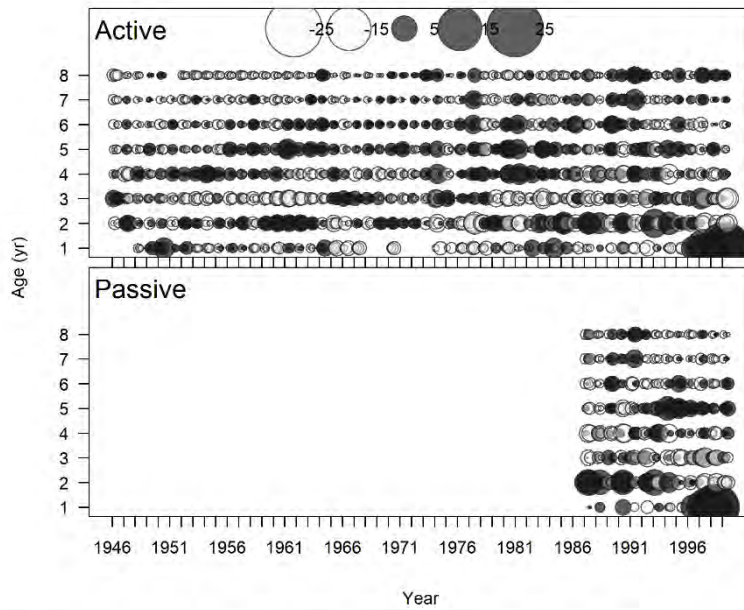


Figure 2.1.17. Eastern Baltic cod in SDs 24-32. Residuals of fits to age (upper panels) and length (lower panels) composition data for different fleets.

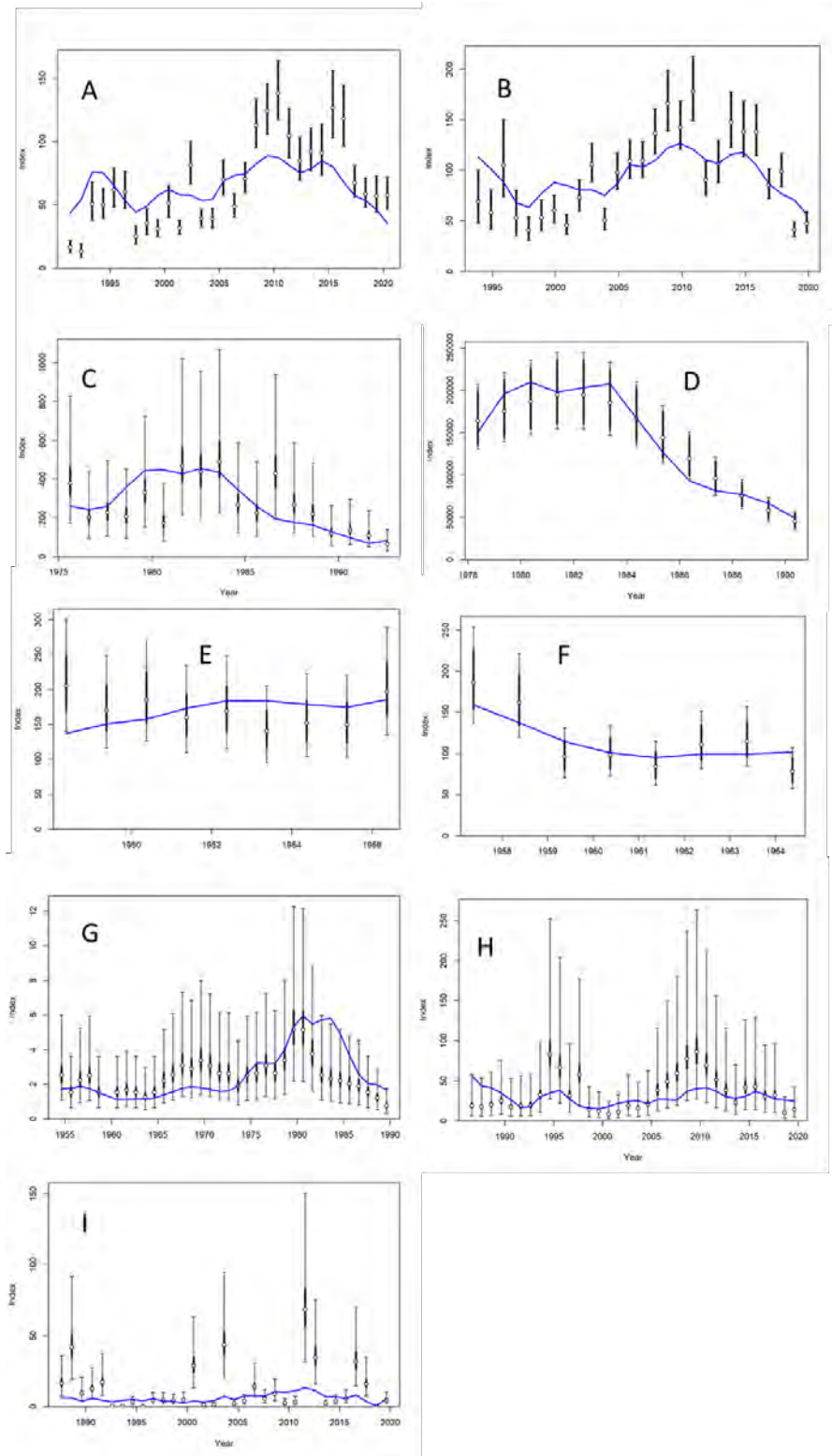


Figure 2.1.18. Eastern Baltic cod in SDs 24-32. Model fits to different tuning indices. A- BITSQ1; B-BITSQ4; C- TrawlSurvey1; D- TrawlSurvey2; E- CommCpue1; F- CommCpue2; G- CommCpue3; H- SSBEGgProd; I- Larvae.

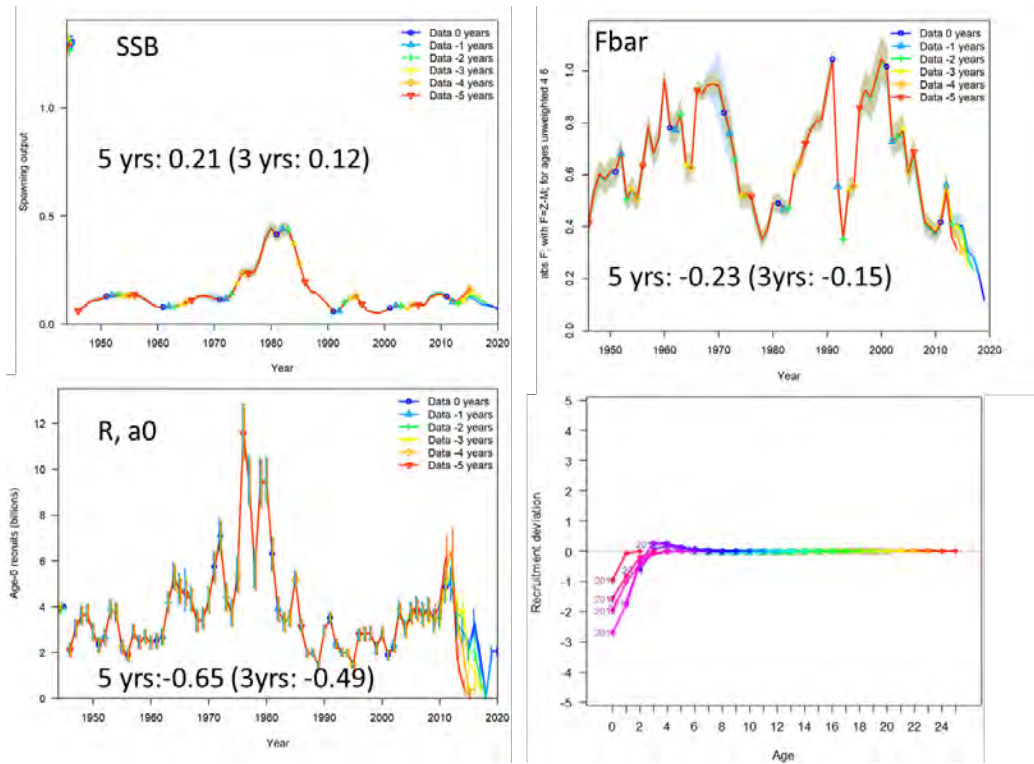


Figure 2.1.19. Eastern Baltic cod in SDs 24-32. Retrospective analyses, including Mohn’s Rho values estimated for 5 years and 3 years (in brackets).

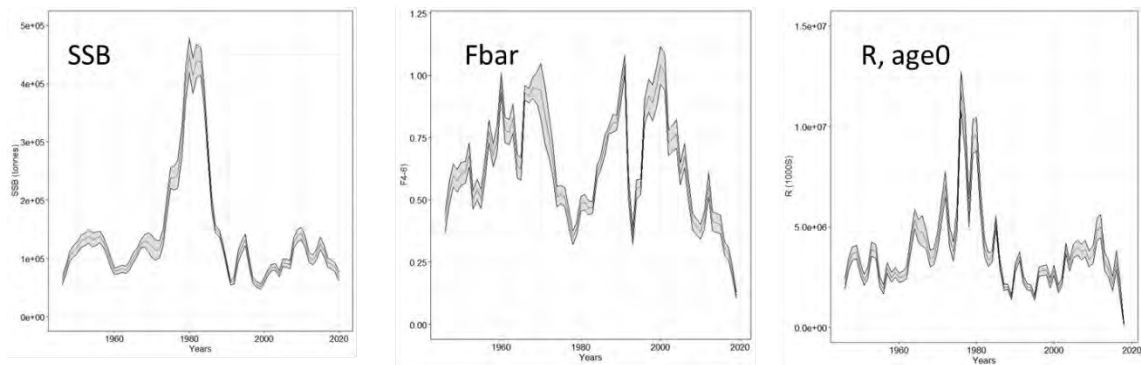


Figure 2.1.20. Eastern Baltic cod in SDs 24-32. Spawning stock biomass, fishing mortality (average of ages 4-6) and recruitment (age 0).

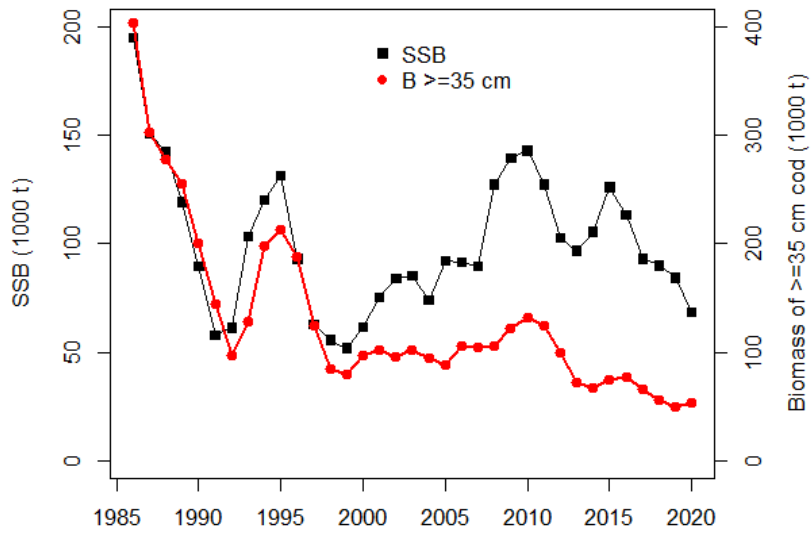
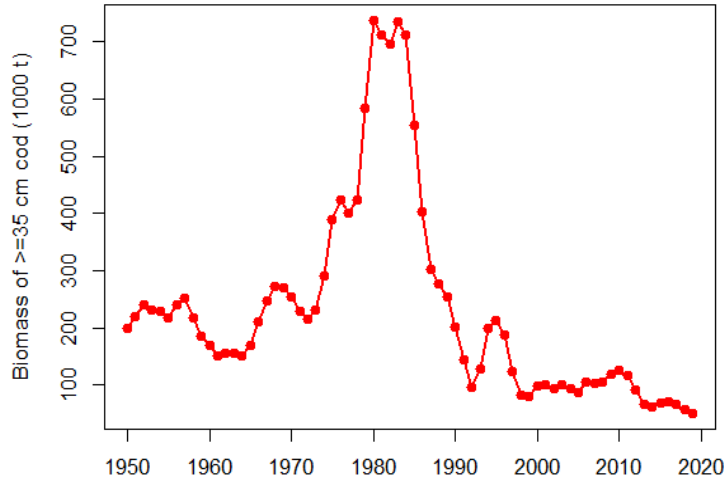


Figure 2.1.21. Eastern Baltic cod in SDs 24-32. Biomass of commercial sized cod (≥ 35 cm in length) (upper panel), compared to SSB in later years (lower panel).

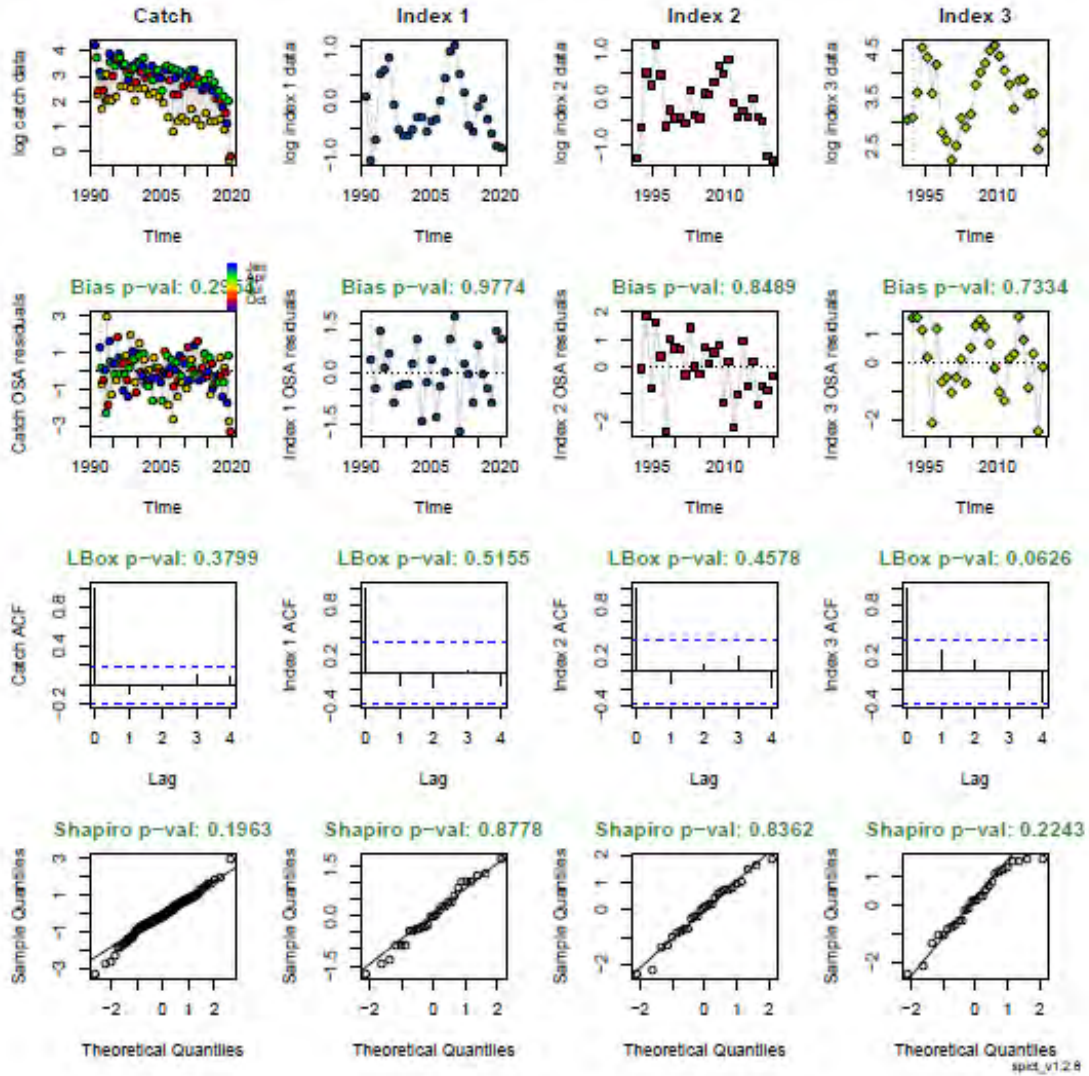


Figure 2.1.22. Eastern Baltic cod in SDs 24-32. Diagnostics of SPIC model.

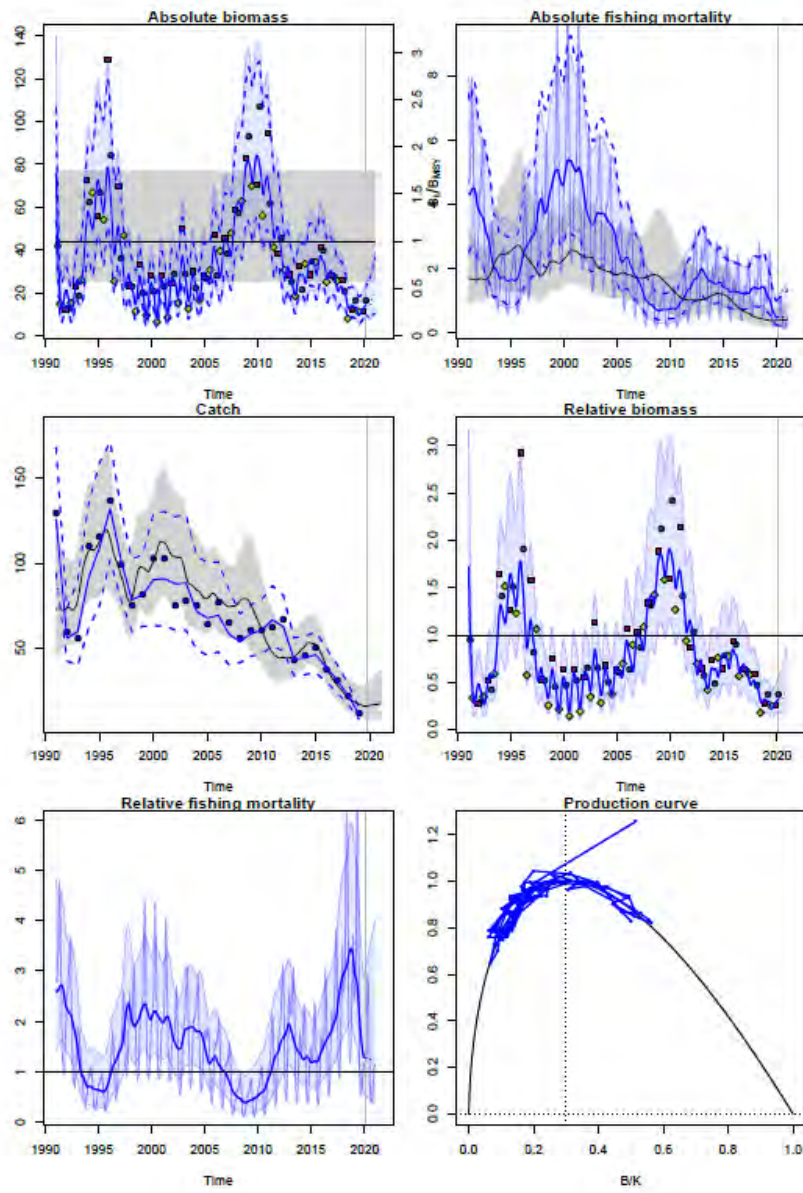


Figure 2.1.23. Eastern Baltic cod in SDs 24-32. Results of SPICT model.

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 Kattegat 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, 1 st quarter, RV Havfisken (age 1-3) (1997-2020) |
| IBTS-3Q | International Bottom Trawl Survey, 3 rd quarter, Kattegat (age 1-4) (1997-2019) |
| IBTS-1Q | International Bottom Trawl Survey, 1 st quarter, Kattegat; (Ages 1-6) (1997-2020) |
| CODS-4Q | Cod survey, 4 th 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.

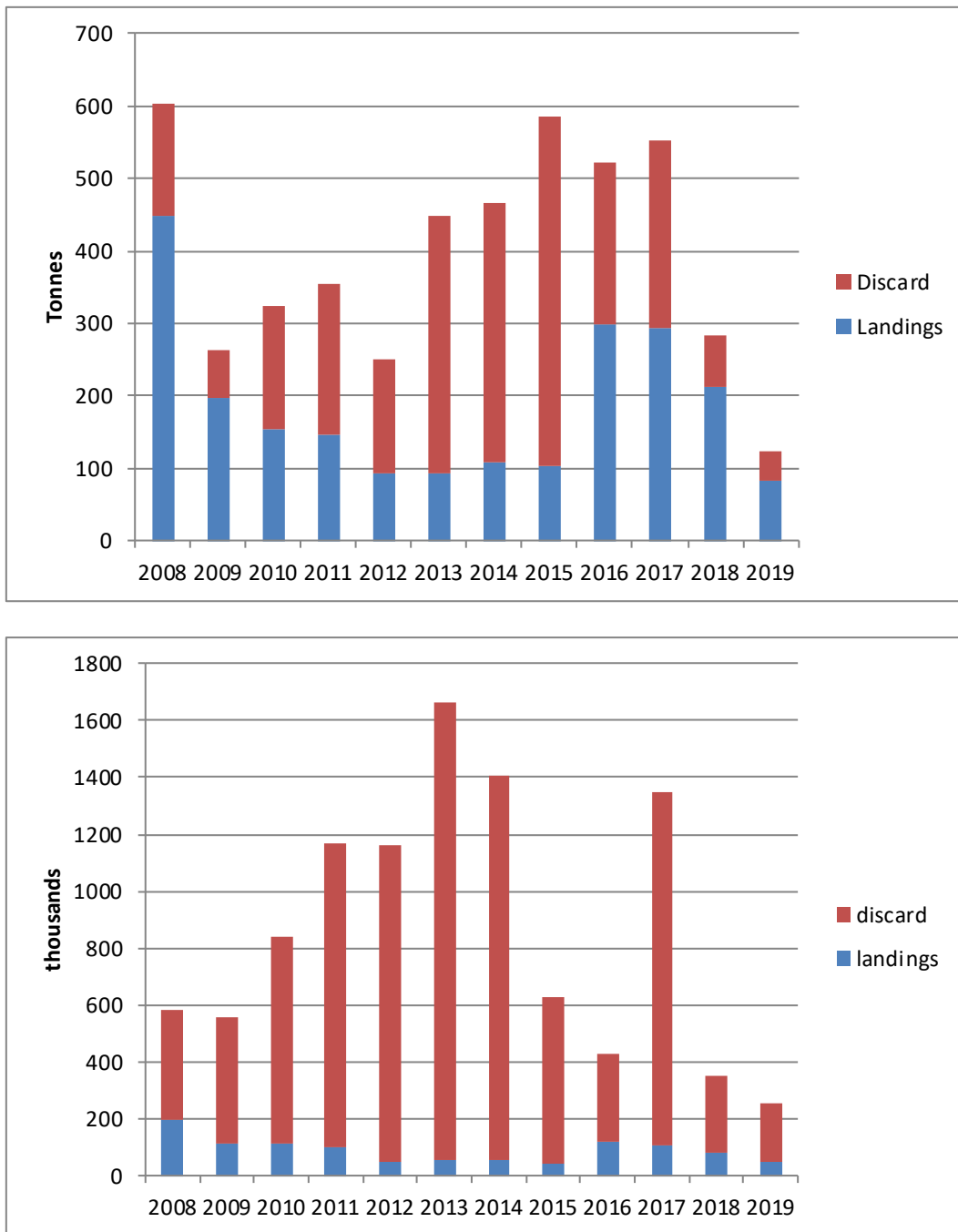


Figure. 2.2.1. Cod in the Kattegat. Estimates of discards (Denmark and Sweden combined) compared to reported landings, in tonnes (upper panel) and in numbers (lower panel).

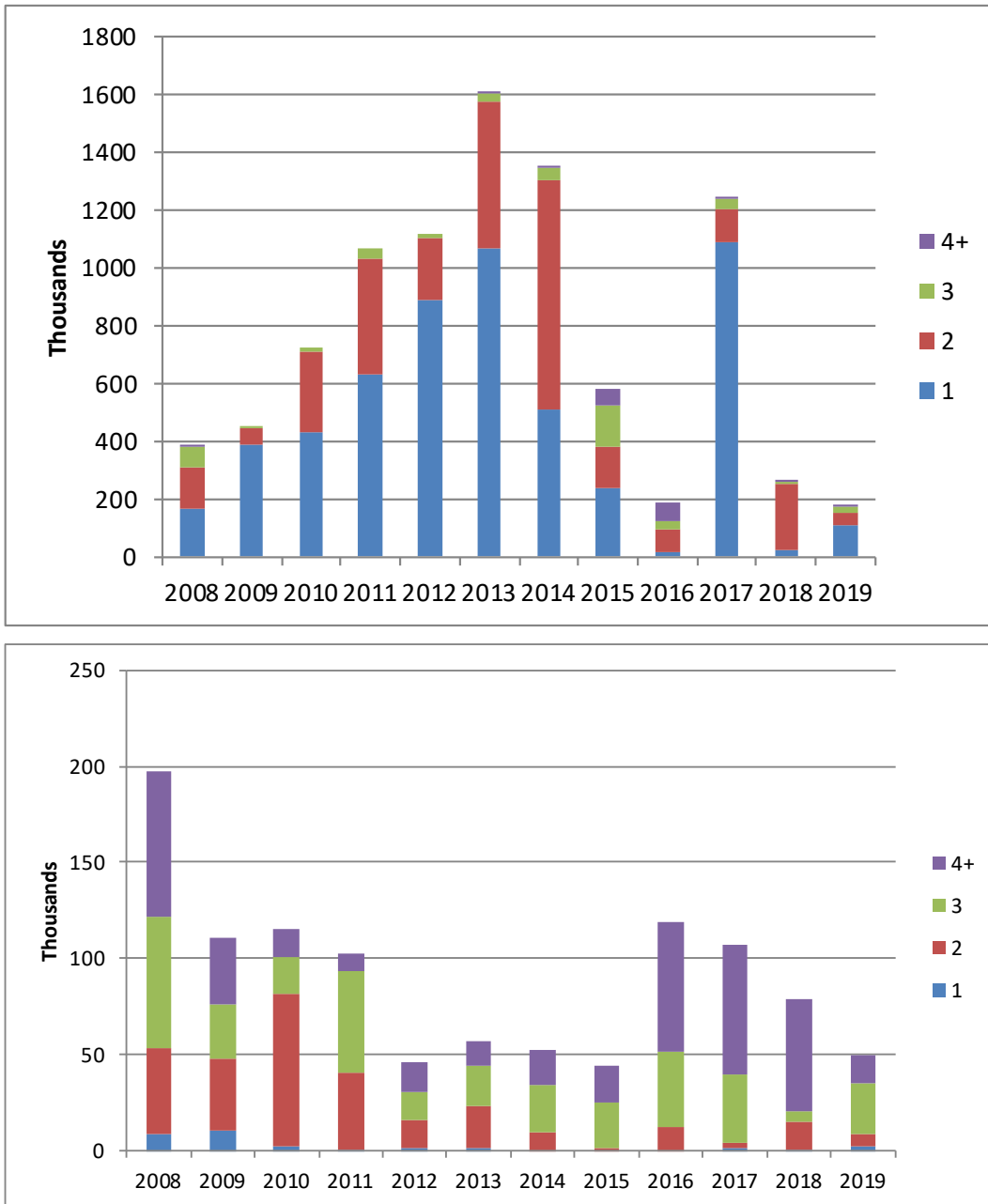
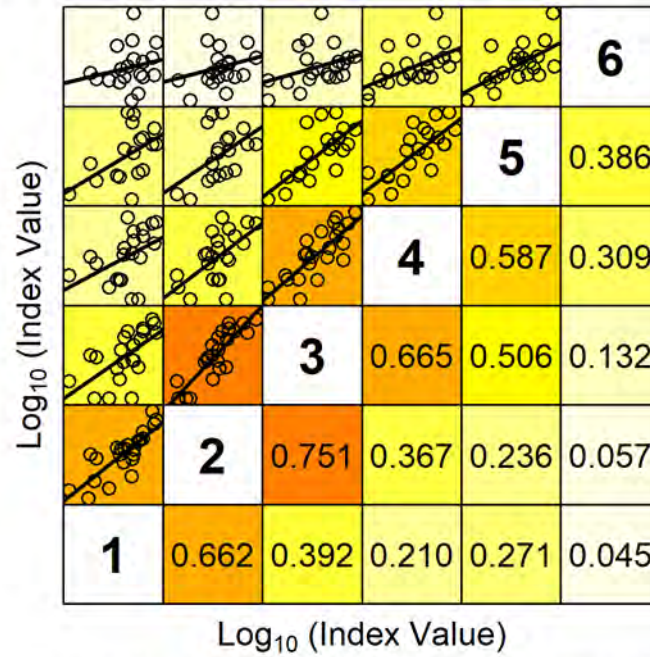


Figure. 2.2.2. Cod in the Kattegat. Estimates of discards in numbers-at-age in the upper panel. Landings in numbers by age in the lower panel (Sweden and Denmark combined).

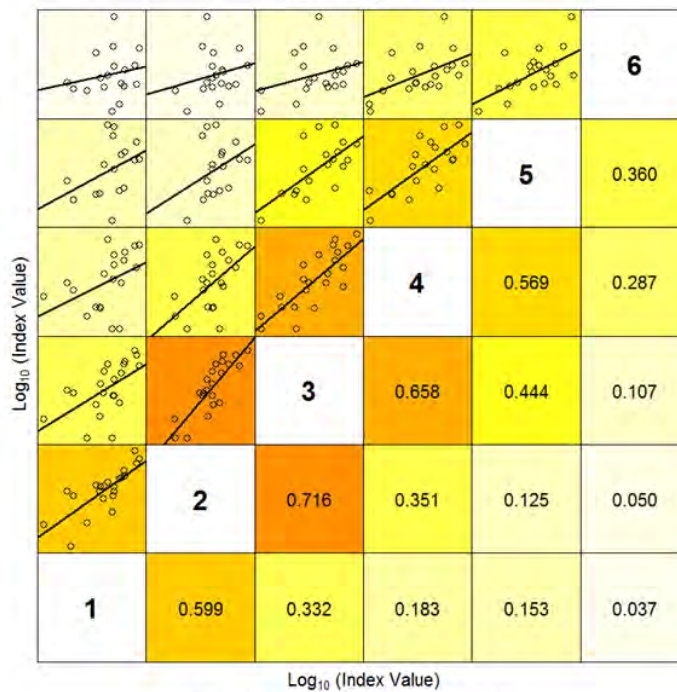
Cohorts consistence in IBTSQ1_1-6



Lower right panels show the Coefficient of Determination (r^2)

2019

IBTSQ1_1-6

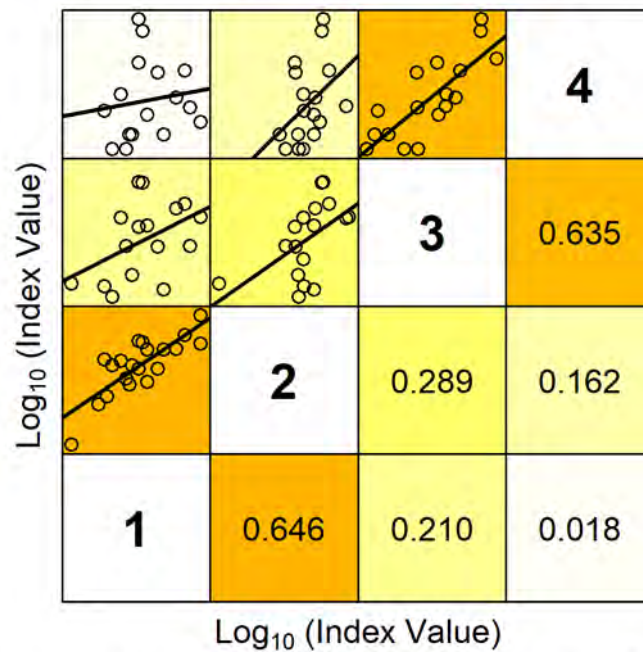


Lower right panels show the Coefficient of Determination (r^2)

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

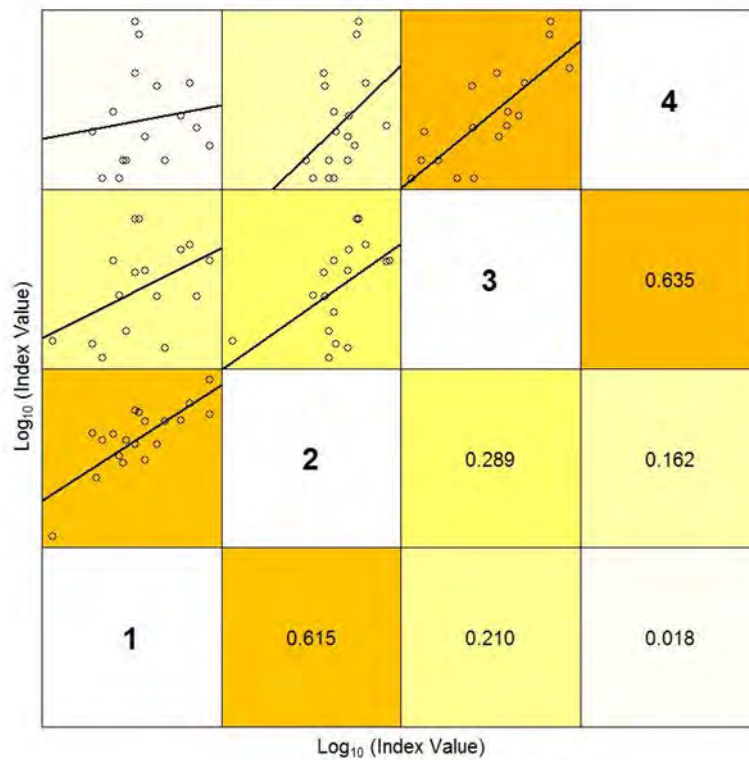
Cohorts consistence in IBTS_Q3



Lower right panels show the Coefficient of Determination (r^2)

2019

IBTS_Q3

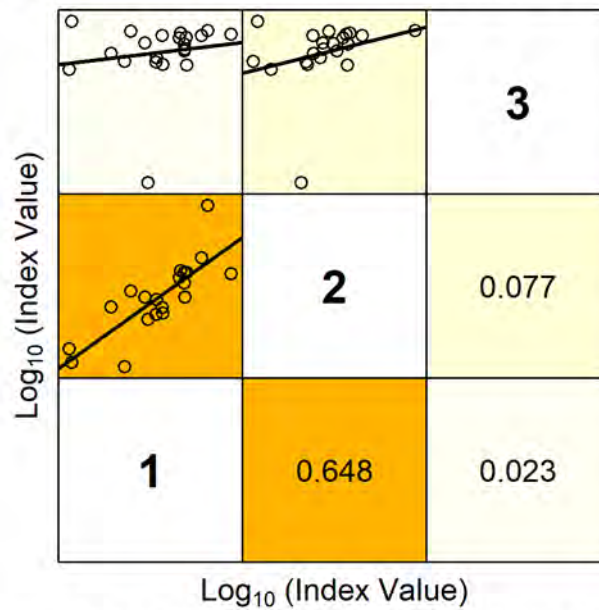


Lower right panels show the Coefficient of Determination (r^2)

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.

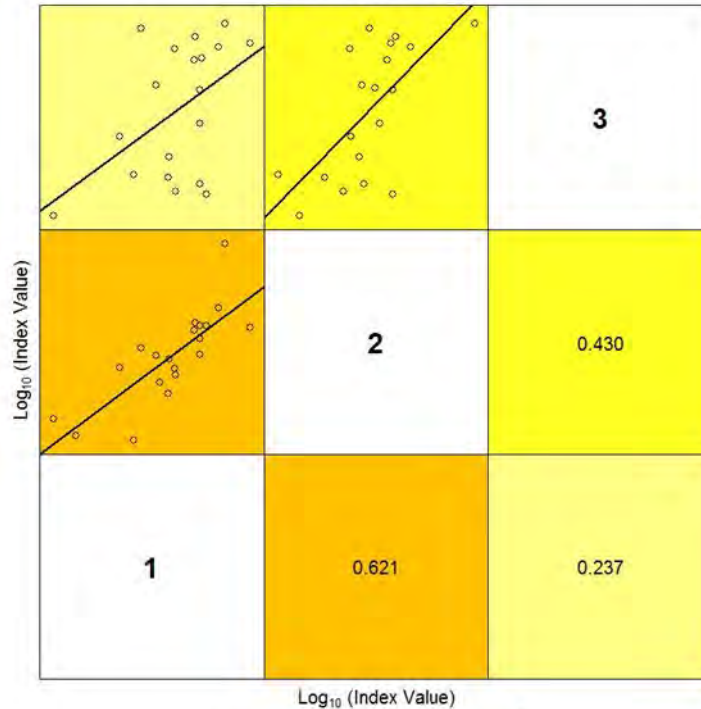
Cohorts consistence in Havfisken_SD21_Q1



Lower right panels show the Coefficient of Determination (r^2)

2019

Havfisken_SD21_Q1

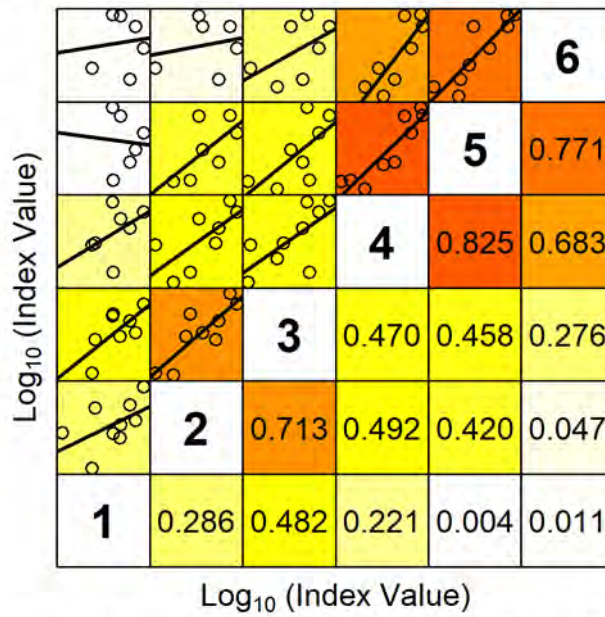


Lower right panels show the Coefficient of Determination (r^2)

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.

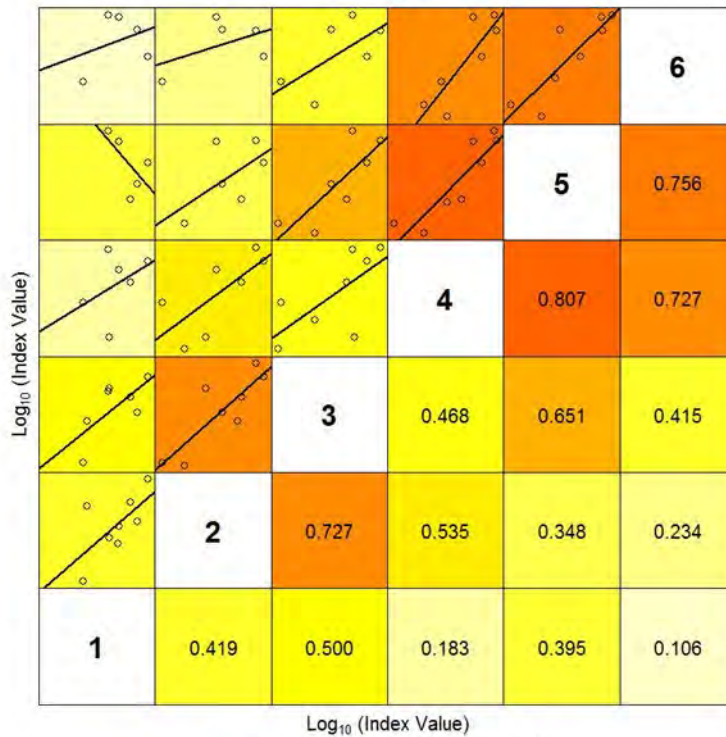
Cohorts consistence in CODS_Q4



Lower right panels show the Coefficient of Determination (r^2)

2019

CODS_Q4



Lower right panels show the Coefficient of Determination (r^2)

2018

Figure 2.2.3d. Cod in Kattegat. Cod survey quarter 4 survey 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

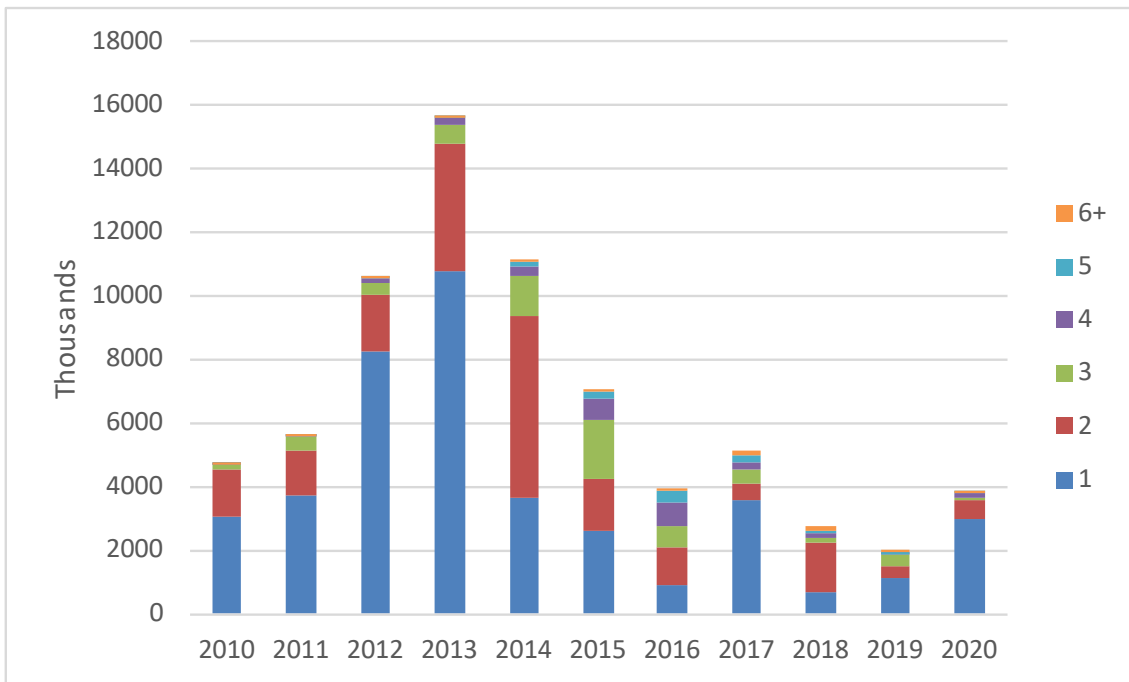


Figure 2.2.4. Stock numbers in numbers-at-age 2010-2020 from SAM output

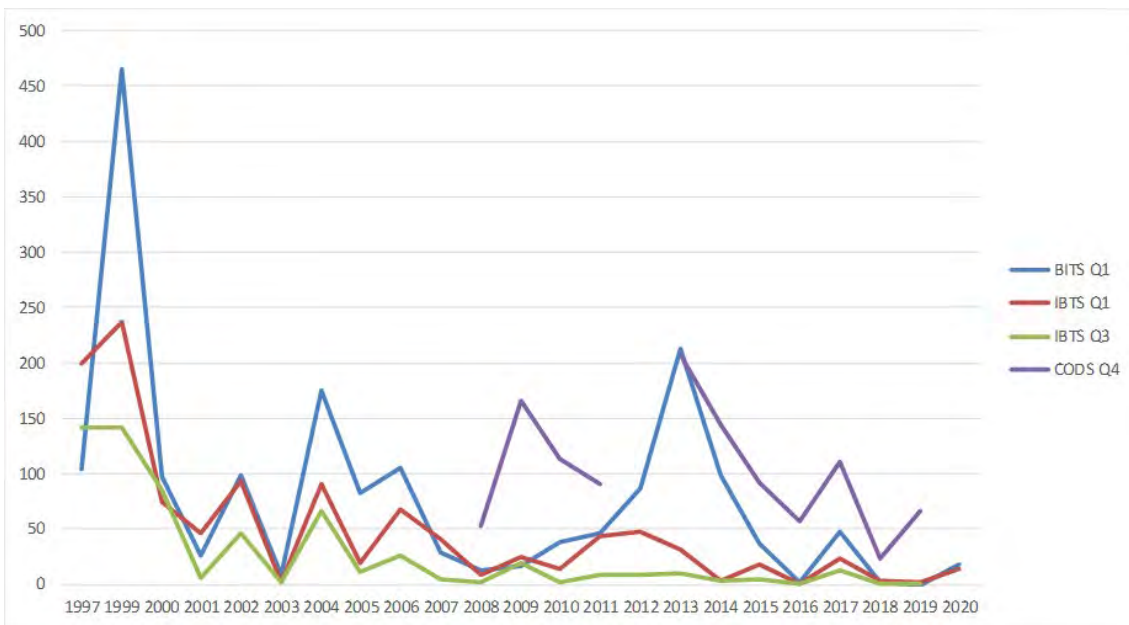


Figure 2.2.5. Cod in the Kattegat. Trends in recruitment index (Age 1) from different surveys.

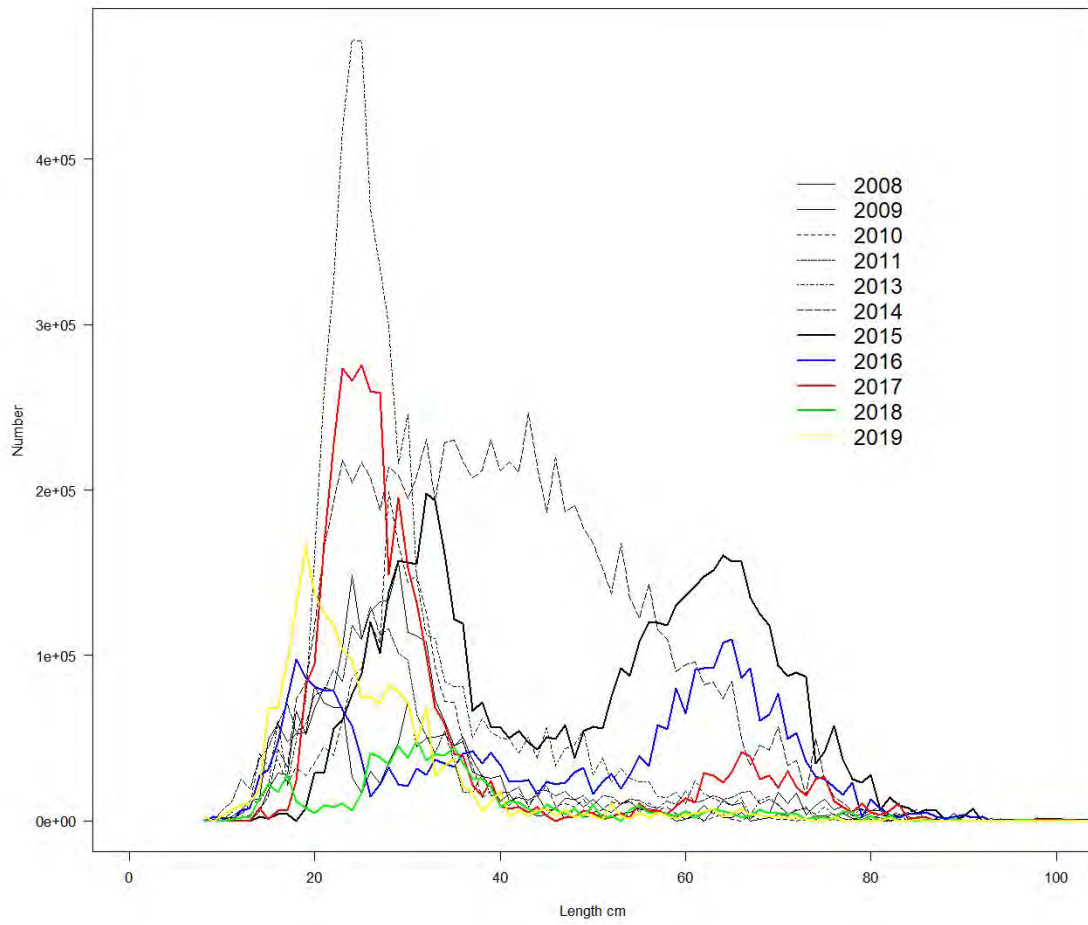


Figure 2.2.6. Length distributions from the Cod survey 2008-2019.

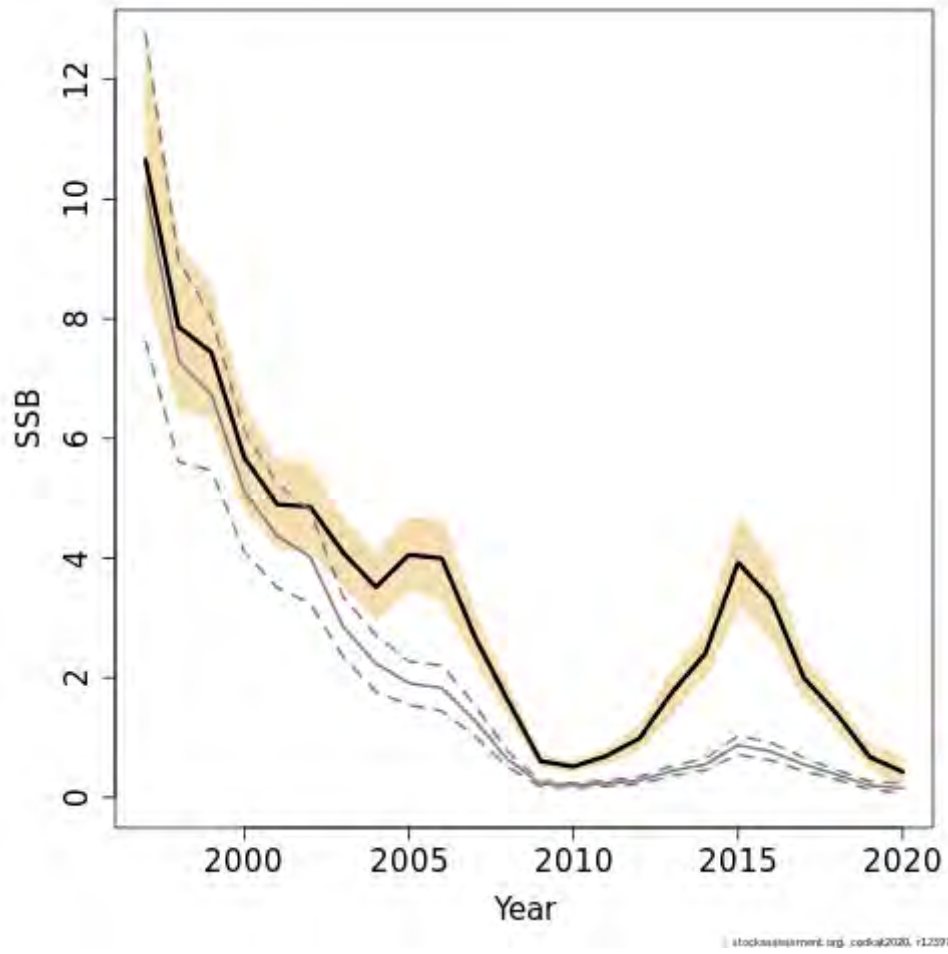


Figure 2.2.7. SSB. SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95% confidence interval).

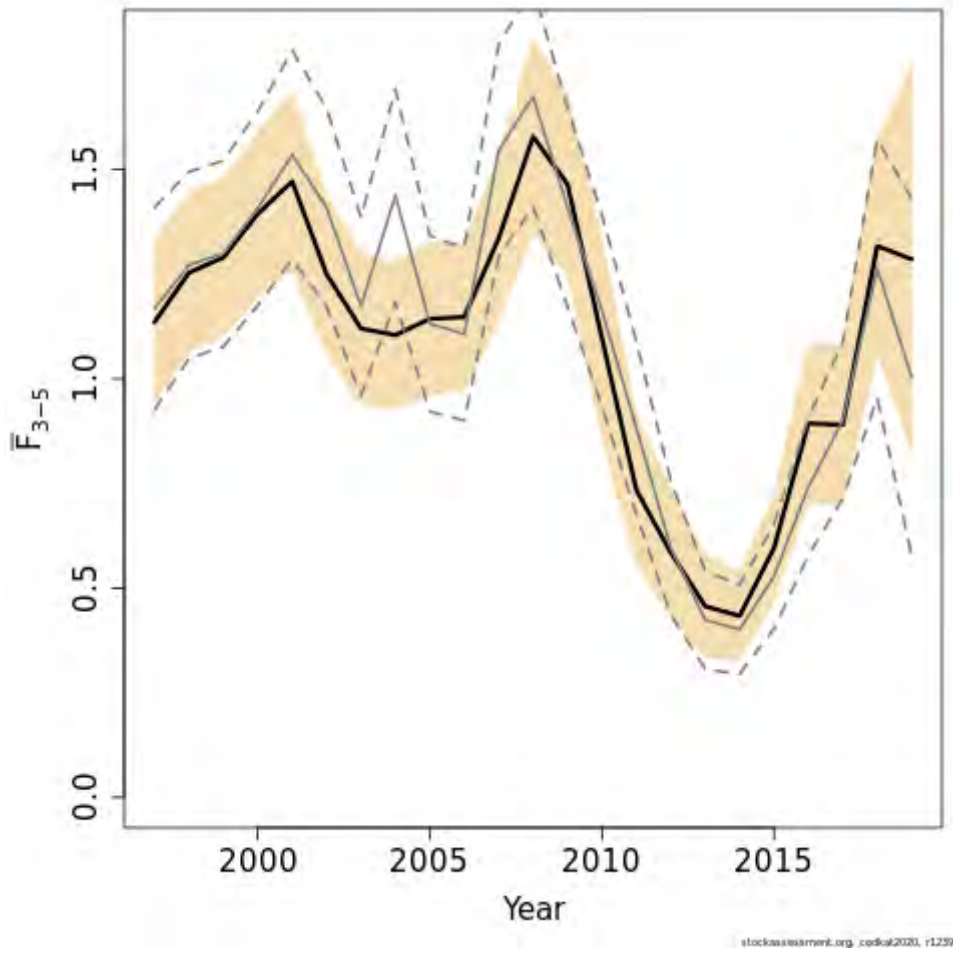


Figure 2.2.8. Unallocated mortality (Z-0.2) SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95% confidence interval).

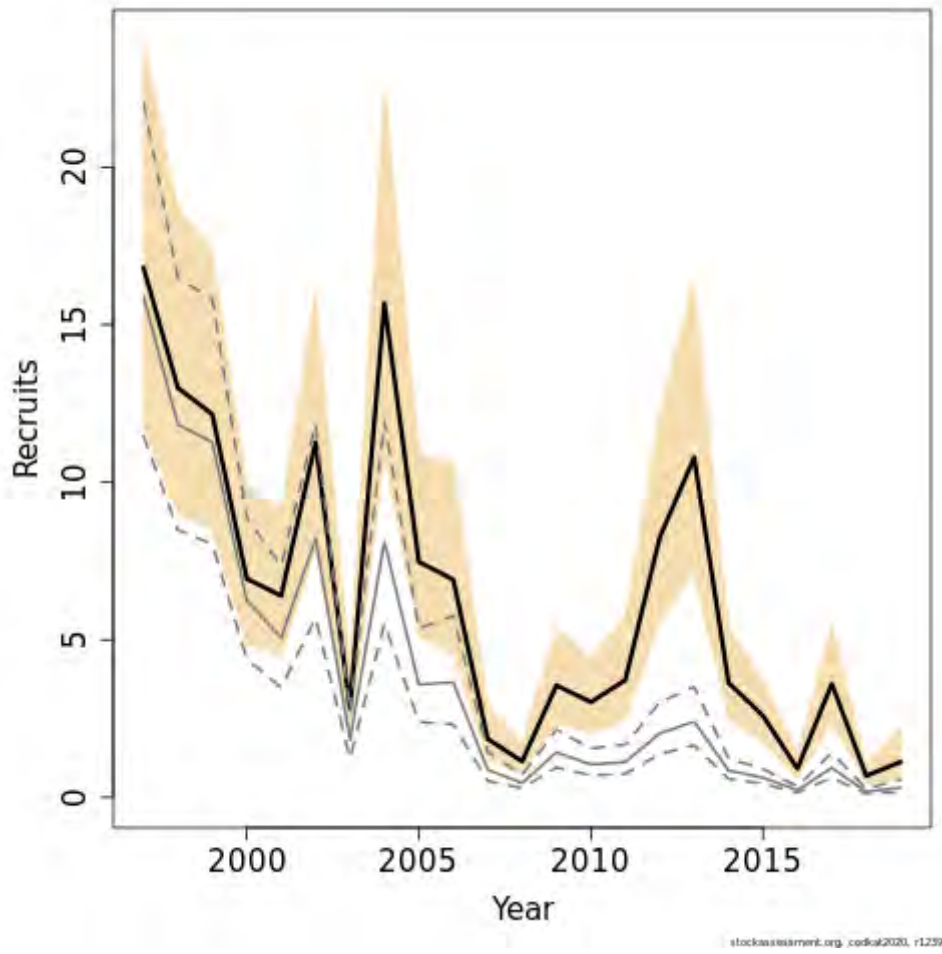
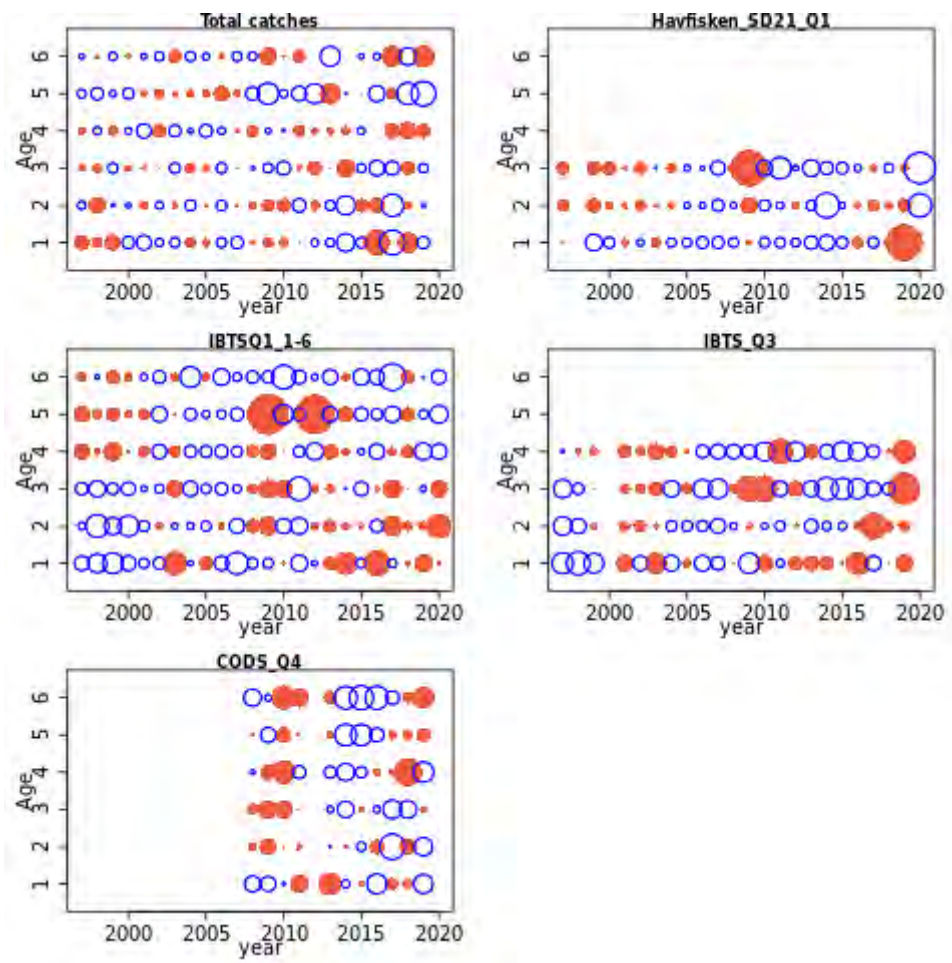


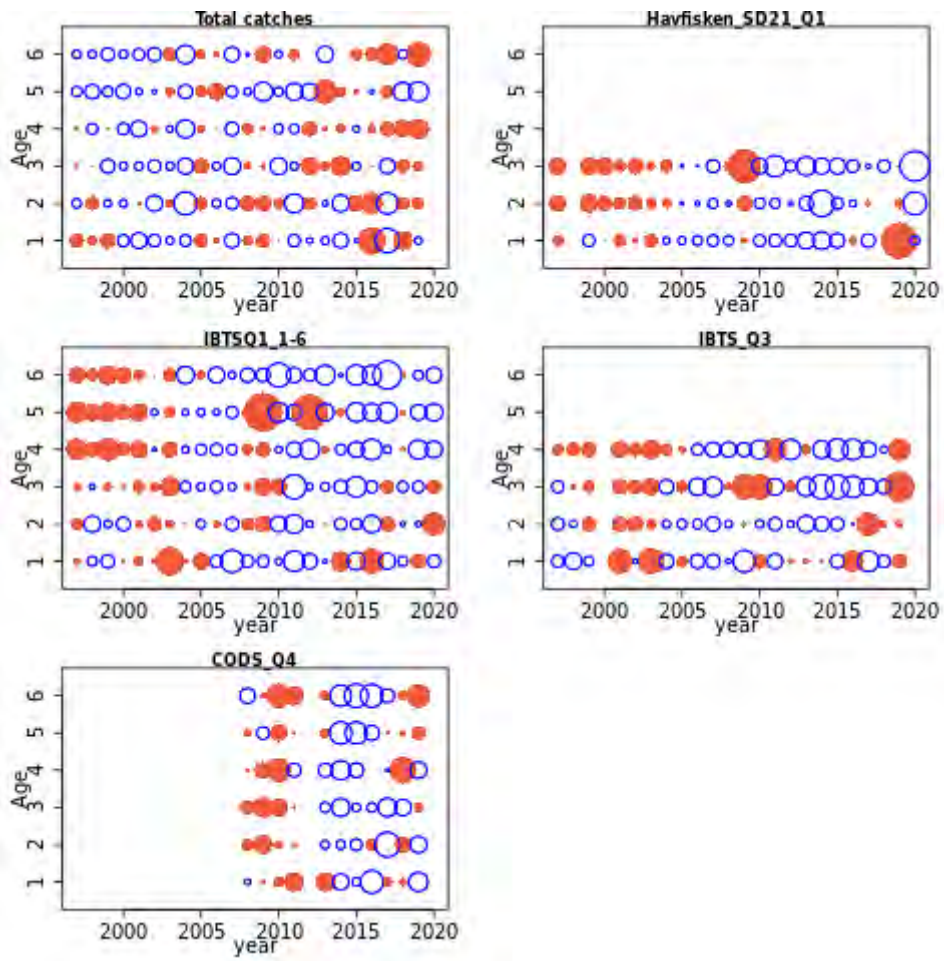
Figure 2.2.9. Recruitment. SAM run without scaling (grey lines) and SAM run with scaling (black line with brown 95% confidence interval).

| 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.



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 pollack⁷ 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+

| Year | Age | | | | | |
|------|------|------|------|------|-----|-----|
| | 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+

| Year | Age | | | | | | | |
|------|-------|-------|-------|-------|-------|-------|-------|--------|
| | 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+

| Year | Age | | | | | | | |
|------|-------|-------|-------|-------|-------|-------|-------|--------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8+ |
| 1971 | 0,059 | 0,355 | 0,919 | 1,673 | 2,518 | 3,553 | 5,34 | 6,635 |
| 1972 | 0,059 | 0,355 | 0,919 | 1,673 | 2,518 | 3,553 | 5,34 | 6,635 |
| 1973 | 0,059 | 0,355 | 0,919 | 1,673 | 2,518 | 3,553 | 5,34 | 6,635 |
| 1974 | 0,059 | 0,355 | 0,919 | 1,673 | 2,518 | 3,553 | 5,34 | 6,635 |
| 1975 | 0,059 | 0,355 | 0,919 | 1,673 | 2,518 | 3,553 | 5,34 | 6,635 |
| 1976 | 0,059 | 0,355 | 0,919 | 1,673 | 2,518 | 3,553 | 5,34 | 6,635 |
| 1977 | 0,059 | 0,355 | 0,919 | 1,673 | 2,518 | 3,553 | 5,34 | 6,635 |
| 1978 | 0,059 | 0,355 | 1,006 | 1,69 | 2,86 | 4,12 | 5,18 | 6,9 |
| 1979 | 0,059 | 0,35 | 0,934 | 1,89 | 2,215 | 3,382 | 7,314 | 6,101 |
| 1980 | 0,058 | 0,361 | 0,817 | 1,44 | 2,478 | 3,157 | 3,526 | 6,903 |
| 1981 | 0,051 | 0,323 | 0,965 | 1,432 | 2,076 | 3,532 | 4,42 | 4,644 |
| 1982 | 0,05 | 0,317 | 1,06 | 1,391 | 2,078 | 2,911 | 3,698 | 6,48 |
| 1983 | 0,05 | 0,304 | 0,971 | 1,943 | 3,348 | 3,141 | 5,301 | 6,325 |
| 1984 | 0,06 | 0,301 | 0,974 | 1,687 | 2,798 | 3,022 | 5,273 | 7,442 |
| 1985 | 0,051 | 0,339 | 0,848 | 1,614 | 2,575 | 4,09 | 6,847 | 7,133 |
| 1986 | 0,056 | 0,285 | 1,077 | 1,955 | 2,956 | 4,038 | 7,1 | 7,29 |
| 1987 | 0,041 | 0,289 | 0,961 | 1,972 | 2,868 | 4,2 | 5,185 | 8,288 |
| 1988 | 0,045 | 0,317 | 0,945 | 1,792 | 2,88 | 4,283 | 5,852 | 7,073 |
| 1989 | 0,052 | 0,372 | 1,091 | 2,296 | 3,856 | 5,733 | 5,166 | 6,527 |
| 1990 | 0,052 | 0,393 | 1,362 | 2,323 | 3,288 | 5,383 | 6,412 | 10,337 |
| 1991 | 0,06 | 0,415 | 1,799 | 2,986 | 4,548 | 4,179 | 9,127 | 12,055 |
| 1992 | 0,052 | 0,34 | 1,191 | 2,662 | 4,048 | 5,888 | 7,067 | 7,895 |
| 1993 | 0,056 | 0,353 | 1,086 | 2,321 | 4,97 | 7,566 | 9,391 | 8,705 |
| 1994 | 0,035 | 0,269 | 1,225 | 2,652 | 3,526 | 7,279 | 9,793 | 10,13 |
| 1995 | 0,032 | 0,148 | 1,31 | 1,947 | 2,404 | 3,537 | 9,973 | 10,708 |
| 1996 | 0,027 | 0,22 | 0,496 | 1,771 | 2,638 | 3,773 | 4,677 | 7,871 |
| 1997 | 0,034 | 0,179 | 0,743 | 1,95 | 2,806 | 3,877 | 5,756 | 7,213 |
| 1998 | 0,049 | 0,213 | 0,442 | 1,68 | 2,497 | 4,317 | 6,669 | 8,948 |
| 1999 | 0,046 | 0,207 | 0,625 | 1,616 | 2,588 | 4,665 | 5,376 | 8,04 |
| 2000 | 0,046 | 0,176 | 0,624 | 1,332 | 2,779 | 3,944 | 5,069 | 9,02 |
| 2001 | 0,065 | 0,269 | 0,72 | 1,585 | 2,597 | 4,693 | 7,117 | 7,691 |
| 2002 | 0,045 | 0,29 | 1,334 | 2,052 | 3,539 | 4,814 | 6,915 | 7,833 |
| 2003 | 0,066 | 0,224 | 1,054 | 2,46 | 3,75 | 5,923 | 7,835 | 10,891 |
| 2004 | 0,052 | 0,407 | 1,007 | 1,63 | 2,7 | 3,916 | 6,181 | 9,423 |
| 2005 | 0,058 | 0,349 | 1,187 | 2,343 | 3,584 | 5,442 | 6,439 | 8,307 |
| 2006 | 0,064 | 0,280 | 1,083 | 3,130 | 3,995 | 4,222 | 5,264 | 6,713 |
| 2007 | 0,058 | 0,289 | 1,060 | 2,275 | 3,344 | 3,829 | 1,802 | 7,897 |
| 2008 | 0,045 | 0,335 | 1,010 | 3,210 | 4,097 | 4,437 | 5,552 | 5,827 |
| 2009 | 0,053 | 0,300 | 1,069 | 2,651 | 4,069 | 4,693 | 4,870 | 5,792 |
| 2010 | 0,052 | 0,285 | 1,171 | 3,081 | 4,038 | 3,592 | 4,252 | 6,404 |
| 2011 | 0,051 | 0,269 | 0,905 | 2,695 | 3,372 | 4,997 | 4,059 | 7,569 |
| 2012 | 0,044 | 0,251 | 0,923 | 3,174 | 4,004 | 5,224 | 4,305 | 6,921 |
| 2013 | 0,041 | 0,255 | 1,043 | 2,545 | 3,726 | 3,310 | 5,1 | NA |
| 2014 | 0,049 | 0,285 | 1,050 | 2,541 | 3,869 | 5,431 | NA | NA |
| 2015 | 0,055 | 0,311 | 1,036 | 2,023 | 3,385 | 2,873 | NA | NA |
| 2016 | 0,045 | 0,338 | 1,041 | 2,448 | 2,72 | 3,665 | NA | NA |
| 2017 | 0,037 | 0,275 | 0,993 | 2,91 | 3,353 | 3,858 | NA | NA |
| 2018 | 0,038 | 0,202 | 1,103 | 2,511 | 3,265 | 3,766 | NA | NA |
| 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 Kattegatt 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 | 1104.552146 | 24.105792 | 16.370021 | | | |
| 1 | -9 | | -9 | | | -9 |
| 1 | 1464.863274 | 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 | 1175.055626 | 11.183467 | 5.333215 | | | |
| 1 | 83.149813 | 86.679327 | 2.545501 | | | |
| 1 | 1105.175603 | 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 | 1212.343689 | 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 (TSB), 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 (TSB), 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 introduced 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 square38G3, 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 split 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 (F_{msy} lower) and 9039 t (F_{msy} 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 F_{MSY} calculation, however, calculated without trigger and $F_{cv}=0$, $F_{phi}=0$. 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 set 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 of 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).

| | Cod in SD 22-24. Total landings (tons) of COD in the ICES Sub-divisions 22, 23, 24. | | | | | | | | | | | | | | | Total | | Grand total |
|------|---|------|-------|---------|-------------------------------|--------------|-------|---------|-----------|--------|--------|------|--------|------|-------|----------|-------|-------------|
| | Denmark | | | Finland | German Dem. Rep. ¹ | Germany, FRG | | Estonia | Lithuania | Latvia | Poland | | Sweden | | | Unalloc. | | |
| | 22 | 23 | 22+24 | 24 | 22 | 22+24 | 22 | 24 | 24 | 24 | 22 | 23 | 22+24 | 22 | 23 | | 24 | |
| 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 | 49433 | |
| 1977 | | 1166 | 27939 | | 3448 | | 11686 | | | | | | 550 | 1516 | 29510 | 1716 | 15079 | |
| 1978 | | 1177 | 19168 | | 7085 | | 10852 | | | | | | 600 | 1730 | 24232 | 1777 | 14603 | |
| 1979 | | 2029 | 23325 | | 7594 | | 9598 | | | | | | 700 | 1800 | 26027 | 2729 | 16290 | |
| 1980 | | 2425 | 23400 | | 5580 | | 6657 | | | | | | 1300 | 2610 | 22881 | 3725 | 15366 | |
| 1981 | | 1473 | 22654 | | 11659 | | 11260 | | | | | | 900 | 5700 | 26340 | 2373 | 24933 | |
| 1982 | | 1638 | 19138 | | 10615 | | 8060 | | | | | | 140 | 7933 | 20971 | 1778 | 24775 | |
| 1983 | | 1257 | 21961 | | 9097 | | 9260 | | | | | | 120 | 6910 | 24478 | 1377 | 22750 | |
| 1984 | | 1703 | 21909 | | 8093 | | 11548 | | | | | | 228 | 6014 | 27058 | 1931 | 20506 | |
| 1985 | | 1076 | 23024 | | 5378 | | 5523 | | | | | | 263 | 4895 | 22063 | 1339 | 16757 | |
| 1986 | | 748 | 16195 | | 2998 | | 2902 | | | | | | 227 | 3622 | 11975 | 975 | 13742 | |
| 1987 | | 1503 | 13460 | | 4896 | | 4256 | | | | | | 137 | 4314 | 12105 | 1640 | 14821 | |
| 1988 | | 1121 | 13185 | | 4632 | | 4217 | | | | | | 155 | 5849 | 9680 | 1276 | 18203 | |
| 1989 | | 636 | 8059 | | 2144 | | 2498 | | | | | | 192 | 4987 | 5738 | 828 | 11950 | |
| 1990 | | 722 | 8584 | | 1629 | | 3054 | | | | | | 120 | 3671 | 5361 | 842 | 11577 | |
| 1991 | | 1431 | 9383 | | | | 2879 | | | | | | 232 | 2768 | 7184 | 1663 | 7846 | |
| 1992 | | 2449 | 9946 | | | | 3656 | | | | | | 290 | 1655 | 9887 | 2739 | 5370 | |
| 1993 | | 1001 | 8666 | | | | 4084 | | | | | | 274 | 1675 | 7296 | 1275 | 7129 | |
| 1994 | | 1073 | 13831 | | | | 4023 | | | | | | 555 | 3711 | 8229 | 1628 | 13336 | |
| 1995 | | 2547 | 18762 | | | | 9196 | | | 15 | | | 611 | 2632 | 16936 | 3158 | 13801 | |
| 1996 | | 2999 | 27946 | 132 | | | 12018 | | 50 | 32 | | | 1032 | 4418 | 21417 | 4031 | 23097 | |
| 1997 | | 1886 | 28887 | 11 | | | 9269 | | 6 | | 263 | | 777 | 2525 | 21966 | 2663 | 18995 | |
| 1998 | | 2467 | 19192 | 13 | | | 9722 | | 8 | | 13 | 623 | 607 | 1571 | 15093 | 3074 | 16049 | |
| 1999 | | 2839 | 23074 | 116 | | | 13224 | | 10 | | 25 | 660 | 682 | 1525 | 20409 | 3521 | 18225 | |
| 2000 | | 2451 | 19876 | 171 | | | 11572 | | 5 | | 84 | 926 | 698 | 2564 | 18934 | 3149 | 16264 | |
| 2001 | | 2124 | 17446 | 191 | | | 10579 | | 40 | | 46 | 646 | 693 | 2479 | 14976 | 2817 | 16451 | |
| 2002 | | 2055 | 11657 | 191 | | | 7322 | | | | 71 | 782 | 354 | 1727 | 11968 | 2409 | 9781 | |
| 2003 | | 1373 | 13275 | 59 | | | 6775 | | | | 124 | 568 | 551 | 1899 | 9573 | 1925 | 13127 | |
| 2004 | | 1927 | 11386 | | | | 4651 | | | | 221 | 538 | 393 | 1727 | 9091 | 2320 | 9430 | |
| 2005 | | 1902 | 9867 | 2 | | | 7002 | 72 | 67 | | 476 | 1093 | 720 | 835 | 8729 | 2621 | 10686 | |
| 2006 | | 1899 | 9761 | 242 | | | 7516 | | | | 586 | 801 | | 1855 | 9979 | 1914 | 10859 | |
| 2007 | | 2169 | 8975 | 220 | | | 8802 | | 69 | | 273 | 2371 | 534 | 2322 | 7840 | 2713 | 13183 | |
| 2008 | | 1612 | 8582 | 159 | | | 5489 | | 134 | | 30 | 1361 | 525 | 2189 | 5687 | 2139 | 12256 | |
| 2009 | | 567 | 7871 | 259 | | | 4020 | | 194 | | 23 | 529 | 269 | 1817 | 3451 | 839 | 11259 | |
| 2010 | | 689 | 6849 | 203 | | | 4250 | | | | 159 | 319 | 490 | 1151 | 3925 | 1179 | 9016 | |
| 2011 | | 783 | 7799 | 149 | | | 4521 | | | 9 | 24 | 487 | 414 | 2153 | 5493 | 1198 | 9641 | |
| 2012 | | 733 | 8381 | 260 | | | 4522 | | 3 | | 11 | 818 | 390 | 1955 | 4896 | 1123 | 11053 | |
| 2013 | | 580 | 6566 | 50 | | | 3237 | | | | | 128 | 708 | 380 | 1317 | 4675 | 960 | 7333 |
| 2014 | | 2206 | 795 | 6804 | 7 | | 2109 | | | | 39 | 854 | 1 | 565 | 1231 | 4316 | 1361 | 7862 |
| 2015 | | 2781 | 738 | 6623 | 28 | | 2213 | | | | 7 | 755 | | 493 | 1858 | 4994 | 1232 | 7193 |
| 2016 | | 1576 | 675 | 4881 | 29 | | 1617 | | | | | 657 | 1 | 448 | 1550 | 3193 | 1123 | 6313 |
| 2017 | | 1167 | 506 | 2352 | | | 1029 | | | | | 926 | | 435 | 352 | 2196 | 941 | 2714 |
| 2018 | | 1010 | 475 | 2235 | 0.5 | | 1005 | | | | | 886 | | 395 | 462 | 2014 | 870 | 2942 |
| 2019 | | 2074 | 608 | 3194 | | | 1653 | | | | | 991 | 2 | 559 | 334 | 3728 | 1167 | 2783 |

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
DK_27.3.b.23_Longline set_3_L,DE_27.3.c.22_Gillnets set_2_L,X
DK_27.3.b.23_Longline set_3_L,DE_27.3.c.22_Gillnets set_3_L,X
DK_27.3.b.23_Longline set_3_L,DE_27.3.c.22_Gillnets set_4_L,X
DK_27.3.b.23_Longline set_3_L,DK_27.3.b.23_Gillnets set_2_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 | | | | Total | Country sum | % |
| Country | Catch Category | Fleets | Season | | | | Season | | | | | |
| Number of samples | | | | | | | | | | | | |
| 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% |
| | | 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% |
| | 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 | | | | | | | | | | | | |
| Number of length measurements | | | | | | | | | | | | |
| Denmark | Discards | Active | 592 | | | 9 | | | | | 601 | |
| TAC 44% | | Gillnets set | | | | | | | | | | 1877 |
| | | 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% |
| | | 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% |
| | Landings | Gillnets set | | | | | 484 | 342 | 333 | 443 | 1602 | |
| Total | | | 4323 | 715 | 826 | 571 | 878 | 731 | 897 | 1124 | 10065 | |
| Number of otoliths age-read | | | | | | | | | | | | |
| Denmark | Discards | Active | 127 | | | 9 | | | | | 136 | |
| TAC 44% | | Gillnets set | | | | | | | | | | 1412 |
| | | 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% |
| | | 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% |
| | Landings | Gillnets set | | | | | 484 | 342 | 333 | 443 | 1602 | |
| Total | | | 1937 | 367 | 491 | 352 | 878 | 731 | 897 | 1124 | 6777 | |

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 | Mean | Numbers | Mean | Numbers | Mean |
| | *10-3 | weight [g] | *10-3 | weight [g] | *10-3 | 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 | Mean | Numbers | Mean | Numbers | Mean |
| | *10-3 | weight [g] | *10-3 | weight [g] | *10-3 | 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 |

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 Advice To- tal | B SDs 22–23 | C SD 24 | D Total | E SD 24 | F SDs 25–32 | G SDs22–24 | H % TAC change (SDs 22–24)* | SDs 25–32 | % TAC change (SDs 25–32)** |
| <i>a. Status quo distribution, with no catch of EB cod in the Western Baltic management area</i> | | | | | | | | | | |
| 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 |
| <i>b. Status quo distribution, with catch of EB cod in the Western Baltic management area</i> | | | | | | | | | | |
| 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).

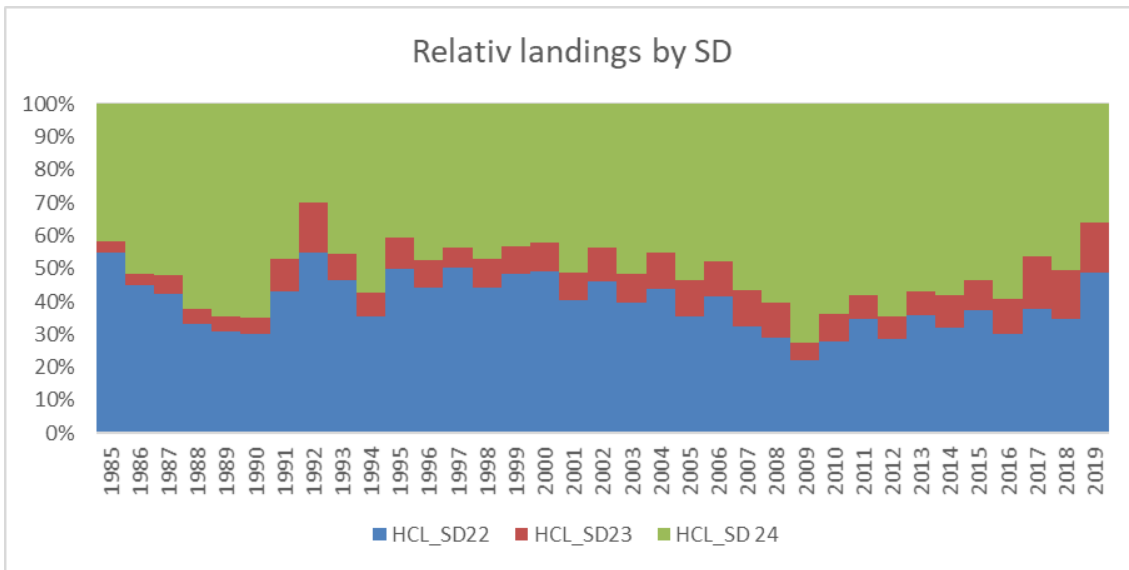


Figure 2.3.1. Western Baltic cod. Relative landings by SD (tonnes) for the western Baltic management area (both east and west cod included). HCL: human consumption landings.

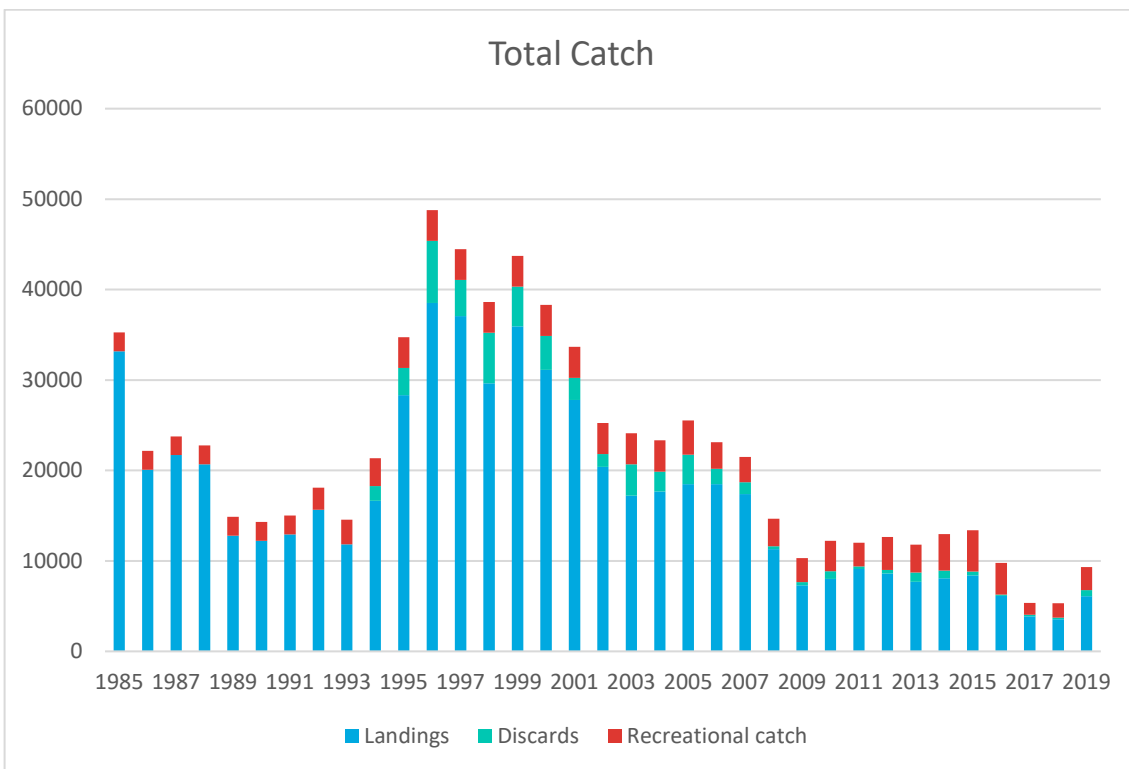


Figure 2.3.2. Western Baltic cod. Commercial landings, discard and recreational catch (tonnes) of the WBC stock.

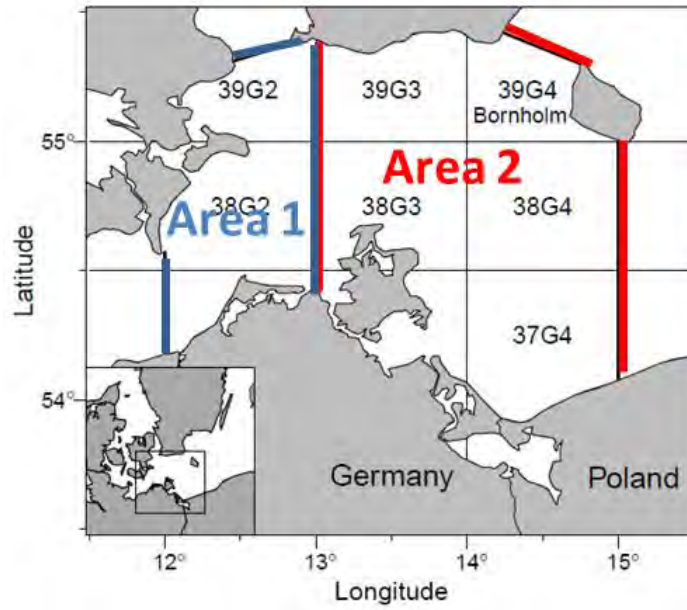


Figure 2.3.3. Western Baltic cod. Subareas (Area 1 and Area 2 within SD 24) for which different keys for splitting between eastern and western Baltic cod catches in SD 24 were applied.

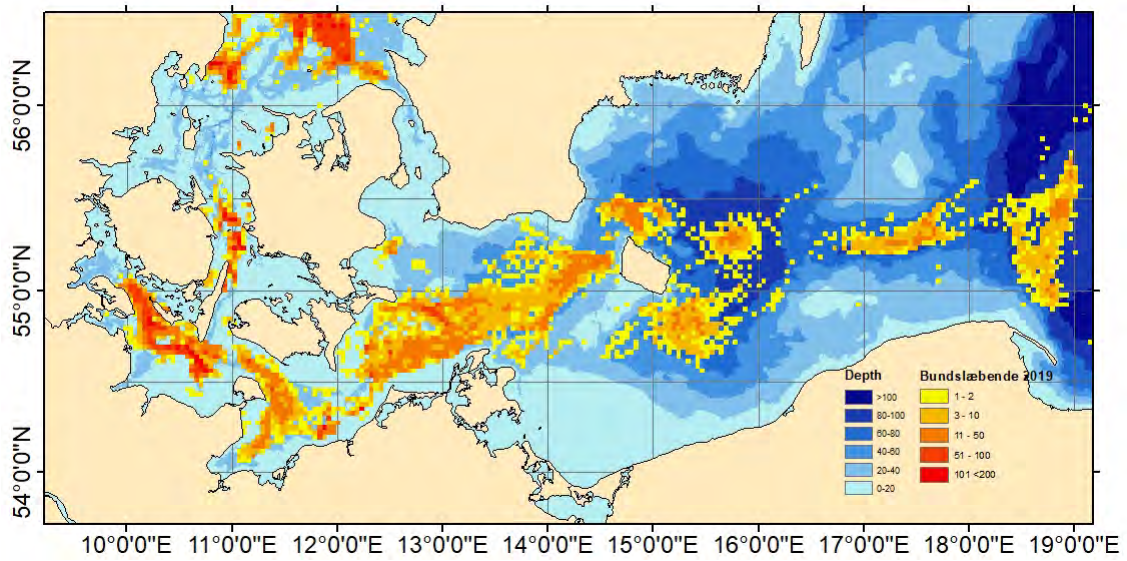


Figure 2.3.4. Danish VMS data from 2019 from OTB.

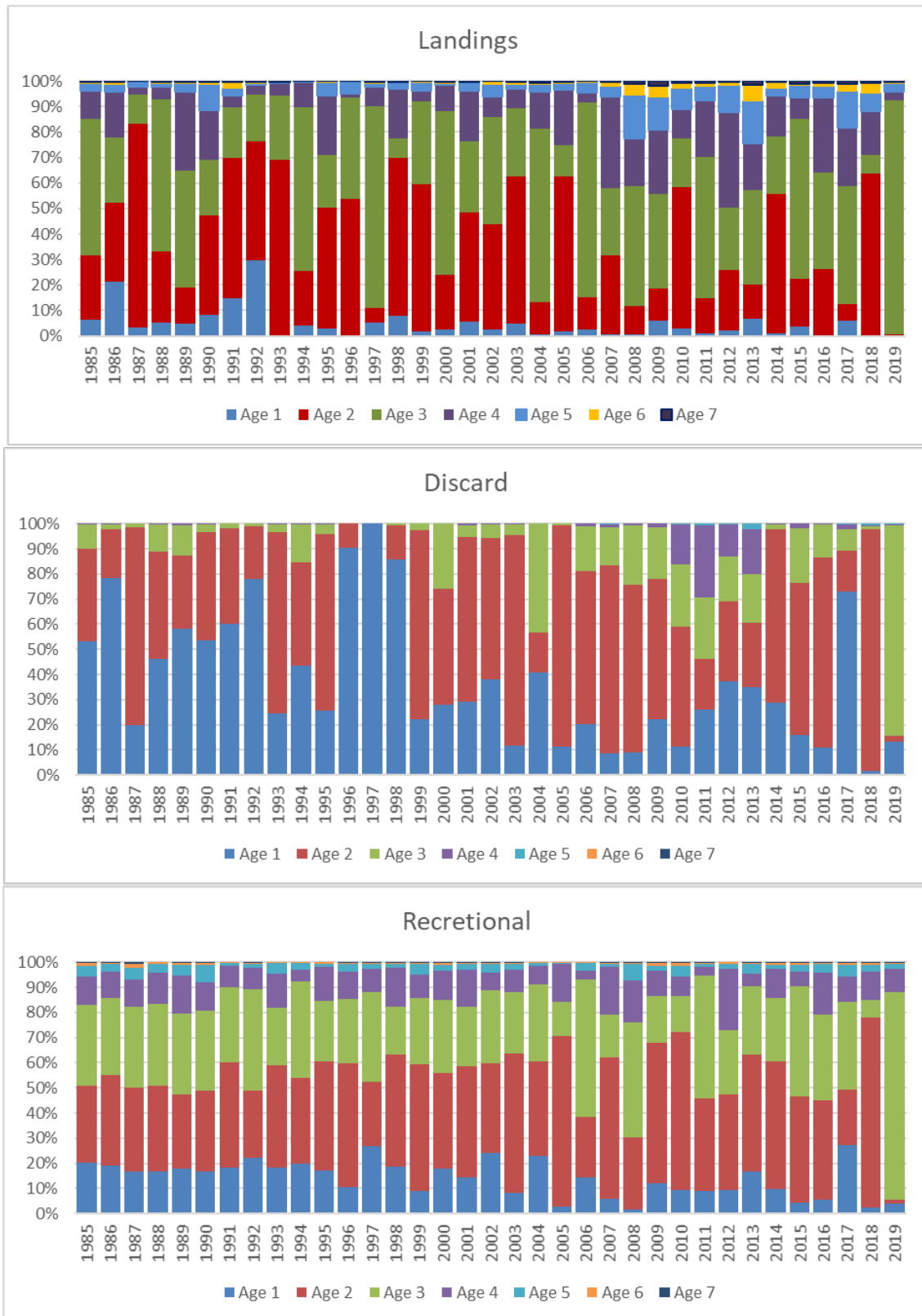


Figure 2.3.5. Western Baltic cod. Number at age distribution of cod in commercial landings, discards and recreational catch (relative proportions).

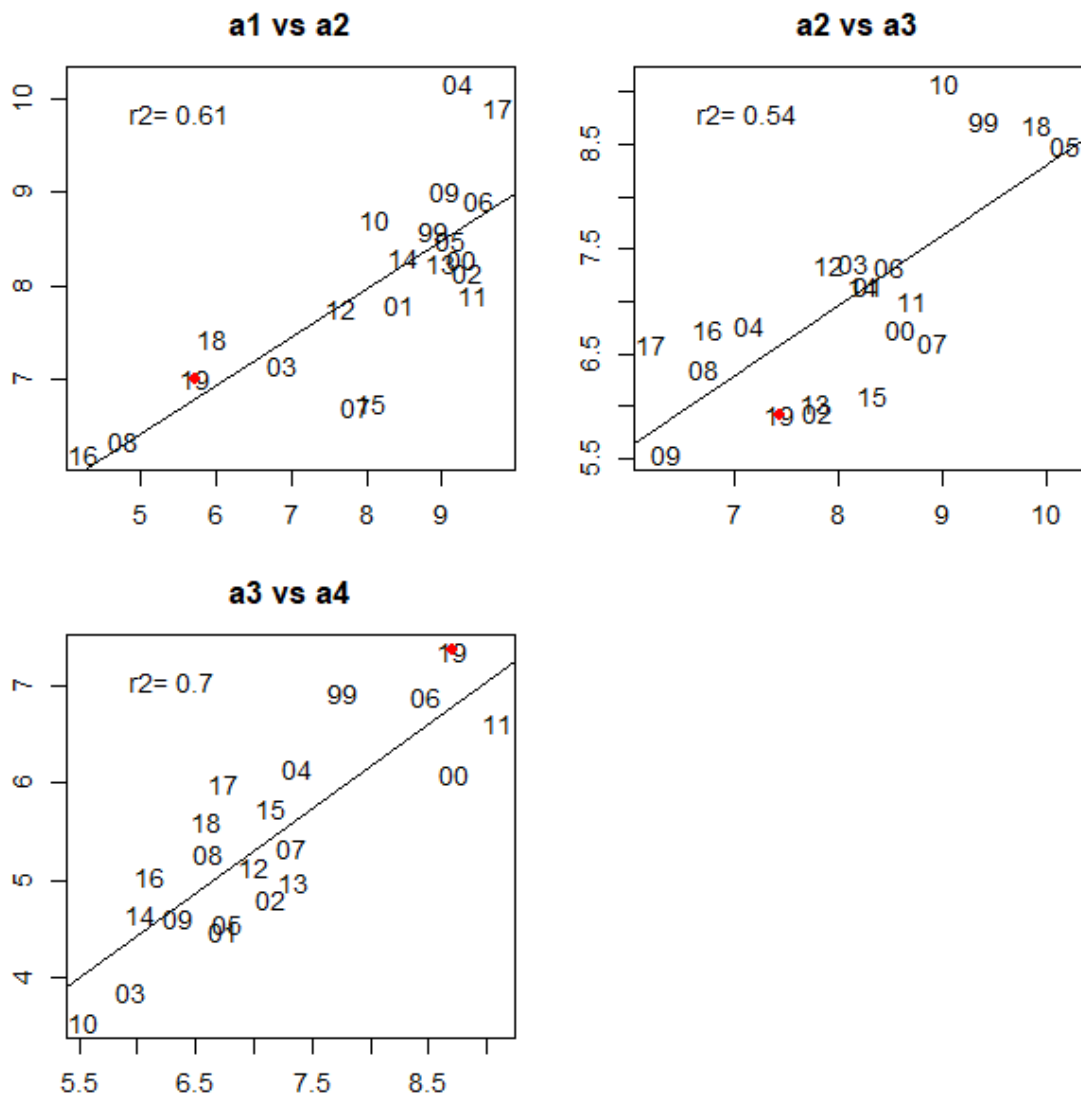


Figure 2.3.6. Western Baltic cod. CPUE at age i vs numbers at age $i+1$ in the following year, in BITS Q1 survey. Red dots highlight the information from the latest year.

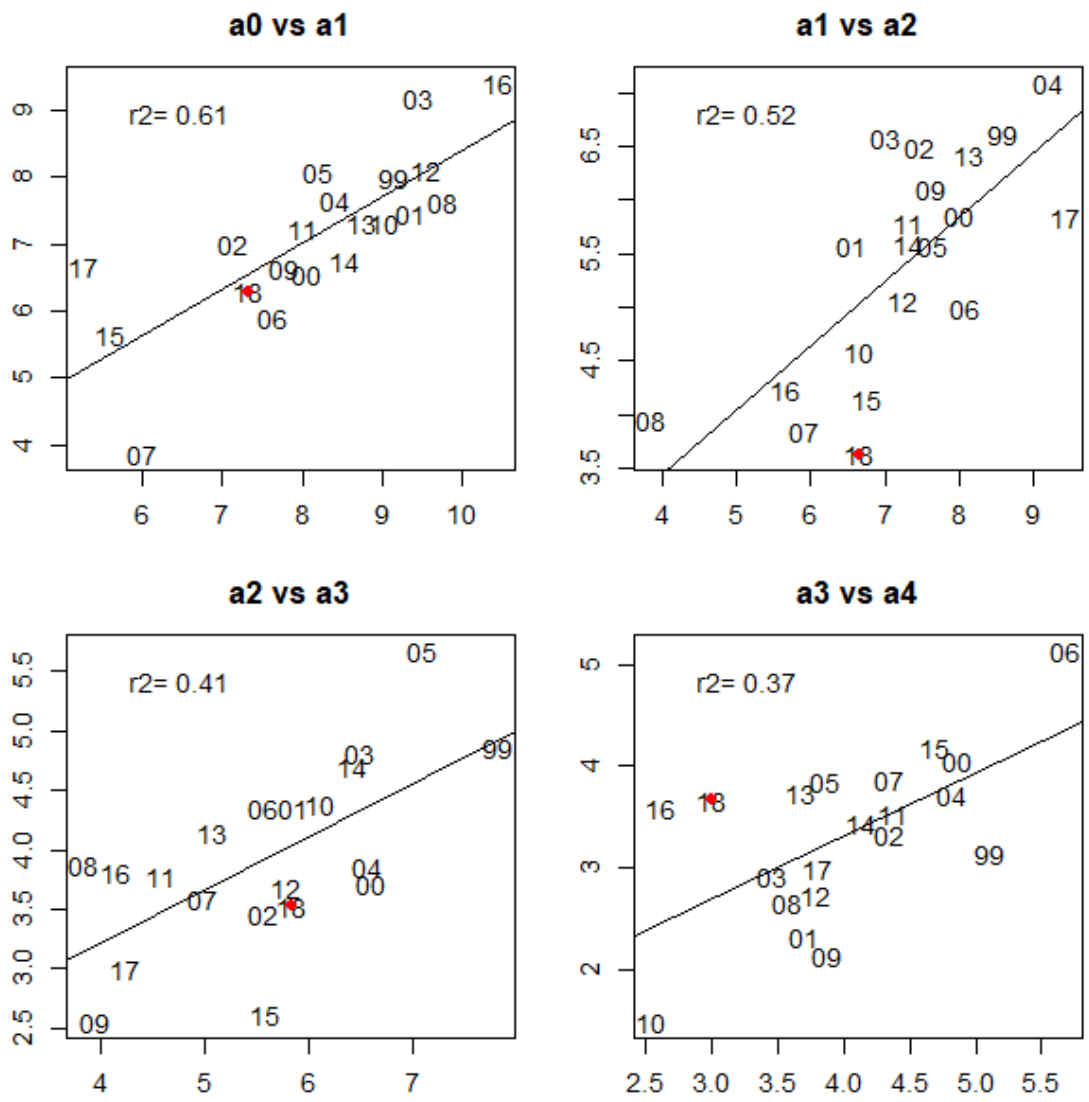


Figure 2.3.7. Western Baltic cod. CPUE at age i vs numbers at age $i+1$ in the following year, in BITS Q4 survey. Red dots highlight the information from the latest year.

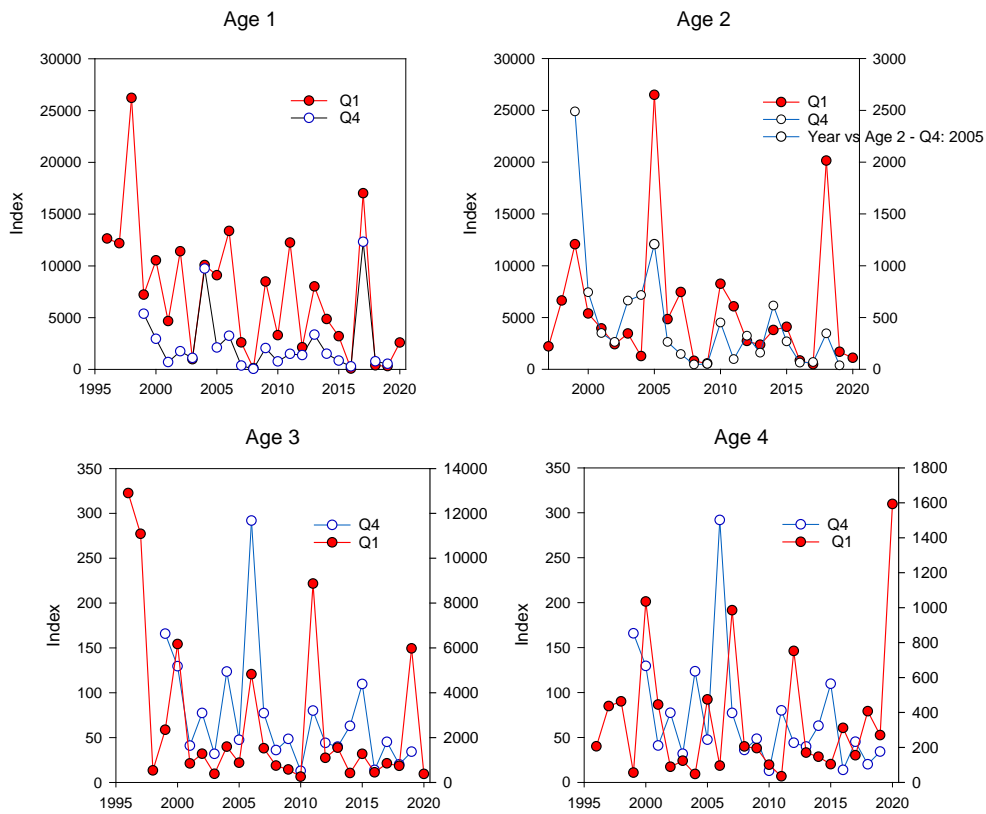


Figure 2.3.8. Western Baltic cod. Time series of BITS Q1 and BITS Q4 in numbers by age groups.

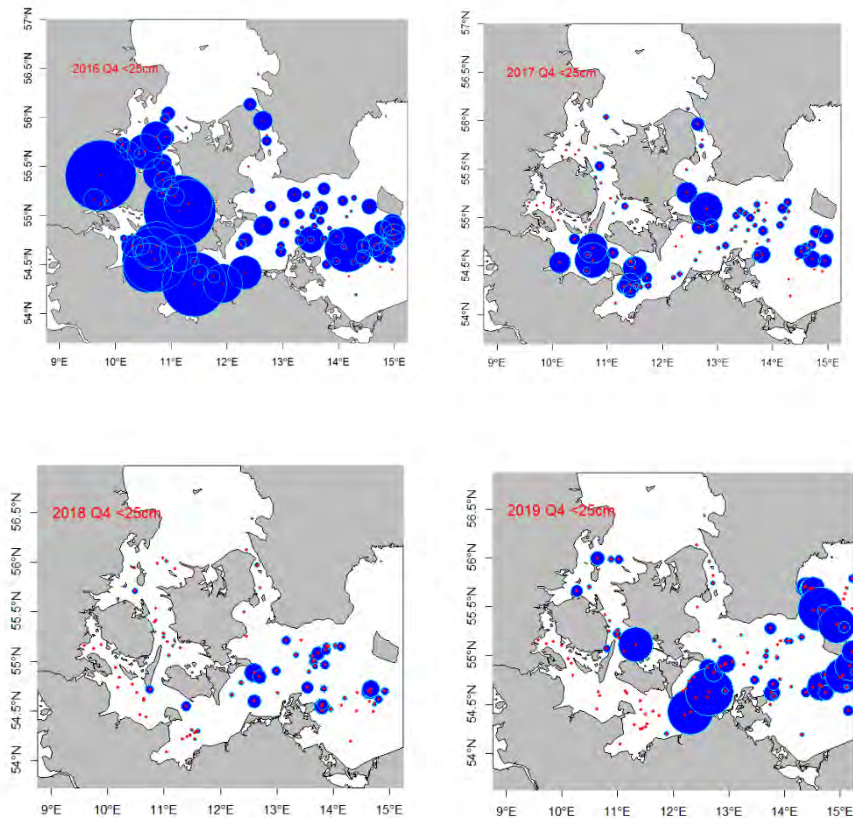


Figure 2.3.9. Western Baltic cod. Distribution of cod <25 cm from BITS Q4 2016, 2017, 2018 and 2019.

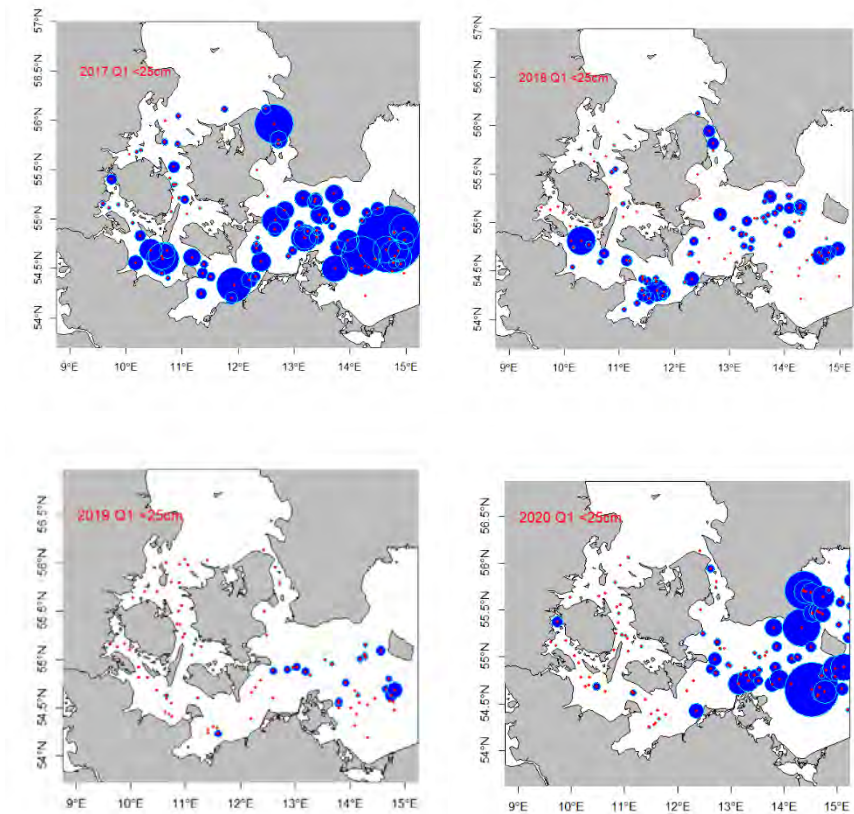


Figure 2.3.10. Western Baltic cod. Distribution of cod<25 cm from BITS Q4 2017, 2018, 2019 and 2020.

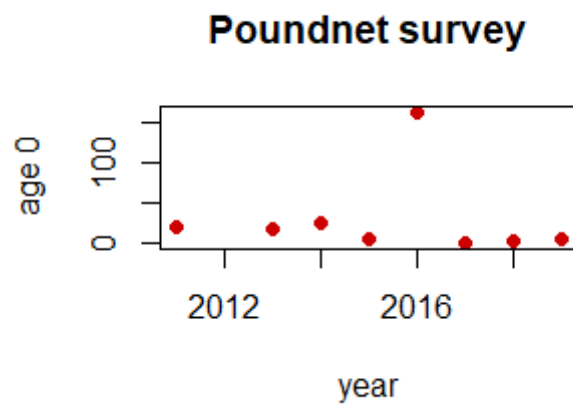


Figure 2.3.11. Western Baltic cod. Fejucs, German Pound net survey age 0.

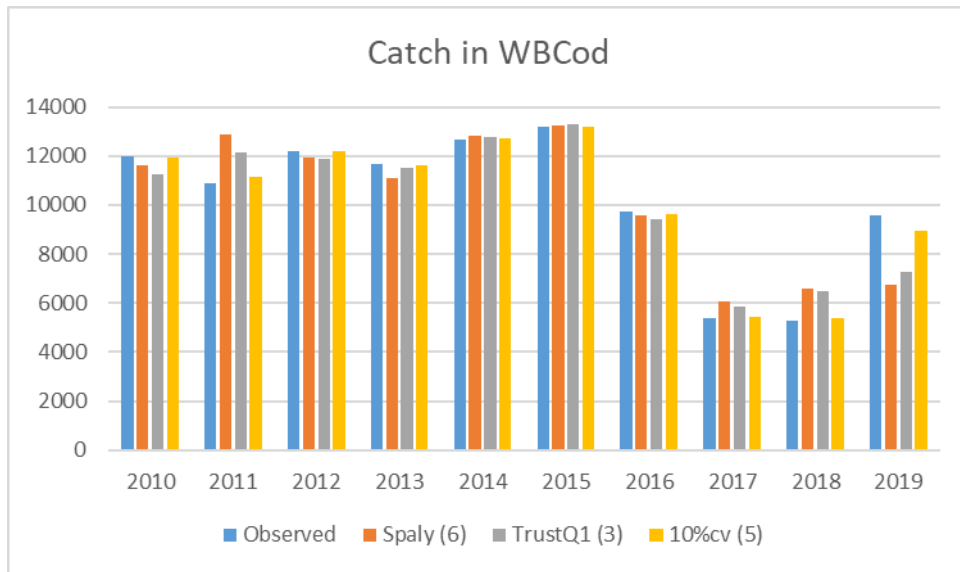


Figure 2.3.12. Western Baltic cod. The catch estimate from the model in 3 different runs compared with the observed estimate (blue).

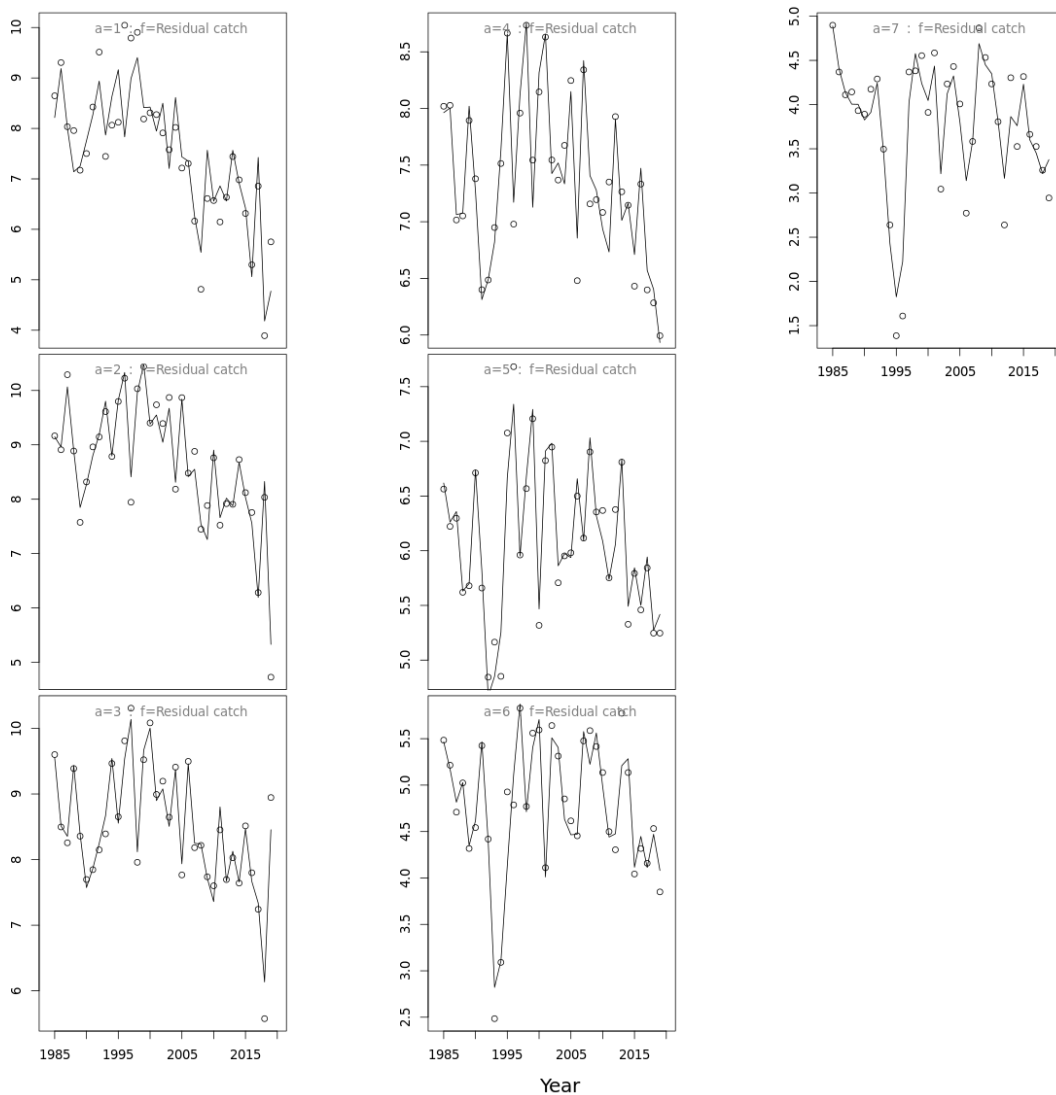


Figure 2.3.13. Western Baltic cod. Commercial catch data fit to the model by age and year.

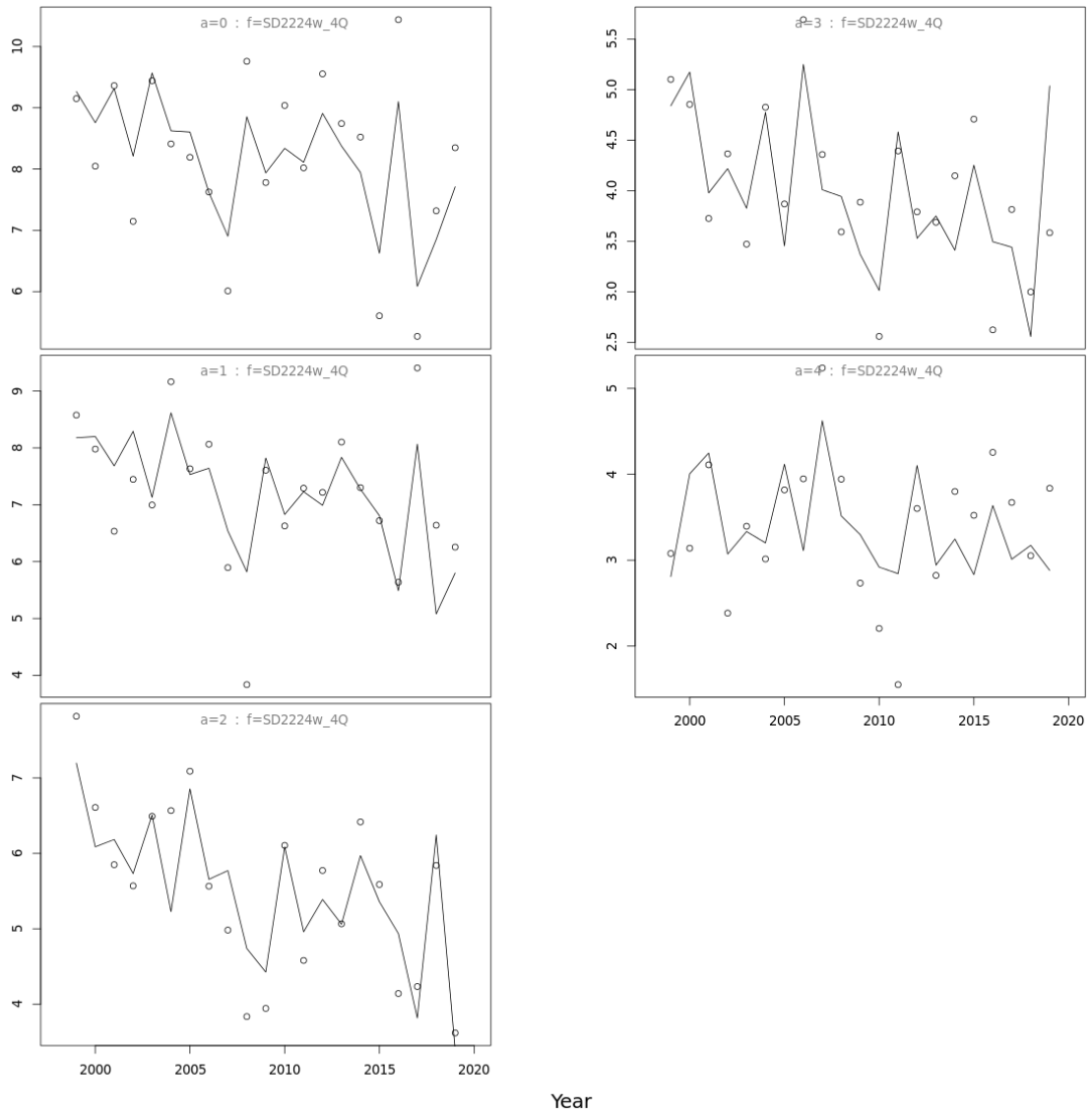


Figure 2.3.14. Western Baltic cod. BITS Q4 data fit to the model by age and year.

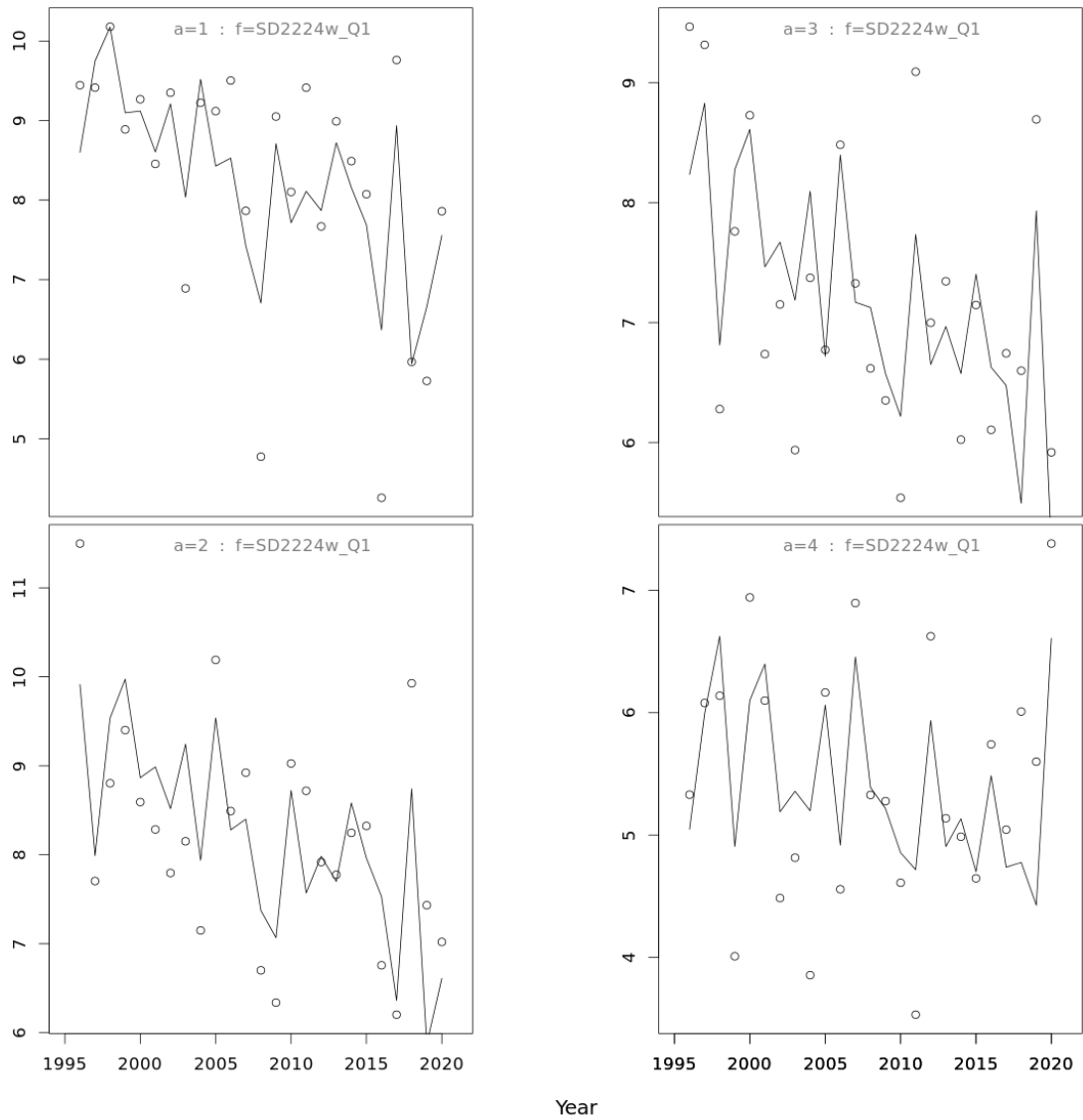


Figure 2.3.15. Western Baltic cod. BITS Q1 data fit to the model by age and year.

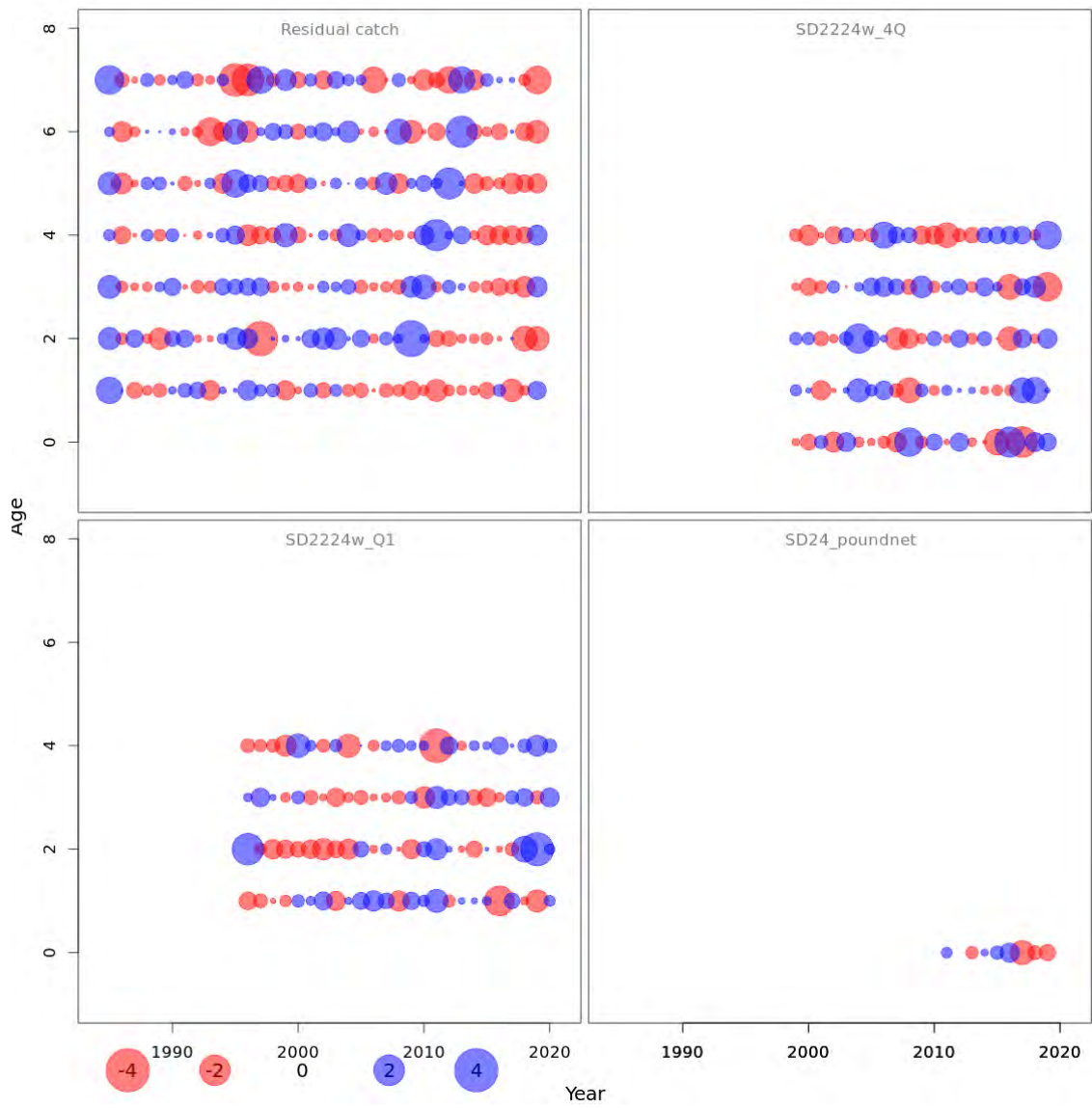


Figure 2.3.16. Western Baltic cod. Standardized residuals from the final SAM run where open circles are positive and filled circles are negative residuals.

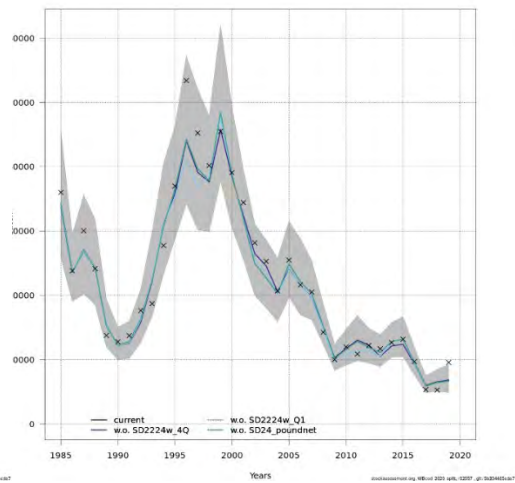
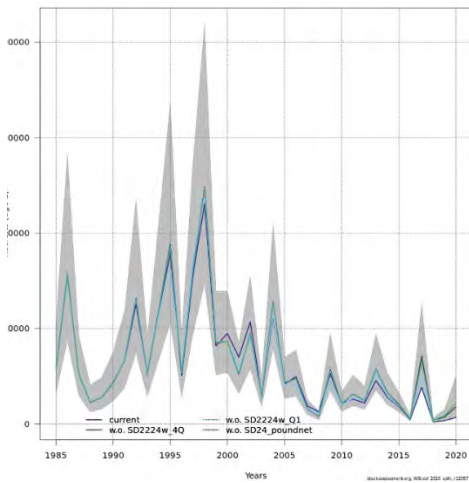
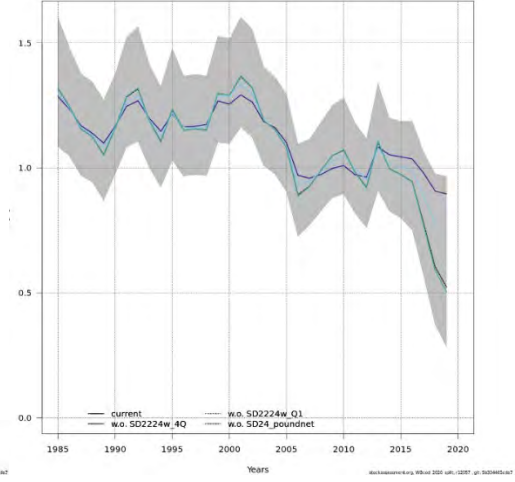
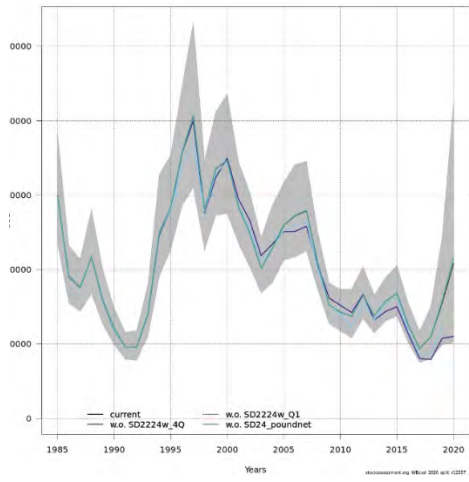


Figure 2.3.17. Western Baltic cod. Leave one out plots on SSB, F, Recruitment and catch.

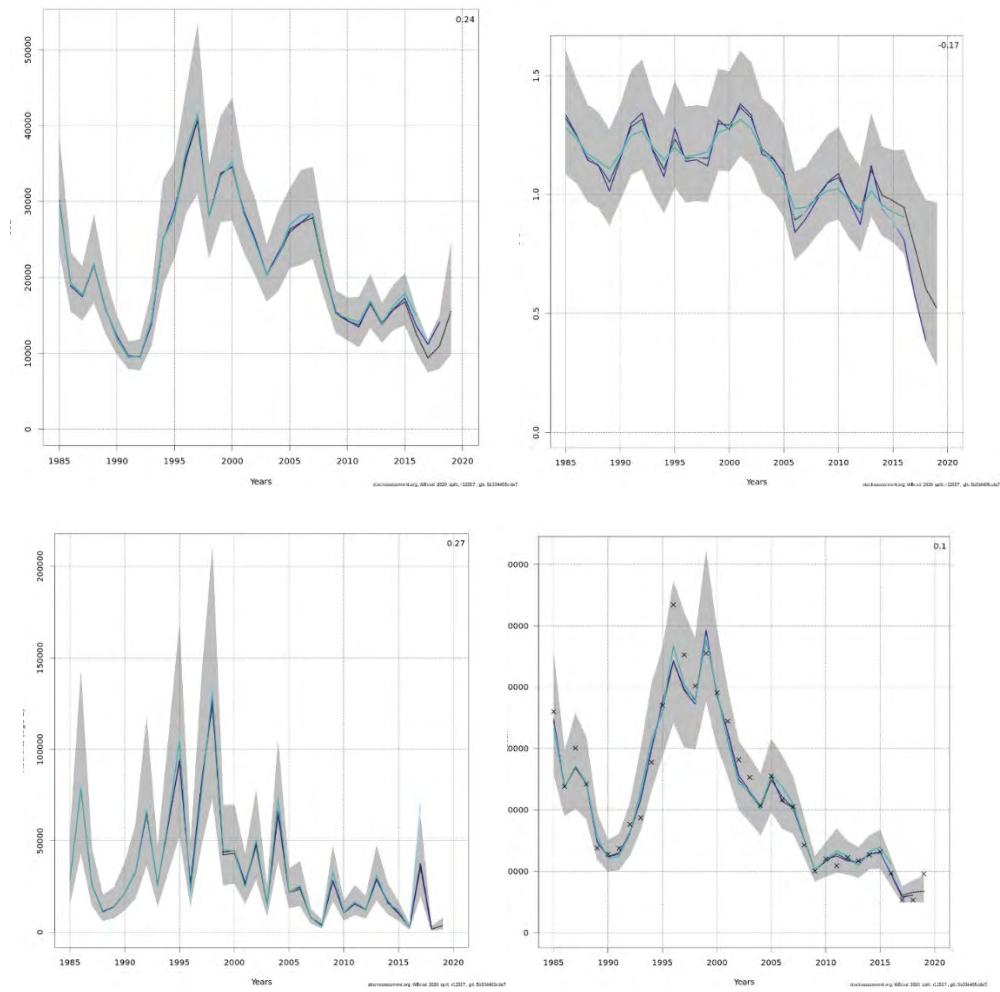


Figure 2.3.18. Western Baltic cod. Retrospective analyses of SSB, F(3–5), recruitment (age 1) and catch.

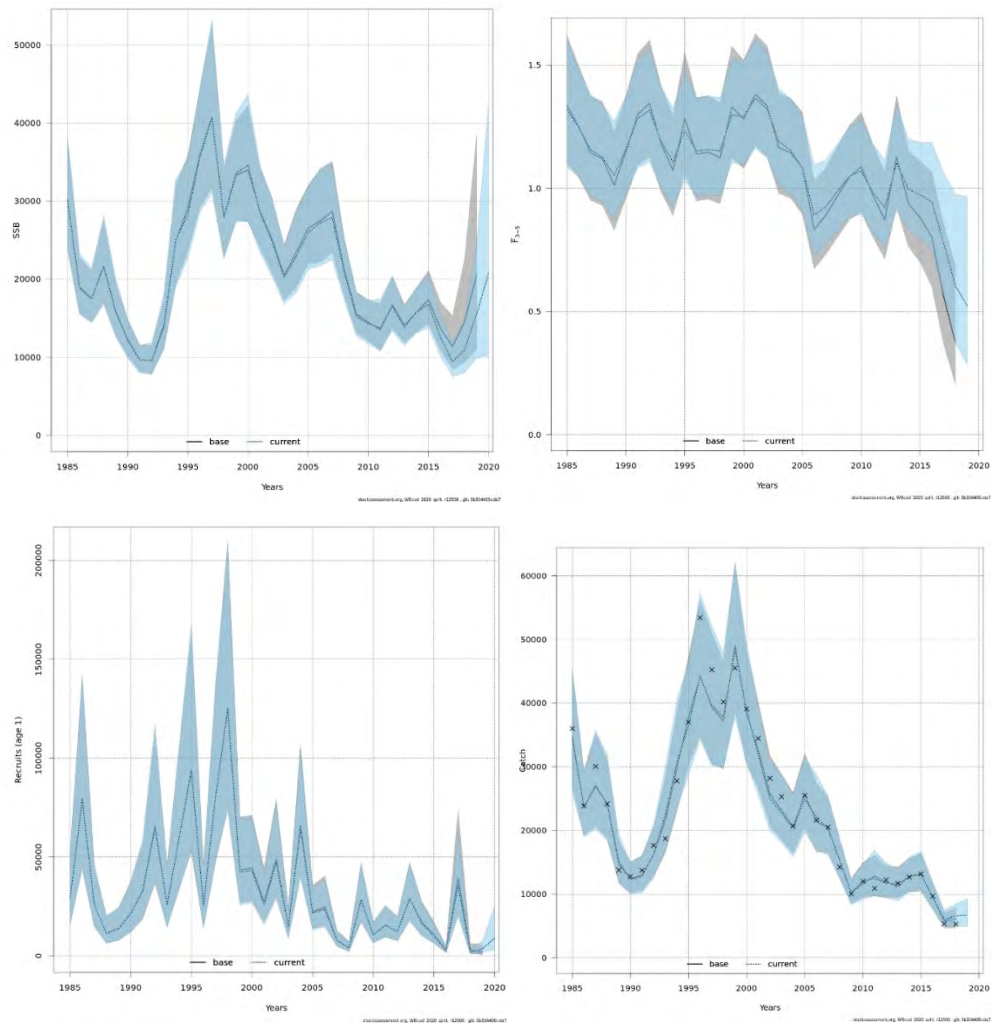


Figure 2.3.19. Western Baltic cod. SSB (upper left), F_{3-5} (upper right) and stock numbers at age 1 (lower left) and catch (lower right) from the final assessment. Grey line is assessment results from last year's assessment and blue stippled line is the updated final assessment.

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 $\rightarrow L_{inf} = 44.3$ cm
- L_{mat} : average of 2002–2018, quarter 1, only females $\rightarrow L_{mat} = 20.5$ 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 ($L_{F=M}$).

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 SD 22-23 |
|------|-------------|-----|-------------------|
| | 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 |
|-------------------|---|--|------------------------------------|----------------|----------------------------------|
| $L_{\max 5\%}$ | Mean length of largest 5% | L_{inf} | $L_{\max 5\%} / L_{\text{inf}}$ | > 0.8 | Conservation (large individuals) |
| $L_{95\%}$ | 95th percentile | | $L_{95\%} / L_{\text{inf}}$ | | |
| P_{mega} | Proportion of individuals above $L_{\text{opt}} + 10\%$ | 0.3–0.4 | P_{mega} | > 0.3 | |
| $L_{25\%}$ | 25th percentile of length distribution | L_{mat} | $L_{25\%} / L_{\text{mat}}$ | > 1 | Conservation (immatures) |
| L_c | Length at first catch (length at 50% of mode) | L_{mat} | L_c / L_{mat} | > 1 | |
| L_{mean} | Mean length of individuals > L_c | $L_{\text{opt}} = \frac{3}{3 + M/k} \times L_{\text{inf}}$ | $L_{\text{mean}} / L_{\text{opt}}$ | ≈ 1 | Optimal yield |
| L_{maxy} | Length class with maximum biomass in catch | $L_{\text{opt}} = \frac{3}{3 + M/k} \times L_{\text{inf}}$ | $L_{\text{maxy}} / L_{\text{opt}}$ | ≈ 1 | |
| L_{mean} | Mean length of individuals > L_c | $LF=M = (0.75L_c + 0.25L_{\text{inf}})$ | $L_{\text{mean}} / LF=M$ | ≥ 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.

| Year | Conservation | | | | Optimizing Yield | MSY |
|------|-----------------|----------------------|------------------------|------------|----------------------|----------------------|
| | 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 |

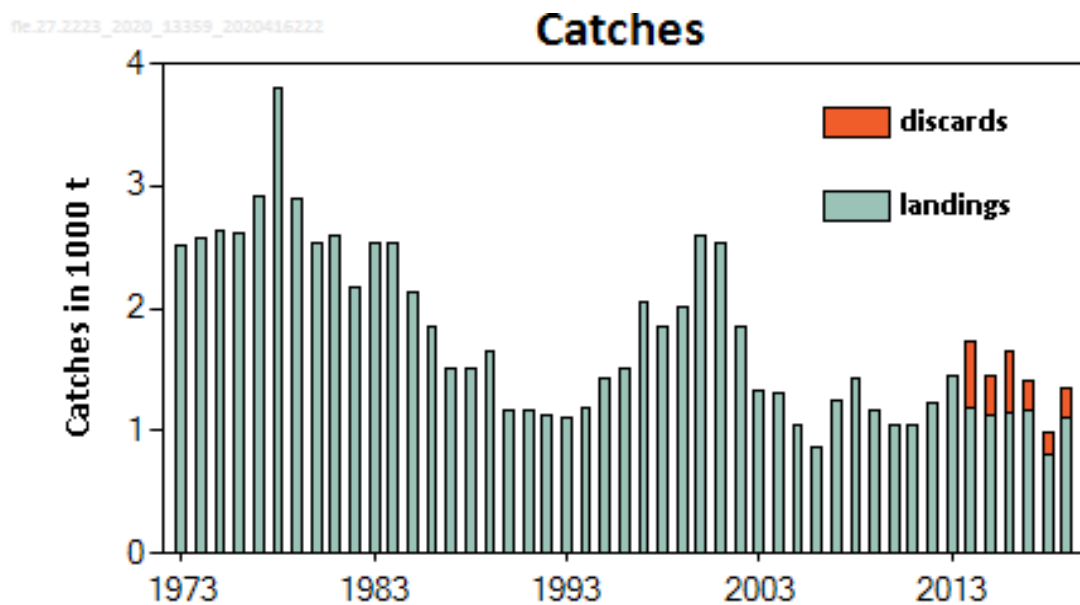


Figure 3.2.1. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings of flounder in tonnes for subdivisions SD 22–23 (Western Baltic Sea). ICES discard estimates are included from 2006 onwards.

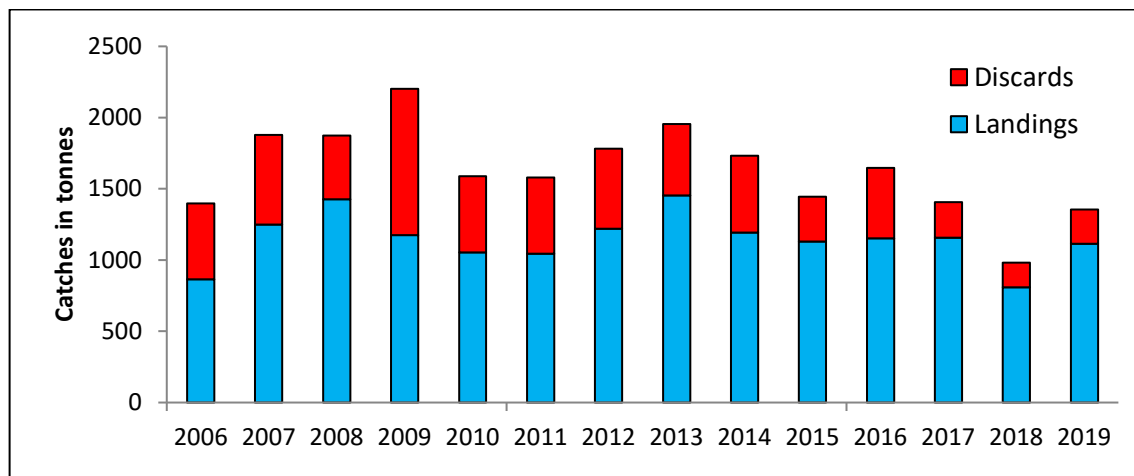


Figure 3.2.2. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Total landings and calculated discards (in tonnes) of flounder for subdivisions SD 22–23 (Western Baltic Sea).

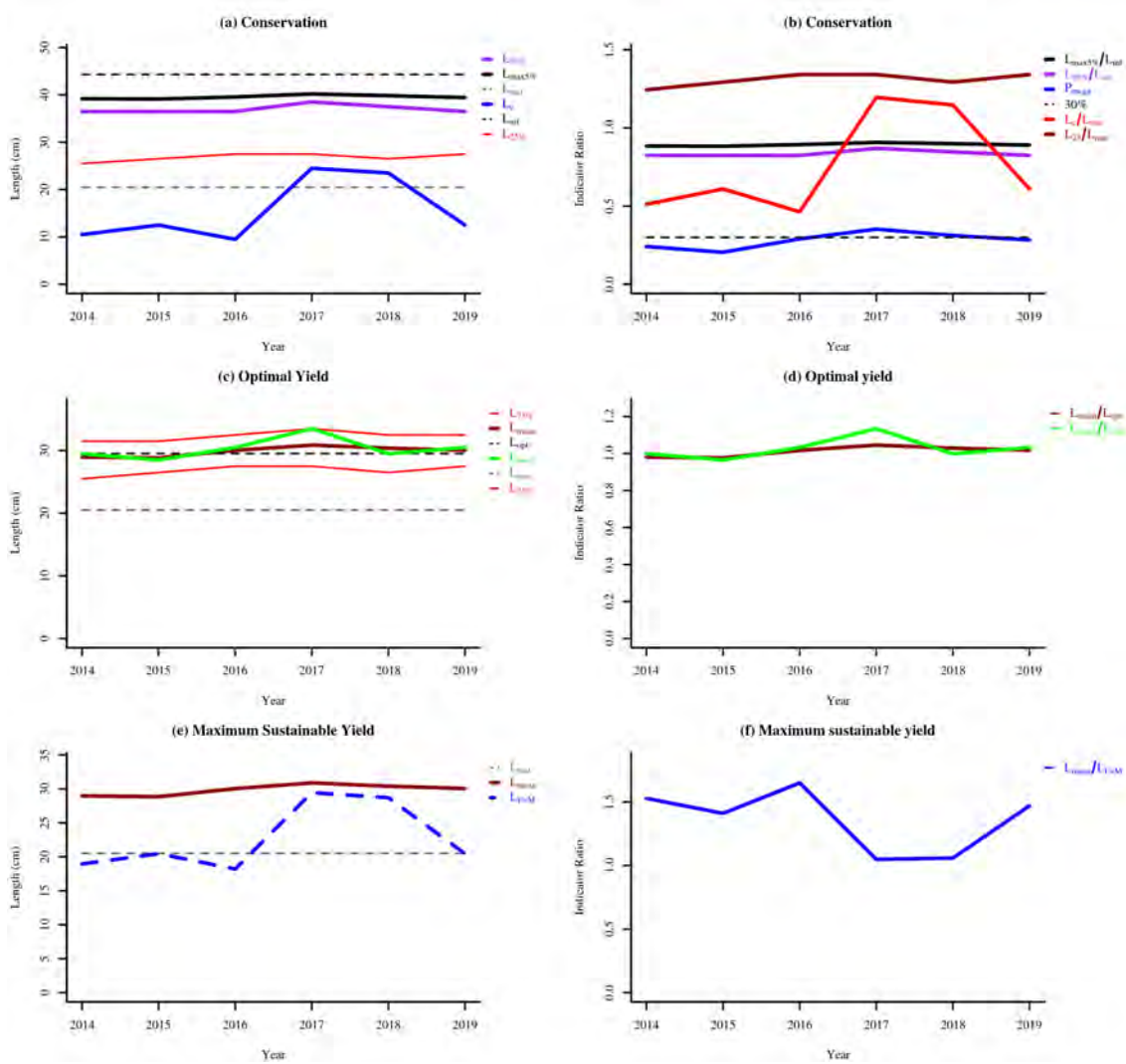


Figure 3.2.3. fle.27.2223. LBI indicator trends

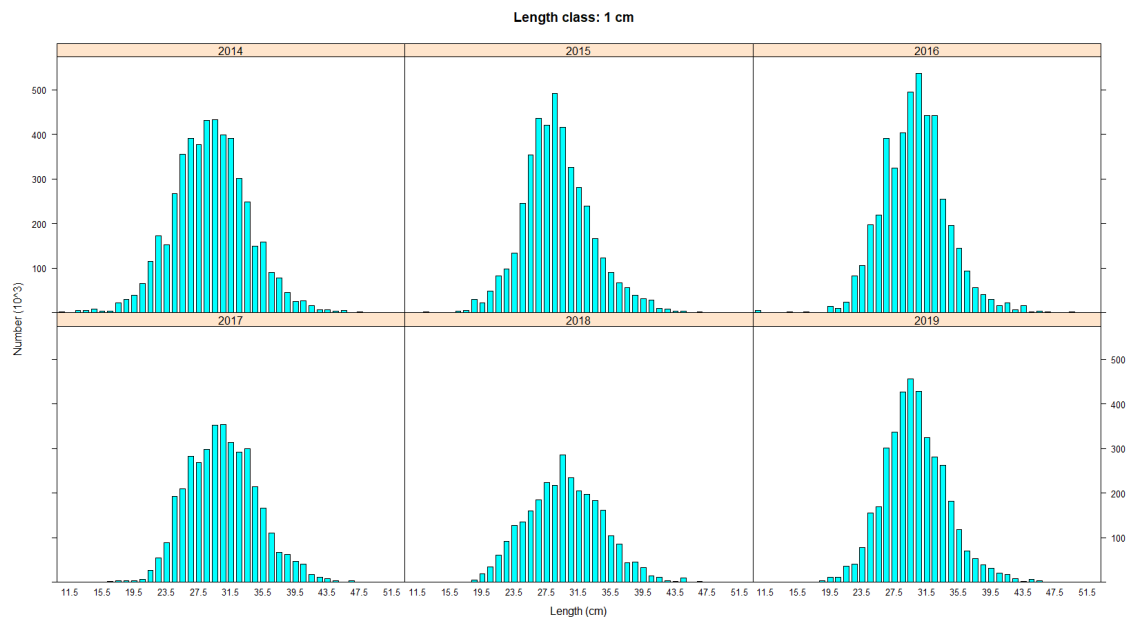


Figure 3.2.4. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Catch in numbers per length class in Sub-division 22 and 23 (Belts and Sound). All countries and fleets were combined.

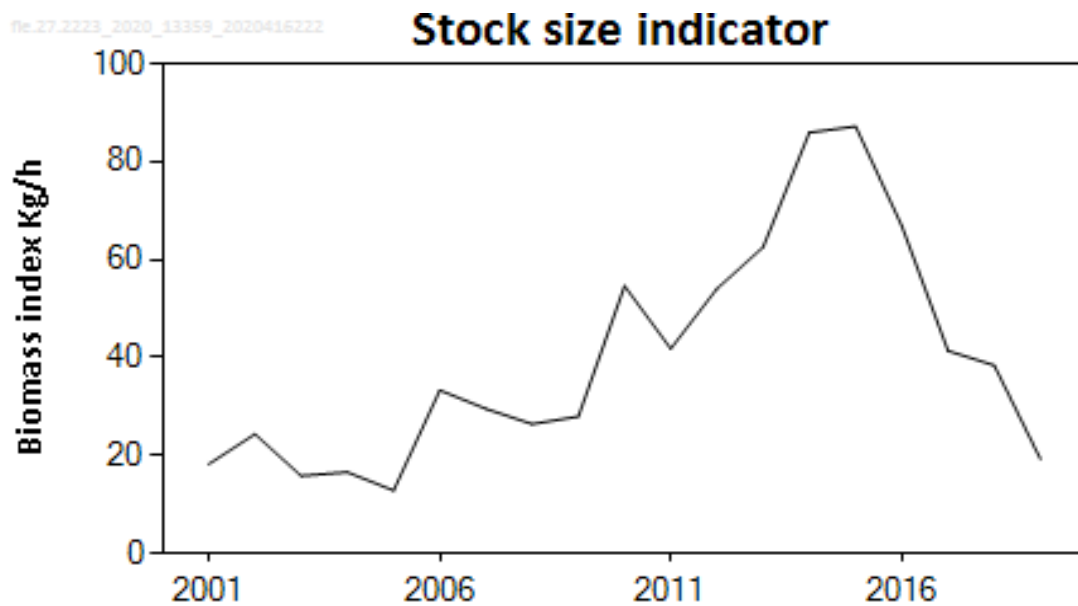


Figure 3.2.7. fle.27.2223/Flounder in subdivisions 22 and 23 (Belts and Sound). Survey-biomass-index (BITS). Dashed lines indicate the average values used for advice (i.e. avg. of the last two years and the avg. of the three years before).

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).

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:

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

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:

$$L_{inf} = 329 \text{ mm}$$

$$L_{mat} = 220 \text{ mm}$$

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.

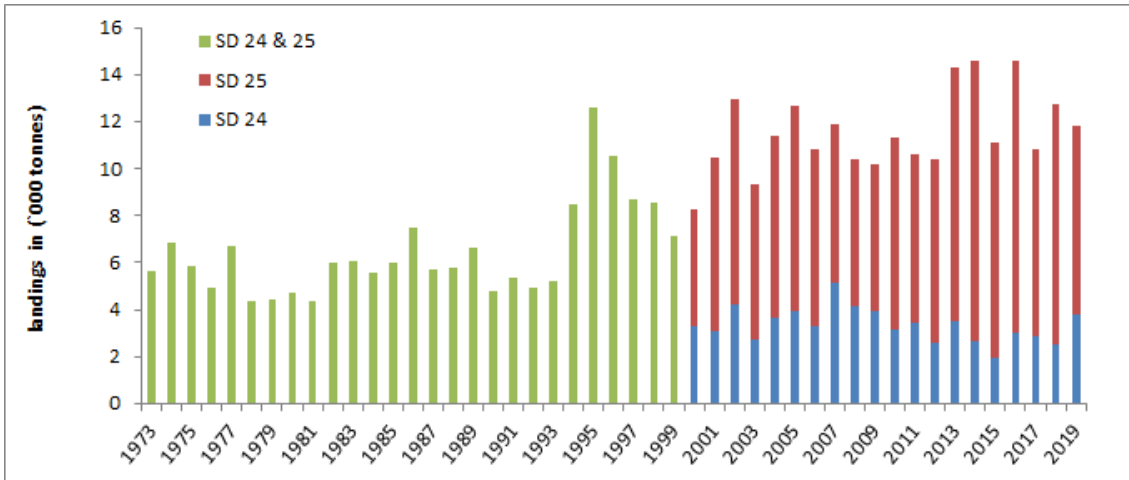


Figure 3.3.1. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Landings in thousand tonnes.

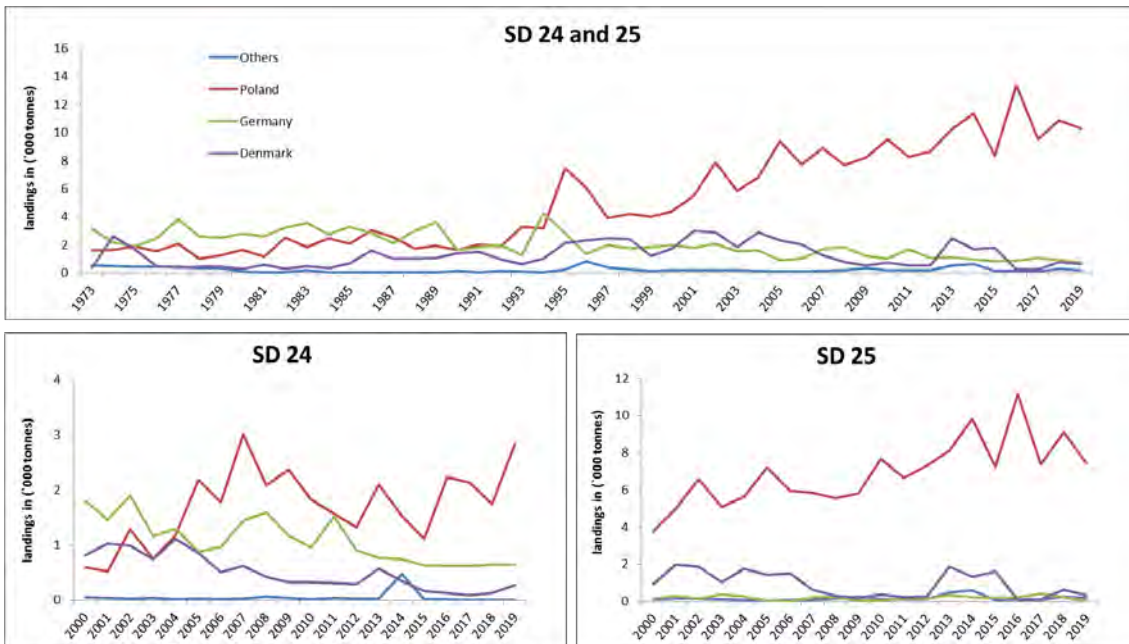


Figure 3.3.2. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Landings by country in thousand tonnes (merged SD 24–25 in upper plot, and separately for SD 24 and SD 25 in lower plots).

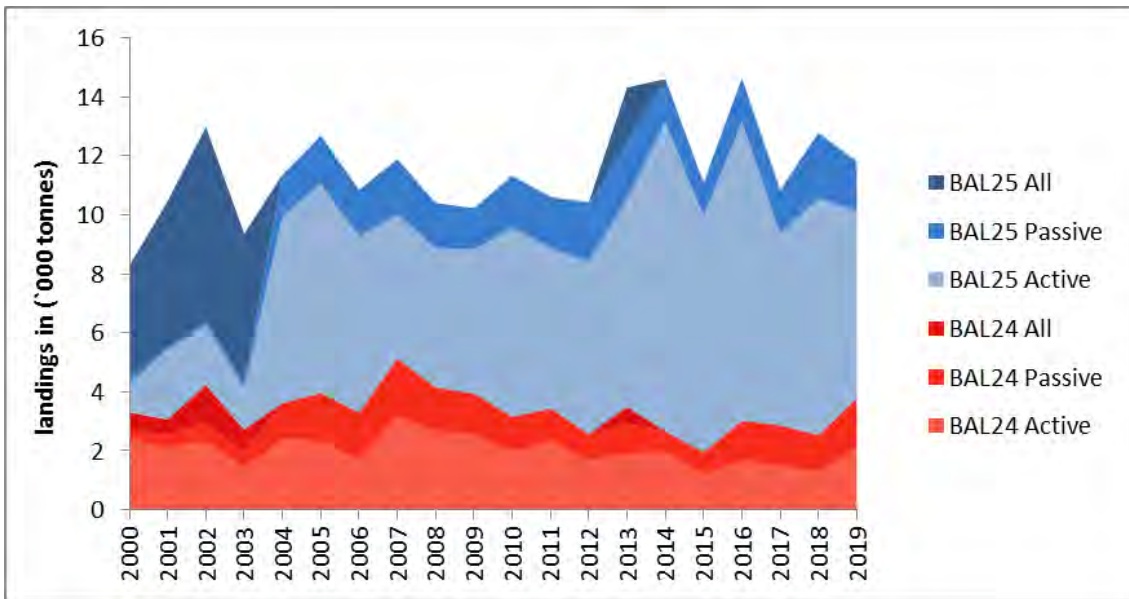


Figure 3.3.3. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Landings by fleet type in thousand tonnes (SD 24: red shades; SD 25: blue shades).

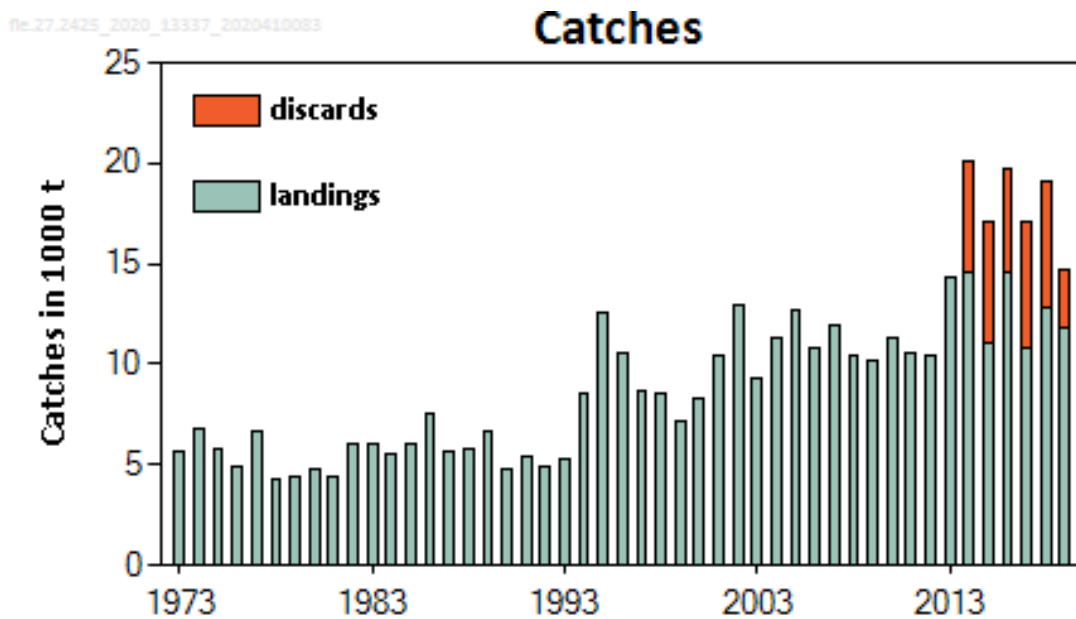


Figure 3.3.4. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Landings and catches in thousand tonnes (catch available since 2014).

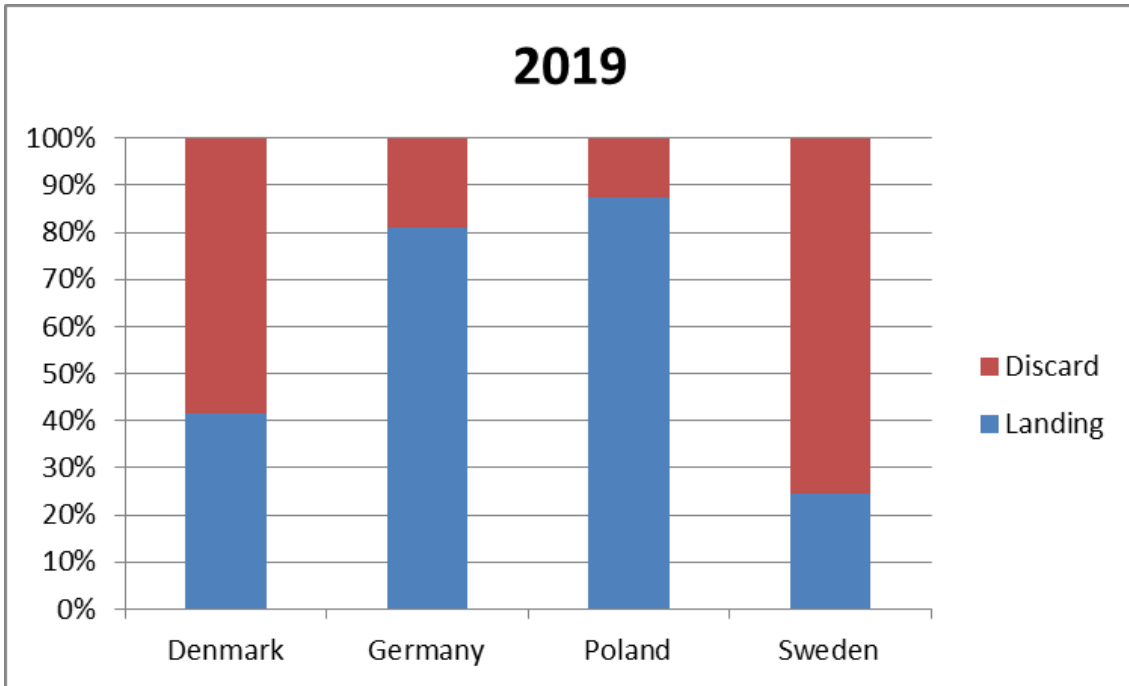


Figure 3.3.5. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Discard and landing proportion in 2018 catches in main fishing countries.

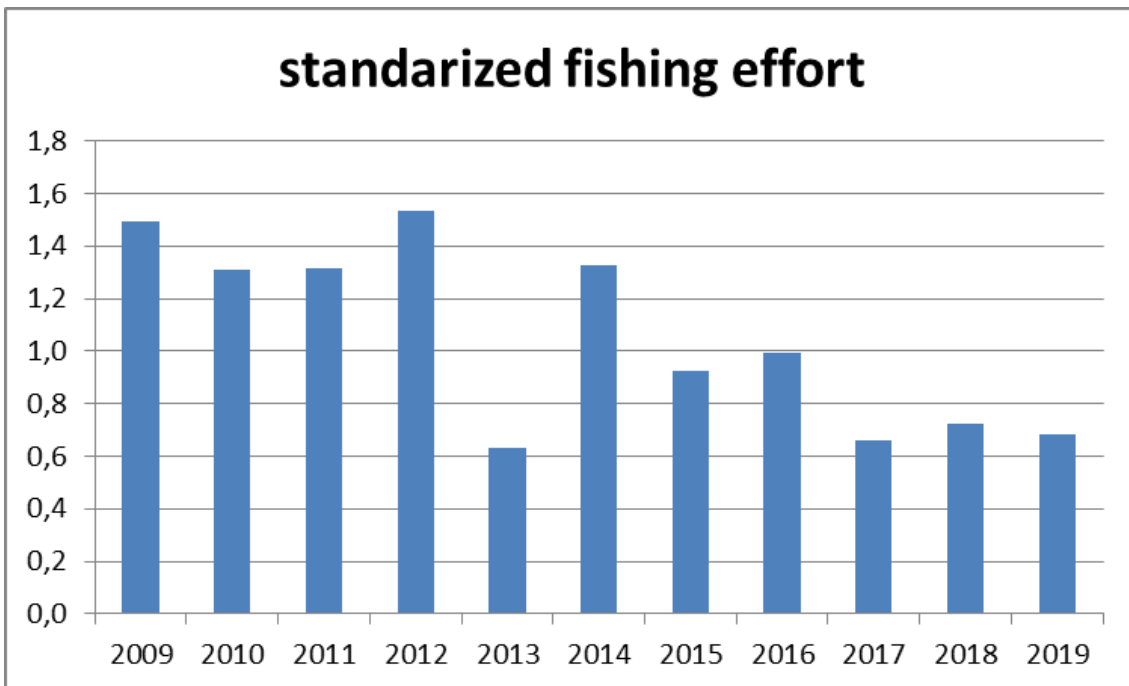


Figure 3.3.6. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Standardized fishing effort (days-at-sea standardised within each country, and weighted by the national demersal fish landings from SD 24–25).

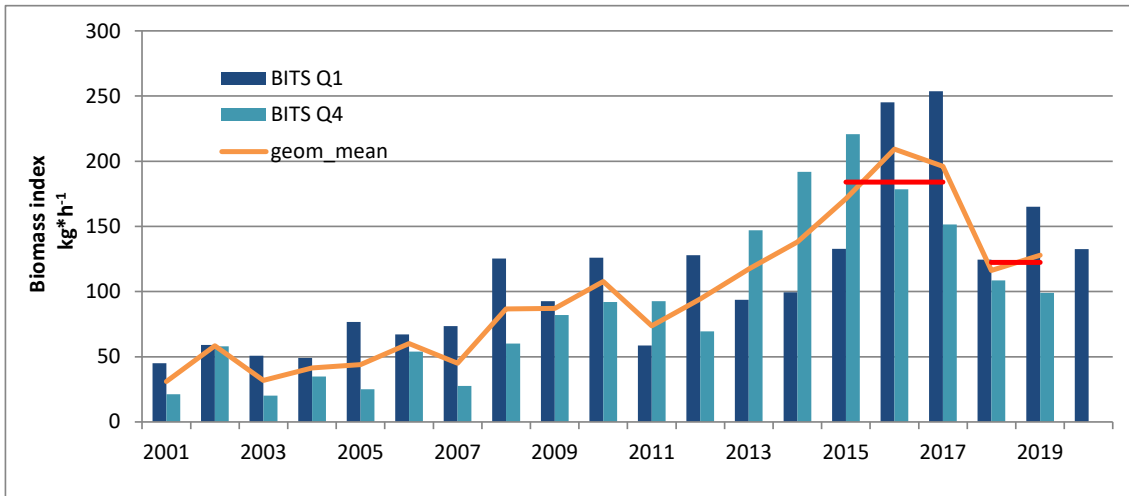


Figure 3.3.7. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Survey biomass index (BITS) Q1 and Q4 from 2001-2019 and geometric mean (line); stock trends from Baltic International Trawl Survey (BITS).

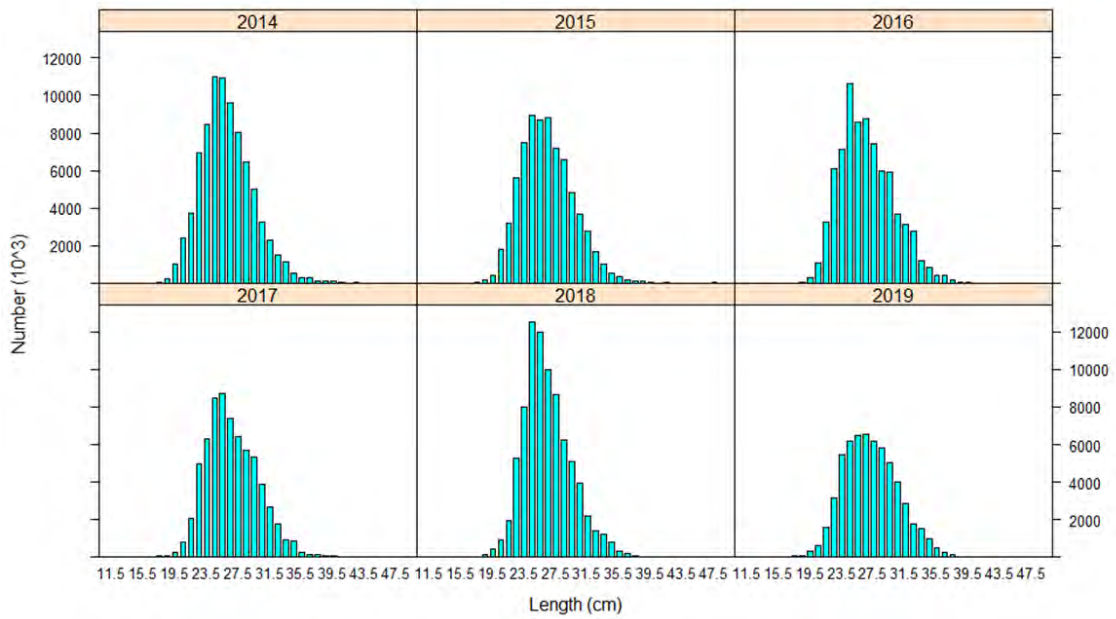


Figure 3.3.8. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). Catch in numbers (CANUM) per length classes.

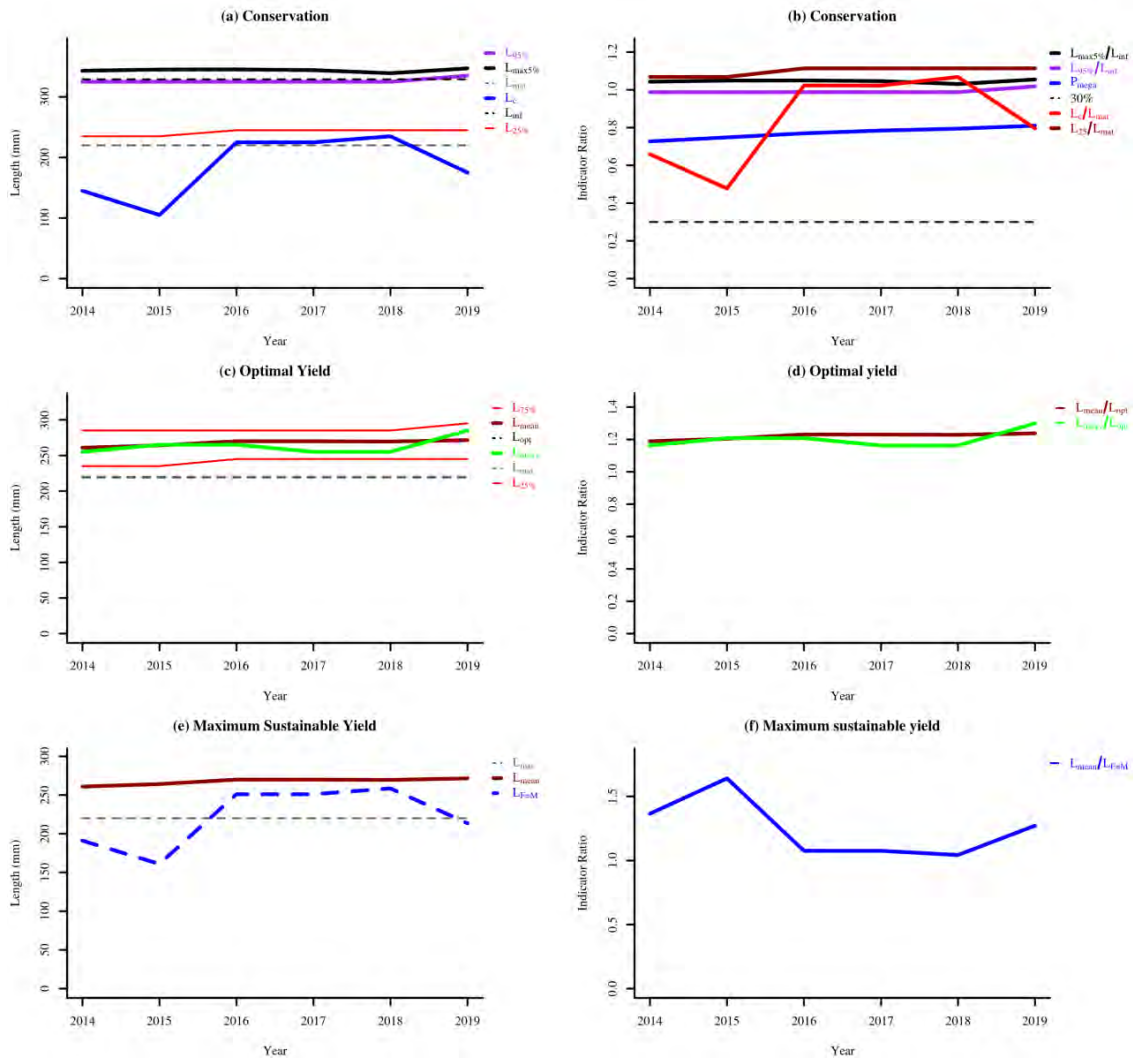


Figure 3.3.9. Flounder in subdivisions 24–25 (West of Bornholm, Southern Central Baltic–West). LBI indicator trends.

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.

| Year | Denmark | | | Estonia | | | Finland | | | Germany | | | Latvia | | | Lithuania | | | Poland | | | Sweden | | | Total | | |
|------|---------|-------|----------|---------|-------|----------|---------|-------|----------|---------|-------|----------|--------|-------|----------|-----------|-------|----------|--------|-------|----------|--------|-------|----------|-------|-----|------|
| | 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 | | | |
| 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 |

| Year | Denmark | | | Estonia | | | Finland | | | Germany | | | Latvia | | Lithuania | | | Poland | | | Sweden | | | Total | | |
|------|---------|-------|----------|---------|-------|----------|---------|-------|----------|---------|-------|----------|--------|-------|-----------|-------|-------|----------|-------|-------|----------|-------|-------|----------|----------|-------|
| | 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 |

| Year | Denmark | | | Estonia | | | Finland | | | Germany | | | Latvia | | | Lithuania | | | Poland | | | Sweden | | | Total |
|------|---------|-------|----------|---------|-------|----------|---------|-------|----------|---------|-------|----------|--------|-------|----------|-----------|-------|----------|--------|-------|----------|--------|-------|----------|----------|
| | 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.

| Year | Denmark | | | Estonia | | | Finland | | | Germany | | | Latvia | | | Lithuania | | | Poland | | | Sweden | | | Total |
|------|---------|-------|----------|---------|-------|----------|---------|-------|----------|---------|-------|----------|--------|-------|----------|-----------|-------|----------|--------|-------|----------|--------|-------|----------|----------|
| | 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.

| SD 24 | Country | Catch category | Catch t | No. of length samples in numbers | No. Measured in numbers |
|---------|----------|----------------|---------|----------------------------------|-------------------------|
| | 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 | |

| SD 25 | Country | Catch category | Catch t | No. of length samples in numbers | No. Measured in numbers |
|-----------|----------|----------------|---------|----------------------------------|-------------------------|
| | 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 |
|-------------------|---|-----------------|---------------------------|----------------|----------------------------------|
| $L_{\max 5\%}$ | Mean length of largest 5% | L_{\inf} | $L_{\max 5\%} / L_{\inf}$ | > 0.8 | Conservation (large individuals) |
| $L_{95\%}$ | 95th percentile | | $L_{95\%} / L_{\inf}$ | | |
| P_{mega} | Proportion of individuals above $L_{\text{opt}} + 10\%$ | 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 > L _c | $L_{opt} = \frac{3}{3+M/k} \times L_{inf}$ | L _{mean} /L _{opt} | ≈ 1 | Optimal yield |
| L _{maxy} | Length class with maximum biomass in catch | $L_{opt} = \frac{3}{3+M/k} \times L_{inf}$ | L _{maxy} / L _{opt} | ≈ 1 | |
| L _{mean} | Mean length of individuals > L _c | 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.

| Year | Conservation | | | P _{mega} | Optimizing Yield | MSY |
|------|-----------------------------------|-------------------------------------|---------------------------------------|-------------------|--------------------------------------|--------------------------------------|
| | L _c / L _{mat} | L _{25%} / L _{mat} | L _{max 5} / L _{inf} | | 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 $w=aL^b$ were fitted, were: $a = 0.0154$ and $b = 2.91$ for 1st quarter and $a = 0.0158$ and $b = 2.90$ for 4th quarter. Next, biomass for fish longer than 20 cm were summed to get 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:

$$L_{inf} = 31.04 \text{ mm}$$

$$L_{mat} = 17.6 \text{ mm}$$

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

| Year | Conservation | | | | Optimizing Yield | MSY |
|------|------------------------|-----------------------------|---------------------------------|-------------------|------------------------------------|--------------------------|
| | L_c / L_{mat} | $L_{25\%} / L_{\text{mat}}$ | $L_{\max 5\%} / L_{\text{inf}}$ | P_{mega} | $L_{\text{mean}} / L_{\text{opt}}$ | $L_{\text{mean}} / LF=M$ |
| 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 |

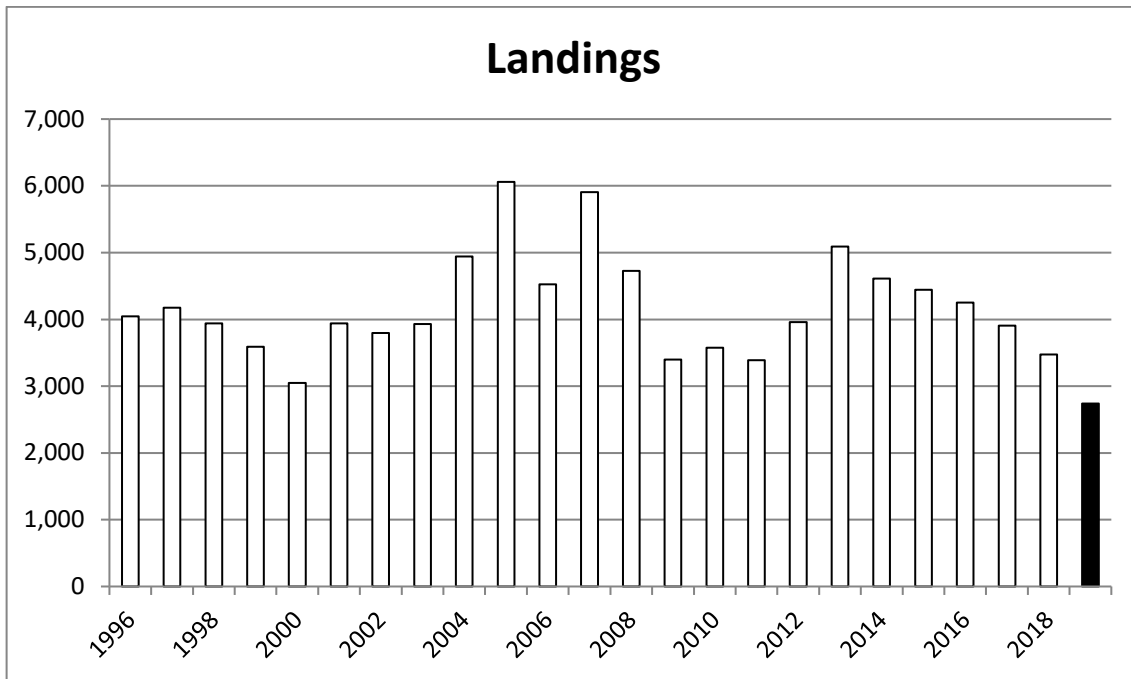


Figure 3.4.1. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder in subdivisions 26 and 28.

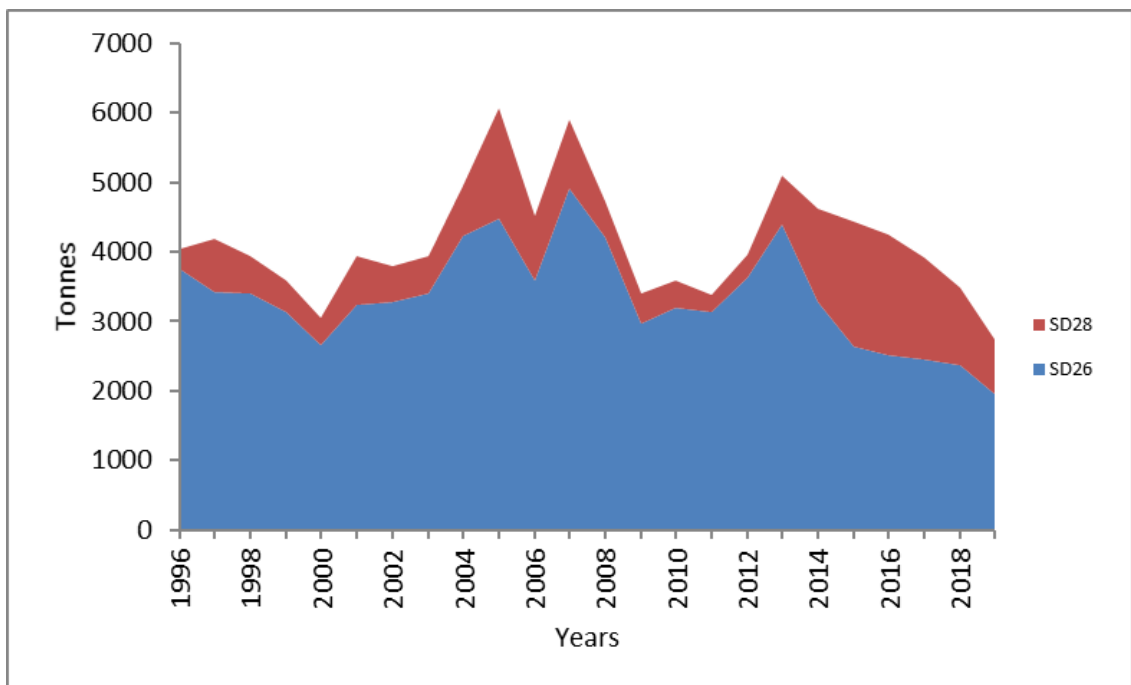


Figure 3.4.2. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). ICES landings of flounder by subdivisions.

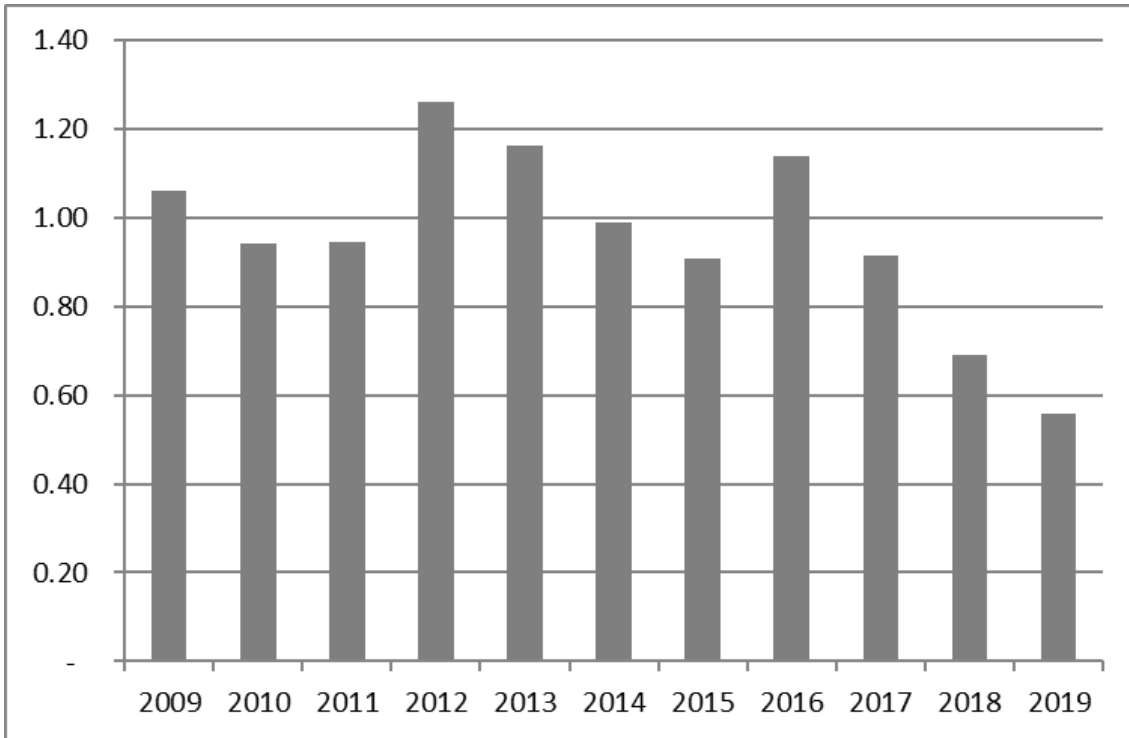


Figure 3.4.3. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Effort data (days-at-sea) of flounder in subdivisions 26 and 28 (days-at-sea).

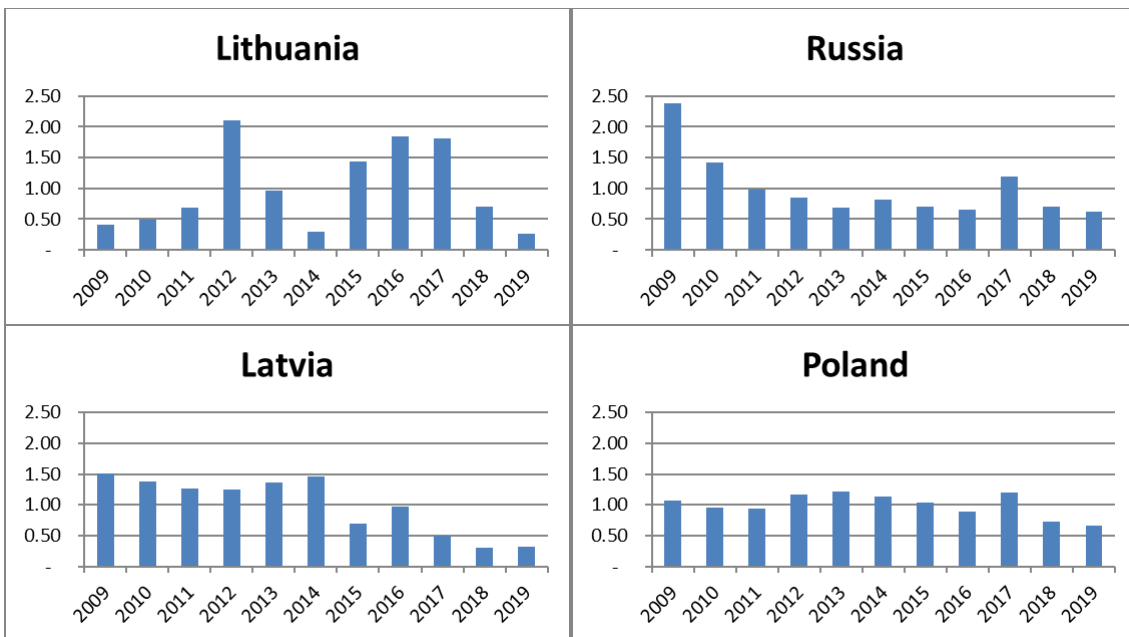


Figure 1 Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Effort data of flounder in subdivisions 26 and 28 by main fishing countries (days-at-sea).

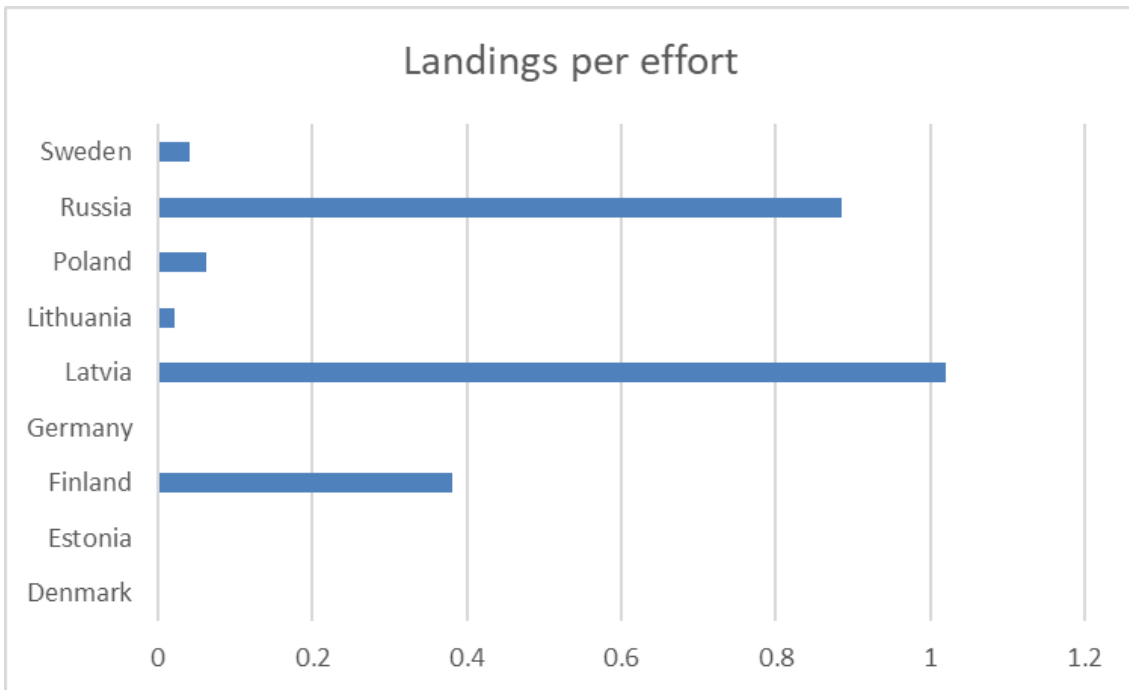


Figure 3.4.5. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Landings of flounder in tonnes per days-at-sea by country in subdivisions 26 and 28.

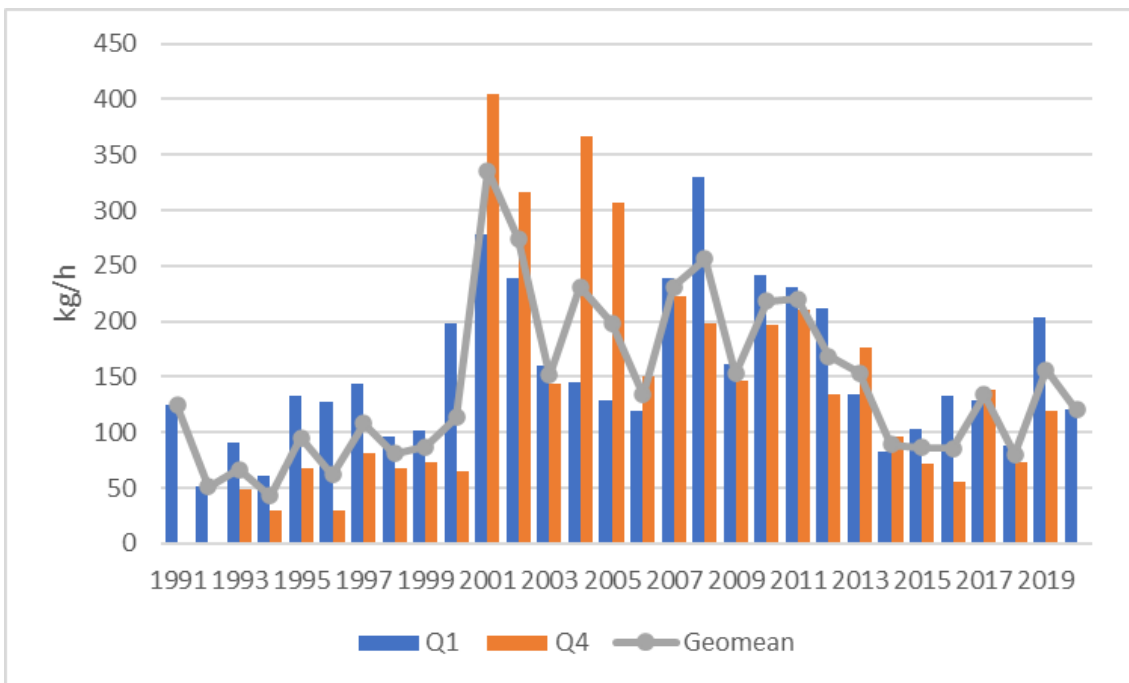


Figure 3.4.6. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch per unit of effort (kg per hour) from BIT Survey in 1st and 4th Quarters, subdivisions 26 and 28.

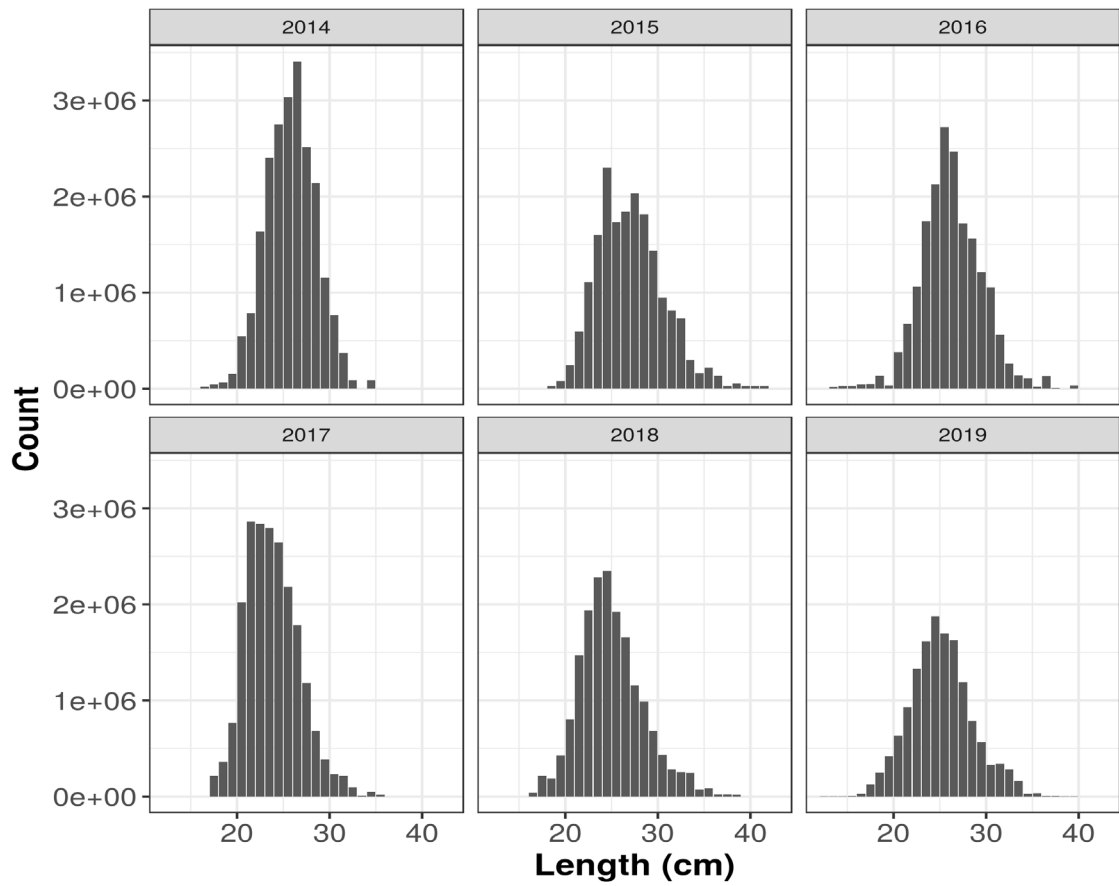


Figure 3.4.7. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Catch in numbers (CANUM) per length classes.

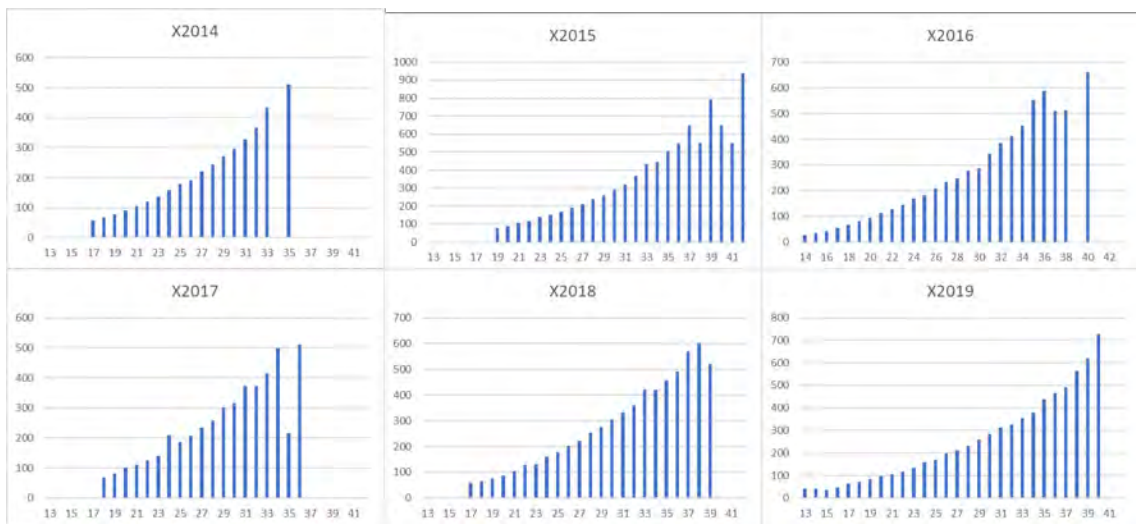


Figure 3.4.8. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Average weight (WECA) per length classes

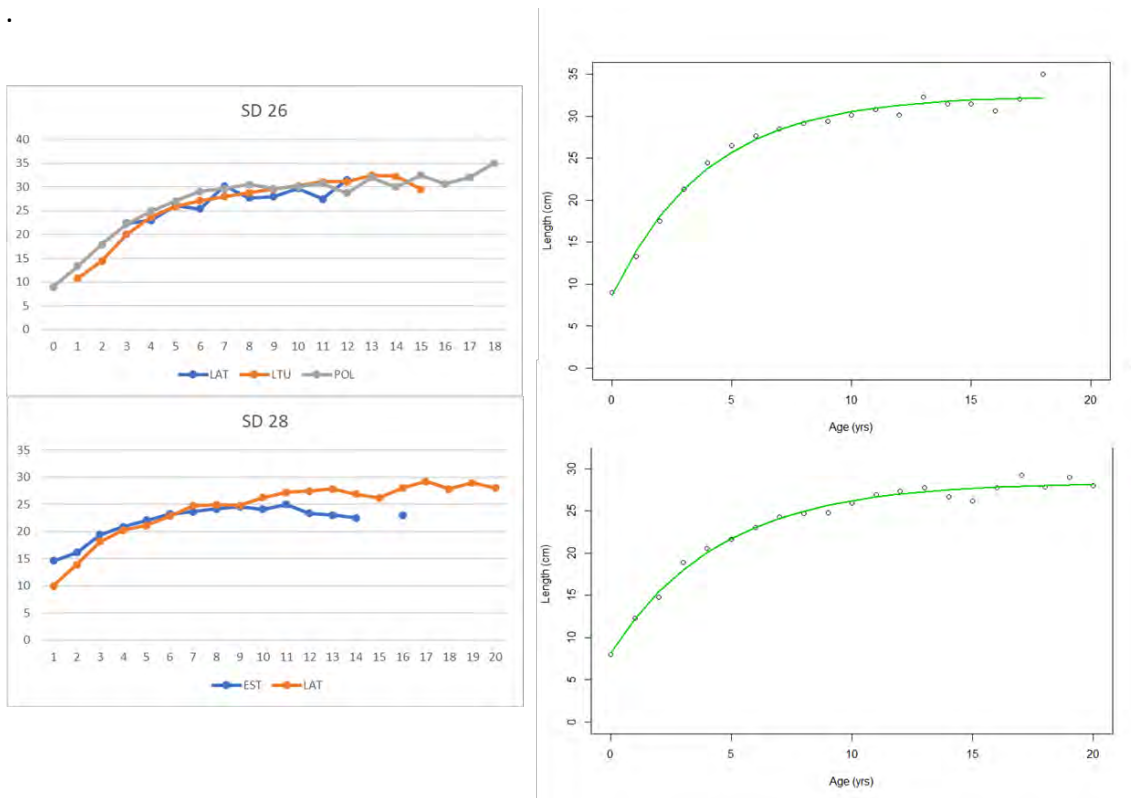


Figure 3.4.9. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Growth of flounder (Subdivision 26 – 1st line, Subdivision 28 – 2nd line) BIT Survey in 4th Quarters from 2014-2019.

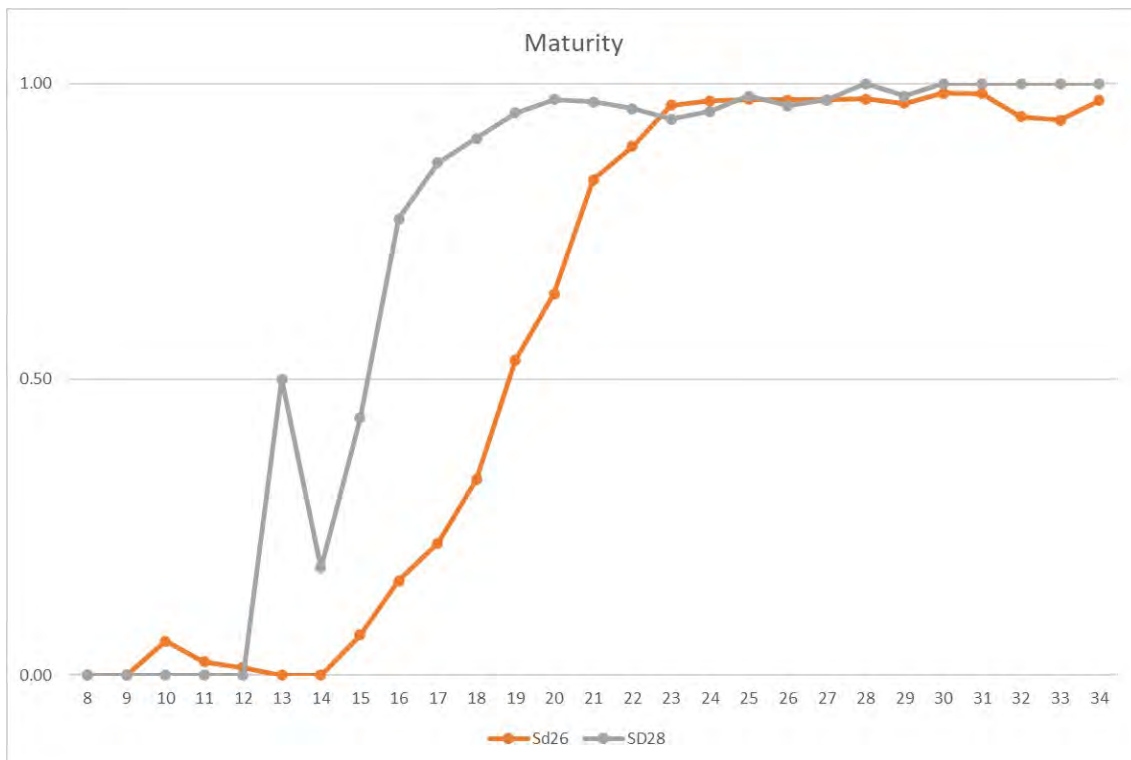


Figure 3.4.10. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Proportion of mature flounder females by Subdivisions, BIT Survey in 4th Quarters from 2014-2019.

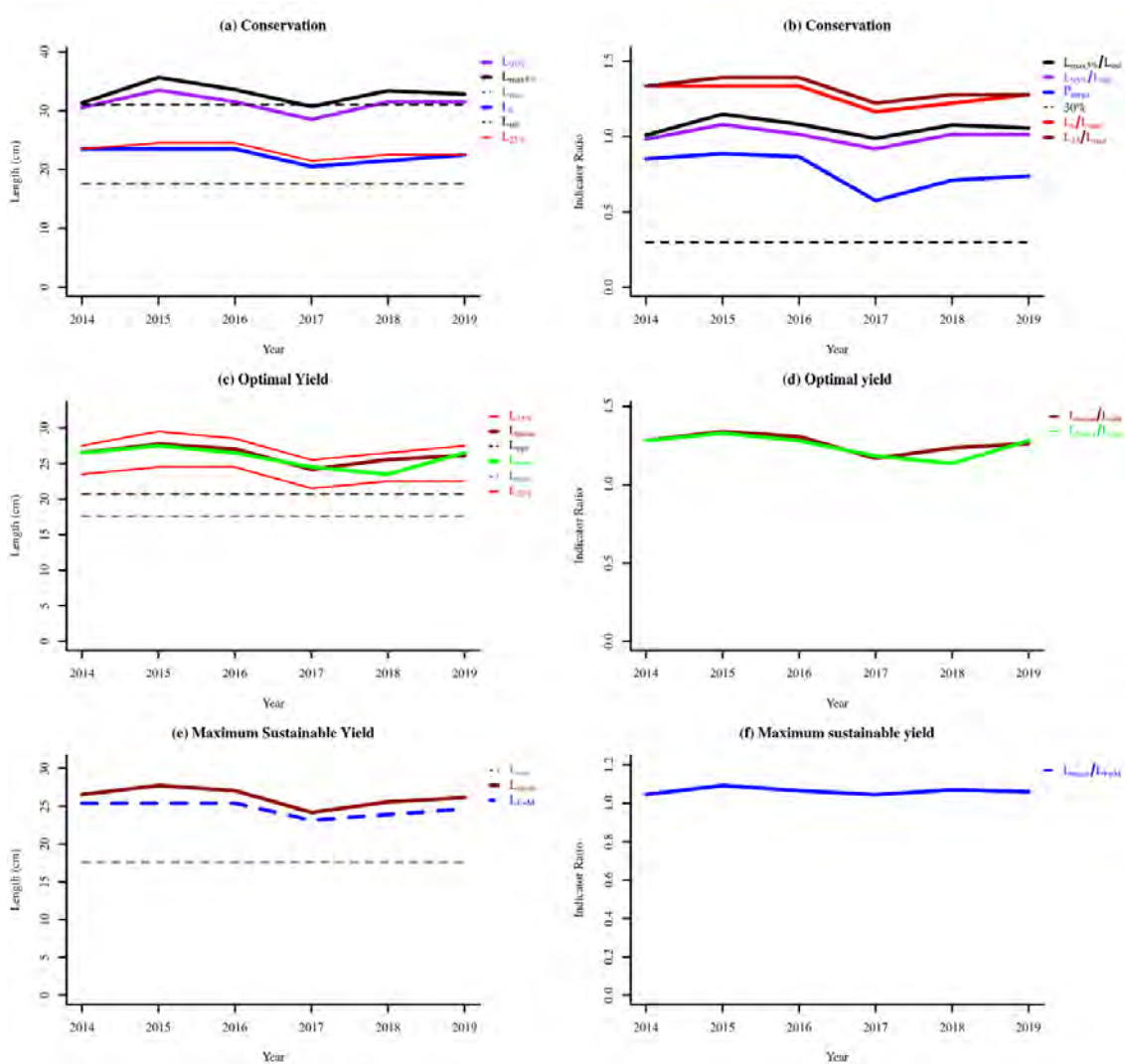


Figure 3.4.11. Flounder in subdivisions 26 and 28 (Eastern Gotland and Gulf of Gdansk). Indicator trends.

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 gill-nets. 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 | Kväddfjärden-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 | Kväddöfjärden-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 | $\sim 1(>0.9)$ | ≥ 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 |

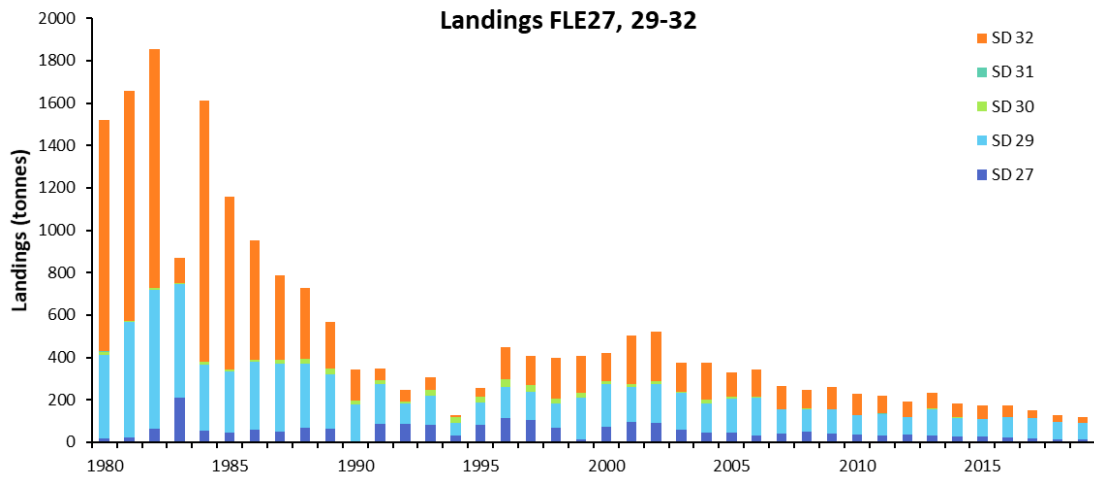


Figure 3.5.1. Flounder SD 27, 29-32 (Northern Baltic Sea). Landings (tonnes) in subdivisions (SDs) 27 and 29-32 from 1980-2019.



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).

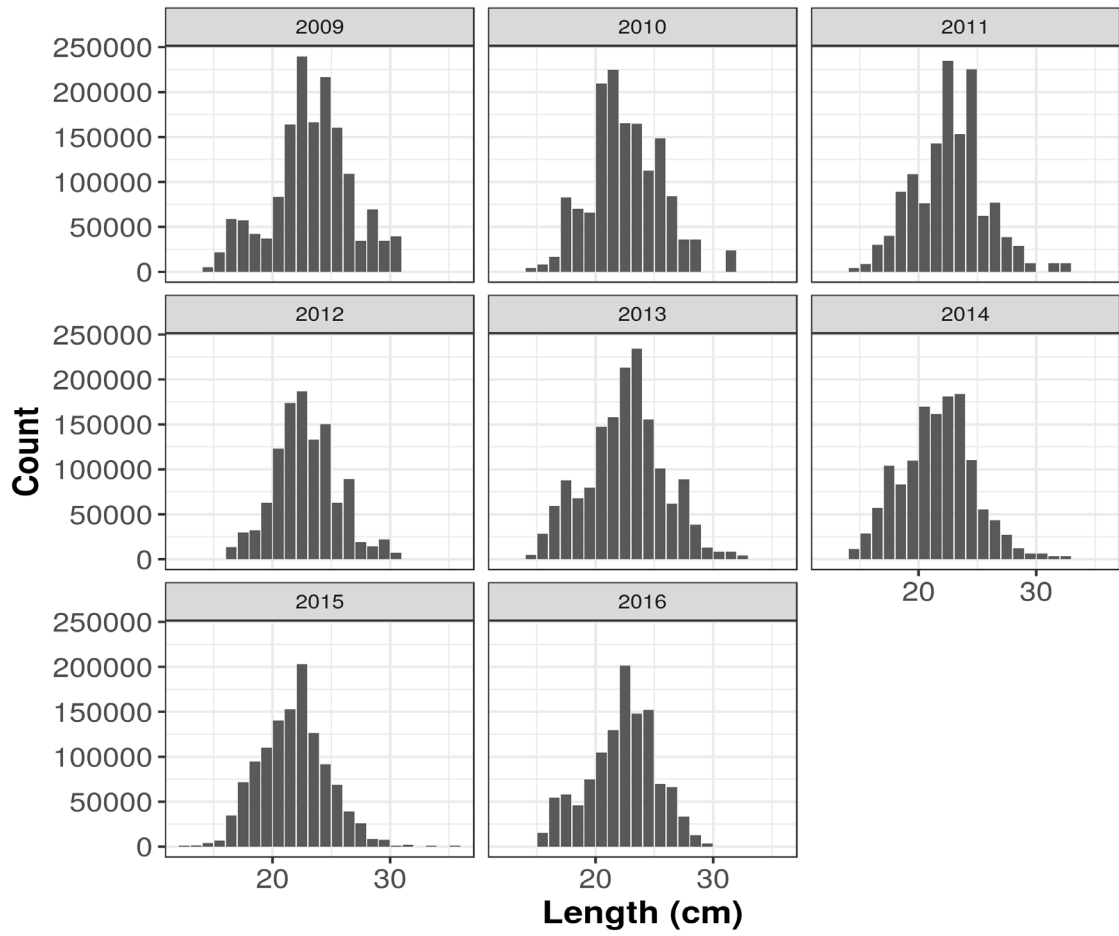


Figure 3.5.3. Flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Representative catch in numbers by length class for flounder commercial landings in subdivisions 27 and 29-32.

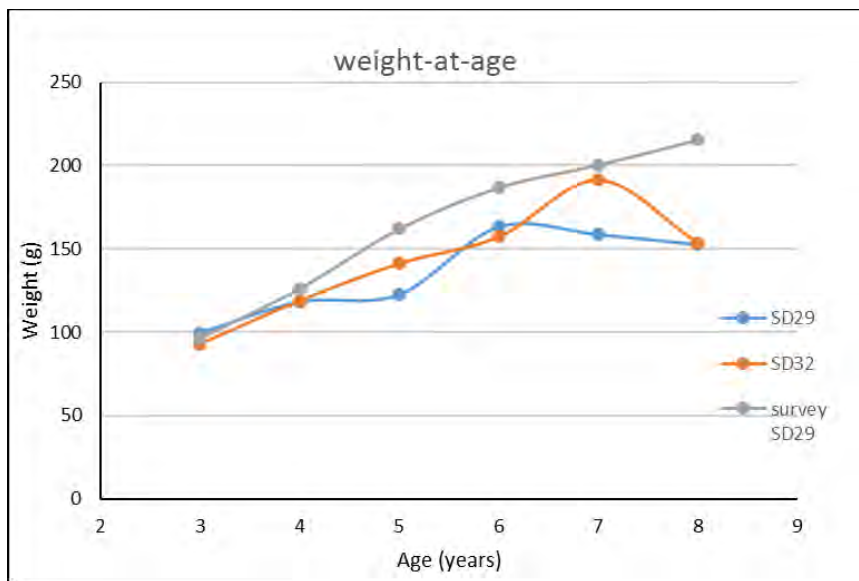


Figure 3.5.4. Flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Mean weights per age for Estonian commercial trap net landings per Subdivision (Q3+4) and for survey in SD 29 (Küdema bay).

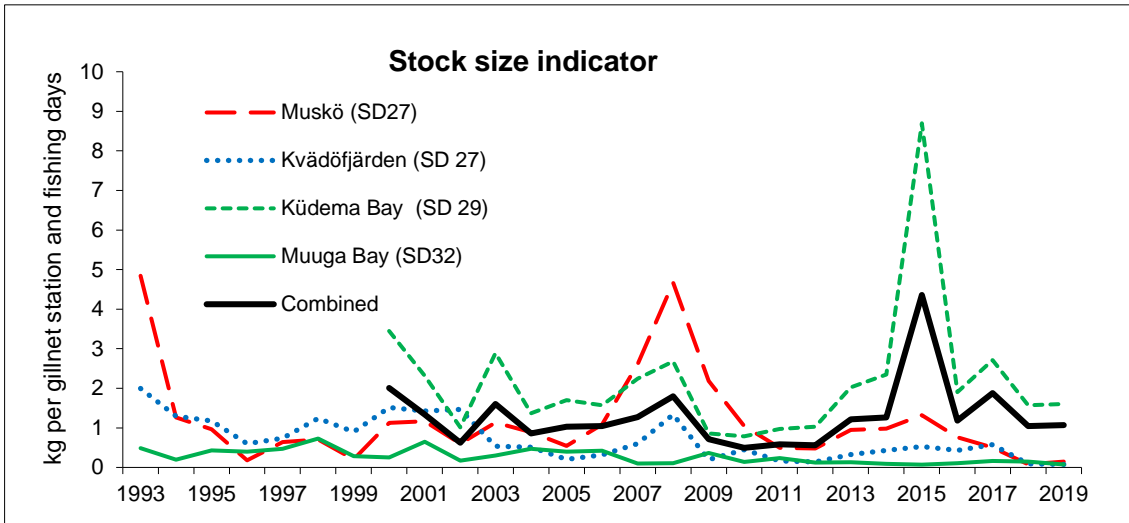


Figure 3.5.5. Flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea). Biomass indices of Muuga Bay (SD 32) (solid green line), Küdema Bay (SD 29) (dashed green line), Muskö (SD 27) (red dash line), Kvädöfjärden (SD 27) (dotted blue line) surveys and combined index (kg per gillnet station and fishing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

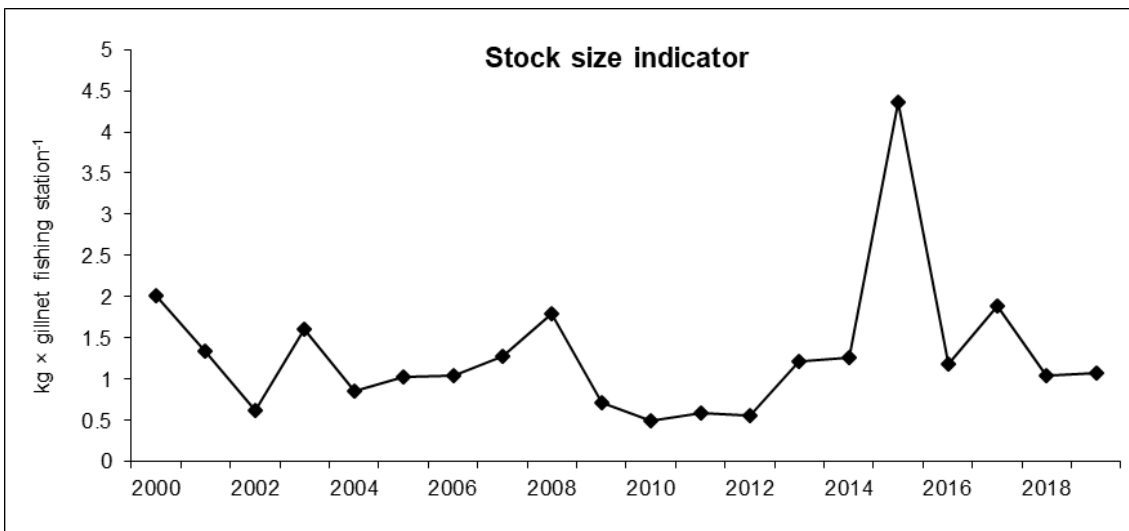


Figure 3.5.6. Flounder in Subdivisions 27 and 29-32 (Northern Baltic Sea) Combined biomass index of four surveys (Muuga Bay (SD 32), Küdema Bay (SD 29), Muskö (SD 27), and Kvädöfjärden (SD 27)) (kg x gillnet fishing station-1)

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 sus- tainably 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 westernmost 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.

| Subdivision 25 | Quarter | Landings in tons | Number of samples | Number of fish meas. | Number of fish aged |
|-----------------------|----------------|---------------------|----------------------|-------------------------|------------------------|
| | 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 | Quarter | Landings in tons | Number of samples | Number of fish meas. | Number of fish aged |
| | 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 | Quarter | Landings in tons | Number of samples | Number of fish meas. | Number of fish aged |
| | 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* | Quarter | Landings in tons | Number of samples | Number of fish meas. | Number of fish aged |
| | 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 | Quarter | Landings in tons | Number of samples | Number of fish meas. | Number of fish aged |
| | 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 | Quarter | Landings in tons | Number of samples | Number of fish meas. | Number of fish aged |
| | 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 | Quarter | Landings in tons | Number of samples | Number of fish meas. | Number of fish aged |
| | 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 | Quarter | Landings in tons | Number of samples | Number of fish meas. | Number of fish aged |
| | 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 | Quarter | Landings in tons | Number of samples | Number of fish meas. | Number of fish aged |
| | 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

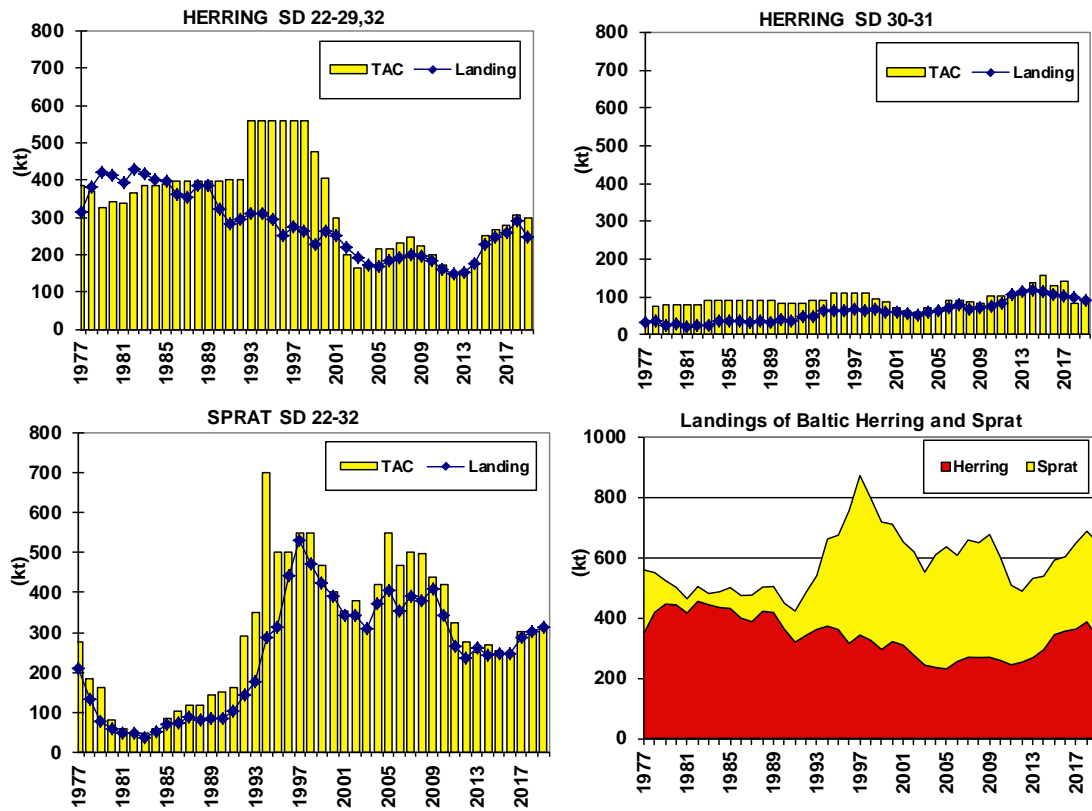


Figure 4.1.1. Reported landings of herring and sprat and agreed TACs in the Baltic Sea (since 2007 TACs for herring and sprat: EC quota + Russian TAC).

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:

- $M_{2019} = M_{2018}$ (WGBFAS 2020)
- M_{2020} 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 (F_{3-6}). 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 F_{MSY} (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 **B**ALtic **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, Gröhler, 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 | $M_{1974-2011} = \text{SMS}$, $M_{2012} - M_{2018} = \text{regression of M against cod SSB}$ | $M_{1974-2028} = \text{SMS}$, $M_{2018} = M_{2019}$ | 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 (F_{3-6} ; 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

| Subdivision 25 | Country | Quarter | Catches in tons | Number of samples | Number of fish meas. | Number of fish aged |
|----------------|--------------|---------------|--------------------|----------------------|-------------------------|------------------------|
| | 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

| Subdivision 26 | Country | Quarter | Catches in tons | Number of samples | Number of fish meas. | Number of fish aged |
|----------------|---------|---------|--------------------|----------------------|-------------------------|------------------------|
| | 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

| Subdivision 27 | Country | Quarter | Catches in tons | Number of samples | Number of fish meas, | Number of fish aged |
|----------------|---------|---------|--------------------|----------------------|-------------------------|------------------------|
| | Denmark | 1 | 2 332 | 0 | 0 | 0 |
| | | 2 | | | | |
| | | 3 | | | | |
| | | 4 | | | | |
| | | Total | | | | |
| | Finland | 1 | 333 | 0 | 0 | 0 |
| | | 2 | | | | |
| | | 3 | | | | |
| | | 4 | | | | |
| Total | | | | | | |
| Lithuania | 1 | 4 | 0 | 0 | 0 | |
| | 2 | | | | | |
| | 3 | | | | | |
| | 4 | | | | | |
| | Total | | | | | |
| Sweden | 1 | 12 476 | 12 | 842 | 840 | |
| | 2 | | | | | |
| | 3 | | | | | |
| | 4 | | | | | |
| | Total | | | | | |
| Total | 1 | 15 144 | 12 | 842 | 840 | |
| | 2 | | | | | |
| | 3 | | | | | |
| | 4 | | | | | |
| | Total | | | | | |

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

| Subdivision 29 | Country | Quarter | Catches in tons | Number of samples | Number of fish meas, | Number of fish aged |
|----------------|---------|---------|--------------------|----------------------|-------------------------|------------------------|
| | 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

| Subdivision 32 | Country | Quarter | Catches in tons | Number of samples | Number of fish meas, | Number of fish aged |
|--|--------------|----------------|----------------------------|------------------------------|---------------------------------|--------------------------------|
| | 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 1000 t).

| 1/2 | | | | | | | |
|------------|----------|---------|---------|---------|---------|---------|---------|
| Quarter: 1 | | | | | | | |
| AGE | Sum | SD 25 | SD 26 | SD 27 | SD 28.2 | SD 29 | SD 32 |
| O | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1 | 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 |

continued
Table 4.2.4.

Herring in SD 25–29, 32 (excl. GoR). Mean weight -at-age (g) per SD.
2/2

| Quarter: 1 | | SD 25 | SD 26 | SD 27 | SD 28.2 | SD 29 | SD 32 |
|------------|------|-------|-------|-------|---------|-------|-------|
| AGE | Mean | | | | | | |
| 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 | | SD 25 | SD 26 | SD 27 | SD 28.2 | SD 29 | SD 32 |
| AGE | Mean | | | | | | |
| 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 | | SD 25 | SD 26 | SD 27 | SD 28.2 | SD 29 | SD 32 |
| AGE | Mean | | | | | | |
| 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 | | SD 25 | SD 26 | SD 27 | SD 28.2 | SD 29 | SD 32 |
| AGE | Mean | | | | | | |
| 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.
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| | | | | | | | | | | |
|---|------------|-----------|-----------|----------|----------|----------|----------|-------|-------|-------|
| 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 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | |
| 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.
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| 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 | 99.99 |
| 2 | 99.99 | 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 | 99.99 |
| 4 | 99.99 | 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 | 99.99 |
| 6 | 99.99 | 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 | 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.
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| 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.

MFD 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 from 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 |
| Exploitation 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.**

MFD 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 |

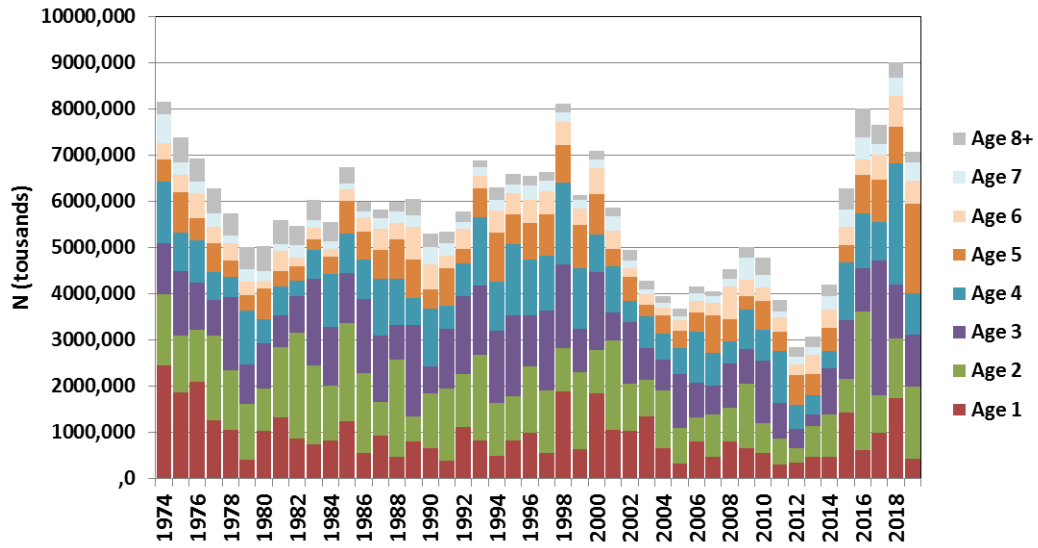


Figure 4.2.1 Herring in SD 25–29, 32 (excl. GoR). Proportions of age groups (numbers) in total catch (CANUM).

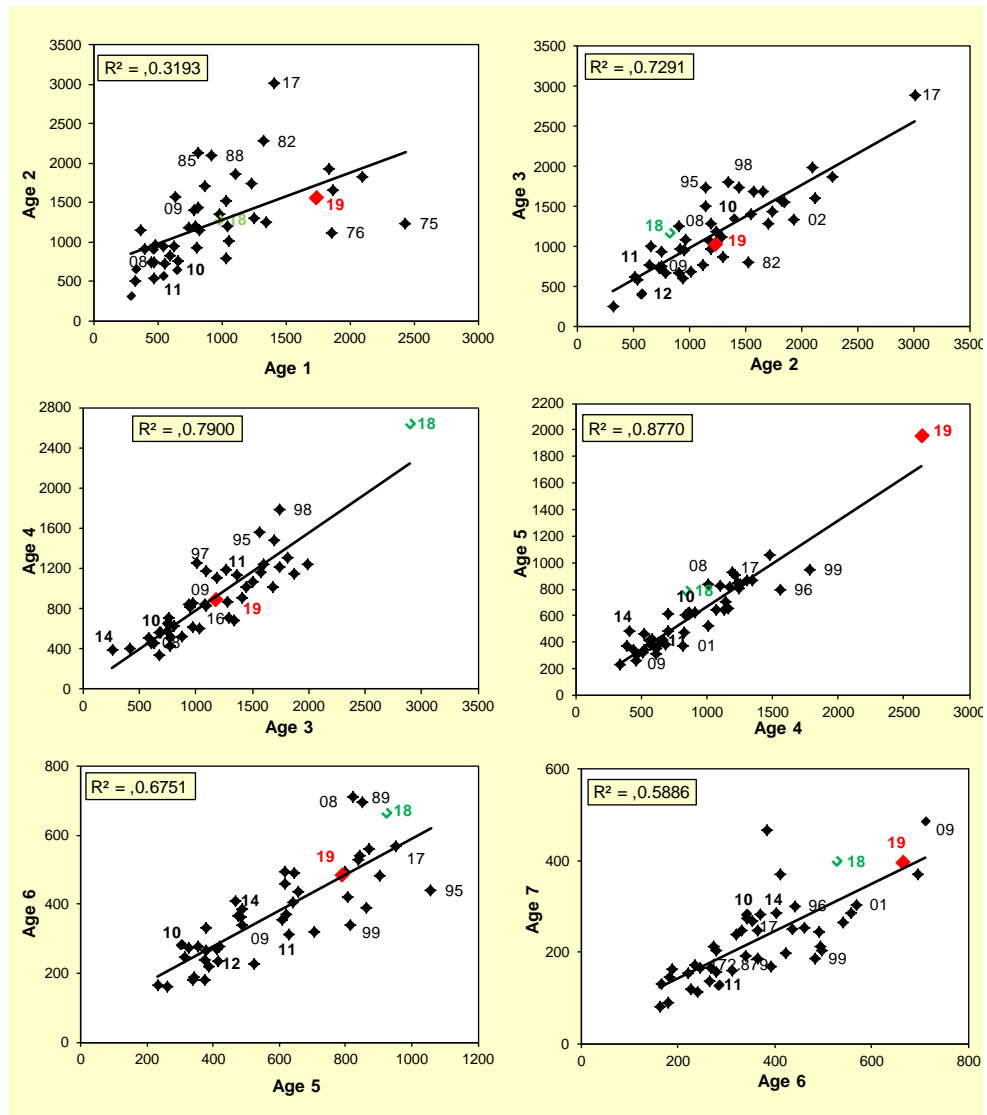


Figure 4.2.2 Herring in SD 25–29, 32 (excl. GoR). Catch in numbers (thousands) at age vs. numbers-at-age +1 of the same cohort in the following year in the period 1974–2019.

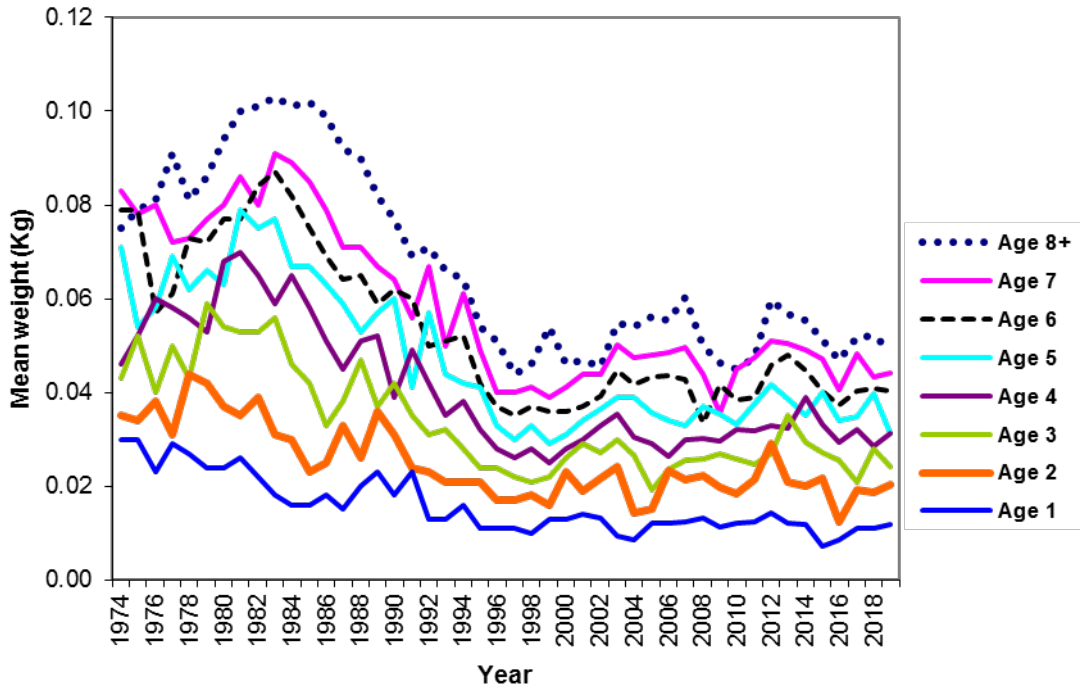


Figure 4.2.3 Herring in SD 25–29, 32 (excl. GoR). Trends in the mean weights at age (kg) in the catch (WECA).

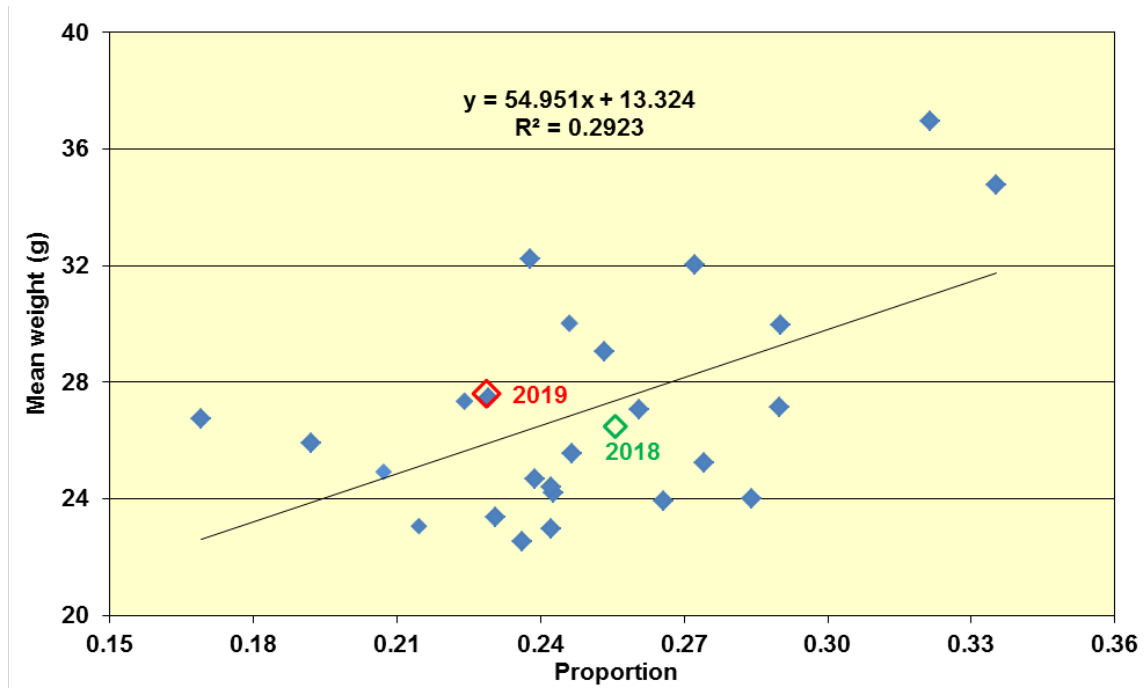


Figure 4.2.4 Herring in SD 25–29, 32 (excl. GoR). Average individual weight in catches vs. the proportion of catches taken in SD 25 and 26 (1993–2019).

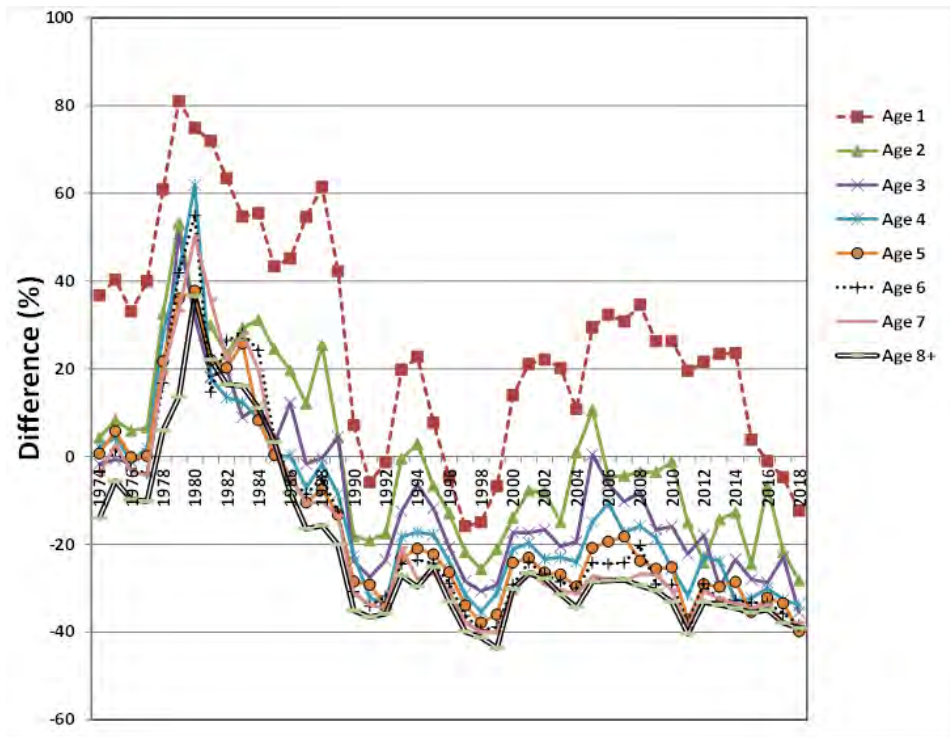


Figure 4.2.5 Herring in SD 25-29, 32 (excl. GOR). Difference (%) of new M (WGSAM 2019) versus old M (WGBFAS 2019).

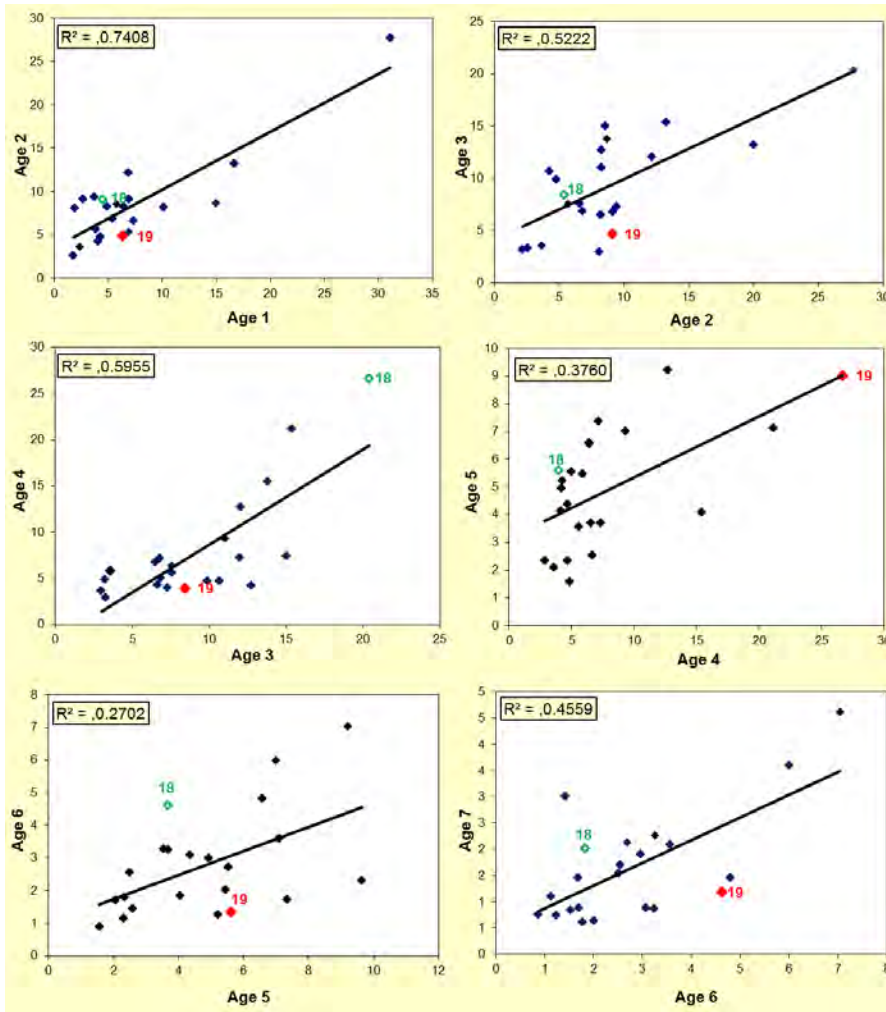


Figure 4.2.6 Herring in SD 25–29, 32 (excl. GoR). Acoustic survey numbers-at-age vs. numbers-at-age +1 of the same cohort in the following year in the period 1991–2019 (STANDARD INDEX). Years 1993, 1995, and 1997 were excluded.

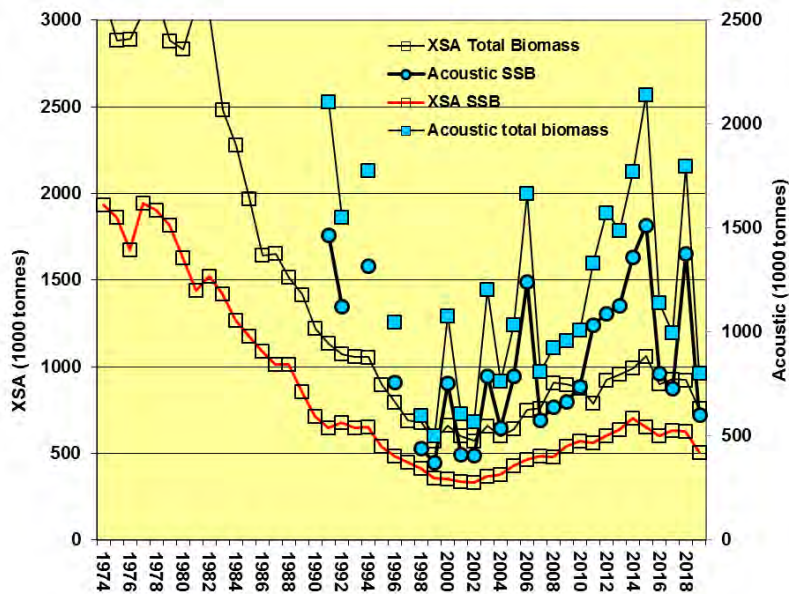


Figure 4.2.7 Herring in SD 25–29, 32 (excl. GoR). Estimates of biomass and SSB from acoustic surveys (BIAS) and from XSA. Acoustic biomasses = Acoustic abundance x WECA; Acoustic SSB = Acoustic abundance x WECA x MATPROP

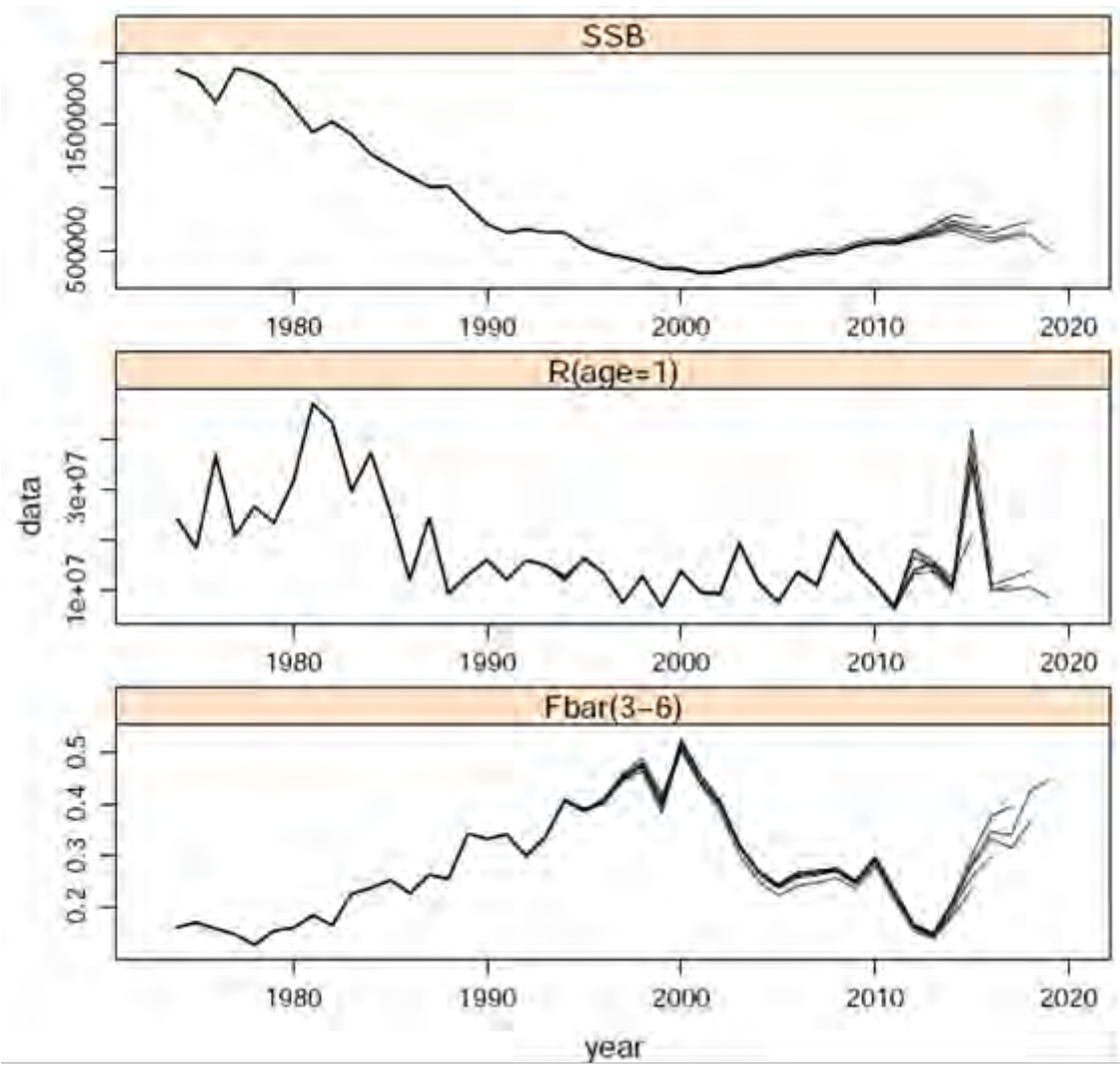


Figure 4.2.8 Herring in SD 25–29, 32 (excl. GoR). Retrospective Analysis.

Mohn’s rho:
 SSB: 0.1131893
 Fbar: -0.07456628
 Recruitment: 0.1009735

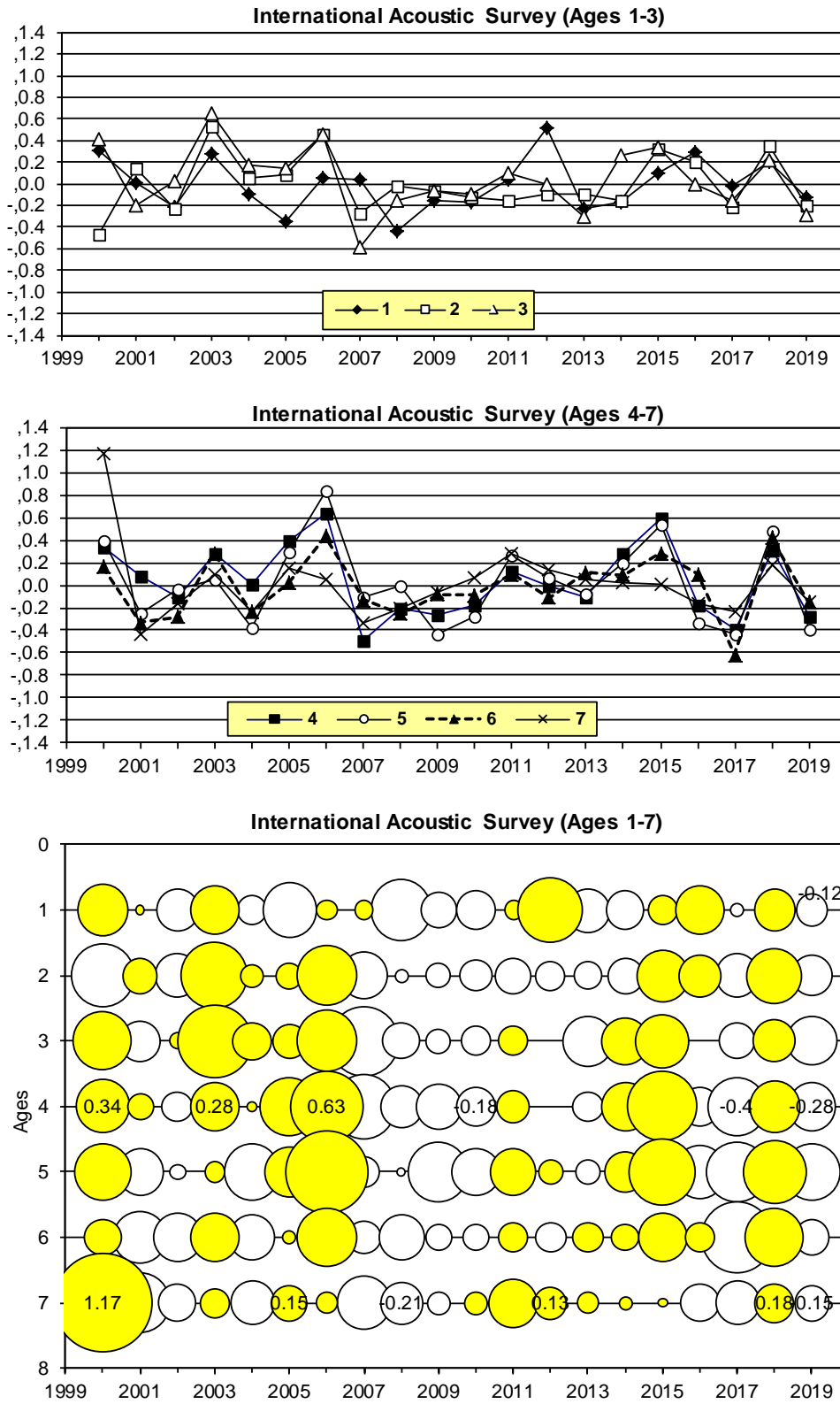


Figure 4.2.9 Herring in SD 25–29, 32 (excl. GoR). International Acoustic Survey (Ages 1–7): Log Catchability residuals. Standardized log catchability residuals (top figure). Observed (circles) vs predicted (line) numbers (bottom figure).

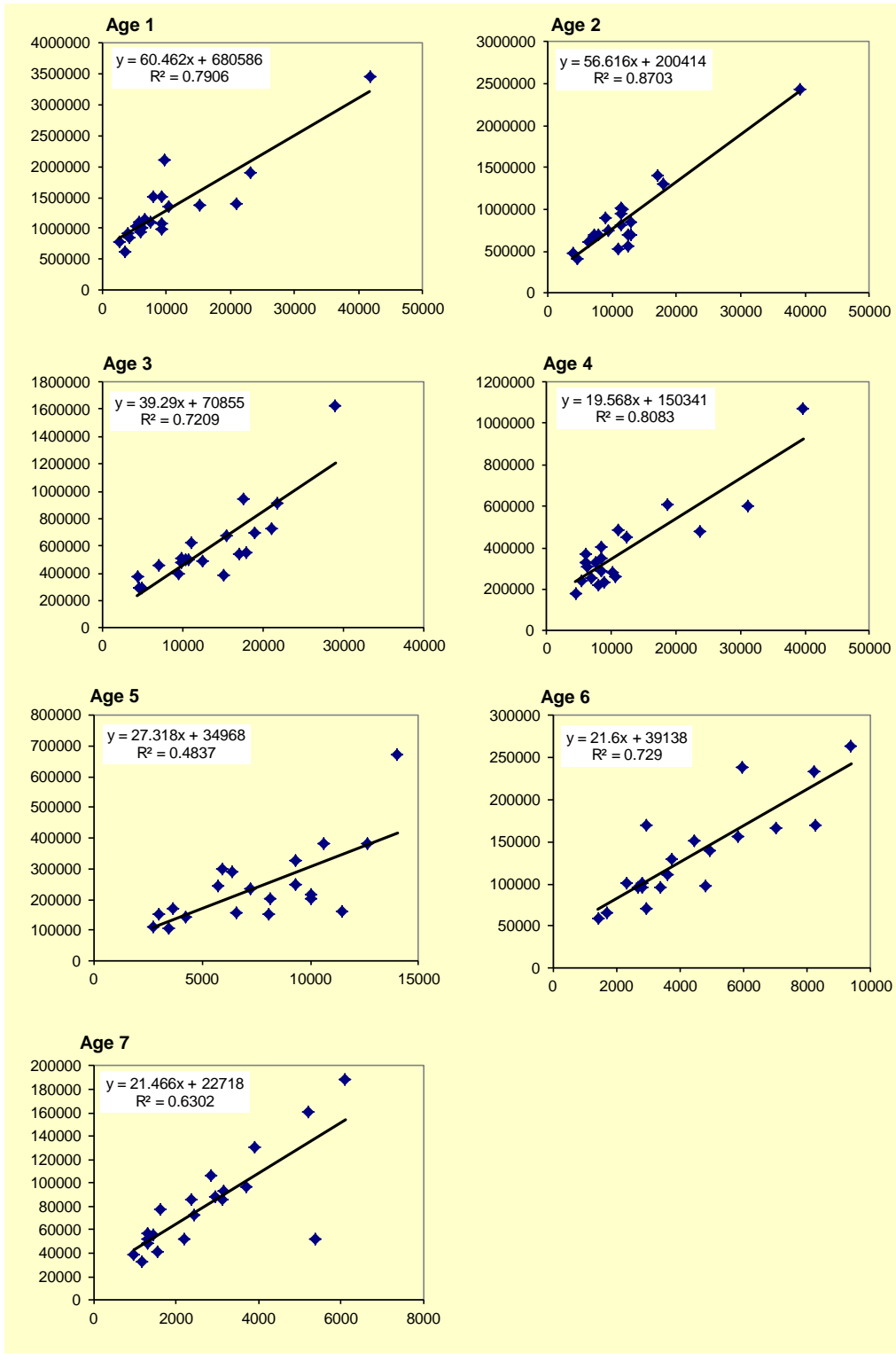


Figure 4.2.10 Herring in SD 25–29, 32 (excl. GoR). Regression of XSA population vs. acoustic survey population numbers. x-axis = Acoustic estimates; y-axis = XSA.

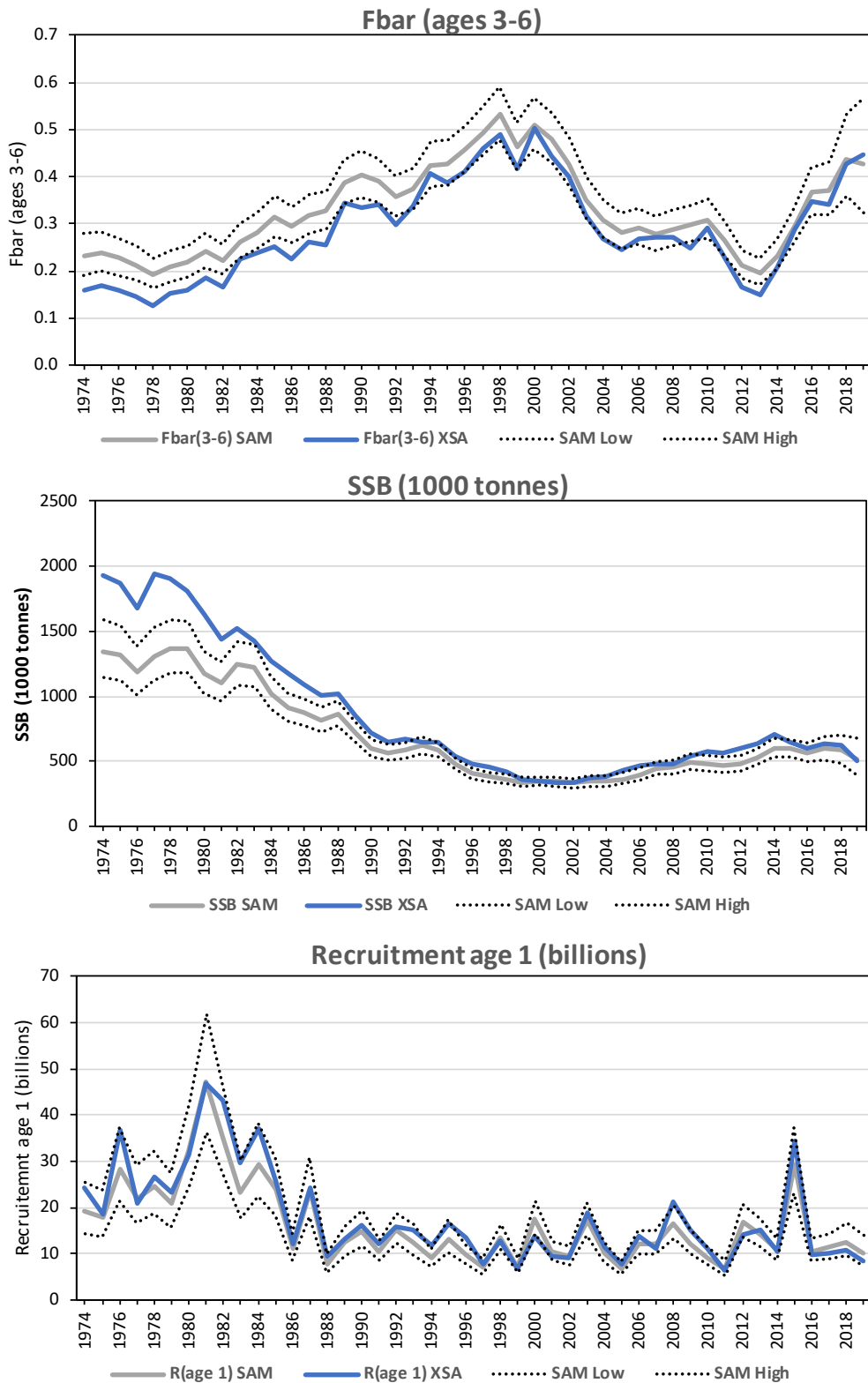


Figure 4.2.11 Herring in SD 25–29, 32 (excl. GoR). Comparison of fishing mortality (F_{3-6}), spawning stock biomass (SSB) and recruitment (age 1) from XSA and SAM (the dotted line represents the 95% confidence intervals of the SAM results).

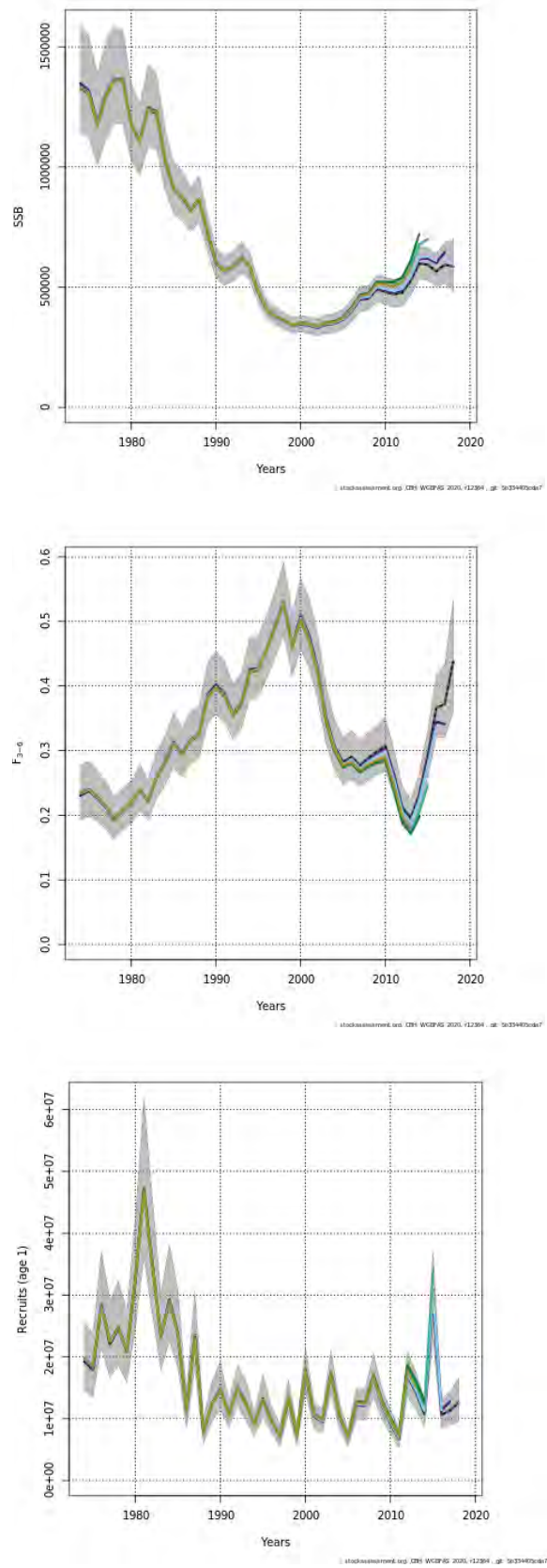


Figure 4.2.12 Herring in SD 25–29, 32 (excl. GoR). Retrospective analysis of SAM.

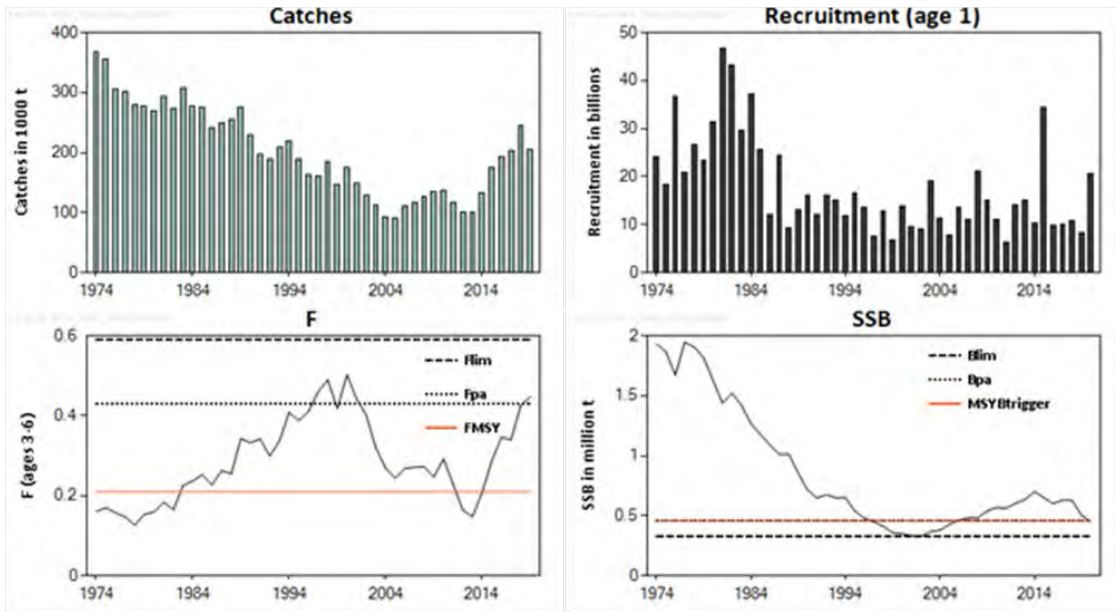


Figure 4.2.13 Herring in SD 25–29, 32 (excl. GoR). Summary sheet plots: Catches, fishing mortality, recruitment (age 1) and SSB. (Recruitment in 2020 from RCT3 & SSB in 2020 predicted)

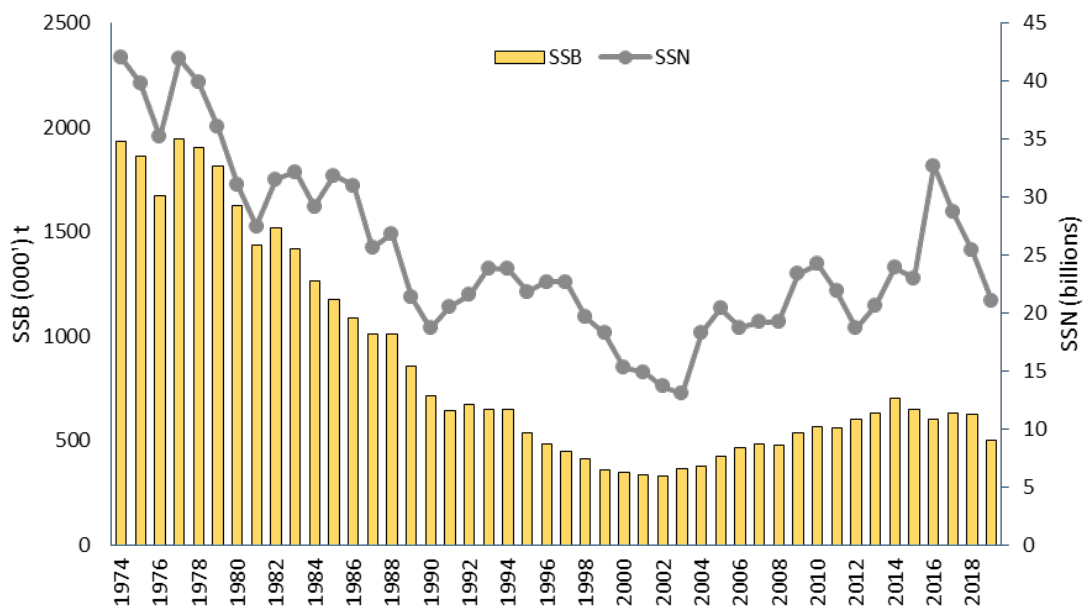


Figure 4.2.14 Herring in SD 25–29, 32 (excl. GoR). SSB (000' t) and Spawning Stock in Numbers (SSN) (billions).

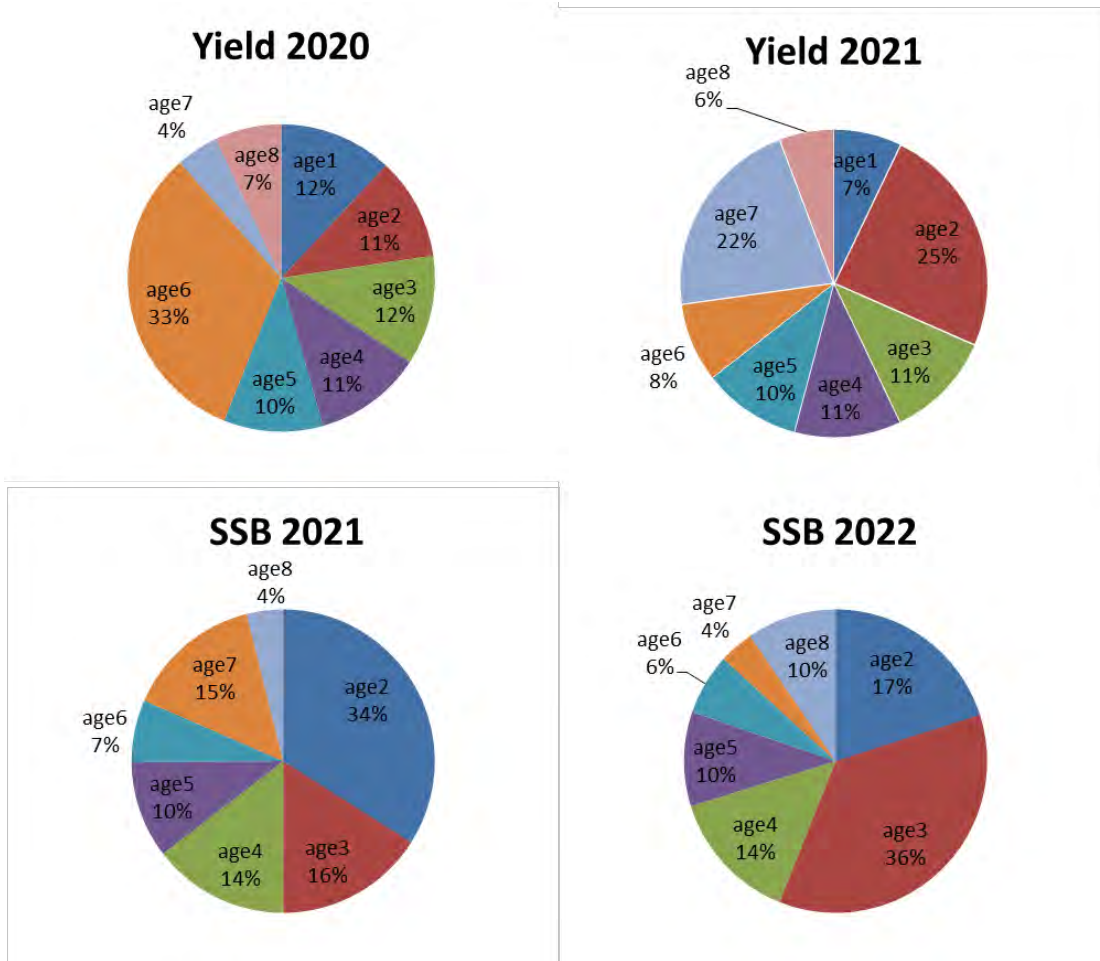


Figure 4.2.15 Herring in SD 25–29, 32 (excl. GoR). Yield and SSB at age 1-8+ as estimated in the short-term forecast for 2020-2022 under the TAC constraint 2020.

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 catches 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 hydro-acoustic survey (Tables 4.3.8 and 4.3.9). The catchability was assumed to be independent of stock size for all ages, and the catchability independent of age for age ≥ 5 was selected. The default level of shrinkage (SE=0.5) was used in terminal population estimation. The diagnostics from XSA is presented in Table 4.3.10 and the XSA results are shown in Tables 4.3.11–4.3.13. In general, the diagnostics were similar to the last year, but they slightly improved for the 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_{3-7}), 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 $B_{lim}=B_{loss}$ is applied. The corresponding value is $B_{lim}=40\ 800$ t. The B_{pa} value was obtained from the following equation: $B_{pa} = B_{lim} \times \exp(\sigma \times 1.645) = B_{lim} \times 1.4 = 57\ 100$ t.

F_{lim} was then derived from B_{lim} in the following way. R/SSB was calculated at B_{lim} , and the slope of the replacement line at B_{lim} , and then it was inverted to give SSB/R . This SSB/R was used to derive F_{lim} from the curve of SSB/R against F . The obtained value $F_{lim} = 0.88$. The F_{pa} value was obtained from the equation $F_{lim}=F_{pa}/1.4$ and was $F_{pa}=0.63$.

Instead of MBAL estimate of 50 000 t used previously, the B_{trigger} value of 60 000 t selected at the Workshop on Multi-annual Management of Pelagic Fish Stocks in the Baltic (ICES, 2009) was used.

4.3.7 Quality of assessment

The catches are estimated on the basis of the national official landing statistics of Latvia and Estonia. The stock is well sampled and the number of measured and aged fish has been historically high (Table 4.3.2.). Since 1993 the total landings of Latvia were increased according to information on misreporting. There was no information on unallocated catches of herring since 2011. Due to scrapping of fishing vessels the fishing fleet in the Gulf of Riga has been considerably reduced and the fishing capacity could be in balance with the fishing possibilities. The number of 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 | 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 2016 | 2011 2017 | 2012 2018 | 2013 2019 | 2014 | 2015 |
|-----|----------------|----------------|----------------|----------------|-------|-------|
| 1 | 0.2 0.129 | 0.094 0.111 | 0.095 0.068 | 0.085 0.077 | 0.08 | 0.131 |
| 2 | 0.246 0.196 | 0.222 0.177 | 0.171 0.157 | 0.171 0.165 | 0.148 | 0.206 |
| 3 | 0.249 0.247 | 0.317 0.226 | 0.277 0.19 | 0.193 0.198 | 0.186 | 0.226 |
| 4 | 0.281 0.262 | 0.311 0.204 | 0.321 0.238 | 0.227 0.234 | 0.207 | 0.252 |
| 5 | 0.325 0.298 | 0.372 0.242 | 0.321 0.243 | 0.229 0.295 | 0.289 | 0.327 |
| 6 | 0.306 0.362 | 0.337 0.31 | 0.289 0.221 | 0.277 0.427 | 0.254 | 0.345 |
| 7 | 0.318 0.371 | 0.322 0.346 | 0.307 0.243 | 0.252 0.269 | 0.281 | 0.446 |

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

| Age | 2010 2016 | 2011 2017 | 2012 2018 | 2013 2019 | 2014 | 2015 |
|-----|------------------------------------|----------------|----------------|----------------|-------|-------|
| 1 | No data for this fleet at this age | | | | | |
| 2 | -0.14 0.16 | -0.16 -0.22 | -0.09 0.05 | 0.01 -0.18 | 0.26 | -0.23 |
| 3 | -0.19 0.03 | 0.05 0.07 | -0.11 0.05 | -0.08 -0.18 | -0.13 | -0.09 |
| 4 | -0.24 0.09 | 0.09 -0.28 | 0.17 0.16 | -0.16 0 | -0.29 | -0.3 |
| 5 | 0.03 0.25 | -0.18 0.11 | -0.03 -0.2 | -0.12 0.03 | -0.32 | -0.44 |
| 6 | 0.1 0.18 | 0.15 0.26 | -0.26 -0.12 | 0 -0.02 | -0.78 | -0.4 |
| 7 | 0.1 0.18 | -0.09 -0.01 | -0.01 0.05 | -0.33 -0.1 | -0.37 | -0.2 |

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

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

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) (10⁴)

| 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 minimum 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
$oobsCorStruct
# 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 highest 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 | %Advice change*** |
|---------------------------------------|-----------------------|----------|------------|------------|----------|----------------------|
| | | | | | 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).

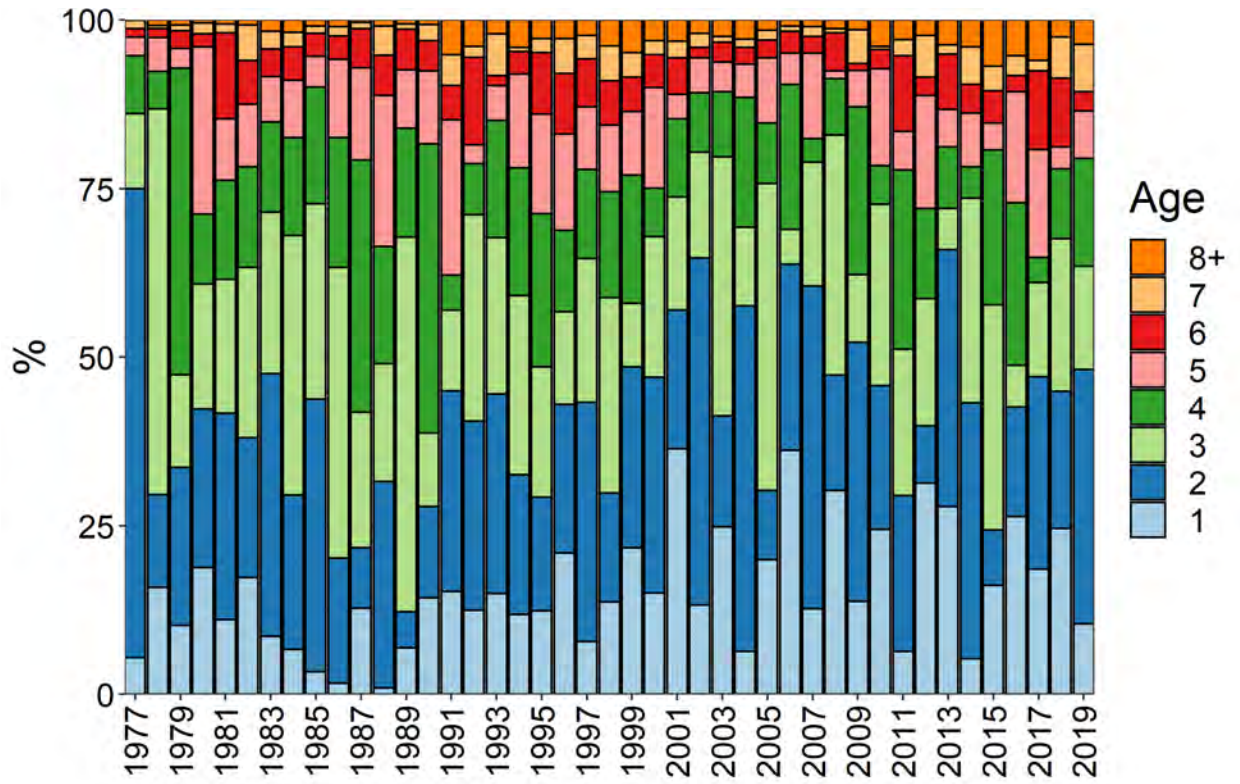


Figure 4.3.1. Gulf of Riga herring. Relative catch at age in numbers in 1977-2019.

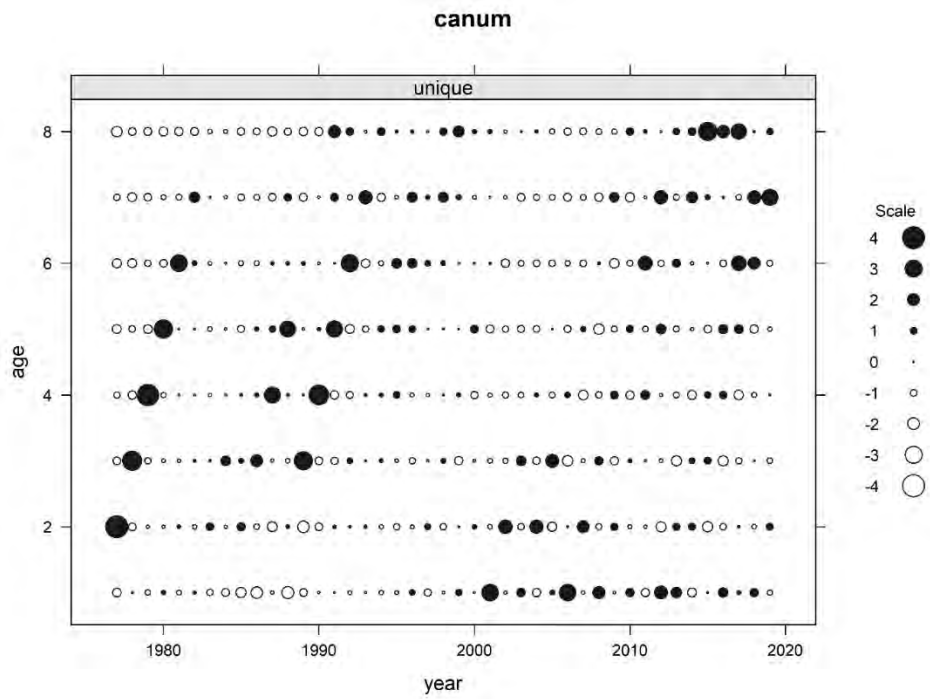


Figure 4.3.2. Gulf of Riga herring. Catch proportion at age.

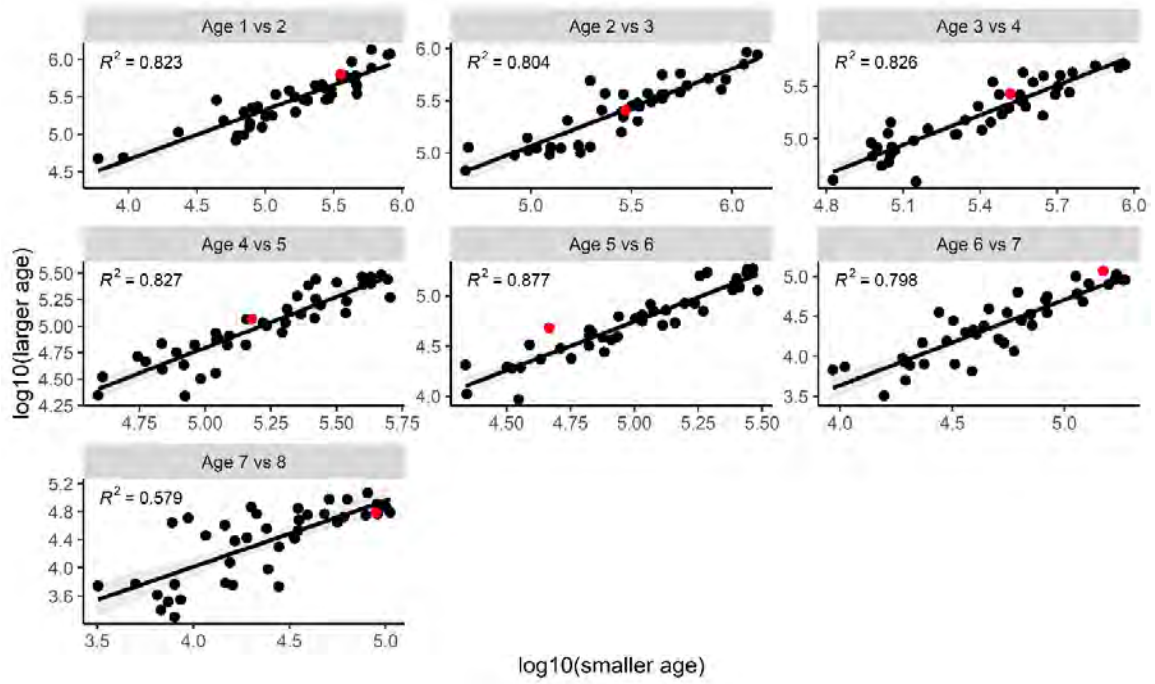


Figure 4.3.3. Gulf of Riga herring. Internal consistency in catch-at-age. Latest year is shown in red.

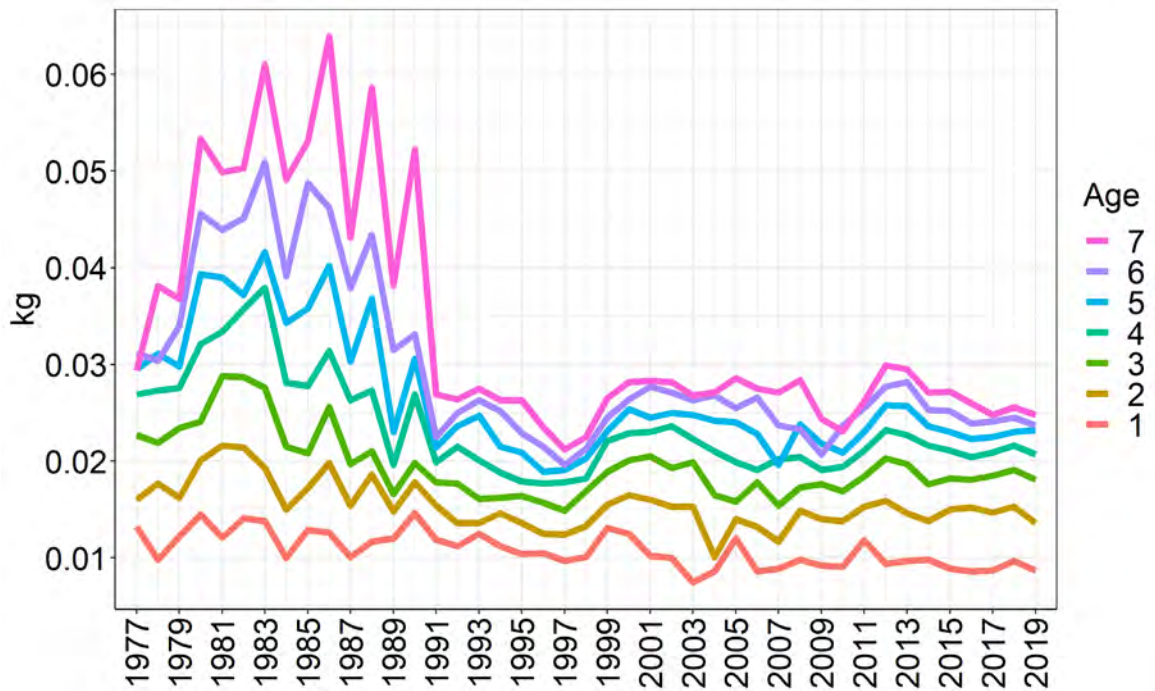


Figure 4.3.4. Gulf of Riga herring. Mean weight at age in the catches.

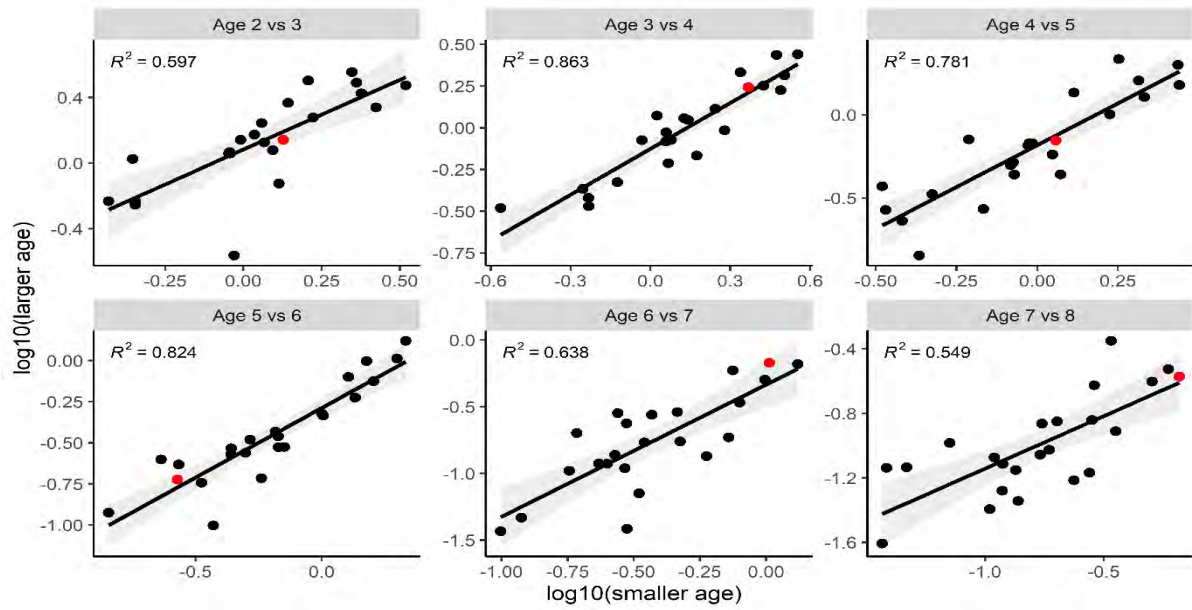


Figure 4.3.5. Gulf of Riga herring. Internal consistency in trap-net tuning fleet. Latest year is shown in red.

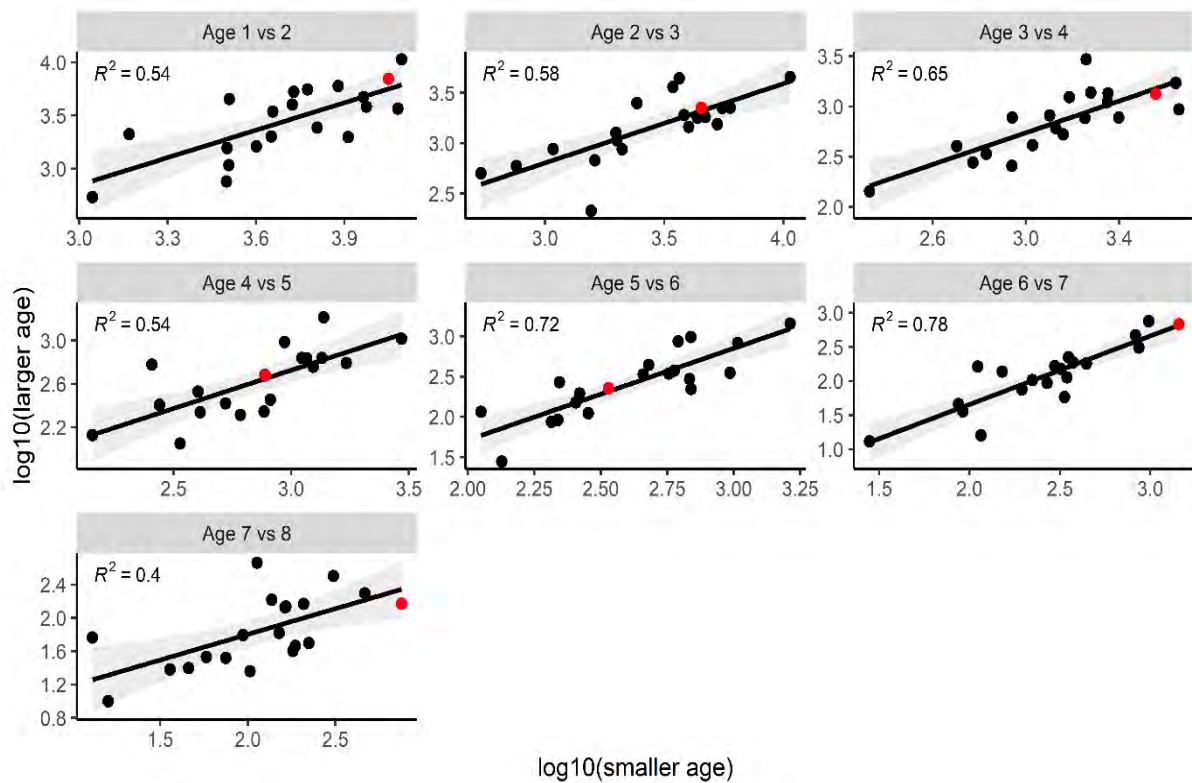


Figure 4.3.6. Gulf of Riga herring. Internal consistency in hydro-acoustics tuning fleet. Latest year is shown in red.

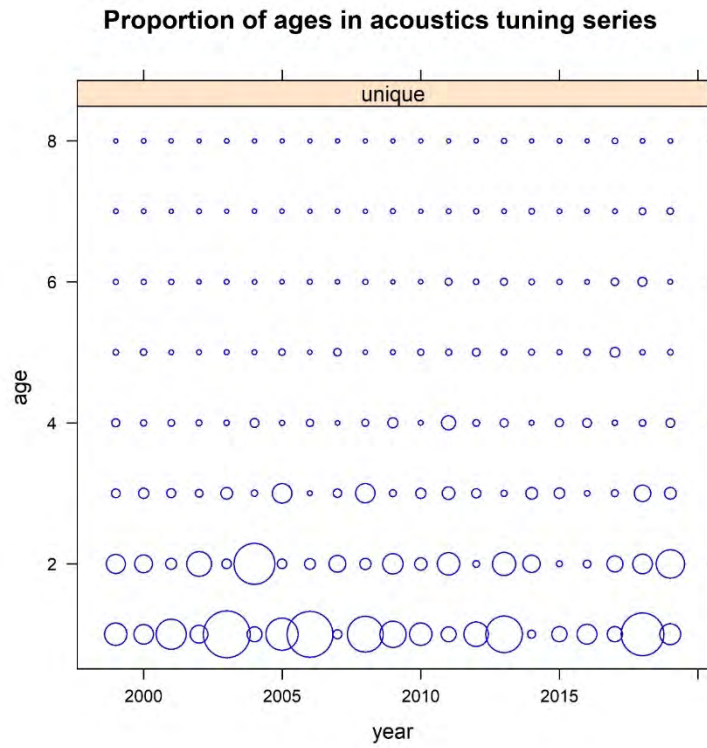


Figure 4.3.7. Gulf of Riga herring. Proportion of ages in hydro-acoustics tuning fleet.

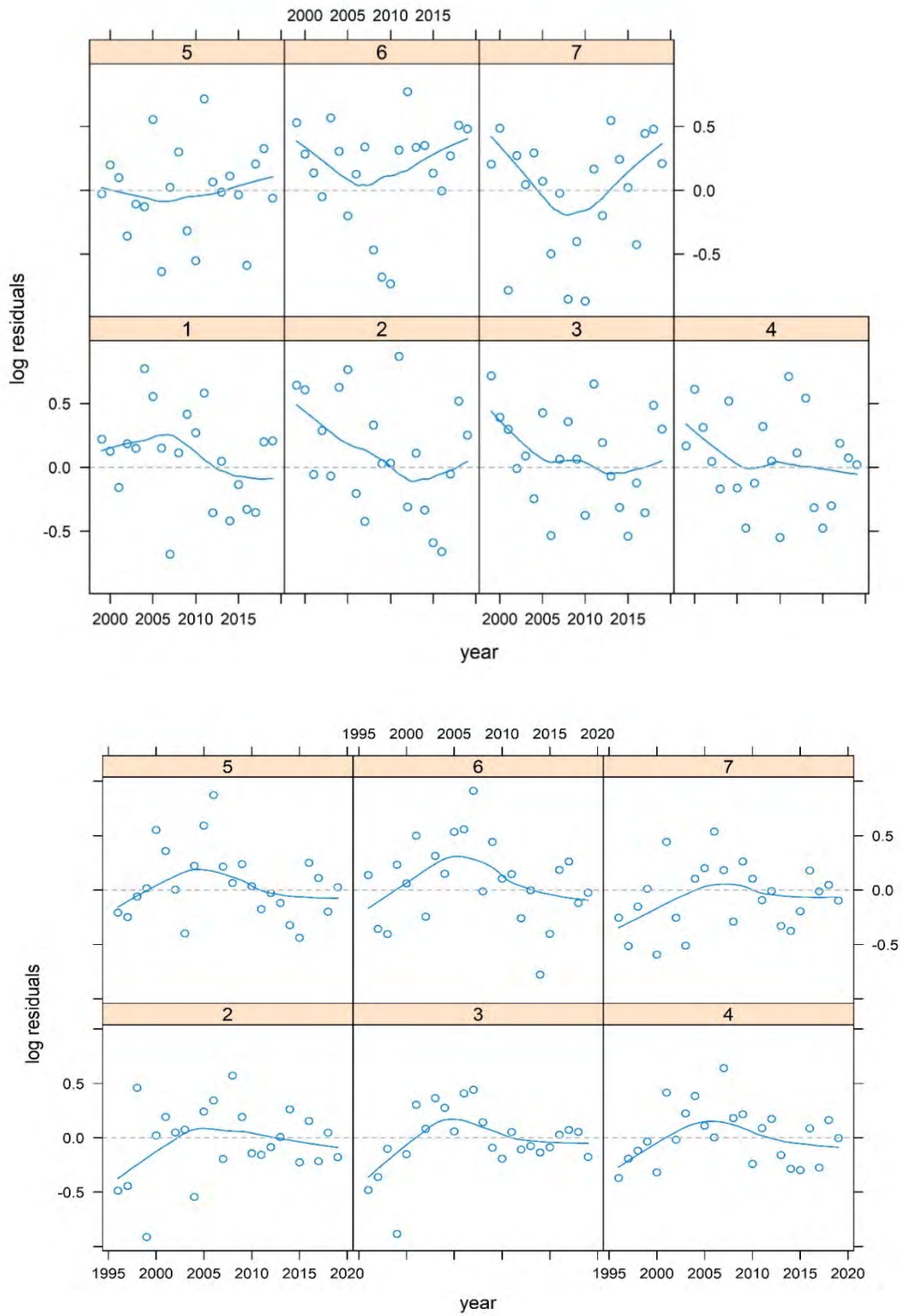


Figure 4.3.8a. Gulf of Riga herring. Log catchability residuals for acoustics survey (top) and trap-nets (bottom).

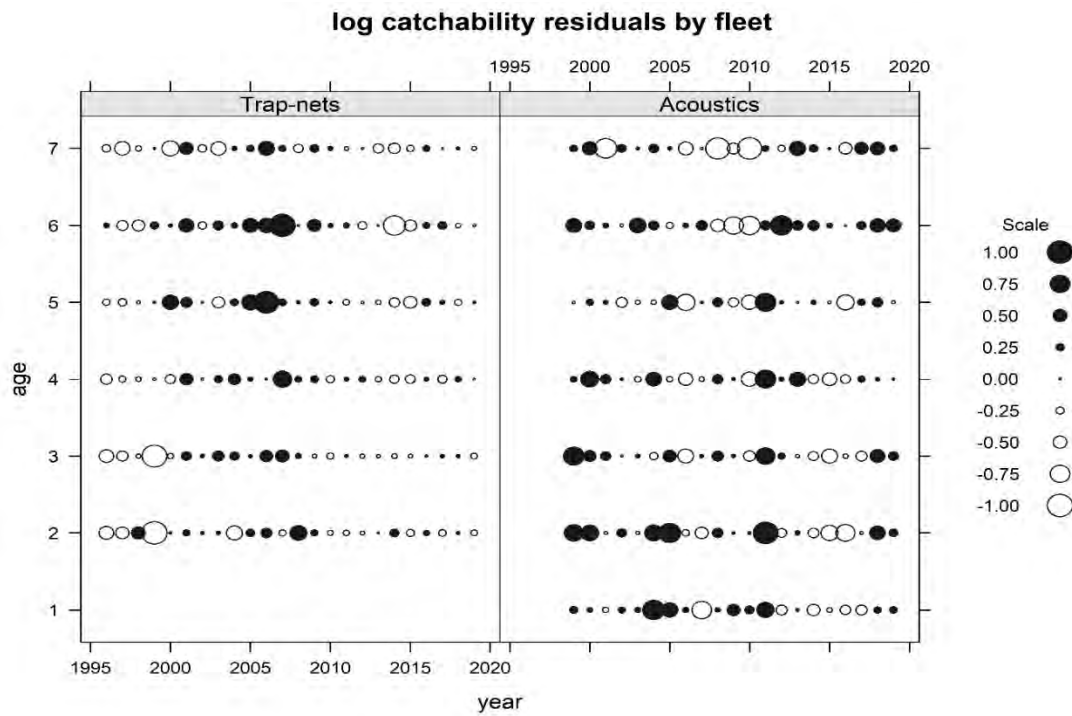


Figure 4.3.8b. Gulf of Riga herring. Log catchability residuals of trap-net fleet (left) and hydro-acoustics fleet (right).

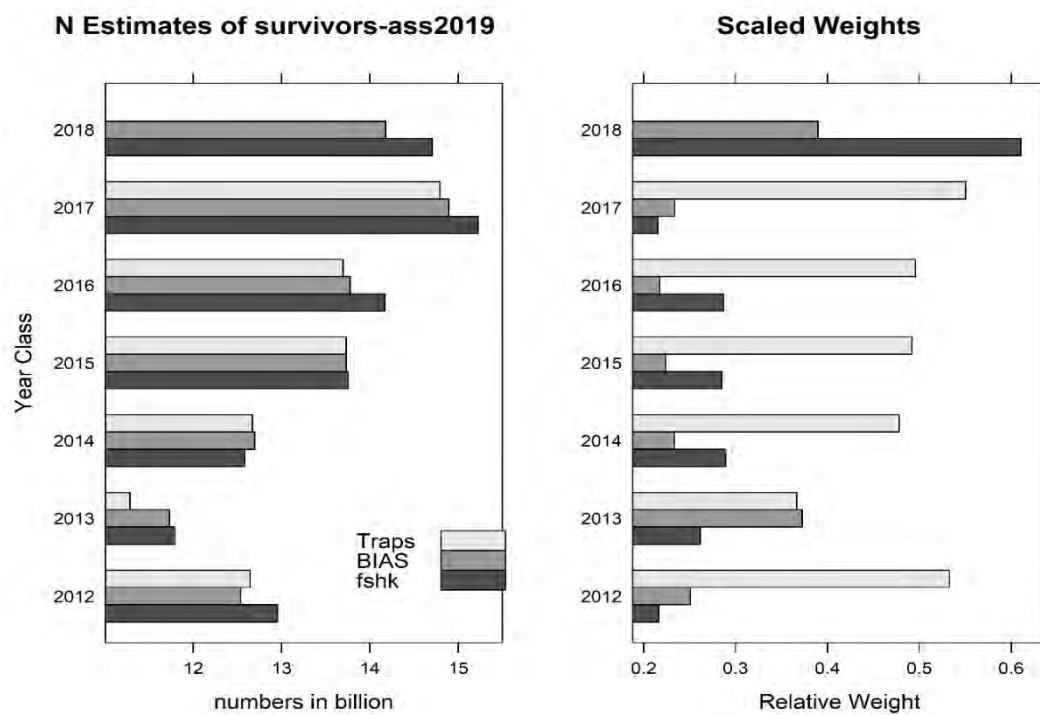


Figure 4.3.9. Gulf of Riga herring. Survivors estimates and scaled weights for both tuning fleets.

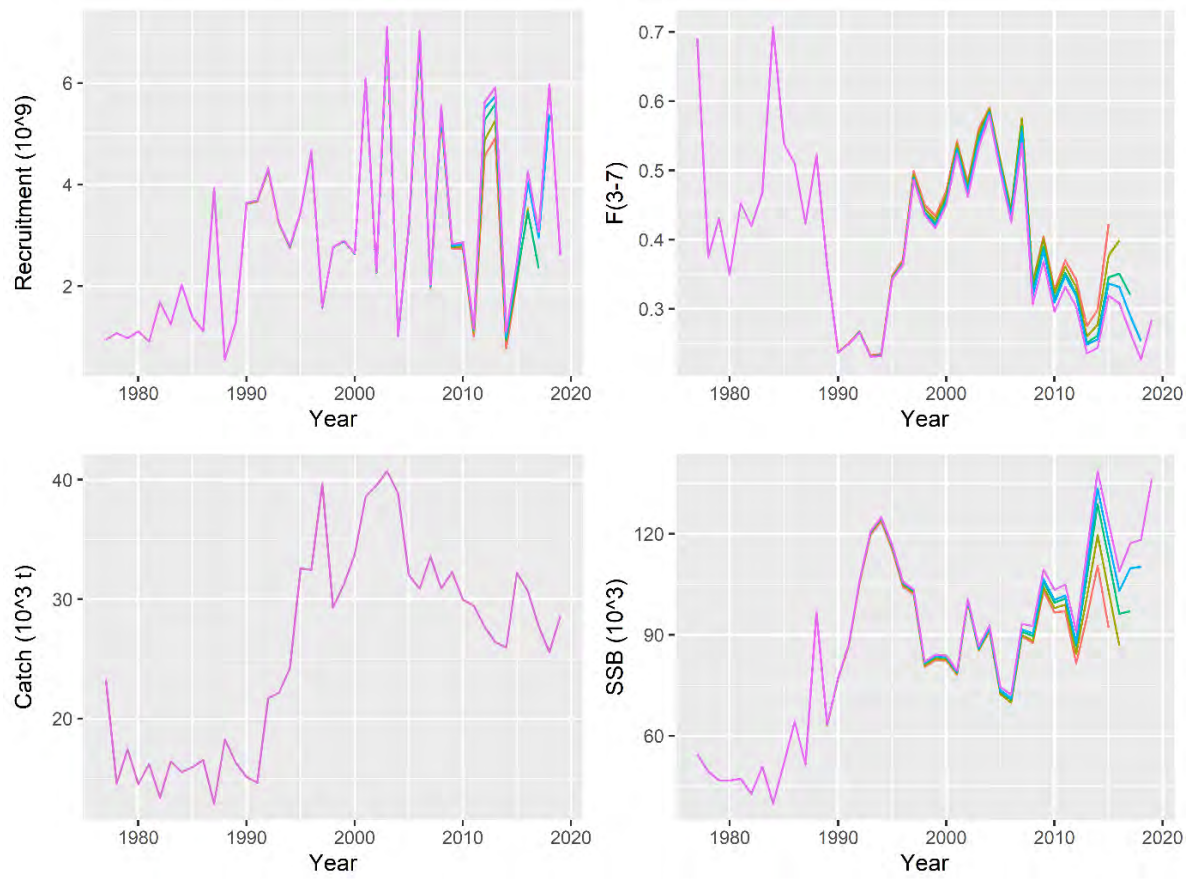


Figure 4.3.10. Gulf of Riga herring. Retrospective analysis (5 years).

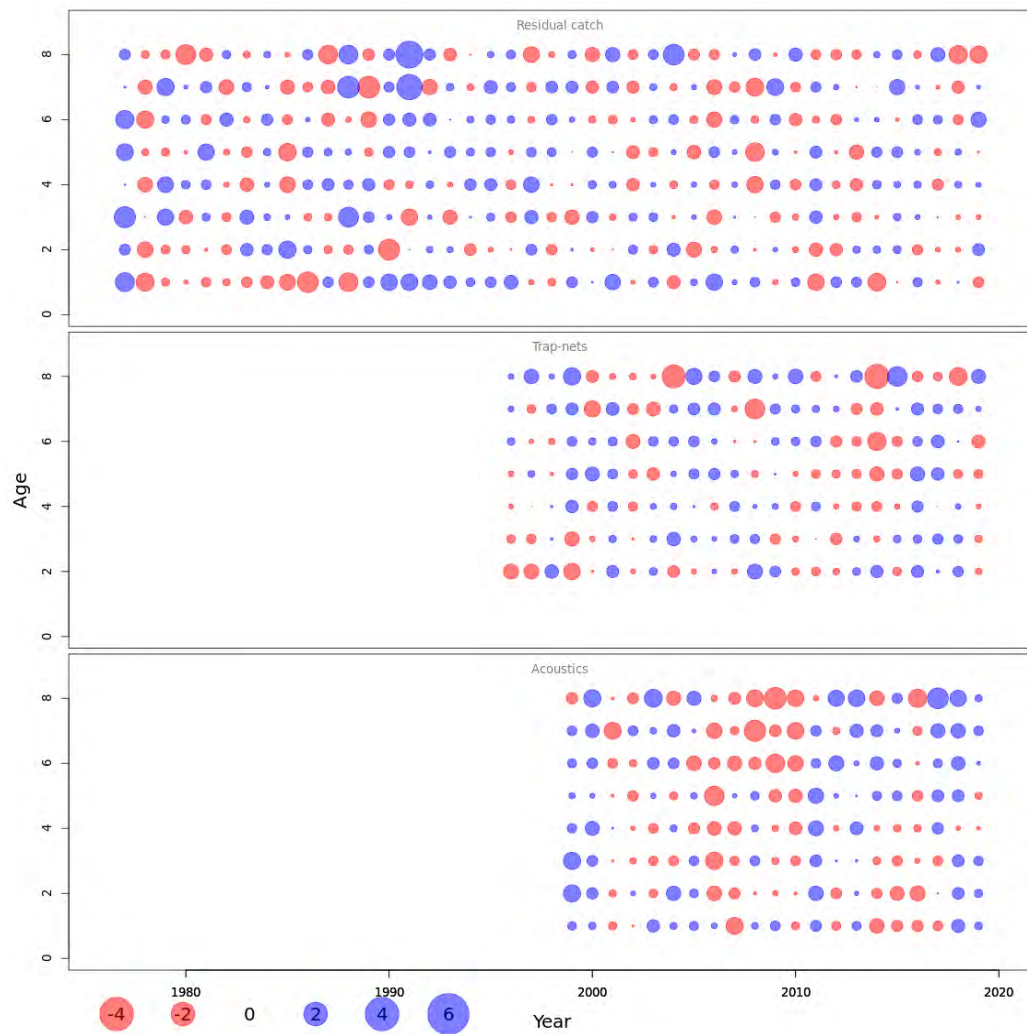


Figure 4.3.11. Gulf of Riga herring. Log catchability residuals from SAM run by fleet and catch.

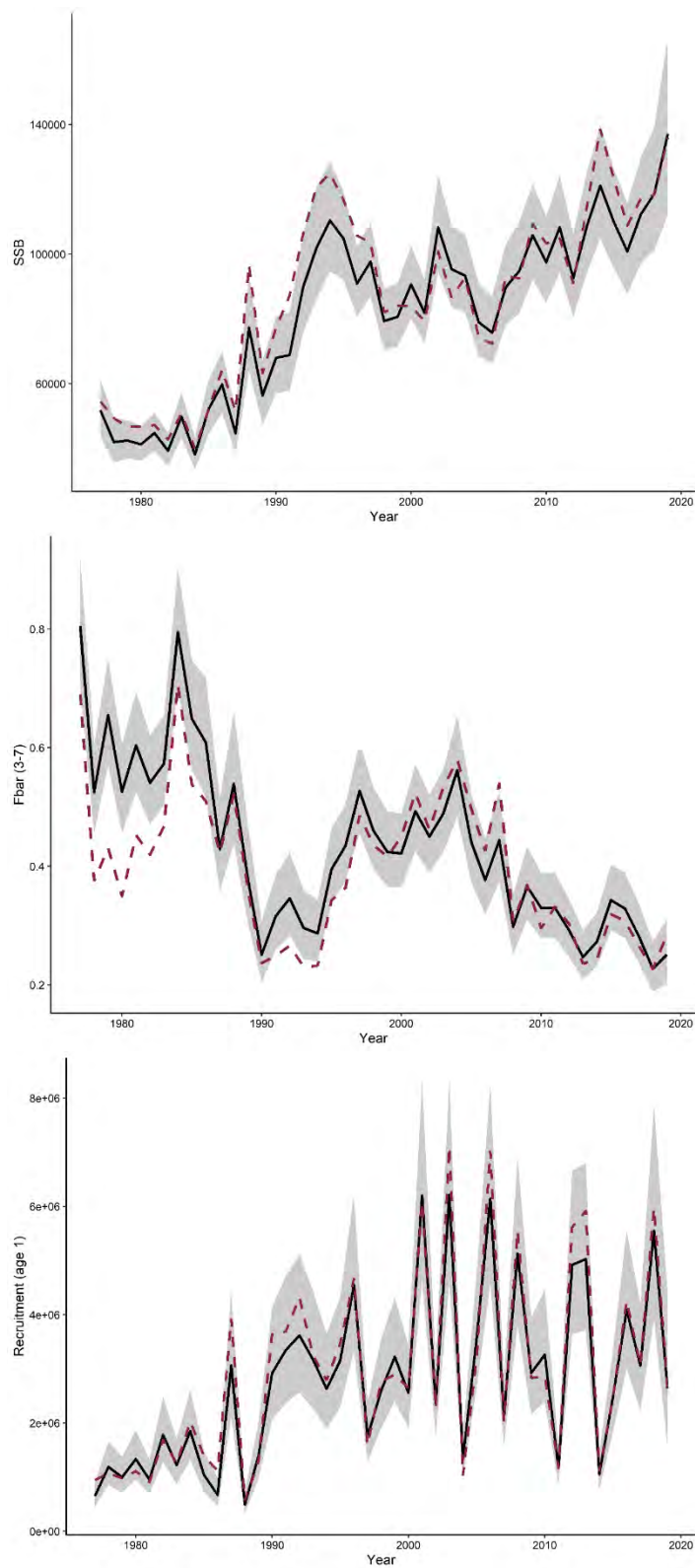
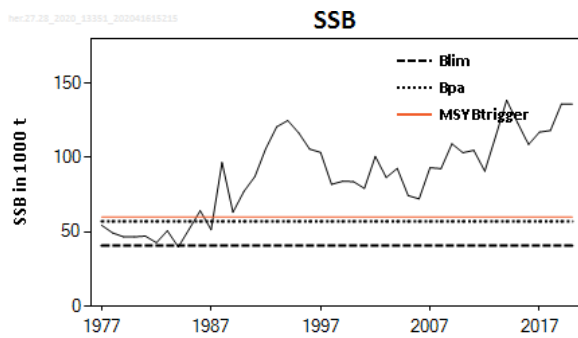
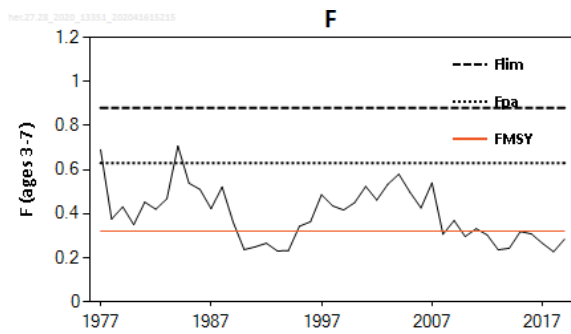
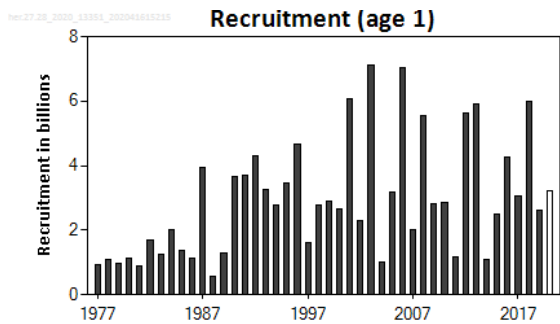
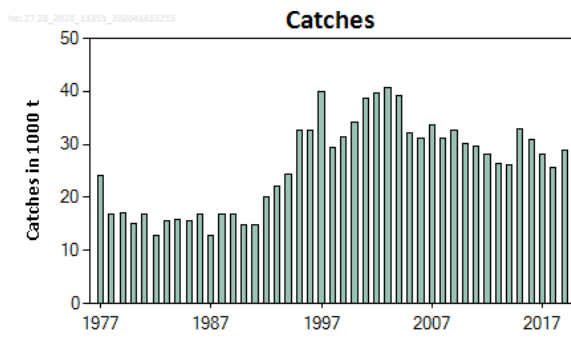


Figure 4.3.12. Gulf of Riga herring. Comparison of spawning stock biomass (SSB in tonnes), fishing mortality (F_{3-7}) and recruitment (age 1 in thousands) from XSA (dashed purple line) and SAM (back, grey shading represents the 95% confidence intervals of the SAM results).



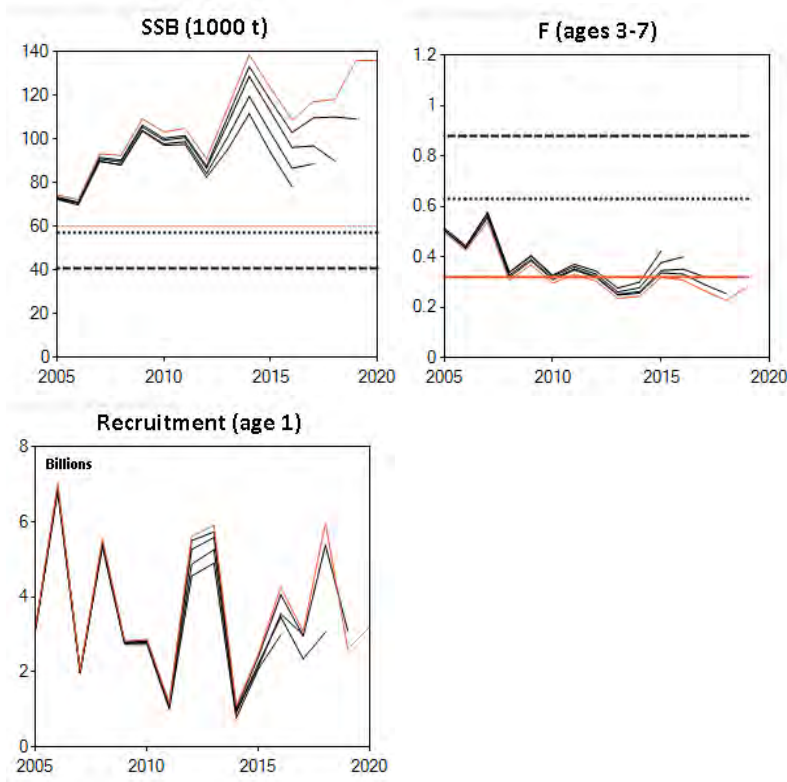


Figure 4.3.13. Gulf of Riga herring. Summary sheet plots: Catches, fishing mortality, recruitment (age 1) and SSB. (Recruitment and SSB in 2020 is predicted). Historical assessment results.

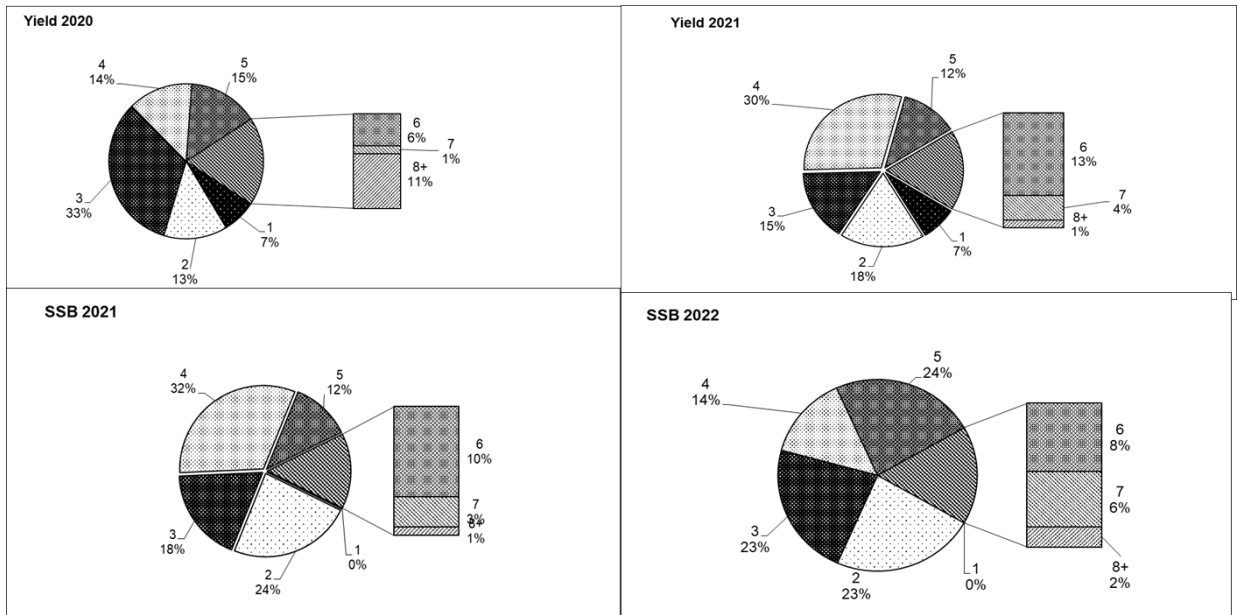


Figure 4.3.14. Gulf of Riga herring. Short term prediction. Age composition of catches and SSB.

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 |

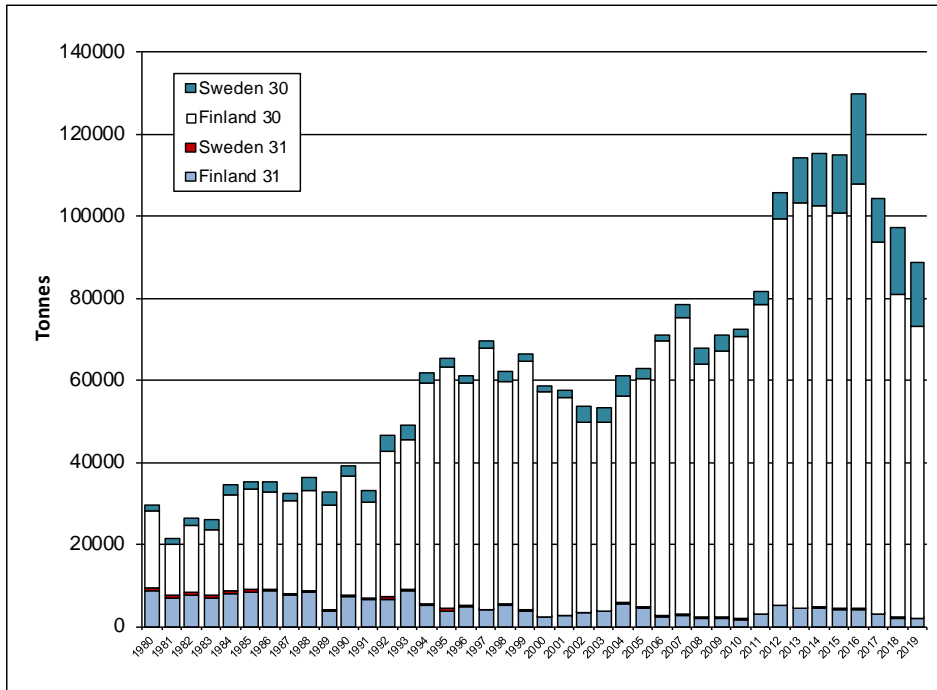


Figure 4.4.1 Herring in SD's 30 and 31. Catches by country

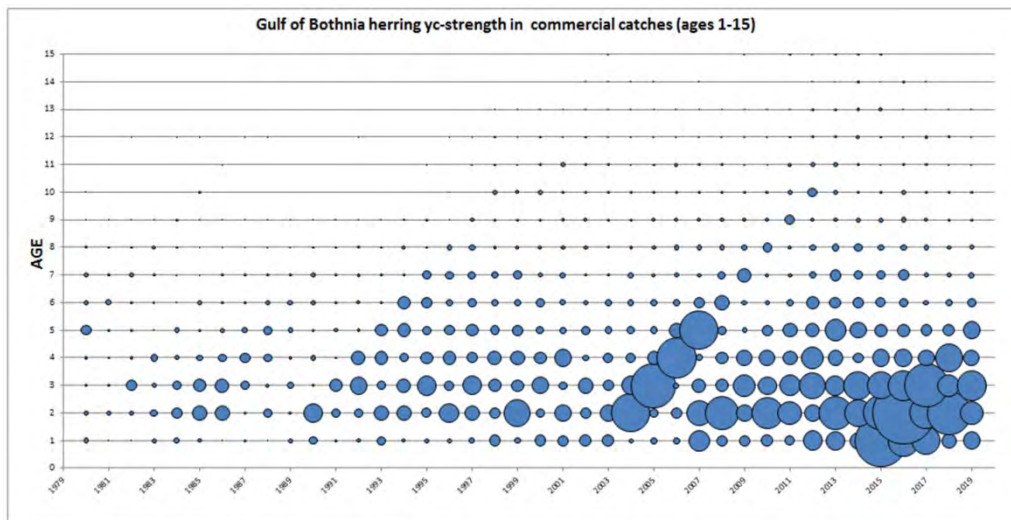


Figure 4.4.2. Herring in SD's 30 and 31 Age composition in commercial catch

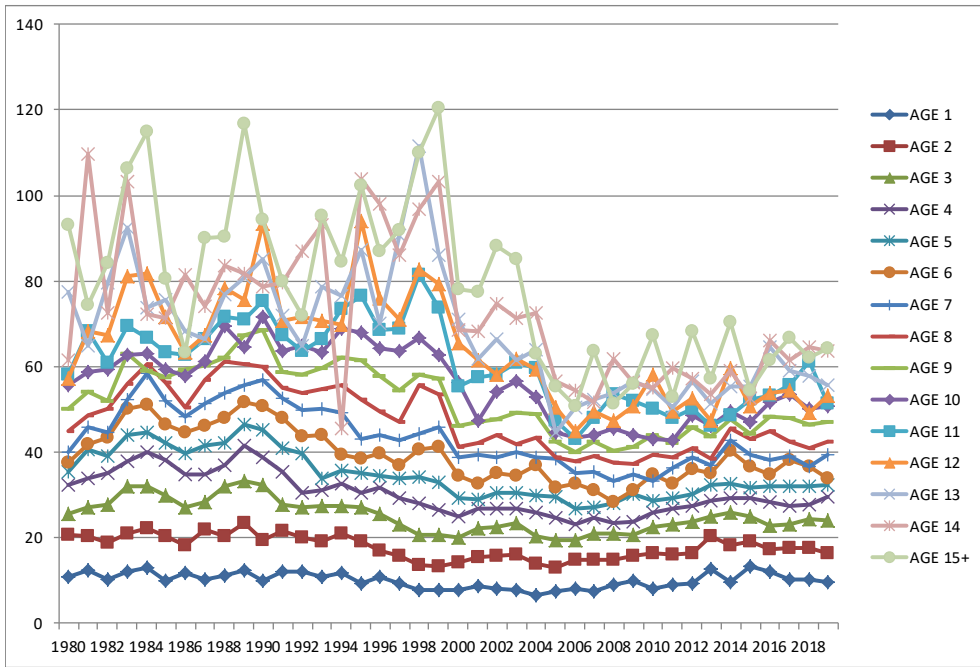


Figure 4.4.3 Herring in SD's 30 and 31 Weights at age in catches

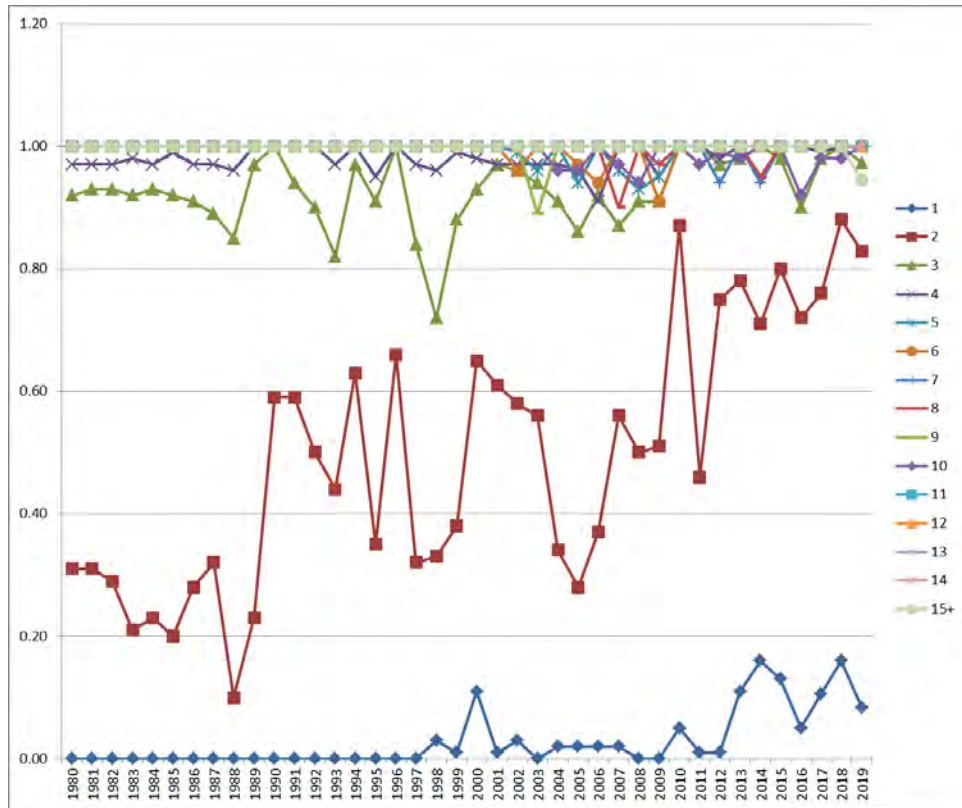


Figure 4.4.4. Herring in SD's 30 and 31. Maturity ogive 1980-2019

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 ≥ 100 mm), 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.

| Year | SD 21 | | | SD 22 | | | SD 23 | | Total |
|------|---------|---------|--------|---------|---------|--------|---------|--------|-------|
| | 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 |

| Year | SD 21 | | | SD 22 | | | SD 23 | | Total |
|------|---------|---------|--------|---------|---------|--------|---------|--------|-------|
| | 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 | $R_{(age1)}$ | Low | High | SSB | Low | High | $F_{bar(3-5)}$ | 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. |
| | $F_{\text{p}}=0.5$ | 0.68 | Without advice rule |
| Precautionary approach | B_{lim} | 3 635 | B_{loss} (lowest observed biomass=Biomass in 2009) |
| | B_{pa} | 4 730 | $B_{\text{lim}} \times e^{1.645\sigma}$, $\sigma = 0.16$ |
| | F_{lim} | 1.00 | Equilibrium scenarios $\text{prob}(\text{SSB} < B_{\text{lim}}) < 50\%$ with stochastic recruitment. |
| | F_{pa} | 0.74 | $F_{\text{lim}} \times e^{-1.645\sigma(F)}$, $\sigma_F = 0.18$ |

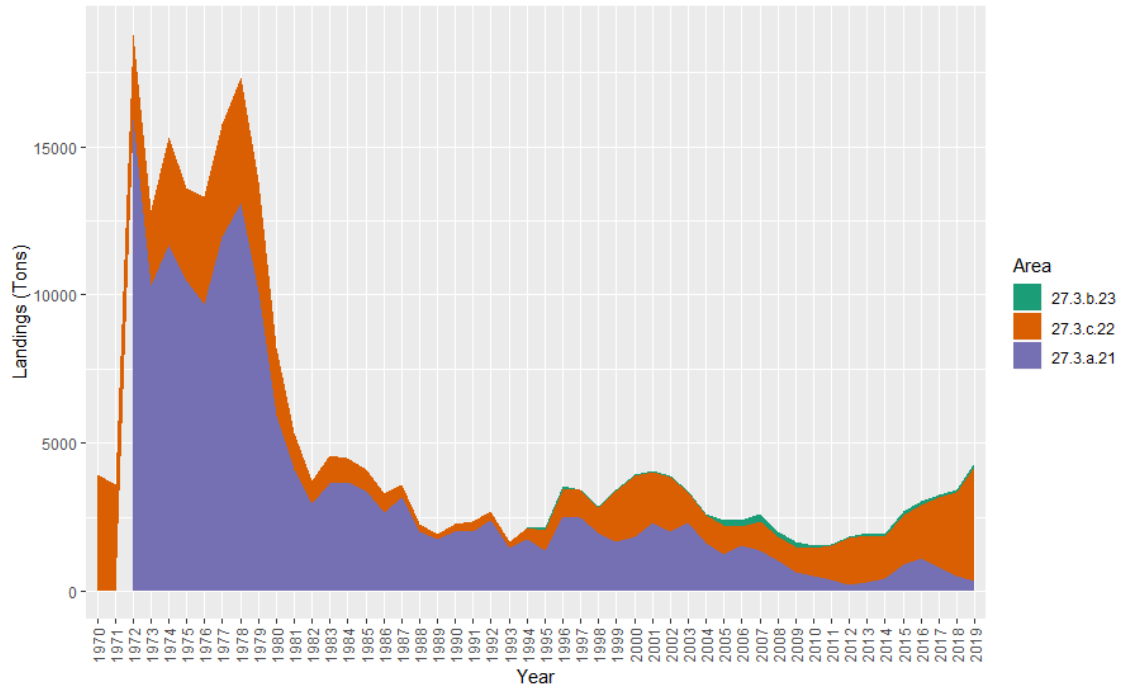


Figure 5.2.1. Plaice in SD 27.21–23. Landings by subdivision by year.

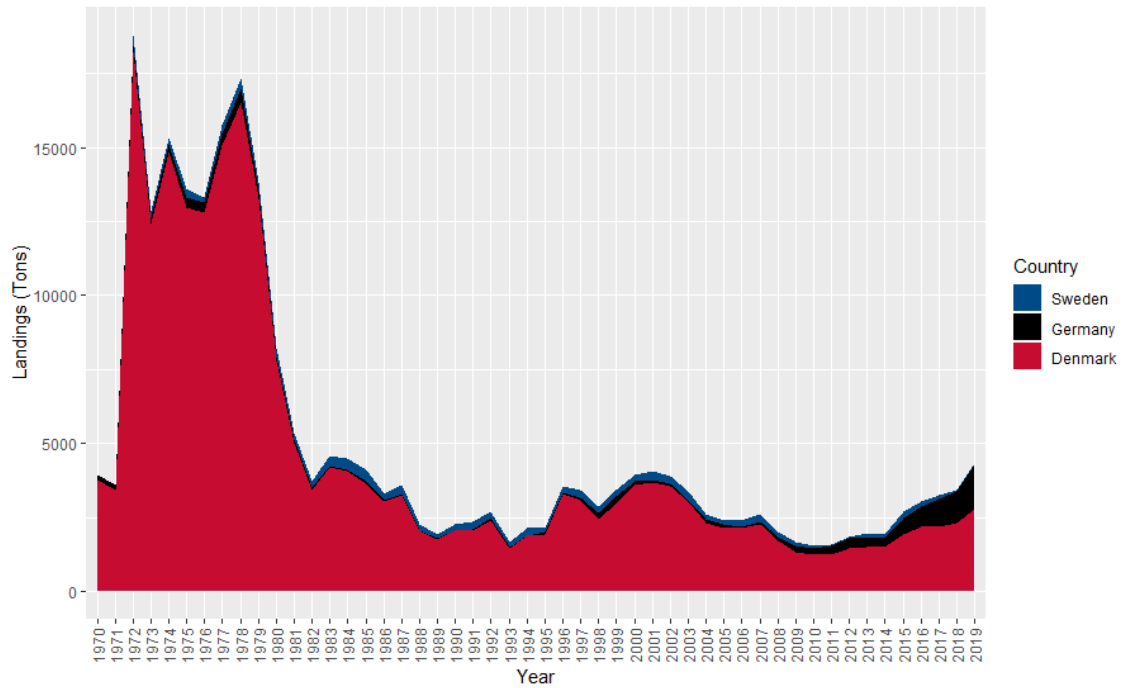


Figure 5.2.2. Plaice in SD 27.21–23. Landings (t) by country by year.

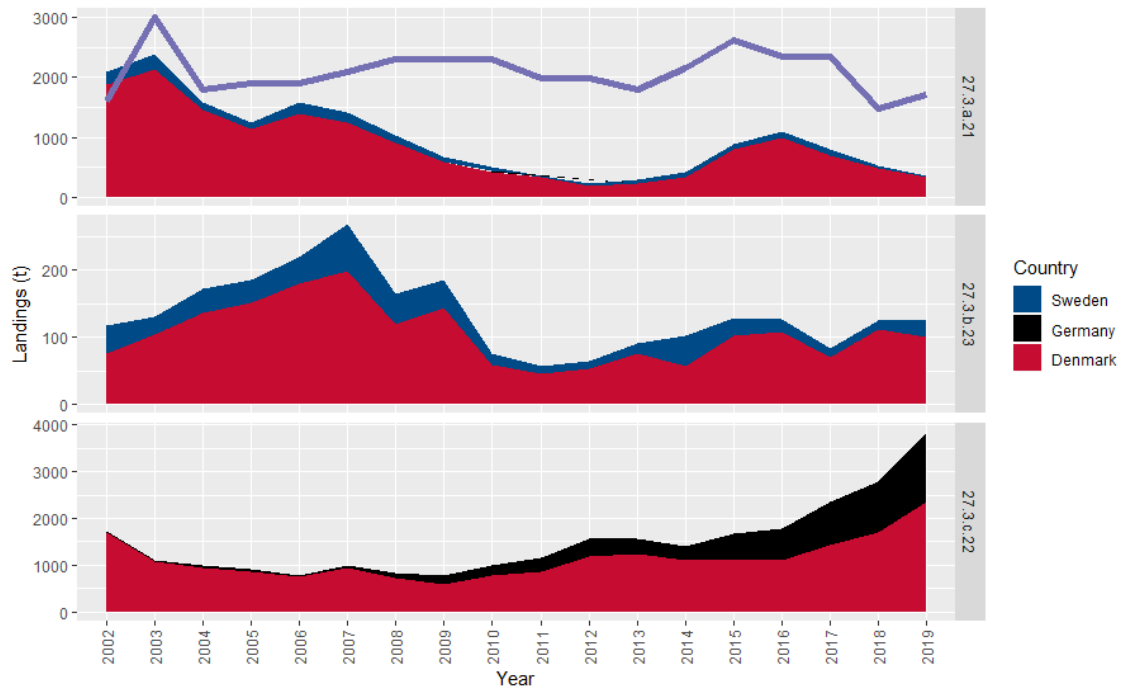


Figure 5.2.3. Plaice in SD 27.21–23. Landings (t) by country by year across areas. Advised TAC for SD 21 is the purple line.

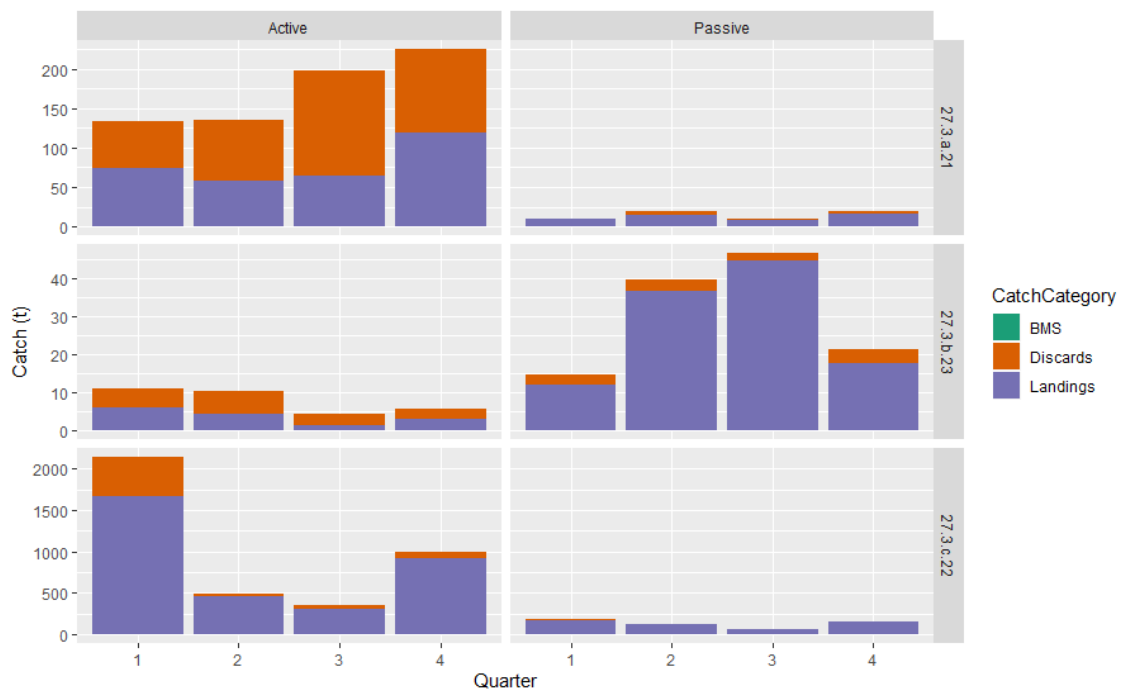


Figure 5.2.4a. Plaice in SD 27.21–23. Catches (t) in 2019 by gear type, area, quarter and catch category. Note varying y-axis values by area.

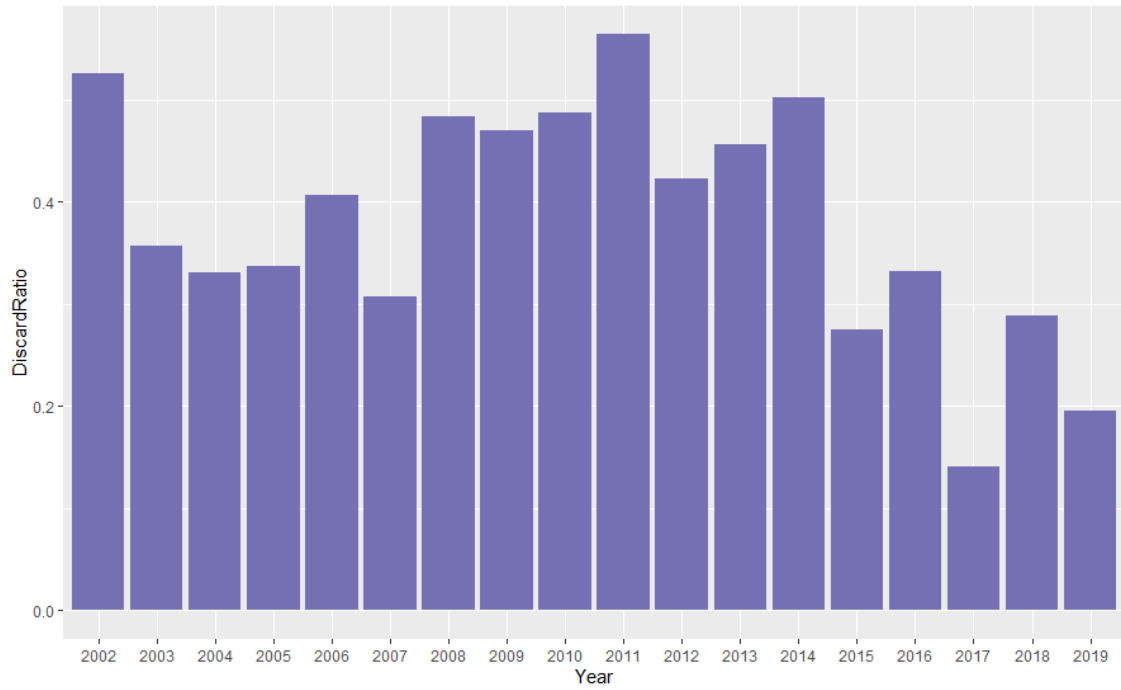


Figure 5.2.4b. Plaice in SD 27.21–23. Discard ratio over time.

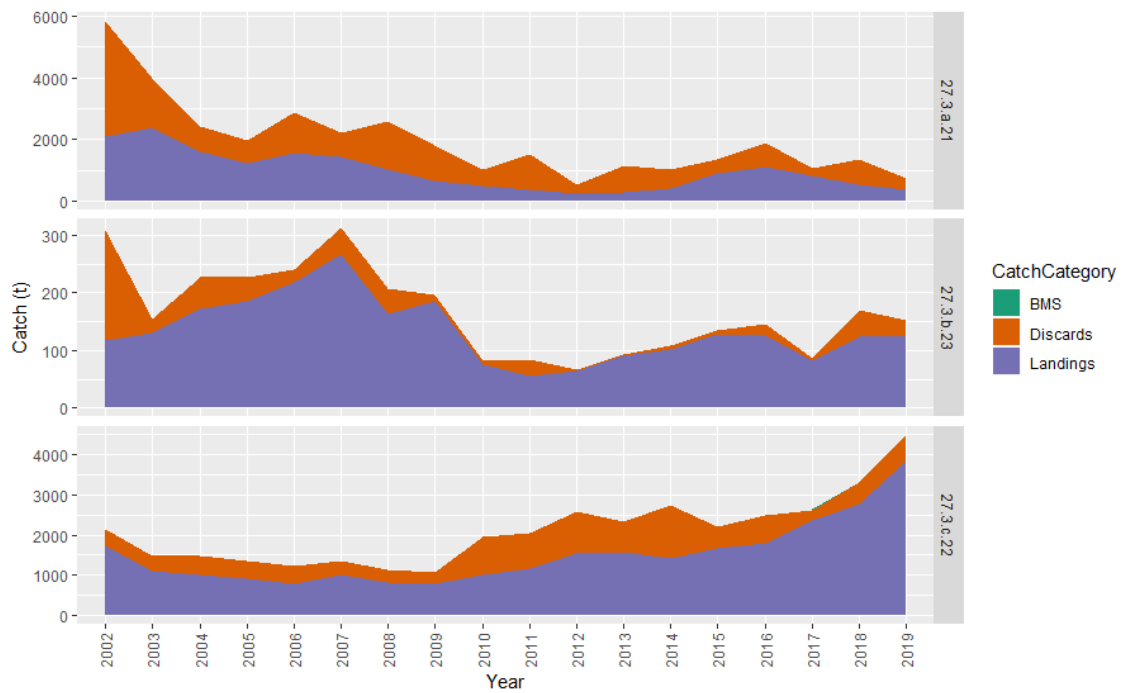


Figure 5.2.4c. Plaice in SD 27.21–23. Catch components over time by Subdivision. Note varying y-axes by subdivision.

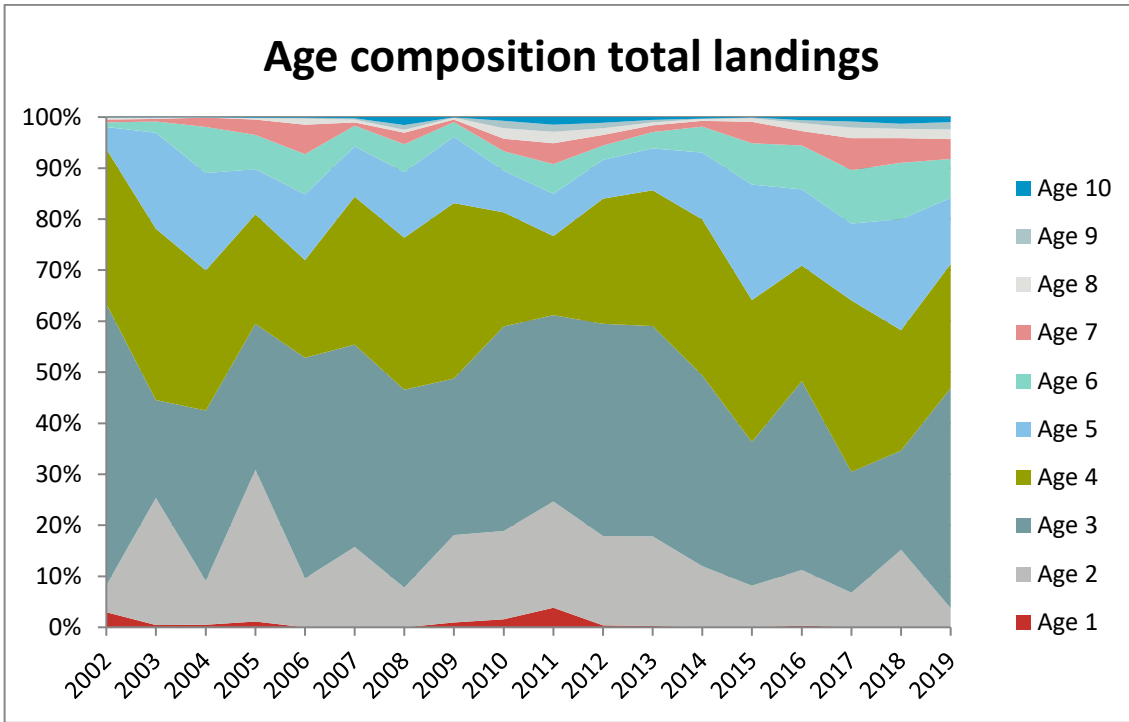


Figure 5.2.5a. Plaice in SD 27.21–23. Age composition for landings from 2002 to 2019.

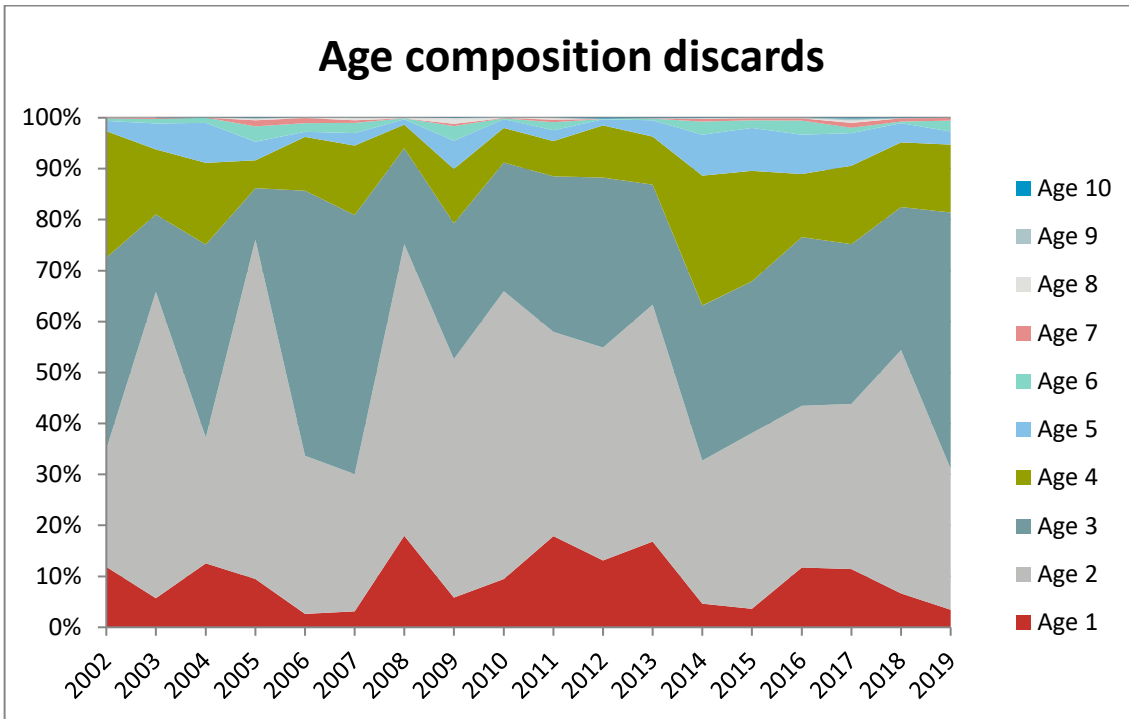


Figure 5.2.5b. Plaice in SD 27.21–23. Age composition for discards from 2002 to 2019.

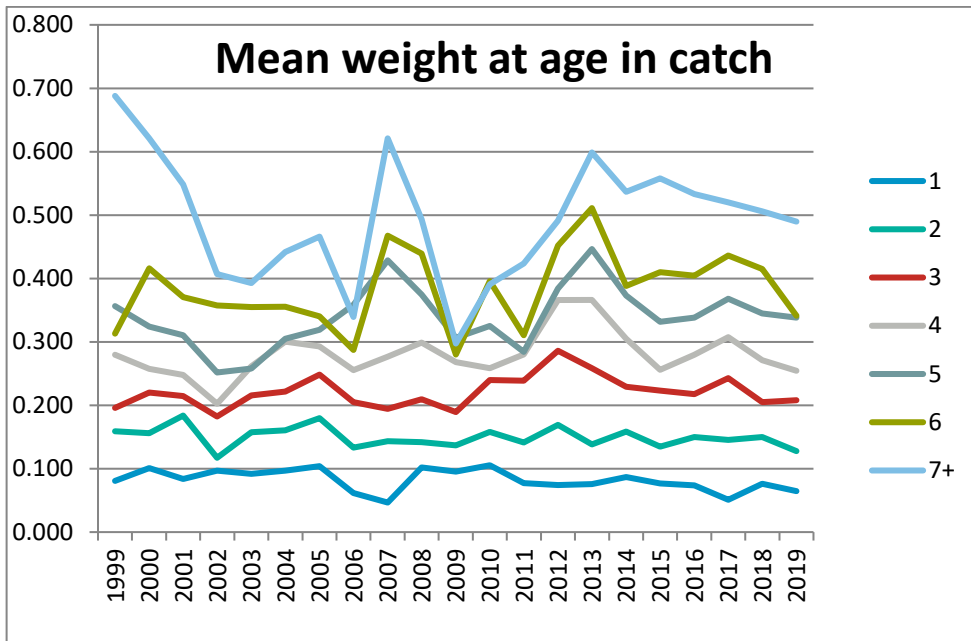


Figure 5.2.6. Plaice in SD 27.21–23. Mean weight (kg) at-age in catch.

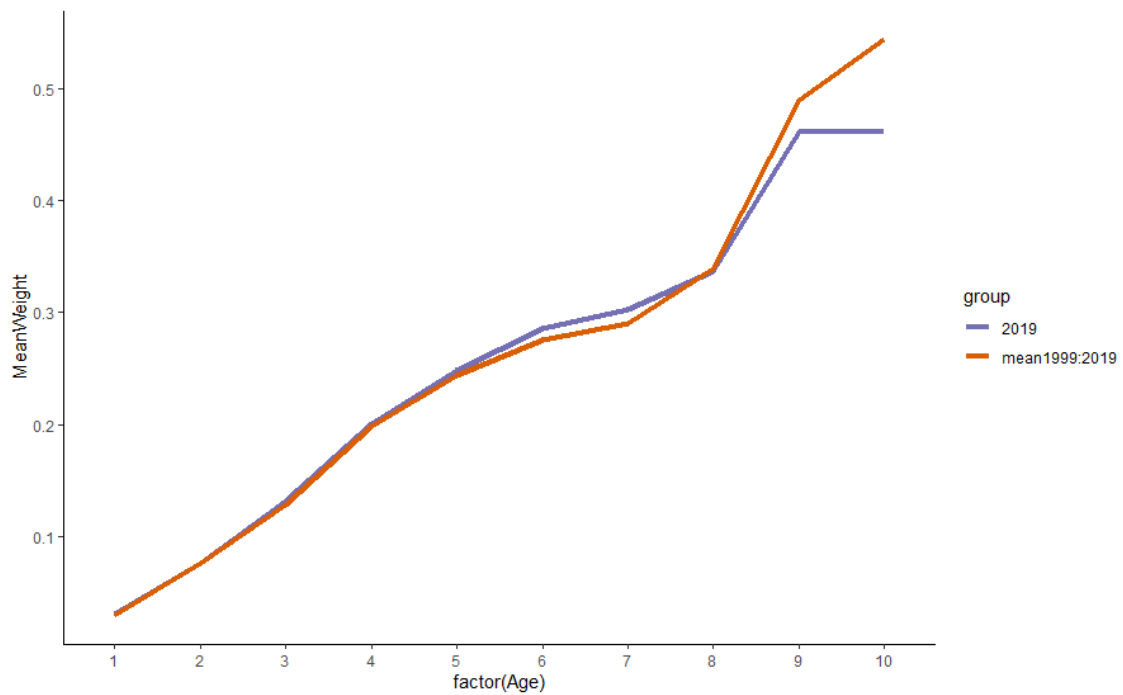


Figure 5.2.7. Plaice in SD 27.21–23. Mean weight (kg) at-age in stock.

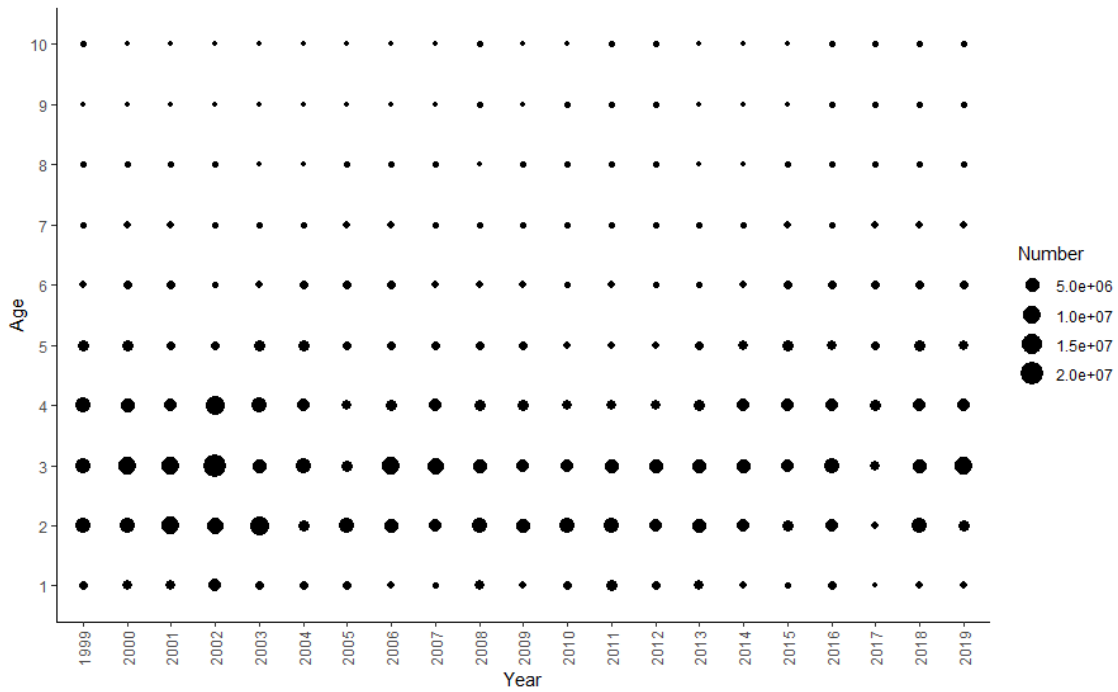


Figure 5.2.8. Plaice in SD 27.21–23. Cohort tracking of the catch-at-age matrix.

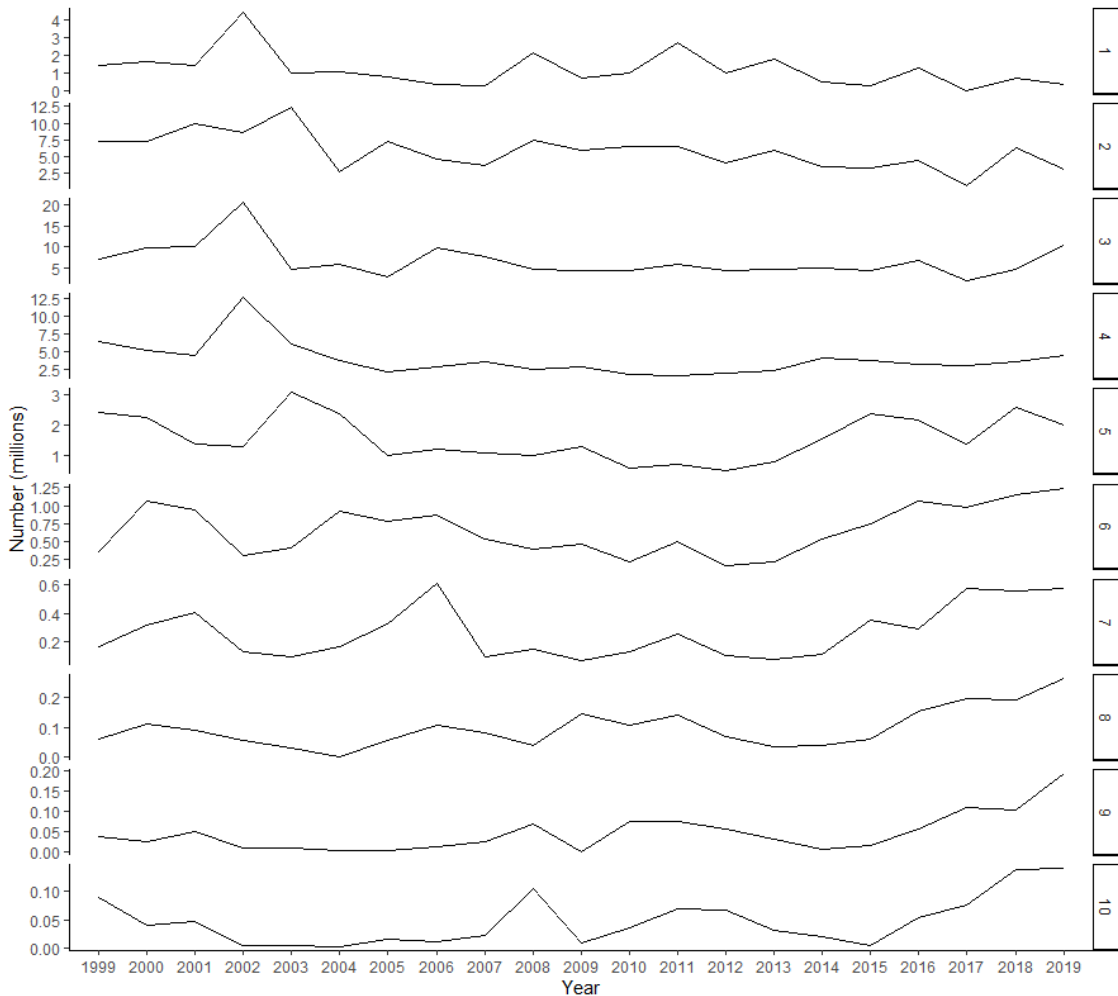


Figure 5.2.9. Plaice in SD 27.21–23. Catch-at-age 1999-2019.

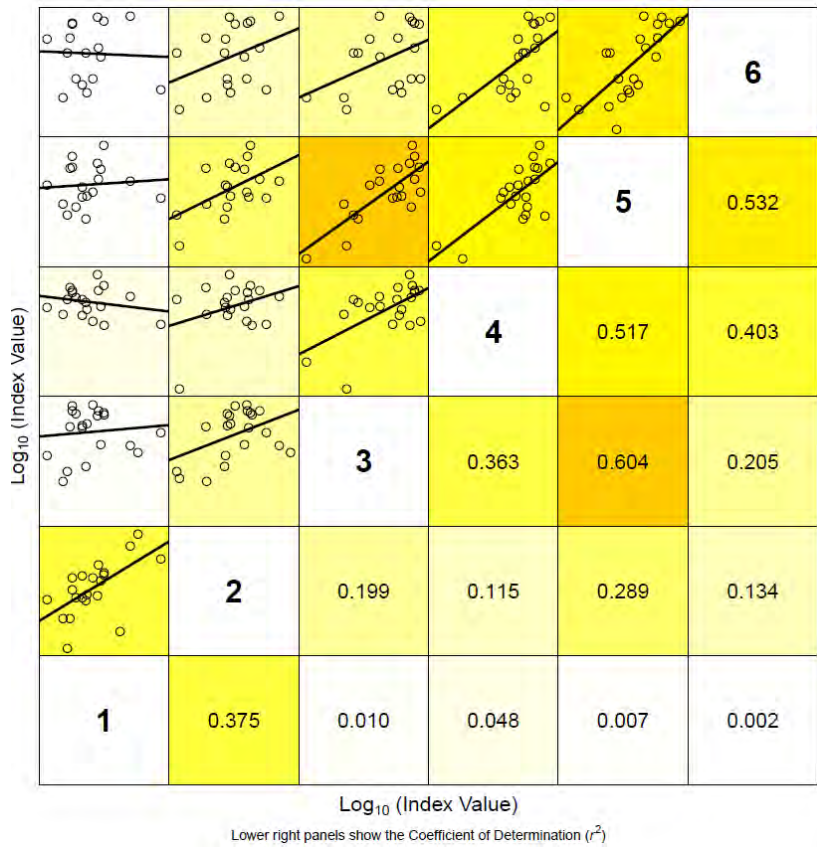
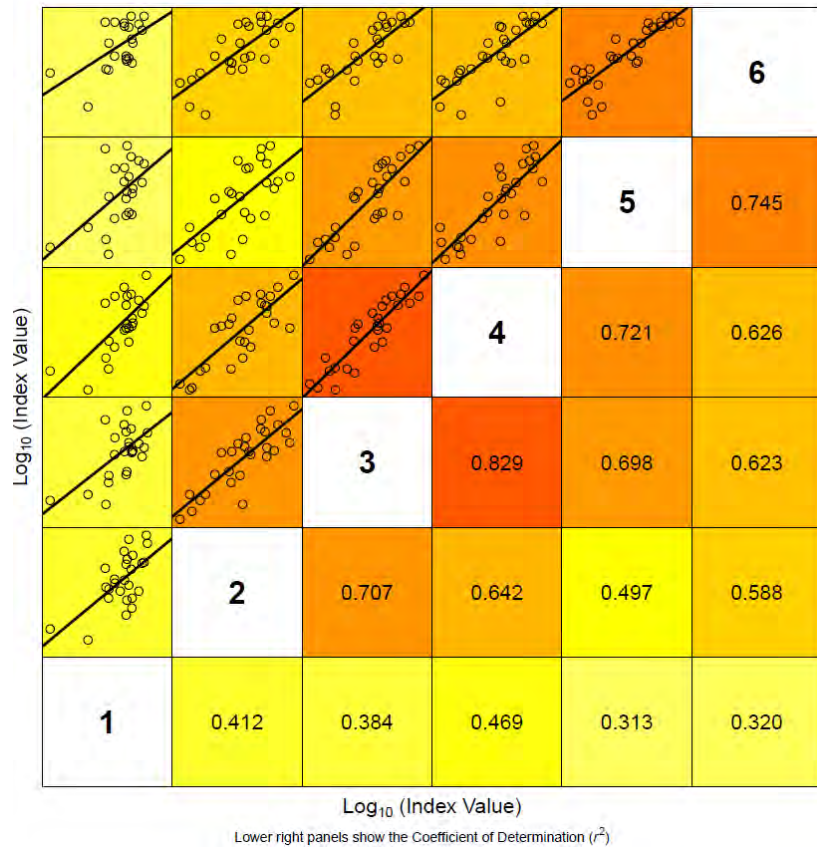


Figure 5.2.10. Plaice in SD 27.21–23. Internal consistency of the two survey indices. Top: Q1 survey. Bottom: Q3-4 survey.

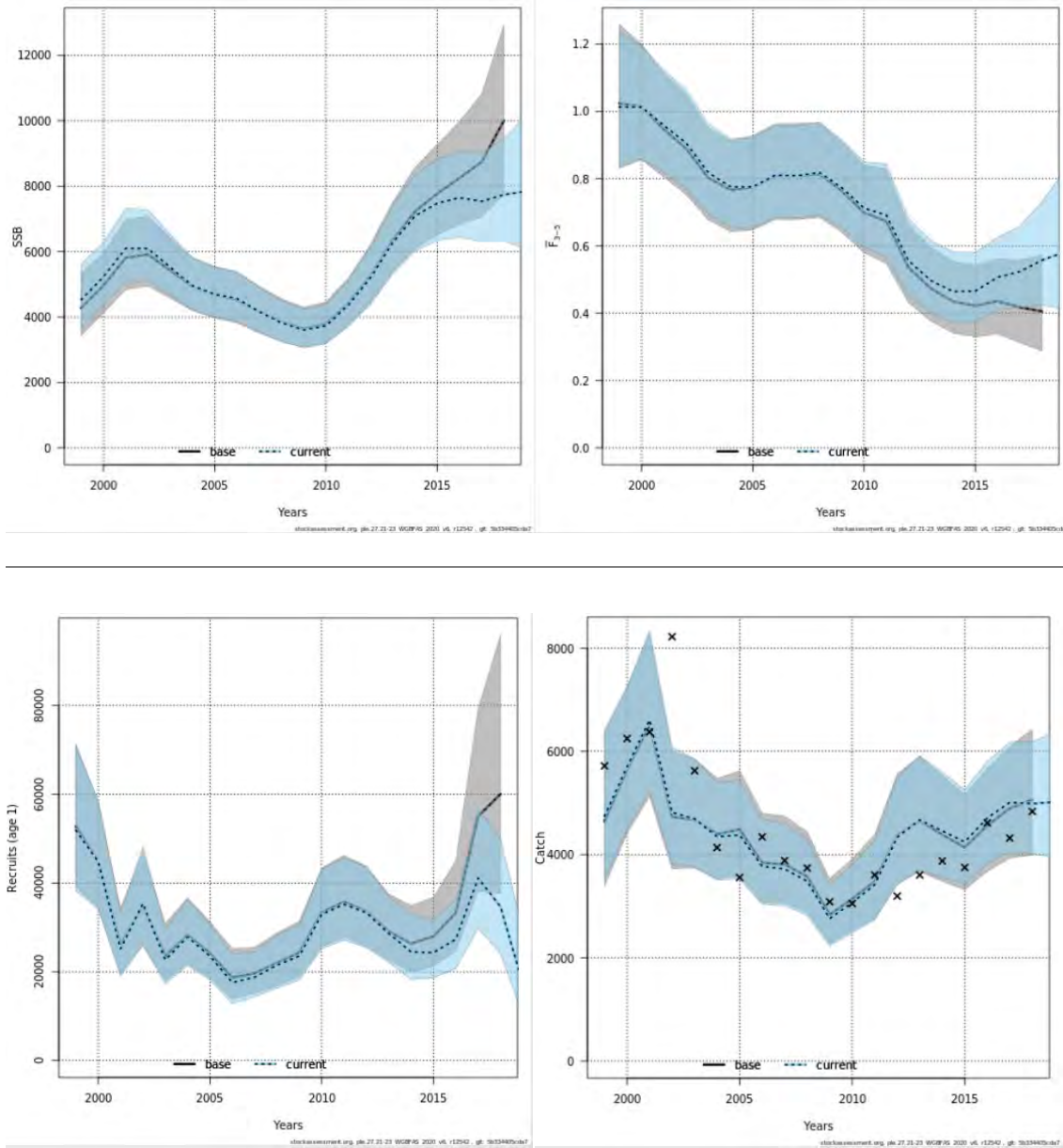


Figure 5.2.11. Plaiice in SD 27.21–23. SPALY SAM run (in blue) in comparison with the 2019 assessment (in grey).

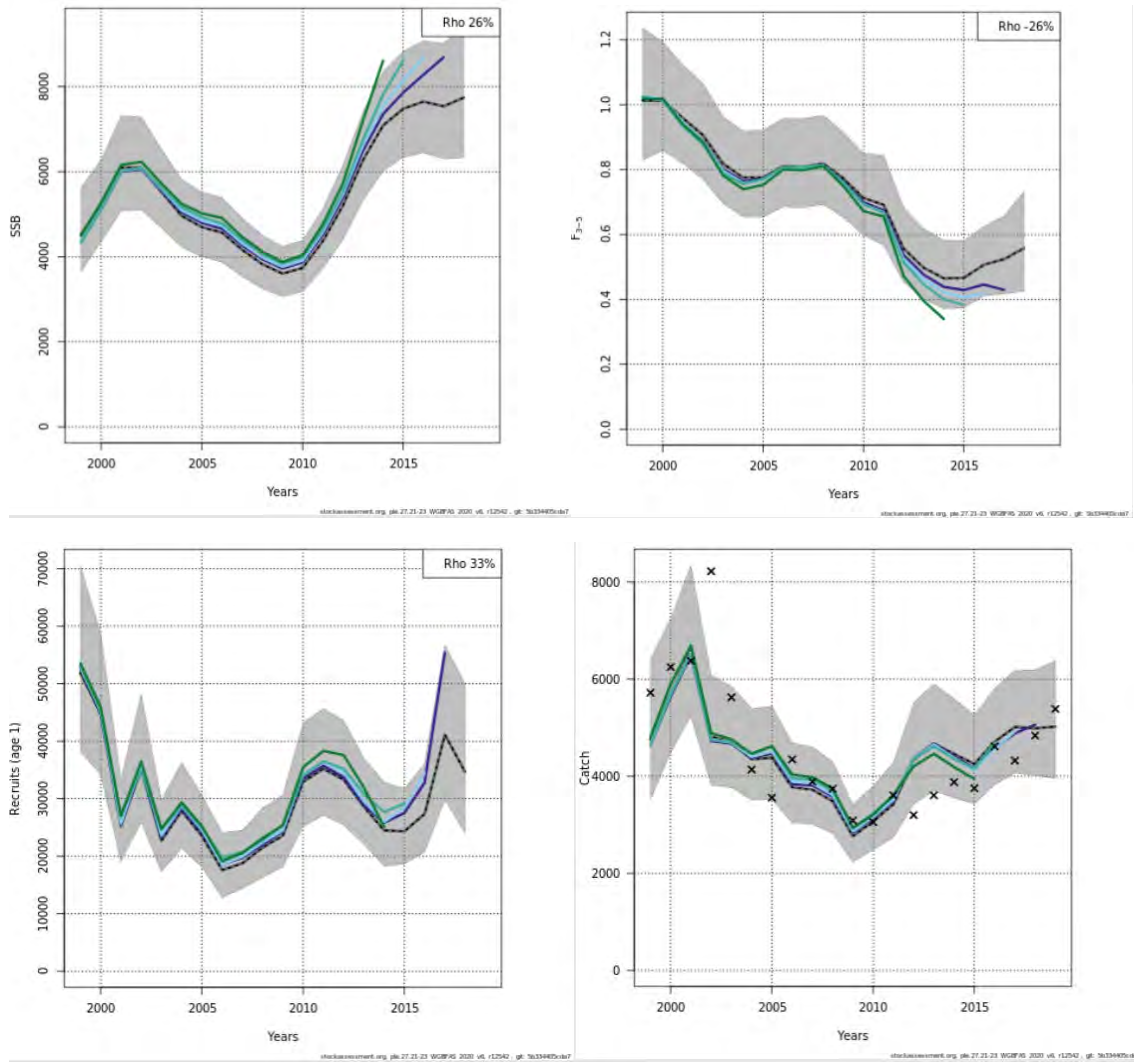
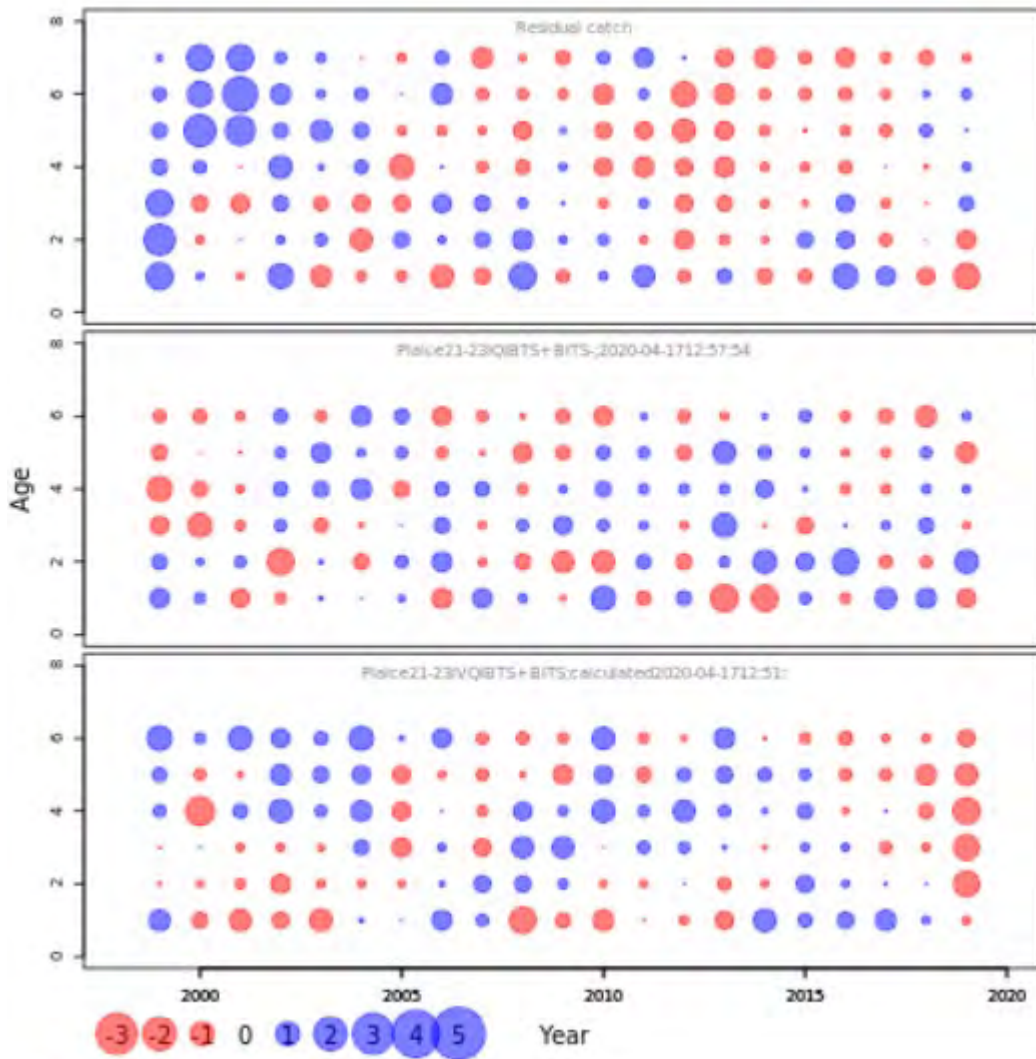


Figure 5.2.12. Plaiice in SD 27.21–23. SPALY SAM run. Retrospective pattern.



Standardized one-observation-ahead residuals.

Figure 5.2.13. Plaiice 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.

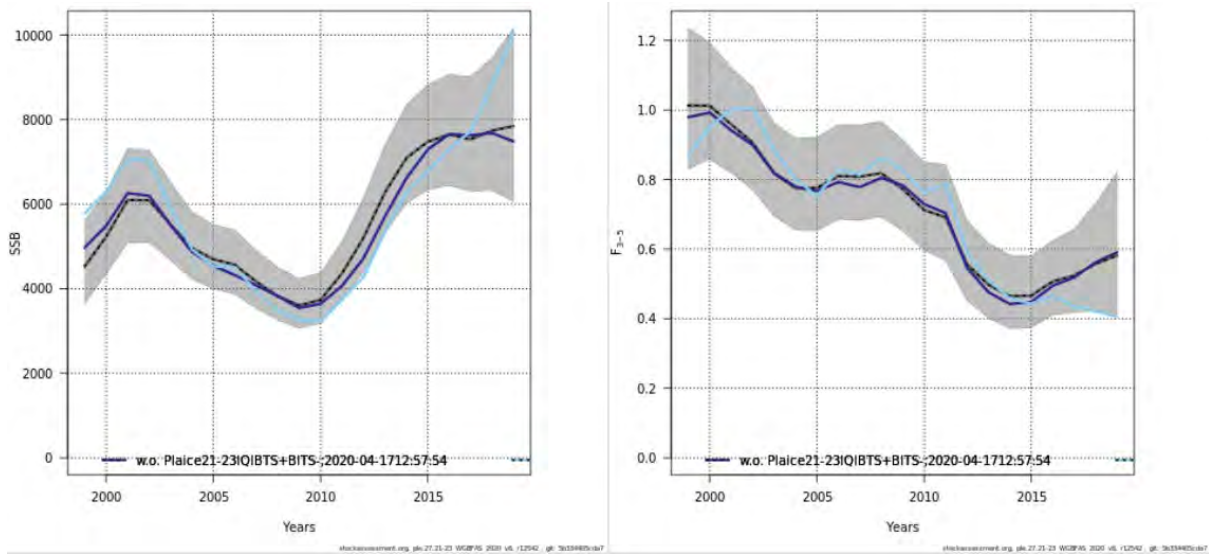


Figure 5.2.14. Plaice in SD 27.21–23. SPALY SAM run. Leave-one-out analysis of surveys in SSB (left) and F (right) with the full model (black), without the Q1 combined indices (dark blue), and without the Q3/4 combined indices (light blue).

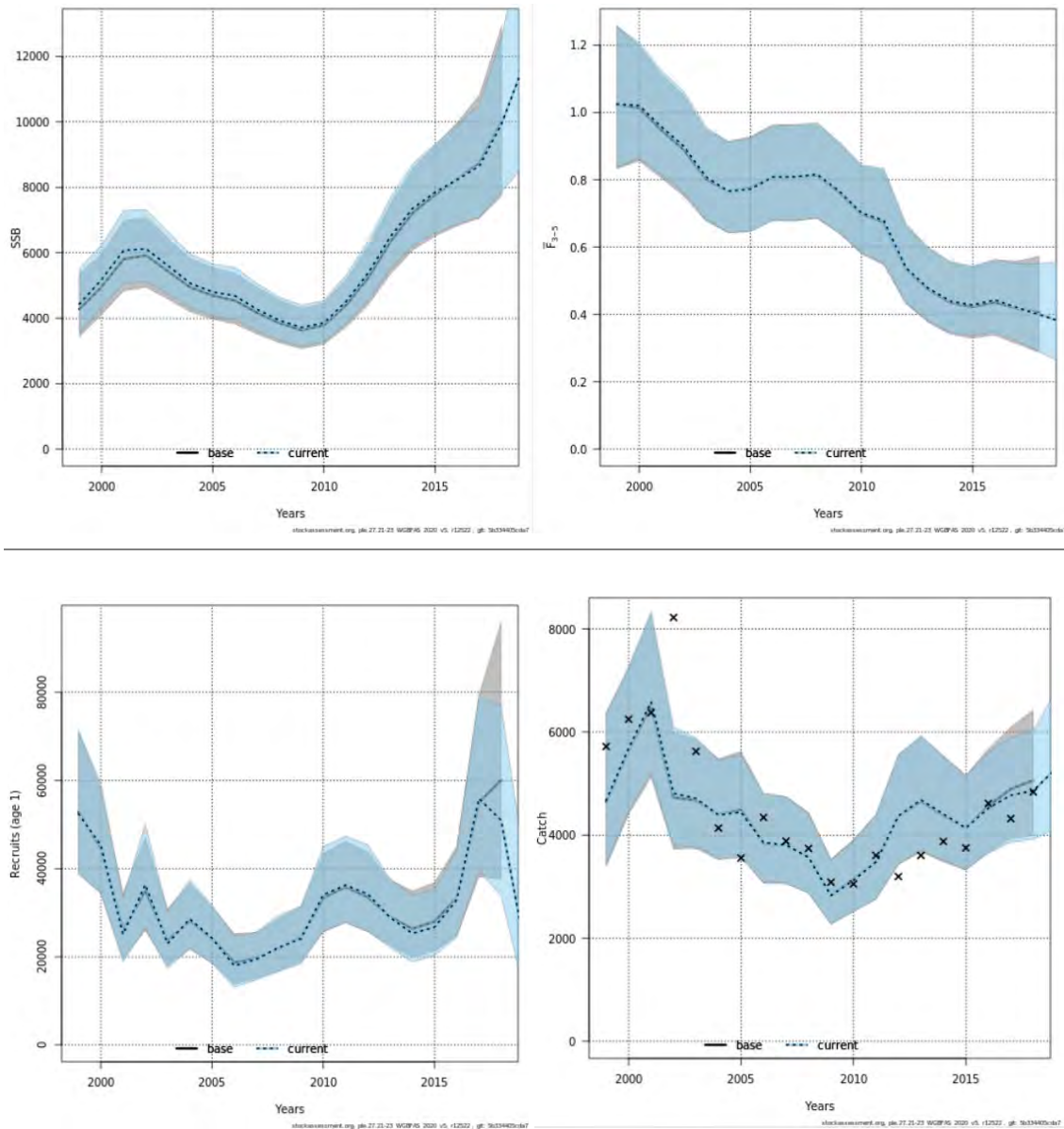


Figure 5.2.15. Plaice in SD 27.21–23. Secondary SAM run (without Q3-Q4 survey indices). Grey lines and ribbons are the 2019 assessment and the dashed lines and blue ribbons are the secondary SAM run from 2020.

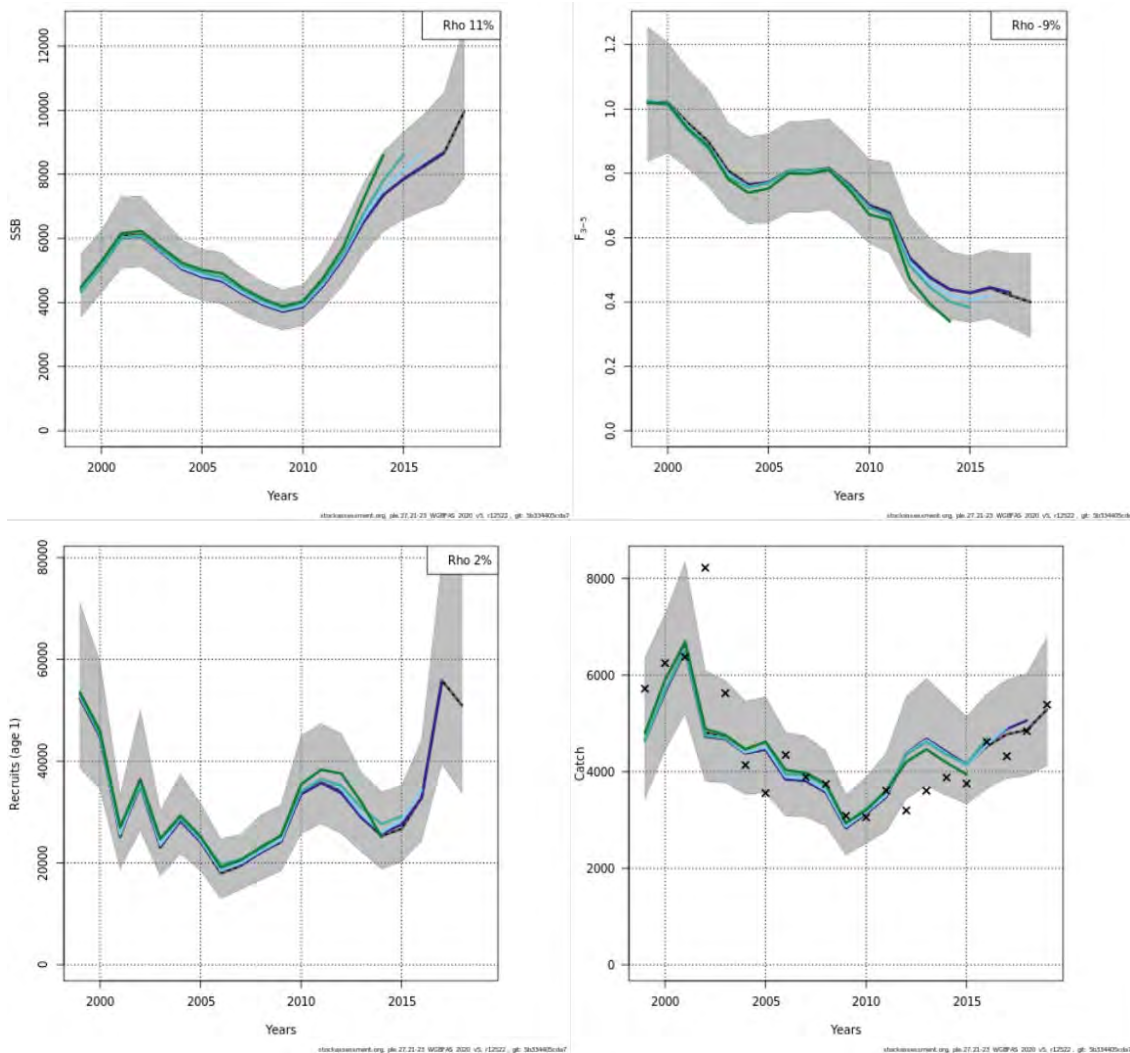


Figure 5.2.16. Plaice in SD 27.21–23. Secondary SAM run (without Q3-Q4 survey indices). Retrospective patterns

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 2017 and 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. |

| | |
|-------------------------|---|
| <i>f</i> | 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). |
| <i>b</i> | Adjustment to reduce catch when the most recent index data I_{y-1} is less than $1.4 \times I_{trigger}$ such that <i>b</i> is set equal to $I_{y-1}/(1.4 \times I_{trigger})$. When the most recent index data I_{y-1} is greater than $1.4 \times I_{trigger}$, <i>b</i> is set equal to 1. $I_{trigger}$ is generally defined as the lowest observed index value for that stock. |
| <i>m</i> | 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. |
| <i>Stability clause</i> | 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,

$C_y = 2359t$ (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 $L_{CAT} = 27.4\text{ cm}$ $L_{target} = 25\text{ cm}$) #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)

$b = 1$ ($I_{trigger} = 0.23$ $I_{y-1} = 2.4 \rightarrow I_{y-1} > 1.4 \times I_{trigger}$)

$m = 0.85$ (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 $F/F_{MSY\text{ proxy}}$ and $B/B_{MSY\text{ proxy}}$ 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 $0.5 \times B_{MSY}$.

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 (0.82), 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 | | | | |
|---------|---------|----|-------|-----------------------|-----------------|--------|---------|----------|-----|----|----|----|---------|----|----|----|----|
| | 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 | | | | | |
|---------|---------|-----|-------|-----------------------|-----------------|--------|---------|----------|----|----|----|---------|----|----|----|----|----|
| | 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 | | | | |
|---------|---------|-----|-------|-----------------------|-----------------|--------|----------|----|----|----|----|----|---------|----|----|----|----|
| | 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 | TBS | 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 $L_{opt} + 10\%$ | 0.3–0.4 | P_{mega} | > 0.3 | |
| $L_{25\%}$ | 25th percentile of length distribution | L_{mat} | $L_{25\%} / L_{mat}$ | > 1 | Conservation (immatures) |
| L_c | Length at first catch (length at 50% of mode) | L_{mat} | L_c / L_{mat} | > 1 | |
| L_{mean} | Mean length of individuals $> L_c$ | $L_{opt} = \frac{3}{3 + M/k} \times L_{inf}$ | L_{mean} / L_{opt} | ≈ 1 | Optimal yield |
| L_{maxy} | Length class with maximum biomass in catch | $L_{opt} = \frac{3}{3 + M/k} \times L_{inf}$ | L_{maxy} / L_{opt} | ≈ 1 | |
| L_{mean} | Mean length of individuals $> L_c$ | $LF=M = (0.75L_c + 0.25L_{inf})$ | $L_{mean} / LF=M$ | ≥ 1 | MSY |

Table 5.3.6. ple.27.24-32. Indicator status for the most recent three years.

| Year | Conservation | | | | Optimizing Yield | MSY |
|------|-----------------|----------------------|-----------------------|------------|----------------------|-------------------|
| | L_c / L_{mat} | $L_{25\%} / L_{mat}$ | $L_{max 5} / L_{inf}$ | P_{mega} | L_{mean} / L_{opt} | $L_{mean} / LF=M$ |
| 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 |

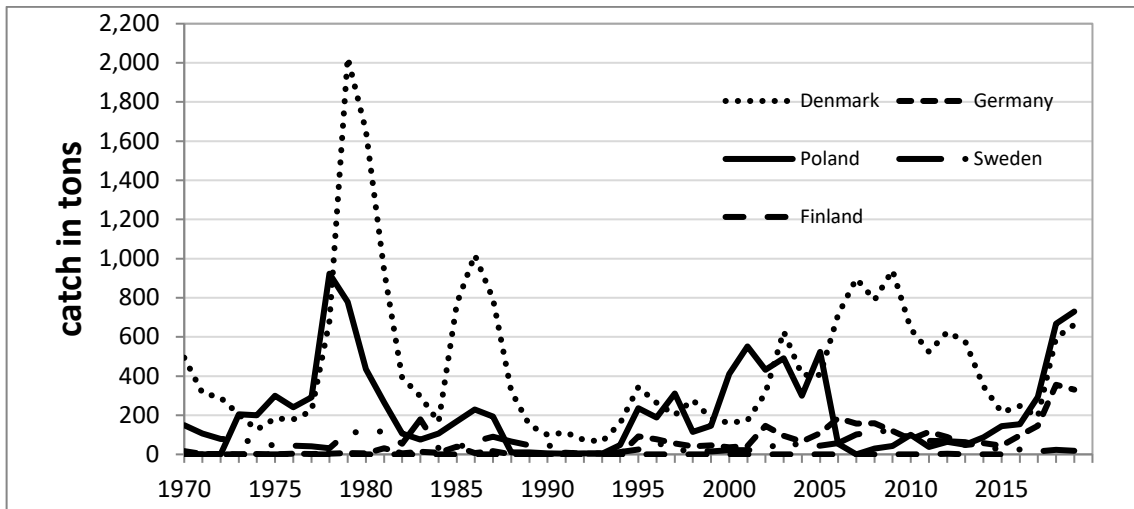


Figure 5.3.1. ple.27.24-32. Historical landings per country (in tonnes).

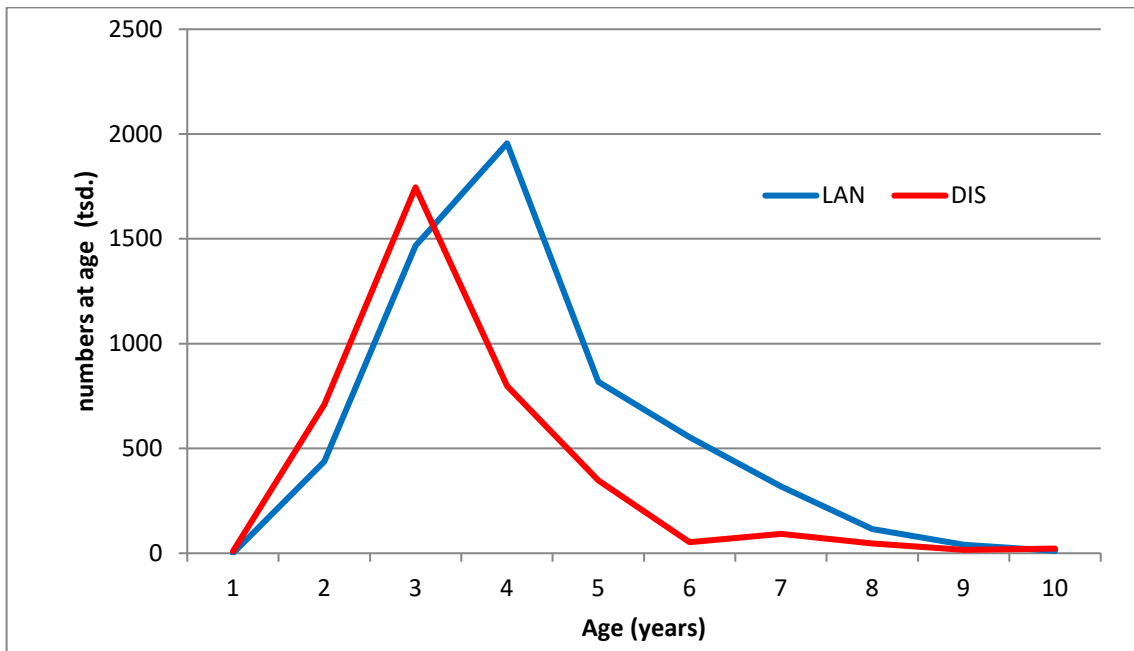


Figure 5.3.2. ple.27.24-32. Catch in numbers per age class and catch category in Subdivision 24 and 25. All countries and fleets were combined.

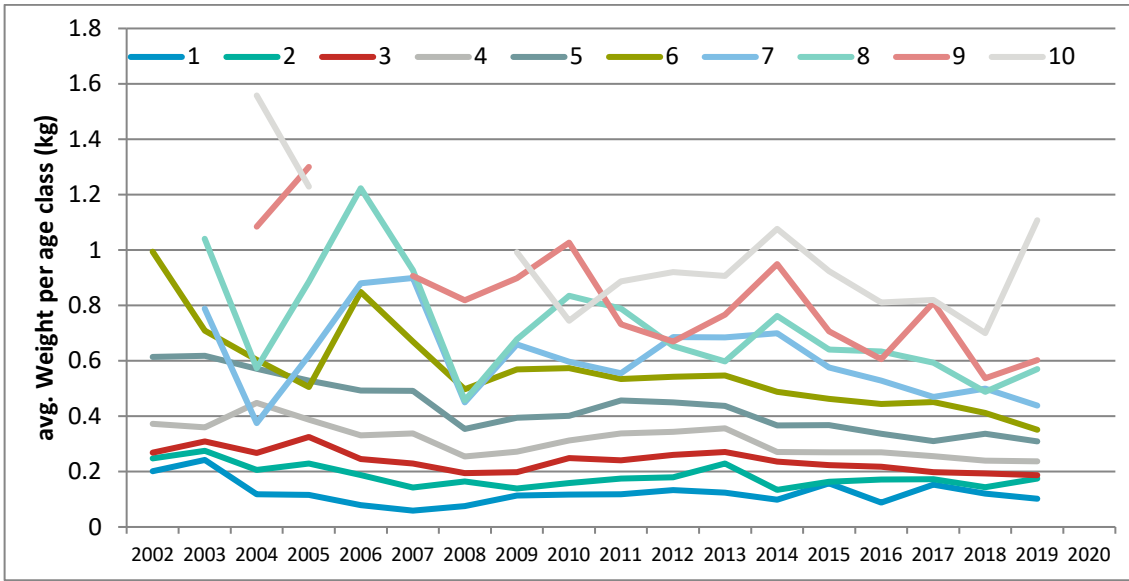


Figure 5.3.3. ple.27.24-32. Average weight-at-age for the age classes 1 to 10 in subdivisions 24 and 25. All countries and fleets were combined.

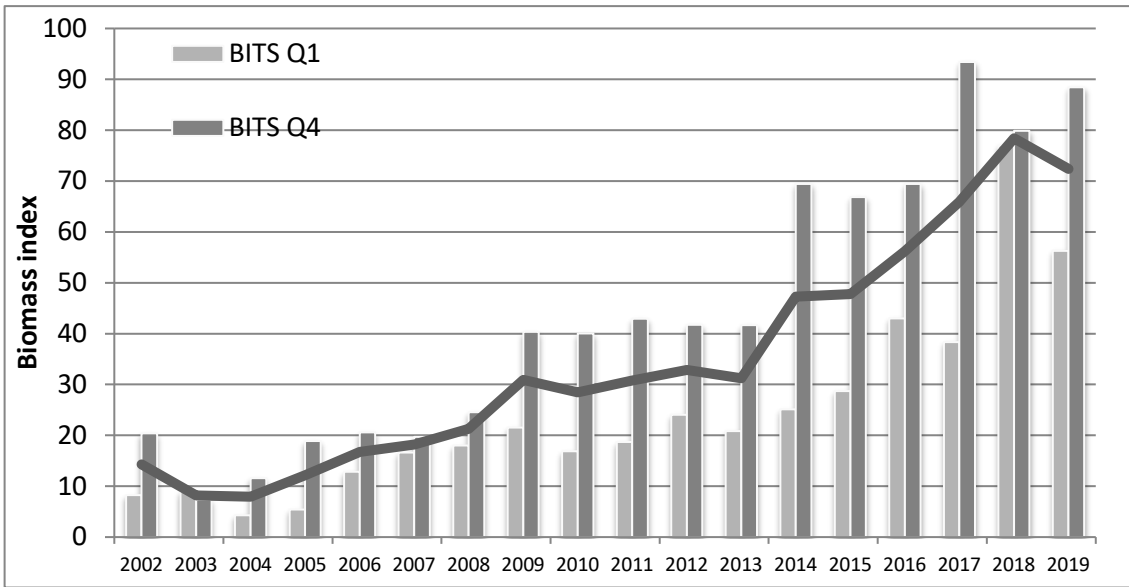


Figure 5.3.4. ple.27.24-32. Average CPUE index from Q1 and Q4 BITS from SD 24-SD 26 (no plaice catches in SD 27+). 2019 data (Q1) are preliminary.

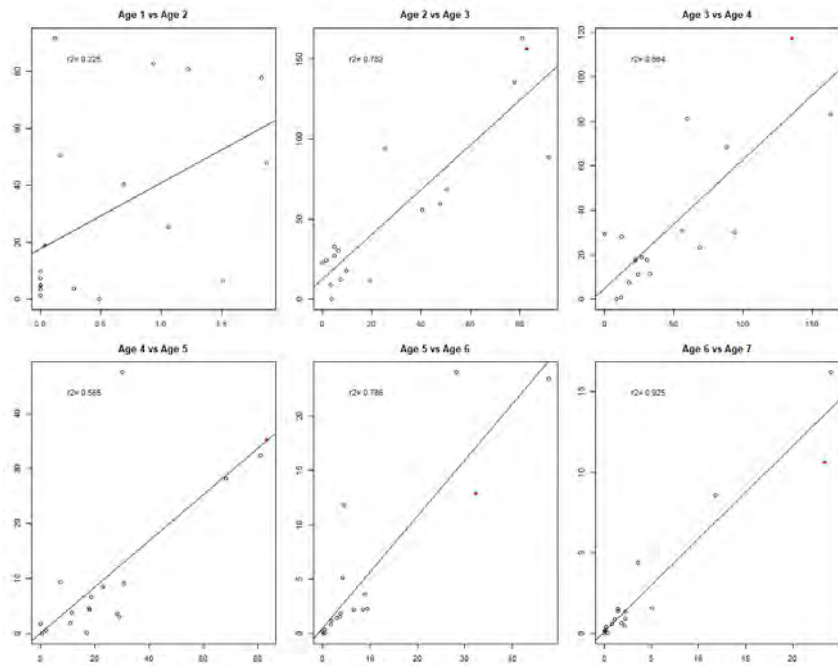


Figure 5.3.5a. ple.27.24-32. Internal consistency of age classes 1–7 from Q1 BITS.

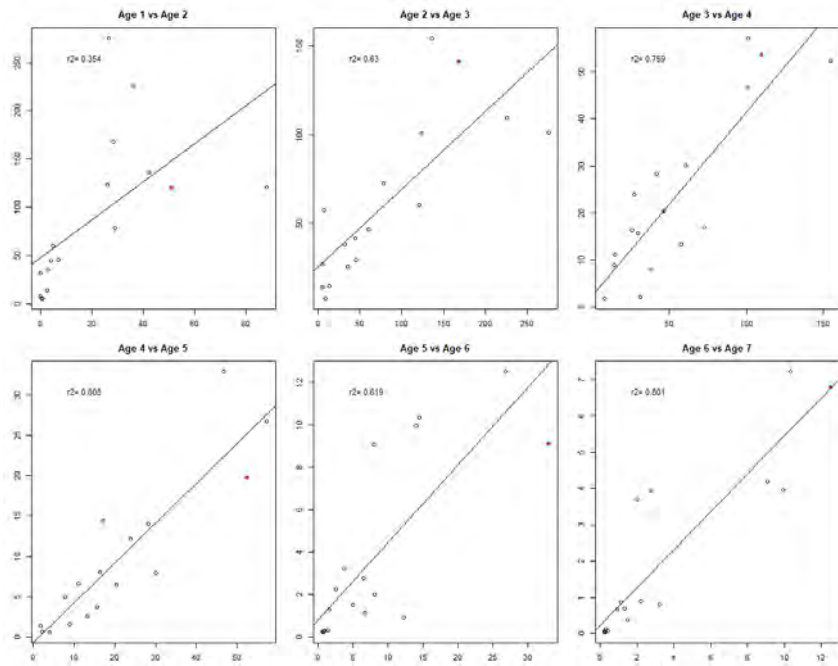


Figure 5.3.5b. ple.27.24-32. Internal consistency of age classes 1–7 from Q4 BITS.

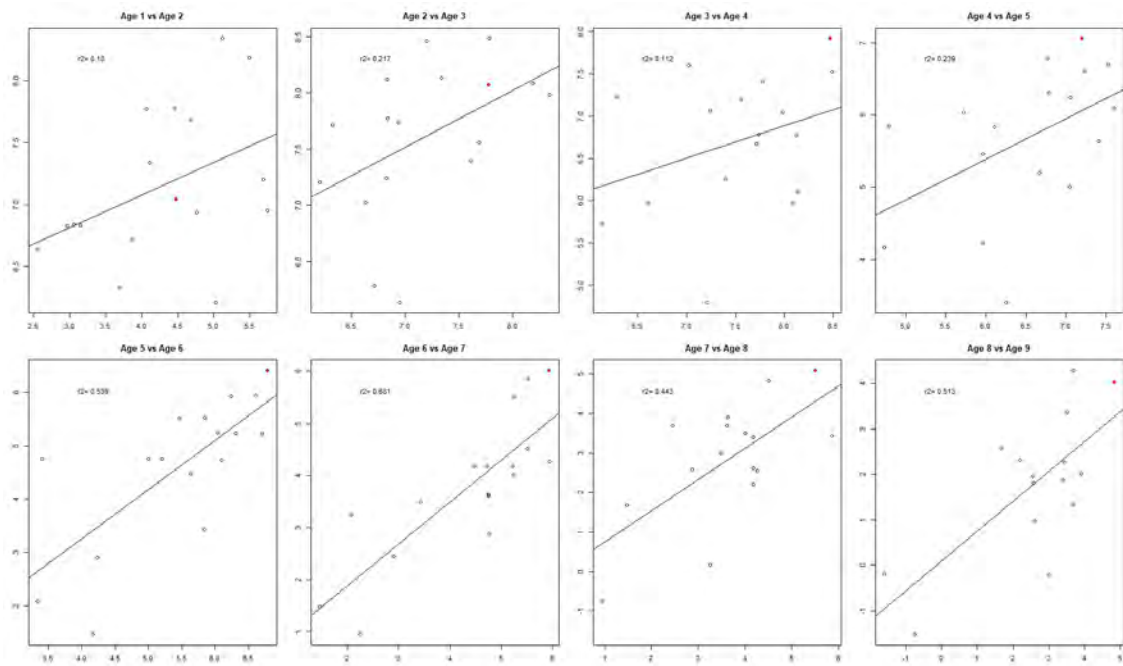


Figure 5.3.6. ple.27.24-32. Internal consistency of age classes 1–7 from commercial catches. All fleets and countries were combined.

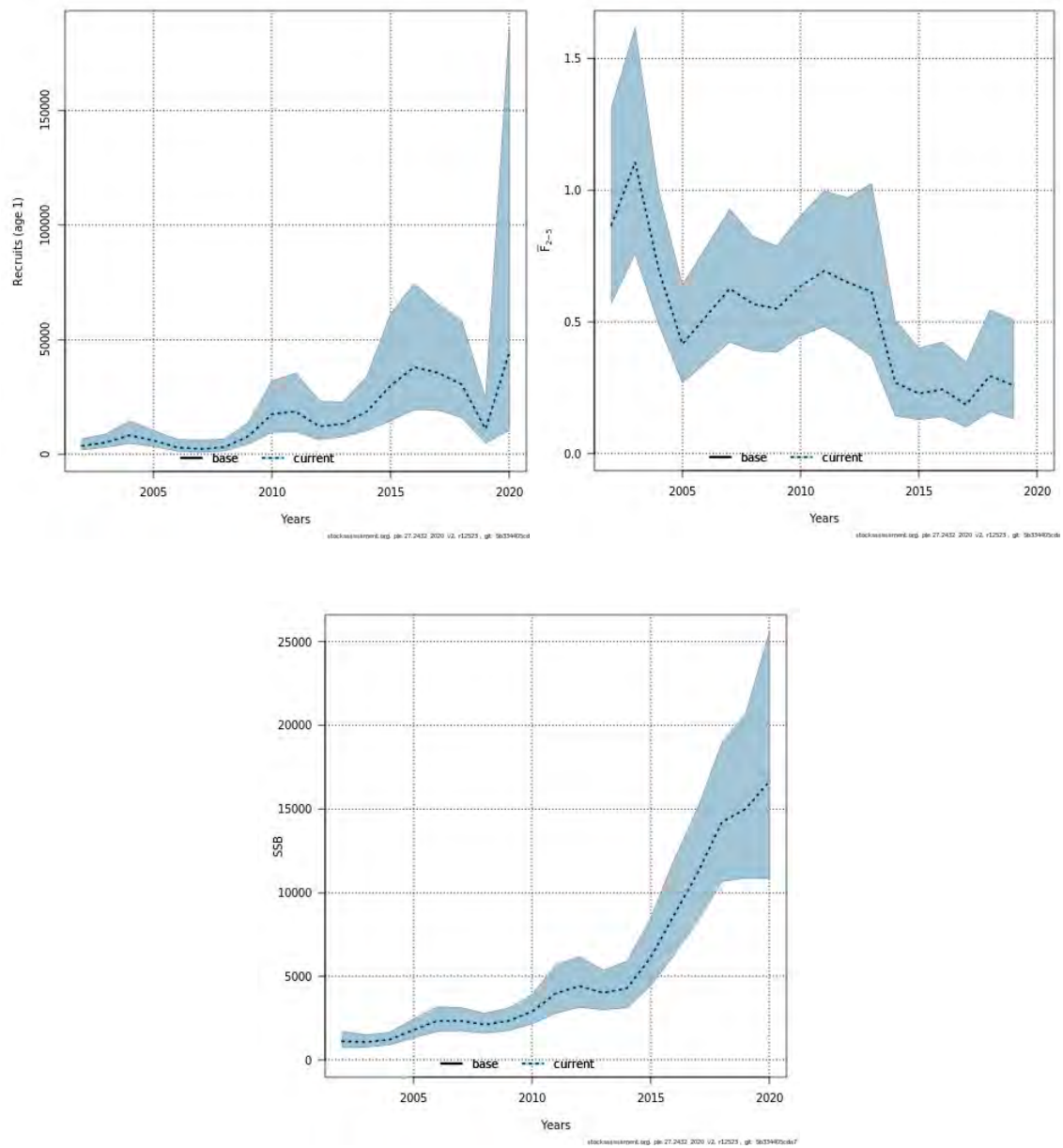


Figure 5.3.7. ple.27.24-32. Results from the exploratory SAM assessment: a) total SSB, b) F (age2–5,) and c) recruitment.

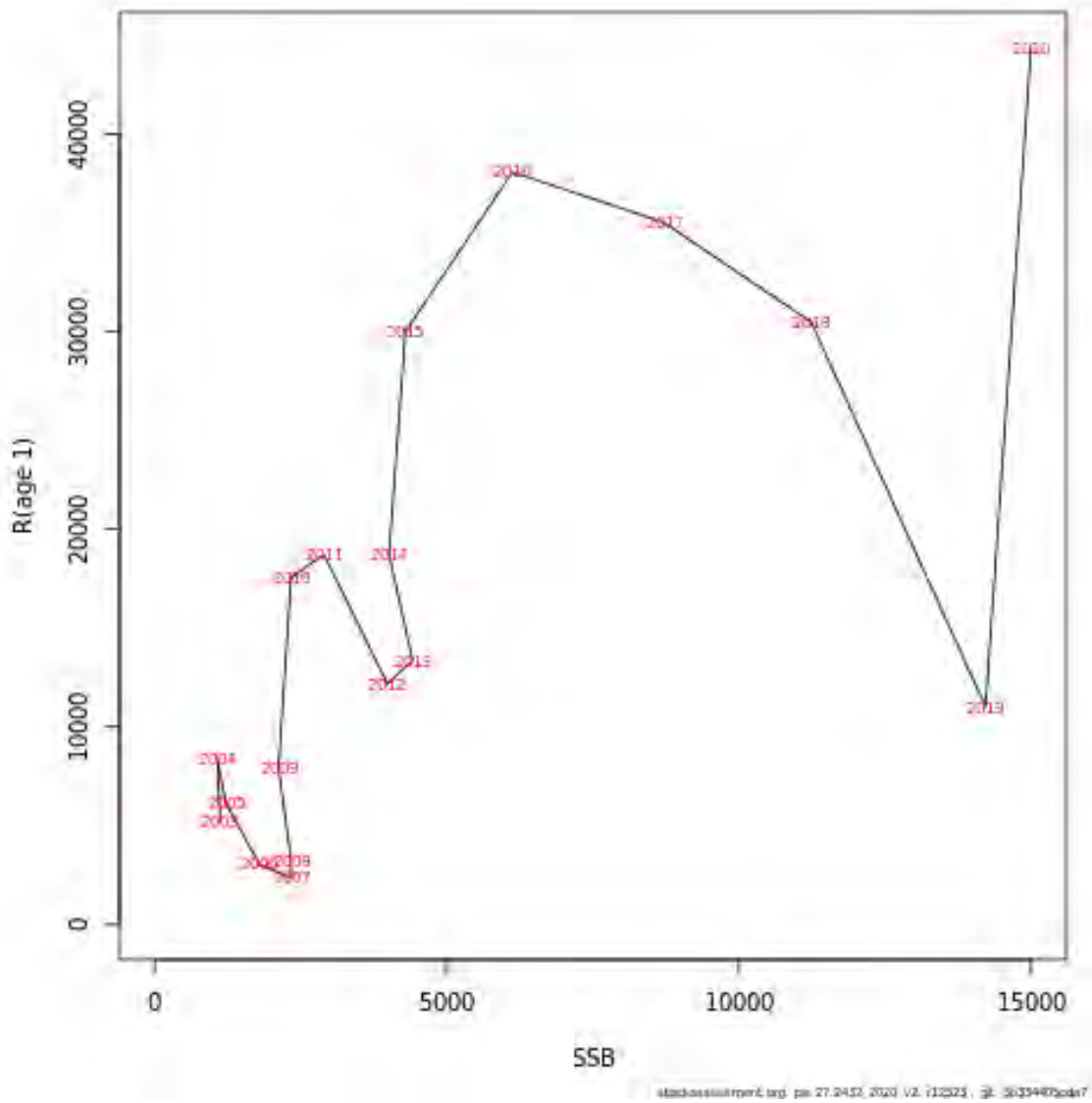


Figure 5.3.8. ple.27.24-32. Estimated recruitment as a function of spawning stock biomass.

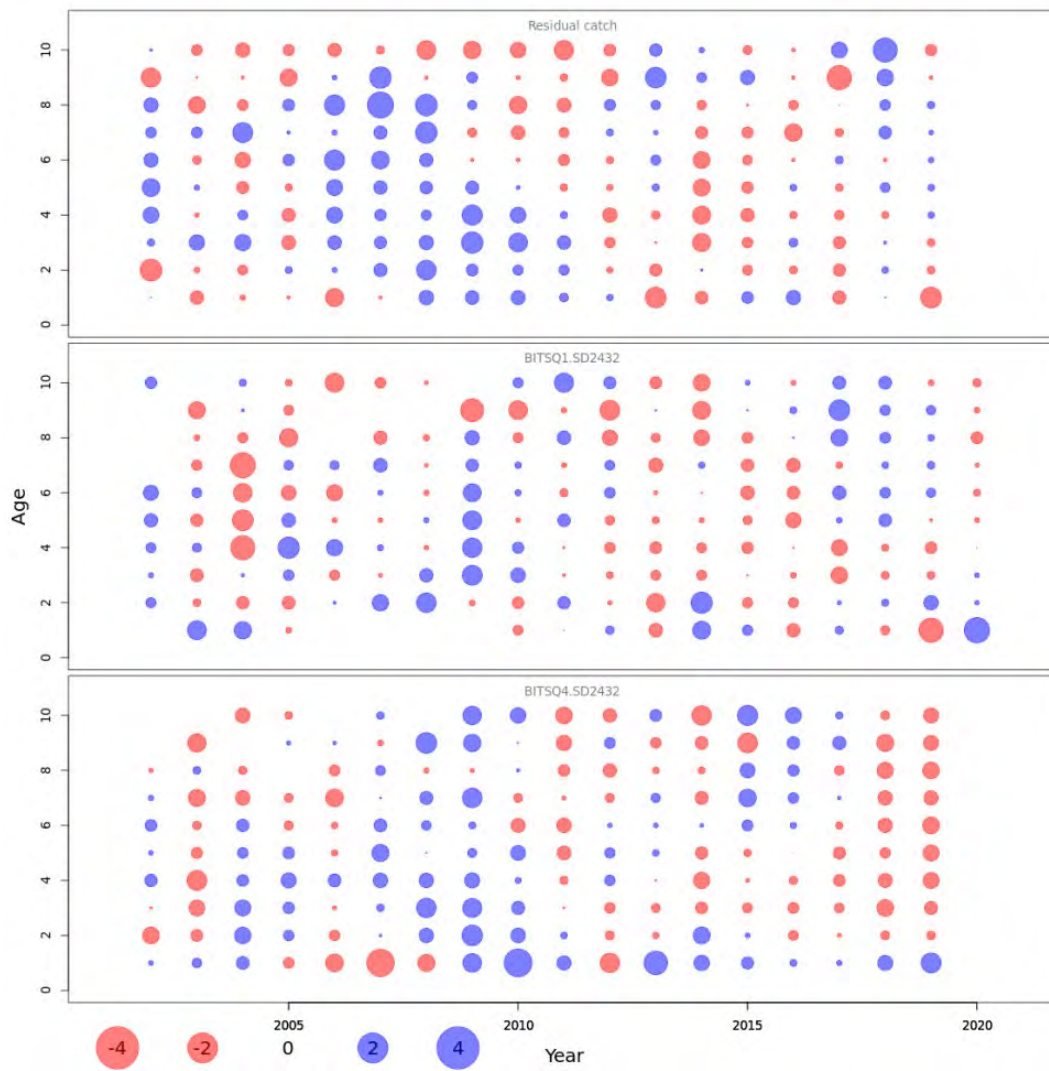


Figure 5.3.9. Normalized residuals for the current run. Blue circles indicate positive residuals (observations larger than predicted) and filled circles indicate negative residuals.

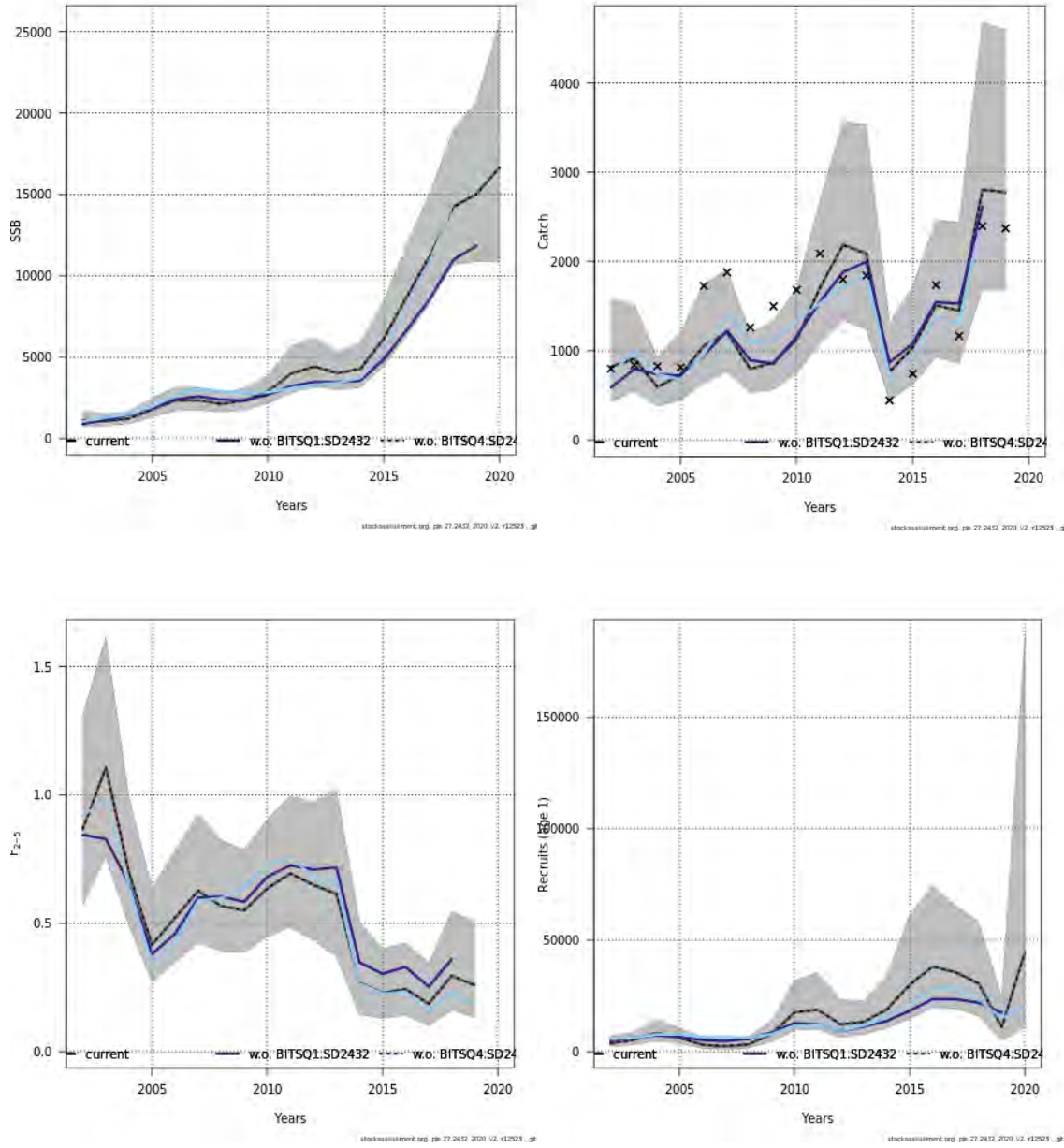


Figure 5.3.10. ple.27.24-32. The results of the retrospective analysis showing SSB, total catch, F (3–5) and recruitment.

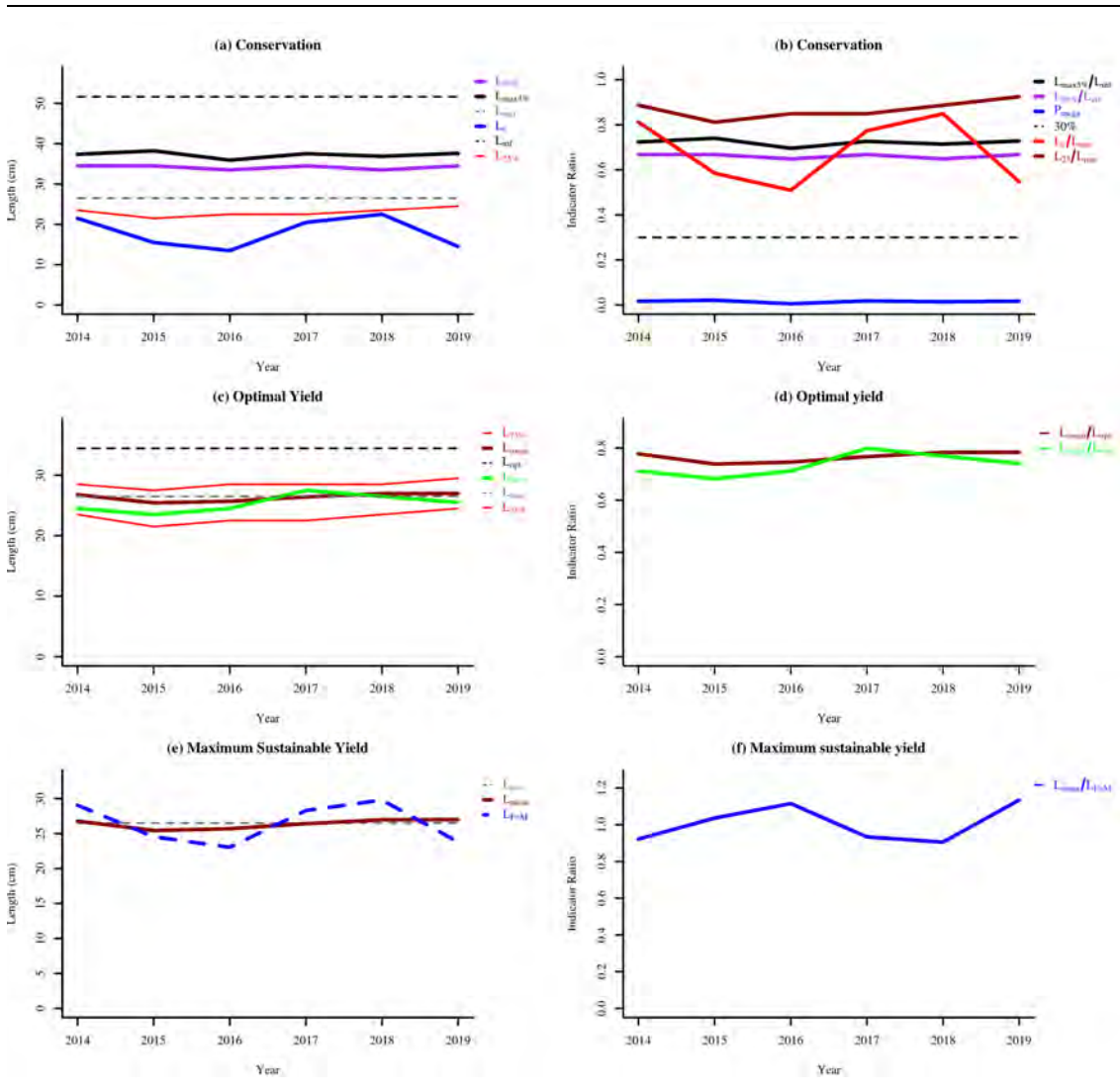


Figure 5.3.11. ple.27.24-32. Indicator trends of the Length-Based Indicator calculations.

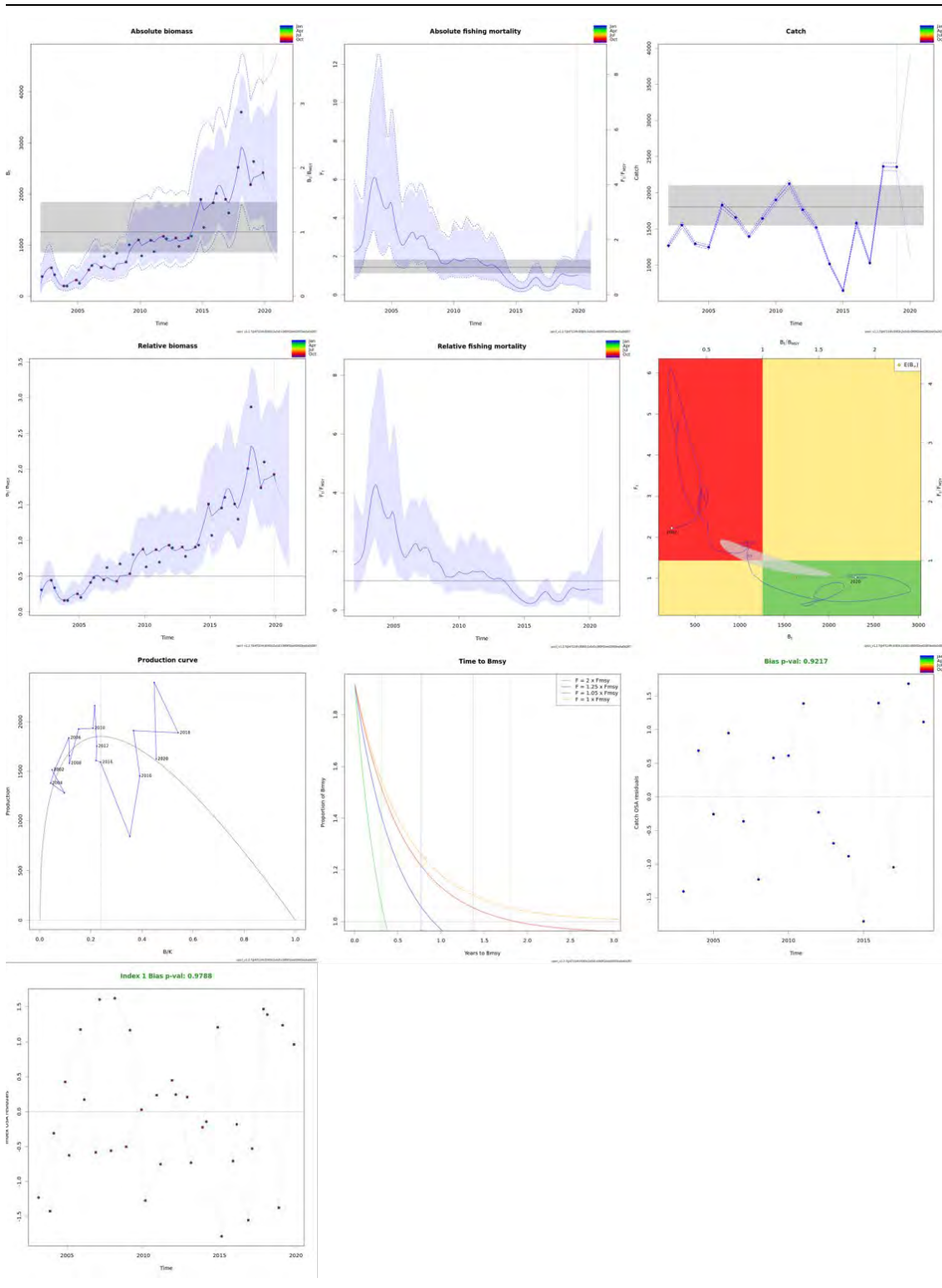


Figure 5.3.12. ple.27.24-32. Overview of the results of the surplus production model (SPiCT) on catch and survey data 2002–2019.

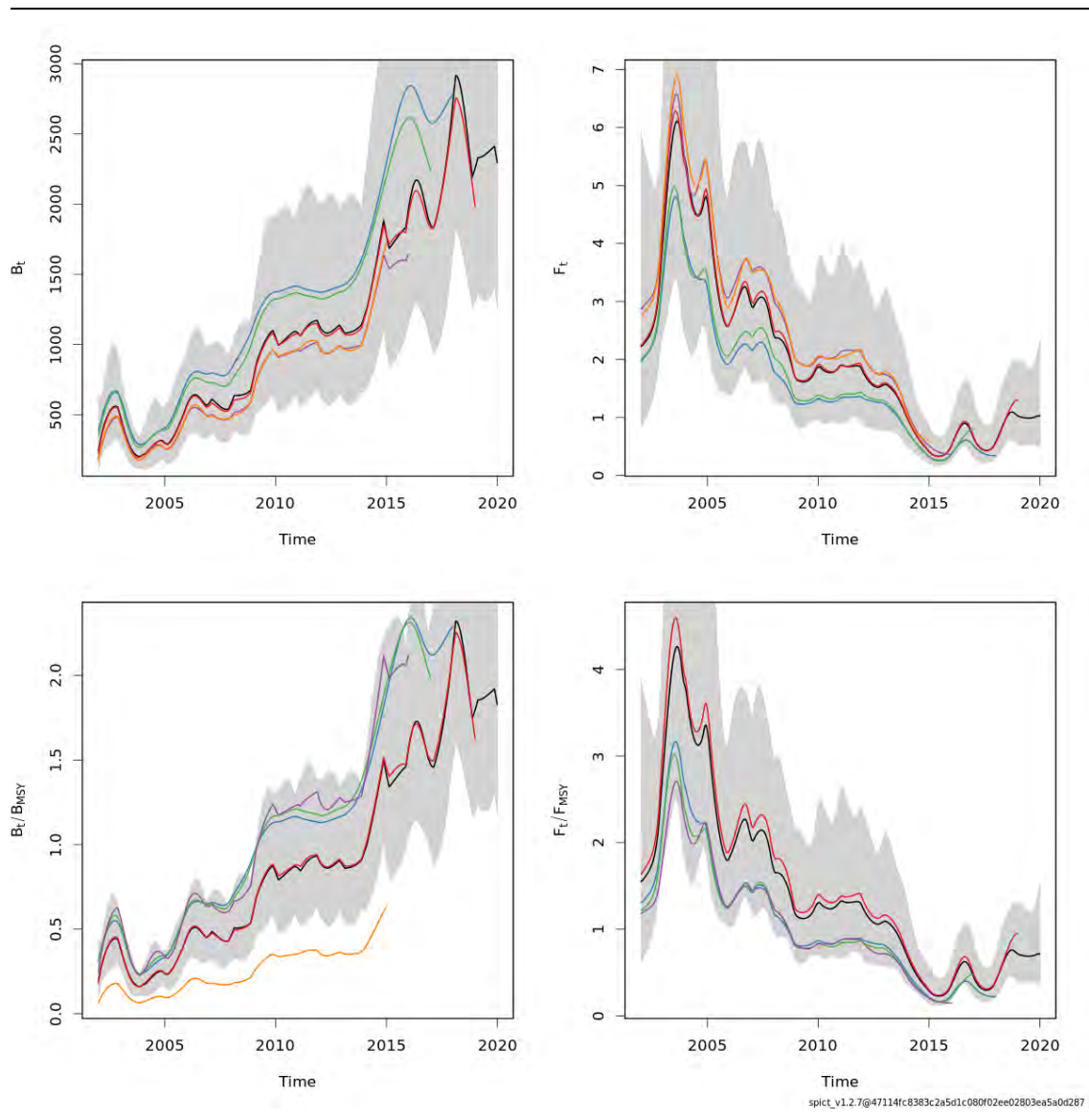


Figure 5.3.13. ple.27.24-32. Overview of the retrospective analysis of the surplus production model (SPiCT) on catch and survey data 2002–2019.

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 addi-

tional 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_{4-8} 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 $B_{trigger}$ | 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 F_{p05} 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 | $B_{lim} \times e^{1.645\sigma}$, $\sigma = 0.20$ | ICES (2015) |
| | F_{lim} | 0.315 | Equilibrium scenarios $\text{prob}(SSB < B_{lim}) < 50\%$ with stochastic recruitment | ICES (2015) |
| | F_{pa} | 0.23 | $F_{lim} \times e^{-1.645\sigma}$, $\sigma = 0.18$ | 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 survey 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 |
|------------------|---------|----|----|----|-------|---------|-------|
| | 1 | 2 | 3 | 4 | Trawl | Gillnet | |
| Nation | | | | | | | |
| 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 |
|-----------------|---------|----|----|----|-------|---------|-------|
| | 1 | 2 | 3 | 4 | Trawl | Gillnet | |
| Nation | | | | | | | |
| 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 |
|----------------------------|---------|----|----|----|-------|---------|-------|
| | 1 | 2 | 3 | 4 | Trawl | Gillnet | |
| Nation | | | | | | | |
| 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 | 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 | | | | | 145 | 990 |
| 2006 | 521 | 114 | 107 | 38 | 43 | | | | | 9 | 836 |
| 2007 | 366 | 81 | 93 | 45 | 39 | | | | | 9 | 633 |
| 2008 | 361 | 102 | 113 | 34 | 35 | | | | | 7 | 655 |
| 2009 | 325 | 103 | 145 | 37 | 27 | | | | | 4 | 641 |
| 2010 | 273 | 61 | 125 | 46 | 26 | | | | | 3 | 538 |
| 2011 | 271 | 127 | 65 | 53 | 33 | | | | | 3 | 552 |
| 2012 | 154 | 140 | 28 | 30 | 0 | | | | | 6 | 358 |
| 2013 | 153 | 78 | 33 | 54 | 9 | | | | | 6 | 332 |
| 2014 | 141 | 104 | 48 | 36 | 2 | | | | | 3 | 335 |
| 2015 | 95 | 66 | 36 | 9 | 7 | | | | | 5 | 224 |
| 2016 | 164 | 78 | 56 | 14 | 17 | | | | | 2 | 348 |
| 2017 | 215 | 166 | 46 | 19 | 21 | | | | | 2 | 501 |
| 2018 | 158 | 140 | 57 | 16 | 15 | | | | | 0 | 434 |
| 2019 | 150 | 88 | 82 | 13 | 15 | | | | | 2 | 417 |

Table 6.3. Sole 20-24. Discard from active gears as obtained from observers.

| Age | Discard in weight (kg) | | | | | | | | | | | | | | | | | | |
|-------------|------------------------|---------|------|-------|--------|------|------|-----------|-------|-------|-------|-------|--------|-------|-------|-------|-------|-------|--|
| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006-2008 | 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(t) | 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.

| Quarter | Belts and Baltic | | | Skagerrak | | | Kattegat | | | Total | | |
|---------|------------------|---------------|------|-----------|---------------|------|----------|---------------|------|----------|---------------|------|
| | 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 | 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 | 0.25 | 0.87 | | | | | | | |
|-------|-------|-------|-------|-------|------|------|------|------|--|
| 1 | 1 | | | | | | | | |
| 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 | 0.75 | 1 | | | |
|------|-------|-------|-------|-------|-------|
| 1 | 1 | | | | |
| 2 | 6 | | | | |
| 712 | 2756 | 5140 | 5562 | 2667 | 954 |
| 876 | 5667 | 7735 | 5361 | 3432 | 1025 |
| 933 | 5097 | 2253 | 3761 | 2825 | 2126 |
| 1174 | 16408 | 10277 | 2753 | 3874 | 1545 |
| 1809 | 16085 | 35139 | 14745 | 4452 | 3878 |
| 3136 | 56849 | 46507 | 16304 | 7177 | 1545 |
| 4035 | 41739 | 44475 | 19945 | 11105 | 6685 |
| 5276 | 9498 | 55455 | 64125 | 19324 | 12725 |

| | | | | | |
|------|-------|-------|-------|-------|-------|
| 4969 | 42026 | 35885 | 41231 | 29359 | 14705 |
| 4294 | 24861 | 38831 | 23489 | 26033 | 16360 |
| 4027 | 3927 | 13138 | 14220 | 10668 | 13279 |
| 2464 | 12543 | 3357 | 1117 | 1041 | 1736 |
| 2142 | 13031 | 24798 | 3690 | 4268 | 3927 |
| 3342 | 9566 | 16153 | 20370 | 3215 | 2692 |
| 2268 | 6292 | 11562 | 6052 | 6953 | 635 |
| 1498 | 29987 | 20538 | 4835 | 5483 | 3963 |
| 2093 | 7473 | 21584 | 14949 | 7199 | 3760 |
| 3999 | 20124 | 39887 | 47640 | 18374 | 8401 |
| 2463 | 7956 | 34026 | 29590 | 16011 | 6975 |
| 3132 | 11878 | 14708 | 24084 | 19146 | 12809 |
| 2730 | 14422 | 11847 | 4636 | 8756 | 515 |
| 1281 | 4393 | 2674 | 2438 | 2735 | 2130 |

Table 6.6. Sole 20-24. Catch in numbers (thousands) by year and age.

| YEAR, | Numbers*10** - 3 | | | | | |
|------------|------------------|-------|-------|-------|-------|-------|
| | 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, |

| YEAR, | Numbers*10** - 3 | | | | | | | | | |
|------------|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 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, | 584, | 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, | 369, | 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, |

| YEAR, | Numbers*10** - 3 | | | | | | | | | |
|------------|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 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, | 108, | 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, |

| YEAR, | Numbers*10** - 3 | | | | | | | | | |
|------------|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 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 | | | |
| | | 0.475 | 0.564 | | | | 0.368 | 0.357 | 0.463 |
| 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 (TSB), 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 predictions¹.

| 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).

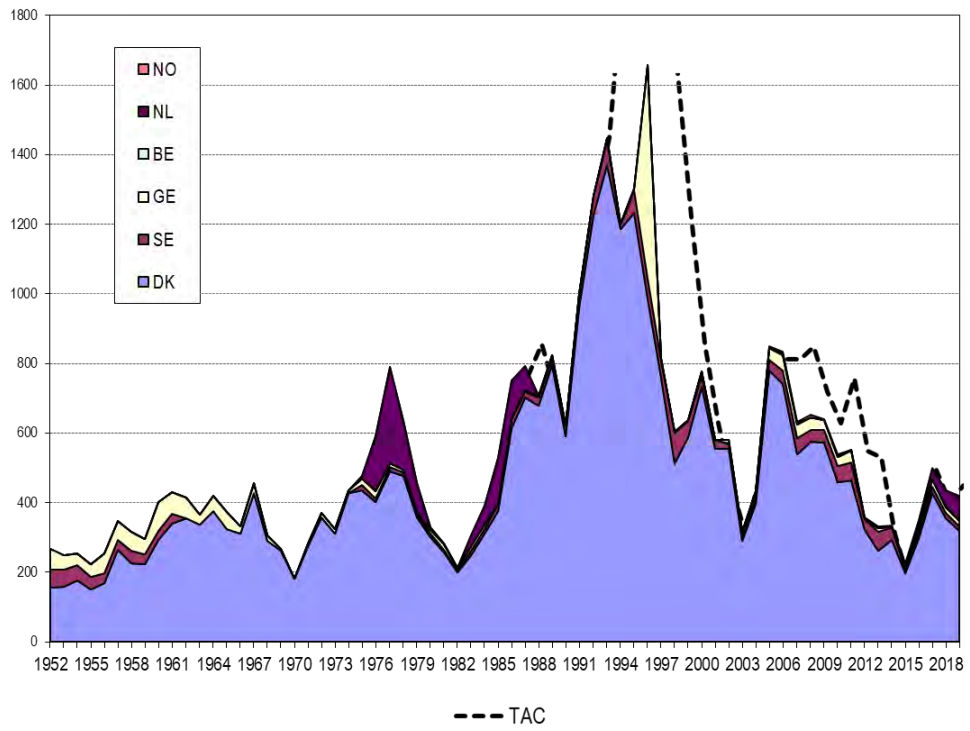
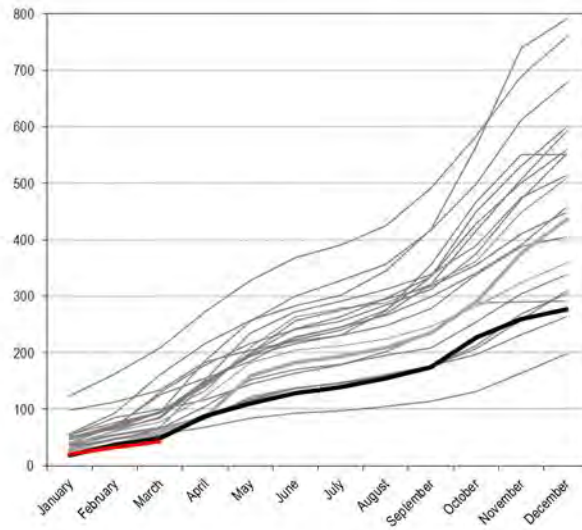


Figure 6.1. Sole 20-24. Landings of sole in divisions 20-24 by nation since 1952 (tonnes/kg).

Cumulative catches (tons)



Cumulative catches %

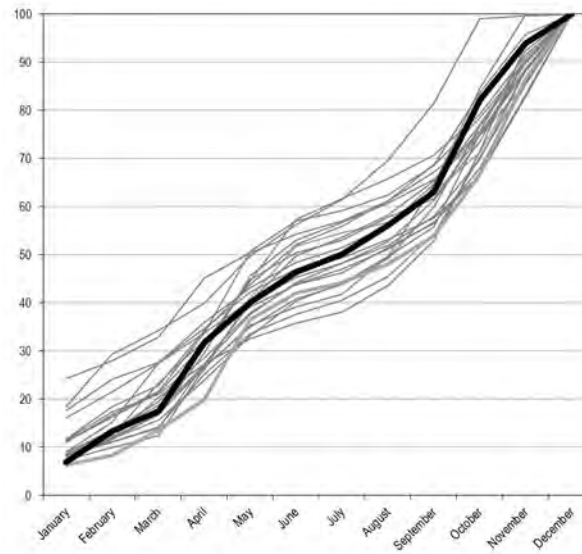


Figure 6.2. Sole 20-24. Cumulative Danish landings of sole by month. Black bold curve is 2019 and red bold curve is 2019 including March.

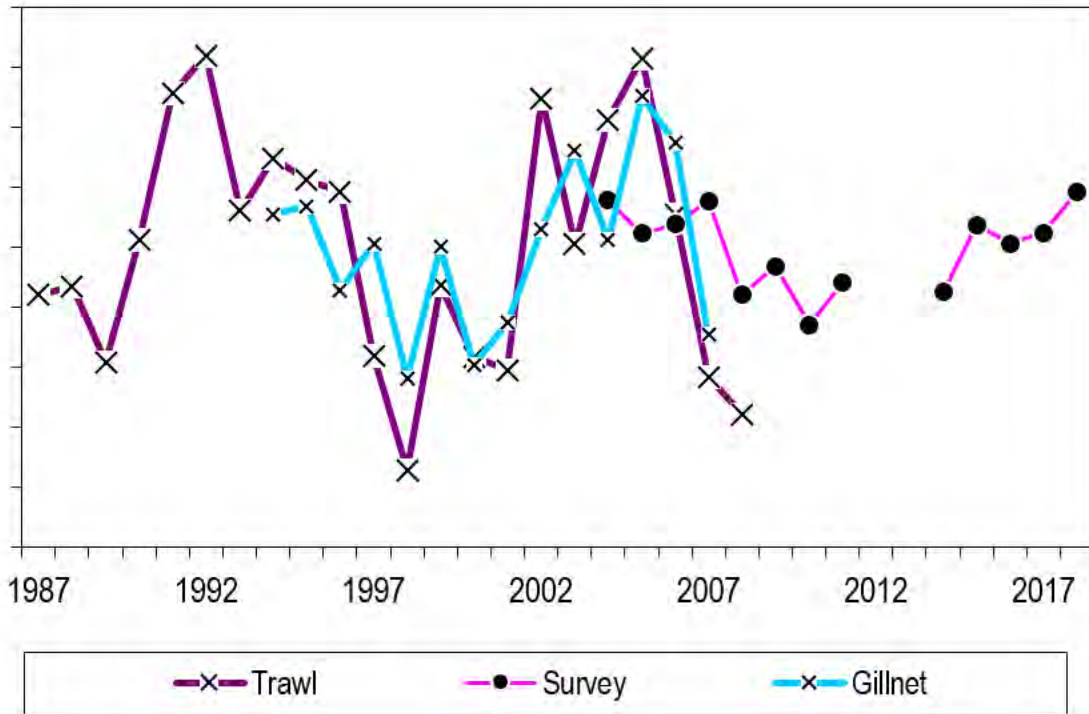


Figure 6.3. Sole 20-24. Standardised age aggregated CPUE indices of sole from private logbooks from trawlers, private logbooks gillnetters and Fisherman/DTU Aqua survey as used in the assessment.

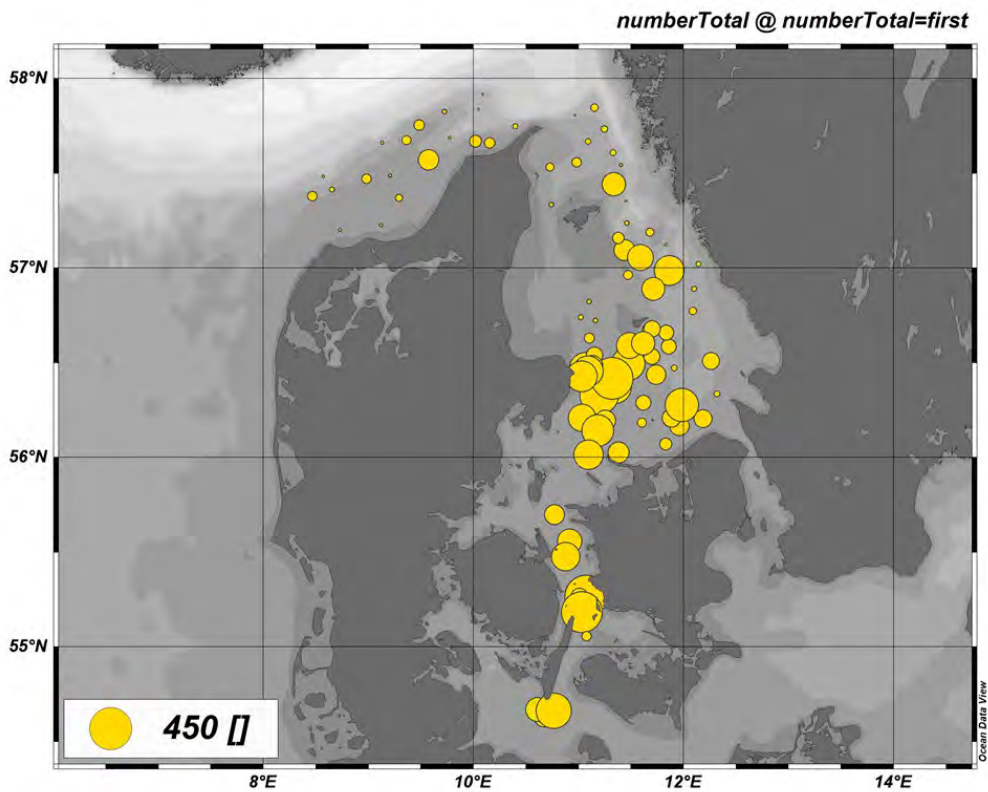


Figure 6.4. 20-24. Fisherman-DTU Aqua survey. Catch rate distribution of stations in 2019.

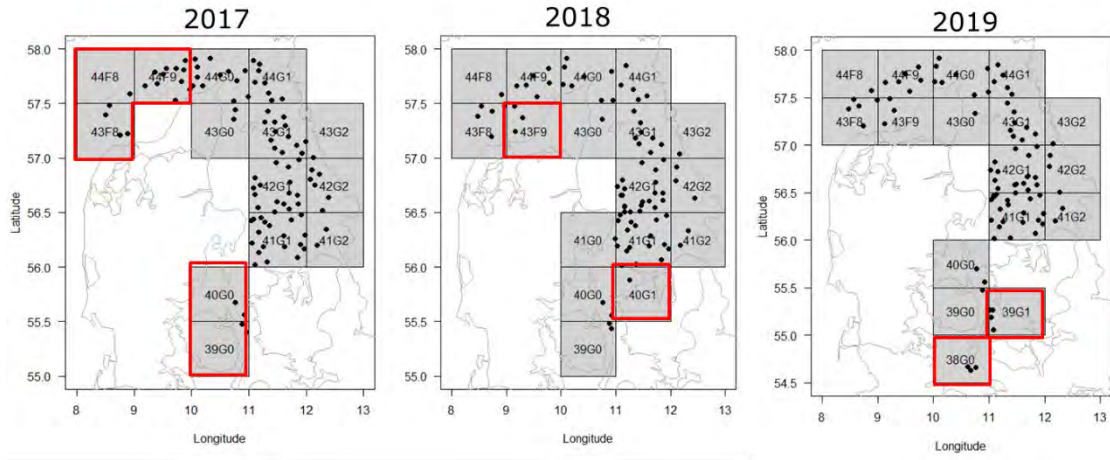


Figure 6.5. Sole 20-24. Map of sole survey station distribution in 2017-2019, red boxes illustrating the successively extended survey area (subdivisions 20 and 22).

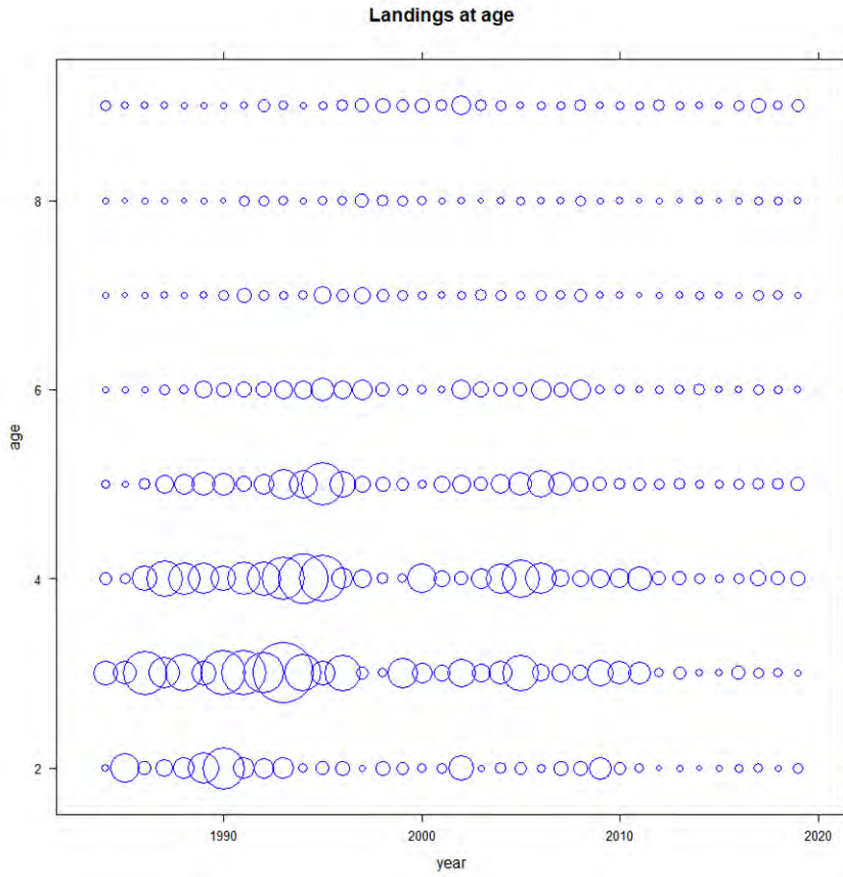


Figure 6.6. Sole 20-24. Landing number- at-age.

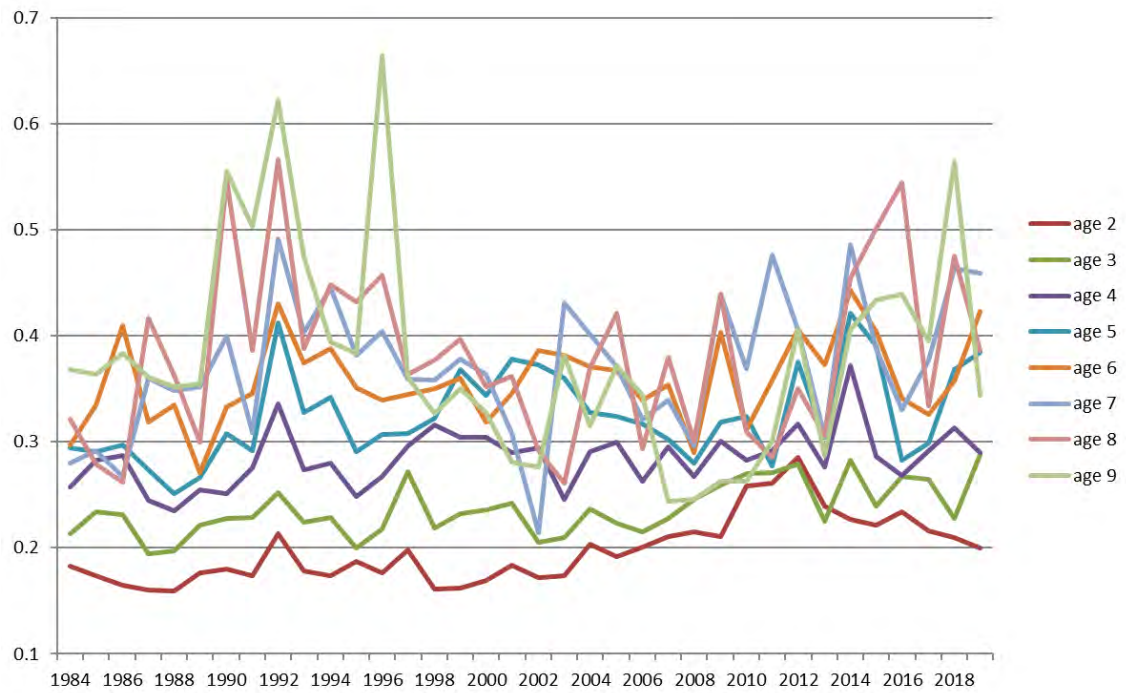


Figure 6.7. Sole in 20-24. Landings weight-at-age (tonnes/kg).

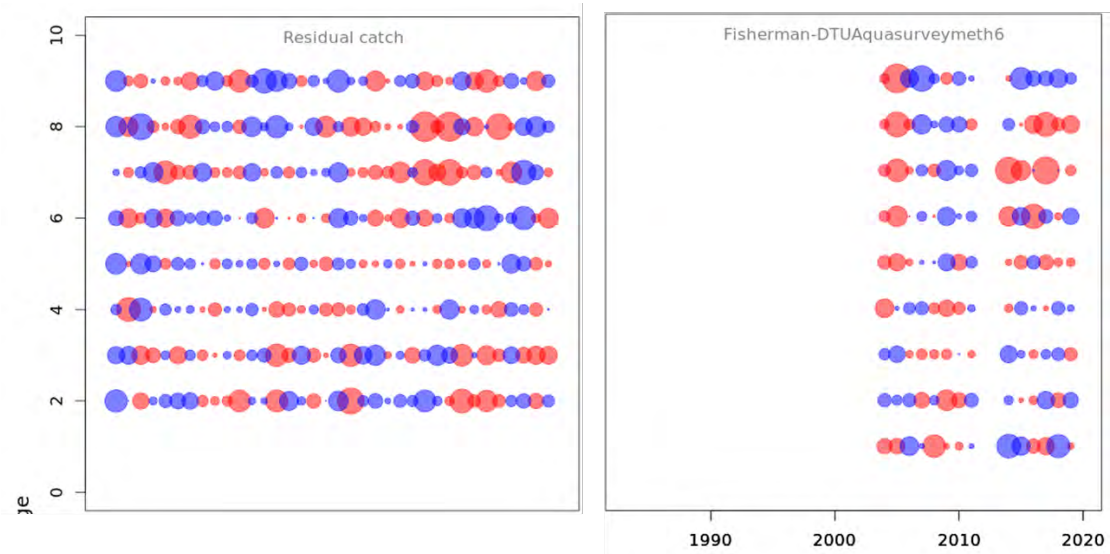


Figure 6.8. Sole 20-24. Model residuals for landings and survey.

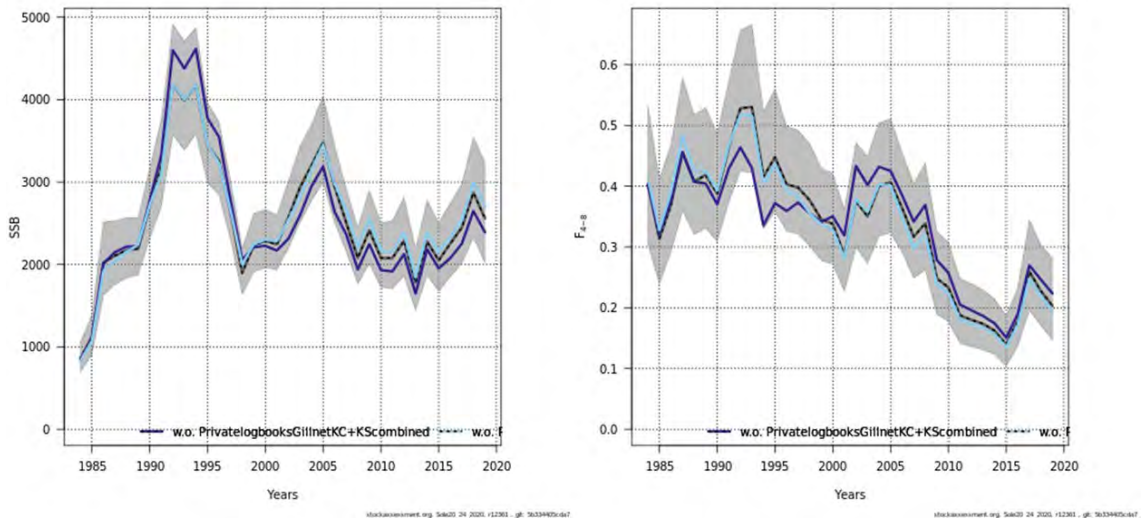


Figure 6.9. 20-24. Fleet sensitivity. Estimated SSB, and fishing mortality from runs leaving single fleets out. Recruitment (age 1) plot is not possible to provide since only the survey contains age 1 group.

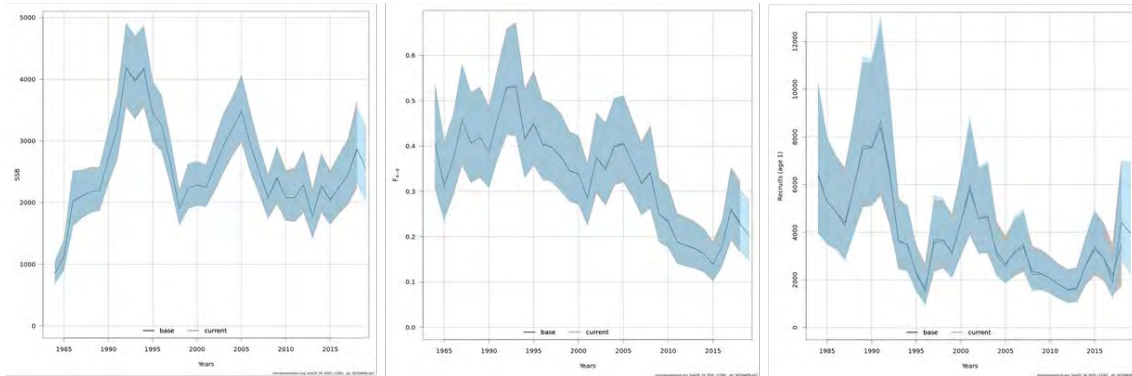


Figure 6.10. Sole 20-24. Stock summary; SSB, F_{4-8} and R (age 1) compared to last year's assessment.

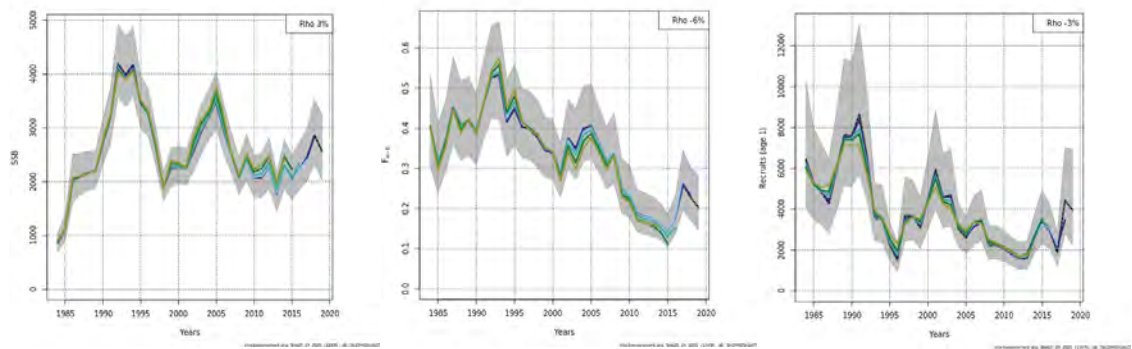


Figure 6.11. Sole 20-24. Retrospective analyses for SSB, F , and recruitment. Confidence limits are provided for the 2019 scenario.

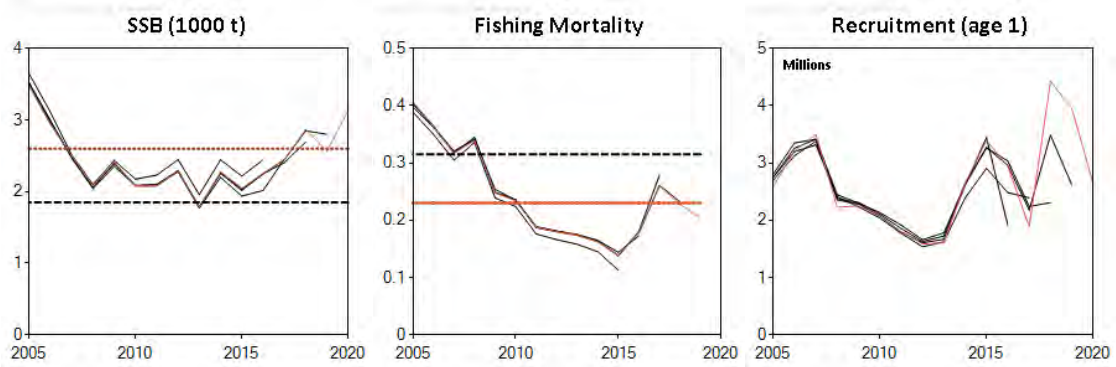


Figure 6.12. Sole 20-24. Historical performance of F, SSB and recruitment.

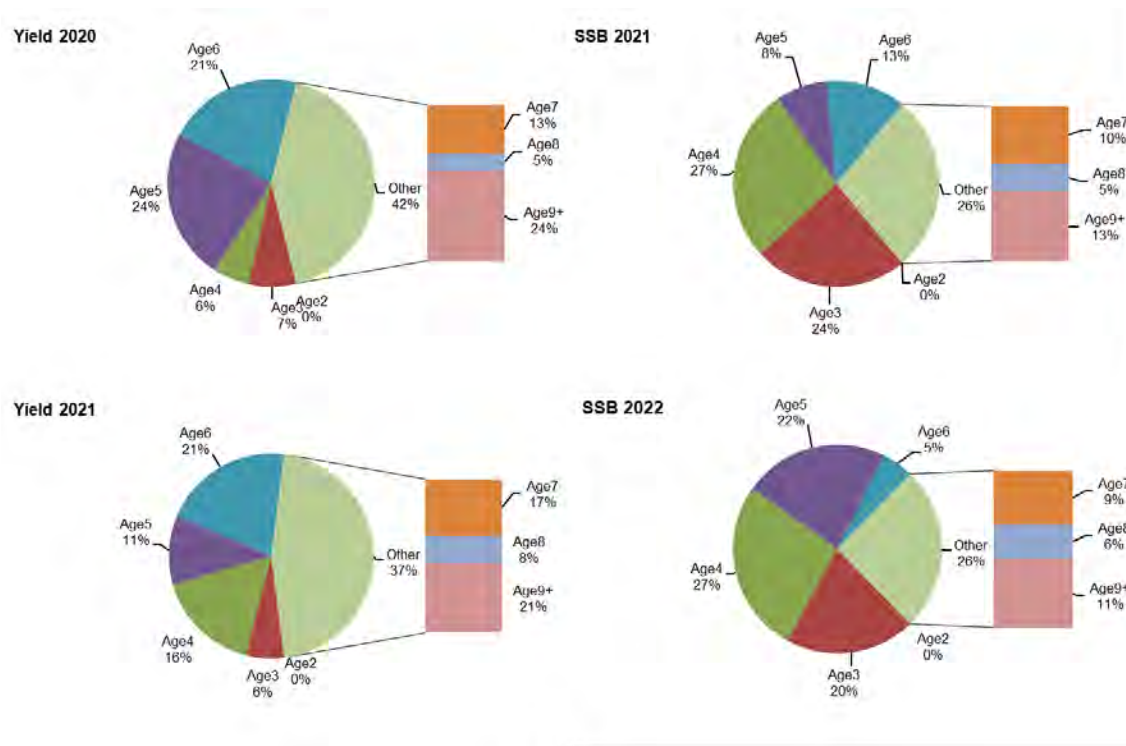


Figure 6.13. Sole 20-24. Short-term forecast for 2020-2022. Yield and SSB at age 2-9+ assuming fishery at F_{sq} in 2020.

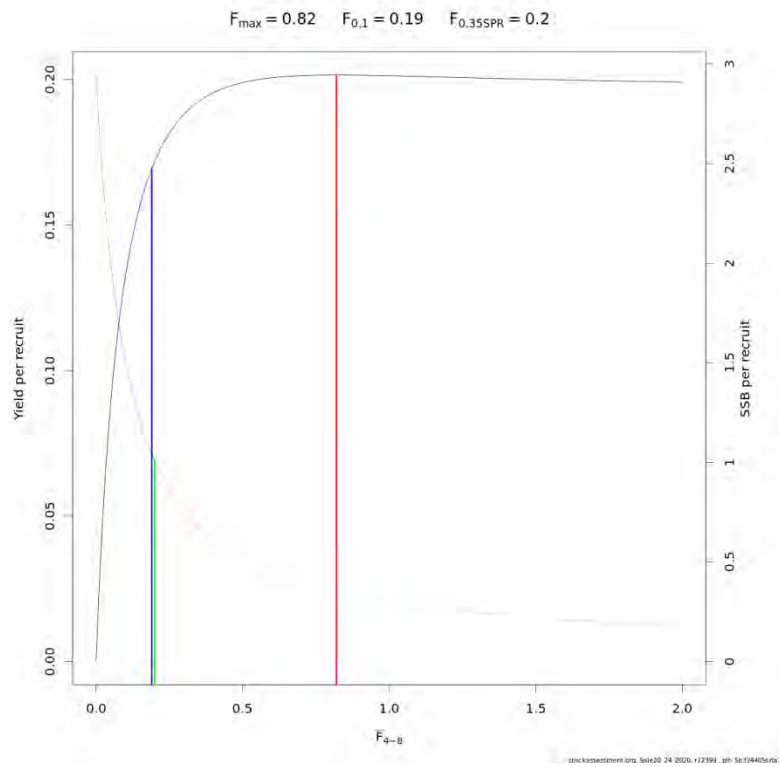


Figure 6.14. Sole 20-24. Yield per recruit curve and reference point estimates (red = F_{max} , green = $F_{35\%SPR}$ and blue = $F_{0.1}$).

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 F_s 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 planned 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 F s 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 Luzencyk, 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 |

| Country | Total | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---------|-------|----|----|----|----|----|----|----|----|----|----|----|
|---------|-------|----|----|----|----|----|----|----|----|----|----|----|

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 | | | | | | | | | |
|-----------------------|--------------------|-----|-----|-----|-------|------------|------|----|------|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|-----------------------|--------------------|----|----|----|-------|------------|----|----|----|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|-----------------------|--------------------|-----|-----|-----|-------|------------|----|----|----|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|-----------------------|--------------------|--------|-------|-------|--------|------------|------|------|------|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|----------------|--------------------|---------|--------|--------|---------|------------|------|------|------|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|----------------|--------------------|--------|------|-------|--------|------------|------|------|------|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|----------------|--------------------|---------|-------|--------|----------|------------|----|----|----|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|----------------|--------------------|--------|------|-------|---------|------------|------|------|------|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|-----------------------|--------------------|--------|--------|---------|---------|------------|------|------|------|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|-----------------------|--------------------|-----|------|-------|--------|------------|------|------|------|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|-----------------------|--------------------|-------|--------|--------|---------|------------|----|----|----|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|-----------------------|--------------------|-------|------|-------|-------|------------|------|------|------|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|----------------|--------------------|------|-------|-----|-------|------------|------|------|----|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|----------------|--------------------|------|------|-------|--------|------------|------|------|------|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|-----------------------|--------------------|--------|--------|---------|---------|------------|----|----|----|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | | | | | | | | | |
|---------------------------|--------------------|---------|---------|---------|----------|------------|------|------|------|
| Age | Numbers (millions) | | | | | Weight (g) | | | |
| | 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 | 0 |
| Estonia | 1 | | | | | |
| | 2 | | | | | |
| | 3 | | | | | |
| | 4 | | | | | |
| | Total | 0,0 | 0 | 0 | 0 | 0 |
| Finland | 1 | 40,5 | 0 | 0 | 0 | 0 |
| | 2 | 5,0 | 0 | 0 | 0 | 0 |
| | 3 | 0,8 | 0 | 0 | 0 | 0 |
| | 4 | | | | | |
| | Total | 46,3 | 0 | 0 | 0 | 0 |
| Germany | 1 | | | | | |
| | 2 | | | | | |
| | 3 | | | | | |
| | 4 | | | | | |
| | Total | 0,0 | 0 | 0 | 0 | 0 |
| Latvia | 1 | | | | | |
| | 2 | | | | | |
| | 3 | | | | | |
| | 4 | | | | | |
| | Total | 0,0 | 0 | 0 | 0 | 0 |
| Lithuania | 1 | 17,0 | 0 | 0 | 0 | 0 |
| | 2 | | | | | |
| | 3 | | | | | |
| | 4 | | | | | |
| | Total | 17,0 | 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 | Number of samples | Number of fish | |
|---------|---------|-----------|-------------------|----------------|------|
| | | in tonnes | | 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 | Number of samples | Number of fish | |
|---------|---------|-----------|-------------------|----------------|------|
| | | in tonnes | | 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: Internatio | 1991 | 2019 | 1 | 7 | 0,75 | 0,85 |
| FLT02: Internatio | 2001 | 2019 | 1 | 7 | 0,35 | 0,42 |
| FLT03: Latvian/Ru | 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 |

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XSA population numbers (Thousands)

| YEAR | AGE | | | | | | |
|------|--------|--------|-------|-------|-------|------|------|
| | 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 |
|--|--------|--------|--------|--------|-------|--------|-------|

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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 |

| Age | Slope | t-value | Intercept | RSquare | No Pts | Reg s.e | Mean Q |
|-----|-------|---------|-----------|---------|--------|---------|--------|
| 1 | | | | | | | |
| 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 |

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 | 0 | 1 | 0,335 |
| FLT02: Internatio | 38267 | 0,403 | 0 | 0 | 0 | 1 | 0,186 |
| FLT03: Latvian/Ru | 31552 | 0,332 | 0 | 0 | 0 | 1 | 0,275 |
| P shrinkage mea | 49633 | 0,49 | | | | | 0,143 |
| F shrinkage mea | 57478 | 0,75 | | | | | 0,061 |

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: Internatio | 31447 | 0,284 | 0,126 | 0,44 | 2 | 0,285 | 0,249 | |
| FLT03: Latvian/Rt | 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: Internatio | 18910 | 0,242 | 0,16 | 0,66 | 3 | 0,322 | 0,227 | |
| FLT03: Latvian/Rt | 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: Internatio | 13068 | 0,255 | 0,191 | 0,75 | 3 | 0,268 | 0,314 | |
| FLT03: Latvian/Rt | 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/Rt | 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 |

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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/Rt | 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/Rt | 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 |

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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:\recspr11.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 | Weighted Average Prediction | Log WAP | Int Std Error | Ext Std Error | Var Ratio | VPA | Log VPA |
|----------------|-----------------------------------|------------|---------------------|---------------------|--------------|--------|------------|
| (Age 1) | | | | | | | |
| 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
 Exploitation 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 | | | | | | |
| 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

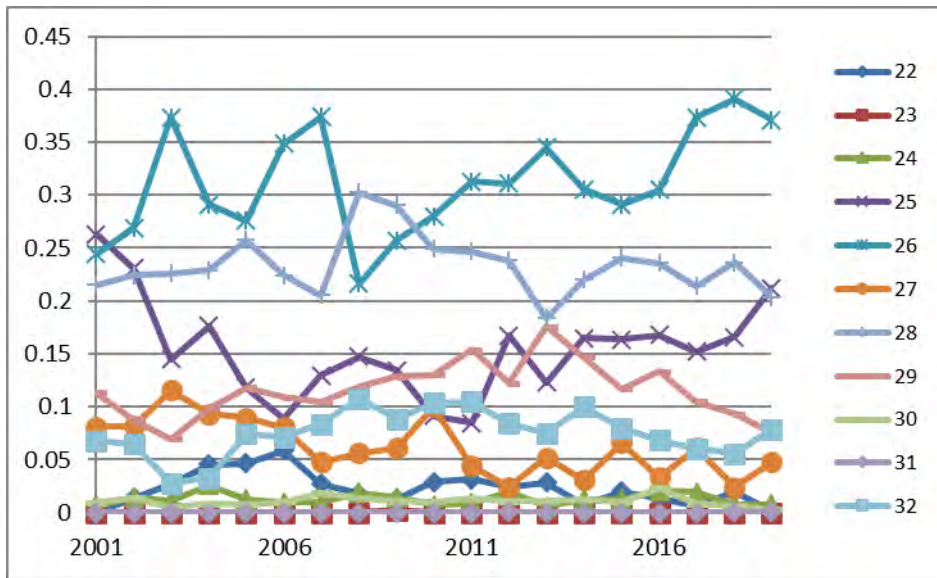


Figure 7.1. Sprat in subdivisions 22-32. Share of catches by Subdivision in 2001-2019

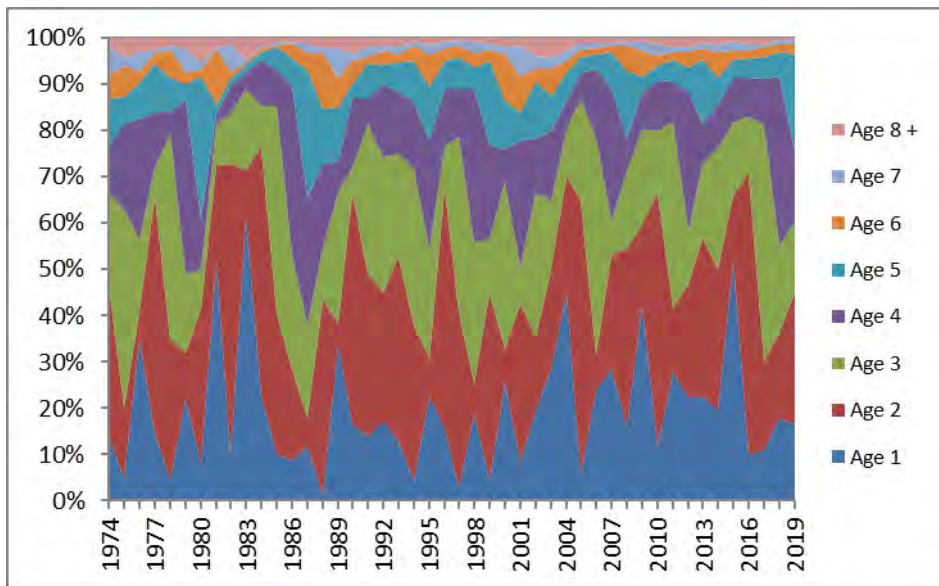


Figure 7.2. Sprat in SD 22-32. Relative catch-at-age in numbers.

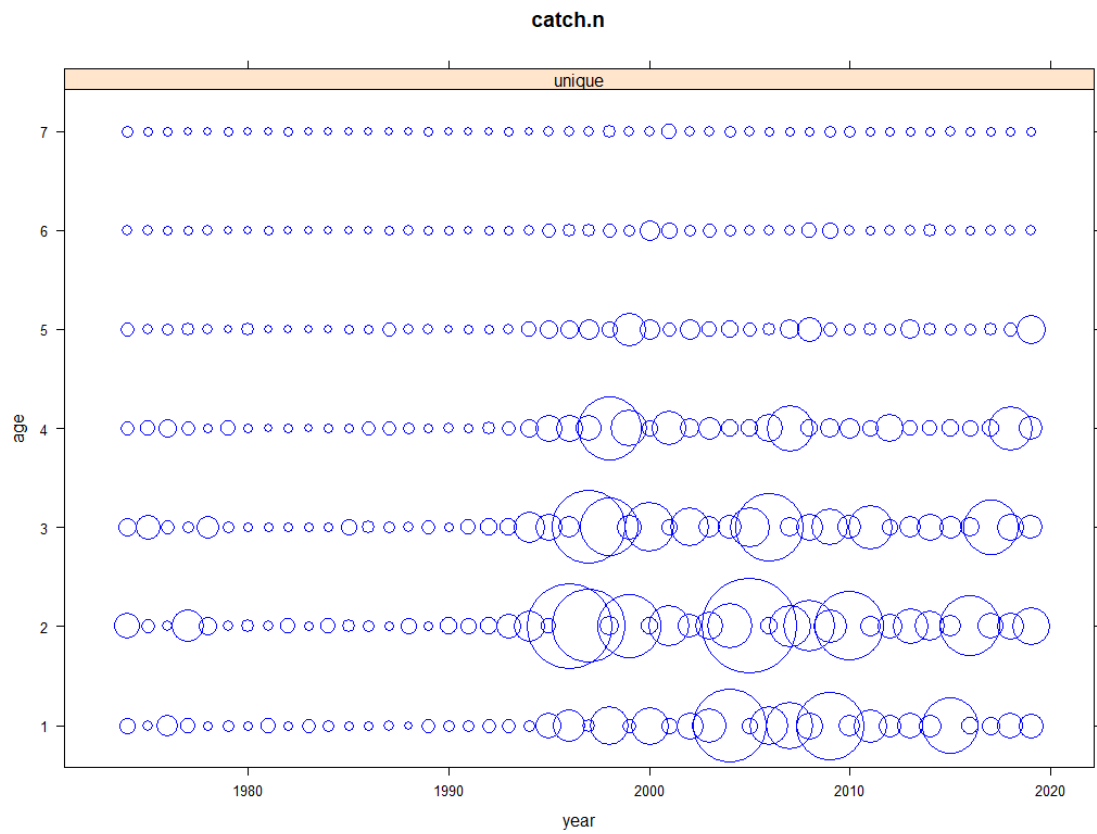


Figure 7.3. Sprat in SD 22-32. CANUM consistency check.

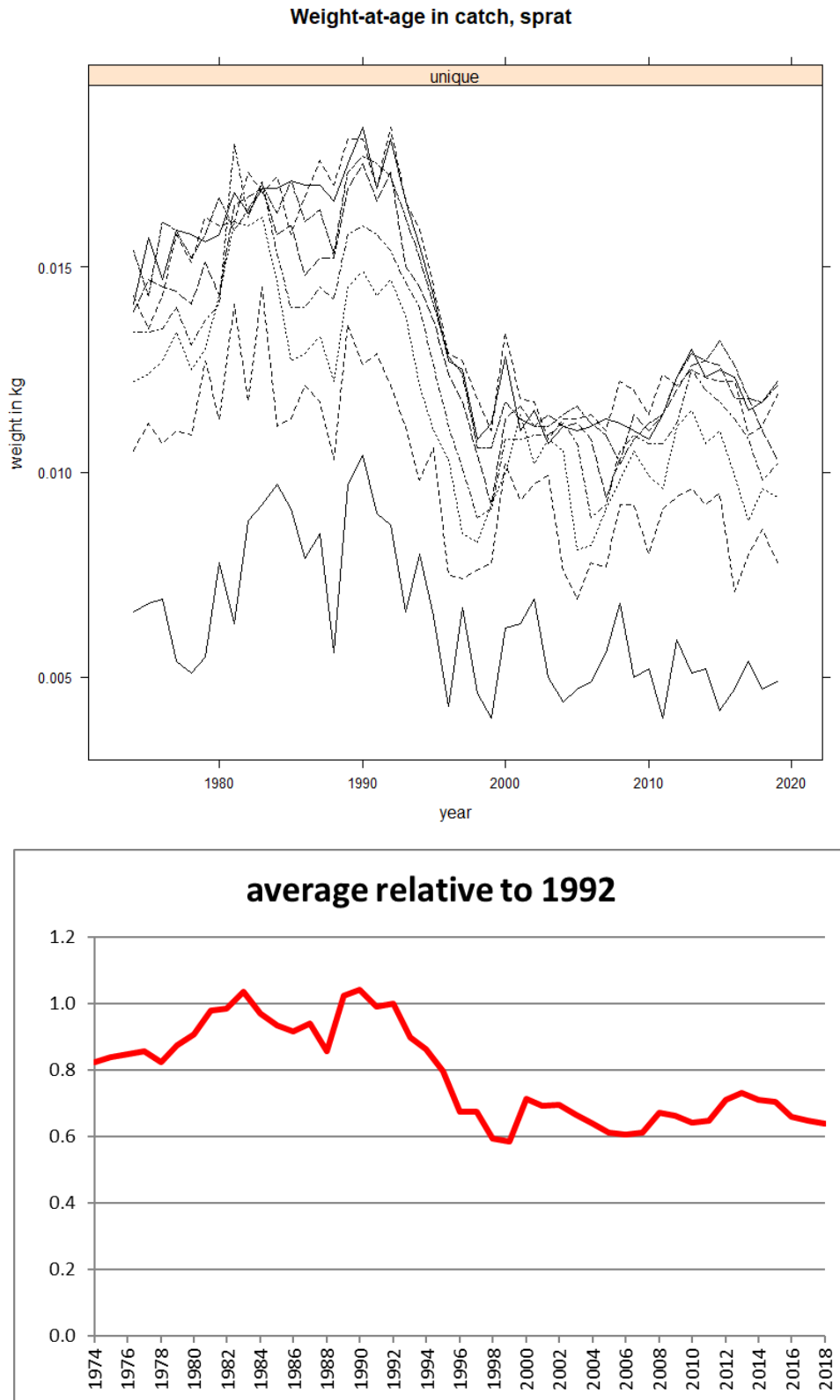


Figure 7.4. Sprat in SD 22-32: mean weight-at-age in the catches by ages and average of values relative to weights in 1992 (weight in the stock assumed as in the catches).

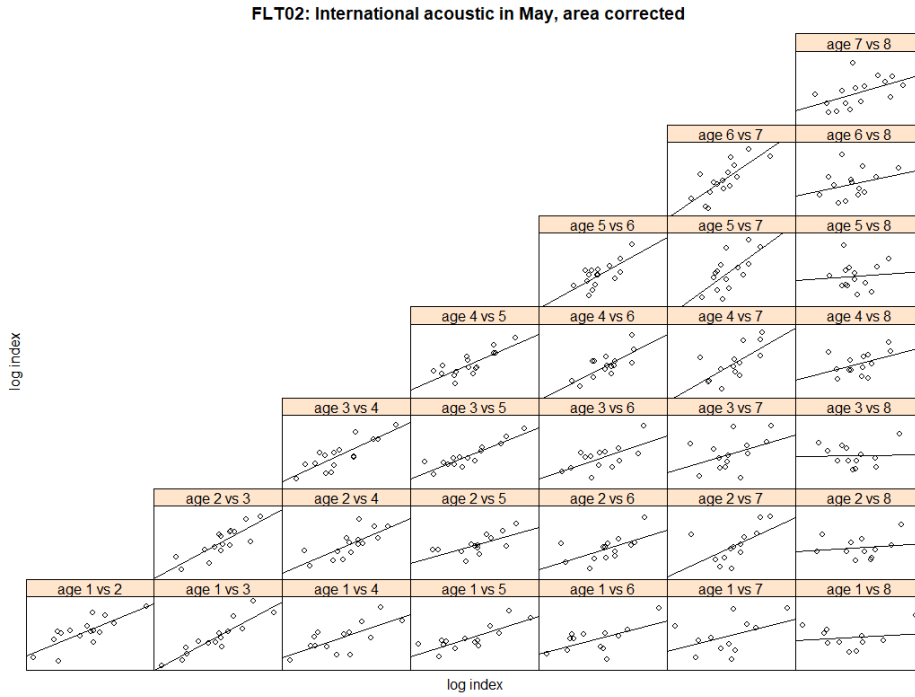


Figure 7.5a. Sprat in SD 22-32. Check for consistency in October acoustic survey estimates.

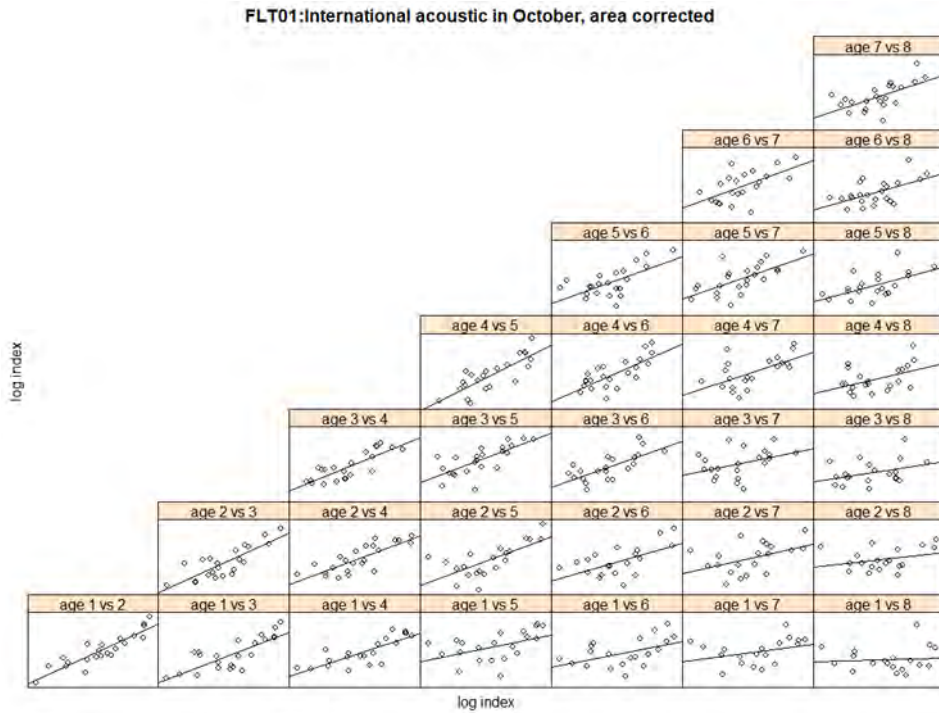


Figure 7.5b. Sprat in SD 22-32. Check for consistency in May acoustic survey estimates.

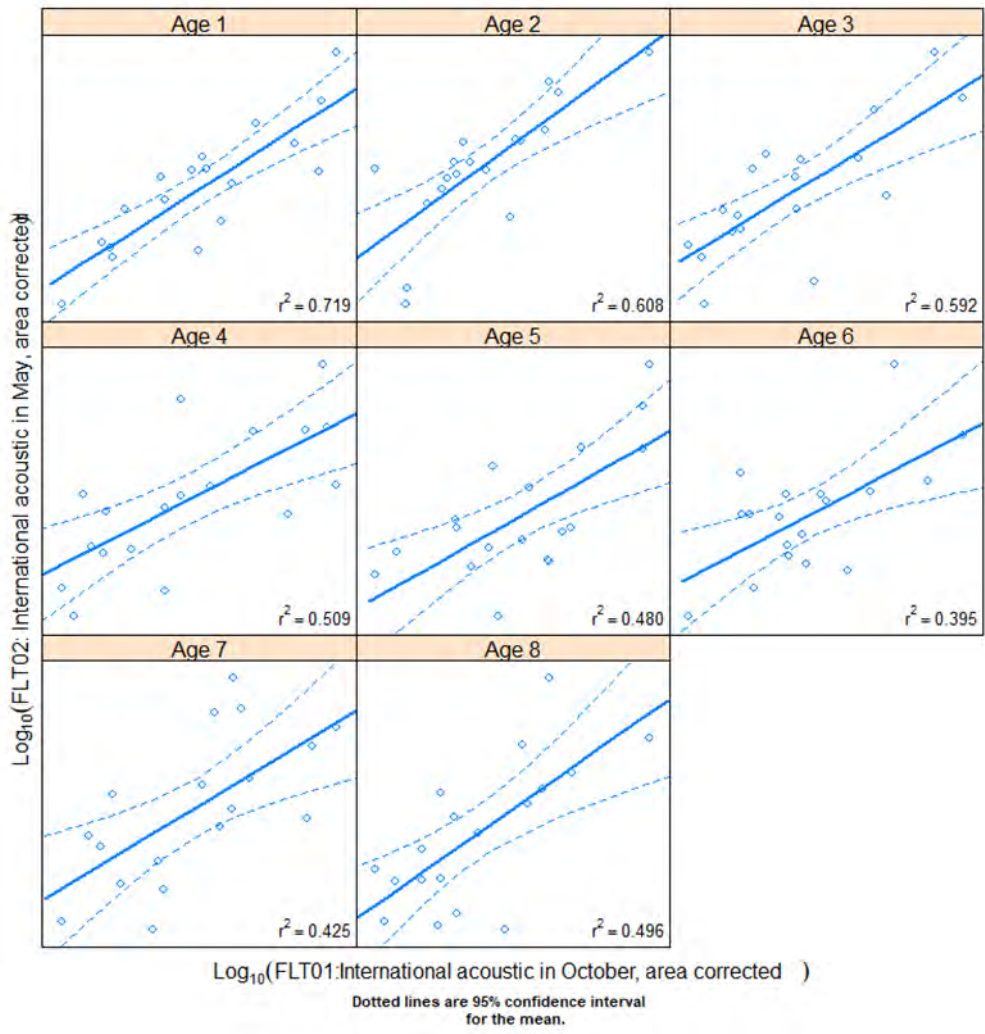


Figure 7.5c. Sprat in SD 22-32. Check for consistency between May and October surveys.

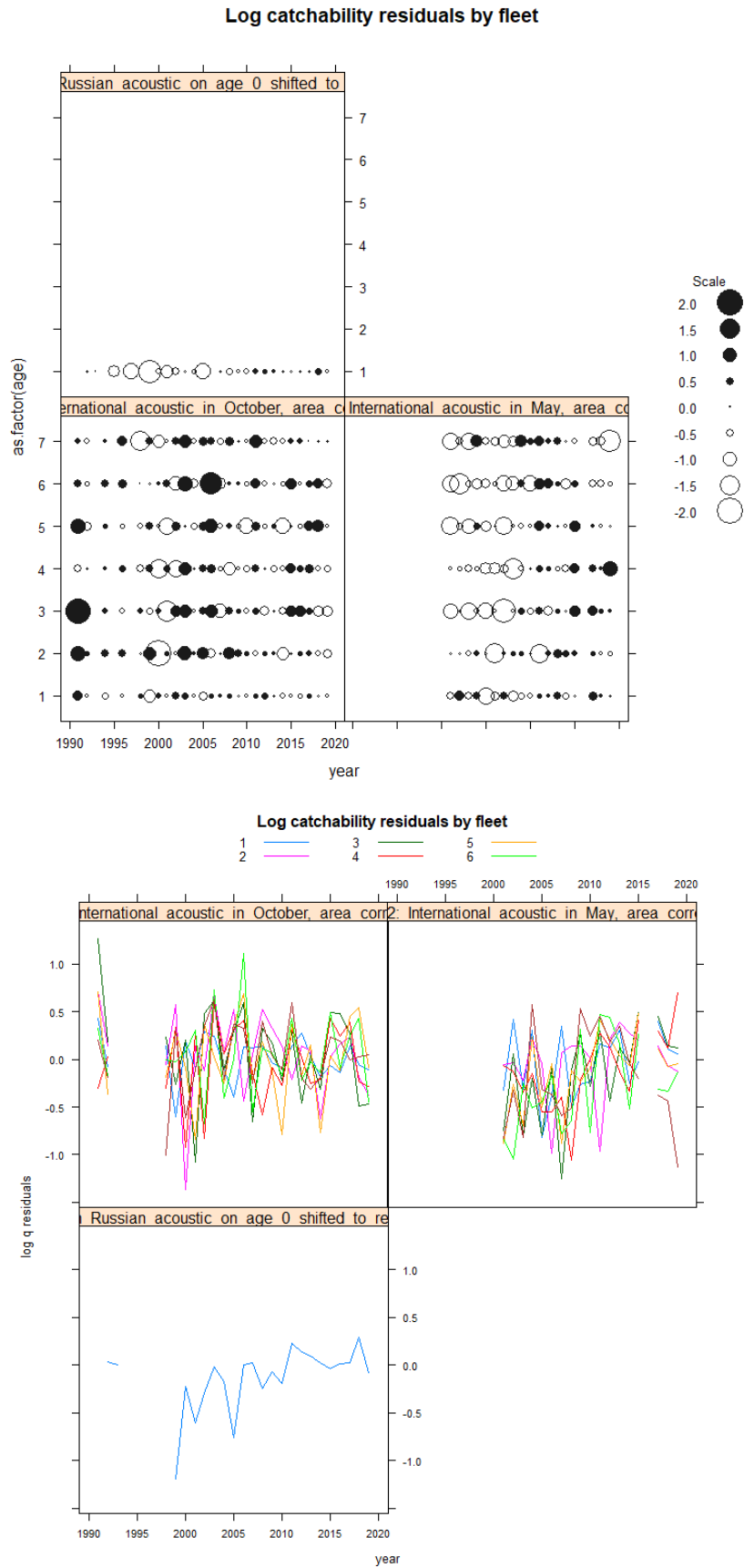


Figure 7.6. Sprat in SD 22-32. Log catchability residuals by fleet presented in two ways.

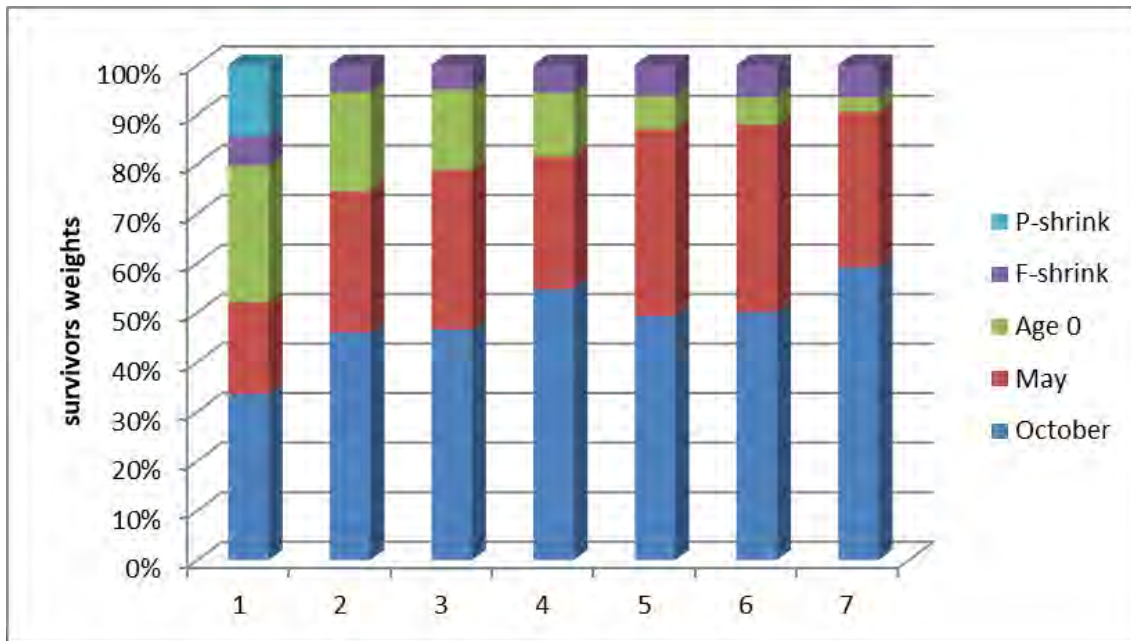


Figure 7.7a. Sprat In SD 22-32. Weights of survivors' estimates by fleet used to provide final survivors estimates.

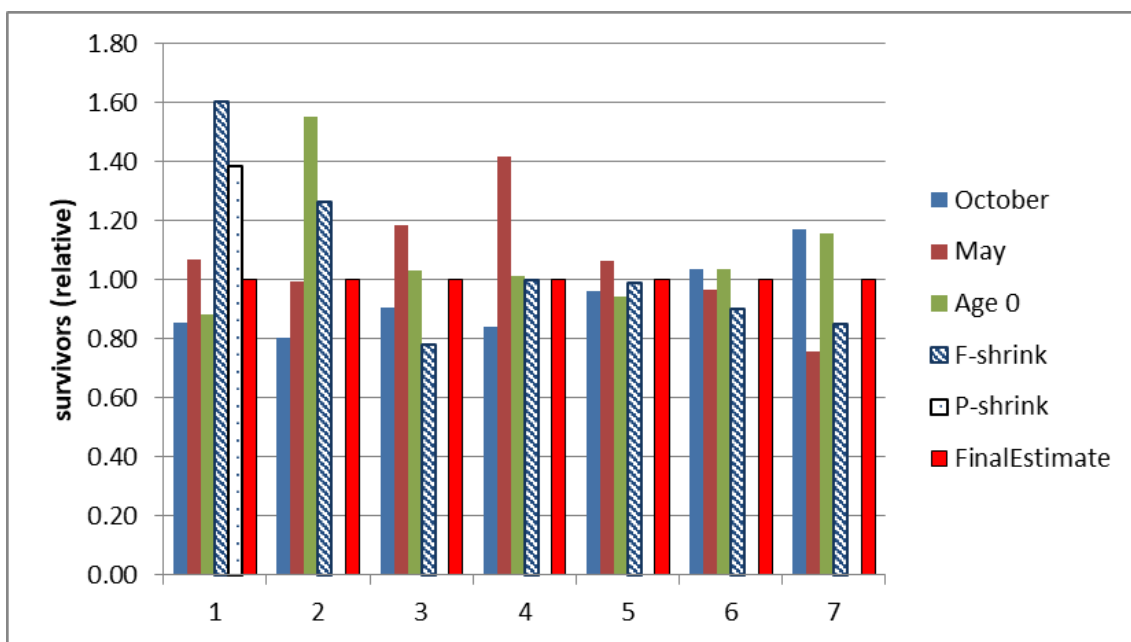


Figure 7.7b. Sprat in SD 22-32. Survivors' estimates by fleet and age relative to final estimate.

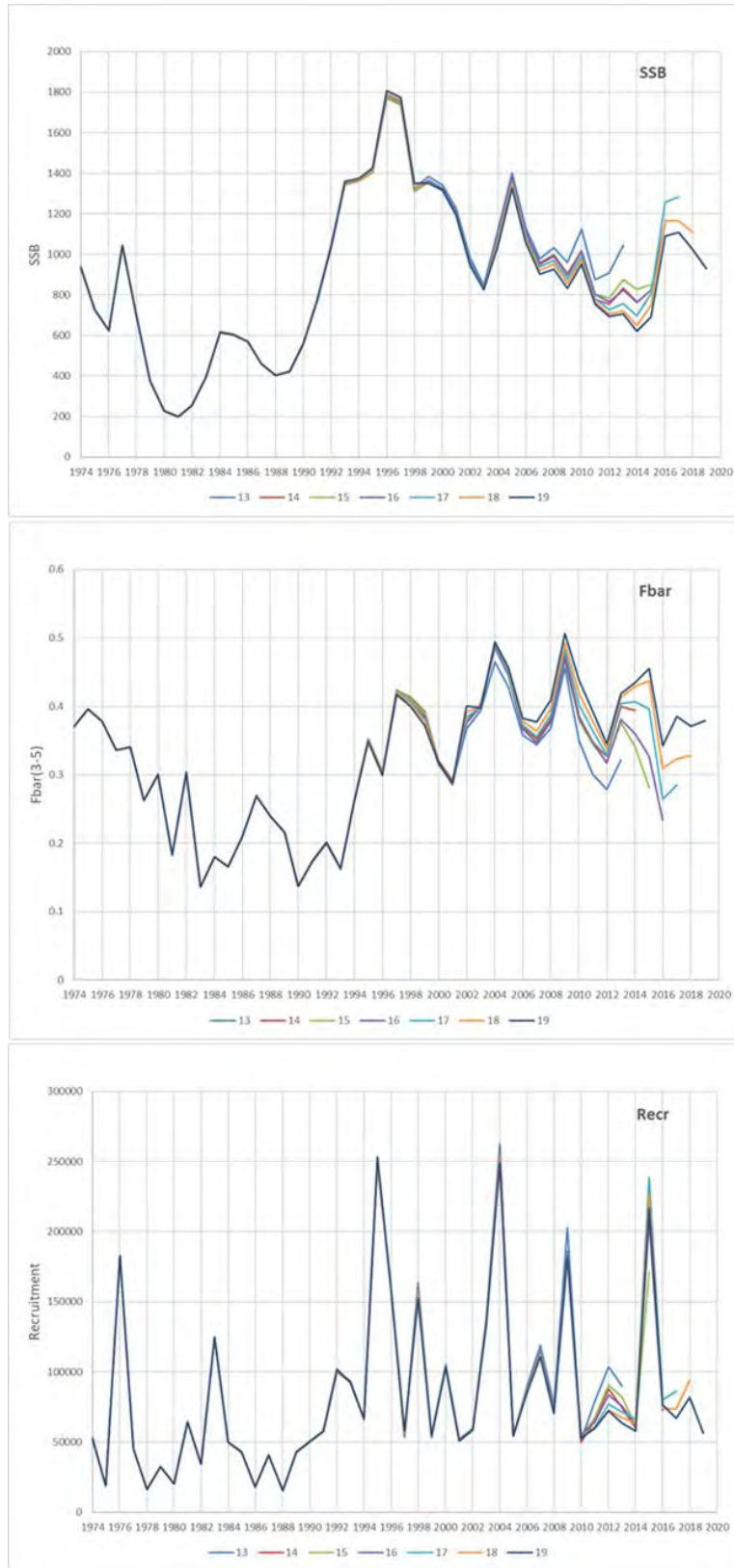


Figure 7.8a. Sprat in SD 22-32. Retrospective analysis from XSA.

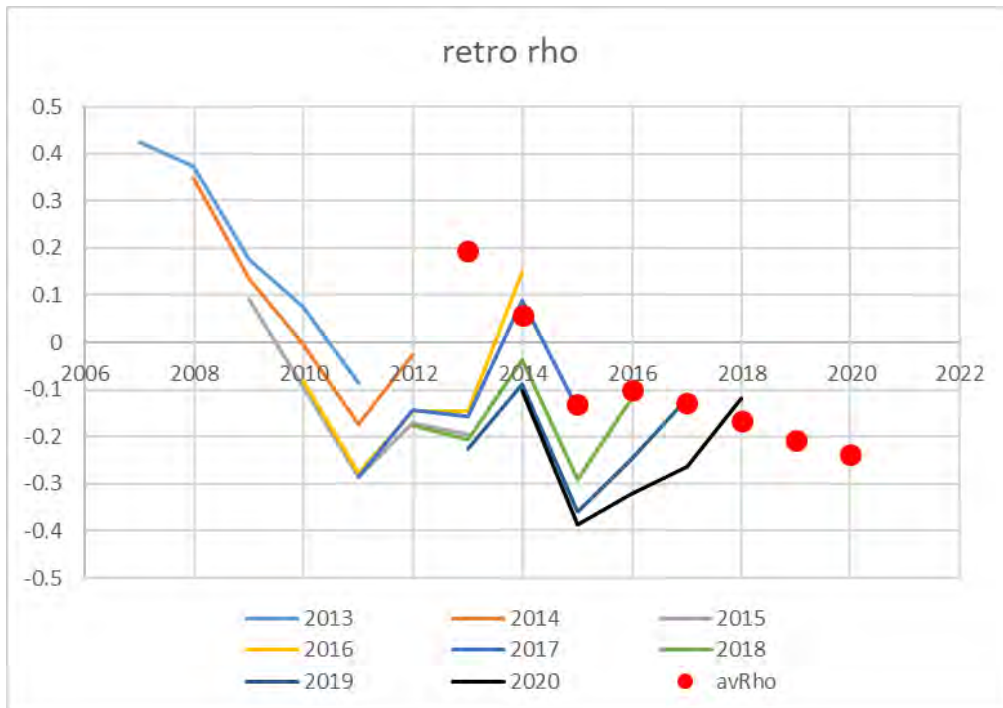


Figure 7.8b. Retrospective estimates of Mohn's rho for fishing mortality. Red dots represent the rho for given assessment year and lines represent deviations of retrospective estimates of F from F in reference assessment (dots are averages of five deviations represented in the lines).

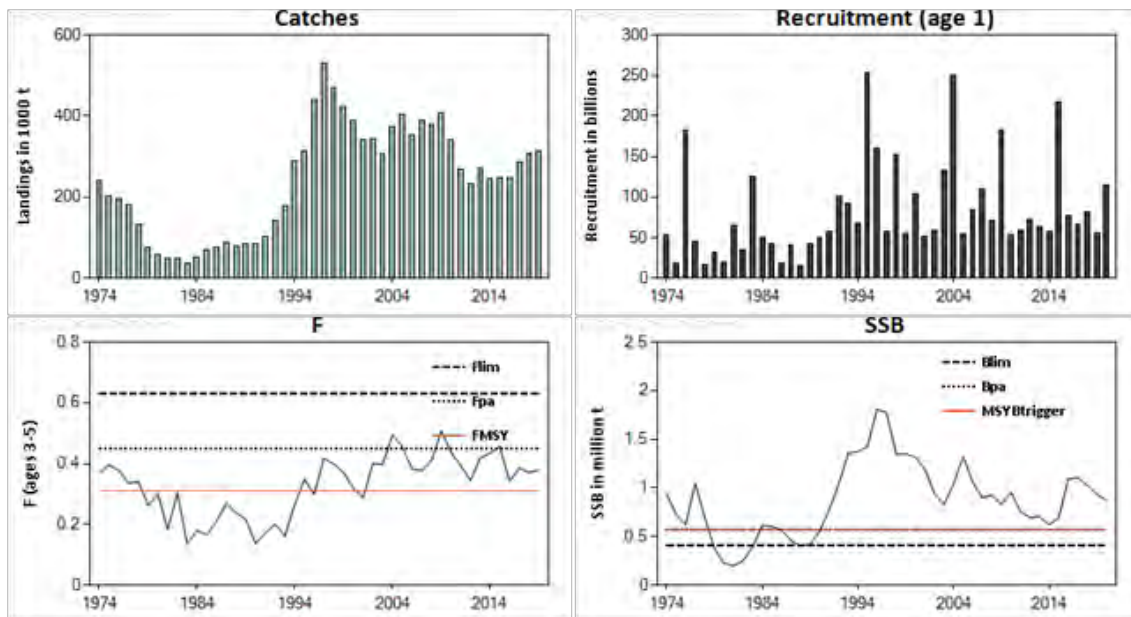


Figure 7.9. Sprat in SD 22–32. Summary sheet plots: landings, fishing mortality, recruitment (age 1) and spawning stock biomass.

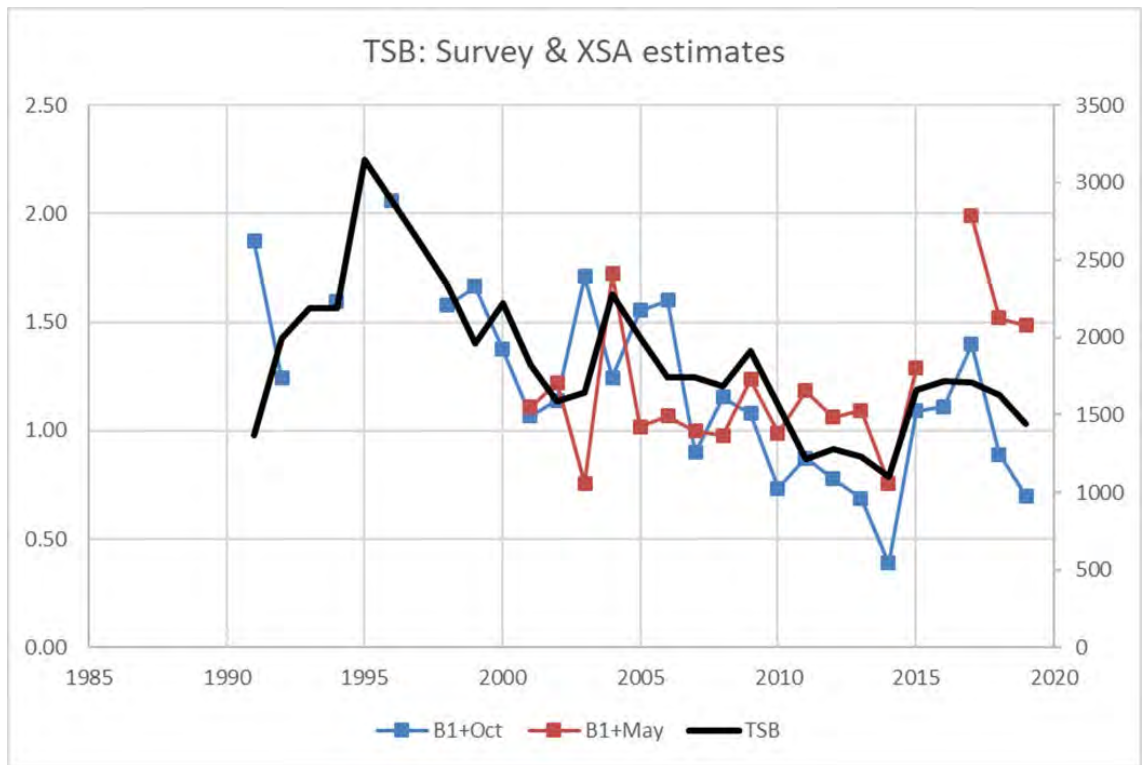


Figure 7.10a. Sprat in SD 22-32. Comparison of survey (age 1+) stock size estimates with TSB.

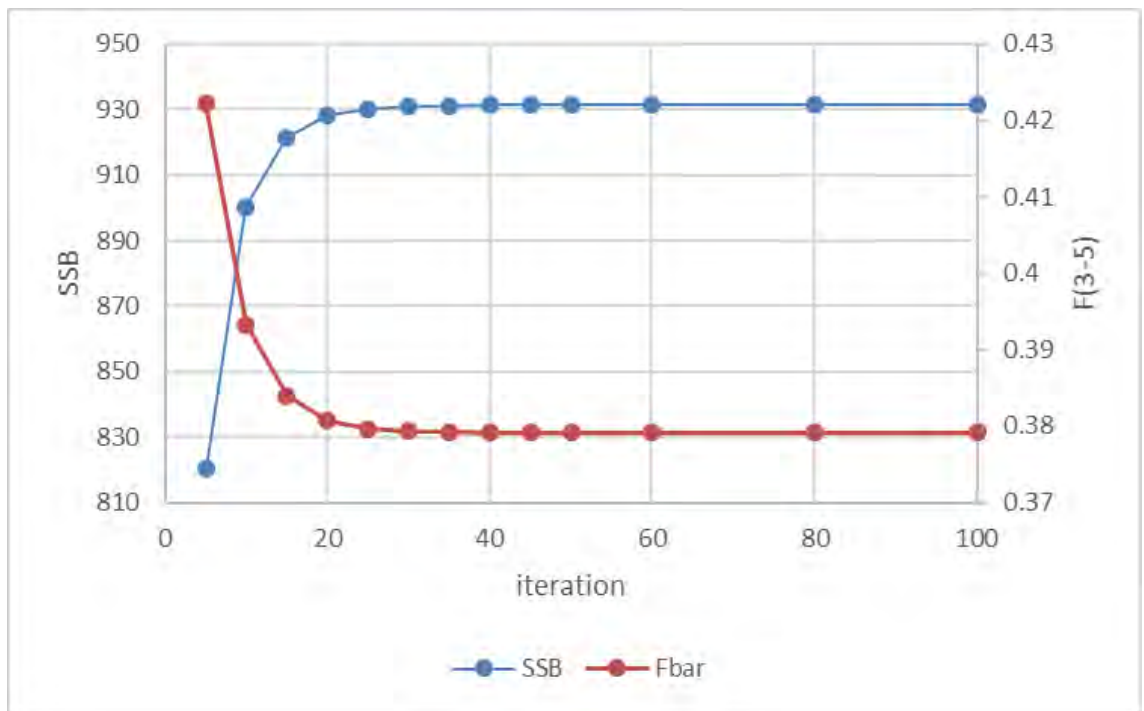


Figure 7.10b Sprat in SD 22-32. Convergence of the method: the dependence of SSB and Fbar estimates in terminal year on number of iterations.

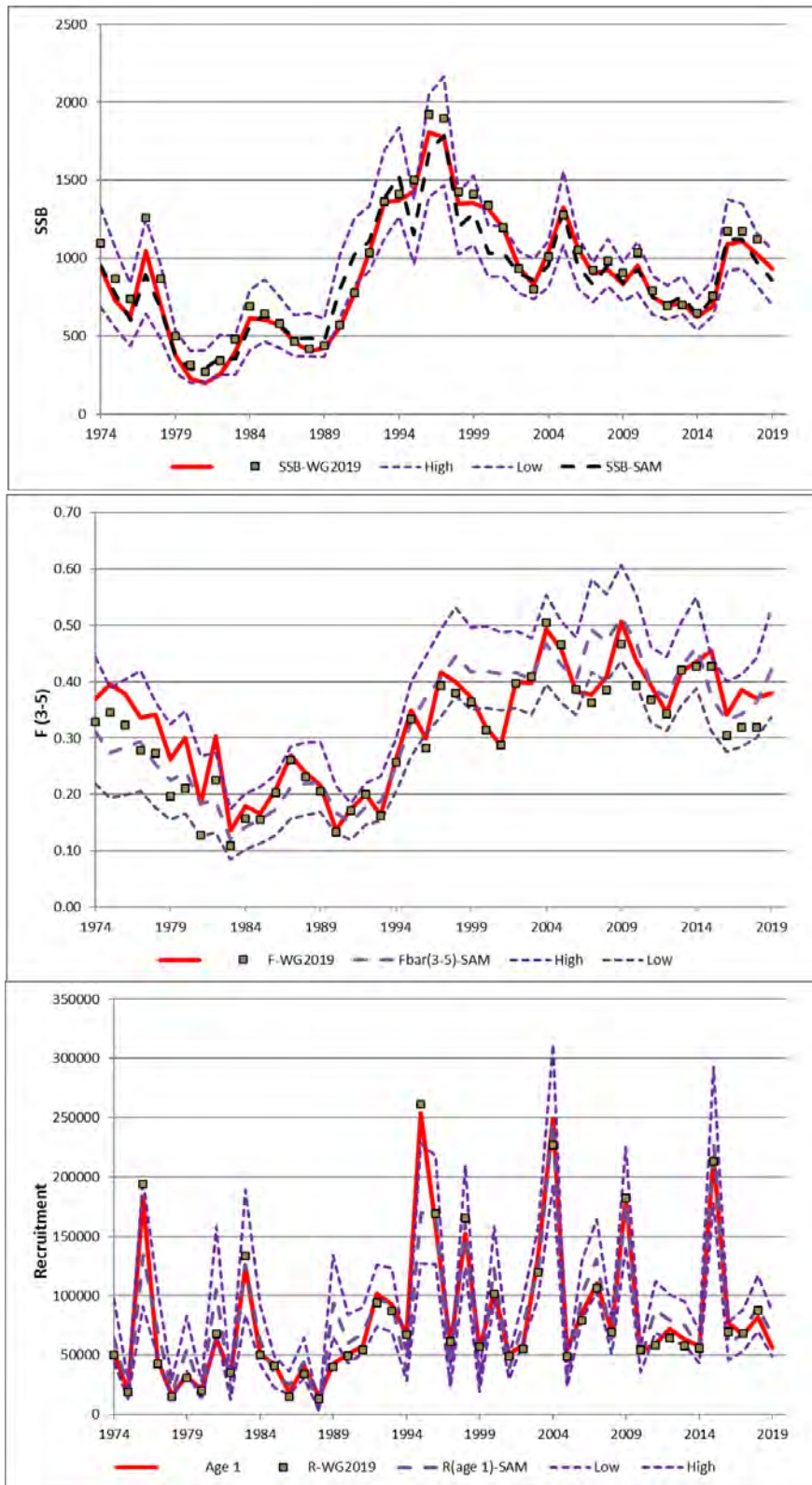


Figure 7.11. Sprat in SD 22-32. Comparison of spawning stock biomass, fishing mortality, and recruitment (age 1) from XSA (present and 2019) and SAM. Uncertainties of SAM estimates are shown (thin, broken lines).

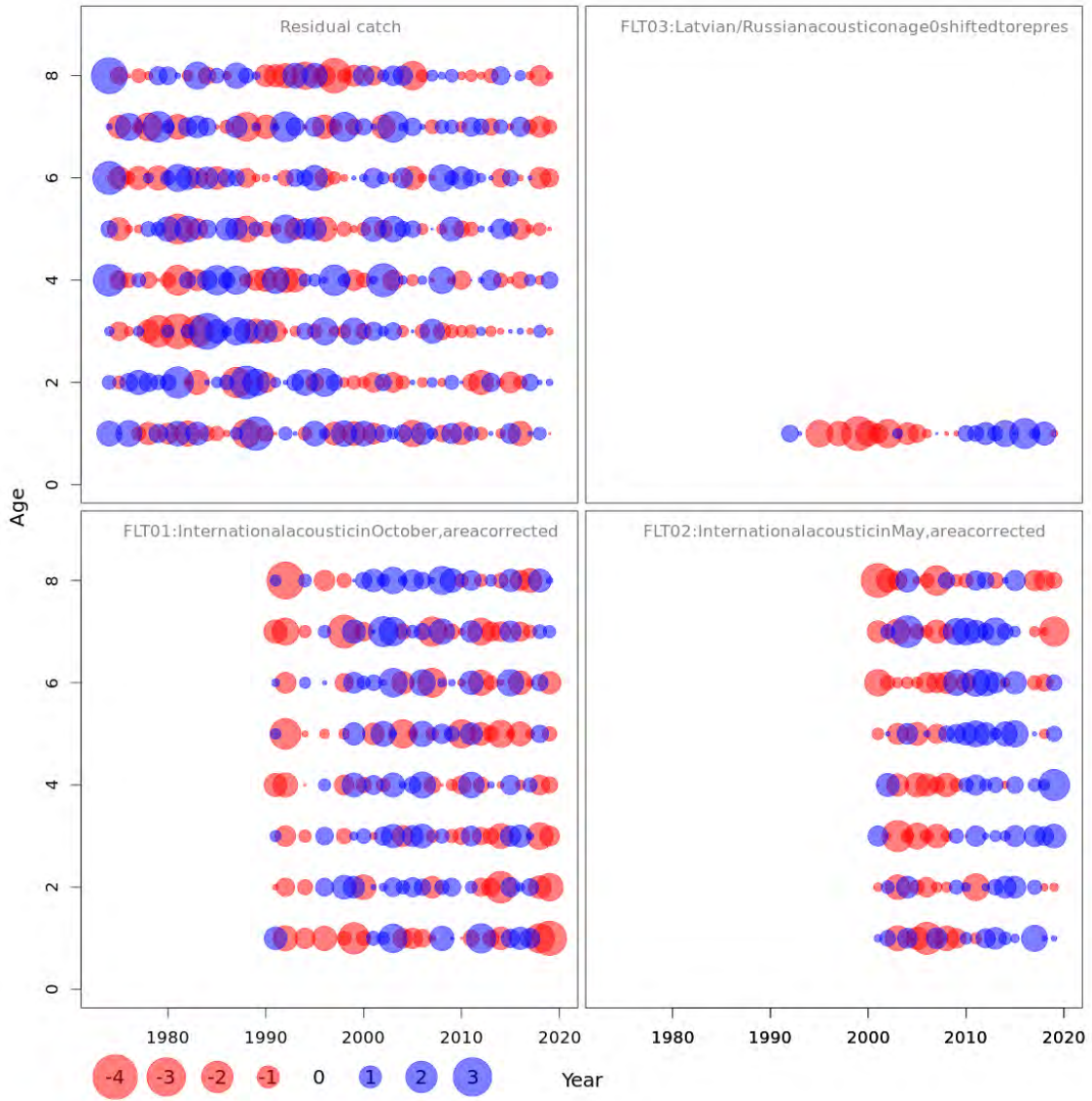


Figure 7.12a. Sprat in SD 22-32. Log catchability residuals by fleet from SAM.

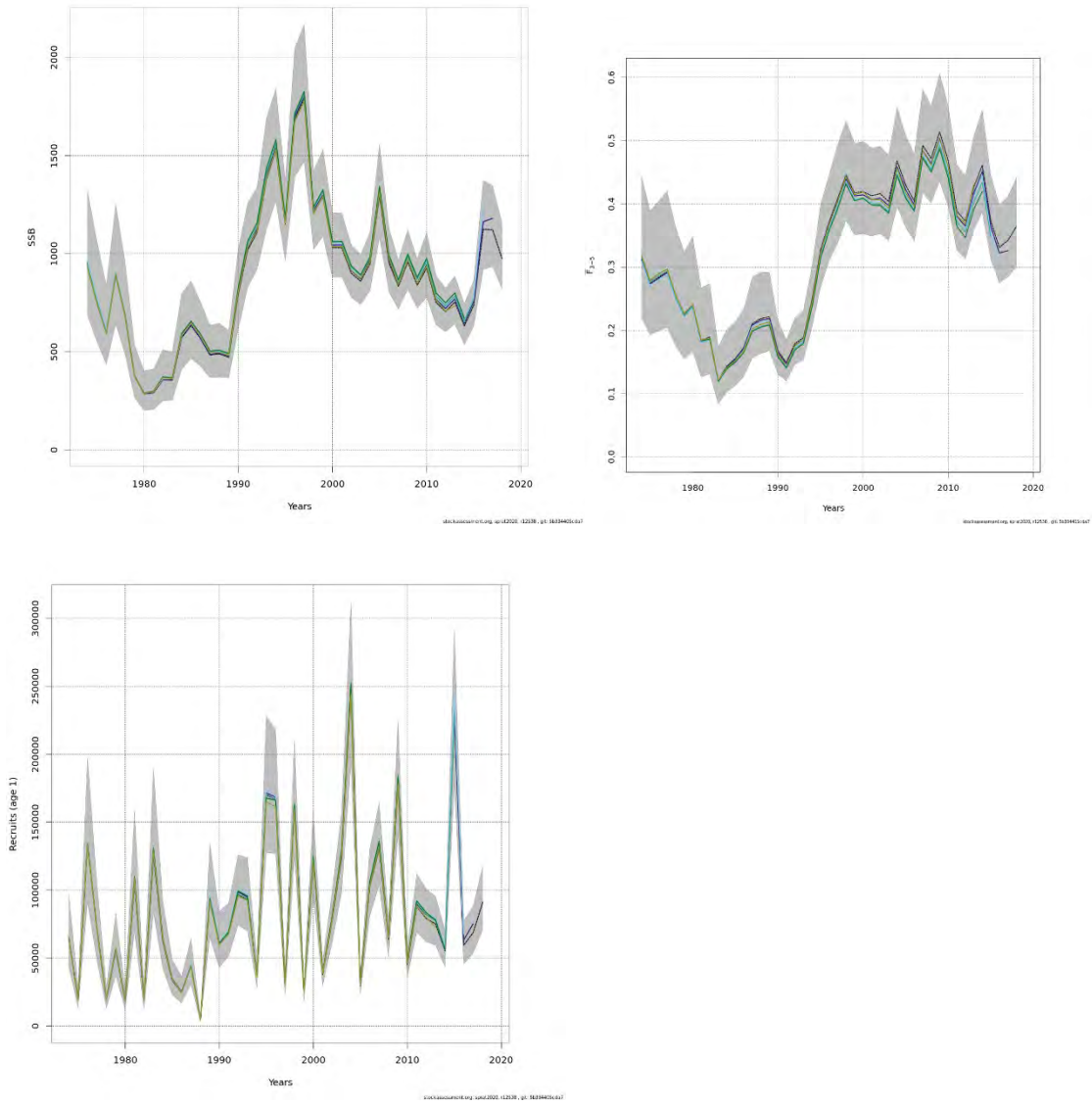


Figure 7.12b. Sprat in SD 22-32. Retrospective analysis from SAM.

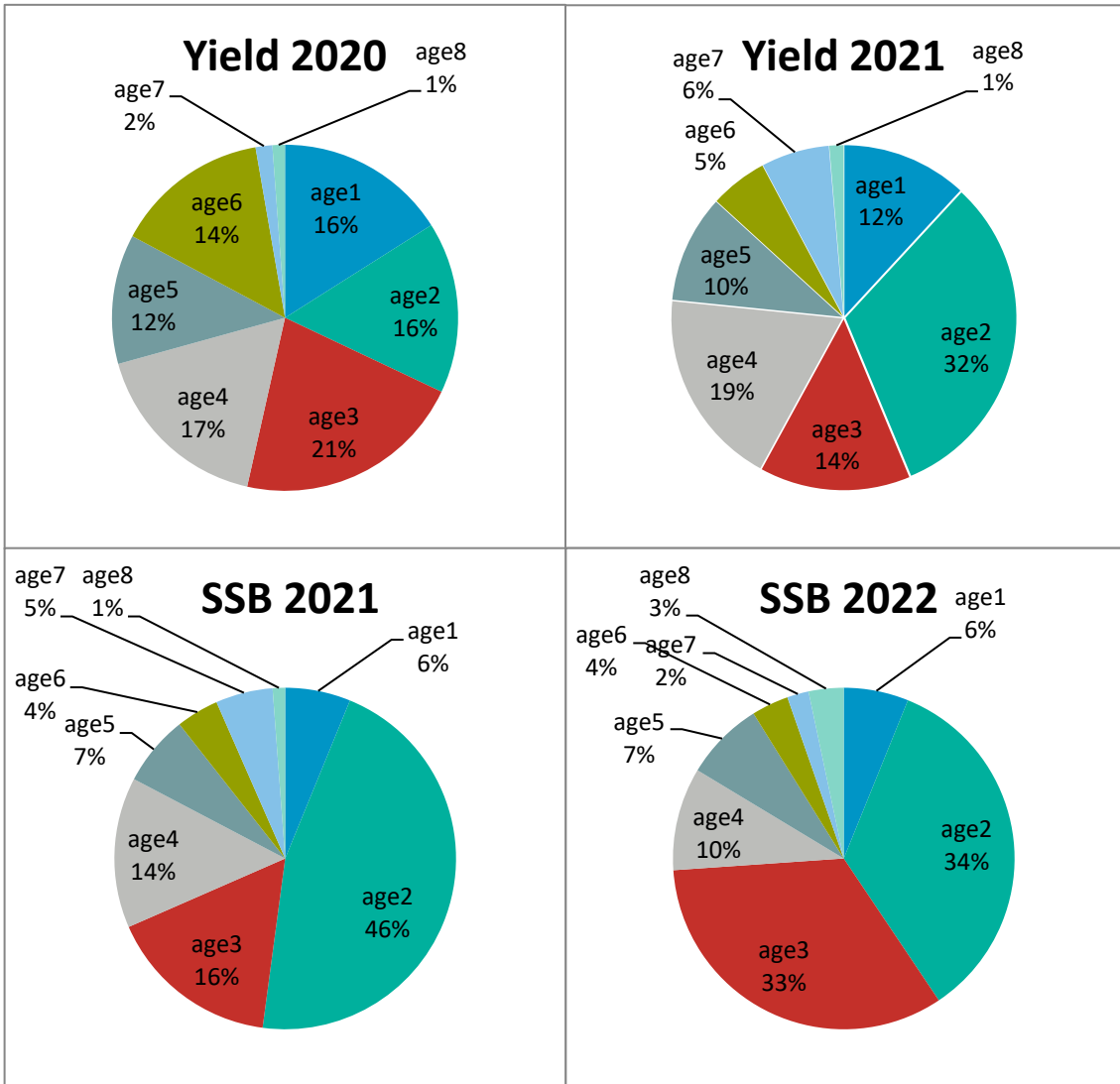


Figure 7.13. Sprat in SD 22-32. Short-term forecast for 2020-2022. Yield and SSB by age 1-8+ under the TAC constraint in 2020

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 decrease 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 significantly different results. Applying the new method, the fishing mortality estimate declined by a factor of about two. WKFLABA did not make suggestions for turbot stocks in the Baltic Sea. Genetic information did not show any stock structure while tagging data indicated the existence of small local stocks. Further investigations, especially in the Eastern part of Baltic Sea are recommended.

8.1.3 Fishery independent information

Stock indices (CPUE) were estimated as mean catch-in-number per hour for turbot with a length of ≥ 20 cm. The CPUE values of the small TV were multiplied with a conversion factor of 1.4 (Figure 8.1.2). Stable index with low fluctuations were observed between 2007 and 2015. The index of 2019 decreased compared to the previous year, but is still on a low level (~ 3.43 turbot/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. Exploitation is consistent with F_{MSY} proxy ($L_{F=M}$) and optimal yield in 2019. $MSY_{Btrigger}$ is unknown. Following the ICES guidelines on DLS stocks, the precautionary buffer was not applied, as the length based indicators 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 $\rightarrow L_{inf} = 54.7$ cm

L_{mat} : average of 2002–2018, quarter 1, only females $\rightarrow L_{mat} = 20.5$ 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 overfishing of immatures (L_c/L_{mat}). Catch is close to the theoretical length of L_{opt} and L_{mean} is stable over time and close to 1, indicating fishing close to the optimal yield/exploitation consistent with F_{MSY} proxy ($L_{F=M}$).

Continued

Table 8.1.1. Turbot in the Baltic Sea. Total landings (tonnes) by ICES Subdivision and country.

| Year | Total by SD | | | | | | | | Total SD 22-32 |
|------|-------------|----|-----------------|-----|-----|----|---------|-------|-------------------|
| | 22 | 23 | 24 ³ | 25 | 26 | 27 | 28(+29) | 30-32 | |
| 1965 | 3 | 0 | 39 | 0 | 0 | 0 | 0 | 0 | 42 |
| 1966 | 21 | 0 | 74 | 0 | 0 | 0 | 0 | 0 | 95 |
| 1967 | 21 | 0 | 30 | 0 | 0 | 0 | 0 | 0 | 51 |
| 1968 | 17 | 0 | 85 | 0 | 0 | 0 | 0 | 0 | 102 |
| 1969 | 17 | 0 | 70 | 0 | 0 | 0 | 0 | 0 | 87 |
| 1970 | 16 | 0 | 55 | 0 | 0 | 0 | 0 | 0 | 71 |
| 1971 | 15 | 0 | 114 | 0 | 0 | 0 | 0 | 0 | 129 |
| 1972 | 13 | 0 | 129 | 0 | 0 | 0 | 0 | 0 | 142 |
| 1973 | 14 | 0 | 68 | 58 | 13 | 0 | 0 | 0 | 153 |
| 1974 | 16 | 0 | 69 | 34 | 36 | 0 | 0 | 0 | 155 |
| 1975 | 45 | 0 | 93 | 23 | 6 | 0 | 0 | 0 | 167 |
| 1976 | 40 | 0 | 83 | 14 | 12 | 0 | 0 | 0 | 149 |
| 1977 | 41 | 0 | 100 | 12 | 55 | 0 | 0 | 0 | 208 |
| 1978 | 44 | 0 | 74 | 7 | 3 | 0 | 0 | 0 | 128 |
| 1979 | 32 | 0 | 89 | 29 | 34 | 0 | 0 | 0 | 184 |
| 1980 | 37 | 0 | 83 | 12 | 20 | 0 | 0 | 0 | 152 |
| 1981 | 37 | 0 | 115 | 10 | 19 | 0 | 0 | 0 | 181 |
| 1982 | 39 | 0 | 81 | 6 | 17 | 4 | 3 | 0 | 150 |
| 1983 | 44 | 0 | 80 | 46 | 4 | 35 | 24 | 0 | 233 |
| 1984 | 57 | 0 | 56 | 17 | 2 | 3 | 2 | 0 | 137 |
| 1985 | 76 | 0 | 60 | 72 | 15 | 4 | 3 | 0 | 230 |
| 1986 | 130 | 0 | 119 | 40 | 37 | 7 | 5 | 0 | 338 |
| 1987 | 168 | 0 | 135 | 166 | 21 | 9 | 6 | 0 | 505 |
| 1988 | 154 | 0 | 157 | 23 | 10 | 14 | 9 | 0 | 367 |
| 1989 | 162 | 0 | 142 | 15 | 11 | 13 | 9 | 0 | 352 |
| 1990 | 208 | 0 | 197 | 24 | 25 | 0 | 0 | 0 | 454 |
| 1991 | 272 | 0 | 178 | 85 | 20 | 16 | 0 | 0 | 571 |
| 1992 | 322 | 0 | 207 | 92 | 85 | 21 | 36 | 0 | 763 |
| 1993 | 233 | 31 | 212 | 534 | 106 | 13 | 38 | 0 | 1167 |
| 1994 | 263 | 20 | 226 | 408 | 46 | 17 | 44 | 0 | 1024 |
| 1995 | 322 | 13 | 150 | 88 | 93 | 31 | 110 | 0 | 807 |
| 1996 | 244 | 15 | 157 | 392 | 236 | 55 | 107 | 0 | 1206 |
| 1997 | 211 | 2 | 126 | 363 | 188 | 53 | 100 | 0 | 1043 |
| 1998 | 182 | 2 | 139 | 125 | 239 | 18 | 93 | 0 | 798 |
| 1999 | 129 | 2 | 111 | 59 | 144 | 17 | 94 | 0 | 556 |
| 2000 | 120 | 2 | 115 | 129 | 95 | 16 | 48 | 0 | 525 |
| 2001 | 95 | 2 | 89 | 137 | 102 | 9 | 30 | 0 | 464 |
| 2002 | 93 | 5 | 56 | 266 | 135 | 7 | 29 | 0 | 591 |
| 2003 | 58 | 1 | 69 | 208 | 225 | 3 | 16 | 0 | 579 |
| 2004 | 73 | 1 | 55 | 241 | 121 | 3 | 22 | 0 | 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 included² For the years 1970-1981 and 1990 catches of Subdivisions 25-28 are included in Subdivision 24³ For the years 1970-1981 and 1990 Swedish catches of Subdivisions 25-28 are included in Subdivision 24⁴ 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 |
|-------------------|---|--|------------------------------------|----------------|----------------------------------|
| $L_{\max 5\%}$ | Mean length of largest 5% | L_{inf} | $L_{\max 5\%} / L_{\text{inf}}$ | > 0.8 | Conservation (large individuals) |
| $L_{95\%}$ | 95th percentile | | $L_{95\%} / L_{\text{inf}}$ | | |
| P_{mega} | Proportion of individuals above $L_{\text{opt}} + 10\%$ | 0.3–0.4 | P_{mega} | > 0.3 | |
| $L_{25\%}$ | 25th percentile of length distribution | L_{mat} | $L_{25\%} / L_{\text{mat}}$ | > 1 | Conservation (immatures) |
| L_c | Length at first catch (length at 50% of mode) | L_{mat} | L_c / L_{mat} | > 1 | |
| L_{mean} | Mean length of individuals > L_c | $L_{\text{opt}} = \frac{3}{3+M/k} \times L_{\text{inf}}$ | $L_{\text{mean}} / L_{\text{opt}}$ | ≈ 1 | Optimal yield |
| L_{maxy} | Length class with maximum biomass in catch | $L_{\text{opt}} = \frac{3}{3+M/k} \times L_{\text{inf}}$ | $L_{\text{maxy}} / L_{\text{opt}}$ | ≈ 1 | |
| L_{mean} | Mean length of individuals > L_c | $LF=M = (0.75L_c + 0.25L_{\text{inf}})$ | $L_{\text{mean}} / LF=M$ | ≥ 1 | MSY |

Table 8.1.3. Turbot in the Baltic Sea Indicator status for the most recent three years 2015-2017.

| Year | Conservation | | | P_{mega} | Optimizing Yield | MSY |
|------|------------------------|-----------------------------|-------------------------------|-------------------|------------------------------------|--------------------------|
| | L_c / L_{mat} | $L_{25\%} / L_{\text{mat}}$ | $L_{\max 5} / L_{\text{inf}}$ | | $L_{\text{mean}} / L_{\text{opt}}$ | $L_{\text{mean}} / LF=M$ |
| 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 |

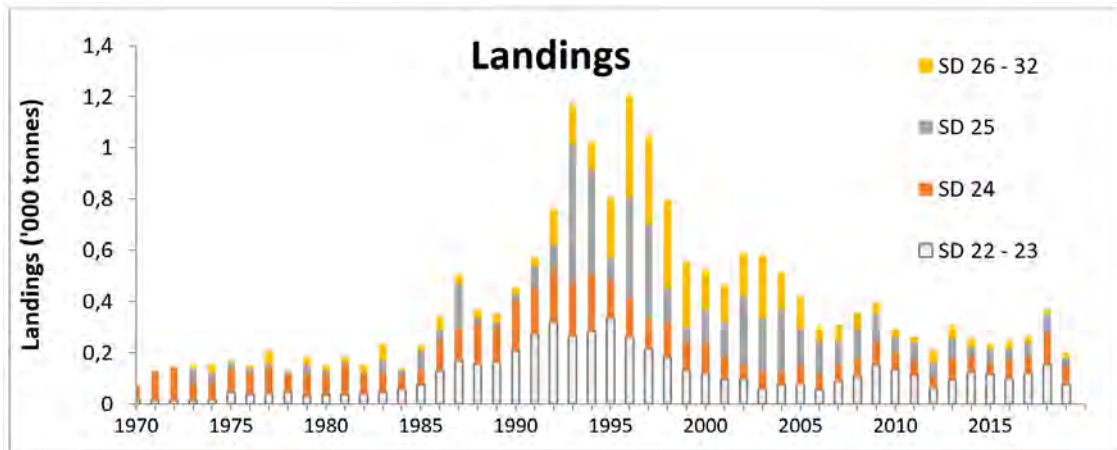


Figure 8.1.1. Turbot in the Baltic Sea. Development of turbot landings (t) from 1970 onwards by ICES subdivision (SD).

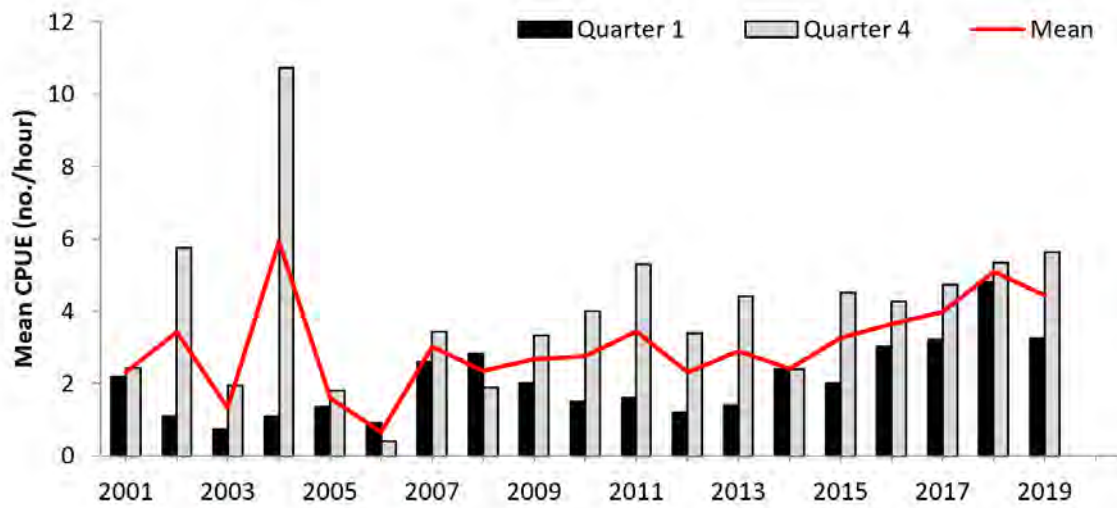


Figure 8.1.2. Turbot in the Baltic Sea. Mean CPUE (no.hr⁻¹) of turbot with L ≥ 20 cm based on arithmetic mean of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22-28.

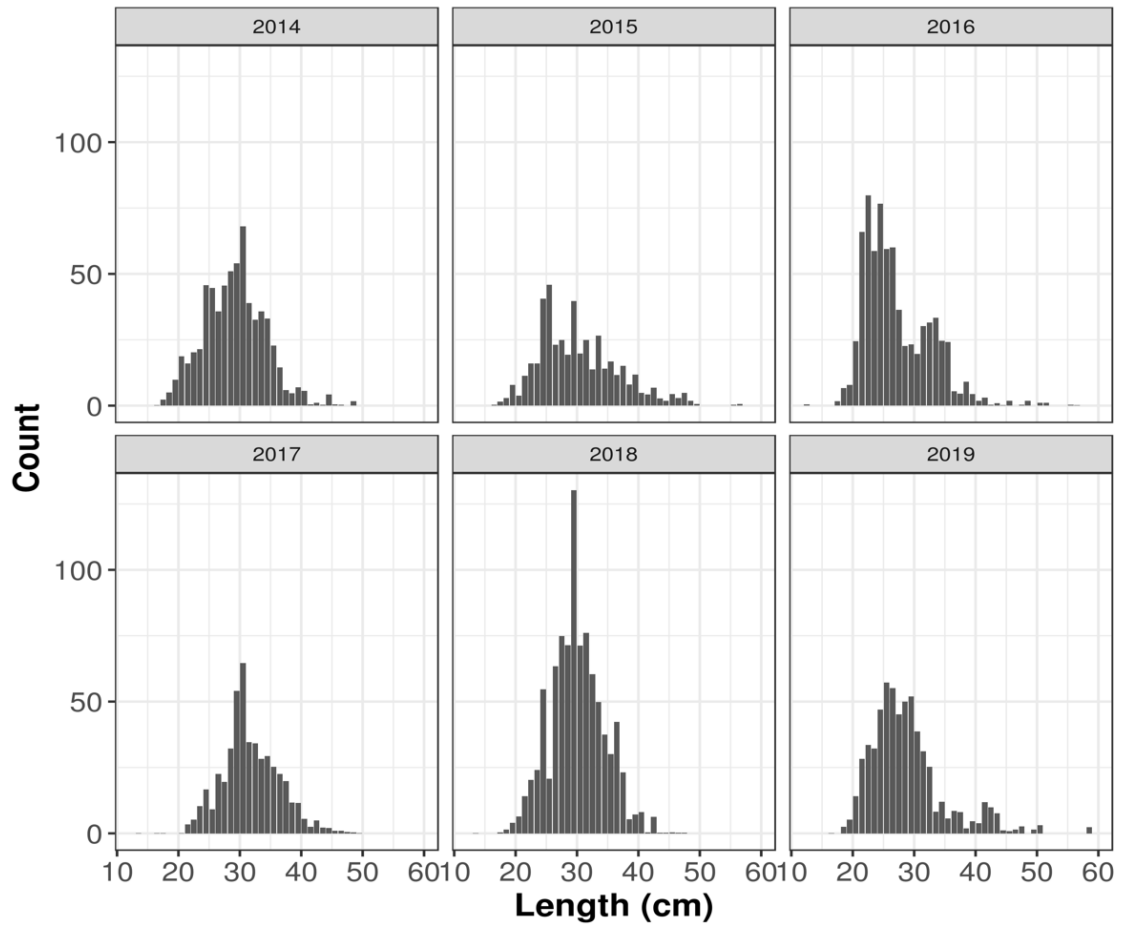


Figure 8.1.3. Turbot in subdivisions 22-32. Binned length frequency distributions.

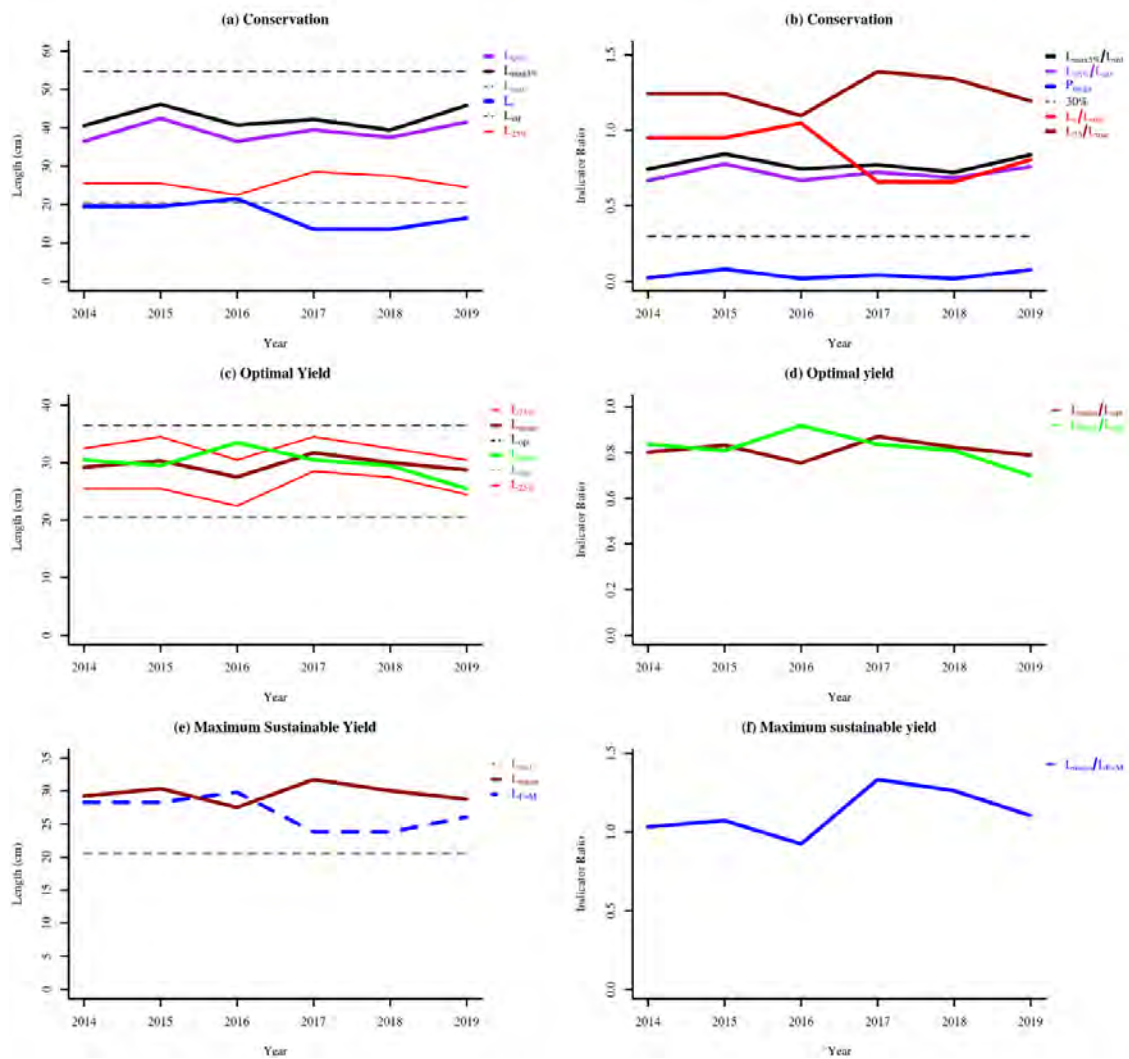


Figure 8.1.4. Turbot in subdivisions 22 to 32. Indicator trends.

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 WK LIFE 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 $\rightarrow L_{inf} = 35.61$ cm

L_{mat} : average of 2002–2018, quarter 1 only, females only $\rightarrow L_{mat} = 18$ 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 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 ($L_{F=M}$) 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 | 0 | 0 | 1.0 | 0 | 0 | 1.0 | 0 | 0 | 1173 | 23 | 89 | 0 | | | | | 1285 | | |
| 2013 | 445 | 18 | 69 | 0 | | | 834 | 17 | 0 | 0 | 0 | 0 | 0 | 1.0 | 0 | 0 | 1.0 | 0 | 0 | 1279 | 18 | 86 | 1 | | | | | 1384 | | |
| 2014 | 373 | 11 | 57 | 0 | | | 801 | 25 | 2 | 0 | 0 | 0 | 0 | 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 | 0 | | | 1027 | 23 | 1 | 0 | 0 | 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 | 0 | | | 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 > L_c | $L_{opt} = \frac{3}{3 + M/k} \times L_{inf}$ | L_{mean} / L_{opt} | ≈ 1 | Optimal yield |
| L_{maxy} | Length class with maximum biomass in catch | $L_{opt} = \frac{3}{3 + M/k} \times L_{inf}$ | L_{maxy} / L_{opt} | ≈ 1 | |
| L_{mean} | Mean length of individuals > L_c | $LF=M = (0.75L_c + 0.25L_{inf})$ | $L_{mean} / LF=M$ | ≥ 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.

| Year | Conservation | | | P_{mega} | Optimizing Yield | MSY |
|------|-----------------|----------------------|------------------------|------------|----------------------|-------------------|
| | L_c / L_{mat} | $L_{25\%} / L_{mat}$ | $L_{max5\%} / L_{inf}$ | | L_{mean} / L_{opt} | $L_{mean} / LF=M$ |
| 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 |

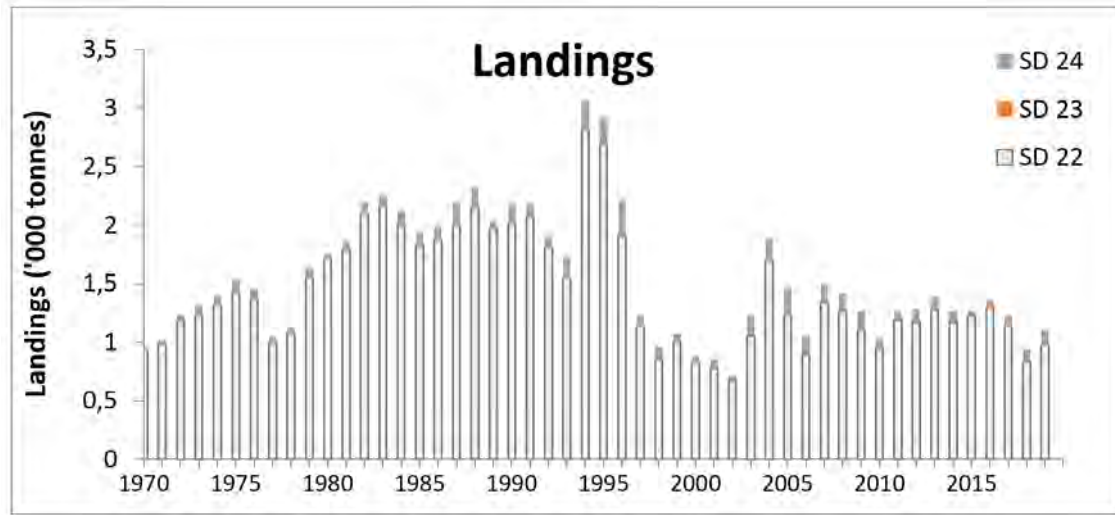


Figure 8.2.1. Dab in subdivisions 22 to 32. Development of dab landings (t) from 1970 onwards by ICES subdivision (SD).

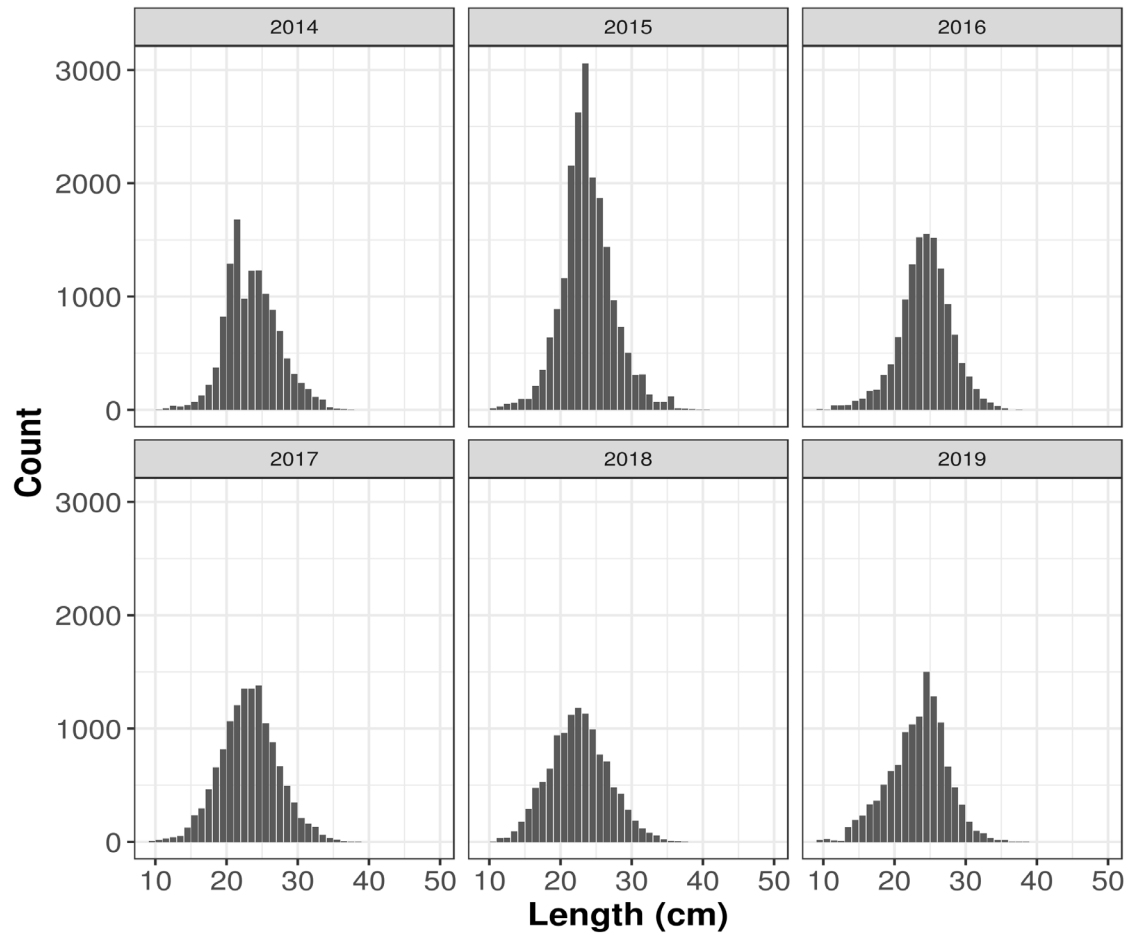


Figure 8.2.2. Dab in subdivisions 22 to 32. Catch in numbers per length for the three most recent years 2014–2019.

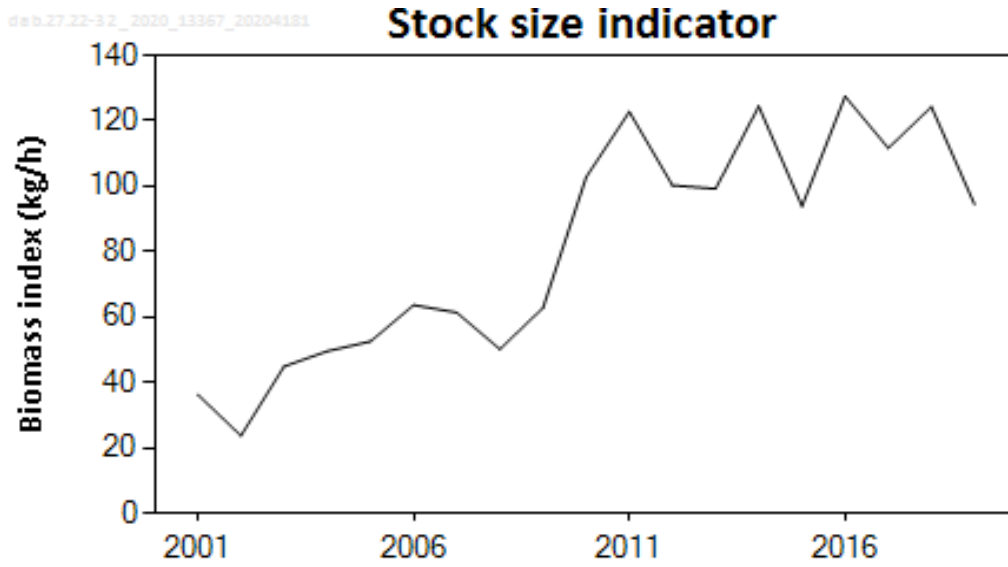


Figure 8.2.3. Dab in subdivisions 22 to 32. Mean biomass (kg hr⁻¹) of dab with L ≥ 15 cm based of the Baltic International Trawl Survey (BITS-Q1+Q4) in subdivisions (SD) 22–24.

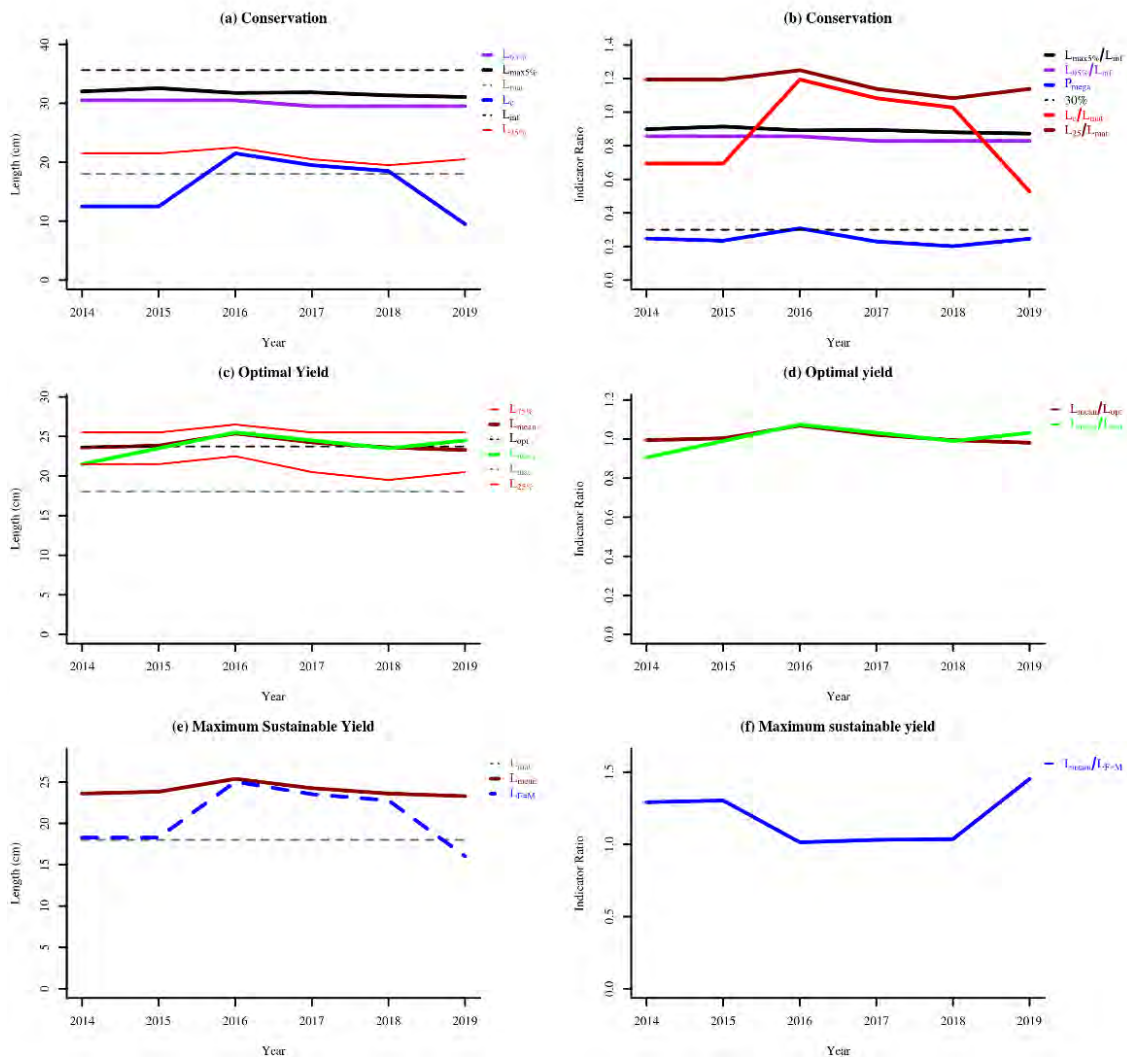


Figure 8.2.4. Dab in subdivisions 22 to 32. LBI F_{MSY} Proxy reference points

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 country¹.

| 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

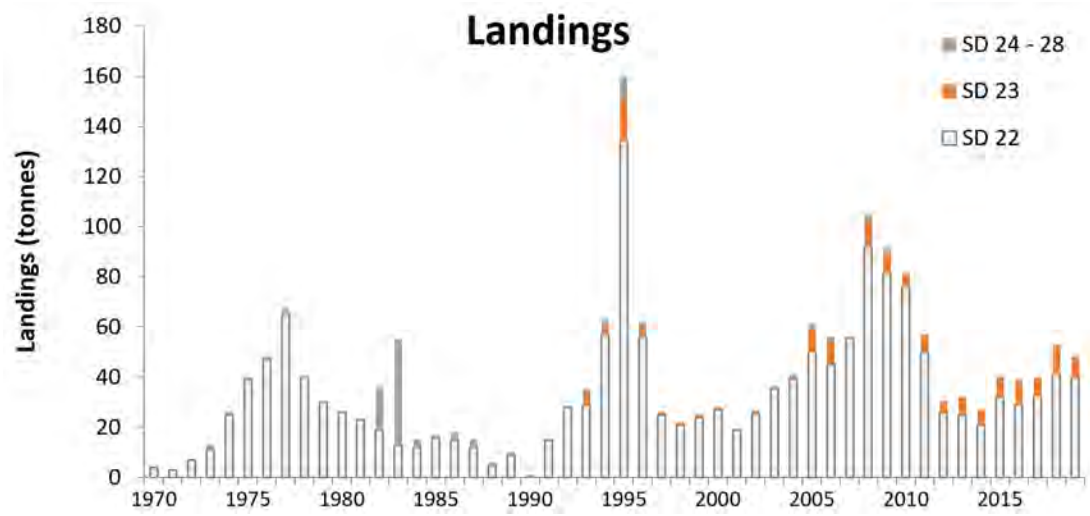


Figure 8.3.1. Development of brill landings (t) from 1970 onwards by ICES Subdivision (SD).

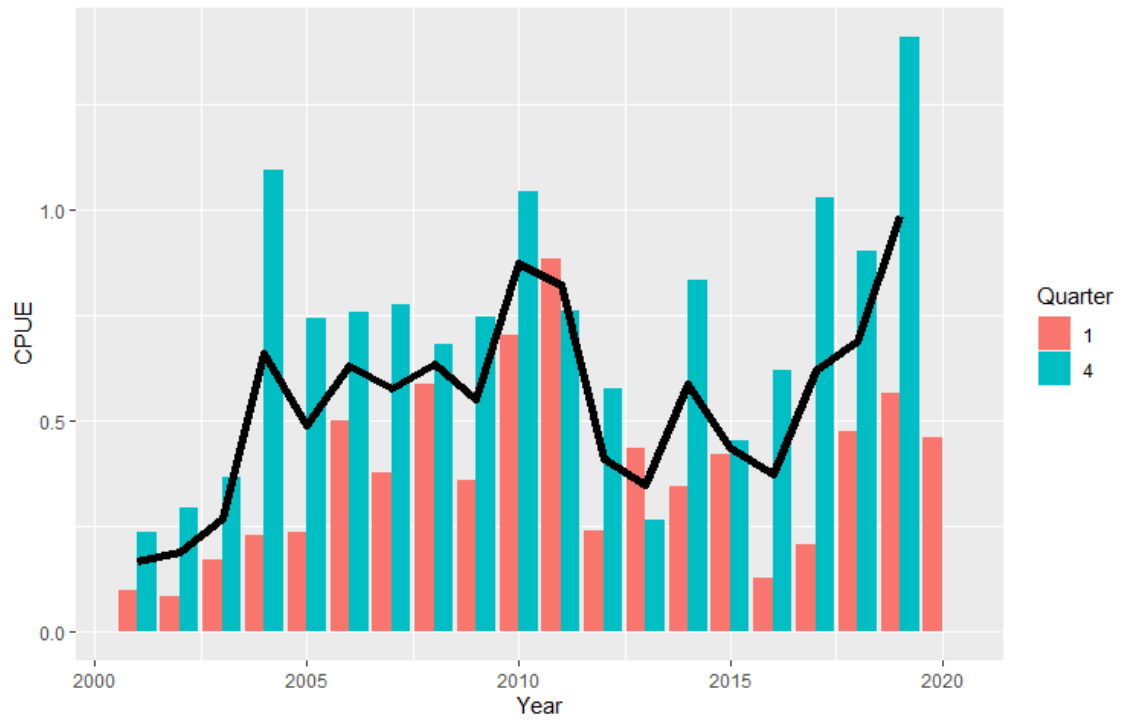


Figure 8.3.2. Mean CPUE (no. hr⁻¹) of brill with L ≥ 20 cm.

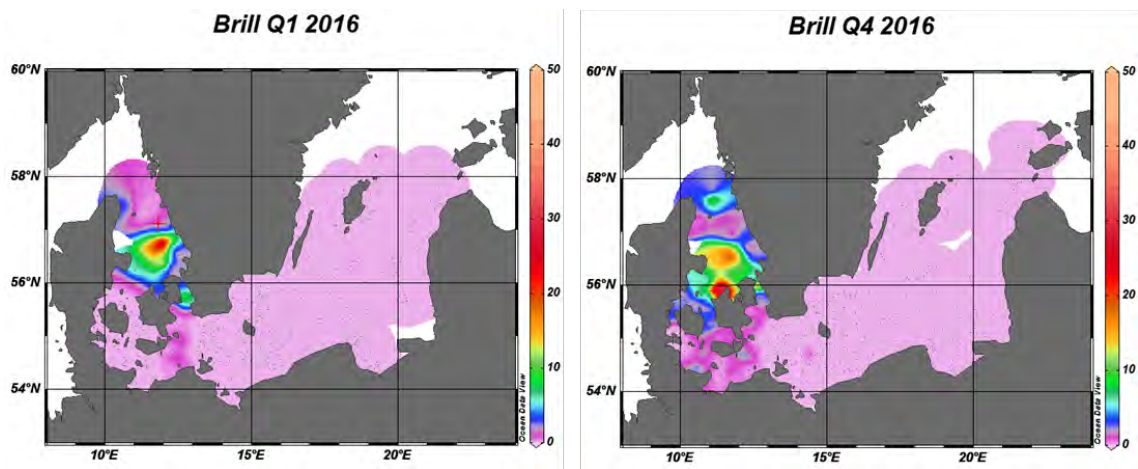


Figure 8.3.3. Brill distribution in the Baltic Sea, CPUE in numbers per hour indicated in colour bars.

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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 |
| Gröhslér, 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 |
| Karpushevskaiia, 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 sub-groups, and only hold larger virtual meetings when necessary.

The requesters of advice have been informed that there will be disruption/change to the delivery of advice for the spring 2020 season.

ACOM will also change the way that ICES gives advice for the spring 2020 season. There will be three types of advice:

- **Standard advice sheet** (the advice sheet following the January 2020 guidelines)
- **Abbreviated advice sheet** (a shortened advice sheet)
- **Rollover advice** (the same advice as in 2019)

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The choice of which type of advice to apply to a stock is based on criteria determined by ACOM:

- a. **Standard advice** - stocks with 2020 benchmarked methods
- b. **Abbreviated advice** – most stocks, including management plan and MSY advice stocks, and some Cat 3 stocks. The abbreviated advice will contain the advice of the headline advice, catch scenario tables, plots and automated tables (last years' advice will be added as an annex to each sheet). The guidance for abbreviated advice is being written now and you should receive it in a few days.
- c. **Rollover advice** – same as 2019 advice. This will be provided for stocks in the following categories:
 - o zero TAC has been advised in recent years and no change likely,
 - o category 3 or greater roll over advice, except if due to be reviewed in 2020
 - o long lived stable stocks, with no strong trends in dynamics in recent years
 - o 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 process¹. 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.

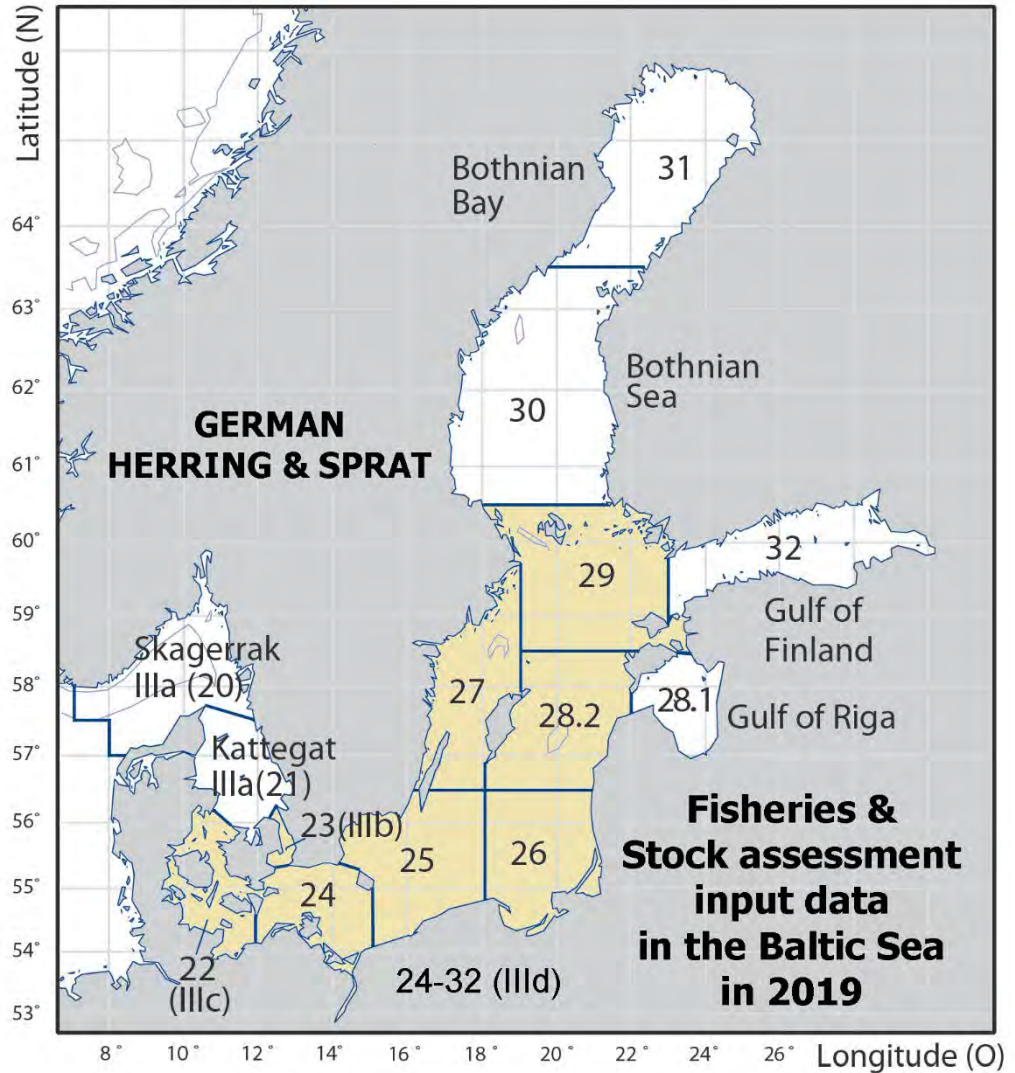
WGBFAS will report by xx April 2021 for the attention of ACOM.

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*)

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14 - 21 April 2020



compiled by
Tomas Gröhler
Thünen Institute of Baltic Sea Fisheries (TI-OF)
Germany

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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 | | (2) Total | |
|---------|--------|-----------|---------|-----------|-------|---------|---------|-----------|-----------|-----------|--------|
| | | | | | | | | SD 25-29 | % (1)/(2) | 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 | - | 187.243 | 144.148 | 1.328.340 | 99.8% | 1.331.514 | 80.0% |
| II | 3.670 | 108.134 | 28.717 | 318.769 | - | 10.000 | - | 353.486 | 76.0% | 465.290 | 6.4% |
| | 0.000 | 0.215 | 16.254 | 295.843 | - | 10.000 | - | 322.097 | 99.8% | 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 | 1.068.835 | 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%

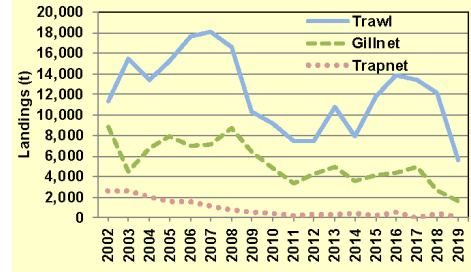
The main fishing season was during spring time as in former years. About 85 % of all herring (SDs 22-29) in 2019 was caught between January and April (2018: 88 %). The majority of the German herring landings (75 %) were taken in Subdivision 24 (2018: 72 %). The German herring fishery in the Baltic Sea 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.

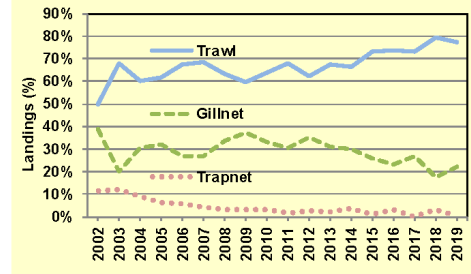
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| Landings in Subdivisions 22-29 (t) | | | | |
|------------------------------------|------------|-----------|-----------|------------|
| Year/Gear | Trawl | Gillnet | Trapnet | Total |
| 2002 | 11,317.813 | 8,783.392 | 2,559.662 | 22,660.867 |
| 2003 | 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% |



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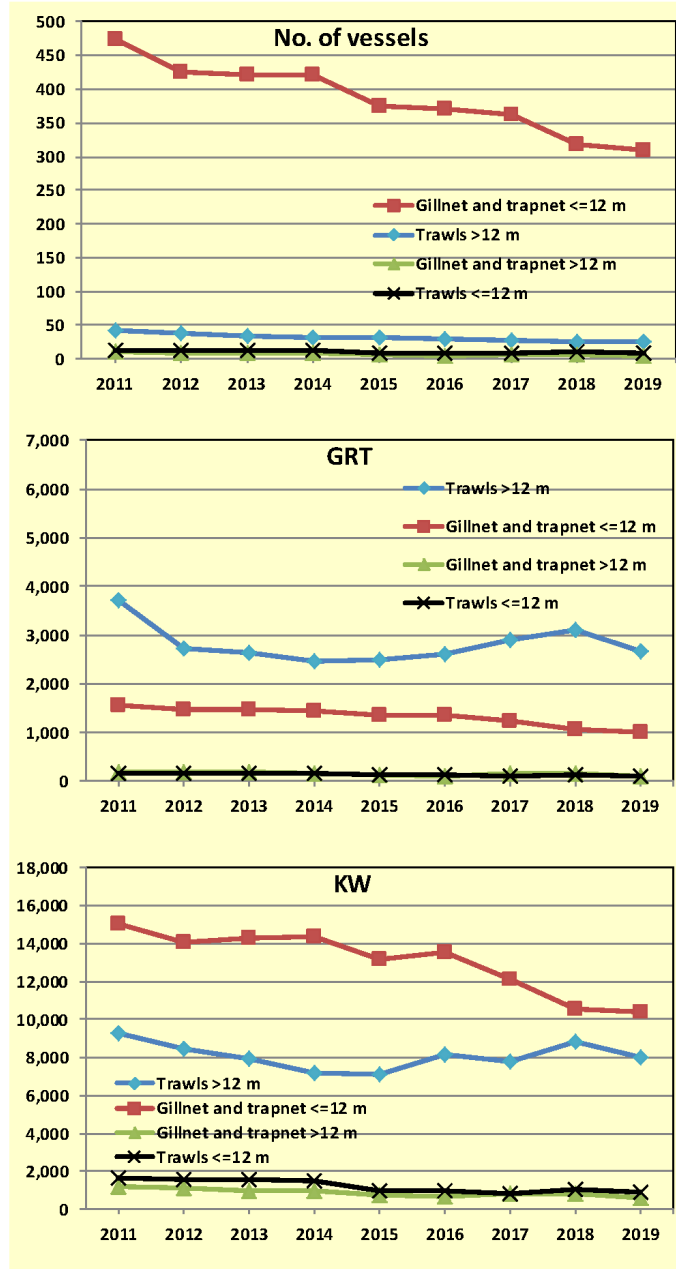
Baltic Fisheries Assessment Working Group (WGBFAS)
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The herring fishing fleet in the Baltic Sea, where all catches are taken in a directed fishery, consists of a:

- 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 (gillnet and trapnet) | ≤ 12 | 473 | 1,566 | 15,020 |
| | | > 12 | 10 | 185 | 1,215 |
| | Trawls | ≤ 12 | 12 | 171 | 1,666 |
| | | > 12 | 43 | 3,710 | 9,325 |
| | TOTAL | | 538 | 5,632 | 27,226 |
| 2012 | Fixed gears (gillnet and trapnet) | ≤ 12 | 426 | 1,485 | 14,105 |
| | | > 12 | 9 | 184 | 1,125 |
| | Trawls | ≤ 12 | 12 | 170 | 1,573 |
| | | > 12 | 38 | 2,712 | 8,480 |
| | TOTAL | | 485 | 4,551 | 25,283 |
| 2013 | Fixed gears (gillnet and trapnet) | ≤ 12 | 421 | 1,459 | 14,289 |
| | | > 12 | 9 | 186 | 1,005 |
| | Trawls | ≤ 12 | 14 | 173 | 1,557 |
| | | > 12 | 35 | 2,638 | 7,960 |
| | TOTAL | | 479 | 4,456 | 24,811 |
| 2014 | Fixed gears (gillnet and trapnet) | ≤ 12 | 421 | 1,443 | 14,351 |
| | | > 12 | 8 | 149 | 970 |
| | Trawls | ≤ 12 | 13 | 170 | 1,502 |
| | | > 12 | 31 | 2,469 | 7,205 |
| | TOTAL | | 473 | 4,231 | 24,028 |
| 2015 | Fixed gears (gillnet and trapnet) | ≤ 12 | 375 | 1,341 | 13,163 |
| | | > 12 | 7 | 133 | 802 |
| | Trawls | ≤ 12 | 9 | 122 | 991 |
| | | > 12 | 31 | 2,503 | 7,148 |
| | TOTAL | | 422 | 4,099 | 22,104 |
| 2016 | Fixed gears (gillnet and trapnet) | ≤ 12 | 371 | 1,341 | 13,532 |
| | | > 12 | 5 | 103 | 699 |
| | Trawls | ≤ 12 | 8 | 137 | 997 |
| | | > 12 | 30 | 2,599 | 8,205 |
| | TOTAL | | 414 | 4,180 | 23,433 |
| 2017 | Fixed gears (gillnet and trapnet) | ≤ 12 | 362 | 1,237 | 12,158 |
| | | > 12 | 6 | 148 | 874 |
| | Trawls | ≤ 12 | 8 | 113 | 872 |
| | | > 12 | 27 | 2,910 | 7,816 |
| | TOTAL | | 403 | 2,910 | 21,720 |
| 2018 | Fixed gears (gillnet and trapnet) | ≤ 12 | 319 | 1,049 | 10,572 |
| | | > 12 | 6 | 148 | 874 |
| | Trawls | ≤ 12 | 11 | 143 | 1,080 |
| | | > 12 | 26 | 3,093 | 8,815 |
| | TOTAL | | 362 | 4,433 | 21,341 |
| 2019 | Fixed gears (gillnet and trapnet) | ≤ 12 | 309 | 1,008 | 10,374 |
| | | > 12 | 4 | 100 | 598 |
| | Trawls | ≤ 12 | 8 | 114 | 897 |
| | | > 12 | 25 | 2,655 | 8,025 |
| | TOTAL | | 846 | 3,877 | 19,894 |



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1.3 Species composition of landings

The catch composition from gillnet and trapnet consists of nearly 100 % of herring.

The results from the species composition of German trawl catches, which were sampled in **Subdivision 24** of quarter 1, 2 and 4 in 2019, are given below:

| SD 24/Quarter I | | Weight (kg) | | | | | Weight (%) | | | |
|------------------|------------|-------------|-------|-----|-------|-------|------------|-------|-----|-------|
| | Sample No. | Herring | Sprat | Cod | Other | Total | Herring | Sprat | Cod | Other |
| January | 1 | 55.9 | 0.0 | 0.0 | 0.0 | 55.9 | 100.0 | 0.0 | 0.0 | 0.0 |
| | 2 | | | | | | | | | |
| | 3 | | | | | | | | | |
| | Mean | 55.9 | 0.0 | 0.0 | 0.0 | 55.9 | 100.0 | 0.0 | 0.0 | 0.0 |
| February | 1 | 47.2 | 0.0 | 0.0 | 0.0 | 47.2 | 99.9 | 0.1 | 0.0 | 0.0 |
| | 2 | 69.4 | 0.0 | 0.0 | 0.0 | 69.4 | 100.0 | 0.0 | 0.0 | 0.0 |
| | 3 | | | | | | | | | |
| | Mean | 58.3 | 0.0 | 0.0 | 0.0 | 58.3 | 99.9 | 0.1 | 0.0 | 0.0 |
| March | 1 | 75.7 | 0.0 | 0.0 | 0.0 | 75.7 | 100.0 | 0.0 | 0.0 | 0.0 |
| | 2 | | | | | | | | | |
| | 3 | | | | | | | | | |
| | Mean | 75.7 | 0.0 | 0.0 | 0.0 | 75.7 | 100.0 | 0.0 | 0.0 | 0.0 |
| Q I | Mean | 63.3 | 0.0 | 0.0 | 0.0 | 63.3 | 100.0 | 0.0 | 0.0 | 0.0 |
| SD 24/Quarter II | | Weight (kg) | | | | | Weight (%) | | | |
| | Sample No. | Herring | Sprat | Cod | Other | Total | Herring | Sprat | Cod | Other |
| April | 1 | 49.4 | 0.1 | 0.0 | 0.0 | 49.6 | 99.7 | 0.3 | 0.0 | 0.0 |
| | 2 | | | | | | | | | |
| | 3 | | | | | | | | | |
| | Mean | 49.4 | 0.1 | 0.0 | 0.0 | 49.6 | 99.7 | 0.3 | 0.0 | 0.0 |
| May | 1 | | | | | | | | | |
| | 2 | | | | | | | | | |
| | Mean | | | | | | | | | |
| June | 1 | | | | | | | | | |
| | 2 | | | | | | | | | |
| | Mean | | | | | | | | | |
| Q II | Mean | 49.4 | 0.1 | 0.0 | 0.0 | 49.6 | 99.7 | 0.3 | 0.0 | 0.0 |
| SD 24/Quarter IV | | Weight (kg) | | | | | Weight (%) | | | |
| | Sample No. | Herring | Sprat | Cod | Other | Total | Herring | Sprat | Cod | Other |
| October | 1 | | | | | | | | | |
| | 2 | | | | | | | | | |
| | 3 | | | | | | | | | |
| | Mean | | | | | | | | | |
| November | 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 |
| December | 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 | 5,670.531 | 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 | | |
| TRAWL | 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 | |
| | | | 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 | | | |

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1.8 Catch in numbers (millions)

1.8.1 Subdivisions 22 and 24

| | SUBDIVISION 22 | | | | SUBDIVISION 24 | | | | SUBDIVISIONS 22+24 | | | |
|----------------|----------------|-------|-------|--------|----------------|-------|-------|-------|--------------------|-------|-------|-------|
| | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| TRAWL | | | | | | | | | | | | |
| W.rings | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | |
| 0 | | | | | | | | | | | | |
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | 0.003 | 0.000 | 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 | | | | | | | | | | | | |
| 0 | | | | | | | | | | | | |
| 1 | | | | | | | | | | | | |
| 2 | | 0.001 | 0.000 | 0.000 | 0.020 | 0.004 | 0.000 | 0.000 | 0.020 | 0.004 | 0.000 | 0.001 |
| 3 | | 0.008 | 0.000 | 0.002 | 0.079 | 0.023 | 0.000 | 0.000 | 0.079 | 0.024 | 0.000 | 0.005 |
| 4 | | 0.003 | 0.000 | 0.001 | 0.157 | 0.008 | 0.000 | 0.000 | 0.157 | 0.009 | 0.000 | 0.002 |
| 5 | | 0.000 | 0.000 | 0.000 | 0.034 | 0.001 | 0.000 | 0.000 | 0.034 | 0.001 | 0.000 | 0.000 |
| 6 | | 0.000 | 0.000 | 0.000 | 0.062 | 0.001 | 0.000 | 0.000 | 0.062 | 0.001 | 0.000 | 0.000 |
| 7 | | 0.000 | 0.000 | 0.000 | 0.014 | 0.000 | 0.000 | 0.000 | 0.014 | 0.000 | 0.000 | 0.000 |
| 8+ | | 0.000 | 0.000 | 0.000 | 0.013 | 0.000 | 0.000 | 0.000 | 0.013 | 0.000 | 0.000 | 0.000 |
| Sum | | 0.001 | 0.000 | 0.000 | 0.378 | 0.037 | 0.000 | 0.000 | 0.378 | 0.038 | 0.000 | 0.008 |
| TOTAL | | | | | | | | | | | | |
| W.rings | | | | | | | | | | | | |
| 0 | | | | 0.000 | | | | 0.047 | | | | 0.047 |
| 1 | 0.002 | | | 0.000 | 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 Gear | Quart. | Area | Gear | Quart. | Area | Missing Gear | Quart. | Area | Gear | Quart. | Area |
| Trapn | 1 | 24 | Trapn | 1 | Gillnet | 2, 3, 4 | 22 | Gillnet | 2 | | |
| Trapn | 2 | 24 | Trapn | 2 | Trapn | 2, 3, 4 | 22 | Trapn | 2 | | |
| Trapn | 4 | 24 | Trapn | 4 | | | | | | | |
| Gillnet | 3, 4 | 22 | Gillnet | 2 | | | | | | | |
| Trapn | 3, 4 | 22 | Trapn | 2 | | | | | | | |

1.8.2 Subdivisions 25-29

No sampling.

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1.9 Mean weight in the catch (grams)

1.9.1 Subdivisions 22 and 24

| | SUBDIVISION 22 | | | | SUBDIVISION 24 | | | | SUBDIVISIONS 22+24 | | | |
|----------------|----------------|-------|-------|-------|----------------|-------|-------|-------|--------------------|-------|-------|-------|
| | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| TRAWL | | | | | | | | | | | | |
| Wrings | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | |
| Wrings | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | |
| Wrings | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | |
| Wrings | | | | | | | | | | | | |
| 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 | Quart. | Area | Gear | Quart. | Area | Missing | Quart. | Area | Gear | Quart. | Area |
| Replacement by | | | | | | Replacement by | | | | | |
| Gear | | | | | | Gillnet | 1, 3, 4 | 22 | Gillnet | 2 | |
| Trapn | 1 | 24 | Trapn | 1 | | Trapn | 2, 3, 4 | 22 | Trapn | 2 | |
| Trapn | 2 | 24 | Trapn | 2 | | | | | | | |
| Trapn | 4 | 24 | Trapn | 4 | | | | | | | |
| Gillnet | 3, 4 | 22 | Gillnet | 3, 4 | | | | | | | |
| Trapn | 3, 4 | 22 | Trapn | 3, 4 | | | | | | | |

1.9.2 Subdivisions 25 and 29

No sampling.

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1.10 Mean length in the catch (cm)

1.10.1 Subdivisions 22 and 24

| | SUBDIVISION 22 | | | | SUBDIVISION 24 | | | | SUBDIVISIONS 22+24 | | | |
|----------------|----------------|------|------|------|----------------|------|------|------|--------------------|------|------|------|
| | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| TRAWL | | | | | | | | | | | | |
| W.rings | | | | | | | | | | | | |
| 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 |
| GILLNET | | | | | | | | | | | | |
| W.rings | | | | | | | | | | | | |
| 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 |
| TRAPNET | | | | | | | | | | | | |
| W.rings | | | | | | | | | | | | |
| 0 | | | | | | | | | | | | |
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | | 20.3 | 20.3 | 20.3 | 20.9 | 20.3 | 20.3 | 20.3 | 20.9 | 20.3 | 20.3 | 20.3 |
| 4 | | 21.9 | 21.9 | 21.9 | 23.3 | 21.9 | 21.9 | 21.9 | 23.3 | 21.9 | 21.9 | 21.9 |
| 5 | | 23.1 | 23.1 | 23.1 | 24.8 | 23.1 | 23.1 | 23.1 | 24.8 | 23.1 | 23.1 | 23.1 |
| 6 | | 24.9 | 24.9 | 24.9 | 25.5 | 24.9 | 24.9 | 24.9 | 25.5 | 24.9 | 24.9 | 24.9 |
| 7 | | 26.4 | 26.4 | 26.4 | 27.5 | 26.4 | 26.4 | 26.4 | 27.5 | 26.4 | 26.4 | 26.4 |
| 8+ | | 26.3 | 26.3 | 26.3 | 26.5 | 26.3 | 26.3 | 26.3 | 26.5 | 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 |
| TOTAL | | | | | | | | | | | | |
| W.rings | | | | | | | | | | | | |
| 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 |

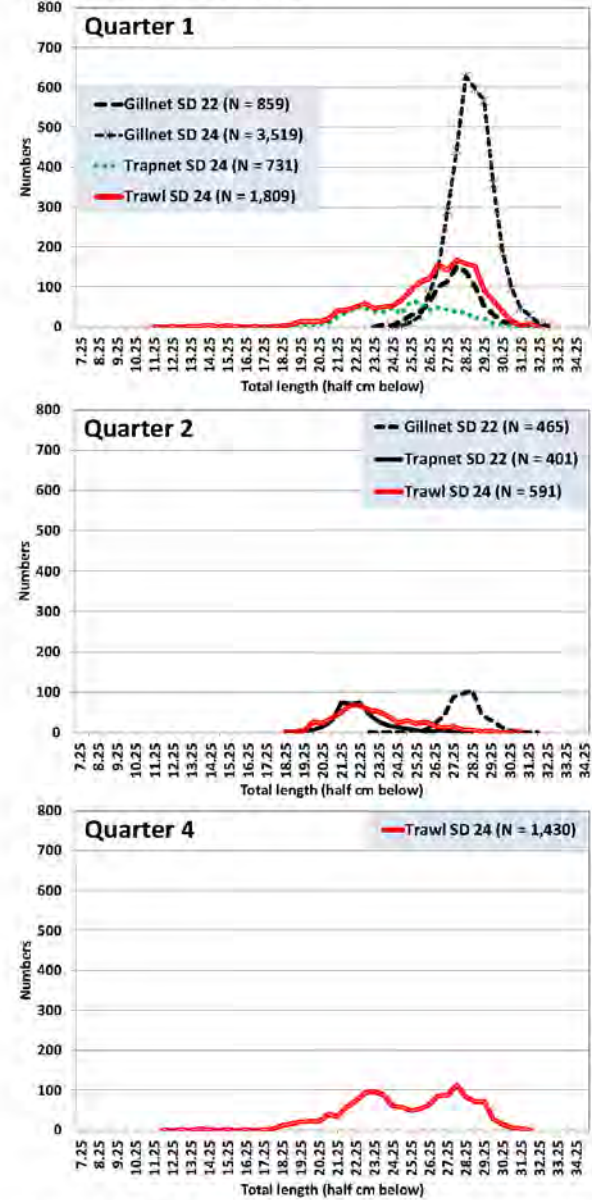
| REPLACEMENT OF MISSING SAMPLES: | | | | | | | | | | | |
|---------------------------------|-------|--------|------|---------|--------|----------------|-------|--------|------|---------|--------|
| SUBDIVISION 22 | | | | | | SUBDIVISION 24 | | | | | |
| Missing | Gear | Quart. | Area | Gear | Quart. | Missing | Gear | Quart. | Area | Gear | Quart. |
| 24.0 | Trapn | 3,4 | 22 | Gillnet | 2 | 24.0 | Trapn | 3,4 | 22 | Gillnet | 2 |
| 26.5 | Trapn | 3,4 | 22 | Trapn | 2 | 26.5 | 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.

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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 | - | 948.381 | 1,388.038 | 8,309.988 | 100.0% | 8,309.988 | 83.8% |
| II | 0.713 | - | 1,008.075 | 4,085.956 | - | 168.876 | - | 5,262.907 | 100.0% | 5,283.620 | 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% |

Fraction of total landings (t) in foreign ports

2019/2018

2019/2018

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:

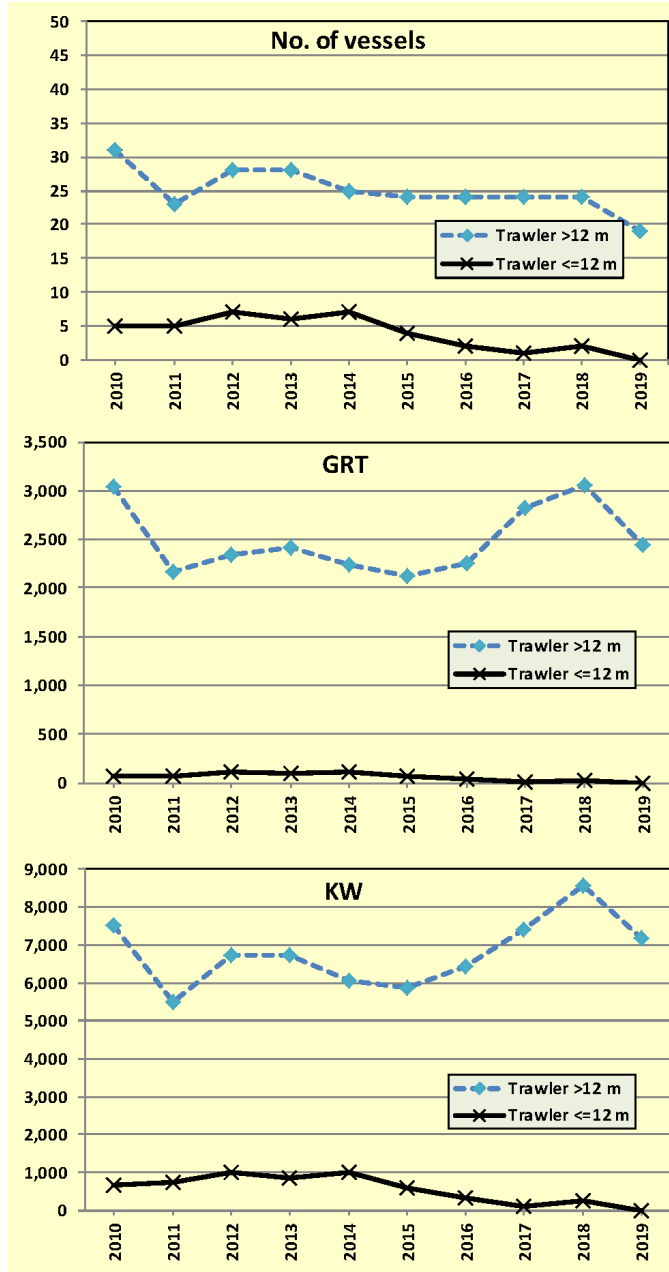
- cutter fleet of total length ≤ 12 m,
- cutter fleet of total length > 12 m.

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 | 21 | 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 |

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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/Quarter 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 1 | | 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 1 | | 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 |

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| 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/Quarter I | | 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 | 1 | 395 | 82.7 | 326 | 68 |
| 25 | 1 | 739 | 99.5 | 735 | 4 |
| 26 | I | 5,510 | 99.6 | 5,489 | 20 |
| | II | 4,086 | 95.1 | 3,884 | 202 |
| 28 | 1 | 1,011 | 100.0 | 1,011 | 0 |
| 29 | 1 | 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).

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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 | - | - | - | 277.580 | 0 | 0 | 0 |
| | Total | 1,388.038 | 1 | 370 | 51 | 14,644.920 | 17 | 5,464 | 874 |

Fraction of landings in foreign ports:
¹SD 22: 0 %
²SD 24: 0 %
³SD 25-29: 13,016 t (92 %)
⁴SD 22-29: 13,016 t (89 %)

2.6 Catch in numbers (millions)

| Age | SUBDIVISION 22 | | | | SUBDIVISION 24 | | | | SUBDIVISION 25 | | | | SUBDIVISION 26 | | | |
|------------|----------------|----|----|----|----------------|-----|----|----|----------------|----|----|----|----------------|----------------|----|----|
| | Q1 | Q2 | Q3 | Q4 | *Q1 | *Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| 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 | | | | SUBDIVISION 28 | | | | SUBDIVISION 29 | | | | SUBDIVISIONS 22-29 | | | |
|------------|----------------|----|----|----|----------------|----|----|----|----------------|----|----|----|--------------------|----------------|----|----|
| | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| 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+ | | | | | | | | | | | | | | | | |
| Sum | | | | | 122.122 | | | | 187.972 | | | | 1096.401 | 524.917 | | |

Working document 01

Baltic Fisheries Assessment Working Group (WGBFAS)
14 - 21 April 2020

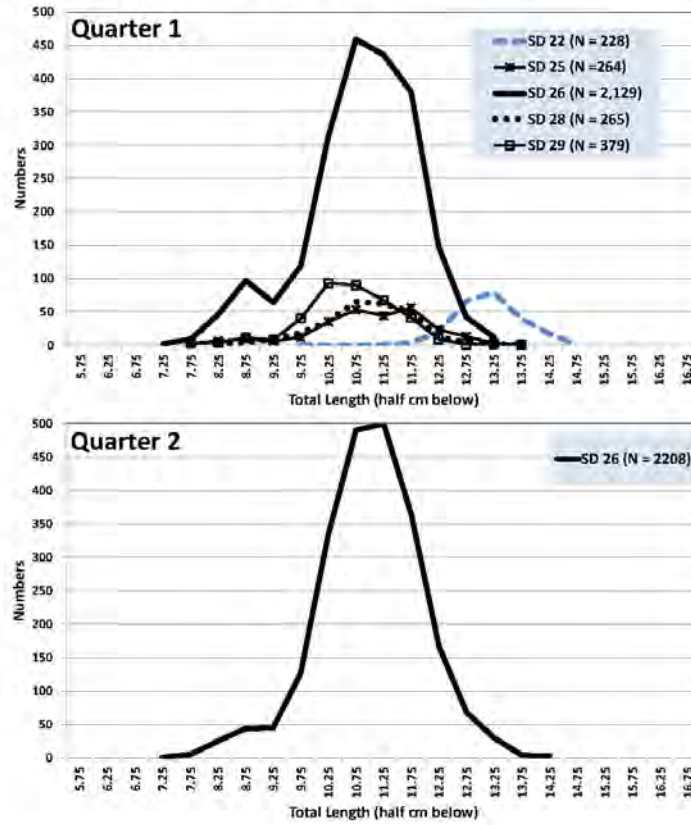
2.7 Mean weight in the catch (grams)

| | | 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 | | | | SUBDIVISION 26 | | | |
|-------|-----|----------------|----|----|----|----------------|----|----|----|----------------|----|----|----|--------------------|------|----|----|
| 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 \leq 10 m and engine power \leq 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 \geq 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 of sprat 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 Griben and Hassensør on Djursland. The total survey area is 10204 km² (Figure 1).

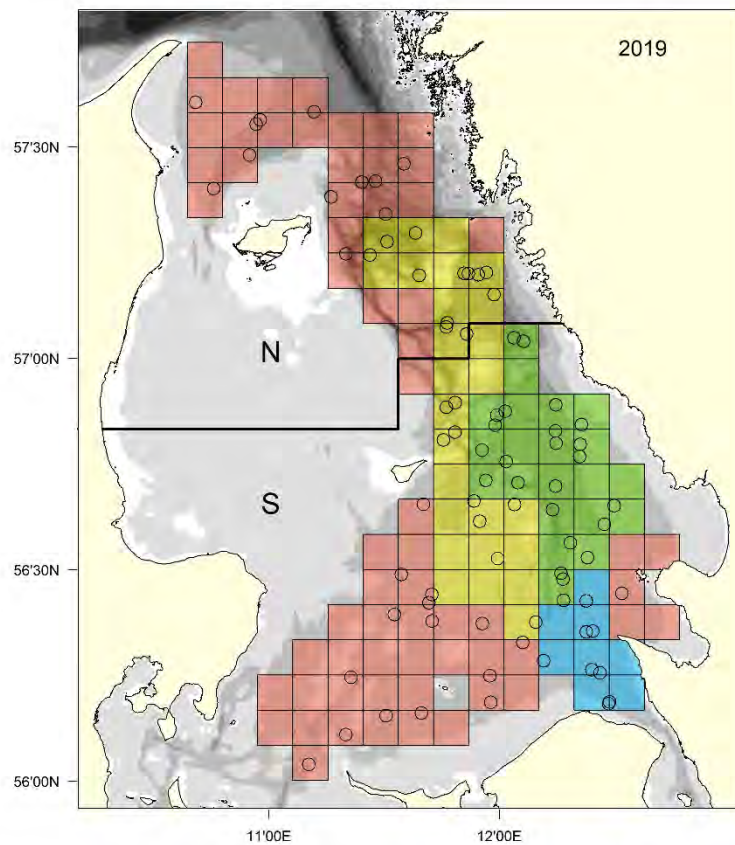


Figure 1. Survey stratification and sampled stations in 2019. Green represents the high-density stratum; yellow the medium-density stratum and red the low-density stratum. In 2013 a fourth stratum was added (marked in blue) to ensure sufficient sampling in the closed area. N (north) and S (south) identifies the two domains 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 start when the trawl is considered stable on the bottom, roughly 5-7 minutes after wires are connected. The tow duration is 1 hour

WD03 Kattegat cod survey 2008-2019

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 km²) 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 5x5 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/km² and total biomass in tonnes. Numbers per km² 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 |

WD03 Kattegat cod survey 2008-2019

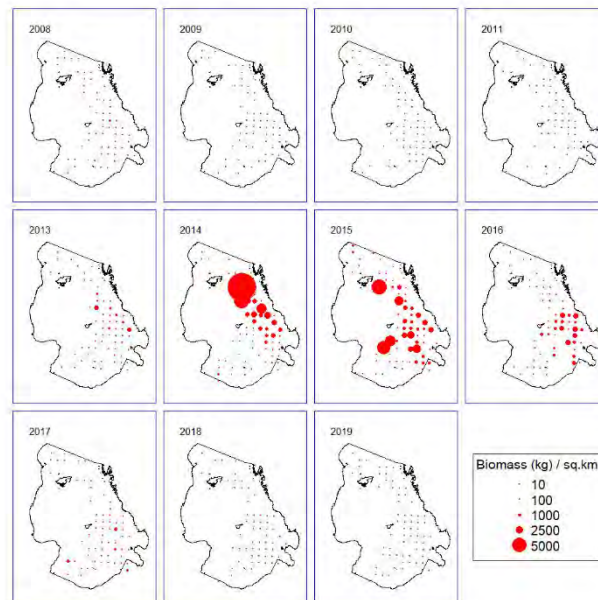


Figure 2a. Biomass of cod per km², calculated as an average from all vessels per square.

WD03 Kattegat cod survey 2008-2019

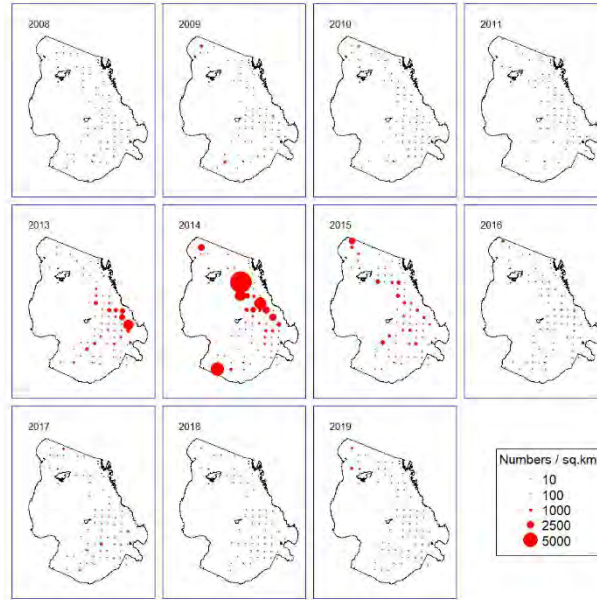


Figure 2b. Abundance of cod per km², calculated as an average from all vessels per square.

Table 5: Stratum area (km²), hauls, mean biomass and Stdev (kg/km²) 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 (km²), hauls, mean number and Stdev (N/km²), 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 |

WD03 Kattegat cod survey 2008-2019

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.

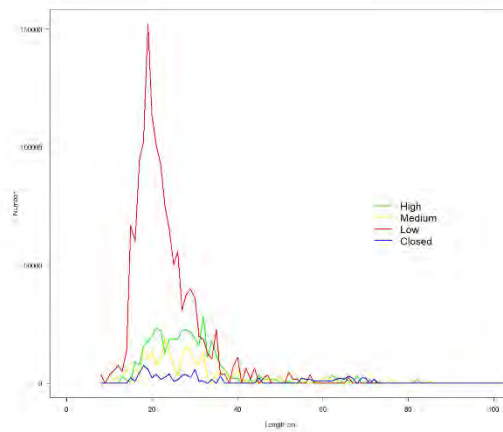


Figure 5. Cod length distribution by strata in 2019.

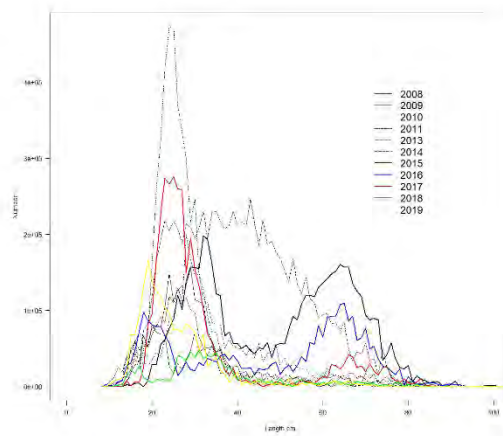


Figure 6. Cod length distributions in the total survey area by year, 2008-2019.

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 |

WD03 Kattegat cod survey 2008-2019

CPUE

The survey swept area index from 2008 to 2019, estimated as the weighted mean catch in numbers at age per km² are shown in table 9.

Table 9: CPUE at age (N/km²)

| 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, Mograth 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

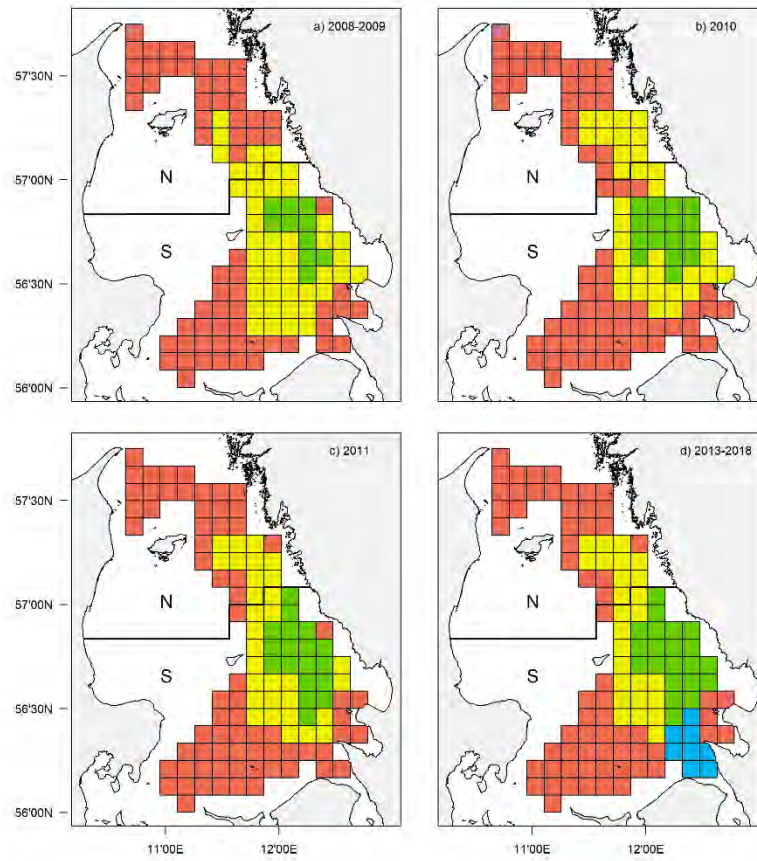
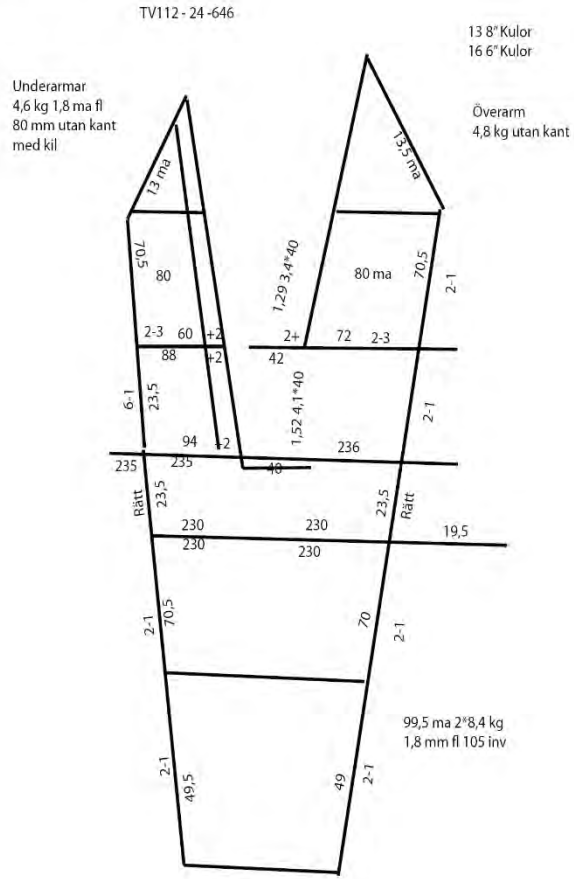


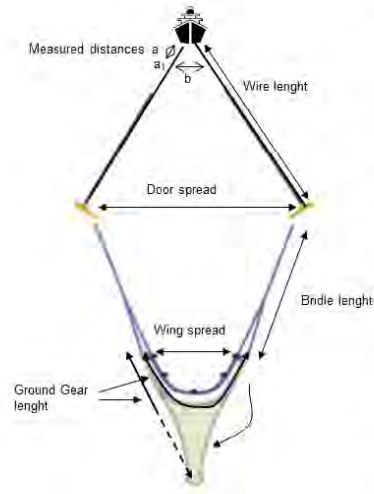
Figure 1a-d. The survey stratification 2008-2019. Green represents the high-density stratum; yellow the medium-density stratum and red the low-density stratum. In 2013 a fourth (blue) stratum was added to ensure sufficient sampling in the closed areas.

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

$$\text{Door spread} = \frac{\text{Wire length} \times \text{measured distance } b}{\text{measured distance } a}$$

For every haul, a length on the wire (distance a) and the length between the wires measured at a₁ (distance b) have been recorded.

Wing spread is estimated as:

$$\text{Wing spread} = \frac{\text{Ground gear length} \times \text{Door spread}}{\text{Bridle length} + \text{Ground gear length}}$$

(Calculation from "Course in Trawl Gear Technology", May 2006, SeaFish Flame 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 (<i>Platichthys solemdali</i>) in subdivisions 27 and 29–32 (northern central and northern Baltic Sea) |
| 2 | bwq.27.2425 | Flounder (<i>Platichthys spp</i>) in subdivisions 24 and 25 (west of Bornholm and southwestern central Baltic) |
| 3 | bwq.27.2628 | Flounder (<i>Platichthys spp</i>) in subdivisions 26 and 28 (east of Gotland and Gulf of Gdansk) |
| 4 | dab.27.22-32 | Dab (<i>Limanda limanda</i>) in subdivisions 22-32 (Baltic Sea) |
| 5 | her.27.25-2932 | Herring (<i>Clupea harengus</i>) in subdivisions 25-29 and 32, excluding the Gulf of Riga (central Baltic Sea) |
| 6 | her27.28 | Herring (<i>Clupea harengus</i>) in Subdivision 28.1 (Gulf of Riga) |
| 7 | her.27.3031 | Herring (<i>Clupea harengus</i>) in subdivisions 30 and 31 (Gulf of Bothnia) |
| 8 | sol.27.20-24 | Sole (<i>Solea solea</i>) in subdivisions 20-24 (Skagerrak and Kattegat, western Baltic Sea) |
| 9 | spr.27.22-32 | Sprat (<i>Sprattus sprattus</i>) 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 ($P_{\text{moye}}=0.25$, expected >0.3). In the most recent year overfishing of immature individuals is indicated ($L_{\text{inf}}/L_{\text{mat}}=0.53$, 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 I commercial CPUE (trapnet) + I 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:** $B > MSYB_{engpr}$, $F_{MSY} < F < F_{PB}$, 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 Karpushevskaja, 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 detected 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_{70}
- 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 $\pm 20\%$ range.
- 7) **Stock status:** $SSB > B_{trigger}$ and $F_{70} > F_{msy}$
- 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 Mürny

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 EC 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), bli.27.22-32

Date: 20.04.2020.

Auditors: A. Karpushevskaia, 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, Victoria 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 than 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% "overreporting" 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 weak. Under F_{msy} the SSB in 2021-22 is predicted to be above B_{pa} (= 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 ($L_t/L_{inf}=0.8$, 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_{P0} 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 EC 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: ADC, 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 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 $MSY B_{ing}$. 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 WGBITS | WGBGFAS recommends the survey working groups, WGBIFS and WGBITS, 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 | <p>WGBGFAS 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 WGBITS 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.</p> <p>Surveys to be sent by the 1 February includes:</p> <p>BASS</p> <p>IBTS Q3</p> <p>FFS: Sole survey</p> <p>CodS_Q4: Cod survey</p> <p>FEJUCS: poundnet survey-</p> <p>BITS Q4</p> |
| ACOM | <p><i>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.</i></p> <p>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.</p> <p>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</p> |

| Target Group | Recommendation |
|--------------|---|
| | <p>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.</p> <p>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.</p> <p>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.</p> <p>The introduction of the 20% rule of thumb limit is based on Hurtado-Ferro <i>et al.</i> (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 <i>et al.</i> (2014) are different from the 20% ICES rule of thumb rule across stock typology and direction of the bias.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>Carvalho <i>et al.</i> (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.</p> <p>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.</p> <p>References</p> <p>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?. <i>Fisheries Research</i>, 192: 28-40.</p> <p>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. <i>ICES Journal of Marine Science</i>, 72(1): 99-110.</p> <p>Maunder, M. N., & Piner, K. R. 2015. Contemporary fisheries stock assessment: many issues still remain. <i>ICES Journal of Marine Science</i>, 72(1): 7-18.</p> |

| 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.

Select a Survey

Baltic International Trawl Survey

Select start year: 1991 | Select end year: 2019 | Select quarter: 1

| Survey | Year | Quarter | Ship/Country | Number of hauls | Insertion date |
|--------|------|---------|--------------|-----------------|---------------------|
| BITS | 2016 | 1 | SOL2/GFR | 60 | 12/04/2019 15:34:00 |
| BITS | 2015 | 1 | HAF/DEN | 49 | 05/04/2019 22:54:00 |
| BITS | 2019 | 1 | SOL2/GFR | 48 | 04/04/2019 17:38:00 |
| BITS | 2019 | 1 | 26HF/DEN | 55 | 29/03/2019 21:11:00 |
| BITS | 2019 | 1 | DANS/SWE | 51 | 29/03/2019 15:47:00 |
| BITS | 2019 | 1 | BAL/POL | 71 | 28/03/2019 08:32:00 |

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/re-moved/changed | only notify, if HL/CA information for the stock are affected |
| HH | Month | Added/re-moved/changed | only notify, if HL/CA information for the stock are affected |
| HH | StatRec | Added/re-moved/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 (1-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 removed (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 |
| <p>Changes made by DATRAS data centre</p> <p>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 „DateofCalculation“ field in the data products changes, it should be given a short explanation.</p> <p>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“).</p> | | | | |

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.

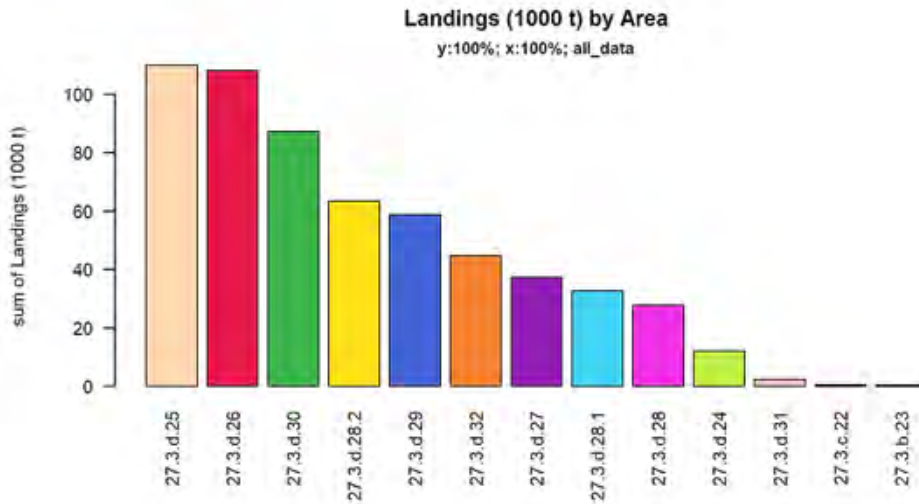


Figure A. Landings of small pelagics (in 1000t) by SD. Ref. RCG 20201.

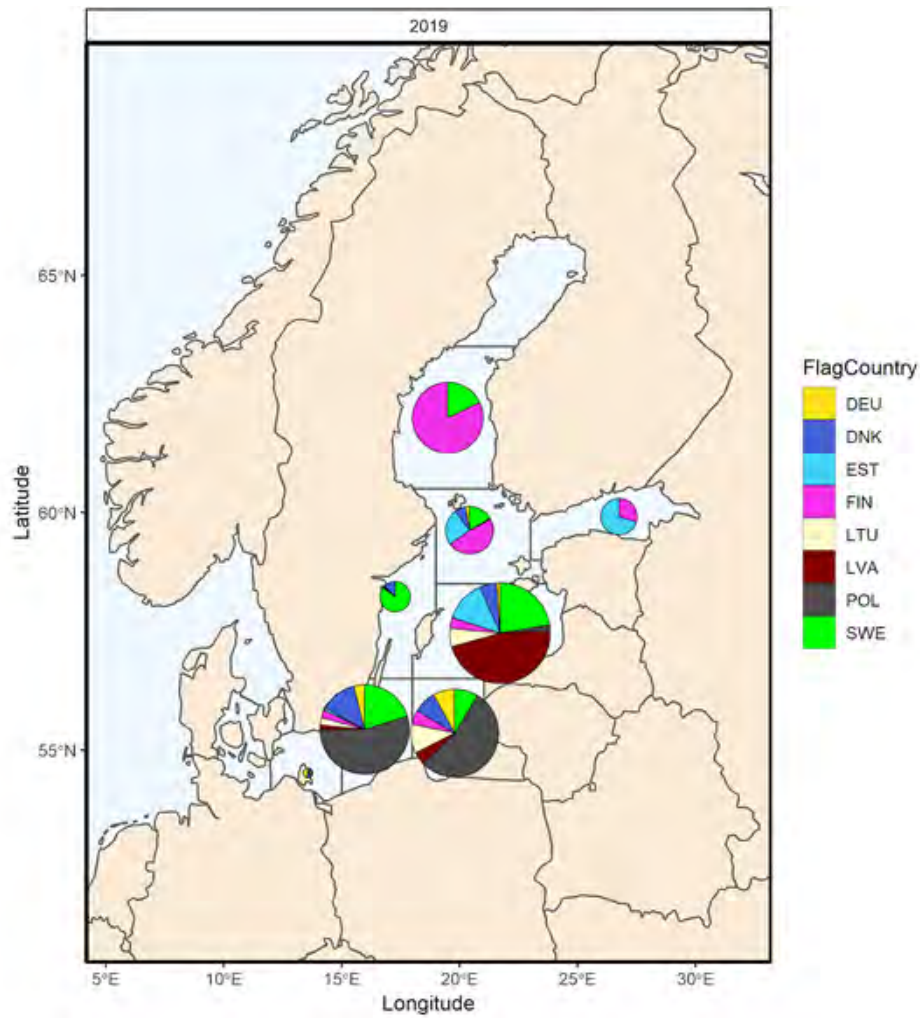


Figure B. Proportion of Landings by Country for each Subdivision (small pelagics). The size of the circles is proportional to total landings in the area. Ref. RCG 2020.

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.

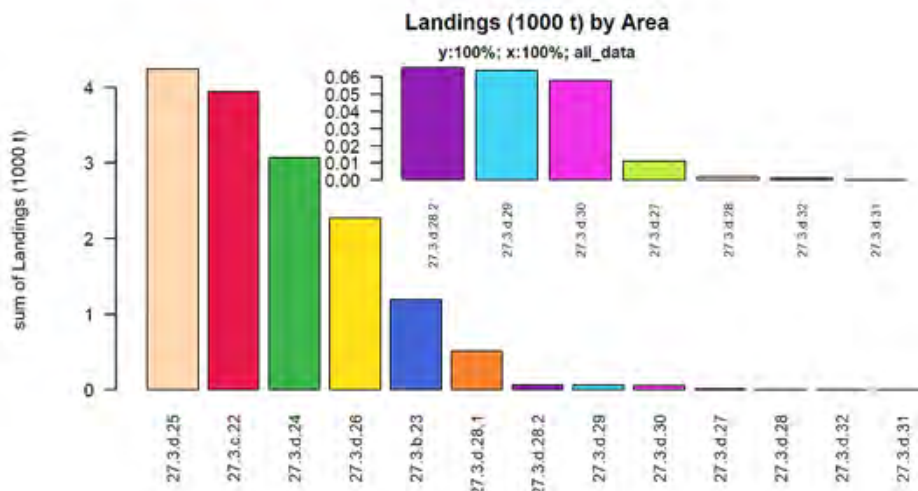


Figure C. Demersal landings (in 1000 t) by Area (SD). Ref. RCG 2020.

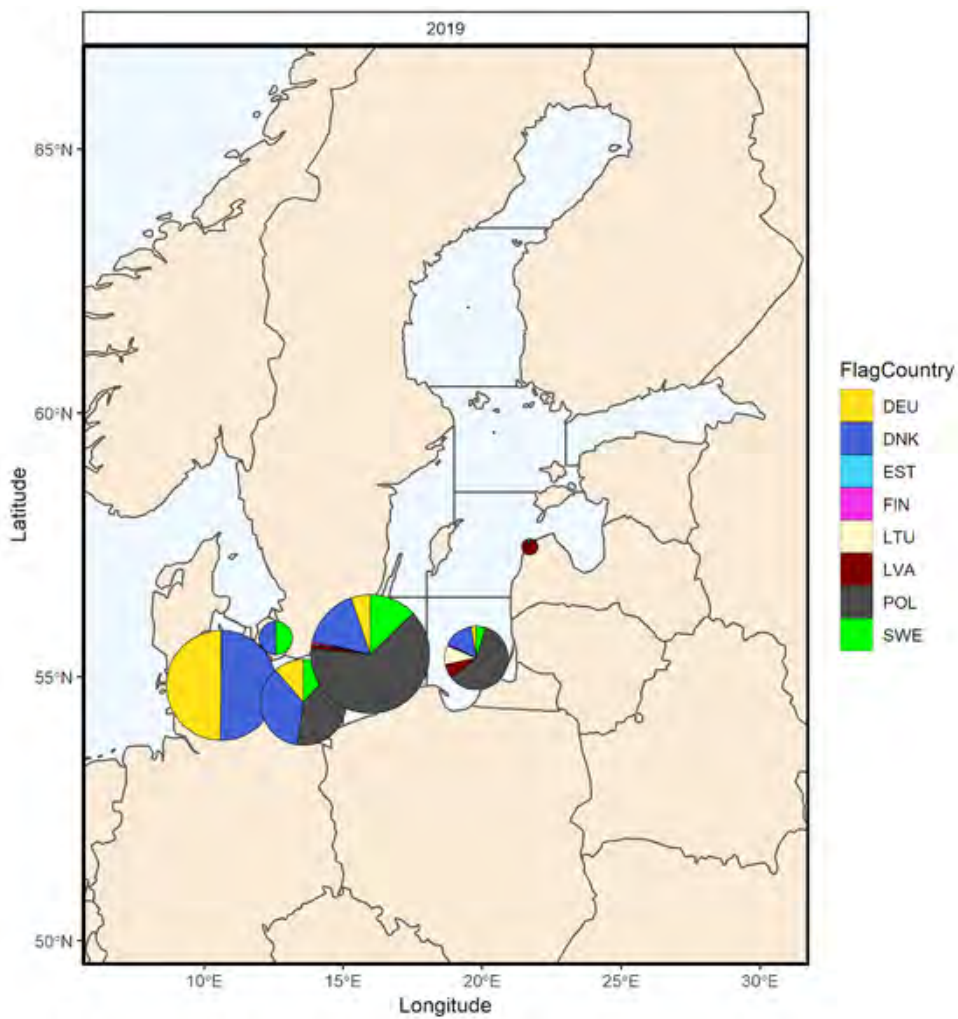


Figure D. Proportion of landings by Country for each Subdivision (demersal). The size of the circles is proportional to total landings in the area. Ref. RCG 2020.

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.

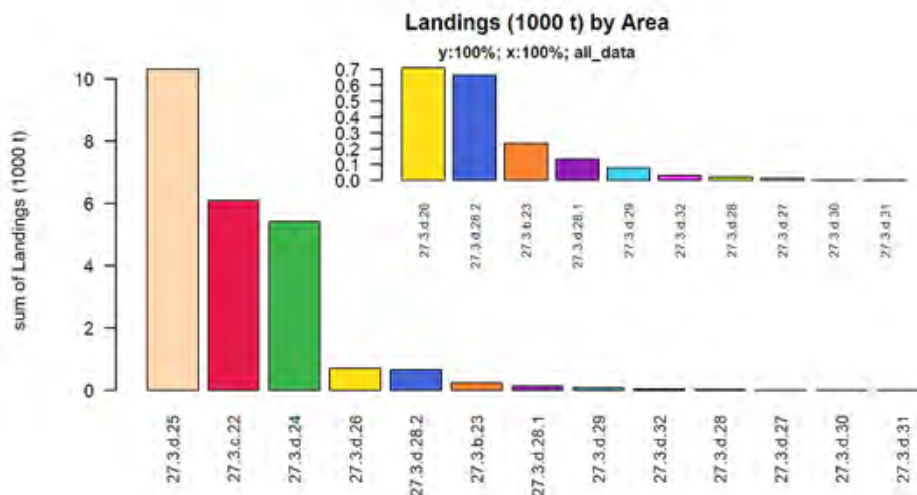


Figure E. Landings of flatfish (in 1000 t) by Area (SD). Ref. RCG 2020.

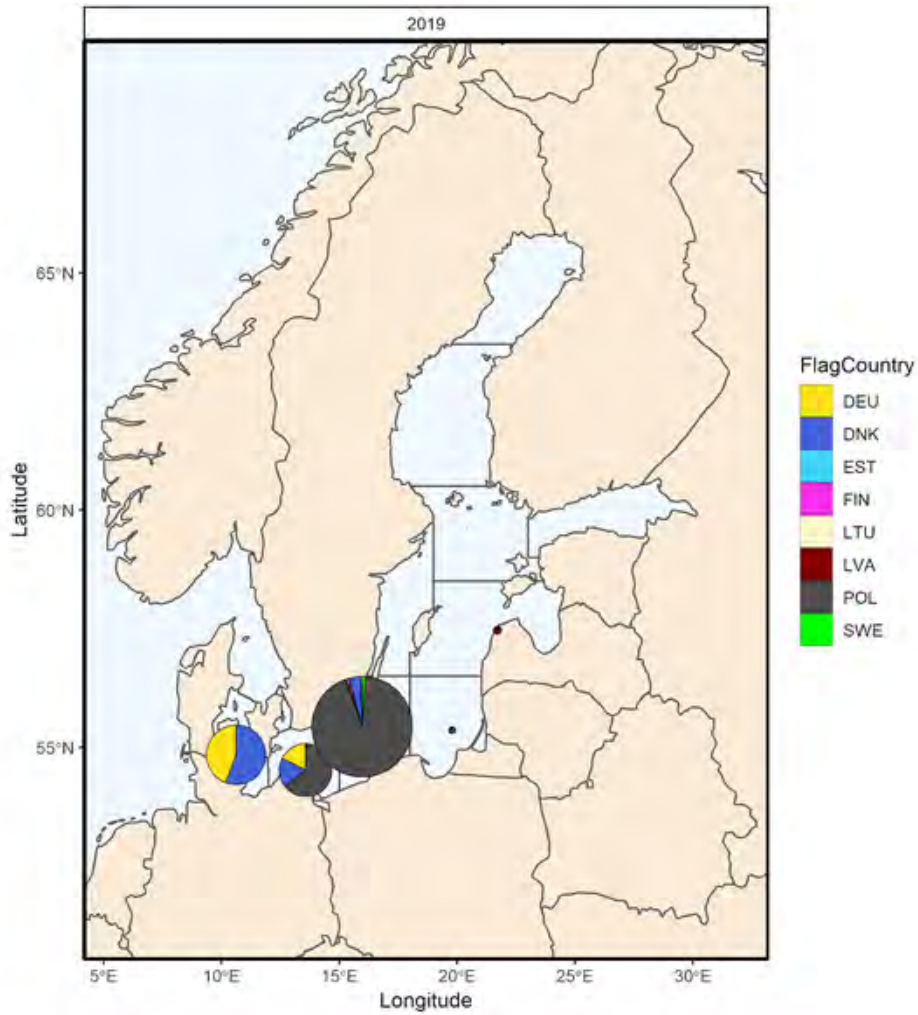


Figure F. Proportion of Landings by Country for each Subdivision (flatfish). The size of the circles is proportional to total landings in the area. Ref. RCG 2020.

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 | | | Land-ings | Dis-cards | Fishing mortality | | |
|------|-------------|---------|---------|------|------|------|-----------|-----------|-------------------|------|------|
| | Age1 | High | Low | SSB | High | Low | | | ages 3–5 | High | Lo w |
| 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 |
|------------------------------|-------|---|
| $F_{\text{ages 3-5}}$ (2020) | 0.38 | $F_{\text{ages 3-5}}$ in 2019. |
| SSB (2021) | 13083 | From the F_{2020} assumption. |
| $R_{\text{age 1}}$ (2020) | 28584 | Median resampled from the entire time-series. |
| $R_{\text{age 1}}$ (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: ($F = F_{\text{MSY}}$) | 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 |
| $F = F_{\text{lim}}$ | 12478 | 1 | 7868 |
| $\text{SSB (2022)} = B_{pa}$ | 16826 | 1.775 | 4732 |
| $\text{SSB (2022)} = \text{MSY } B_{\text{trigger}}$ | 16826 | 1.775 | 4732 |
| $\text{SSB (2022)} = B_{\text{lim}}$ | 18399 | 2.253 | 3630 |
| MSY approach: ($F = F_{\text{MSY}}$) Lower | 3194 | 0.18 | 14909 |
| MSY approach: ($F = F_{\text{MSY}}$) 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 |
| 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 x 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 <i>status quo</i> (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).